TelePACE Ladder Logic

Overview

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1 TelePACE Ladder Logic Overview

TelePACE ladder logic is ideal for electricians, engineers, and programmers who program sequencing and process control. The ladder logic editor is a powerful tool for writing, debugging and documenting ladder logic programs. The SCADAPack and TeleSAFE family of controllers executes ladder logic and C application programs simultaneously, providing you with maximum flexibility in implementing your control strategy.

This manual provides full documentation on the TelePACE program including the Ladder Network Editor and the ladder logic programming language. We strongly encourage you to read it, and to notify us if you identify any items that you feel should be clarified, or included in future documentation releases.

We sincerely hope that the reliability and flexibility afforded by this fully programmable controller enable you and your company to solve your automation problems in a cost effective and efficient manner.

To use TelePACE, you need to install the program on your system. The automated installation takes only a few minutes.

Some virus checking software may interfere with Setup. If you experience problems with Setup, disable your virus checker and run Setup again.

1.1 System Requirements

The TelePACE ladder editor requires the following minimum system configuration.

- Microsoft Windows NT, Windows 2000 or Windows XP operating systems. Note that Windows 95, 98 and ME operating systems are no longer supported.
- Mouse or compatible pointing device; and
- Hard disk with approximately 2.5 Mbytes of free disk space.

1.2 Installation on a Hard Disk

To install the TelePACE Ladder Logic Editor:

1. Click **Start**, then select **Run**.
2. From the **Run** dialog box, select **Browse** and select the **setup.exe** file in the TelePACE Demo folder on the CD.
3. Follow the setup directions on the screen.

1.3 Running TelePACE Ladder Logic Editor

To run the ladder logic editor:

- Click Start, then select the TelePACE icon grouping, and select **TelePACE Ladder Editor**.

2 Ladder Editor Environment

2.1 Introduction

The TelePACE Ladder Network Editor is a powerful programming and monitoring tool that enables the user to create, edit, document, save, and read or write Ladder Logic programs for the controller.

This section of the manual outlines the features of the Ladder Logic Editor. A full description of the Editor is described in the **TelePACE Program Reference** section of this manual. The user is encouraged to read the following sections to gain an understanding of the many programming and monitoring features available.

2.2 Ladder Editor Display

The following figure illustrates the TelePACE Ladder Editor:

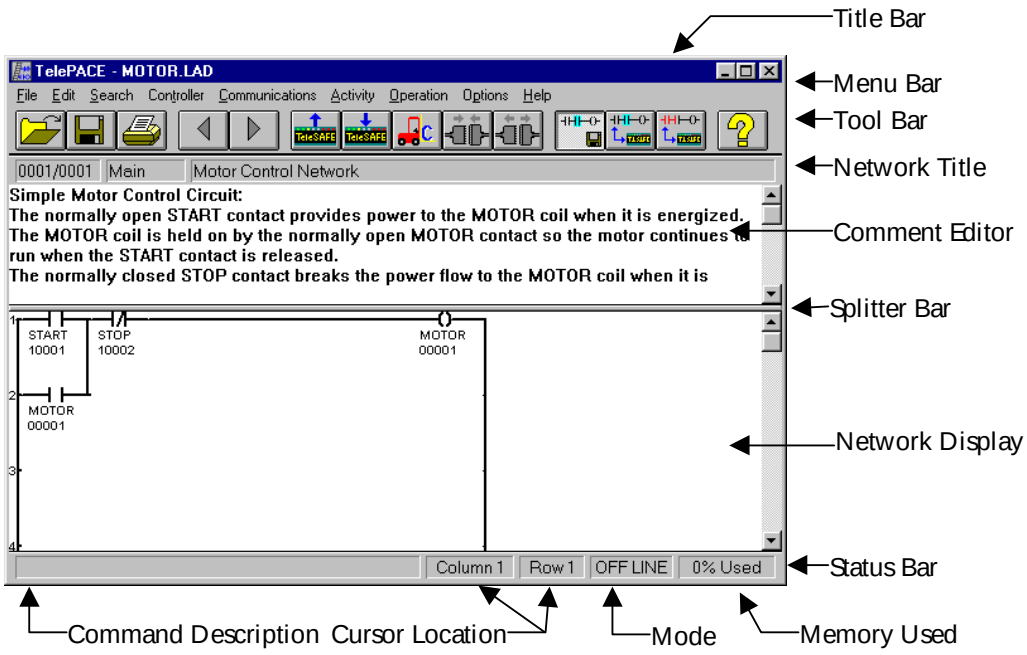


Figure 1: TelePACE Ladder Editor Display

2.2.1 Title Bar

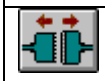
The title bar displays the TelePACE program title and the name of the ladder logic file. The file name area is blank if there is no file in use or the file is new and has not been saved.

2.2.2 Menu Bar

The menu bar displays the programming, editing, monitoring and utility functions available within the Editor. Menu commands can be displayed by clicking the mouse on the menu item or by pressing the alt key and the underlined letter of the menu item.

2.3 Tool Bar

The Tool Bar contains buttons for commonly used commands.

Icon	Command	Description
	Open File	Opens an existing ladder program file. This is the same as the **Open** command in the **File** menu.
	Save File	Saves the currently open ladder program file. This is the same as the **Save** command on the File menu.
	Print	Prints the currently open ladder program file. This is the same as the **Print** command on the **File** menu. The Print dialog box appears. This option is disabled when the editor is in Monitor On Line mode.
	Previous Network	Displays the previous network in the currently open ladder program. This is the same as selecting **Previous** from the **Go To Network** command in the **Search** menu.
	Next Network	Displays the next network in the currently open ladder program. This is the same as selecting **Next** from the **Go To Network** command in the **Search** menu.
	Read From Controller	The ladder logic program, register assignment and serial port settings in the controller are read into TelePACE memory. This is the same as the **Read From Controller** command on the **Communication** menu.
	Write To Controller	The ladder logic program, register assignment and serial port settings in the TelePACE program are written to the controller. This is the same as the **Write To Controller** command on the **Communication** menu.
	C Program Loader	The C Program Loader dialog box appears. This is the same as the **C Program Loader** command on the **Controller** menu.
	Connect to Controller	Establishes a connection to a remote unit using a dial up modem. This button is disabled if the current controller is not a dial up connection. This is the same as the **Connect To Controller** command on the **Communication** menu.
	Disconnect from Controller	Ends a connection to a remote unit using a dial up modem. This button is disabled if the current controller is not a dial up connection. This is the same as the **Disconnect From Controller** command on the **Communication** menu.
	Edit Off Line	Places the editor in Off Line editing mode. This mode is used for creation and editing of a ladder program file. This is the same as the **Edit Off Line** command on the **Activity** menu.
	Edit On Line	Places the editor in On Line editing mode. In this mode, any change to the ladder program is immediately written to the controller. This is the same as the **Edit On Line** command on the **Activity** menu.
	Monitor On Line	Places the TelePACE program in Monitor On Line mode. This mode is used to monitor ladder program execution in real time. Color is used to indicate power flow within the displayed network. The contents of a user-defined list of registers (see **Monitor List**) are updated in real time. This is the same as the **Monitor On Line** command on the **Activity** menu.
	Help	Displays the TelePACE program on-line help file. This is the same as selecting **Contents** from the **Help** menu.

2.3.1 Network Title

The network title has three sections. The left section displays the number of the network being edited and the total number of networks (current/total). Clicking the left mouse button here opens the **Go To Network** dialog.

The center section displays Main if the current network is in the main program and Sub x if it's in a subroutine.

The right section of the Network Title shows the network title. Clicking here opens the **Edit Network Title** pop up dialog box.

2.3.2 Comment Editor

Each network in the ladder program can have approximately three pages of text documentation. The text in the comment editor can be cut or copied to the Windows clipboard or pasted from the clipboard.

The comment editor is selected for editing by positioning the mouse pointer anywhere in the comment editor pane and left clicking the mouse button. A vertical bar indicates the cursor position within the comment editor pane. The scroll bar to the right of the comment editor pane scrolls the editor text within the pane.

2.3.3 Splitter Bar

The splitter bar divides the Comment Editor and the Ladder Editor Panes. Positioning the mouse pointer over the bar and dragging the bar to a new location changes the position of the splitter bar.

2.3.4 Status Bar

The status bar displays command and programming status of the Network Editor. The Status Bar is divided into five panels.

The leftmost panel describes the Toolbar or Menu command pointed to by the mouse.

The second and third panels show the column and row position of the cursor in the Ladder Editor pane.

The fourth panel displays the execution mode of the attached controller, or OFFLINE if the Network Editor is not communicating with a controller.

The last panel displays the percentage of ladder logic memory used in the target controller.

2.3.5 Network Display

The Ladder Editor Pane displays the current network of the open program. This area is used for creation and editing of the ladder logic. When in Monitor On Line mode, this area also contains the Monitor list.

2.3.6 Register List

The register list is a display window containing a list of selected I/O database registers and their real time contents. The I/O database registers to be included in monitor list display window are defined by selecting **Registers** from the **Edit** Menu.

2.3.7 Cursor

To position the cursor in the Ladder editor pane move the mouse pointer to any position in the displayed Ladder network and click the left mouse button. The cursor highlights the element or function where it is positioned. The cursor can be moved about the network using the arrow keys on the keyboard.

2.4 TelePACE Major Components

The major components of a ladder program are ladder networks, function elements, subroutines, and comments. Understanding how these components work and how a program is executed is important to writing an effective program.

NOTE: Program execution order (described below) must be considered when organizing the ladder logic program.

2.4.1 Networks

A network is a diagrammatic representation of control logic similar to a wiring schematic, showing interconnection of relays, timers, contacts and other control elements.

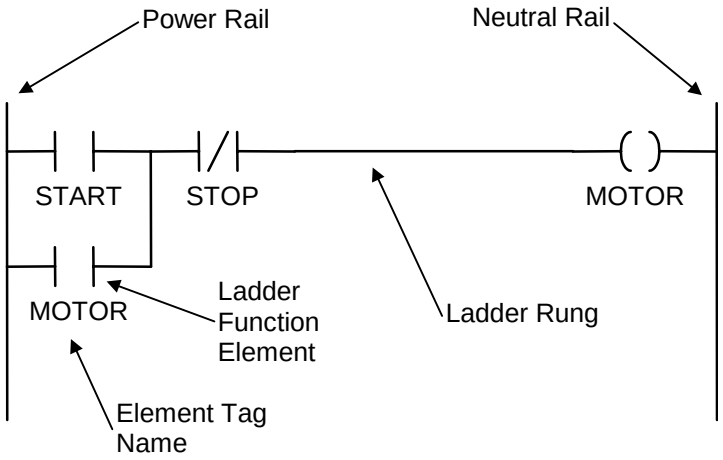


Figure 2: A Ladder Network

Networks in the TelePACE Ladder Editor contain up to eight rungs. Each rung can contain a maximum of 10 logic elements. The highlighted cursor in the Ladder Editor pane occupies one logic element position.

The number of networks in a program is only limited by the memory available.

2.4.2 Network Elements

Network elements are contacts, coils, and function blocks. Shunts are used to interconnect elements. Coils are always found connected to the neutral rail and represent either physical outputs in the controller or internal (memory only) outputs in the I/O database. Contacts represent physical status inputs from the controller or internal (memory only) status inputs in the I/O database. Function blocks are used to perform specific functions, such as moving data, manipulating data or communicating data.

2.4.3 Subroutines

Subroutines permit conditional execution of parts of a Ladder Logic program. Subroutines can be used to reduce the scan time of a program by only scanning code when it is absolutely needed. Reduced scan time will increase the frequency of program execution.

Subroutines can also reduce the size of the program by placing frequently used or repeated code into subroutines that are called from various locations in the main program.

The Ladder Logic program consists of the main program followed by a number of subroutines.

The main program is defined as all the logic networks up to the start of the first subroutine, or until the end of the program if no subroutines exist.

A subroutine is defined as all the logic networks from a subroutine element until the next subroutine element, or the end of the program if there are no more subroutines.

The program is executed from the start of the main program to the end of the main program. If a subroutine call function block is encountered, execution transfers to the start of the subroutine and continues until the end of the subroutine. Execution then returns to the element after the subroutine call element.

Subroutine execution can be nested. This allows subroutines to call other subroutines.

Subroutine execution cannot be recursive. This prevents potential infinite loops in the ladder logic program.

Two elements control the definition and execution of subroutines. The **SUBR** element defines the start of a subroutine. The **CALL** element executes a subroutine.

2.4.4 Program Execution Order

The controller evaluates each element, or function block, in the network in a sequence that starts at the top left hand corner; or ROW 1, COLUMN 1.

The ladder evaluation moves down column 1 until it reaches row 8. The evaluation then continues at the top of column 2 and moves down to row 8 again.

This process continues until the entire network has been evaluated. If there is more than one network, evaluation continues to the next sequential network in the program until the entire program has been evaluated.

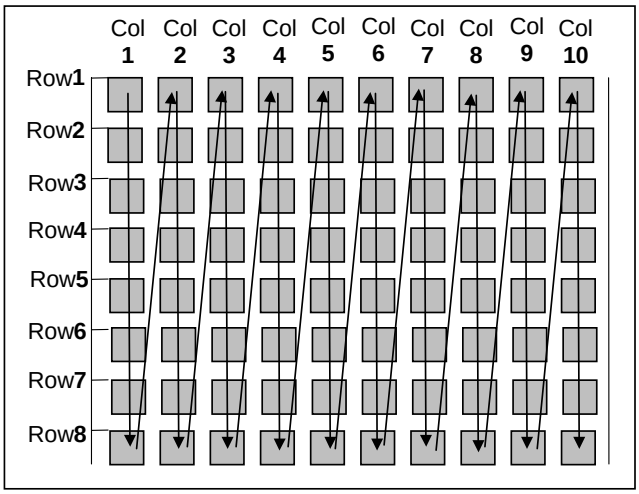


Figure 3: TelePACE Ladder Editor Network Execution

2.4.5 Ladder Logic Memory Usage

Memory usage in a Ladder Logic application program is based on the number of networks and number of elements used by a program.

Networks	Each network in an application requires one word of memory, whether the network is used or not.
Columns	Each column that is occupied in a network requires one word of memory.

Single Elements	Each single element requires one word of memory.
Double Elements	Each double element requires two words of memory.
Triple Elements	Each triple element requires three words of memory.

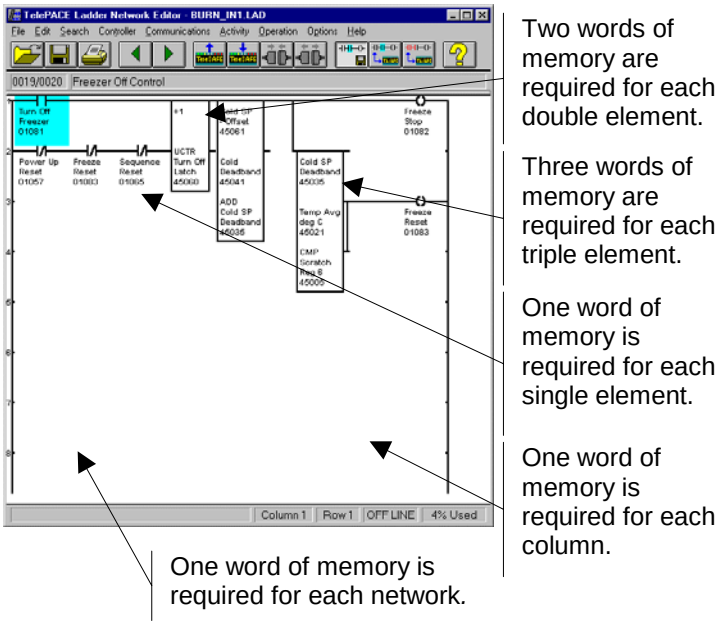


Figure 4: Ladder Logic Memory Usage

2.5 TelePACE I/O Database Registers

The I/O Database is different on the 16 and 32-bt controllers.

The 16-bit controllers comprise of SCADAPack (Light and Plus), SCADAPack 100, SCADAPack LP, SCADASense 4202 DR and SCADASense 4202 DS. The SCADAPack 100: 1024K controller differs from the SCADAPack 100: 256 K controller in that it has the same I/O database as other SCADAPack controllers. The SCADAPack 100: 1024K controller has firmware version 1.80 or newer and a controller ID that is greater than or equal to A182922.

The 32-bit controllers comprise SCADAPack 350, SCADAPack 32, SCADASense 4203 DR and SCADASense 4203 DS.

Note: In this manual, the SCADASense 4202 DR and DS controllers are collectively referred to as the SCADASense 4202 Series controller. The SCADASense 4203 DR and DS are collectively referred to as the SCADASense 4203 Series controllers. The 4202 and 4203 controllers are collectively referred to as the SCADASense controllers.

2.5.1 16-bit Controller I/O Database

The 16-bit controllers which comprise of SCADAPack (Light and Plus), SCADAPack 100:1024K, SCADAPack LP, and SCADASense 4202 Series controllers all have the same IO database. The IO database in the SCADAPack 100: 256K is different as indicated in section ***2.5.3-SCADAPack 100: 256K I/O Database.***

The I/O database allows data to be shared between C programs, Ladder Logic programs and communication protocols. A simplified diagram of the I/O Database is shown **in Figure 5:**

SCADAPack, SCADAPack 100: 1024K, SCADAPack LP, SCADASense 4202 Series I/O Database Block Diagram.

The I/O database contains general purpose and user-assigned registers. Ladder Logic and C application programs to store processed information and to receive information from a remote device may use general-purpose registers. Initially all registers in the I/O Database are general-purpose registers.

User-assigned registers are mapped directly from the I/O database to physical I/O hardware, or to controller system configuration and diagnostic parameters. The Register Assignment performs the mapping of registers from the I/O database to physical I/O hardware and system parameters.

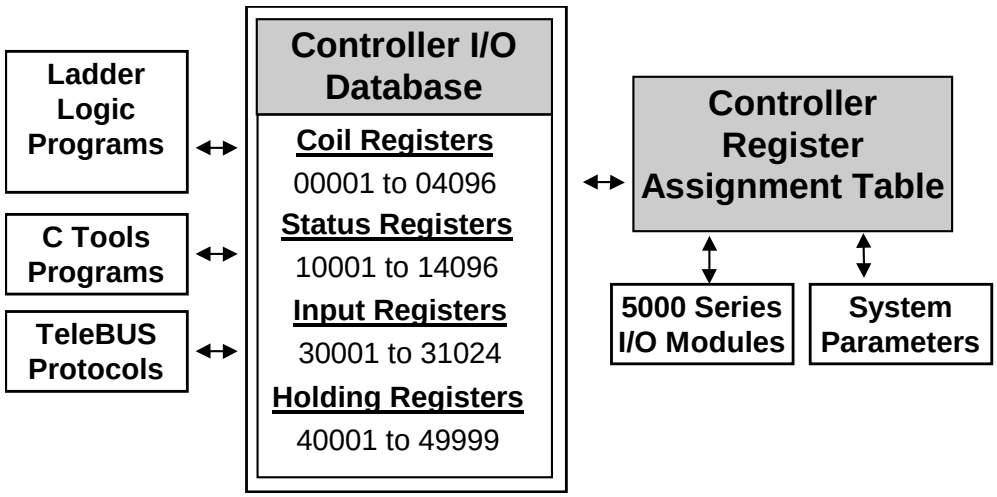


Figure 5: SCADAPack, SCADAPack 100: 1024K, SCADAPack LP, SCADASense 4202 Series I/O Database Block Diagram

User-assigned registers are initialized to the default hardware state or system parameter when the controller is reset. Assigned output registers do not maintain their values during power failures. Assigned output registers do retain their values during application program loading.

General-purpose registers retain their values during power failures and application program loading. The values change only when written by an application program or a communication protocol.

The TeleBUS communication protocols provide a standard communication interface to the controller. The TeleBUS protocols are compatible with the widely used Modbus RTU and ASCII protocols. They provide full access to the I/O database in the controller.

2.5.1.1 I/O Database register types

The I/O database is divided into four types of I/O registers. Each of these types is initially configured as general purpose registers by the controller.

2.5.1.1.1 Coil Registers

Coil registers are single bit registers located in the digital output section of the I/O database. Coil, or digital output, database registers may be assigned to 5000 Series digital output modules or SCADAPack I/O modules through the Register Assignment. Coil registers may also be assigned to controller on board digital outputs and to system configuration modules.

There are 4096 coil registers numbered 00001 to 04096. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

2.5.1.1.2 Status Registers

Status registers are single bit registers located in the digital input section of the I/O database. Status, or digital input, database registers may be assigned to 5000 Series digital input modules or SCADAPack I/O modules through the Register Assignment. Status registers may also be assigned to controller on board digital inputs and to system diagnostic modules.

There are 4096 status registers numbered 10001 to 14096. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

2.5.1.1.3 Input Registers

Input registers are 16 bit registers located in the analog input section of the I/O database. Input database registers may be assigned to 5000 Series analog input modules or SCADAPack I/O modules through the Register Assignment. Input registers may also be assigned to controller internal analog inputs and to system diagnostic modules.

There are 1024 input registers numbered 30001 to 31024. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

2.5.1.1.4 Holding Registers

Holding registers are 16 bit registers located in the analog output section of the I/O database. Holding, or analog output, database registers may be assigned to 5000 Series analog output modules or SCADAPack analog output modules through the Register Assignment. Holding registers may also be assigned to system diagnostic and configuration modules.

There are 9999 holding registers numbered 40001 to 49999. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

2.5.2 32-bit Controller I/O Database

The 32-bit controllers, which comprise of SCADAPack32, SCADAPack 350, SCADASense 4203 Series (SCADASense 4203 DR and SCADASense 4203 DS) , all have the same IO database.

The I/O database allows data to be shared between C programs, Ladder Logic programs and communication protocols. A simplified diagram of the I/O Database is shown in **Figure 6: SCADASense 4203 Series, SCADAPack 350 and SCADAPack 32 I/O** Database Block Diagram.

The I/O database contains general purpose and user-assigned registers. Ladder Logic and C application programs to store processed information and to receive information from a remote device may use general-purpose registers. Initially all registers in the I/O Database are general-purpose registers.

User-assigned registers are mapped directly from the I/O database to physical I/O hardware, or to controller system configuration and diagnostic parameters. The Register Assignment performs the mapping of registers from the I/O database to physical I/O hardware and system parameters.

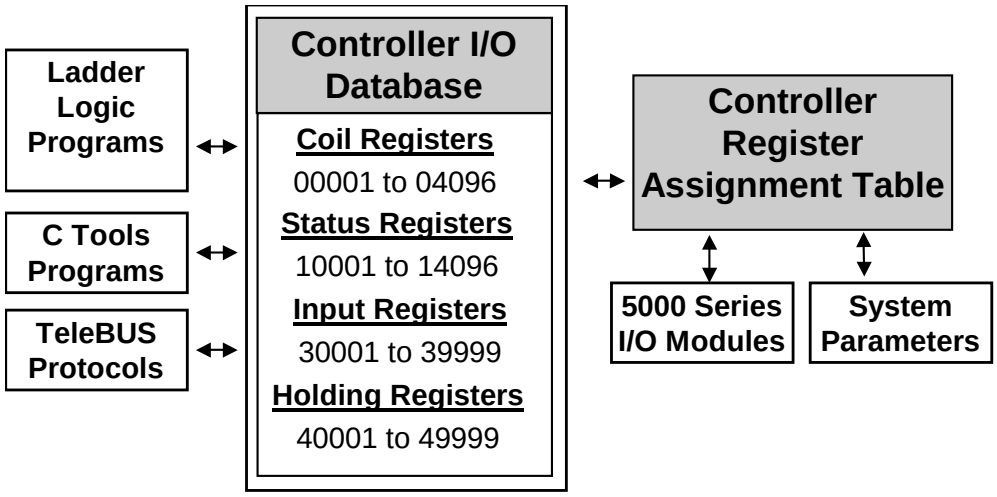


Figure 6: SCADASense 4203 Series, SCADAPack 350 and SCADAPack 32 I/O Database Block Diagram

User-assigned registers are initialized to the default hardware state or system parameter when the controller is reset. Assigned output registers do not maintain their values during power failures. Assigned output registers do retain their values during application program loading.

General-purpose registers retain their values during power failures and application program loading. The values change only when written by an application program or a communication protocol.

The TeleBUS communication protocols provide a standard communication interface to the controller. The TeleBUS protocols are compatible with the widely used Modbus RTU and ASCII protocols. They provide full access to the I/O database in the controller.

2.5.2.1 I/O Database register types

The I/O database is divided into four types of I/O registers. Each of these types is initially configured as general purpose registers by the controller.

2.5.2.1.1 Coil Registers

Coil registers are single bit registers located in the digital output section of the I/O database. Coil, or digital output, database registers may be assigned to 5000 Series digital output modules or SCADAPack I/O modules through the Register Assignment. Coil registers may also be assigned to controller on board digital outputs and to system configuration modules.

There are 4096 coil registers numbered 00001 to 04096. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

2.5.2.1.2 Status Registers

Status registers are single bit registers located in the digital input section of the I/O database. Status, or digital input, database registers may be assigned to 5000 Series digital input modules or SCADAPack I/O modules through the Register Assignment. Status registers may also be assigned to controller on board digital inputs and to system diagnostic modules.

There are 4096 status registers numbered 10001 to 14096. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

2.5.2.1.3 Input Registers

Input registers are 16 bit registers located in the analog input section of the I/O database. Input database registers may be assigned to 5000 Series analog input modules or SCADAPack I/O modules through the Register Assignment. Input registers may also be assigned to controller internal analog inputs and to system diagnostic modules.

There are 9999 input registers numbered 30001 to 39999. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

2.5.2.1.4 Holding Registers

Holding registers are 16 bit registers located in the analog output section of the I/O database. Holding, or analog output, database registers may be assigned to 5000 Series analog output modules or SCADAPack analog output modules through the Register Assignment. Holding registers may also be assigned to system diagnostic and configuration modules.

There are 9999 holding registers numbered 40001 to 49999. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

2.5.3 SCADAPack 100: 256K I/O Database

The SCADAPack 100: 256K controller differs from the SCADAPack 100: 1024K controller in that it has a limited I/O database. The SCADAPack 100: 256K controller has firmware version older than 1.80 and a controller ID that is less or equal to A182921.

The SCADAPack 100: 256K I/O database allows data to be shared between C programs, Ladder Logic programs and communication protocols. A simplified diagram of the I/O Database is shown in **Figure 7: SCADAPack 100 – 256K I/O Database Block** Diagram.

The I/O database contains general purpose and user-assigned registers. Ladder Logic and C application programs to store processed information and to receive information from a remote device may use general-purpose registers. Initially all registers in the I/O Database are general-purpose registers.

User-assigned registers are mapped directly from the I/O database to physical I/O hardware, or to controller system configuration and diagnostic parameters. The Register Assignment performs the mapping of registers from the I/O database to physical I/O hardware and system parameters.

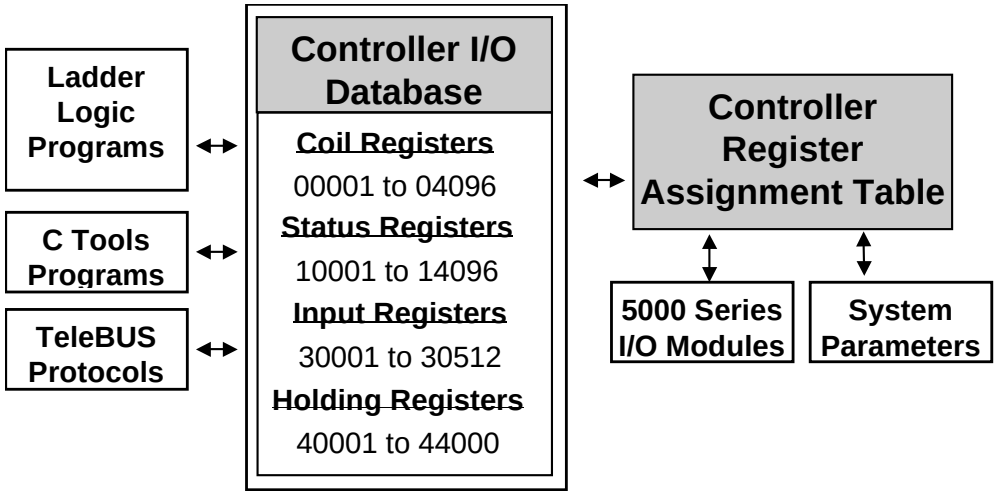


Figure 7: SCADAPack 100 – 256K I/O Database Block Diagram

User-assigned registers are initialized to the default hardware state or system parameter when the controller is reset. Assigned output registers do not maintain their values during power failures. Assigned output registers do retain their values during application program loading.

General-purpose registers retain their values during power failures and application program loading. The values change only when written by an application program or a communication protocol.

The TeleBUS communication protocols provide a standard communication interface to the controller. The TeleBUS protocols are compatible with the widely used Modbus RTU and ASCII protocols. They provide full access to the I/O database in the controller.

2.5.3.1 I/O Database register types

The I/O database is divided into four types of I/O registers. Each of these types is initially configured as general purpose registers by the controller.

2.5.3.1.1 Coil Registers

Coil registers are single bit registers located in the digital output section of the I/O database. Coil, or digital output, database registers may be assigned to 5000 Series digital output modules or SCADAPack I/O modules through the Register Assignment. Coil registers may also be assigned to controller on board digital outputs and to system configuration modules.

There are 4096 coil registers numbered 00001 to 04096. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

2.5.3.1.2 Status Registers

Status registers are single bit registers located in the digital input section of the I/O database. Status, or digital input, database registers may be assigned to 5000 Series digital input modules or SCADAPack I/O modules through the Register Assignment. Status registers may also be assigned to controller on board digital inputs and to system diagnostic modules.

There are 4096 status registers numbered 10001 to 14096. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

2.5.3.1.3 Input Registers

Input registers are 16 bit registers located in the analog input section of the I/O database. Input database registers may be assigned to 5000 Series analog input modules or SCADAPack I/O modules through the Register Assignment. Input registers may also be assigned to controller internal analog inputs and to system diagnostic modules.

The I/O database for the SCADAPack 100: 256K controller has 512 input registers numbered 30001 to 30512. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

2.5.3.1.4 Holding Registers

Holding registers are 16 bit registers located in the analog output section of the I/O database. Holding, or analog output, database registers may be assigned to 5000 Series analog output modules or SCADAPack analog output modules through the Register Assignment. Holding registers may also be assigned to system diagnostic and configuration modules.

The I/O database for the SCADAPack 100: 1924K controller has 4000 holding registers numbered 40001 to 44000. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

TelePACE Ladder Logic

Program Development

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Table of Contents

1 TelePACE Program Development

1.1 Introduction

A Ladder Logic program may be developed in any sequence. Best results, particularly for new users, will be obtained using the following sequence:

1. Configure **TelePACE**.
2. Create the ladder program.
3. Create the Register Assignment.
4. Select Outputs-On-Stop settings.
5. Define serial port settings.
6. Create Ladder Logic Program.
7. Initialize controller.
8. Write program to the controller.
9. Run and test program.

These steps are described in more detail in the sections that follow.

1.2 Configuration of the TelePACE Program

The configuration of the **TelePACE** program involves setting the serial port parameters for the target controller and selecting options to customize the Ladder Editor environment.

1.2.1 PC Communication Settings

Configure **TelePACE** communications to satisfy the requirements of the communication media between the **TelePACE** program and the target controller. Refer to the **PC Communication Settings** in the **TelePACE Program Reference**.

For **SCADAPack**, **SCADAPack Light** and **SCADAPack Plus** controllers, com3 is supported only when the **SCADAPack 5601 or 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the **TelePACE** program.

1.2.2 Options

Set the Ladder Editor environment options to suit the display resolution and color capability of your computer. From the **Options** menu select **Screen Font** to change the Editor screen font and **Colors** to change the Ladder Logic display color.

The format of floating point numbers may be changed using the **Floating-Point Settings** option.

The **Tool Bar**, **Title Bar** and the **Status Bar** may be removed from the Editor Display by selecting or de-selecting the option in the **Option** menu.

Select tag names display options to meet your personal preference. The selections are **Single Tag Names**, **Double Tag Names**, **Tag and Address** and **Numeric Address**.

In most cases it is recommended that the **Allow Multiple Coils** and **Warning Messages** be selected.

1.3 Initializing the Controller

The controller should be initialized before a new program is loaded into the controller. The **Initialize Controller** dialog appears when **Initialize** is selected in the **Controller** menu. Ladder Logic programs C programs and the Register Assignment may be erased from this dialog.

WARNING: If the controller is initialized, using the Initialize command in the Controller menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller. Element Configuration may be used for the following functions:

- DIAL – Control Dial-Up Modem;
- INIM – Initialize Dial-Up Modem;
- MSTR – Master Message;
- SLP – Put Controller into Sleep Mode;
- HART – Protocol Driver;
- DLOG – Data Logger;
- FLOW – Flow Accumulation;
- TOTL – Flow Totalizer;
- PIDA – PID controller for analog output; and
- PIDD – PID controller for digital output.

Refer to the **Ladder Logic Function Reference** for a description of these functions.

1.4 Define Register Assignment

All I/O hardware that is used by the controller must be assigned to I/O database registers in order for the I/O points to be used by the ladder program. Ladder logic programs may read data from, or write data to, the I/O hardware through user-assigned registers in the I/O database.

The Register Assignment assigns I/O database registers to user-assigned registers using I/O modules. An I/O Module can refer to an actual I/O hardware module (e.g. *5401 Digital Input Module*) or it may refer to a set of controller parameters, such as serial port settings.

The ***Register Assignment Reference*** section describes the purpose of each module and the register assignment requirements for the module.

Register assignments are stored in the user configured Register Assignment and are downloaded with the ladder logic application program.

1.5 Create Ladder Logic Program

1.5.1 Inserting Elements

To insert an element in the Ladder network, position the cursor at the network position where the element is to be inserted. Double click the left mouse button. The **Insert/Edit Network Element** dialog box pops up and an element or function can be selected to insert.

The **Insert/Edit Network Element** dialog box only displays the elements and functions that will fit from the cursor position.

Elements can be inserted using the right mouse button and selecting **Edit Element** from the drop down menu.

Elements can be inserted from the keyboard by positioning the cursor at the desired network position and pressing the Insert key.

1.5.2 Inserting Networks

To insert another network, select **Insert** from the **Edit** menu. The **Insert** dialog pops up. Selections are made in this dialog by moving the mouse pointer to the required radio button and clicking the left mouse button. Networks may be inserted before or after the current network.

1.5.3 Editing Elements

To edit an element in the Ladder network, position the cursor on the element to be edited. Double click the left mouse button. The **Insert/Edit Network Element** dialog box pops up and the element can be edited.

Elements can be edited using the right mouse button and selecting **Edit Element** from the drop down menu.

Elements can be edited from the keyboard by positioning the cursor at the desired element the pressing the Insert key.

1.5.4 Deleting Elements

To remove an element from a network, press the Delete key, or select **Delete** from the **Edit** menu. The element at the cursor position or selected elements, columns, rows or networks can be selected for deleting.

Selected elements can be deleted using the right mouse button and selecting **Delete** from the drop down menu.

1.5.5 Selecting Elements

To select multiple elements position the cursor on the first element or function of the selection and press the left mouse button. Hold the button down and drag the pointer to the last element or function. The elements selected will be highlighted in the same way as the cursor. Releasing the mouse button does not change the highlighting.

Individual disconnected elements may also be selected and copied to the clipboard. To select disconnected elements position the cursor on the first element. Hold the keyboard shift key down. Using the left mouse button, click on elements to be copied to the clipboard.

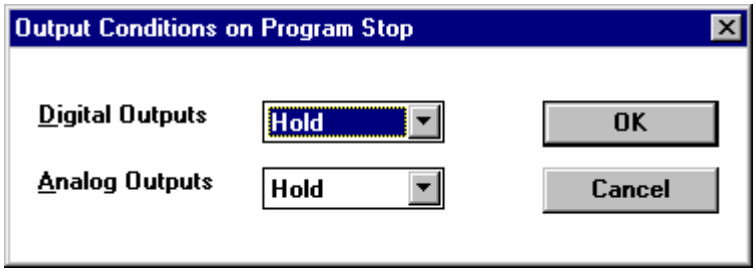
To select elements or functions with the keyboard move the cursor to the first element or function. Hold the shift key down while using the directional arrow keys to move the cursor to the last element or function. The selected elements are highlighted.

1.6 Setting Outputs On Stop

Select **Outputs on Stop** from the **Controller** menu and the **Output Conditions on Program Stop** dialog appears. This dialog controls the state of the controller analog and digital outputs when the ladder logic program is stopped.

The state of the digital outputs may be set to **hold** their last value or to turn **off** when the ladder program is stopped.

The state of the analog outputs may be set to **hold** their last value or to go to **Zero** when the ladder program is stopped.



1.7 Controller Serial Port Settings

Select the **Serial Ports** command from the **Controller** menu to configure the controller serial ports. The **Controller Serial Ports Settings** dialog box pops up when the Serial Ports command is selected.

For **SCADAPack**, **SCADAPack Light**, and **SCADAPack Plus** controllers, Com3 is supported only when the **SCADAPack 5601 or 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the **TelePACE** program.

1.8 Write program to controller

The **Write to Controller** command in the **Communications** menu writes the Ladder Logic program to the controller. The program replaces the program in the controller.

If the program in the controller is executing a dialog box will request whether to stop execution of the new program when the write is complete or to continue execution of the new program after the write is complete.

WARNING: Exercise caution when selecting the **Continue** option. The program will execute with the changes you make, even if the changes are not complete. This may cause undesired operation. Select **Stop** if you are making multiple changes.

1.9 Monitor Program On Line

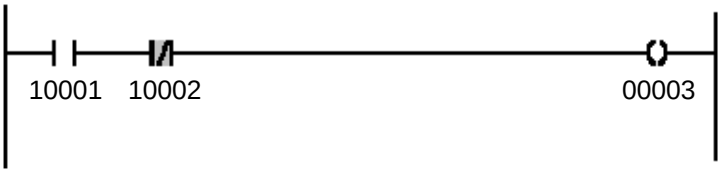
The **Monitor On Line** selection in the **Activity** menu enables the real time monitoring of a program executing in a controller. The editor shows the power flow through the network on the screen. No changes can be made to the program in monitor mode. The **Register Editor** window is displayed when **Monitor On Line** is selected.

1.9.1 Contact Monitoring

It is often necessary, while in Monitor On line mode, to determine whether a contact would pass power if power were supplied to it. This feature is extremely useful when testing the operation of ladder logic programs.

In Monitor On line mode, **TelePACE** shows the power flow through the network. It also colors contacts that are not powered to show how power would flow if they were.

The following diagram illustrates how power flow information is displayed in Monitor On line mode:



In the above example, normally open contact 10001 and normally closed contact 10002, are not energized. The shaded background, in contact 10002, indicates power would flow through the contact if the input side were powered.

- The background of a normally open contact is colored when it is energized and its input is not powered.
- The background of a normally closed contact is colored when it is not energized and its input is not powered.

The background is only displayed on contacts if the input side of the contact is not powered.

The color used for contact monitoring can be changed using the *Colors* command.

1.10 Edit Program On Line

The **Edit On Line** selection in the **Activity** menu is used to edit a ladder logic program that is executing in the controller. All editing commands affect the program in the controller and the program in the **TelePACE Ladder Network Editor**.

1.11 Force Registers

The Register Editor dialog allows the user to modify registers in the memory of the controller. This dialog is only available in the on-line mode. Data modified by the dialog is stored only in the memory of the controller. It does not form part of the ladder logic program. Refer to the **Program Reference** section for detailed information on the Register Editor.

1.12 Preventing Unauthorized Changes

A **TeleSAFE** Micro16 or **SCADAPack** controller can be locked to prevent unauthorized changes. A password is required to unlock the controller to make changes.

The controller will reject commands sent to the unit when it is locked. A controller that is unlocked operates without restriction. Three levels of locks are provided.

- Locking the programming commands prevents modifying or viewing the program in the controller. Communication protocols can read and write the I/O database.
- Locking programming and database write a command prevent modifying or viewing the program; and prevents writing to the I/O database. Communication protocols can read data from the I/O database, but cannot modify any data.
- Locking programming and database commands prevents modifying or viewing the program and prevents reading and writing the I/O database. Communication protocols cannot read or write the I/O database.

Refer to the sections Lock Controller, Unlock Controller, Override Controller Lock and Show Lock Status for details on using this feature.

TelePACE Ladder Logic

Program Reference

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SCADA products... for the distance

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Trademarks

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1 Introduction

The TelePACE program is a powerful programming and monitoring tool that enables the user to create, edit, document and save Ladder Logic programs for the controller. TelePACE also loads and runs C programs in the controller. Ladder Logic programs can be written to a controller or read from a controller using the TelePACE Ladder Logic Editor. The on-line monitoring and editing features enable efficient debugging of program and control problems.

The TelePACE program can be used locally – connected directly to the controller – or remotely – connected to the controller through a communication network or dial up modem. TelePACE supports connections to remote controllers using SCADAServer and Modbus\IP. All features of TelePACE are available locally and remotely.

This section of the manual describes each of the TelePACE program commands available from the TelePACE menu bar. The user is encouraged to read through the following sections to gain an understanding of the many programming and monitoring features available.

The menu bar selections and the functions available for each selection are described in the following sections.

2 File Menu

The File menu contains commands to create, open and save Ladder Logic files; utility commands to import and export tag names; and commands to configure printer options and print Ladder Logic programs.

2.1 New

The **New** command starts a new TelePACE Ladder Logic program. The comment editor window and the ladder editor window are cleared and the network display shows network one of one. The TelePACE Ladder Network Editor retains all information from the previous editor settings with the exception that the I/O Assignments are defaulted to inputs for all channels.

If the current file has not been saved, the editor warns you to save the current file. You may save the changes, discard the changes or cancel the New command.

2.2 Open

The **Open** command loads a ladder logic program from disk into the editor. The file replaces the existing file in the editor. If the current file has not been saved, the editor warns you to save the current file. You may save the changes, discard the changes or cancel the Open command.

The Open command will cause the Open File dialog box to appear. This dialog box is used to select the file to Open. Ladder logic files normally end with the file extension LAD. The dialog box displays these files by default. Press **Ctrl-O** to execute the **Open** command.

2.3 Save

The **Save** command stores the current file on disk. If the current file has not yet been named, the Save As File dialog box will appear. The file name and working directory can be selected from this dialog box. The title bar at the top of the editor window shows the current file name. Press **Ctrl-S** to execute the **Save** command.

2.4 Save As

The **Save As** command stores a file with a different name, or location, than the current file. The Save As File dialog box is used to specify the file name and directory in which to save the file. Ladder logic file names normally end with the extension LAD. The editor uses the extension LAD automatically, if you do not type it. Press **Ctrl-A** to execute **Save As** command.

2.5 Page Setup

The Page Setup dialog controls the appearance of printed documentation. The items to be documented are selected with the **Select Print Items** command.

The **Margins** section defines the printing margins for the page. Use the margins to adjust the look of the printed output. The **Measurement Units** box selects the units of measurement for the margins.

The **Page Headings** section selects headers for each page of printed documentation.

- Check the **Page Header** box to print headings on all pages. The heading includes the file name, a page description, and the items described below.
- Check the **Date and Time** box to print the time and date on each page.
- Check the **Page Numbers** box to print page numbers on each page. Page numbers normally begin with page 1. You can specify the starting page.

2.6 Print

The Print command is used to print documentation on your printer. The Print dialog box is used to select the printer and printer options such as page size and orientation for the print job.

The items to be documented are selected with the **Select Print Items** command. The page layout and margins are selected with the **Page Setup** command.

2.7 Select Print Items

The **Select Print Items** command is used to select the program documentation and print topics to be printed. Through the selections in the Select Print Items dialog box, shown below, a customized program print-out can be created.

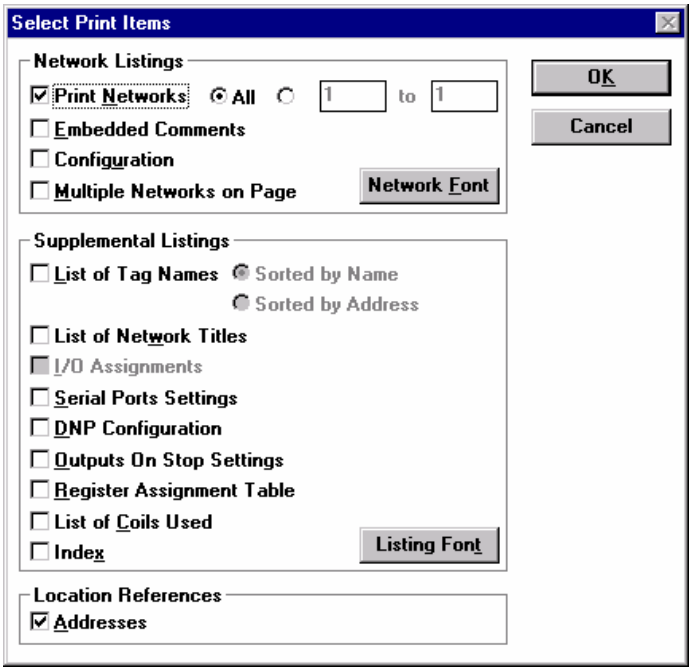


Figure 1: Select Print Items Dialog Box

The **Network Listings** section contains selections for defining the networks and comments to be printed.

The **Print Networks** selection defines the networks to print. All networks in the ladder program or a range of networks may be selected for printing.

The **Print Embedded Comments** selection enables network comments to be printed with the networks.

The **Configuration** selection enables the printing of the element configuration parameters for elements that use the element configuration dialog.

Select **Multiple Networks on Page** to allow multiple unbroken, networks and embedded comments to be printed on each page.

Select **Network Font** to modify the font used in printing the embedded comments and network functions, addresses, tag names and network titles.

The **Supplemental Listings** section contains selections for detailed program information that can be printed. Each item selected in the supplemental listings section is printed as a separate section with page header, if selected in page setup.

The **List of Tag Names** selection adds a complete list of all tag names used to the print out. Tag names can be sorted by their name or address.

A list of all network titles and network numbers used in the program are printed when the **List of Network Titles** is selected.

Selecting the **DNP Configuration** prints the complete configuration for the DNP protocol if it is used in the application.

Selecting the **Serial Port Settings** selection prints complete serial port settings for each serial port.

The **Outputs On Stop Settings** for the analog and digital outputs are printed when this item is selected.

Register Assignment selection enables the complete register assignment used in the application to be printed.

A list of destination coils and tag names in use is added to the print-out when **List of Coils Used** is selected.

An index of all print topics selected is added to the print-out by selecting **Index**.

The font used for printing the supplemental listings is can be modified by selecting **Listing Font**.

Selecting **Addresses** in the **Location References** section adds a complete cross-reference of all addresses used in the ladder logic program. The addresses are cross-referenced to Network / Row / Column locations for all occurrences of each address.

- Click **OK** to accept the selected print items and close the dialog box.
- Click **Cancel** to discard changes.

2.8 Quick File List

The quick file list area displays the names of the four most recently used Ladder Logic files. Select a file from this list by clicking the left mouse button on the file name or by pressing the number of the file.

2.9 Exit

The Exit command terminates the TelePACE program. The editor warns you to save the current file, if it changed since the last save. You may save the changes, throw away the changes or cancel the Exit command. Press **Ctrl-Q** to execute the **Exit** command.

Selecting Close from the system menu also terminates the program. The editor prompts you to save changes to your program.

3 Edit Menu

The Edit menu commands are used to insert, delete and modify the logic elements, function blocks, comments and networks used in the Ladder Logic program. Clicking the left mouse button on the desired command, or, from the keyboard by pressing the underlined letter accesses all Edit menu commands.

3.1 Undo

The Undo command reverses the last change made in the Ladder editor or Comment editor. This is a single level command and only the last change made before selecting Undo is reversible. Selecting Undo again reverses the action of the last Undo.

- Press **Ctrl-Z** to execute the **Undo** command from the keyboard.
- Right click your mouse and select **Undo** from the command list.

3.2 Cut Selected

The Cut Selected command removes the selected elements in the Ladder Editor or the Comment editor and puts them on the Clipboard. Items on the clipboard remain there until they are replaced by other selected elements.

- Press **Ctrl-X** to execute the **Cut Selected** command from the keyboard.
- Right click your mouse and select **Cut Selected** from the command list.

3.3 Copy Selected

The Copy Selected command copies the selected elements in the Ladder editor to the clipboard. Items on the clipboard remain there until they are replaced by other selected elements.

- Press **Ctrl-C** to execute the **Copy Selected** command from the keyboard.
- Right click your mouse and select **Copy Selected** from the command list.

3.4 Copy Networks

The Copy Networks command copies a network or block of networks to the clipboard. Comments for the network are also copied to the clipboard.

Networks to copy are selected from the Copy Networks dialog box. Continuous networks from the First Network selection to the Last Network selection may be copied to the clipboard.

3.5 Cut Networks

The Cut Networks command cuts a network or block of networks to the clipboard. Comments for the network are also cut to the clipboard.

Networks to cut are selected from the Cut Networks dialog box. Continuous networks from the First Network selection to the Last Network selection may be cut to the clipboard.

3.6 Paste

The Paste command is used to paste items on the clipboard to the current cursor position. The paste command in the Edit menu box is grayed out when there are no items on the clipboard or the cursor is in the wrong pane for the clipboard items. For example text cannot be pasted into the Ladder Editor pane and network elements cannot be pasted into the Comment Editor pane.

Text cannot be pasted into the Comment Editor if the clipboard text will cause the Comment Editor to exceed 16 Kbytes of text for the network. In the Ladder Editor pane if there is not enough room between the cursor and the edge of the network to paste the selected items an error message is displayed.

When a network or block of networks are pasted from the clipboard the Paste Block of Networks dialog box appears. This dialog box is used to determine if the block of networks is to be pasted before or after the current network and whether network titles and comments are pasted with the block of networks.

- Press **Ctrl-V** to execute the **Paste** command from the keyboard.
- Right click your mouse and select **Paste** from the command list.

3.7 Insert

The Insert command is used to insert changes to the current ladder logic network. When the Insert command is selected the Insert dialog box pops up. Items that can be inserted into the ladder logic program are displayed in the dialog box. Items in the dialog are inaccessible (grayed) if they cannot be used from the current cursor position. Items to be inserted are selected by selecting the radio button associated with each selection.

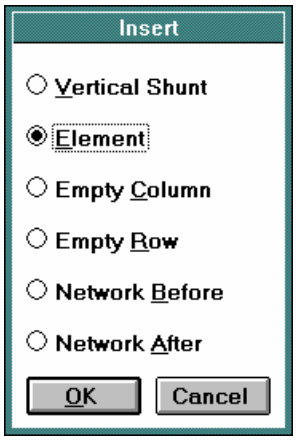


Figure 2: Insert Dialog Box

3.7.1 Insert Vertical Shunt

The insert Vertical Shunt selection inserts a vertical shunt on the right side of the element highlighted by the cursor. Where a multiple cell element is selected, the vertical shunt is inserted in the cursor position shown on the status bar. This command is not available in the Comment Editor pane.

- Press **F5** to insert a vertical shunt.
- Right click your mouse and select **Insert Vertical Shunt** from the command list.

3.7.2 Insert Element

The insert Element selection inserts or edits an element at the current cursor position. A dialog box appears displaying the Ladder Editor function block list. This command is not available in the Comment Editor pane.

- Press **Insert** to execute this function from the keyboard.

- Right click your mouse and select **Insert/Edit Element** from the command list.

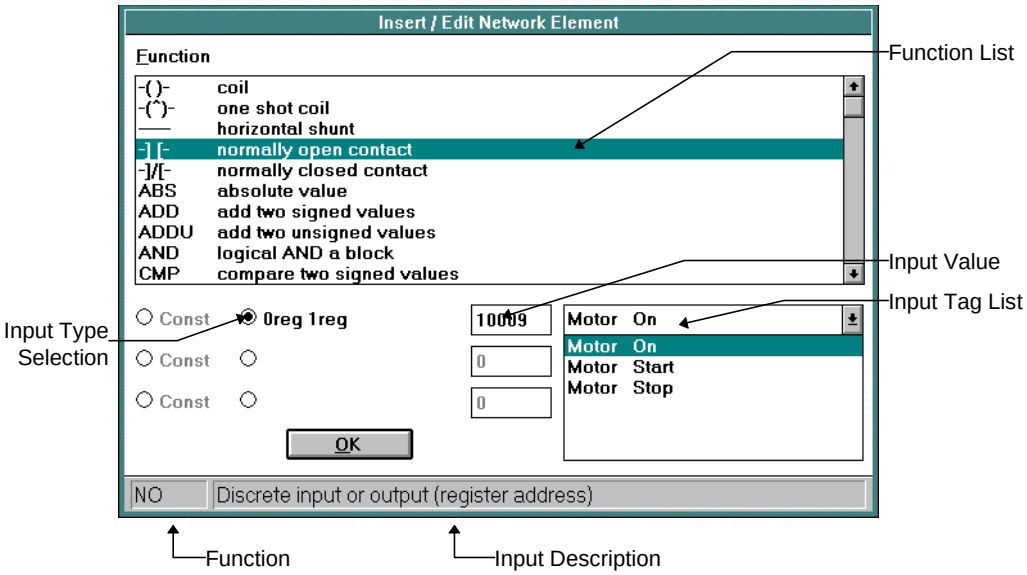


Figure 3: Insert / Edit Network Element Dialog Box

The function block list shows the function blocks that fit in the current position. If the cursor is over an existing function block, the list shows only function blocks of the same size. If the cursor is over a blank space, the list shows all function blocks that fit. Function blocks occupy one, two, or three cells in a network. The left side of the status bar at the bottom of the dialog shows the selected function block name.

Selecting a function activates the input boxes at the bottom of the dialog. There are one, two, or three inputs depending on the function. A description of the input is shown on the status bar, when an input is selected for editing.

Some function blocks allow either addresses or constants as inputs. The radio buttons on the left of the input box indicate if the value in the input box is an address or a constant. Click the left radio button to input a constant. Click the right radio button to input an address of the type displayed. The radio button defaults to the address type selection.

There are two ways to edit an input:

When an address type is selected the register address can be typed into the input edit box. By default the first register address, of the type required, is displayed in the edit box. Some functions require a range of registers to define an input. In these cases the first and last register of the range are displayed. Edit the displayed address to the meet the requirements of your application. The upper range limit is recalculated automatically as soon as any valid start register is entered.

When a constant type is selected the constant value can be typed into the input edit box. By default the number of the first register address, of the type required, is displayed in the edit box. Edit the displayed constant to the meet the requirements of your application.

A tag name can be selected from the tag selection list. Click the tag list and choose the tag for the address or constant desired. The tag selection list will show only tags that are allowed on the selected input.

3.7.3 Address Types

The text beside the address button indicates the register types that are valid for the current function.

Type	Description	Registers
0reg	Discrete output register address	Single bit register
0blk	Discrete output register block address	16 single bit registers
1reg	Discrete input register address	Single bit register
1blk	Discrete input register block address	16 single bit registers
3reg	Analog input register address	Sixteen bit register
4reg	Analog output register address	Sixteen bit register

Table 1: Address Types

Note: Discrete input and output register blocks (blk types) must begin at the start of a 16-bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

3.7.4 Empty Column

The Empty Column selection inserts an empty column to the left of the current cursor position. This selection is greyed if an empty column already exists to the left of the cursor or if there is no room for an empty column in the network. This command is not available in the Comment Editor pane.

3.7.5 Empty Row

The Empty Row selection inserts an empty row above the current cursor position. This selection is greyed if an empty row already exists to the left of the cursor or if there is no room for an empty row in the network. This command is not available in the Comment Editor pane.

3.7.6 Network Before

The Network Before selection inserts an empty network before the current network. The cursor moves to column 1 Row 1 of the new network. This command is available in the Comment Editor pane.

3.7.7 Network After

The Network After selection inserts an empty network after the current network. The cursor moves to column 1 Row 1 of the new network. This command is available in the Comment Editor pane.

3.8 Delete

The Delete command removes items from the current Ladder Editor network. Press **Delete** to execute this function. A dialog box showing items that can be deleted appears. Items in the dialog box may be inaccessible (grayed) if they do not apply to the selected elements. The delete command is grayed out in the Edit menu when the cursor is in the Comment Editor pane. Items to delete are selected by clicking on the radio button associated with each selection.

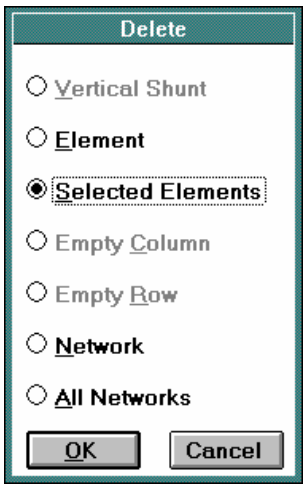


Figure 4: Delete Dialog Box

3.8.1 Vertical Shunt

The Vertical Shunt selection deletes the vertical shunt on the element highlighted by the cursor. This command is greyed if there is no vertical shunt on the element.

3.8.2 Element

The Element selection deletes the element at the current cursor position. This will delete a single element only, even if multiple elements are selected.

3.8.3 Selected Elements

The Selected Element selection deletes the elements highlighted in the network. Elements are highlighted by dragging the network cursor to highlight more than a single element.

3.8.4 Empty Column

The Empty Column selection deletes a column that contains no elements, and moves the elements in the columns to the right of it one column to the left.

3.8.5 Empty Row

The Empty Row selection deletes a row that contains no elements, and moves the elements in the rows below it up one row.

3.8.6 Network

The delete Network command deletes the current network and all the elements in it. Deleting a network does not remove the Tag names from the program.

3.8.7 Delete All Networks

The delete All Networks command deletes all ladder logic networks in the current file. You are asked to confirm that you wish to delete the networks. Deleting all networks does not change tag names, I/O assignments or the file name.

3.9 Toggle Vertical Shunt

The Toggle Vertical Shunt command toggles (inserts or deletes) a vertical shunt on the right side of the element highlighted by the cursor. The **F5** key also performs this command.

3.10 Tag Names

The Tag Names selection is used to edit names that can be used in place of addresses and constants. Tag names may be used once only for a constant or an address. Numbers can occur once for a constant and once for an address.

- Tag names must conform to the .CSV file format naming convention.
- Tag names may be up to 16 characters long and up to 2500 tag names can be created.
- The Edit Tag Names dialog box appears allowing the editing of Tag names.

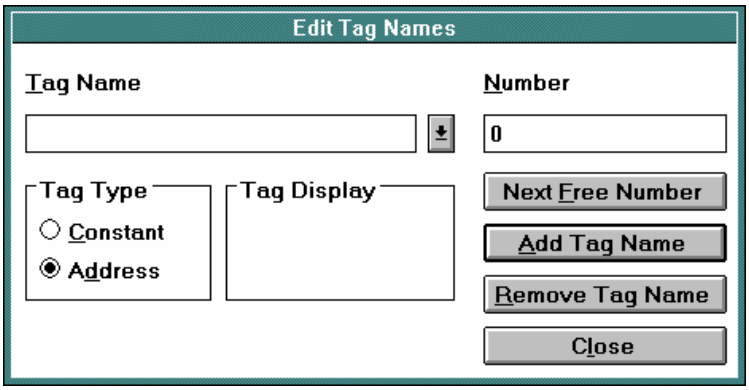


Figure 5: Edit Tag Names Dialog Box

The **Edit Tag Names** edit box is used to enter tag names. The drop down menu to the right of the box displays tag names already created.

The **Number** edit box is used to enter the number associated with the tag.

The **Tag Type** radio buttons select the type of tag. A Tag Type can be an address or a constant.

The **Tag Display** edit box displays the Tag Name entered in the Tag Name edit box. Tag names are a maximum of sixteen characters with eight characters on each line. The tag display box shows the tag name as it will be displayed in the Ladder Editor.

The **Next Free Number** button will cause the value in the Number edit box to be replaced by the next unused address or number of the Tag Type that is not in use.

The **Add Tag Name** button adds the tag to the list of tag names. An error dialog will appear if the tag name exists with a different type or number, or if a number exists with the same type and a different name.

The **Remove Tag Name** button removes the selected tag from the list of tag names. An error dialog will appear if the name is in the list but the other data does not match the type button or number box.

The **Close** button closes the Edit Tag Names dialog.

3.11 Erase All Tags

The Erase All Tags command is used to erase all tag names in a TelePACE Ladder Logic application program. This command can be used before importing tags from another program or a CSV file to eliminate errors when there are conflicts between existing tag names and imported tag names.

The command opens the following message box:

Figure 6: Erase All Tags Dialog Box

- Click on **Yes** to erase all tags.
- Click on **No** to abort the command.

Note: Erasing all tags cannot be undone. If you are unsure you should save your file before executing this command.

3.12 Export Tag Names

The Export Tag Names command is used to write the program tag names into a CSV (comma separated value) file. A CSV file can be opened, and edited in most spreadsheet programs. Note that the modified tag names must conform to the .CSV format.

The Export Tag Names to File dialog box is used to specify the file name and directory of the export file. Tag name files normally end with the extension CSV. The editor uses the extension CSV automatically, if you do not type it.

The CSV file contains a title line followed by multiple data lines containing the type_specifier, address and tag_name fields. Commas separate these fields. The type_specifier is A for an address tag, and C for a constant tag. The tag name can be enclosed in quotes. If the tag name contains a comma, it must be enclosed in quotes.

Note that if a type and register value is specified, a corresponding tag name must be entered otherwise an error will result.

Title line: Type, Value, Tag
Data line: type_specifier, address, tag_name

Note: A blank tag name is not allowed. If a type and register value is specified, a corresponding tag name must be entered otherwise an error will result.

3.13 Import Tag Names

The Import Tag Names command is used to read tag names into the editor. Tag names may be read from another ladder logic program, or from a CSV file. New tags are added to the existing tag list.

The *Import Tag Names From File* dialog box is used to select the file containing the tag names. Files with the extensions LAD and CSV are displayed by default.

As the tags are imported, they are checked for errors. If a tag is imported that that already exists in the program an error will occur. If an error occurs, you may continue to process the input file to look for more errors, or you may abort the import. If an error occurs, no tags are imported.

A CSV file consists of a title line followed by multiple data lines containing the type_specifier, address and tag_name fields. Commas separate these fields. The type_specifier is A for an address tag, and C for a constant tag. The tag name can be enclosed in quotes. If the tag name contains a comma, it must be enclosed in quotes.

Title line: Type, Value, Tag
Data line: type_specifier, address, tag_name

3.14 Network Title

The edit Network Title selection is used to edit the title of the current network. When selected the Edit Network Title dialog box appears and the title can be edited. The title may be a maximum of 28 characters long.

3.15 Element Configuration

The element configuration command edits initial values for 40000 series registers used by the MSTR, DIAL, INIM, HART, FLOW, SCAL, TOTL, PIDD, PIDA and SLP elements. The register values are written to the controller with the program. The register values may be modified later by other elements of the program.

Right click your mouse and select **Element Configuration** from the command list.

WARNING

If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.

Any change made to an element configuration in the Edit On Line mode will be downloaded to the controller immediately.

3.16 Registers

The Registers command replaces, and enhances, the Monitor List command from previous versions of TelePACE. The Registers command allows the online monitoring and control and the offline editing of registers used in a TelePACE application. These registers may be saved in a single group, or in multiple groups for monitoring. Individual registers may be selected for on-line and off-line editing of their data.

When the Registers command is selected the **Register Editor** is opened. The Register Editor is used to add registers to the Register list; edit registers in the list and to display register data.

All registers in the Register list are automatically added to the Register data file see the **Register Data File** section for complete details on this file. Through using the Register Editor and the associated Register Data File users are able to easily:

Save a list, or lists, of registers for monitoring and control that is specific for each TelePACE application program.

Preload registers used in a TelePACE application with data.

Save a ‘snap shot’ of data in registers used in a TelePACE application.

Create meaningful groups of registers for monitoring and control.

3.16.1 Register Editor

The Register Editor displays registers and allows the editing of register content. The dialog is divided into three main areas. The **Groups** section allows the user to create and manage groups of registers. The **Register List** section displays the registers, and register attributes, for each register in a group. The **Update Rate** section allows the user to control the refresh frequency for the registers in a displayed group.

The Register Editor may be opened in the off-line and on-line editing modes. When opened the Register Editor is displayed on top of the Ladder Editor. Ladder Logic cannot be modified while the Register Editor is open. The Register Editor dialog is opened automatically in the Monitor on-line mode.

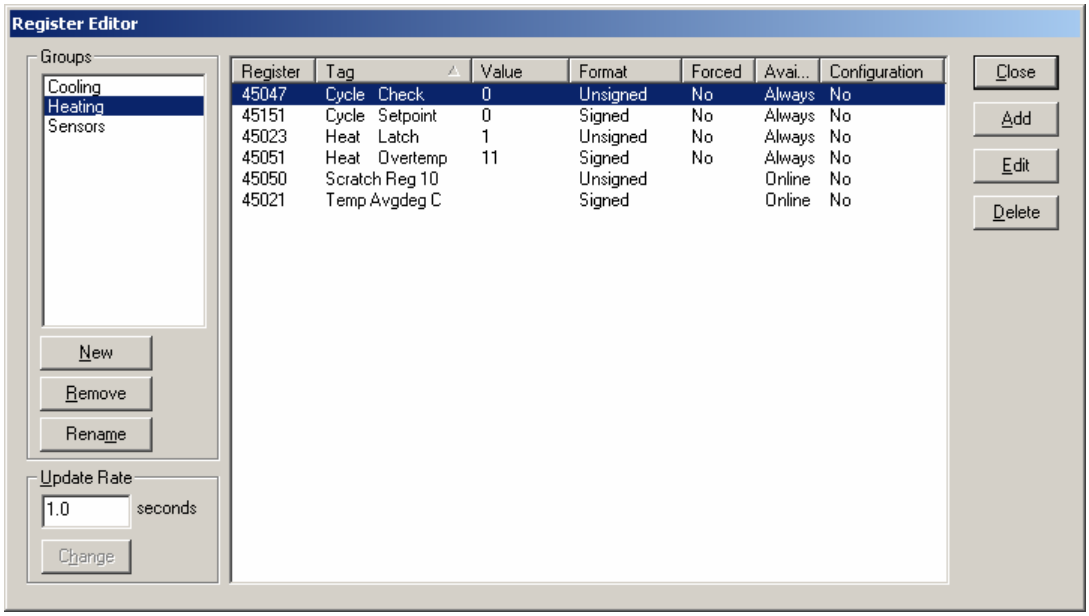


Figure 7: Register Editor Dialog Box

3.16.1.1 Groups

Register groups allows users to manage how registers are viewed in the Register Editor. Registers that are used in various parts of an application can be grouped together to provide an easy to view, and edit, list of registers. When in the on-line mode, only the registers in the current group are updated. This improves response time as large groups of registers can take a long time to update. Registers may be assigned to more than one group.

The **Groups** list box displays the register groups that have been created. When a group is selected the registers in the group are displayed in the Registers window. The group that was last selected the previous time the Register Editor was opened is displayed. Only one group can be selected at a time.

The **New** button creates a new group. It opens the New Group dialog.

Figure 8: New Group Dialog Box

The **Group** edit box specifies the name of the new group. The group name may contain letters, numbers, and spaces. The group name is 1 to 16 characters long. Group names are case insensitive.

The **OK** button creates the new group and closes the dialog. If the group name already exists an error message is displayed and the dialog remains open.

The **Cancel** button closes the dialog.

The **Remove** button deletes a group from the group list. All the registers in the group are deleted. The button is disabled (greyed) if no group is selected.

The **Rename** button renames a group. It opens the Rename Group dialog.

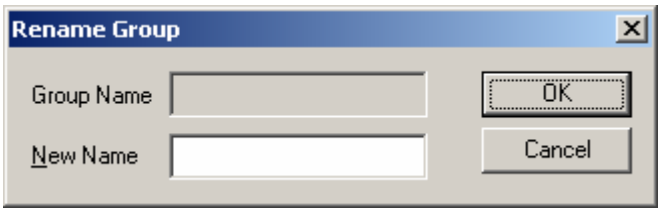


Figure 9: Rename Group Dialog Box

The **Group Name** field shows the current name of the group.

The **New Name** edit box specifies the new name of the group. The group name may contain letters, numbers, and spaces. The group name is 1 to 16 characters long. Group names are case insensitive.

The **OK** button renames the group and closes the dialog. If the group name already exists an error message is displayed and the dialog remains open.

The **Cancel** button closes the dialog.

3.16.1.2 Update Rate

The **Update Rate** edit box determines how often the register editor updates values when on-line. Valid values are 0.1 to 1000 seconds. The default value is 1 second. This value is used for all files opened by TelePACE and is saved when TelePACE is closed.

The **Change** button sets the current update rate. The modification in the **Update Rate** edit box will not take effect until the **Change** button is pressed. This button is disabled when the Register Editor is offline.

3.16.1.3 Register List

The Register list is displayed in the center of the Register Editor dialog. The Register List displays the registers for the selected group. Each register in the list has seven fields, or columns associated with it. The columns can be resized by dragging the edge of the column heading. The columns may be sorted by clicking the heading of each column.

The **Register** column displays the register number.

The **Tag** column displays the tag name associated with the register.

The **Value** column displays the value of the register in the selected **format**. Coil and status registers are shown as OFF or ON.

The **Format** column displays the register format. The register format is one of the following:

Register Format	Description
Unsigned	Displays a single register as an unsigned integer
Signed	Displays a single register as a signed integer
Unsigned Double	Displays two consecutive registers as an unsigned double integer
Signed Double	Displays two consecutive registers as a signed double integer
Floating Point	Displays two consecutive registers as a floating point number
Hexadecimal	Displays a single register as a hexadecimal number
Binary	Displays a single register as a binary number
ASCII	Displays a single register as two ASCII characters
Boolean	Displays coil and status registers which have no format

Table 2: Register Formats

The **Forced** column indicates if the register value is forced. Valid selections are **No** and **Forced**.

The **Available** column indicates if the register value is available always or only when TelePACE is on-line with the controller.

The **Configuration** column indicates if the register is part of an element configuration. It is recommended that registers that are part of an element configuration not be modified in the register editor. Use the element configuration feature instead.

The **Add** button adds registers to the selected group. It opens the **Add Registers Dialog**. This button is disabled if no group is selected.

The **Delete** button deletes the selected registers from the group. This button is disabled if no register is selected. This button is disabled if no group is selected.

The **Edit** button opens the **Edit Register Dialog** to edit the selected register value, format, force status, and register availability. This button is disabled if no register is selected or more than one register is selected. This button is disabled if no group is selected.

The **Close** button closes the dialog. This button is disabled in the monitor on-line mode.

The dialog is resizable. Click on the lower right corner and drag to change the size of the dialog.

3.16.2 Add Registers Dialog

The Add Registers dialog adds registers to the current group in the Register Editor dialog. The group name is displayed in the window title.

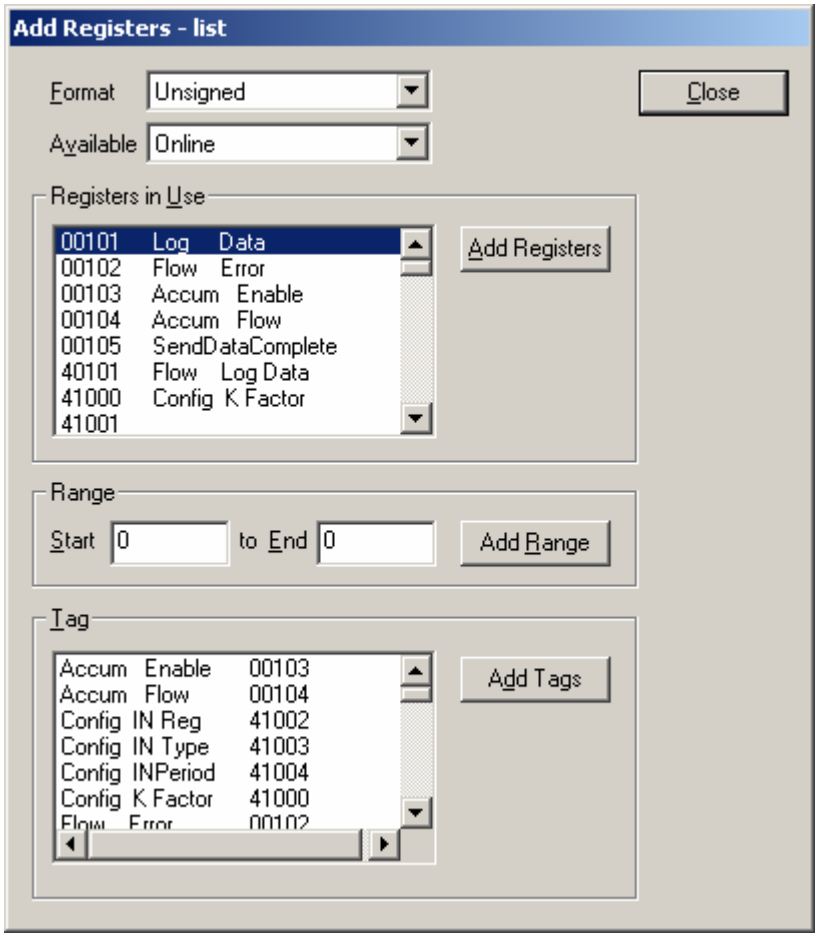


Figure 10: Add Registers – List Dialog Box

The **Format** drop-down list box specifies how the registers will be displayed. Select the format before adding registers.

Display	Description
Unsigned	Displays a single register as an unsigned integer
Signed	Displays a single register as a signed integer
Unsigned Double	Displays two consecutive registers as an unsigned double integer
Signed Double	Displays two consecutive registers as a signed double integer
Floating Point	Displays two consecutive registers as a floating point number
Hexadecimal	Displays a single register as a hexadecimal number
Binary	Displays a single register as a binary number
ASCII	Displays a single register as two ASCII characters
Boolean	Displays coil and status registers which have no format

Table 3: Register Display Properties

If a register or tag is used by element configuration its format cannot be changed. The register cannot be merged with adjacent registers or split if the format of an adjacent register is changed.

If a register or tag is already in the any register editor group but has a different format, the format of the register is changed in all groups.

The Unsigned Double, Signed Double, and Floating Point formats add two registers to the register editor group. The pair of registers is displayed as a single number.

If a single register is added that is part of an existing pair, the existing pair will become invalid and only new single register is displayed.

If a pair of registers is added that overlaps an existing single register, the single register and the following register will be made part of the register pair. If the following register is a part of the existing pair, that existing pair will become invalid.

If a pair of registers is added that overlaps one register of an existing pair, or two registers of two existing pairs, the new pair will be added and the existing overlapped pair will become invalid.

The **Available** list box specifies when register values can be viewed and edited. Valid values are Always and Online. The Always selection makes the register values available in both online and offline editing modes. The Online selection makes the register values available only in the online editing modes. The default is Online.

3.16.2.1 Registers In Use

The **Registers in Use** list box displays all registers that are used in the Ladder Logic program. One or more registers may be selected.

- To select a register, click on it.
- To select more than one register, hold the Ctrl key and click on each register to be added.
- To select a range of registers, click on the first register and hold down the Shift key while clicking on the last register. A second method is to hold the Shift key and use the Down Arrow key or Up Arrow key to select the registers.

The **Add Registers** button adds the selected registers to the register editor group. The registers are added in the format selected.

3.16.2.2 Range

The **Start** and **End** edit boxes specify a range of registers to add.

- To select a range, enter the Start and End registers.
- To select a single register, enter it in the Start edit box and enter 0 in the End edit box.

The **Add Range** button adds the selected registers to the register editor group. The registers are added in the format selected.

3.16.2.3 Tags

The **Tags** list box displays all tags and the corresponding register number that are defined in the Ladder Logic program. One or more tags may be selected.

- To select a tag, click on it.
- To select more than one tag, hold the Ctrl key and click on tags.
- To select a range of tags, click on the first tag and hold down the Shift key while clicking on the last tag or use Down Arrow key or Up Arrow key.

- To select a range of tags, click on the first tag and hold down the Shift key while clicking on the last tag. A second method is to hold the Shift key and use the Down Arrow key or Up Arrow key to select the tags.

The **Add Tags** button adds the selected tags to the register editor group. The tags are added in the format selected.

The **Close** button closes the dialog.

3.16.3 Edit Register Dialog

The **Edit Register** dialog modifies values for a register. There are two forms of the dialog. The following dialog is used for editing input registers (3xxxx type) and holding registers (4xxxx type).

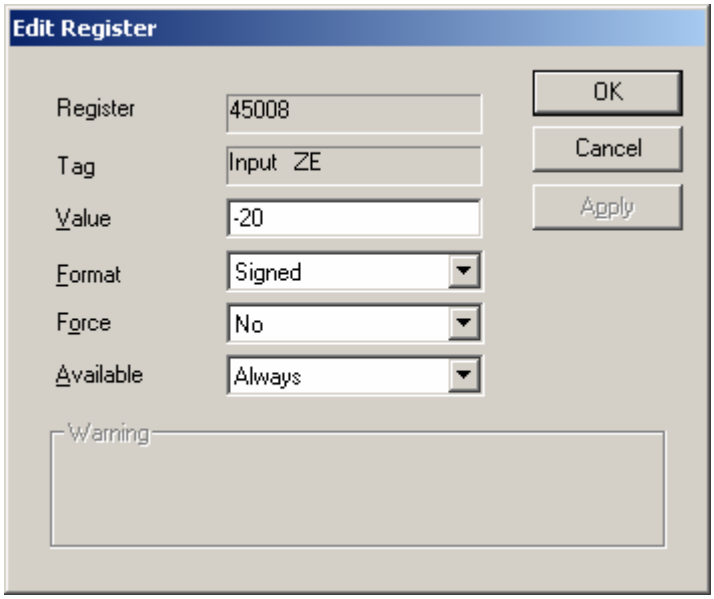


Figure 11: Edit Register Dialog Box

The following dialog is used for editing coil registers (0xxxx type) and status registers (0xxxx type).

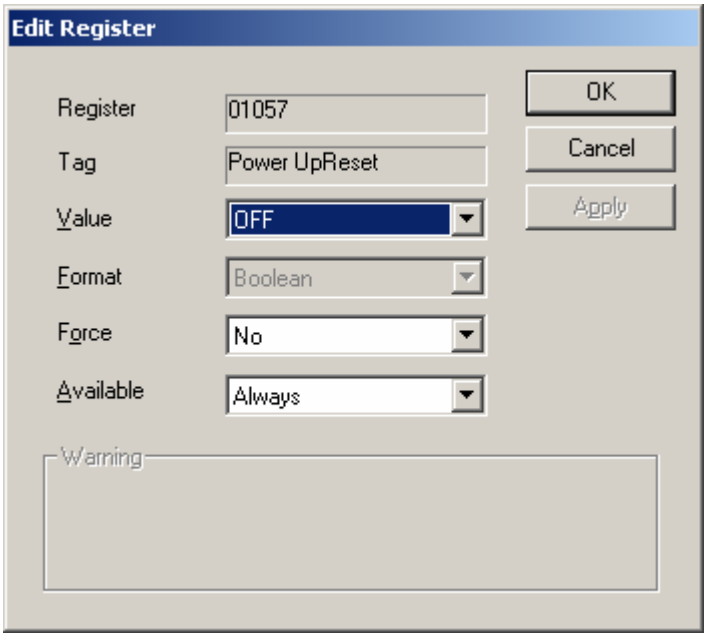


Figure 12: Edit Register Dialog Box- Value Off

The **Register** field displays the register number. This field cannot be edited.

The **Tag** field displays the tag for the register. This field cannot be edited.

The **Value** edit box displays and allows the editing of register values.

For input and holding registers the **Value** edit box displays the current value of the register. Valid values depend on the format of the register. The edit box is disabled if the register is not available Always and the editor is in the off-line mode.

For coil and status registers the **Value** drop-down list box shows the value of the register. Valid values are ON and OFF. The list box is disabled if the register is not available Always and the editor is in the off-line mode.

The **Format** list box selects the format of the register. The list box is disabled and shows none for coil and status registers. The list box is disabled if the register is used for Element Configuration - the format of these registers cannot be changed. The following formats are available.

Format	Description
Unsigned	Displays a single register as an unsigned integer
Signed	Displays a single register as a signed integer
Unsigned Double	Displays two consecutive registers as an unsigned double integer
Signed Double	Displays two consecutive registers as a signed double integer
Floating Point	Displays two consecutive registers as a floating point number
Hexadecimal	Displays a single register as a hexadecimal number
Binary	Displays a single register as a binary number
ASCII	Displays a single register as two ASCII characters
Boolean	Displays coil and status registers which have no format

Table 4: Register Formats

The **Force** drop-down list box indicates if the value is forced. Valid values are No and Forced. The list box is disabled if the register is not available Always and the editor is in the off-line mode.

The **Available** drop-down list box indicates when register values can be viewed and edited. Valid values are Always and Online. The Always selection makes the register values available in both online and offline editing modes. The Online selection makes the register values available only in the online editing modes. The default is Always if the editor is off-line and Online if the editor is on-line.

The **Warning** is displayed if the register is used by element configuration. It is recommended Element Configuration be used to change the register value. The Element Configuration function performs additional error checking specific to the Ladder Logic element.

The **OK** button saves changes and closes the dialog. If the Editor is on-line, changes are written to the controller.

The **Cancel** button closes the dialog.

The **Apply** button writes the changes to the controller, when the editor is on-line. The Apply button is disabled if the editor is off-line.

3.16.4 Register Data File

The register data file is created, saved and opened with the Ladder Logic file. The register data file contains the information for any registers that have been added to the Register Editor and any registers used in an element configuration. The Register Data file will contain only the header record (see **Register Data File Format**) if there are no Register Editor entries or element configuration.

Users can easily edit the register data file providing a rapid way to add or remove registers or modify their values or format.

3.16.4.1 Register Data File Format

The register data file is saved as a CSV (comma separated value) format file. The file is saved in the format: ***filename* - Registers.csv**. Where *filename* is the TelePACE Ladder Logic file name.

Each line in the CSV file is one record. The following is an example of a Register Data file.

```
Register,Value,Format,Forced,Available,Groups
01057,0,BO,No,Always,Sensors
30002,9440,S,No,Online,Sensors
30004,312,S,No,Online,Sensors
40238,1826,U,No,Always,all
45021,606,U,No,Online,Heating;Cooling
45035,+23.6250,F,No,Always,Cooling
45041,32,B,No,Always,Cooling
48016,1074,U,No,Always,*Element
```

The first line in the file is a header record and it contains the names of each of the fields. The following table describes each of the fields in the file.

Field	Description
Register	The address of the register or first register of a register pair. Register pairs are used for unsigned double, signed double and floating point registers. Valid register addresses are: 00001 to 09999 Digital Output registers. 10001 to 19999 Digital Input registers. 30001 to 39999 Analog Input registers. 40001 to 49999 Analog Output registers.
Value	Value of the register or registers. Boolean: 0 to 1 Unsigned: 0 to 65535 Signed: -32768 to 32767 Unsigned double: 0 to 2^{32}-1 Signed double: -2^{31} to 2^{31}-1 Hexadecimal: same as unsigned Binary: same as unsigned ASCII: same as unsigned
Format	Display format for the register or registers. BO Boolean U Unsigned S Signed UD Unsigned double SD Signed double F Floating point H Hexadecimal B Binary A ASCII
Force	Indicates if register value is forced. No Indicates register is not forced Forced Indicates register is forced
Available	Indicates if register is available always or online only. Always Indicates that the register may be edited in either the Online or Off line mode. Online Indicates that the register may be edited in the Online mode only.
Groups	List of groups that include this register. If the register is included in more than one group each group is listed with semicolons separating the group names. The special value `*Element` is reserved for registers used by element configuration.

Table 5: Insert Table Caption Here

3.16.5 Editing the Register Data File

The CSV file may be edited using a text editor, such as Notepad or a spreadsheet program such as Excel. The following operations can be done easily with a text editor or spreadsheet: adding, inserting, replacing, removing or editing many registers, searching for registers, and sorting.

Care must be exercised when editing the CSV file. Improper changes may result in loss of element configuration or register data. The following list gives some suggestions when editing a CSV file.

- Make a backup copy of the file before changing it. The file can be restored if you make invalid changes.
- A register can occur only once in the CSV file. Check that a register is listed only once after copying lines.
- Do not change the header record.
- Do not change the order of the columns.
- Do not use empty fields.
- Avoid including the header record when sorting column.
- Avoid sorting only some of the columns.
- Avoid overlapped registers with different register formats.
- Group names may contain spaces, letters, and numbers only. Don’t use other characters.
- Separate group names with semicolons.
- Group names are case insensitive the case does not matter.
- If registers containing part of an element configuration are deleted, the value for that register will be missing. This may cause unexpected operation of your ladder logic program.

4 Search Menu

Search Menu commands are used to locate networks, devices, addresses and tag names in the current Ladder Editor program. Addresses may be located, or located and replaced from the Search menu.

4.1 Next Network

Selecting the Next Network command from the Search Menu moves the Ladder Editor to the next Network in the program. The next network command is grayed out if the current network is the last network. Press **F8** to move the Ladder Editor to the next network.

4.2 Previous Network

Selecting the Previous Network command from the Search Menu moves the Ladder Editor to the previous Network in the program. The Previous Network command is grayed out if the current network is the first network. Press **F7** on the keyboard to move the Ladder Editor to the previous network.

4.3 Go To Network

The Go To Network command is used to move the Ladder Editor to a desired network. When the Go To Network command is selected the Go To Network dialog box pops up. The network titles or number to go to is entered in this dialog box. The Title box selects the title of the network. A drop down list shows multiple network titles in use. Networks that have no title are displayed showing the network number only. The Network box selects the number of the network. The Previous button moves backward through the list of networks. The Next button moves forwards through the list of networks.

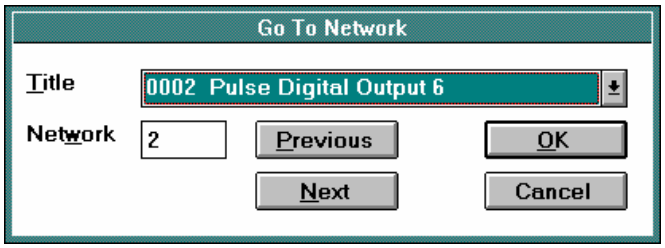


Figure 13: Go To Network Dialog Box

4.4 Find Address

The Find Address command searches the program for an address, or range of addresses, and moves to the first element containing any address in the range. The search proceeds down the rows from the present column, to column ten, row eight in the current network, then moves to the next network.

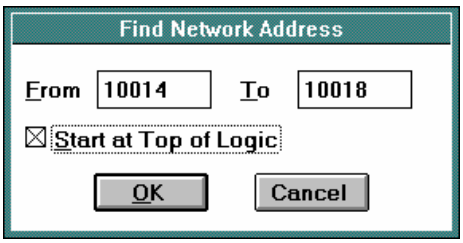


Figure 14: Find Network Address Dialog Box

The Find Network Address dialog box is used to enter the address, or range of addresses to find. The From box specifies the first address to locate. The initial value comes from the element at the current cursor position. The To box specifies the last address in a range. A value of 0 indicates that only the address in the From field is to be located. Checking the Start at Top of Logic box starts the search at the beginning of the program. The search starts at the current cursor position when this box is unchecked.

4.5 Find Device

The Find Device command is used to search the program for a device, and move to the first element containing that device. The search proceeds down rows from the present column to column ten row eight in the current network, then moves to the next network.

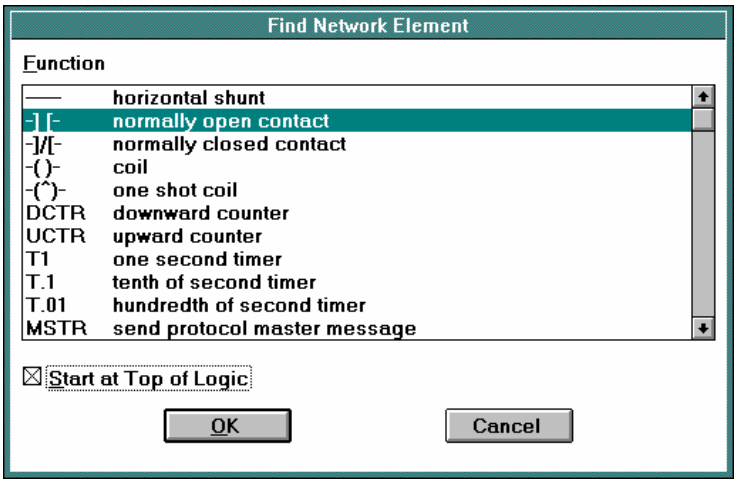


Figure 15: Find Network Element Dialog Box

The Find Network Element dialog box pops up when the Find Device command is selected. The Function list specifies the device to locate. The initial value comes from the element at the current cursor position. Checking the Start at Top of Logic box starts the search at the beginning of the program. Leaving this box unchecked starts the search at the current cursor position.

4.6 Find Tag Name

The Find Tag Name command is used to search the program for a tag name, and move to the first element containing the tag name. The search proceeds down rows from the present column to column ten, row eight in the current network, then moves to the next network.

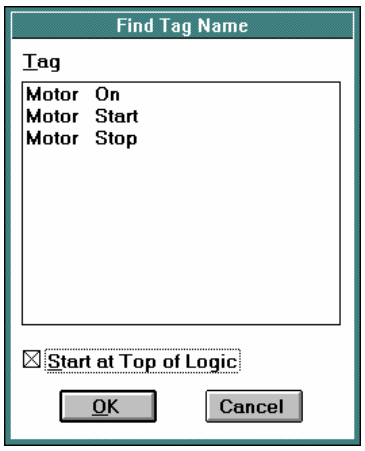


Figure 16: Find Tag Name Dialog Box

The Find Tag Name dialog box, displaying all the tag names used in the program, pops up when the Find Tag Name command is selected. Select a tag name in the Tag list by left clicking the mouse on the desired tag name. Checking the Start at Top of Logic box starts the search for the selected tag name at the beginning of the program. If left unchecked, the search starts at the current cursor position.

4.7 Repeat Last Find

The Repeat Last Find command repeats the last search performed. Press F3 to repeat the last find.

4.8 Replace Address

The Replace Address command is used to search the program for an address and then replace the address with another address. The search proceeds down rows from the present column to column ten, row eight in the current network, then moves to the next network.

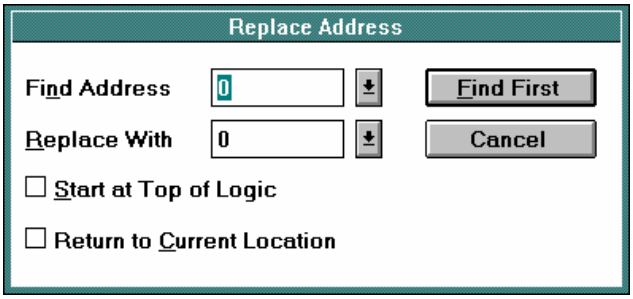


Figure 17: Replace Address Dialog Box

When the Replace Address command is selected the Replace Address dialog box pops up. The address to find and the replacement address are selected from this dialog box.

The Find Address box specifies the address to be replaced. The Replace With box specifies the replacement address.

Checking the Start at Top of Logic box starts the search at the beginning of the program. If left unchecked, the search starts at the current cursor position. Checking the Return to Current Location box returns the cursor to the current network after the command is executed. If left unchecked, the cursor is in the last program network after the command is executed.

The Find First button, when selected, will cause the Change Address dialog box to appear each time the search finds the address to be replaced. The With box allows changing of the replacement address. Selecting the Replace button replaces the address. The Find Next button continues the search to the next occurrence of the address to find.

4.9 Multiple Coils

Selecting the Multiple Coils command causes the Multiple Coils dialog box to pop up. This dialog box displays all coils that are used more than once in the current program.

5 Controller Menu

The Controller menu commands are used to configure the Micro16 and SCADAPack controllers. Controller selection, serial port configuration, I/O assignments, register assignment, and outputs on stop are defined in this menu selection. Controller initialization, I/O forcing and the C Program Loader are also selected from this menu.

5.1 Type

The TelePACE program is used to program and configure the Micro16, SCADAPack and SCADASense controllers. The selected controller determines controller specific options for other menus and communication functions.

TelePACE verifies the controller type when writing to the target controller and when entering the on-line modes. If the controller type selected in the application is different than the target controller, the following message appears:

"Cannot write to a different type or model of controller. Do you want to switch the controller type to *xxxx*?"

Where xxxx is the detected controller type.

The various controller types available in TelePACE are:

- SCADASense 4202 DR
- SCADASense 4202 DS
- SCADASense 4203 DR
- SCADASense 4203 DS
- Micro16
- SCADAPack
- SCADAPack 100: 1024K: This controller type can only be used when the controller firmware is version 1.80 or newer and the controller ID is greater than or equal to A182922.
- SCADAPack 100: 256K: This controller type can only be used when the controller firmware is version older than 1.80 and the controller ID is less than or equal to A182921.
- SCADAPack 32
- SCADAPack 32P
- SCADAPack LIGHT
- SCADAPack LP
- SCADAPack PLUS
- SCADAPack 350

Select the appropriate target controller this application is intended for.

5.2 Serial Ports

The Serial Ports selection is used to configure the serial port settings on the controller. There is a set of port settings for each serial port on the controller. Each serial port is independently configured for all serial and protocol parameters.

The Controller Serial Ports Settings dialog box pops up when the Serial Ports command is selected. Changes to serial port parameters are made within this dialog box.

To optimize communication performance on SCADAPack, SCADAPack Light and SCADAPack Plus controllers, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

Each item in the dialog is explained in the following paragraphs.

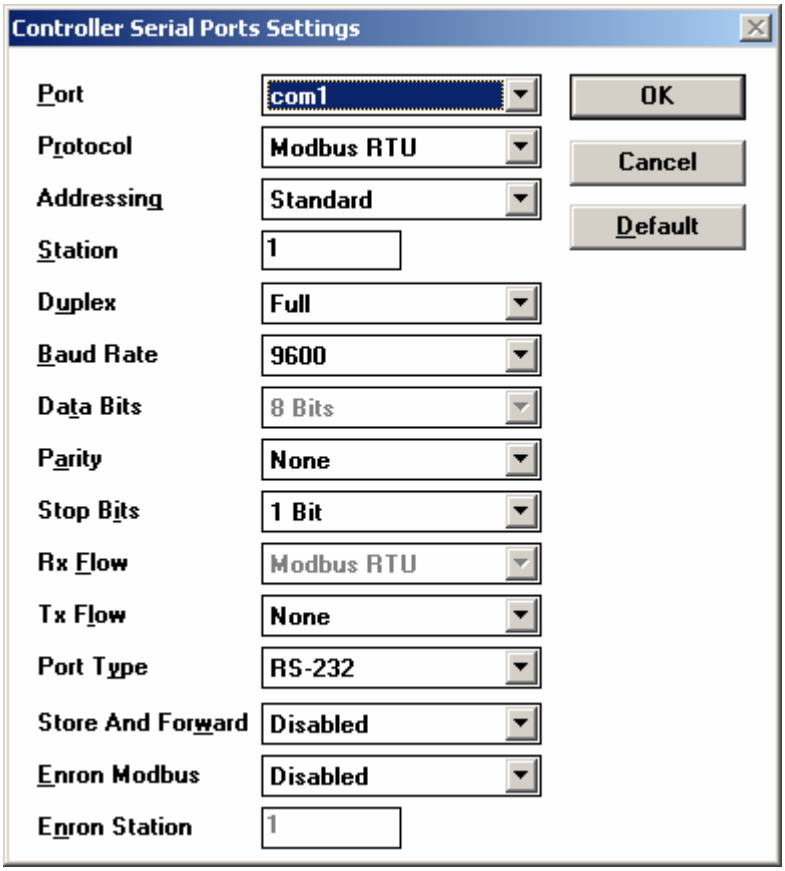


Figure 18: Controller Serial Ports Settings Dialog Box

The **Port** drop down menu selects the controller serial port to configure. The settings for the port are displayed in the Port Settings controls section of the dialog. The valid serial ports depend on the controller type. The default serial port is com1.

Controller Type	com1	com2	com3	com4
Micro16	X	X		
SCADAPack	X	X	X	
SCADAPack Plus	X	X	X	X
SCADAPack Light	X	X		X
SCADAPack LP	X	X	X	
SCADAPack 100	X	X		
SCADAPack 32	X	X	X	X
SCADAPack 32P	X	X		X

Controller Type	com1	com2	com3	com4
SCADAPack 350	X	X	X	
SCADASense 4202 DR	X	X	X	
SCADASense 4202 DS	X	X	X	
SCADASense 4203 DR	X	X	X	
SCADASense 4203 DS	X	X	X	

Table 6: Controller Port Settings

The **Protocol** drop down menu selects the communication protocol type. Valid protocols depend on the controller type as shown in the following table.

Controller Type	Valid Protocols	Default Protocol
Micro16 SCADAPack SCADAPack Plus SCADAPack Light SCADAPack LP SCADAPack 100	None Modbus RTU Modbus ASCII DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC DNP * Note that SCADAPack 100 controllers with firmware older than version 1.80 do not support DF1 protocols.	Modbus RTU
SCADAPack 32 SCADAPack 32P	None Modbus RTU Modbus ASCII DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC DNP PPP	Modbus RTU
SCADASense family of programmable controllers (4202 DR, 4202 DS, 4203 DR and 4203 DS)	Com 1 fixed as Sensor. Com 2 and Com 3: None Modbus RTU Modbus ASCII DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC DNP	Com 1 fixed as Sensor. Com 2 and Com 3 default is Modbus RTU.
SCADAPack 350	None Modbus RTU Modbus ASCII DF1 Full Duplex BCC	Modbus RTU

Controller Type	Valid Protocols	Default Protocol
	DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC DNP	

Table 7: Valid Protocols

The **Addressing** drop down menu selects the addressing mode for the selected protocol. The control is disabled if the protocol does not support it. Valid addressing modes depend on the selected protocol as shown in the following table.

Protocol	Valid Mode	Default Mode
Modbus RTU Modbus ASCII	Standard Extended	Standard
DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC	Control is disabled	N/A
DNP	Control is disabled	N/A
PPP	Control is disabled	N/A
None	Control is disabled	N/A

Table 8: Valid Addressing Modes

The **Station** entry sets the station address for the selected controller serial port. Valid addresses depend on the protocol and addressing mode selected, as shown in the table below.

Protocol	Valid Addresses	Default Address
Modbus RTU Modbus ASCII	Standard addressing: 1 to 255 Extended addressing: 1 to 65534	1
DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC	0 to 254	N/A
DNP	Control is disabled	N/A
PPP	Control is disabled	N/A
None	Control is disabled	N/A

Table 9: Valid Addresses

The **Duplex** drop down menu selects full or half-duplex operation for the selected Port. Valid and default duplex settings depend on the serial port and controller type, as shown in the table below. Note that the duplex is forced to Half if a SCADASense transmitter is configured on the port.

Controller Type	com1		com2		com3		com4	
	Valid	Def.	Valid	Def.	Valid	Def.	Valid	Def.
Micro16	Full Half	Full	Full Half	Full				
SCADAPack	Full Half	Full	Full Half	Full	Half	Half		
SCADAPack Plus	Full Half	Full	Full Half	Full	Half	Half	Half	Half
SCADAPack Light	Full Half	Full	Full Half	Full			Half	Half
SCADAPack LP	Half	Half	Full Half	Full	Half	Half		
SCADAPack 100	Full Half	Full	Full Half	Full				
SCADAPack 32	Full Half	Full	Full Half	Full	Half	Half	Full Half	Full
SCADAPack 32P	Full Half	Full	Full Half	Full			Full Half	Full
SCADASense 4202 DR SCADASense 4202 DS	Full	Full	Half	Half	Half	Half		
SCADASense 4203 DR SCADASense 4203 DS	Half	Half	Full Half	Half	Full Half	Full		
SCADAPack 350	Half	Half	Full Half	Half	Half Full	Full		

Table 10: Duplex Settings

The **Baud Rate** drop down menu selects the communication speed for the selected serial port. Valid baud rates depend on the serial port and controller type, as shown in the table below. The default value is always 9600 baud.

Baud Rate Controller	300	600	1200	2400	4800	9600	19200	38400	57600	115200
Micro 16										
Com 1, Com 2	X	X	X	X	X	X	X	X		
SCADAPack										
Com 1, Com 2	X	X	X	X	X	X	X	X		
Com 3			X	X	X	X	X	X	X	X
SCADAPack Plus										
Com 1, Com 2	X	X	X	X	X	X	X	X		
Com 3, Com 4			X	X	X	X	X	X	X	X

Baud Rate / Controller	300	600	1200	2400	4800	9600	19200	38400	57600	115200
SCADAPack Light										
Com 1, Com 2	X	X	X	X	X	X	X	X		
Com 4			X	X	X	X	X	X	X	X
SCADAPack LP										
Com 1, Com 2	X	X	X	X	X	X	X	X		
Com 3			X	X	X	X	X	X	X	X
SCADAPack 100: 1024K										
Com 1, Com 2	X	X	X	X	X	X	X	X		
SCADAPack32										
Com 1, Com 2, Com 4	X	X	X	X	X	X	X	X	X	X
Com 3			X	X	X	X	X	X	X	X
SCADAPack32P										
Com 1, Com 2, Com 4	X	X	X	X	X	X	X	X	X	X
SCADAPack 350										
Com 1, Com2, Com3	X	X	X	X	X	X	X	X	X	X
SCADASense Series of Programmable Controllers										
Com1					X					
Com2	X	X	X	X	X	X	X	X		
Com3			X	X	X	X	X	X	X	X

Table 11: Baud Rates

The **Data Bits** drop down menu selects the number of data bits. Valid selections are 7 and 8 bits. This parameter is forced to 8 bits when the protocol type is Modbus RTU, PPP or any DF1 protocol. The default selection is 8 bits.

The **Parity** drop down menu selects the parity for the selected port. Valid selections depend on the serial port, controller type and data bits, as shown in the table below. The default selection is always none.

Controller Type	com1	com2	com3		com4	
			7 bits	8 bits	7 bits	8 bits
Micro16	None even odd	none even odd	N/A		N/A	
SCADAPack	None	none		none	N/A	

Controller Type	com1	com2	com3		com4	
			7 bits	8 bits	7 bits	8 bits
	even odd	even odd	even odd space mark	even odd mark		
SCADAPack Plus	None even odd	none even odd	 even odd space mark	none even odd mark	 even odd space mark	none even odd mark
SCADAPack Light	none even odd	none even odd	N/A		 even odd space mark	none even odd mark
SCADAPack LP	none even odd	none even odd	 even odd space mark	none even odd mark	N/A	
SCADAPack 100	none even odd	none even odd				
SCADAPack 32	none even odd	none even odd	 even odd space mark	none even odd mark	none even odd	
SCADAPack 32P	none even odd	none even odd	N/A		none even odd	
SCADASense 4202 DR SCADASense 4202 DS	none	none even odd	none even odd mark		N/A	
SCADASense 4203 DR SCADASense 4203 DS	none	none even odd	none even odd		N/A	
SCADAPack 350	none even odd	none even odd	None even odd		N/A	

Table 12: Parity Settings

The **Stop Bits** drop down menu selects the number of stop bits for the selected serial port. Besides the SCADAPack 350 with a preset stop bit of 1, valid selections are 1 and 2 for all other controllers. Valid selection for com3 is 1 stop bit. The default selection is 1.

Note: The SCADAPack 350 has only 1 stop bit. This cannot be changed.

The **Rx Flow** drop down menu selects the receiver flow control for the selected port. Valid selections depend on the protocol, controller type, and serial port, as shown in the table below. If there is only one valid value the control is disabled. If there is more than one possible value, the default selection is none.

Protocol	Controller	com1	com2	com3	com4
DF1 Full BCC DF1 Full CRC DF1 Half BCC DF1 Half CRC DNP	Micro16	None	None	N/A	N/A
	SP	None	None	None	N/A
	SP Plus	None	None	None	None
	SP Light	None	None	N/A	none
	SP LP	None	None	None	N/A
	SP 100	None	None	N/A	N/A
	SP 32	None	None	None	None
	SP 32P	None	None	N/A	None
	SCADASense 4202 DR SCADASense 4202 DS	N/A	None	None Ignore CTS	N/A
	SCADASense 4203 DR SCADASense 4203 DS	N/A	None	None	N/A
	SCADAPack 350	None	None	None	N/A
Modbus RTU	Micro16	None	None	N/A	N/A
	SP	None	None	Modbus RTU	N/A
	SP Plus	None	None	Modbus RTU	Modbus RTU
	SP Light	None	None		Modbus RTU
	SP LP	None	None	Modbus RTU	
	SP 100	None	None	N/A	N/A
	SP 32	Modbus RTU	Modbus RTU	Modbus RTU	Modbus RTU
	SP 32P	Modbus RTU	Modbus RTU		Modbus RTU
	SCADASense 4202 DR SCADASense 4202 DS	None	None	Modbus RTU	
	SCADASense 4203 DR SCADASense 4203 DS	None	Modbus RTU	Modbus RTU	N/A
	SCADAPack 350	Modbus RTU	Modbus RTU	Modbus RTU	N/A
None Modbus ASCII	Micro16	None Xon/Xoff	none Xon/Xoff		N/A
	SP	None Xon/Xoff	none Xon/Xoff	None	N/A

Protocol	Controller	com1	com2	com3	com4
	SP Plus	None Xon/Xoff	none Xon/Xoff	None	None
	SP Light	None Xon/Xoff	none Xon/Xoff	N/A	None
	SP LP	None Xon/Xoff	none Xon/Xoff	None	N/A
	SP 100	None Xon/Xoff	none Xon/Xoff	None	None
	SP 32	None	None	None	None
	SP 32P	None	None	N/A	None
	SCADASense 4202 DR SCADASense 4202 DS	None	None	None Modbus RTU	N/A
	SCADASense 4203 DR SCADASense 4203 DS	None	None	None	N/A
	SCADAPack 350	None	None	None	N/A
PPP	SP 32	Queued	Queued	Queued	Queued
	SP 32P	Queued	Queued	Queued	Queued

Table 13: RX Flow Settings

The **Tx Flow** drop down menu selects the transmitter flow control for the selected port. Valid selections depend on the protocol, controller type, and serial port, as shown in the table below. The default selection is none.

Protocol	Controller	com1	com2	com3	com4
Modbus RTU DF1 Full BCC DF1 Full CRC DF1 Half BCC DF1 Half CRC DNP	Micro16	None	None	N/A	N/A
	SP	None	None	None Ignore CTS	N/A
	SP Plus	None	None	None Ignore CTS	None Ignore CTS
	SP Light	None	None	N/A	None Ignore CTS
	SP LP	None	None	None Ignore CTS	N/A
	SP 100	None	None	N/A	N/A
	SP 32	None Ignore CTS	None Ignore CTS	None Ignore CTS	None Ignore CTS
	SP 32P	None Ignore CTS	None Ignore CTS	N/A	None Ignore CTS
	SCADASense 4202 DR SCADASense 4202 DS	None	None	None Ignore CTS	N/A
	SCADASense 4203 DR SCADASense 4203 DS	None	None	None	N/A
	SCADAPack 350	None	None	None	N/A

Protocol	Controller	com1	com2	com3	com4
None Modbus ASCII	Micro16	None Xon/Xoff	None Xon/Xoff	N/A	N/A
	SP	None Xon/Xoff	None Xon/Xoff	None Ignore CTS	N/A
	SP Plus	None Xon/Xoff	None Xon/Xoff	None Ignore CTS	None Ignore CTS
	SP Light	None Xon/Xoff	None Xon/Xoff	N/A	None Ignore CTS
	SP LP	None Xon/Xoff	None Xon/Xoff	None Ignore CTS	N/A
	SP 100	None Xon/Xoff	None Xon/Xoff	N/A	N/A
	SP 32	None Ignore CTS	None Ignore CTS	None Ignore CTS	None Ignore CTS
	SP 32P	None Ignore CTS	None Ignore CTS	N/A	None Ignore CTS
	SCADASense 4202 DR SCADASense 4202 DS	N/A	None	None Ignore CTS	N/A
	SCADASense 4203 DR SCADASense 4203 DS	N/A	None	None	N/A
	SCADAPack 350	None	None	None	N/A

Table 14: TX Flow Settings

The **Port Type** drop down menu selects the type of serial port. Valid selections depend on the serial port and controller type as shown in the table below. The default selection is RS-232. The options are as follows:

- RS-232 for a regular RS-232 connection.
- RS-232 Dial-up modem: If an external dial-up modem is used on the RS-232 connection.

This setting is required if the RTU is initiating a dialup connection through an external modem connected to the corresponding serial port. For SCADASense controllers, the digital input point can be used to provide a DCD signal, as required by the external modem.

- RS-232 Collision Avoidance: RS-232 connection with collision avoidance based on the CD signal is available **only when the DNP protocol type is selected on the serial port, and the serial port supports handshaking**.

When this flow control is enabled, the protocol uses the Carrier Detect (CD) signal provided by the serial port to detect if the communication medium is in use. If it is, it waits until the medium is free before transmitting.

Prior to transmitting each Data Link (DL) frame, the controller will test the CD line. If it is active, a countdown equal to the DL timeout will be set and CD will be monitored every 100 ms throughout this countdown period. If the Data Link timeout is set to the minimum of 100 ms, the CD line will be tested once.

If the CD line reports inactive (line not in use), a frame will be transmitted immediately, and a new DL timeout is started as normal. On the other hand, if CD remains active during the DL timeout, the transmission attempt will fail. If a non-zero retry is configured in the Data Link layer, the test will be repeated until the number of retries has been exhausted.

Note: RS-232 Collision Avoidance is supported only on serial ports which support handshaking and whose protocol type is set for DNP.

- RS-485: for a regular RS-485 connection.

Controller Type	com1	com2, com4	com3
Micro16 SCADAPack SCADAPack Plus SCADAPack Light	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance RS-485	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance **Note:** com4 is available on the SCADAPack Light and Plus only.	S-232 RS-232 dial-up modem
SCADAPack 32 SCADAPack 32P	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance **NOTE:** Port type RS-232 applies for RS-232 or RS-485 operation on COM1. Jumper J9 on the controller board must be installed to configure COM1 for RS-485 operation.	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance	S-232 RS-232 dial-up modem

Controller Type	com1	com2, com3
SCADASense Programmable Controllers (4202 DR, 4202 DS, 4203 DR and 4203 DS).	N/A (RS-232)	RS-232 RS-232 Dialup Up Modem (com 2 only) **NOTE:** RS-232 Port Type applies for RS-232 or RS-485 operation.
SCADAPack 100	RS-232 RS-232 Collision Avoidance **NOTE:** Port type RS-232 applies for RS-232 or RS-485 operation on Com 1.	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance Com 3: not available
SCADAPack LP	RS-485	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance
SCADAPack 350	RS-485	RS-232 RS-232 dial-up modem RS-232 Collision Avoidance **NOTE:** Port type RS-232 applies for RS-232 or RS-485 operation on COM2. Jumper J13 on the controller board must be installed to configure COM2 for RS-485 operation.

Table 15: Serial Port Type

The **Store and Forward** drop down menu selects whether store and forward messaging is enabled for the port. Valid selections are enabled and disabled. If this option is enabled, messages will be forwarded according to the settings in the store and forward routing table. The default selection is disabled. This control is disabled when PPP protocol is selected for a serial port, or if any of the DF1 protocols are selected and for Com2 and Com3 on the SCADASense series of controllers.

The **Store and Forward** menu selection changes to **Routing** menu selection when DNP protocol is selected for a serial port. Valid selections are enabled and disabled. Routing must be enabled on a serial port to enable routing of DNP messages.

The **Enron Modbus** drop down menu selects whether Enron Modbus is enabled for the port. If this option is enabled, the controller, in addition to regular Modbus messages, will handle Enron Modbus messages. Valid selections depend on the protocol as shown in the table below. This control is disabled when PPP protocol is selected for a serial port and for com 1 on the SCADASense series of controllers.

Protocol	Valid Selections	Default Selection
Modbus RTU Modbus ASCII	Enabled Disabled	Disabled
DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC	Control is disabled	N/A
DNP	Control is disabled	N/A
None	Control is disabled	N/A

Table 16: Enron Modbus Settings

The **Enron Station** entry selects the Enron Modbus station address for the serial port. Valid entries depend on the protocol. The Enron station must be different from the Modbus station set in the **Station** control. This ensures Enron Modbus and Modbus communication can occur on the same port. This entry is greyed out if Enron Modbus is not enabled.

Protocol	Valid Values	Default Value
Modbus RTU Modbus ASCII	Standard addressing: 1 to 255 Extended addressing: 1 to 65534	2
DF1 Full Duplex BCC DF1 Full Duplex CRC DF1 Half Duplex BCC DF1 Half Duplex CRC	Control is disabled	N/A
DNP	Control is disabled	N/A
None	Control is disabled	N/A

Table 17: Enron Modbus Station Settings

- The **OK** button saves the settings for all serial ports and closes the dialog.
- The **Cancel** button closes the dialog without saving.
- The **Default** button sets the parameters for the port to their default values.

5.3 IP Configuration

When the IP Configuration menu item is clicked under the Controller menu the IP Configuration dialog is opened. This dialog is available only when the controller type is set to SCADAPack 350, SCADAPack 32 or SCADAPack 32P.

The IP Configuration dialog has a tree control on the left side of the window. The SCADAPack 32 and SCADAPack 32P support Point-To-Point Protocol (PPP) on the serial ports. The tree control displays headings for com 1 Port through com 4 Port and PPP Login are displayed for configuring the serial ports for PPP. The SCADAPack 350 does not support PPP on the serial ports and the headings for com 1 Port through com 4 Port and PPP Login are not displayed.

Each of the tree control selections is explained in the following sections of this user manual.

This tree control for the SCADAPack 32 and SCADAPack 32P contains headings for:

- LAN Port
- com 1 Port
- com 2 Port
- com 3 Port
- com 4 Port
- PPP Login
- Modbus Common
- Modbus/TCP
- Modbus RTU in UDP
- Modbus ASCII in UDP
- DNP in TCP
- DNP in UDP
- Friendly IP List

This tree control for the SCADAPack 350 contains headings for:

- LAN Port
- Modbus Common
- Modbus/TCP
- Modbus RTU in UDP
- Modbus ASCII in UDP
- DNP in TCP
- DNP in UDP
- Friendly IP List

When a tree control is selected by clicking the mouse on a heading, a property page is opened for the header selected. From the property page the IP configuration parameters for the selected header is displayed.

The **Default** button selects the default values for the current property page.

The **OK** button saves the configuration and closes the Controller IP Configuration dialog.

The **Cancel** button closes the Controller IP Configuration dialog without saving any changes.

5.3.1 LAN Port

The LAN Port property page is selected for editing by clicking LAN Port in the tree control section of the Controller IP Configuration dialog. When selected the LAN Port property page is active.

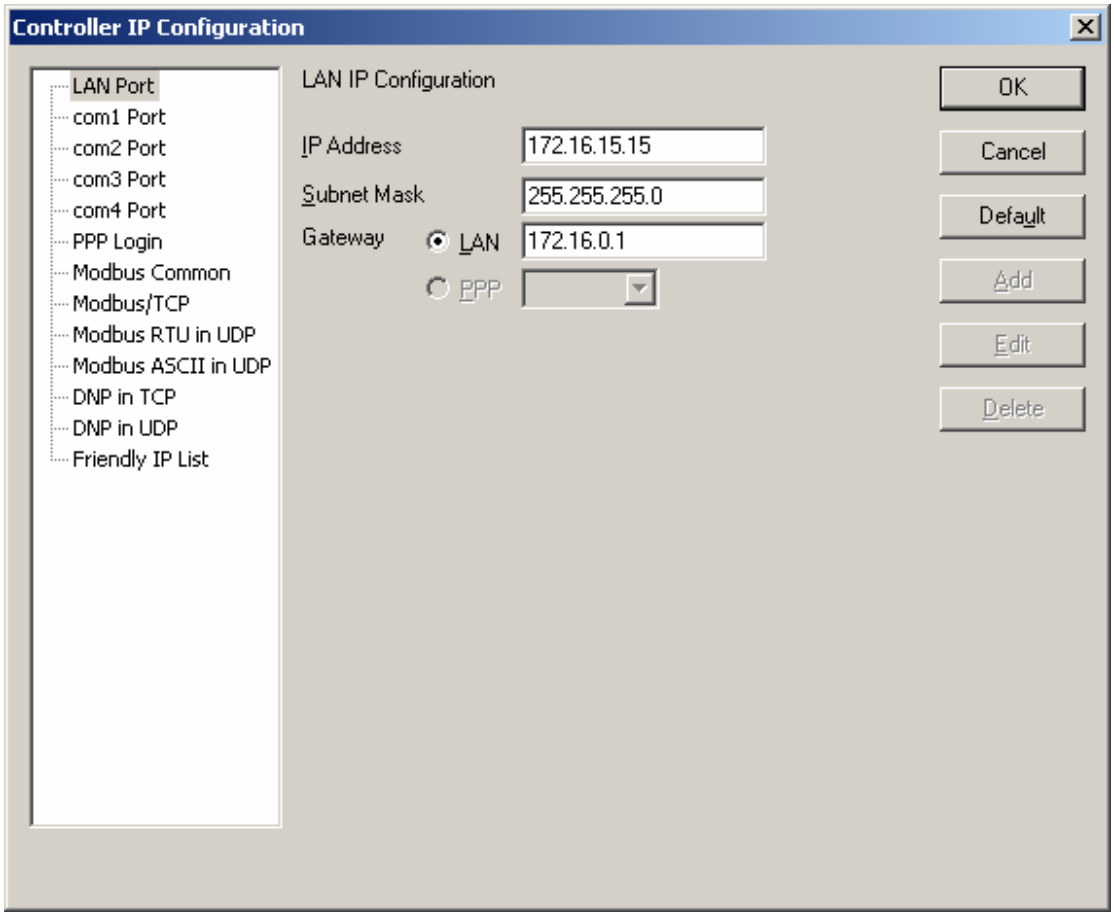


Figure 19: Controller IP Configuration – LAN Port Dialog Box

The **IP Address** is the address of the controller LAN port. The IP address is statically assigned. Contact your network administrator to obtain an IP address for the controller. The default value is 0.0.0.0.

The **Subnet Mask** is determines the subnet on which the controller LAN port is located. The subnet mask is statically assigned. Contact your network administrator to obtain the subnet mask for the controller. The default value is 255.255.255.0.

The **Gateway** determines how your controller communicates with devices outside its subnet. The **LAN** radio button selects the gateway specified in the **LAN** edit box. Enter the IP address of the gateway. The gateway is located on the LAN port subnet. The gateway is statically assigned. Contact your network administrator to obtain the gateway IP address. The default value is 0.0.0.0.

The **PPP** radio button selects the serial port where the gateway is located. The **PPP** drop down menu displays only those serial ports currently configured for the PPP protocol. Select a serial port from this menu to select its remote IP address as the gateway. The gateway is automatically assigned to the remote IP address of the selected serial port.

5.3.2 com1 Port

The com1 Port property page is selected for editing by clicking com1 Port in the tree control section of the Controller IP Configuration dialog. When selected the com1 Port property page is active. This page configures the IP settings for com1 when the PPP protocol is selected for this serial port.

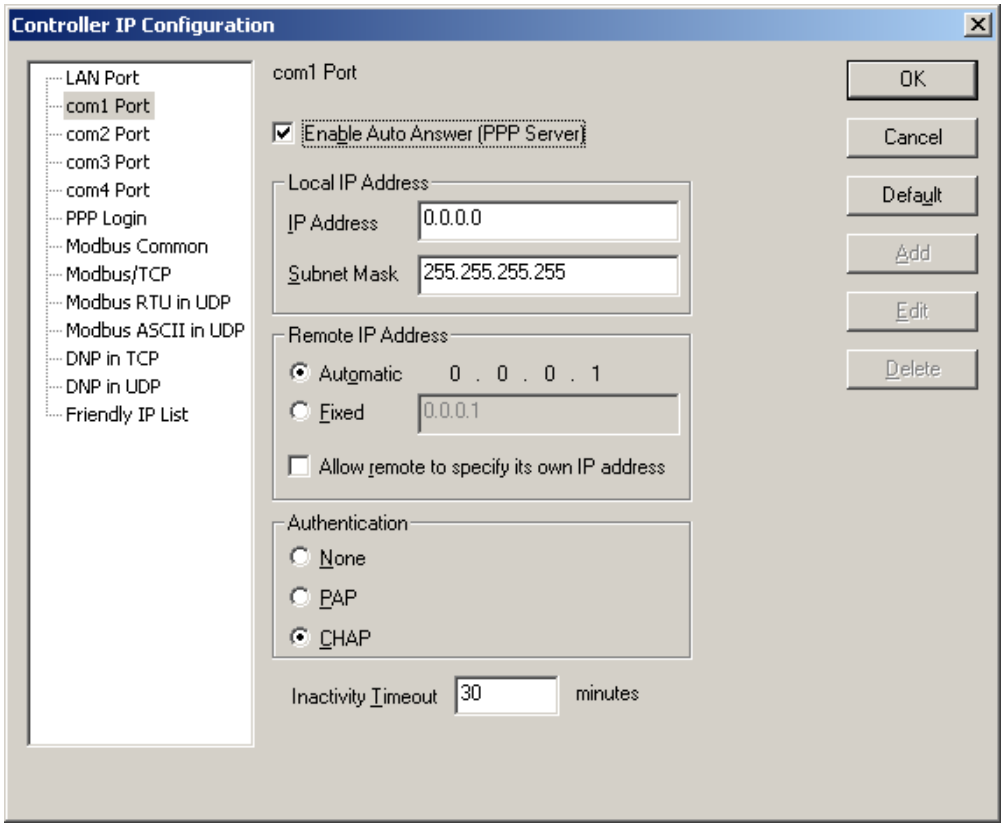


Figure 20: Controller IP Configuration – com1 Port Dialog Box

The **Enable Auto Answer (PPP Server)** checkbox enables the PPP Server on this serial port. Check this box if you want to allow a remote PPP client to connect to this port. This checkbox enables the remaining settings in the page.

The **IP Address** is the address of this serial port. The IP address is statically assigned. Contact your network administrator to obtain an IP address for this serial port.

The **Subnet Mask** determines the subnet on which this serial port is located. The subnet mask is statically assigned. Contact your network administrator to obtain the subnet mask for this serial port. In a standard PPP configuration, a subnet mask of 255.255.255.255 is used to restrict routing on this serial port to a single host (i.e. the **Remote IP Address**).

If another subnet mask is used, all packets on that subnet will be forwarded to this serial port. Any address on that subnet in addition to the **Remote IP Address** can be used for the remote host in this case.

The **Remote IP Address** is the address that will be assigned to the remote PPP client connected to this serial port. The **Automatic** radio button automatically selects the address to be the serial port's IP address + 1. The second radio button selects the address specified in the edit box. Enter the IP address to assign to the remote client.

The **Allow remote to specify its own IP address** checkbox allows the remote PPP client to assign its own IP address. Check this box if you want to allow this option. Note that the client may or may not request its own IP address. If the client does not make this request, the PPP Server will assign the IP address selected.

The **Authentication** determines the login protocol used at the start of every PPP connection. The **None** radio button removes the login step. The **PAP** radio button selects the Password Authentication Protocol (PAP). The **CHAP** radio button selects the Challenge-Handshake Authentication Protocol (CHAP). PAP and CHAP usernames and passwords are configured on the **PPP Login** page.

The **Inactivity Timeout** is the inactivity timeout for this serial port. If there has been no activity on an existing PPP connection for the selected number of minutes, then the connection is automatically closed. If there is a modem connected it is hung up. Setting this value to zero disables the timeout.

5.3.3 com2 Port

The com2 Port property page is selected for editing by clicking com2 Port in the tree control section of the IP Configuration dialog. When selected the com2 Port property page is active. This page configures the IP settings for com2 when the PPP protocol is selected for this serial port.

The com2 Port property page provides the same options as the com1 Port page. See the com1 Port page for a description of these options.

5.3.4 com3 Port

The com3 Port property page is selected for editing by clicking com3 Port in the tree control section of the IP Configuration dialog. When selected the com3 Port property page is active. This page configures the IP settings for com3 when the PPP protocol is selected for this serial port.

The com3 Port property page provides the same options as the com1 Port page. See the com1 Port page for a description of these options.

5.3.5 com4 Port

The com4 Port property page is selected for editing by clicking com4 Port in the tree control section of the IP Configuration dialog. When selected the com4 Port property page is active. This page configures the IP settings for com4 when the PPP protocol is selected for this serial port.

The com4 Port property page provides the same options as the com1 Port page. See the com1 Port page for a description of these options.

5.3.6 PPP Login

The PPP Login property page is selected for editing by clicking PPP Login in the tree control section of the IP Configuration dialog. When selected the PPP Login property page is active.

This page configures the username and password list for PPP login authentication. The list is used only by those serial ports configured for the PPP protocol using PAP or CHAP authentication.

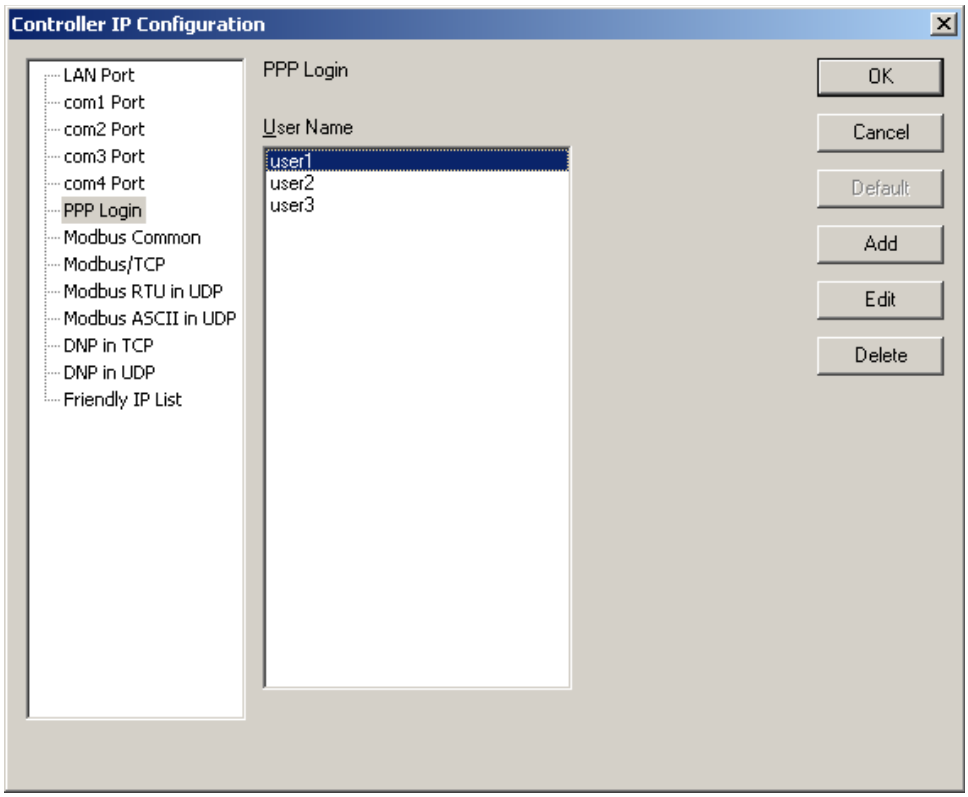


Figure 21: Controller IP Configuration – PPP Login Dialog Box

- Click **Add** to enter a new username to the list. Selecting the Add button opens the Add PPP Username dialog.
- Click **Edit** to edit the username highlighted in the list. Selecting the Edit button opens the Edit PPP Username dialog. This button is disabled if there are no entries in the list.
- Click **Delete** to remove the selected usernames from the list. This button is disabled if there are no entries in the list.

5.3.6.1 Add PPP Username dialog

This dialog selects a new PPP username and password.

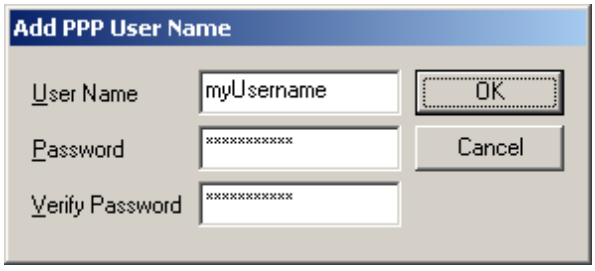


Figure 22: Add PPP User Name Dialog Box

The **Username** edit box selects the username. A username is any alphanumeric string 1 to 16 characters in length, and is case sensitive.

The **Password** edit box selects the password. A password is any alphanumeric string 1 to 16 characters in length, and is case sensitive.

The **Verify Password** edit box selects the verify password. Enter the same string entered for the password.

The **Cancel** button discards any changes made to this dialog and exits the dialog.

The **OK** button to accepts all changes made to this dialog and exits the dialog.

5.3.6.2 Edit PPP Username dialog

This dialog edits a PPP username and password selected from the list.

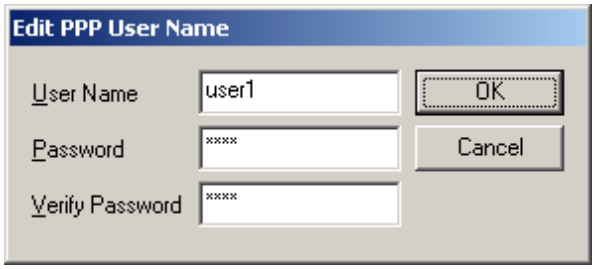


Figure 23: Edit PPP User Name Dialog Box

The **Username** edit box selects the username. A username is any alphanumeric string 1 to 16 characters in length, and is case sensitive.

The **Password** edit box selects the password. A password is any alphanumeric string 1 to 16 characters in length, and is case sensitive.

The **Verify Password** edit box selects the verify password. Enter the same string entered for the password.

The **Cancel** button discards any changes made to this dialog and exits the dialog.

The **OK** button to accepts all changes made to this dialog and exits the dialog.

5.3.7 Modbus Common

The Modbus Common property page is selected for editing by clicking Modbus Common in the tree control section of the IP Configuration dialog. When selected the Modbus Common property page is active.

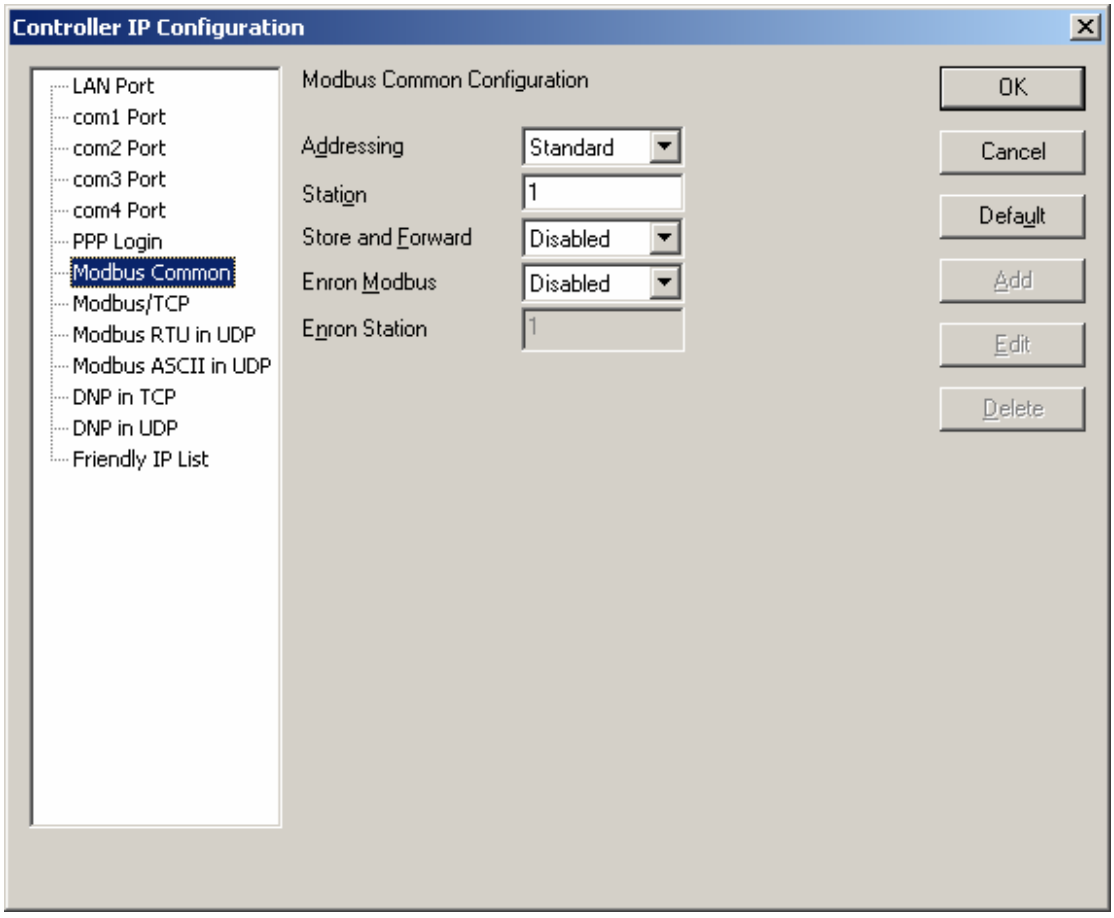


Figure 24: Controller IP Configuration - Modbus Common Dialog Box

The **Addressing** menu selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default value is standard.

The **Station** menu sets the station number of the controller. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default value is 1.

The **Store and Forward** selection controls forwarding of messages using IP based protocols. If this option is enabled, messages will be forwarded according to the settings in the store and forward routing table. The default value is disabled.

The **Enron Modbus** box selects whether Enron Modbus is enabled for the port. If this option is enabled, the controller, in addition to regular Modbus messages, will handle Enron Modbus messages.

The **Enron Station** box selects the Enron Modbus station address. The valid range for Enron Station is 1 to 255 if the Addressing control is set to Standard. The valid range for Enron Station is 1 to 65534 if the Addressing control is set to Extended. The Enron station must be different from the Modbus station set in the **Station** edit box. This ensures Enron Modbus and Modbus communication can occur on the same port.

5.3.8 Modbus/TCP

The Modbus/TCP property page is selected for editing by clicking Modbus/TCP in the tree control section of the IP Configuration dialog. When selected the Modbus/TCP property page is active.

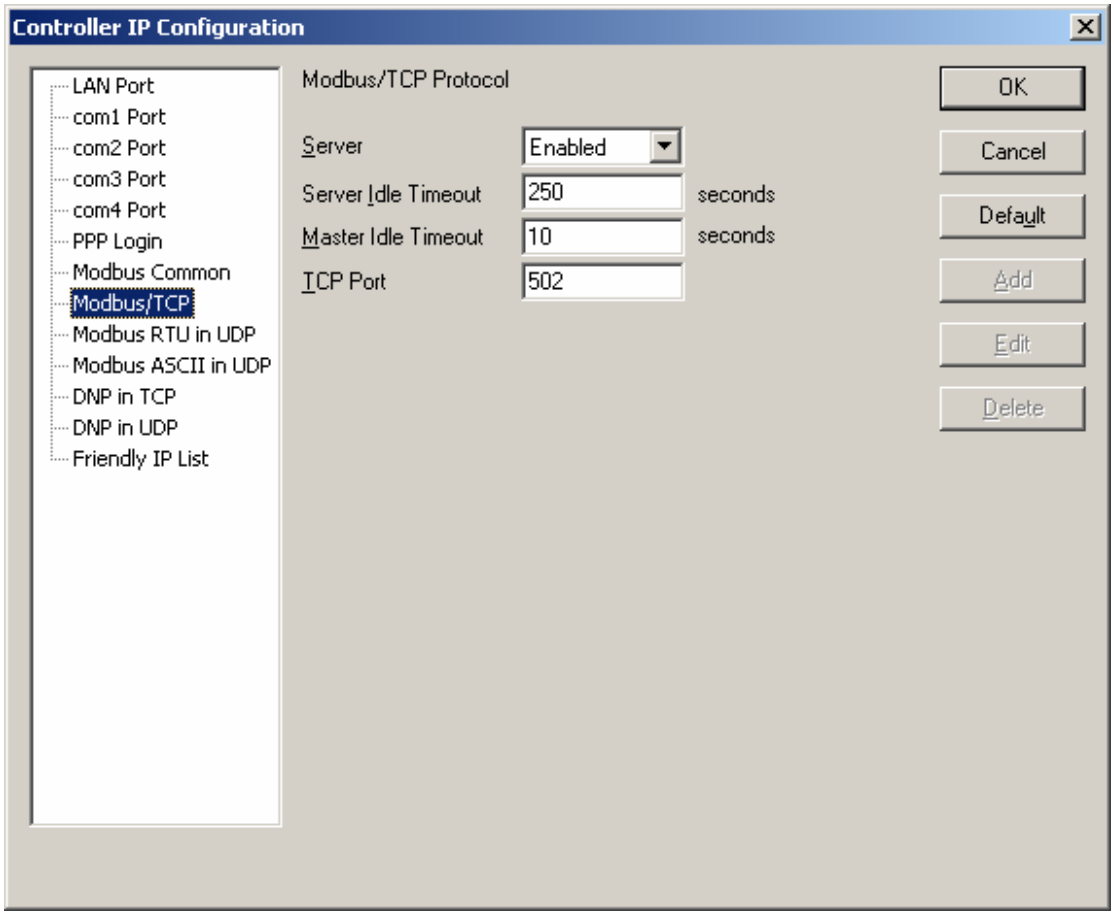


Figure 25: Controller IP Configuration - Modbus/TCP Dialog Box

The **Server** selection selects whether the server is enabled. If this option is enabled the controller supports incoming slave messages. Disabling this option prevents the controller from processing slave messages. Master messaging is always enabled.

The **Master Idle Timeout** determines when connections to a slave controller are closed. Setting this value to zero disables the timeout; the connection will be closed only when your program closes it. Any other value sets the timeout in seconds. The connection will be closed if no messages are sent in that time. This allows the slave device to free unused connections. Valid timeout range is 0 to 4294967295 seconds. The default value is 10 seconds.

The **Server Idle Timeout** determines when connections from a remote device are closed. Setting this value to zero disables the timeout; the connection will be closed only when the remote device closes it. Any other value sets the timeout in seconds. The connection will be closed if no messages are received in that time. This allows the controller to free unused connections. Valid timeout range is 0 to 4294967295 seconds. The default value is 250 seconds.

The **TCP Port** sets the port used by the Modbus/TCP protocol. In almost all cases this should be set to 502. This is the well-known port number for Modbus/TCP. Modbus/TCP devices use 502 by

default, and on many devices the value cannot be changed. It is suggested that you change this value only if this port is used by another service on your network. Valid port number range is 1 to 65534. Consult your network administrator to obtain a port if you are not using the default.

5.3.9 Modbus RTU in UDP

The Modbus RTU in UDP property page is selected for editing by clicking Modbus RTU in UDP in the tree control section of the IP Configuration dialog. When selected the Modbus RTU in UDP property page is active.

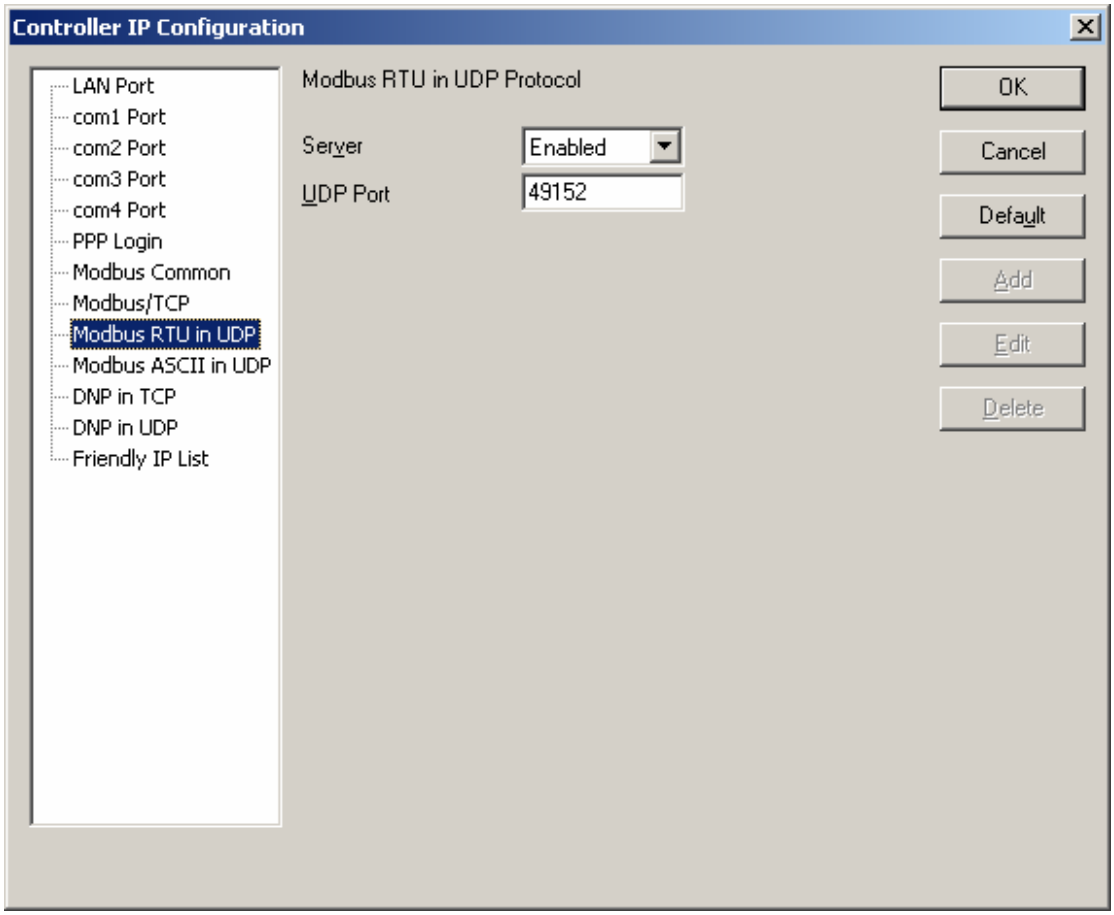


Figure 26: Controller IP Configuration Modbus RTU in UDP Dialog Box

The **Server** selection selects whether the server is enabled. If this option is enabled the controller supports incoming slave messages. Disabling this option prevents the controller from processing slave messages. Master messaging is always enabled.

The **UDP Port** sets the port used by the protocol. Valid port number range is 1 to 65534. The default value is 49152. This is a recommendation only. Consult your network administrator to obtain a port if you are not using the default.

5.3.10 Modbus ASCII in UDP

The Modbus ASCII in UDP property page is selected for editing by clicking Modbus ASCII in UDP in the tree control section of the IP Configuration dialog. When selected the Modbus ASCII in UDP property page is active.

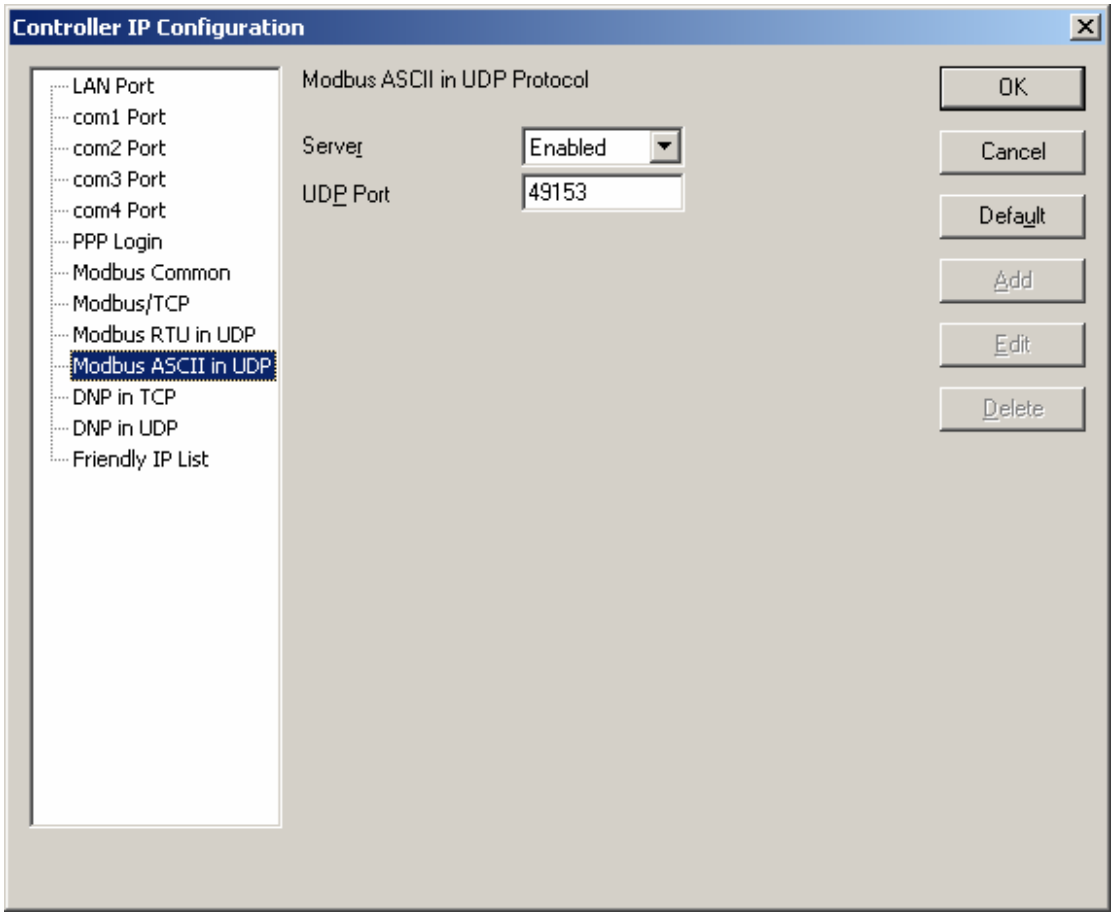


Figure 27: Controller IP Configuration – Modbus ASCII in UDP Dialog Box

The **Server** selection selects whether the server is enabled. If this option is enabled the controller supports incoming slave messages. Disabling this option prevents the controller from processing slave messages. Master messaging is always enabled.

The **UDP Port** sets the port used by the protocol. Valid port number range is 1 to 65534. The default value is 49153. This is a recommendation only. Consult your network administrator to obtain a port if you are not using the default.

5.3.11 DNP in TCP

The DNP in TCP property page is selected for editing by DNP in TCP in the tree control section of the IP Configuration dialog. When selected the DNP in TCP property page is active.

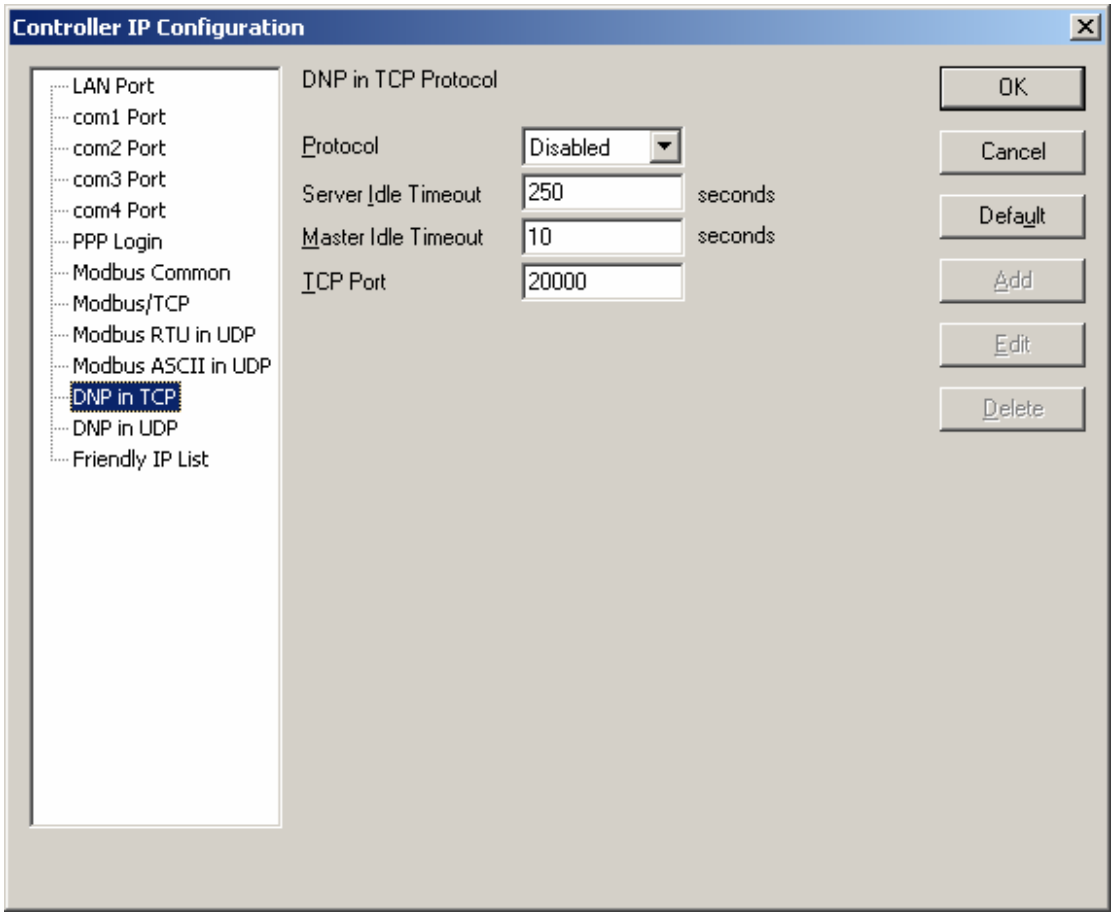


Figure 28: Controller IP Configuration – DNP in TCP Dialog Box

The **Protocol** selection selects whether the DNP in TCP protocol is enabled. If this option is enabled the controller supports DNP in TCP protocol. Disabling this option prevents the controller from processing DNP in TCP protocol messages. Master messaging is always enabled. The default selection is disabled.

The **Server Idle Timeout** determines when connections from a remote device are closed. Setting this value to zero disables the timeout; the connection will be closed only when the remote device closes it. Any other value sets the timeout in seconds. The connection will be closed if no messages are received in that time. This allows the controller to free unused connections. Valid timeout range is 0 to 4294967295 seconds. The default value is 250 seconds.

The **Master Idle Timeout** determines when connections to a slave controller are closed. Setting this value to zero disables the timeout; the connection will be closed only when your program closes it. Any other value sets the timeout in seconds. The connection will be closed if no messages are sent in that time. This allows the slave device to free unused connections. Valid timeout range is 0 to 4294967295 seconds. The default value is 10 seconds.

The **TCP Port** sets the port used by the DNP in TCP protocol. Valid port number range is 1 to 65534. The default value is 20000. Consult your network administrator to obtain a port if you are not using the default.

5.3.12 DNP in UDP

The DNP in UDP property page is selected for editing by DNP in UDP in the tree control section of the IP Configuration dialog. When selected the DNP in UDP property page is active.

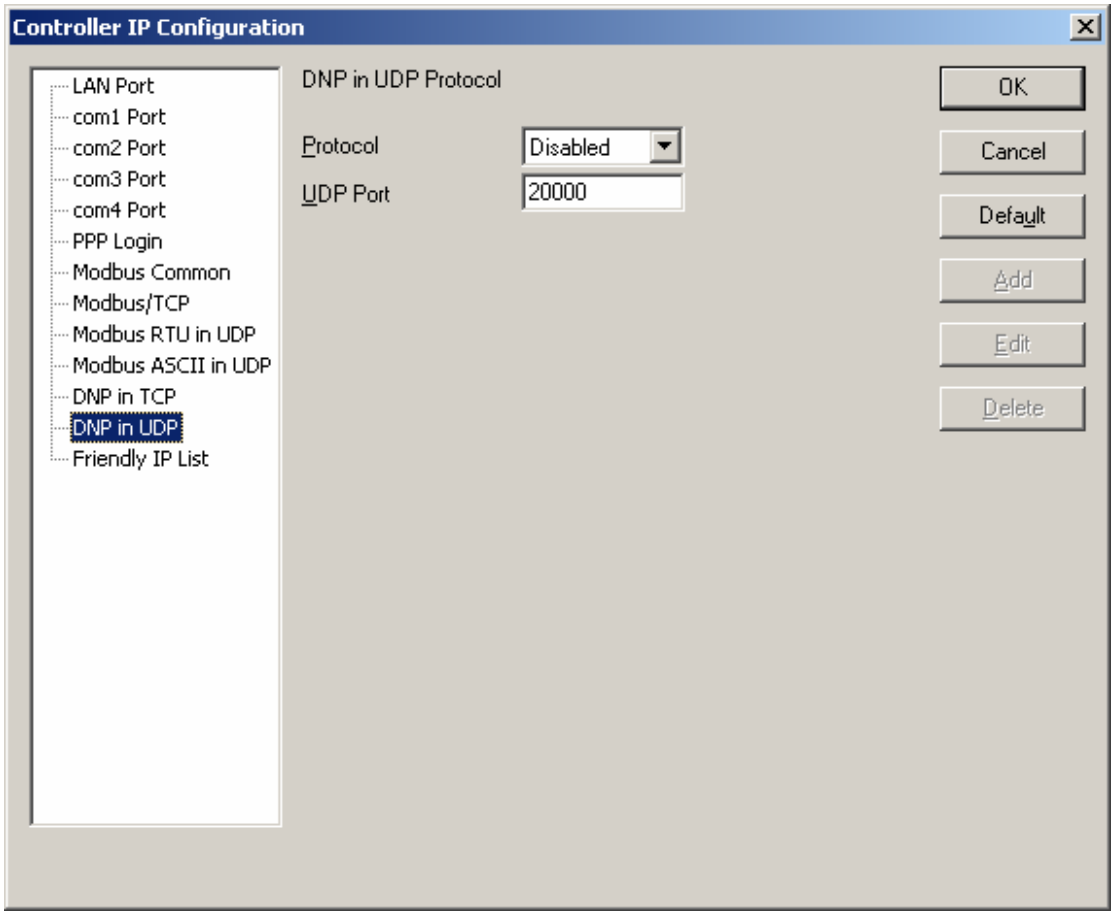


Figure 29: Controller IP Configuration – DNP in UDP Dialog Box

The **Protocol** selection selects whether the DNP in UDP protocol is enabled. If this option is enabled the controller supports DNP in UDP protocol. Disabling this option prevents the controller from processing DNP in UDP protocol messages and sending DNP in UDP master messages. The default selection is disabled.

The **UDP Port** sets the port used by the DNP in UDP protocol. Valid port number range is 1 to 65534. The default value is 20000. Consult your network administrator to obtain a port if you are not using the default.

5.3.13 Friendly IP List

The Friendly IP property page is selected for editing by Friendly IP in the tree control section of the IP Configuration dialog.

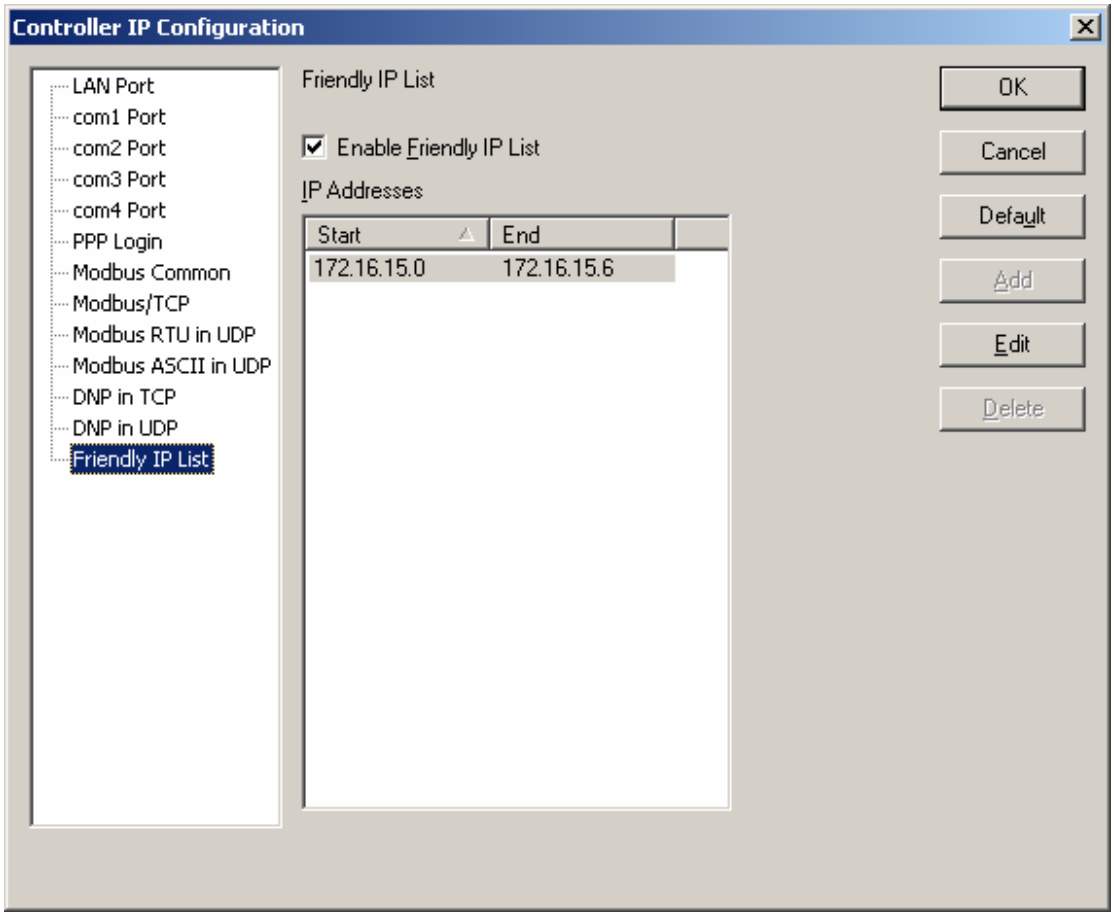


Figure 30: Controller IP Configuration – Friendly IP List Dialog Box

The **Enable Friendly IP List** checkbox enables or disables the friendly IP list. Check this box to accept messages from only the IP addresses in the list. Uncheck this to accept message from all IP addresses.

Click **Add** to enter a new row in the Friendly IP list. Selecting the Add button opens the **Add Friendly IP address** dialog. The button is disabled if the **Enable Friendly IP List** control is not checked. The button is disabled if the table is full. Up to 32 entries can be added to the table.

Click **Edit** to edit range in the Friendly IP list. Selecting the Edit button opens the **Edit Friendly IP address** dialog. The button is disabled if the **Enable Friendly IP List** control is not checked.

The **Delete** button removes the selected rows from the list. This button is disabled if there are no entries in the list. The button is disabled if the **Enable Friendly IP List** control is not checked.

Click on the column headings to sort the list by that column. Click a second time to reverse the sort order. The order is indicated by the triangle next to the text.

The settings are verified when the OK button is pressed or another settings page is selected.

An error message is displayed if the friendly IP list is enabled and the list is empty.

A warning message is displayed if the IP address of the PC is not in the friendly IP table.

5.3.13.1 Add Friendly IP Address Range Dialog

The Add Friendly IP Address Range dialog specifies an IP address range to add to the Friendly IP list.

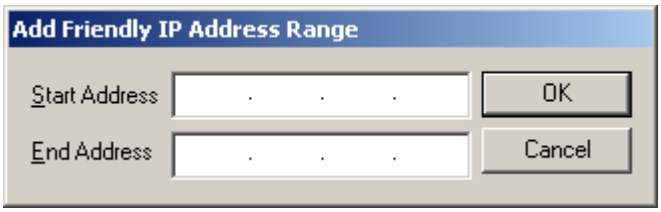


Figure 31: Add Friendly IP Address Range Dialog Box

Start Address specifies the starting IP address in the range. Enter any valid IP address.

End Address specifies the ending IP address in the range. Enter a valid IP address that is numerically greater than or equal to the IP Start Address. This field can be left blank if only a single IP address is required.

The **OK** button adds the IP address range to the list and closes the dialog. An error is displayed if the address range is invalid.

The **Cancel** button closes the dialog without making any changes.

5.4 Register Assignment

The Register Assignment dialog displays the current register assignment list. The user may edit the list or the entries in the list.

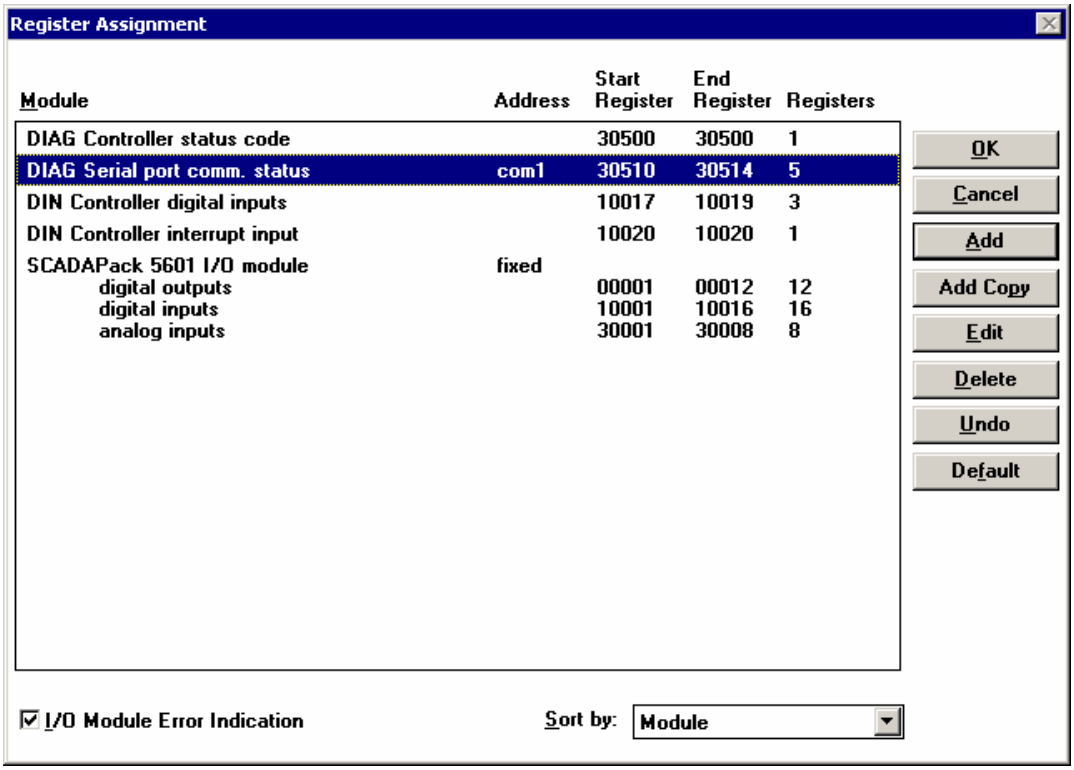


Figure 32: Register Assignment Dialog Box

The main portion of the dialog is a list showing the modules in the register assignment list. The module list displays the Module, Module Address, Start Register, End Register and the number of Registers for the module.

The **Module** field displays the type and name of I/O modules that have been added to the Register Assignment. For modules that support more than one type of I/O, there are multiple lines in the row of the table, one for each input or output I/O type.

The **Address** field displays the unique module address of the physical hardware, such as a 5000 Series 5401 Digital I/O module. Some module types have no address that can be set by the user. The address is blank for these modules.

The **Start Register** field displays the first register address in the I/O database where the module data is stored. A start register is required for each type of input or output on the module.

The **End Register** field displays the last address in the I/O database used by the module. An end register is required for each type of input or output on the module.

The **Registers** field displays the number of registers used by the module. A size is required for each type of input or output on the module.

The **I/O Module Error Indication** check box determines if the controller displays I/O module communication errors. If enabled, the controller will blink the Status LED if there is an I/O error. See the DIAG Controller Status Code diagnostic module for information on the controller status code. If disabled, the controller will not display the module communication status. The module communication status is always checked. This option controls only the indication on the Status LED.

The **Sort by:** window selects how the Register Assignment List is sorted. The selections are: **Module**, **Start Register**, or **Address**.

Click **OK** to update the register assignment list and close the dialog.

If the register assignment is changed it is written to the controller as follows.

If TelePACE is Off Line the changes are not written.

If TelePACE is On Line, the changes are downloaded automatically.

Selecting **Cancel** exits the dialog without saving changes. If changes were made, the user is prompted for confirmation before exiting. This protects against accidentally discarding a large number of changes. Press **ESC** to **Cancel**.

If changes were made the following dialog appears.

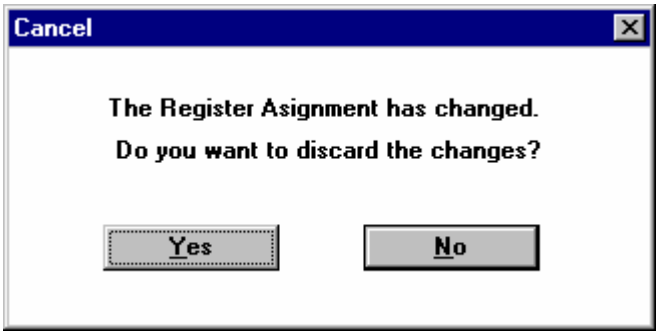


Figure 33: Cancel Register Assignment Dialog Box

Click **Yes** to close the Register Assignment dialog and the register assignment list is not changed.

Click **No** to return to the Register Assignment dialog. **No** is the default selection. Press **Enter** or **ESC** to select **No**.

Click **Add** to open the ***Edit Register Assignment*** dialog. The Add function adds a new module to the register assignment.

Click **Add Copy** to open the ***Edit Register Assignment*** dialog. The Address field is set to the first unused address for the currently selected module type. All other fields are set to the values from the currently selected I/O module. The Add Copy button is grayed if:

- the table is empty,
- all I/O modules of the given type are in use (i.e. modules are already defined for all possible addresses for the selected module type),

Selecting **Edit** opens the Edit Register Assignment dialog. All fields are set to the values from the currently selected I/O module. The Edit button is grayed if:

- the table is empty,
- no module is selected in the table.

The **Delete** function removes the selected module from the register assignment. The **Delete** button is grayed if:

- the table is empty,
- no module is selected in the table.

Selecting the **Undo** button undoes the last change to the register assignment list. A single level of undo is provided. Selecting the Undo function a second time, restores the list to its state before the first Undo.

The **Default** function replaces the current Register Assignment with the Default Register Assignment for the controller type selected.

If the controller is a SCADAPack or SCADAPack 32 the following prompt is displayed.

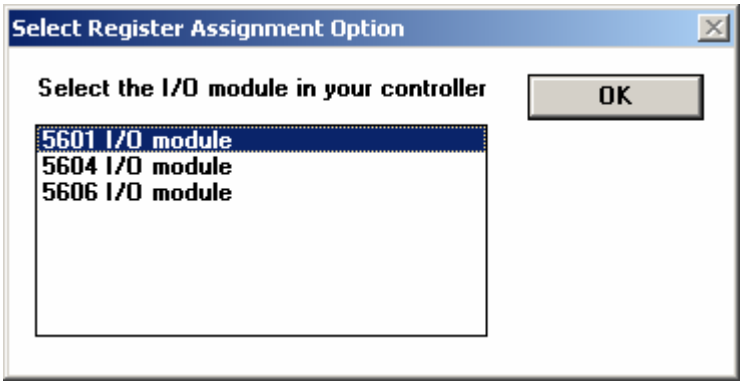


Figure 34: Select Register Assignment Option Dialog Box

Select the I/O module, 5601, 5604 or 5606 that you are using in your controller and click OK.

If the controller type is a SCADASense 4202 DR, the following dialog appears.

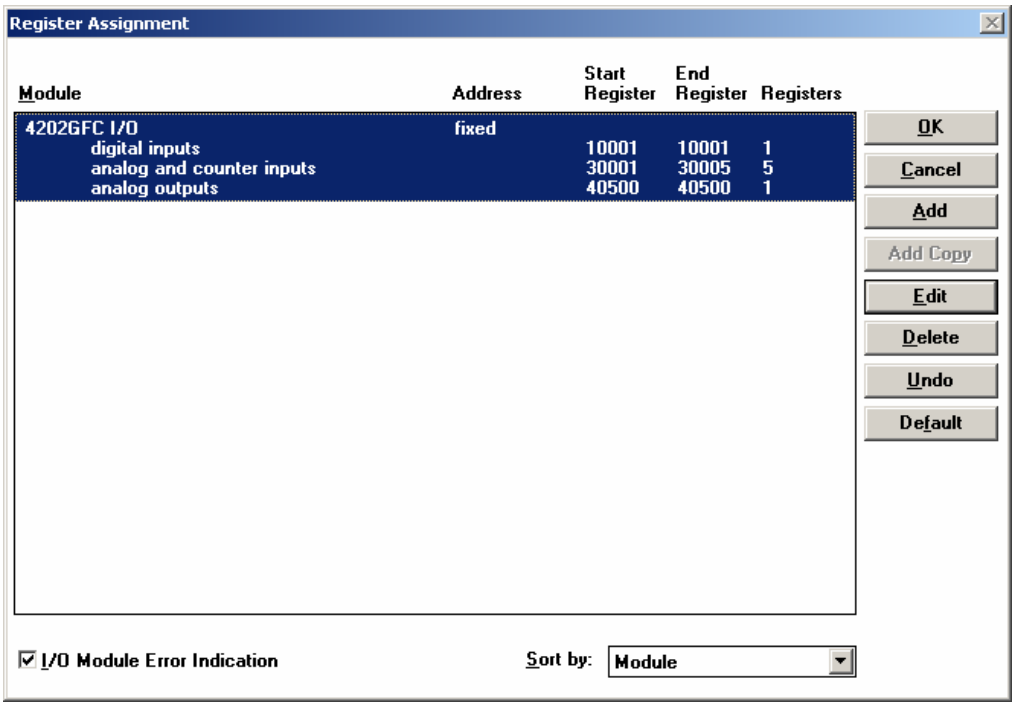


Figure 35: Register Assignment Dialog Box

5.4.1 Edit Register Assignment Dialog

The Edit Register Assignment dialog modifies an entry in the register assignment. The following example shows the dialog editing a module with more than one I/O type.

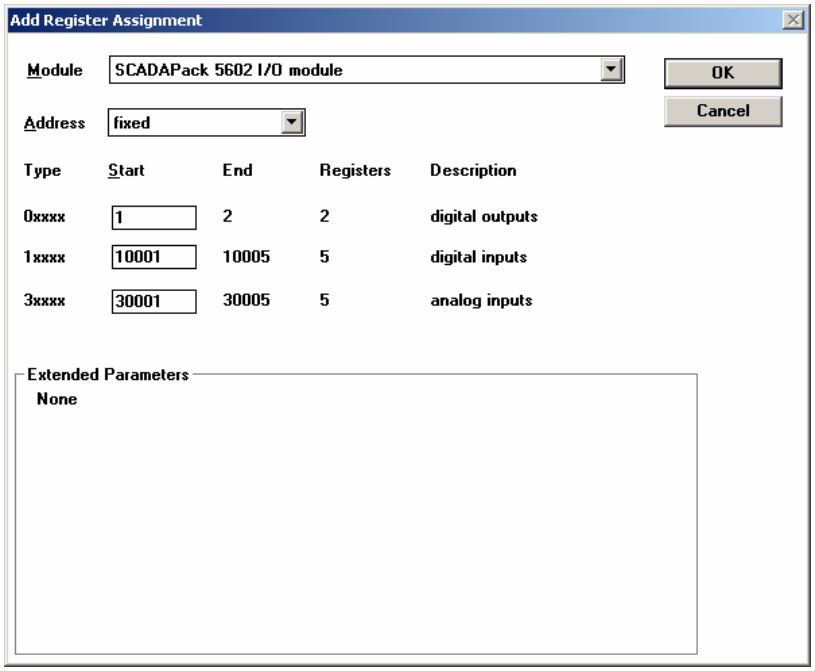


Figure 36: Edit Register Assignment Dialog Box

The **Module** drop-down list box shows the current module type. The drop-down list displays all available modules. If the maximum number of modules of a particular I/O module type is already configured, no modules of this class are shown in the drop-down list.

The **Address** drop-down list box shows the current module address. The drop-down list displays all addresses valid for the current module type that are not already used. If all addresses are in use, the list will be empty.

There are up to four **Type** description fields. The text displays the type of the input or output register. The type descriptions are 0xxxx, 1xxxx, 3xxxx and 4xxxx.

- Digital output data is read from coil (**0xxxx**) registers. The digital outputs are updated continuously with data read from the coil registers.
- Digital input data is stored in status (**1xxxx**) registers. The status registers are updated continuously with data read from the digital inputs.
- Analog input data is stored in input (**3xxxx**) registers. The input registers are updated continuously with data read from the analog inputs.
- Analog output data is stored in holding (**4xxxx**) registers. The analog output registers are updated continuously with data read from the holding registers.

The **Start** edit box holds the starting register in the I/O database for the I/O type. The edit box allows any number to be entered.

The **End** field shows the last register used by the module for the I/O type. TelePACE automatically fills this field.

The **Registers** field shows the number of registers in the I/O module. TelePACE automatically fills this field

The **Description** field displays the I/O type for multiple I/O modules. TelePACE automatically fills this field

The **Extended Parameters** window will contain I/O module extended parameters if they are used. Extended parameters may include such items as analog input type for example. Refer to the Register Assignment Reference for information on all I/O modules.

Selecting **OK** checks the data entered. If the data is correct the dialog is closed and the Register Assignment dialog returns with the changes made. If any data is incorrect, a beep will sound and the cursor will select the field containing the first error found. Press **ENTER** to select **OK**.

Click **Cancel** to exit the dialog without saving changes. Press **ESC** to select **Cancel**.

5.5 Outputs On Stop

Select Outputs on Stop command and the Output Conditions on Program Stop dialog appears. This dialog controls the state of the controller analog and digital outputs when the ladder logic program is stopped.

The state of the digital outputs may be set to Hold their last value or to turn Off when the ladder program is stopped.

The state of the analog outputs may be set to Hold their last value or to go to Zero when the ladder program is stopped.

Figure 37: Output Conditions on Program Stop Dialog Box

The **Digital Output** drop-down list box specifies the state of the digital outputs. It has two options: Hold and Off.

The **Analog Output** drop-down list box specifies the state of the analog outputs. It has two options: Hold and Zero.

5.6 Store and Forward

The Store and Forward command is used to configure store and forward messaging. A controller configured for store and forward operation receives messages destined for a remote Slave Station on the Slave Interface. The controller forwards the message on the Forward Interface to the Forward Station.

Note:	This command is available only when the controller type is set to SCADAPack 350, SCADAPack 32 or SCADAPack 32P.

Refer to the following diagram as a reference for the terminology used in the following Store and Forward command reference.

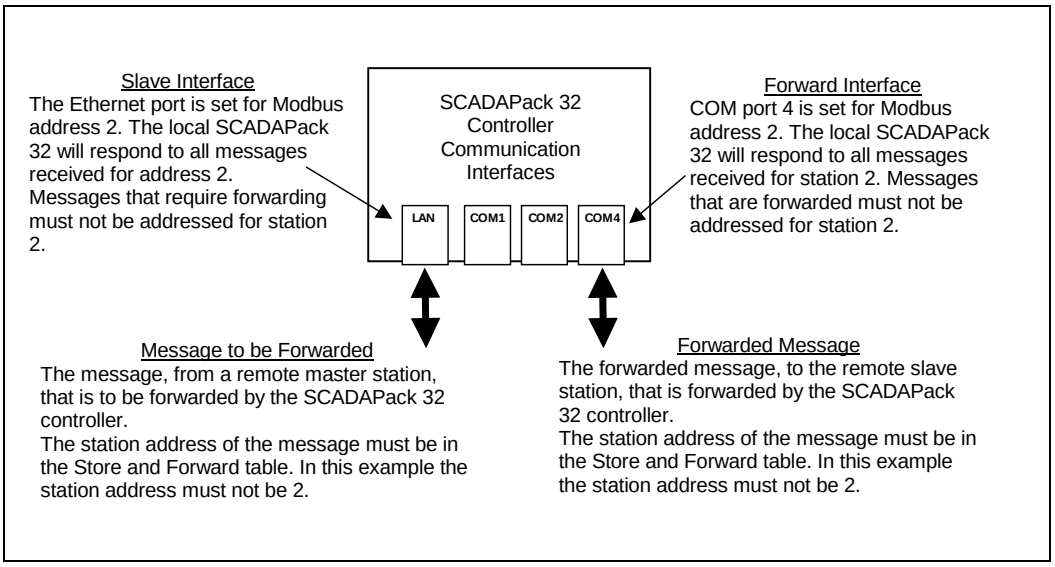


Figure 38: Store and Forward Command Reference

When the Store and Forward command is selected the Store and Forward dialog appears. This dialog displays the Store and Forward table for the controller.

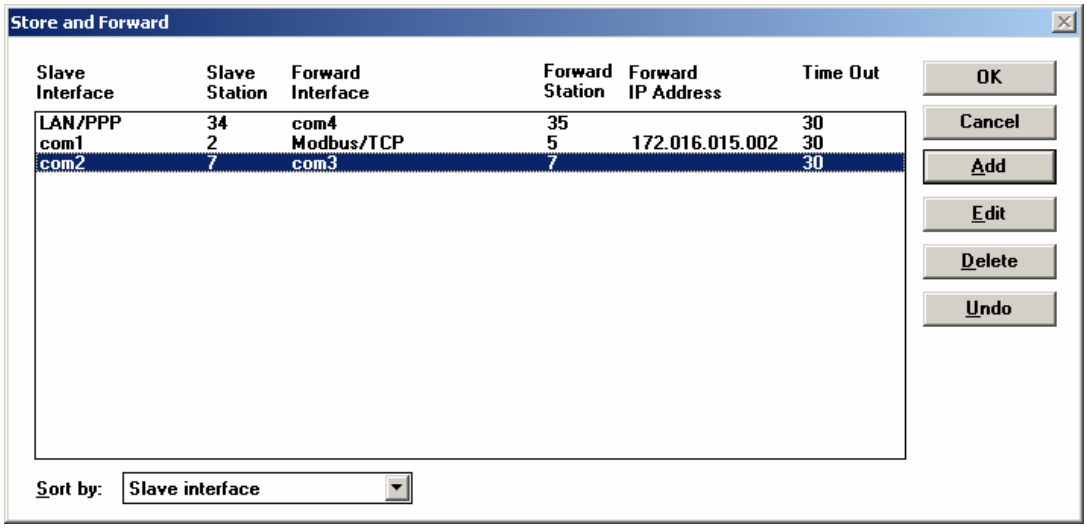


Figure 39: Store and Forward Dialog Box

The Store and Forward table displays each Store and Forward translation as a row, with column headings, in the table. The table may have up to 128 entries. A vertical scroll bar is used if the list exceeds the window size.

The **Slave Interface** heading displays the receiving slave interface the message is received from for each translation.

The **Slave Station** heading displays the Modbus station address of the slave message.

The **Forward Interface** heading displays the interface the message is forwarded from. When forwarding to a Modbus TCP or UDP network, the protocol type is selected for the Forward Interface. The IP Stack automatically determines the exact interface (e.g. LAN/PPP) to use when it searches the network for the Forward IP Address. If a serial port is selected for the Forward Interface, and the serial port is configured for PPP protocol, the message will not be forwarded.

The **Forward Station** heading displays the Modbus station address of the forwarded message.

The **Forward IP Address** heading displays the IP address of the Forward Station. This field is blank unless a TCP or UDP network is selected for Forward Interface.

The **Time Out** heading displays the maximum time (in tenths of seconds) the forwarding task waits for a valid response from the Forward Station. The time out should be equal to or less than the time out set for the master message received on the Slave Interface.

The **OK** button saves the table data. No error checking is done on the table data.

The **Cancel** button closes the dialog without saving changes.

Click **Add** to enter a new row in the store and forward table. Selecting the Add button opens the **Add/Edit Store and Forward** dialog.

Click **Edit** to modify the selected row in the store and forward table. Selecting the Edit button opens the **Add/Edit Store and Forward** dialog containing the data from the selected row. This button is disabled if more than one row is selected. This button is disabled if there are no entries in the table.

The **Delete** button removes the selected rows from the table. This button is disabled if there are no entries in the table.

The **Undo** button undoes the action performed by the last button selection since the dialog was opened. This applies to the buttons Add, Edit, Delete and Undo. This button is disabled when the dialog is opened, and is enabled as soon as any of the applicable buttons are selected.

The **Sorted by** menu box lists each of the five column headings. The rows are sorted according to the selected heading. Headings in the table are, by default, sorted by the Slave Interface heading.

5.6.1 Add/Edit Store and Forward Dialog

This dialog is used to edit an entry or add a new entry in the store and forward table.

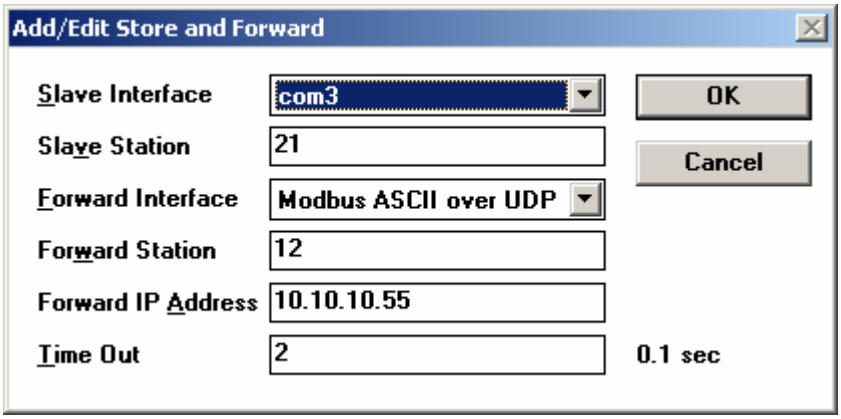


Figure 40: Add/Edit Store and Forward Dialog Box

The **Slave Interface** is the receiving slave interface the message received from. The drop down list allows the following selection:

- com1
- com2
- com3
- com4
- LAN/PPP

The **Slave Station** is the Modbus station address of the slave message. This address must be different from the Modbus address assigned to the Slave Interface. Valid range for Slave Station is:

1 to 255 when standard addressing is selected for the interface.

1 to 65534 when extended addressing is selected for the interface.

The **Forward Interface** is the interface the message is forwarded from. The drop down list allows the following selection:

- com1
- com2
- com3
- com4
- Modbus/TCP
- Modbus RTU in UDP

- Modbus ASCII in UDP

The **Forward Station** is the Modbus station address of the forwarded message. This address must be different from the Modbus address assigned to the Forward Interface. Valid range for Forward Station is:

1 to 255 when standard addressing is selected for the interface.

1 to 65534 when extended addressing is selected for the interface.

The **Forward IP Address** edit box is disabled and the address is forced to "0.0.0.0" whenever the Forward Interface is set to com1, com2, com3 or com4. The Forward IP Address edit box is enabled only when the Forward Interface is set to a TCP or UDP network. Valid entries are 0 to 255 for each byte in the IP address.

The **Time Out** is the maximum time the forwarding task waits for a valid response from the Forward Station, in tenths of second. Valid entries are 0 to 65535. The time out should be equal to or less than the time out set for the master message received on the Slave Interface.

The **OK** button checks the data for this table entry. If the data is valid the dialog is closed. If the table data entered is invalid, an error message is displayed and the dialog remains open. The table entry is invalid if any of the fields is out of range. The data is also invalid if it conflicts with another entry in the table.

The **Cancel** button closes the dialog without saving changes.

5.7 DNP

The DNP command is used to configure the DNP protocol settings for the controller. When selected the DNP Settings window is opened, as shown below.

For complete information on DNP configuration refer to the ***DNP 3 User and Reference Manual.***

5.8 DNP Status

The DNP Status command opens the DNP Status dialog. This dialog shows the run-time DNP diagnostics and current data values for the local DNP points.

For complete information on the DNP Status command refer to the ***DNP 3 User and Reference Manual.***

5.9 DNP Master Status

The DNP Status command opens the DNP Master Status dialog. This dialog shows the run-time DNP diagnostics and status of the DNP outstations defined in the Master Poll table and current data values for the DNP points in these outstations.

For complete information on the DNP Status command refer to the ***DNP 3 User and Reference Manual.***

5.10 Initialize

The initialize command is used to restore a controller to default settings. This is typically done when starting a new project with a controller. The Initialize controller dialog is displayed when this command is selected. The Initialize Controller dialog presented depends on the type of controller selected. The dialog is different between the SCADAPack 32 or SCADAPack series controllers (Micro16, SCADAPack, SCADAPack Light, SCADAPack Plus, SCADAPack 100, SCADAPack

350, and the SCADASense Series of programmable controllers (4202 DR, 4202 DS, 4203 DR and 4203 DS). The different dialogs are described in the following sections.

5.10.1 SCADAPack and SCADAPack 32 Controllers

The Initialize Controller dialog shown below appears when the command is selected and the Controller Type is SCADAPack or SCADAPack 32 (**not** SCADAPack 350).

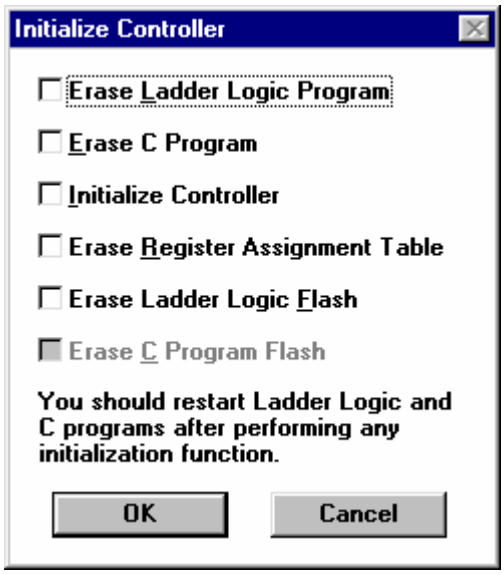


Figure 41: Initialize Controller Dialog Box SCADAPack and SCADAPack 32 Controllers

Check the **Erase Ladder Logic Program** selection to erase the ladder logic program in the controller RAM memory.

Check the **Erase C Program** selection to erase the C application program in the controller RAM memory.

Check the **Initialize Controller** selection to reset all values in the I/O database to default settings. The Initialize controller command will do the following:

- The default communication parameters are set for all serial ports. If you are communicating using settings other than the default, the PC Communication Settings will have to be changed once the command is complete. Note that the Ethernet port on SCADAPack 32 controllers is not changed by the initialize controller command.
- The registers in the I/O database are initialized to their default values.
- All forcing is removed.
- The controller is unlocked.

Check the **Erase Register Assignment** selection to erase the controller register assignments. The Register Assignment is cleared and must be reconfigured.

Check the **Erase Ladder Logic Flash** selection to erase the Ladder Logic program in Flash. This control is greyed if the controller firmware does not support programs in Flash or if the Flash is used by the operating system.

Check the **Erase C Program Flash** selection to erase the C program in Flash. This control is greyed if the controller firmware does not support programs in Flash or if the Flash is used by the operating system.

- Click **OK** to perform the requested initializations.
- Click **Cancel** to exit without performing any action.

Erasing Programs in Flash

Erasing the Flash memory requires the Ladder Logic and C programs be stopped. The following message is displayed if the OK button is selected.

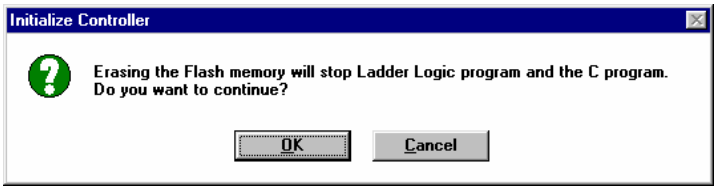


Figure 42: Initialize Controller Dialog Box

- Click **OK** to stop the execution and erase the flash memory. The following actions occur.

The Ladder Logic and C programs in the controller are stopped.

If it was selected, the Ladder Logic program is erased.

If it was selected, the C program is erased.

Programs that were stopped to allow Flash to be erased are not re-started. These programs must be re-started.

5.10.2 SCADAPack 350 and SCADASense 4203 Series of Controllers

For SCADAPack 350 and SCADASense 4203 Series of controllers (4203 DR and 4203 DS), the Initialize dialog shown below appears when the command is selected.

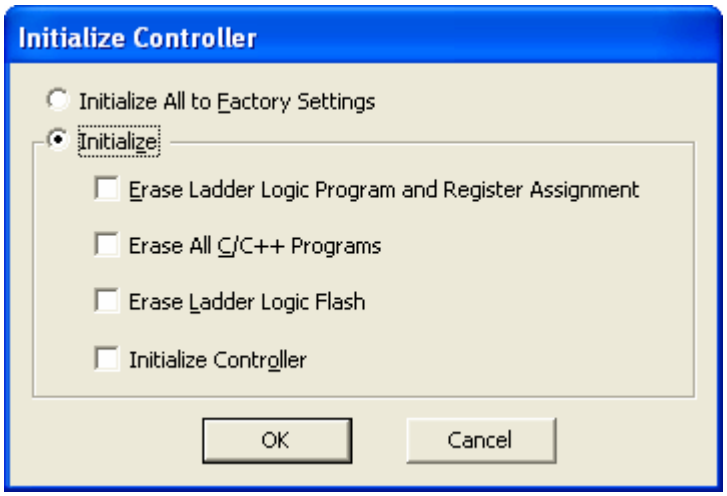


Figure 43: Initialize Dialog for SCADAPack 350 and SCADASense 4203 Series Controllers

Select the **Initialize All to Factory Settings** radio button to erase all programs in the controller memory and initialize the controller to factory settings. Please see *Actions Performed when Controller is Initialized* below for details. Erasing all programs includes all C/C++ programs, the Ladder Logic program in RAM, and the Ladder Logic program in ROM, if applicable.

Select the **Initialize** radio button to initialize only the selected items. The items that may be selected are as follows:

- Check the **Erase Ladder Logic Program and Register Assignment** selection to erase the ladder logic program and register assignment in the controller RAM memory.
- Check the **Erase All C/C++ Programs** selection to erase all C/C++ programs in the controller.
- Check the **Erase Ladder Logic Flash** selection to erase the Ladder Logic program in Flash (ROM).
- Check the **Initialize Controller** selection to initialize the controller to default settings. Please see *Actions Performed when Controller is Initialized* below for details. The default settings used depends on the radio button selected below this selection:

- Click on the **OK** button to perform the requested initializations.
- Click on the **Cancel** button to exit without performing any action.

5.10.2.1 Actions Performed when Controller is Initialized

The following actions are performed when the controller is initialized:

- The controller settings below are set to default values. If you are communicating using settings other than the default, the PC Communication Settings will have to be changed once the command is complete. Note that the Ethernet port is not changed by the initialize controller command.
  - Serial port communication parameters
  - Modbus/IP and DNP/IP protocol settings
  - Outputs on Stop settings
  - HART modem configurations
  - LED power control
- All forcing is cleared.
- All Modbus registers are set to zero.
- If there is a register assignment, the assigned registers are initialized to their default values. For example, if a configuration module for a group of controller settings is in the register assignment, the assigned registers are initialized to the default values for those controller settings.
- All digital outputs and analog outputs are cleared.
- Data logged by all DLOG functions is erased.
- Alarm clock is cleared.
- Serial port event counters are cleared.
- Store and forward table is cleared.

- Friendly IP List is cleared.
- The power mode changes to full power.

5.11 Real Time Clock

The Real Time Clock command is used to set the controller Real Time Clock. The user may set the clock to the PC time, to a user specified time or adjust the clock forward or back by a number of seconds. The Real Time Clock Setting dialog shown below appears when the command is selected.

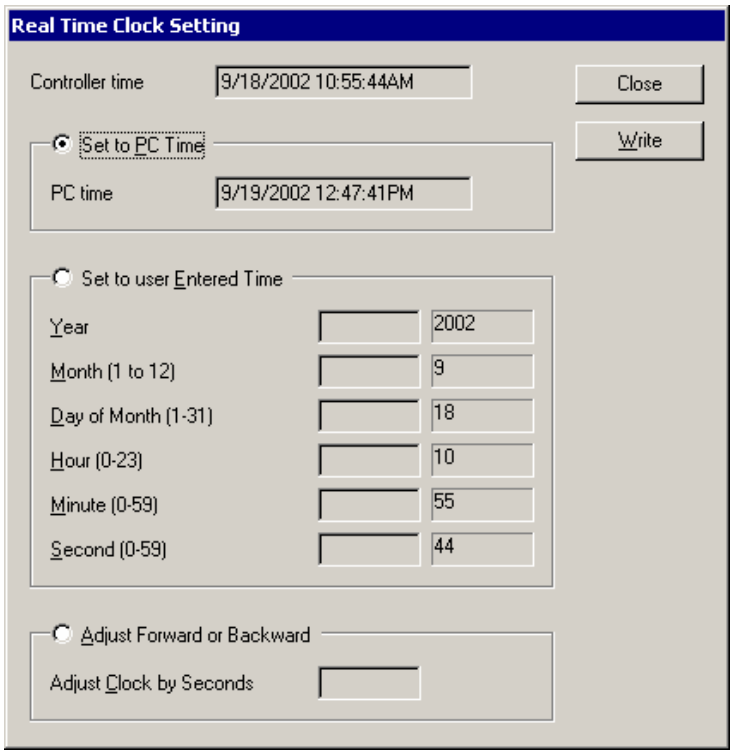


Figure 44: Real Time Clock Setting Dialog Box

The following controls are available from the Real Time Clock Setting dialog.

Controller time shows the current time and date in the controller. It is updated continuously while the dialog is open. The time and date are displayed in the short time format as defined in the Windows Control Panel.

The **Set to PC Time** radio button selects setting the controller time to match the PC time. The current PC time and date are shown to the right of the button. The time and date are displayed in the short format as defined in the Windows Control Panel.

The **Set to User Entered Time** radio button selects setting the time and date to the values specified by the user in the **Year**, **Month**, **Day**, **Hour**, **Minute** and **Second** controls. The valid values for entry are shown in the dialog. If the Set to User Entered Time radio button is not selected these controls are grayed.

The **Adjust Forward or Backward** radio button selects adjusting the time by the number of seconds specified in the **Adjust Clock by Seconds** edit box. The value can be negative or positive. The edit box is grayed if the *Adjust by* radio button is not selected.

- The **Close** button closes the dialog.

- The **Write** button writes the selected time to the controller.

5.12 Monitor Element

The Monitor Element command is used to add registers used by selected elements to the Register Editor. All registers used by the currently selected element, or elements, are added to the Register Editor. This command is available only if an element, or multiple elements, is selected.

This command may be selected by right click your mouse button on a highlighted element, or group of elements, and selecting **Monitor Element** from the list of commands.

To add registers to the Register Editor using the Monitor Registers command first highlight an element by clicking the left mouse button on an element or dragging the cursor over a group of elements. Then select the Monitor Element command from the Controller menu or from the mouse right click menu.

When the Monitor Element command is selected the Monitor Element dialog is displayed.

Figure 45: Monitor Element Dialog Box

The **Add to Group** list box selects which group the registers are added to. A drop down selection displays all created groups. If no groups have been created use the New Group button to add a Register Editor group.

The **OK** button adds the registers and closes the dialog. The registers are added to the Register Editor in the format used by the selected element or elements.

The Available status is set to ***Online*** for all registers except registers contained in elements that use Element Configuration.

The Available status is set to ***Always*** for all registers contained in elements that use Element Configuration.

The **Cancel** button closes the dialog without adding the registers to the Register Editor.

The **New Group** button opens New group dialog. This dialog is used to create a new group in the Register Editor.

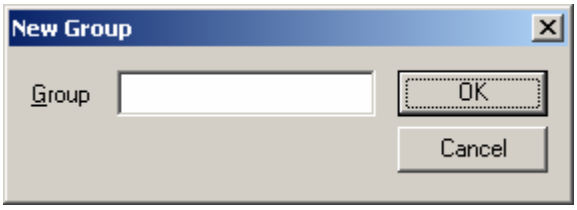


Figure 46: New Group Dialog Box

The **Group** edit box is used to enter the name of the new group. The group name may contain letters, numbers, and spaces. The group name may be 1 to 16 characters long and the name is not case sensitive.

The **OK** button creates the new group and closes the dialog. If the group name already exists an error message is displayed and the dialog remains open.

The **Cancel** button closes the dialog.

5.13 List Force Registers

The List Forced Registers command displays the Forced Registers dialog. This dialog displays a list of registers that are forced. The user may view and edit the registers, add registers to the list, remove registers from the list and clear all forces. The dialog appears as shown below.

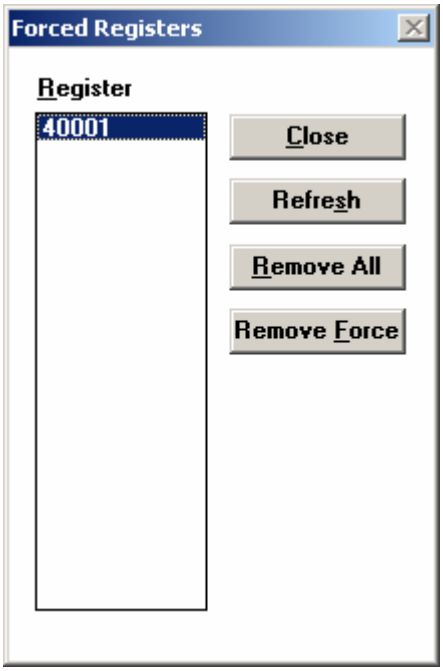


Figure 47: Forced Registers Dialog Box

The **Register** list box shows all registers in the controller that are currently forced.

Click **Close** to close the dialog box. Press **ESC** to select **Close**.

Selecting the **Remove All** button clears the force status for all registers. All registers are removed from the register list box. When selected the user is prompted for confirmation.

Figure 48: Remove All Forces Dialog Box

Selecting **Yes** removes all forcing. Selecting **No** aborts the command. The **No** button is the default selection. Press **ENTER** or **ESC** to select **No**. This button is grayed when there are no registers in the register list box.

The **Remove Force** button clears the force status for the selected register. The register is removed from the register list box. This button is grayed when there are no registers in the register list box.

5.14 Remove All Forces

Selecting the Remove All Forces command clears the force status for all forced registers. This command is only available in the on-line mode.

Selecting **Remove All Forces** prompts the user for confirmation:

Figure 49: Remove All Forces Dialog Box

- Selecting **Yes** removes all forcing.
- Selecting **No** aborts the command. The **No** button is the default selection. Press **ENTER** or **ESC** to select **No**.

5.15 Lock Controller

Locking a controller prevents unauthorized access. Commands sent to the controller when it is locked will be rejected. A controller that is unlocked operates without restriction.

The Lock Controller dialog specifies a password to be used to lock the controller and the commands that are locked.

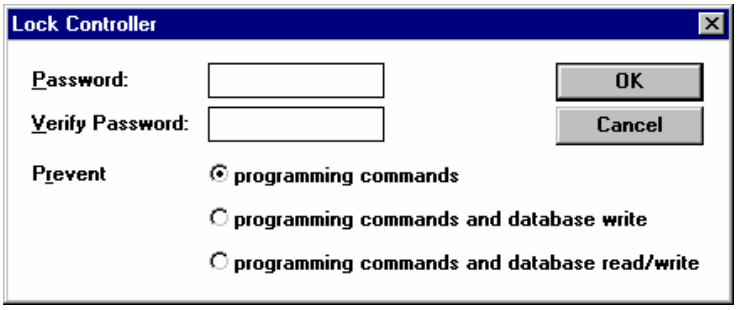


Figure 50: Lock Controller Dialog Box

Enter a password in the Password edit box. Re-enter the password in the Verify Password edit box. Any character string up to eight characters in length may be entered. Typing in these edit boxes is masked. An asterisk is shown for each character typed.

The Prevent radio buttons select the commands that are locked.

Locking the programming commands prevents modifying or viewing the program in the controller. Communication protocols can read and write the I/O database.

Locking programming and database write commands prevents modifying or viewing the program and prevents writing to the I/O database. Communication protocols can read data from the I/O database, but cannot modify any data.

Locking programming and database commands prevents modifying or viewing the program and prevents reading and writing the I/O database. Communication protocols cannot read or write the I/O database.

The **OK** button verifies the passwords are the same and sends the lock controller command to the controller. The dialog is closed. If the passwords are not the same an error message is displayed. Control returns to the dialog.

The **Cancel** button closes the dialog without any action.

If the controller is already locked, a message indicating this is shown instead of the dialog.

5.16 Unlock Controller

The Unlock Controller dialog prompts the user for a password to be used to unlock the controller. If the controller is locked, the following dialog is displayed.

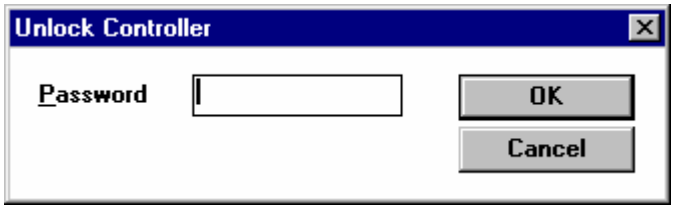


Figure 51: Unlock Controller Dialog Box

Enter the password that was used to lock the controller in the Password edit box. Typing in this edit box is masked. An asterisk is shown for each character typed.

The **Cancel** button closes the dialog without any action.

The **OK** button sends the *Unlock Controller* command to the controller. If the password is correct the controller will be unlocked. If the password is not correct, the controller will remain locked.

If you forget the controller password, the Override Controller Lock command can be used to unlock the controller. It will erase all programs in the controller.

5.17 Override Controller Lock

The Override Controller Lock dialog allows the user to unlock a controller without knowing the password. This can be used in the event that that the password is forgotten.

To prevent unauthorized access to the information in the controller, the C and Ladder Logic programs are erased. Use this command with caution, as you will lose the programs in the controller.

Selecting the Override Controller Lock command displays the following dialog.

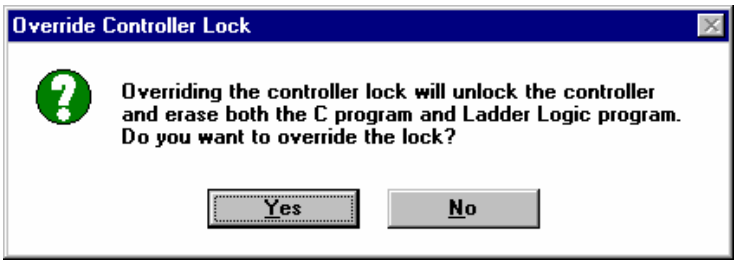


Figure 52: Override Controller Lock

- The **Yes** button unlocks the controller and erases all programs.
- The **No** button closes the dialog without any action.

5.18 Show Lock Status

The Show Lock Status command displays the controller lock state. It opens a dialog showing one of the following states:

- unlocked
- locked against programming commands
- locked against programming commands and database write
- locked against programming commands and database read/write
- The **OK** button closes the dialog.

5.19 C/C++ Program Loader

The C/C++ Program Loader command opens the C/C++ Program Loader dialog. This dialog allows the user to load, run, stop and delete C/C++ programs.

The C/C++ Program Loader dialog presented is the same for all controller types. For all controllers except the SCADAPack 350, this dialog may be used to load, run, stop or delete just one C/C++ program.

5.19.1 SCADAPack and SCADAPack 32 Controllers

The dialog shown below appears when the C/C++ Program Loader command is selected from the controller menu and the Controller Type is either a SCADAPack32 or any one of the SCADAPack series of controllers (Micro16, SCADAPack, SCADAPack Light, SCADAPack Plus, SCADAPack 100 and SCADASense 4202 DR and DS) but **not** a SCADAPack 350.

For all controllers except the SCADAPack 350, the C/C++ Program Loader dialog may be used to load just one C/C++ program.

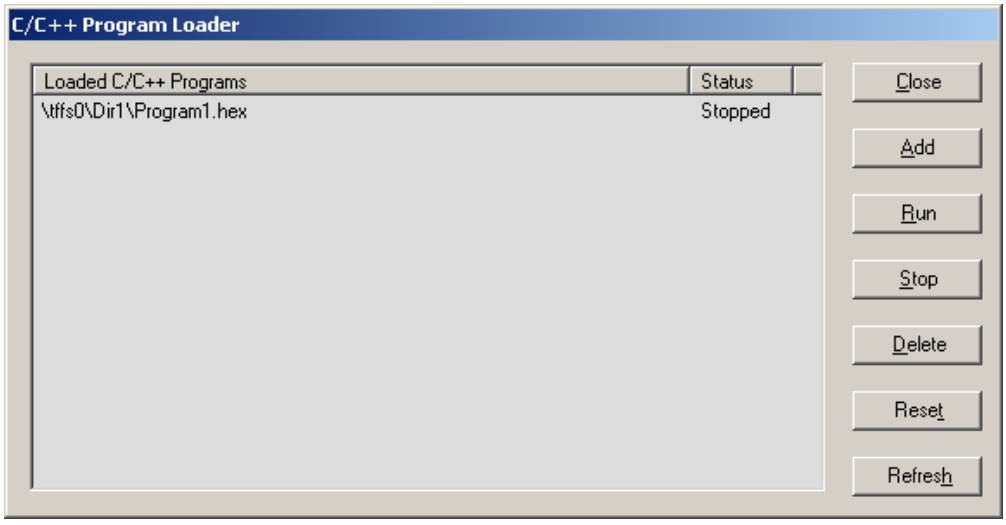


Figure 53: C/C++ Program Loader dialog for SCADAPack Series

The dialog displays the status of the C/C++ Program if one has been loaded in the controller. The status of the program is indicated as **Running** or **Stopped**. The list is empty if there is no C/C++ Program loaded in the controller.

The **Close** button closes the dialog.

The **Add** button writes a C/C++ program to the controller. Selecting the Write button opens the **Add C/C++ Program** dialog.

The **Run** button stops and restarts the C/C++ program in the controller.

The **Stop** button stops the selected C/C++ program in the controller.

The **Delete** button stops and erases the selected C/C++ program in the controller.

The **Run**, **Stop** and **Delete** buttons are disabled if there is no C/C++ program loaded in the controller.

The **Reset** button resets the controller. A reset restarts the controller processor, the C/C++ program and the Ladder Logic program.

The **Refresh** button refreshes the status of the loaded C/C++ program.

5.19.1.1 Add C/C++ Program Dialog

The Add C/C++ Program dialog writes a C/C++ Program to the controller.

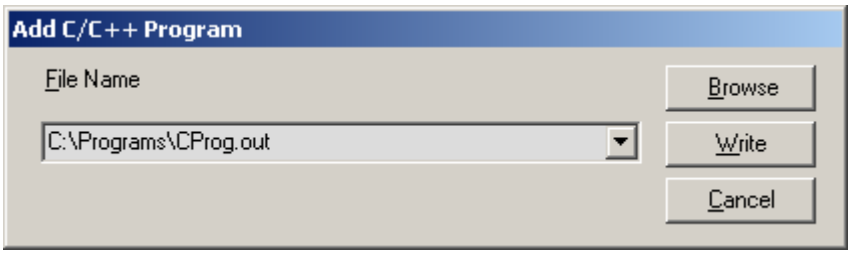


Figure 54: Write C/C++ Program dialog

File Name specifies the C/C++ Program to write to controller. The file name may be selected in a number of ways.

- Click on the **Browse** button to open a standard file open dialog.
- Use the drop-down menu to select the file from a list of previously written files.
- Type the path and file name directly into the edit box.

The **Write** button writes the selected file to the controller. The communication progress dialog box displays information about the write in progress, and allows you to cancel the write. If a C/C++ program is already loaded, it is stopped and erased before the selected file is written to the controller.

The **Cancel** button exits the dialog without writing to the controller.

5.19.2 SCADAPack 350 and SCADASense 4203 Series Controllers

If the controller type is a SCADAPack 350 or a SCADASense 4203 Series controller, the C/C++ Program Loader dialog displayed is shown below. In contrast to all other SCADAPack controllers, this dialog allows multiple C/C++ programs to be loaded, monitored, and controlled. The number of C/C++ programs that can be loaded into a SCADAPack 350 or a SCADASense 4203 Series controller depends on the memory capacity of RAM of Flash.

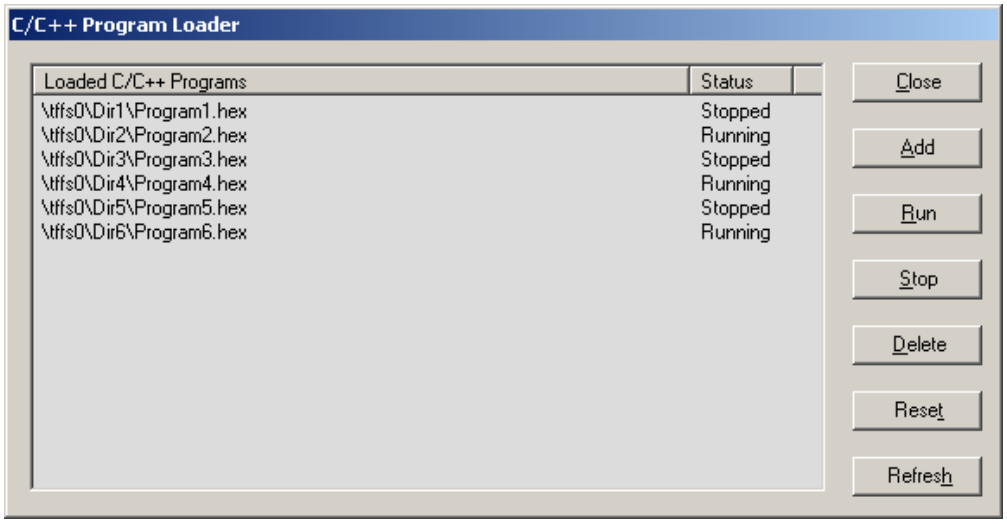


Figure 55: C/C++ Program Loader dialog

The dialog displays the C/C++ Programs that have been loaded in the controller. The status of each program is indicated as **Running** or **Stopped**.

The **Close** button closes the dialog.

The **Add** button writes a new C/C++ program to the controller. Selecting the Add button opens the **Add C/C++ Program** dialog. Refer to ***5.19.1.1-Add C/C++ Program Dialog*** for a description of the Add C/C++ program dialog.

The **Run**, **Stop** and **Delete** buttons apply to the C/C++ program selected from the list of loaded C/C++ programs. These buttons are disabled when there are no C/C++ programs loaded.

The **Run** button stops and restarts the selected C/C++ program in the controller.

The **Stop** button stops the selected C/C++ program in the controller.

The **Delete** button stops and erases the selected C/C++ program in the controller.

The **Reset** button resets the controller. A reset restarts the controller processor, all C/C++ programs and the Ladder Logic program.

The **Refresh** button refreshes the list of loaded programs and their status.

Click on the column headings to sort the list by that column. Click a second time to reverse the sort order.

5.20 Flash Loader

The Flash Loader command opens the Flash Loader dialog. This dialog is used to write Ladder Logic and C/C++ programs into Flash memory. This memory is permanently programmed and does not require power or a backup battery. The programs in Flash can be written through all supported communication media.

When this command is selected TelePACE checks if the controller supports Flash memory and, if a Flash memory chip is installed.

If the controller does not support Flash memory, the message “Controller does not support Flash memory” is displayed.

If the controller supports flash memory but there is no Flash memory installed in the application ROM socket, the message “Flash memory is not installed in the application socket (U14)” is displayed. Flash memory will have to be installed in the controller.

If there is Flash memory installed in the application program socket U14, the Flash Loader dialog is displayed as shown below.

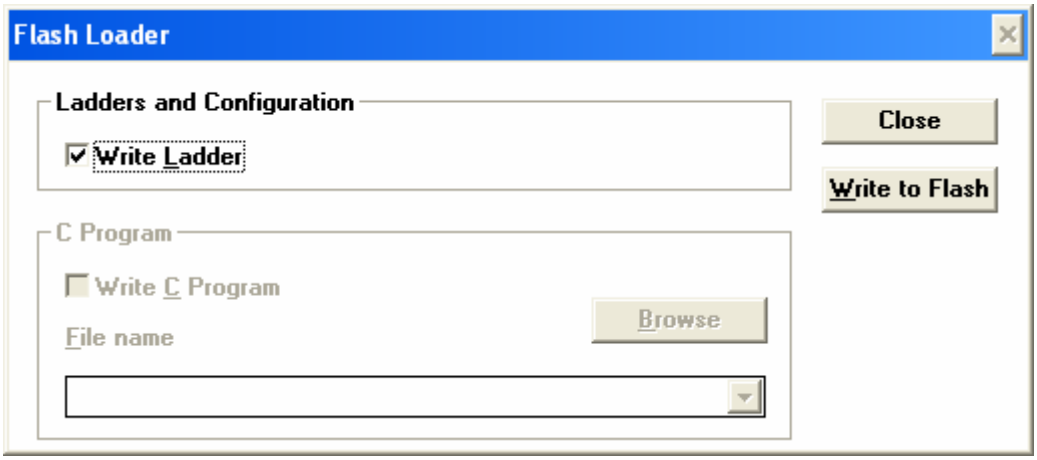


Figure 56: Flash Loader Dialog Box

The **Write Ladder** check-box controls writing of the Ladder Logic program and configuration data. Configuration data includes serial port settings, register assignment, outputs on stop settings and, element configuration. The file currently open Ladder Logic program in TelePACE will be written. This control is disabled if the controller has operating system code in the Ladder Logic section of Flash.

The **Write C Program** check-box controls writing of the C/C++ programs. This area is greyed out if the controller type is one of the following:

- SCADAPack 350

- SCADAPack 32 or SCADAPack 32P
- SCADAPack
- SCADASense 4202 DR and DS with firmware 1.65 or newer
- SCADASense 4203 DR and DS

The following controls select which file will be written. These controls are disabled if the controller has operating system code in the C Program section of Flash.

The **File name** edit-box contains the full path name of the file to be written.

The **Browse** button opens standard file open dialog. It displays files of type *.abs. Selecting a file fills in the File name edit-box.

The **Message Length** edit-box selects the maximum message length to be used while writing the programs to the controller. Control over message length is needed when writing large amounts of data over certain communication networks. The C program is written more quickly with a longer message length. The allowable range is 26 to 255 bytes. The default value is 255.

- The **Close** button closes the dialog.
- The **Write to Flash** button writes the selected programs to Flash memory in the controller.

5.20.1 Writing Programs to Flash

Programming the Flash memory requires the Ladder Logic and C programs be stopped. The following message is displayed when the Write to Flash button is selected.

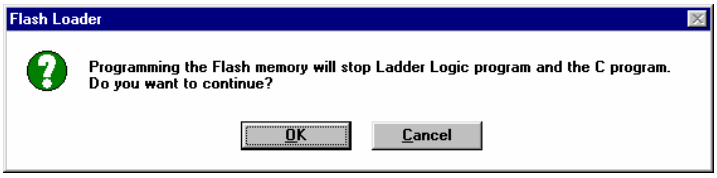


Figure 57: Flash Loader Dialog Box

- Click **OK** to stop the program execution and proceed with writing the program to Flash.
- Click **Cancel** to stop the write to Flash operation.

Ladder Logic and C application programs can both be programmed into RAM and into Flash.

If there is a Ladder Logic program in RAM, the following message is displayed.

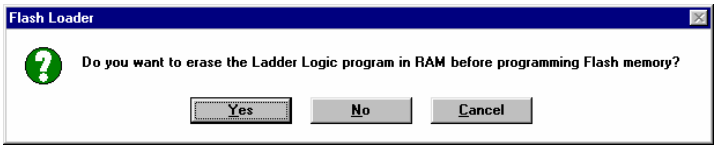


Figure 58: Flash Loader Dialog Box

- Click **Yes** to erase the RAM program and continue with the write to Flash.
- Click **No** to leave the RAM program in its place and continue with the write to Flash.
- Click **Cancel** to stop the entire operation.

If there is a C program in RAM, the following message is displayed.

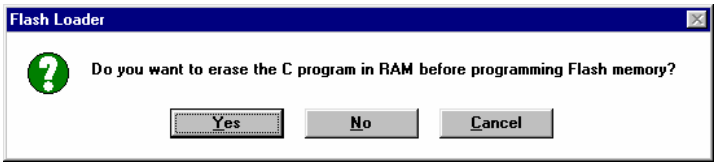


Figure 59: Flash Loader Dialog Box

- Click **Yes** to erase the RAM program and continue with the write to Flash.
- Click **No** to leave the RAM program in its place and continue with the write to Flash.
- Click **Cancel** to stop the entire operation

During the write to Flash operation a communication progress dialog is opened displaying the status of the write operation. Click on the Cancel button to abort the write to Flash at any time. The following actions occur during the write to Flash.

- The programs in the controller are stopped.
- The programs in RAM are erased if required.
- The Flash is erased if required.
- If it was selected, the Ladder Logic program is written to the controller.
- If it was selected, the C program is written to the controller.

If a Ladder Logic program is loaded in RAM or Flash in the controller, a prompt is displayed asking if the program should be started. If there is a Ladder Logic program in RAM the prompt asks if the Ladder Logic program in RAM should be started. If there is a Ladder Logic program in Flash the prompt asks it the Ladder Logic program in Flash should be started.

- Click **Yes** to run the Ladder Logic program. This will happen immediately.
- Click **No** to leave the program stopped.

If a C program is loaded in RAM or Flash in the controller, a prompt is displayed asking if the program should be started. If there is a C program in RAM the prompt asks if the C program in RAM should be started. If there is a C program in Flash the prompt asks it the C program in Flash should be started.

- Click **Yes** to run the C Program. This will happen immediately.
- Click **No** to leave the C Program stopped.

5.21 Program Status

The Program Status dialog displays information about programs loaded in the controller memory. The Program Status dialog is displayed when this command is selected. The Program Status dialog displayed is different for SCADAPack 32 controllers and SCADAPack series controllers (Micro16, SCADAPack, SCADAPack Light, SCADAPack Plus, SCADAPack 100, SCADAPack 350, and SCADASense Series of programmable controllers. The Program Status is described for each controller type in the following sections.

5.21.1 SCADAPack and SCADAPack 32 Controllers

Programs in RAM memory always take precedence over programs in Flash or EPROM memory. When a command to run a program is received, the controller first checks for a program in RAM, then for one in Flash or EPROM.

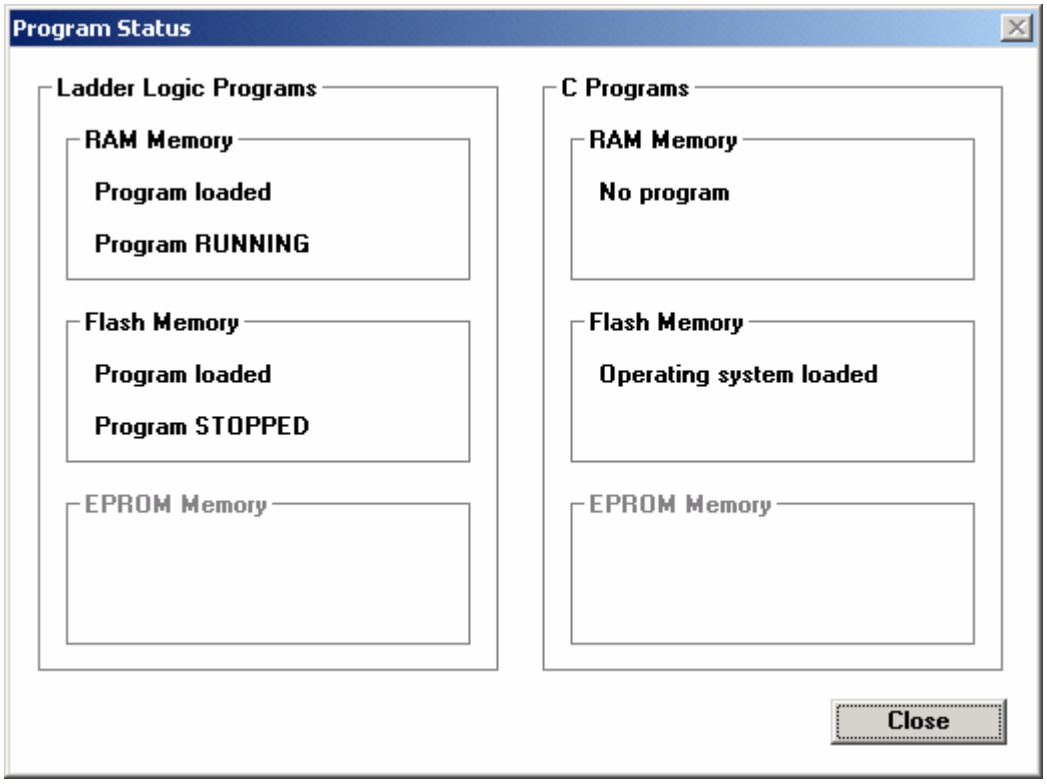


Figure 60: Program Status Dialog Box SCADAPack and SCADAPack 32 Controllers

The **Ladder Logic Programs** section shows information about the Ladder Logic programs.

The **RAM Memory** section shows if a program is loaded and the execution state of the program.

The **Flash Memory** section shows if a program is loaded and the execution state of the program. The program in Flash will be running only if there is no program in RAM. This section is greyed if the controller does not have Flash memory installed.

If the controller has operating system code in the Ladder Logic section of Flash then the Flash Memory or EPROM Memory section displays “Operating System”.

The **EPROM Memory** section shows if a program is loaded and the execution state of the program. This section is greyed if the controller has Flash memory installed.

The **C Programs** section shows information about the C programs.

The **RAM Memory** section shows if a program is loaded and the execution state of the program.

The **Flash Memory** section shows if a program is loaded. This section is greyed if the controller does not have Flash memory installed. If the controller type is SCADAPack 32 or SCADAPack 32P the section displays “Operating System Loaded”.

If the controller has operating system code in the C Program section of Flash then the Flash Memory or EPROM Memory section displays “Operating System”.

The **EPROM Memory** section shows if a program is loaded. This section is greyed if the controller has Flash memory installed.

The **Close** button closes the dialog.

The table below shows the messages that are displayed for the various conditions.

Condition	Message
A program was found in the memory	Program loaded
No program was found in the memory	No program
Ladder Logic mode is running	Program RUNNING
Ladder Logic mode is debug	Program RUNNING in DEBUG
Ladder Logic mode is stopped	Program STOPPED

Table 18: Program Status Settings

5.21.2 SCADAPack 350 and SCADASense 4203 Series of Controllers

When the controller type is SCADAPack 350 or a member of the SCADASense 4203 series of controllers, the Program Status dialog displays the current status of the Ladder Logic program and all C\C++ programs loaded in controller as shown in the diagram below.

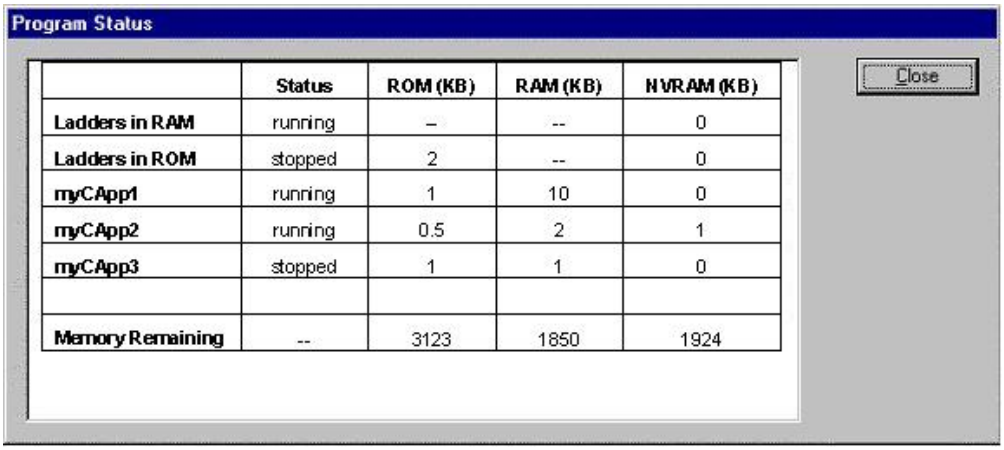


Figure 61: Program Status Dialog for SCADAPack 350 and SCADASense 4203 Series Controllers

The status may be one of the following:

- **Stopped** indicates the program has been downloaded and is currently stopped.
- **Running** indicates the program has been downloaded and is currently running.
- **Debug** indicates the program has been downloaded and is currently running in debug mode (Ladder Logic program only).
- **No Program** indicates that there is no program in the controller.

The memory used by each program is displayed in addition to the program status.

- The **ROM (KB)** column describes the amount of memory used in ROM by each program.
- The **RAM (KB)** column describes the amount of memory used in RAM by each program.

- The **NVRAM** (KB) column describes the amount of memory used in non-volatile RAM by each program.
- The **Memory Remaining** row describes the unused memory of each type available to all programs.

The Ladder Logic program in RAM memory always takes precedence over a Ladder Logic program in ROM. When a command to run a program is received, the controller first checks for a program in RAM, then for one in ROM. A Ladder Logic program in ROM may only be run if there is no Ladder Logic program in RAM.

The **Close** button closes the dialog.

6 Communications Menu

Communication menu commands are used to transfer programs between the Host PC and the controller. PC Communication settings for the host PC are configured in this menu selection.

6.1 Read from Controller

The Read from controller command is used to read the ladder logic program, register assignment and serial port settings from a controller into the TelePACE program. The program replaces the current program in the ladder editor. The communication progress dialog box displays information about the read in progress, and allows you to Start or Cancel the read. Click **Cancel** to abort a read in progress.

6.2 Write to Controller

The Write to controller command writes the ladder logic program, register assignment and serial port settings in the TelePACE program to the controller. The program replaces the current program in the controller. The communication progress dialog box displays information about the write progress, and allows you to Start or Cancel the write. Click **Cancel** to stop a write in progress.

If the program in the controller is executing, a dialog box appears to request the next action. Press **Stop** to stop execution of the ladder logic program when the write is complete. Press **Continue** to continue execution of the new program after the write is complete. Press **Cancel** to abort the write. TelePACE stops the program in the controller before writing the new program to the controller.

Programs that are executing in the target controller are paused momentarily when commands are written. The length of the pause depends on the command written.

6.3 PC Communications Settings

The PC Communication Settings command defines the communication protocol and communication link used for communication between the personal computer (PC) and SCADAPack or 4202 series controllers.

When the command is select the Communication Protocols Configuration dialog is displayed as shown below.

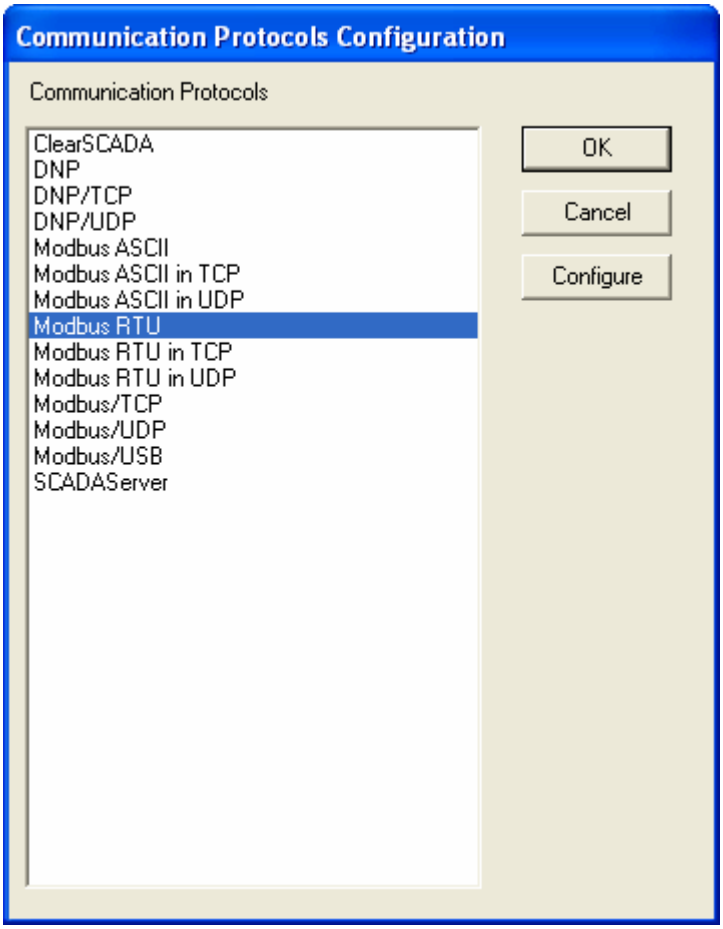


Figure 62: Communication Protocols Configuration dialog.

6.3.1 ClearSCADA

The ClearSCADA protocol driver is used for communicating with a local or remote ClearSCADA server. The ClearSCADA server will then, in turn, communicate with devices as per its configuration. The ClearSCADA protocol driver communicates with the ClearSCADA server using a TCP connection.

- To configure a ClearSCADA protocol connection, highlight **ClearSCADA** in the Communication Protocols window and click the **Configure** button. The ClearSCADA Configuration window is displayed.
- To select a configured ClearSCADA protocol connection, highlight **ClearSCADA** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.1.1 General Parameters

When ClearSCADA protocol is selected for configuration the ClearSCADA Configuration dialog is opened with the General tab selected as shown below.

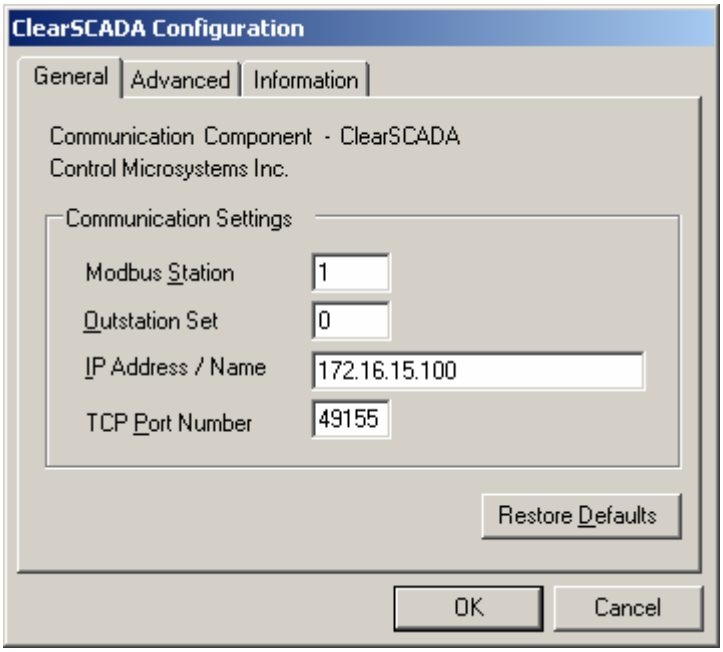


Figure 63: ClearSCADA Configuration (General) Dialog Box

The General tab component information section contains the name of Communication Component and the author, Control Microsystems.

The **Communications Settings** grouping contains all the essential details necessary to establish communication to a device through a local or remote ClearSCADA installation.

The **Modbus Station** entry specifies the station address of the target device. Valid values are 1 to 65534.

The **Outstation Set** entry specifies the ClearSCADA outstation set to which the target device is attached. The valid range is 0 to 65535. The default value is 0.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **TCP Port Number** entry specifies the TCP port on the **ClearSCADA** server. The valid range is 0 to 65535. The default value is 49155

- Click **Restore Defaults** to restore default values to all fields on this page, except for the **IP Address / Name** field. The contents of this field will remain unchanged.

6.3.1.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger

value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

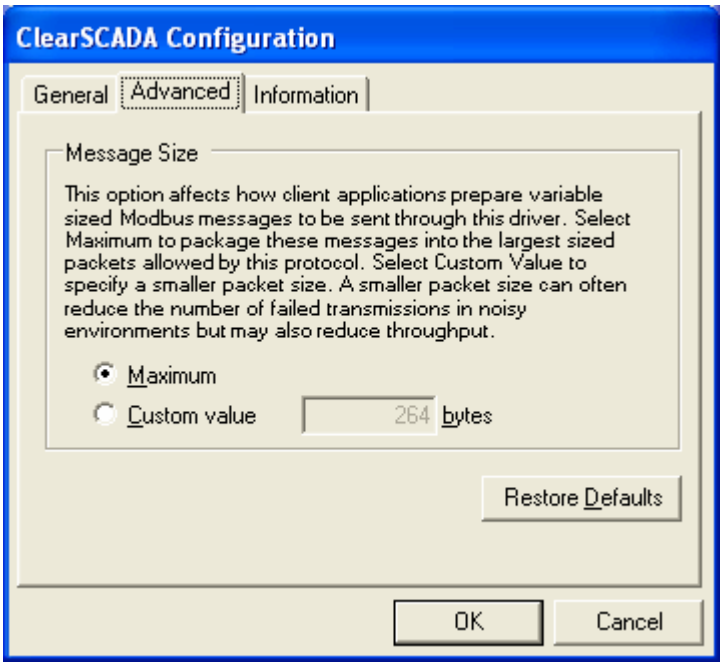


Figure 64: ClearSCADA Configuration (Advanced) Dialog Box

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value will indicate to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 264. The default value is 264.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.1.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

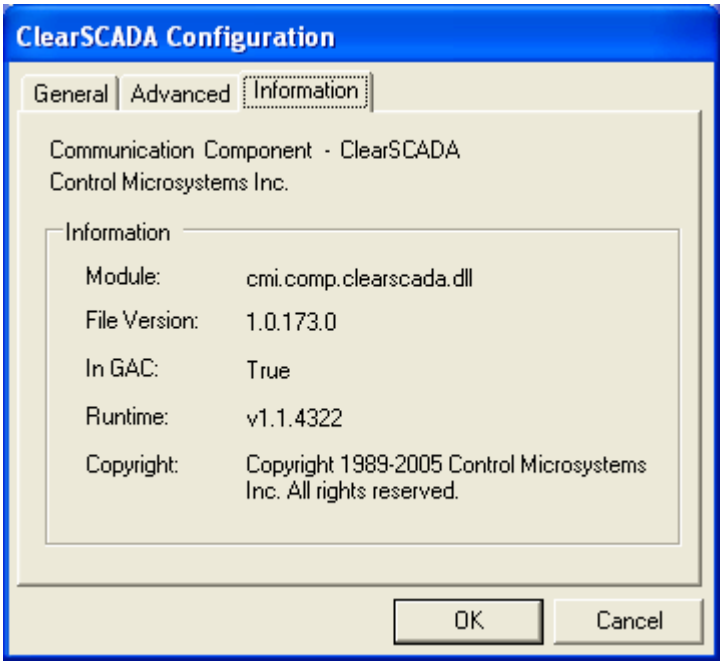


Figure 65: ClearSCADA Configuration (Information) Dialog Box

6.3.1.3.1 Information

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.2 DNP

The DNP protocol driver is used to communicate over a serial DNP network to SCADAPack controllers configured for DNP communication.

- To configure a DNP protocol connection, highlight **DNP** in the Communication Protocols window and click the **Configure** button. The DNP Configuration window is displayed.
- To select a configured DNP protocol connection, highlight **DNP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.2.1 General Parameters

When DNP is selected for configuration the DNP Configuration dialog is opened with the General tab selected as shown below.

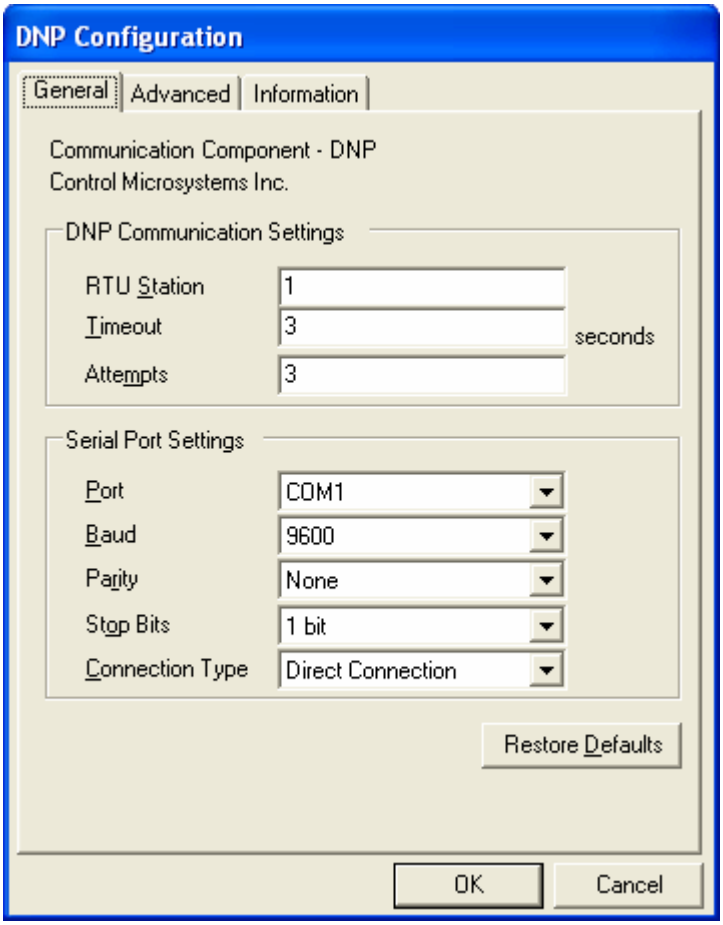


Figure 66: DNP Configuration (General) Dialog Box

The General tab component information section contains the name of Communication Component and the author, Control Microsystems.

The **DNP Communication Settings** logical grouping contains DNP specific communication settings including the DNP Station address, the timeout interval as well as the number of attempts.

The **RTU Station** parameter sets the target **DNP** station number. Valid entries are 0 to 65519. The default address is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

This **Serial Port Settings** grouping contains details directly related to the PC's communication port including the port number, the baud rate, parity and stop bit settings.

The **Port** parameter specifies the PC serial port to use. The DNP driver determines what serial ports are available on the PC and presents these in the drop-down menu list. The available serial ports list will include any USB to serial converters used on the PC. The default value is the first existing port found by the driver.

The **Baud** parameter specifies the baud rate to use for communication. The menu list displays selections for 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, and 57600. The default value is 9600.

The **Parity** parameter specifies the type of parity to use for communication. The menu list displays selections for none, odd and even parity. The default value is None.

The **Stop Bits** parameter specifies the number of stop bits to use for communication. The menu list displays selections for 1 and 2 stop bits. The default value is 1 bit.

The **Connection Type** parameter specifies the serial connection type. The DNP driver supports direct serial connection with no flow control, Request-to-send (RTS) and clear-to-send (CTS) flow control and PSTN dial-up connections. The menu list displays selections for Direct Connection, RTS/CTS Flow Control and Dial Up Connection. The default selection is Direct Connection.

- Select **Direct Connection** for RS-232 for RS-485 connections that do not require the hardware control lines on the serial ports.
- Select **RTS/CTS Flow Control** to communicate over radio or leased-line networks using modems that require RTS/CTS handshaking. Selecting RTS/CTS Flow Control adds a new tab, Flow Control, to the DNP Configuration dialog. Refer to the Flow Control Parameters section below for configuration details.
- Select **Dial Up Connection** to communication over dial up modems. Selecting Dial Up Connection adds a new tab, Dial Up, to the DNP Configuration dialog. Refer to the Dial Up Parameters section below for configuration details.
- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.2.2 Flow Control Parameters

Flow Control parameters are used to configure how RTS and CTS control is used. When RTS/CTS Flow Control is selected for Connection Type the Flow Control tab is added to the DNP Configuration dialog. When the Flow Control tab heading is clicked the Flow Control dialog is opened as shown below.

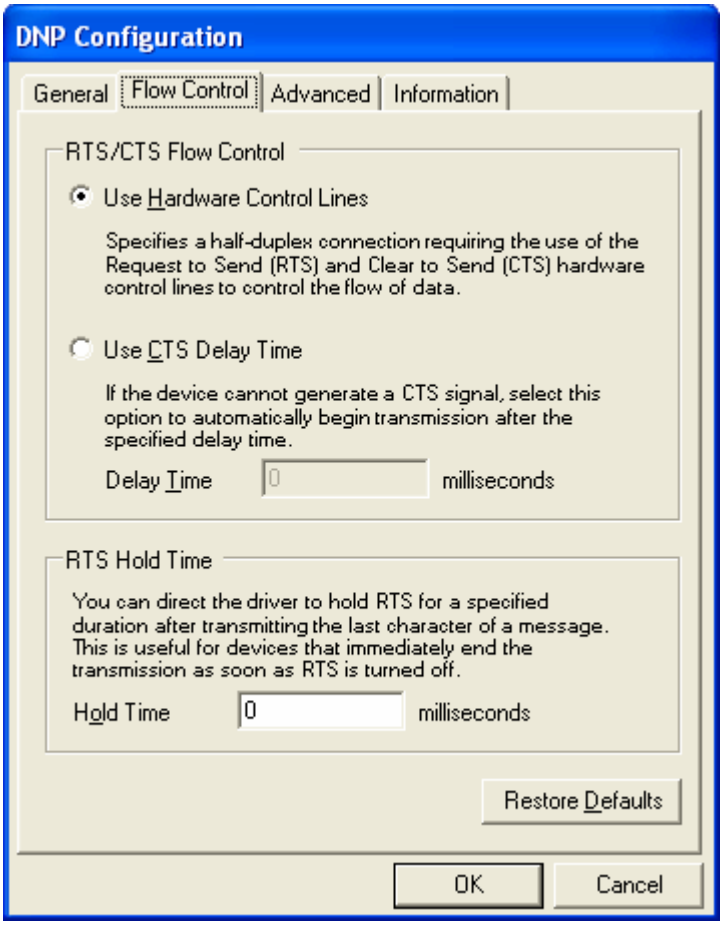


Figure 67: DNP Configuration (Flow Control) Dialog Box

6.3.2.2.1 RTS/CTS Flow Control

The **RTS/CTS Flow Control** grouping contains two mutually exclusive options, Use Hardware Control Lines and Use CTS Delay Time. These options enable the driver to communicate over radio or leased-line networks using modems that require RTS/CTS handshaking.

The **Use Hardware Control Lines** option specifies a half-duplex connection requiring the use of the Request to Send (RTS) and Clear to Send (CTS) hardware control lines to control the flow of data. This selection is used with radios and dedicated telephone line modems. The driver turns on the RTS signal when it wants to transmit data. The modem or other device then turns on CTS when it is ready to transmit. The driver transmits the data, and then turns off the RTS signal. This selection is mutually exclusive of the Use CTS Delay Time selection described below. This is the default selection.

The **Use CTS Delay Time** option is selected if the device cannot generate a CTS signal. The driver will assert RTS then wait the specified Delay Time, in milliseconds, before proceeding. This option is mutually exclusive with the Use Hardware Control Lines selection described above.

The **Delay Time** parameter sets the time in milliseconds that the driver will wait after asserting RTS before proceeding. The value of this field must be smaller than the Time Out value set in the General parameters dialog. For example, if the Timeout value is set to 3 seconds, the CTS Delay Time can be

set to 2999 milliseconds or less. The minimum value for this field is 0 milliseconds. The value is initially set to 0 by default.

The **Hold Time** parameter specifies the time, in milliseconds, that the driver will hold RTS after the last character is transmitted. This is useful for devices that immediately end transmission when RTS is turned off. The value of this field must be smaller than the Time Out value set in the General parameters dialog. For example, if the Timeout value is set to 3 seconds, the CTS Delay Time can be set to 2999 milliseconds or less. The minimum value for this field is 0 milliseconds. The value is initially set to 0 by default.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.2.3 Dial Up Parameters

Dial Up parameters are used to configure a dial up connection. When Dial Up is selected for Connection Type the Dial Up tab is added to the DNP Configuration dialog. When the Dial Up tab heading is clicked the Dial Up dialog is opened as shown below.

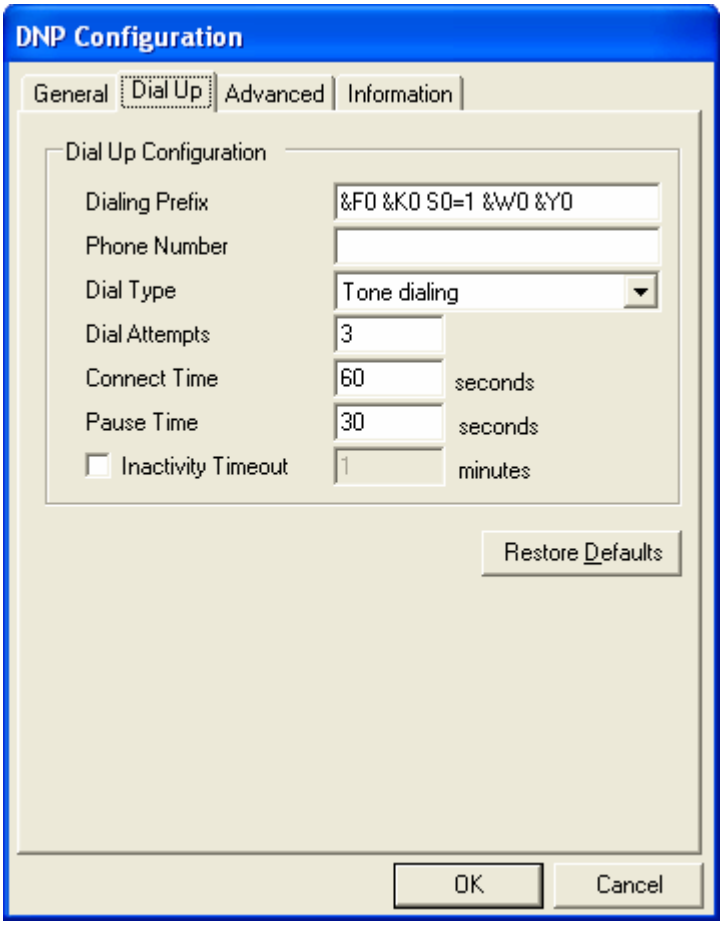


Figure 68: DNP Configuration (Dial Up) Dialog Box

The **Dialing Prefix** parameter specifies the commands sent to the modem before dialing. A maximum of 32 characters can be entered. All characters are valid. The default value is "&F0 &K0 S0=1 &W0 &Y0".

The **Phone Number** parameter specifies the telephone number of the remote controller. A maximum of 32 characters can be entered. All characters are valid. This field's default value is blank.

The **Dial Type** parameter specifies the dialing type. Valid values are Pulse and Tone. The default value is Tone.

The **Dial Attempts** parameter specifies how many dialing attempts will be made. Valid values are 1 to 10. The default value is 1.

The **Connect Time** parameter specifies the amount of time in seconds the modem will wait for a connection. Valid values are 6 to 300. The default value is 60.

The **Pause Time** parameter specifies the time in seconds between dialing attempts. Valid values are 6 to 600. The default value is 30.

Check the **Inactivity Timeout** check box to automatically terminate the dialup connection after a period of inactivity. The Inactivity Time edit box is enabled only if this option is checked. The default state is checked.

Enter the inactivity period, in minutes, in the **Inactivity Timeout** box. The dialup connection will be terminated automatically after the specified number of minutes of inactivity has lapsed. This option is only active if the Inactivity Timeout box is checked. Valid values are from 1 to 30 minutes. The default value is 1.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the Phone Number field. The content of this field will remain unchanged.

6.3.2.4 Advanced Parameters

DNP Configuration Advanced parameters set the DNP master station address and message size control. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

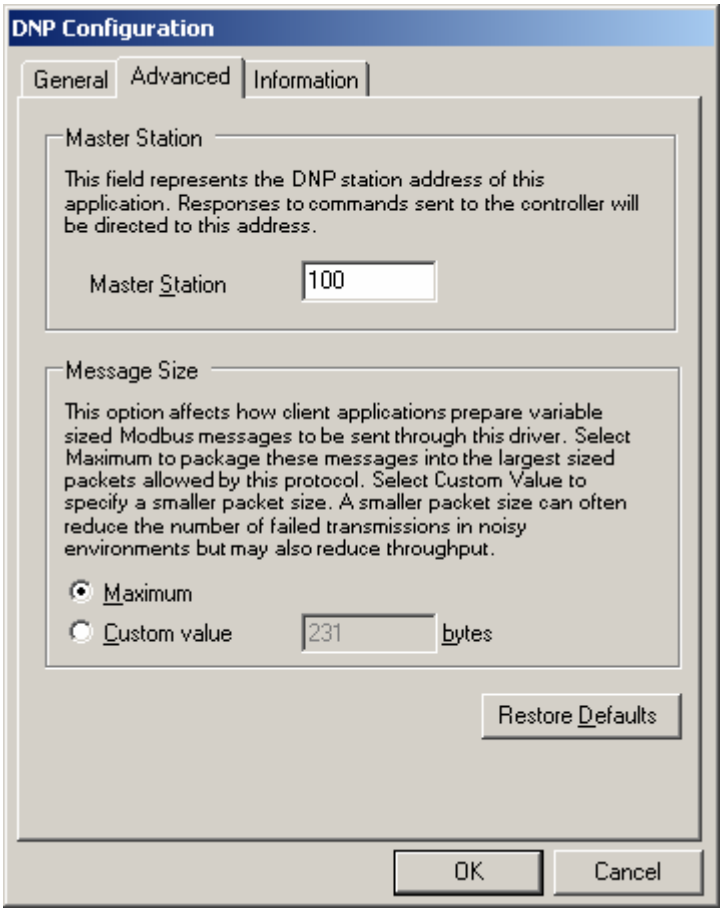


Figure 69: DNP Configuration (Advanced) Dialog Box

The **Master Station** parameter is the DNP station address assumed by this communication component. When this driver sends out commands, responses form the controller will be directed to this address. The default value is 100.

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 231. The default value is 231.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.2.5 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

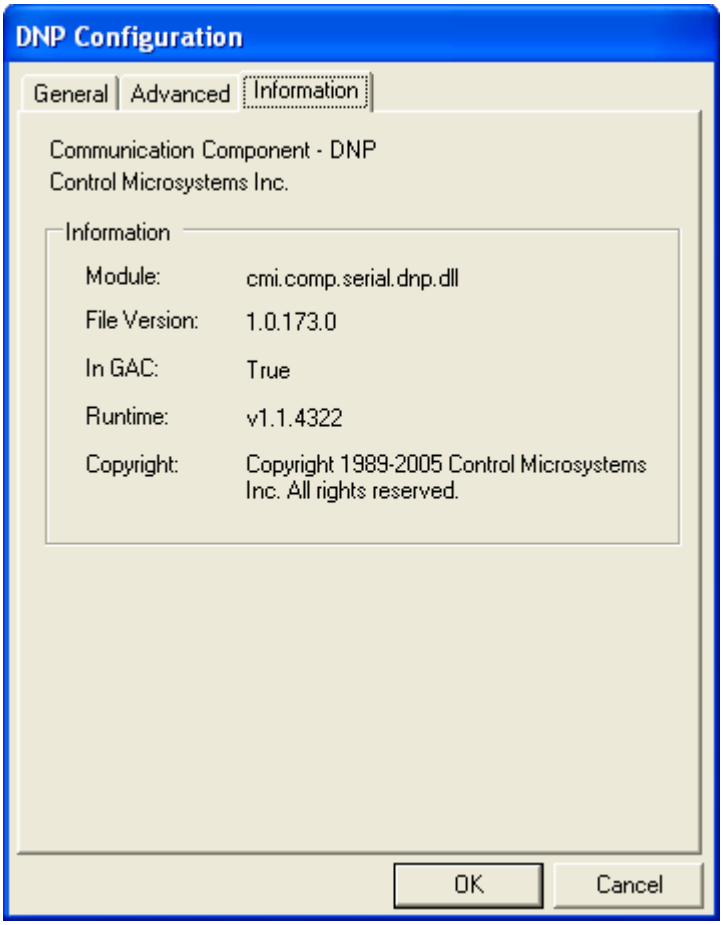


Figure 70: DNP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.3 DNP/TCP

The DNP/TCP protocol driver is used to communicate over an Ethernet DNP network to SCADAPack controllers configured for DNP/TCP communication.

- To configure a DNP/TCP protocol connection, highlight **DNP/TCP** in the Communication Protocols window and click the **Configure** button. The DNP/TCP Configuration window is displayed.
- To select a configured DNP/TCP protocol connection, highlight **DNP/TCP** in the Communication Protocols window and click the **OK** button.

- To close the dialog, without making a selection click the **Cancel** button.

6.3.3.1 General Page

When DNP/TCP protocol is selected for configuration the DNP/TCP Configuration dialog is opened with the General tab selected as shown below.

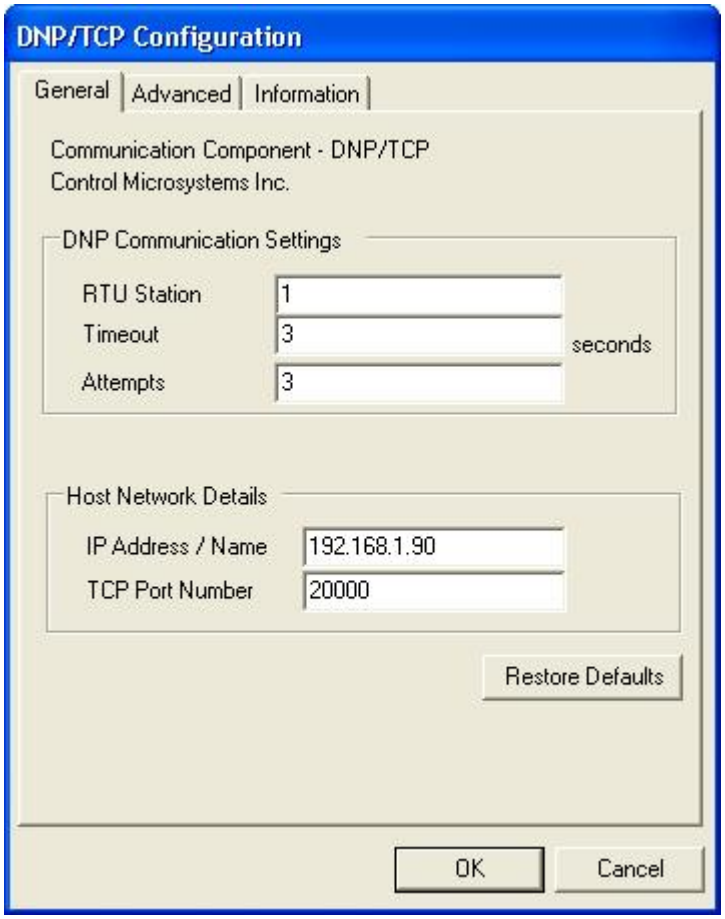


Figure 71: DNP in TCP Configuration (General) Dialog Box

The **DNP Communication Settings** grouping contains DNP specific communication settings including the DNP Station address, the timeout interval as well as the number of attempts.

The **RTU Station** parameter specifies the DNP station number of the target device. The valid range is 0 to 65519. The default is station 1.

The **Timeout** parameter specifies the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts) or ultimately failing. Valid values are 1 to 255. The default value is 3 seconds.

The **Attempts** parameter specifies the number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid values are 1 to 20. The default value is 3 attempts.

The **Host Network Details** grouping contains information about the IP network including the target's IP address or name, and the TCP port number on which it is listening. More details on these below.

6.3.3.1.1 IP Address / Name

The IP Address / Name parameter specifies the Ethernet IP address of the target RTU, or a DNS name that can be resolved to an IP address. The default value is blank. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **TCP Port No.** field specifies the TCP port of the remote device. Valid values are 0 to 65535. The default value is 20000.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.3.2 Advanced Page

Advanced parameters are used to set the Master Station address and control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

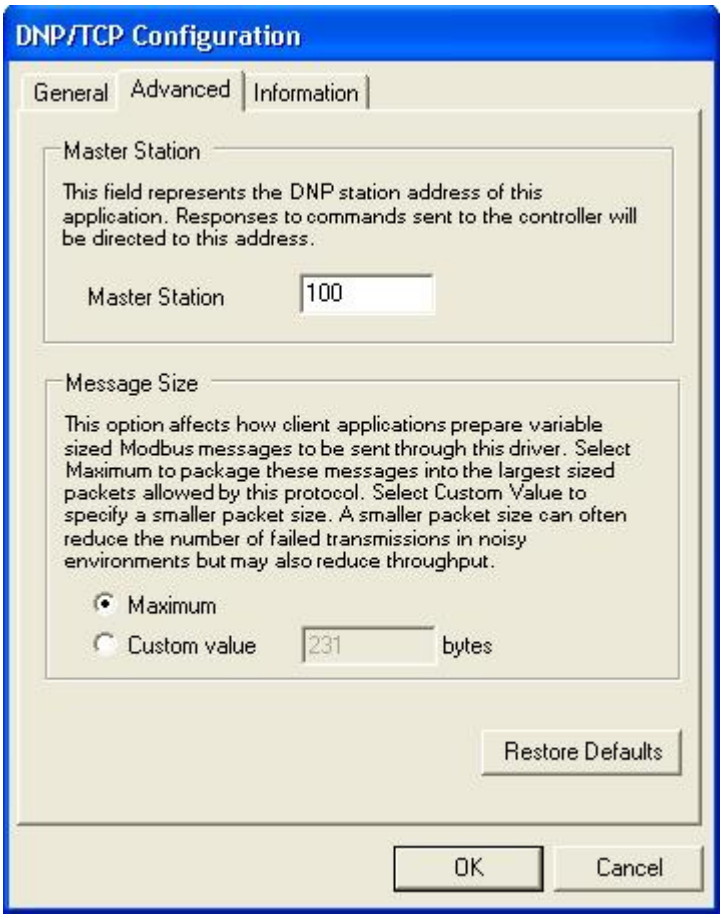


Figure 72: DNP n TCP Configuration (Advanced) Dialog Box

The **Master Station** parameter specifies the DNP station address of the RealFLO application. When RealFLO sends out commands, responses from the target controller will be directed to this address. The valid range is 0 to 65519, except that this value cannot be the same as the target RTU Station number. The default value is 100.

The **Maximum** selection indicates that you want the host application to package messages using the maximum size allowable by the protocol.

The **Custom value** selection specifies a custom value for message size. This value indicates to the host application to package messages to be no larger than what is specified if possible. The valid range for the Custom value field is from 2 to 231. *Maximum* is selected by default.

- Click **Restore Defaults** to restore default values to all fields on this page

6.3.3.3 Information Page

The Information page displays detailed driver information. When the Information tab is clicked the Information dialog is opened as shown below.

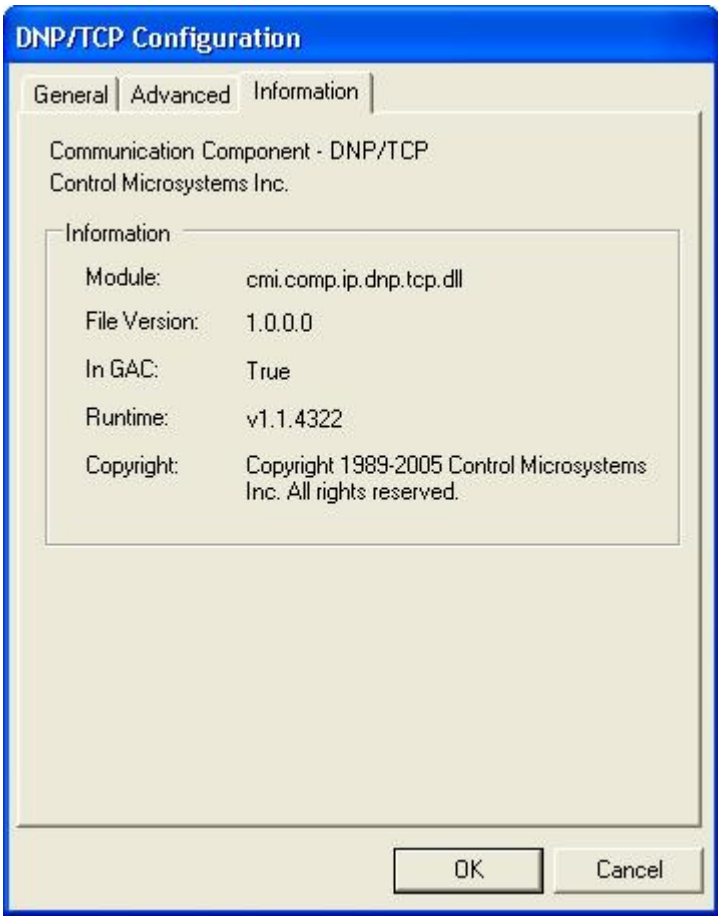


Figure 73: DNP in TCP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.4 DNP/UDP

The DNP/UDP protocol driver is used to communicate over an Ethernet DNP network to SCADAPack controllers configured for DNP/UDP communication.

- To configure a DNP/UDP protocol connection, highlight **DNP/UDP** in the Communication Protocols window and click the **Configure** button. The DNP/UDP Configuration window is displayed.
- To select a configured DNP/UDP protocol connection, highlight **DNP/UDP** in the Communication Protocols window and click the **OK** button.

- To close the dialog, without making a selection click the **Cancel** button.

6.3.4.1 General Page

When DNP/UDP protocol is selected for configuration the DNP/UDP Configuration dialog is opened with the General tab selected as shown below.

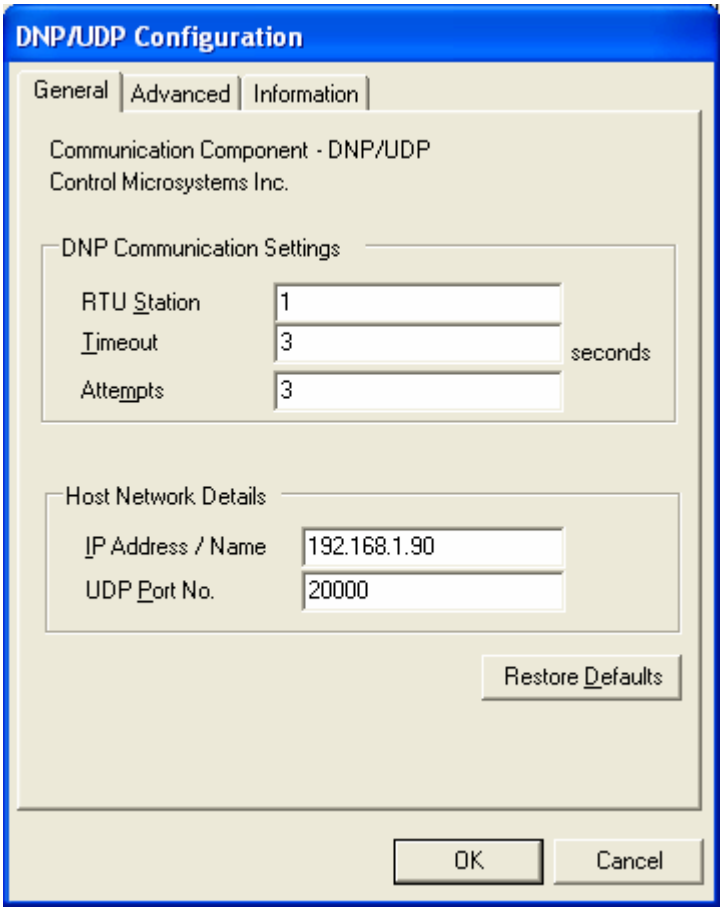


Figure 74: DNP in UDP Configuration (General) Dialog Box

The **DNP Communication Settings** grouping contains DNP specific communication settings including the DNP Station address, the timeout interval as well as the number of attempts.

The **RTU Station** parameter specifies the DNP station number of the target device. The valid range is 0 to 65519. The default is station 1.

The **Timeout** parameter specifies the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts) or ultimately failing. Valid values are 1 to 255. The default value is 3 seconds.

The **Attempts** parameter specifies the number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid values are 1 to 20. The default value is 3 attempts.

The **Host Network Details** grouping contains information about the IP network including the target's IP address or name, and the UDP port number on which it is listening. More details on these below.

6.3.4.1.1 IP Address / Name

The IP Address / Name parameter specifies the Ethernet IP address of the target RTU, or a DNS name that can be resolved to an IP address. The default value is blank. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **UDP Port No.** field specifies the UDP port of the remote device. Valid values are 0 to 65534. The default value is 20000.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.4.2 Advanced Page

Advanced parameters are used to set the Master Station address and control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

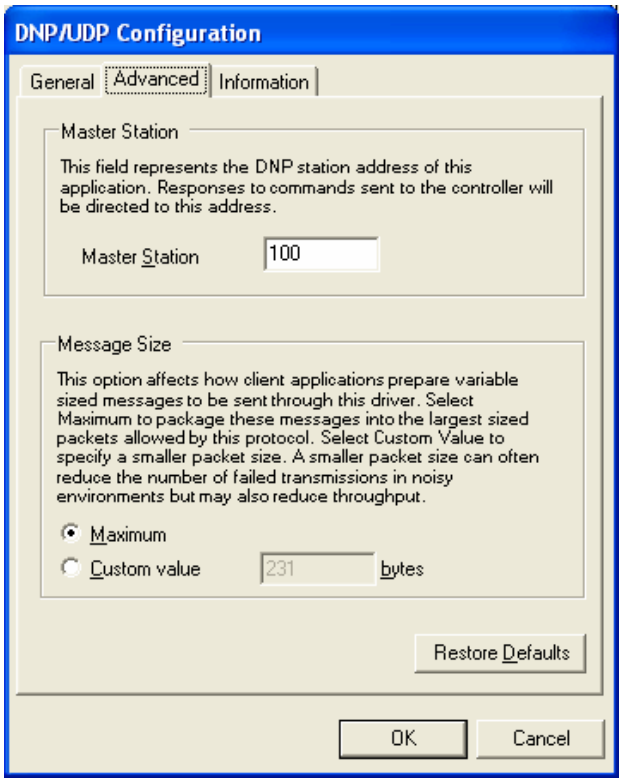


Figure 75: DNP in UDP Configuration (Advanced) Dialog Box

The **Master Station** parameter specifies the DNP station address of the RealFLO application. When RealFLO sends out commands, responses from the target controller will be directed to this address. The valid range is 0 to 65519, except that this value cannot be the same as the target RTU Station number. The default value is 100.

The **Maximum** selection indicates that you want the host application to package messages using the maximum size allowable by the protocol.

The **Custom value** selection specifies a custom value for message size. This value indicates to the host application to package messages to be no larger than what is specified if possible. The valid range for the Custom value field is from 2 to 231. *Maximum* is selected by default.

- Click **Restore Defaults** to restore default values to all fields on this page

6.3.4.3 Information Page

The Information page displays detailed driver information. When the Information tab is clicked the Information dialog is opened as shown below.

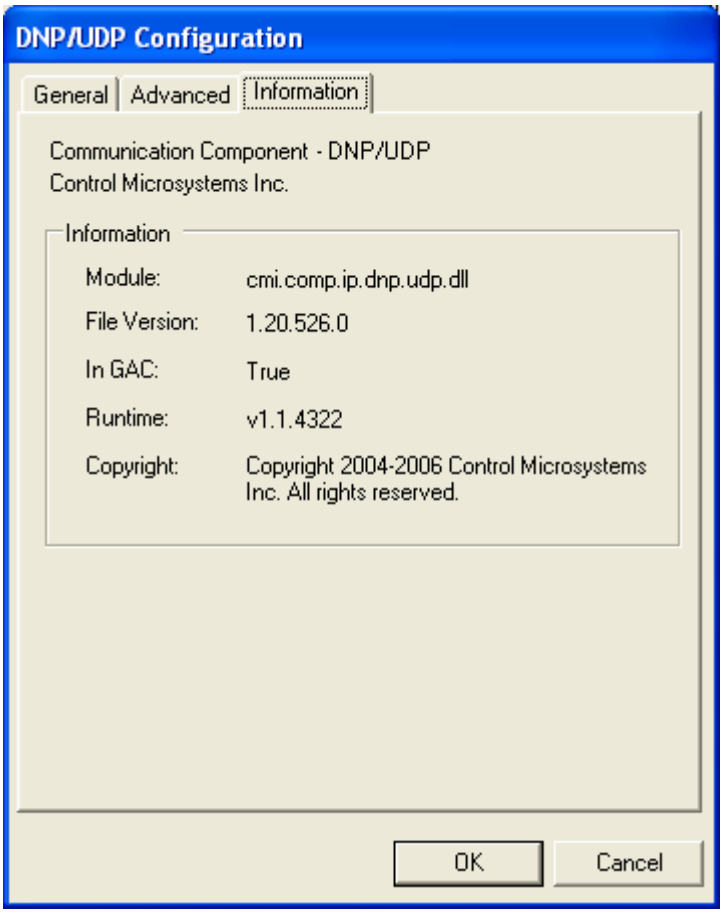


Figure 76: DNP in UDP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.5 Modbus ASCII

The Modbus ASCII protocol driver is used to communicate over a serial network, using Modbus ASCII framing, to SCADAPack controllers configured for Modbus ASCII protocol.

- To configure a Modbus ASCII protocol connection, highlight **Modbus ASCII** in the Communication Protocols window and click the **Configure** button. The Modbus ASCII Configuration window is displayed.
- To select a configured Modbus ASCII protocol connection, highlight **Modbus ASCII** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.5.1 General Parameters

When Modbus ASCII is selected for configuration the Modbus ASCII Configuration dialog is opened with the General tab selected as shown below.

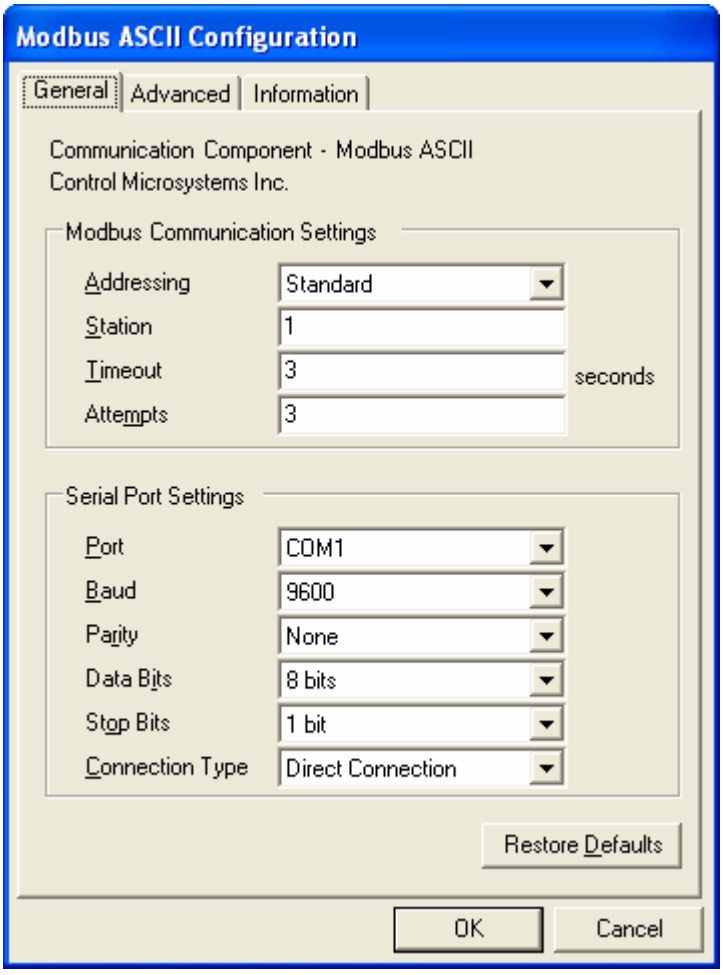


Figure 77: Modbus ASCII Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

This **Serial Port Settings** grouping contains details directly related to the PC's communication port including the port number, the baud rate, parity and stop bit settings.

The **Port** parameter specifies the PC serial port to use. The DNP driver determines what serial ports are available on the PC and presents these in the drop-down menu list. The available serial ports list will include any USB to serial converters used on the PC. The default value is the first existing port found by the driver.

The **Baud** parameter specifies the baud rate to use for communication. The menu list displays selections for 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, and 57600. The default value is 9600.

The **Parity** parameter specifies the type of parity to use for communication. The menu list displays selections for none, odd and even parity. The default value is None.

The **Data Bits** parameter specifies the number of data bits contained in the character frame. Valid values are for this field is 7 and 8 bits. The default value is 8 bits.

The **Stop Bits** parameter specifies the number of stop bits to use for communication. The menu list displays selections for 1 and 2 stop bits. The default value is 1 bit.

The **Connection Type** parameter specifies the serial connection type. The Modbus ASCII driver supports direct serial connection with no flow control, Request-to-send (RTS) and clear-to-send (CTS) flow control and PSTN dial-up connections. The menu list displays selections for Direct Connection, RTS/CTS Flow Control and Dial Up Connection. The default selection is Direct Connection.

- Select **Direct Connection** for RS-232 for RS-485 connections that do not require the hardware control lines on the serial ports.
- Select **RTS/CTS Flow Control** to communicate over radio or leased-line networks using modems that require RTS/CTS handshaking. Selecting RTS/CTS Flow Control adds a new tab, Flow Control, to the Modbus ASCII Configuration dialog. Refer to the Flow Control Parameters section below for configuration details.
- Select **Dial Up Connection** to communication over dial up modems. Selecting Dial Up Connection adds a new tab, Dial Up, to the Modbus ASCII Configuration dialog. Refer to the Dial Up Parameters section below for configuration details.
- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.5.2 Modbus ASCII Configuration (Flow Control)

Flow Control parameters are used to configure how RTS and CTS control is used. When RTS/CTS Flow Control is selected for Connection Type the Flow Control tab is added to the Modbus ASCII Configuration dialog. When the Flow Control tab heading is clicked the Flow Control dialog is opened as shown below.

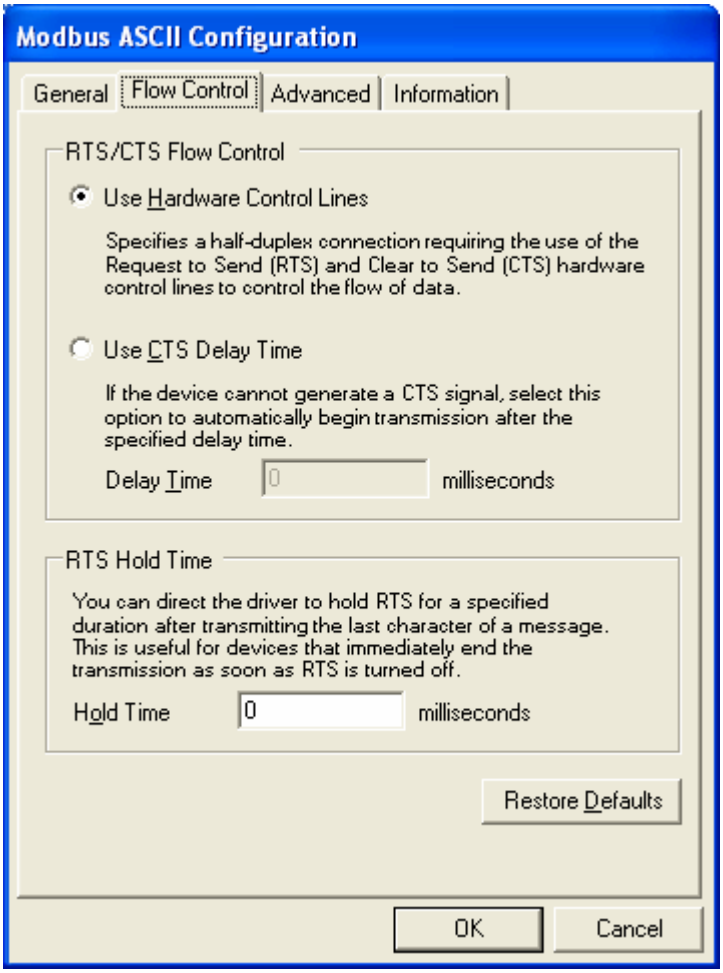


Figure 78: Modbus ASCII Configuration (Flow Control)

The **RTS/CTS Flow Control** grouping contains two mutually exclusive options, Use Hardware Control Lines and Use CTS Delay Time. These options enable the driver to communicate over radio or leased-line networks using modems that require RTS/CTS handshaking.

The **Use Hardware Control Lines** option specifies a half-duplex connection requiring the use of the Request to Send (RTS) and Clear to Send (CTS) hardware control lines to control the flow of data. This selection is used with radios and dedicated telephone line modems. The driver turns on the RTS signal when it wants to transmit data. The modem or other device then turns on CTS when it is ready to transmit. The driver transmits the data, and then turns off the RTS signal. This selection is mutually exclusive of the Use CTS Delay Time selection described below. This is the default selection.

The **Use CTS Delay Time** option is selected if the device cannot generate a CTS signal. The driver will assert RTS then wait the specified Delay Time, in milliseconds, before proceeding. This option is mutually exclusive with the Use Hardware Control Lines selection described above.

The **Delay Time** parameter sets the time in milliseconds that the driver will wait after asserting RTS before proceeding. The value of this field must be smaller than the Time Out value set in the General parameters dialog. For example, if the Timeout value is set to 3 seconds, the CTS Delay Time can be

set to 2999 milliseconds or less. The minimum value for this field is 0 milliseconds. The value is initially set to 0 by default.

The **Hold Time** parameter specifies the time, in milliseconds, that the driver will hold RTS after the last character is transmitted. This is useful for devices that immediately end transmission when RTS is turned off. The value of this field must be smaller than the Time Out value set in the General parameters dialog. For example, if the Timeout value is set to 3 seconds, the CTS Delay Time can be set to 2999 milliseconds or less. The minimum value for this field is 0 milliseconds. The value is initially set to 0 by default.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.5.3 Modbus ASCII Configuration (Dial Up)

Dial Up parameters are used to configure a dial up connection. When Dial Up is selected for Connection Type the Dial Up tab is added to the Modbus ASCII Configuration dialog. When the Dial Up tab heading is clicked the Dial Up dialog is opened as shown below.

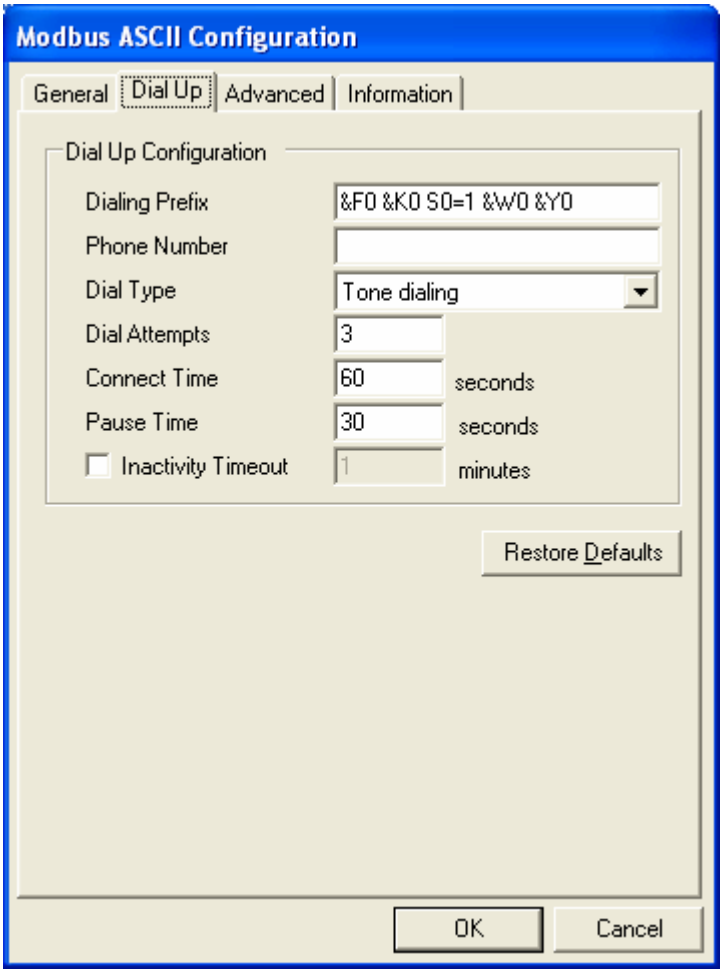


Figure 79: Modbus ASCII Configuration (Dial Up)

The **Dialing Prefix** parameter specifies the commands sent to the modem before dialing. A maximum of 32 characters can be entered. All characters are valid. The default value is "&F0 &K0 S0=1 &W0 &Y0".

The **Phone Number** parameter specifies the telephone number of the remote controller. A maximum of 32 characters can be entered. All characters are valid. This field's default value is blank.

The **Dial Type** parameter specifies the dialing type. Valid values are Pulse and Tone. The default value is Tone.

The **Dial Attempts** parameter specifies how many dialing attempts will be made. Valid values are 1 to 10. The default value is 1.

The **Connect Time** parameter specifies the amount of time in seconds the modem will wait for a connection. Valid values are 6 to 300. The default value is 60.

The **Pause Time** parameter specifies the time in seconds between dialing attempts. Valid values are 6 to 600. The default value is 30.

Check the **Inactivity Timeout** check box to automatically terminate the dialup connection after a period of inactivity. The Inactivity Time edit box is enabled only if this option is checked. The default state is checked.

Enter the inactivity period, in minutes, in the **Inactivity Timeout** box. The dialup connection will be terminated automatically after the specified number of minutes of inactivity has lapsed. This option is only active if the Inactivity Timeout box is checked. Valid values are from 1 to 30 minutes. The default value is 1.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the Phone Number field. The content of this field will remain unchanged.

6.3.5.4 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

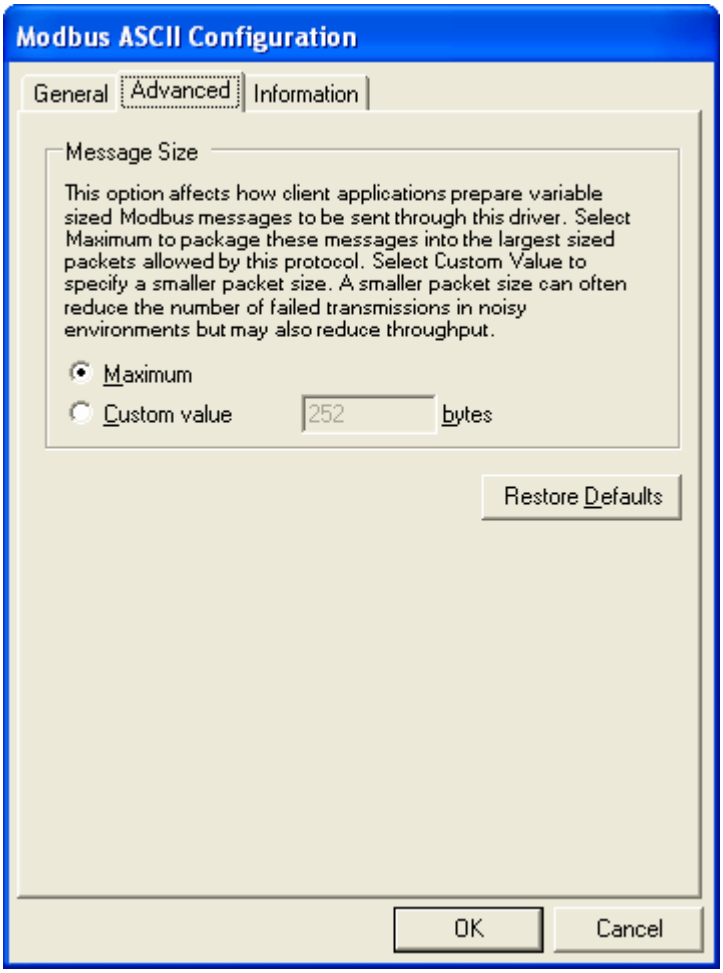


Figure 80: Modbus ASCII Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 250 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 252. When Addressing is set to Standard valid values are 2 to 252.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.5.5 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

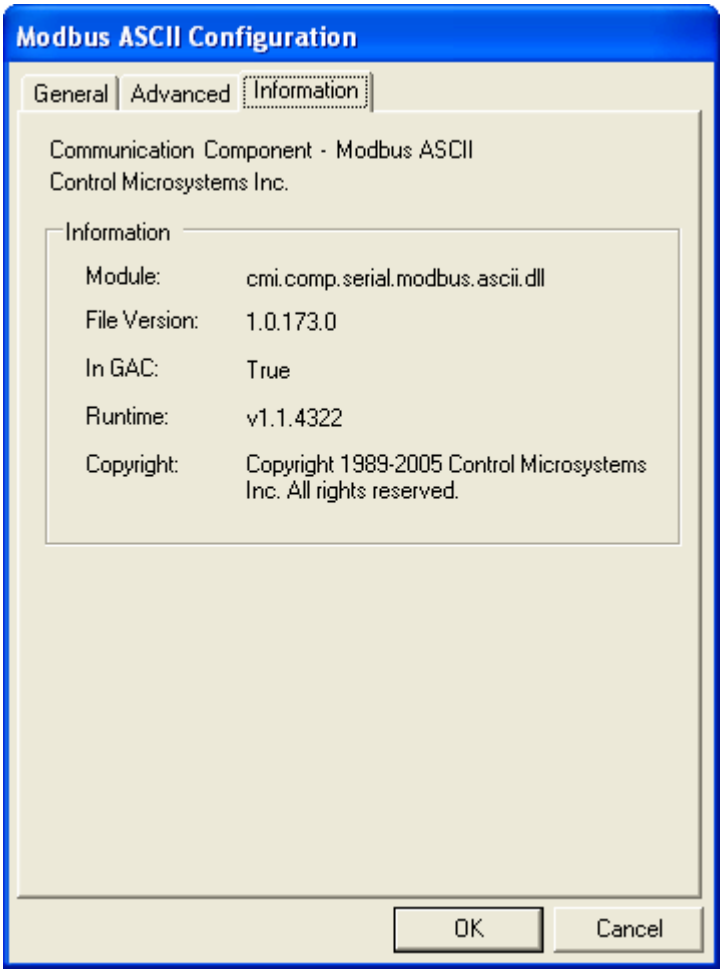


Figure 81: Modbus ASCII Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.6 Modbus ASCII in TCP

Modbus ASCII in TCP message format is exactly same as that of the Modbus ASCII protocol. The main difference is that Modbus ASCII in TCP protocol communicates with a SCADAPack controller through the Internet and Modbus ASCII through the serial port. The Modbus ASCII in TCP protocol does not include a six-byte header prefix, as with the Modbus\TCP, but does include the Modbus 'CRC-16' or 'LRC' check fields.

- To configure a Modbus ASCII in TCP protocol connection, highlight **Modbus ASCII in TCP** in the Communication Protocols window and click the **Configure** button. The Modbus ASCII in TCP Configuration window is displayed.
- To select a configured Modbus ASCII in TCP protocol connection, highlight **Modbus ASCII in TCP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.6.1 General Parameters

When Modbus ASCII in TCP is selected for configuration the Modbus ASCII in TCP Configuration dialog is opened with the General tab selected as shown below.

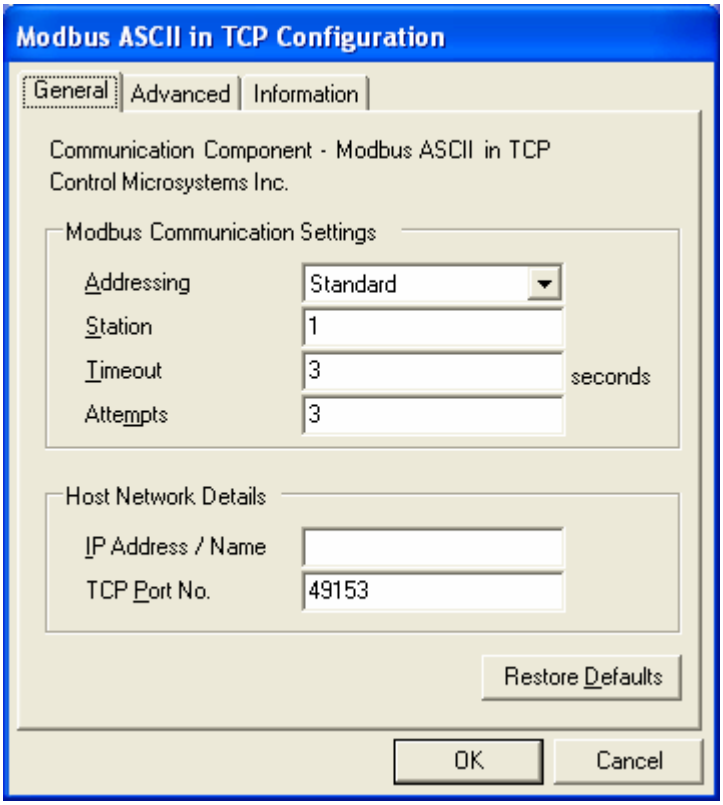


Figure 82: Modbus ASCII in TCP Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

The **Host Network Details** grouping contains entries for the host's IP address or name and the TCP port on which it is listening.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **TCP Port No.** field specifies the TCP port of the remote device. Valid values are 0 to 65535. The default value is 49153.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.6.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

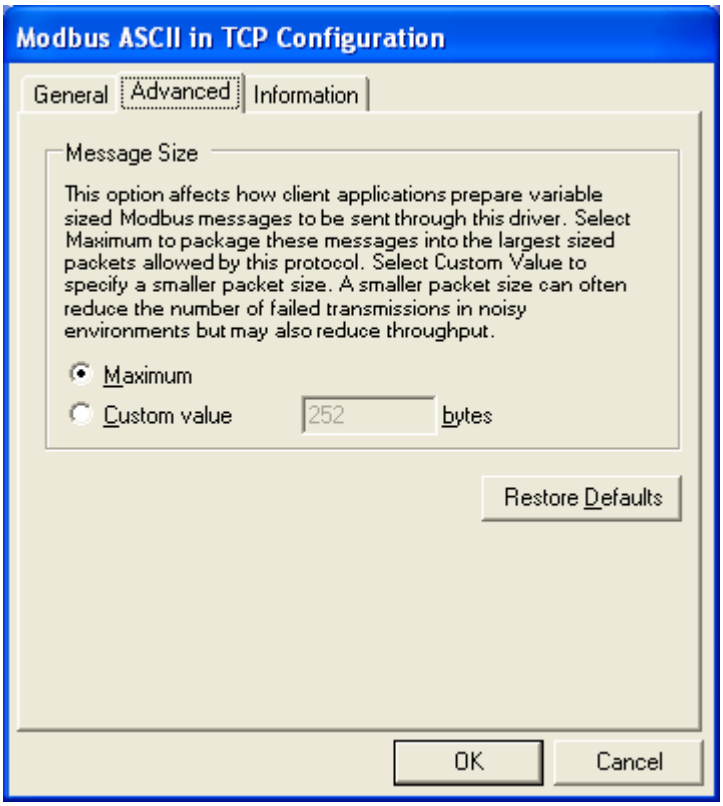


Figure 83: Modbus ASCII in TCP Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 250 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 252. When Addressing is set to Standard valid values are 2 to 252.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.6.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

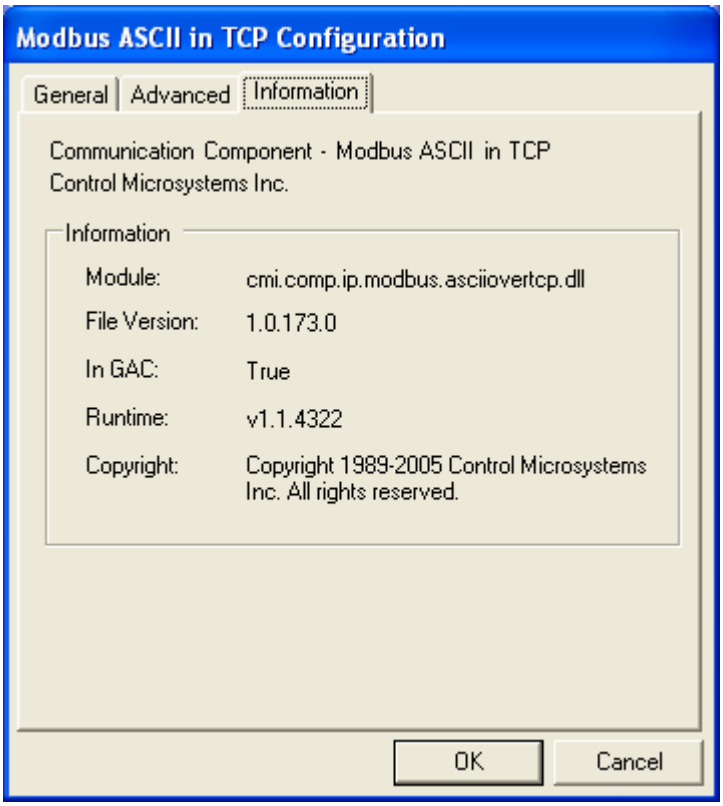


Figure 84: Modbus ASCII in TCP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.7 Modbus ASCII in UDP

Modbus ASCII in UDP protocol is similar to Modbus ASCII in TCP protocol. It has the same message format as the Modbus ASCII in TCP. The only difference between them is one uses TCP protocol and another uses UDP protocol.

- To configure a Modbus ASCII in TCP protocol connection, highlight **Modbus ASCII in UDP** in the Communication Protocols window and click the **Configure** button. The Modbus ASCII in UDP Configuration window is displayed.

- To select a configured Modbus ASCII in TCP protocol connection, highlight **Modbus ASCII in UDP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.7.1 General Parameters

When Modbus ASCII in UDP is selected for configuration the Modbus ASCII in UDP Configuration dialog is opened with the General tab selected as shown below.

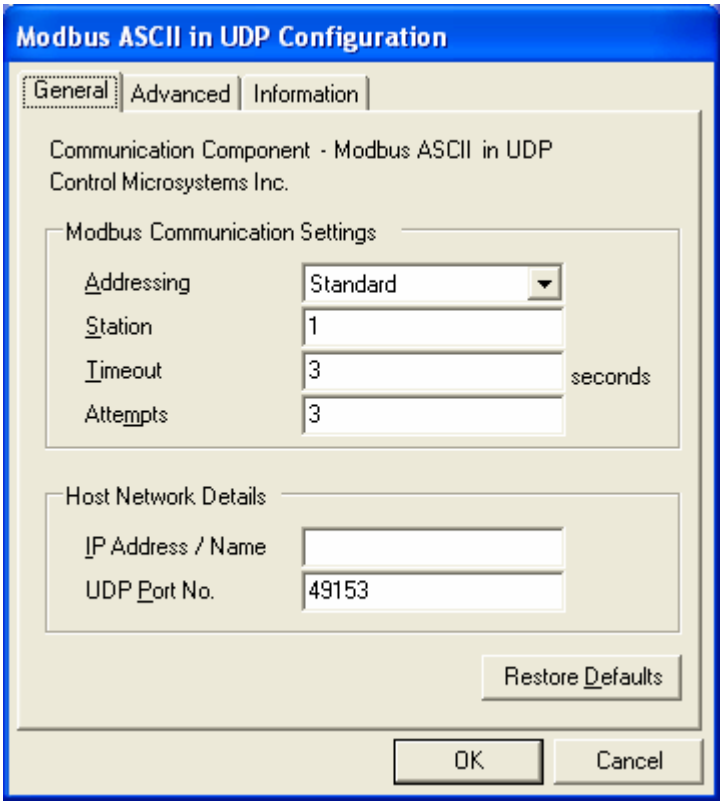


Figure 85: Modbus ASCII in UDP Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

The **Host Network Details** grouping contains entries for the host's IP address or name and the TCP port on which it is listening.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **UDP Port No.** field specifies the UDP port of the remote device. Valid values are 0 to 65535. The default value is 49153.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.7.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

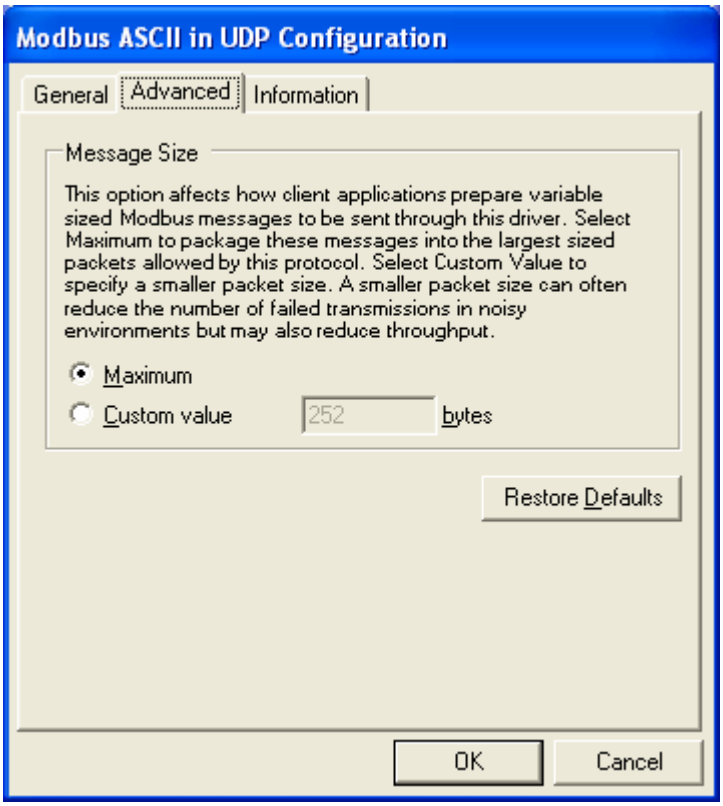


Figure 86: Modbus ASCII in UDP Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 250 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 252. When Addressing is set to Standard valid values are 2 to 252.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.7.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

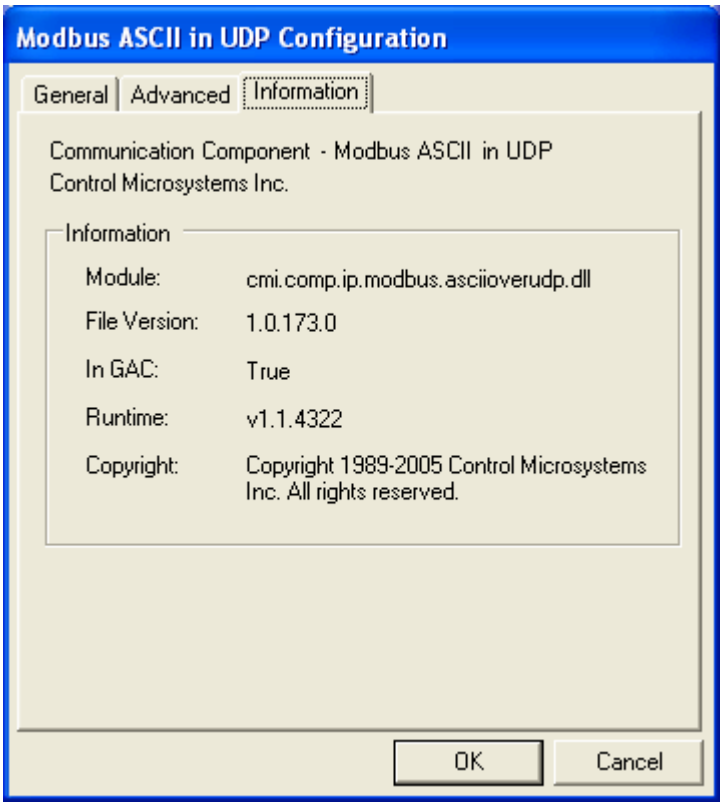


Figure 87: Modbus ASCII in UDP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.8 Modbus RTU

6.3.8.1 Introduction

The Modbus RTU protocol driver is used to communicate over a serial network, using Modbus RTU framing, to SCADAPack controllers configured for Modbus RTU protocol.

- To configure a Modbus RTU protocol connection, highlight **Modbus RTU** in the Communication Protocols window and click the **Configure** button. The Modbus RTU Configuration window is displayed.
- To select a configured Modbus RTU protocol connection, highlight **Modbus RTU** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.8.2 General Parameters

When Modbus RTU is selected for configuration the Modbus RTU Configuration dialog is opened with the General tab selected as shown below.

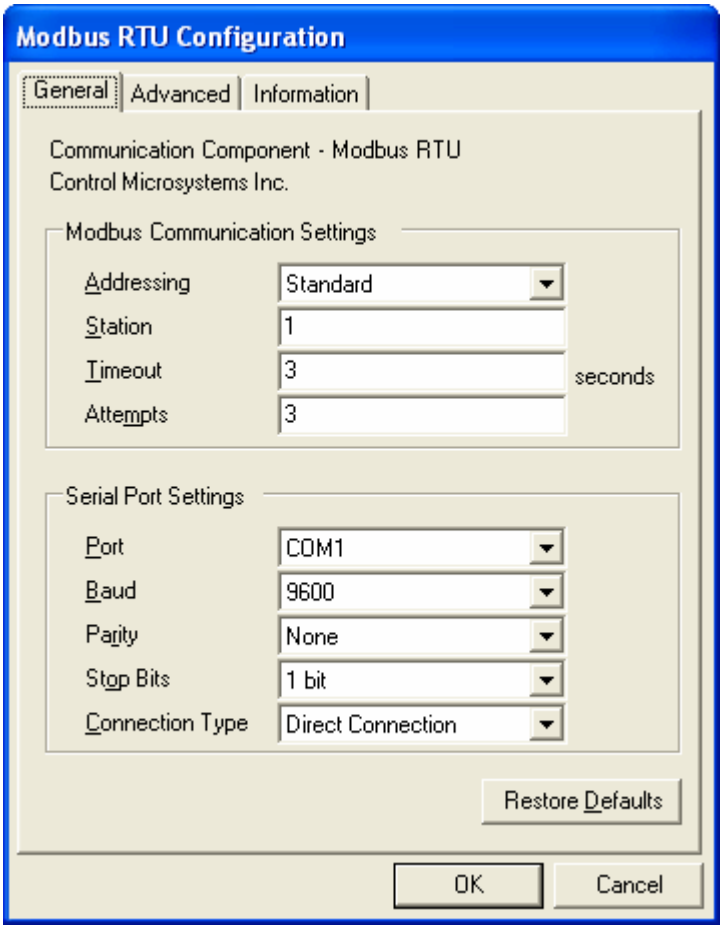


Figure 88: Modbus RTU Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

This **Serial Port Settings** grouping contains details directly related to the PC's communication port including the port number, the baud rate, parity and stop bit settings.

The **Port** parameter specifies the PC serial port to use. The DNP driver determines what serial ports are available on the PC and presents these in the drop-down menu list. The available serial ports list

will include any USB to serial converters used on the PC. The default value is the first existing port found by the driver.

The **Baud** parameter specifies the baud rate to use for communication. The menu list displays selections for 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, and 57600. The default value is 9600.

The **Parity** parameter specifies the type of parity to use for communication. The menu list displays selections for none, odd and even parity. The default value is None.

The **Stop Bits** parameter specifies the number of stop bits to use for communication. The menu list displays selections for 1 and 2 stop bits. The default value is 1 bit.

The **Connection Type** parameter specifies the serial connection type. The Modbus RTU driver supports direct serial connection with no flow control, Request-to-send (RTS) and clear-to-send (CTS) flow control and PSTN dial-up connections. The menu list displays selections for Direct Connection, RTS/CTS Flow Control and Dial Up Connection. The default selection is Direct Connection.

- Select **Direct Connection** for RS-232 for RS-485 connections that do not require the hardware control lines on the serial ports.
- Select **RTS/CTS Flow Control** to communicate over radio or leased-line networks using modems that require RTS/CTS handshaking. Selecting RTS/CTS Flow Control adds a new tab, Flow Control, to the Modbus RTU Configuration dialog. Refer to the Flow Control Parameters section below for configuration details.
- Select **Dial Up Connection** to communication over dial up modems. Selecting Dial Up Connection adds a new tab, Dial Up, to the Modbus RTU Configuration dialog. Refer to the Dial Up Parameters section below for configuration details.
- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.8.3 Modbus RTU Configuration (Flow Control)

Flow Control parameters are used to configure how RTS and CTS control is used. When RTS/CTS Flow Control is selected for Connection Type the Flow Control tab is added to the Modbus RTU Configuration dialog. When the Flow Control tab heading is clicked the Flow Control dialog is opened as shown below.

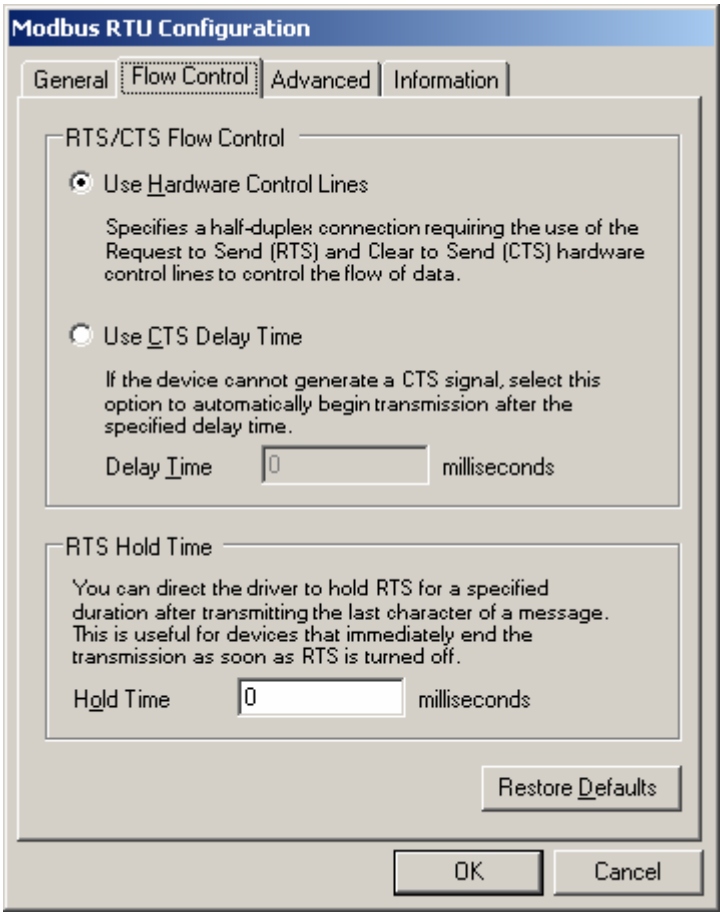


Figure 89: Modbus RTU Configuration (Flow Control)

The **RTS/CTS Flow Control** grouping contains two mutually exclusive options, Use Hardware Control Lines and Use CTS Delay Time. These options enable the driver to communicate over radio or leased-line networks using modems that require RTS/CTS handshaking.

The **Use Hardware Control Lines** option specifies a half-duplex connection requiring the use of the Request to Send (RTS) and Clear to Send (CTS) hardware control lines to control the flow of data. This selection is used with radios and dedicated telephone line modems. The driver turns on the RTS signal when it wants to transmit data. The modem or other device then turns on CTS when it is ready to transmit. The driver transmits the data, and then turns off the RTS signal. This selection is mutually exclusive of the Use CTS Delay Time selection described below. This is the default selection.

The **Use CTS Delay Time** option is selected if the device cannot generate a CTS signal. The driver will assert RTS then wait the specified Delay Time, in milliseconds, before proceeding. This option is mutually exclusive with the Use Hardware Control Lines selection described above.

The **Delay Time** parameter sets the time in milliseconds that the driver will wait after asserting RTS before proceeding. The value of this field must be smaller than the Time Out value set in the General parameters dialog. For example, if the Timeout value is set to 3 seconds, the CTS Delay Time can be set to 2999 milliseconds or less. The minimum value for this field is 0 milliseconds. The value is initially set to 0 by default.

The **Hold Time** parameter specifies the time, in milliseconds, that the driver will hold RTS after the last character is transmitted. This is useful for devices that immediately end transmission when RTS is turned off. The value of this field must be smaller than the Time Out value set in the General parameters dialog. For example, if the Timeout value is set to 3 seconds, the CTS Delay Time can be set to 2999 milliseconds or less. The minimum value for this field is 0 milliseconds. The value is initially set to 0 by default.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.8.4 Modbus RTU Configuration (Dial Up)

Dial Up parameters are used to configure a dial up connection. When Dial Up is selected for Connection Type the Dial Up tab is added to the Modbus RTU Configuration dialog. When the Dial Up tab heading is clicked the Dial Up dialog is opened as shown below.

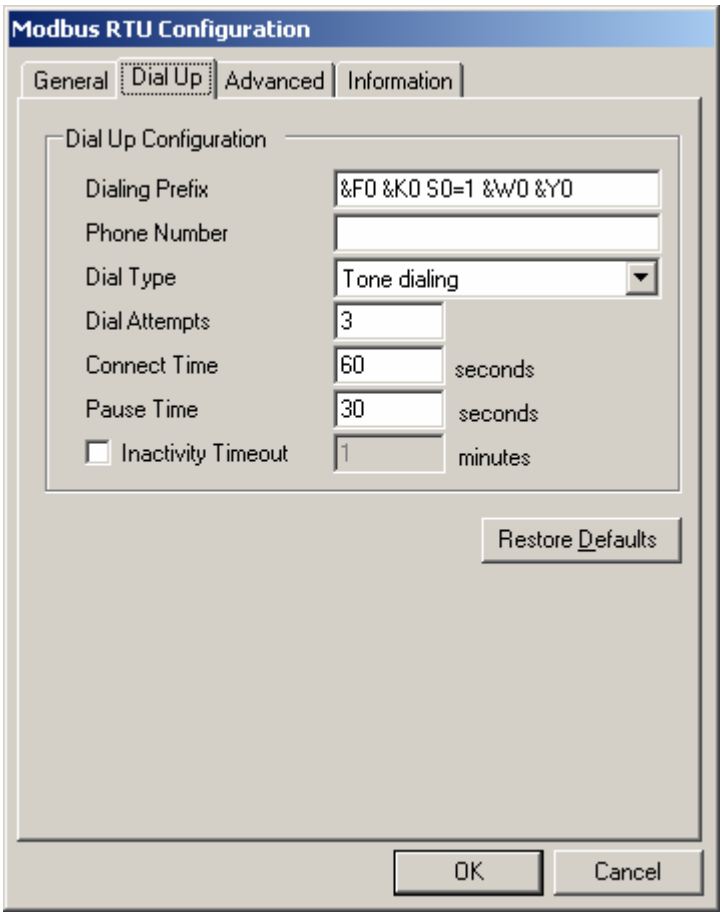


Figure 90: Modbus RTU Configuration (Dial Up)

The **Dialing Prefix** parameter specifies the commands sent to the modem before dialing. A maximum of 32 characters can be entered. All characters are valid. The default value is "&F0 &K0 S0=1 &W0 &Y0".

The **Phone Number** parameter specifies the telephone number of the remote controller. A maximum of 32 characters can be entered. All characters are valid. This field's default value is blank.

The **Dial Type** parameter specifies the dialing type. Valid values are Pulse and Tone. The default value is Tone.

The **Dial Attempts** parameter specifies how many dialing attempts will be made. Valid values are 1 to 10. The default value is 1.

The **Connect Time** parameter specifies the amount of time in seconds the modem will wait for a connection. Valid values are 6 to 300. The default value is 60.

The **Pause Time** parameter specifies the time in seconds between dialing attempts. Valid values are 6 to 600. The default value is 30.

Check the **Inactivity Timeout** check box to automatically terminate the dialup connection after a period of inactivity. The Inactivity Time edit box is enabled only if this option is checked. The default state is checked.

Enter the inactivity period, in minutes, in the **Inactivity Timeout** box. The dialup connection will be terminated automatically after the specified number of minutes of inactivity has lapsed. This option is only active if the Inactivity Timeout box is checked. Valid values are from 1 to 30 minutes. The default value is 1.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the Phone Number field. The content of this field will remain unchanged.

6.3.8.5 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

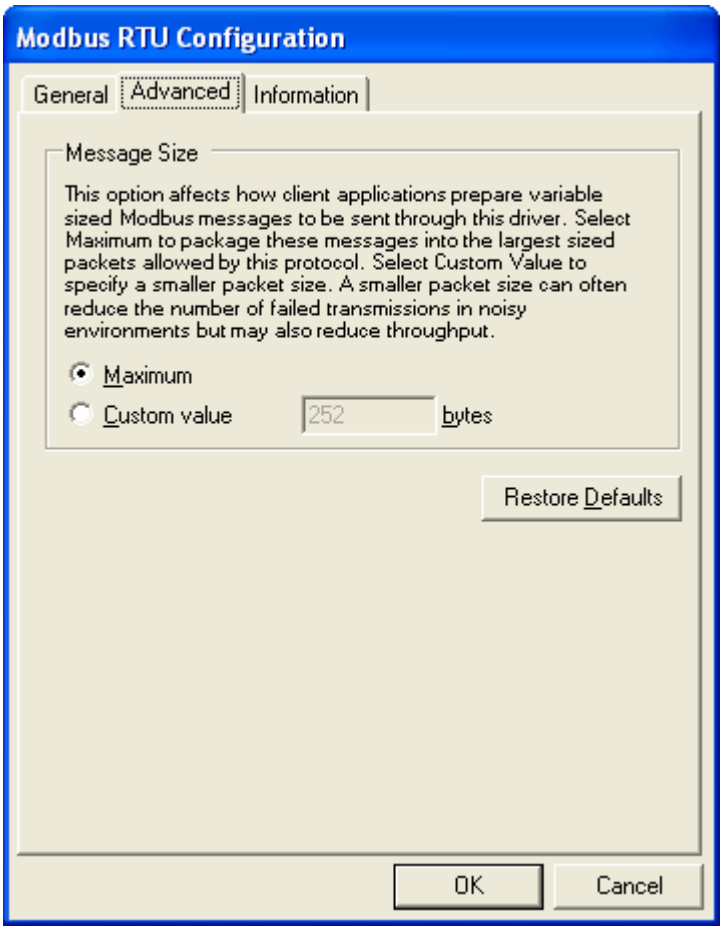


Figure 91: Modbus RTU Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 250 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 252. When Addressing is set to Standard valid values are 2 to 252.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.8.6 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

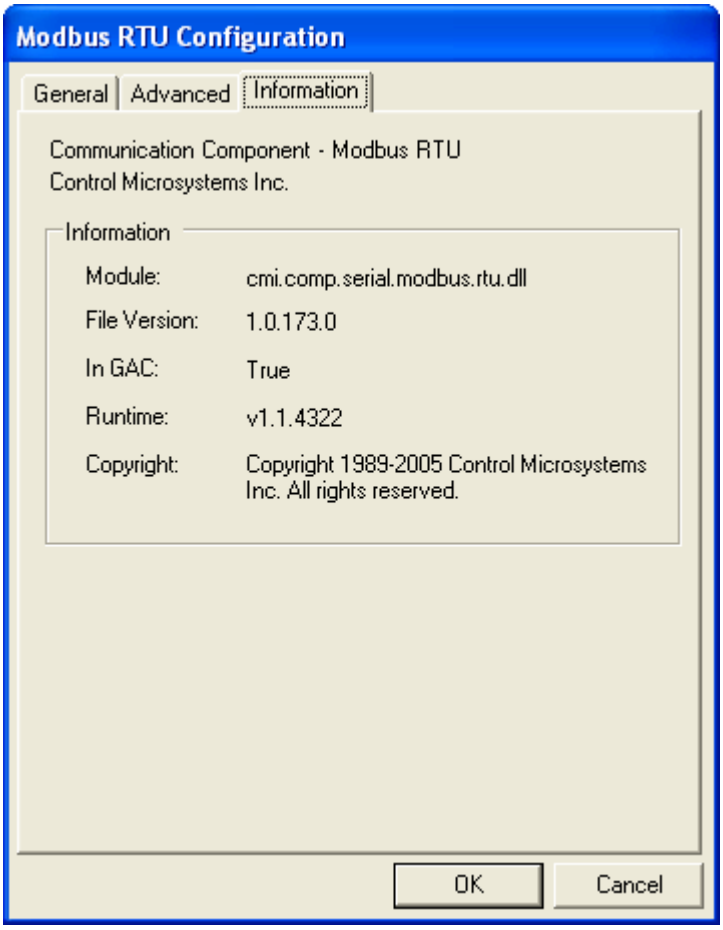


Figure 92: Modbus RTU Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.9 Modbus RTU in TCP

Modbus RTU in TCP message format is exactly same as that of the Modbus RTU protocol. The main difference is that Modbus RTU in TCP protocol communicates with a controller through the Internet and Modbus RTU protocol through the serial port. The Modbus RTU in TCP protocol does not

include a six-byte header prefix, as with the Modbus\TCP, but does include the Modbus 'CRC-16' or 'LRC' check fields. The Modbus RTU in TCP message format supports Modbus RTU message format.

- To configure a Modbus RTU in TCP protocol connection, highlight **Modbus RTU in TCP** in the Communication Protocols window and click the **Configure** button. The Modbus RTU in TCP Configuration window is displayed.
- To select a configured Modbus RTU in TCP protocol connection, highlight **Modbus RTU in TCP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.9.1 General Parameters

When Modbus RTU in TCP is selected for configuration the Modbus RTU in TCP Configuration dialog is opened with the General tab selected as shown below.

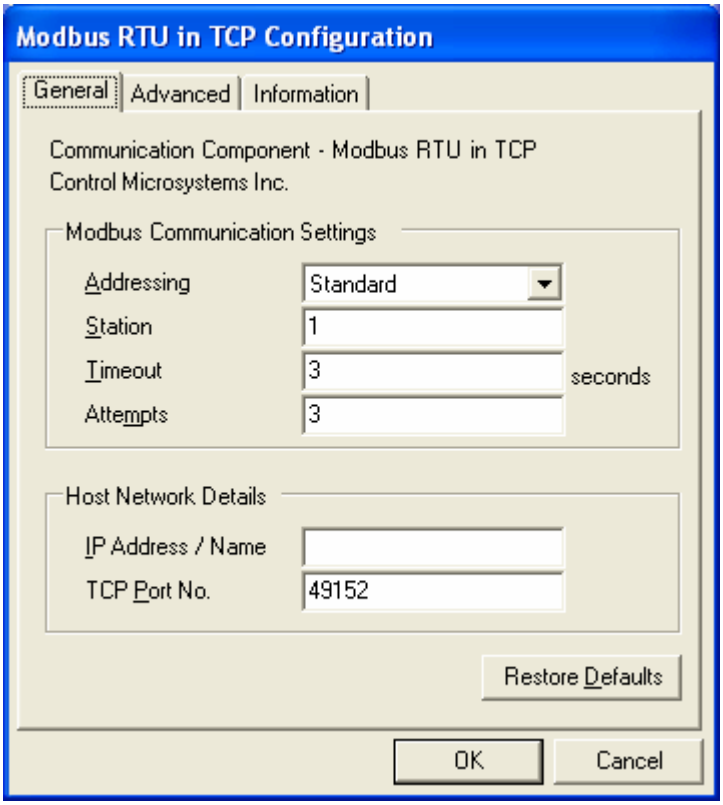


Figure 93: Modbus RTU in TCP Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

The **Host Network Details** grouping contains entries for the host's IP address or name and the TCP port on which it is listening.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **TCP Port No.** field specifies the TCP port of the remote device. Valid values are 0 to 65535. The default value is 49152.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.9.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

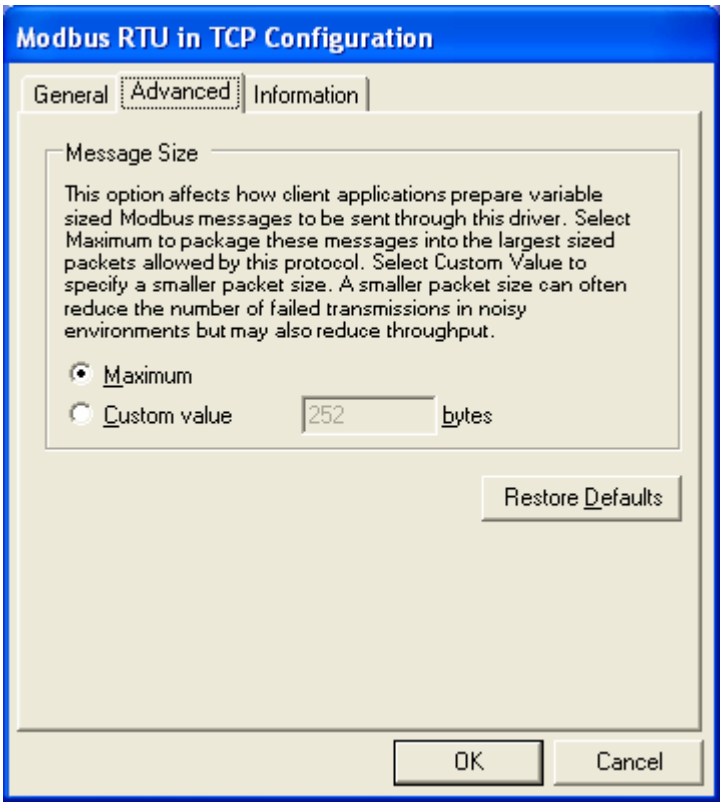


Figure 94: Modbus RTU in TCP Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 250 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 252. When Addressing is set to Standard valid values are 2 to 252.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.9.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

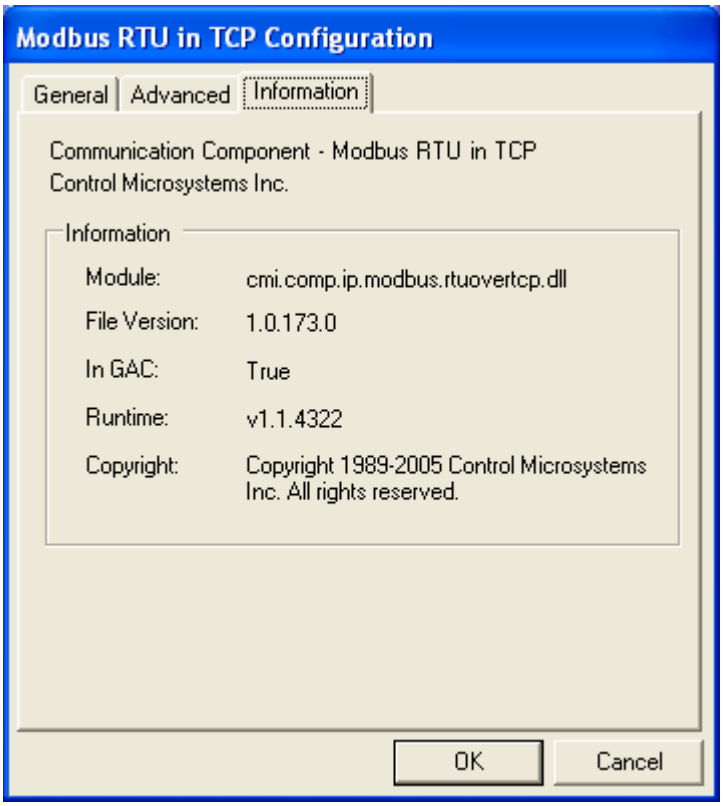


Figure 95: Modbus RTU in TCP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.10 Modbus RTU in UDP

Modbus RTU in UDP protocol is similar to Modbus RTU in TCP protocol. It has the same message format as the RTU in TCP message. The only difference between them is one uses TCP protocol and another uses UDP protocol.

- To configure a Modbus RTU in UDP protocol connection, highlight **Modbus RTU in UDP** in the Communication Protocols window and click the **Configure** button. The Modbus RTU in UDP Configuration window is displayed.

- To select a configured Modbus RTU in UDP protocol connection, highlight **Modbus RTU in UDP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.10.1 General Parameters

When Modbus RTU in UDP is selected for configuration the Modbus RTU in UDP Configuration dialog is opened with the General tab selected as shown below.

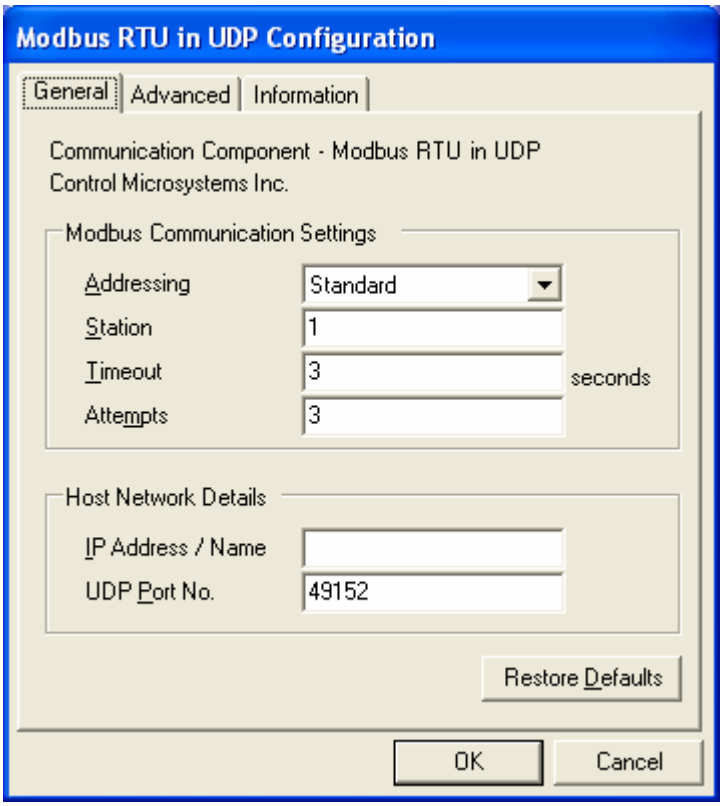


Figure 96: Modbus RTU in UDP Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

The **Host Network Details** grouping contains entries for the host's IP address or name and the TCP port on which it is listening.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **UDP Port No.** field specifies the UDP port of the remote device. Valid values are 0 to 65535. The default value is 49152.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.10.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

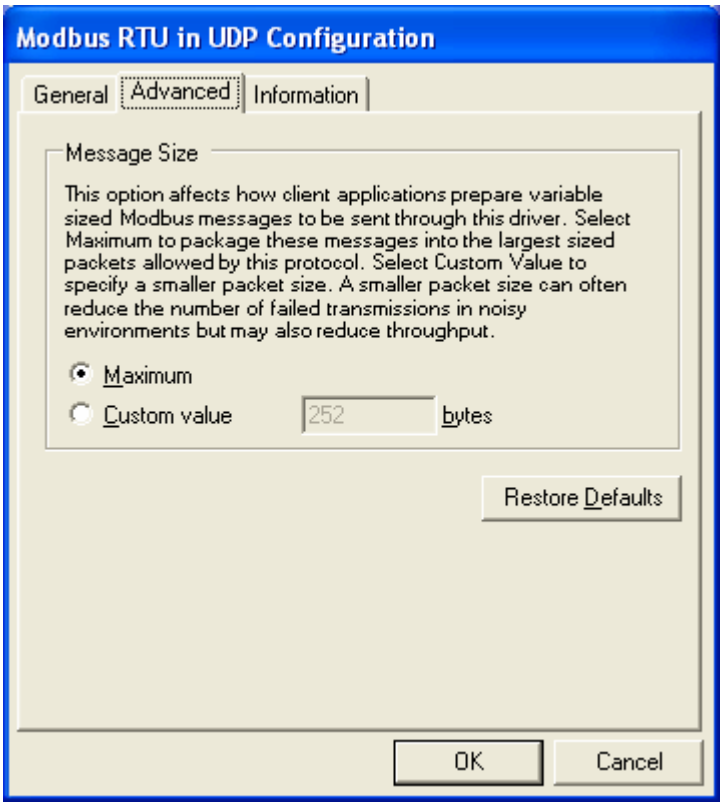


Figure 97: Modbus RTU in UDP Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 250 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 252. When Addressing is set to Standard valid values are 2 to 252.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.10.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

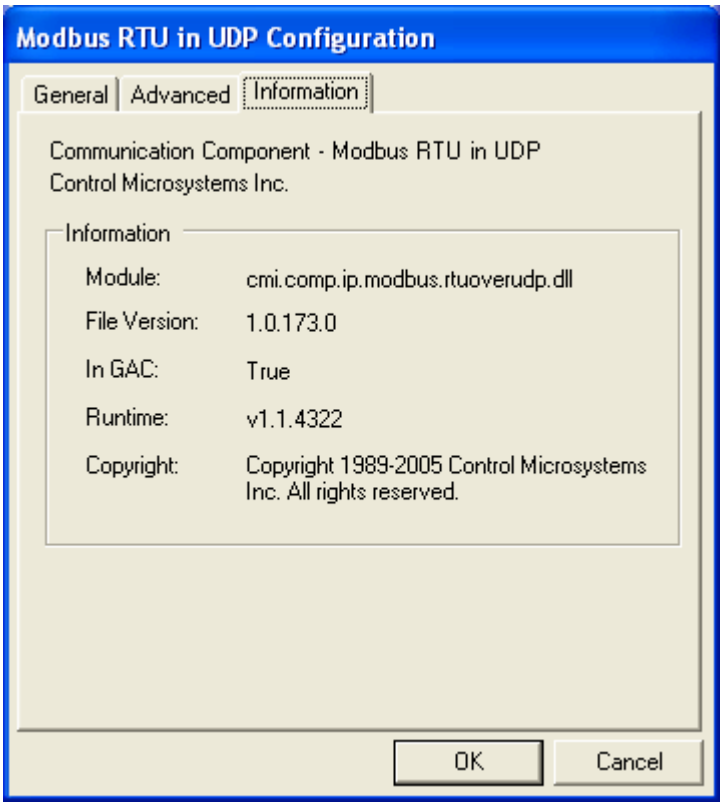


Figure 98: Modbus RTU in UDP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.11 Modbus/TCP

Modbus/TCP is an extension of serial Modbus, which defines how Modbus messages are encoded within and transported over TCP/IP-based networks. The Modbus/TCP protocol uses a custom Modbus protocol layer on top of the TCP protocol. Its request and response messages are prefixed by six bytes. These six bytes consist of three fields: transaction ID field, protocol ID field and length field. The encapsulated Modbus message has exactly the same layout and meaning, from the function code to the end of the data portion, as other Modbus messages. The Modbus 'CRC-16' or 'LRC' check fields are not used in Modbus/TCP. The TCP/IP and link layer (e.g. Ethernet) checksum mechanisms instead are used to verify accurate delivery of the packet.

- To configure a Modbus/TCP protocol connection, highlight **Modbus/TCP** in the Communication Protocols window and click the **Configure** button. The Modbus/TCP Configuration window is displayed.
- To select a configured Modbus/TCP protocol connection, highlight **Modbus/TCP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.11.1 General Parameters

When Modbus/TCP is selected for configuration the Modbus/TCP Configuration dialog is opened with the General tab selected as shown below.

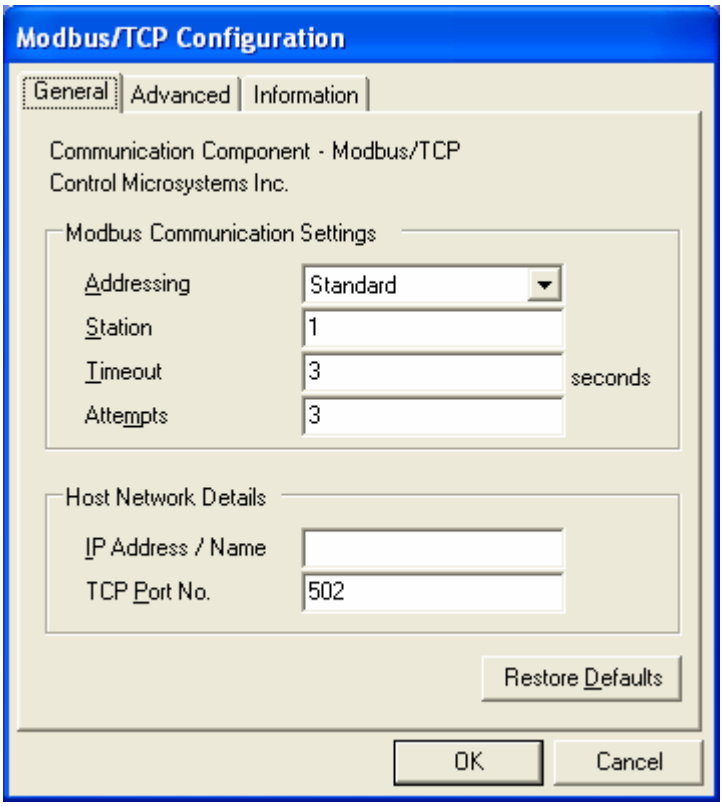


Figure 99: Modbus/TCP Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

The **Host Network Details** grouping contains entries for the host's IP address or name and the TCP port on which it is listening.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **TCP Port No.** field specifies the UDP port of the remote device. Valid values are 0 to 65535. The default value is 502.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.11.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

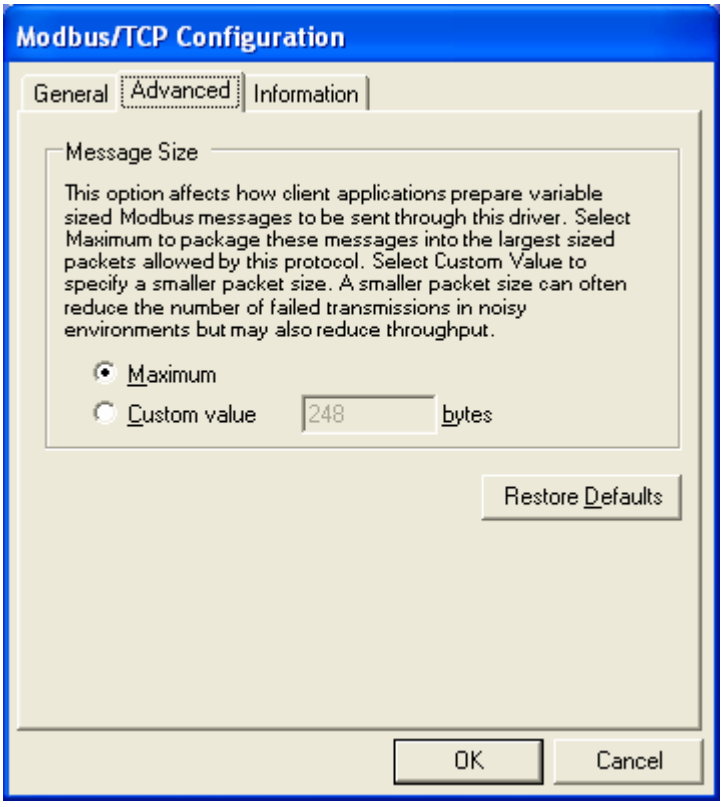


Figure 100: Modbus/TCP Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication

networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 246 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 248. When Addressing is set to Standard valid values are 2 to 248.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.11.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

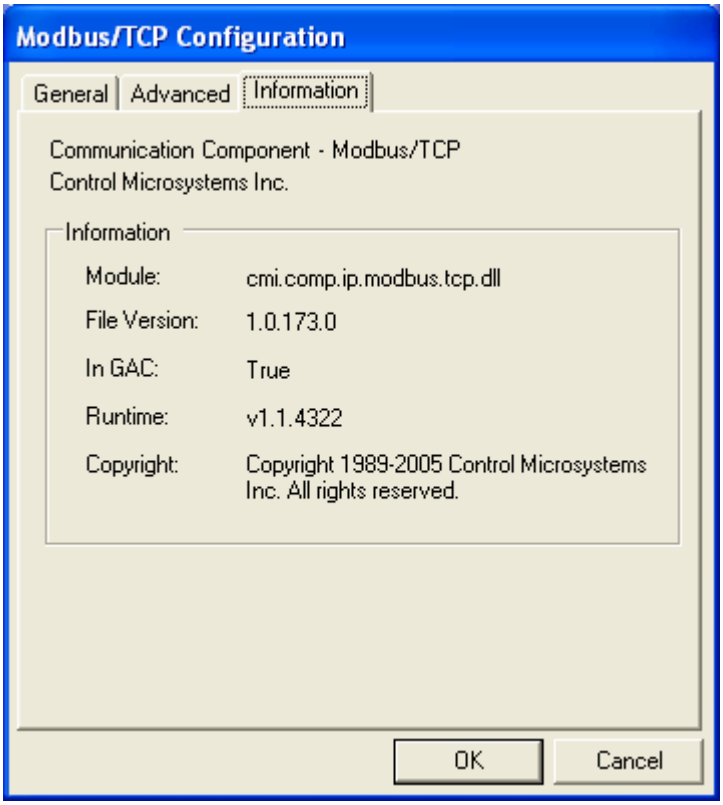


Figure 101: Modbus/TCP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.12 Modbus/UDP

Modbus/UDP communication mode is similar to Modbus/TCP communication mode. It has the same message format with the Modbus/TCP. The only difference between them is one uses TCP protocol and another uses UDP protocol.

- To configure a Modbus/UDP protocol connection, highlight **Modbus/UDP** in the Communication Protocols window and click the **Configure** button. The Modbus/ UDP Configuration window is displayed.
- To select a configured Modbus/UDP protocol connection, highlight **Modbus/ UDP** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.12.1 General Parameters

When Modbus/UDP is selected for configuration the Modbus/ UDP Configuration dialog is opened with the General tab selected as shown below.

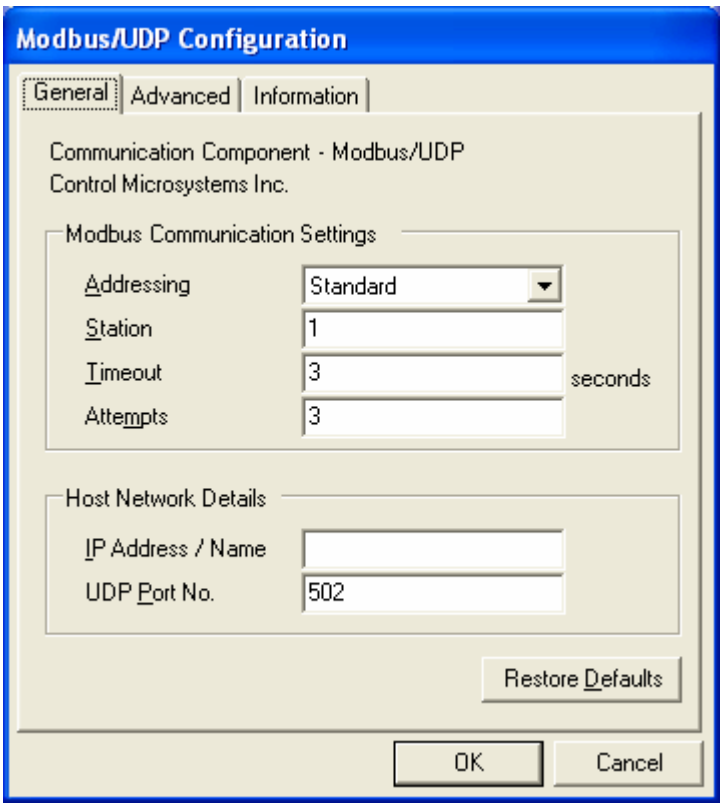


Figure 102: Modbus/UDP Configuration (General) Dialog Box

The **Modbus Communication Settings** grouping contains Modbus specific communication settings including the addressing mode, the station address, the timeout interval as well as the number of attempts.

The **Addressing** parameter selects standard or extended Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices. Extended addressing allows 65534 stations, with stations 1 to 254 compatible with standard Modbus devices. The default is Standard.

The **Station** parameter sets the target station number. The valid range is 1 to 255 if standard addressing is used, and 1 to 65534 if extended addressing is used. The default is 1.

The **Timeout** parameter sets the length of time, in seconds, to wait for a response from the controller before retrying (see Attempts), or ultimately failing. Valid entries are 1 to 255. The default is 3.

The **Attempts** parameter sets number of times to send a command to the controller before giving up and reporting this failure to the host application. Valid entries are 1 to 20. The default is 3.

The **Host Network Details** grouping contains entries for the host's IP address or name and the TCP port on which it is listening.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)
- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

The **UDP Port No.** field specifies the UDP port of the remote device. Valid values are 0 to 65535. The default value is 502.

- Click **Restore Defaults** to restore default values to all fields on this page, except for the IP Address / Name field. The content of this field will remain unchanged.

6.3.12.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

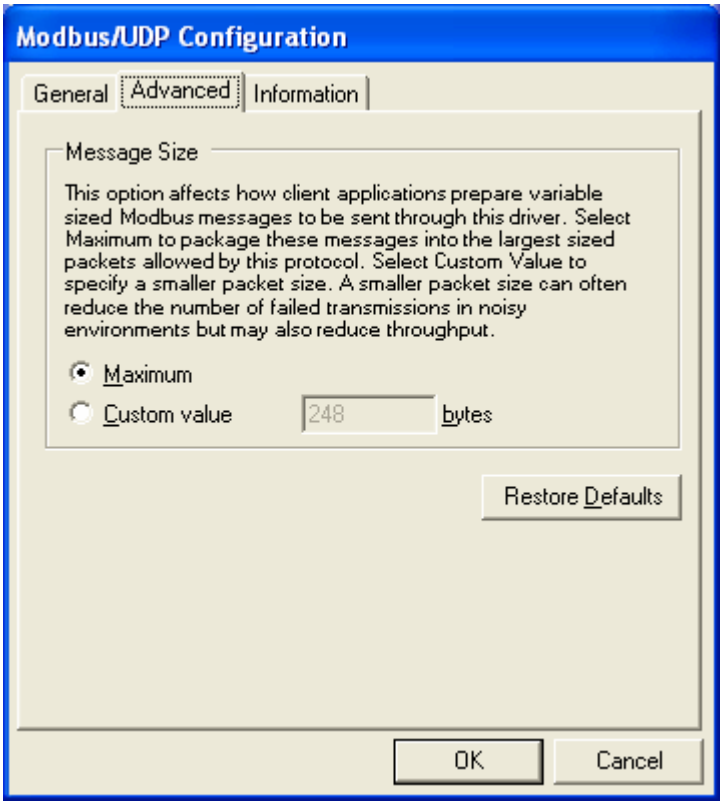


Figure 103: Modbus/UDP Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 246 when Addressing is set to Extended and Station is 255 or higher. When Addressing is set to Extended and Station is less than 255 valid values are 2 to 248. When Addressing is set to Standard valid values are 2 to 248.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.12.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

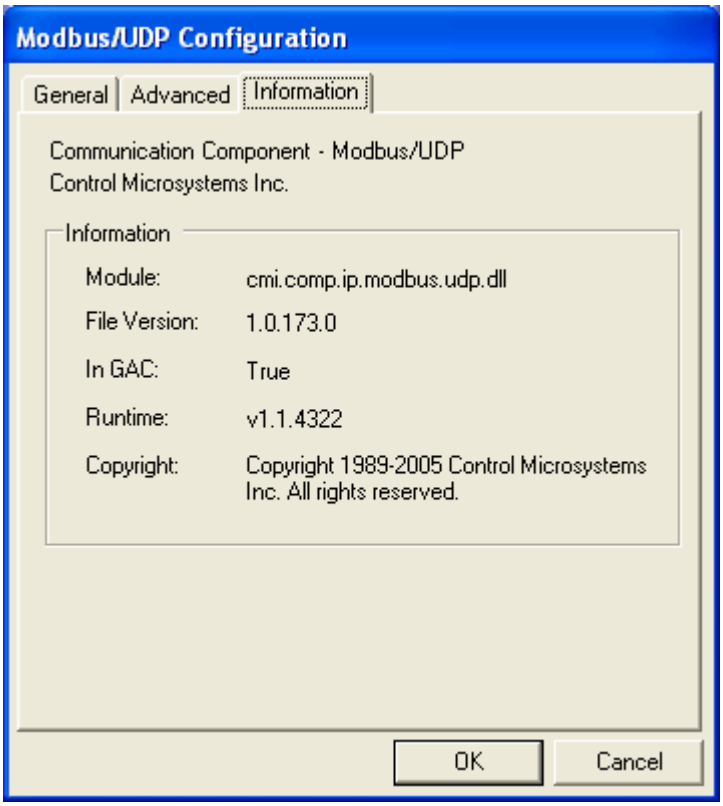


Figure 104: Modbus/UDP Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.13 Modbus/USB

This driver provides the means to communicate with SCADAPack controllers equipped with a Universal Serial Bus (USB) peripheral port using Modbus/USB messaging. The driver does not require configuration making it possible to connect and communicate with a SCADAPack controller almost instantaneously.

- To configure a Modbus/USB protocol connection, highlight **Modbus/USB** in the Communication Protocols window and click the **Configure** button. The Modbus/ USB

Configuration window is displayed. The pages in this configuration window are described in the sections below.

- To select a configured Modbus/USB protocol connection, highlight **Modbus/ USB** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

The following sections describe the information presented and user input required to configure the **Modbus/USB** driver.

6.3.13.1 General Page

The general page identifies the type of driver and its author. This page also allows a user to specify how the application searches and connects to a USB equipped SCADAPack controller. User input depends on the number of USB equipped controllers connected on the bus.

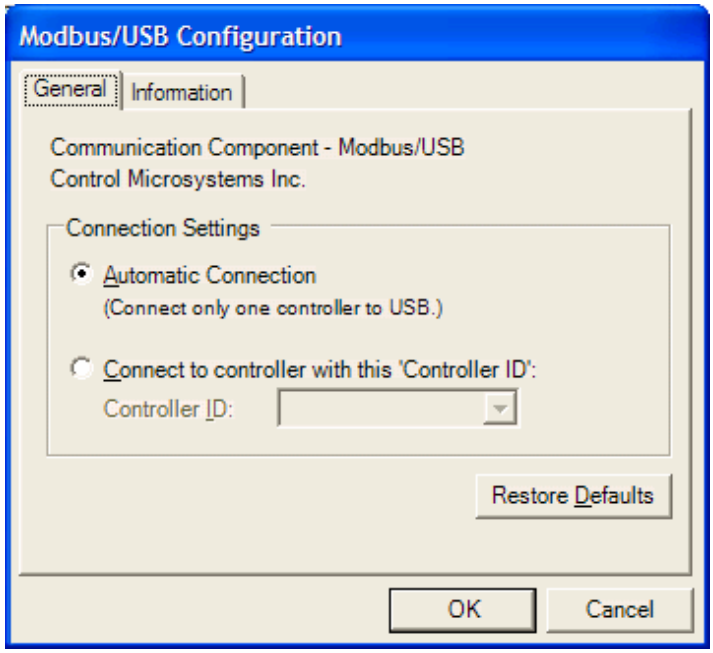


Figure 105: Modbus/USB Configuration (General) Dialog Box

The **Connection Settings** grouping presents two connection options:

- Select **Automatic Connection** when a single controller is present on the bus.

A typical scenario involves a single controller connected directly to a USB port on the host PC.

The driver will reject connection requests by the application if this mode is selected with multiple controllers detected on the bus. In this case, the following error message is displayed:

Figure 106: Multiple Controller USB Error Dialog

Note that this option is selected by default.

- Select **Connect to controller with this 'Controller ID** when multiple controllers are present on the bus.

A typical scenario involves more than one USB equipped SCADAPack controller connected via a USB hub to the host PC.

If multiple controllers exist on the bus, the controller ID drop down box will display a list of all identifiable devices. The user connects to the controller in question by selecting its Controller ID from the list. The Controller ID takes on the format 'A123456' and can be found printed on the controller casing or the circuit board.

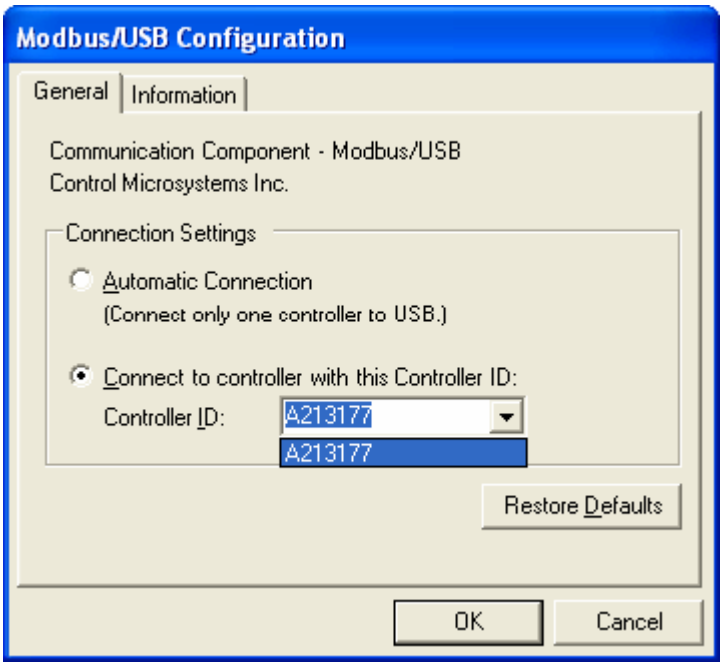


Figure 107: Selecting a USB controller from list

Note that this option can also be used when there is a single controller present on the bus. However, the Controller ID must be known and entered in the Controller ID dialog.

The chosen controller does need to be present on the bus at configuration time.

- Click on the **Restore Defaults** button to reset the page contents to its default state.

In the default state, the **Automatic Connection** option is selected and the **Controller ID** text box is disabled. Any text in the Controller ID text box remains but is displayed in grey.

6.3.13.2 Information Page

The Information page identifies the driver type and author. This page further provides detailed driver information which can be useful in identification and troubleshooting scenarios.

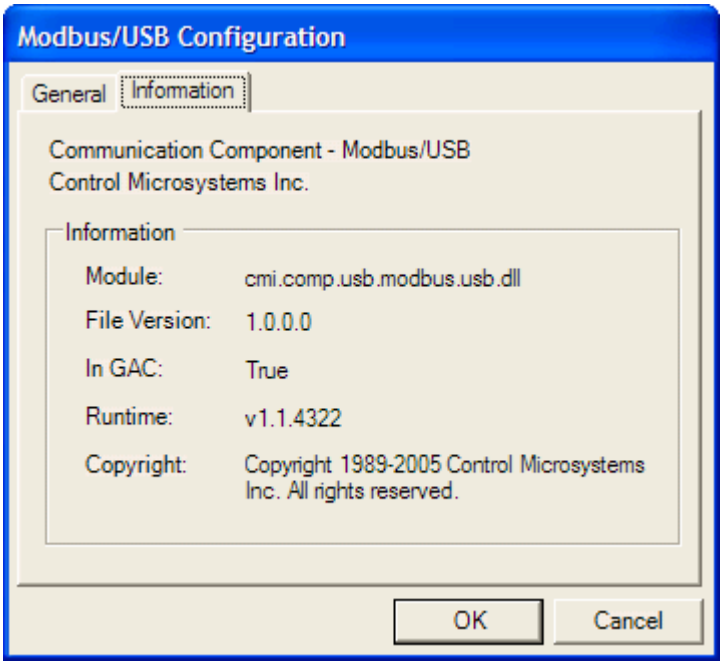


Figure 108: Modbus/USB Configuration (Information) Dialog Box

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

6.3.14 SCADAServer

The SCADAServer protocol specifies a SCADAServer Host connection. Applications will act as an OPC client and route all programming commands through the SCADAServer Host to the SCADAPack controller. The type of connection to the field device: no flow control, hardware flow control or dial-up modem is configured in the SCADAServer Host itself.

- To configure a SCADAServer protocol connection, highlight **SCADAServer** in the Communication Protocols window and click the **Configure** button. The SCADAServer Configuration window is displayed.
- To select a configured SCADAServer protocol connection, highlight **SCADAServer** in the Communication Protocols window and click the **OK** button.
- To close the dialog, without making a selection click the **Cancel** button.

6.3.14.1 General Parameters

When SCADAServer is selected for configuration the SCADAServer Configuration dialog is opened with the General tab selected as shown below.

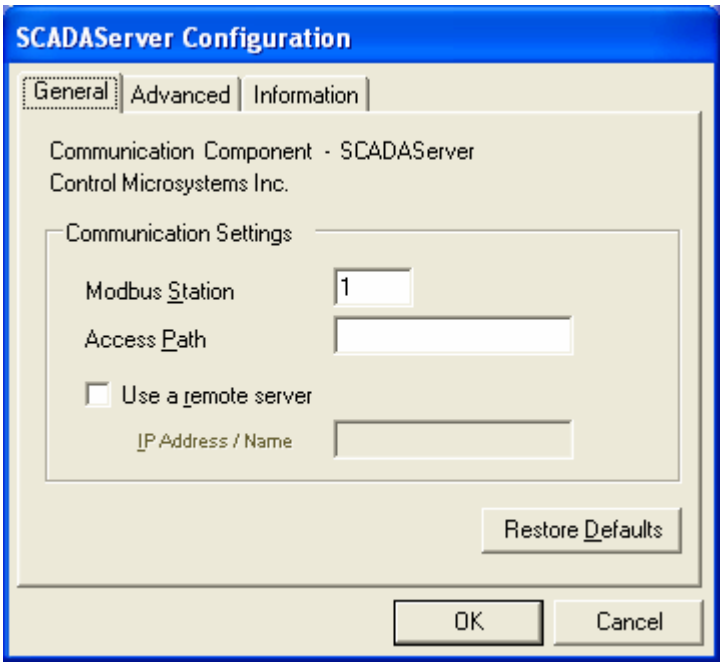


Figure 109: SCADAServer Configuration (General) Dialog Box

The **Communication Settings** grouping contains all essential details necessary to establish communication to a device through a local or remote SCADAServer installation.

The **Modbus Station** parameter specifies the station address of the target device. The valid range is 1 to 65534. The default is station 1.

The **Access Path** parameter specifies the access path to a SCADAServer connection. This parameter is entered as a string with a maximum size of 16 characters. This access path was named when a connection was defined within the SCADAServer installation. If the access path is left blank, the default SCADAServer connection will be used, as defined within the SCADAServer installation. The default for this entry is blank.

The **Use a remote server** check box defines whether the SCADAServer connection uses a SCADAServer installation installed on the same physical PC as the client application or on a remote PC. If the SCADAServer installation is located on a separate machine, check this option and enter the host name or IP address of the remote PC into the "IP Address / Name" edit box. If the SCADAServer installation is located on the same PC as the client application leave this box unchecked. The default state for this check box is unchecked.

The **IP Address / Name** entry specifies the Ethernet IP address in dotted quad notation, or a DNS host name that can be resolved to an IP address, of the PC where the ClearSCADA server is installed. The following IP addresses are not supported and will be rejected:

- 0.0.0.0 through 0.255.255.255
- 127.0.0.0 through 127.255.255.255 (except 127.0.0.1)

- 224.0.0.0 through 224.255.255.255
- 255.0.0.0 through 255.255.255.255.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.14.2 Advanced Parameters

Advanced parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput. When the Advanced tab heading is clicked the Advanced dialog is opened as shown below.

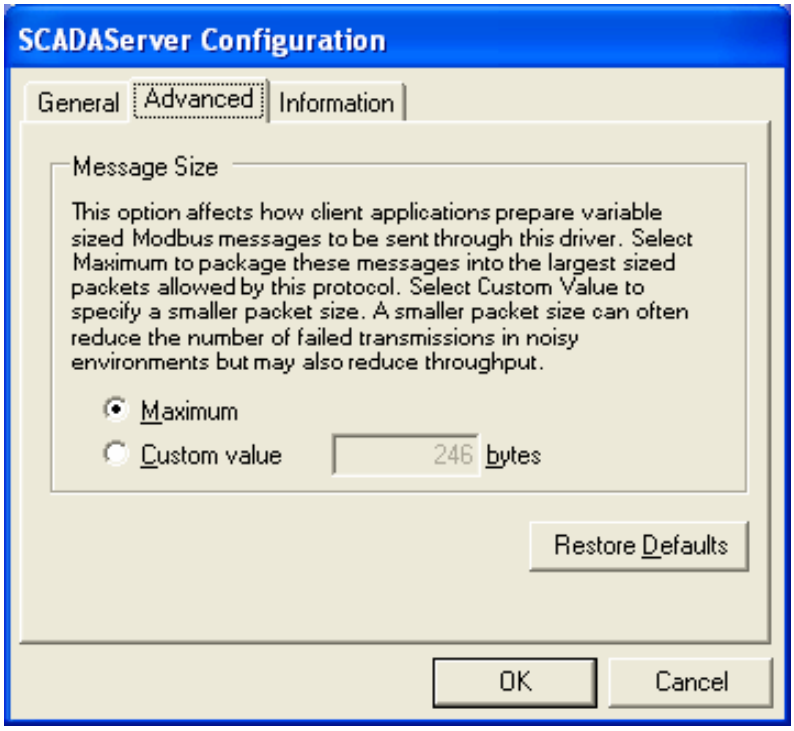


Figure 110: SCADAServer Configuration (Advanced) Dialog Box

The **Message Size** grouping parameters are used to control the message size for the protocol. Control over message length is needed when writing large amounts of data over certain communication networks. A larger value can improve communication speed but can increase the number of failed transmissions. A smaller value can reduce the number of failed transmissions but may reduce throughput.

The **Maximum** selection indicates that the host application is to package messages using the maximum size allowable by the protocol.

The **Custom Value** selection specifies a custom value for the message size. This value indicates to the host application to package messages to be no larger than what is specified, if it is possible. Valid values are 2 to 246.

- Click **Restore Defaults** to restore default values to all fields on this page.

6.3.14.3 Information

Information displays detailed driver information. When the Information tab heading is clicked the Information dialog is opened as shown below.

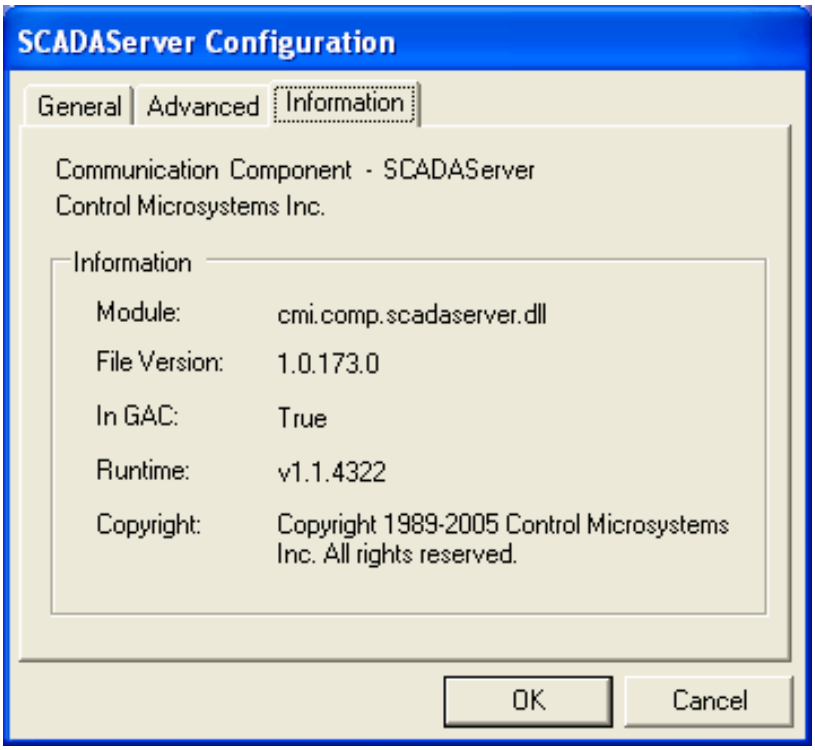


Figure 111: SCADAServer Configuration (Information) Dialog Box

The Information grouping presents informative details concerning the executing protocol driver.

Module is the physical name of the driver.

File Version is the version number of the driver.

In GAC indicates whether the module (assembly) was loaded from the Global Assembly Cache (GAC).

Runtime is the version of the Common Language Runtime (CLR) the driver was built against.

Copyright indicates the copyright information of the protocol driver.

7 Activity Menu

The Activity commands select the mode of operation for the TelePACE program. The TelePACE program can operate in three different programming modes, Edit Off Line, Edit On Line and Monitor On Line. A check mark on the Activity drop down menu selection indicates the current mode.

7.1 Edit Off Line

The Edit Off Line selection enables editing of a ladder logic program without a connection to a controller. The editing commands affect only the program file in use in the TelePACE Network Ladder Editor. Forcing commands cannot be used in this mode. All other TelePACE commands can be used in this mode.

7.2 Edit On Line

The Edit On Line selection is used to edit a ladder logic program loaded into a controller. All editing commands affect the program in the controller and the file in the TelePACE Ladder Network Editor. The multiple element selection and the cut, copy and paste functions of the Editor are not available in this mode. Forcing commands can be used in this mode.

7.3 Monitor On Line

The Monitor On Line selection enables the monitoring of a program executing in a controller. The editor shows the power flow through the ladder network on the screen. The Monitor List window is displayed. No changes can be made to the program in monitor mode. Editing commands are disabled on the menus. Forcing commands can be used in this mode. The C program loader is disabled in this mode.

8 Operation Menu

The Operation menu commands control the execution of the ladder logic program in the controller. (Control of execution of a C Program in the controller is controlled from the C Program Loader dialog.) The status of ladder logic program execution in the controller is displayed on the Status Bar.

8.1 Stop

The Stop command stops execution of the ladder logic program in the controller.

8.2 Debug

The Debug command start's the execution of the ladder logic program in debug mode. In debug mode the monitor on line feature of the editor can be used to monitor the operation of the program. The program runs slower in debug mode than in run mode.

8.3 Run

The Run command starts execution of the ladder logic program in run mode. The monitor on line feature of the editor cannot be used to monitor execution in this mode.

9 Options Menu

The Options menu commands are used to modify the Ladder Network Editor display, the use of multiple coils and warning message options. The Option drop-down menu allows selection of the option to modify.

9.1 Screen Font

The Screen Font selection selects the font used to display text on the Ladder Editor pane. This selection does not affect the font in the Comment Editor pane, this pane uses the system font. A dialog box appears that allows selection of the Font, Font Style and the Size of the font to be used in the Ladder Editor pane.

9.2 Colors

The Colors dialog sets the colors used to display networks on the ladder editor and monitor on line screens. The sample text and elements show how the colors look for the Edit Modes, Monitor Mode, Forced Elements and the Contact Monitor.

The **Item** drop-down list box selects which item to modify. The follow items can be changed:

- Element
- Power Flow
- Cursor
- Forced (Foreground)
- Forced (Background)
- Contact Power Flow
- The **Color** drop-down list box selects the color for the item.
- Click **Default** to return the color selections to default values.
- Click **OK** to accept the changes or **Cancel** to cancel the changes.

9.3 Floating-Point Settings

The Floating Point dialog controls the display precision and format of floating point numbers used in TelePACE.

The Display Precision selection sets the number of digits after the decimal place that will be displayed. Valid entries are 1 through 7. The default value is 2.

The Format drop down box selects the format of floating point numbers. The valid selections are:

- Fixed displays numbers in the format ####.##.
- Scientific displays numbers in the format #.### E###.

Click **OK to** close the dialog and save the settings.

Click **Cancel** to close the dialog and discards the changes.

9.4 Tool Bar

Selecting the Tool Bar option enables the Tool Bar to be displayed in the Network Editor. A check mark to the left of the selection indicates the Tool Bar is active.

9.5 Title Bar

Selecting the Title Bar option enables the Title Bar to be displayed in the Network Editor. A check mark to the left of the selection indicates the Title Bar is active.

9.6 Status Bar

Selecting the Status Bar option enables the Status Bar to be displayed in the Network Editor. A check mark to the left of the selection indicates the Status Bar is active.

9.7 Single Tag Names

The Single Tag Names selection enables the Editor to use one line to display tag names and addresses on the Editor screen and printed network listings. The first 8 characters of the tag name are displayed. A numeric value will be displayed if no tag name is defined for the address or constant. A check beside the selection on the pull down menu indicates the mode selected.

9.8 Double Tag Names

The Double Tag Names selection enables the Editor to use two lines to display tag names and addresses on the Editor screen and printed network listings. The first 16 characters of the tag name will be displayed. A numeric value will be displayed if no tag name is defined for the address or constant, or if the tag name is 8 characters or less in length. A check beside the selection on the pull down menu indicates the mode selected.

9.9 Tag and Address

The Tag and Address selection enables the Editor to use three lines to display tag names and addresses on the Editor screen and printed network listings. The first 16 characters of the tag name are displayed, followed by the numeric address. A numeric value alone will be displayed if no tag name is defined for the address or constant. A check beside this selection on the pull down menu indicates the mode selected. A check beside the selection on the pull down menu indicates the mode selected.

9.10 Numeric Address

The Numeric Address selection enables the Editor to use one line for numeric addresses on the editor screen and printed network listings. No tag name is displayed, even if one is defined. A check beside the selection on the pull down menu indicates the mode selected.

9.11 Allow Multiple Coils

The Allow Multiple Coils selection enables the use of multiple coils. Multiple coils are coils with the same address.

When the Allow Multiple Coils is not selected the Editor will not allow the insertion of a coil that has an address already in use in the program. An error message is displayed when the insertion is attempted.

When the Allow Multiple Coils is enabled a Dialog box is displayed asking for confirmation when a coil is inserted that has an address already in use in the program. A check beside this selection in the pull down menu indicates multiple coils are allowed.

A check mark is displayed beside this command when it is enabled.

9.12 Warning Messages

The Warning Messages option enables additional warning messages. A check mark is displayed beside this command when it is enabled.

When this option is enabled warning messages are displayed on all errors.

When this option is disabled, some warning messages are replaced by a beep. This speeds up editing for experienced users as they do not have to clear a message box when they occasionally make a mistake.

10 Help Menu

The Help selection allows access to the TelePACE program extensive on line help. A drop down menu displays the selections for Contents, How to Use Help and About Program.

10.1 Contents

The Contents selection displays the TelePACE Program Help Window. Help is available on the following topics.

The **TelePACE Program Reference** describes how each TelePACE command works.

The **Ladder Logic Function** *Reference* describes the logic function blocks.

The **Controller Register Assignment** describes the I/O modules used in the Register Assignment.

10.2 About Program

The About Program selection displays program version information and technical support phone and fax numbers.

TelePACE Ladder Logic

Function Reference

CONTROL MICROSYSTEMS

SCADA products... for the distance

48 Steacie Drive
Kanata, Ontario
K2K 2A9
Canada

Telephone: 613-591-1943
Facsimile: 613-591-1022
Technical Support: 888-226-6876
888-2CONTROL

TelePACE Ladder Logic Function Reference

Printed in Canada.

Trademarks

Table of Contents

1 Register Types

TelePACE function elements support a number of different register formats. The type of register format used will depend on the type function. The following table defines the register formats used.

Unsigned Integer	Unsigned integer data are in the range 0 to 65535. This data requires a single 16-bit register, 3xxxx or 4xxxx.
Signed Integer	Signed integer data are in the range –32768 to 32767. This data requires a single 16-bit register, 3xxxx or 4xxxx.
Unsigned Double	Unsigned long integer data are in the range 0 to 4,294,967,295. This data requires two 16 bit registers, 3xxxx or 4xxxx. The lower numbered register contains the lower order word.
Signed Double	Signed long integer data are in the range -2,147,483,648 to 2,147,483,647. This data requires two 16 bit registers, 3xxxx or 4xxxx. The lower numbered register contains the lower order word.
Floating Point	Floating-point data are in the IEEE single precision floating-point format. This data requires two 16 bit registers, 3xxxx or 4xxxx. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

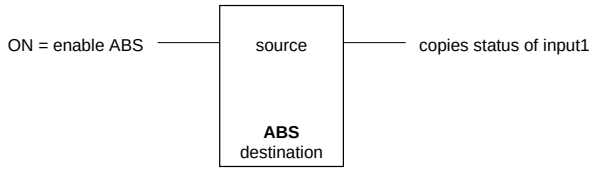
2 Ladder Logic Functions

The function blocks are described in detail in the pages that follow.

2.1 ABS – Absolute Value

Description

The **ABS** function stores the absolute value of a signed constant or register into a holding register. When the **enable ABS** is ON the absolute value of the **source** register or constant is stored in the **destination** holding register.



Function Variables

Variable	Valid Types	Description
Source	Constant (-32768...32767) input register (3xxxx) holding register (4xxxx)	a signed value or register
Destination	holding register (4xxxx)	destination = abs(source)

Related Functions

ABSF - Floating-Point Absolute Value

Example

network 1:

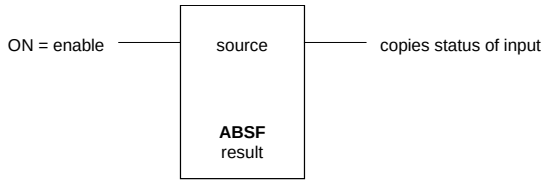
In this example the **absolute value** of the **source,** holding register 44001, is stored in the **destination,** holding register 45211. Assuming holding register 44001 has a value of -4455, the value stored in holding register 45211 would be +4455.

2.2 ABSF - Floating-Point Absolute Value

Description

The ABSF element stores the absolute value of a floating-point register or constant in a floating-point holding register.

When the **enable** input is ON the absolute value of the source is stored in the **result** floating-point holding register. The element output is ON when the input is.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
Source	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant value
Result	2 holding registers (4xxxx)	floating-point absolute value of source register

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

Floating point numbers can represent positive and negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

ABS – Absolute Value

Example

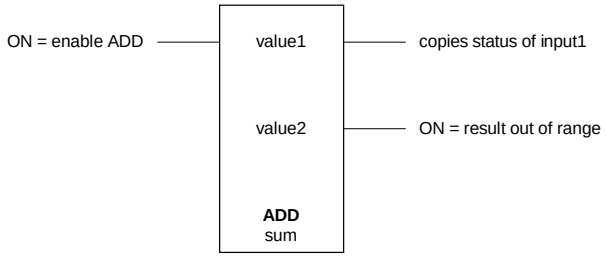
In this example the **absolute value** of the **source,** holding register 40001, is stored in the **result,** floating point register 45555. Assuming floating point register 40001 contains a floating-point value of – 77988.99, the value stored in floating point register 45555 would be +77988.99.

2.3 ADD – Add Signed Values

Description

The **ADD** function block adds two registers or constants and stores the result in a holding register. Signed addition is used. If the result is out of range, the sum rolls over and the out of range output is enabled.

When the **enable ADD** input is ON the sum of **value 1** and **value 2** is stored in **sum** holding register. If the sum is out of range (–32768...32767) the **result out of range** output is ON.



Function Variables

Variable	Valid Types	Description
Value 1	Constant (-32768...32767) input register (3xxxx) holding register (4xxxx)	first signed value to add
Value 2	constant (-32768...32767) input register (3xxxx) holding register (4xxxx)	second signed value to add
Sum	holding register (4xxxx)	sum = value 1 + value 2

Related Functions

ADDF - Add Floating-Point Values

ADDU – Add Unsigned Values

Example

The ADD function in network 1 adds holding register 42399 to holding register 43567 and stores the result is holding register 44981. When the addition is out of range – less than –32768 or greater than 32767-output coil 00017 is energized. The table below shows some examples.

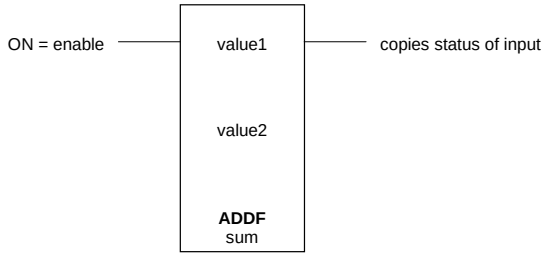
value 1	Value 2	sum	out of range
Holding Register 42399	Holding Register 43567	Holding Register 44981	Output Coil 00017
23411	1098	24509	OFF
–2047	819	–1228	OFF
12767	23000	–29769	ON

2.4 ADDF - Add Floating-Point Values

Description

The **ADDF** element adds two floating-point registers or constants and stores the result in a floating-point holding register.

When the **enable** input is ON the sum **value 1** + **value 2** is stored in the **sum** floating point register. The element output is ON when the input is.



Function Variables

The element has three parameters.

Variable	Valid Types	Description
Value1	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	first floating-point register or constant value to add
Value2	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	second floating-point register or constant value to add
Sum	2 holding registers (4xxxx)	floating-point sum = value1+value2

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

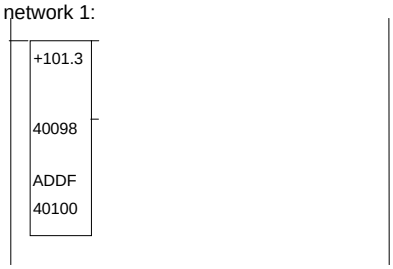
Floating point numbers can represent positive and negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

ADD – Add Signed Values

ADDU – Add Unsigned Values

Example



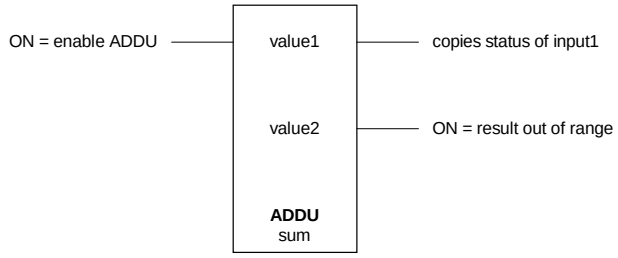
The ADDF function in network 1 adds floating-point constant +101.3 to floating-point register 40098 (registers 40098 and 40099). Assuming floating point register 40098 contains a value of +1000.00 then the result is +1101.30. This value is stored in floating-point register 40100 (registers 40100 and 40101).

2.5 ADDU – Add Unsigned Values

Description

The **ADDU** function block adds two registers or constants and stores the result in a holding register. Unsigned addition is used. If the result is out of range, the sum rolls over and the out of range output is enabled.

When the **enable ADDU** input is ON the sum of **value 1** and **value 2** is stored in **sum** holding register. If the sum is out of range (> 65535) the **result out of range** output is ON.



Function Variables

Variable	Valid Types	Description
Value 1	constant (0...65535) input register (3xxxx) holding register (4xxxx)	first unsigned value to add
Value 2	constant (0...65535) input register (3xxxx) holding register (4xxxx)	Second unsigned value to add
Sum	holding register (4xxxx)	Sum = value 1 + value 2

Related Functions

ADD – Add Signed Values

ADDF - Add Floating-Point Values

Example

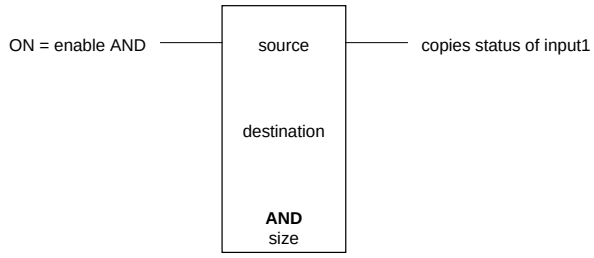
The ADDU function in network 1 adds holding register 46549 to holding register 44723 and stores the result is holding register 44483. When the addition is out of range, greater than 65535, output coil 00021 is energized. The table below shows some examples.

value 1	Value 2	Sum	out of range
Holding Register 46549	Holding Register 44723	Holding Register 44483	Output Coil 00021
2048	819	2867	OFF
23000	42530	65530	OFF
35000	35000	4464	ON

2.6 AND – And Block

Description

The **AND** function block logically ANDs the **source** block of registers with the **destination** block of registers and stores the result in the **destination** block of registers. The number of registers in the source and destination blocks is determined by the **size**.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the first source block. The address for a coil or status register block is the first register in a group of 16 registers that will be ANDed.
Destination	coil block (0xxxx) holding register (4xxxx)	The first register in the second source block and destination block. The address for a coil register block is the first register in a group of 16 registers that will be ANDed.
Size	constant (1...100)	The number of 16 bit words in the block.

Notes

AND accesses 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

Related Functions

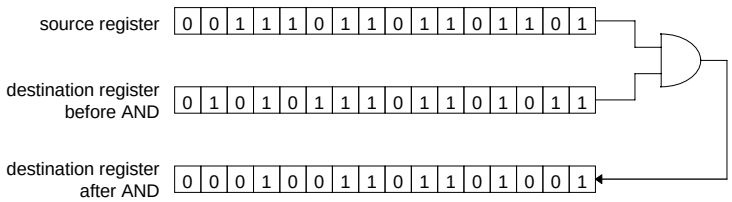
OR – Or Block

XOR – Exclusive Or Block

NOT – Not Block

Example

In this example the source register has a value of 1521310 (0011101101101101). The destination register has a value of 2237910 (0101011101101011) before the AND function and a value of 496910 (0001001101101001) after the AND function.



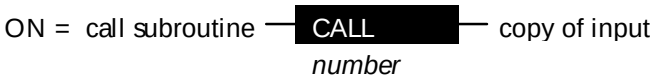
2.7 CALL - Execute Subroutine

Description

The **CALL** element transfers execution from the **main** program to a **subroutine**. Execution of the main program is suspended until the subroutine returns.

Subroutine calls can be used to execute parts of a program only when needed. The subroutine is called only if the input to the **CALL** element is ON.

The function variable *number* indicates which subroutine to call. The subroutine number must correspond to the number of a SUBR element.



Function Variables

The **CALL** element has one parameter:

Variable	Valid Types	Description
Number	Constant	the number of the subroutine. Any number in the range 1 to 500 is valid.

Notes

A subroutine can call other subroutines. This is called nesting. The maximum level of nesting is 20 calls.

Subroutine calls cannot be recursive. For example, subroutine 1 cannot call itself or call another subroutine that calls subroutine 1. This prevents potential infinite loops in the ladder logic program.

The normal order of network evaluation is followed when executing each network. Execution proceeds down the columns, then across the rows. When the **CALL** function is executed, the execution of the current network is suspended at the point of the **CALL** until the subroutine returns.

A subroutine can be called by one or more **CALL** elements.

Related Functions

SUBR - Start of Subroutine

Example

This example calls subroutine 1 when input 10001 is on. Subroutine 1, in turn, calls Subroutine 2. The sequence of execution is as follows.

The networks in the start of the main program are executed.

If input 10001 is on, Subroutine 1 is called.

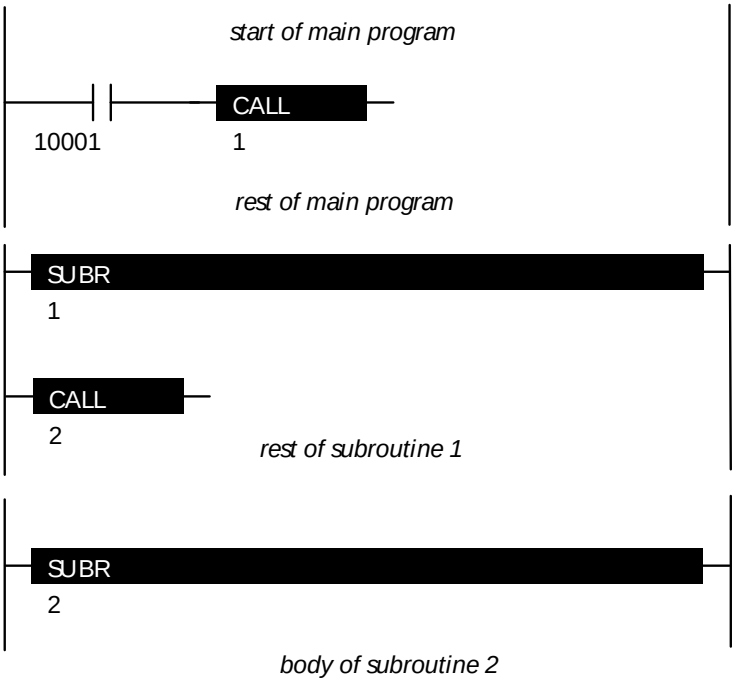
At the beginning of Subroutine 1, Subroutine 2 is called.

The body of Subroutine 2 is executed.

The rest of Subroutine 1 is executed.

The networks in the rest of the main program are executed.

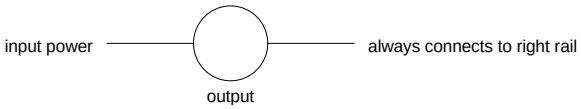
When execution reaches the start of Subroutine 1, the main program is complete. Execution starts over at the start of the main program.



2.8 Coil

Description

The **COIL** function block enables an **output** coil when its **input power** is ON.



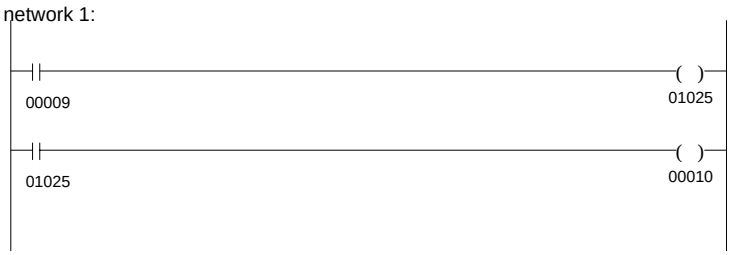
Function Variables

Variable	Valid Types	Description
Output	coil register (0xxxx)	output register address

Related Functions

One Shot Coil

Example

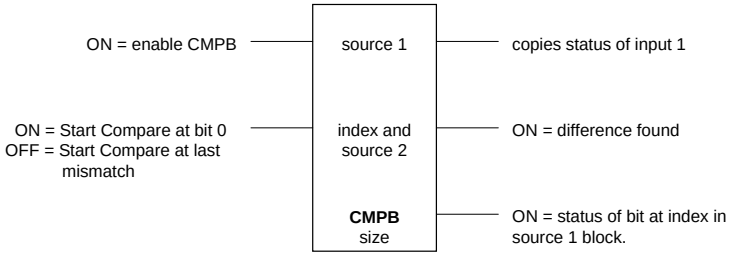


When discrete input contact 00009 is closed power is applied to the **input power** input of coil 01025. This will enable the coil and the associated contact of 01025 is energized. The NO contacts 01025 are closed and this causes power to be applied to output coil 00010.

2.9 CMPB – Compare Bit

Description

The **CMPB** function block compares two blocks of registers, bit by bit and identifies the first bit that does not match. The bit index will be set to the bit offset of the first mismatched bit.



Function Variables

Variable	Valid Types	Description
Source 1	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the first source block. The address for a coil or status register block is the first register in a group of 16 registers that will be compared.
Index and source 2	holding register (4xxxx)	The bit index register and the second block of source registers. The bit index is in register [4xxxx]. A bit index of 0 is the most significant bit of the first register of the source blocks. The second source register block is at register [4xxxx+1] to register [4xxxx+ size].
Size	constant (1..100)	The number of 16 bit words in the blocks.

Notes

Compare accesses 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

Related Functions

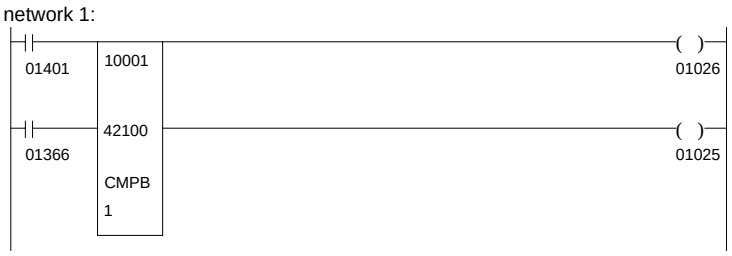
CMP – Compare Signed Values

CMPU – Compare Unsigned Values

GTEF – Floating-Point Greater Than or Equal

LTEF - Floating-Point Less Than or Equal

Example



The CMPB function in network 1 is used to check the status inputs 10001 to 10016. If Holding Register 42100 is set to zero, with a PUTU function, any status inputs in the range 10001 to 10016 that are on will be detected by the CMPB function.

Using the information in the chart below, status input registers 10004,10013 and 10014 are on. Closing contacts 01366 will start the index at bit 0 and the index will be set to the bit offset of the first mismatched bit, bit 2. Discrete output coil 01026 will be on and discrete output coil 01025 will be on.

If contacts 01366 are left closed the index will start at bit 0 and be set to the bit offset of the first mismatched bit, bit 2, on each scan of network 1. Discrete output coil 01026 will be on and discrete output coil 01025 will be on.

Opening contacts 01366 will allow the index to start at bit 2 on the next scan of network 1. The index will be set to the bit offset of the next mismatched bit, bit 3. Discrete output coil 01026 will be on and coil register 01025 will be on.

On the next scan of network 1 the index will start at bit 3. The index will be set to the bit offset of the next mismatched bit, bit 12. Coil 01026 will be on and coil register 01025 will be on.

The next scan of network 1 will have the index starting at bit 12. The remaining bits are compared and no further mismatches occur. The index will be set to bit 15 and wait for the contacts 01366 to close to start the compare at bit index 0.

Bit Index:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discrete Input State:	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Discrete Input Address: (read top to bottom)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1

2.10 CMP – Compare Signed Values

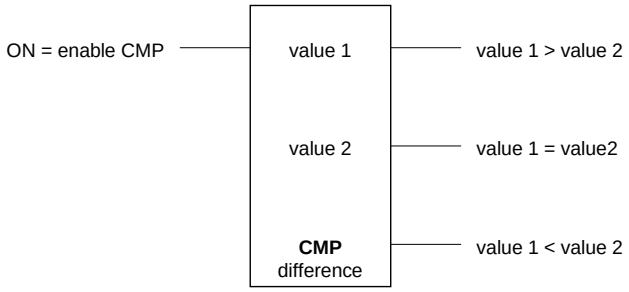
Description

The **CMP** function compares two signed registers or constants and stores the difference in a holding register. When the **enable CMP** input is energized **value 1** is compared to **value 2**.

If value 1 is greater than value 2 the **value 1 > value 2** output is energized and the difference of value 1 minus value 2 is stored in **difference** register.

If value 1 is less than value 2 the **value 1 < value 2** output is energized and the difference of value 2 minus value 1 is stored in the **difference** register.

If value 1 equals value 2 the **value 1 = value 2** output is energized and zero is stored in the **difference** register.



Function Variables

Variable	Valid Types	Description
value 1	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	first signed value to compare
Value 2	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	Second signed value to compare
Difference	holding register (4xxxx)	if value 1 > value 2 then difference = value 1 - value 2 if value 2 > value 1 then difference = value 2 - value 1

Related Functions

CMPU – Compare Unsigned Values

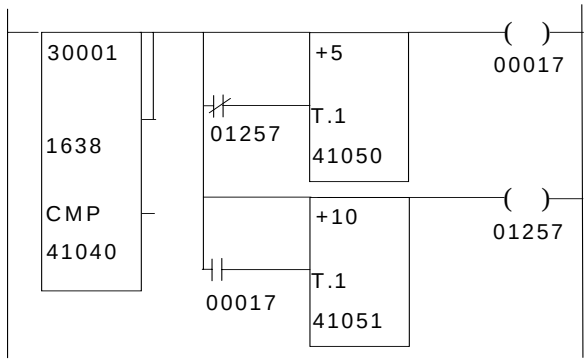
CMPB – Compare Bit

GTEF – Floating-Point Greater Than or Equal

LTEF - Floating-Point Less Than or Equal

Example

network 1:



The CMP function in network 1 above compares the signed value of Analog Input Register 30001 with the value 1638. The output coil 00017 could be tied to a light to indicate when the Input Register value is over 1638.

The **value 1 > value 2** and **value 1 = value 2** outputs are tied together. When value of register 30001 is greater than or equal to 1638 these outputs are energized. This will enable the flasher circuit of Timers 41050 and 41051 to energize and output coil 00017 will cycle at a rate of 1 second on and 0.5 seconds off.

2.11 CMPU – Compare Unsigned Values

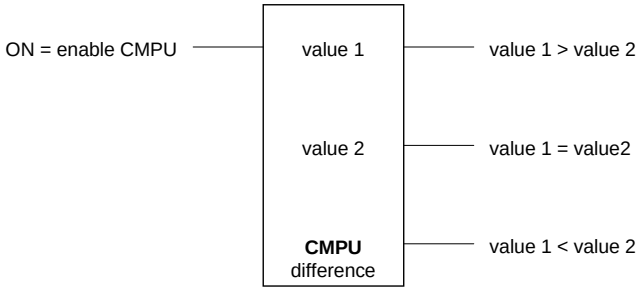
Description

The **CMPU** function compares two unsigned registers or constants and stores the difference in a holding register. When **enable CMPU** input is energized **value 1** is compared to **value 2**.

If value 1 is greater than value 2 the **value 1 > value 2** output is energized and the difference of value 1 minus value 2 is stored in **difference** register.

If value 1 is less than value 2 the **value 1 < value 2** output is energized and the difference of value 2 minus value 1 is stored in the **difference** register.

If value 1 equals value 2 the **value 1 = value 2** output is energized.



Function Variables

Variable	Valid Types	Description
value 1	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	first unsigned value to compare
Value 2	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	Second unsigned value to compare

Difference	holding register (4xxxx)	If value 1 > value 2 then
		Difference = value 1 - value 2.
		If value 2 > value 1 then
		difference = value 2 - value 1.

Related Functions

CMPB – Compare Bit

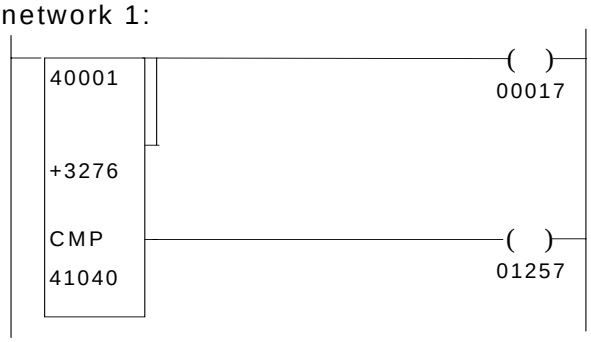
CMP – Compare Signed Values

GTEF – Floating-Point Greater Than or Equal

LTEF - Floating-Point Less Than or Equal

Example

network 1:



The CMPU function in network 1 above compares the unsigned value of holding register 40001 with the value 3276. Coil 00017 is energized when holding register 40001 is **greater than or equal to** the constant 3276.

The **value 1 > value 2** and **value 1 = value 2** outputs are tied together.

2.12 DCTR – Down Counter

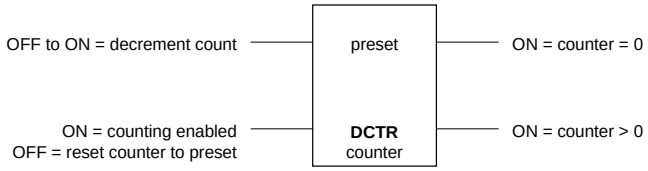
Description

The **DCTR** function block decrements (subtracts 1 from) the value in the **preset** register or constant and stores it in the **counter** holding register when the **decrement count input** changes from OFF to ON. The counter stops counting when it reaches 0.

When the **counting enabled** input is ON and the **decrement count** goes from OFF to ON the counter decrements by one. When the **counting enabled** input is OFF the counter value is reset to preset.

When the **counting enabled** input is ON and the counter has decremented to zero then the **counter = 0** output is ON.

When the **counting enabled** input is ON and the counter is greater than the preset then the **counter > 0** output is ON.



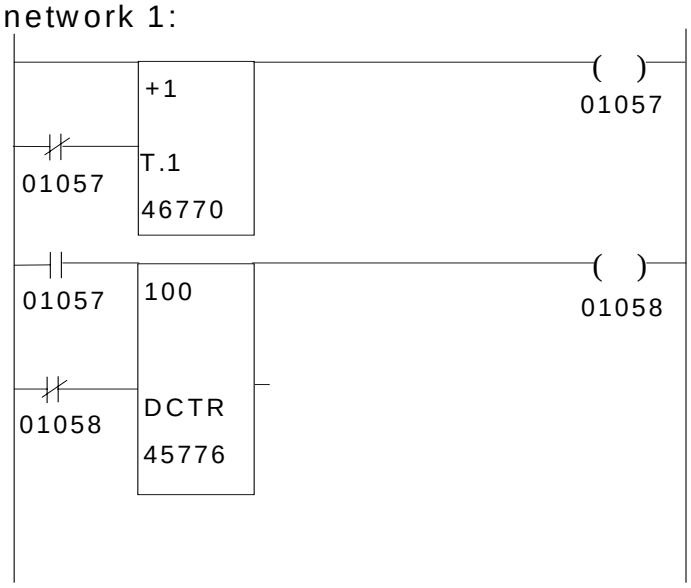
Function Variables

Variable	Valid Types	Description
Preset	constant (1..65535) input register (3xxxx) holding register (4xxxx)	Preset value for counter
Counter	holding register (4xxxx)	Current counter value

Related Functions

UCTR – Up Counter

Example



The DCTR function in network 1 decrements each time the timer output is enabled. The timer limit is 0.1 seconds and it will take 10 seconds for the DCTR to decrement 100 times.

When the DCTR decrements to 0, output coil 01058 is energized. NC contacts 01058 will open and the DCTR will reset counter to preset. This will happen every 10 seconds.

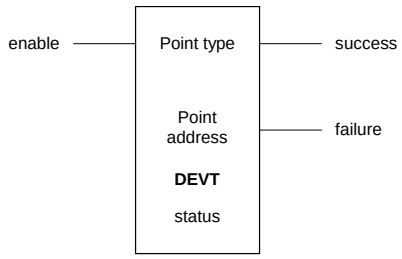
2.13 DEVT – Generate DNP Event

Description

This function generates a DNP change event for the specified DNP point.

A change event is generated for the **Point Address** specified when the **enable** input changes from OFF to ON. The **status** register is set to 0 and the **success** output is energized if the function is successful and a change event was generated.

The status register is set to 1 and the **failure** output is energized if the function failed and a change event was not generated. The failure output indicates that the specified DNP point is invalid, or the DNP configuration has not been created.



Function Variables

Variable	Valid Types	Description
Point Type	Constant or holding register (4xxxx)	DNP Point Type. Valid values are: 0 = Binary Input, 1 = 16-bit Analog Input, 2 = 32-bit Analog Input, 3 = Float Analog Input, 5 = 16-bit Counter Input, 6 = 32-bit Counter Input.
Point Address	Constant or holding register (4xxxx)	DNP Point Address
Status	Holding register (4xxxx)	Status of the operation 0 = success 1 = failure

Related Functions

DUNS – Trigger a DNP unsolicited response message

DPOL – Trigger a DNP class poll

Error! Not a valid link.

2.14 DIAL – Control Dial-Up Modem

Description

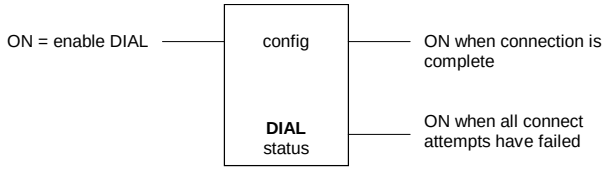
The DIAL function connects an internal modem or an external modem to a remote modem. Only one DIAL block may be active on each serial communication port at any one time. The DIAL function handles all port sharing and multiple dialing attempts.

Note: The SCADAPack 100 does not support dial up connections on com port 1. SCADASense Series controllers do not support dialup connections.

When the **enable DIAL** input is ON the DIAL element sends the modem initialization string to the modem. The modem will attempt to connect to the remote modem. If a connection is made the **ON when connection complete** output is turned ON. If a connection is not made in the specified number of attempts the **ON when all connect attempts have failed** output is turned ON.

The **enable DIAL** input must be energized for the entire DIAL time, including multiple dial attempts.

Note: A pause is required between hanging up the phone line after a DIAL and initiating a new DIAL attempt. This is required for the external modem to hang-up.



Function Variables

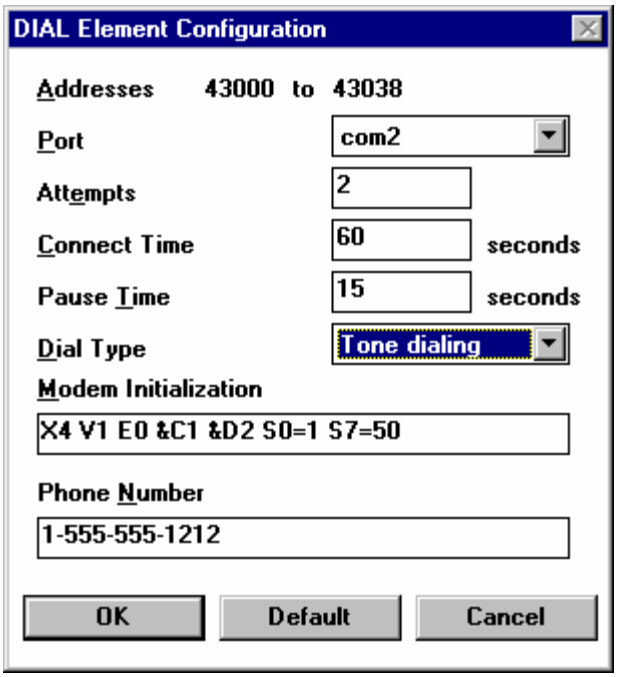
Variable	Valid Types	Description
Config	Holding register (4xxxx)	Address of the first register in the configuration block. There are 39 registers in the block at addresses config+0 to config+38. +0 = Communication port +1 = Dialing attempts +2 = Connect time +3 = Pause time +4 = Dialing type +5 = Length of modem string +6 = Modem initialization string +22 = Length of phone number +23 = Phone number NOTE: Registers should be programmed using the Element Configuration command.

Variable	Valid Types	Description
Config	Holding register (4xxxx)	Address of the first register in the configuration block. There are 39 registers in the block at addresses config+0 to config+38. +0 = Communication port +1 = Dialing attempts +2 = Connect time +3 = Pause time +4 = Dialing type +5 = Length of modem string +6 = Modem initialization string +22 = Length of phone number +23 = Phone number NOTE: Registers should be programmed using the Element Configuration command.
Status	Holding register (4xxxx)	address of the first register in the status block. There are 2 registers in the block at addresses status+0 and status+1. +0 = error code +1 = reservation identifier

Element Configuration

This element is configured using the DIAL Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the Initialize command in the Controller menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.



The modem initialization string and the phone number are packed. Two ASCII characters are stored in each register.

The **error** codes are:

Error Code	Description
0	No Error
1	Bad configuration error occurs when an incorrect initialization string is sent to the modem. This usually means the modem does not understand a specific command in the initialization string.
2	No modem connected to the controller serial port, or the controller serial port is not set to RS232 Modem.
3	Initialization error occurs when the modem does not respond to the initialization string and may be turned off.
4	No dial tone error indicates modem is not connected to a telephone line or the S6 setting in the modem is too short.
5	Busy line indicates another device is using the phone line.
6	Call aborted by the program. This will occur if the enable DIAL input goes OFF before a modem connection occurs.
7	Failed to connect error occurs when there are no other errors but the modem failed to make a connection with the remote modem.
8	Carrier lost error occurs when carrier is lost for a time exceeding the S10 setting in the modem. Phone lines with call waiting are very susceptible to this condition.
9	“Serial port is not available” error occurs when the DIAL function attempts to use the serial port when another ladder communication element, C program or an incoming call has control of the port.

Notes

The reservation identifier is required for the operation of the dialer but can be ignored by the ladder program.

The DIAL function outputs are powered only when the **enable DIAL** input is powered ON.

The dial-up connection handler prevents outgoing calls from using the serial port when an incoming call is in progress and communication is active. If communication stops for more than five minutes, then outgoing call requests are allowed to end the incoming call. This prevents problems with the modem or the calling application from permanently disabling outgoing calls.

Note:	The SCADAPack 100 does not support dial up connections on com port 1. SCADASense Series controllers do not support dial up connections.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

Related Functions

INIM – Initialize Dial-Up Modem

Example

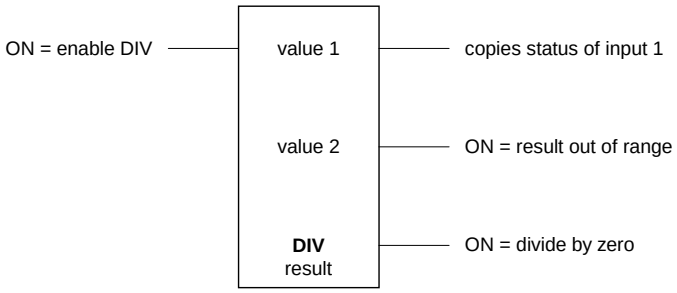
An example of dialing using the DIAL block is the file **DIAL.LAD**. This file is automatically installed on the computer when the TelePACE program is installed. It is located in the **TELEPACE\EXAMPLES** directory.

2.15 DIV – Divide Signed Values

Description

The **DIV** function block divides two registers or a constant, **value 1**, by a register or constant, **value 2**, and stores the quotient in a Holding Register, **result**. Signed division is used. The values and result are signed numbers.

The **result out of range** output is enabled if the result is greater than 32767 or less than –32768. The **divide by zero output** is enabled if **value 2** equals 0.



Function Variables

Variable	Valid Types	Description
value 1	constant (-32768..32767) 2 Input registers (3xxxx) 2 holding registers (4xxxx)	Signed value to divide The low order word is stored in the first register if registers are used.
Value 2	constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	Signed value to divide by
Result	holding registers (4xxxx)	Result = value 1 / value 2

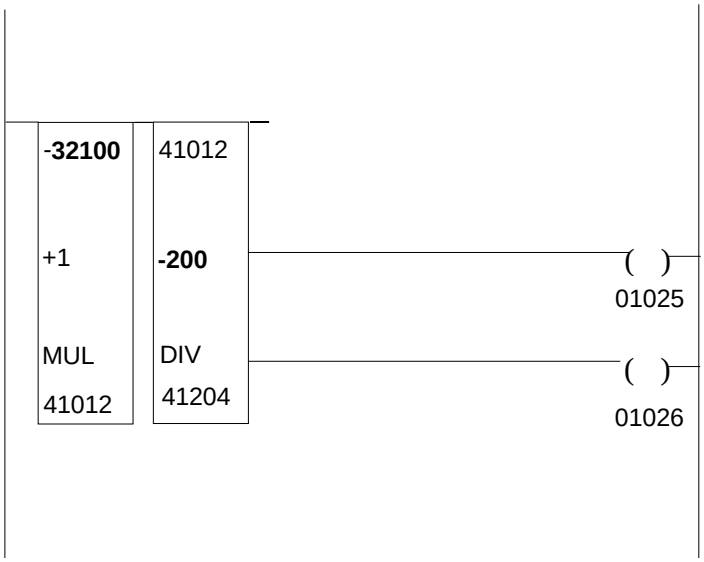
Related Functions

DIVF - Divide Floating-Point Values

DIVU – Divide Unsigned Values

Example

network 1:



The **MUL** function is used to create the double precision values required for **value 1**. A constant is multiplied by 1 with the result stored in Holding Register 41012. The low order word, 41012, and the high order word, 41013, are returned from the MUL function.

The following table illustrates various **value 1** and **value 2** values and the **result** of the division.

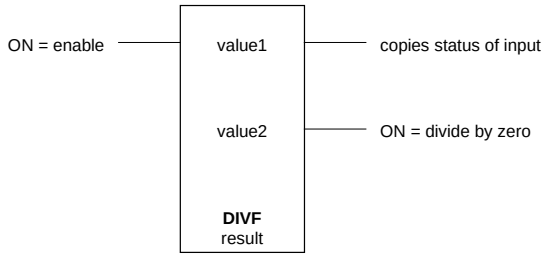
	high order	low order		
	Register 41013	Register 41012	Constant Value	Register 41204
	value 1		value 2	result
Example 1	-1	-32070	-200	160
Example 2	0	32070	-200	-160
Example 3	-1	-2048	16	-128
Example 4	0	3276	30	109

2.16 DIVF - Divide Floating-Point Values

Description

The DIVF element divides one floating-point register or constant by another and stores the result in a floating-point holding register.

When the **enable** input is ON the result **value 1 ÷ value 2** is stored in the **result** floating-point register. The top output is ON when the input is. The middle output is ON if value2 equals 0 and the input is ON.



Function Variables

The element has three parameters.

Variable	Valid Types	Description
value1	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	Floating-point register or constant value to divide
Value2	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	Floating-point register or constant value to divide by
Result	2 holding registers (4xxxx)	Floating-point result = value1 ÷ value2

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

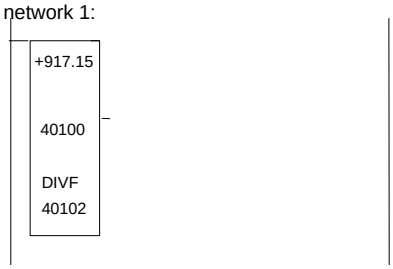
Floating point numbers can represent positive and negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

DIV – Divide Signed Values

DIVU – Divide Unsigned Values

Example



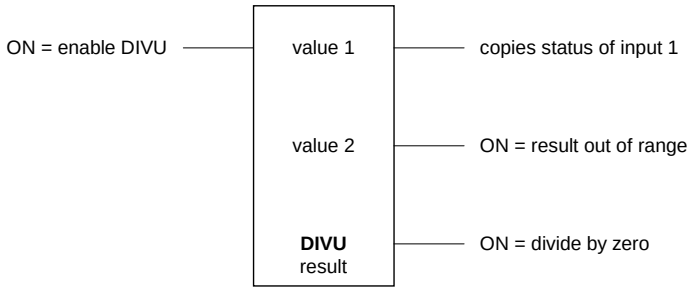
The DIVF function in network 1 divides floating-point constant +917.15 by the contents of floating-point register 40100 (registers 40100 and 40101). Assuming floating-point register 40100 has a value of 5.00 then the result is +183.43. This value is stored in floating-point register 40102 (registers 40102 and 40103).

2.17 DIVU – Divide Unsigned Values

Description

The **DIVU** function block divides two registers or a constant, **value 1**, by a register or constant, **value 2**. The quotient is stored in a Holding Register, **result**. Unsigned division is used. The values and result are unsigned numbers.

The **result out of range output** is enabled if the result is greater than 65535 or less than 0. The **divide by zero** output is enabled if **value 2** equals 0.



Function Variables

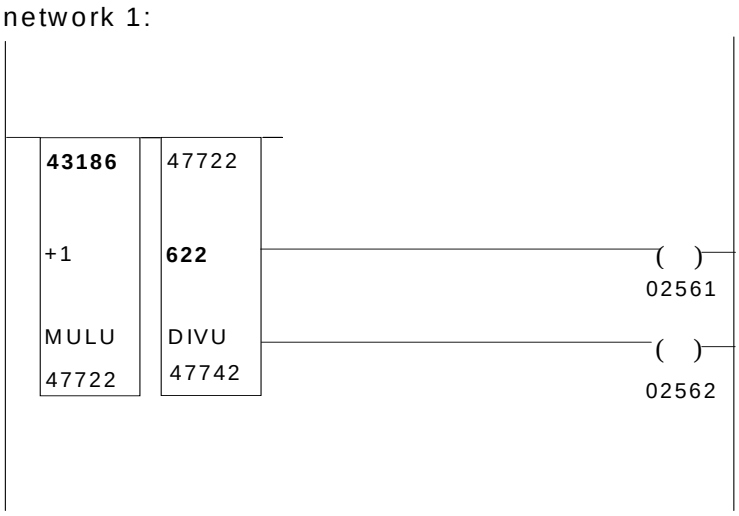
Variable	Valid Types	
value 1	constant (0..65535) 2 Input registers (3xxxx) 2 holding registers (4xxxx)	Unsigned value to divide The low order word is stored in the first register if registers are used.
Value 2	constant (0..65535) input register (3xxxx) holding register (4xxxx)	Unsigned value to divide by
Result	holding registers (4xxxx)	Result = value 1 / value 2

Related Functions

DIV – Divide Signed Values

DIVF - Divide Floating-Point Values

Examples



The MULU function is used to create the double precision values required for **value 1**. A constant is multiplied by 1 with the result stored in Holding Register 47722. The low order word, 47722, and the high order word, 47723, are returned from the MULU function. The MULU function ensures a value of 0 in the high order word.

The following table illustrates various **value 1** and **value 2** values and the **result** of the **DIVU** function.

	high order	**low order**		
	Register 47723	**Register 47722**	**Constant Value**	**Register 47742**
	value 1		**value 2**	**result**
Example 1	0	53186	622	85
Example 2	0	7000	70	100
Example 3	0	8192	819	10
Example 4	0	42998	226	190

2.18 DLOG - Data Logger

Description

The **DLOG** function records entries in a data log. When a low to high transition occurs on the **enable DLOG** input, the data log identified by `LogID` is created and initialized. If the data log exists and has a different configuration then an error will be generated. If an error is generated (see status codes below) then a different `LogID` must be used or the log must be deleted using the **delete log** input.

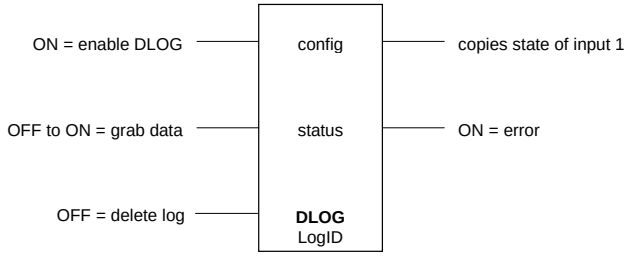
While the **enable DLOG** is ON and a low to high transition occurs on the **grab data** input, an entry is recorded in the data log identified by `LogID`.

When the **delete log** input is low, all records in the data log are deleted.

The top output is a copy of the top input. The **error** output is ON if there was a creation, configuration or data logging error. The outputs are powered only when the enable input is powered.

NOTE: In order for the changes to an existing DLOG configuration to take effect, the following steps must be followed:

- Read the data from the log, if desired.
- Disable the DLOG
- Delete the log
- Write the new configuration
- Enable the log



Function Variables

Variable	Valid Types	Description
Config	18 holding registers (4xxxx)	Address of the first register of the log configuration block. There are 18 registers in the block at config+0 to config+17. +0 = Maximum number of records in the log. +1 = number of data fields. +2 = Field #1 register address +3 = Field #1 data type (see data types below) +4 = Field #2 register address +5 = Field #2 data type +6 = Field #3 register address +7 = Field #3 data type +8 = Field #4 register address +9 = Field #4 data type +10 = Field #5 register address +11 = Field #5 data type +12 = Field #6 register address +13 = Field #6 data type +14 = Field #7 register address +15 = Field #7 data type +16 = Field #8 register address +17 = Field #8 data type
Status	Holding register (4xxxx)	Address of the status register. +0 = status code (see status codes below)
Log ID	Constant (1 to 16)	Identifies the internal log.

Configuration Register

A Field Register Address is the address of a Modbus register, or the address of the first Modbus register of a small block of consecutive registers. Valid values are any register in the range 00001 to 49999.

The configuration data types are:

Data Type	Description
0	16 bit unsigned integer
1	16 bit signed integer
2	32 bit unsigned integer
3	32 bit signed integer
4	32 bit floating point
5	Days and hundredths of seconds in two 32 bit unsigned integers. The first two registers are an Unsigned Double containing the number of complete days since 01/01/97 The last two registers are an Unsigned Double containing the number of hundredths of a second since the start of the current day.

Status Register

The status register stores the result of a log attempt. It can have the following values. If the status register is not equal to 10 then the error output is turned on.

The status codes are:

Status Code	Description
10	The configuration is valid and data can be logged.
11	A different configuration already exists for the log.
12	The log ID is invalid.
13	The configuration was not valid and was rejected.
14	There is not enough memory available to create a log of the request size.
15	The number of data fields was invalid.
16	The log was successfully deleted. No log configuration exists.
17	Undefined status. This should never occur.

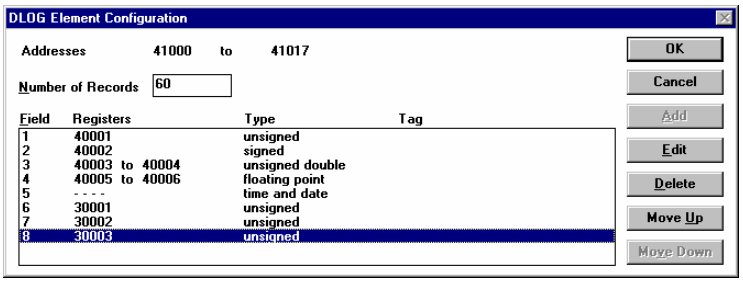
DLOG Element Configuration

This element is configured using the DLOG Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the Initialize command in the Controller menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.

DLOG Element Configuration Dialog

Selecting Element Configuration from the Edit menu while the cursor is over a DLOG element can access this dialog.



The **addresses** are determined from the ladder element. They cannot be modified in this dialog.

The **Number of Records** selects the number of records in the log. Each record contains the data for all the fields in the log. The number of records available will depend on the type of controller used.

For ***SCADAPack 100: 256K*** controllers the maximum number of records is 190 records of 8 unsigned integer fields.

For ***SCADAPack LP and SCADAPack 100: 1024K*** controllers the maximum number of records is approximately 22970 records of 8 unsigned integer fields.

For ***SCADAPack*** and ***Micro16*** controller the number of records depends on the available memory in socket U10 in the controller. For example a 128K RAM in U10 will allow approximately 190

records of 8 unsigned integer fields and a 512K RAM in U10 will allow approximately 22970 records of 8 unsigned integer fields.

For ***SCADAPack 32*** controllers the maximum number of records is 58,352 records of 8 unsigned integer fields for a total of 466816 words. The maximum number of records will be reduced if DNP protocol, RealFLO or custom C++ applications are used in the controller.

For ***SCADAPack 350*** controllers the maximum number of records is 56,743 records of 8 unsigned integer fields for a total of 453947 words. The maximum number of records will be reduced if DNP protocol, RealFLO or custom C++ applications are used in the controller.

The **Field** entries contain information about each item in the log. The fields are numbered,1 through 8, as they are added to the record. The **Registers** column contains the Modbus registers used in for the field. The **Type** column contains the Modbus register type and the **Tag** column contains the tag name for the Modbus Register.

Press the **Add** key to add an item to the end of the list. When selected the **Add/Edit DLOG Field** dialog is displayed, see description of this dialog below. The key is grayed if the list is full.

Press the **Edit** key to modify the currently selected item in the list. When selected the Add/Edit DLOG Field dialog is displayed. The key is grayed if the list is empty.

Press the **Delete** key to delete the currently selected item from the list. The key is grayed if the list is empty.

Press the **Move Up** key to move the currently selected item up one position in the list. The key is grayed if the list is empty or the selected item is at the top of the list.

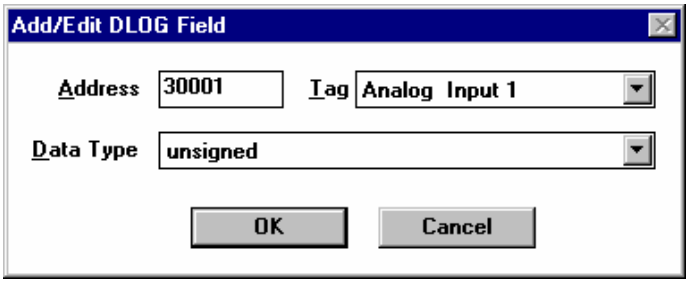
Press the **Move Down** key to move the currently selected item down one position in the list. The key is grayed if the list is empty or the selected item is at the bottom top of the list.

Press **OK** to accept the current list.

Press **Cancel** to discard the changes made to the list.

Data Log Field Dialog

This dialog can be accessed by pressing **Add** or **Edit** from the DLOG Element Configuration dialog.



The **Address** entry will contain the Modbus register address for the record if the Edit button was selected. This entry will be zero if the Add button was selected. Valid values are any register in the range 00001 to 49999.

The **Tag** entry contains the tagname for the selected register address if one exists. The drop down list will display all tag names for valid address. Selecting a tag name from the list will cause the associated register address to be displayed in the Address entry.

The **Data Type** selection allows the selection of one of the following data types:

16 bit unsigned integer

16 bit signed integer

32 bit unsigned integer

32 bit signed integer

32 bit floating point

Days and hundredths of seconds in two 32 bit unsigned integers

Press **OK** to validate the data and close the dialog.

Press **Cancel** to discard the changes made in the dialog.

The output bits are powered only when the enable input is powered.

Related Functions:

GETL - Data Logger Extract

2.19 DPOL – Trigger a DNP class poll

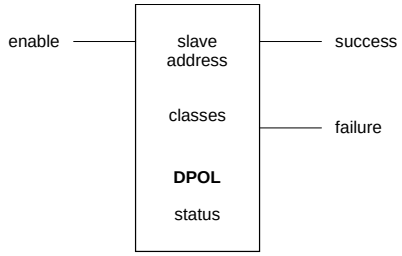
Description

This function sends a DNP Class Poll message to request the specified data classes from a DNP slave. The DNP class poll is requested when the **enable** input changes from OFF to ON.

The **status** register is set to 0 and the **success** output is energized if the function was successful.

The 'success' output is energized immediately if the poll was triggered successfully. It does not provide any information about the success or otherwise of the actual message transaction.

The **status** register is set to 1 and the **failure** output is energized if the function failed. Failure indicates the specified slave address has not been configured in the DNP Routing Table, or the DNP configuration has not been created.



Function Variables

Variable	Valid Types	Description
Slave Address	Constant or holding register (4xxxx)	DNP slave station address
Classes	Constant or holding register (4xxxx)	This is a bit-mapped register containing the classes of data to be included in the class poll message. If multiple classes are required the following values should be added together. 1 = class 0 data 2 = class 1 data 4 = class 2 data 8 = class 3 data
Status	Holding register (4xxxx)	Status of the operation 0 = success 1 = failure

Notes

This function is available on the SCADAPack 350 SCADAPack 32 controllers only.

The function sets internal flags to trigger a DNP poll message, and returns immediately. The DNP message will be sent some time after the function call.

Related Functions

DEVT – Generate DNP Event

DUNS – Trigger a DNP unsolicited response message

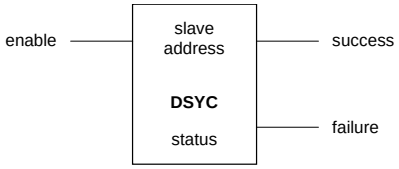
2.20 DSYC – Trigger a DNP clock synchronization

Description

This function sends a Clock Synchronization message to a DNP slave.

The Clock Synchronization message is sent to the **slave address** when the **enable** input changes from OFF to ON. The status register is set to 0 and the **success** output is energized if the function was successful.

The **status** register is set to 1 and the **failure** output is energized if the Time Synchronization message failed. The **failure** output indicates the specified slave address has not been configured in the DNP Routing Table, or the DNP configuration has not been created.



Function Variables

Variable	Valid Types	Description
Slave Address	Constant or holding register (4xxxx)	DNP slave station address
Status	Holding register (4xxxx)	Status of the operation 0 = success 1 = failure

Notes

This function is available on the SCADAPack 32 only.

The function sets internal flags to trigger a DNP message and returns immediately. The DNP message will be sent some time after the function call.

Related Functions

DEVT – Generate DNP Event

DPOL – Trigger a DNP class poll

DUNS – Trigger a DNP unsolicited response message

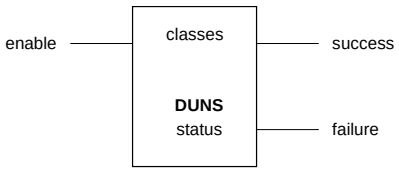
2.21 DUNS – Trigger a DNP unsolicited response message

Description

The DUNS function triggers a DNP unsolicited response message of the specified class or classes.

The unsolicited response for the specified **classes** is triggered when the **enable** input changes from OFF to ON. The **status** register is set to 0 and the success output is energized if the message was triggered successfully.

The **status** register is set to 1 and the **failure** output is energized if the unsolicited response message failed. The failure output indicates master addresses have not been configured in the DNP Routing Table, or the DNP configuration has not been created.



Function Variables

Variable	Valid Types	Description
Classes	Constant or holding register (4xxxx)	This is a bit-mapped register containing the classes of data to be included in the unsolicited message. If multiple classes are required the following values should be added together. 1 = class 0 data 2 = class 1 data 4 = class 2 data 8 = class 3 data
Status	Holding register (4xxxx)	Status of the operation 0 = success 1 = failure

Notes

The function sets internal flags to trigger a DNP unsolicited message, and returns immediately. The DNP message will be sent some time after the function call.

DNP unsolicited messages do not have to be enabled in the Application Layer configuration for events to be sent with this function. Unsolicited messages at Start Up must be enabled, or the master must enable unsolicited messages before the first message can be sent.

If no events are pending an empty unsolicited message will be sent.

The message will be sent to the configured DNP master station or stations.

The return status indicates whether the flags were set. The status will be FALSE if the DNP engine is not running.

Related Functions

DPOL – Trigger a DNP class poll

DUNS – Trigger a DNP unsolicited response message

2.22 FIN – FIFO Queue Insert

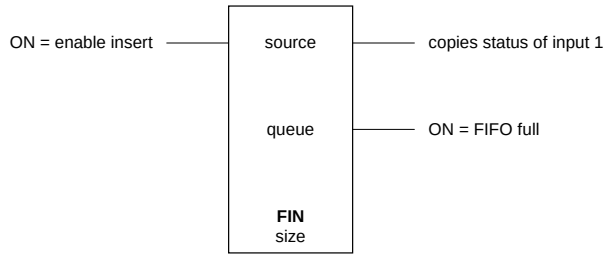
Description

The **FIN** function inserts the contents of the source register into the First-In-First-Out (FIFO) queue. Values in the FIFO queue are pushed down until the queue is full.

When the **enable insert** input is ON and the **FIFO full** is not ON, the source register is inserted into the queue.

The index is incremented by one after each insert until the index value equals the size. When the index equals the size and **enable insert** is ON then **FIFO full** turns ON and no further insertions can take place.

The FIFO Queue Insert function is used with the FIFO Queue Remove function to enable full control of the FIFO Queue.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The address of the source register. The address for a coil or status register block is the first register in a group of 16 registers that will be inserted.
Queue	holding register (4xxxx)	The address of the index register and the queue registers. The index is stored in register [4xxxx]. The FIFO queue is located in register [4xxxx+1] to register [4xxxx + size].
Size	constant (1..9999)	The number of registers in the queue.

Notes

FIN accesses 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

Related Functions

FOUT – FIFO Queue Remove

Example

See the example for the FOUT function.

2.23 FOUT – FIFO Queue Remove

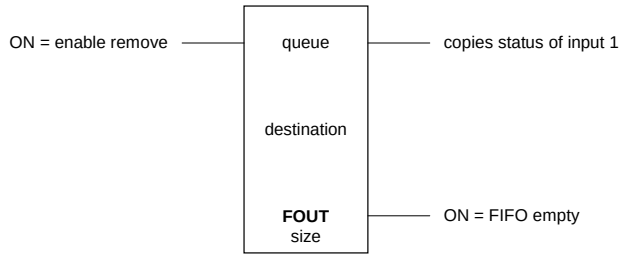
Description

The **FOUT** function removes a value from the first-in-first-out (FIFO) queue and transfers it into the destination register. Values in the queue are moved up, until the queue is empty.

When the **enable remove** input is ON and the **FIFO empty** is not ON, the first queue register is transferred into the destination register.

The index is decremented by one after each transfer until the index value equals zero. When the index equals zero and the **enable remove** input is ON the **FIFO empty** turns ON and no further removals can take place.

The FIFO Queue Remove function is used with the FIFO Queue Insert function to enable full control of the FIFO Queue. See FIFO Queue example.



Function Variables

Variable	Valid Types	Description
Queue	Holding register (4xxxx)	The address of the index register and the queue registers. The index is stored in register [4xxxx]. The FIFO queue in located in register [4xxxx+1] to Register [4xxxx + size].
Destination	coil block (0xxxx) holding register (4xxxx)	The address of the destination register. The address for a coil register block is the first register in a group of 16 registers.
Size	Constant (1..9999)	The number of 16 bit registers in the queue.

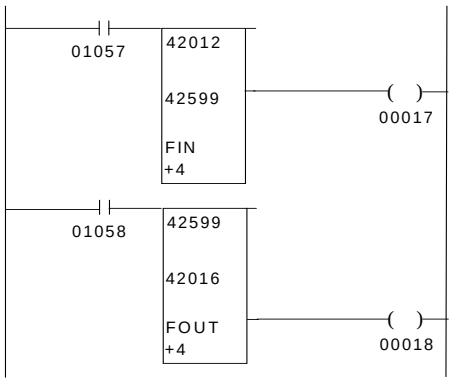
Notes

FOUT accesses 16 bit words. Coil blocks are groups of 16 registers that start with the register specified as the block address. Coil blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 00033, etc.

Related Functions

FIN – FIFO Queue Insert

Example



The following discussion describes the operation of a FIN function. The queue starts out empty with the FIFO index register having a value of zero.

Source Register	Source Register Data		FIFO Queue Registers
		FIFO Index-->	42599
42012	Xxxx	FIFO register 0-->	42600
		FIFO register 1-->	42601
		FIFO register 2-->	42602
		FIFO register 3-->	42603

When FIFO queue index register 42599 has a value of 0 and the FIN function is enabled, by closing contact 1057, the contents of source register 42012 is inserted into FIFO Queue register 42600 and the index is incremented to 1.

When FIFO queue index register 42599 has a value of 1 and the FIN function is enabled, by closing contact 1057, the contents of queue register 42600 is transferred to queue register 42601. The contents of source register 42012 are inserted into FIFO queue register 42600, and the index is incremented to 2.

When FIFO queue index register 42599 has a value of 2 and the FIN function is enabled, by closing contact 1057, the contents of queue register 42601 is transferred to queue register 42602. The contents of queue register 42600 is transferred to queue register 42601, the contents of source register 42012 is inserted into FIFO queue register 42600 and the index is incremented to 3.

When FIFO queue index register 42599 has a value of 3 and the FIN function is enabled, by closing contact 1057, the contents of queue register 42602 is transferred to queue register 42603. The contents of queue register 42601 is transferred to queue register 42602, the contents of queue register 42600 is transferred to queue register 42601, the contents of source register 42012 is inserted into FIFO queue register 42600 and the index is incremented to 4.

The queue is now full and no further insertions are allowed. Coil 00017 will turn ON. The FOUT Queue Remove function must be used to remove values from the queue.

The following discussion describes the operation of a FOUT function. The queue starts out full with the FIFO index register having a value of three.

	FIFO Queue Registers	FIFO Queue Register Data	Destination Register
FIFO Index-->	42599		
FIFO register 0-->	42600		
FIFO register 1-->	42601		
FIFO register 2-->	42602		
FIFO register 3-->	42603	xxxx	42016

When FIFO queue index register 42599 has a value of 4 and the FOUT function is enabled, by closing contact 1058, the contents of queue register 42603, pointed to by the index is transferred to the FIFO destination register 42016 and the index is decremented by one.

When FIFO queue index register 42599 has a value of 3 and the FOUT function is enabled, by closing contact 1058, the contents of queue register 42602 is transferred to the FIFO destination register 42016 and the index is decremented by one.

When FIFO queue index register 42599 has a value of 2 and the FOUT function is enabled the contents of queue register 42601 is transferred to the FIFO destination register 42016 and the index register is decremented by one.

When FIFO queue index register 42599 has a value of 1 and the FOUT function is enabled, by closing contact 1058, the contents of queue register 42600 is transferred to the FIFO destination register 42016 and the index is decremented to 0.

The queue is now empty and no further removals are allowed. Coil 00018 will be now be energized. The FIN Queue Insert function must be used to insert values into the queue.

2.24 FLOW – Flow Accumulator

Description

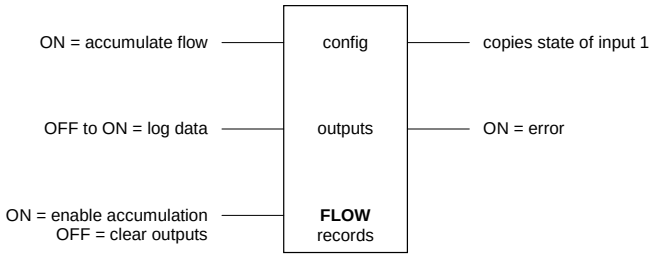
The FLOW function accumulates flow from pulse type devices such as turbine flow meters.

When the accumulate input is ON the function accumulates volume and calculates the flow rate.

When the Log Data input goes from OFF to ON, the accumulated volume, flow time and the time at the end of the period is saved in the history registers. Older history is pushed down and the oldest record is discarded. The Log Data input must be triggered at least once every 119 hours (at the maximum pulse rate). Otherwise the volume accumulator will overflow, and the accumulated volume will not be accurate.

When the accumulator enabled input is ON, accumulation and rate calculations are enabled. When the input is OFF, all accumulators and the rate outputs are set to zero.

The function reads and accumulates the number of pulses, and divides by the K factor to calculate the total volume. This is done on each scan of the controller logic. The function calculates the flow rate in engineering units based on the K-factor provided. The rate updates once per second if there is sufficient flow. If the flow is insufficient, the update slows to as little as once every ten seconds to maintain resolution of the calculated rate.



Function Variables

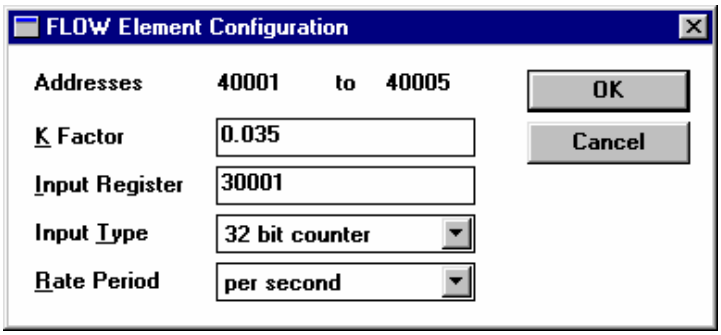
Variable	Valid Types	Description
Config	holding register (4xxxx)	Address of the first register of the configuration block. There are five registers in the block at config+0 to config+4. +0, 1 = K factor (floating-point) +2 = input register (3xxxx or 4xxxx) +3 = input type (see table below) +4 = rate period (see table below)

Variable	Valid Types	Description
Outputs	holding register (4xxxx)	Address of the first register of the output block. There are 18 to 222 registers in the block at outputs+0 to outputs+221. The number of registers used depends on the records variable. +0 = status (see table below) +1,2 = flow rate (floating-point) +3,4 = internal: rate accumulator +5,6 = internal: time of last rate +7,8 = internal: input at last sample +9,10 = internal: pulse accumulator +11 = number of records to follow +12,13 = volume for period 1 (float) +14,15 = time at end of period 1 +16,17 = flow time for period 1 +18,19= volume for period 2 (float) +20,21 = time at end of period 2 +22,23 = flow time for period 2 +24,25= volume for period 3 (float) +26,27 = time at end of period 3 +28,29 = flow time for period 3 … +216,217 = volume for period 35 (float) +218,219 = time at end of period 35 +220,221 = flow time for period 35
Records	Constant	The number of measurement records stored in the output array. The valid values are 1 to 35. This value determines the number of output registers used by the function.

Element Configuration

This element is configured using the FLOW Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the Initialize command in the Controller menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.



The **K Factor** is a floating-point value. It may be any non-zero, positive value.

The **Input Register** is the address of the register that holds the input pulse count. Valid values are any input or holding register in the range 30001 to 49999.

The **Input Type** may be one of the following.

16 bit counter A free running 16-bit counter.
Holding register (4xxxx) = 0

32 bit counter A free running 32-bit counter with low word in the first register.
Holding register (4xxxx) = 1

16 bit difference The 16-bit difference between any two counters.
Holding Register (4xxxx) = 2

The **Rate Period** determines the units of time used to display the flow rate. It may be one of the following. Note that this value does not affect when the rate calculation is performed.

per second Holding register (4xxxx) = 0

per minute Holding register (4xxxx) = 1

per hour Holding register (4xxxx) = 2

per day Holding Resister (4xxxx) = 3

Output Registers

The output registers store the results of the flow accumulation and act as internal workspace for the accumulation.

The **status** register indicates the status of the flow accumulation. It can have the following values. If the status register is non-zero, the error output is turned ON.

Status Register Value	Description
0	no error
1	invalid *K factor* configuration
2	invalid *Input Register* configuration
3	invalid I*nput Type* configuration
4	invalid *Rate Period* configuration
5	pulse rate is too low for accurate flow rate calculation

The **flow rate** register contains the flow rate in engineering units based on the K-factor and rate period provided.

The eight **internal** registers are used for the accumulation of the flow and calculation of the flow rate.

The **Number of Records** register indicates how many sets of flow and time registers follow. This value is equal to the *Records* variable. There are four registers in each record.

The **Volume for Period n** is stored as a floating-point number in two consecutive registers.

The **End Time for Period n** is stored as a 32-bit integer in two consecutive registers. The registers hold the number of seconds since January 1, 1970. This is an unsigned number.

The **Flow Time for Period n** is stored as a 32-bit integer in two consecutive registers. The register holds the number of seconds flow was accumulated in the period. This measures the time the Accumulate input is ON, including times when the flow was zero.

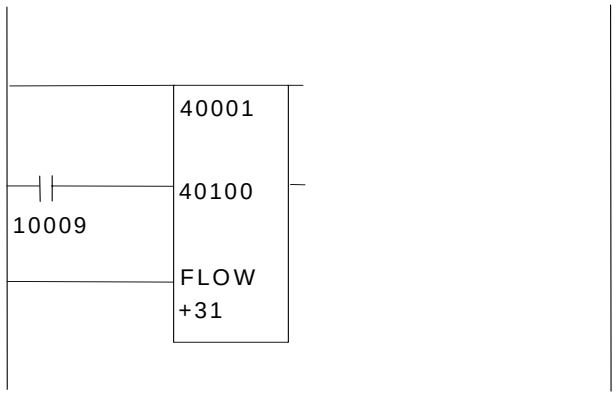
Notes

The maximum pulse rate is 10 kHz.

The accumulated flow is calculated by measuring the accumulated pulses and dividing by the K factor. The K factor cannot be changed while an accumulation is in progress. Only change the K factor while accumulation is stopped.

Example

network 1:



The FLOW function in network 1 has the *accumulate flow* and *enable accumulation* inputs connected to the left power rail. When these inputs are continuously powered the FLOW function accumulates volume and calculates flow rate.

Each time contact 10009 is closed, powering the log data input, the accumulated volume, flow time and the time at the end of the period is saved in the history registers.

The *records* value is set to 31. This means that 31 sets of history registers, volume, flow time and end of period time, will be logged. In this example the accumulation input is never turned off meaning that once 31 sets of history registers are saved the next time contact 10009 is closed the 31st record is removed and the newest record is added to the history.

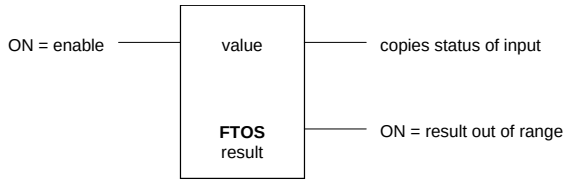
2.25 FTOS - Floating-Point to Signed Integer

Description

The FTOS element converts a floating-point register or constant into a signed integer and stores the result in a holding register.

When the **enable** input is ON, **value** is converted into a signed number and stored in the **result** register. The value is rounded to the nearest integer. If the value is less than –32768, then –32768 is stored. If the value is greater than 32767, then 32767 is stored.

The top output is ON when the input is. The bottom output is ON if the floating-point value is less than –32768 or greater than 32767.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
value	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant
Result	holding register (4xxxx)	Converted signed value

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

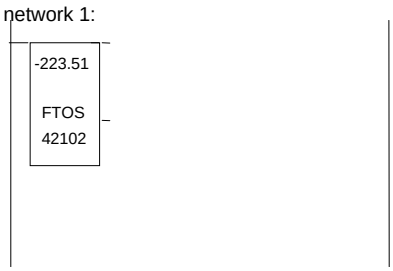
Related Functions

UTOF - Unsigned Integer to Floating-Point

STOF - Signed Integer to Floating-Point

FTOU - Floating-Point to Unsigned Integer

Example



The FTOS function in network 1 converts floating-point constant –223.51 to a signed integer value and puts the value into register 42102. In this example the content of register 42102 is the signed integer –224.

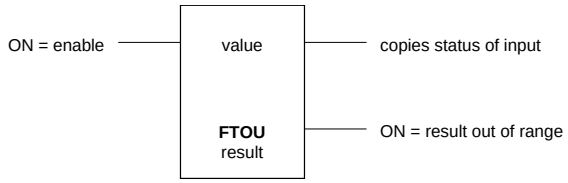
2.26 FTOU - Floating-Point to Unsigned Integer

Description

The FTOU element converts a floating-point register or constant into an unsigned integer and stores the result in a holding register.

When the **enable** input is ON, **value** is converted into an unsigned number and stored in the **result** register. The value is rounded to the nearest integer. If the value is less than zero, then zero is stored. If the value is greater than 65535, then 65535 is stored.

The top output is ON when the input is. The bottom output is ON if the floating-point value is less than 0 or greater than 65535.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
value	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant
Result	holding register (4xxxx)	Converted unsigned value

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

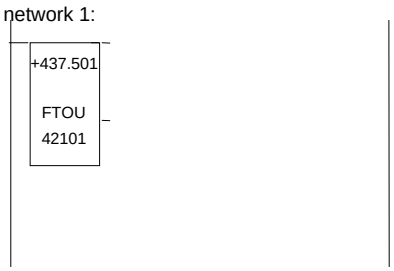
Related Functions

UTOF - Unsigned Integer to Floating-Point

STOF - Signed Integer to Floating-Point

FTOS - Floating-Point to Signed Integer

Example



The FTOU function in network 1 converts floating-point constant +437.501 to an unsigned integer value and puts the value into register 42101. In this example the content of register 42101 is the unsigned integer +438.

2.27 GETB – Get Bit from Block

Description

The **GETB** function block reads the status of a bit, at the bit index, from the source block of registers.

When the **bit index** is defined as a holding register the **enable GETB** input must be ON to increment bit index or reset bit index to zero.

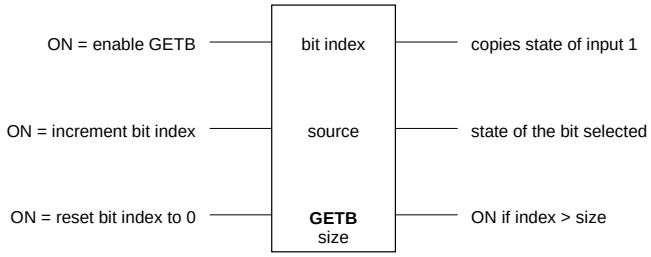
The **increment bit index** input increments the bit index once, each scan, when enabled.

The **reset bit index to 0** input resets the bit index to 0 when enabled.

When the bit index is defined as a constant, the GETB function checks the status of the bit at the bit index when **enable GETB** is ON. The **increment bit index** and **reset bit index to 0** inputs have no effect on the function block in this condition.

When the **enable GETB** is ON, the **state of bit selected** output is ON if the source bit is 1 and OFF if the source bit is 0.

The **index>size** output is enabled when the bit index is equal to **size** + 1 and the **enable GETB** input is ON. The **reset bit index to 0** input must be set to continue function operation.



Function Variables

Variable	Valid Types	Description
bit index	Constant (0..65535) holding register (4xxxx)	The index of the bit within the source block. A bit index of 0 is the most significant bit of the first register of the source block.
Source	coil block (0xxxx) holding register (4xxxx)	The address of the source register. The address for a coil register block is the first register in a group of 16 registers.
Size	Constant (1..100)	number of 16 bit words in the block.

Notes

The Get bit from block function accesses 16 bit words. Coil blocks are groups of 16 registers that start with the register specified as the block address. Coil blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 00033, etc.

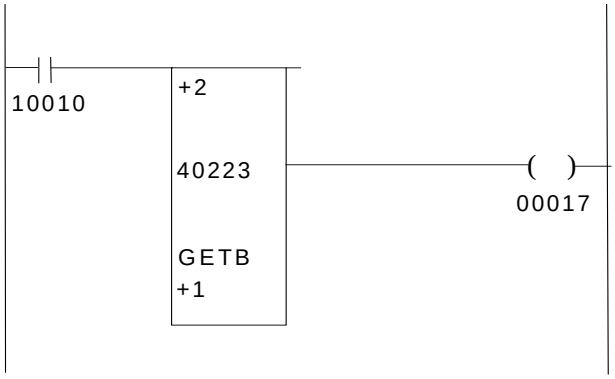
Related Functions

PUTB – Put Bit into Block

ROTB – Rotate Bits in Block

CMPB – Compare Bit

Example



In this example the GETB function is used to test bit 13 of the PID block 0 Status register to check if the Control Block is in manual mode.

The twenty-five holding registers used for PID block 0 are assigned to the **CNFG PID Control Block I/O Module** in the Register Assignment. In this case holding registers 40220 through 40245 are assigned to the I/O module.

The Control Block status register, 40223 is tested to see if bit 13 is ON. The GETB function uses bit index of 0 for the most significant bit. This means that a bit index of 2 will test for bit 13 of the Control Block register.

Closing contacts 10010 sets the **enable GETB** input on. If PID block 0 is in manual mode output 00017 will turn ON.

2.28 GETL - Data Logger Extract

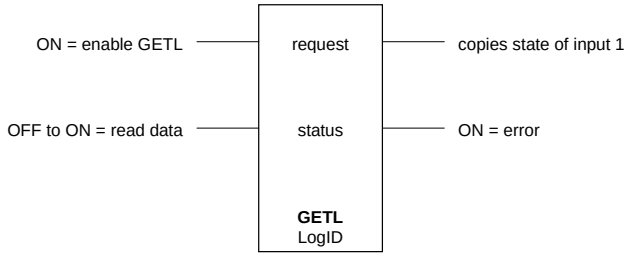
Description

The **GETL** function extracts one record from a data log and writes it into holding registers.

When a low to high transition occurs on the **enable GETL** input, the error code and sequence number status registers are updated and the data length is cleared.

When the **enable GETL** input is ON and a low to high transition occurs on the **read data** input, the status registers are updated and the data for the requested sequence number is copied to the data from log holding registers.

The **error** output is ON if the log is not configured or if there was a data reading error, see table below. The outputs are powered only when the enable input is powered.



Function Variables

Variable	Valid Types	Description
Request	2 holding registers (4xxxx)	Unsigned long sequence number requested from the log. +0 = least significant word +1 = most significant word
Status	Up to 36 holding registers (4xxxx)	Status and data registers +0 = error code +1,2 = sequence number +3 = length of data +4 to+35 = data from log
LogID	Constant (1 to 16)	Identifies the internal log.

Status Register

The status register stores the result of an enable log attempt and a log data attempt. It can have the following values. If the status register is does not contain the code 20 then the error output is turned on. The **status** error codes are:

Error Code	Description
20	The configuration is valid and data can be retrieved.
21	The log ID is invalid.
22	The log is not configured.
23	The requested sequence number was not in the valid range.

Notes:

To get the oldest sequence number in the log toggle the **enable GETL** input, the error code and sequence number status registers are updated and the data length is cleared. To clear the error 23 the **enable GETL** input must be turned off.

Related Functions:

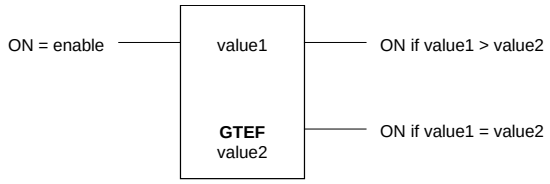
DLOG - Data Logger

2.29 GTEF – Floating-Point Greater Than or Equal

Description

The GTEF element tests if a floating-point register or constant is greater than or equal to another floating-point register or constant.

When the **enable** input is ON, value1 and value2 are compared. If value1 is greater than value2, the top output is ON. If value1 is equal to value2 the bottom output is ON.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
Value1	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant
Value2	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant

Notes

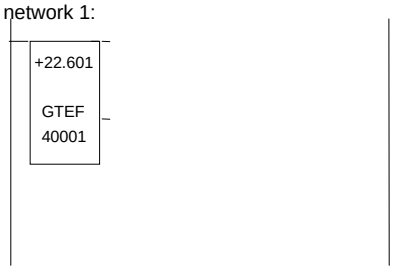
Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number. Floating point numbers can represent positive and negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

CMP – Compare Signed Values

CMPU – Compare Unsigned Values

Example



The GTEF function in network 1 compares the floating-point constant +22.601 to the contents of floating-point register 40001. The top output of the GTEF function is ON if the value of register 40001 is less than +22.601. The bottom output of the GTEF is ON if the value of register 40001 is equal to +22.601.

2.30 HART – Send HART Command

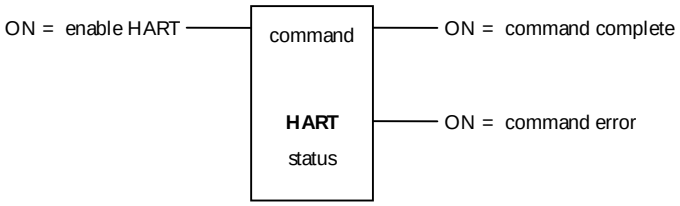
Description

The HART element sends a HART protocol command and processes the response. The SCADAPack 100 or SCADASense Series controllers do not support this command.

The HART element is a two-cell element, with one input and two outputs. When the **enable HART** input changes from OFF to ON, the element sends the HART command to the HART device. When the **enable HART** input changes from ON to OFF, the current command is aborted and no response is processed.

When a response is received, the data in the response is stored in the I/O database and the **command complete** output turns ON. If there is an error in the command, or if the HART device fails to respond to any of the attempts, the **command error** output turns ON.

The **enable HART** input must remain ON until the response has been received or an error has occurred. All outputs turn OFF when the input is OFF.



Function Variables

The HART element has two parameters:

Variable	Valid Types	Description
command	Holding register (4xxxx)	Address of the first register in the HART command block. There are 5 registers in the block at addresses command+0 to command+4. +0 = 5904 HART interface module number +1 = HART device address +2 = command number +3 = command data register address +4 = response register address
status	Holding register (4xxxx)	Address of the first register of the status block. There are two registers in the block at addresses status+0 and status+1. +0 = command status +1 = additional information code

The **5904 HART interface module number** must be set to 0, 1, 2 or 3. This must correspond with the module number of a *CNFG 5904 HART Interface* module in the Register Assignment.

The **HART device address** must be in the range 0 to 15.

Valid values for **command number** are shown below.

The **command data register address** specifies an I/O database register where the data for the command is stored. The program must set the values in these registers. The tables below show how this address is used.

The **response register address** specifies an I/O database register where the data in the response is stored. The tables below show how this address is used. Registers marked as (float) contain floating-point values.

Command	0
Purpose	Read the device identifier
Command Data Registers	Not used
Response Registers	+0 = manufacturer ID +1 = manufacturer Device Type +2 = preambles Requested +3 = command Revision +4 = transmitter Revision +5 = software Revision +6 = hardware Revision +7 = flags +8,9 = device ID (double)
Notes	This command is also the link initialization command. The HART element performs link initialization automatically. The user does not have to send this command unless the device identifier is needed.

Command	1
Purpose	Read primary variable (PV)
Command Data Registers	Not used
Response Registers	+0,1 = PV (float) +2 = PV units code

Command	2
Purpose	Read primary variable current and percent of span
Command Data Registers	Not used
Response Registers	+0,1 = PV current (float) +2 = PV current units code +3,4 = PV percent (float) +5 = PV percent units code

Command	3
Purpose	Read dynamic variables and primary variable current
Command Data Registers	Not used
Response Registers	+0,1 = primary variable current (float) +2 = primary variable current units code +3,4 = primary variable value (float) +5 = primary variable units code +6,7 = secondary variable value (float) +8 = secondary variable units code +9,10 = tertiary variable value (float) +11 = tertiary variable units code +12,13 = fourth variable value (float) +14 = fourth variable units code
Notes	Not all devices return primary, secondary, tertiary and fourth variables. If the device does not support them, zero is written into the value and units code for that variable.

Command	33
Purpose	Read specified transmitter variables
Command Data Registers	+0 = variable code 0 +1 = variable code 1 +2 = variable code 2 +3 = variable code 3
Response Registers	+0,1 = variable 0 value (float) +2 = variable 0 units code +3,4 = variable 1 value (float) +5 = variable 1 units code +6,7 = variable 2 value (float) +8 = variable 2 units code +9,10 = variable 3 value (float) +11 = variable 3 units code

The **status** registers contains the current command status and additional code returned from the HART interface. The table below shows the values.

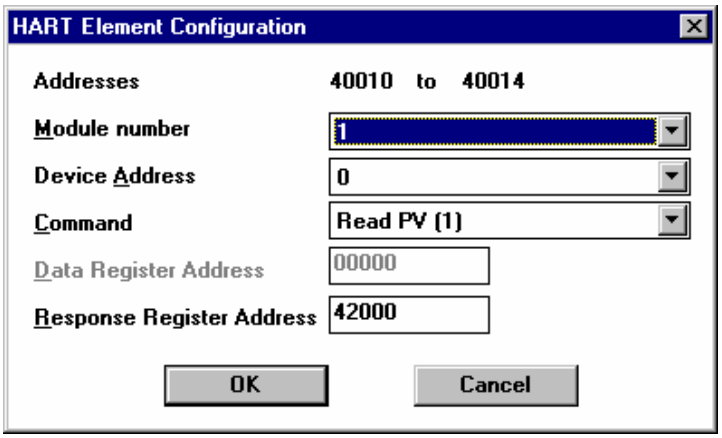
status	Description	Code
0	HART interface module is not communicating	not used
1	Command ready to send to device	not used
2	Command sent to device	current attempt number
3	Response received	response code from HART device (see Notes)

status	Description	Code
4	No valid response received after all attempts made	0=no response from HART device. Other = error response code from HART device (see Notes)
5	HART interface is not ready to transmit	not used

Element Configuration

This element is configured using the HART Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized (using the TelePACE *Initialize* command), all I/O database registers used for element configuration are set to zero. The Ladder Logic program must be re-loaded to the controller to restore the element configuration.



Addresses shows the register addresses that will be used by the element.

Module number selects the HART interface module to which the command will be sent. The valid range is 0 to 3.

Device Address selects the address of the HART device. The valid range is 0 to 15.

Command selects the HART command to be sent to the device. The valid values are:

Read Device Identifier = 0

Read PV = 1

Read PV Current and % = 2

Read Dynamic Variables = 3

Read Specified Variables = 33

Data Register Address selects the resisters where data for the command is stored. This field is grayed for the *Read Device Identifier*, *Read PV*, *Read PV Current and %*, and *Read Dynamic Variables* commands. These commands do not have any data.

Response Register Address selects the registers where the data in the response from the command will be stored.

Notes

The HART element performs link initialization automatically. The user does not have to send the link initialization command. If the command fails after all attempts, the link is automatically reinitialized by the HART element, at the time of the next command.

Some variables read from HART devices are 32-bit floating-point values. Each floating-point value is stored in two consecutive database registers. The most significant 16 bits of the value is stored in the lower numbered register. The least significant 16 bit of the value is stored in the higher numbered register.

The variable codes specify which variables are read from the HART device. See the documentation for your HART device for valid values for the variable codes.

The unit codes are standardized for all HART devices. See the HART specification or the documentation for your HART device for valid values.

The response code from the HART device contains communication error and status information. The information varies by device, but there are some common values.

If bit 7 of the high byte is set, the high byte contains a communication error summary. This field is bit-mapped. The following table shows the meaning of each bit as defined by the HART protocol specifications. Consult the documentation for the HART device for more information.

Bit	Description
6	vertical parity error
5	overrun error
4	framing error
3	longitudinal parity error
2	reserved – always 0
1	buffer overflow
0	Undefined

If bit 7 of the high byte is cleared, the high byte contains a command response summary. The following table shows common values. Other values may be defined for specific commands. Consult the documentation for the HART device.

Code	Description
32	Busy – the device is performing a function that cannot be interrupted by this command
64	Command not Implemented – the command is not defined for this device.

The low byte contains the field device status. This field is bit-mapped. The following table shows the meaning of each bit as defined by the HART protocol specifications. Consult the documentation for the HART device for more information.

Bit	Description
7	field device malfunction
6	Configuration changed
5	cold start

Bit	Description
4	more status available (use command 48 to read)
3	primary variable analog output fixed
2	primary variable analog output saturated
1	non-primary variable out of limits
0	primary variable out of limits

Example

An example of polling using the HART block is in the file **HART.LAD**. This file is automatically installed on the computer when the TelePACE program is installed. It is located in the **TELEPACE\EXAMPLES** directory.

See Also

MSTR - Master Message

2.31 INIM – Initialize Dial-Up Modem

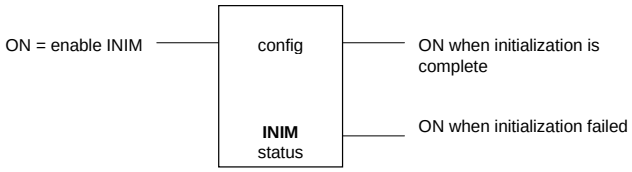
Description

The **INIM** function initializes an internal modem or an external modem, typically to set it to receive calls. Only one INIM block may be active on each serial communication port at any one time.

When **enable INIM** input is ON, the INIM element sends the modem initialization string to the modem. When the initialization is complete the **ON when initialization is complete** output is turned ON. If an error occurs, the **ON when initialization failed** output is turned ON.

The **enable INIM** input must be energized for the entire INIM time, including multiple initialization attempts.

Note: The SCADAPack 100 does not support dial up connections on com port 1. SCADASense Series controllers do not support dial connections on any serial port.



Function Variables

Variable	Valid Types	Description
Config	holding register (4xxxx)	Address of the first register in the configuration block. There are 18 registers in the block at addresses configuration+0 to configuration+17. +0 = Communication port +1 = Length of modem string +2 = Modem initialization string Registers should be programmed using the Element Configuration command.
Status	Holding register (4xxxx)	Address of the first register in the status block. There are 2 registers in the block at addresses status+0 to status+1. +0 = error code +1 = reservation identifier

Notes

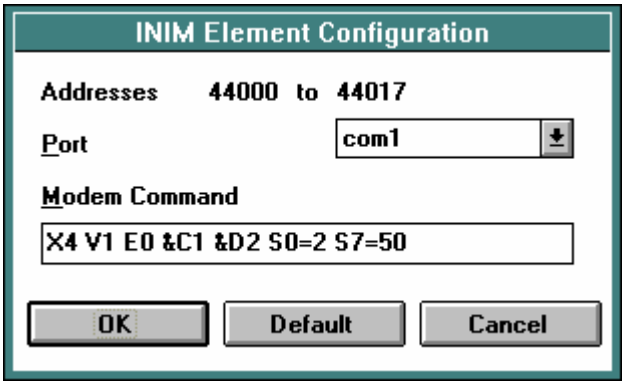
The modem initialization string is packed. Two ASCII characters are stored in each register.

The reservation identifier is required for the operation of the dialer but can be ignored by the ladder program.

Element Configuration

This element is configured using the INIM Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.



Error Code	Description
0	No Error
1	Bad configuration error occurs when an incorrect initialization string is sent to the modem. This usually means the modem does not understand a specific command in the initialization string.
2	No modem is connected to the controller serial port, or the controller serial port is not set to RS232 Modem.
3	Initialization error occurs when the modem does not respond to the initialization string and may be turned off.
6	Call aborted by the program. This will occur if the enable INIM input goes OFF before a modem connection occurs.
9	"Serial port is not available" error occurs when the INIM function attempts to use the serial port when another ladder communication element, C program or an incoming call has control of the port.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

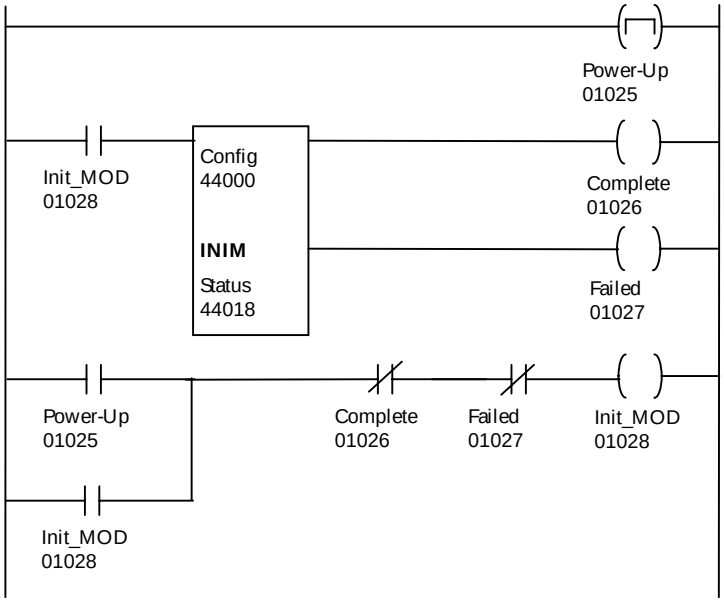
Related Functions

DIAL – Control Dial-Up Modem

Example

The following network configures a generic Hayes compatible modem to answer on the second ring. The modem is initialized when the controller is powered up.

Network 1: Initialize Modem on Power Up



2.32 L–>L – List to List Transfer

Description

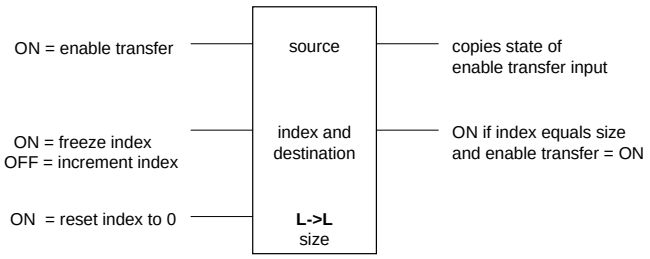
The **L–>L** function transfers the contents of one register from the source list of registers into one register from the destination list of registers, at the position of the index. The index register points to the same position in both the source and the destination list of registers.

When the **enable transfer** input is ON, and the **index equals size** output is not ON, the source list register is transferred to the destination list register at the position of the index in both lists.

The **freeze/increment index** input allows control of the index. If this input is ON the index is not incremented. If the input is OFF the index is incremented by one after each transfer.

When the **reset index** input is ON the index is reset to zero.

The index is incremented by one on each transfer until the index equals size. When the **index equals size** output is ON no further increments in index value occur until the index is reset.



Function Variables

Variable	Valid Types	Description
source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The address of the source register list. The address for a coil or status register block is the first register in a group of 16 registers that will be copied.
Index and destination	holding register (4xxxx)	The address of the index register and the destination register list. The index is stored in register [4xxxx]. The data is stored in register [4xxxx+1] to register [4xxxx+size]
Size	constant (1..9999)	The number of registers in the source and destination lists.

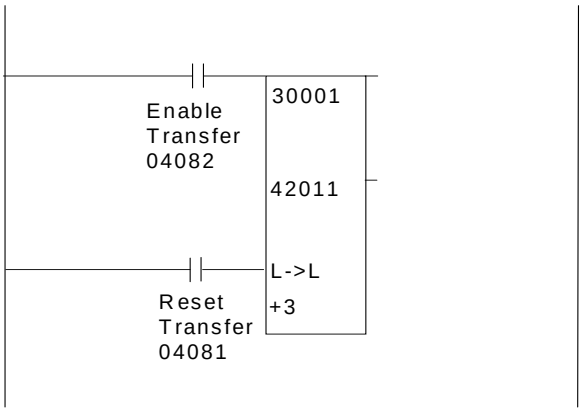
Related Functions

L–>R – List to Register Transfer

R–>L – Register to List Transfer

MOVE – Move Block

Example



The List to List function transfers the contents of one register in the **source** list of registers into one register of the **destination** list of registers, at the position of the index. The index register points to the same position in the source and destination lists.

	Source List		Destination List
		List Index---->	42011
list register 0-->	30001	list register 0-->	42012
list register 1-->	30002	list register 1-->	42013
list register 2-->	30003	list register 2-->	42014
list register 3-->	30004	list register 3-->	42015

In this example the **source** register list starts at input register 30001. The **index** is holding register 42011 and the **destination** register list starts at holding register 42012. The source register list contains the first four analog input registers. The index is a general purpose analog output register that will have a value of 0, 1, 2 or 3. The destination register list starts at the next sequential register after the index register. The destination list contains four general purpose analog output registers and has a size of four.

When list index register 42011 has a value of 0 and the L->L function is enabled the contents of source list register 30001 is transferred to destination list register 40012.

When list index register 42011 has a value of 1 and the L->L function is enabled the contents of source list register 30002 is transferred to destination list register 42013.

When list index register 42011 has a value of 2 and the L->L function is enabled the contents of source list register 30003 is transferred to destination list register 42014.

When list index register 42011 has a value of 3 and the L->L function is enabled the contents of source list register 30004 is transferred to destination register 42015.

2.33 L–>R – List to Register Transfer

Description

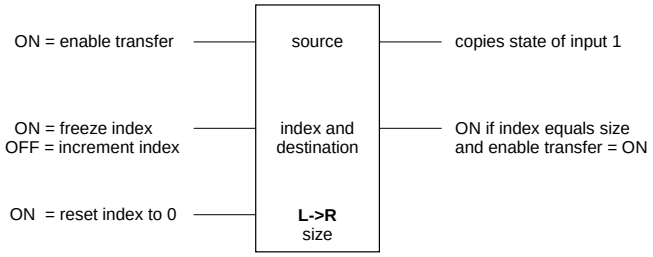
The **L->R** function transfers the contents of a register indicated by the index from the source list of registers into the destination register.

When the **enable transfer** input is ON, and the **index equals size** output is OFF, the source list register pointed to by the index is transferred to the destination register.

The **freeze/increment index** input allows control of the index. If this input is ON the index is not incremented. If the input is OFF the index is incremented by one after each transfer.

When the **reset index** input is ON the index is reset to zero.

The index is incremented by one on each transfer until the index equals size. When the **index equals size** output is ON no further increments in the index value occur until the index is reset.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The address of the source register list. The address for a coil or status register block is the first register in a group of 16 registers that will be read.
Index and destination	holding register (4xxxx)	The address of the index register and the destination register. The index to the source list is stored in holding register [4xxxx]. The destination register is holding register [4xxxx+1].
Size	constant (1..9999)	The number of registers in the source list.

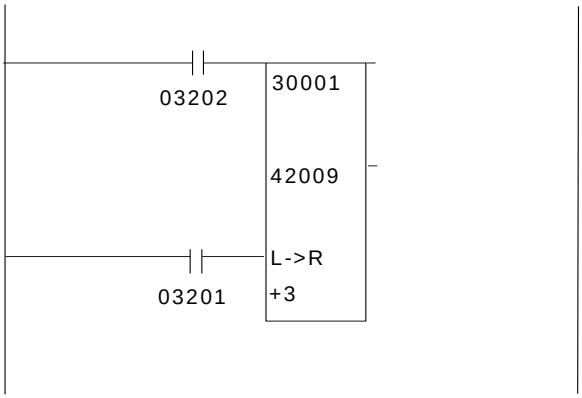
Related Functions

R–>L – Register to List Transfer

L–>L – List to List Transfer

MOVE – Move Block

Example



The List to Register function transfers the contents of a register indicated by the index from the source list of registers into the destination register.

	Source Register List
list register 0-->	30001
list register 1-->	30002
list register 2-->	30003
list register 3-->	30004

List Index---->	42009
Destination Register->	42010

An example of the registers used in a List to Register (L->R) transfer is shown in the above diagram. The source register list contains the first four analog input registers and has a size of four. The index is a general purpose analog output register that will have a value of 0, 1, 2 or 3. The destination register is a general purpose analog output register that is the next sequential register after the index register.

When list index register 42009 has a value of 0 and the L->R function is enabled, the contents of source register 30001 is transferred to destination register 42010.

When list index register 42009 has a value of 1 and the L->R function is enabled, the contents of source register 30002 is transferred to destination register 42010.

When list index register 42009 has a value of 2 and the L->R function is enabled, the contents of source register 30003 is transferred to destination register 42010.

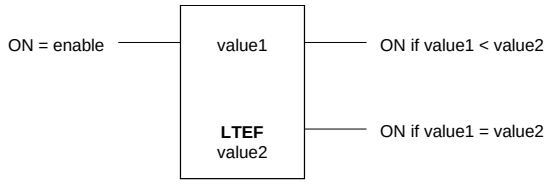
When list index register 42009 has a value of 3 and the L->R function is enabled, the contents of source register 30004 is transferred to destination register 42010.

2.34 LTEF - Floating-Point Less Than or Equal

Description

The LTEF element tests if a floating-point register or constant is less than or equal to another floating-point register or constant.

When the **enable** input is ON, value1 and value2 are compared. If value1 is less than value2, the top output is ON. If value1 is equal to value2 the bottom output is ON.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
value1	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant
Value2	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant

Notes

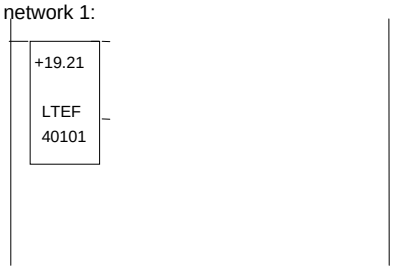
Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number. Floating point numbers can represent positive and negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

CMP – Compare Signed Values

CMPU – Compare Unsigned Values

Example



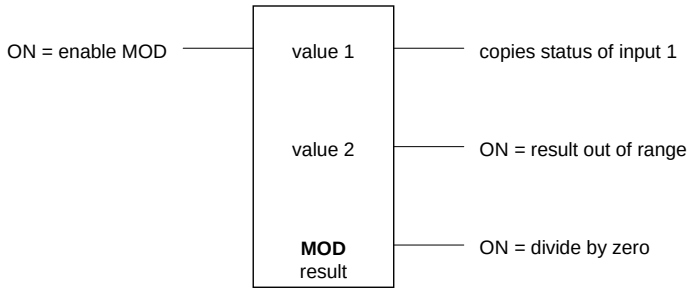
The LTEF function in network 1 compares the floating-point constant +19.21 to the contents of floating-point register 40101. The top output of the LTEF function is ON if the value of register 40101 is greater than +19.21. The bottom output of the LTEF is ON if the value of register 40001 is equal to +19.21.

2.35 MOD – Modulus of Signed Values

Description

The **MOD** function divides two registers or a constant, **value 1**, by a register or constant, **value 2**, and stores the modulus (remainder) in a holding register, **result**. Signed division is used. The value 1, value 2 and result are signed numbers.

The **out of range** output is enabled if the result is greater than 32767 or less than -32768. The **divide by zero** output is enabled if value 2 equals 0.



Function Variables

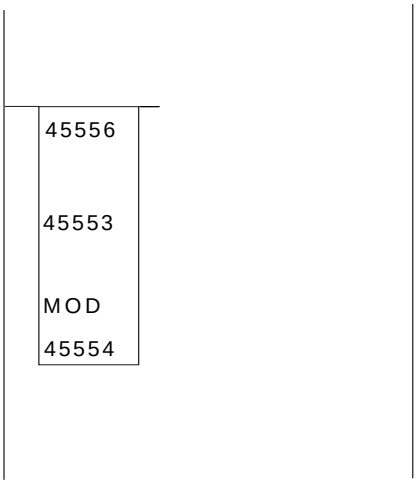
Variable	Valid Types	Description
Value 1	constant (-32768..32767) 2 Input registers (3xxxx) 2 holding registers (4xxxx)	Signed value to divide. The low order word is stored in the first register if registers are used.
Value 2	constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	Signed value to divide by
Result	holding register (4xxxx)	Result = value 1 modulo value 2

Related Functions

MODU – Modulus of Unsigned Values

Example

network 1:



The MOD function in network 1 divides **value 1**, double word registers 45556 and 45557 by **value 2**, register 45553. The modulus of this division is stored in register 45554. The table below shows some examples of different values for the registers in the MOD function.

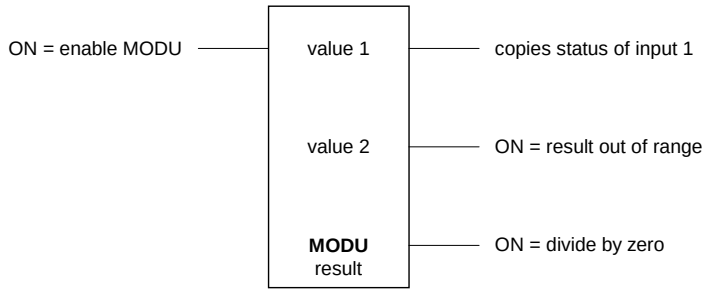
	Value of Register 45556	**Value of Register 45553**	**Modulus Register 45554**
example 1	5689	77	68
example 2	-32600	-234	-74
example 3	-22765	7659	-7447
Example 4	19823	-7692	4439

2.36 MODU – Modulus of Unsigned Values

Description

The **MODU** function divides two registers or a constant, **value 1**, by a register or constant, **value 2**, and stores the modulus (remainder) in a holding register, **result**. Unsigned division is used. The value 1, value 2 and result are unsigned numbers.

The **out of range output** is enabled if the result is greater than 65535 or less than 0. The **divide by zero output** is enabled if value 2 equals 0.



Function Variables

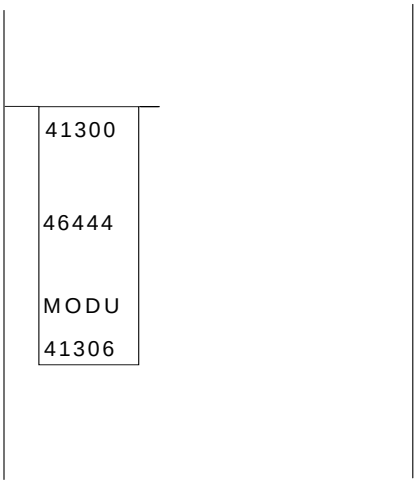
Variable	Valid Types	Description
Value 1	constant (0..65535) 2 Input registers (3xxxx) 2 holding registers (4xxxx)	Unsigned value to divide. The low order word is stored in the first register if registers are used.
Value 2	constant (0..65535) input register (3xxxx) holding register (4xxxx)	unsigned value to divide by
Result	holding register (4xxxx)	result = value 1 modulo value 2

Related Functions

MOD – Modulus of Signed Values

Example

network 1:



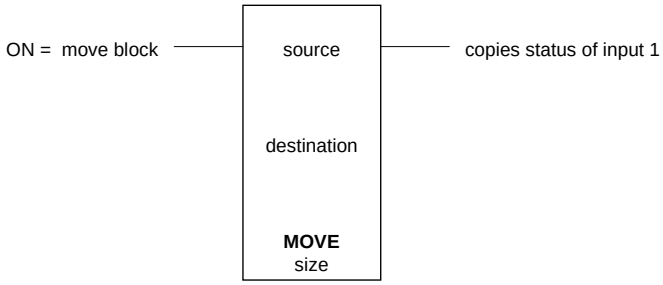
The MODU function in network 1 divides **value 1**, double word registers 41300 and 41301 by **value 2**, register 46444. The modulus of this division is stored in register 41306. The table below shows some examples of different values for the registers in the MOD function.

	Value of Register 45556	**Value of Register 45553**	**Modulus Register 45554**
Example 1	26744	320	184
Example 2	56398	34022	20878
Example 3	37697	2366	2207
Example 4	33005	1100	5

2.37 MOVE – Move Block

Description

The **MOVE** function block copies the **source** block of registers into the **destination** block of coil, or holding, registers.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the source block. The address for a coil or status register block is the first register in a group of 16 registers that will be copied.
Destination	coil block (0xxxx) holding register (4xxxx)	The first register in the destination block. The address for a coil register block is the first register in a group of 16 registers into which data will be copied.
Size	constant (1..100)	The number of 16 bit words in the block.

Block move copies 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

Related Functions

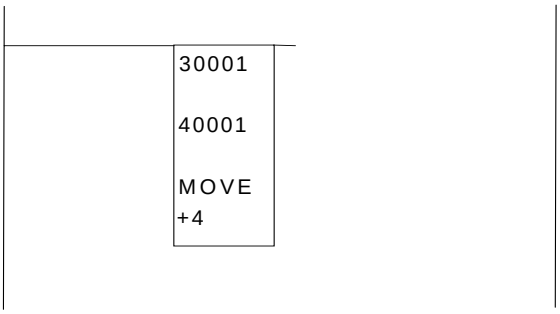
Error! Not a valid link.

L–>L – List to List Transfer

L–>R – List to Register Transfer

Example

network 1:



In the above figure the source register entered is 30001 (3reg) and the destination register entered is 40001 (4reg) and the block size entered is 4.

When this MOVE block is enabled:

the contents of register 30001 are copied to register 40001

the contents of register 30002 are copied to register 40002

the contents of register 30003 are copied to register 40003

the contents of register 30004 are copied to register 40004

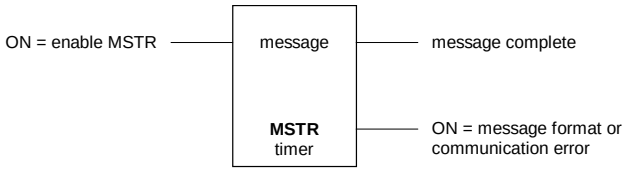
2.38 MSTR – Master Message

Description

The **MSTR** function exchanges data with another controller using either the Modbus or the DF1 communication protocols.

Note	Only one **MSTR** block may be active on each serial communication port at any one time.

When the **enable MSTR** goes from OFF to ON the MSTR function will send one master message to the slave address. The **enable MSTR** must go from OFF to ON to send another MSTR message. The **message complete** output will be energized if the MSTR receives a valid response from the slave station. The **message format or communication** error is energized if an error occurs. See the status code table below for a list of possible errors.



Function Variables

Variable	Valid Types	Description
Message	holding register (4xxxx)	Address of the first register in the message control block. There are 7 registers in the block at addresses message+0 to message+6. +0 = port +1 = function code +2 = slave controller address +3 = slave register address +4 = master register address +5 = length +6 = time-out in 0.1s increments
Timer	holding register (4xxxx)	timer accumulator register

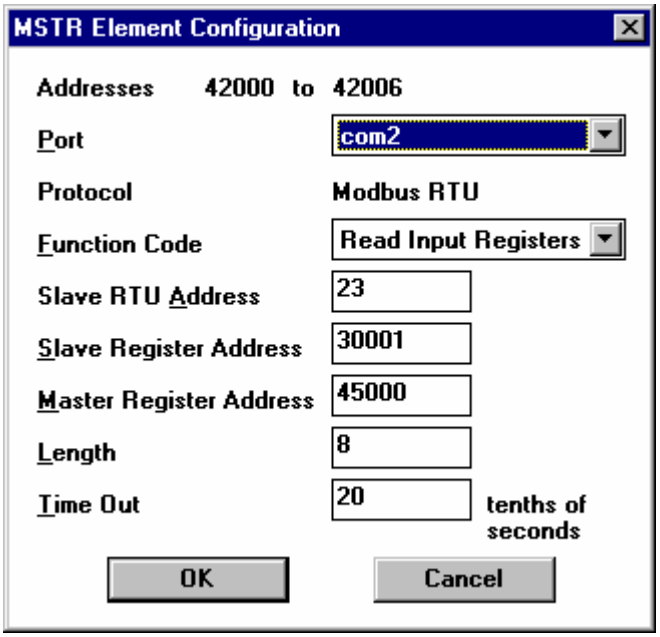
Notes

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

WARNING: If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.

Using MSTR with Modbus Protocol

This element is configured using the MSTR Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.



Valid **Function Codes** are shown below. Functions 05, 06, 15, and 16 support broadcast messages. Functions 129, 130, 132, 133, 135, 136, 138, and 139 may be broadcast, but some Enron Modbus slave devices may not support broadcast messages. See the ***TeleBUS Protocols Modbus Compatible Protocols User Manual*** for details on each function code.

Function	Description	Purpose	Maximum Registers
01	Read Coil Status	Read digital output registers.	2000
02	Read Input Status	Read digital input registers.	2000
03	Read Holding Register	Read analog output registers.	125
04	Read Input Register	Read analog input registers.	125
05	Write Single Coil	Write digital output register.	1
06	Write Single Register	Write analog output registers.	1
15	Write Multiple Coils	Write digital output registers.	880
16	Write Multiple Registers	Write analog output registers.	60
128	Read Enron Boolean	Read Enron Boolean registers	2000
129	Write Enron Single Boolean	Write Enron Boolean register	1

Function	Description	Purpose	Maximum Registers
130	Write Enron Multiple Booleans	Write Enron Boolean registers	880
131	Read Enron Short Integers	Read Enron short integer register	125
132	Write Enron Single Short Integer	Write Enron short integer register	1
133	Write Enron Multiple Short Integers	Write Enron short integer registers	60
134	Read Enron Long Integers	Read Enron long integer register	62
135	Write Enron Single Long Integer	Write Enron long integer register	1
136	Write Enron Multiple Long Integers	Write Enron long integer registers	30
137	Read Enron Floats	Read Enron floating-point register	62
138	Write Enron Single Float	Write Enron floating-point register	1
139	Write Enron Multiple Floats	Write Enron floating-point registers	30

The **port** must be set to 1, 2, 3 or 4 corresponding to the com1, com2, com3 and com4 serial ports.

The **slave controller address** edit-box sets the station number of the controller. For the Modbus ASCII and Modbus RTU protocols, the valid range is 0 to 255 if standard addressing is used, and 0 to 65534 if extended addressing is used. Address 0 is reserved for broadcast messages.

The **slave register address** specifies the first register where data will be read from or written to in the slave controller. The following table shows the valid slave register addresses for each command.

Function Code	Slave Register Address	Length
Read Coil Status	00001 to 09999	2000
Read Input Status	10001 to 19999	2000
Read Holding Register	40001 to 49999	125
Read Input Register	30001 to 39999	125
Write Single Coil	00001 to 09999	1
Write Single Register	40001 to 49999	1
Write Multiple Coils	00001 to 09999	880
Write Multiple Registers	40001 to 49999	60
Read Enron Boolean	0 to 65535	2000
Write Enron Boolean	0 to 65535	1
Write Enron Multiple Boolean	0 to 65535	880
Read Enron Short Integer	0 to 65535	125
Write Enron Short Integer	0 to 65535	1
Write Enron Multiple Short Integer	0 to 65535	60
Read Enron Long Integer	0 to 65535	62
Write Enron Long Integer	0 to 65535	1
Write Enron Multiple Long Integer	0 to 65535	30

Function Code	Slave Register Address	Length
Read Enron Floating Point	0 to 65535	62
Write Enron Floating Point	0 to 65535	1
Write Enron Multiple Floating Point	0 to 65535	30

The **master register address** specifies the first register where data will be written to or read from in this controller. The register type does not have to match the type of the slave register address. It is possible to store input registers from a slave into output registers on the master and vice-versa.

The **length** parameter specifies how many registers are to be transferred. The maximum length for each function code is shown in the above table. Functions 05 and 06 always transfer 1 register, regardless of the value of **length**.

The **time-out** is in 0.1s increments. The error output is energized if the time-out period ends without a valid response to the message.

When an error occurs, an error status code is stored in the master command status register in the analog input database. There is one status register for each port.

The module **DIAG Serial port protocol status** must be added to the register assignment to monitor the master command status register for the desired serial port. The status codes are shown in the following table.

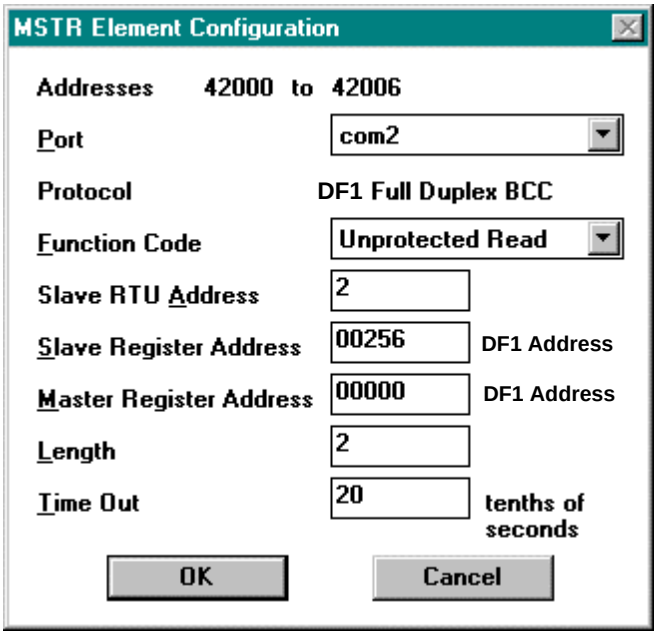
Status Code	Description
0	Message sent - waiting for response
1	Response received (no error occurred)
3	bad value in function code register
4	bad value in slave controller address register
5	bad value in slave register address register
6	bad value in length register
7	serial port or protocol is invalid
12	response timeout
24	exception response: invalid function code
25	exception response: invalid address
26	exception response: invalid value
27	protocol is invalid or serial port queue is full
28	slave and master stations are equal; they must be different
29	exception response: slave device failure
30	exception response: slave device busy

Example

An example of polling using the MSTR block is in the file **MSTR.LAD**. This file is automatically installed on the computer when the TelePACE program is installed. It is located in the **TELEPACE\EXAMPLES** directory.

Using MSTR with DF1 Protocol

This element is configured using the MSTR Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.



The **Port** must be set to 1, 2, 3 or 4 corresponding to the com1, com2, com3 and com4 serial ports.

Valid **Function Codes** are:

Function	Description	Purpose	Maximum Registers
00	Protected Write	Writes words of data to limited areas of the database.	121
01	Unprotected Read	Reads words of data from any area of the database.	122
02	Protected Bit Write	Sets or resets individual bits within limited areas of the database.	1
05	Unprotected Bit Write	Sets or resets individual bits in any area of the database.	1
08	Unprotected Write	Writes words of data to any area of the database.	121

The **Slave RTU Address** must be in the range 0 to 254.

The **Slave Register Address** specifies the first DF1 physical 16-bit address where data will be read from or written to in the slave controller.

The **Master Register Address** specifies the first physical 16-bit address where data will be written to or read from in this controller. The register type does not have to match the type of the slave register address. It is possible to store input registers from a slave into output registers on the master and vice-versa.

The **Length** parameter specifies how many 16-bit registers are to be transferred for functions 00, 01 and 08. For function codes 02 and 05, this field is labeled **Bit Mask**. **Bit Mask** selects the 16-bit bitmask specifying which bits in the **Master Register** to send. If a bit is set in **Bit Mask**, the corresponding bit in the register will be sent.

The **Time Out** is in 0.1s increments. The error output is energized if the time-out period ends without a valid response to the message. If the MSTR function is used to send a broadcast message, the **Slave RTU Address** must be 255 and the **Time Out** can be set to 0 since there is no response to wait for.

The module **DIAG Serial port protocol status** must be added to the register assignment to monitor the master command status register for the desired serial port. The status codes are shown in the following table.

Status Code	Description
0	Message sent - waiting for response
1	Response received (no error occurred)
3	bad value in function code register
4	bad value in slave controller address register
5	bad value in slave register address register
6	bad value in length register
7	slave has no more responses to send.
8	Response received didn't match command sent.
9	Specified protocol is not supported by this controller.
16	slave error - illegal command or format.
80	slave error - addressing problem or memory protect rungs.
Other	error codes from other DF1 compatible controllers - Consult the documentation for specific controller.

Notes

Details about the DF1 driver implementation on the SCADAPack controllers can be found in the **TeleBUS DF1 Protocol** Booklet in this manual**.**

An example of polling using the MSTR block is in the file **ab_mstr.lad**. This file is automatically installed on the computer when the TelePACE program is installed. It is located in the **TELEPACE\EXAMPLES** directory.

2.39 MSIP – Master IP Message

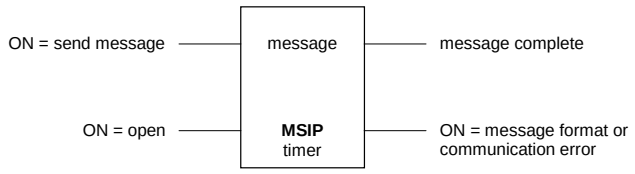
Description

The **MSIP** function exchanges data with another controller using the Modbus IP communication protocol. This function sends a master message to a remote IP address.

Note Unlike the **MSTR** function, multiple **MSIP** blocks may be active on the same communication interface at the same time. The number of active **MSIP** blocks is limited only by the number of available connections (typical capacity is 20 connections).

When the **open** input goes from OFF to ON the MSIP function opens an IP connection. Set the **open** input to OFF to close the connection.

When the **send message** input goes from OFF to ON, and the **open** input is ON, the MSIP function will send one Modbus IP master message to the slave address. The **send message** input must go from OFF to ON to send another MTCP message. Each master message is complete when either output is energized: The **message complete** output will be energized if the MSIP block receives a valid response from the slave station. The **message format or communication** error is energized if an error occurs. See the status code table below for a list of possible errors.



Function Variables

Variable	Valid Types	Description
message	holding register (4xxxx)	Address of the first register in the message control block. There are 11 registers in the block at addresses message+0 to message+11. +0 = byte1 of slave IP address MSB, using format byte1.byte2.byte3.byte4 +1 = byte2 of slave IP address +2 = byte3 of slave IP address +3 = byte4 of slave IP address LSB +4 = protocol type +5 = function code +6 = slave controller address +7 = slave register address +8 = master register address +9 = length +10 = time-out in 0.1s increments

Variable	Valid Types	Description
timer	holding register (4xxxx)	Address of the first register in the timer control block. There are 5 registers in the block at addresses timer+0 and timer+4. +0 = timer accumulator register +1 = command status register +2 = internal: connection ID +3 = internal: closing state +4 = internal: initialized

Sending a Message

Set the **open** input to ON to open an IP connection. This input may be set to ON at the same time as the **send message** input in the next step.

If the maximum number of opened connections has been reached, an error occurs: The **error** output is energized and the value of the **command status register** indicates the maximum number of connections has been reached. Close the connection used by another MSIP function to correct the error and repeat step 1.

Send one command message by toggling the **send message** input from OFF to ON.

The value of the **command status register** is 0 indicating that the message was sent.

Sending is complete when either the **message complete** output or **error** output is energized. The **message complete** output is energized if the response is received successfully. The **error** output is energized if there was a command error, timeout, or connection failure. The value of the **command status register** is 1 for success or another value for error conditions.

Repeat steps 2 to 4 to send additional command messages.

Notes

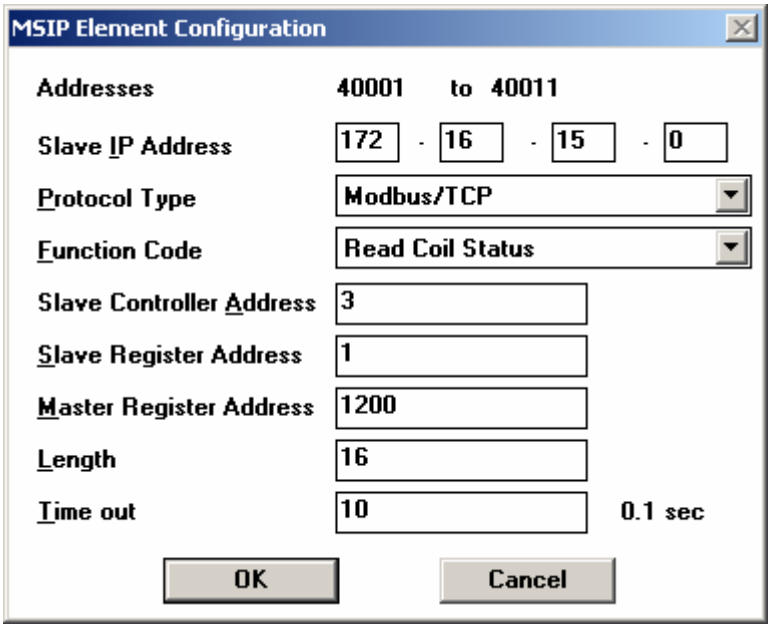
The **time-out** register determines how long to wait for a response before closing the connection and reporting an error. The connection is re-connected automatically when the next message is sent. The **open** input does not need to be toggled to do this.

Leave the **open** input ON to keep the connection open for this MTCP function.

WARNING: If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.

Element Configuration

This element is configured using the MSIP Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.



The **slave IP address** has the format 255.255.255.255 where one register is used for each byte: byte1.byte2.byte3.byte4

The **protocol type** must be one of the values shown below:

Protocol Type	Description
1	Modbus/TCP
2	Modbus RTU over UDP
3	Modbus ASCII over UDP

Valid **Function Codes** are shown below. Functions 05, 06, 15, and 16 support broadcast messages. Functions 129, 130, 132, 133, 135, 136, 138, and 139 may be broadcast, but some Enron Modbus slave devices may not support broadcast messages. See the ***TeleBUS Protocols Modbus Compatible Protocols User Manual*** for details on each function code.

Function	Description	Purpose	Maximum Registers
01	Read Coil Status	Read digital output registers.	2000
02	Read Input Status	Read digital input registers.	2000
03	Read Holding Register	Read analog output registers.	125 note 1
04	Read Input Register	Read analog input registers.	125 note 1
05	Write Single Coil	Write digital output register.	1
06	Write Single Register	Write analog output registers.	1
15	Write Multiple Coils	Write digital output registers.	880
16	Write Multiple Registers	Write analog output registers.	60

Function	Description	Purpose	Maximum Registers
128	Read Enron Booleans	Read Enron Boolean registers	2000
129	Write Enron Single Boolean	Write Enron Boolean register	1
130	Write Enron Multiple Booleans	Write Enron Boolean registers	880
131	Read Enron Short Integers	Read Enron short integer register	125 note 1
132	Write Enron Single Short Integer	Write Enron short integer register	1
133	Write Enron Multiple Short Integers	Write Enron short integer registers	60
134	Read Enron Long Integers	Read Enron long integer register	62 note 2
135	Write Enron Single Long Integer	Write Enron long integer register	1
136	Write Enron Multiple Long Integers	Write Enron long integer registers	30
137	Read Enron Floats	Read Enron floating-point register	62
138	Write Enron Single Float	Write Enron floating-point register	1
139	Write Enron Multiple Floats	Write Enron floating-point registers	30

Notes

For SCADASense Series controllers, the MSIP function can read a maximum of 123 registers with a single MSIP function. Note that SCADASense Series controllers do not support Enron Modbus commands.

The slave controller address edit-box sets the station number of the controller. The valid range is 0 to 255 if standard addressing is used, and 0 to 65534 if extended addressing is used. Address 0 is reserved for broadcast messages, which are directed to the IP address specified in the slave IP address field only.

The slave register address specifies the first register where data will be read from or written to in the slave controller. The following table shows the valid slave register addresses for each command.

Function Code	Slave Register Address	Length
Read Coil Status	00001 to 09999	2000
Read Input Status	10001 to 19999	2000
Read Holding Register	40001 to 49999	125
Read Input Register	30001 to 39999	125
Write Single Coil	00001 to 09999	1
Write Single Register	40001 to 49999	1
Write Multiple Coils	00001 to 09999	880
Write Multiple Registers	40001 to 49999	60
Read Enron Boolean	0 to 65535	2000

Function Code	Slave Register Address	Length
Write Enron Boolean	0 to 65535	1
Write Enron Multiple Boolean	0 to 65535	880
Read Enron Short Integer	0 to 65535	125
Write Enron Short Integer	0 to 65535	1
Write Enron Multiple Short Integer	0 to 65535	60
Read Enron Long Integer	0 to 65535	62
Write Enron Long Integer	0 to 65535	1
Write Enron Multiple Long Integer	0 to 65535	30
Read Enron Floating Point	0 to 65535	62
Write Enron Floating Point	0 to 65535	1
Write Enron Multiple Floating Point	0 to 65535	30

The **master register address** specifies the first register where data will be written to or read from in this controller. The register type does not have to match the type of the slave register address. It is possible to store input registers from a slave into output registers on the master and vice-versa.

The **length** parameter specifies how many registers are to be transferred. The maximum length for each function code is shown in the above table. Functions 05 and 06 always transfer 1 register, regardless of the value of **length**.

The **time-out** is in 0.1s increments. The error output is energized if the time-out period ends without a valid response to the message.

When an error occurs, an error status code is stored in the **command status register** in the timer control block. The status codes are shown in the following table.

Status Code	Description
0	valid command has been sent
1	response was received
2	no message was sent
3	invalid function code
4	invalid slave station address
5	invalid database address
6	invalid message length
7	serial port or protocol is invalid
8	connecting to slave IP address
9	connected to slave IP address
10	timeout while connecting to slave IP address
11	TCP/IP error has occurred while sending message
12	timeout has occurred waiting for response
13	slave has closed connection; incorrect response; or, incorrect response length
14	disconnecting from slave IP address is in progress
15	connection to slave IP address is disconnected
16	invalid connection ID
17	invalid protocol type
18	invalid slave IP address

Status Code	Description
19	last message is still being processed
20	master connection has been released
21	error while connecting to slave IP address
22	no more connections are available
24	exception response: invalid function code
25	exception response: invalid address
26	exception response: invalid value
27	protocol is invalid or serial port queue is full
28	slave and master stations are equal; they must be different
29	exception response: slave device failure
30	exception response: slave device busy

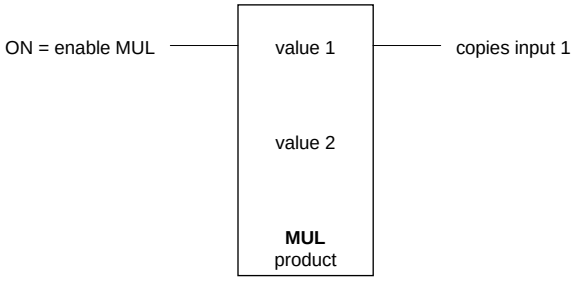
Example

An example of polling using the MSIP block is in the file **MTCP.LAD**. This file is automatically installed on the computer when the TelePACE program is installed. It is located in the **TELEPACE\EXAMPLES** directory.

2.40 MUL – Multiply Signed Values

Description

The **MUL** function block multiplies a signed register or constant, **value 1**, by a signed register or constant, **value 2** and stores the result in two consecutive holding registers, **product**. Signed multiplication is used.



Function Variables

Variable	Valid Types	Description
Value 1	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	first signed value to multiply
Value 2	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	Second signed value to multiply
Product	2 holding registers (4xxxx)	product = value 1 x value 2 The result is stored in two consecutive holding registers. The low order word is stored in the first register.

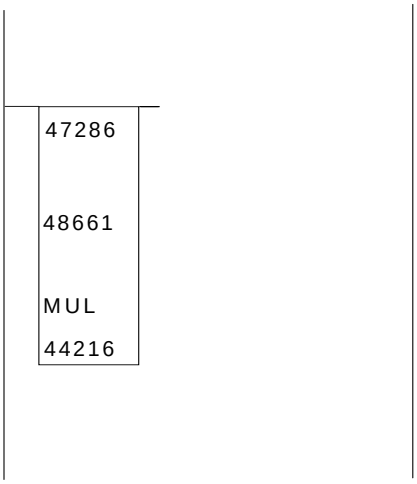
Related Functions

MULF - Multiply Floating-Point Values

MULU – Multiply Unsigned Values

Example

network 1:



In network 1 a **MUL** function is used to multiply the contents of Holding Register 47286, **value 1**, with the contents of Holding Register 48661, **value 2**. The product is stored in Holding Registers 44216, **low order word** and Holding Register 44217, **high order word**.

The examples in the table below show the product of the multiplication for various values in registers 47286 and 48661. The product is displayed as registers 44216, **low order word** and register 44217, **high order word**.

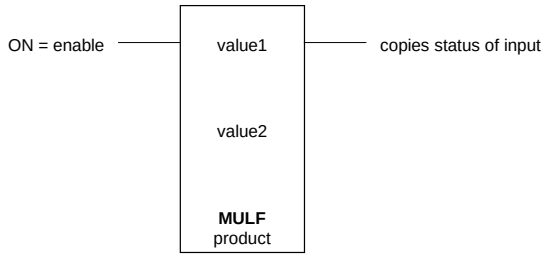
			high order	**low order**
	Register 47286	**Register 48661**	**Register 44217**	**Register 44216**
	Value 1	**value 2**	**Product**	**product**
example 1	-3057	-10	0	30570
example 2	-15	100	-1	-1500
example 3	1654	17	0	28118
example 4	164	-55	-1	-9020

2.41 MULF - Multiply Floating-Point Values

Description

The MULF element multiplies two floating-point registers or constants and stores the result in a floating-point holding register.

When the **enable** input is ON the product **value 1** × **value 2** is stored in the **product** floating-point register. The element output is ON when the input is.



Function Variables

The element has three parameters.

Variable	Valid Types	Description
Value1	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	first floating-point register or constant to multiply
Value2	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	second floating-point register or constant to multiply
Product	2 holding registers (4xxxx)	floating-point product = value1 × value2

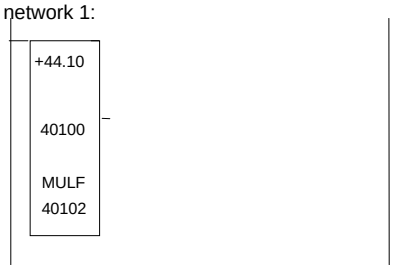
Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number. Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

MULU – Multiply Unsigned Values

Example

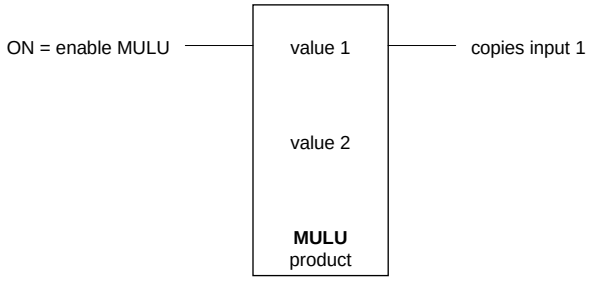


The MULF function in network 1 multiplies floating-point constant +44.10 by the contents of floating-point register 40100 (registers 40100 and 40101). Assuming floating-point register 40100 contains a value of +3.5 then the result is +154.35. This value is stored in floating-point register 40102 (registers 40102 and 40103).

2.42 MULU – Multiply Unsigned Values

Description

The **MULU** function block multiplies an unsigned register or constant, **value 1**, and an unsigned register or constant , **value 2**. The result is stored in two consecutive Holding Registers, **product**. Unsigned multiplication is used.



Function Variables

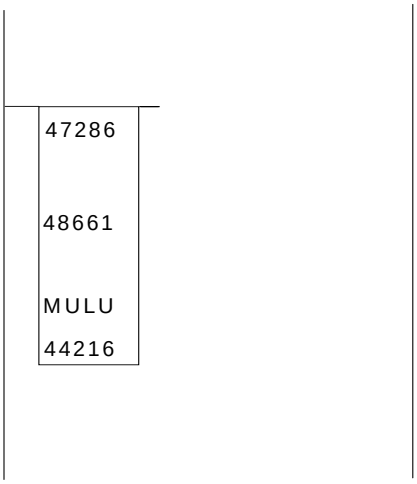
Variable	Valid Types	Description
value 1	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	first unsigned value to multiply
value 2	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	Second unsigned value to multiply
Product	2 holding registers (4xxxx)	Product = value 1 x value 2 The result is stored in two consecutive holding registers. The low order word is stored in the first register.

Related Functions

MULF - Multiply Floating-Point Values

Example

network 1:



In network 1 a **MULU** function is used to multiply the contents of Holding Register 47286, **value 1**, with the contents of Holding Register 48661, **value 2**. The product is stored in Holding Registers 44216, **low order word** and Holding Register 44217, **high order word**.

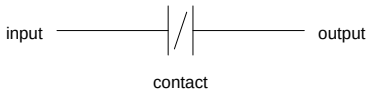
The examples in the table below show the product of the multiplication for various values in registers 47286 and 48661. The product is displayed as registers 44216, **low order word** and register 44217, **high order word**.

			high order	low order
	Register 47286	Register 48661	Register 44217	Register 44216
	Value 1	value 2	Product	product
Example 1	2048	30	0	61440
Example 2	251	251	0	63001
Example 3	77	77	0	5929
Example 4	650	735	7	18998

2.43 Normally Closed Contact

Description

The **NC** contact function block conducts power when the coil or status register is OFF.



Function Variables

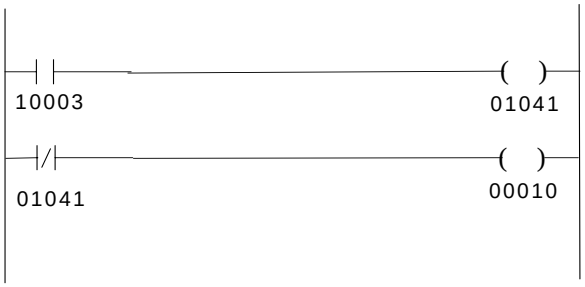
Variable	Valid Types	Description
contact	coil register (0xxxx) status register (1xxxx)	Output is ON if contact is OFF and input is ON

Related Functions

Normally Open Contact

Example

network 1:

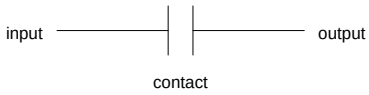


Network 1 shows NO contact 10003 and **NC** contact 01041. Power conducts through **NC** contact 01041 keeping coil 00010 ON. When **NO** contact 10003 is closed coil 01041 turns ON and **NC** contact 01041 will open, turning OFF coil 00010.

2.44 Normally Open Contact

Description

The **NO** contact function block conducts power when the coil or status register is ON.



Function Variables

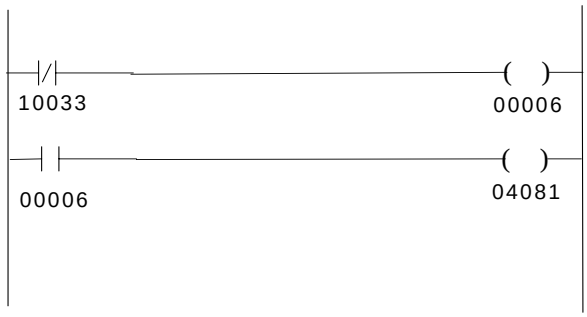
Variable	Valid Types	Description
contact	coil register (0xxxx) status register (1xxxx)	output is ON if contact is ON and input is ON

Related Functions

Normally Closed Contact

Example

network 1:

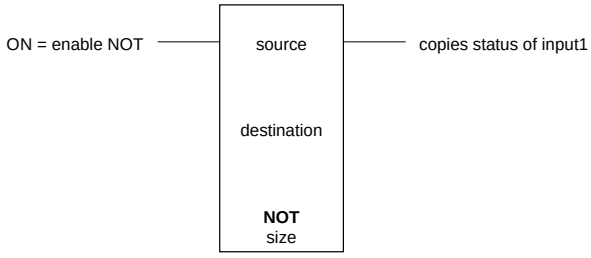


Network 1 shows NC contact 10033 and **NO** contact 00006. Power conducts through NC contact 10033 keeping coil 00006 ON. With coil 00006 ON, **NO** contact 00006 is closed and coil 04081 is ON.

2.45 NOT – Not Block

Description

The **NOT** function block inverts the **source** block of registers and stores the result in the **destination** block of coil or Holding registers. **NOT** changes bits that are ON to OFF, and changes bits that are OFF to ON.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the source block. The address for a coil or status register block is the first register in a group of 16 registers that will be complemented.
Destination	coil block (0xxxx) holding register (4xxxx)	The first register in the destination block. The address for a coil register block is the first register in a group of 16 registers where the result will be stored.
Size	Constant (1..100)	The number of 16 bit words in the block.

Notes

NOT accesses 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

Related Functions

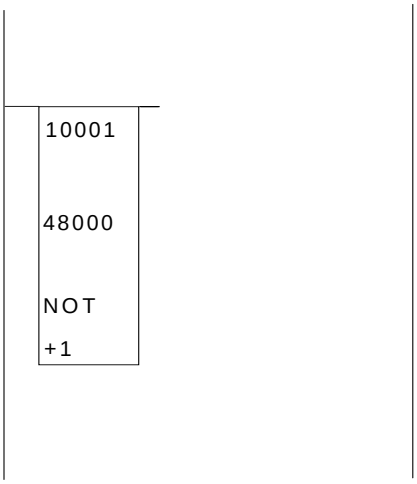
AND – And Block

OR – Or Block

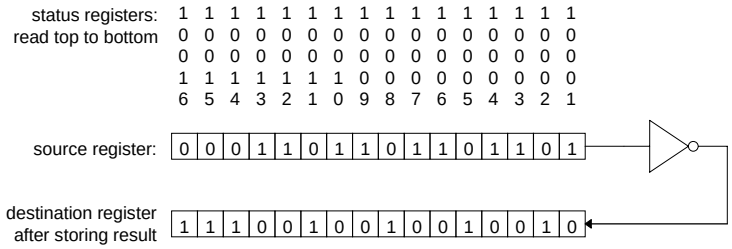
XOR – Exclusive Or Block

Example

network 1:



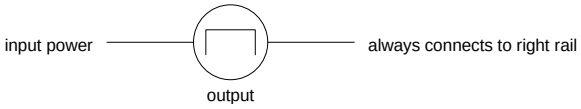
In this example the status of discrete inputs 10001 through 10016 are used as the **source** for the NOT function. These inputs are inverted and stored in the **destination** register 48000.



2.46 One Shot Coil

Description

The **One Shot Coil** function block enables an output coil for one scan when the input power changes from OFF to ON.



Function Variables

Variable	Valid Types	Description
Output	coil register (0xxxx)	output register address

Related Functions

Coil

Example

network 1:

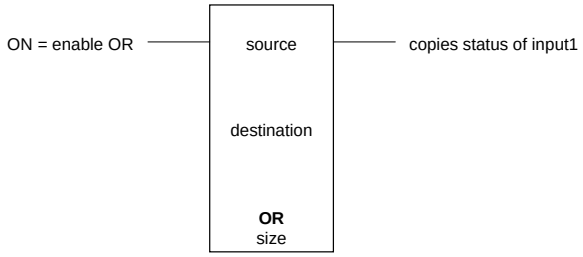
One shot coil 00004 is energized for one scan on power up of the ladder logic program.

Refer to the *I/O Database Registers* section of this manual for more information on coil outputs.

2.47 OR – Or Block

Description

The **OR** function block logically ORs the **source** block of registers with the **destination** block of registers and stores the result in the **destination** block of registers.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the source block. The address for a coil or status register block is the first register in a group of 16 registers that will be ORed.
Destination	coil block (0xxxx) holding register (4xxxx)	The first register in the destination block. The address for a coil register block is the first register in a group of 16 registers that will be ORed.
Size	Constant (1..100)	The number of 16 bit words in the block.

Notes

OR accesses 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

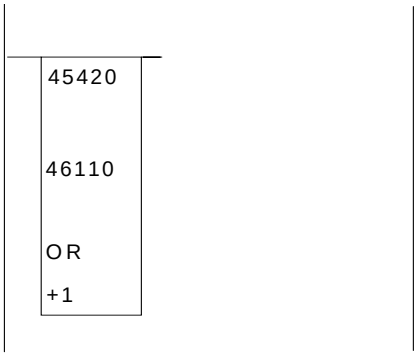
Related Functions

AND – And Block

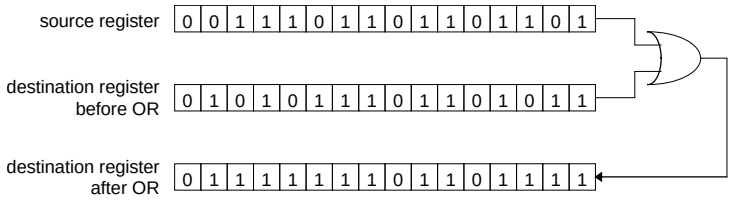
NOT – Not Block

XOR – Exclusive Or Block

Example



In this example the contents of source register, 45420, are ORed with the destination register, 46110. The result is stored in the destination register. The content of register 45420 is 15213_{10} (11101101101101). The content of the destination register before the OR function is 22379_{10} (101011101101011). The content of the destination register after the OR function is 32623_{10} (111111101101111).

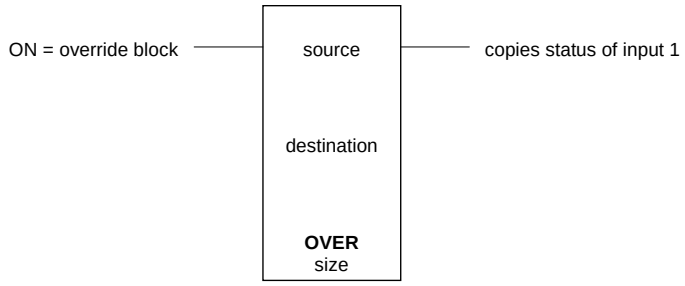


2.48 OVER – Override Block of Registers

Description

The **OVER** function copies, in one scan, the **source** block of registers into the destination block of registers and forces all registers in the **destination** block. When the **override block** input transitions from OFF to ON the destination registers are forced. The **destination** register values are overwritten with the **source** register values while the **override block** input is ON. Destination registers are unforced when the override block input transitions from ON to OFF. The function block output copies the input state.

The FORCE led on the controller is turned on when the OVER function is enabled. This function is useful for simulating inputs while debugging a control program.



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the source block. The address for a coil or status register block is the first register in a group of 16 registers that will be copied.
Destination	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the destination block. The address for a coil or status register block is the first register in a group of 16 registers.
Size	constant (1 to 100)	The number of 16 bit words in the block.

Notes

The OVER function copies 16-bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16-bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

An ON to OFF transition of the input must occur to remove the forcing on the registers. If you place an OVER function in a subroutine, be sure to execute the subroutine at least once with the input OFF to clear forcing (see the example below).

If forcing is cleared with a TelePACE command while the OVER function is enabled, the forcing will not be set again by the OVER function. You must disable and re-enable the function to force the registers. The function will continue to attempt to write to destination registers even though they are not forced.

Related Functions

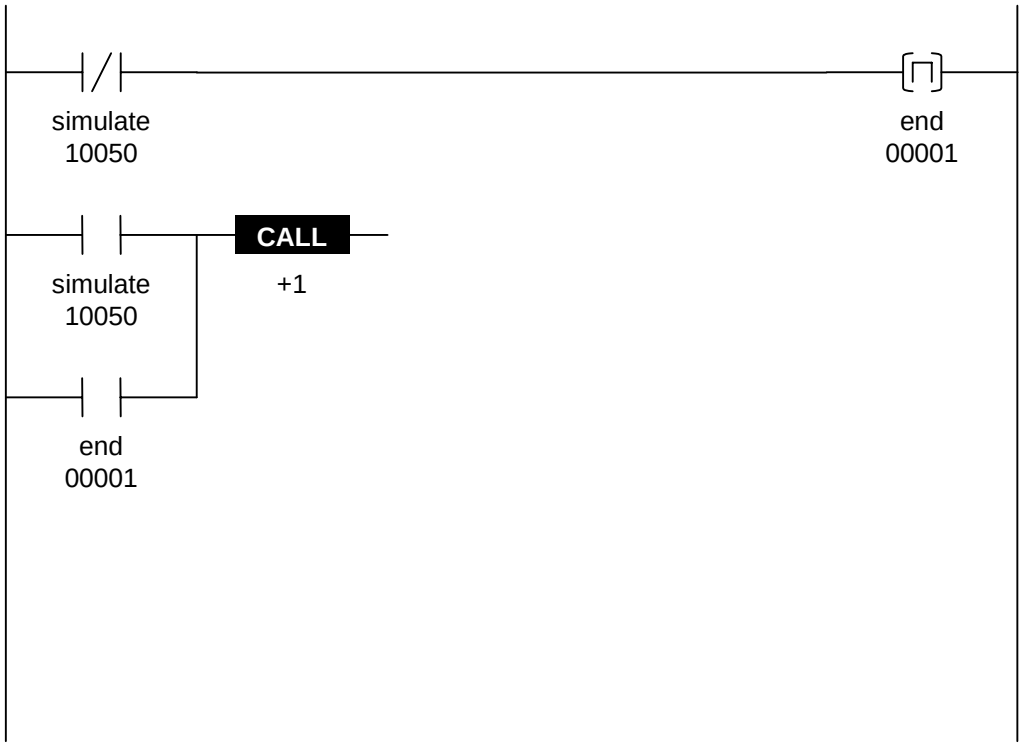
MOVE – Move Block

Example

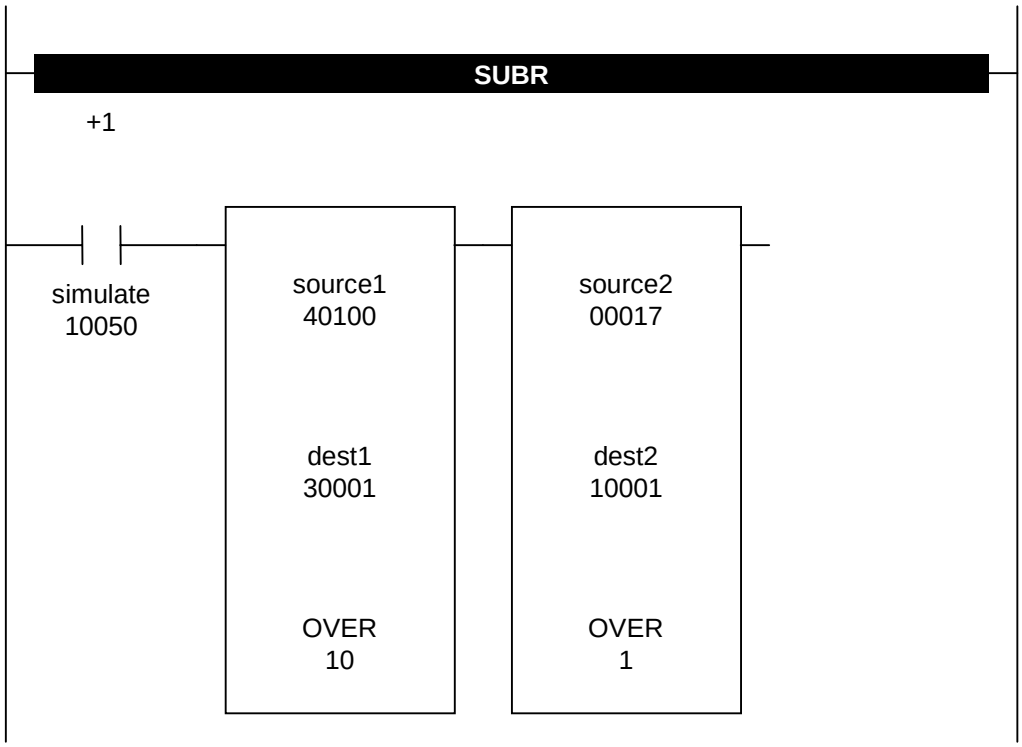
This example shows how simulated values can be written over input values in the I/O database. For this example, assume there is a register assignment that connects input hardware to registers 30001 to 30011, and to registers 10001 to 10016.

The simulate contact (10050) enables and disables the simulation. When the contact is ON simulated values are used. To simulate the values of the inputs, the program overrides the values in registers 30001 to 30011, and registers 10001 to 10016.

The first network calls the subroutine when the simulate contact is ON, and one additional time when the contact goes from ON to OFF.



The second network is a subroutine that overrides the destination registers while the simulate contact is closed. A subroutine is used so that the logic is not scanned when the simulated values are not needed. In most programs this is the normal operating state, so scanning the functions would add unnecessarily to the execution time of the program.


SUBR
+1
simulate
10050
source1
40100
dest1
30001
OVER
10
source2
00017
dest2
10001
OVER
1

2.49 PID – PID Controller

Description

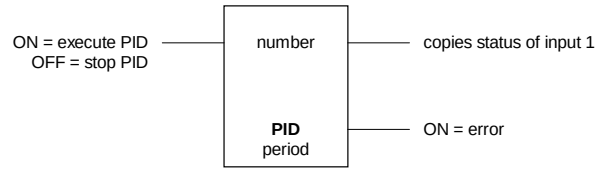
The **PID** function controls the execution of a PID controller. PID controllers execute independently of the ladder logic scan. A PID controller is configured by writing data into the PID controller registers defined in the register assignment.

The PID block starts execution of the PID controller number on the rising edge of the **execute PID** input. Execution of the PID controller is stopped when the **execute PID** is OFF.

The **execute PID** input must be toggled from OFF to ON under program control to start PID execution. The **execute PID** input cannot be directly connected to the power rail or PID execution will not restart when the program restarts.

The **error** output is enabled if the PID number is not found in the Register Assignment. The error output is also enabled if an error code is present in the PID Status Register (SR).

For a detailed description of the operation of the PID function refer to the ***TelePACE PID Controllers User Manual***.



Function Variables

Variable	Valid Types	Description
number	Constant (0..31)	PID controller number
period	Constant (0..65535)	PID controller execution period (tenths of seconds)

The I/O module, **CNFG PID control block**, must be configured in the Register Assignment when PID functions are used. The I/O module **CNFG PID control block** provides control over the configuration of a PID control block and provides access to the control block parameters. Control block parameters are assigned to 25 consecutive holding registers. The I/O module address refers to the PID control block number.

Notes

The SCADAPack 32 controller does not support the PID function. See the function ***PIDA – Analog Output PID*** and the function ***PIDD – Digital Output PID***.

2.50 PIDA – Analog Output PID

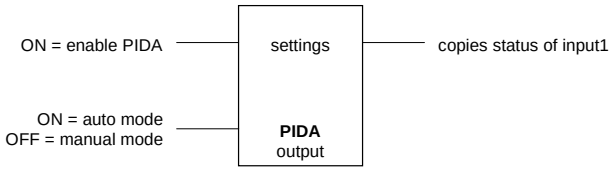
Description

The **PIDA** function performs a PID algorithm and calculates an analog output.

When the **enable PIDA** input is ON, the function executes the PID algorithm. Execution of the PID algorithm is stopped when the **enable PIDA** is OFF.

When the **auto/manual mode** input is ON, the PID is placed in automatic mode. In automatic mode the **output** is calculated using the PID algorithm. A new calculation is done at the rate specified by **cycle time**.

When the **auto/manual mode** input is OFF, the PID is placed in manual mode. In manual mode the **output** is set to the value specified by **manual mode output**. The **output** is limited to the range set by **full** and **zero**.



Function Variables

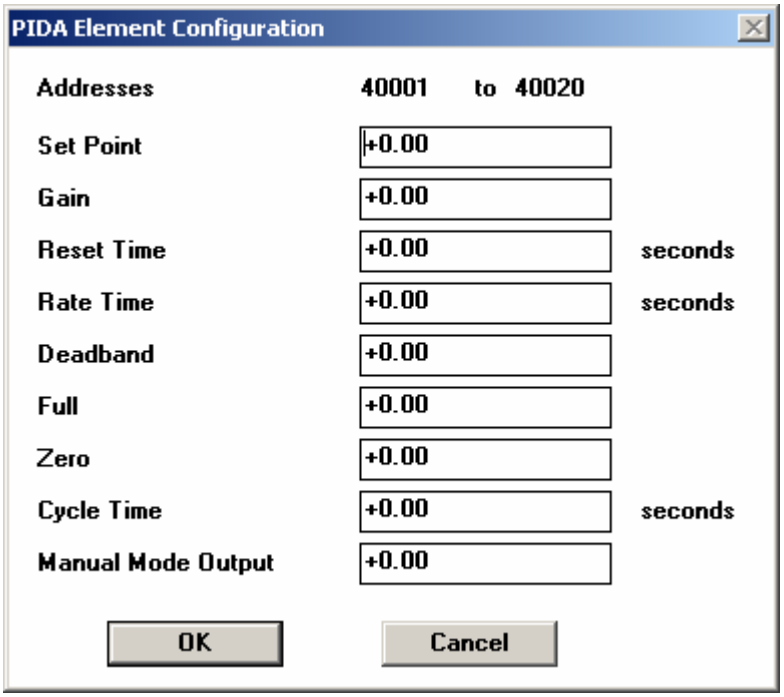
Variable	Valid Types	Description
Settings	holding register (4xxxx)	Address of the first register in the settings control block. There are 20 registers in the block at addresses settings+0 to settings+19. +0,1 = process value (float) +2,3 = setpoint (float) +4,5 = gain (float) +6,7 = reset time in seconds (float) +8,9 = rate time in seconds (float) +10,11 = deadband (float) +12,13 = full (float) +14,15 = zero (float) +16,17 = cycle time in seconds (float) +18,19 = manual mode output (float)
Output	holding register (4xxxx)	+0,1 = PID output (float) +2,3 = internal: process value N-1st (float) +4,5 = internal: process value N-2nd (float) +6,7 = internal: error N-1st (float) +8,9 = internal: time of last scan (UINT32)

The **process value** is a value that represents the actual state of the process being controlled. This value is typically input to the controller as an analog input signal or as a signal from a MVT. The process value is a floating-point number. If the process value is an analog input signal to the controller it must be converted to a floating-point number using the STOF function. If the analog

input requires scaling use the SCAL function to scale the input and provide a floating-point number for the process value.

Element Configuration

This element is configured using the PIDA Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.



PID Velocity Algorithm

The PIDD function uses the velocity form of the PID algorithm. The velocity form calculates the change in the output and adds it to the previous output.

$$e_n = s_n - p_n$$

$$m_n = m_{n-1} + K\left[e_n - e_{n-1} + \frac{T}{T_i}e_n + \frac{R}{T}\left(p_n - 2p_{n-1} + p_{n-2}\right)\right]$$

Where: e = error
s = setpoint
p = process value
K = gain
T = execution period
T_i = integral or reset time
R = rate gain
m = output

The Element Configuration dialog is used to input each parameter into the calculation. These parameters are described below.

Setpoint

The **setpoint** is a floating-point value representing the desired value of the process value. The error value is the difference between the process value and the setpoint.
error = process value – setpoint (+/- deadband).

Process Value

The **process value** is a value that represents the actual state of the process being controlled. See the Function Variables section above for the registers to use for the process value input to the PIDD.

Gain

The proportional (P) part of the PID algorithm is the **gain.** A positive value of gain configures a forward-acting PID controller and a negative value of gain configures a reverse acting controller.

Reset Time

The integral (I) part of the PID algorithm is the **reset time**. This value, in seconds, controls the reset gain (or magnitude of integral action) in a PI or PID controller. This is typically referred to as Seconds Per Repeat. From the equation above it is seen that the integral action of the PI or PID controller is a function of the reset time and the execution period (cycle time). A smaller reset time provides more integral action and a larger reset time provides less integral action. Valid range is any value greater than 0. A value of 0 disables the reset action.

Rate Gain

The derivative (D) part of the PID algorithm is the **rate time.** This value, in seconds, controls the rate gain (or magnitude of derivative action) in a PD or PID controller. From the equation above it is seen that the derivative action of the PD or PID controller is a function of the rate gain and the execution period (cycle time). A larger rate gain provides more derivative action and a smaller rate gain provides less derivative action. Valid range is any value greater than 0. A value of 0 disables the rate action.

Deadband

The **deadband** parameter is used by the PID algorithm to determine if the process requires the control outputs to be changed. If the absolute value of the error is less than the deadband, then the function block skips execution of the control algorithm. This prevents changes to the output when the process value is near the setpoint and can reduce wear on the control elements. Valid range is any value greater than 0.The **setpoint** is a floating-point value representing the desired value of the process value.

Full

The **full** setting is used in limiting the maximum output value of the PIDA function. If the PID algorithm calculates an **output** quantity that is greater than the value stored in **full**, the output quantity is set equal to the value stored in **full**. The **full** setting should always be greater than the **zero** setting.

Zero

The **zero** setting is used in limiting the minimum output value of the PIDA function. If the PID algorithm calculates an **output** quantity that is less than the value stored in **zero**, the **output** quantity is set equal to the value stored in **zero**. The **zero** setting should always be less than the **full** setting.

Cycle Time

The **cycle time** is the floating-point value of the PID algorithm execution period measured in seconds. Any value greater than or equal to 0.001 seconds (1 ms) may be specified. If the cycle time specified is less than the scan time of the TelePACE program, the program scan time becomes the PID cycle time.

Manual Mode

The **manual mode output** is the value that the **output** is set to when the PIDA function is in manual mode.

Related Functions

PIDD – Digital Output PID

2.51 PIDD – Digital Output PID

Description

The **PIDD** function performs a PID velocity algorithm (see description below) and operates two discrete outputs to maintain PID control.

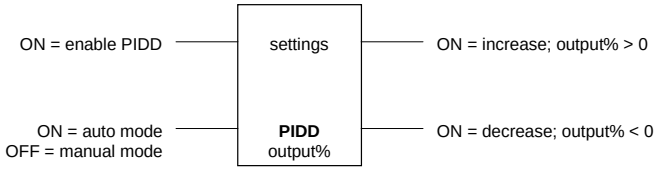
The output of the PIDD is the output percent value **output%**. The **output%** is a duty cycle of the **cycle time** as defined by the **zero%** and **full%** parameters.

The **increase** output is cycled when the **output%** is greater than zero. The **decrease** output is cycled when the **output%** is less than zero.

When the **enable PIDD** input is ON, the function executes the PID algorithm. Execution of the PID algorithm is stopped when the **enable PIDD** is OFF.

When the **auto/manual mode** input is ON, the PID is placed in automatic mode. In automatic mode the output is calculated using the PID algorithm. A new calculation is done at the rate specified by **cycle time**.

When the **auto/manual mode** input is OFF, the PID is placed in manual mode. In manual mode the **output%** is set to the value specified by **manual output%**. The output is limited to the range set by **full%** and **zero%**.



Function Variables

Variable	Valid Types	Description
settings	holding register (4xxxx)	Address of the first register in the settings control block. There are 21 registers in the block at addresses settings+0 to settings+20. +0,1 = process value (float) +2,3 = setpoint (float) +4,5 = gain (float) +6,7 = reset time in seconds (float) +8,9 = rate time in seconds (float) +10,11 = deadband (float) +12,13 = full% (float) +14,15 = zero% (float) +16,17 = cycle time in seconds (float) +18,19 = manual mode output% (float) +20 = motor output enabled
output%	holding register (4xxxx)	+0,1 = PID output % (float) +2,3 = internal: process value N-1st (float)

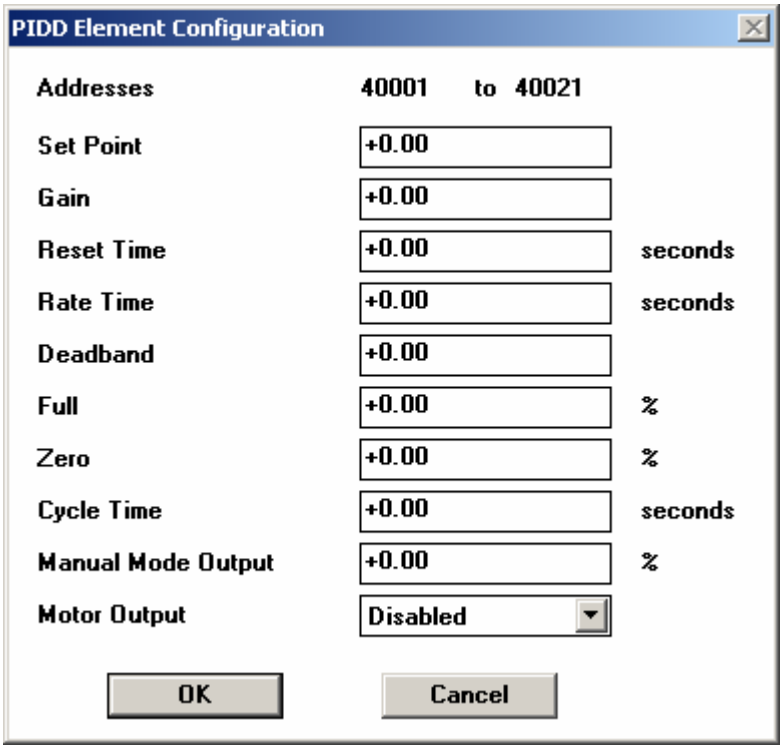
Variable	Valid Types	Description
		+4,5 = internal: process value N-2nd (float) +6,7 = internal: error N-1st (float) +8,9 = internal: time of last scan (UINT32) +10,11 = internal: on time for controller (UINT32)

The **process value** is a value that represents the actual state of the process being controlled. This value is typically input to the controller as an analog input signal or as a signal from a MVT. The process value is a floating-point number. If the process value is an analog input signal to the controller it must be converted to a floating-point number using the STOF function. If the analog input requires scaling use the SCAL function to scale the input and provide a floating-point number for the process value.

The remaining **settings** and **output%** registers are described in the Element Configuration section below.

Element Configuration

This element is configured using the PIDD Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.



PID Velocity Algorithm

The PIDD function uses the velocity form of the PID algorithm. The velocity form calculates the change in the output and adds it to the previous output.

$$e_n = s_n - p_n$$

$$m_n = m_{n-1} + K\left[e_n - e_{n-1} + \frac{T}{T_i} e_n + \frac{R}{T}\left(p_n - 2p_{n-1} + p_{n-2}\right) \right]$$

Where: e = error
s = setpoint
p = process value
K = gain
T = execution period
T_i = integral or reset time
R = rate gain
m = output

The Element Configuration dialog is used to input each parameter into the calculation. These parameters are described below.

Setpoint

The **setpoint** is a floating-point value representing the desired value of the process value. The error value is the difference between the process value and the setpoint.
error = process value – setpoint (+/- deadband).

Process Value

The **process value** is a value that represents the actual state of the process being controlled. See the Function Variables section above for the registers to use for the process value input to the PIDD.

Gain

The proportional (P) part of the PID algorithm is the **gain.** A positive value of gain configures a forward-acting PID controller and a negative value of gain configures a reverse acting controller.

Reset Time

The integral (I) part of the PID algorithm is the **reset time**. This value, in seconds, controls the reset gain (or magnitude of integral action) in a PI or PID controller. This is typically referred to as Seconds Per Repeat. From the equation above it is seen that the integral action of the PI or PID controller is a function of the reset time and the execution period (cycle time). A smaller reset time provides more integral action and a larger reset time provides less integral action. Valid range is any value greater than 0. A value of 0 disables the reset action.

Rate Gain

The derivative (D) part of the PID algorithm is the **rate time.** This value, in seconds, controls the rate gain (or magnitude of derivative action) in a PD or PID controller. From the equation above it is seen that the derivative action of the PD or PID controller is a function of the rate gain and the execution period (cycle time). A larger rate gain provides more derivative action and a smaller rate gain provides less derivative action. Valid range is any value greater than 0. A value of 0 disables the rate action.

Deadband

The **deadband** parameter is used by the PID algorithm to determine if the process requires the control outputs to be changed. If the absolute value of the error is less than the deadband, then the function block skips execution of the control algorithm. This prevents changes to the output when the process value is near the setpoint and can reduce wear on the control elements. Valid range is any value greater than 0.

Full Scale Output

The **full%** setting is the full-scale output limit in percent of **cycle time**. For example if the cycle time is 10 seconds and the full% value is 100 then the maximum duty cycle of the output% is 100 percent or 10 seconds.

When the zero% value is 0 or greater then the increase output is turned on for the duty cycle of the output%. When the zero% value is less than zero the decrease output is turned on for the duty cycle of the output% when the output% is negative.

Zero Scale Output

The **zero%** setting is the zero scale output limit in percent of **cycle time**. When the zero% value is 0 or greater then the increase output is turned on for the duty cycle of the output%. When the zero% value is less than zero the decrease output is turned on for the duty cycle of the output% when the output% is negative.

Cycle Time

The **cycle time** is the floating-point value of the PID algorithm execution period measured in seconds. Any value greater than or equal to 0.001 seconds (1 ms) may be specified. If the cycle time specified is less than the scan time of the TelePACE program, the program scan time becomes the PID cycle time.

Manual Mode Output

The **manual mode output%** is the value that the **output%** is set to when the PIDD function is in manual mode.

Motor Output

When the **motor output** is set to **enabled** the **increase** and **decrease** outputs are de-energized when error is within the deadband. When the **motor output** is set to **disabled** the **increase** and **decrease** outputs operate continuously based on the **output%**.

Related Functions

PIDA – Analog Output PID

2.52 POWR – Floating-Point Raised to Power

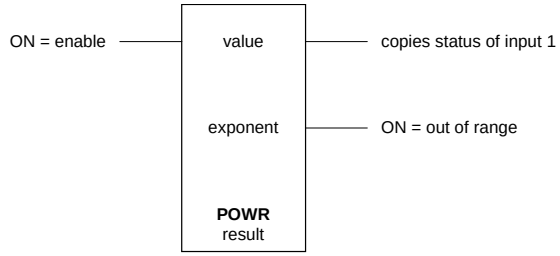
Description

The **POWR** function calculates the result of a value raised to an exponent and stores the result in a floating-point holding register.

When the **enable** input is ON, **value** is raised to the **exponent** and stored in the **result** floating-point register.

The top output is ON when the input is.

The **out-of-range** output is ON if the **value** is zero and **exponent** is less than zero; and if **value** is negative. The result is not calculated in these cases.



Function Variables

Variable	Valid Types	Description
Value	Floating Point Constant 2 input registers (3xxxx) 2 holding register (4xxxx)	Floating Point value to be raised. The high order word is stored in the first register.
Exponent	Floating Point Constant 2 input registers (3xxxx) 2 holding register (4xxxx)	Floating Point value to raise value to. The high order word is stored in the first register.
Result	2 holding register (4xxxx)	result = value^{exponent} The high order word is stored in the first register.

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

The calculation is performed using a single-precision floating-point number.

Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

ABSF - Floating-Point Absolute Value

ADDF - Add Floating-Point Values

DIVF - Divide Floating-Point Values

MULF - Multiply Floating-Point Values

SQRF - Square Root of Floating-Point Value

SUBF – Subtract Floating-Point Values

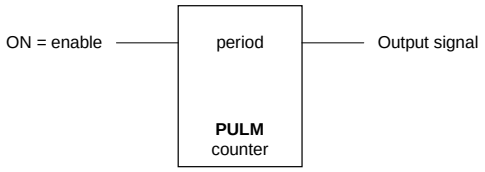
2.53 PULM - Pulse Minutes

Description

The **PULM** function controls a square wave digital signal.

While the **enable** is ON, the **output** signal will be active ON or OFF based on the period. The output is powered only when the enable input is ON.

For example when the enable input is on and a period of 10 minutes is used the result will be an output square wave that is ON for 5 minutes and then OFF for 5 minutes.



Function Variables

Variable	Valid Types	Description
Period	Constant (1..65535) input register (3xxxx) holding register (4xxxx)	The period of the waveform, in minutes.
Counter	2 holding registers (4xxxx)	Contains the accumulated time of the period in seconds.

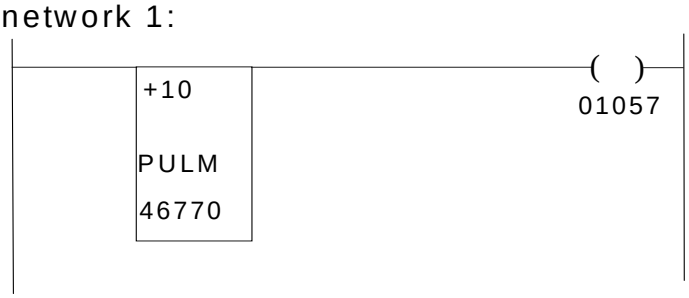
Notes

The Period is from 1 to 65535 minutes.

Related Functions

PULS - Pulse Seconds

Example



In this example the PULM function has a period value of 10 minutes. Coil 01057 will be on for 5 minutes and then off for 5 minutes. When the program is first run coil 01057 will start in on state for 5 minutes then go off for 5 minutes, repeating this cycle as long as the enable input is true. Registers 46770 and 46771 contain the accumulated time for the period in seconds.

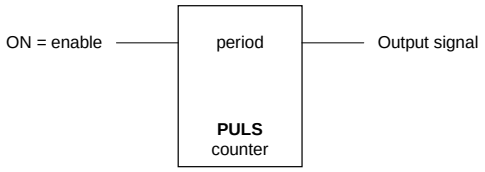
2.54 PULS - Pulse Seconds

Description

The **PULS** function controls a square wave digital signal.

While the **enable** is ON, the **output** signal will be active ON or OFF based on the period. The output is powered only when the enable input is ON.

For example when the enable input is on and a period of 10 seconds is used the result will be an output square wave that is ON for 5 seconds and then OFF for 5 seconds.



Function Variables

Variable	Valid Types	Description
Period	Constant (1..65535) input register (3xxxx) holding register (4xxxx)	The period of the waveform, in seconds.
Counter	2 holding registers (4xxxx)	Contains the accumulated time of the period in tenths of seconds.

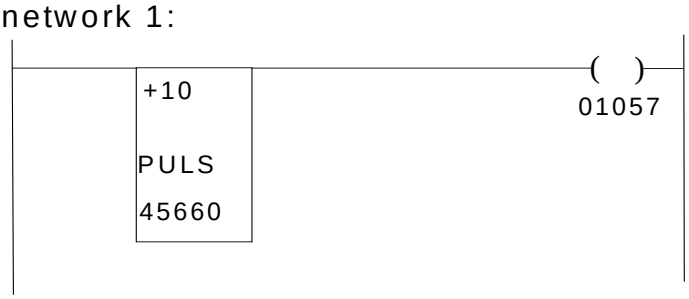
Notes

The Period is from 1 to 65535 seconds. The smallest actual period will depend on the ladder scan time. Smaller ladder programs will be able to handle smaller periods.

Related Functions

Timers

Example



In this example the PULM function has a period value of 10 seconds. Coil 01057 will be on for 5 seconds and then off for 5 seconds. When the program is first run coil 01057 will start in on state for 5 seconds then go off for 5 minutes, repeating this cycle as long as the enable input is true. Registers 46770 and 46771 contain the accumulated time for the period in seconds.

2.55 PUTB – Put Bit into Block

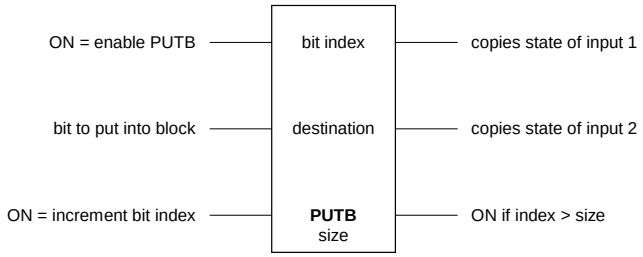
Description

The **PUTB** function block writes the status of a bit, at the **bit index**, into the **destination** block of registers.

The **enable PUTB** input must be energized for a PUTB function to execute.

The **bit to put into block** input is the bit value that will be written into the destination register at the location of the bit index when **enable PUTB** is energized.

The **increment bit index** input increments the index, once each scan, when **enable PUTB** is energized.



Function Variables

Variable	Valid Types	Description
bit index	Constant (0..65535) Holding register (4xxxx)	The index of the bit within the destination block. A bit index of 0 is the most significant bit of the first register of the destination block.
Destination	coil block (0xxxx) holding register (4xxxx)	The address of the destination register block. The address for a coil register block is the first register in a group of 16 registers.
Size	Constant (1..100)	number of 16 bit words in the block.

Notes

Put bit into block accesses 16 bit words. Coil blocks are groups of 16 registers that start with the register specified as the block address. Coil blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 00033, etc.

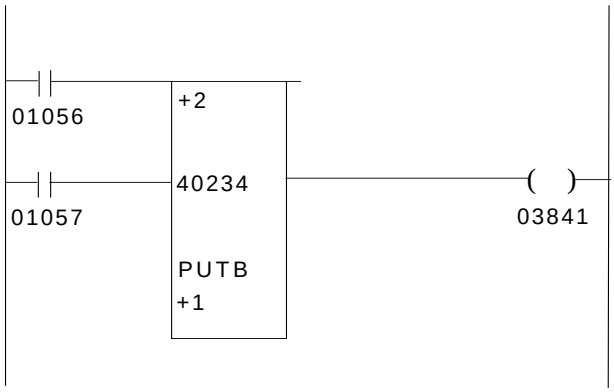
Related Functions

GETB – Get Bit from Block

ROTB – Rotate Bits in Block

CMPB – Compare Bit

Example



In network 1 the PUTB function is being used to set the manual control bit in the PID Block 0 Control Register, bit 13 of register 40234. The bit index of the manual control bit is 2, with 0 being the most significant bit.

Closing contacts 01056 allows power to be supplied to the **enable PUTB** input of the PUTB function block. With the function block enabled, closing contacts 01057 allows power to the **put bit into block** input of the function block. The bit at the index is then set in the destination register, the PID Block 0 Control Register. Output coil 03841 is energized.

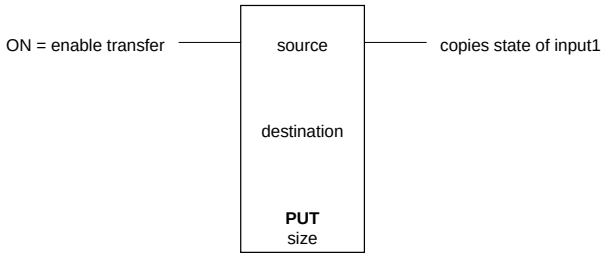
2.56 PUT – Put Signed Value into Registers

Description

The **PUT** function transfers, in one scan, the **source** holding register or signed constant into the **destination** holding registers. The number of destination registers is determined by **size**. The same value is stored in each destination register.

The source register, or signed constant, is transferred to the destination holding register when **enable transfer** is ON.

If the source is a register, this function is identical to the **PUTU** function.



Function Variables

Variable	Valid Types	Description
source	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	The signed value or address of the register containing the value to be stored.
destination	Holding register (4xxxx)	The address of the first destination register.
Size	Constant (1..9999)	The number of destination registers.

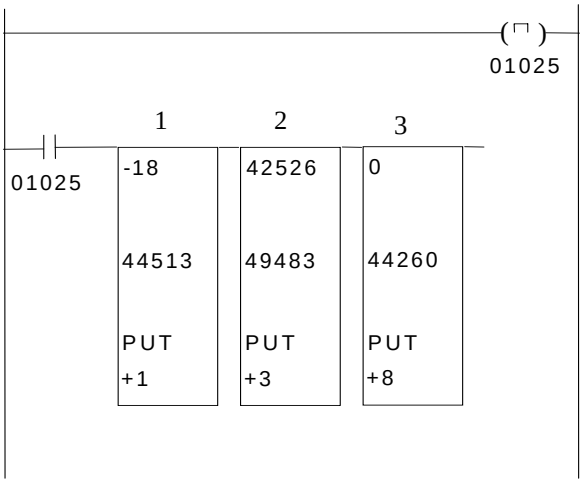
Related Functions

PUTU – Put Unsigned Value into Registers

PUTF - Put Floating-Point Value

Example

network 1:



In this example there are three PUT functions in network 1. On power up One Shot coil 01025 is energized for one scan. This will cause NO contacts 01025 to close, applying power to the enable transfer input on PUT functions 1,2 and 3.

In PUT 1 the constant value -18 is transferred to holding register 44513.

In PUT 2 the value of holding register 42526 (1000) is transferred to holding registers 49483 through 49485.

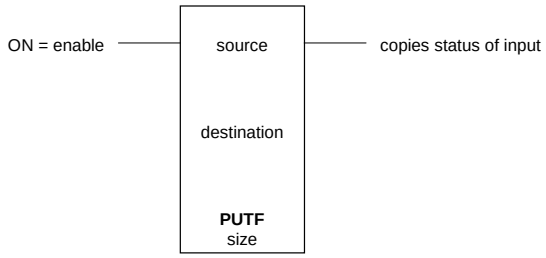
In PUT 3 the constant value 0 is transferred to holding registers 44260 through 44267.

2.57 PUTF - Put Floating-Point Value

Description

The PUTF element transfers, in one scan, the **source** floating-point holding register or constant into the **destination** floating-point holding registers. The number of floating-point destination registers is determined by **size**. The same value is stored in each floating-point register pair.

When the **enable** input is ON, the source register or constant is transferred to the destination registers. The element output is ON when the input is.



Function Variables

The element has three parameters.

Variable	Valid Types	Description
source	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	Floating-point register or constant to be stored
Destination	Holding register (4xxxx)	Address of the first pair of destination registers
Size	Constant (1…4999)	the number of floating-point destination registers pairs to store

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number. Floating point numbers can represent positive and negative values in the range -3.402×10^{38} to 3.402×10^{38}.

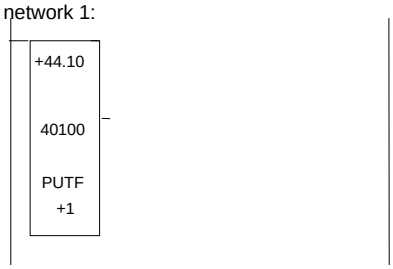
The size parameter determines the number of floating-point register pairs affected. The number of registers affected is twice the value of size, since each floating-point value uses two registers.

Related Functions

PUT – Put Signed Value into Registers

PUTU – **Put Unsigned Value into Registers**

Example



The PUTF function in network 1 puts the floating-point constant +44.10 value into floating-point register 40100 (registers 40100 and 40101).

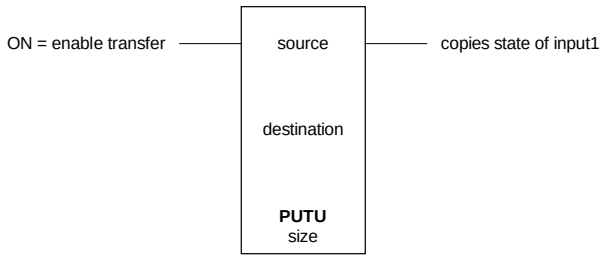
2.58 PUTU – Put Unsigned Value into Registers

Description

The **PUTU** function transfers, in one scan, the **source** holding register or unsigned constant into the **destination** holding registers. The number of destination registers is determined by **size**. The same value is stored in each destination register.

The source register, or unsigned constant, is transferred to the destination holding register when **enable transfer** is ON.

If the source is a register, this function is identical to the **PUT** function.



Function Variables

Variable	Valid Types	Description
source	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	The unsigned value or address of the register containing the value to be stored.
Destination	Holding register (4xxxx)	The address of the first destination register.
Size	Constant (1..9999)	The number of destination registers.

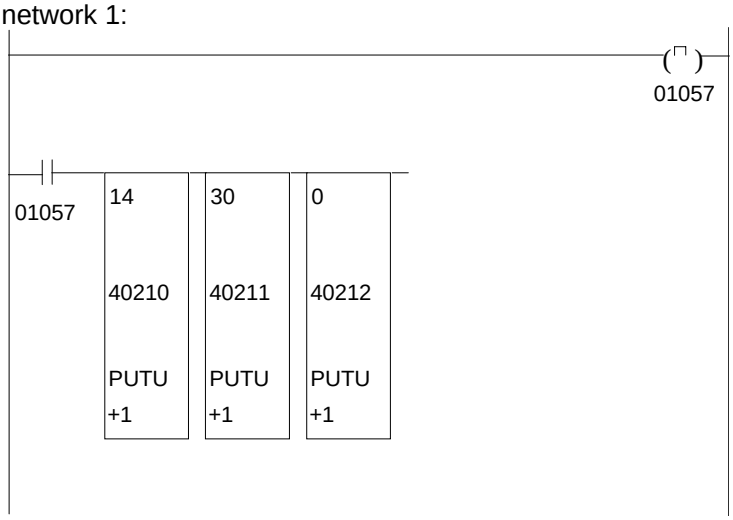
Related Functions

PUT – Put Signed Value into Registers

PUTF - Put Floating-Point Value

Example

network 1:



This example uses two PUTU functions to write the correct time to the Real Time Clock. The time for this example is 14:30:00.

The holding registers used to in this example must be assigned to the **CNFG Real Time Clock and Alarm I/O Module** in the Register Assignment. Holding registers 40210 through 40220 are assigned to this I/O module.

On power up One Shot coil 01057 is energized for one scan. This will cause NO contacts 01057 to close, applying power to the enable transfer inputs on the two PUTU functions.

The real time clock continues to run with the new time setting immediately after these PUTU functions are enabled. Note that all seven clock registers must be set to valid values for the clock to operate correctly.

Another method for setting the clock, is to use the *Edit/Force Register* dialog to write the current time to the appropriate module registers. Leave the force box in the dialog unchecked so that the data is only written, not forced.

2.59 R–>L – Register to List Transfer

Description

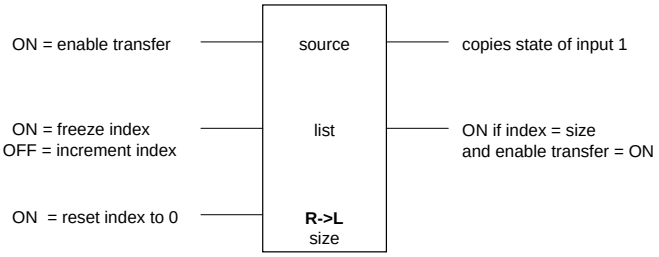
The **R->L** function transfers the contents of the source register into a register in the destination list of registers indicated by the index.

When the **enable transfer** input is ON and the **index equals size** output is OFF, the source register is transferred to the destination list register at the position of the index.

The **freeze/increment index** input allows control of the index. If this input is ON the index is not incremented. If the input is OFF the index is incremented by one after each transfer.

When the **reset index** input is ON the index is reset to zero.

The index is incremented by one on each transfer until the index equals size. When the **index equals size** output is ON no further increments of the index value occur until the index is reset**.**



Function Variables

Variable	Valid Types	Description
source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The address of the source register. The address for a coil or status register block is the first register in a group of 16 registers that will be read.
index and destination	Holding register (4xxxx)	The address of the index register and the data registers. The index is stored in register [4xxxx]. The data is stored in register [4xxxx+1] to register [4xxxx+size]
Size	Constant (1..9999)	The number of registers in the list.

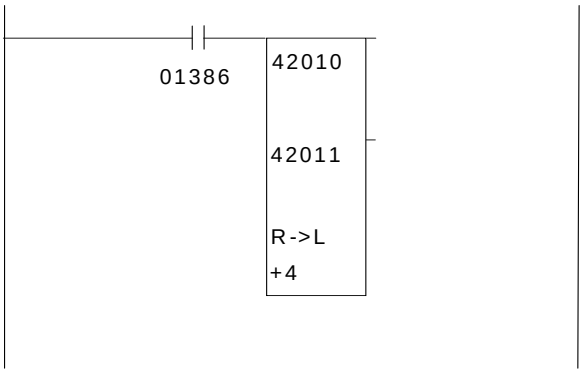
Related Functions

L–>L – List to List Transfer

L–>R – List to Register Transfer

MOVE – Move Block

Example



The Register to List function transfers the contents of the source register 42010 into a register in the destination list of registers, 42012 to 42015, indicated by the index register 42011.

			Destination Register List
		List Index-->	42011
Source Register->	42010	list register 0-->	42012
		list register 1-->	42013
		list register 2-->	42014
		list register 3-->	42015

An example of the registers used in a Register to List (R->L) transfer is shown in the above diagram. The source register is a general purpose analog output register. The index is a general purpose analog output register that will have a value of 0, 1, 2 or 3. The destination register list starts at the next sequential register after the index register. The destination list contains four general purpose analog output registers and has a size of 4.

When list index register 42011 has a value of 0 and the R->L function is enabled the contents of source register 42010 is transferred to destination list register 40012.

When list index register 42011 has a value of 1 and the R->L function is enabled the contents of source register 42010 is transferred to destination list register 42013.

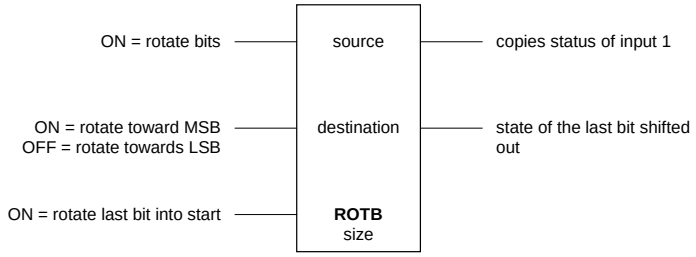
When list index register 42011 has a value of 2 and the R->L function is enabled the contents of source register 42010 is transferred to destination list register 42014.

When list index register 42011 has a value of 3 and the R->L function is enabled the contents of source register 42010 is transferred to destination register 42015.

2.60 ROTB – Rotate Bits in Block

Description

The **ROTB** function block rotates the bits in the **source** block by one bit and stores the result in the **destination block**. The block can be rotated towards either the most significant bit (MSB) or towards the least significant bit (LSB).



Function Variables

Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The address of the first source register. The address for a coil or status register block is the first register in a group of 16 registers that will be rotated.
Destination	coil block (0xxxx) holding register (4xxxx)	The address of the first destination register. The address for a coil or status register block is the first register in a group of 16 registers that will be rotated.
Size	Constant (1..100)	The number of 16 bit words in the block.

Related Functions

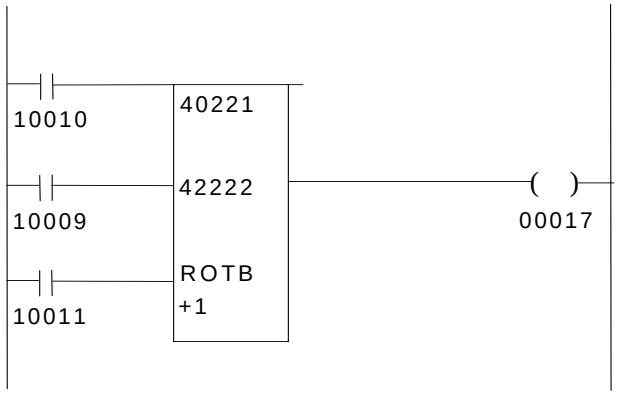
PUTB – Put Bit into Block

GETB – Get Bit from Block

CMPB – Compare Bit

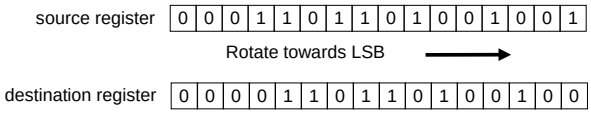
Example

network 1:

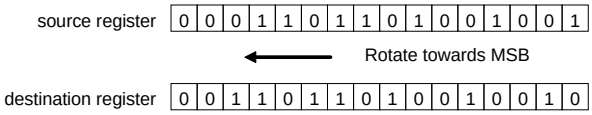


The ROTB function in network 1 is configured to demonstrate the operation of the function block. Register 40221, the source register, has a value of 6985. Register 40222 is the destination register.

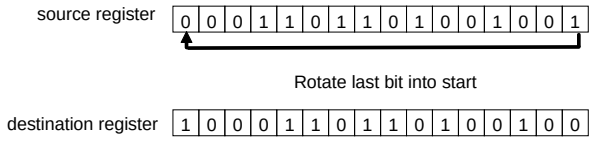
The first example is a rotate towards LSB. Closing the **rotate bits** input, contacts 10010, will cause the bits in the source register to rotate right by one bit and the result to be stored in the destination register.



The next example is a rotate towards MSB. Closing the **rotate towards MSB** input, contacts 10009 and then closing the **rotate bits** input, contacts 10010, will cause the bits in the source register to rotate once to the left. The result is stored in the destination register.



In the last example the **rotate bits** input is enabled by closing contact 10010. Closing contacts 10011 will enable the **rotate last bit to start** input. The LSB of the source register is rotated to the MSB and the remaining bits are rotated right.



2.61 SCAL – Scale Analog Value

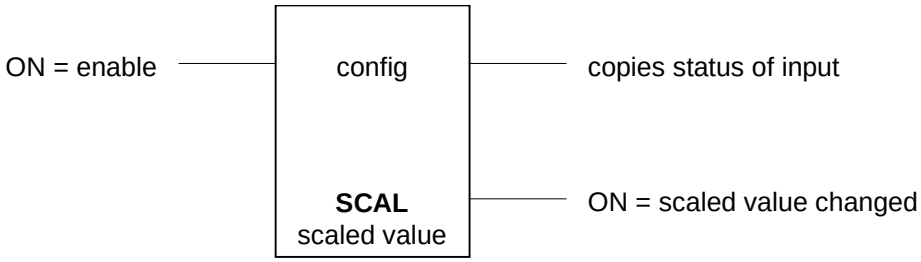
Description

The SCAL function scales an integer into a floating-point value and detects changes in the floating-point value.

When the **Enable** input is ON the SCAL function calculates the scaled value.

When the **Enable** input is ON the scaled value is compared to the previous scaled value. If the difference is greater than the deadband the scaled value changed output is turned ON and the scaled value is copied to the previous scaled value. The previous scaled value does not change if scaled value is within the deadband.

When the **Enable** input changes from OFF to ON, the scaled value is copied to previous scaled value.



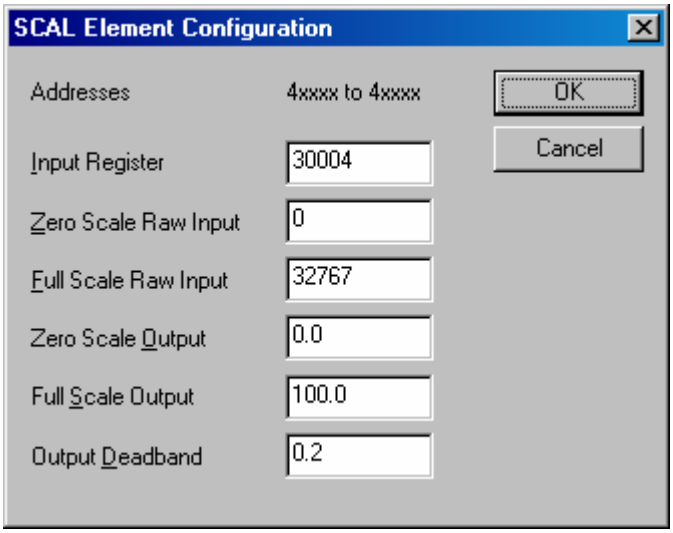
Function Variables

Variable	Valid Types	Description
config	holding register (4xxxx)	Address of the first register in the configuration block. There are 9 registers in the block at addresses message+0 to message+8. +0 = input register +1 = zero scale raw input +2 = full scale raw input +3-4 = zero scale output (floating point) +5-6 = full scale output (floating point) +7-8 = deadband (floating point)
scaled value	4 holding registers (4xxxx)	Address of the first register in the output block. There are 4 registers in the block at addresses output+0 to output+3 +0-1: scaled value (floating point) +2-3: previous scaled value (floating point)

Element Configuration

This element is configured using the SCAL Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.



The **Input Register** specifies the register from which the input is read. Valid values are any input (3xxxx) or holding (4xxxx) register. The range depends upon the registers supported in the selected controller type.

The **Zero Scale Raw Input** specifies the minimum raw input value. Valid values are -32768 to 32767. This value must be less than the full-scale raw input.

The **Full Scale Raw Input** specifies the maximum raw input value. Valid values are -32768 to 32767. This value must be greater than the zero scale raw input.

The **Zero Scale Output** is the floating-point value calculated when the input is equal to the zero scale raw input. This value must be less than the full-scale output. Valid values are any floating-point number.

The **Full Scale Output** is the floating-point value calculated when the input is equal to the full-scale raw input. This value must be greater than the zero scale output. Valid values are any floating-point number.

The **Output Deadband** is the amount by which the output must change for the **scaled value changed** output to be energized. Valid values are any floating-point number greater than or equal to 0.0.

Notes

The input is scaled using this formula.

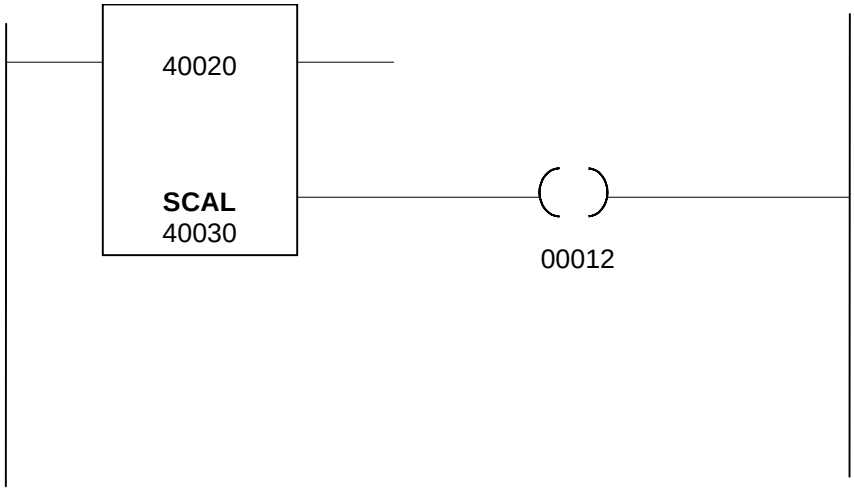
$$scaled = \frac{input - zero\_raw}{full\_raw - zero\_raw} \times (full\_output - zero\_output) + zero\_output$$

The previous scaled value changes only when difference between the current and previous values is greater than the deadband. The **scaled value changed** output is energized when this occurs.

The input register may contain values less than the zero scale raw input or greater than the full-scale raw input. The scaling calculation is still performed.

Example

In this example a SCAL block is used to convert an analog input into engineering units and close a contact each time a change of 10 units occurs.



The element configuration for the SCAL block is as follows

Parameter	Value	Notes
Input Register	30001	assign to analog input module in register assignment
Zero Scale Raw Input	0	minimum value for unipolar analog input
Full Scale Raw Input	32767	maximum value for analog input
Zero Scale Output	0	corresponds to the minimum value of analog input
Full Scale Output	1000	corresponds to the maximum value of analog input
Output Deadband	10	change in output to turn on change output

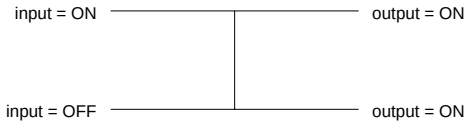
2.62 Shunts

Horizontal

The horizontal shunt conducts power from left to right.

Vertical

The vertical shunt conducts power between rows. If any of the rows connected by vertical shunts are powered, all output rows will be powered, as shown in the example below.

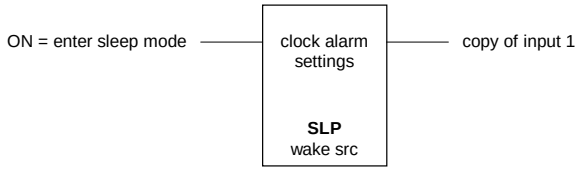


2.63 SLP – Put Controller into Sleep Mode

Description

The **SLP** function places the controller into sleep mode. Sleep mode reduces power consumption to a minimum by halting the microprocessor clock and shutting down the power supply. All programs halt until the controller resumes execution. All output points turn off while the controller is in sleep mode.

This function is not supported in the SCADAPack 32, SCADAPack 100 or SCADASense Series controllers.



Function Variables

Variable	Valid Types	Description
clock alarm settings	holding register (4xxxx)	Address of the first register in the clock alarm settings block. There are 4 registers in the block at addresses settings+0 to settings + 3 +0 = type +1 = hour +2 = minute +3 = second Valid values for type are 0 = no alarm 1 = absolute time alarm 2 = elapsed time alarm
wake src	holding register (4xxxx)	address of the wake up source register. This register indicates the reason the controller left sleep mode. Valid values are: 1 = real time clock alarm 2 = interrupt input 4 = led power switch 8 = counter 0 overflow 16 = counter 1 overflow 32 = counter 2 overflow 256 = Assertion of: - digital input 0 for SCADAPack 350 - Any digital input on SCADAPack LP - INT/Cntr digital Input on SCADAPack with 5203/5204 controller board

Notes

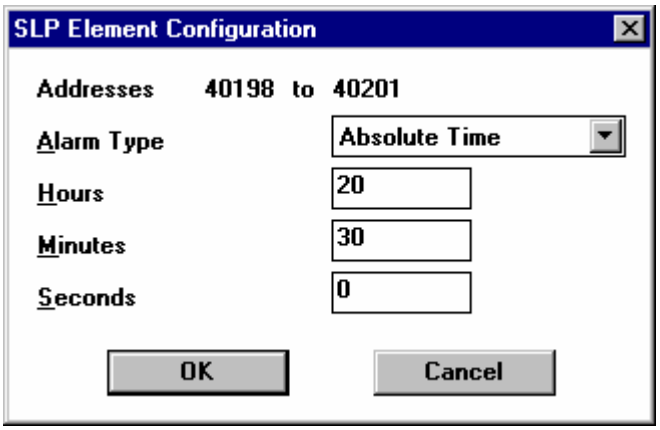
The SCADAPack 32 and SCADAPack 100 controllers do not support the SLP function

Note that this function block triggers the same interrupt as the CNFG Real Time Clock and Alarm register assignment. Using both alarm settings, therefore, in the same program is not recommended.

Element Configuration

This element is configured using the SLP Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.



Valid values for the time parameters are listed in the table below.

Alarm Type	Parameter	Range
Absolute	Hours Minutes Seconds	0 to 23 0 to 59 0 to 59
Elapsed	Hours Minutes Seconds	0 to 23 0 to 1439 0 to 65535 Total of all time must be less than 23 hours, 59 minutes, 59 seconds

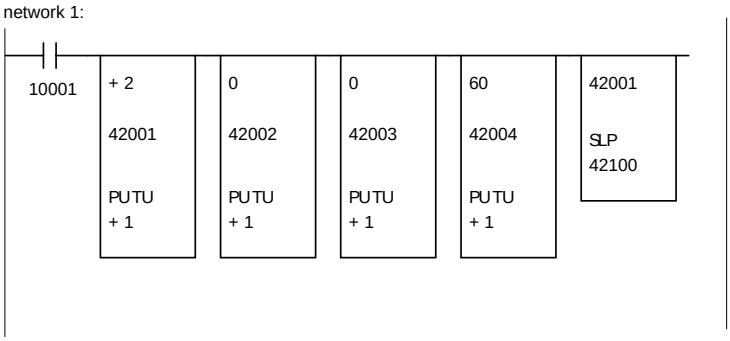
The controller will wake up under the following conditions.

Condition	Wake Up Effects
Hardware Reset	Application programs execute from start of program.
External Interrupt	Program execution continues from point sleep function was executed.
Real Time Clock Alarm	Program execution continues from point sleep function was executed.
LED Power Button	Program execution continues from point sleep function was executed.

Condition	Wake Up Effects
Hardware Counter Rollover	Software portion of counter is incremented. Program execution continues from point sleep function was executed.

Example

The following network will put the controller into sleep mode. The clock alarm is set to wake the controller in 60 seconds. Other conditions may wake up the controller before the 60 seconds expires.



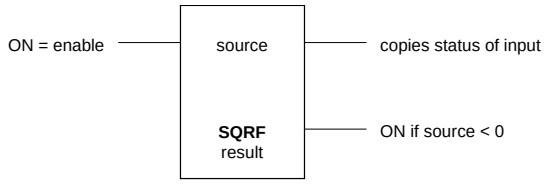
The **Element Configuration** dialog may be used to edit the configuration of the SLP block, instead of PUTU functions. This reduces the memory used by the program. However, the alarm settings are written to the controller only when the program is loaded. The network using the PUTU elements configures the alarm settings on every execution of the SLP element.

2.64 SQRF - Square Root of Floating-Point Value

Description

The SQRF element stores the square root of a floating-point register or constant in a floating-point holding register.

When the **enable** input is ON the square root of the **source** is stored in the **result** floating-point holding register. The top output is ON when the input is. The bottom output is ON if the source is negative, and the input is ON.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
source	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	a floating-point register or constant
result	2 holding registers (4xxxx)	Floating-point square root of source

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number. Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

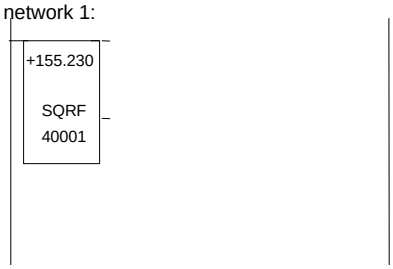
The square root of a negative number cannot be calculated. The source must be positive or zero to calculate a result..

Related Functions

DIV – Divide Signed Values

DIVU – Divide Unsigned Values

Example



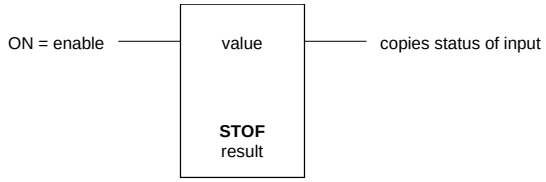
The SQRF function in network 1 takes the square root of the floating-point constant +155.23 and puts the result in floating-point register 40001 (registers 40001 and 40002). The value in 40001 is =12.459.

2.65 STOF - Signed Integer to Floating-Point

Description

The STOF element converts a signed register or constant into a floating-point number and stores the result in a floating-point holding register.

When the **enable** input is ON, **value** is converted into a floating-point number and stored in the **result** floating-point register. The element output is ON when the input is.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
Value	Constant (–32768…32767) input register (3xxxx) holding register (4xxxx)	Signed value to convert
Result	2 holding registers (4xxxx)	Converted floating-point value

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

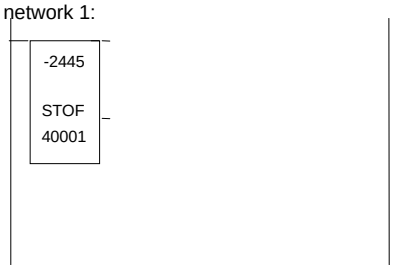
Related Functions

UTOF - Unsigned Integer to Floating-Point

FTOS - Floating-Point to Signed Integer

FTOU - Floating-Point to Unsigned Integer

Example

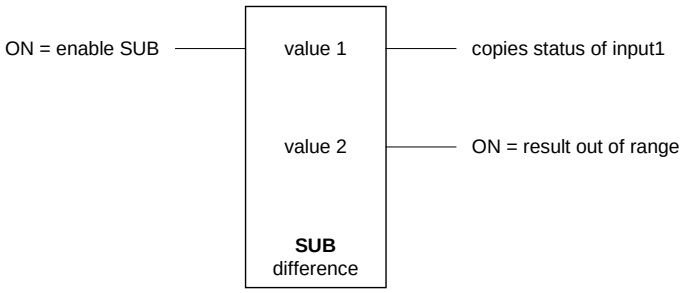


The STOF function in network 1 converts signed integer constant -2445 to a floating-point value and puts the value into floating point-register 40001 (registers 40001 and 40002). In this example the content of floating-point register 40001 is the floating-point value –2445.00.

2.66 SUB – Subtract Signed Values

Description

The **SUB** function block subtracts a signed register or constant, **value 2**, from a signed register or constant, **value 1**, and stores the result in a holding register, **result**. Signed subtraction is used. The **result out of range** output is enabled if the result is greater than 32767 or less than -32768.



Function Variables

Variable	Valid Types	Description
value 1	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	Signed value to subtract from
value 2	Constant (-32768..32767) input register (3xxxx) holding register (4xxxx)	Signed value to subtract
Difference	holding register (4xxxx)	Difference = value 1 - value 2

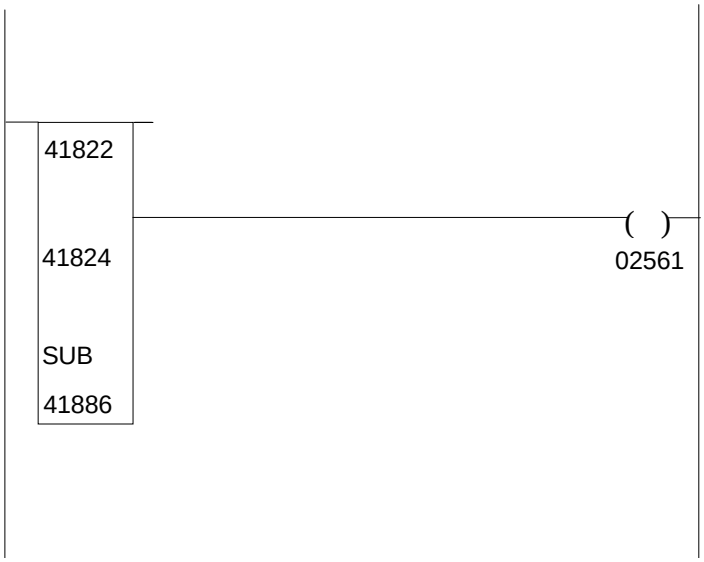
Related Functions

SUBF – Subtract Floating-Point Values

SUBU –Subtract Unsigned Values

Example

network 1:



The SUB function in network 1 subtracts the contents of register 41824, **value 2**, from the contents of register 41822, **value 1**. The **difference** is stored in register 41886. Some examples of different values for registers 41822 and 41824 are shown in the table below.

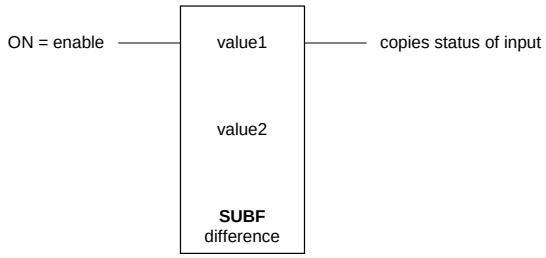
	Register 41822	Register 41824	Register 41886	Coil 02561
	value 1	value 2	difference	out of range
Example 1	-27765	-18755	-9010	OFF
Example 2	3276	-12269	15545	OFF
Example 3	-30000	27881	7655	ON

2.67 SUBF – Subtract Floating-Point Values

Description

The SUBF element subtracts one floating-point register or constant from another and stores the result in a floating-point holding register.

When the **enable** input is ON the difference **value 1** – **value 2** is stored in the **difference** holding register. The element output is ON when the input is.



Function Variables

The element has three parameters.

Variable	Valid Types	Description
value1	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	Floating-point register or constant to subtract from
Value2	FP constant 2 input registers (3xxxx) 2 holding registers (4xxxx)	floating-point register or constant to subtract
Difference	2 holding registers (4xxxx)	floating-point difference = value1 – value2

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

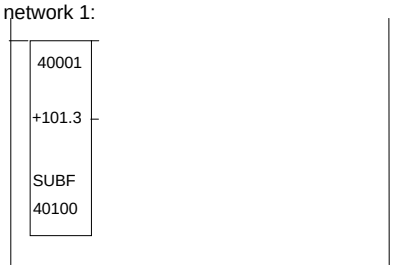
Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

Related Functions

SUB – Subtract Signed Values

SUBU –Subtract Unsigned Values

Example



The SUBF function in network 1 subtracts floating-point constant +101.3 from floating-point register 40001 (registers 40001 and 40002). Assuming floating-point register 40001 contains a value of 1000.00 the result is +898.7. The result is stored in floating-point register 40100 (registers 40100 and 40101).

2.68 SUBR - Start of Subroutine

Description

The **SUBR** element defines the start of a **subroutine**.

A subroutine is a group of logic networks that can be executed conditionally. The subroutine begins with the network containing the **SUBR** element. A subroutine ends when another subroutine element is encountered, or when the end of the ladder logic program is reached.

The element is a single cell element. Visually it covers the entire width of the first row of the network.

Function Variables

The **SUBR** element has one parameter:

Variable	Valid Types	Description
number	Constant	The number of the subroutine. Any number in the range 1 to 500 is valid.

Notes

The **SUBR** element must be located in row 1, column 1 of a network.

No other element can be located to the right of the **SUBR** element.

Outputs of a subroutine remain in their last state when a subroutine is not called. For example, a coil that is turned on by a subroutine remains on when the subroutine is *not* called. The output will only turn off when the subroutine is called and it turns the output off.

The subroutine number is a constant. Constant tag names are used with this value.

The subroutine number must be unique. No other subroutine can use the same number.

Subroutines do not have to be programmed in any particular numerical order. For example, subroutine 1 can follow subroutine 2, subroutine 200 can follow subroutine 400.

Related Functions

CALL - Execute Subroutine

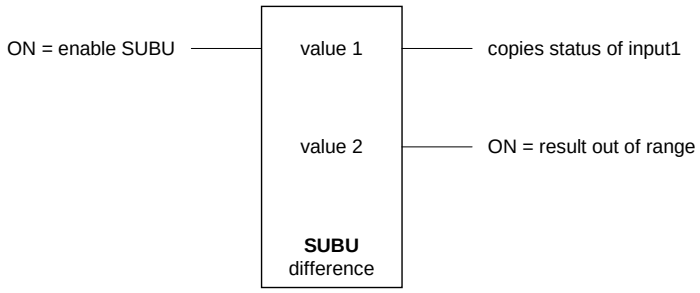
Example

See the example for the CALL function.

2.69 SUBU –Subtract Unsigned Values

Description

The **SUBU** function block subtracts an unsigned register or constant, **value 2**, from an unsigned register or constant, **value 1**, and stores the result in a holding register, difference. Unsigned subtraction is used. The **result out of range** output is enabled if the result is greater than 65535 or less than 0.



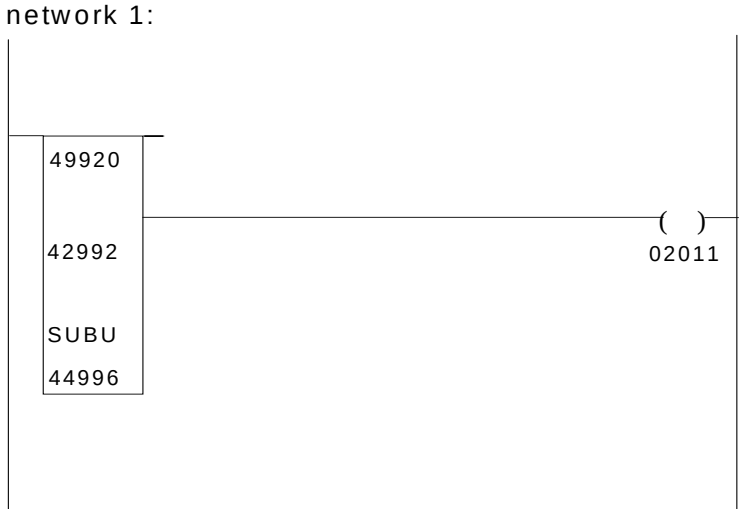
Variable	Valid Types	Description
value 1	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	Unsigned value to subtract from
Value 2	Constant (0..65535) input register (3xxxx) holding register (4xxxx)	Unsigned value to subtract
Difference	holding register (4xxxx)	Difference = value 1 - value 2

Related Functions

SUB – Subtract Signed Values

SUBF – Subtract Floating-Point Values

Example



The SUBU function in network 1 subtracts the contents of register 42992, **value 2**, from the contents of register 49920, **value 1**. The **difference** is stored in register 44996. Some examples of different values for registers 49920 and 42992 are shown in the table below.

	Register 49920	Register 42992	Register 44996	Coil 02011
	value 1	value 2	Difference	out of range
Example 1	22675	1988	20687	OFF
Example 2	61223	2399	58824	OFF
Example 3	3877	54440	14973	ON

2.70 Timers

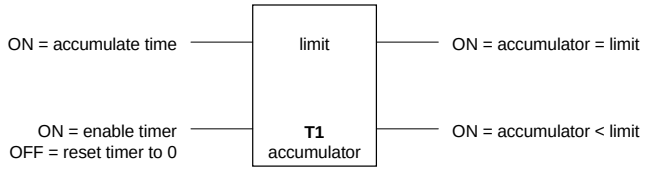
Description

The three timer functions measure elapsed time and save it in a holding register, **accumulator**. The **T1** timer measures time in 1.0 second intervals. The **T.1** timer measures time in 0.1 second intervals. The **T.01** timer measures time in 0.01 second intervals.

When the **enable timer** input is ON and the **accumulate time** is ON the accumulator increments by the Timer interval to the value of the **limit.** When the **enable timer** is off the accumulator is reset to zero.

When the **enable timer** is ON and the **accumulator** equals the **limit** then the **accumulator = limit** output is On.

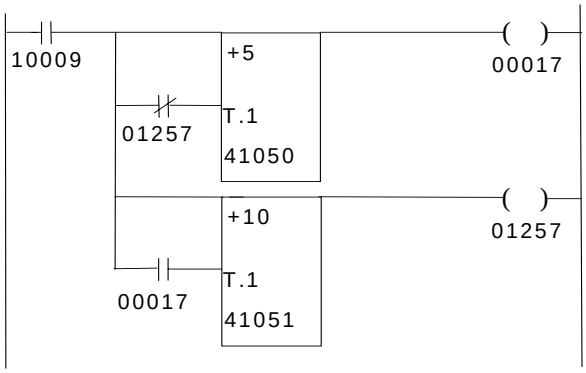
When the **enable timer** is ON and the **accumulator** is less than the **limit** then the **accumulator < limit** output is On.



Variable	Valid Types	Description
Limit	Constant (1..65535) input register (3xxxx) holding register (4xxxx)	Upper limit for accumulator
Accumulator	Holding register (4xxxx)	Register holds time during which accumulate time input has been ON

Example

network 1:



In network 1 two Timer functions are configured such that output coil 00017 is ON for 1.0 second (10 * 0.1) and OFF for 0.5 second (5 * 0.1).

When power is applied to the circuit by closing contacts 10009, output coil 00017 is OFF and Timer 41050 starts to accumulate time. When the accumulator reaches the limit of 5, output coil 00017 turns ON. Timer 41051 is enabled by the NO contacts of output coil 00017 and starts to accumulate

time. When the accumulator reaches the limit of 10, output coil 01257 turns ON and resets Timer 41050 by the NC contacts of 01257. Output coil 00017 turns OFF. The process is then repeated until contacts 10009 are opened.

2.71 TOTL – Analog Totalizer

Description

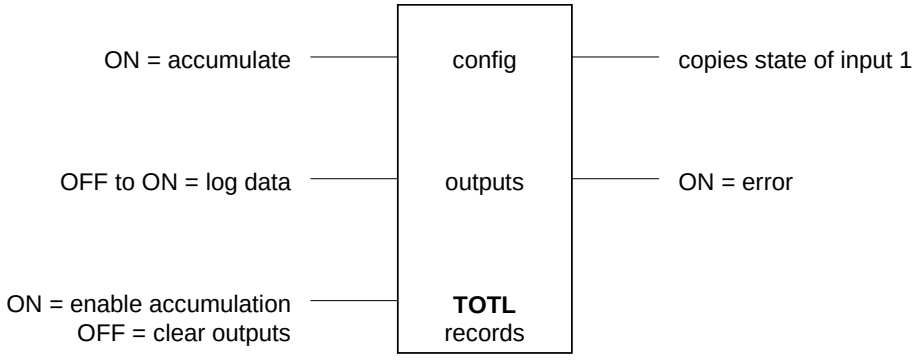
The TOTL function reads a rate input and accumulates (integrates) a total. It is used to measure a flow rate and accumulate a volume, or a similar calculation.

When the **Accumulate** input is ON and it has been longer than the sample interval since the last accumulation, the function reads the value of the input, scales it by time difference from the previous accumulation, and adds it into the total.

When the **Log Data** input goes from OFF to ON, the accumulated total, accumulation time, and the time at the end of the period is saved in the history registers. Older history is pushed down and the oldest record is discarded.

When the **Enable Accumulation** input is ON, accumulation is enabled. When the input is OFF, all accumulators and outputs are set to zero.

The **Error** output is ON if there is an error in the configuration registers.



Function Variables

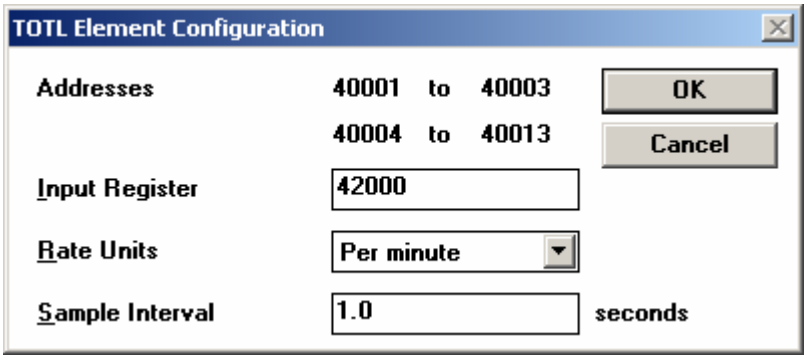
Variable	Valid Types	Description
Config	holding register (4xxxx)	Address of the first register in the configuration block. There are 3 registers in the block at addresses message+0 to message+2. +0 = rate input register +1 = input rate (see table below) +2 = sample interval (tenths of seconds)

Variable	Valid Types	Description
Outputs	holding register (4xxxx)	Address of the first register of the output block. There are 10 to 214 registers in the block at outputs+0 to outputs+213. The number of registers used depends on the records variable. +0 = number of records to follow +1 = status +2,3 = internal: time at last sample +4,5 = period 1: total (float) +6,7 = period 1: end time +8,9 = period 1: accumulation time +10,11= period 2: total (float) +12,13 = period 2: end time +14,15 = period 2: accumulation time +16,17= period 3: total (float) +18,19 = period 3: end time +20,21 = period 3: accumulation time … +208,209 = period 35: total (float) +210,211 = period 35: end time +212,213 = period 35: accumulation time
Records	Constant	The number of measurement records stored in the output array. The valid values are 1 to 35. This value determines the number of output registers used by the function.

Element Configuration

This element is configured using the TOTL Element Configuration dialog. Highlight the element by moving the cursor over the element and then use the **Element Configuration** command on the **Edit** menu to modify the configuration block.

WARNING: If the controller is initialized, using the **Initialize** command in the **Controller** menu, all I/O database registers used for Element Configuration are set to zero. The application program must be re-loaded to the controller.



The **Input Register** specifies the register address from which the rate input is read. Valid value for this register is any floating point register. The function will use the specified register, and the next

sequential register, as a floating point rate value. The address range depends upon the registers supported in the selected controller type.

The **Rate Units** specifies the units of time for the rate input. It may be one of the following.

per second (holding register = 0)

per minute (holding register = 1)

per hour (holding register = 2)

per day (holding register = 3)

The **Sample Interval** specifies the interval at which the rate input will be sampled. A sample is taken and a calculation performed if the time since the last sample is greater than or equal to the sample interval. The exact time depends on the scan time of the logic program. The valid values are 0.1 to 6553.5 seconds (1 to 65535 tenths of a second). The dialog shows the value in seconds; the register contains an integer value in tenths of seconds.

Output Registers

The output registers store the results of the accumulation and act as internal workspace for the accumulation.

The **Number of Records** register indicates how many sets of total and time registers follow. This value is equal to the *Records* variable. There are six registers in each record.

The **status** register indicates the status of the accumulation. It can have the following values. If the status register is non-zero, the error output is turned ON.

Status	Description
0	no error
1	invalid rate units configuration
2	invalid sample interval

The function block uses the two **internal** registers. The registers are not intended for use in a ladder logic program.

The **Period n: Total** is stored as a floating-point number in two consecutive registers.

The **Period n: End Time** is stored as a 32-bit integer in two consecutive registers. The registers hold the number of seconds since January 1, 1970. This is an unsigned number.

The **Period n: Accumulation** is stored as a 32-bit integer in two consecutive registers. The register holds the number of seconds accumulation occurred in the period. This measures the time the Accumulate input is ON, including times when the rate was zero.

Notes

The accumulated value is a floating-point number. All floating-point numbers are approximations. If the accumulated value grows large, then low rate inputs will have little or no effect on the accumulated value and the accumulated value will not be accurate. Use the Log Data input to save the accumulated value and start a new accumulation when the accumulated value grows large.

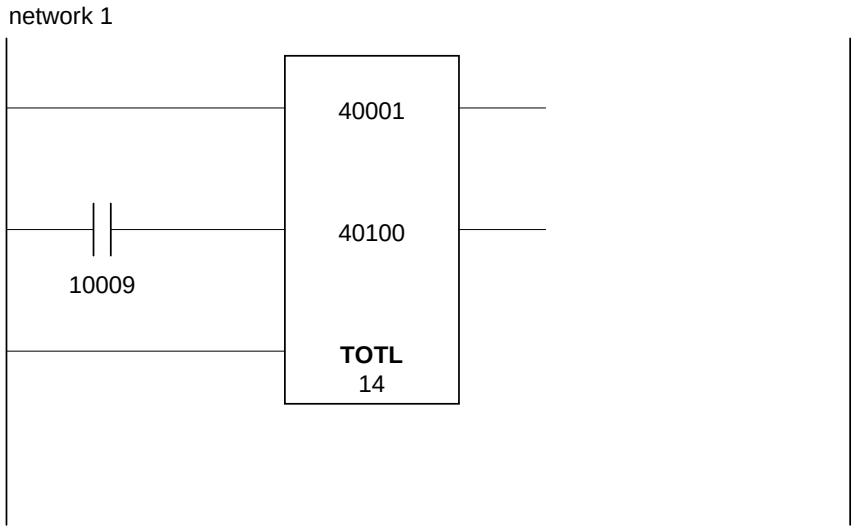
The Log Data input must be triggered at a suitable rate or the accumulator will overflow, and the accumulated value will not be accurate.

Related Functions

FLOW – Flow Accumulator

Example

In this example a TOTL function is used to read a flow rate from an analog input and accumulate 14 days of data. The analog input measures a flow rate in gallons per minute.



The TOTL function in network 1 has the **Accumulate** and **Enable Accumulation** inputs connected to the left power rail. When these inputs are continuously powered the TOTL function accumulates totals.

The **Records** variable is set to 14. This means 14 sets of history registers (total, flow time and end of period time) will be logged. In this example the accumulation input is never turned off meaning that once 14 sets of history registers are saved the next time contact 10009 is closed the 14th record is removed and the newest record is added to the history.

Each time contact 10009 is closed it powers the log data input. The accumulated total, accumulation time and the time at the end of the period is saved in the history registers. The contact should be closed by another network once per day for this example.

The element configuration for the TOTL block is as follows

Parameter	Value	Notes
Input Register	42000	The register that contains the rate input. This is a floating point value contained in register 42000 and 42001.
Rate Units	per minute	The value in floating point register 42000 represents the flow rate in units/minute
Sample Interval	10	sample, calculate, and accumulate approximately every 10.0 seconds

2.72 UCTR – Up Counter

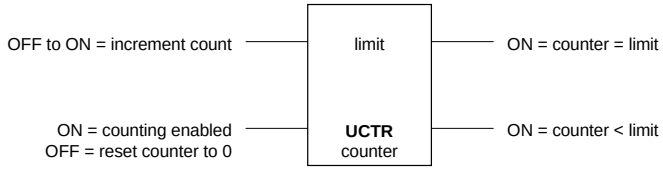
Description

The **UCTR** function block increments (adds one to) the value in the **counter** register when the **increment count** input changes from OFF to ON. The counter stops counting when the **limit** register or constant is reached.

When the **counting enabled** input is ON and the **increment count** changes from OFF to ON the counter value increments by one. When the **counting enabled** input is OFF the counter is reset to zero.

When the **counting enabled** input is ON and the counter equals the limit then the **counter = limit** output is ON.

When the **counting enabled** input is ON and the counter is less than the limit then the **counter < limit** output is ON.

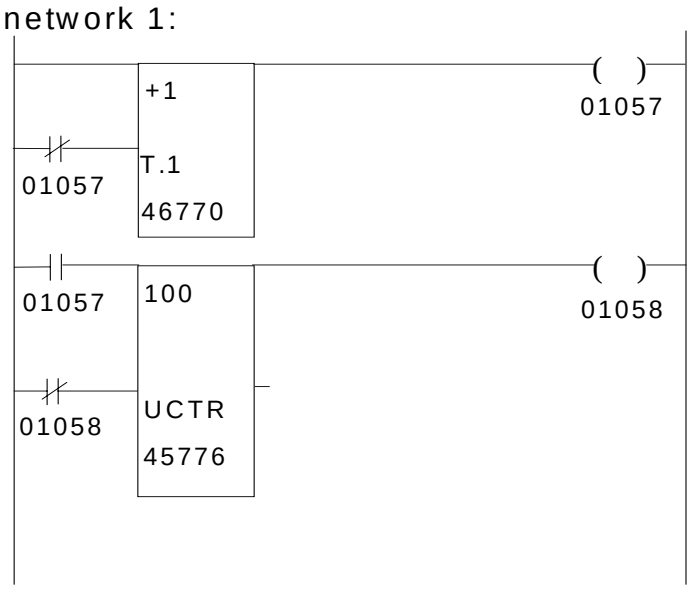


Variable	Valid Types	Description
Limit	constant (1..65535) input register (3xxxx) holding register (4xxxx)	Upper limit for counter
Counter	holding register (4xxxx)	Register holds current counter value

Related Functions

DCTR – Down Counter

Example



The UCTR function in network 1 increments each time the timer output is enabled. The timer limit is 0.1 seconds and it will take 10 seconds for the UCTR to increment 100 times.

When the timer limit is reached after 0.1 seconds the output coil 01057 is energized. NC contact 01057 will open resetting the timer and NO contact 01057 will close incrementing the UCTR.

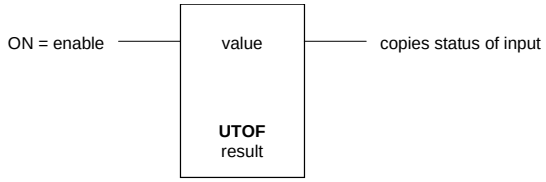
When the UCTR increments to 100 output coil 01058 is energized. NC contacts 01058 will open and the UCTR will reset counter to zero. This will happen every 10 seconds.

2.73 UTOF - Unsigned Integer to Floating-Point

Description

The UTOF element converts an unsigned register or constant into a floating-point number and stores the result in a floating-point holding register.

When the **enable** input is ON, **value** is converted into a floating-point number and stored in the **result** floating-point register. The element output is ON when the input is.



Function Variables

The element has two parameters.

Variable	Valid Types	Description
value	Constant (0…65535) input register (3xxxx) holding register (4xxxx)	Unsigned value to convert
result	2 holding registers (4xxxx)	Converted floating-point value

Notes

Floating-point values are stored in two consecutive I/O database registers. The lower numbered register contains the upper 16 bits of the number. The higher numbered register contains the lower 16 bits of the number.

Floating point numbers can represent positive or negative values in the range -3.402×10^{38} to 3.402×10^{38}.

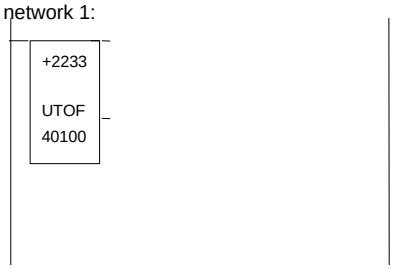
Related Functions

STOF - Signed Integer to Floating-Point

FTOS - Floating-Point to Signed Integer

FTOU - Floating-Point to Unsigned Integer

Example

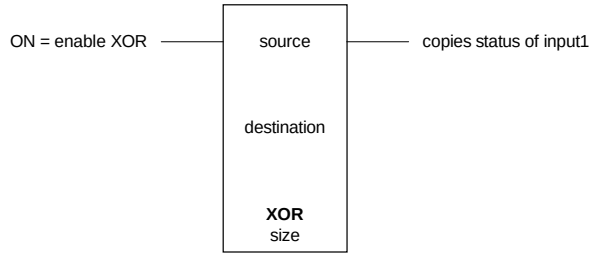


The UTOF function in network 1 converts unsigned constant +2233 to a floating-point number and puts the value into register 40100. In this example the content of floating point-register 40100 (registers 40100 and 40101) is 2233.00.

2.74 XOR – Exclusive Or Block

Description

The **XOR** function block logically EXCLUSIVE-ORs the **source** block of registers with the **destination** block of registers and stores the result in the destination block of registers.



Variable	Valid Types	Description
Source	coil block (0xxxx) status block (1xxxx) input register (3xxxx) holding register (4xxxx)	The first register in the first source block. The address for a coil or status register block is the first register in a group of 16 registers that will be EXCLUSIVE-ORed.
Destination	coil block (0xxxx) holding register (4xxxx)	The first register in the second source block and destination block. The address for a coil register block is the first register in a group of 16 registers that will be EXCLUSIVE-ORed.
Size	constant (1..100)	The number of 16 bit words in the block.

Notes

Exclusive-or accesses 16 bit words. Coil and status register blocks are groups of 16 registers that start with the register specified as the block address. A block size of 2 corresponds to 32 coils, or two holding registers.

Coil and status register blocks must begin at the start of a 16 bit word within the controller memory. Suitable addresses are 00001, 00017, 10001, 10033, etc.

Related Functions

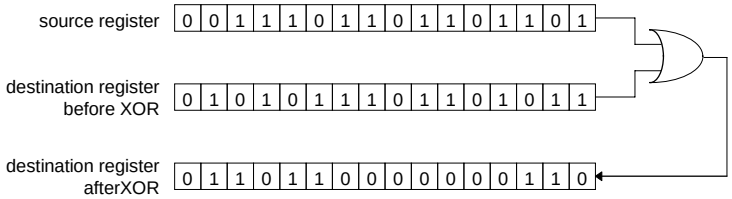
AND – And Block

NOT – Not Block

OR – Or Block

Example

In this example the source block has a value of 15213_{10} (11101101101101). The destination register has a value of 22379_{10} (101011101101011) before the XOR function and a value of 27654_{10} after the XOR function.



TelePACE Ladder Logic

Register Assignment Reference

CONTROL MICROSYSTEMS

SCADA products... for the distance

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Trademarks

Table of Contents

1 Register Assignment Reference

A complete description of each I/O Module in the Register Assignment is presented in this reference. The I/O modules are divided into classes that group similar modules together for ease of reference.

All I/O hardware that is used by the controller must be assigned to I/O database registers in order for the I/O data to be used by the ladder program. Ladder logic programs may read data from, or write data to the I/O hardware through user-assigned registers in the I/O database.

Register assignments are stored in the user configured Register Assignment and are downloaded with the ladder logic application program.

The Register Assignment assigns I/O database registers to user-assigned registers using I/O Modules. An I/O Module can refer to an actual I/O hardware module (e.g. 5401 Digital Input Module) or it may refer to a set of controller parameters, such as serial port settings.

Analog Input (AIN)

These modules are used to assign data from physical analog inputs to input registers in the I/O Database. The physical analog inputs are specific 5000 Series I/O modules, generic I/O modules, and internal controller data such as RAM battery voltage and board temperature.

Note:	To properly view analog input/output registers, the register type should be set to type signed. Setting the register type to anything else may result in inaccurate readings being displayed/written to these registers.

Analog Output (AOUT)

These modules are used to assign data from the I/O Database to physical analog outputs. The physical analog outputs are specific 5000 Series I/O modules or generic I/O modules.

Note:	To properly view analog input/output registers, the register type should be set to type signed. Setting the register type to anything else may result in inaccurate readings being displayed/written to these registers.

Digital Input (DIN)

These modules are used to assign data from physical digital inputs to input registers in the I/O Database. The physical digital inputs are specific 5000 Series I/O modules, generic I/O modules, and controller digital inputs.

Digital Output (DOUT)

These modules are used to assign data from the I/O Database to physical digital outputs. The physical digital outputs are specific 5000 Series I/O modules or generic I/O modules.

Counter Input (CNTR)

These modules are used to assign data from physical counter inputs to input registers in the I/O Database. The physical counter inputs are specific 5000 Series I/O modules and controller counter inputs.

SCADAPack (SCADAPack 5601, SCADAPack 5602, SCADAPack 5604, and SCADAPack AOUT)

These modules are used to assign data to registers in the I/O Database, from physical SCADAPack digital and analog I/O. The physical inputs and outputs are specific SCADAPack I/O modules.

Controller Diagnostic (DIAG)

These modules are used to assign diagnostic data from the controller to input or status registers in the I/O Database. The diagnostic data is used to monitor internal controller data such as controller status code, the force LED, serial port communication status and serial port protocol status.

Controller Configuration (CNFG)

These modules are used to assign data from I/O Database coil and holding registers to controller configuration registers. The configuration data is used to configure controller settings such as clearing protocol and serial counters, real time clock settings, HART protocol interface and PID control blocks.

Default Register Assignment

This provides a default assignment of registers for the selected controller type.

1.1 Register Assignment Specification

The Register Assignment I/O modules described in this manual are formatted as follows.

Header

The module header displays the I/O module name.

Module Description

The module description section describes the function, data origin and data destination of the I/O module.

Register Assignment

The register assignment description is used to describe the information required in the **Add Register Assignment** dialog. The information required for each section of the **Add Register Assignment** dialog is explained in the table shown below.

The column at the left of the table indicates the information that is required for the I/O module in the **Add Register Assignment** dialog. The requirements vary depending on the I/O module.

Module	Module Name	
Address	Physical I/O modules are assigned a unique module address between 0 and 15. No other similar type modules may use this module address. Diagnostic and configuration modules and SCADAPack 5601, 5602 and 5604 I/O modules do not require a physical address.	
Type	Register type of 0xxxx, 1xxxx, 3xxxx or 4xxxx.	
Start	First register of any unused block of consecutive registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	Number of registers for module.	
Description	Description of module.	
Extended Parameters	Additional parameters, if applicable.	

Register Data

The register data table describes what data each assigned register will contain.

Notes Section

The notes section is used to provide any additional information that may be useful when using the module.

1.2 Register Assignment Example

In this example, the application program requires a 5501 Analog Input module. The analog input data from the 5000 Series 5501 module must be assigned to the I/O Database before the Ladder Logic application program can access it. The register assignment is used to assign the input data to the I/O database.

Run the TelePACE program.

Select **File** from the menu bar. From the drop down **File** menu, select **New**.

Select **Controller** from the menu bar. From the drop down **Controller** menu, select **Register Assignment**.

The Register Assignment is displayed. The table is initially empty when a new file is started.

Selecting the **Add** button opens the **Add Register Assignment** dialog.

The first I/O module in the I/O module list is displayed and highlighted in the **Module** window.

Click the left mouse button on the down arrow at the left side of the **Module** window.

The entire I/O module list is displayed in the drop down window. Use the up and down arrows at the right side of the list to scroll through the list of I/O modules.

Select the AIN 5501 module by clicking the left mouse button on the AIN 5501 module text. When selected the AIN 5501 module is highlighted and the module list is closed.

The AIN 5501 module is described in the ***Register Assignment*** section of this manual.

The module reference for the AIN module is described in detail below. Each section of the module reference provides information that is required to configure the register assignment. All modules in the *Register Assignment* follow a similar format.

Header

The module header displays the I/O module name. For example, AIN 5501 Module is displayed.

Module Description

The module description section describes the function, data origin and data destination of the I/O module. The description for the AIN 5501 module indicates that data is received from the 5501 Analog Input module. This data is then assigned to eight consecutive input (3xxxx**)** registers in the I/O database. The I/O database registers used by the AIN 5501 module are continuously updated with data from the 5000 Series 5501 analog input module.

Register Assignment Description

The register assignment description is used to describe the information required in the **Add Register Assignment** dialog. The information required for each section of the **Add Register Assignment** dialog is explained in the table. A sample is shown below.

Module	AIN 5501 Module
Address	This module is assigned a unique module address between 0 and 15. No other AIN-type module may use this module address.
Type	Input Register

Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

The column at the left of the table indicates the information that is required for the I/O module in the **Add Register Assignment** dialog. The requirements vary depending on the I/O module.

Module The I/O module highlighted in the **Module** window.

Address The physical address of the 5000 Series 5501 analog input module. This address is set equal to the address of 5501 analog input module. See the *5501 Analog Input Module User Manual*.

Type The I/O database register type that the I/O module will assign data to. The I/O database register types are:

Coil Register **0xxxx**

Status Register **1xxxx**

Input Register **3xxxx**

Holding Register **4xxxx**

The AIN 5501 module will assign data to input registers (3xxxx).

Start The I/O database register address where the AIN 5501 module begins the register assignment. For the AIN 5501 module, this is the first of eight consecutive input registers.

End The I/O database register where the AIN 5501 module ends the register assignment. This value is automatically set to **Start + 8** by the AIN 5501 module.

Registers Number of I/O database registers that the AIN 5501 module assigns. This is automatically set to 8 for the AIN 5501 module.

Description The register type description for I/O modules that assign multiple types of registers. The AIN 5501 module does not have an entry for this field.

Extended Parameters None.

Register Data

The register data table describes what data each assigned register will contain. In the case of the AIN 5501 Module, the data will be the physical analog input channels from the 5000 Series 5501 module.

Notes Section

The notes section is used to provide any additional information that may be useful when using this module.

1.3 Analog Input I/O Modules

Analog input modules are used to assign data from physical analog inputs to input registers in the I/O Database. The physical analog inputs are specific 5000 Series I/O modules, generic I/O modules, and internal controller data such as RAM battery voltage and board temperature.

Analog input I/O modules may assign data to any input registers in the I/O database that are not being used by another Analog Input or Counter I/O module. There are 1024 I/O database input registers available. These input registers are numbered 30001 - 31024. Input registers are referred to as 3xxxx registers throughout this manual.

All I/O database input registers that are not assigned to any other I/O modules may be used as general purpose input registers in a ladder program. The I/O modules available are described in the following pages.

Note: To properly view analog input/output registers, the register type should be set to type signed. Setting the register type to anything else may result in inaccurate readings being displayed/written to these registers.

1.3.1 AIN Controller RAM Battery V

Description

The module, **AIN Controller RAM battery V**, reads the RAM backup battery voltage of the SCADAPack controllers. This module reads the input voltage for the SCADASense programmable controllers.(SCADASense 4202 DR, 4202 DS, 4203 DR, and 4203 DS) The voltage value is assigned to one input register. The input register is updated continuously with voltage data read from the RAM battery.

Register Assignment

Module	AIN Controller RAM battery V	
Address	No physical address is required.	
Type	Input Register	
Start	Any unused input register.	3xxxx
End	Same as start register.	
Registers	1 input register	
Description	None	
Extended Parameters	None	

Register Data

Register Assignment	Assignment to Module Hardware
1 input register	RAM battery voltage (0-5000 millivolts for SCADAPack controllers). Input power voltage (0-32767 millivolts for SCADASense Programmable Controllers.

Notes

One input register is always assigned to the I/O Database when this module is used.

The 3.6V lithium battery will return a typical value of 3600 or 3700. A reading less than 3000 (3.0V) indicates that the lithium battery requires replacement. The RAM battery voltage resolution is 100 millivolts.

1.3.2 AIN Controller temperature

Description

The module, **AIN Controller temperature**, reads the circuit board temperature of the 5203 or 5204 controller. The temperature data is assigned to two consecutive input registers. The input registers are updated continuously with data read from the controller.

Register Assignment

Module	AIN Controller temperature	
Address	No physical address is required.	
Type	Input Register	
Start	First register of any unused block of 2 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 1
Registers	2 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Register Assignment	Assignment to Module Hardware
Start Register	Board temperature (degrees C)
Start Register + 1	Board temperature (degrees F)

Notes

Two input registers are always assigned to the I/O Database when this module is used.

The temperature sensor returns a value in the range -40°C to 75°C or -40°F to 167°F. Temperatures outside this range cannot be measured.

Refer to the *System Manual* for further information on the circuit board temperature.

1.3.3 AIN 5501 Module

Description

The **AIN 5501 module** provides eight analog inputs, from the 5501 analog input module, for each module address. Data from each module is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

Register Assignment

Module	AIN 5501 module	
Address	This module is assigned a unique module address between 0 and 15. No other AIN-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Notes

Eight input registers are always assigned to the I/O Database when this module is used.

Refer to the *5501 Analog Input Module User Manual* for further information.

1.3.4 AIN 5502 Module

Description

The **AIN 5502 module** provides eight analog inputs, from the 5502 analog input module, for each module address. Data from each module is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

Register Assignment

Module	AIN 5502 module	
Address	This module is assigned a unique module address between 0 and 15. No other AIN-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Notes

Eight input registers are always assigned to the I/O Database when this module is used.

Refer to the *5502 Analog Input Module User Manual* for further information.

1.3.5 AIN 5503 Module

Description

The **AIN 5503 module** provides four analog inputs, from the 5503 RTD analog input module, for each module address. Data is assigned to four consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

Register Assignment

Module	AIN 5503 module	
Address	This module is assigned a unique module address between 0 and 15. No other AIN-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 4 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 3
Registers	4 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3

Notes

Four input registers are always assigned to the I/O Database when this module is used.

Refer to the *5503 RTD Analog Input Module User Manual* for further information.

1.3.6 AIN 5504 Module

Description

The **AIN 5504 module** provides eight analog inputs, from the Thermocouple analog input module, for each module address. Data is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

Register Assignment

Module	AIN 5504 module	
Address	This module is assigned a unique module address between 0 and 15. No other AIN-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Notes

Eight input registers are always assigned to the I/O Database when this module is used.

Refer to the *5504 Thermocouple Analog Input Module User Manual* for further information.

1.3.7 AIN 5505 Module

Description

The **AIN 5505 module** provides four RTD analog input points from a 5505 RTD module. A maximum of sixteen 5505 RTD modules may be installed on the I/O bus. The 5505 RTD module can operate in Native mode or in 5503 Emulation Mode. The operating mode is determined via a DIP switch on the 5505 RTD module. Refer to the ***Control Microsystems Hardware Manual*** for details on the DIP switch settings for the module.

When using the 5505 RTD module in 5503 Emulation mode the AIN 5503 module is used in the register assignment. See the ***AIN 5503 Module*** section if the module is to be used in 5503 Emulation mode.

The 5505 RTD module native mode provides enhanced capability over the 5503 emulation mode. The module operates in native mode if the 5503 Emulation DIP switch is open. This mode is recommended for all new installations.

- Each input is individually configurable for resistance measurement or RTD temperature measurement
- Each RTD input is configurable to return the measured temperature in degrees Celsius, Kelvin, or Fahrenheit.
- All inputs have a common configurable filter rate that can be used to dampen process variations or noise.
- The module returns diagnostic and status information for each input, such as RTD type (3 or 4 wire), open RTD annunciation, and RTD out of range annunciation.
- Data is returned as an IEEE 32 bit, single precision floating point number that requires no additional scaling.

RTD data is assigned to eight consecutive input (3xxxx) registers, two for each floating point RTD value. The input registers are updated continuously with data read from the analog inputs.

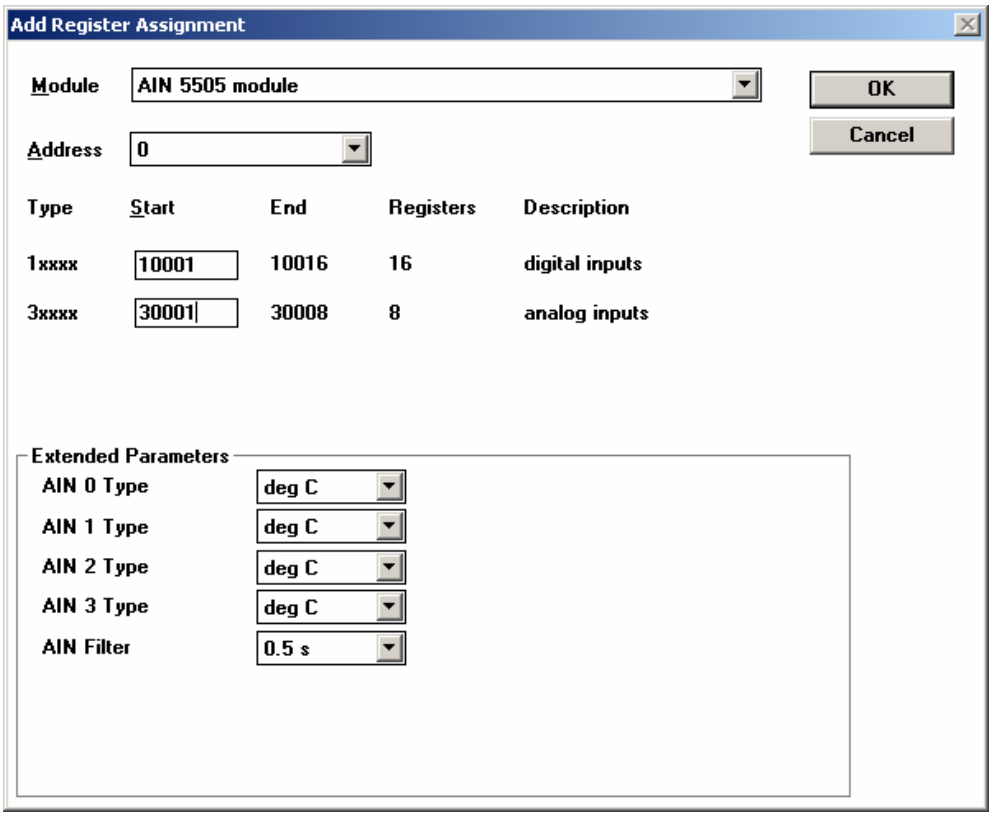
The 5505 RTD module provides 16 internal digital input (1xxxx) registers that return status and diagnostic information about the RTDs. The digital input registers are updated continuously with data read from the digital inputs.

Register Assignment

The register assignment for the AIN 5505 module is used to configure the registers used for the module data and the Extended Parameters available for the module. To open the register assignment dialog for the AIN 5505 module:

- Select **Register Assignment** from the **Controller** menu in TelePACE.
- In the **Register Assignment** window select the **Add** button.
- In the **Add Register Assignment** dialog select the **AIN 5505 module** from the list presented in the **Module** window.

The register assignment dialog for the **AIN 5505 module** is shown below.



The **Module** selection displays the name of the 5505 RTD module used for the register assignment.

The **Address** selection displays the module address of the physical 5505 RTD module. The address on the module is selected via dip switches on the module. A maximum of sixteen AIN type modules may be added to a system.

The register type **1xxxx** defines the register range for the digital input status data. Sixteen sequential registers are needed for the AIN 5505 module status data. Any unused block of sixteen registers may be used. See the **Status Register Data** section below for an explanation of the digital input status data.

The register type **3xxxx** defines the register range for the analog input data. Eight sequential registers are needed for the AIN 5505 module analog data. Any unused block of eight registers may be used. See the **Input Register Data** section below for an explanation of the analog input.

The **Extended Parameters** grouping defines the type of data returned from the 5505 RTD module, for each RTD input, and the filtering used by all RTD inputs.

The **Type** selection for each input (AIN 0, 1, 2 and 3) defines the measurement type. The data in the input registers assigned to the input is set to the type selected.

- The **deg C** selection sets the input point measurement type to degrees Celsius.
- The **deg F** selection sets the input point data measurement to degrees Fahrenheit.
- The **deg K** selection sets the input point data measurement to degrees Kelvin.
- The **ohms** selection sets the input point data measurement as resistance measurement in ohms.

The **AIN Filter** selection set the input filter rate for all RTD inputs. The filter rate is used to dampen process variations or noise.

- The **0.5s** selection sets the filter rate to 0.5 seconds.
- The **1s** selection sets the filter rate to 1 second.
- The **2s** selection sets the filter rate to 2 seconds.
- The **4s** selection sets the filter rate to 4 seconds.

Status Register Data

Status register data is assigned to sixteen consecutive status (1xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for sixteen registers.

Registers	Assignment to Module Hardware
Start Register	OFF = channel 0 RTD is good ON = channel 0 RTD is open or PWR input is off
Start Register + 1	OFF = channel 0 data in range ON = channel 0 data is out of range
Start Register + 2	OFF = channel 0 RTD is using 3-wire measurement ON = channel 0 RTD is using 4-wire measurement
Start Register + 3	Reserved for future use
Start Register + 4	OFF = channel 1 RTD is good ON = channel 1 RTD is open or PWR input is off
Start Register + 5	OFF = channel 1 data in range ON = channel 1 data is out of range
Start Register + 6	OFF = channel 1 RTD is using 3-wire measurement ON = channel 1 RTD is using 4-wire measurement
Start Register + 7	Reserved for future use
Start Register + 8	OFF = channel 2 RTD is good ON = channel 2 RTD is open or PWR input is off
Start Register + 9	OFF = channel 2 data in range ON = channel 2 data is out of range
Start Register + 10	OFF = channel 2 RTD is using 3-wire measurement ON = channel 2 RTD is using 4-wire measurement
Start Register + 11	Reserved for future use

Registers	Assignment to Module Hardware
Start Register + 12	OFF = channel 3 RTD is good ON = channel 3 RTD is open or PWR input is off
Start Register + 13	OFF = channel 3 data in range ON = channel 3 data is out of range
Start Register + 14	OFF = channel 3 RTD is using 3-wire measurement ON = channel 3 RTD is using 4-wire measurement
Start Register + 15	Reserved for future use

Input Register Data

Input register data is assigned to eight consecutive input (3xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for eight registers. Note that each input point uses two input registers formatted in IEEE 754 floating point format.

Registers	Assignment to Module Hardware
Start Register and Start Register + 1 (in IEEE 754 floating point format)	Analog input 0
Start Register + 2 and Start Register + 3 (in IEEE 754 floating point format)	Analog input 1
Start Register + 4 and Start Register + 5 (in IEEE 754 floating point format)	Analog input 2
Start Register + 6 and Start Register + 7 (in IEEE 754 floating point format)	Analog input 3

Notes

Refer to the *5505 RTD Analog Input Module User Manual* for further information.

1.3.8 AIN 5506 Module

Description

The **AIN 5506 module** provides eight analog inputs from a 5506 Analog Input module. A maximum of sixteen 5506 analog input modules may be installed on the I/O bus. The 5506 Analog Input module can operate in Native mode or in 5501 Emulation Mode. The operating mode is determined via a DIP switch on the 5506 Analog Input. Refer to the ***Control Microsystems Hardware Manual*** for details on the DIP switch settings for the module.

When using the 5506 Analog Input module in 5501 Emulation mode the AIN 5501 module is used in the register assignment. See the ***AIN 5501 Module*** section if the module is to be used in 5501 Emulation mode.

5506 native mode provides enhanced capability over the 5501 emulation mode. The module operates in native mode if the 5501 Emulation DIP switch is open.

- Each input is individually configurable for 0-5V, 1-5V, 0-20mA, or 4-20mA operation.
- Converted analog input data is returned as a signed 15-bit value, providing 8 times more resolution than in 5501 mode. Negative values are possible, for example if a 4-20mA is open loop.
- The module returns status information for each analog input indicating if the analog input is in or out of range for the defined signal type.
- All inputs have a configurable filter rate.
- The input-scanning rate is software configurable to 50 or 60 hertz.

Analog input data is assigned to eight consecutive input (3xxxx) registers. The input registers are updated continuously with data read from the analog inputs.

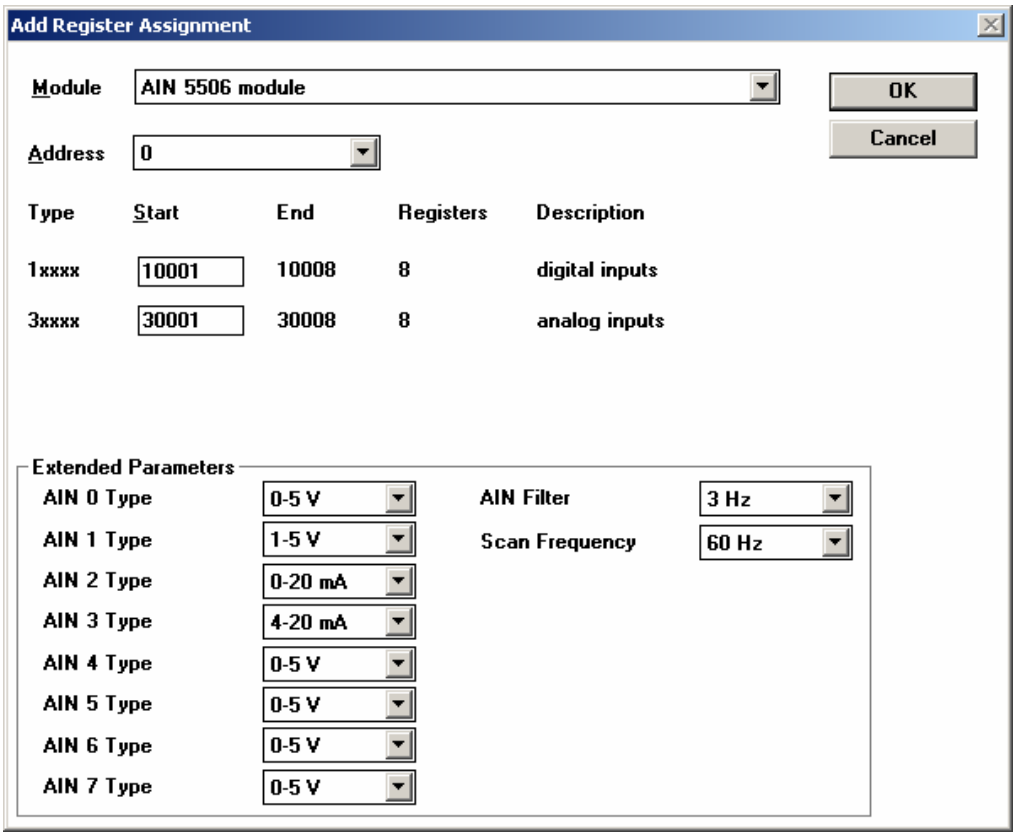
The 5506 Analog Input module provides 8 internal digital input (1xxxx) registers that return status information about the analog inputs. The digital input registers are updated continuously with data read from the digital inputs.

Register Assignment

The register assignment for the AIN 5506 module is used to configure the registers used for the module data and the Extended Parameters available for the module. To open the register assignment dialog for the AIN 5505 module:

- Select **Register Assignment** from the **Controller** menu in TelePACE.
- In the **Register Assignment** window select the **Add** button.
- In the **Add Register Assignment** dialog select the **AIN 5506 module** from the list presented in the **Module** window.

The register assignment dialog for the **AIN 5506 module** is shown below.



The **Module** selection displays the name of the 5506 Analog Input module used for the register assignment.

The **Address** selection displays the module address of the physical 5506 Analog Input module. The address on the module is selected via dip switches on the module. A maximum of sixteen AIN type modules may be added to a system.

The register type **1xxxx** defines the register range for the digital input status data. Eight sequential registers are needed for the AIN 5506 module status data. Any unused block of eight registers may be used. See the **Status Register Data** section below for an explanation of the digital input status data.

The register type **3xxxx** defines the register range for the analog input data. Eight sequential registers are needed for the AIN 5506 module analog data. Any unused block of eight registers may be used. See the **Input Register Data** section below for an explanation of the analog input.

The **Extended Parameters** grouping defines the type of data returned from the 5506 AIN module, filtering used by all inputs and the scan frequency.

The **Type** selection for each input (AIN 0, 1, 2, 3, 4, 5, 6, and 7) defines the input measurement type for the analog input.

- The **0-5V** selection sets the input type to measure 0 to 5V input signals.
- The **1-5V** selection sets the input type to measure 1 to 5V input signals.
- The **0-20** mA selection sets the input type to measure 0 to 20mA input signals.
- The **4-20** mA selection sets the input type to measure 4 to 20mA input signals.

The **AIN Filter** selection set the input filter for all analog inputs. Filtering is used to dampen process variations or noise.

- The **3 Hz** filter selection sets the response time to 155ms at 60Hz and 185ms at 50Hz.
- The **6 Hz** filter selection sets response time to 85ms at 60Hz and 85ms at 50Hz.
- The **11 Hz** filter selection sets response time to 45ms at 60Hz and 55ms at 50Hz.
- The **30 Hz** filter selection sets response time to 30ms at 60Hz and 30ms at 50Hz.

The **Scan Frequency** selection set the input scan rate for all analog inputs. The scan rate selection is not critical but AC noise rejection is improved at the correct frequency. If the module is used in a DC environment, the 60 Hz setting will yield slightly faster response time.

- The **60 Hz** selection synchronies the input scanning to 60Hz.
- The **50 Hz** selection synchronies the input scanning to 50Hz.

Status Register Data

Status register data is assigned to sixteen consecutive status (1xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for sixteen registers.

Registers	Assignment to Module Hardware
Start Register	OFF = channel 0 is OK ON = channel 0 is over or under range
Start Register + 1	OFF = channel 1 is OK ON = channel 1 is over or under range
Start Register + 2	OFF = channel 2 is OK ON = channel 2 is over or under range
Start Register + 3	OFF = channel 3 is OK ON = channel 3 is over or under range
Start Register + 4	OFF = channel 4 is OK ON = channel 4 is over or under range
Start Register + 5	OFF = channel 5 is OK ON = channel 5 is over or under range

Registers	Assignment to Module Hardware
Start Register + 6	OFF = channel 6 is OK ON = channel 6 is over or under range
Start Register + 7	OFF = channel 7 is OK ON = channel 7 is over or under range

Input Register Data

Input register data is assigned to eight consecutive input (3xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for eight registers.

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Notes

Refer to the *5506 Analog Input Module User Manual* for further information.

1.3.9 AIN 5521 Module

Description

The **AIN 5521 module** provides eight analog inputs, from the 5521 Potentiometer analog input module, for each module used. Data is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

Register Assignment

Module	AIN 5521 module	
Address	This module is assigned a unique module address between 0 and 7. No other AIN-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Notes

Eight input registers are always assigned to the I/O Database when this module is used.

Refer to the *5521 Potentiometer Analog Input Module User Manual* for further information.

1.3.10 AIN Generic 8 Point Module

Description

The **AIN Generic 8 point module** provides eight analog inputs. Data is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the analog inputs. The **AIN Generic 8 point module** may be used in place of any other 8 point AIN-type module.

The **AIN Generic 8 point module** type is a useful selection early on in the system design stage before the final selection of the specific AIN module type is known.

Register Assignment

Module	AIN Generic 8 Point Module	
Address	This module is assigned a unique module address between 0 and 15. No other AIN-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Notes

Eight input registers are always assigned to the I/O Database when this module is used.

1.4 Analog Output I/O Modules

Analog output modules are used to assign data from the I/O Database to physical analog outputs. The physical analog outputs are specific 5000 Series I/O modules or generic I/O modules.

Analog output I/O modules may assign data to any holding registers in the I/O database that are not being used by another Analog output I/O module. There are 9999 holding registers available. These holding registers are numbered 40001 - 49999. Holding registers are referred to as 4xxxx registers throughout this manual.

All holding registers that are not assigned to any other I/O modules may be used as general purpose holding registers in a ladder program. The I/O modules available are described in the following pages.

Note: To properly view analog input/output registers, the register type should be set to type signed. Setting the register type to anything else may result in inaccurate readings being displayed/written to these registers.

1.4.1 AOUT 5301 Module

Description

The **AOUT 5301 module** provides two analog outputs, to the 5000 Series 5301 Analog output module, for each module used. Data is assigned from two consecutive holding registers. The analog outputs are updated continuously with data read from the holding registers.

Register Assignment

Module	AOUT 5301 module	
Address	This module is assigned a unique module address between 0 and 15. No other AOUT-type module may use this module address.	
Type	Holding Register	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 1
Registers	2 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1

Notes

Two holding registers are always assigned to the I/O Database when this module is used.

Refer to the *5301 Analog Output Module User Manual* for further information.

1.4.2 AOUT 5302 Module

Description

The **AOUT 5302 module** provides four analog outputs, to the 5000 Series 5302 Analog output module, for each module used. Data is assigned from four consecutive holding registers. The analog outputs are updated continuously with data read from the holding registers.

Register Assignment

Module	AOUT 5302 module	
Address	This module is assigned a unique module address between 0 and 15. No other AOUT-type module may use this module address.	
Type	Holding Register	
Start	First register of any unused block of 4 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 3
Registers	4 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1
Start Register + 2	Analog output 2
Start Register + 3	Analog output 3

Notes

Four holding registers are always assigned to the I/O Database when this module is used.

Refer to the *5302 Analog Output Module User Manual* for further information.

1.4.3 AOUT 5304 Module

Description

The **AOUT 5304 module** provides four analog outputs, to the 5000 Series 5304 Analog output module, for each module used. Data is assigned from four consecutive holding registers. The analog outputs are updated continuously with data read from the holding registers.

Register Assignment

Module	AOUT 5304 module	
Address	This module is assigned a unique module address between 0 and 15. No other AOUT-type module may use this module address.	
Type	Holding Register	
Start	First register of any unused block of 4 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 3
Registers	4 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1
Start Register + 2	Analog output 2
Start Register + 3	Analog output 3

Notes

Four holding registers are always assigned to the I/O Database when this module is used.

Refer to the *5304 Analog Output Module User Manual* for further information.

1.4.4 AOUT Generic 2 Point Module

Description

The **AOUT Generic 2 point module** provides two analog outputs. Data is assigned from two consecutive holding registers. The analog outputs are updated continuously with data read from the holding registers. The **AOUT Generic 2 point module** may be used in place of any other 2 point AOUT-type module.

The **AOUT Generic 2 point module** type is a useful selection early on in the system design stage before the final selection of the specific AOUT module type is known.

Register Assignment

Module	AOUT Generic 2 point module	
Address	This module is assigned a unique module address between 0 and 15. No other AOUT-type module may use this module address.	
Type	Holding Register	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 1
Registers	2 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1

Notes

Two holding registers are always assigned to the I/O Database when this module is used.

1.4.5 AOUT Generic 4 Point Module

Description

The **AOUT Generic 4 point module** provides four analog outputs. Data is assigned from four consecutive holding registers. The analog outputs are updated continuously with data read from the holding registers. The **AOUT Generic 4 point module** may be used in place of any other 4 point AOUT-type module.

The **AOUT Generic 4 point module** type is a useful selection early on in the system design stage before the final selection of the specific AOUT module type is known.

Register Assignment

Module	AOUT Generic 4 point module	
Address	This module is assigned a unique module address between 0 and 15. No other AOUT-type module may use this module address.	
Type	Holding Register	
Start	First register of any unused block of 4 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 3
Registers	4 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1
Start Register + 2	Analog output 2
Start Register + 3	Analog output 3

Notes

Four holding registers are always assigned to the I/O Database when this module is used.

1.5 Configuration I/O Modules

Configuration modules are used to assign data from the I/O Database coil and holding registers to controller configuration settings. The configuration data is used to configure controller settings such as clearing protocol and serial counters, real time clock settings, HART protocol interface and PID control blocks.

Configuration I/O modules assign data to I/O database coil or holding registers, depending on the type of data. Configuration I/O modules may assign data to any coil or holding registers in the I/O database that are not being used by another I/O module.

All I/O database coil or holding registers that are not assigned to any other I/O modules may be used as general purpose coil or holding registers in a ladder program. The configuration modules available are described in the following pages.

1.5.1 CNFG Clear Protocol Counters

Description

The module, **CNFG Clear protocol counters**, provides a way of clearing the protocol event counters for a specific serial port. The protocol event counters for the serial port are cleared when the assigned coil register is set to 1. Once the counters are cleared, the assigned coil register is automatically reset to zero.

Register Assignment

Module	CNFG Clear protocol counters	
Address	com1, com2, com3, or com4.	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Clear protocol event counters.

Notes

Refer to the module, **DIAG Serial port protocol status**, for a description of the individual counters.

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

1.5.2 CNFG Clear Serial Port Counters

Description

The module, **CNFG Clear serial port counters**, provides a way of clearing the communication event counters for a specific serial port. The serial port counters are cleared when the assigned coil register is set to 1. Once the counters are cleared the assigned coil register is automatically reset to 0.

Register Assignment

Module	CNFG Clear serial port counters	
Address	Com1, com2, com3, or com4.	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Clear communication event counters.

Notes

Refer to the module, **DIAG Serial port comm. status**, for a description of the individual counters.

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

1.5.3 CNFG DTR Off

Description

The module, **CNFG DTR Off**, provides a way of controlling the DTR signal for a specific serial port. When the assigned coil is energized DTR for the serial port is de-asserted. DTR is constantly turned off when the coil is energized.

When the assigned coil is de-energized DTR for the serial port is asserted. The DTR signal is not constantly asserted. It is asserted on the transition from an energized coil to a de-energized coil. Since DTR is not constantly re-asserted other programs will be able to control the DTR setting. This way other ladder blocks and programs will be able to control the DTR settings.

Register Assignment

Module	CNFG DTR Off	
Address	com1, com2, com3, or com4.	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Controls DTR signal 0 = DTR asserted 1 = DTR not asserted Default: 0 = DTR asserted

Notes

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

1.5.4 CNFG 5904 HART Interface Module

Description

The module, **CNFG 5904 HART Interface** provides control of 5904 HART Interface modules. When configured the module maintains communication with a 5904 interface. Up to four 5904 interfaces may be attached to a controller.

The interface settings are assigned from four consecutive holding registers. The registers are initialized with the current value of the module parameters when the controller is reset, and when the Register Assignment is downloaded to the controller. Thereafter the data from all four holding registers are written to the module parameters, whenever any of the registers change.

Register Assignment

Module	CNFG 5904 HART Interface	
Address	0 to 3	
Type	Holding Register	
Start	The first register of any unused block of 4 consecutive holding registers.	4xxxx
End	The last register of the block	4xxxx + 3
Registers	4 holding registers	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Attempts: the number of times each HART command will be sent. Valid values are 1 to 4. Default : = 3
Start Register + 1	Preambles: number of preambles to send if fixed preambles selected. Valid values are 2 to 15. This value must be set as it is used by link initialization. Default : = 15
Start Register + 2	Auto-preamble control: 0 = use fixed number of preambles 1 = use number of preambles requested by device except for link initialization Default : = 1
Start Register + 3	Device type 0 = secondary master device 1 = primary master device (recommended) Default : = 1

Notes

This module provides the basis for communication with HART devices connected to the 5904 interface module. It does not send commands to the HART devices. Use the Ladder Logic HART element or the C Tools HART API functions to send commands to the HART devices.

The number of preambles must be set even if the auto-preamble control is selected. The preambles value will be used for the link initialization command which determines the number of preambles requested by the device.

In most sensor networks, the controller is the primary master device. A hand-held programmer is typically a secondary master device. Set the device type to primary unless another HART primary master device is connected to the network.

The settings can be saved to EEPROM with the *CNFG Save Settings to EEPROM* module.

1.5.5 CNFG IP Settings

Description

The module, **CNFG IP settings**, provides control of the IP settings for a specific communication interface. Settings are assigned from thirteen consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all thirteen holding registers is written to the module parameters, whenever any of the registers change.

This module is used by the SCADAPack 32 controller series only.

Use this module only when IP settings need to be changed within a Ladders program. It is more convenient to use the *Controller TCP/IP Settings* dialog to download IP settings with the Ladders program.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the TCP/IP communication will result.

Register Assignment

Module	CNFG IP settings	
Address	Ethernet1	
Type	Holding Register	
Start	First register of any unused block of 13 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 12
Registers	13 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	**Byte1** of the IP Address using format: **Byte1.Byte2.Byte3.Byte4** Default: 0
Start Register + 1	**Byte2** of the IP Address Default: 0
Start Register + 2	**Byte3** of the IP Address Default: 0
Start Register + 3	**Byte4** of the IP Address Default: 0
Start Register + 4	**Byte1** of the Subnet Mask using format: **Byte1.Byte2.Byte3.Byte4** Default: 255

Registers	Assignment to Module Hardware
Start Register + 5	**Byte2** of the Subnet Mask Default: 255
Start Register + 6	**Byte3** of the Subnet Mask Default: 255
Start Register + 7	**Byte4** of the Subnet Mask Default: 255
Start Register + 8	**Byte1** of the Default Gateway using format **Byte1.Byte2.Byte3.Byte4** Default: 0
Start Register + 9	**Byte2** of the Default Gateway Default: 0
Start Register + 10	**Byte3** of the Default Gateway Default: 0
Start Register + 11	**Byte4** of the Default Gateway Default: 0
Start Register + 12	IP Configuration Mode 0 = Default gateway is on the LAN subnet 1 = Default gateway is on the com1 PPP subnet 2 = Default gateway is on the com2 PPP subnet 3 = Default gateway is on the com3 PPP subnet 4 = Default gateway is on the com4 PPP subnet

Notes

Thirteen holding registers are always assigned to the I/O Database when this module is used.

1.5.6 CNFG LED Power Settings

Description

The module, **CNFG LED power settings**, provides control of the power settings for the controller LEDs. The state of the assigned coil register is the default state for the LED power. The time to return to the Default State is contained within the assigned holding register.

The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the module parameters are updated continuously with data read from the assigned registers.

Register Assignment

Module	CNFG LED power settings	
Address	No physical address is required.	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	default state	
Type	Holding Register	
Start	Any unused holding register	4xxxx
End	Same as start register	
Registers	1 holding register	
Description	time to return to default state	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Default state for power to the controller LEDs 0 = off 1 = on Default Value: 1 = on

Holding Register Data

Registers	Assignment to Module Hardware
Start Register	Time in minutes to return to the default state. 1 to 65535 minutes Default Value: 5 minutes

Notes

One holding register and one coil register are always assigned to the I/O Database when this module is used.

Refer to the *System Manual* for further information on LED power settings.

1.5.7 CNFG Modbus IP Interface

Description

The module, **CNFG Modbus IP Interface**, provides control of the protocol interface settings used by all Modbus IP protocols on the specified communication interface. Settings are assigned from five consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all five holding registers is written to the module parameters, whenever any of the registers change.

This module is used by the SCADAPack 32 controller series only.

Use this module only when Modbus IP protocol interface settings need to be changed within a Ladders program. It is more convenient to use the *Controller Modbus IP Protocols* dialog to download protocol interface settings with the Ladders program.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the Modbus IP communication will result.

Register Assignment

Module	CNFG Modbus IP Interface	
Address	Ethernet1	
Type	Holding Register	
Start	First register of any unused block of 5 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 4
Registers	5 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Modbus station number 1 to 255 in standard Modbus 1 to 65534 in extended Modbus Default: 1
Start Register + 1	Modbus store and forward enable 0 = disabled 1 = enabled Default: 0 = disabled

Registers	Assignment to Module Hardware
Start Register + 2	Modbus addressing mode 0 = standard 1 = extended Default: 0 = standard
Start Register + 3	Enron Modbus enable 0 = disabled 1 = enabled Default: 0 = disabled
Start Register + 4	Enron Modbus station number 1 to 255 in standard Modbus 1 to 65534 in extended Modbus Default: 1

Notes

Five holding registers are always assigned to the I/O Database when this module is used.

1.5.8 CNFG Modbus IP Protocols

Description

The module, **CNFG Modbus IP Protocols**, provides control of the settings for a Modbus IP protocol. Settings are assigned from ten consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all ten holding registers is written to the module parameters, whenever any of the registers change.

This module is used by the SCADAPack 32 controller series only.

Use this module only when Modbus IP protocol settings need to be changed within a Ladders program. It is more convenient to use the *Controller Modbus IP Protocols* dialog to download protocol settings with the Ladders program.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the Modbus IP communication will result.

Register Assignment

Module	CNFG Modbus IP Protocols	
Address	1 = Modbus/TCP, 2 = Modbus RTU over UDP, or 3 = Modbus ASCII over UDP	
Type	Holding Register	
Start	First register of any unused block of 10 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 9
Registers	10 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware	
Start Register	Protocol Port Number: 1 to 65534	
	Modbus/TCP	Default: 502
	Modbus RTU over UDP	Default: 49152
	Modbus ASCII over UDP	Default: 49153

Registers	Assignment to Module Hardware
Start Register + 1 and Start Register + 2	Master Idle Timeout: The length of time, in seconds, that a master connection will wait for the user to send the next command before ending the connection. This allows the slave device to free unused connections while the master application may retain the connection allocation. (32 bit register) 0 = disable timeout and let application close the connection. Default: 10 TCP protocols only. Not used by UDP protocols.
Start Register + 3 and Start Register + 4	Server Idle Timeout: The length of time, in seconds, that a server connection will wait for a message before ending the connection. (32 bit register) 0 = disable timeout and let client close connection. Default: 250 TCP protocols only. Not used by UDP protocols.
Start Register + 5	Protocol Server Enable: 0 = disable server. 1 = enable server. Default: 1
Start Register + 6	Reserved
Start Register + 7	Reserved
Start Register + 8	Reserved
Start Register + 9	Reserved

1.5.9 CNFG Modbus/TCP Settings

Description

The module, **CNFG Modbus/TCP settings**, provides control of the Modbus/TCP protocol settings. Settings are assigned from six consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all six holding registers is written to the module parameters, whenever any of the registers change.

This module is used by the SCADAPack 32 controller series only.

Use this module only when Modbus/TCP settings need to be changed within a Ladders program. It is more convenient to use the *Controller Modbus/TCP Settings* dialog to download Modbus/TCP settings with the Ladders program.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the Modbus/TCP communication will result.

Register Assignment

Module	CNFG Modbus/TCP settings	
Address	No physical address is required.	
Type	Holding Register	
Start	First register of any unused block of 6 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 5
Registers	6 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Port for Modbus/TCP protocol Default: 502
Start Register + 1 and Start Register + 2	Master Idle Timeout: The length of time, in seconds, that a master connection will wait for the user to send the next command before ending the connection. (32 bit register) 0 = disable timeout and let user close the connection. Default: 10

Registers	Assignment to Module Hardware
Start Register + 3 and Start Register + 4	Server Idle Timeout: The length of time, in seconds, that a server connection will wait for a message before ending the connection. (32 bit register) 0 = disable timeout and let client close connection. Default: 250
Start Register + 5	Maximum number of server connections up to the capacity available (typical capacity is 20 connections) Default: 20

1.5.10 CNFG PID Control Block

Description

The module, **CNFG PID control block**, provides control over the configuration of a PID control block and provides access to the control block parameters. Control block parameters are assigned to 25 consecutive holding registers. The module address refers to the PID control block number.

The holding registers are updated continuously with data read from the module parameters. Whenever a Ladder Logic program or C Application changes any of the registers, only data from the changed register is written to the corresponding module parameter.

Register Assignment

Module	CNFG PID control block	
Address	This module is assigned a unique module address between 0 and 31. No other PID-type module may use this module address.	
Type	Holding Register	
Start	First register of any unused block of 25 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +24
Registers	25 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware	
Start Register	Process Value	(PV)
Start Register + 1	Error	(ER)
Start Register + 2	Output Quantity	(OP)
Start Register + 3	Status Register	SR)
Start Register + 4	Integrated Error	(IN)
Start Register + 5	Setpoint	(SP)
Start Register + 6	Deadband	(DB)
Start Register + 7	Gain	(GA)
Start Register + 8	Reset Time	(RE)
Start Register + 9	Rate Time	(RA)
Start Register + 10	Full Scale Output Limit	(FS)
Start Register + 11	Zero Scale Output Limit	(ZE)
Start Register + 12	High Alarm Level	(HI)
Start Register + 13	Low Alarm Level	(LO)
Start Register + 14	Control Register	(CR)

Registers	Assignment to Module Hardware	
Start Register + 15	Input Source	(IP)
Start Register + 16	Increase Output Address	(IO)
Start Register + 17	Decrease Output Address	(DO)
Start Register + 18	Input Bias	(IB)
Start Register + 19	Output Bias	(OB)
Start Register + 20	Inhibit Execution Address	(IH)
Start Register + 21	Alarm Output Address	(AO)
Start Register + 22	Cascade Setpoint Source	(CA)
Start Register + 23	Execution Period	
Start Register + 24	Execution Period at Power Up	

Notes

Twenty-five holding registers are always assigned to the I/O Database when this module is used.

Refer to the *TelePACE PID Controller Reference Manual* for further information.

1.5.11 CNFG Power Mode

Description

The module, **CNFG Power Mode**, provides control over the power consumption of the controller. The LAN port and USB host port can be individually disabled to conserve power. The controller can also run at a reduced speed to conserve power.

The status registers are updated continuously with the current LAN, controller, and USB host power states. The current settings can be changed by writing to the appropriate holding register.

Register Assignment

Module	**CNFG Power Mode**	
Address	fixed	
Type	**Holding Register**	
Start	First register of any unused block of 3 consecutive holding registers.	**4xxxx**
End	Last register of block	**4xxxx + 2**
Registers	3 holding registers	
Description	None	

Holding Register Data

Registers	***Assignment to Module Hardware***
Start Register	LAN Operation State (0 = LAN Enabled, 1 = LAN Disabled)
Start Register + 1	Controller Power State (0 = Normal Power Mode, 1 = Reduced Power Mode)
Start Register + 2	USB Host Port Power State (0 = USB host port enabled, 1 = USB host port disabled)

Notes

Three holding registers are always assigned to the I/O Database when this module is used.

1.5.12 CNFG Protocol Settings Method 1

Description

The module, **CNFG Protocol settings method 1**, provides control of the protocol settings for a specific serial port. Settings are assigned from three consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all three holding registers is written to the module parameters, whenever any of the registers change.

Use this module only when protocol settings need to be changed within a Ladders program. It is more convenient to use the *Controller Serial Ports Settings* dialog to download protocol settings with the program. Refer to the *Serial Ports* section in this manual for further information on serial port settings.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the serial communication will result.

Register Assignment

Module	CNFG Protocol settings	
Address	com1, com2, com3, or com4.	
Type	Holding Register	
Start	First register of any unused block of 3 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 2
Registers	3 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Protocol type 0 = none 1 = Modbus RTU 2 = Modbus ASCII 3 = DF1 Full Duplex BCC 4 = DF1 Full Duplex CRC 5 = DF1 Half Duplex BCC 6 = DF1 Half Duplex CRC 7 = DNP 8 = PPP Default : 1 = Modbus RTU
Start Register + 1	Protocol station number 1 to 255 in Modbus 0 to 254 in DF1 Default : 1
Start Register + 2	Store and forward enable 0 = disabled 1 = enabled Default : 0 = disabled

Notes

This register assignment module replaces the CNFG Protocol Settings module used in earlier versions of TelePACE.

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 or 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

Refer to the *TeleBUS Protocols User Manual* for further information on protocols.

Three holding registers are always assigned to the I/O Database when this module is used.

1.5.13 CNFG Protocol Settings Method 2

The module, **CNFG Protocol settings method 2**, provides control of the protocol settings for a specific serial port. This module supports the use of extended addressing.

Settings are assigned from four consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all four holding registers is written to the module parameters, whenever any of the registers change.

Use this module only when protocol settings need to be changed within a Ladders program. It is more convenient to use the *Controller Serial Ports Settings* dialog to download protocol settings with the program. Refer to the *Serial Ports* section in this manual for further information on serial port settings.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the serial communication will result.

Register Assignment

Module	CNFG Protocol Extended Settings	
Address	com1, com2, com3, or com4.	
Type	Holding Register	
Start	First register of any unused block of 4 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 3
Registers	4 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Protocol type 0 = none 1 = Modbus RTU 2 = Modbus ASCII 3 = DF1 Full Duplex BCC 4 = DF1 Full Duplex CRC 5 = DF1 Half Duplex BCC 6 = DF1 Half Duplex CRC 7 = DNP 8 = PPP Default : 1 = Modbus RTU

Registers	Assignment to Module Hardware
Start Register + 1	Protocol station number 1 to 255 in standard Modbus 1 to 65534 in extended Modbus 0 to 254 in DF1 Default : 1
Start Register + 2	Store and forward enable 0 = disabled 1 = enabled Default : 0 = disabled
Start Register + 3	Protocol addressing mode 0 = standard 1 = extended Default: 0 = standard

Notes

This register assignment module replaces the CNFG Protocol Extended Settings module used in earlier versions of TelePACE.

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

Extended addressing is supported only by the Modbus RTU and Modbus ASCII protocols.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

Refer to the *TeleBUS Protocols User Manual* for further information on protocols.

Four holding registers are always assigned to the I/O Database when this module is used.

1.5.14 CNFG Protocol Settings Method 3

Description

The module, **CNFG Protocol Settings Method 3**, provides control of the protocol settings for a specific serial port. This module supports extended addressing and Enron Modbus parameters.

Settings are assigned from six consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all six holding registers is written to the module parameters, whenever any of the registers change.

Use this module only when protocol settings need to be changed within a Ladders program. It is more convenient to use the *Controller Serial Ports Settings* dialog to download protocol settings with the program. Refer to the *Serial Ports* section in this manual for further information on serial port settings.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the serial communication will result.

Register Assignment

Module	CNFG Protocol Settings Method3	
Address	com1, com2, com3, or com4.	
Type	Holding Register	
Start	First register of any unused block of 6 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 5
Registers	6 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Protocol type 0 = none 1 = Modbus RTU 2 = Modbus ASCII 3 = DF1 Full Duplex BCC 4 = DF1 Full Duplex CRC 5 = DF1 Half Duplex BCC 6 = DF1 Half Duplex CRC 7 = DNP 8 = PPP Default : 1 = Modbus RTU
Start Register + 1	Protocol station number 1 to 255 in standard Modbus 1 to 65534 in extended Modbus 0 to 254 in DF1 Default : 1
Start Register + 2	Store and forward enable 0 = disabled 1 = enabled Default : 0 = disabled
Start Register + 3	Protocol addressing mode 0 = standard 1 = extended Default: 0 = standard
Start Register + 4	Enron Modbus enable 0 = disabled 1 = enabled Default : 0 = disabled
Start Register + 5	Enron Modbus station number 1 to 255 in standard Modbus 1 to 65534 in extended Modbus Default : 1

Notes

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program. Extended addressing is supported only by the Modbus RTU and Modbus ASCII protocols.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

Refer to the *TeleBUS Protocols User Manual* for further information on protocols.

Six holding registers are always assigned to the I/O Database when this module is used.

1.5.15 CNFG Real Time Clock and Alarm

Description

The module, **CNFG Real time clock and alarm**, provides access to the controller real time clock data and alarm settings. Real Time Clock and Alarm settings are assigned from eleven consecutive holding registers. The registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller.

The clock data from the first 7 holding registers is written to the module parameters, whenever any of these registers are changed by a Ladders program or C Application. Otherwise, these holding registers are updated continuously with data read from the real time clock.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is continuously energized the controller real time clock will not change.

The alarm settings are updated continuously with data read from the last 4 holding registers.

Register Assignment

Module	CNFG Real time clock and alarm	
Address	No physical address is required.	
Type	Holding Register	
Start	First register of any unused block of 11 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +10
Registers	11 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Real time clock hour 0 to 23
Start Register + 1	Real time clock minute 0 to 59
Start Register + 2	Real time clock second 0 to 59
Start Register + 3	Real time clock year 00 to 99
Start Register + 4	Real time clock month 1 to 12
Start Register + 5	Real time clock day 1 to 31
Start Register + 6	Real time clock day of week 1 to 7, 1=Sunday, 2=Monday…7=Saturday
Start Register + 7	Alarm hour 0 to 23

Registers	Assignment to Module Hardware	
Start Register + 8	Alarm minute	0 to 59
Start Register + 9	Alarm second	0 to 59
Start Register + 10	Alarm control	0 = no alarm 1 = absolute time 2 = elapsed time alarm (relative from now) ** See note below.

** The Alarm Control register (Start Register + 10) enables or disables the alarm. A value of 0 in this register disables the alarm. A value of 1 sets an alarm to be triggered in absolute time, based on the values in the preceding three registers. A value of 2 sets the alarm to be triggered at a latter time, starting now.

Note that the alarm settings above and those in the Sleep (SLP) function block will trigger the same interrupt. See the ***Ladder Logic Function Reference*** in this book for details on the SLP function. Using both alarm settings, therefore, in the same program is not recommended.

Additional Notes

The *5203/4 Controllers* have a hardware based real-time clock that independently maintains the time and date for the operating system. The time and date remain accurate during power-off. The calendar automatically handles leap years.

One method for setting the clock is to use the *Edit/Force Register* dialog to write the current time to the appropriate module registers. Leave the force box in the dialog unchecked so that the data is only written, not forced.

All seven registers for the real time clock must be set to valid values for the clock to operate properly. Refer to real time clock specifications in the *Controller System Manual* for further information.

Eleven holding registers are always assigned to the I/O Database when this module is used.

1.5.16 CNFG Save Settings to EEPROM

Description

The module, **CNFG Save settings to EEPROM**, provides a way to save controller settings to EEPROM. Saving to EEPROM is controlled by one assigned coil register. The controller settings are saved when the coil register is set to 1. Once saved the coil register is automatically reset to 0.

Register Assignment

Module	CNFG Save settings to EEPROM	
Address	No physical address is required.	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Save the following controller settings: Serial port settings Protocol settings Enable store and forward settings LED power settings Mask for wake-up sources HART interface configuration Execution period on power-up for each PID

1.5.17 CNFG Serial Port Settings

Description

The module, **CNFG Serial port settings**, controls the configuration settings for a serial port. Settings are assigned from nine consecutive holding registers. The holding registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the data from all 9 holding registers is written to the module parameters, whenever any of the registers change.

Use this module only when serial port settings need to be changed within a Ladders program. It is more convenient to use the *Controller Serial Ports Settings* dialog to download settings with the program. Refer to the *Serial Ports* section under *Controller Menu,* in this manual, for further information on serial port settings.

Note: Any block transfer Ladder Logic function may be used to write data to the holding registers used for this module. The data in the holding registers is written to the module parameters only when the ladder function is energized. Users must ensure the ladder function is only energized for one program scan. If the ladder function is always energized problems with the serial communication will result.

Register Assignment

Module	CNFG Serial port settings	
Address	Com1, com2, com3, or com4.	
Type	Holding Register	
Start	First register of any unused block of 9 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +8
Registers	9 holding registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Baud rate 0 = 75 baud 1 = 110 baud 2 = 150 baud 3 = 300 baud 4 = 600 baud 5 = 1200 baud 6 = 2400 baud 7 = 4800 baud 8 = 9600 baud 9 = 19200 baud 10 =38400 11 = 115200 com3, com4 only 12 = 57600 com3, com4 only Default : 8 = 9600 baud

Start Register + 1	Duplex 0 = half duplex 1 = full duplex com1, com2 Default : 1 = full com3, com4 Default : 0 = half
Start Register + 2	Parity 0 = none 1 = even 2 = odd Default : 0 = none
Start Register + 3	Data bits 0 = 7 bits 1 = 8 bits Default : 1 = 8 bits
Start Register + 4	Stop bits 0 = 1 bit 1 = 2 bits Default : 0 = 1 bit
Start Register + 5	Receiver flow control Com1, Com2 0 = none (default) 1 = XON/XOFF Com3, Com4 0 = none 1 = Receive Disable (default)
Start Register + 6	Transmitter flow control Com1, Com2 0 = none (default) 1 = XON/XOFF Com3, Com4 0 = none (default) 1 = Ignore CTS
Start Register + 7	Port type 0 = automatic 1 = RS232 3 = RS485 6 = RS232 MODEM 7 = RS232 Collision Avoidance Default : 1 = RS232
Start Register + 8	Serial time-out delay 0 to 65535 (x 0.1 seconds) Default : 600 = 60 seconds

Notes

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

1.5.18 CNFG Store and Forward

Description

The module, **CNFG Store and forward**, controls the store and forward table. Store and Forward table data is assigned from 512 consecutive holding registers. One coil register is assigned to clear the translation table.

This module is used by the SCADAPack controller series only. For SCADAPack 32 controllers use the Store and Forward command in TelePACE.

The holding registers are initialized with the current value of the module parameters on power-up, and when the Register Assignment is downloaded to the controller. Thereafter the table is updated continuously with data read from the holding registers. The table is cleared when the coil register is set to 1. Once cleared the coil register is automatically reset to 0.

Register Assignment

Module	CNFG Store and Forward	
Address	No physical address is required.	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	clear Store and Forward table	
Type	Holding Register	
Start	First register of any unused block of 512 consecutive holding registers.	4xxxx
End	Last register in block.	4xxxx +511
Registers	512 holding registers	
Description	Translation table	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Clear Translation table

Holding Register Data

Registers	Assignment to Module Hardware
Start Register	Translation table entry 0 Port A 0 = com1 1 = com2 2 = com3 3 = com4 Default : 0
Start Register + 1	Translation table entry 0 Station A 0 to 255 standard addressing 0 to 65534 extended addressing 65535 = disable Default : 65535
Start Register + 2	Translation table entry 0 Port B 0 = com1 1 = com2 2 = com3 3 = com4 Default : 0
Start Register + 3	Translation table entry 0 Station B 0 to 255 standard addressing 0 to 65534 extended addressing 65535 = disable Default : 65535
Start Register + 4 to Start Register + 7	Translation table entry 1
Start Register + 8 to Start Register + 11	Translation table entry 2
Start Register + 12 to Start Register + 511	Translation table entries 3 to 127

Notes

Refer to the *TeleBUS Protocols User Manual* for further information on Store and Forward messaging.

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

Store and forward messaging is enabled on the required serial ports using the module **CNFG Protocol settings**.

1.6 Counter I/O Modules

Counter input modules are used to assign data from physical counter inputs to input registers in the I/O Database. The physical counter inputs are specific 5000 Series I/O modules and controller counter inputs.

Counter input modules may assign data to any input registers that are not used by another Analog Input module or Counter input module. There are 1024 I/O database input registers available. These input registers are numbered 30001 - 31024. Input registers are referred to as 3xxxx registers throughout this manual.

All I/O database input registers that are not assigned to any other I/O modules may be used as general purpose input registers in a ladder program. The I/O modules available are described in the following pages.

1.6.1 CNTR Controller Counter Inputs

Description

The module, **CNTR controller counter inputs**, reads the three counter inputs on the Micro16, SCADAPack, SCADAPack Light, SCADAPack, SCADAPack Plus, SCADAPack 32 and SCADAPack 32P controllers. Data is assigned to six consecutive input registers. The input registers are updated continuously with data read from the counters.

Each counter is a 32-bit number, stored in two 16-bit registers. The first register holds the least significant 16 bits of the counter. The second register holds the most significant 16 bits of the counter. To obtain the correct count, both registers must be read with the same protocol read command. Ladder Logic programs can read the registers in any order, provided both registers are examined on the same pass through the program.

The maximum count is 4,294,967,295. Counters roll over to 0 when the maximum count is exceeded.

Register Assignment

Module	CNTR controller counter inputs	
Address	No physical address is required.	
Type	Input Register	
Start	First register of any unused block of 6 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +5
Registers	6 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register and Start Register + 1	Controller counter input 0 (32 bit register)
Start Register + 2 and Start Register + 3	Controller counter input 1 (32 bit register)
Start Register + 4 and Start Register + 5	Controller counter input 2 (32 bit register)

Notes

Refer to the *Hardware User Manual* for further information on controller board counter inputs.

1.6.2 CNTR Controller Interrupt Input

Description

The module, **CNTR controller interrupt input**, reads the interrupt input on the Micro16, SCADAPack, SCADAPack Light, SCADAPack, SCADAPack Plus, SCADAPack 32 and SCADAPack 32P controllers as a counter input. Data is assigned to two consecutive input registers. The input registers are updated continuously with data read from the counter.

The counter is a 32-bit number, stored in two 16-bit registers. The first register holds the least significant 16 bits of the counter. The second register holds the most significant 16 bits of the counter. To obtain the correct count, both registers must be read with the same protocol read command. Ladder Logic programs can read the registers in any order, provided both registers are examined on the same pass through the program.

The maximum count is 4,294,967,295. The counter rolls over to 0 when the maximum count is exceeded.

Register Assignment

Module	CNTR controller interrupt input	
Address	No physical address is required.	
Type	Input Register	
Start	First register of any unused block of 2 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +1
Registers	2 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register and Start Register + 1	Interrupt input counter (32 bit register)

Notes

Refer to the *SCADAPack and Micro16 System Manual* for further information on controller board counter inputs.

1.6.3 CNTR 5410 input module

Description

The module, **CNTR 5410 input module**, provides four counter inputs. Data is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the counters.

Each counter is a 32-bit number, stored in two 16-bit registers. The first register holds the least significant 16 bits of the counter. The second register holds the most significant 16 bits of the counter. To obtain the correct count, both registers must be read with the same Modbus protocol read command. Ladder Logic programs can read the registers in any order, provided both registers are examined on the same pass through the program.

The maximum count is 4,294,967,295. Counters roll back to 0 when the maximum count is exceeded.

Register Assignment

Module	CNTR 5203/4 counter inputs	
Address	This module is assigned a unique module address between 0 and 15. No other CNTR-type module may use this module address.	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +7
Registers	8 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register and Start Register + 1	Counter input 0 (32 bit register)
Start Register + 2 and Start Register + 3	Counter input 1 (32 bit register)
Start Register + 4 and Start Register + 5	Counter input 2 (32 bit register)
Start Register + 6 and Start Register + 7	Counter input 3 (32 bit register)

Notes

Refer to the *5410 High Speed Counter Input Module User Manual* for further information.

1.7 Diagnostic I/O Modules

Diagnostic modules are used to assign diagnostic data from the controller to input or status registers in the I/O Database. The diagnostic data is used to monitor internal controller data such as controller status code, the force LED, serial communication status and protocol status.

Diagnostic I/O modules assign data to I/O database input or status registers, depending on the type of data. Diagnostic I/O modules may assign data to any input or status registers in the I/O database that are not being used by another I/O module.

All I/O database input and status registers that are not assigned to any other I/O modules may be used as general purpose input or status registers in a ladder program. The I/O modules available are described in the following pages.

1.7.1 DIAG Controller Status Code

Description

The module, **DIAG Controller Status Code**, reads the controller status code and assigns it in one input register. The input register is updated continuously with the status code.

The Status LED blinks a binary sequence equal to the controller status code. Note that if a "*Register assignment table checksum error*" occurs, only the Status LED will indicate this status code. The I/O scan is disabled if this error occurs, so that the module **DIAG Controller status code** is no longer updated.

Register Assignment

Module	DIAG Controller Status Code	
Address	No physical address is required.	
Type	Input Register	
Start	Any unused input register.	3xxxx
End	Same as start register.	
Registers	1 input register.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Controller status code: 0 = Normal 1 = I/O module communication failure 2 = Register Assignment Checksum error

Status LED - I/O Error Indication

When the Status LED flashes the error code 1 (i.e. a short flash, once every second), there is a communication failure with one or more I/O module. To correct the problem, do one of the following:

1. Ensure that every module contained in the Register Assignment is connected to the controller. Check that the module address selected for each module agrees with the selection made in the Register Assignment.
2. If a module is currently not connected to the controller, delete it from the Register Assignment. Download the new Register Assignment to the controller.
3. If a module is still suspect of having failed, confirm the failure by removing the module from the Register Assignment. Download the new Register Assignment to the controller. The Status LED should stop flashing.
4. If unused modules must be intentionally left in the Register Assignment, the I/O error indication may be disabled from a selection box on the Register Assignment dialog.

Notes

Refer to the *5203/4 System Manual* or the *SCADAPack System Manual* for further information on the Status LED and Status Output.

1.7.2 DIAG DNP Connection Status

Description

This module determines the connection status of a remote DNP station, by repeatedly sending a short message to the selected remote station and monitoring the response.

The connection status information is assigned to an input register, which is updated continuously.

One holding register is assigned to specify the repeat time period for polling the remote station. A second holding register specifies the remote station address.

This register assignment is available for the SCADAPack 32 controller only.

Register Assignment

Module	DIAG DNP connection status	
Address	No address is required	
Type	Input Register	
Start	Any unused input register	3xxxx
End	Same as start register	
Registers	1 input register	
Description	Connection status: 0 = connection OK 1 = connection failed	
Type	Holding Register	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +1
Registers	2 holding registers.	
Description	Configuration data	
Extended Parameters	None	

Holding Register Data

Registers	Assignment to Module Hardware
Start Register	DNP station address
Start Register + 1	Repeat rate (in seconds) for connection request message

1.7.3 DIAG DNP Event Status Module

Description

This module provides diagnostic data about DNP change events. The number of change events stored in the event buffers is totalled for all DNP classes, and for all DNP point types.

The status information is assigned to nine consecutive input registers. The input registers are updated continuously with data concerning the DNP change events.

One coil register is assigned to clear the change event buffers. The data is cleared when the coil register is set to 1. Once the data is cleared the coil register is automatically reset to 0.

Register Assignment

Module	DIAG DNP event status	
Address	No address is required	
Type	Input Register	
Start	First register of any unused block of 9 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +8
Registers	12 input registers	
Description	diagnostic data	
Type	Coil Register	
Start	Any unused coil register	0xxxx
End	Same as start register	
Registers	1 coil register	
Description	clear event buffers	
Extended Parameters	None	

Input Register Data

Registers	Assignment to Module Hardware
Start Register	DNP event count for Binary Inputs
Start Register + 1	DNP event count for 16-bit Counter Inputs
Start Register + 2	DNP event count for 32-bit Counter Inputs
Start Register + 3	DNP event count for 16-bit Analog Inputs
Start Register + 4	DNP event count for 32-bit Analog Inputs
Start Register + 5	DNP event count for Short Float Analog Inputs
Start Register + 6	DNP event count for Class 1 Data
Start Register + 7	DNP event count for Class 2 Data
Start Register + 8	DNP event count for Class 3 Data
Start Register + 9	reserved for future use
Start Register +10	reserved for future use
Start Register +11	reserved for future use

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Clear change event buffers

1.7.4 DIAG DNP Port Status Module

Description

This module provides DNP diagnostic data for a specific communication port. Diagnostic information is totaled for all DNP connections on the selected communication port.

The status information is assigned to nine consecutive input registers. The input registers are updated continuously with the DNP diagnostic data.

One coil register is assigned to clear the diagnostic data. The data is cleared when the coil register is set to 1. Once the data is cleared the coil register is automatically reset to 0.

Register Assignment

Module	DIAG DNP port status	
Address	com1, com2, com3, com4, or LAN1	
Type	Input Register	
Start	First register of any unused block of 7 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +6
Registers	10 input registers	
Description	diagnostic data	
Type	Coil Register	
Start	Any unused coil register	0xxxx
End	Same as start register	
Registers	1 coil register	
Description	clear diagnostic data	
Extended Parameters	None	

Input Register Data

Registers	Assignment to Module Hardware
Start Register	DNP message successes Number of successful DNP message transactions initiated by this station
Start Register + 1	DNP message failures Number of failed DNP message transactions initiated by this station
Start Register + 2	DNP fails since last success Number of consecutive failed DNP message transactions initiated by this station since the last success
Start Register + 3	DNP format errors Number of received DNP message frames with formatting errors (including checksum errors and unrecognized commands)
Start Register + 4	DNP message frames received Number of DNP message frames received

Registers	Assignment to Module Hardware
Start Register + 5	DNP message frames sent Number of DNP message frames sent. This includes any message retries at application or data link layer.
Start Register + 6	DNP messages received Number of complete DNP messages received
Start Register + 7	DNP messages sent Number of complete DNP messages sent. This includes any message retries at the application layer.
Start Register + 8	reserved for future use
Start Register + 9	reserved for future use

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Clear diagnostic data

1.7.5 DIAG DNP Station Status

Description

This module provides DNP diagnostic data for a specific DNP remote station address. Diagnostic information is totaled for all DNP communication with the station.

The status information is assigned to nine consecutive input registers. The input registers are updated continuously with data concerning the DNP status of the specific interface.

One coil register is assigned to clear the diagnostic data. The data is cleared when the coil register is set to 1. Once the data is cleared the coil register is automatically reset to 0.

One holding register specifies the remote station address.

Register Assignment

Module	DIAG DNP station status	
Address	No address is required	
Type	Input Register	
Start	First register of any unused block of 10 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +9
Registers	10 input registers	
Description	diagnostic data	
Type	Coil Register	
Start	Any unused coil register	0xxxx
End	Same as start register	
Registers	1 coil register	
Description	clear diagnostic data	
Type	Holding Register	
Start	Any unused holding register.	4xxxx
End	Same as start register	
Registers	1 holding register.	
Description	DNP station address	
Extended Parameters	None	

Input Register Data

Registers	Assignment to Module Hardware
Start Register	DNP message successes Number of successful DNP message transactions initiated by this station
Start Register + 1	DNP message failures Number of failed DNP message transactions initiated by this station
Start Register + 2	DNP fails since last success Number of consecutive failed DNP message transactions initiated by this station since the last success

Registers	Assignment to Module Hardware
Start Register + 3	DNP format errors Number of received DNP message frames with formatting errors (including checksum errors and unrecognized commands)
Start Register + 4	DNP message frames received Number of DNP message frames received
Start Register + 5	DNP message frames sent Number of DNP message frames sent. This includes any message retries at application or data link layer.
Start Register + 6	DNP messages received Number of complete DNP messages received
Start Register + 7	DNP messages sent Number of complete DNP messages sent. This includes any message retries at the application layer.
Start Register + 8	reserved for future use
Start Register + 9	reserved for future use

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Clear diagnostic data

Holding Register Data

Registers	Assignment to Module Hardware
Start Register	DNP station address

1.7.6 DIAG Force

Description

All user accessible Modbus registers in a SCADAPack controller can be forced to a desired state or value. The **DIAG Force** module is used to determine if a Modbus register in a SCADAPack controller is forced to some state or value. This module reads the 'forced' state of a SCADAPack controller, and assigns it to one status register. The status register is updated continuously with the current 'forced' state of the controller.

Note that the Force LED on SCADAPack controllers, excluding the SCADASense programmable controllers, also indicates if a Modbus register is forced.

Register Assignment

Module	DIAG Force	
Address	No physical address is required.	
Type	Status Register	
Start	Any unused status register.	1xxxx
End	Same as start register.	
Registers	1 status register.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	0 = Modbus register is not forced 1 = Modbus register is forced Force LED: 0 = Force LED is OFF 1 = Force LED is ON

1.7.7 DIAG IP Connections

Description

The module, **DIAG IP connections**, provides a summary of the IP connections. The connection information is assigned to three consecutive input registers. The input registers are updated continuously with connection data.

This module is used by the SCADAPack 32 controller series only. The connection statistics include all IP connection types.

Register Assignment

Module	DIAG IP connections	
Address	No physical address is required.	
Type	Input Register	
Start	First register of any unused block of 3 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 2
Registers	3 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Number of current slave IP connections.
Start Register + 1	Number of current master IP connections.
Start Register + 2	Number of free IP connections.

1.7.8 DIAG Logic Status

Description

The module, **DIAG Logic Status**, reads the Ladder Logic Application status in the RAM and FLASH memory and assigns it to two input registers. The input registers are updated continuously with the current application status.

Register Assignment

Module	DIAG Logic Status	
Address	No physical address is required.	
Type	Input Register	
Start	Any unused input register.	3xxxx
End	Last register in block.	3xxxx+1
Registers	2 input registers	
Description	None	

Input Register Data

Registers	Assignment to Module Hardware
Start Register	Ladder Logic Program Status 0 = No Program 1 = Program Stopped 2 = Program Running in Debug Mode 3 = Program Running
Start Register + 1	Type of memory where Ladder Logic program is loaded: 0 = No program in RAM or FLASH; 1 = Program loaded in RAM 2 = Program loaded in FLASH 3 = Program loaded in RAM and FLASH

1.7.9 DIAG Modbus Protocol Status

Description

The module, **DIAG Modbus protocol status**, provides diagnostic data about Modbus protocols for a specific communication interface. Diagnostic information is totaled for all Modbus protocols on the selected communication interface. When multiple Modbus IP connections exist on the same interface, diagnostic information is totaled for all connections.

This module is used by the SCADAPack 32 controller series only.

The status information is assigned to nine consecutive input registers. The input registers are updated continuously with data concerning the Modbus protocol status of the specific interface.

One coil register is assigned to clear the diagnostic data. The data is cleared when the coil register is set to 1. Once the data is cleared the coil register is automatically reset to 0.

Register Assignment

Module	DIAG Modbus protocol status	
Address	com1, com2, com3, com4, or Ethernet1	
Type	Input Register	
Start	First register of any unused block of 9 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +8
Registers	9 input registers	
Description	diagnostic data	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as start register.	
Registers	1 coil register.	
Description	clear diagnostic data	
Extended Parameters	None	

Input Register Data

Registers	Assignment to Module Hardware
Start Register	Modbus command errors
Start Register + 1	Modbus format errors
Start Register + 2	Modbus checksum errors
Start Register + 3	Modbus slave commands received
Start Register + 4	Modbus master commands sent
Start Register + 5	Modbus master responses received
Start Register + 6	Modbus slave responses sent
Start Register + 7	Modbus stored messages
Start Register + 8	Modbus forwarded messages

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Clear diagnostic data

1.7.10 DIAG Serial Port Comm. Status

Description

The module, **DIAG Serial port comm. status**, provides diagnostic data about a specific serial port. The status information is assigned to five consecutive input registers. The input registers are updated continuously with data concerning the communication status of the serial port.

Register Assignment

Module	DIAG Serial port comm. Status	
Address	com1, com2, com3, or com4.	
Type	Input Register	
Start	First register of any unused block of 5 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 4
Registers	5 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Framing errors
Start Register + 1	Parity errors
Start Register + 2	Character overrun errors
Start Register + 3	Buffer overrun errors
Start Register + 4	Integer value indicating the status of Port I/O lines CTS and DCD: The LSB = state of the CTS line. Second to LSB = state of DCD input Example: Value of 3 implies CTS and DCD is ON. Value of 1 implies CTS is ON and DCD is OFF.

Notes

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for

com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

1.7.11 DIAG Serial Port Protocol Status

Description

The module, **DIAG Serial port protocol status**, provides diagnostic data about a specific serial port. The status information is assigned to ten consecutive input registers. The input registers are updated continuously with data concerning the protocol status of the serial port.

Register Assignment

Module	DIAG Serial port comm. Status	
Address	com1, com2, com3, or com4.	
Type	Input Register	
Start	First register of any unused block of 10 consecutive input registers.	3xxxx
End	Last register of block	3xxxx + 9
Registers	10 input registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Protocol command errors
Start Register + 1	Protocol format errors
Start Register + 2	Protocol checksum errors
Start Register + 3	Protocol slave commands received
Start Register + 4	Protocol master commands sent
Start Register + 5	Protocol master responses received
Start Register + 6	Protocol slave responses sent

Registers	Assignment to Module Hardware
Start Register + 7	Protocol master command status 0 = message sent, waiting for response 1 = response received, no error occurred 2 = not used 3 = bad value in function code register 4 = bad value in slave controller address register 5 = bad value in slave register address 6 = bad value in length register 7 = serial port or protocol is invalid 8 = not used 9 = specified protocol is not supported by this controller 11 = an unexpected length response was received This means corrupt messages for regular Modbus. Check the format and checksum counters. For Enron Modbus, this is normal. 12 = response timeout 24 = exception response: invalid function code 25 = exception response: invalid address 26 = exception response: invalid value 27 = protocol is invalid or serial port queue is full 28 = slave and master stations are equal; they must be different 29 = exception response: slave device failure 30 = exception response: slave device busy
Start Register + 8	Protocol stored messages
Start Register + 9	Protocol forwarded messages

Notes

For SCADAPack, SCADAPack Light and SCADAPack Plus controllers Com3 is supported only when the **SCADAPack 5601 and 5604 I/O module** is installed. Com4 is supported only when the **SCADAPack 5602 I/O module** is installed. To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator terminals, and for programming and diagnostics using the TelePACE program.

1.8 Digital Input I/O Modules

Digital input modules are used to assign data from physical digital inputs to status registers in the I/O Database. The physical digital inputs are specific 5000 Series I/O modules, generic I/O modules, and controller digital inputs.

Digital input modules may assign data to any status registers in the I/O database that are not being used by another Digital input module. There are 4096 I/O database status registers available. These status registers are numbered 10001 - 14096. Status registers are referred to as 1xxxx registers throughout this manual.

All I/O database status registers that are not assigned to any other I/O modules may be used as general-purpose status registers in a ladder program. The I/O modules available are described in the following pages.

1.8.1 DIN Controller Digital Inputs

Description

The module, **DIN controller digital inputs**, reads the three digital inputs on the Micro16, SCADAPack, SCADAPack Light, SCADAPack, SCADAPack Plus, SCADAPack 32 and SCADAPack 32P controllers. Data is assigned to three consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Register Assignment

Module	DIN controller digital inputs	
Address	No physical address is required.	
Type	Status Register	
Start	First register of any unused block of 3 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 2
Registers	3 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Controller board digital input 0
Start Register + 1	Controller board digital input 1
Start Register + 2	Controller board digital input 2

Notes

Refer to the *Hardware User Manual* for further information.

1.8.2 DIN Controller Interrupt Input

Description

The module, **DIN controller interrupt input**, reads the state of the interrupt input on the Micro16, SCADAPack, SCADAPack Light, SCADAPack, SCADAPack Plus, SCADAPack 32 and SCADAPack 32P controllers. Data is assigned to one status register. The status register is updated continuously with the state of the interrupt input.

Register Assignment

Module	DIN controller interrupt input	
Address	No physical address is required.	
Type	Status Register	
Start	Any unused status register.	1xxxx
End	Same as start register.	
Registers	1 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Controller board Interrupt Input

Notes

Refer to the Hardware User Manual for further information on the Controller interrupt input.

1.8.3 DIN Controller Option Switches

Description

The module, **DIN Controller option switches**, reads the state of the three option switches on the Micro16, SCADAPack, SCADAPack Light, SCADAPack, SCADAPack Plus, SCADAPack 32 and SCADAPack 32P controllers. Data is assigned to three status registers. The status registers are updated continuously with data read from the option switches.

Register Assignment

Module	DIN 5203/4 option switches	
Address	No physical address is required.	
Type	Status Register	
Start	First register of any unused block of 3 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 2
Registers	3 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Controller board option switch 1
Start Register + 1	Controller board option switch 2
Start Register + 2	Controller board option switch 3

Notes

The option switches are also used as configuration switches for the SCADAPack I/O modules. Refer to these I/O modules for details.

Refer to the *5203/4 System Manual* or the *SCADAPack System Manual* for further information on the controller option switches.

1.8.4 DIN SCADAPack 32 Option Switches

Description

The module, **DIN SCADAPack 32 option switches**, reads the state of the four option switches on the SCADAPack 32 controller board. Data is assigned to four status registers. The status registers are updated continuously with data read from the option switches.

Register Assignment

Module	DIN SCADAPack 32 option switches	
Address	No physical address is required.	
Type	Status Register	
Start	First register of any unused block of 4 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 3
Registers	4 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Controller board option switch 1
Start Register + 1	Controller board option switch 2
Start Register + 2	Controller board option switch 3
Start Register + 3	Controller board option switch 4

Notes

The option switches are also used as configuration switches for the SCADAPack I/O modules. Refer to these I/O modules for details.

Refer to the *SCADAPack 32 System Manual* for further information on the controller option switches.

1.8.5 DIN 5401 Module

Description

The **DIN 5401 module** provides eight digital inputs. Data is assigned to eight consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

When there are digital outputs being used in combination with digital inputs on the 5401, a full 8 status registers must still be assigned to the **DIN 5401 module**. When this is the case, a **DOUT 5401 module** must also be added to the Register Assignment with the same module address.

Register Assignment

Module	DIN 5401 module	
Address	This module is assigned a unique module address between 0 and 7. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 8 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 7
Registers	8 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7

Notes

Refer to the *5401 Digital I/O Module User Manual* for further information.

1.8.6 DIN 5402 Module

Description

The **DIN 5402 module** provides sixteen digital inputs. Data is assigned to sixteen consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Register Assignment

Module	DIN 5402 module	
Address	This module is assigned a unique module address between 0 and 15. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 16 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 15
Registers	16 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15

Notes

Refer to the *5402 Digital I/O Module User Manual* for further information.

1.8.7 DIN 5403 Module

Description

The **DIN 5403 module** provides eight digital inputs. Data is assigned to eight consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Register Assignment

Module	DIN 5403 module	
Address	This module is assigned a unique module address between 0 and 7. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 8 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 7
Registers	8 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7

Notes

Refer to the *5403 Digital Input Module User Manual* for further information.

1.8.8 DIN 5404 Module

Description

The **DIN 5404 module** provides sixteen digital inputs. Data is assigned to sixteen consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Register Assignment

Module	DIN 5404 module	
Address	This module is assigned a unique module address between 0 and 15. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 16 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 15
Registers	16 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15

Notes

Refer to the *5404 Digital Input Module User Manual* for further information.

1.8.9 DIN 5405 Module

Description

The **DIN 5405 module** provides thirty-two digital inputs. Data is assigned to thirty-two consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Register Assignment

Module	DIN 5404 module	
Address	This module is assigned a unique module address between 0 and 15. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 32 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 31
Registers	32 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15
Start Register + 16	Digital input 16
Start Register + 17	Digital input 17
Start Register + 18	Digital input 18
Start Register + 19	Digital input 19
Start Register + 20	Digital input 20

Registers	Assignment to Module Hardware
Start Register + 21	Digital input 21
Start Register + 22	Digital input 22
Start Register + 23	Digital input 23
Start Register + 24	Digital input 24
Start Register + 25	Digital input 25
Start Register + 26	Digital input 26
Start Register + 27	Digital input 27
Start Register + 28	Digital input 28
Start Register + 29	Digital input 29
Start Register + 30	Digital input 30
Start Register + 31	Digital input 31

Notes

Refer to the *5405 Digital Input Module User Manual* for further information.

1.8.10 DIN 5421 Module

Description

The **DIN 5421 module** provides eight digital inputs. Data is assigned to eight consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Register Assignment

Module	DIN 5421 module	
Address	This module is assigned a unique module address between 0 and 7. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 8 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 7
Registers	8 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7

Notes

Refer to the *5421 Switch Input Module Manual* for further information.

1.8.11 DIN Generic 16 Point Module

Description

The **DIN Generic 16 point module** provides sixteen digital inputs. Data is assigned to sixteen consecutive status registers. The status registers are updated continuously with data read from the digital inputs. The **DIN Generic 16 point module** may be used in place of any other 16 point DIN-type module.

The **DIN Generic 16 point module** type is a useful selection early on in the system design stage before the final selection of the specific DIN module type is known.

Register Assignment

Module	DIN Generic 16 point module	
Address	This module is assigned a unique module address between 0 and 15. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 16 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 15
Registers	16 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15

Notes

For further information, refer to the *User Manual* for the specific 16 point DIN module used.

1.8.12 DIN Generic 8 Point Module

Description

The **DIN Generic 8 point module** provides eight digital inputs. Data is stored in eight consecutive status registers. The status registers are updated continuously with data read from the digital inputs. The **DIN Generic 8 point module** may be used in place of any other 8 point DIN-type module.

The **DIN Generic 8 point module** type is a useful selection early on in the system design stage before the final selection of the specific DIN module type is known.

Register Assignment

Module	DIN Generic 8 point module	
Address	This module is assigned a unique module address between 0 and 7. No other DIN-type module may use this module address.	
Type	Status Register	
Start	First register of any unused block of 8 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 7
Registers	8 status registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7

Notes

For further information, refer to the *User Manual* for the specific 8 point DIN module used.

1.9 Digital Output I/O Modules

Digital output modules are used to assign data from the I/O Database to physical digital outputs. The physical digital outputs are specific 5000 Series I/O modules or generic I/O modules.

Digital output modules may assign data to any coil registers in the I/O database that are not being used by another Digital output module. There are 4096 I/O database coil registers available. These coil registers are numbered 00001 - 04096. Coil registers are referred to as 0xxxx registers throughout this manual.

All I/O database coil registers that are not assigned to any other I/O modules may be used as general-purpose coil registers in a ladder program. The I/O modules available are described in the following pages.

1.9.1 DOUT 5401 Module

Description

The **DOUT 5401 module** provides eight digital outputs. Data is assigned from eight consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

When there are digital inputs being used in combination with digital outputs on the 5401, a full 8 coil registers must still be assigned to the **DOUT 5401 module**. When this is the case, a **DIN 5401 module** must also be added to the Register Assignment with the same module address.

Register Assignment

Module	DOUT 5401 module	
Address	This module is assigned a unique module address between 0 and 7. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 8 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 7
Registers	8 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7

Notes

Refer to the *5401 Digital I/O Module User Manual* for further information.

1.9.2 DOUT 5402 Module

Description

The **DOUT 5402 module** provides sixteen digital outputs. Data is assigned from sixteen consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Register Assignment

Module	DOUT 5402 module	
Address	This module is assigned a unique module address between 0 and 15. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 16 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 15
Registers	16 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 11
Start Register + 12	Digital output 12
Start Register + 13	Digital output 13
Start Register + 14	Digital output 14
Start Register + 15	Digital output 15

Notes

Refer to the *5402 Digital I/O Module User Manual* for further information.

1.9.3 DOUT 5406 Module

Description

The **DOUT 5406 module** provides sixteen digital outputs. Data is assigned from sixteen consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Register Assignment

Module	DOUT 5406 module	
Address	This module is assigned a unique module address between 0 and 15. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 16 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 15
Registers	16 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 11
Start Register + 12	Digital output 12
Start Register + 13	Digital output 13
Start Register + 14	Digital output 14
Start Register + 15	Digital output 15

Notes

Refer to the *5406 Digital Output Module User Manual* for further information.

1.9.4 DOUT 5407 Module

Description

The **DOUT 5407 module** provides eight digital outputs. Data is assigned from eight consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Register Assignment

Module	DOUT 5407 module	
Address	This module is assigned a unique module address between 0 and 7. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 8 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 7
Registers	8 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7

Notes

Refer to the *5407 Relay Output Module Manual* for further information.

1.9.5 DOUT 5408 Module

Description

The **DOUT 5408 module** provides eight digital outputs. Data is assigned from eight consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Register Assignment

Module	DOUT 5408 module	
Address	This module is assigned a unique module address between 0 and 7. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 8 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 7
Registers	8 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7

Notes

Refer to the *5408 Digital Output Module Manual* for further information.

1.9.6 DOUT 5409 Module

Description

The **DOUT 5409 module** provides eight digital outputs. Data is assigned from eight consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Register Assignment

Module	DOUT 5409 module	
Address	This module is assigned a unique module address between 0 and 7. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 8 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 7
Registers	8 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7

Notes

Refer to the *5409 Digital Output Module Manual* for further information.

1.9.7 DOUT 5411 Module

Description

The **DOUT 5411 module** provides thirty-two digital outputs. Data is assigned from thirty-two consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Register Assignment

Module	DOUT 5411 module	
Address	This module is assigned a unique module address between 0 and 15. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 32 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 31
Registers	32 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 11
Start Register + 12	Digital output 12
Start Register + 13	Digital output 13
Start Register + 14	Digital output 14
Start Register + 15	Digital output 15
Start Register + 16	Digital output 16
Start Register + 17	Digital output 17
Start Register + 18	Digital output 18
Start Register + 19	Digital output 19

Registers	Assignment to Module Hardware
Start Register + 20	Digital output 20
Start Register + 21	Digital output 21
Start Register + 22	Digital output 22
Start Register + 23	Digital output 23
Start Register + 24	Digital output 24
Start Register + 25	Digital output 25
Start Register + 26	Digital output 26
Start Register + 27	Digital output 27
Start Register + 28	Digital output 28
Start Register + 29	Digital output 29
Start Register + 30	Digital output 30
Start Register + 31	Digital output 31

Notes

Refer to the *5411 Digital Output Module User Manual* for further information.

1.9.8 DOUT Generic 16 Point Module

Description

The **DOUT Generic 16 point module** provides sixteen digital outputs. Data is assigned from sixteen consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers. The **DOUT Generic 16 point module** may be used in place of any other 16 point DOUT-type module.

The **DOUT Generic 16 point module** type is a useful selection early on in the system design stage before the final selection of the specific DOUT module type is known.

Register Assignment

Module	Generic 16 point module	
Address	This module is assigned a unique module address between 0 and 15. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 16 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 15
Registers	16 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 11
Start Register + 12	Digital output 12
Start Register + 13	Digital output 13
Start Register + 14	Digital output 14
Start Register + 15	Digital output 15

Notes

For further information, refer to the *Digital Output Module User Manual* for the specific 16-point DOUT module used.

1.9.9 DOUT Generic 8 Point Module

Description

The **DOUT Generic 8 point module** provides eight digital outputs. Data is assigned from eight consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers. The **DOUT Generic 8 point module** may be used in place of any other 8 point DOUT-type module.

The **DOUT Generic 8 point module** type is a useful selection early on in the system design stage before the final selection of the specific DOUT module type is known.

Register Assignment

Module	DOUT Generic 8 point module	
Address	This module is assigned a unique module address between 0 and 7. No other DOUT-type module may use this module address.	
Type	Coil Register	
Start	First register of any unused block of 8 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 7
Registers	8 coil registers.	
Description	None	
Extended Parameters	None	

Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7

Notes

For further information, refer to the *Digital Output Module Manual* for the specific 8 point DOUT module used.

1.10 SCADAPack and SCADASense Series I/O Modules

SCADAPack and SCADASense Series I/O modules assign data from registers to physical outputs, and assign data from physical inputs to registers. These I/O modules provide analog I/O points, digital I/O points and may assign data to registers that are not used by any other I/O module.

The following modules interface with SCADAPack and SCADASense Series I/O hardware.

1.10.1 4202 DR Extended/4203 DR IO

Description

The SCADASense 4203 DR, and a SCADASense 4202 DR manufactured after July 13, 2004, may use the 4202 DR Extended/4203 DR I/O register assignment. The 4202 DR must have controller board version 5 and terminal board version 6.

A SCADASense 4203 DR, or 4202 DR with Extended I/O, provides one digital point, which may operate as a digital input/counter or as a digital output. The digital output shares the same physical connections as the digital input. When the output is turned OFF, the point may be used as input. When the output is turned on it functions only as a digital output.

Digital point data is assigned to a single coil register and a single status register. The coil register is updated continuously with data read from the coil register. The status register is updated continuously with data read from the digital input.

Analog and counter input data is assigned to five consecutive input registers. One input register is used to monitor the controller input power and two counter input double registers (32 bit). These input registers are updated continuously with data read from the analog inputs and counter input.

Analog output data is assigned to a single analog output register. The analog output is updated continuously with the data read from the holding register.

Register Assignment

Module	4202 DR Extended/4203 DR I/O Module	
Address	Fixed	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Same as first register.	0xxxx
Registers	1 coil registers	
Description	digital output	
Type	Status Register	
Start	Any unused status register	1xxxx
End	Same as first register.	1xxxx
Registers	1 status register	
Description	Digital input	
Type	Input Register	
Start	First register of any unused block of 5 consecutive status registers.	3xxxx
End	Last register of block	3xxxx + 4
Registers	5 input registers	
Description	Analog and counter inputs	
Type	Analog Output Register	
Start	Any unused analog output register	4xxxx
End	Same as first register	4xxxx
Registers	1 analog output register	

Description	Analog outputs
Extended Parameters	None

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0

Analog and Counter Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input Supply Voltage (mV)
Start Register + 1 and +2	Counter input, 32 bit register
Start Register + 3 and +4	Counter input, 32 bit register

Analog Output Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output – Input Voltage (mV)

Notes

Only one **4202 DR Extended/4203 DR I/O** may be assigned.

Refer to the **SCADASense 4202 DR Hardware Manual** for information on analog and digital I/O usage.

1.10.2 4202 DR I/O

Description

Digital input data is assigned to a single status register. The status register is updated continuously with data read from the digital input.

Analog and counter input data is assigned to five consecutive input registers. One input register is used to monitor the controller input power and two counter input double registers (32 bit). These input registers are updated continuously with data read from the analog inputs and counter input.

Analog output data is assigned to a single analog output register. The analog output is updated continuously with the data read from the holding register.

Register Assignment

Module	4202 DR I/O Module	
Address	Fixed	
Type	Status Register	
Start	Any unused status register	1xxxx
End	Same as first register.	1xxxx
Registers	1 status register	
Description	Digital input	
Type	Input Register	
Start	First register of any unused block of 5 consecutive status registers.	3xxxx
End	Last register of block	3xxxx + 4
Registers	5 input registers	
Description	Analog and counter inputs	
Type	Analog Output Register	
Start	Any unused analog output register	4xxxx
End	Same as first register	4xxxx
Registers	1 analog output register	
Description	Analog outputs	
Extended Parameters	None	

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0

Analog and Counter Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input Supply Voltage (mV)
Start Register + 1 and +2	Counter input, 32 bit register

Registers	Assignment to Module Hardware
Start Register + 3 and +4	Counter input, 32 bit register

Analog Output Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output – Input Voltage (mV)

Notes

Only one **4202 DR I/O** may be assigned.

Refer to the **SCADASense 4202 DR Hardware Manual** for information on analog and digital I/O usage.

1.10.3 4202/4203 DS I/O

Description

The 4202/4203 DS I/O register assignment is used for the SCADASense DS Series of controllers (4202 DS and 4203 DS). This module provides two digital input/output (I/O) points point. The first DI/O point may be used as a digital input/counter or as a digital output. The digital output shares the same physical connections as the digital input/counter. When the output is turned OFF, the point may be used as input/counter. When the output is turned on it functions only as a digital output. Digital point data is assigned to a single coil register and a single status register. The coil register is updated continuously with data read from the coil register. The status register is updated continuously with data read from the digital input.

The second DI/O point may be used as a turbine meter counter input or as a digital output. The digital output shares the same physical connections as the turbine meter counter input. When the output is turned OFF, the point may be used as a turbine meter counter input. When the output is turned on it functions only as a digital output. Digital point data is assigned to a single coil register. The coil register is updated continuously with data read from the coil register.

Analog and counter input data is assigned to seven consecutive input registers. Two input registers are used for the two analog inputs; one input register is used to monitor the controller input power; two input registers are used for the counter input (32 bit double word uses two registers) and two input registers are used for the turbine meter counter input (32 bit double word uses two registers). These input registers are updated continuously with data read from the analog inputs and counter inputs.

Register Assignment

Module	4202/4203 DS I/O Module	
Address	Fixed	
Type	Coil Register	
Start	Any unused coil register.	0xxxx
End	Last register of block.	0xxxx + 1
Registers	2 coil registers	
Description	Digital output	
Type	Status Register	
Start	Any unused status register	1xxxx
End	Same as first register.	1xxxx
Registers	1 status register	
Description	Digital input	
Type	Input Register	
Start	First register of any unused block of 7 consecutive status registers.	3xxxx
End	Last register of block	3xxxx + 6
Registers	7 input registers	
Description	Analog and counter inputs	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register +1	Digital output 1

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0

Analog and Counter Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog Input 0
Start Register +1	Analog Input 1
Start Register +2	Analog input Supply Voltage (mV)
Start Register +3 and +4	Counter 0 input, 32 bit register
Start Register +5 and +6	Counter 1 input, 32 bit register

Notes

Only one **4202/4203 DS I/O** may be assigned.

Refer to the **SCADASense 4202 DS Hardware Manual** for information on analog and digital I/O usage.

1.10.4 SCADAPack AOUT Module

Description

The **SCADAPack AOUT module** provides two analog outputs. Data is read from two consecutive holding (4xxxx) registers. The analog outputs are updated continuously with the data read from the holding registers.

Register Assignment

Module	SCADAPack AOUT module	
Address	This module has a fixed module address of 0. No other AOUT-type module may use this module address when this module is used.	
Type	Holding Register	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx + 1
Registers	2 holding registers.	
Description	None	
Extended Parameters	None	

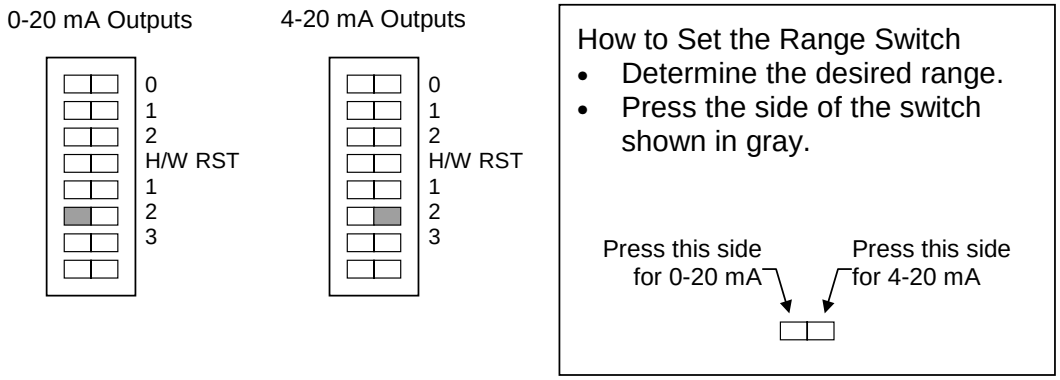
Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1

Output Range Selection

The SCADAPack Option Switch 2 selects the signal range. Both analog outputs are set to the same range.

The figure below shows the switch settings for selecting the output range.



Notes

Refer to the **SCADAPack Hardware Manual** for further information on the option switches.

Option Switch 2 functions as the Output Range Switch regardless of whether the module, **5203/4 option switches**, is added to the Register Assignment or not.

1.10.5 SCADAPack 5601 I/O Module

Description

Digital output data is assigned from twelve consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Digital input data is assigned to sixteen consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Analog input data is assigned to eight consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

Register Assignment

Module	SCADAPack 5601 I/O Module	
Address	fixed at 0	
Type	Coil Register	
Start	First register of any unused block of 12 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 11
Registers	12 coil registers	
Description	digital outputs	
Type	Status Register	
Start	First register of any unused block of 16 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 15
Registers	16 status registers	
Description	digital inputs	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +7
Registers	8 input registers	
Description	analog inputs	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7

Registers	Assignment to Module Hardware
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 12

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15

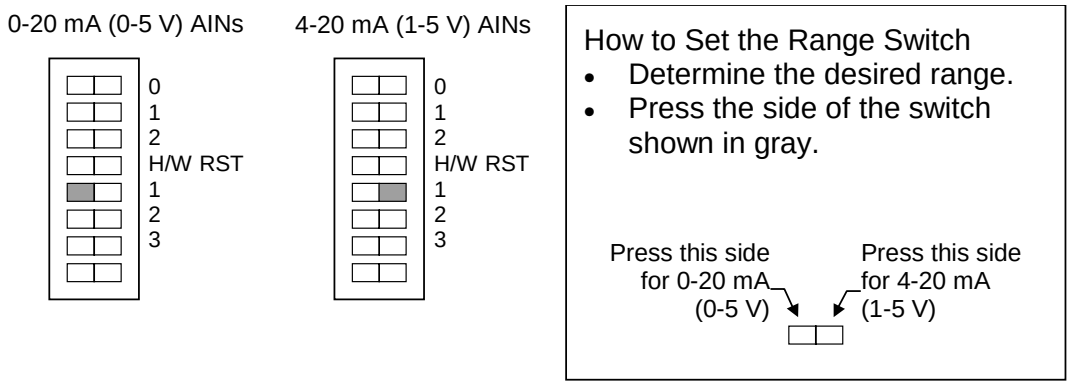
Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Analog Input Measurement Range Selection

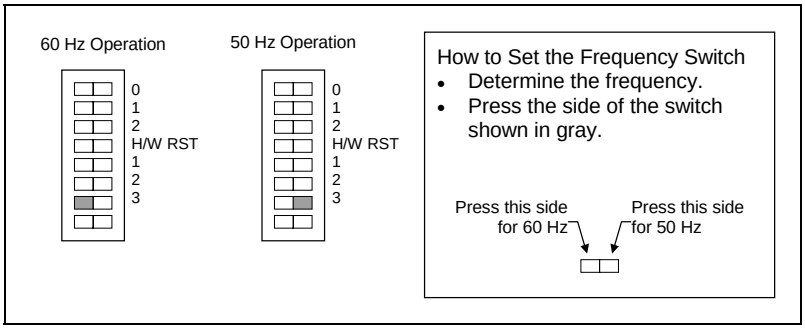
The SCADAPack Option Switch 1 selects the measurement range. All 8 analog inputs are set to the same range.

The figure below shows the switch settings for selecting the measurement range.



Line Frequency Selection

The SCADAPack I/O board may select 50 or 60 Hz line frequency for digital and analog input processing. The SCADAPack Option Switch 3 selects this option. The figure below shows the switch settings for selecting the line frequency.



Notes

Only one **SCADAPack 5601 or 5604 I/O module** may be assigned to the same controller.

Option switches 1 and 3 function as described above regardless of whether the module, **DIN 5203/4 option switches**, is added to the Register Assignment or not.

Refer to the **SCADAPack Hardware Manual** for information on the option switches.

Two analog outputs are available for the **SCADAPack 5601 I/O module**. Refer to the **SCADAPack AOUT module** for more information.

1.10.6 SCADAPack 5602 I/O Module

Description

Digital output data is assigned from two consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Analog input data is assigned to five consecutive input registers. The input registers are updated continuously with data read from the analog inputs.

The same five analog inputs are also read as digital inputs. The digital input data is assigned to five consecutive status registers. The status registers are updated continuously with data read from the analog inputs.

A digital input is ON if the corresponding filtered analog input value is greater than or equal to 20% of its full-scale value, otherwise it is OFF.

Register Assignment

Module	SCADAPack 5602 I/O Module	
Address	fixed at 0	
Type	Coil Register	
Start	First register of any unused block of 2 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 1
Registers	2 coil registers	
Description	digital outputs	
Type	Status Register	
Start	First register of any unused block of 5 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 4
Registers	5 status registers	
Description	analog inputs read as digital inputs	
Type	Input Register	
Start	First register of any unused block of 5 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +4
Registers	5 input registers	
Description	analog inputs	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0 *
Start Register + 1	Analog input 1 *
Start Register + 2	Analog input 2 *
Start Register + 3	Analog input 3 *
Start Register + 4	Analog input 4 *

* Analog inputs are read again as digital inputs.

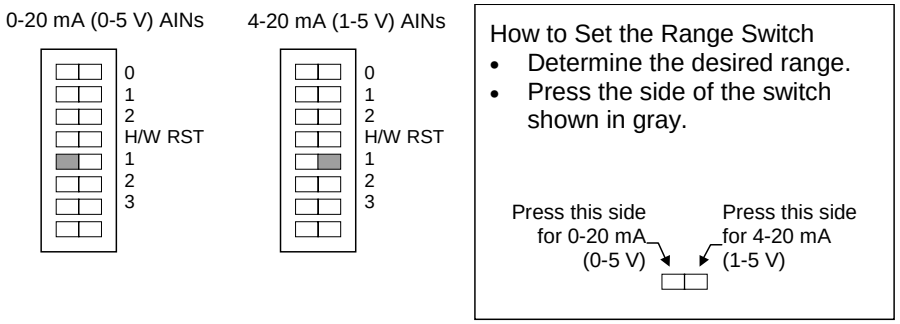
Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4

Analog Input Measurement Range Selection

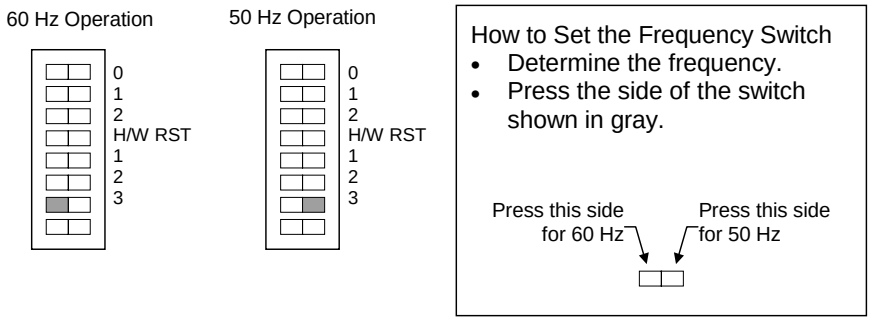
The SCADAPack Option Switch 1 selects the measurement range. All 5 analog inputs are set to the same range.

The figure below shows the switch settings for selecting the measurement range.



Line Frequency Selection

The SCADAPack I/O board may select 50 or 60 Hz line frequency for analog input processing. The SCADAPack Option Switch 3 selects this option. The figure below shows the switch settings for selecting the line frequency.



Notes

Only one **SCADAPack 5602 I/O module** may be assigned to the same controller. Option switches 1 and 3 function as described above regardless of whether the module, **DIN 5203/4 option switches**, is added to the Register Assignment or not. Refer to the **SCADAPack Hardware Manual** for information on the option switches.

1.10.7 SCADAPack 5604 I/O Module

Description

The **SCADAPack 5604 I/O Module** is comprised of four different types of I/O channels. The SCADAPack 5604 I/O hardware contains ten analog inputs, two analog outputs, thirty-five digital inputs and thirty-six digital outputs.

The **analog input** assignment provides ten I/O channels for the analog input data from the SCADAPack 5604 I/O Module hardware.

- Analog input channels 0 to 7 provide eight external analog inputs (0-10V or 0-40mA)
- Analog input channel 8 provides an external analog input for battery monitoring (0 to 32.768V)
- Analog input channel 9 provides an internal analog input for DC/DC converter monitoring.

The **analog output** assignment provides two I/O channels for the analog output data for the SCADAPack 5604 I/O Module hardware.

The **digital input** assignment provides thirty-five I/O channels for the digital input data from the SCADAPack 5604 I/O Module hardware.

The SCADAPack 5604 I/O Module provides thirty-two universal digital inputs or outputs. The inputs are for use with dry contacts such as switches and relay contacts.

- These are defined as digital input channels 0 to 31.
  0 = contact open (LED off)
  1 = contact closed (LED on)

The SCADAPack 5604 I/O Module also provides three internal digital inputs.

- Digital input channel 32 returns the DC/DC converter status.
  0 = DC/DC converter off
  1 = DC/DC converter on
- Digital input channel 33 returns the DC/DC converter over current status.
  0 = Over current not detected
  1 = Over current detected
- Digital output channel 34 returns the digital output mismatch status.
  0 = No mismatch
  1 = One or more digital outputs mismatch

The **digital output** assignment provides thirty-six I/O channels for the digital outputs of the SCADAPack 5604 I/O Module I/O hardware.

> The SCADAPack 5604 I/O Module provides thirty-two universal digital inputs or outputs. Outputs are open-collector/open drain type.

- These are defined as digital output channels 0 to 31.
  0 = output transistor off

1 = output transistor on

The SCADAPack 5604 I/O Module also provides two internal digital outputs.

- Digital output channel 32 is used to control the DC/DC converter.
  0 = DC/DC converter off
  1 = DC/DC converter on
- Digital output channel 33 is used to control the VLoop power supply.
  0 = VLoop output off
  1 = VLoop output on
- Digital output channels 34 and 35 control the SCADAPack 5604 I/O Module Analog Input filters.

Filter Setting	Digital Output 34	Digital Output 35
< 3 Hz	OFF	OFF
6 Hz	OFF	**ON**
11 Hz	**ON**	OFF
30 Hz	**ON**	**ON**

Register Assignment

Module	SCADAPack 5604 I/O Module	
Address	Fixed at 0	
Type	Coil Register	
Start	First register of any unused block of 36 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 35
Registers	36 coil registers	
Description	Digital outputs	
Type	Status Register	
Start	First register of any unused block of 35 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 34
Registers	35 status registers	
Description	Digital inputs	
Type	Input Register	
Start	First register of any unused block of 10 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +9
Registers	10 input registers	
Description	analog inputs	
Type	Holding Register	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +1
Registers	2 input registers	
Description	analog outputs	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 11
Start Register + 12	Digital output 12
Start Register + 13	Digital output 13
Start Register + 14	Digital output 14
Start Register + 15	Digital output 15
Start Register + 16	Digital output 16
Start Register + 17	Digital output 17
Start Register + 18	Digital output 18
Start Register + 19	Digital output 19
Start Register + 20	Digital output 20
Start Register + 21	Digital output 21
Start Register + 22	Digital output 22
Start Register + 23	Digital output 23
Start Register + 24	Digital output 24
Start Register + 25	Digital output 25
Start Register + 26	Digital output 26
Start Register + 27	Digital output 27
Start Register + 28	Digital output 28
Start Register + 29	Digital output 29
Start Register + 30	Digital output 30
Start Register + 31	Digital output 31
Start Register + 32	Digital output 32
Start Register + 33	Digital output 33
Start Register + 34	Digital output 34
Start Register + 35	Digital output 35

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3

Registers	Assignment to Module Hardware
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15
Start Register + 16	Digital input 16
Start Register + 17	Digital input 17
Start Register + 18	Digital input 18
Start Register + 19	Digital input 19
Start Register + 20	Digital input 20
Start Register + 21	Digital input 21
Start Register + 22	Digital input 22
Start Register + 23	Digital input 23
Start Register + 24	Digital input 24
Start Register + 25	Digital input 25
Start Register + 26	Digital input 26
Start Register + 27	Digital input 27
Start Register + 28	Digital input 28
Start Register + 29	Digital input 29
Start Register + 30	Digital input 30
Start Register + 31	Digital input 31
Start Register + 32	Digital input 32
Start Register + 33	Digital input 33
Start Register + 34	Digital input 34

Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

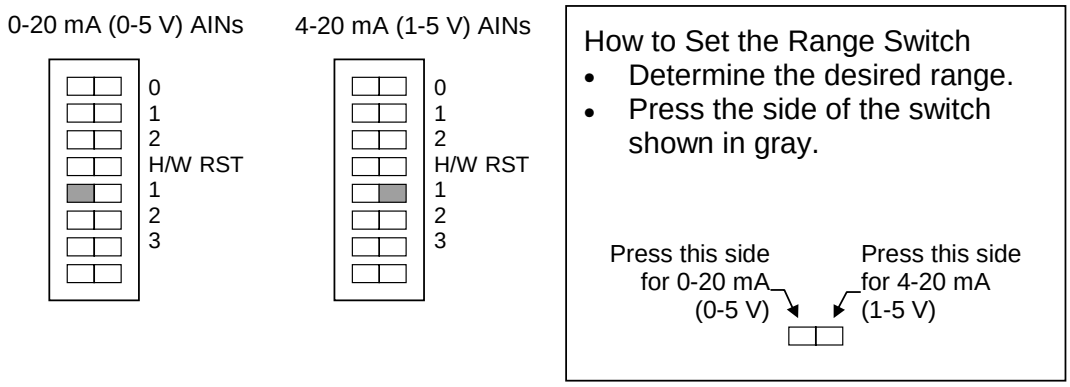
Holding Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1

Analog Input Measurement Range Selection

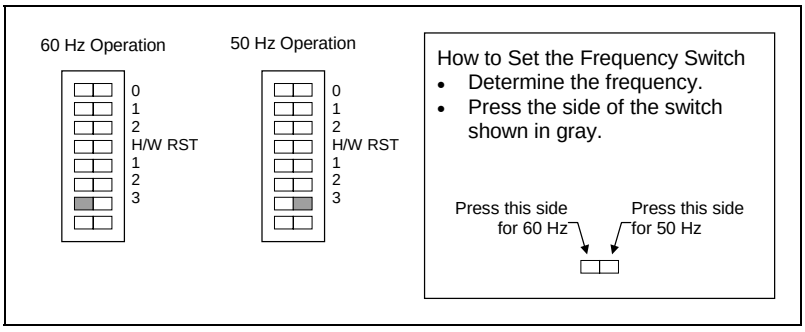
The SCADAPack Option Switch 1 selects the measurement range. All 8 analog inputs are set to the same range.

The figure below shows the switch settings for selecting the measurement range.



Line Frequency Selection

The SCADAPack I/O board may select 50 or 60 Hz line frequency for digital and analog input processing. The SCADAPack Option Switch 3 selects this option. The figure below shows the switch settings for selecting the line frequency.



Notes

Only one **SCADAPack 5601 or 5604 I/O module** may be assigned to the same controller.

Option switches 1 and 3 function as described above regardless of whether the module, **DIN 5203/4 option switches**, is added to the Register Assignment or not.

Refer to the **SCADAPack Hardware Manual** for information on the option switches.

Two analog outputs are available for the **SCADAPack 5601 I/O module**. Refer to the **SCADAPack AOUT module** for more information.

1.10.8 SCADAPack 5606 I/O Module

Description

The **SCADAPack 5606 I/O Module** is comprised of four types of I/O channels, digital inputs, digital outputs, analog inputs, and analog outputs.

The **digital input** assignment provides forty I/O channels for the digital input data from the SCADAPack 5606 I/O Module hardware.

- The 5606 I/O Module provides thirty-two external digital inputs. These are externally wetted inputs.
- The module provides 8 internal digital inputs, which indicate if the corresponding analog input is in or out of range.

The **digital output** assignment provides sixteen digital outputs. All are digital output relays.

The **analog input** assignment provides eight I/O channels for the analog input data from the SCADAPack 5606 I/O Module hardware.

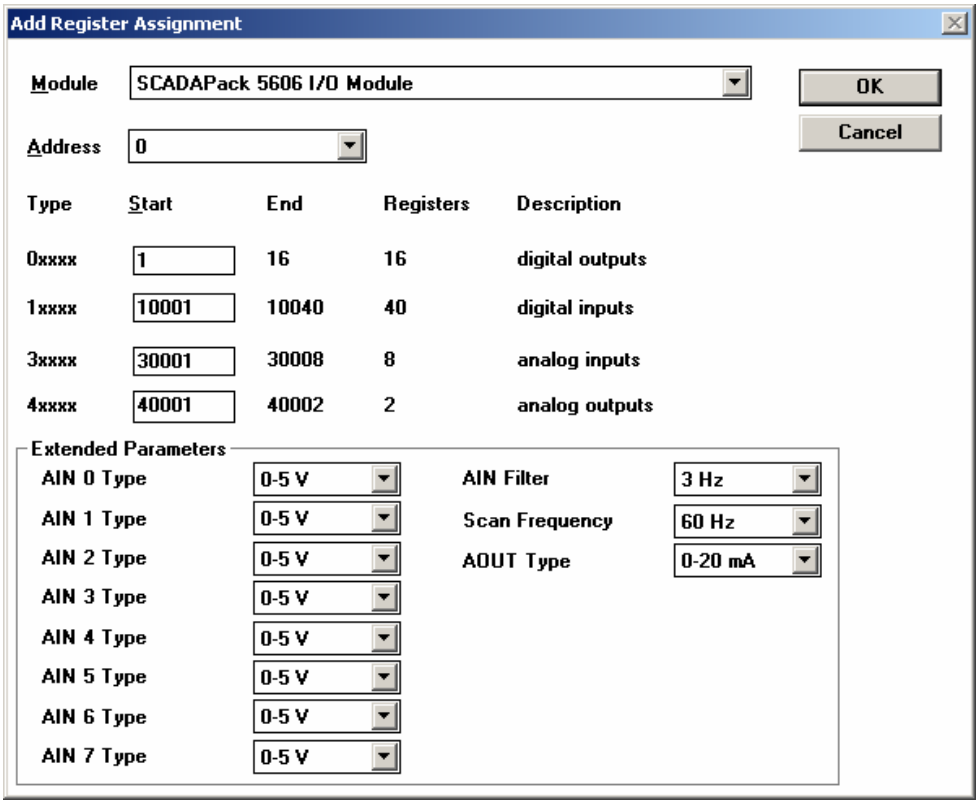
The **analog output** assignment provides two I/O channels for the analog output data for the SCADAPack 5606 I/O Module hardware when the optional analog output module is installed.

Register Assignment

The register assignment for the SCADAPack 5606 I/O Module is used to configure the registers used for the module data and the Extended Parameters available for the module. To open the register assignment dialog for the SCADAPack 5606 I/O module:

- Select **Register Assignment** from the **Controller** menu in TelePACE.
- In the **Register Assignment** window select the **Add** button.
- In the **Add Register Assignment** dialog select the **SCADAPack 5606 I/O Module** from the list presented in the **Module** window.

The register assignment dialog for the **SCADAPack 5606 I/O Module** is shown below.



The **Module** selection displays the name of the SCADAPack 5606 I/O module used for the register assignment.

The **Address** selection displays the module address of the physical SCADAPack 5606 I/O module. The address on the module is selected via dip switches on the module. A maximum of eight SCADAPack 5606 I/O type modules may be added to a system.

The register type **0xxxx** defines the register range for the digital output data. Sixteen sequential registers are needed for the SCADAPack 5606 I/O module digital output data. Any unused block of sixteen registers may be used. See the **Digital Output Register Data** section below for an explanation of the digital output data.

The register type **1xxxx** defines the register range for the digital input status data. Forty sequential registers are needed for the SCADAPack 5606 I/O module digital Input data. Any unused block of forty registers may be used. See the **Digital Input Register Data** section below for an explanation of the digital input status data.

The register type **3xxxx** defines the register range for the analog input data. Eight sequential registers are needed for the SCADAPack 5606 I/O module analog input data. Any unused block of eight registers may be used. See the **Input Register Data** section below for an explanation of the analog input data.

The register type **4xxxx** defines the register range for the analog output data. Two sequential registers are needed for the SCADAPack 5606 I/O module analog output data. Any unused block of two registers may be used. See the **Analog Output Register Data** section below for an explanation of the analog output data.

The **Extended Parameters** grouping defines the type of data returned from the SCADAPack 5606 I/O module analog inputs, the type of analog output signal, filtering used by all analog inputs and the scan frequency.

The **AIN Type** selection for each input (AIN 0, 1, 2, 3, 4, 5, 6, and 7) defines the input measurement type for the analog input.

- The **0-5V** selection sets the input type to measure 0 to 5V input signals.
- The **1-5V** selection sets the input type to measure 1 to 5V input signals.
- The **0-20** mA selection sets the input type to measure 0 to 20mA input signals.
- The **4-20** mA selection sets the input type to measure 4 to 20mA input signals.

The **AIN Filter** selection set the input filter for all analog inputs. Filtering is used to dampen process variations or noise.

- The **3 Hz** filter selection sets the response time to 155ms at 60Hz and 185ms at 50Hz.
- The **6 Hz** filter selection sets response time to 85ms at 60Hz and 85ms at 50Hz.
- The **11 Hz** filter selection sets response time to 45ms at 60Hz and 55ms at 50Hz.
- The **30 Hz** filter selection sets response time to 30ms at 60Hz and 30ms at 50Hz.

The **Scan Frequency** selection set the input scan rate for all analog inputs. The scan rate selection is not critical but AC noise rejection is improved at the correct frequency. If the module is used in a DC environment, the 60 Hz setting will yield slightly faster response time.

- The **60 Hz** selection synchronies the input scanning to 60Hz.
- The **50 Hz** selection synchronies the input scanning to 50Hz.

The **AOUT Type** selection for each input (AOUT 0 and 1) defines the output signal type for the analog output.

- The **0-20** mA selection sets the output type for 0 to 20mA signals.
- The **4-20** mA selection sets the output type for 4 to 20mA signals.

Digital Output Register Data

Digital output data is assigned to sixteen consecutive digital output (0xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for sixteen registers.

Registers	Assignment to Module Hardware
Start Register	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 1	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 2	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 3	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 4	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 5	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 6	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 7	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 8	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 9	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 10	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 11	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 12	0 = OFF (relay open); 1= ON (relay closed)

Registers	Assignment to Module Hardware
Start Register + 13	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 14	0 = OFF (relay open); 1= ON (relay closed)
Start Register + 15	0 = OFF (relay open); 1= ON (relay closed)

Digital Input Register Data

Status register data is assigned to forty consecutive status (1xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for forty registers.

Registers	Assignment to Module Hardware
Start Register	0 = OFF (led off); 1= ON (led on)
Start Register + 1	0 = OFF (led off); 1= ON (led on)
Start Register + 2	0 = OFF (led off); 1= ON (led on)
Start Register + 3	0 = OFF (led off); 1= ON (led on)
Start Register + 4	0 = OFF (led off); 1= ON (led on)
Start Register + 5	0 = OFF (led off); 1= ON (led on)
Start Register + 6	0 = OFF (led off); 1= ON (led on)
Start Register + 7	0 = OFF (led off); 1= ON (led on)
Start Register + 8	0 = OFF (led off); 1= ON (led on)
Start Register + 9	0 = OFF (led off); 1= ON (led on)
Start Register + 10	0 = OFF (led off); 1= ON (led on)
Start Register + 11	0 = OFF (led off); 1= ON (led on)
Start Register + 12	0 = OFF (led off); 1= ON (led on)
Start Register + 13	0 = OFF (led off); 1= ON (led on)
Start Register + 14	0 = OFF (led off); 1= ON (led on)
Start Register + 15	0 = OFF (led off); 1= ON (led on)
Start Register + 16	0 = OFF (led off); 1= ON (led on)
Start Register + 17	0 = OFF (led off); 1= ON (led on)
Start Register + 18	0 = OFF (led off); 1= ON (led on)
Start Register + 19	0 = OFF (led off); 1= ON (led on)
Start Register + 20	0 = OFF (led off); 1= ON (led on)
Start Register + 21	0 = OFF (led off); 1= ON (led on)
Start Register + 22	0 = OFF (led off); 1= ON (led on)
Start Register + 23	0 = OFF (led off); 1= ON (led on)
Start Register + 24	0 = OFF (led off); 1= ON (led on)
Start Register + 25	0 = OFF (led off); 1= ON (led on)
Start Register + 26	0 = OFF (led off); 1= ON (led on)
Start Register + 27	0 = OFF (led off); 1= ON (led on)
Start Register + 28	0 = OFF (led off); 1= ON (led on)
Start Register + 29	0 = OFF (led off); 1= ON (led on)
Start Register + 30	0 = OFF (led off); 1= ON (led on)
Start Register + 31	0 = OFF (led off); 1= ON (led on)
Start Register + 32	OFF = AIN channel 0 is OK ON = AIN channel 0 is over or under range
Start Register + 33	OFF = AIN channel 1 is OK ON = AIN channel 1 is over or under range

Registers	Assignment to Module Hardware
Start Register + 34	OFF = AIN channel 2 is OK ON = AIN channel 2 is over or under range
Start Register + 35	OFF = AIN channel 3 is OK ON = AIN channel 3is over or under range
Start Register + 36	OFF = AIN channel 4 is OK ON = AIN channel 4 is over or under range
Start Register + 37	OFF = AIN channel 5 is OK ON = AIN channel 5 is over or under range
Start Register + 38	OFF = AIN channel 6 is OK ON = AIN channel 6is over or under range
Start Register + 39	OFF = AIN channel 7 is OK ON = AIN channel 7 is over or under range

Input Register Data

Input register data is assigned to eight consecutive analog input (3xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment and continues for eight registers.

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Analog Output Register Data

Analog output register data is assigned to two consecutive analog output (4xxxx) registers. The following table begins at the **Start** address defined in the Register Assignment.

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1

Notes

Refer to the **SCADAPack Hardware Manual** for information on the SCADAPack 5606 I/O module.

1.10.9 SCADAPack LP I/O

Description

The **SCADAPack LP I/O Module** is comprised of four different types of I/O channels. The SCADAPack LP I/O hardware contains eight analog inputs, two analog outputs, sixteen digital inputs and twelve digital outputs.

The **analog input** assignment provides seven I/O channels for the analog input data. Analog input data is a signed value in the range –32768 to 32767.

- Analog input channels 0 to 4 provide eight external analog inputs (0-10V or 0-40mA)
- Analog input channel 5 provides an external analog input for battery monitoring (0 to 32.768V)
- Analog input channel 6 provides an internal analog input for DC/DC converter monitoring.

The **analog output** assignment provides two I/O channels for the analog output data. Analog input data is a signed value in the range –32768 to 32767.

The **digital input** assignment provides sixteen I/O channels for the digital input data.

The SCADAPack LP provides eight universal digital inputs or outputs. The inputs are for use with dry contacts such as switches and relay contacts.

- These are defined as digital input channels 0 to 7.

  0 = contact open (LED off)

  1 = contact closed (LED on)

The SCADAPack LP also provides eight internal digital inputs.

- Digital input channel 8 returns the Com1 (RS-485) power status.

  0 = off

  1 = on

- Digital input channel 9 returns the Com3 (HMI) power output status.

  0 = off

  1 = on

- Digital input channel 10 returns the VLOOP output status.

  0 = off

  1 = on

- Digital input channel 11 returns the DC/DC converter status. This bit reports the true status of the DC/DC converter. If over-current causes the converter to be turned off, this bit will clear.

  0 = off

  1 = on

- Digital input channel 12 returns the VLOOP over-current status. This indicates VLOOP over-current has been detected. This input clears when VLOOP output is off, or the over-current condition clears.

  0= off

1 = on

- Digital input channel 13 returns the digital output mismatch status.

  0= No mismatch

  1 = One or more digital outputs mismatch

- Digital input channel 14 returns the SCADAPack Vision power.

  0 = No power to SCADAPack Vision

  1 = Power to SCADAPack Vision

The **digital output** assignment provides twelve I/O channels for the digital outputs of the SCADAPack LP.

The SCADAPack LP provides eight universal digital inputs or outputs. Outputs are open-collector/open drain type.

- These are defined as digital output channels 0 to 7.

  0 = output transistor off

  1 = output transistor on

The SCADAPack LP also provides four internal digital outputs.

- Digital output channel 8 is not used. This is for internal use only.
- Digital output channel 9 is used to control com3 (HMI) power.

  0= off

  1 = on

- Digital output channel 10 is used to control the VLoop power supply.

  0= VLoop output off

  1= VLoop output on

- Digital output channel 11 is used to control the DC/DC converter.

  0= off

  1 = on

Register Assignment

Module	SCADAPack LP I/O Module	
Address	fixed	
Type	Coil Register	
Start	First register of any unused block of 12 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 11
Registers	12 coil registers	
Description	digital outputs	
Type	Status Register	
Start	First register of any unused block of 16 consecutive status registers.	1xxxx

Module	SCADAPack LP I/O Module	
Address	fixed	
End	Last register of block	1xxxx + 15
Registers	16 status registers	
Description	digital inputs	
Type	Input Register	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +7
Registers	8 input registers	
Description	analog inputs	
Type	Holding Register	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +1
Registers	2 output registers	
Description	analog outputs	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10
Start Register + 11	Digital output 11

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7

Registers	Assignment to Module Hardware
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12
Start Register + 13	Digital input 13
Start Register + 14	Digital input 14
Start Register + 15	Digital input 15

Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Analog Output Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0
Start Register + 1	Analog output 1

Notes

Only one SCADAPack LP I/O may be assigned to the same controller.

Refer to the SCADAPack LP Hardware Manual for information on analog and digital I/O usage.

1.10.10 SCADAPack 100 I/O

Description

Digital output data is assigned from six consecutive coil registers. The digital outputs are updated continuously with data read from the coil registers.

Digital input data is assigned to six consecutive status registers. The status registers are updated continuously with data read from the digital inputs.

Analog and counter input data is assigned to eight consecutive input registers. There are six analog input registers, and a counter input double register (32 bit). These input registers are updated continuously with data read from the analog inputs and counter input.

Register Assignment

Module	SCADAPack 100 I/O Module	
Address	Fixed	
Type	Coil Register	
Start	First register of any unused block of 6 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 5
Registers	6 coil registers	
Description	digital outputs	
Type	Status Register	
Start	First register of any unused block of 6 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 5
Registers	8 status registers	
Description	digital inputs	
Type	Input Register	
Start	First register of any unused block of 4 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +8
Registers	8 input registers	
Description	analog inputs	
Extended Parameters	None	

Coil Register Data

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6

Analog and Counter Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4 Board Temperature (°C)
Start Register + 5	Analog input 5 Ram Battery Voltage (mV)
Start Register + 6 and + 7	Counter input, 32 bit register

Notes

Only one **SCADAPack 100 I/O** may be assigned to the same controller.

Refer to the **SCADAPack 100 Hardware Manual** for information on analog and digital I/O usage.

1.10.11 SCADAPack 350 I/O

Description

The **SCADAPack 350 I/O** is comprised of four different types of I/O channels: eight analog inputs, two analog outputs, thirteen digital inputs and eleven digital outputs.

The **analog input** assignment provides eight I/O channels for the analog input data.

- Analog input channels 0 to 4 provide five external analog inputs (0-10V or 0-40mA)
- Analog input channel 5 provides an external analog input for battery monitoring (0 to 32.768V)
- Analog input channel 6 provides an internal analog input for DC/DC converter monitoring.
- Analog input channel 7 is used internally by the SCADAPack 350.

The **analog output** assignment provides two I/O channels for the analog output data.

The **digital input** assignment provides thirteen I/O channels for the digital input data.

The SCADAPack 350 provides eight universal digital inputs or outputs. The inputs are for use with dry contacts such as switches and relay contacts.

- These are defined as digital input channels 0 to 7.
  0 = contact open (LED off)
  1 = contact closed (LED on)

The SCADAPack 350 I/O hardware also provides five internal digital inputs.

- Digital input channel 8 returns the VLOOP output status.
  0 = off
  1 = on
- Digital input channel 9 returns the DC/DC converter status. This bit reports the true status of the DC/DC converter. If over-current causes the converter to be turned off, this bit will clear.
  0 = off
  1 = on
- Digital input channel 10 returns the VLOOP over-current status. This indicates VLOOP over-current has been detected. This input clears when VLOOP output is off, or the over-current condition clears.
  0 = off
  1 = on
- Digital input channel 11 returns the digital output mismatch status.
  0 = No mismatch
  1 = One or more digital outputs mismatch
- Digital input channel 12 returns the Com3 (HMI) power control status.
  0 = off
  1 = on

The **digital output** assignment provides eleven I/O channels for the digital outputs of the SCADAPack 350.

The SCADAPack 350 provides eight universal digital inputs or outputs. Outputs are open-collector/open drain type.

- These are defined as digital output channels 0 to 7.
  0 = output transistor off
  1 = output transistor on

The SCADAPack 350 I/O hardware also provides three internal digital outputs.

- Digital output channel 8 is used to control the VLoop power supply.
  0 = VLoop output off
  1 = VLoop output on
- Digital output channel 9 is used to control the DC/DC converter.
  0 = off
  1 = on
- Digital output channel 10 is used to control the Com3 (HMI) power.
  0 = off
  1 = on

Register Assignment

Module	**SCADAPack 350 I/O**	
Address	fixed	
Type	Coil Register	
Start	First register of any unused block of 11 consecutive coil registers.	0xxxx
End	Last register of block	0xxxx + 9
Registers	10 coil registers	
Description	digital outputs	
Type	**Status Register**	
Start	First register of any unused block of 13 consecutive status registers.	1xxxx
End	Last register of block	1xxxx + 11
Registers	12 status registers	
Description	digital inputs	
Type	**Input Register**	
Start	First register of any unused block of 8 consecutive input registers.	3xxxx
End	Last register of block	3xxxx +7
Registers	8 input registers	
Description	analog inputs	
Type	**Holding Register**	
Start	First register of any unused block of 2 consecutive holding registers.	4xxxx
End	Last register of block	4xxxx +1
Registers	2 output registers	
Description	analog outputs	

Coil Register Data

Registers	**Assignment to Module Hardware**

Registers	Assignment to Module Hardware
Start Register	Digital output 0
Start Register + 1	Digital output 1
Start Register + 2	Digital output 2
Start Register + 3	Digital output 3
Start Register + 4	Digital output 4
Start Register + 5	Digital output 5
Start Register + 6	Digital output 6
Start Register + 7	Digital output 7
Start Register + 8	Digital output 8
Start Register + 9	Digital output 9
Start Register + 10	Digital output 10

Status Register Data

Registers	Assignment to Module Hardware
Start Register	Digital input 0
Start Register + 1	Digital input 1
Start Register + 2	Digital input 2
Start Register + 3	Digital input 3
Start Register + 4	Digital input 4
Start Register + 5	Digital input 5
Start Register + 6	Digital input 6
Start Register + 7	Digital input 7
Start Register + 8	Digital input 8
Start Register + 9	Digital input 9
Start Register + 10	Digital input 10
Start Register + 11	Digital input 11
Start Register + 12	Digital input 12

Input Register Data

Registers	Assignment to Module Hardware
Start Register	Analog input 0
Start Register + 1	Analog input 1
Start Register + 2	Analog input 2
Start Register + 3	Analog input 3
Start Register + 4	Analog input 4
Start Register + 5	Analog input 5
Start Register + 6	Analog input 6
Start Register + 7	Analog input 7

Analog Output Register Data

Registers	Assignment to Module Hardware
Start Register	Analog output 0

Start Register + 1	Analog output 1

Notes

Only one **SCADAPack 350 I/O** may be assigned to the same controller.

Refer to the **SCADAPack 350 Hardware Manual** for information on analog and digital I/O usage.

1.11 Controller Default Register Assignments

1.11.1 4202 DR Extended/4203 DR I/O Register Assignment

A default Register Assignment is provided for the SCADASense series of controllers. The table below provides the default register assignment for these controllers.

To enable the default register assignment for a SCADASense controller:

- Select **Type** from the **Controller** menu.
- Select the appropriate SCADASense controller.
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- If the controller type selected is a SCADASense 4202 DR, the user is presented with the default register assignment for a 4202 DR and 4202 DR Extended/4203 DR. Select the appropriate module depending on your controller type.

Module	Address	Default Register Assignment
SCADASense 4202 DR I/O	Fixed	
digital inputs		10001 to 10001
analog inputs		30001 to 30005
analog outputs		40500 to 40500
SCADASense 4202 DR Extended/4203 DR I/O	Fixed	
Digital output		00001 to 00001
digital inputs		10001 to 10001
analog inputs		30001 to 30005
analog outputs		40500 to 40500

Note: Note that the SCADASense 4202 DR Extended/4203 DR I/O module, while the default for the SCADASense 4203 DR, applies to the SCADASense 4202 DR series controllers manufactured after July 13, 2004.

1.11.2 SCADASense 4202/4203 DS I/O Default Register Assignment

A default Register Assignment is provided for the SCADASense DS series of controllers (4202 or 4203 DR). The table below contains a convenient assignment for the 4202 DR and 4203 DR controllers.

To enable the default register assignment:

- Select **Type** from the **Controller** menu.
- Select the appropriate SCADASense DS series controller.
- Select **Register Assignment** from the **Controller** menu.

Select the **Default** button in the *Register Assignment* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack.

Module	Address	Default Register Assignment
SCADASense 4202/4203 DS I/O Digital output digital inputs analog inputs	Fixed	 00001 to 00002 10001 to 10001 30001 to 30007

1.11.3 Micro16 Default Register Assignment (Backwards Compatible Modules)

The purpose of the Default Register Assignment is to provide backward compatibility to programs written for older TeleSAFE Micro16 controller firmware (versions 1.22 or earlier).

Instead of configurable Register Assignment older versions of the firmware use fixed mapping of the I/O hardware to the I/O database. The Default Register Assignment assigns all possible I/O modules according the previously fixed mapping used by the older firmware.

Note 1: It is recommended that all unused modules in the default table be deleted in order to optimize performance of the I/O scan.

Note 2: Only those I/O modules that were available to the older firmware are assigned in the default table.

To enable the default register assignment:

- Select **Type** from the **Controller** menu.
- Select **Micro16.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.
- Select Backwards Compatible Modules in the *Select Register Assignment Option* dialog.
- Use the **Delete** button to delete from the default table all modules that are not needed in your program.

The Default Register Assignment results in the following unassigned I/O database registers:

Coil Registers	01025 to 04096
Status Registers	11025 to 14096
Input Registers	30513 to 31024
Holding Register	41712 to 49999

These registers may be used as general purpose registers in ladder logic programs.

1.11.3.1 Default Analog Input Module Assignment

Module Type	Module Address	Default Register Assignment
AIN Generic 8 point	0	30001 to 30008
AIN Generic 8 point	1	30009 to 30016
AIN Generic 8 point	2	30017 to 30024
AIN Generic 8 point	3	30025 to 30032
AIN Generic 8 point	4	30033 to 30040
AIN Generic 8 point	5	30041 to 30048
AIN Generic 8 point	6	30049 to 30056
AIN Generic 8 point	7	30057 to 30064
AIN 5203/4 temperature	N/A	30193 to 30194
AIN 5203/4 RAM battery voltage	N/A	30195

1.11.3.2 Default Analog Output Module Assignment

Module Type	Module Address	Default Register Assignment
AOUT Generic 2 point	0	40001 to 40002
AOUT Generic 2 point	1	40003 to 40004
AOUT Generic 2 point	2	40005 to 40006
AOUT Generic 2 point	3	40007 to 40008
AOUT Generic 2 point	4	40009 to 40010
AOUT Generic 2 point	5	40011 to 40012
AOUT Generic 2 point	6	40013 to 40014
AOUT Generic 2 point	7	40015 to 40016
AOUT Generic 2 point	8	40017 to 40018
AOUT Generic 2 point	9	40019 to 40020
AOUT Generic 2 point	10	40021 to 40022
AOUT Generic 2 point	11	40023 to 40024
AOUT Generic 2 point	12	40025 to 40026
AOUT Generic 2 point	13	40027 to 40028
AOUT Generic 2 point	14	40029 to 40030
AOUT Generic 2 point	15	40031 to 40032

1.11.3.3 Default Configuration Module Assignment

Module Type	Module Address	Default Register Assignment
CNFG Clear serial port counters	0	00209
CNFG Clear serial port counters	1	00210
CNFG Clear protocol counters	0	00217
CNFG Clear protocol counters	1	00218
CNFG Save settings to EEPROM	N/A	00225
CNFG LED power settings • default state • time to return to default state	N/A	 00242 40211
CNFG Serial port settings	0	40131 to 40139
CNFG Protocol settings	0	40140 to 40142
CNFG Serial port settings	1	40146 to 40154
CNFG Protocol settings	1	40155 to 40157
CNFG Real time clock and alarm	N/A	40191 to 40201
CNFG PID control block	0	40220 to 40244
CNFG PID control block	1	40250 to 40274
CNFG PID control block	2	40280 to 40304
CNFG PID control block	3	40310 to 40334
CNFG PID control block	4	40340 to 40364
CNFG PID control block	5	40370 to 40394
CNFG PID control block	6	40400 to 40424
CNFG PID control block	7	40430 to 40454
CNFG PID control block	8	40460 to 40484
CNFG PID control block	9	40490 to 40514
CNFG PID control block	10	40520 to 40544

Module Type	Module Address	Default Register Assignment
CNFG PID control block	11	40550 to 40574
CNFG PID control block	12	40580 to 40604
CNFG PID control block	13	40610 to 40634
CNFG PID control block	14	40640 to 40664
CNFG PID control block	15	40670 to 40694
CNFG PID control block	16	40700 to 40724
CNFG PID control block	17	40730 to 40754
CNFG PID control block	18	40760 to 40784
CNFG PID control block	19	40790 to 40814
CNFG PID control block	20	40820 to 40844
CNFG PID control block	21	40850 to 40874
CNFG PID control block	22	40880 to 40904
CNFG PID control block	23	40910 to 40934
CNFG PID control block	24	40940 to 40964
CNFG PID control block	25	40970 to 40994
CNFG PID control block	26	41000 to 41024
CNFG PID control block	27	41030 to 41054
CNFG PID control block	28	41060 to 41084
CNFG PID control block	29	41090 to 41114
CNFG PID control block	30	41120 to 41144
CNFG PID control block	31	41150 to 41174
CNFG Store and forward Translation table Clear store and forward table	N/A	 41200 to 41711 00226

1.11.3.4 Default Counter Input Module Assignment

Module Type	Module Address	Default Register Assignment
CNTR 5410 input	0	30201 to 30208
CNTR 5410 input	1	30209 to 30216
CNTR 5410 input	2	30217 to 30224
CNTR 5410 input	3	30225 to 30232
CNTR 5410 input	4	30233 to 30240
CNTR 5410 input	5	30241 to 30248
CNTR 5410 input	6	30249 to 30256
CNTR 5410 input	7	30257 to 30264
CNTR 5410 input	8	30265 to 30272
CNTR 5410 input	9	30273 to 30280
CNTR 5410 input	10	30281 to 30288
CNTR 5410 input	11	30289 to 30296
CNTR 5410 input	12	30297 to 30304
CNTR 5410 input	13	30305 to 30312
CNTR 5410 input	14	30313 to 30320
CNTR 5410 input	15	30321 to 30328
CNTR 5203/4 counter inputs	N/A	30329 to 30334

1.11.3.5 Default Diagnostic Module Assignment

Module Type	Module Address	Default Register Assignment
DIAG Controller status code	N/A	30196
DIAG Serial port comm. Status	0	30401 to 30405
DIAG Serial port protocol status	0	30406 to 30415
DIAG Serial port comm. Status	1	30421 to 30425
DIAG Serial port protocol status	1	30426 to 30435

1.11.3.6 Default Digital Input Module Assignment

Module Type	Module Address	Default Register Assignment
DIN Generic 8 point	0	10001 to 10008
DIN Generic 8 point	1	10009 to 10016
DIN Generic 8 point	2	10017 to 10024
DIN Generic 8 point	3	10025 to 10032
DIN Generic 8 point	4	10033 to 10040
DIN Generic 8 point	5	10041 to 10048
DIN Generic 8 point	6	10049 to 10056
DIN Generic 8 point	7	10057 to 10064
DIN Generic 16 point	8	10065 to 10080
DIN Generic 16 point	9	10081 to 10096
DIN Generic 16 point	10	10097 to 10112
DIN Generic 16 point	11	10113 to 10128
DIN Generic 16 point	12	10129 to 10144
DIN Generic 16 point	13	10145 to 10160
DIN Generic 16 point	14	10161 to 10176
DIN Generic 16 point	15	10177 to 10192
DIN 5203/4 digital inputs	N/A	10193 to 10195
DIN 5203/4 option switches	N/A	10196 to 10198
DIN 5203/4 interrupt input	N/A	10199

1.11.3.7 Default Digital Output Module Assignment

Module Type	Module Address	Default Register Assignment
DOUT Generic 8 point	0	00001 to 00008
DOUT Generic 8 point	1	00009 to 00016
DOUT Generic 8 point	2	00017 to 00024
DOUT Generic 8 point	3	00025 to 00032
DOUT Generic 8 point	4	00033 to 00040
DOUT Generic 8 point	5	00041 to 00048
DOUT Generic 8 point	6	00049 to 00056
DOUT Generic 8 point	7	00057 to 00064
DOUT Generic 16 point	8	00065 to 00080
DOUT Generic 16 point	9	00081 to 00096
DOUT Generic 16 point	10	00097 to 00112
DOUT Generic 16 point	11	00113 to 00128
DOUT Generic 16 point	12	00129 to 00144

Module Type	Module Address	Default Register Assignment
DOUT Generic 16 point	13	00145 to 00160
DOUT Generic 16 point	14	00161 to 00176
DOUT Generic 16 point	15	00177 to 00192

1.11.4 Micro16 Default Register Assignment (Controller I/O Only)

A default Register Assignment is provided for the Micro16 controller. The table contains a convenient assignment for the Micro16 controller board only.

To enable the SCADAPack LIGHT default register assignment:

- Select **Type** from the **Controller** menu.
- Select **Micro16.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.
- Select Controller I/O Only in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the Micro16.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10001 to 10003
DIN Controller interrupt input		10004 to 10004

1.11.5 SCADAPack (5601 I/O Module) Default Register Assignment

A default Register Assignment is provided for the SCADAPack controller. The table contains a convenient assignment for the SCADAPack controller and 5601 I/O module.

To enable the SCADAPack default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- Select 5601 I/O Module in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack.

See the ***SCADAPack 5601 I/O Module*** section for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10017 to 10019
DIN Controller interrupt input		10020 to 10020
SCADAPack 5601 I/O module digital outputs digital inputs analog inputs	Fixed	 00001 to 00012 10001 to 10016 30001 to 30008

1.11.6 SCADAPack (5604 I/O Module) Default Register Assignment

A default Register Assignment is provided for the SCADAPack controller. The table contains a convenient assignment for the SCADAPack controller and 5604 I/O module.

To enable the SCADAPack default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- Select 5604 I/O Module in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack.

See the ***SCADAPack 5604 I/O Module*** section for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10017 to 10019
DIN Controller interrupt input		10020 to 10020
SCADAPack 5604 I/O module digital outputs digital inputs analog inputs analog outputs	Fixed	 00001 to 00036 10001 to 10035 30001 to 30010 40001 to 40002

1.11.7 SCADAPack LIGHT Default Register Assignment

A default Register Assignment is provided for the SCADAPack LIGHT controller. The table contains a convenient assignment for the SCADAPack controller and 5602 I/O module.

To enable the SCADAPack LIGHT default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack LIGHT.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.

The following table summarizes the Default Register Assignment for the SCADAPack LIGHT.

See the ***SCADAPack 5602 I/O Module*** section for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10006 to 10008
DIN Controller interrupt input		10009 to 10009
SCADAPack 5602 I/O module digital outputs digital inputs analog inputs	Fixed	 00001 to 00002 10001 to 10005 30001 to 30005

1.11.8 SCADAPack PLUS (5601 I/O Module) Default Register Assignment

A default Register Assignment is provided for the SCADAPack PLUS controller. The table contains a convenient assignment for the SCADAPack controller the 5601I/O module and 5602 I/O module.

To enable the SCADAPack PLUS default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack PLUS.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- Select 5601 I/O Module in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack PLUS.

See the ***SCADAPack 5601 I/O Module*** and ***SCADAPack 5602 I/O Module*** sections for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10022 to 10024
DIN Controller interrupt input		10025 to 10025
SCADAPack 5601 I/O module digital outputs digital inputs analog inputs	fixed	 00001 to 00012 10001 to 10016 30001 to 30008
SCADAPack 5602 I/O module digital outputs digital inputs analog inputs	Fixed	 00013 to 00014 10017 to 10021 30009 to 30013

1.11.9 SCADAPack Plus (5604 I/O Module) Default Register Assignment

A default Register Assignment is provided for the SCADAPack controller. The table contains a convenient assignment for the SCADAPack controller and 5604 I/O module.

To enable the SCADAPack default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack Plus.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- Select 5604 I/O Module in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack. See the **SCADAPack 5604 I/O Module** section for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10041 to 10043
DIN Controller interrupt input		10044 to 10044
SCADAPack 5604 I/O module digital outputs digital inputs analog inputs analog outputs	Fixed	 00001 to 00036 10001 to 10035 30001 to 30010 40001 to 40002
SCADAPack 5602 I/O module digital outputs digital inputs analog inputs	Fixed	 00037 to 00038 10036 to 10040 30011 to 30015

1.11.10 SCADAPack LP Default Register Assignment

A default Register Assignment is provided for the SCADAPack LP controller. The table contains a convenient assignment for the SCADAPack LP controller.

To enable the SCADAPack LP default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack LP.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.

The following table summarizes the Default Register Assignment for the SCADAPack LP.

See the ***SCADAPack LP I/O*** section for information on the registers used.

Module	Address	Default Register Assignment
CNTR Controller counter inputs		30009 to 30014
SCADAPack LP I/O digital outputs digital inputs analog inputs analog outputs	fixed	 00001 to 00012 10001 to 10016 30001 to 30008 40001 to 40002

1.11.11 SCADAPack 350 Default Register Assignment

A default Register Assignment is provided for the SCADAPack 350 controller. The table contains a convenient assignment for the SCADAPack 350 controller.

To enable the SCADAPack 350 default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack 350.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.

The following table summarizes the Default Register Assignment for the SCADAPack 350.

See the ***SCADAPack 5606 I/O Module*** section for information on the registers used.

Module	***Address***	***Default Register Assignment***
CNTR Controller counter inputs		30009 to 30014
SCADAPack 350 I/O • digital outputs • digital inputs • analog inputs • analog outputs	fixed	 00001 to 00011 10001 to 10013 30001 to 30008 40001 to 40002

1.11.12 SCADAPack 32 (5601 I/O Module) Default Register Assignment

A default Register Assignment is provided for the SCADAPack 32 controller. The table contains a convenient assignment for the SCADAPack 32 controller.

To enable the SCADAPack 32 default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack 32.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- Select 5601 I/O Module in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack 32.

See the ***SCADAPack 5601 I/O Module*** section for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10017 to 10019
DIN Controller interrupt input		10020 to 10020
SCADAPack 5601 I/O module	Fixed	
digital outputs		00001 to 00012
digital inputs		10001 to 10016
analog inputs		30001 to 30008

1.11.13 SCADAPack 32 (5604 I/O Module) Default Register Assignment

A default Register Assignment is provided for the SCADAPack 32 controller. The table contains a convenient assignment for the SCADAPack 32 controller.

To enable the SCADAPack 32 default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack 32.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment* dialog.
- Select 5601 I/O Module in the *Select Register Assignment Option* dialog.

The following table summarizes the Default Register Assignment for the SCADAPack 32.

See the ***SCADAPack 5604 I/O Module*** section for information on the registers used.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10017 to 10019
DIN Controller interrupt input		10020 to 10020
SCADAPack LP I/O digital outputs digital inputs analog inputs analog outputs	fixed	 00001 to 00012 10001 to 10016 30001 to 30008 40001 to 40002

1.11.14 SCADAPack 32P Default Register Assignment

A default Register Assignment is provided for the SCADAPack 32P controller. The table contains a convenient assignment for the SCADAPack 32P controller.

To enable the SCADAPack 32P default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack 32P.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.

The following table summarizes the Default Register Assignment for the SCADAPack 32P.

Module	Address	Default Register Assignment
DIN Controller digital inputs		10001 to 10003
DIN Controller interrupt input		10004 to 10004

1.11.15 SCADAPack 100 Default Register Assignment

A default Register Assignment is provided for the SCADAPack 100 controller. The table contains a convenient assignment for the SCADAPack 100 controller.

To enable the SCADAPack 100 default register assignment:

- Select **Type** from the **Controller** menu.
- Select **SCADAPack 100.**
- Select **Register Assignment** from the **Controller** menu.
- Select the **Default** button in the *Register Assignment dialog*.

The following table summarizes the Default Register Assignment for the SCADAPack 100.

See the ***SCADAPack 100 I/O*** section for information on the registers used.

Module	Address	Default Register Assignment
SCADAPack 100 I/O	fixed	
digital outputs		00001 to 00006
digital inputs		10001 to 10006
analog inputs and counters		30001 to 30008

TeleBUS Protocols

User and Reference Manual

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TeleBUS Protocols Overview

The TeleBUS communication protocols provide a standard communication interface to SCADAPack and TeleSAFE controllers. The TeleBUS protocols are compatible with the widely used Modbus RTU and ASCII protocols. Additional TeleBUS commands provide remote programming and diagnostics capability.

The TeleBUS protocols operate on a wide variety of serial data links. These include RS-232 serial ports, RS-485 serial ports, radios, leased line modems, and dial up modems. The protocols are generally independent of the communication parameters of the link, with a few exceptions.

TeleBUS protocol commands may be directed to a specific device, identified by its station number, or broadcast to all devices. Using extended addressing up to 65534 devices may connect to one communication network.

The TeleBUS protocols provide full access to the I/O database in the controller. The I/O database contains user-assigned registers and general purpose registers. Assigned registers map directly to the I/O hardware or system parameter in the controller. General purpose registers can be used by ladder logic and C application programs to store processed information, and to receive information from a remote device.

Application programs can initiate communication with remote devices. A multiple port controller can be a data concentrator for remote devices, by polling remote devices on one port and responding as a slave on another port.

The protocol type, communication parameters and station address are configured separately for each serial port on a controller. One controller can appear as different stations on different communication networks. The port configuration can be set from an application program, from the TelePACE programming software, or from another Modbus compatible device.

Compatibility

There are two TeleBUS protocols. The TeleBUS RTU protocol is compatible with the Modbus RTU protocol. The TeleBUS ASCII protocol is compatible with the Modbus ASCII protocol.

Compatibility refers to communication only. The protocol defines communication aspects such as commands, syntax, message framing, error handling and addressing. The controllers do not mimic the internal functioning of any programmable controller. Device specific functions – those that relate to the hardware or programming of a specific programmable controller – are not implemented.

Serial Port Configuration

Communication Parameters

The TeleBUS protocols are, in general, independent of the serial communication parameters. The baud rate, word length and parity may be chosen to suit the host computer and the characteristics of the data link.

The port configuration can be set in four ways:

- using the TelePACE program;
- using the **set_port** function from a C application program;
- writing to the I/O database from a C or ladder logic application program; or
- writing to the I/O database remotely from a Modbus compatible device.

To configure a serial port through the I/O database, add the module, CNFG Serial port settings, to the Register Assignment Table.

RTU Protocol Parameters

The TeleBUS RTU protocol is an eight bit binary protocol. The table below shows possible and recommended communication parameters.

Parameter	***Possible Settings***	***Recommended Setting***
Baud Rate	see Baud Rate section below	see Baud Rate section below
Data Bits	8 data bits	8 data bits
Parity	None Even Odd	none
Stop bits	1 stop bit 2 stop bits[1]	1 stop bit
Flow control	Disabled	disabled
Duplex	see Duplex section below	see Duplex section below

[1] Not applicable to SCADAPack 350

ASCII Protocol Parameters

The TeleBUS ASCII protocol is an seven bit character based protocol. The table below shows possible and recommended communication parameters.

Parameter	***Possible Settings***	***Recommended Setting***
Baud Rate	see Baud Rate section below	see Baud Rate section below
Data Bits	7 data bits 8 data bits	7 data bits
Parity	None Even Odd	none
Stop Bits	1 stop bit 2 stop bits[1]	1 stop bit

Parameter	*Possible Settings*	*Recommended Setting*
Flow Control	Enabled Disabled	disabled
Duplex	see Duplex section below	see Duplex section below

[1] Not applicable to SCADAPack 350

NOTE: Flow control should never be enabled with modems or in noisy environments. Noise can result in the accidental detection of an XOFF character, which shuts down communication. Flow control is not recommended for any environment, but can be used on high quality, full duplex, direct wiring where speeds greater than 4800 baud are required.

Baud Rate

The baud rate sets the communication speed. The type of serial data link used determines the possible settings. The table below shows the possible settings for SCADAPack and TeleSAFE controllers. Note that not all port types and baud rates are available on all controller ports.

Port Type	*Possible Settings*	*Recommended Setting*
RS-232 or RS-232 Dial-up modem	75 baud 110 baud 150 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud	Use the highest rate supported by all devices on the network.
RS-485	75 baud 110 baud 150 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud	Use the highest rate supported by all devices on the network.

Duplex

The TeleBUS protocols communicate in one direction at a time. However the type of serial data link used determines the duplex setting. The table below shows the possible settings for SCADAPack and TeleSAFE controllers. Note that not all port types are available on all controllers.

Port Type	*Possible Settings*	*Recommended Setting*
RS-232 or RS-232 Dial-up modem	half duplex full duplex	Use full duplex wherever possible. Use half duplex for most external modems.
RS-485	half duplex full duplex	Slave stations always use half duplex. Master stations can use full duplex only on 4 wire systems.

Protocol Parameters

The TeleBUS protocols operate independently on each serial port. Each port may set the protocol type, station number, protocol task priority and store-and-forward messaging options.

The port configuration can be set in four ways:

- using the TelePACE or ISaGRAF programs;
- using the **set_protocol** function from a C or C++ application program;
- writing to the I/O database from a C, C++, ISaGRAF or ladder logic application program;
- writing to the I/O database remotely from a Modbus compatible device.

To configure protocol settings through the I/O database, add the module, CNFG Protocol settings, to the Register Assignment for TelePACE applications or use the setprot function in ISaGRAF applications.

Protocol Type

The protocol type may be set to emulate the Modbus ASCII and Modbus RTU protocols, or it may be disabled. When the protocol is disabled, the port functions as a normal serial port.

Station Number

The TeleBUS protocol allows up to 254 devices on a network using standard addressing and up to 65534 devices using extended addressing. Station numbers identify each device. A device responds to commands addressed to it, or to commands broadcast to all stations.

The station number is in the range 1 to 254 for standard addressing and 1 to 65534 for extended addressing. Address 0 indicates a command broadcast to all stations, and cannot be used as a station number. Each serial port may have a unique station number.

Task Priority

A task is responsible for monitoring each serial port for messages. The real time operating system (RTOS) schedules the tasks with the application program tasks according to the task priority. The priority can be changed only with the **set_protocol** function from an application program.

The default task priority is 3. Changing the priority is not recommended.

Store and Forward Messaging

Store and forward messaging re-transmits messages received by a controller. Messages may be re-transmitted on any serial port, with or without station address translation. A user-

defined translation table determines actions performed for each message. The ***Store and Forward Messaging*** section below describes this feature in detail.

Store and forward messaging may be enabled or disabled on each port. It is disabled by default.

I/O Database

The TeleBUS protocols read and write information from the I/O database. The I/O database contains user-assigned registers and general purpose registers.

User-assigned registers map directly to the I/O hardware or system parameter in the controller. Assigned registers are initialized to the default hardware state or system parameter when the controller is reset. Assigned output registers do not maintain their values during power failures. However, output registers do retain their values during application program loading.

General purpose registers are used by ladder logic and C application programs to store processed information, and to receive information from remote devices. General purpose registers retain their values during power failures and application program loading. The values change only when written by an application program or a communication protocol.

The I/O database is divided into four sections.

- Coil registers are single bits which the protocols can read and write. Coil registers are located in the digital output section of the I/O database. The number of registers depends on the controller. Coil registers are numbered from 1 to the maximum for the controller.
- Status registers are single bits which the protocol can read. Status registers are located in the digital input section of the I/O database. The number of registers depends on the controller. Status registers are numbered from 10001 to the maximum for the controller.
- Input registers are 16 bit registers which the protocol can read. Input registers are located in the analog input section of the I/O database. The number of registers depends on the controller. Input registers are numbered from 30001 to the maximum for the controller.
- Holding registers are 16 bit registers that the protocol can read and write. Holding registers are located in the analog output section of the I/O database. The number of registers depends on the controller. Holding registers are numbered from 40001 to the maximum for the controller.

Accessing the I/O Database

TelePACE ladder logic programs access the I/O database through function blocks. All function blocks can access the I/O database. Refer to the ***TelePACE Ladder Logic Reference and User Manual*** for details.

ISaGRAF applications access the I/O database through dictionary variables with assigned network addresses or using Permanent Non-Volatile Modbus registers. See the ***ISaGRAF User and Reference Manual*** for details.

C language programs access the I/O database with two functions. The **dbase** function reads a value from the I/O database. The **setdbase** function writes a value to the I/O database. Refer to the ***TelePACE C Tools Reference and User Manual*** for full details on these functions.

Coil and Status Registers

Coil and status registers contain one bit of information, that is, whether a signal is off or on.

Writing any non-zero value to the register turns the bit on. Writing zero to the register turns the bit off. If the register is assigned to an I/O module, the bit status is written to the module output hardware or parameter.

Reading a coil or status register returns –1 if the bit is on, or 0 if the bit is off. The stored value is returned from general purpose registers. The I/O module point status is returned from assigned registers.

Input and Holding Registers

Input and holding registers contain 16 bit values.

Writing any value to a general purpose register stores the value in the register. Writing a value to an assigned register, writes the value to the assigned I/O module.

Reading a general purpose register returns the value stored in the register. Reading an assigned register returns the value read from the I/O module.

Exception Status

The exception status is a single byte containing controller specific status information. It is returned in response to the Read Exception Status function (see the ***Slave Mode*** section).

A C language application program can define the status information. The **modbusExceptionStatus** function sets the status information. Ladder logic programs cannot set this information.

Slave ID

The slave ID is a variable length message containing controller specific information. It is returned in response to the Report Slave ID function (see the ***Slave Mode*** section).

A C language application program can define the information and the length of the message. The **modbusSlaveID** function sets the information. Ladder logic programs cannot set this information.

Extended Station Addressing

The TeleBUS RTU and ASCII protocols support two type of Modbus station addressing. Standard Modbus addressing allows a maximum of 255 stations and is compatible with standard Modbus devices.

Extended Modbus addressing allows a maximum of 65534 stations. Extended Modbus addressing is fully compatible with standard Modbus addressing for addresses between 0 and 254.

Theory of Operation

The address field of a Modbus message is a single byte. Address 0 is a broadcast address; messages sent to this address are sent to all stations. Addresses 1 to 255 are station addresses. Figure 1 shows the format of a standard Modbus message.

Field	Address	Function	...
Size	1	1	N

Figure 1: Standard Modbus Message

The address field extension adds a two-byte extended address field to the message. Figure 2 shows the format of an extended address Modbus message.

Field	Address = 255	Extended Address (high)	Extended Address (low)	Function	...
Size	1	1	1	1	n

Figure 2: Extended Address Modbus Message

Messages for addresses 0 to 254 use the standard format message. The station address is stored in the address byte.

Messages for stations 255 to 65534 use the extended address format message. The address byte is set to 255. This indicates the extended address format is used. The actual address is stored in the two extended address bytes.

Station address 65535 is reserved and cannot be used as a station number. This station address is used in store-and-forward tables to indicate a disabled station.

Slave, master and store-and-forward stations treat the addresses in the same manner. The application program controls the use of the extended addressing format. It may enable or disable the extended addressing.

Slave Mode

The TeleBUS protocols operate in slave and master modes simultaneously. In slave mode the controller responds to commands sent by another device. Commands may be sent to a specific device or broadcast to all devices.

The TeleBUS protocols emulate the Modbus protocol functions required for communication with a host device. These functions are described below. It also implements functions for programming and remote diagnostics. These functions are not required for host communication, so are not described here.

A technical specification for the TeleBUS protocol is available from Control Microsystems. It describes all the functions in detail. In most cases knowledge of the actual commands is not required.

Broadcast Messages

A broadcast message is sent to all devices on a network. Each device executes the command. No device responds to a broadcast command. The device sending the command must query each device to determine if the command was received and processed. Broadcast messages are supported for some function codes that write information.

A broadcast message is sent to station number 0.

Function Codes

The table summarizes the implemented function codes. The maximum number of registers that can be read or written with one message is shown in the maximum column.

Function	***Name***	***Description***	***Maximum***
01	Read Coil Status	Reads digital output registers.	2000
02	Read Input Status	Reads digital input registers.	2000
03	Read Holding Register	Reads analog output registers.	125
04	Read Input Register	Reads analog input registers.	125
05	Force Single Coil	Writes digital output register.	1
06	Preset Single Register	Writes analog output registers.	1
07	Read Exception Status	Reads special information.	N/A
15	Force Multiple Coils	Writes digital output registers.	880
16	Preset Multiple Registers	Writes analog output registers.	60
17	Report Slave ID	Reads controller type information	N/A

Functions 5, 6, 15, and 16 support broadcast messages. The functions are described in detail below.

Read Coil Status

The Read Coil Status function reads data from the digital output section of the I/O database. Any number of registers may be read up to the maximum number. The read may start at any address, provided the entire block is within the valid register range. Each register is one bit.

Read Input Status

The Read Input Status function reads data from the digital input section of the I/O database. Any number of registers may be read up to the maximum number. The read may start at any address, provided the entire block is within the valid register range. Each register is one bit.

Read Holding Register

The Read Holding Register function reads data from the analog output section of the I/O database. Any number of registers may be read up to the maximum number. The read may start at any address, provided the entire block is within the valid register range. Each register is 16 bits.

Read Input Register

The Read Input Register function reads data from the analog input section of the I/O database. Any number of registers may be read up to the maximum number. The read may start at any address, provided the entire block is within the valid register range. Each register is 16 bits.

Force Single Coil

The Force Single Coil function writes one bit into the digital output section of the I/O database. The write may specify any valid register.

Preset Single Register

The Preset Single Register function writes one 16 bit value into the analog output section of the I/O database. The write may specify any valid register.

Read Exception Status

The Read Exception Status function reads a single byte containing controller specific status information. The information is defined by the application program. This function is included for compatibility with devices expecting to communicate with a Modicon PLC.

Force Multiple Coils

The Force Multiple Coils function writes single bit values into the digital output section of the I/O database. Any number of registers may be written up to the maximum number. The write may start at any address, provided the entire block is within the valid register range. Each register is 1 bit.

Preset Multiple Registers

The Preset Multiple Register function writes 16 bit values into the analog output section of the I/O database. Any number of registers may be written up to the maximum number. The write may start at any address, provided the entire block is within the valid register range. Each register is 16 bits.

Report Slave ID

The Report Slave ID function reads a variable length message containing controller specific information. The information and the length of the message is defined by the application

program. This function is included for compatibility with devices expecting to communicate with a Modicon PLC.

Modbus Master Mode

The TeleBUS protocol may act as a communication master on any serial port. In master mode, the controller sends commands to other devices on the network. Simultaneous master messages may be active on all ports.

The protocol cannot support master mode and store-and-forward mode simultaneously on a serial port. Enabling store and forward messaging disables processing of responses to master mode commands. Master mode may be used on one port and store-and-forward mode on another port.

Modbus Function Codes

The table shows the implemented function codes. The maximum number of registers that can be read or written with one message is shown in the maximum column. The slave device may support fewer registers than shown; consult the manual for the device for details.

Function	***Name***	***Description***	***Maximum***
01	Read Coil Status	Reads digital output registers.	2000
02	Read Input Status	Reads digital input registers.	2000
03	Read Holding Register	Reads analog output registers.	125
04	Read Input Register	Reads analog input registers.	125
05	Force Single Coil	Writes digital output register.	1
06	Preset Single Register	Writes analog output registers.	1
15	Force Multiple Coils	Writes digital output registers.	880
16	Preset Multiple Registers	Writes analog output registers.	60

Read Coil Status

The Read Coil Status function reads data from coil registers in the remote device. Data can be written into the digital input or the digital output sections of the I/O database.

Any number of registers may be read up to the maximum number supported by the slave device or the maximum number above, whichever is less. The read may start at any address, provided the entire block is within the valid register range. Each register is one bit.

Read Input Status

The Read Input Status function reads data from input registers in the remote device. Data can be written into the digital input or the digital output sections of the I/O database.

Any number of registers may be read up to the maximum number supported by the slave device or the maximum number above, whichever is less. The read may start at any address, provided the entire block is within the valid register range. Each register is one bit.

Read Holding Register

The Read Holding Register function reads data from holding registers in the remote device. Data can be written into the analog input or the analog output sections of the I/O database.

Any number of registers may be read up to the maximum number supported by the slave device or the maximum number above, whichever is less. The read may start at any address, provided the entire block is within the valid register range. Each register is 16 bits.

Read Input Register

The Read Input Register function reads data from input registers in the remote device. Data can be written into the analog input or the analog output sections of the I/O database.

Any number of registers may be read up to the maximum number supported by the slave device or the maximum number above, whichever is less. The read may start at any address, provided the entire block is within the valid register range. Each register is 16 bits.

Force Single Coil

The Force Single Coil function writes one bit into a coil register in the remote device. The data may come from the digital input or digital output sections of the I/O database.

The write may specify any valid coil register in the remote device.

Preset Single Register

The Preset Single Register function writes one 16 bit value into a holding register in the remote device. The data may come from the analog input or output sections of the I/O database.

The write may specify any valid holding register in the remote device.

Force Multiple Coils

The Force Multiple Coils function writes single bit values coil registers in the remote device. The data may come from the digital input or digital output sections of the I/O database.

Any number of registers may be written up to the maximum number supported by the slave device or the maximum number above, which ever is less. The write may start at any address, provided the entire block is within the valid register range of the remote device. Each register is 1 bit.

Preset Multiple Registers

The Preset Multiple Register function writes 16 bit values into holding registers of the remote device. The data may come from the analog input or output sections of the I/O database.

Any number of registers may be written up to the maximum number supported by the slave device or the maximum number above, which ever is less. The write may start at any address, provided the entire block is within the valid register range of the remote device. Each register is 16 bits.

Enron Modbus Master Mode

The Enron Modbus protocol is based on the Modbus ASCII and RTU protocols. Message framing is identical to the Modbus protocols. However, there are many differences in message formatting and register numbering, at both the logical and protocol levels.

The document ***Specifications and Requirements for an Electronic Flow Measurement Remote Terminal Unit*** describes the Enron Modbus protocol.

Variable Types

There are ranges of Enron registers to hold short integers, long integers and single precision floats. The ranges are as follows.

Range	***Data Type***
1001 - 1999	Boolean
3001 - 3999	Short integer
5001 - 5999	Long integer
7000 - 9999	Float

In general, both Numeric and Boolean function codes can be used to read and write all types of registers. Consult the Enron Modbus specification for details.

Boolean Registers

Enron Modbus Boolean registers are usually numbered 1001 to 1999.

Boolean registers are read using Modbus command 1. Boolean registers are written using Modbus command 5 for single registers and 15 for multiple registers.

The address offset in the message is equal to the register number.

The number of Modbus registers is equal to the number of Enron registers.

The response format is identical to the Modbus response format.

Short Integer Registers

Enron Modbus Short Integer registers are usually numbered 3001 to 3999.

Short Integer registers are read using Modbus command 3. Short Integer registers are written using Modbus command 6 for single registers and 16 for multiple registers.

The address offset in the message is equal to the register number.

The number of Modbus registers is equal to the number of Enron registers.

The response format is identical to the Modbus response format.

Long Integer Registers

Enron Modbus Long Integer registers are usually numbered 5001 to 5999.

Long Integer registers are read using Modbus command 3. Long Integer registers are written using Modbus command 6 for single registers and 16 for multiple registers.

The address offset in the message is equal to the register number.

The number of Modbus registers requested is equal to the number of Enron registers.

The number of Modbus registers expected in the response is equal to two times the number of Enron registers.

Floating Point Registers

Enron Modbus Floating-point registers are usually numbered 7001 to 7999.

Floating-point registers are read using Modbus command 3. Floating-point registers are written using Modbus command 6 for single registers and 16 for multiple registers.

The address offset in the message is equal to the register number.

The number of Modbus registers requested is equal to the number of Enron registers.

The number of Modbus registers expected in the response is equal to two times the number of Enron registers.

Enron Modbus Function Codes

The following table shows the implemented function codes for Enron Modbus. The maximum number of registers that can be read or written with one message is shown in the maximum column. The slave device may support fewer registers than shown; consult the manual for the device for details.

Functions 129, 130, 132, 133, 135, 136, 138, and 139 may be broadcast, but some Enron Modbus slave devices may not support broadcast messages. Consult the manual for the device for details.

Function	***Name***	***Description***	***Maximum***
128	Read Enron Boolean	Read Enron Boolean registers	2000
129	Write Enron Boolean	Write Enron Boolean register	1
130	Write Enron Multiple Boolean	Write Enron Boolean registers	880
131	Read Enron Short Integer	Read Enron short integer register	125
132	Write Enron Short Integer	Write Enron short integer register	1
133	Write Enron Multiple Short Integer	Write Enron short integer registers	60
134	Read Enron Long Integer	Read Enron long integer register	62
135	Write Enron Long Integer	Write Enron long integer register	1
136	Write Enron Multiple Long Integer	Write Enron long integer registers	30
137	Read Enron Floating Point	Read Enron floating-point register	62
138	Write Enron Floating Point	Write Enron floating-point register	1
139	Write Enron Multiple Floating Point	Write Enron floating-point registers	30

Sending Messages

A master message is initiated in one of five ways:

- using the **master_message** function from a C or C++ application program; or
- using the **MSTR** function block from a TelePACE ladder logic program; or
- using the **MSIP** function block from a TelePACE ladder logic program; or
- using the **master** function in an ISaGRAF program; or
- using the **masterip** function in an ISaGRAF program.

These functions specify the port on which to issue the command, the function code, the type of station addressing, the slave station number, and the location and size of the data in the slave and master devices. The protocol driver, independent of the application program receives the response to the command.

The application program detects the completion of the transaction by:

- calling the **get_protocol_status** function in a C application program; or
- using the output of the **MSTR** function block in a TelePACE ladder logic program; or
- using the output of the **master** function in an ISaGRAF program.

A communication error has occurred if the slave does not respond within the expected maximum time for the complete command and response. The application program is responsible for detecting this condition. When errors occur, it is recommended that the application program retry several times before indicating a communication failure.

The completion time depends on the length of the message, the length of the response, the number of transmitted bits per character, the transmission baud rate, and the maximum message turn-around time. One to three seconds is usually sufficient. Radio systems may require longer delays.

Store and Forward Messaging

Store and forward messaging is required on systems where there is no direct link between a host computer and all the remote sites. This occurs on radio systems where the host computer transmission cannot be heard by all remote sites. It occurs on systems where one controller is used as a data concentrator for several remote units. With store and forward messaging, a request to a controller that cannot be directly accessed by a host is routed through an intermediate controller, which can communicate with both the host and the remote controller.

The TeleBUS protocol provides store and forward messaging through address translation. A controller configured for store and forward operation receives messages destined for a remote station, re-addresses them according to translation table, and forwards the message to the remote station. Responses from the remote station are processed in the same manner.

The TeleBUS protocol allows messages to be re-transmitted on the same port with address translation. This is used with radio systems. The radio at the intermediate site is used as a type of repeater. The protocol allows messages to be re-transmitted on a different port, with or without address translation. This is used where the intermediate controller is a bridge between two networks.

The TeleBUS protocol driver maintains diagnostics counters at the store and forward site on the number of messages received and transmitted to aid in the diagnosing of communication problems.

The protocol cannot support master mode and store-and-forward mode simultaneously on a serial port. Enabling store and forward messaging disables processing of responses to master mode commands. Master mode may be used on one port and store-and-forward mode on another port. Applications requiring both modes on a single port must switch the modes under control of the application program.

Translation Table

The translation table specifies address and communication port translation. The translation table differs for SCADAPack and SCADAPack 32 controllers. Each entry in the translation table for SCADAPack controllers has four components, as shown in the table entry below.

Port A	Station Address A	Port B	Station Address B

The entry defines a bi-directional transfer. A message (poll or reply) received for station A on port A is re-transmitted to station B on port B. A message received for station B on port B is re-transmitted to station A on port A.

Each entry in the translation table for SCADAPack 32 controllers has five components, as shown in the table entry below.

Slave Interface	Slave Station	Forward Interface	Forward Station	Forward IP Address

The Slave Interface entry contains the receiving slave interface the message is received from for each translation.

The Slave Station entry contains the Modbus station address of the slave message.

The Forward Interface entry contains the interface the message is forwarded from. When forwarding to a TCP or UDP network, the protocol type is selected for the Forward Interface.

The IP Stack automatically determines the exact interface (e.g. Ethernet1) to use when it searches the network for the Forward IP Address.

The Forward Station entry contains the Modbus station address of the forwarded message.

The Forward IP Address entry contains the IP address of the Forward Station. This field is blank unless a TCP or UDP network is selected for Forward Interface.

Table Size

The translation table holds 128 translation entries. This is sufficient to re-transmit one-half of 256 possible addresses. On a single port controller only 128 translations are required since each address must translate to a different address for re-transmission on the same port see Invalid Translations.

Invalid Translations

The following translations are not valid. The described action is taken when these translations are encountered.

- Re-transmission on the same port with the same address is not valid, except for broadcast messages. This restriction is required because many message responses are identical to the command. It is impossible for the master station to distinguish between the re-transmitted message and the response from the slave. The re-transmitted message would appear to be the response.
- The protocol re-transmits broadcast messages on the same port. Some stations will receive the broadcast message twice. The master station will also receive the message and may execute it if it is able to operate as a slave. The user must bear these consequences in mind when forwarding broadcast messages.
- The store and forward controller also processes broadcast messages.
- Translations where either of the station addresses are the same as the controller station address for the port, are not valid. The protocol processes these messages as if they were directed to the controller. It does not look up the address in the translation table.
- Translations with non-existent port numbers or invalid addresses are not valid.
- Multiple translations for a port and station address combination are not valid.
- Translations where one station is DISABLED and the other station is not, are not valid. A DISABLED translation is a valid translation.

Store and Forward Configuration

The Store and Forward configuration varies depending on the controller you are configuring. The configuration for each type of controller is described in the following sections.

SCADAPack Controller

An application program, written in TelePACE Ladder Logic or TelePACE C Tools and ISaGRAF IEC61131 or ISaGRAF IEC61131 C Tools programming, enables and configures store and forward messaging. A HMI host may enable and configure store and forward messaging through the controller I/O database.

TelePACE Ladder Logic

1. To enable the use of store and forward messaging on one or more serial ports the Configuration I/O Module ***CNFG Protocol Settings Method 1, 2 or 3*** must be added to the register assignment. The store and forward enable register must be set to enable.
2. Add the Configuration I/O Module ***CNFG Store and Forward*** to the register assignment to configure the translation table.
3. Configure the translation table by writing the necessary translation table entries to the registers defined in the CNFG Store and Forward I/O module.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when TelePACE programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

TelePACE C Tools

The TelePACE C language application program interface provides the following functions. Refer to the ***TelePACE C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED (station 256).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

ISaGRAF IEC61131

1. To enable the use of store and forward messaging on one or more serial ports the Custom Function **setprot** or **setprot2** must be added to the project. The SandFEnabled input must be set to TRUE.
2. Configure the translation table by using the **setsf** function to write the necessary translation table entries.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when ISaGRAF IEC61131 programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

ISaGRAF IEC61131 C Tools

The ISaGRAF C language application program interface provides the following functions. Refer to the ***ISaGRAF C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.

- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

SCADAPack Light Controller

An application program, written in TelePACE Ladder Logic or TelePACE C Tools and ISaGRAF IEC61131 or ISaGRAF IEC61131 C Tools programming, enables and configures store and forward messaging. A HMI host may enable and configure store and forward messaging through the controller I/O database.

TelePACE Ladder Logic

1. To enable the use of store and forward messaging on one or more serial ports the Configuration I/O Module ***CNFG Protocol Settings Method 1, 2 or 3*** must be added to the register assignment. The store and forward enable register must be set to enable.
2. Add the Configuration I/O Module ***CNFG Store and Forward*** to the register assignment to configure the translation table.
3. Configure the translation table by writing the necessary translation table entries to the registers defined in the CNFG Store and Forward I/O module.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when TelePACE programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

TelePACE C Tools

The TelePACE C language application program interface provides the following functions. Refer to the ***TelePACE C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).

- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

ISaGRAF IEC61131

1. To enable the use of store and forward messaging on one or more serial ports the Custom Function **setprot** or **setprot2** must be added to the project. The SandFEnabled input must be set to TRUE.
2. Configure the translation table by using the **setsf** function to write the necessary translation table entries.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when ISaGRAF IEC61131 programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

ISaGRAF IEC61131 C Tools

The ISaGRAF C language application program interface provides the following functions. Refer to the ***ISaGRAF C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

SCADAPack Plus Controller

An application program, written in TelePACE Ladder Logic or TelePACE C Tools and ISaGRAF IEC61131 or ISaGRAF IEC61131 C Tools programming, enables and configures store and forward messaging. A HMI host may enable and configure store and forward messaging through the controller I/O database.

TelePACE Ladder Logic

1. To enable the use of store and forward messaging on one or more serial ports the Configuration I/O Module ***CNFG Protocol Settings Method 1, 2 or 3*** must be added to the register assignment. The store and forward enable register must be set to enable.
2. Add the Configuration I/O Module ***CNFG Store and Forward*** to the register assignment to configure the translation table.
3. Configure the translation table by writing the necessary translation table entries to the registers defined in the CNFG Store and Forward I/O module.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when TelePACE programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

TelePACE C Tools

The TelePACE C language application program interface provides the following functions. Refer to the ***TelePACE C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

ISaGRAF IEC61131

1. To enable the use of store and forward messaging on one or more serial ports the Custom Function **setprot** or **setprot2** must be added to the project. The SandFEnabled input must be set to TRUE.
2. Configure the translation table by using the **setsf** function to write the necessary translation table entries.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when ISaGRAF IEC61131 programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

ISaGRAF IEC61131 C Tools

The ISaGRAF C language application program interface provides the following functions. Refer to the ***ISaGRAF C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).

- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

SCADAPack LP Controller

An application program, written in TelePACE Ladder Logic or TelePACE C Tools and ISaGRAF IEC61131 or ISaGRAF IEC61131 C Tools programming, enables and configures store and forward messaging. A HMI host may enable and configure store and forward messaging through the controller I/O database.

TelePACE Ladder Logic

1. To enable the use of store and forward messaging on one or more serial ports the Configuration I/O Module ***CNFG Protocol Settings Method 1, 2 or 3*** must be added to the register assignment. The store and forward enable register must be set to enable.
2. Add the Configuration I/O Module ***CNFG Store and Forward*** to the register assignment to configure the translation table.
3. Configure the translation table by writing the necessary translation table entries to the registers defined in the CNFG Store and Forward I/O module.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when TelePACE programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

TelePACE C Tools

The TelePACE C language application program interface provides the following functions. Refer to the ***TelePACE C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

ISaGRAF IEC61131

1. To enable the use of store and forward messaging on one or more serial ports the Custom Function **setprot** or **setprot2** must be added to the project. The SandFEnabled input must be set to TRUE.
2. Configure the translation table by using the **setsf** function to write the necessary translation table entries.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when ISaGRAF IEC61131 programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

ISaGRAF IEC61131 C Tools

The ISaGRAF C language application program interface provides the following functions. Refer to the ***ISaGRAF C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

SCADAPack 100 Controller

An application program, written in TelePACE Ladder Logic or TelePACE C Tools and ISaGRAF IEC61131 or ISaGRAF IEC61131 C Tools programming, enables and configures store and forward messaging. A HMI host may enable and configure store and forward messaging through the controller I/O database.

TelePACE Ladder Logic

1. To enable the use of store and forward messaging on one or more serial ports the Configuration I/O Module ***CNFG Protocol Settings Method 1, 2 or 3*** must be added to the register assignment. The store and forward enable register must be set to enable.
2. Add the Configuration I/O Module ***CNFG Store and Forward*** to the register assignment to configure the translation table.
3. Configure the translation table by writing the necessary translation table entries to the registers defined in the CNFG Store and Forward I/O module.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when TelePACE programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

TelePACE C Tools

The TelePACE C language application program interface provides the following functions. Refer to the ***TelePACE C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.

- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

ISaGRAF IEC61131

1. To enable the use of store and forward messaging on one or more serial ports the Custom Function **setprot** or **setprot2** must be added to the project. The SandFEnabled input must be set to TRUE.
2. Configure the translation table by using the **setsf** function to write the necessary translation table entries.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when ISaGRAF IEC61131 programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

ISaGRAF IEC61131 C Tools

The ISaGRAF C language application program interface provides the following functions. Refer to the ***ISaGRAF C Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

SCADAPack 350, SCADAPack 32 and 32P Controller

An application program, written in TelePACE Ladder Logic or TelePACE C++ Tools and ISaGRAF IEC61131 or ISaGRAF IEC61131 C++ Tools programming, enables and configures store and forward messaging. A HMI host may enable and configure store and forward messaging through the controller I/O database.

TelePACE Ladder Logic

When a SCADAPack 350, SCADAPack 32 or SCADAPack 32P controllers are used the store and forward translation table is configured using an **Element Configuration** dialog. From the **Controller** menu select the **Store and Forward** command to access the element configuration. Refer to the TelePACE Ladder Logic Program Reference Manual for complete information on using the Store and Forward element configuration.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when TelePACE programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

TelePACE C++ Tools

The SCADAPack 32 C++ language application program interface provides the following functions. Refer to the ***SCADAPack 32 C++ Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).
- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

ISaGRAF IEC61131

1. To enable the use of store and forward messaging on one or more serial ports the Custom Function **setprot** or **setprot2** must be added to the project. The SandFEnabled input must be set to TRUE.
2. Configure the translation table by using the **setsfip2** function to write the necessary translation table entries.

The translation table must be initialized before store and forward messaging is enabled. Forwarding of messages is disabled when ISaGRAF IEC61131 programming software or a SERVICE boot initializes the controller. This prevents inadvertent forwarding of messages when new controllers are installed on networks.

ISaGRAF IEC61131 C++ Tools

The SCADAPack 32 C++ language application program interface provides the following functions. Refer to the ***SCADAPack 32 C++ Tools Reference and User Manual*** for details.

- The **getSFTranslation** function returns an entry from the store and forward translation table. The entry consists of two port and station address pairs.
- The **setSFTranslation** function writes an entry into the store and forward translation table. The entry consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored. The function returns a

status code indicating success or an error if the translation is not valid. A translation is cleared from the table by writing a translation with both stations set to DISABLED_STATION (65535).

- The **clearSFTranslationTable** function clears all entries in the translation table. A cleared entry has the port set to 0 (com1) and the station set to DISABLED_STATION (65535).
- The **checkSFTranslationTable** function checks the translation table for invalid entries. It returns a status structure indicating if the table is valid and the location and type of the first error if it is not valid.

Diagnostics Counters

The TeleBUS protocol provides diagnostics counters for each serial port. The counters aid in determining the source of communication errors. Store and forward messaging provides the following counters for each communication port. All counters have a maximum count of 65535. Counters roll back to zero on the next event.

- **Stored Message Counter**: the number of messages received, which qualified for forwarding. A message qualifies for forwarding if a valid translation is found for the port and station in the translation table.
- **Forwarded Message Counter**: the number of messages forwarded (transmitted) on this port.

Refer to the user manual for the controller and programming environment you are using for information on the diagnostics counters.

Point–To–Point Protocol (PPP)

SCADAPack 32 and SCADAPack 32P controllers support Point-to-Point Protocol (PPP) on the serial ports. Any serial port may be configured for the PPP protocol. Once a PPP connection is established the serial port has access to all IP protocol servers enabled on the controller.

A serial port configured for PPP supports an auto answer mode when dialed up through a modem. After answering the modem the serial port performs the login steps according to the authentication option selected for the port.

PPP provides two authentication protocols, which automates logins - PAP (Password Authentication Protocol) and CHAP (Challenge-Handshake Authentication Protocol).

PPP settings are configurable for each serial port on the SCADAPack 32 or SCADAPack 32P controller.

An inactivity timeout closes the PPP connection and hangs up the modem when the connection becomes idle. The timeout may also be disabled. Timeout range is 1 to 65535 minutes (~1092 hours maximum).

When the PPP protocol is selected for a serial port, the serial port must be assigned a unique IP address, different from the IP address assigned to Ethernet or any other active PPP connection.

The remote end of a PPP connection may request an IP address from the controller PPP Server. The PPP Server will provide this IP address if requested.

Only one default gateway may be assigned to the controller. A PPP connection may be configured as the gateway.

PPP Client Setup in Windows 2000

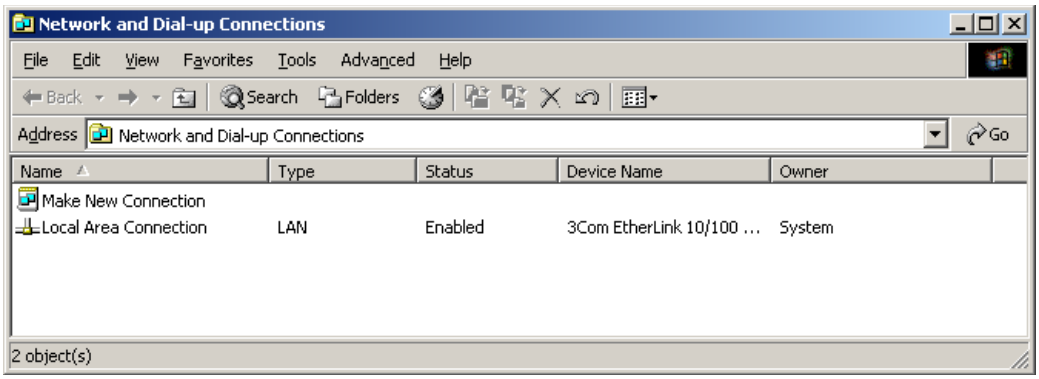
This section describes the procedure for setting up a PPP client from a Windows 2000 PC. Client setup for a dialup PPP connection and a direct serial PPP connection are presented.

Direct Serial PPP Connection using Windows 2000

Connection Setup

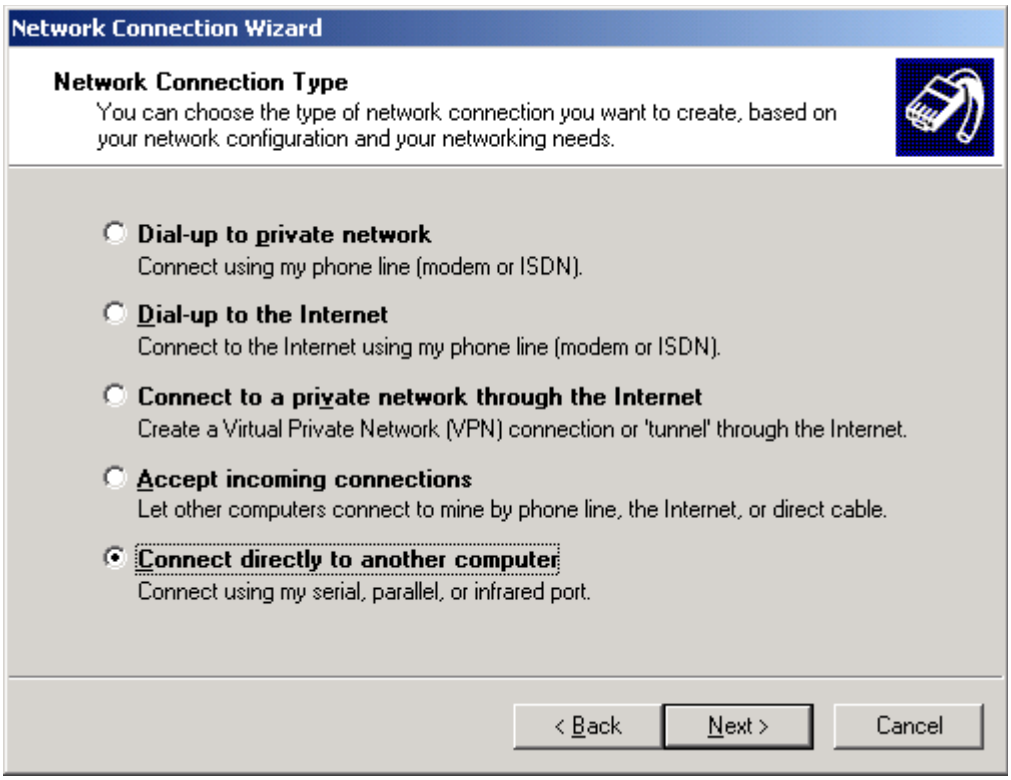
Use this connection when an only serial cable is used to establish a PPP connection between a Windows 2000 PC and a SCADAPack 32, without a dialup modem.

1. From the ***Start*** menu, right click ***Network and Dial-up Connections*** from the ***Settings*** group, and select **Open**. The *Network and Dial-up Connections* dialog is displayed.



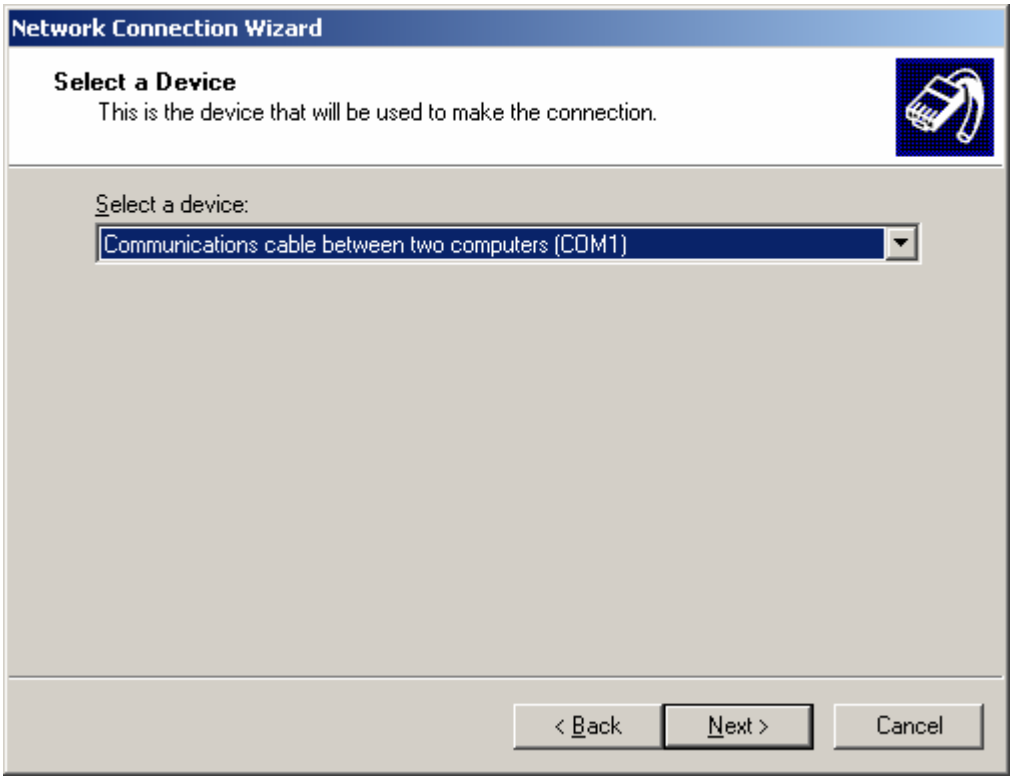
2. Double click the item ***Make New Connection*** from the *Network and Dial-up Connections dialog.* The connection wizard dialog is displayed.

3. Select the ***Next*** button to display the connection type options dialog.

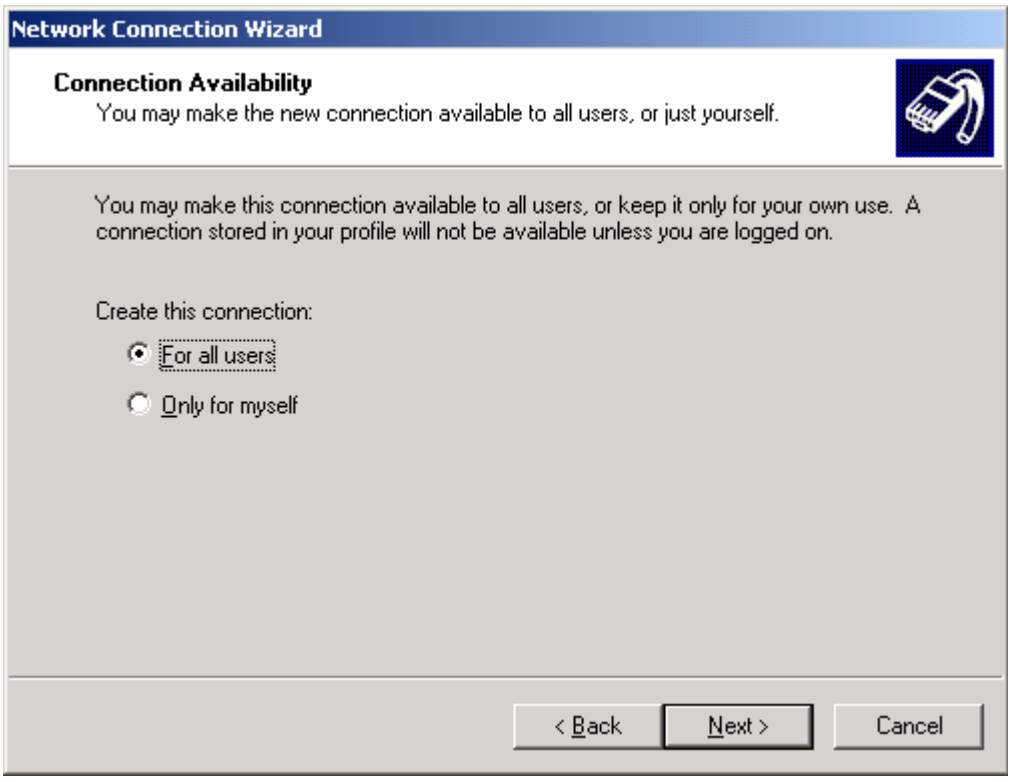


4. For Network Connection Type select the type ***Connect directly to another computer*** and select the ***Next*** button. The Host or Guest options dialog is displayed.

5. Select the ***Guest*** option and the ***Next*** button. The *Select a Device* dialog is displayed.

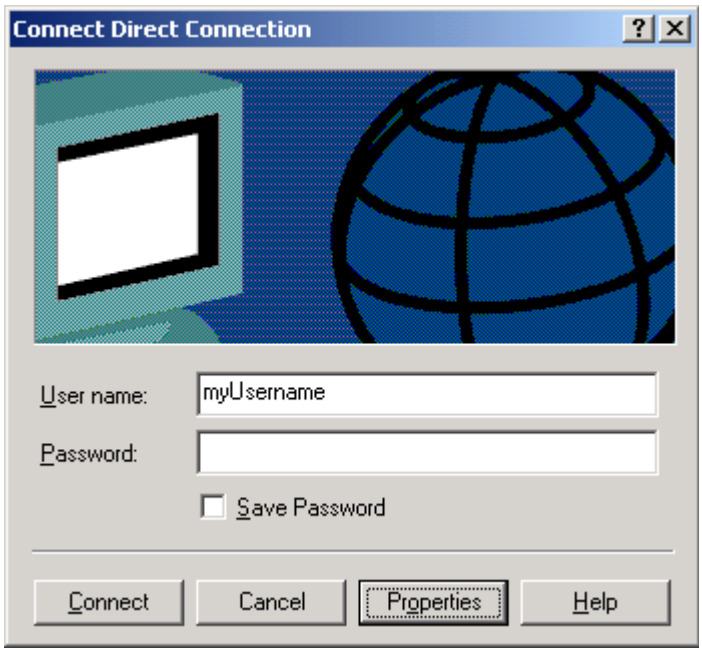


6. From the menu select the serial port on your PC that will be used to connect to the SCADAPack 32. Select the ***Next*** button. The *Connection Availability* dialog is displayed.

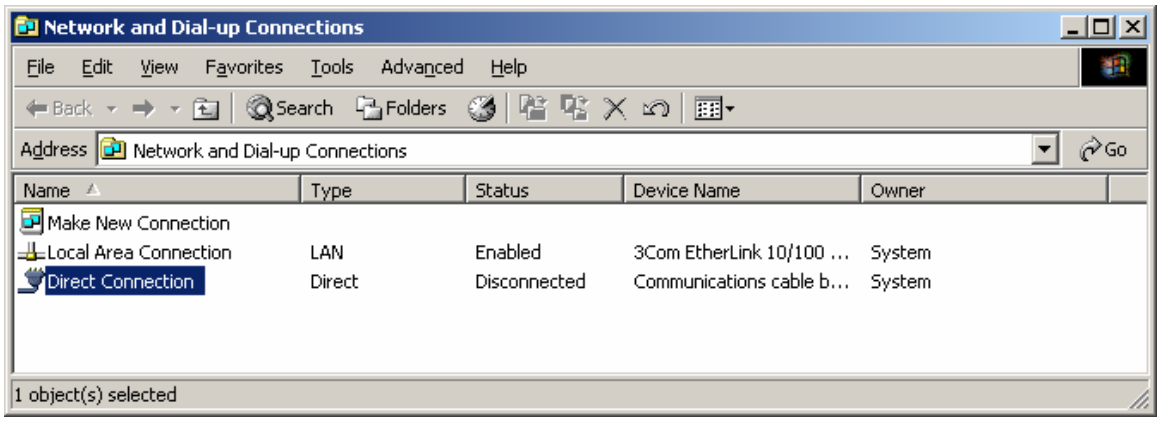


7. Select either option and then select the ***Next*** button. The *Connection Name* dialog is displayed.

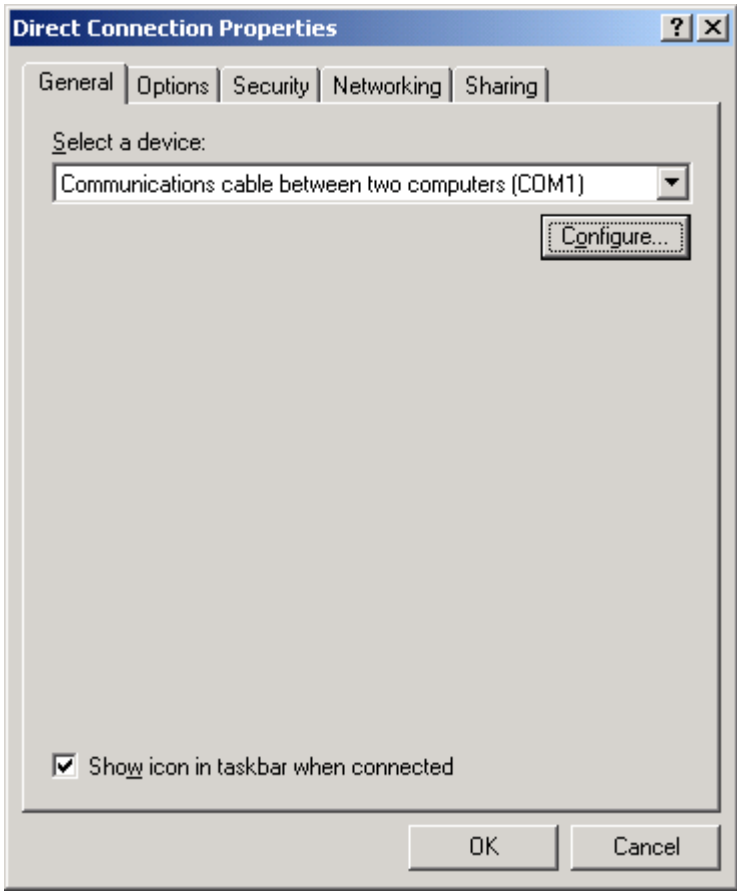
8. Enter a name for the connection and select the ***Finish*** button. The username and password prompt is displayed.



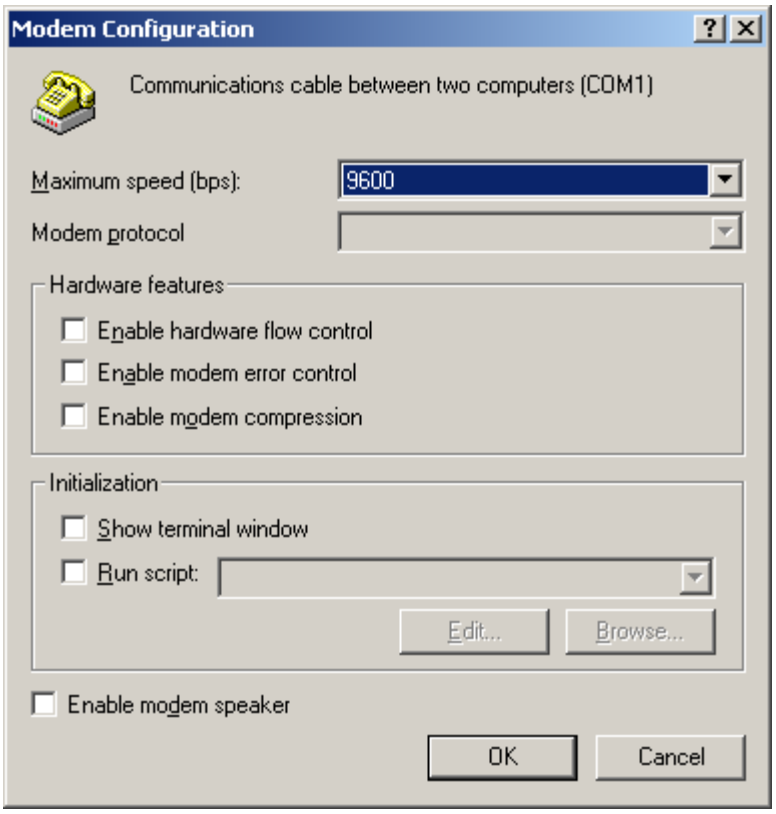
9. Select the ***Cancel*** button. The *Network and Dial-up Connections* dialog should be visible again.



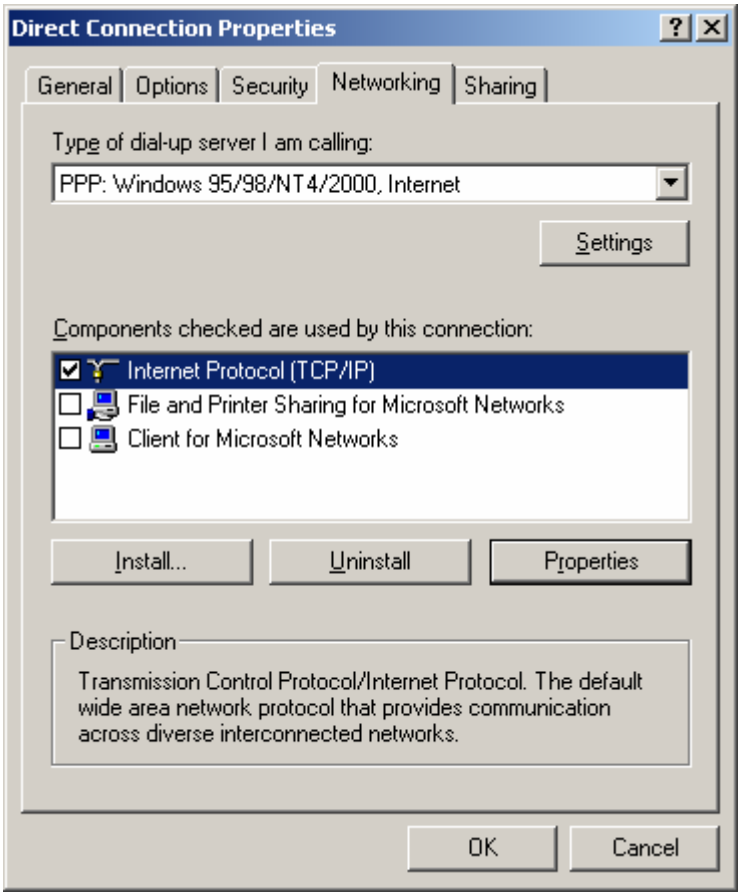
10. Right click your new *Direct Connection* icon from the *Network and Dial-up Connections* dialog and select ***Properties*** from the list. The *Properties* dialog is displayed.



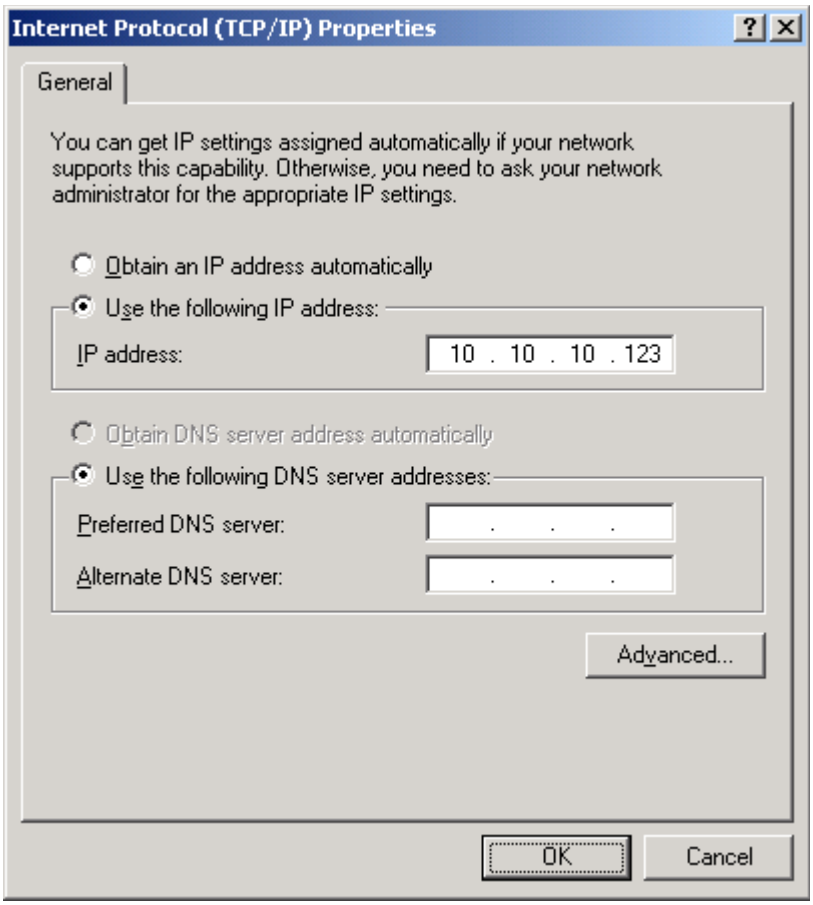
11. Select the ***Configure*** button from the *General* page. The *Modem Configuration* dialog is displayed.



12. There is no modem in this direct serial connection so uncheck all items including *hardware flow control.* Select the baud rate you intend to use (e.g. 9600 bps). Select ***OK*** to return to the *Properties* dialog.
13. From the *Properties* dialog select the ***Networking*** page.



14. Uncheck all components except the component ***Internet Protocol (TCP/IP***). Select the component ***Internet Protocol (TCP/IP)*** and select the ***Properties*** button. The *Internet Protocol (TCP/IP) Properties* dialog is displayed.

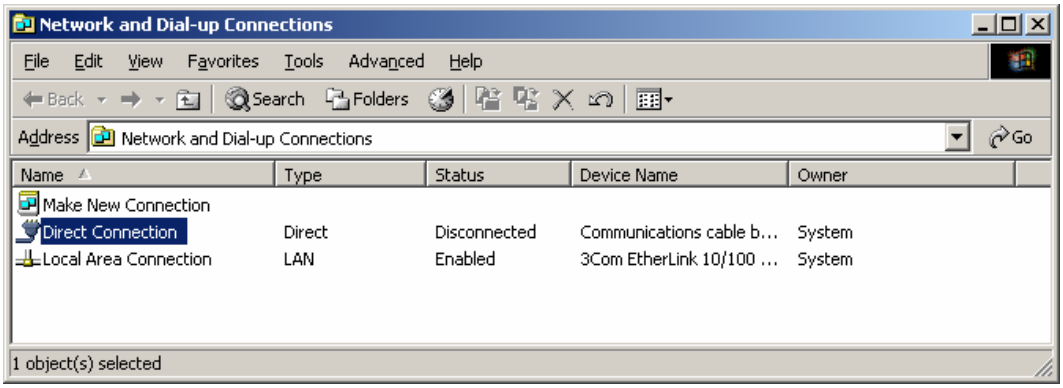


15. The SCADAPack 32 does not have a DHCP server to automatically provide an IP address. Instead the PC's serial port must be given a fixed IP address to use for PPP connections. Select the option ***Use the following IP address.*** Enter an IP address to assign to your PC's serial port. Obtain this IP address from your Network Administrator. Then select ***OK*** to return to the *Properties* dialog.
16. Select ***OK*** again to close the dialog.

Making a PPP Connection to the SCADAPack 32

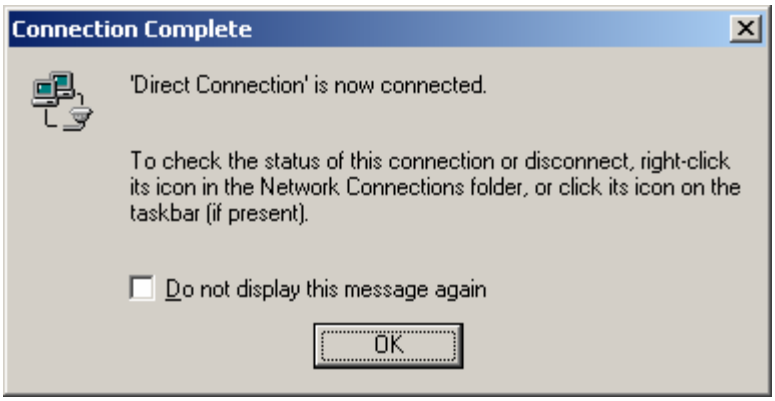
A connection can only be made after successfully setting up a Direct Connection icon as described in the section *Connection Setup* above. Also, a serial port on the SCADAPack 32 must already be configured for the PPP protocol using the *Controller IP Configuration* dialog and must be downloaded to the SCADAPack 32.

1. From the ***Start*** menu, double click ***Network and Dial-up Connections*** from the ***Settings*** group. The *Network and Dial-up Connections* dialog is displayed.

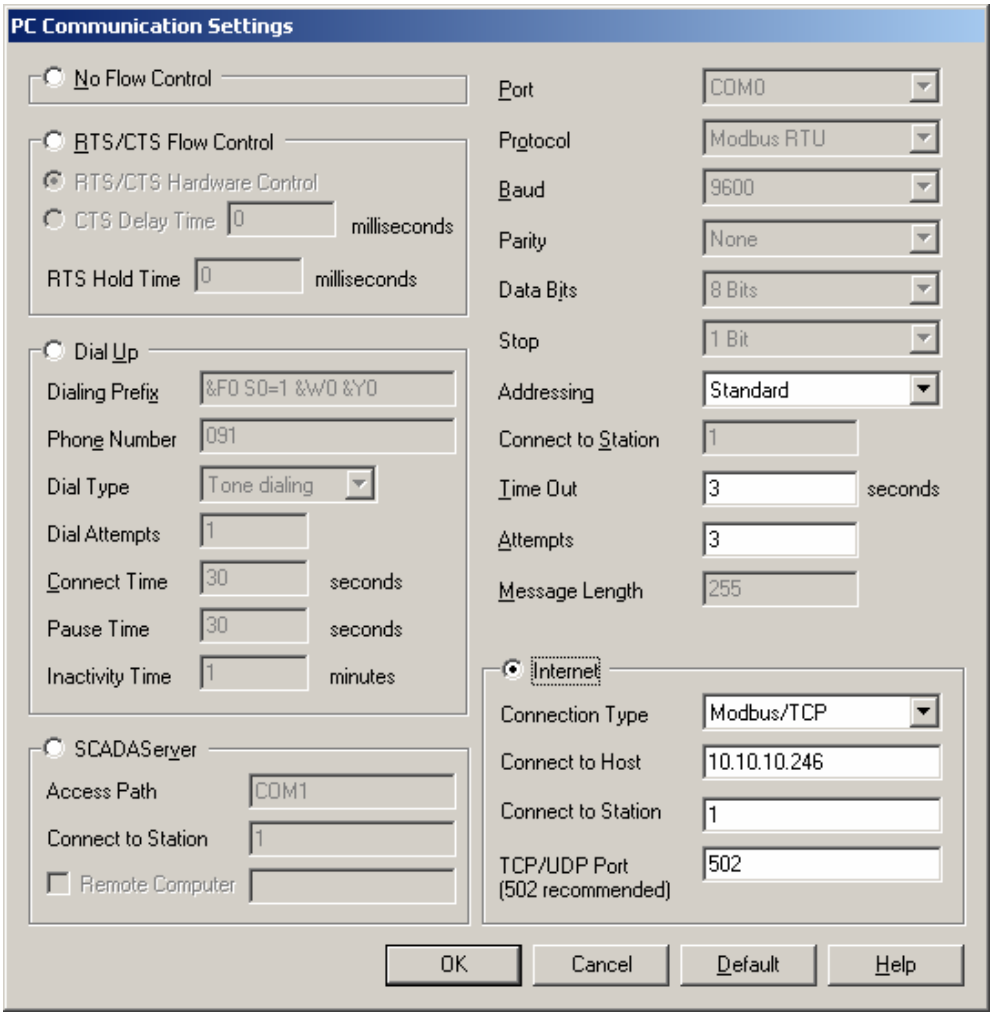


2. Right click your *Direct Connection* icon that was setup in the previous section and select ***Connect*** from the list. A prompt for username and password is displayed.

3. Enter a valid PAP or CHAP username and password. Valid usernames and passwords are configured on the *PPP Login* page of the *Controller IP Configuration* dialog and must be downloaded to the SCADAPack 32. Then select the ***Connect*** button. If neither PAP nor CHAP is being used, ignore the prompt and just select the ***Connect*** button.
4. A progress message is displayed. If the connection is successful the following message is displayed.



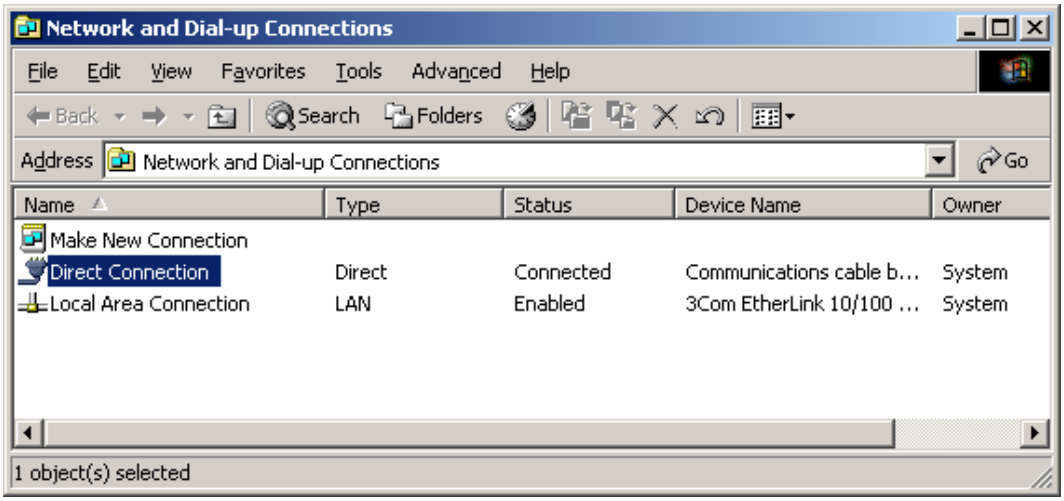
5. You may now connect to the IP address assigned to SCADAPack 32 PPP serial port using an appropriate application and a supported protocol (e.g. Modbus/TCP). In the example below, **Firmware Loader** is used to connect over PPP to the SCADAPack 32. From the *PC Communication Setting*s dialog, the IP address assigned to the SCADAPack 32 PPP serial port is selected as the ***Connect to Host***.



Disconnecting a PPP Connection

To disconnect a PPP connection made using the Windows PPP Client, do the following:

1. From the ***Start*** menu, double click ***Network and Dial-up Connections*** from the ***Settings*** group. The *Network and Dial-up Connections* dialog is displayed.



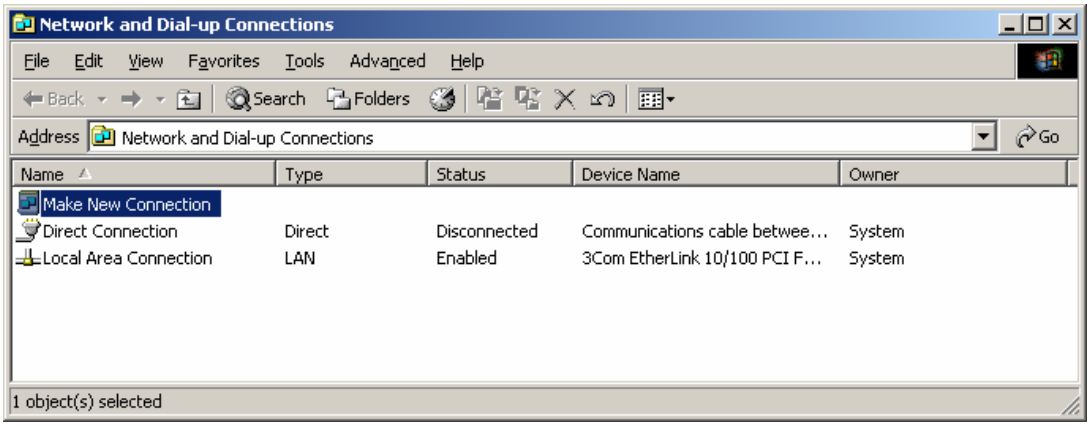
2. Your *Direct Connection* icon should display the word *Connected* in the Status column. To disconnect, right click your *Direct Connection* icon and select ***Disconnect*** from the list.

Dial-up PPP Connection using Windows 2000

Connection Setup using Windows 2000

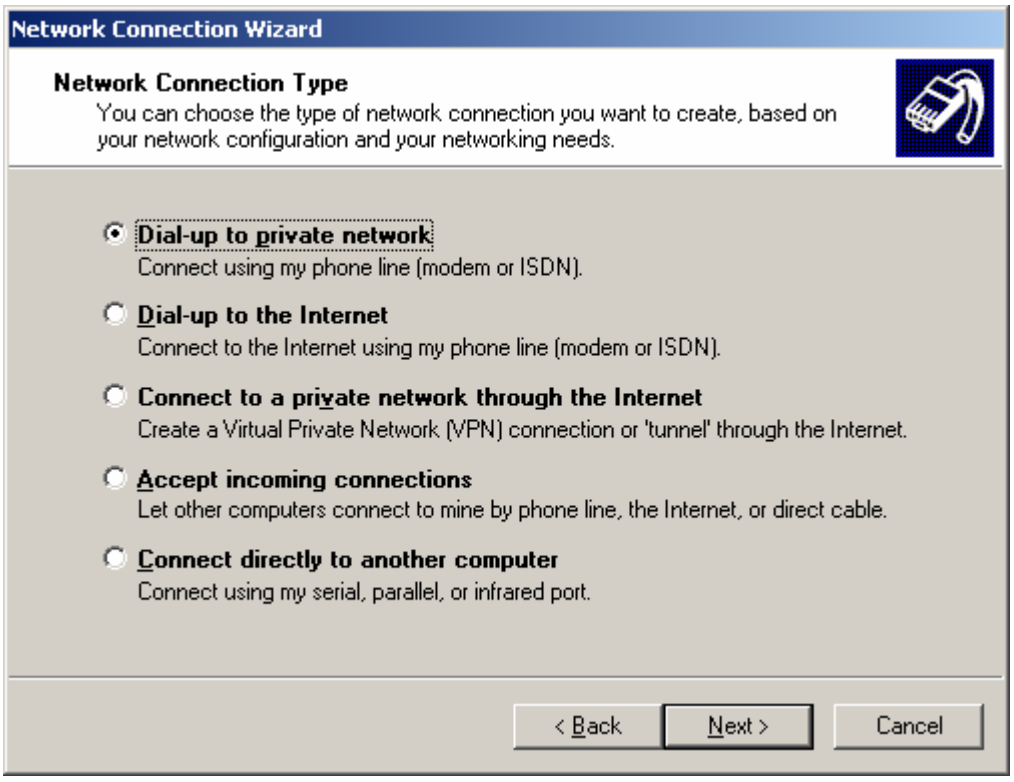
Use this connection when a dial-up modem is used to establish a PPP connection between a Windows 2000 PC and a SCADAPack 32.

1. From the ***Start*** menu, right click ***Network and Dial-up Connections*** from the ***Settings*** group, and select **Open**. The *Network and Dial-up Connections* dialog is displayed.

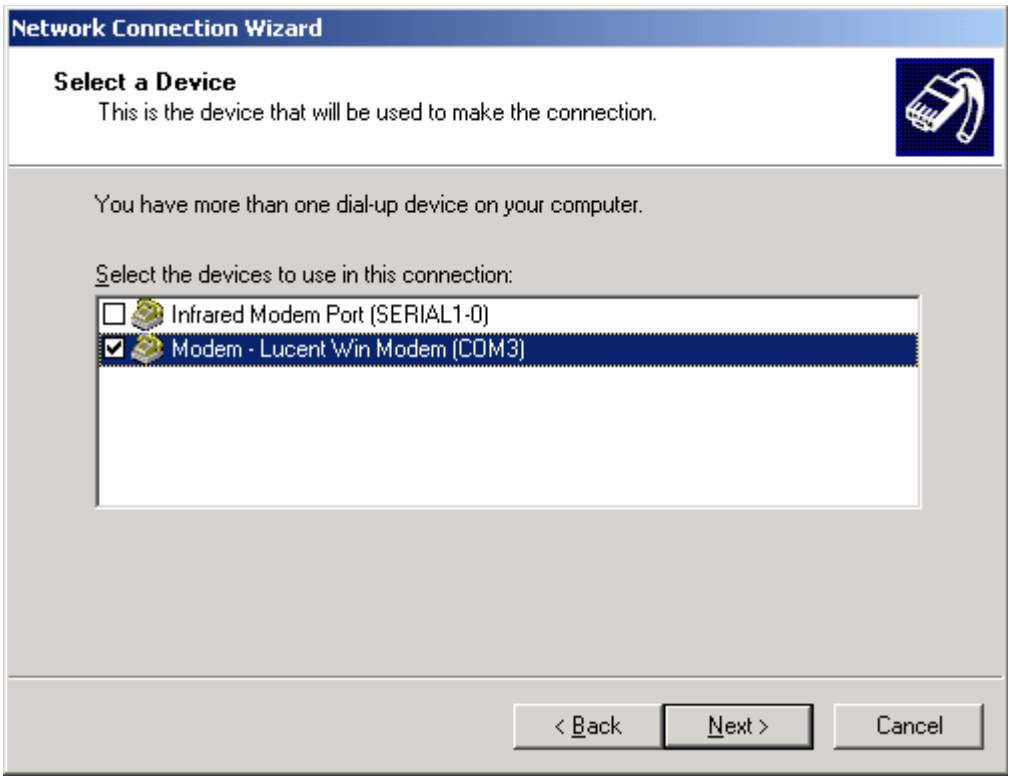


2. Double click the item ***Make New Connection*** from the *Network and Dial-up Connections dialog.* The connection wizard dialog is displayed.

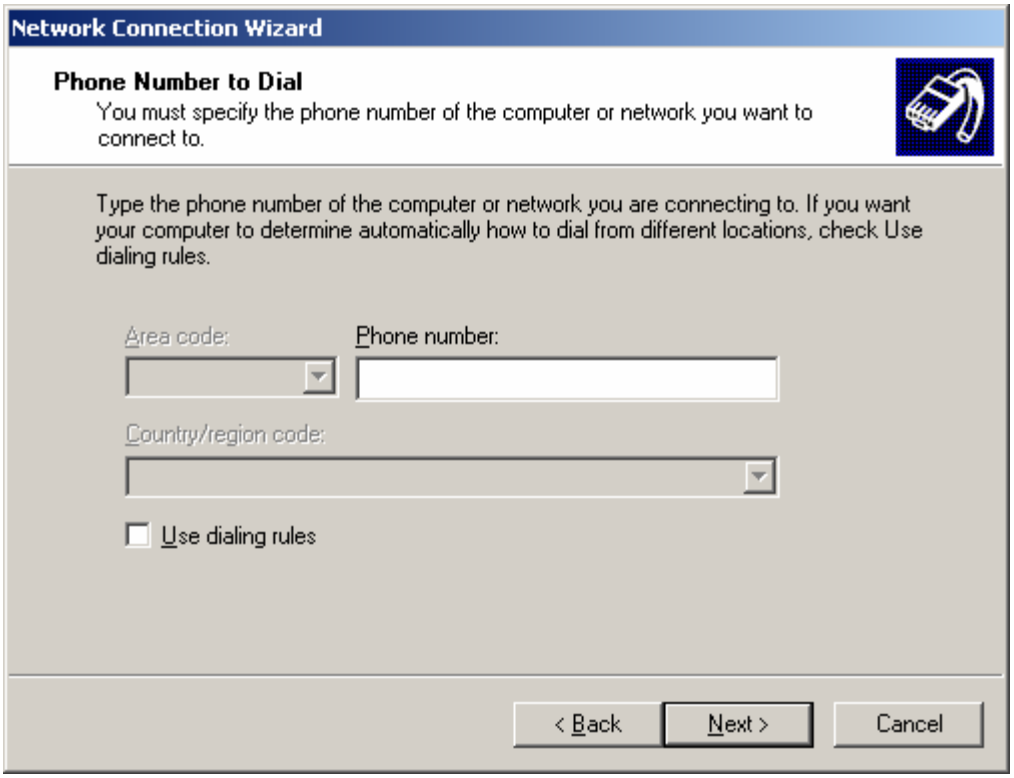
3. Select the ***Next*** button to display the connection type options dialog.



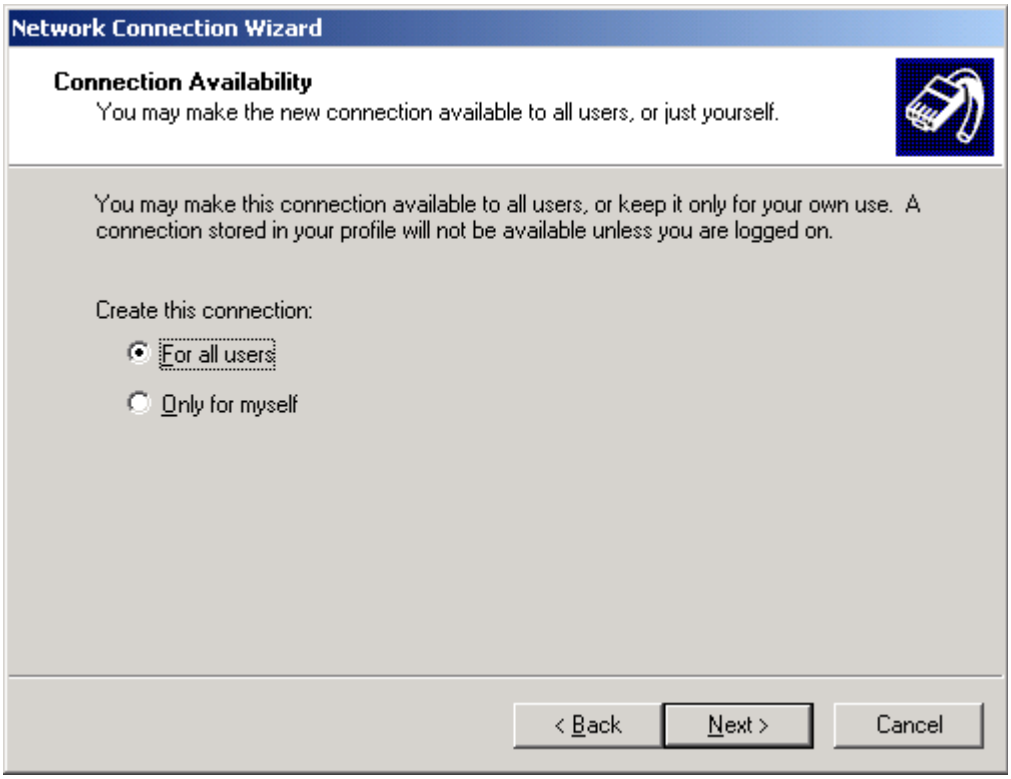
4. For Network Connection Type select the type ***Dial-up to private network*** and select the ***Next*** button. If there is more than one modem installed on the PC, the *Select a Device* dialog is displayed. If not, proceed to the next step.



5. From the menu select the modem installed on your PC that will be used to connect to the SCADAPack 32. Select the ***Next*** button. The *Phone Number to Dial* dialog is displayed.



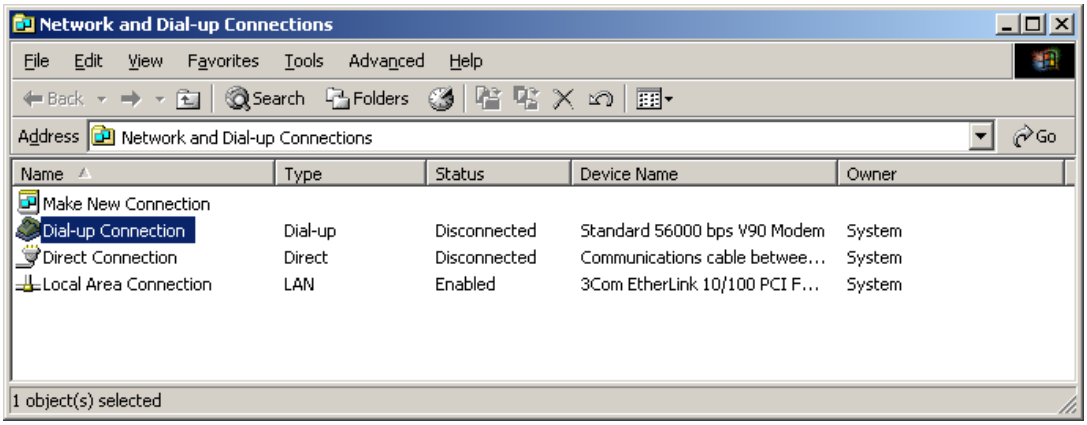
6. Enter the phone number to dial (this can be changed later) and select the ***Next*** button. The *Connection Availability* dialog is displayed.



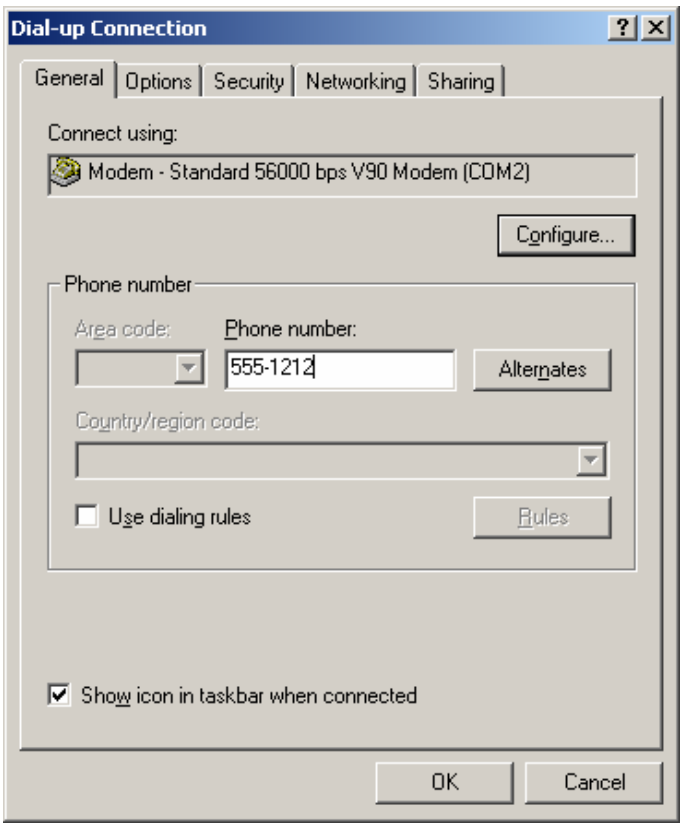
7. Select either option and then select the ***Next*** button. The *Connection Name* dialog is displayed.

8. Enter a name for the connection and select the ***Finish*** button. The username and password prompt is displayed.

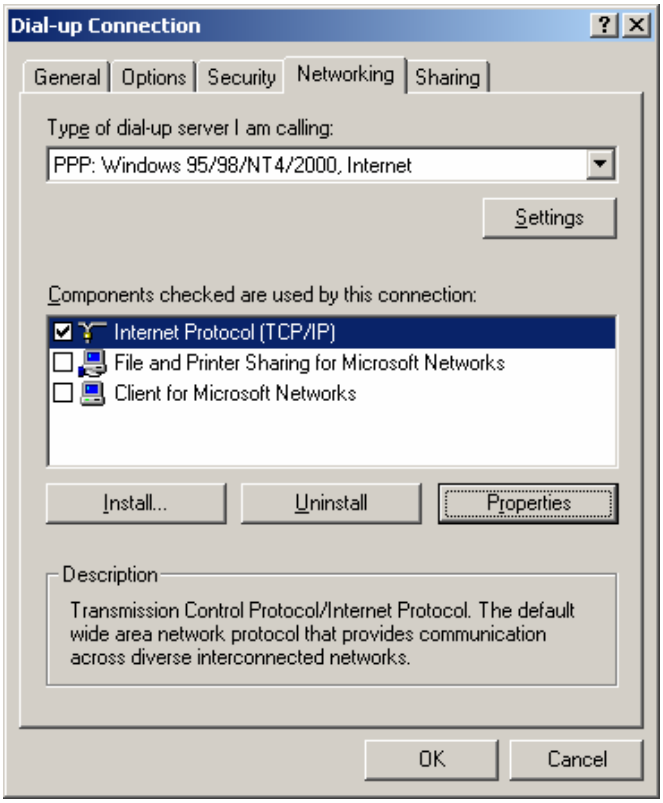
9. Select the ***Cancel*** button. The *Network and Dial-up Connections* dialog should be visible again.



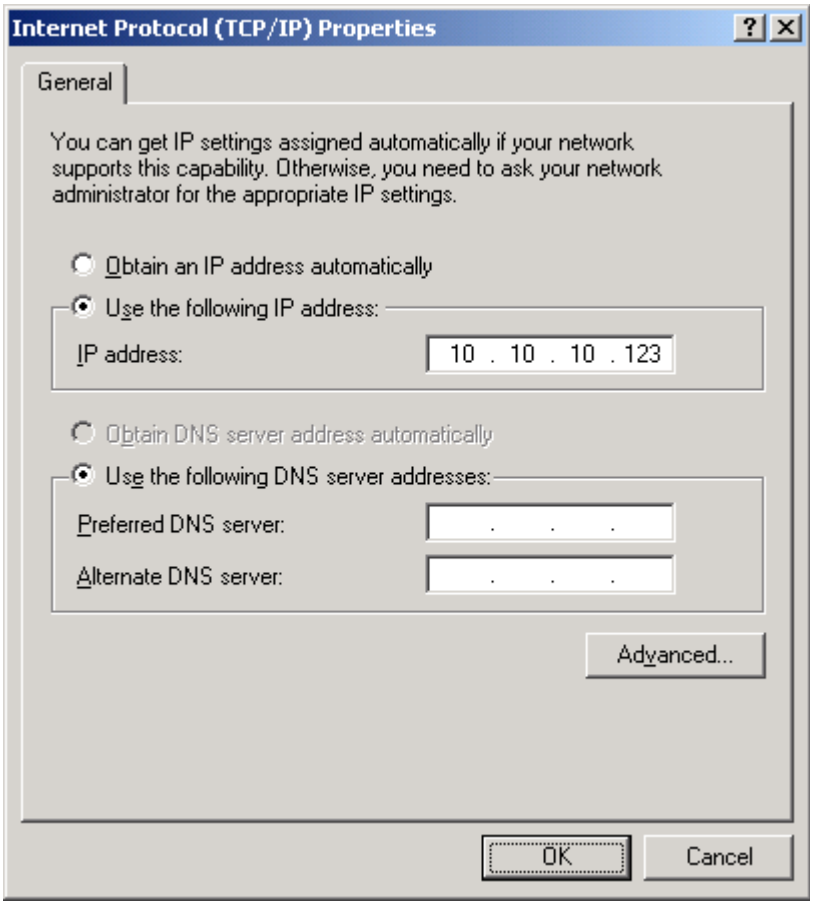
10. Right click your new *Dial-up Connection* icon from the *Network and Dial-up Connections* dialog and select ***Properties*** from the list. The *Properties* dialog is displayed.



11. From the *Properties* dialog select the ***Networking*** page.



12. Uncheck all components except the component ***Internet Protocol (TCP/IP***). Select the component ***Internet Protocol (TCP/IP)*** and select the ***Properties*** button. The *Internet Protocol (TCP/IP) Properties* dialog is displayed.

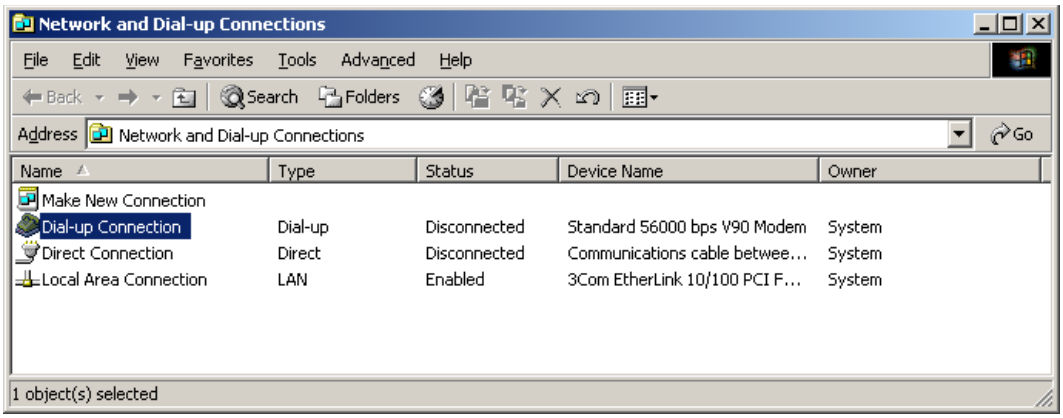


13. The SCADAPack 32 does not have a DHCP server to automatically provide an IP address. Instead the PC's serial port must be given a fixed IP address to use for PPP connections. Select the option ***Use the following IP address.*** Enter an IP address to assign to your PC's serial port. Obtain this IP address from your Network Administrator. Then select ***OK*** to return to the *Properties* dialog.
14. Select ***OK*** again to close the dialog.

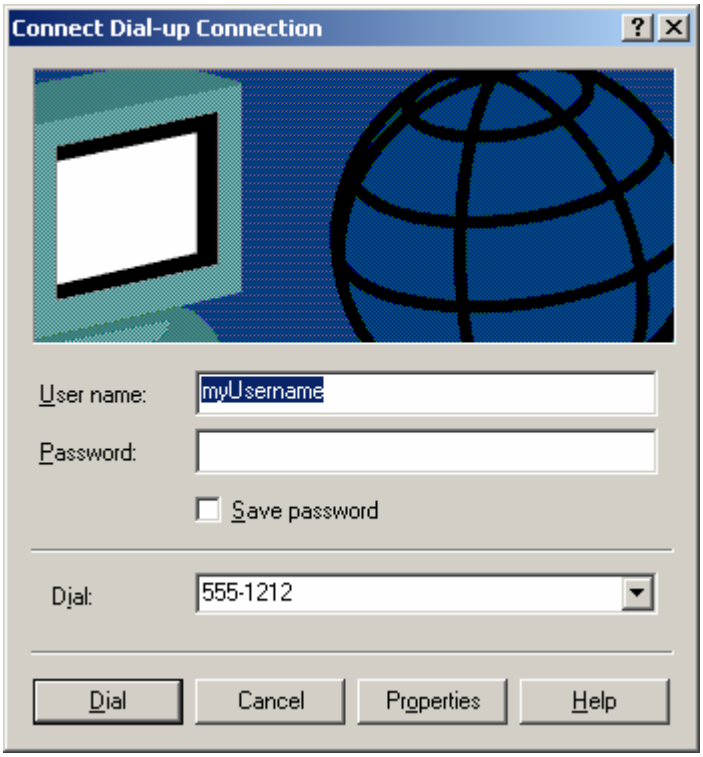
Making a PPP Dial-up Connection to the SCADAPack 32 using Windows 2000

A connection can only be made after successfully setting up a Dial-up Connection icon as described in the section *Connection Setup* above. Also, a serial port on the SCADAPack 32 must already be configured for the PPP protocol using the *Controller IP Configuration* dialog and must be downloaded to the SCADAPack 32.

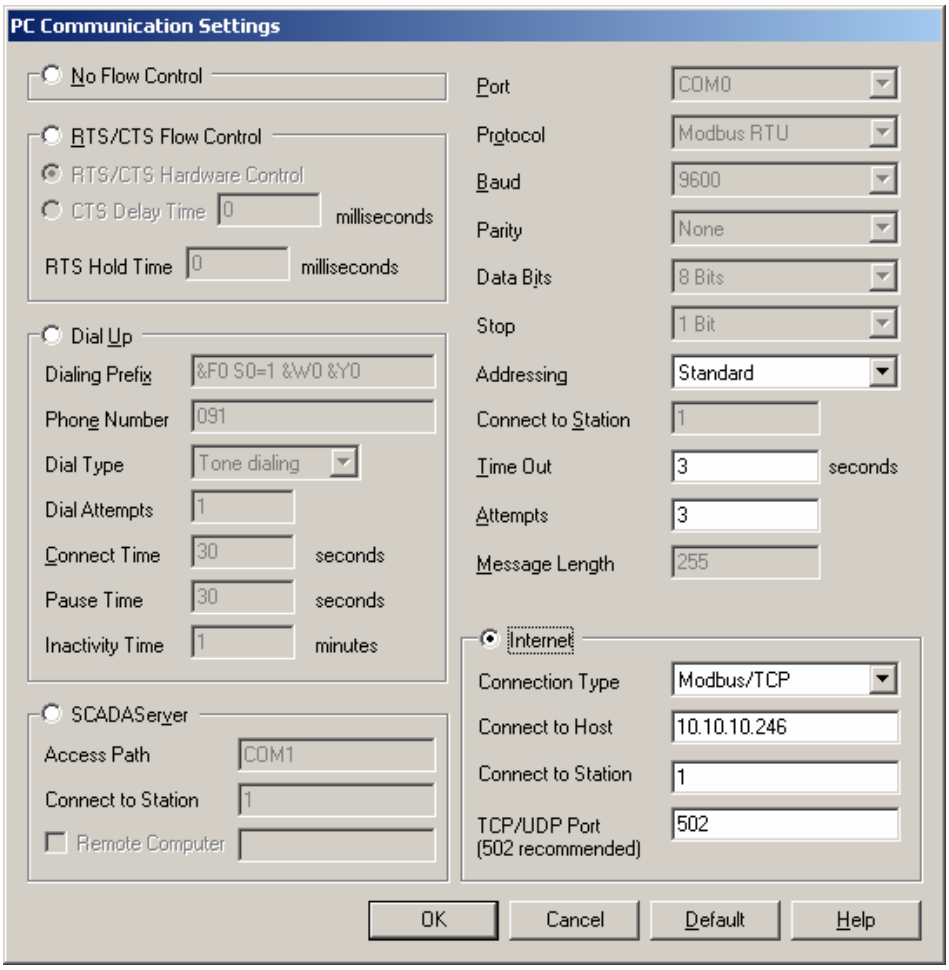
1. From the ***Start*** menu, right click ***Network and Dial-up Connections*** from the ***Settings*** group, and select **Open**. The *Network and Dial-up Connections* dialog is displayed.



2. Right click your *Dial-up Connection* icon that was setup in the previous section and select ***Connect*** from the list. A prompt for username and password is displayed.



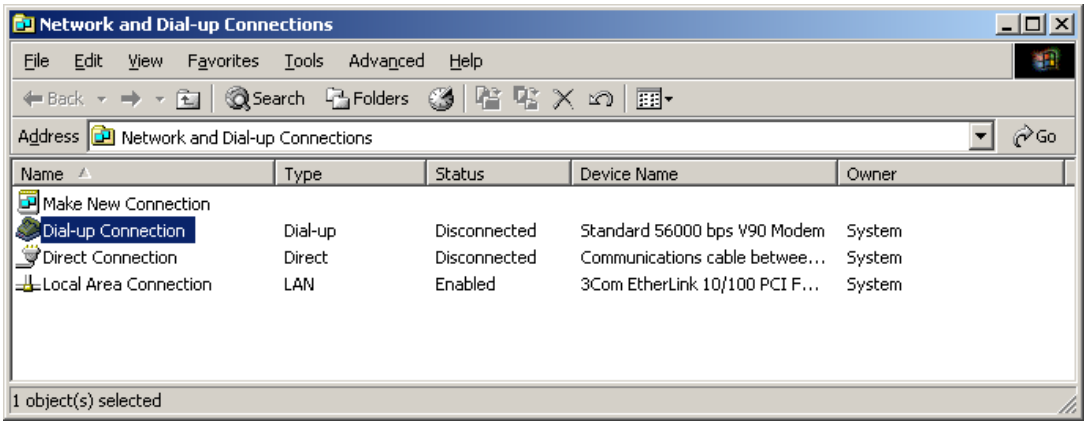
3. Enter a valid PAP or CHAP username and password. Valid usernames and passwords are configured on the *PPP Login* page of the *Controller IP Configuration* dialog and must be downloaded to the SCADAPack 32. Then select the ***Dial*** button. If neither PAP nor CHAP is being used, ignore the prompt and just select the ***Dial*** button.
4. A progress message is displayed. If the connection is successful your *Dial-up Connection* icon should display the word *Connected* in the Status column.
5. You may now connect to the IP address assigned to SCADAPack 32 PPP serial port using an appropriate application and a supported protocol (e.g. Modbus/TCP). In the example below, **Firmware Loader** is used to connect over PPP to the SCADAPack 32. From the *PC Communication Settings* dialog, the IP address assigned to the SCADAPack 32 PPP serial port is selected as the ***Connect to Host***.



Disconnecting a PPP Connection using Windows 2000

To disconnect a PPP connection made using the Windows PPP Client, do the following:

1. From the ***Start*** menu, right click ***Network and Dial-up Connections*** from the ***Settings*** group, and select **Open**. The *Network and Dial-up Connections* dialog is displayed.



2. Your *Dial-up Connection* icon should display the word *Connected* in the Status column. To disconnect, right click your *Dial-up Connection* icon and select ***Disconnect*** from the list.

TelePACE Ladder Logic

DF1 Protocol User Manual

CONTROL MICROSYSTEMS

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Table of Contents

TeleBUS DF1 Protocol Overview

TeleBUS communication protocols provide a standard communication interface to the controller. The protocols operate on a wide variety of serial data links. These include RS-232 serial ports, RS-485 serial ports, radios, leased line modems, and dial up modems. The protocols are generally independent of the communication parameters of the link, with a few exceptions.

TeleBUS protocol commands may be directed to a specific device, identified by its station number, or broadcast to all devices. Up to 255 devices may connect to one communication network.

The TeleBUS protocols provide full access to the I/O database in the controller. The I/O database contains user-assigned registers and general purpose registers. Assigned registers map directly to the I/O hardware or system parameter in the controller. General purpose registers can be used by ladder logic and C application programs to store processed information, and to receive information from a remote device.

Application programs can initiate communication with remote devices. A multiple port controller can be a data concentrator for remote devices, by polling remote devices on one port and responding as a slave on another port.

The protocol type, communication parameters and station address are configured separately for each serial port on a controller. One controller can appear as different stations on different communication networks. The port configuration can be set from an application program, from the TelePACE programming software, or from another Modbus or DF1 compatible device.

Compatibility

There are four TeleBUS DF1 protocols:

- The **TeleBUS DF1 Full-Duplex BCC** protocol is compatible with the DF1 Full-Duplex data link layer protocol with block check character (BCC) error checking.
- The **TeleBUS DF1 Full-Duplex CRC** protocol is compatible with the DF1 Full-Duplex data link layer protocol with 16-bit cyclic redundancy check (CRC-16) error checking.
- The **TeleBUS DF1 Half-Duplex BCC** protocol is compatible with the DF1 Half-Duplex data link layer protocol with block check character (BCC) error checking.
- The **TeleBUS DF1 Half-Duplex CRC** protocol is compatible with the DF1 Half-Duplex data link layer protocol with 16-bit cyclic redundancy check (CRC-16) error checking.

Compatibility refers to communication only. The protocol defines communication aspects such as commands, syntax, message framing, error handling and addressing. The controllers do not mimic the internal functioning of any programmable controller. Device specific functions – those that relate to the hardware or programming of a specific programmable controller – are not implemented.

Serial Port Configuration

Communication Parameters

The TeleBUS DF1 protocols are, in general, independent of the serial communication parameters. The baud rate and parity may be chosen to suit the host computer and the characteristics of the data link.

The port configuration can be set in four ways:

- using the TelePACE program;
- using the **set_port** function from a C application program;
- writing to the I/O database from a C or ladder logic application program; or
- writing to the I/O database remotely from a Modbus or DF1 compatible device.

To configure a serial port through the I/O database, add the module, CNFG Serial port settings, to the Register Assignment.

Protocol Parameters

The TeleBUS DF1 protocols are eight bit character-oriented protocols. The table below shows possible and recommended communication parameters.

Parameter	Possible Settings	Recommended Setting
Baud Rate	see *Baud Rate* section below	see *Baud Rate* section below
Data Bits	8 data bits	8 data bits
Parity	none even odd	none
Stop bits	1 stop bit 2 stop bits[1]	1 stop bit
Flow control	disabled	disabled
Duplex	see *Duplex* section below	see *Duplex* section below

[1] Not applicable on the SCADAPack 350

Baud Rate

The baud rate sets the communication speed. The possible settings are determined by the type of serial data link used. The table below shows the possible settings for the controller. Note that not all port types and baud rates are available on all controller ports.

Port Type	Possible Settings	Recommended Setting
RS-232 or RS-232 Dial-up modem	75 baud 110 baud 150 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud	Use the highest rate supported by all devices on the network.
RS-485	75 baud 110 baud 150 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud	Use the highest rate supported by all devices on the network.

Duplex

The TeleBUS DF1 protocols communicate in one direction at a time. However the duplex setting is determined by the type of serial data link used. The table below shows the possible settings for the controller. Note that not all port types are available on all controllers.

Port Type	Possible Settings	Recommended Setting
RS-232 or RS-232 Dial-up modem	half duplex full duplex	Use full duplex wherever possible. Use half duplex for most external modems.
RS-485	half duplex full duplex	Slave stations always use half duplex. Master stations can use full duplex only on 4 wire systems.

Protocol Parameters

The TeleBUS DF1 protocols operate independently on each serial port. Each port may set the protocol type, station number, protocol task priority and store-and-forward messaging options.

The protocol configuration can be set in four ways:

- using the TelePACE or ISaGRAF programs;
- using the **set_protocol** function from a C application program;
- writing to the I/O database from a C or ladder logic application program; or
- writing to the I/O database remotely from a Modbus or DF1 compatible device.

To configure protocol settings through the I/O database, add the module, CNFG Protocol settings, to the Register Assignment.

Protocol Type

The protocol type may be set to emulate the DF1 or Modbus protocols, or it may be disabled. When the protocol is disabled, the port functions as a normal serial port.

Station Number

The TeleBUS DF1 protocols allow up to 255 devices on a network. Station numbers identify each device. A device responds to commands addressed to it, or to commands broadcast to all stations.

The station number is in the range 0 to 254. Address 255 indicates a command broadcast to all stations, and cannot be used as a station number. Each serial port may have a unique station number.

Task Priority

A task is responsible for monitoring each serial port for messages. The real time operating system (RTOS) schedules the tasks with the application program tasks according to the task priority. The priority can be changed only with the **set_protocol** function from a C application program.

The default task priority is 3. Changing the priority is not recommended.

Store and Forward Messaging

Store and forward messaging is not supported by the TeleBUS DF1 protocols.

Default Parameters

All ports are configured at reset with default parameters when the controller is started in SERVICE mode. The ports use user-defined parameters when the controller is reset in the RUN mode. The default parameters are listed below.

Parameter	com1	com2	Com3	com4
Baud rate	9600	9600	9600	9600
Parity	none	none	None	none
Data bits	8	8	8	8

Parameter	com1	com2	Com3	com4
Stop bits	1	1	1	1
Duplex	full	full	Half	half
Protocol	Modbus RTU	Modbus RTU	Modbus RTU	Modbus RTU
Station	1	1	1	1
Rx flow control	none	none	Rx disable	Rx disable
Tx flow control	none	none	None	none
Serial time out	60 s	60 s	60 s	60 s
Type	RS-232	RS-232	RS-232	RS-232
Minimum Protected DF1 Address	0	0	0	0
Maximum Protected DF1 Address	11534	11534	11534	11534

Notes

com3 is supported only when the SCADAPack Lower I/O module is installed. com4 is supported only when the SCADAPack Upper I/O module is installed.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

I/O Database

The TeleBUS protocols read and write information from the I/O database. The I/O database is an area of memory that can be accessed by C programs, Ladder Logic programs, ISaGRAF programs and communication protocols. The I/O database allows data to be shared between these programs. The I/O database contains user-assigned registers and general purpose registers.

User-assigned registers map directly to the I/O hardware or system parameter in the controller. Assigned registers are initialized to the default hardware state or system parameter when the controller is reset. Assigned output registers do not maintain their values during power failures. However, output registers do retain their values during application program loading.

General purpose registers are used by ladder logic, ISaGRAFand C application programs to store processed information, and to receive information from remote devices. General purpose registers retain their values during power failures and application program loading. The values change only when written by an application program or a communication protocol.

Coil and Status Registers

Coil and status registers contain one bit of information, that is whether a signal is off or on.

For TelePACE firmware coil registers are single bits, which the protocols can read and write. There are 4096 coil registers located in the digital output section of the I/O database. Coil registers are contained within the DF1 16-bit addresses 0 to 255.

For TelePACE firmware status registers are single bits, which the protocols can read. There are 4096 status registers located in the digital input section of the I/O database. Status registers are contained within the DF1 16-bit addresses 256 to 511.

For ISaGRAF firmware coil registers are single bits, which the protocols can read and write. There are 9999 coil registers located in the digital output section of the I/O database. Coil registers are contained within the DF1 16-bit addresses 0 to 624.

For ISaGRAF firmware status registers are single bits, which the protocols can read. There are 9999 status registers located in the digital input section of the I/O database. Status registers are contained within the DF1 16-bit addresses 625 to 1249.

Coil and status registers are accessed 16 at a time or individually (in some commands) using a bitmask. Writing a one to a bit within the 16-bit address turns the bit on. Writing zero to the bit turns the bit off. If the register is assigned to an I/O module, the bit status is written to the module output hardware or parameter.

Reading a coil or status register returns 1 if the bit is on, or 0 if the bit is off. The stored value is returned from general purpose registers. The I/O module point status is returned from assigned registers.

Input and Holding Registers

Input and holding registers contain 16-bit values.

Input registers are 16-bit registers, which the protocol can read. For TelePACE firmware, there are 1024 input registers located in the analog input section of the I/O database. Input registers are contained within the DF1 addresses 512 to 1535.

For ISaGRAF firmware there are 9999 input registers located in the analog input section of the I/O database. Input registers are contained within the DF1 addresses 1250 to 11247.

Holding registers are 16-bit registers that the protocol can read and write. For TelePACE firmware there are 9999 holding registers located in the analog output section of the I/O database. Holding registers are contained within the DF1 addresses 1536 to 11534.

For ISaGRAF firmware there are 9999 holding registers located in the analog output section of the I/O database. Holding registers are contained within the DF1 addresses 11248 to 21247.

Writing any value to a general purpose register stores the value in the register. Writing a value to an assigned register, writes the value to the assigned I/O module.

Reading a general purpose register returns the value stored in the register. Reading an assigned register returns the value read from the I/O module.

Accessing the I/O Database Using TelePACE

Ladder logic programs access the I/O database through function blocks. All function blocks can access the I/O database. The function blocks in ladder logic use only the Modbus addressing scheme. Refer to the ***TelePACE Ladder Logic Reference and User Manual*** for details.

C language programs access the I/O database with two functions. The **dbase** function reads a value from the I/O database. The **setdbase** function writes a value to the I/O database. These functions use either Modbus or DF1 physical addressing. Refer to the ***TelePACE C Tools Reference and User Manual*** for full details on these functions.

Modbus Addressing

Modbus addressing is used in all ladder logic program functions. The controller's Register Assignment is also configured using Modbus addresses. The C functions **dbase** and **setdbase** support Modbus addressing. When the specified port is configured for one of the Modbus protocols, the function **master_message** uses Modbus addressing.

The range of Modbus registers available depends on the controller being used. The following sections list the Modbus registers available for each controller type.

SCADAPack, SCADAPack 100: 1024K and SCADASense 4202 Series

Coil registers are single bit addresses ranging from 00001 to 04096.

Status registers are single bit addresses ranging from 10001 to 14096.

Input registers are 16-bit addresses in the range 30001 to 31024.

Holding registers are 16-bit addresses in the range 40001 to 49999.

SCADAPack 100: 256K Controllers

Coil registers are single bit addresses ranging from 00001 to 04096.

Status registers are single bit addresses ranging from 10001 to 14096.

Input registers are 16-bit addresses in the range 30001 to 30512.

Holding registers are 16-bit addresses in the range 40001 to 44000.

SCADAPack 350, SCADAPack 32, and SCADASense 4203 Series

Coil registers are single bit addresses ranging from 00001 to 04096.

Status registers are single bit addresses ranging from 10001 to 14096.

Input registers are 16-bit addresses in the range 30001 to 39999.

Holding registers are 16-bit addresses in the range 40001 to 49999.

DF1 Addressing

DF1 addressing is used by the **MSTR** ladder logic function when the specified port is configured for one of the DF1 protocols. Modbus addressing must be used in all other ladder logic program functions.

DF1 addressing is used by function **master_message** when the specified port is configured for one of the DF1 protocols. The functions **dbase**, **setdbase**, **setABConfiguration** and **getABConfiguration** also support DF1 addressing.

All DF1 addresses are absolute word addresses beginning with the first 16-bit register in the I/O database at address 0.

Converting Modbus to DF1 Addresses

I/O database registers are assigned within the controller's Register Assignment using Modbus addressing. When polling the controller from a DF1 device it is necessary to know the DF1 address corresponding to each assigned register. Refer to the section for the controller type being used.

SCADAPack, SCADAPack 100: 1024K and SCADASense 4202 Series

In general, the cross-reference between Modbus and DF1 addressing is shown in the following table. DF1 addresses in this table are described in the format **word/bit** where **word** is the address of a 16-bit word and **bit** is the bit within that word. The bit address is optional.

Address Range		Description
Modbus DF1	00001 to 04096 0/0 to 255/15	Digital Output Database (single bit registers)
Modbus DF1	10001 to 14096 256/0 to 511/15	Digital Input Database (single bit registers)
Modbus DF1	30001 to 31024 512 to 1535	Analog Input Database (16-bit registers)
Modbus DF1	40001 to 49999 1536 to 11534	Analog Output Database (16-bit registers)

Coil Registers

To convert a Modbus coil register, *ModbusCoil*, to a DF1 address word/bit:

word = (*ModbusCoil* - 00001) / 16
bit = remainder of { (*ModbusCoil* - 00001) / 16 }

Status Registers

To convert a Modbus status register, *ModbusStatus*, to a DF1 address word/bit:

word = (*ModbusStatus* - 10001) / 16 + 256
bit = remainder of { (*ModbusStatus* - 10001) / 16 }

Input Registers

To convert a Modbus input register, *ModbusInput*, to a DF1 address word:

word = (*ModbusInput* - 30001) + 512

Holding Registers

To convert a Modbus holding register, *ModbusHolding*, to a DF1 address word:

word = (*ModbusHolding* - 40001) + 1536

Example

In this example the equivalent DF1 addresses are shown next to a sample SCADAPack Register Assignment specified with Modbus addresses.

Module	Start Register	End Register	DF1 Address Range
SCADAPack 5601 I/O module			
digital outputs	00001	00012	0/0 to 0/11
digital inputs	10001	10016	256/0 to 256/15
analog inputs	30001	30008	512 to 519
DIN Controller digital inputs	10017	10019	257/0 to 257/2
DIAG Force LED	10020	10020	257/3
SCADAPack AOUT module	40001	40002	1536 to 1537

SCADAPack 350 and SCADAPack 32 Controllers

In general, the cross-reference between Modbus and DF1 addressing is shown in the following table. DF1 addresses in this table are described in the format **word/bit** where **word** is the address of a 16-bit word and **bit** is the bit within that word. The bit address is optional.

Address Range		Description
Modbus DF1	00001 to 04096 0/0 to 255/15	Digital Output Database (single bit registers)
Modbus DF1	10001 to 14096 256/0 to 511/15	Digital Input Database (single bit registers)
Modbus DF1	30001 to 39999 512 to 10510	Analog Input Database (16-bit registers)
Modbus DF1	40001 to 49999 10511 to 20511	Analog Output Database (16-bit registers)

Coil Registers

To convert a Modbus coil register, *ModbusCoil*, to a DF1 address word/bit:

word = (*ModbusCoil* - 00001) / 16
bit = remainder of { (*ModbusCoil* - 00001) / 16 }

Status Registers

To convert a Modbus status register, *ModbusStatus*, to a DF1 address word/bit:

word = (*ModbusStatus* - 10001) / 16 + 256
bit = remainder of { (*ModbusStatus* - 10001) / 16 }

Input Registers

To convert a Modbus input register, *ModbusInput*, to a DF1 address word:

word = (*ModbusInput* - 30001) + 512

Holding Registers

To convert a Modbus holding register, *ModbusHolding*, to a DF1 address word:

word = (*ModbusHolding* - 40001) + 10511

Example

In this example the equivalent DF1 addresses are shown next to a sample SCADAPack Register Assignment specified with Modbus addresses.

Module	Start Register	End Register	DF1 Address Range
SCADAPack 5601 I/O module			
digital outputs	00001	00012	0/0 to 0/11
digital inputs	10001	10016	256/0 to 256/15
analog inputs	30001	30008	512 to 519
DIN Controller digital inputs	10017	10019	257/0 to 257/2
DIAG Force LED	10020	10020	257/3
SCADAPack AOUT module	40001	40002	10511 to 10512

Accessing the I/O Database Using ISaGRAF

ISaGRAF programs access the I/O database through function blocks. The function blocks in ISaGRAF may use the Modbus addressing scheme when a Network Address is defined for a variable. Refer to the ***IEC 61131 User Manual*** for details.

C language programs access the I/O database with two functions. The **dbase** function reads a value from the I/O database. The **setdbase** function writes a value to the I/O database. These functions use either Modbus or DF1 physical addressing. Refer to the ***IEC 61131 User Manual*** for full details on these functions.

Modbus Addressing

Modbus addressing can be used in ISaGRAF program functions.

The C functions **dbase** and **setdbase** support Modbus addressing. When the specified port is configured for one of the Modbus protocols, the function **master_message** uses Modbus addressing.

Modbus addresses coil registers with a single bit address ranging from 00001 to 09999. Status registers are also addressed with single bit addresses ranging from 10001 to 19999. Input registers are addressed with 16-bit addresses in the range 30001 to 39999. And holding registers are addressed with a 16-bit address in the range 40001 to 49999.

DF1 Addressing

DF1 addressing is used by the **master** function when the specified port is configured for one of the DF1 protocols. Modbus addressing must be used in all other ladder logic program functions.

DF1 addressing is used by function **master_message** when the specified port is configured for one of the DF1 protocols. The functions **dbase**, **setdbase**, **setABConfiguration** and **getABConfiguration** also support DF1 addressing.

All DF1 addresses are absolute word addresses beginning with the first 16-bit register in the I/O database at address 0 and ending at address 21247.

Converting Modbus to DF1 Addresses

I/O database registers are assigned within the controller's Register Assignment using Modbus addressing. When polling the controller from an DF1 device it is necessary to know the DF1 address corresponding to each assigned register.

In general, the cross-reference between Modbus and DF1 addressing is shown in the following table. DF1 addresses in this table are described in the format **word/bit** where **word** is the address of a 16-bit word and **bit** is the bit within that word. The bit address is optional.

Address Range		Description
Modbus DF1	00001 to 09999 0/0 to 624/15	Digital Output Database (single bit registers)
Modbus DF1	10001 to 19999 625/0 to 1249/15	Digital Input Database (single bit registers)
Modbus DF1	30001 to 39999 1250 to 11248	Analog Input Database (16-bit registers)
Modbus DF1	40001 to 49999 11249 to 21247	Analog Output Database (16-bit registers)

Coil Registers

To convert a Modbus coil register, *ModbusCoil*, to an DF1 address word/bit:

word = (*ModbusCoil* - 00001) / 16

bit = remainder of { (*ModbusCoil* - 00001) / 16 }

Status Registers

To convert a Modbus status register, *ModbusStatus*, to an DF1 address word/bit:

word = (*ModbusStatus* - 10001) / 16 + 625

bit = remainder of { (*ModbusStatus* - 10001) / 16 }

Input Registers

To convert a Modbus input register, *ModbusInput*, to an DF1 address word:

word = (*ModbusInput* - 30001) + 1250

Holding Registers

To convert a Modbus holding register, *ModbusHolding*, to an DF1 address word:

word = (*ModbusHolding* - 40001) + 11249

Example

In this example the equivalent DF1 addresses are shown next to a sample SCADAPack Register Assignment specified with Modbus addresses.

Module	Start Register	End Register	DF1 Address Range
SCADAPack 5601 I/O module			
digital outputs	00001	00012	0/0 to 0/11
digital inputs	10001	10016	625/0 to 625/15
analog inputs	30001	30008	1250 to 1257

Module	Start Register	End Register	DF1 Address Range
DIN Controller digital inputs	10017	10019	626/0 to 626/2
DIAG Force LED	10020	10020	626/3
SCADAPack AOUT module	40001	40002	11249 to 111250

Slave Mode

The TeleBUS DF1 protocols operate in slave and master modes simultaneously. In slave mode the controller responds to commands sent by another device. Commands may be sent to a specific device or broadcast to all devices.

The TeleBUS DF1 protocols emulate the protocol functions required for communication with a host device which uses the Non-Privileged commands from the DF1 Basic Command Set. These functions are described below.

Consult the DF1 I/O driver documentation included with the SCADA package, or specific DF1 documentation, for details on these commands. In most cases a knowledge of the actual commands is not required to set up the host system.

Broadcast Messages

A broadcast message is sent to all devices on a network. Each device executes the command. No device responds to a broadcast command. The device sending the command must query each device to determine if the command was received and processed. Broadcast messages are supported for function codes that write information.

A broadcast message is sent to station number 255.

Function Codes

The table summarizes the implemented function codes. Note that slave commands at the protocol layer access the I/O database in physical byte addresses. However, in master mode the interface to the TeleBUS DF1 protocol accesses the I/O database in physical 16-bit word addresses. The interface function block **MSTR** and C function **master_message** are described in the *Master Mode* section below.

The maximum number of 16-bit words that can be read or written with one slave command message is shown in the maximum column.

Function	Name	Description	Maximum
00	Protected Write	Writes words of data to limited areas of the database.	121
01	Unprotected Read	Reads words of data from any area of the database.	122
02	Protected Bit Write	Sets or resets individual bits within limited areas of the database.	30
05	Unprotected Bit Write	Sets or resets individual bits in any area of the database.	30
08	Unprotected Write	Writes words of data to any area of the database.	121

Functions 0, 2, 5 and 8 support broadcast messages. The functions are described in detail below.

Protected Write

The Protected Write function writes 8 bit values into limited areas of the I/O database. Access to the I/O database is limited to the protected address range.

Any number of bytes may be written up to the maximum number. The write may start at any byte address, provided the entire block is within the protected address range.

The protected address range is set using the **setABConfiguration** function from a C application program.

Unprotected Read

The Unprotected Read function reads 8 bit values from any area of the I/O database. Access to the I/O database is limited to the unprotected address range.

Any number of bytes may be read up to the maximum number. The read may start at any byte address, provided the entire block is within the unprotected address range.

Protected Bit Write

The Protected Bit Write function sets or resets individual bits within limited areas of the I/O database. Access to the I/O database is limited to the protected address range.

Bits are accessed one byte at a time and may be written up to the maximum number of bytes. The write may start at any byte address, provided the entire block is within the protected address range.

Unprotected Bit Write

The Unprotected Bit Write function sets or resets individual bits in any area of the I/O database. Access to the I/O database is limited to the unprotected address range.

Bits are accessed one byte at a time and may be written up to the maximum number of bytes. The write may start at any byte address, provided the entire block is within the unprotected address range.

Unprotected Write

The Unprotected Write function writes 8 bit values into any area of the I/O database. Access to the I/O database is limited to the unprotected address range.

Any number of bytes may be written up to the maximum number. The write may start at any byte address, provided the entire block is within the unprotected address range.

Master Mode

The TeleBUS DF1 protocols may act as a communication master on any serial port. In master mode, the controller sends commands to other devices on the network. Simultaneous master messages may be active on all ports.

Function Codes

The table shows the implemented function codes. Note that slave commands at the protocol layer access the I/O database in physical byte addresses. However, in master mode the interface to the TeleBUS DF1 protocol accesses the I/O database in physical 16-bit word registers. The interface function block **MSTR** and C function **master_message** are described in the *Sending Messages* section below.

The maximum number of 16-bit registers that can be read or written with one message is shown in the maximum column. The slave device may support fewer registers than shown; consult the manual for the device for details.

Function	Name	Description	Maximum
00	Protected Write	Writes words of data to limited areas of the database.	121
01	Unprotected Read	Reads words of data from any area of the database.	122
02	Protected Bit Write	Sets or resets individual bits within limited areas of the database.	1
05	Unprotected Bit Write	Sets or resets individual bits in any area of the database.	1
08	Unprotected Write	Writes words of data to any area of the database.	121

Protected Write

The Protected Write function writes 16-bit values into the I/O database of the slave device. Access to the I/O database is limited to the protected address range of the slave device. The data may come from any area of the master I/O database within its unprotected address range.

Any number of 16-bit registers may be written up to the maximum number supported by the slave device or the maximum number above, which ever is less. The write may start at any 16-bit register, provided the entire block is within the protected address range of the slave device.

Unprotected Read

The Unprotected Read function reads 16-bit values from any area of the I/O database of the slave device. Access to the I/O database is limited to the unprotected address range of the slave device. Data can be written into any area of the master I/O database within its unprotected address range.

Any number of 16-bit registers may be read up to the maximum number supported by the slave device or the maximum number above, which ever is less. The read may start at any

16-bit register, provided the entire block is within the unprotected address range of the slave device.

Protected Bit Write

The Protected Bit Write function sets or resets individual bits in the I/O database of the slave device. Access to the I/O database is limited to the protected address range of the slave device. The data may come from any area of the master I/O database within the unprotected address range.

One 16-bit register with a bitmask is used to write up to 16 bits of data. The register must be within the protected address range of the slave device.

Unprotected Bit Write

The Unprotected Bit Write function sets or resets individual bits in any area of the I/O database of the slave device. Access to the I/O database is limited to the unprotected address range of the slave device. The data may come from any area of the master I/O database within its unprotected address range.

One 16-bit register with a bitmask is used to write up to 16 bits of data. The register must be within the unprotected address range of the slave device.

Unprotected Write

The Unprotected Write function writes 16-bit values into any area of the I/O database of the slave device. Access to the I/O database is limited to the unprotected address range of the slave device. The data may come from any area of the master I/O database within its unprotected address range.

Any number of 16-bit registers may be written up to the maximum number supported by the slave device or the maximum number above, which ever is less. The write may start at any 16-bit register, provided the entire block is within the unprotected address range of the slave device.

Sending Messages

A master message is initiated in two ways:

- using the **master_message** function from a C application program; or
- using the **MSTR** function block from a ladder logic program.

These functions specify the port on which to issue the command, the function code, the slave station number, and the location and size of the data in the slave and master devices. The protocol driver, independent of the application program, receives the response to the command.

The application program detects the completion of the transaction by:

- calling the **get_protocol_status** function in a C application program; or
- using the output of the **MSTR** function block in a ladder logic program.

A communication error has occurred if the slave does not respond within the expected maximum time for the complete command and response. The application program is responsible for detecting this condition. When errors occur, it is recommended that the application program retry several times before indicating a communication failure.

The completion time depends on the length of the message, the length of the response, the number of transmitted bits per character, the transmission baud rate, and the maximum message turn-around time. One to three seconds is usually sufficient. Radio systems may require longer delays.

Polling DF1 PLCs

All DF1 PLCs, except the PLC-5/VME, will support some portion of the basic commands implemented.

AB PLC	Unprotected Read	Unprotected Write	Protected Write	Protected Bit Write	Unprotected Bit Write
MicroLogix 1000 [4]	√	√			
SLC500 [1,3]	√	√			
SLC5/01 [1,3]	√	√			
SLC5/02 [1,2,3]	√	√			
SLC5/03 [2,3]	√	√			
SLC5/04 [2,3]	√	√			
1774-PLC	√	√	√	√	√
PLC-2	√	√	√	√	√
PLC-3 [5]	√	√	√	√	√
PLC-5 [5]	√	√	√	√	√
PLC-5/250 [5]	√	√		√	√
PLC-5/VME					

Notes

[1] At the protocol level these commands convert and send the slave word address as a byte address. The SLC500, 5/01 (and 5/02, prior to Series C FRN 3) treat this byte address as if it were a word address in the SLC500. This means that the (desired word address)/2 must be specified for the Slave Register Address in MSTR or master_message. Note that this always results in an even starting word address in the slave SLC. (E.g. Slave word address of 7 specified in MSTR accesses SLC word address 14.)

[2] The SLC5/02, 5/03 and 5/04 have a status selection bit (S:2/8) which allows selection of either word or byte addressing when interpreting only these commands. (Setting SLC bit S:2/8 = 1 selects byte addressing so that, for example, a slave word address of 7 specified in MSTR accesses SLC word address 7.)

[3] These commands can access SLC memory only in the CIF or Common Interface File: N9. See further details in section 12-15 of the SLC500 Instruction Set manual.

[4] These commands can access MicroLogix memory only in the CIF or Common Interface File: N7. See further details in section 12-15 of the MicroLogix 1000 Instruction Set manual.

[5] These commands can access memory only in the CIF or “PLC-2 compatibility file”: N7. See further details in section 16-7 of the PLC-5 manual.

DNP3

User and Reference Manual

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Table of Contents

1 Using This Manual

The manual details implementation of the Distributed Network Protocol (DNP3) on SCADAPack controllers. The manual describes the functionality of SCADAPack controllers under certain DNP network topologies and fully details each DNP configuration parameter available on SCADAPack controllers. Although we continuously add tidbits of relevant information, especially when explaining each SCADAPack parameter in the overall scheme of the DNP3 concept, this manual does not serve as a complete DNP3 Technical Reference guide.

The manual is arranges as follows:

Section **2- *DNP3 Overview*** provides background information on DNP.

Section **3-*DNP Network*** describes network configurations for using DNP in a SCADA system.

Section **4-*Configuration of DNP*** Operation Modes describes the configuration guidelines for using SCADAPack controllers in DNP networks.

Section **5-*DNP Configuration*** is the complete reference for the DNP Configuration command when selected in TelePACE, ISaGRAF, and RealFLO applications.

Section ***6.1-DNP Status*** is the complete reference for the DNP Status command when selected in TelePACE, ISaGRAF, and RealFLO applications. DNP Status provides run-time DNP diagnostics and current data values for the local DNP points.

Section ***6.2-DNP Master Status*** section is the complete reference for the DNP Master Status command when selected in TelePACE, ISaGRAF, and RealFLO applications. DNP Status provides run-time DNP diagnostics and status of the DNP outstations defined in the Master station and current data values for the DNP points in these outstations.

Section **7-*DNP Device Profile Document - Master*** contains the DNP device profile for SCADAPack DNP master stations. All objects and function codes supported by the DNP master are listed in this document.

Section **8-*DNP Device Profile Document - Slave*** contains the DNP device profile for SCADAPack DNP slave stations. All objects and function codes supported by the DNP slave are listed in this document.

2 DNP3 Overview

DNP, the Distributed Network Protocol, is a standards-based communications protocol developed to achieve interoperability among systems in the electric utility, oil & gas, water/waste water and security industries. This robust, flexible non-proprietary protocol is based on existing open standards to work within a variety of networks.

DNP offers flexibility and functionality that go far beyond conventional communications protocols. Among its robust and flexible features DNP 3.0 includes:

- Multiple data types (Data Objects) may be included in both request and response messages.
- Multiple master stations are supported for outstations.
- Unsolicited responses may be initiated from outstations to master stations.
- Data types (Objects) may be assigned priorities (Class) and be requested based on the priority.
- Addressing for over 65,000 devices on a single link.
- Time synchronization and time-stamped events.
- Broadcast messages
- Data link and application layer confirmation

2.1 DNP Architecture

DNP is a layered protocol that is based on the Open System Connection (OSI) 7-layer protocol. DNP supports the physical, data link and application layers only and terms this the Enhanced Performance Architecture (EPA). In addition to these three layers an additional layer, the pseudo-transport layer, is added to allow for larger application layer messages to be broken down into smaller frames for the data link layer to transmit.

Object Library	The data objects (Binary Inputs, Binary Outputs, and Analog Inputs etc.) that reside in the master or outstation.
Application Layer	Application tasks for sending of solicited requests (master messages) to outstations or sending of unsolicited responses from outstations. These request and response messages are referred to as fragments in DNP.
Pseudo-Transport Layer	Breaks the application layer messages into smaller packets that can be handled by the data link layer. These packets are referred to as frames in DNP.
Data Link Layer	Handles the transmission and reception of data frames across the physical layer.
Physical Layer	This is the physical media, such as serial or Ethernet, which DNP communicates.

These layers are described in the following sections of this manual.

2.1.1 Object Library

The data types that are used in DNP are broadly grouped together into Object Groups such as Binary Input Objects and Analog Input Objects etc. Individual data points, or objects within each group, are further defined using Object Variations such as Binary Input Change with Time and 16-Bit Analog Inputs for example.

The data objects and variations supported by the SCADAPack series controllers are found in the ***DNP Device Profile Document - Slave*** and ***DNP Device Profile Document - Master*** sections of this user manual.

In general there are two categories of data within each data type, static objects and event objects. Static objects contain the current value of the field point or software point. Event objects are generated as a result of the data changing.

In addition to the object group and variation data objects can be assigned to classes. In DNP there are four object classes, Class 0, Class 1, Class 2 and Class 3. Class 0 contains all static data. Classes 1, 2 and 3 provide a method to assign priority to event objects. While there is no fixed rule for assigning classes to data objects typically class 1 is assigned to the highest priority data and class 3 is assigned to the lowest priority data.

This object library structure enables the efficient transfer of data between master stations and outstations. The master station can poll for high priority data (class 1) more often than it polls for low priority data (class 3). As the data objects assigned to classes is event data when the master polls for a class only the changed, or event data, is returned by the outstation. For data in an outstation that is not assigned a class the master uses a class 0 poll to retrieve all static data from the outstation.

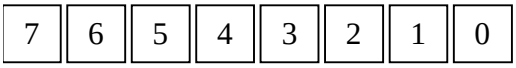
DNP allows outstations to report data to one or more master stations using unsolicited responses (report by exception) for event data objects. The outstation reports data based on the assigned class of the data. For example the outstation can be configured to only report high priority class 1 data.

2.1.1.1 Internal Indication (IIN) Flags

An important data object is the Internal Indications (IIN) object. The Internal Indication (IIN) flags are set by a slave station to indicate internal states and diagnostic results. The following tables show the IIN flags supported by SCADAPack controllers. All bits except *Device Restarted* and *Time Synchronization required* are cleared when the slave station receives any poll or read data command.

The IIN is set as a 16 bit word divided into two octets of 8 bits. The order of the two octets is:

2.1.1.1.1 IIN First Octet



First Octet Bit	Description
0	last received message was a broadcast message
1	Class 1 data available
2	Class 2 data available
3	Class 3 data available
4	Time Synchronization required
5	not used (returns 0)
6	Device trouble • Indicates memory allocation error in the slave, or • For master in mimic mode indicates communication failure with the

First Octet Bit	Description
	slave device.
7	Device restarted (set on a power cycle)

2.1.1.1.2 IIN Second Octet

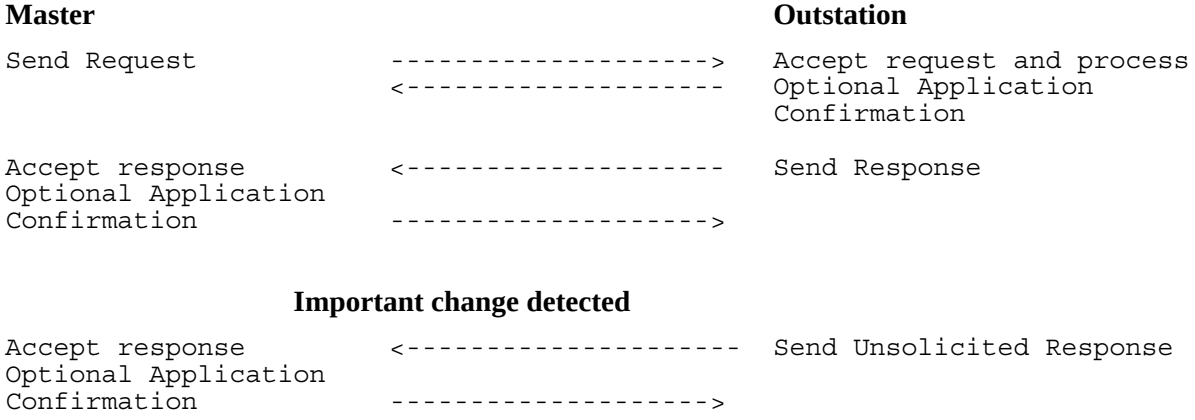
7	6	5	4	3	2	1	0	Bit Number

Second Octet Bit	Description
0	Function Code not implemented
1	Requested object unknown or there were errors in the application data
2	Parameters out of range
3	Event buffer overflowed Indicates event buffer overflow in the slave or master. The slave will set this bit if the event buffer in the slave is overflowed. The master will set this bit if the event buffer in the master has overflowed with events read from the slave. Ensure the event buffer size, in the master and slave, is set to a value that will ensure the buffer does not overflow and events are lost.
4	not used (returns 0)
5	not used (returns 0)
6	not used (returns 0)
7	not used (returns 0)

2.1.2 Application Layer

The application layer in DNP is responsible for the processing of complete messages for requesting, or responding to requests, for data.

The following shows the sequence of Application Layer messages between one master and one outstation.



The complete messages are received from and passed to the pseudo-transport layer. Application layer messages are broken into fragments with each fragment size usually a maximum of 2048 bytes. An application layer message may be one or more fragments in size and it is the responsibility of the application layer to ensure the fragments are properly sequenced.

Application layer fragments are sent with or without a confirmation request. When a confirmation is requested the receiving device replies with a confirmation indicating the message was received and parsed without any errors.

2.1.3 Pseudo-Transport Layer

The pseudo-transport layer formats the larger application layer messages into smaller packets that can be handled by the data link layer. These packets are referred to as frames in DNP. The pseudo-transport layer inserts a single byte of information in the message header of each frame. This byte contains information such as whether the frame is the first or last frame of a message as well as a sequence number for the frame.

2.1.4 Data Link Layer

The data link layer handles the transmission and reception of data frames across the physical layer. Each data link frame contains a source and destination address to ensure the receiving device knows where to send the response. To ensure data integrity data link layer frames contain two CRC bytes every 16 bytes.

Data link layer frames are sent with or without a confirmation request. When a confirmation is requested the receiving device replies with a confirmation indicating the message was received and the CRC checks passed.

2.1.5 Physical Layer

The physical layer handles the physical media, such as serial or Ethernet, which DNP communicates.

2.2 Modbus Database Mapping

In SCADAPack series controllers static DNP objects such as binary input, analog input, binary counter and analog output are associated with Modbus registers. Whenever a DNP object is created an associated Modbus register(s) is also assigned. Application programs executing in the SCADAPack controller, C or logic, are able to assign physical I/O to Modbus registers using the TelePACE Register Assignment or the ISaGRAF I/O Connection and these physical I/O points can then be assigned to DNP objects. User application data such as runtimes, flow totals etc. may be also be assigned to DNP objects.

This architecture enables DNP master stations and outstations to pass not only physical data points between them but also to monitor and control user applications executing in the SCADAPack controller. For example a master station can monitor a level in an outstation and then, based on the application program, send a setpoint value to another outstation to control the level.

3 DNP Network Architectures

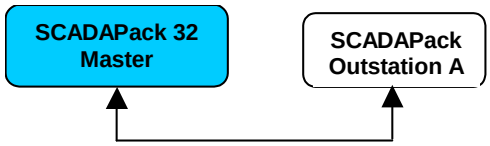
This section of the manual describes some of the DNP networks in which SCADAPack controllers are used. The network descriptions provide an overview of network. A step-by-step procedure for configuring a SCADAPack for each network implementation is described in proceeding sections.

3.1 DNP Master and Outstation

This configuration is a simple DNP Master (Client) and Outstation (Server). The SCADAPack DNP Master may be configured to periodically poll the SCADAPack Outstation for Class 0, 1, 2, and 3 data objects and receive unsolicited responses from the outstation. The SCADAPack outstation may be configured to report change event data to the master station using unsolicited responses.

The arrowed line between the Master and Outstation in the diagram below represents a communication path connecting the two stations. This communication medium may be any type that is supported by both controllers, such as direct serial, leased line modem, dial-up modem and radio for example.

See the sections ***DNP Master*** and ***DNP Outstation*** for configuration details on this type of network.



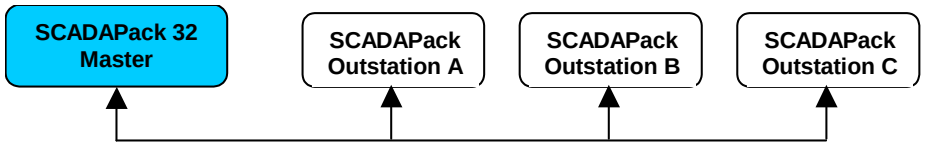
Note: A DNP Master can be configured on SCADAPack 350 and SCADAPack32 controllers only.

3.2 DNP Master and Multidrop Outstations

This configuration is a modification of the above example. In this configuration a DNP Master is connected to a number of Outstations. The SCADAPack DNP Master may be configured to periodically poll each SCADAPack Outstation for Class 0, 1,2, and 3 data objects and receive unsolicited responses from the outstations. The SCADAPack Outstations may be configured to report change event data to the master station using unsolicited responses.

The arrowed line between the Master and Outstations in the diagram below represents the communication path connecting the stations. This communication path may be any type that is supported by the controllers, such as leased line modem, dial-up modem and radio for example.

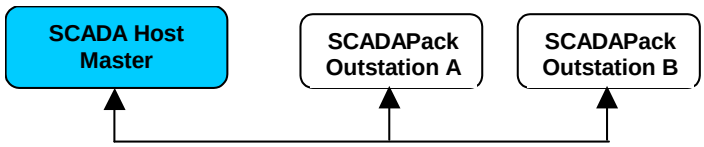
See the sections ***4.2- DNP Master*** and ***4.1-DNP Outstation*** for configuration details.



Note: A DNP Master can be configured on SCADAPack 350 and SCADAPack32 controllers only.

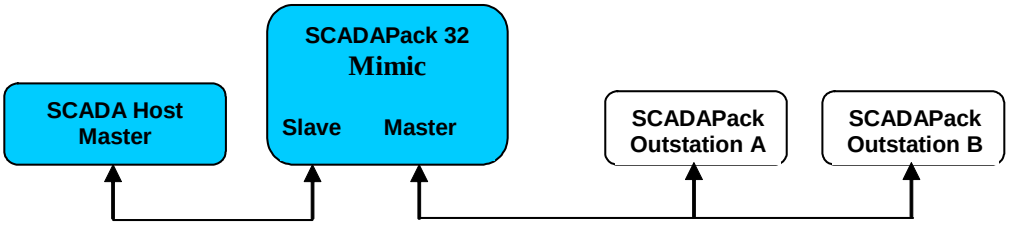
3.3 DNP Mimic Mode

In a typical DNP network a SCADA Host master communicates with a number of outstations. The SCADA Host will poll each outstation for data and may receive change event data in the form of unsolicited responses from the outstations. This type of DNP network is shown in the following diagram.



In the above configuration the SCADA Host manages the communication path with each outstation as represented by the arrowed lines in the diagram. When the communication path is slow, such as with dial-up communication, or subject to high error rates, such as with some radio communication the data update rate at the SCADA host can become very slow.

Adding a SCADAPack 32 master configured for Mimic Mode to the network, for instance, allows for the SCADA Host Master to poll the SCADAPack 32 (Mimic Master) for all outstation data instead. The following diagram shows the addition of the SCADAPack 32 master.



In this configuration the outstation side of the network has been decoupled from the host side of the network, as the SCADAPack 32 mimic master now manages all the communication with the outstations. The SCADA Host still communicates as before, through one link, targeting each outstation. However the SCADAPack 32 master now intercepts all these messages, and responds on behalf of the targeted outstation. From the perspective of the SCADA Host, the response is coming back from the remote outstation.

In order to provide current outstation data to the SCADA Host, the SCADAPack mimicking master independently communicates with each outstation to update a local copy of its database with data from the outstations. This communication may be initiated by the SCADAPack mimicking master, either by polling each outstation in turn using solicited messages; or the outstations could initiate unsolicited messages back to the mimicking master. There could also be a combination of solicited and unsolicited messages between the mimicking master and the outstations.

In the Mimic mode diagram above the SCADAPack mimic master polls each outstation, A and B, for data and holds images of this data in its memory. When the SCADA Host poll outstations A and B for data, the mimic master replies from its own images of the outstations. The SCADA Host can also poll the SCADAPack master for its own local data. See Section ***4.4-DNP Mimic Mode Configuration*** for configuration details on the Mimic Mode.

Typically the messaging strategy chosen will depend on the relative importance of the data, and the required maximum end-to-end delays for data being transferred through the network. If the requirement is for a reasonably short end-to-end delay for all data points, a round-robin polling scheme is best, without any unsolicited messages. If there are some data points, which are higher priority and must be transferred as fast as possible, unsolicited messages should be used.

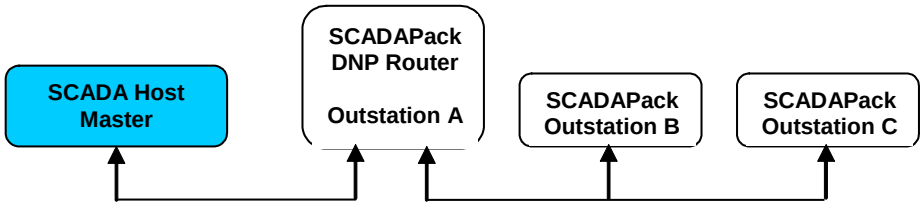
The advantage of having the SCADA system communicating with the SCADAPack 32 mimic, instead of direct communication to the outstations is that communication delays and high error rates are effectively removed. The physical connection between the SCADA system and mimic master SCADAPack is typically a direct high-speed reliable connection and all message transactions are fast. Outstations may often be connected via slow PSTN or radio links, and therefore message transactions are subject to substantial delays. They may also be unreliable communication links subject to high error rates.

By having a multiple-level network the communication between the SCADAPack master and outstations is separated from communication between SCADA system and the SCADAPack master. The delays and error rates, which may be inherent in the outstation communication paths, can be isolated from communications with the SCADA system, thereby increasing overall system performance.

One particular advantage of Mimic Mode is that the master SCADAPack does not need to know, or be configured with, any details of the DNP points configured in the outstations. This makes it relatively simple to insert such a SCADAPack master into any existing DNP network. The SCADAPack master in Mimic Mode behaves transparently to the higher-level SCADA system, and can easily be configured with communication paths and polling instructions for each connected outstation.

3.4 DNP Routing

DNP Routing is similar to DNP Mimic mode in that the SCADA Host has only one connection to a SCADAPack configured for DNP routing. The following diagram shows a simple DNP routing system.



In this configuration the SCADAPack DNP router (Outstation A above) manages all the communication with the outstations. The SCADAPack DNP router receives messages from the SCADA Host for each outstation and ***routes*** the messages to the outstations. Change event data in the form of unsolicited responses from the outstations are routed by the SCADAPack DNP router, to the SCADA Host in the same manner.

As with Mimic mode, the advantage of using DNP Routing is that the responsibility of managing multiple communications paths is removed from the SCADA Host. The SCADAPack DNP router handles all communications paths to outstations, including such tasks as dial-up radio communication. In contrast to Mimic mode, however, the SCADA Host system still has to handle the long delays and high error rates that may be present on the communications links to the outstations.

See the section ***DNP Data Router*** for configuration details for using DNP Routing in a SCADA system.

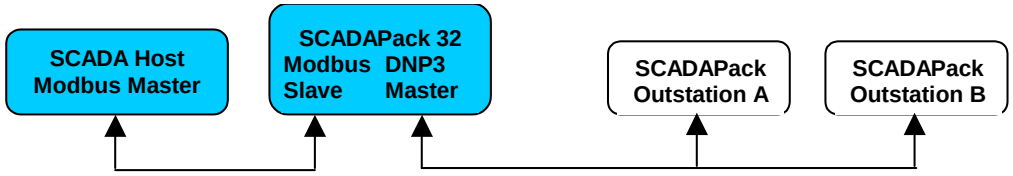
3.5 DNP Address Mapping

Setting up a SCADAPack controller as a DNP Mimic Master or even a DNP router is relatively straight forward, as one does not need to explicitly map data from the remote devices into the local DNP database of the SCADAPack master.

In certain cases, however, data from the remote DNP devices may need to be accessible to an application program running in the master SCADAPack controller. DNP Address Mapping allows this capability, by providing a method to map outstation DNP points into local Modbus registers in the SCADAPack master controller.

By configuring the Address Mapping table these remote DNP points are mapped to local Modbus registers in the SCADAPack master. As mapped Modbus points the data is available for use in application programs such as TelePACE and ISaGRAF. In addition a Modbus SCADA Host polling the SCADAPack master may access these points. See the Section ***5.5- Address Mapping*** for information on configuring DNP Address Mapping.

The following diagram shows a simple DNP Address Mapping network.



In this network the SCADAPack master updates is local database with mapped outstation data. The manner and frequency with which the SCADAPack master updates the local Modbus registers, depends on the number and type of I/O object types the registers are mapped to.

For 'Input' object types, address mapping simply links the remote DNP points to local Modbus Input registers (1xxxx or 3xxxx). These local Modbus registers are updated after the corresponding DNP point gets updated (usually by a class 0 poll to the remote DNP device).

For ‘Output' object types, there is a similar relationship between the local Modbus registers (0xxxx or 4xxxx) and the remote DNP point, with one significant difference in the way local changes are propagated to the remote DNP device. Changes made to the local Modbus register will affect the value of the associated DNP point, subsequently triggering a DNP Write message to the remote DNP outstation.

It is, therefore, necessary to ensure that all local Modbus addresses mapped to a remote device via Address Mapping, are associated with a local DNP address.

Note:	Mapping numerous local Modbus output registers (0xxxx and 4xxxx), to a remote DNP device may cause frequent communications between the master and the slave, if the associated registers are being changed frequently in the master. On limited bandwidth or radio networks, care must be taken to ensure that your network capacity can handle all the traffic that will be generated from these local changes.

4 Configuration of DNP Operation Modes

SCADAPack controllers support a number of DNP operating modes. In this section of the user manual the operating modes supported and the steps required to configure the operating modes is explained.

The DNP operating modes described in this section include:

- DNP Outstation
- DNP Master
- DNP Data Router
- DNP Mimic Mode

4.1 DNP Outstation Configuration

A DNP outstation is the basic configuration for a SCADAPack controller operating in a DNP network. When configured as a DNP outstation a SCADAPack controller is able to:

- Map physical I/O data to DNP points.
- Define DNP points as Class 1, Class 2 or Class 3 data types.
- Respond to requests from one or more master stations such as a SCADA hosts or SCADAPack 32 controllers that are configured for DNP master operation.
- Initiate unsolicited responses to one or more master stations.

See the section ***DNP Network*** for examples of where an outstation may be used in typical DNP networks.

The following describes the general steps required to configure a SCADAPack series controller as a DNP outstation.

4.1.1 Configuration Steps

The steps below provide an outline of the configuration needed for an outstation. References are made to sections of this manual and to other user manuals. These sections and manual should be referred to for complete information.

1. Enable DNP for the serial or Ethernet port.

The SCADAPack controller is connected to a DNP network through one of the serial ports or in the case of a SCADAPack 32 controller through a serial port or Ethernet port. The serial or Ethernet ports need to be set to use DNP protocol and to enable DNP Routing.

- For TelePACE applications see the section **Controller Menu >> Serial Ports** and **Controller Menu >> IP Configuration** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section **Controller Menu Commands >> Controller Serial Port Command** and **Controller Menu Commands >> Controller IP** in the ISaGRAF User and Reference Manual.

2. Configure Register Assignment or I/O Connections.

The physical I/O for a SCADAPack controller is made available to application programs and protocols by assigning the physical I/O to Modbus registers in TelePACE and to Dictionary Variables (with Modbus network addresses) in ISaGRAF. SCADAPack controllers use the Modbus addresses when DNP objects are created.

- For TelePACE applications see the section **Controller Menu >> Register Assignment** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section I**/O Connection Reference** in the ISaGRAF User and Reference Manual.

3. Configure Application Layer Parameters.

The application layer parameters primarily define how the application layer communicates; how often time synchronization is done, whether the station initiates unsolicited responses and if application layer confirmation is used in the communication. In addition the global Operate Timeout parameter is set for Select Before Operate binary output objects and the Dial Up parameters are set if dial up communication is used.

- See the section **DNP Configuration >> Application Layer Configuration** in this manual for information on the parameters used in the Application layer.

4. Configure Data Link Layer Parameters.

The data link layer parameters define the outstation DNP address, the master station address(s) the outstation will communicate with and whether data link layer confirmation will be used in the communication.

- See the section **DNP Configuration >> Data Link Layer Configuration** in this manual for information on the parameters used in the Data Link Layer.

5. Configure DNP Routing.

SCADAPack controllers use DNP routing to direct DNP messages based on instructions in the routing table. The routing table defines which serial port or Ethernet port messages will be sent to other DNP stations. In the case of an outstation DNP routing defines the station address of the master station and the communication port to be used when communicating with the master station.

- See the section **DNP Configuration >> Routing** in this manual for information on the routing table and adding entries to the routing table.

6. Configure Data Objects.

The SCADAPack controller physical I/O and user application data may be assigned to DNP objects and given DNP point addresses. DNP input points can be assigned a class (1,2 or 3) for event data. These change events can be sent to the master station(s) if unsolicited responses are enable for the assigned class.

The DNP objects that are supported in the SCADAPack controller are shown below. See the appropriate section in the **DNP Configuration** section of this manual for complete information on configuring DNP data objects.

- Binary Inputs
- Binary Outputs
- 16-bit Analog Inputs
- 32-bit Analog Inputs
- Short Floating Point Analog Inputs
- 16-bit Analog Outputs
- 32-bit Analog Outputs

- Short Floating Point Analog Outputs
- 16-bit Counter Inputs
- 32-bit Counter Inputs

4.2 DNP Master Configuration

This option is available on the SCADAPack 350 and SCADAPack 32 controllers only.

The SCADAPack 350 and SCADAPack 32 controllers can be configured as a DNP master station in a DNP network. When configured as a DNP master station the controller is able to:

- Map local physical I/O data to DNP points.
- Define local DNP points as Class 1, Class 2 or Class 3 data types.
- Respond to requests from one or more master stations such as a SCADA hosts or other controllers that are configured for DNP master operation.
- Initiate unsolicited responses to one or more master stations.
- Poll DNP outstations for static (Class 0) data and Class 1, 2 and 3 event data.
- Accept unsolicited response messages from polled outstations.
- Map Outstation DNP data to local DNP points and Modbus registers. This data can then be used in application programs executing in the local controller or made available to other DNP master station(s) that poll this local controller.

See Section ***3-DNP Network Architectures*** for examples of where a DNP master may be used in typical DNP networks.

The following describes the general steps required to configure a SCADAPack controller as a DNP master station.

Note: Only the SCADAPack 350 or SCADAPack32 controller can be configured as a DNP master.

4.2.1 Configuration Steps

The steps below provide an outline of the configuration needed for a SCADAPack master station. References are made to sections of this manual and to other user manuals. These sections and manual should be referred to for complete information.

1. Enable DNP for the serial or Ethernet port.

The SCADAPack controller is connected to a DNP network through one of the serial ports or the Ethernet port. The serial or Ethernet ports need to be set to use DNP protocol and to enable DNP Routing.

- For TelePACE applications see the section **Controller Menu >> Serial Ports** and **Controller Menu >> IP Configuration** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section **Controller Menu Commands >> Controller Serial Port Command** and **Controller Menu Commands >> Controller IP** in the ISaGRAF User and Reference Manual.

2. Configure Register Assignment or I/O Connections.

The physical I/O for a SCADAPack controller is made available to application programs and protocols by assigning the physical I/O to Modbus registers in TelePACE and to Dictionary

Variables (with Modbus network addresses) in ISaGRAF. SCADAPack controllers use the Modbus addresses when DNP objects are created.

- For TelePACE applications see the section **Controller Menu >> Register Assignment** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section I**/O Connection Reference** in the ISaGRAF User and Reference Manual.

3. Configure Application Layer Parameters.

The application layer parameters primarily define how the application layer communicates; how often time synchronization is done, whether the station initiates unsolicited responses and if application layer confirmation is used in the communication. In addition the global Operate Timeout parameter is set for Select Before Operate binary output objects and the Dial Up parameters are set if dial up communication is used.

- See the section **DNP Configuration >> Application Layer Configuration** in this manual for information on the parameters used in the Application layer.

4. Configure Data Link Layer Parameters.

The data link layer parameters define the SCADAPack outstation DNP address, the master station address(s) the SCADAPack master will communicate with and whether data link layer confirmation will be used in the communication.

- See the section **DNP Configuration >> Data Link Layer Configuration** in this manual for information on the parameters used in the Data Link Layer.

5. Configure Master Parameters (Applicable for SCADAPack 350 and SCADAPack 32 only)

There are two Master parameters, Mimic Mode enable or disable and the Base Poll Interval. The concept behind Mimic Mode operation is described in section ***3.3-DNP Mimic Mode***.

The Base Poll interval is used to determine the frequency of master polling of outstations. Each type of master poll, Class 0, 1, 2 or 3 is polled at a frequency that is based on the Base Poll Interval.

- See the section **DNP Configuration >> Master** in this manual for information on the parameters used in the Master.

6. Configure Master Poll Parameters

The Master Poll parameters define how often the master station polls each outstation, how often to request time synchronization and whether unsolicited responses are accepted from the outstation. The polling frequency is configured independently for outstation Class 0,1,2 and 3 data. Master polling interval, or frequency, is based on the number of base poll intervals as set in the Master parameters.

- See the section DNP Configuration >> Master Poll in this manual for information on the parameters used in for the Master Poll.

7. Configure Address Mapping Parameters

The Address Mapping parameters define the mapping rules, which allow outstation DNP objects to be mapped into local SCADAPack master Modbus registers. This allows the outstation data to be used locally in application programs.

- See the section **DNP Configuration >> Address Mapping** in this manual for information on the parameters used in for Address Mapping.

8. Configure DNP Routing.

SCADAPack controllers use DNP routing to direct DNP messages based on instructions in the routing table. The routing table defines which serial port or Ethernet port messages will be sent to other DNP outstations or master stations. The DNP routing table defines the station address of the master station and the communication port to be used when communicating with the master station and the station addresses of the outstations the SCADAPack master station is polling.

9. See the section DNP Configuration >> Routing **in this manual for information on the routing table and adding entries to the routing table.**

10. Configure Data Objects.

The SCADAPack controller physical I/O and user application data may be assigned to DNP objects and given DNP point addresses. DNP input points can be assigned a class (1,2 or 3) for event data. These change events can be sent to the master station(s) if unsolicited responses are enable for the assigned class.

The DNP objects that are supported in the SCADAPack controllers are shown below. See the appropriate section in the **DNP Configuration** section of this manual for complete information on configuring DNP data objects.

- Binary Inputs
- Binary Outputs
- 16-bit Analog Inputs
- 32-bit Analog Inputs
- Short Floating Point Analog Inputs
- 16-bit Analog Outputs
- 32-bit Analog Outputs
- Short Floating Point Analog Outputs
- 16-bit Counter Inputs
- 32-bit Counter Inputs

4.3 DNP Data Router Configuration

All SCADAPack controllers can be configured as a DNP Router. When configured as a DNP router a SCADAPack controller is able to:

- Map local physical I/O data to DNP points.
- Define local DNP points as Class 1, Class 2 or Class 3 data types.
- Respond to requests from one or more master stations such as a SCADA hosts or other SCADAPack 32 controllers that are configured for DNP master operation.
- Initiate unsolicited responses to one or more master stations.
- Route DNP messages as defined in the Routing table.

See the Section ***3-3-Modbus Database Mapping*** for examples of where a DNP Data Router may be used in typical DNP networks.

The following describes the general steps required to configure a SCADAPack series controller as a DNP Data Router.

4.3.1 Configuration Steps

The steps below provide an outline of the configuration needed for a SCADAPack DNP router. References are made to sections of this manual and to other user manuals. These sections and manual should be referred to for complete information.

1. Enable DNP for the serial or Ethernet port.

The SCADAPack controller 32 is connected to a DNP network through one of the serial ports or the Ethernet port. The serial or Ethernet ports need to be set to use DNP protocol and to enable DNP Routing.

- For TelePACE applications see the section **Controller Menu >> Serial Ports** and **Controller Menu >> IP Configuration** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section **Controller Menu Commands >> Controller Serial Port Command** and **Controller Menu Commands >> Controller IP** in the ISaGRAF User and Reference Manual.

2. Configure Register Assignment or I/O Connections.

The physical I/O for a SCADAPack 32 controller is made available to application programs and protocols by assigning the physical I/O to Modbus registers in TelePACE and to Dictionary Variables (with Modbus network addresses) in ISaGRAF. SCADAPack controllers use the Modbus addresses when DNP objects are created.

- For TelePACE applications see the section **Controller Menu >> Register Assignment** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section I**/O Connection Reference** in the ISaGRAF User and Reference Manual.

3. Configure Application Layer Parameters.

The application layer parameters primarily define how the application layer communicates; how often time synchronization is done, whether the station initiates unsolicited responses and if application layer confirmation is used in the communication. In addition the global Operate Timeout parameter is set for Select Before Operate binary output objects and the Dial Up parameters are set if dial up communication is used.

- See the section **DNP Configuration >> Application Layer Configuration** in this manual for information on the parameters used in the Application layer.

4. Configure Data Link Layer Parameters.

The data link layer parameters define the SCADAPack 32 outstation DNP address, the master station address(s) the SCADAPack 32 master will communicate with and whether data link layer confirmation will be used in the communication.

- See the section **DNP Configuration >> Data Link Layer Configuration** in this manual for information on the parameters used in the Data Link Layer.

5. Configure DNP Routing.

SCADAPack series controllers use DNP routing to direct DNP messages based on instructions in the routing table. The routing table defines which serial port or Ethernet port messages will be sent to other DNP outstations or master stations. The DNP routing table defines the station address of each outstation and the communication port to be used when communicating with outstations.

- See the section **DNP Configuration >> Routing** in this manual for information on the routing table and adding entries to the routing table.

6. Configure Data Objects.

The SCADAPack controller physical I/O and user application data may be assigned to DNP objects and given DNP point addresses. DNP input points can be assigned a class (1,2 or 3) for event data. These change events can be sent to the master station(s) if unsolicited responses are enable for the assigned class.

The DNP objects that are supported in the SCADAPack controller are shown below. See the appropriate section in the **DNP Configuration** section of this manual for complete information on configuring DNP data objects.

- Binary Inputs
- Binary Outputs
- 16-bit Analog Inputs
- 32-bit Analog Inputs
- Short Floating Point Analog Inputs
- 16-bit Analog Outputs
- 32-bit Analog Outputs
- Short Floating Point Analog Outputs
- 16-bit Counter Inputs
- 32-bit Counter Inputs

4.4 DNP Mimic Mode Configuration

This option is applicable to the SCADAPack 350 and SCADPack32 controllers only.

The SCADAPack 350 and SCADAPack 32 controller can be configured as a DNP master station, in mimic mode, in a DNP network. When configured as a Mimic Mode DNP master station a SCADAPack 32 controller is able to:

- Map local physical I/O data to DNP points.
- Define local DNP points as Class 1, Class 2 or Class 3 data types.
- Respond to requests from one or more master stations such as a SCADA hosts or other SCADAPack controllers that are configured for DNP master operation.
- Initiate unsolicited responses to one or more master stations.
- Poll DNP outstations for static (Class 0) data and Class 1, 2 and 3 event data.
- Accept unsolicited response messages from polled outstations.
- Respond directly to SCADA Host polls that are destined for outstations that are defined in its Master Poll table.

See Section ***3-DNP Network Architectures*** for examples of where a DNP master may be used in typical DNP networks.

The following describes the general steps required to configure a SCADAPack controller as a Mimic Mode DNP master station.

4.4.1 Configuration Steps

The steps below provide an outline of the configuration needed for a SCADAPack DNP Mimic Mode master station. References are made to sections of this manual and to other user manuals. These sections and manual should be referred to for complete information.

1. **Enable DNP for the serial or Ethernet port.**

The SCADAPack controller is connected to a DNP network through one of the serial ports or the Ethernet port.

- For TelePACE applications see the section **Controller Menu >> Serial Ports** and **Controller Menu >> IP Configuration** in the TelePACE User and Reference Manual.
- Enable **Routing** on the serial or Ethernet ports that have been configured for DNP communication.
- For ISaGRAF Applications see the section **Controller Menu Commands >> Controller Serial Port Command** and **Controller Menu Commands >> Controller IP** in the ISaGRAF User and Reference Manual.

2. **Configure Register Assignment or I/O Connections.**

The physical I/O for a SCADAPack controller is made available to application programs and protocols by assigning the physical I/O to Modbus registers in TelePACE and to Dictionary Variables (with Modbus network addresses) in ISaGRAF. SCADAPack controllers use the Modbus addresses when DNP objects are created.

- For TelePACE applications see the section **Controller Menu >> Register Assignment** in the TelePACE User and Reference Manual.
- For ISaGRAF Applications see the section I**/O Connection Reference** in the ISaGRAF User and Reference Manual.

3. **Configure Application Layer Parameters.**

The application layer parameters primarily define how the application layer communicates; how often time synchronization is done, whether the station initiates unsolicited responses and if application layer confirmation is used in the communication. In addition the global Operate Timeout parameter is set for Select Before Operate binary output objects and the Dial Up parameters are set if dial up communication is used.

- See the section **DNP Configuration >> Application Layer Configuration** in this manual for information on the parameters used in the Application layer.

4. **Configure Data Link Layer Parameters.**

The data link layer parameters define the SCADAPack outstation DNP address, the master station address(s) the SCADAPack Mimic master will communicate with and whether data link layer confirmation will be used in the communication.

- See the section **DNP Configuration >> Data Link Layer Configuration** in this manual for information on the parameters used in the Data Link Layer.

5. **Configure Master Parameters**

There are two Master parameters, Mimic Mode enable or disable and the Base Poll Interval. The Mimic Mode must be set to enable for Mimic Mode. Mimic Mode operation is described in Section ***4.4-DNP Mimic Mode.***

he Base Poll interval is used to determine the frequency of master polling of outstations. Each type of master poll, Class 0, 1, 2 or 3 is polled at a frequency that is based on the Base Poll Interval.

- See the section **DNP Configuration >> Master** in this manual for information on the parameters used in the Master.

6. Configure Master Poll Parameters

The Master Poll parameters define how often the master station polls each outstation, how often to request time synchronization and whether unsolicited responses are accepted from the outstation. The polling frequency is configured independently for outstation Class 0,1,2 and 3 data. Master polling interval, or frequency, is based on the number of base poll intervals as set in the Master parameters.

- See the section **DNP Configuration >> Master Poll** in this manual for information on the parameters used in for the Master Poll.

7. Configure Address Mapping Parameters

The Address Mapping parameters define the mapping rules, which allow outstation DNP objects to be mapped into local SCADAPack master Modbus registers and DNP points. This allows the outstation data to be used locally in application programs.

- See the section **DNP Configuration >> Address Mapping** in this manual for information on the parameters used in for Address Mapping.

8. Configure DNP Routing.

SCADAPack controllers use DNP routing to direct DNP messages based on instructions in the routing table. The routing table defines which serial port or Ethernet port messages will be sent to other DNP outstations or master stations. The DNP routing table defines the station address of the master station and the communication port to be used when communicating with the master station and the station addresses of the outstations the SCADAPack master station is polling.

- See the section **DNP Configuration >> Routing** in this manual for information on the routing table and adding entries to the routing table.

9. Configure Data Objects.

The SCADAPack controller physical I/O and user application data may be assigned to DNP objects and given DNP point addresses. DNP input points can be assigned a class (1,2 or 3) for event data. These change events can be sent to the master station(s) if unsolicited responses are enable for the assigned class.

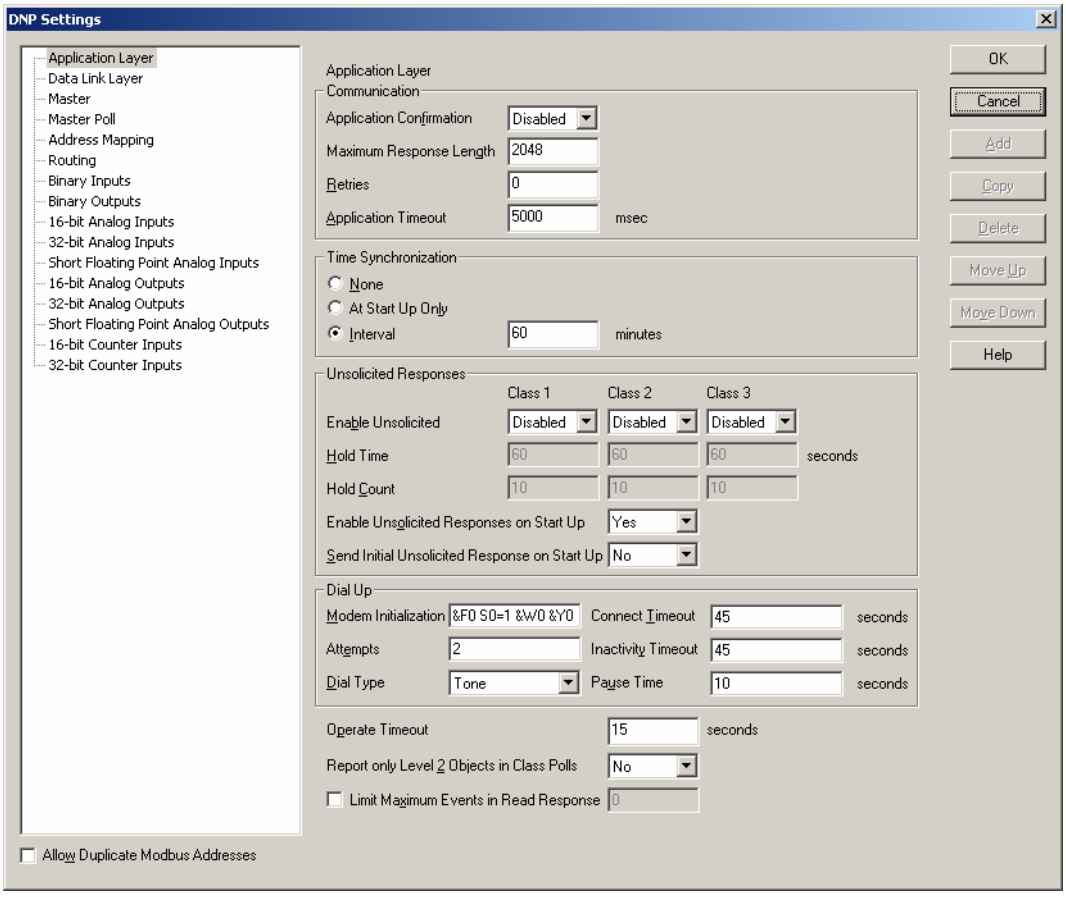
The DNP objects that are supported in the SCADAPack controller are shown below. See the appropriate section in the **DNP Configuration** section of this manual for complete information on configuring DNP data objects.

- Binary Inputs
- Binary Outputs
- 16-bit Analog Inputs
- 32-bit Analog Inputs
- Short Floating Point Analog Inputs
- 16-bit Analog Outputs
- 32-bit Analog Outputs

- Short Floating Point Analog Outputs
- 16-bit Counter Inputs
- 32-bit Counter Inputs

5 DNP Configuration Menu

The DNP command is used to configure the DNP protocol settings for the controller. When selected the DNP Settings window is opened, as shown below.



The DNP Settings window has a tree control on the left side of the window. The tree control appears differently depending on the controller type selected. The SCADAPack 350, SCADAPack 32 and SCADAPack 32P controllers support DNP master and include the bolded items in the following list. Other SCADAPack controllers do not support DNP master and do not include the bolded items. This tree control contains headings for:

- Application Layer
- Data Link Layer
- **Master**
- **Master Poll**
- **Address Mapping**
- Routing
- Binary Inputs
- Binary Outputs
- 16-Bit Analog Inputs
- 32-Bit Analog Inputs

- Short Floating Point Analog Inputs
- 16-Bit Analog Outputs
- 32-Bit Analog Outputs
- Short Floating Point Analog Outputs
- 16-Bit Counter Inputs
- 32-Bit Counter Inputs

When a tree control is selected by clicking the mouse on a heading a property page is opened for the header selected. From the property page the DNP configuration parameters for the selected header is displayed.

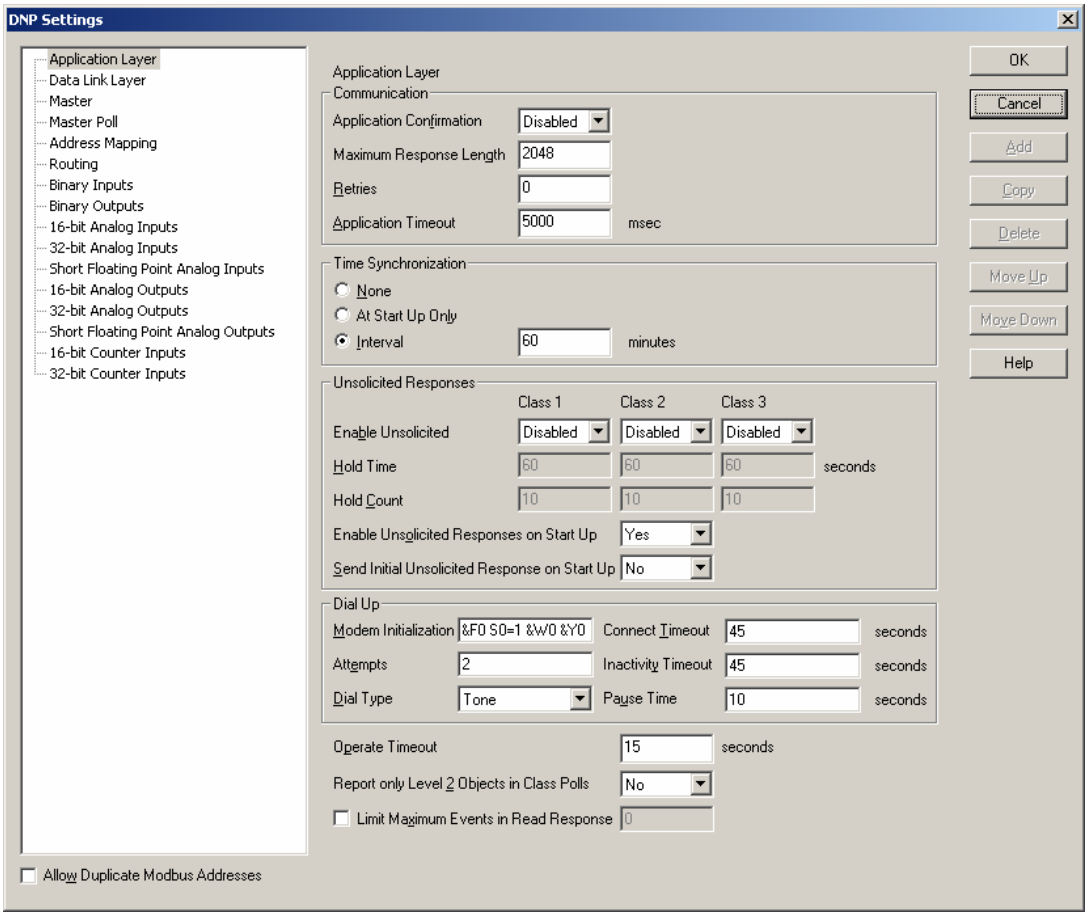
As DNP objects are defined they are added as leaves to the object branch of the tree control. When an object is defined the object branch will display a collapse / expand control to the left of the branch.

The **Allow Duplicate Modbus Addresses** checkbox (in the bottom left corner) determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Uncheck the box if you want to be warned about duplicate addresses. If an attempt is made to use a Modbus address that has already been used for another DNP point the following warning is displayed.

5.1 Application Layer Configuration

The Application Layer property page is selected for editing by clicking Application Layer in the tree control section of the DNP Settings window. When selected the Application Link Layer property page is active.



Application Layer parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Communication** section of the dialog contains the configurable application layer communication parameters.

When the **Application Confirmation** feature is enabled, the SCADAPack controller requests a confirmation from the master station for any data transmitted. When it is disabled, the controller does not request a confirmation from the master station and assumes that the master receives the data it sends successfully. However if the data includes event data (including unsolicited messages), the controller requests a confirmation from the master regardless of whether this feature is enabled or disabled. Valid selections for this parameter are:

- Enabled
- Disabled

The **Maximum Fragment Length** is maximum size of a single response fragment that the RTU will send. If the complete response message is too large to fit within a single fragment, then the SCADAPack controller will send the response in multiple fragments. Valid values are between 100 and 2048 bytes.

This parameter is adjustable to allow for interoperability with simple DNP3 devices that require smaller application layer fragments. Devices with limited memory may restrict the application layer fragment size to as low as 249 bytes.

Note: The Maximum Fragment Length parameter applies to responses from read commands only. It does not affect unsolicited responses.

The **Retries** entry maximum number of times the application layer will retry sending a response or an unsolicited response to the master station. This does not include any retries performed by the data link layer. Valid values are between 0 and 255.

Note: Using application layer Confirmation and Retries is inherently more efficient than using data link layer Confirmation and Retries. Each fragment sent by the Application layer may require as many as 10 data link layer frames to be sent, each with its own confirmation message. The application layer is typically preferred for message confirmation for this reason.

The **Application Timeout** is the expected time duration (in milliseconds) that the master station's application layer requires to process and respond to a response from the SCADAPack controller. This SCADAPack controller uses this value in setting its time-out interval for master station responses. This value should be large enough to prevent response time-outs. The value must be kept small enough so as not to degrade system throughput. The value of this element is dependent on the master station. Valid values are between 100 and 60000 milliseconds.

The **Time Synchronization** section of the dialog defines when and how often the SCADAPack outstation prompts the master station to synchronize the SCADAPack controller time. Messages must be sent between the Master and Remote stations for Time Synchronization to work. Valid selections for this parameter are:

- The **None** selection will cause the SCADAPack controller to never request Time Synchronization.
- The **At Start Up Only** selection will cause the SCADAPack controller to request Time Synchronization at startup only.
- **The Interval** selection will cause the SCADAPack controller to request Time Synchronization at startup and then every **Interval** minutes after receiving a time synchronization from the master. Valid entries for Interval are between 1 and 32767 minutes. The default value is 60 minutes.

Note: Time Synchronization may instead be initiated by the Master for each Outstation. This may be selected in the Add/Edit Master Poll dialog. It is not required to enable Time Synchronization at both the Master and the Outstation.

The Un**solicited Response** section of the dialog defines which **class** objects are enabled or disabled from generating report by exception responses. Unsolicited responses are individually configured for Class 1, Class 2, and Class 3 data.

The **Enable Unsolicited** controls enables or disables unsolicited responses for Class 1, Class 2 or Class 3 data. If unsolicited responses are disabled for a Class the controller never sends unsolicited responses for that Class. If unsolicited responses are enabled the controller does not start sending responses until the master enables the classes to report. Valid selections are:

- Enabled
- Disabled

The **Hold Time** parameter is used only when unsolicited responses are enabled for a Class. This parameter defines the maximum period (in seconds) the RTU will be allowed to hold its events before reporting them to the DNP master station. When the hold time has elapsed since the first event

occurred, the RTU will report to the DNP master station all events accumulated up to then. This parameter is used in conjunction with the **Hold Count** parameter in customizing the unsolicited event reporting characteristics. The value used for the Hold Time depends on the frequency of event generation, topology and performance characteristics of the system. The valid values for this parameter are 0 - 65535. The default value is 60 seconds.

The **Hold Count** parameter is used only when unsolicited responses are enabled for a Class. This parameter defines the maximum number of events the RTU will be allowed to hold before reporting them to the DNP master station. When the hold count threshold is reached, the RTU will report to the master, all events accumulated up to that point. This parameter is used in conjunction with the **Hold Time** in customizing the unsolicited event reporting characteristics. To guarantee an unsolicited response is sent as soon as an event occurs, set the Hold Count parameter to 1. The valid values for this parameter are 1 - 65535. The default value is 10.

The **Enable Unsolicited Responses on Start Up** parameter enables or disables unsolicited responses on startup. This affects the default controller behaviour after a start-up or restart. Some hosts require devices to start up with unsolicited responses enabled. It should be noted this is non-conforming behaviour according to the DNP standard. Valid selections are:

- Yes
- No

The default selection is Yes.

The **Send Initial Unsolicited Response on Startup** parameter enables or disables Send Initial unsolicited responses on startup. This parameter controls whether an initial unsolicited response with null data is sent after a start-up or restart. Valid selections are:

Yes

No

The default selection is No.

The **Dial Up** section of the dialog defines modem parameters used when a dial up modem is used to communicate with stations that use dial up communication. The phone numbers for the stations are defined in the Routing table.

The **Modem Initialization** is the string that will be sent to the modem prior to each call. This is an ASCII null-terminated string. The maximum length of the string is 64 characters, including the null terminator.

The **Attempts** controls the maximum number of dial attempts that will be made to establish a Dial Up connection. The valid values for this parameter are 1 – 10. The default value is 2.

The **Dial Type** parameter controls whether tone or pulse dialing will be used for the call. Valid values are Tone dialing or Pulse dialing. The default value is Tone dialing.

The **Connect Timeout** controls the maximum time (in seconds) after initiating a dial sequence that the firmware will wait for a carrier signal before hanging up. The valid values for this parameter are 1 – 65535. The default value is 45.

The **Inactivity Timeout** controls the maximum time after message activity that a connection will be left open before hanging up. The valid values for this parameter are 1 – 65535 seconds. The default value is 45 seconds.

The **Pause Time** controls the delay time (in seconds) between dial events, to allow time for incoming calls. The valid values for this parameter are 1 – 65535. The default value is 10.

The **Operate Timeout** parameter specifies the timeout interval between a Select and Operate request from the Master. If after receiving a valid ***Select*** control output request from the master, the RTU does not receive the corresponding ***Operate*** request within this time-out interval, the control output request fails. The value of this parameter, expressed in seconds, is dependent on the master station, the data link and physical layer. Valid values are 1 to 6500 seconds. The default value is 15 seconds. The Master must have the Select/Operate functionally in order to use this feature.

The **Report only Level 2 Compliant Objects in Class Polls** parameter affects how Short Float Analog Input, Short Float Analog Output, and 32-bit Analog Output objects are reported. These objects are converted to 32-bit Analog Input and 16-bit Analog Output objects when this parameter is selected. Valid selections are:

- Yes
- No

The default selection is No.

The **Limit Maximum Events in Read Response** parameter allows limiting the number of events in a read response. Select the checkbox to enable the limit. Valid values are 1 to 65535. The default value is disabled.

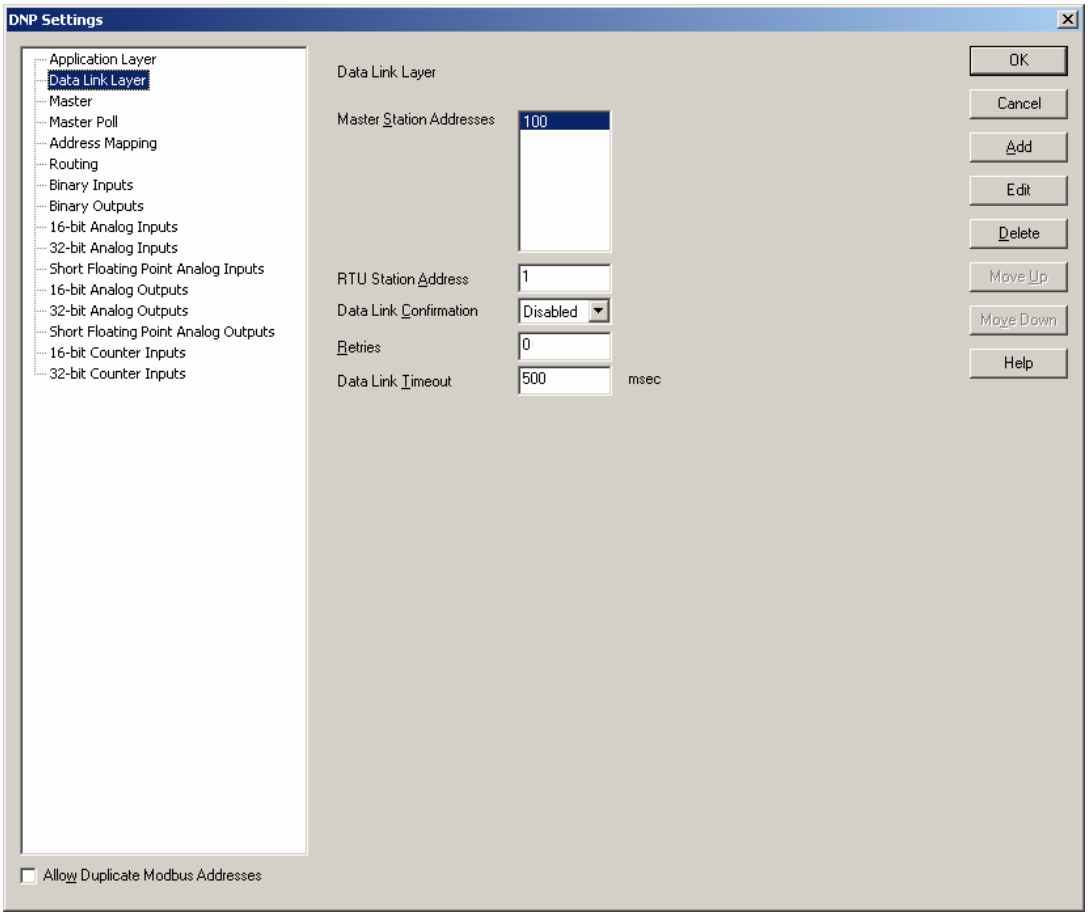
Note:	The Maximum Events parameter applies to responses from read commands only. It does not affect unsolicited responses.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

- Click the **OK** button to accept the configuration changes and close the DNP Settings dialog.
- Click the **Cancel** button to close the dialog without saving any changes.

5.2 Data Link Layer Configuration

The Data Link Layer property page is selected for editing by clicking Data Link Layer in the tree control section of the DNP Settings window. When selected the Data Link Layer property page is active.



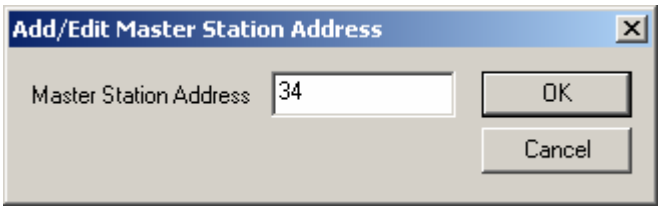
Data Link Layer parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Master Station Addresses** list box contains a list of Master station addresses that the SCADAPack controller will respond to. The default list contains one master address of 100. This address may be edited, or changed, and up to 8 master stations may be added to the list. Valid entries for Master Station Addresses are 0 to 65519.

- When a master station polls for event data, the controller will respond with any events that have not yet been reported to that master station.
- When an unsolicited response becomes due, it will be sent to each configured master station in turn. A complete unsolicited response message transaction, including retries, will be sent to the first configured master station. When this transaction has finished, a complete unsolicited response message transaction including retries will be sent to the next configured master station, and so on for all the configured master stations.
- Change events will be retained in the event buffer until they have been successfully reported to all configured master stations.

Select the **Add** button to enter a new address to the Master Station Address list. Selecting the Add button opens the **Add Master Station Address** dialog. Up to 8 entries can be added to the table. An error message is displayed if the table is full.

Select the **Edit** button to edit address in the Master Station Address list. Selecting the Edit button opens the **Edit Master Station Address** dialog. The button is disabled if there are no entries in the list.



The **Master Station Address** edit box specifies the Master Station Address. Enter any valid Station address from 0 to 65519.

- The **OK** button adds the Master Station Address to the list and closes the dialog. An error is displayed if the Master Station Address is invalid, if the address is already in the list, or if the address conflicts with the RTU station address.
- The **Cancel** button closes the dialog without making any changes.

The **RTU Station Address** parameter specifies the address of this RTU. It is the source address used by this DNP driver when communicating with a master station. Each DNP station in a network must have a unique address, including the Master station. Valid entries for RTU Station Address are 0 to 65519.

The **Data Link Confirmation** parameter specifies whether or not the RTU requests the underlying data link transmitting its response to use a high quality service, which generally means that the data link requires the receiving data link to confirm receipt of all messages.

The **Retries** parameter specifies the maximum number of times the data link layer will retry sending a message to the master station. This parameter is only used when responding to a request from a Master station, when there is no corresponding entry in the Routing dialog for that station. This is independent of the application layer retries. The valid values for this parameter are 0 - 255. Setting the value to 0 disables sending retries.

Note:	Using data link layer Confirmation and Retries is inherently less efficient than application layer Confirmation and Retries. Each fragment sent by the Application layer may require as many as 10 data link layer frames to be sent, each with its own confirmation message. The data link layer is typically not used for message confirmation for this reason.

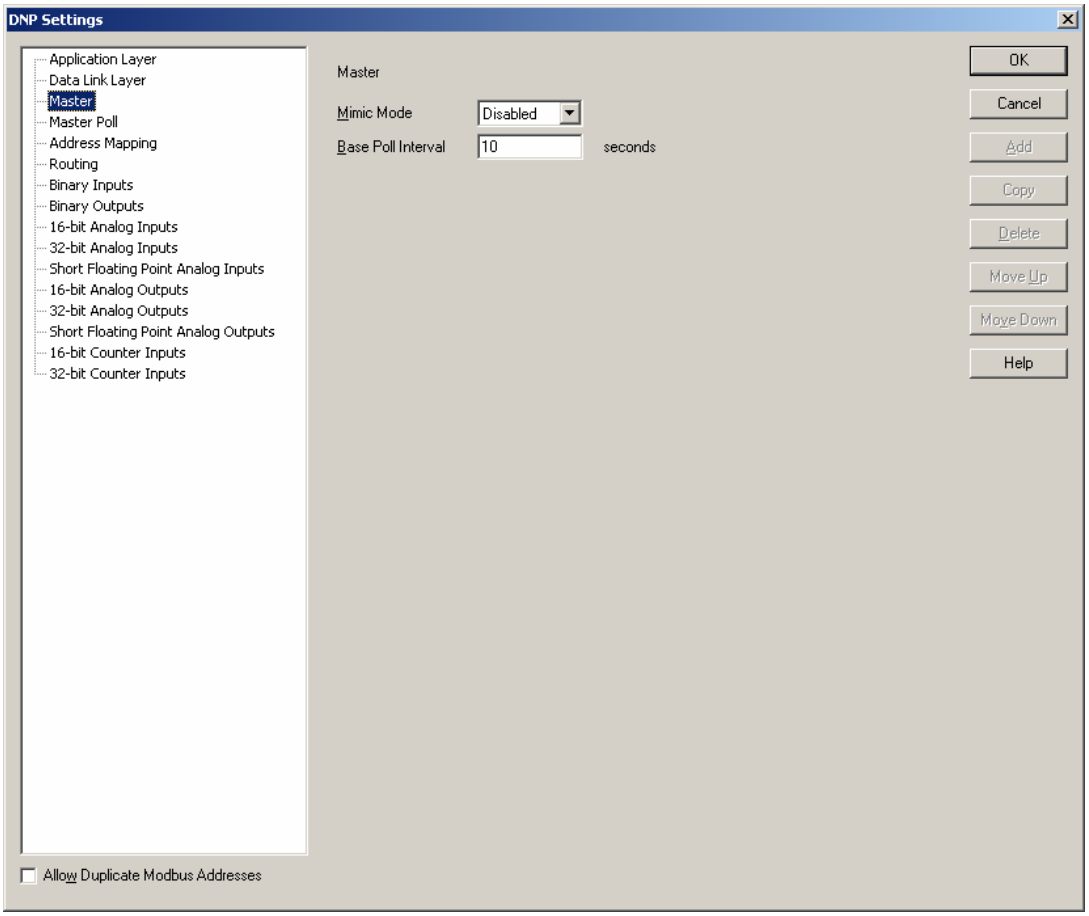
The **Data Link Timeout** parameter specifies the expected time duration that the master station's data link layer requires to process and respond to a message from the RTUs data link layer. It is used by the RTU in setting its time-out interval for master station responses. This value should be large enough to prevent response time-outs. The value must be kept small enough so as not to degrade system throughput. The value of this element is dependent on the master station. It is expressed in milliseconds. Valid values are 10 to 60000 milliseconds. The default value is 500 milliseconds.

- Click the **OK** button to accept the configuration changes and close the DNP Settings dialog.
- Click the **Cancel** button to close the dialog without saving any changes.
- Click the **Delete** button to remove the selected rows from the list. This button is disabled if there are no entries in the list.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.3 Master

The Master property page is selected for editing by clicking Master in the tree control section of the DNP Settings window. This selection is only visible if the controller type is SCADAPack 350, SCADAPack 32 or SCADAPack 32P. These controllers support DNP Master. When selected the Master Application Link Layer property page is active.



Master parameters are set in this property page. Each parameter is described in the following paragraphs.

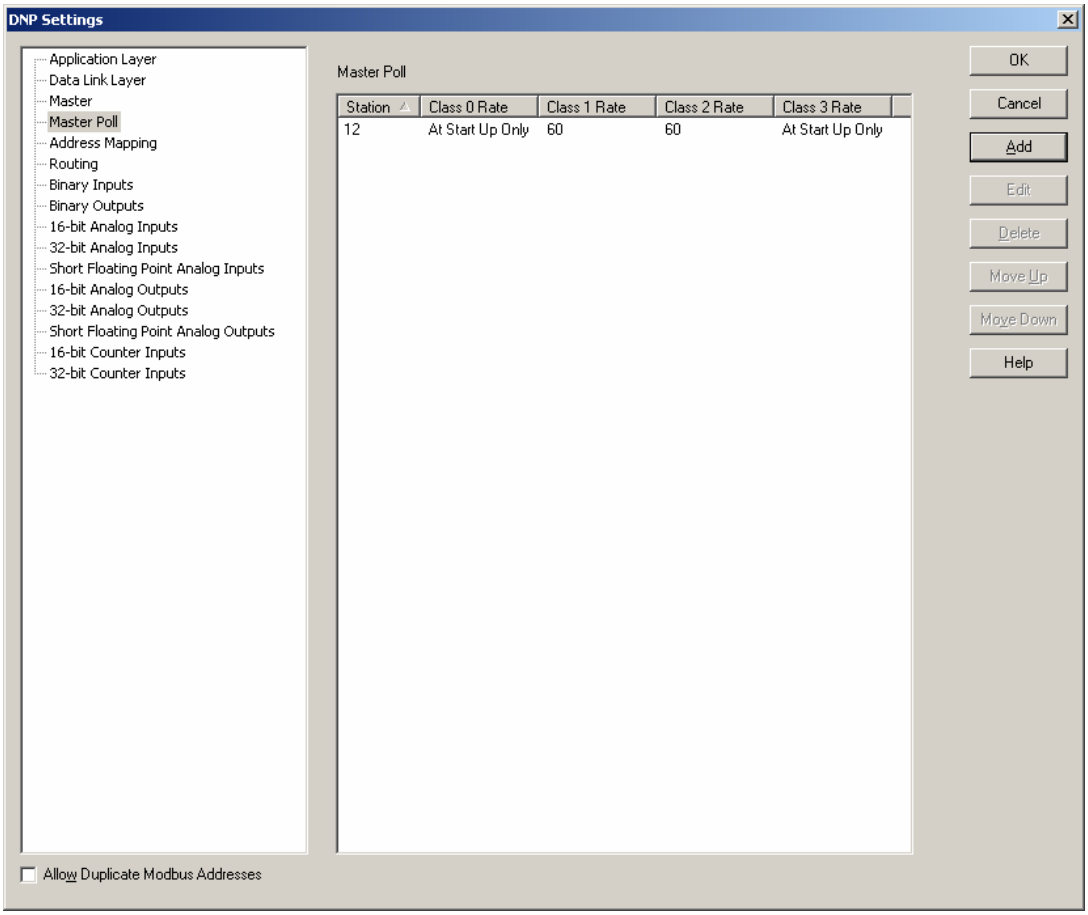
The **Mimic Mode** parameter specifies the DNP Mimic Mode. The valid selections are Enable or Disable. When DNP Mimic Mode is enabled the controller will intercept DNP messages destined for a remote DNP station address, and will respond directly, as though the controller were the designated target. For read commands, the controller will respond with data from its Remote DNP Objects corresponding with the intended target address. For write commands, the controller will write data into its Remote DNP Objects, and issue a direct response to acknowledge the command. It will then issue a new command to write the data to the designated target. See Section ***3.3-DNP Mimic Mode*** section for an explanation of the concept around Mimic Mode. The default selection is Disabled.

The **Base Poll Interval** parameter is the base interval (in seconds) for polling slave devices. The poll rates and issuing time synchronisation will be configured in multiples of the base poll interval. The

slave devices with the same poll rates will be polled in the order they appear in the poll table. The valid values for this parameter are 1 to 65535. The default value is 10 seconds.

5.4 Master Poll

The Master Poll property page is selected for editing by clicking Master Poll in the tree control section of the DNP Settings window. This selection is only visible if the controller type is a SCADAPack 350, SCADAPack 32 or SCADAPack 32P. These controllers support DNP Master. When selected the Master Poll property page is active and button Copy is renamed to Edit.



The Master Poll displays slave devices to be polled by this master station as a row, with column headings, in the table. The table may have up to 1000 entries. A vertical scroll bar is used if the list exceeds the window size.

Note: All slave devices in the Master Poll table need to be added to the Routing table.

The **Station** column displays the address of the DNP slave device to be polled. Each entry in the table should have unique DNP Station Address.

The **Class 0 Rate** column displays the rate of polling for Class 0 data, as a multiple of the base poll interval.

The **Class 1 Rate** column displays the rate of polling for Class 1 data, as a multiple of the base poll interval.

The **Class 2 Rate** column displays the rate of polling for Class 2 data, as a multiple of the base poll interval.

The **Class 3 Rate** column displays the rate of polling for Class 3 data, as a multiple of the base poll interval.

- The **OK** button saves the table data and closes the DNP Settings dialog.
- The **Cancel** button closes the dialog without saving changes.

Select the **Add** button to enter a new row in the Master Poll. Selecting the Add button opens the **Add/Edit Master Poll** dialog.

Select the **Edit** button to modify the selected row in the Master Poll. Selecting the Edit button opens the **Add/Edit Master Poll** dialog containing the data from the selected row. This button is disabled if more than one row is selected or if there are no entries in the table.

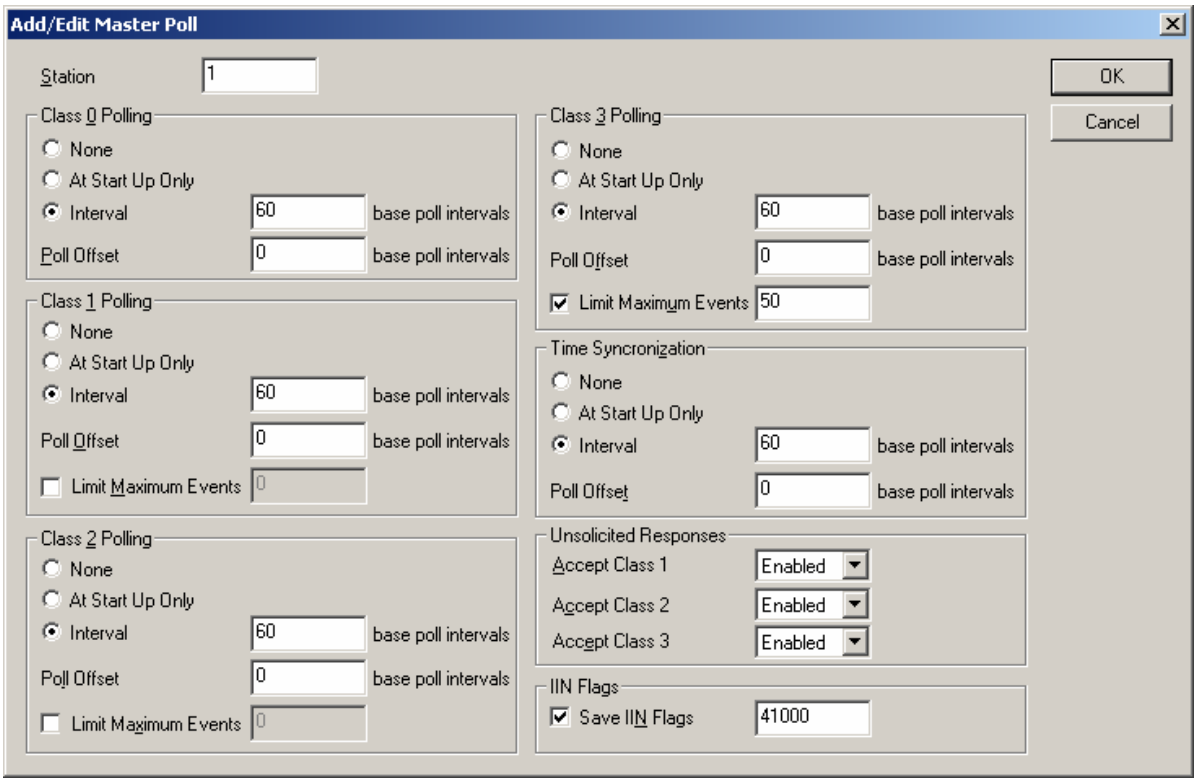
The **Delete** button removes the selected rows from the table. This button is disabled if there are no entries in the table.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click on the column headings to sort the data. Clicking once sorts the data in ascending order. Clicking again sorts the data in descending order.

5.4.1 Add/Edit Master Poll Dialog

This dialog is used to edit an entry or add a new entry in the Master Poll.



The **Station** edit control displays the address of the DNP slave device to be polled. Valid values are 0 to 65519.

The **Class 0 Polling** section of the dialog specifies the type and rate of polling for Class 0 data.

- The **None** selection disables class 0 polling for the slave station. This is the default selection.
- The **At Start Up Only** selection will cause the master to poll the slave station at startup only.
- The **Interval** selection will cause the master to poll the slave station at startup and then every **Interval** of the base poll interval. For example if the base poll interval is 60 seconds and the Interval parameter is set to 60 then the master will poll the slave station every hour. Valid values are 1 to 32767. The default value is 60.
- The **Poll Offset** parameter is used to distribute the load on the communication network. The Poll Offset is entered in multiples of the base poll interval. Valid values for this parameter are 0 to the Poll Interval value minus 1. Any non-zero value delays the start of polling for the specified objects by that amount. The default value is 0. This control is disabled when None is selected, and enabled otherwise. For an example of using the Poll Offset parameter see the ***Poll Offset Example*** at the end of this section.

The **Class 1 Polling** section of the dialog specifies the type and rate of polling for Class 1 data.

- The **None** selection disables class 1 polling for the slave station. This is the default selection.
- The **At Start Up Only** selection will cause the master to poll the slave station at startup only.
- The **Interval** selection will cause the master to poll the slave station at startup and then every **Interval** of the base poll interval. For example if the base poll interval is 60 seconds and the Interval parameter is set to 60 then the master will poll the slave station every hour. Valid values are 1 to 32767. The default value is 60.

- The **Poll Offset** parameter is used to distribute the load on the communication network. The Poll Offset is entered in multiples of the base poll interval. Valid values for this parameter are 0 to the Poll Interval value minus 1. Any non-zero value delays the start of polling for the specified objects by that amount. The default value is 0. This control is disabled when None is selected, and enabled otherwise. For an example of using the Poll Offset parameter see the ***Poll Offset Example*** at the end of this section.
- **Limit Maximum Events** allows limiting the number of events in poll responses for Class 1/2/3 data. The checkbox is not checked by default, meaning there is no limit on the number of events. Select the checkbox to specify a limit. The valid values for this parameter are 1 to 65535. The default value is 65535. This control is disabled when None is selected, and enabled otherwise. The Maximum Events parameter can be used to manage communication load on a system.

  Consider the example of a master polling some data logging remotes, and the case where one of the remotes has been offline for a long time. The remote will have built up a large number of buffered events. If the master polled it for all events, the reply might take a long time, and cause an unwanted delay in the master's polling cycle. However if the master limits the number of events returned, the reply message duration will be more deterministic and the master can ensure its poll loop timing is maintained. In this case, the event retrieval from the data logger will be distributed over a number of poll cycles.

The **Class 2 Polling** section of the dialog specifies the type and rate of polling for Class 2 data.

- The **None** selection disables class 1 polling for the slave station. This is the default selection.
- The **At Start Up Only** selection will cause the master to poll the slave station at startup only.
- The **Interval** selection will cause the master to poll the slave station at startup and then every **Interval** of the base poll interval. For example if the base poll interval is 60 seconds and the Interval parameter is set to 60 then the master will poll the slave station every hour. Valid values are 1 to 32767. The default value is 60.
- The **Poll Offset** parameter is used to distribute the load on the communication network. The Poll Offset is entered in multiples of the base poll interval. Valid values for this parameter are 0 to the Poll Interval value minus 1. Any non-zero value delays the start of polling for the specified objects by that amount. The default value is 0. This control is disabled when None is selected, and enabled otherwise. For an example of using the Poll Offset parameter see the ***Poll Offset Example*** at the end of this section.
- **Limit Maximum Events** allows limiting the number of events in poll responses for Class 1/2/3 data. The checkbox is not checked by default, meaning there is no limit on the number of events. Select the checkbox to specify a limit. The valid values for this parameter are 1 to 65535. The default value is 65535. This control is disabled when None is selected, and enabled otherwise.

  The Maximum Events parameter can be used to manage communication load on a system. Consider the example of a master polling some data logging remotes, and the case where one of the remotes has been offline for a long time. The remote will have built up a large number of buffered events. If the master polled it for all events, the reply might take a long time, and cause an unwanted delay in the master's polling cycle. However if the master limits the number of events returned, the reply message duration will be more deterministic and the master can ensure its poll loop timing is maintained. In this case, the event retrieval from the data logger will be distributed over a number of poll cycles.

The **Class 3 Polling** section of the dialog specifies the type and rate of polling for Class 3 data.

- The **None** selection disables class 1 polling for the slave station. This is the default selection.

- The **At Start Up Only** selection will cause the master to poll the slave station at startup only.
- The **Interval** selection will cause the master to poll the slave station at startup and then every **Interval** of the base poll interval. For example if the base poll interval is 60 seconds and the Interval parameter is set to 60 then the master will poll the slave station every hour. Valid values are 1 to 32767. The default value is 60.
- The **Poll Offset** parameter is used to distribute the load on the communication network. The Poll Offset is entered in multiples of the base poll interval. Valid values for this parameter are 0 to the Poll Interval value minus 1. Any non-zero value delays the start of polling for the specified objects by that amount. The default value is 0. This control is disabled when None is selected, and enabled otherwise. For an example of using the Poll Offset parameter see the ***Poll Offset Example*** at the end of this section.
- **Limit Maximum Events** allows limiting the number of events in poll responses for Class 1/2/3 data. The checkbox is not checked by default, meaning there is no limit on the number of events. Select the checkbox to specify a limit. The valid values for this parameter are 1 to 65535. The default value is 65535. This control is disabled when None is selected, and enabled otherwise.

  The Maximum Events parameter can be used to manage communication load on a system. Consider the example of a master polling some data logging remotes, and the case where one of the remotes has been offline for a long time. The remote will have built up a large number of buffered events. If the master polled it for all events, the reply might take a long time, and cause an unwanted delay in the master's polling cycle. However if the master limits the number of events returned, the reply message duration will be more deterministic and the master can ensure its poll loop timing is maintained. In this case, the event retrieval from the data logger will be distributed over a number of poll cycles.

The **Time Synchronization Rate** section of the dialog specifies the rate of issuing a time synchronization to this device, as a multiple of the base poll interval. Valid selections for this parameter are:

- The **None** selection will disable issuing a time sync to this device. This is the default selection.
- The **At Start Up Only** selection will cause issuing a time synchronization at startup only.
- The **Interval** selection will cause the RTU to issue a time synchronization at startup and then every **Interval** of the base poll interval seconds. Valid entries for **Interval** are between 1 and 32767 the base poll interval seconds. The default value is 60.

The **Unsolicited Responses** section is used in conjunction with the Enable Unsolicited Responses on Start Up parameter on the Application Layer page. Certain non-SCADAPack slave devices are designed to start with their Enable Unsolicited Responses on Start Up parameter set to No. Selecting Enabled for any class causes the master to (after it detects the slave come online) send a command allowing the slave to begin sending Unsolicited Responses of that class.

With SCADAPack slaves the Enable Unsolicited Responses on Start Up parameter may be set to Yes, and the Accept Class parameters may be left at Disabled.

- The **Accept Class 1** selection displays the enable/disable status of unsolicited responses from the slave device for Class 1 events. The default selection is disabled.
- The **Accept Class 2** selection displays the enable/disable status of unsolicited responses from the slave device for Class 1 events. The default selection is disabled.
- The **Accept Class 3** selection displays the enable/disable status of unsolicited responses from the slave device for Class 1 events. The default selection is disabled.

The **Save IIN Flags** checkbox enables storing the IIN (Internal Indications) flags from the slave station in a Modbus database register. When this parameter is checked the IIN flags are saved to the entered Modbus register address. Valid entries are Modbus register addresses 30001 to 39999 and 40001 to 49999. The default value is 0.

The IIN flags are set by the slave to indicate the events in the following table. The events are bit mapped to the Modbus register. All bits except *Device Restarted* and *Time Synchronization required* are cleared when the slave station receives any poll or read data command. The master will write to bits 5 and 11 depending on the local conditions in the master.

Bit	Description
0	last received message was a broadcast message
1	Class 1 data available
2	Class 2 data available
3	Class 3 data available
4	Time Synchronization required
5	not used (returns 0)
6	Device trouble Indicates memory allocation error in the slave, or For master in mimic mode indicates communication failure with the slave device.
7	Device restarted (set on a power cycle)
8	Function Code not implemented
9	Requested object unknown or there were errors in the application data
10	Parameters out of range
11	Event buffer overflowed Indicates event buffer overflow in the slave or master. The slave will set this bit if the event buffer in the slave is overflowed. The master will set this bit if the event buffer in the master has overflowed with events read from the slave. Ensure the event buffer size, in the master and slave, is set to a value that will ensure the buffer does not overflow and events are lost.
12	not used (returns 0)
13	not used (returns 0)
14	not used (returns 0)
15	not used (returns 0)

The **OK** button checks the data for this table entry. If the data is valid the dialog is closed. If the table data entered is invalid, an error message is displayed and the dialog remains open. The table entry is invalid if any of the fields is out of range. The data is also invalid if it conflicts with another entry in the table. Such conflict occurs when the station number is not unique. The ordering of items in this table is important.

The **Cancel** button closes the dialog without saving changes.

5.4.2 Poll Offset Example

The Poll Offset parameter enhances the control over timing of master poll messages, by allowing master poll messages to be staggered.

For example, a master station may have 10 slaves to poll, and must poll them every hour. If these are included in the poll table without any poll offset, they will all be polled in quick succession on the hour – resulting in a large burst of communication activity once per hour. On some types of

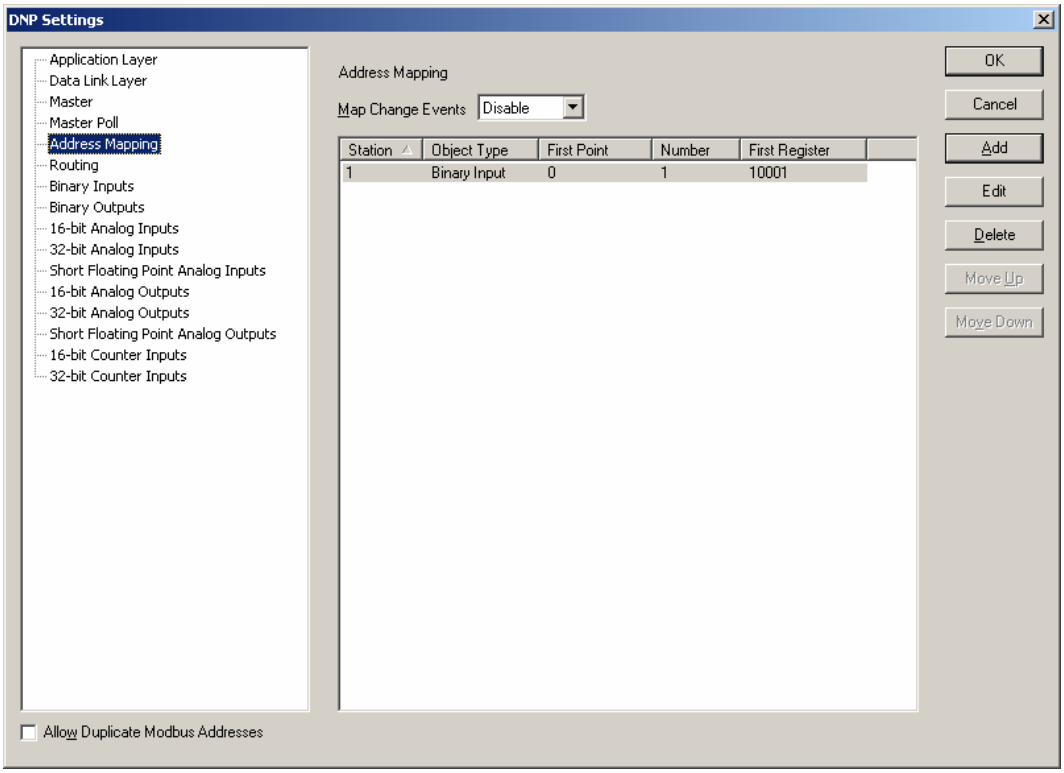
communications networks (particularly radio) it is desirable to distribute communication load more evenly, to minimize the chance of collisions and to avoid the possibility of consuming bandwidth continuously for an extended period of time.

The poll offset parameter enables you to distribute the communication load evenly. In the above example, it is possible to stagger the master polls so slave stations are polled at 6-minute intervals. To do this, set the base poll interval to 6 minutes, and for each slave station set the poll rate and poll offset parameters as follows:

Base Poll	Poll Rate	Poll Offset
6	10	0
6	10	1
6	10	2
6	10	3
6	10	4
6	10	5
6	10	6
6	10	7
6	10	8
6	10	9

5.5 Address Mapping

The Address Mapping property page is selected for editing by clicking Address Mapping in the tree control section of the DNP Settings window. This selection is only visible if the controller type is a SCADAPack 350, SCADAPack 32 or SCADAPack 32P. These controllers support DNP Master.



The Address Mapping contains a set of mapping rules, which will allow the Remote DNP Objects to be mapped into local Modbus registers. This makes the data accessible locally, to be read and/or

written locally in logic. It is also possible to perform data concentration – to map the remote DNP Objects into the local DNP address space – by defining local DNP objects and then mapping the remote DNP objects to the same Modbus registers. Change events can also be mapped in the same way - there is a configuration option to allow mapping of change events from a remote DNP slave into the local DNP change event buffer. The table may have up to 1000 entries. See the ***DNP Address Mapping*** section for further information. A vertical scroll bar is used if the list exceeds the window size.

The **Station** column displays the address of the remote DNP station.

The **Object Type** column displays the DNP data object type.

The **First Point** column displays the starting address of the remote DNP data points.

The **Number** column displays the number of remote points to be mapped.

The **First Register** column displays the starting address of local Modbus register where the remote data points are to be mapped.

The **Map Change Events** combo box enables or disables mapping of change events from a remote DNP slave into the local DNP change event buffer. Mapped change events may trigger an Unsolicited message to be sent, after the Hold Count or Hold Time is reached. It may be desired instead to map only static (live) values into local Modbus registers. The default selection is Disabled.

The default selection is Disabled.

The **OK** button saves the table data. No error checking is done on the table data.

The **Cancel** button closes the dialog without saving changes.

Select the **Add** button to enter a new row in the Address Mapping. Selecting the Add button opens the **Add/Edit Address Mapping** dialog.

Select the **Edit** button to modify the selected row in the Address Mapping. Selecting the Edit button opens the **Add/Edit Address Mapping** dialog containing the data from the selected row. This button is disabled if more than one row is selected. This button is disabled if there are no entries in the table.

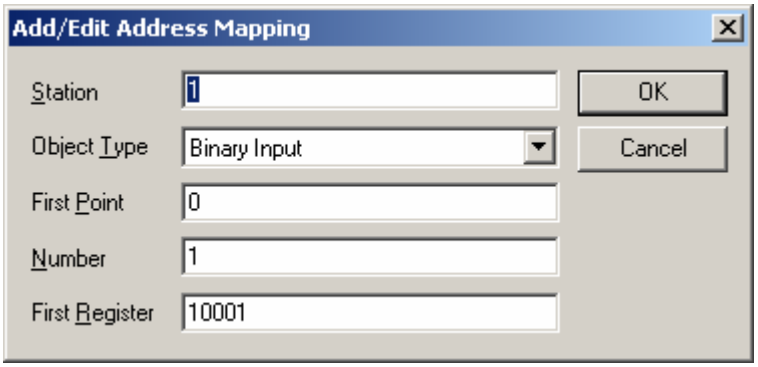
The **Delete** button removes the selected rows from the table. This button is disabled if there are no entries in the table.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click on the column headings to sort the data. Clicking once sorts the data in ascending order. Clicking again sorts the data in descending order.

5.5.1 Add/Edit Address Mapping Dialog

This dialog is used to edit an entry or add a new entry in the Address Mapping.



The **Station** edit control displays the address of the remote DNP station. Valid values for this field are from 0 to 65519.

The **Object Type** combo box displays the DNP data Object Type. The list of available types includes: Binary Input, Binary Output, 16-bit Analog Input, 32-bit Analog Input, Short Floating Point Analog Input, 16-bit Analog Output, 32-bit Analog Output, Short Floating Point Analog Output, 16-bit Counter Input, 32-bit Counter Input. The Default selection is Binary Input.

The **First Point** edit control displays the starting address of the remote DNP data points. Valid values are from 0 to 65519.

The **Number** edit control displays the number of remote points to be mapped. Valid values for this field are from 1 to 9999.

The **First Register** edit control displays the starting address of local Modbus register where the remote data points are to be mapped. Valid values depend on the selection of DNP Object Type and are as follows:

For Binary Inputs valid range is from 10001 to 14096.

For Binary Outputs valid range is from 00001 to 04096.

For Analog Inputs and Counter Inputs valid range is from 30001 to 39999.

For Analog Outputs valid range is from 40001 to 49999.

The **OK** button checks the data for this table entry. If the data is valid the dialog is closed. If the table data entered is invalid, an error message is displayed and the dialog remains open. The table entry is invalid if any of the fields is out of range. The data is also invalid if it conflicts with another entry in the table. Such conflict occurs when the combination of station number, object type, and object address is not unique. The ordering of items in this table is not important.

The **Cancel** button closes the dialog without saving changes.

5.6 Routing

In a typical application the SCADAPack controller, configured for DNP, will act as a DNP slave station in a network. The SCADA system will communicate directly with all the DNP slave stations in the SCADA system.

DNP routing is a method for routing, or forwarding, of messages received from the SCADA system, through the SCADAPack controller, to a remote DNP slave station. The SCADAPack DNP slave station will respond to all messages sent to it from the SCADA system, as well as broadcast messages. When it receives a message that is not sent to it the message is sent on the serial port defined in the routing table. See section ***3.4-DNP Routing*** for an explanation of using and configuring DNP Routing.

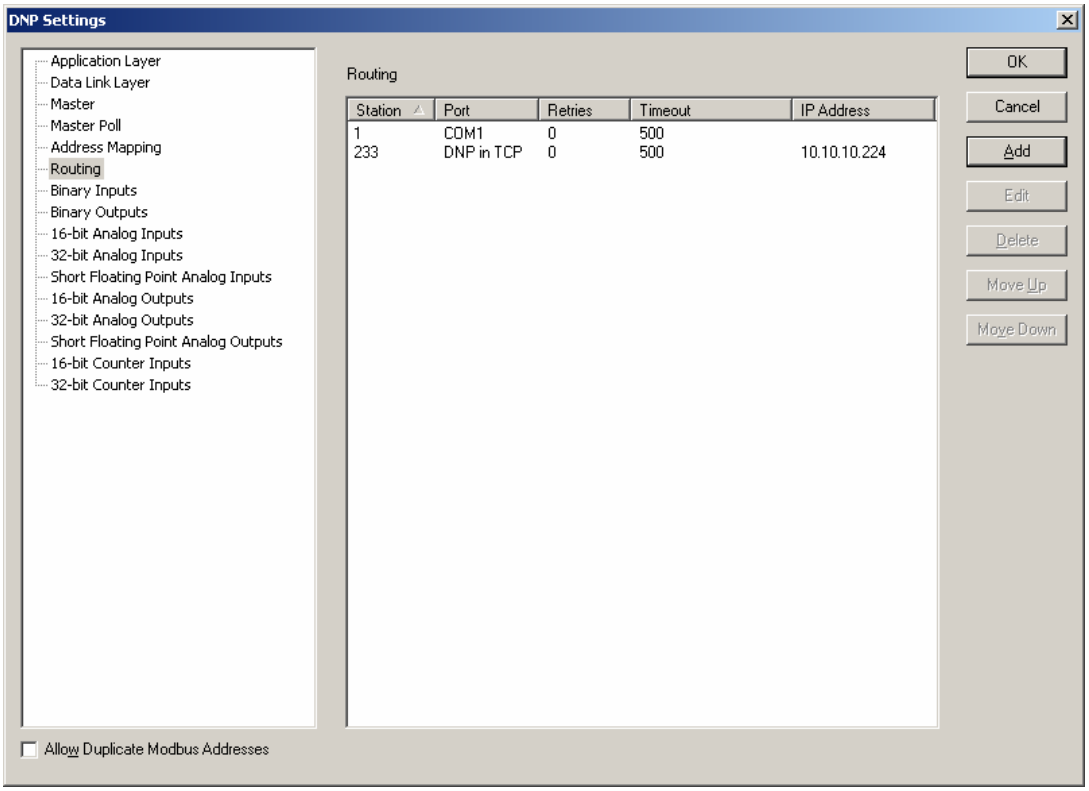
The advantage of this routing ability is that the SCADA system can communicate directly with the SCADAPack controller and the SCADAPack controller can handle the communication to remote DNP slave stations.

The DNP Routing table displays each routing translation as a row, with column headings, in the table. Entries may be added, edited or deleted using the button selections on the table. The table will hold a maximum of 128 entries.

The DNP Routing property page is selected for editing by clicking DNP Routing in the tree control section of the DNP Settings window. When selected the DNP Routing property page is displayed.

Notes:

- Routing must be enabled for the controller serial port in order to enable DNP routing.
- TelePACE version 2.63 cannot open files created with version 2.64, unless the Routing table is empty.
- TelePACE version 2.64 cannot open files created with version 2.65, unless the Routing table is empty.



The **Station** column displays the address of the remote DNP station.

The **Port** column displays the serial communications port, which should be used to communicate with this DNP station.

The **Retries** column displays the maximum number of Data Link retries, which should be used for this DNP station in the case of communication errors.

The **Timeout** column displays the maximum time (in milliseconds) to wait for a Data Link response before retrying or failing the message.

The **IP Address** column displays the IP address of the remote DNP station.

The **OK** button saves the table data. No error checking is done on the table data.

The **Cancel** button closes the dialog without saving changes.

Select the **Add** button to enter a new row in the DNP Routing table. Selecting the Add button opens the **Add/Edit DNP Route** dialog.

Select the **Edit** button to modify the selected row in the DNP Routing table. Selecting the Edit button opens the **Add/Edit DNP Route** dialog containing the data from the selected row. This button is disabled if more than one row is selected. This button is disabled if there are no entries in the table.

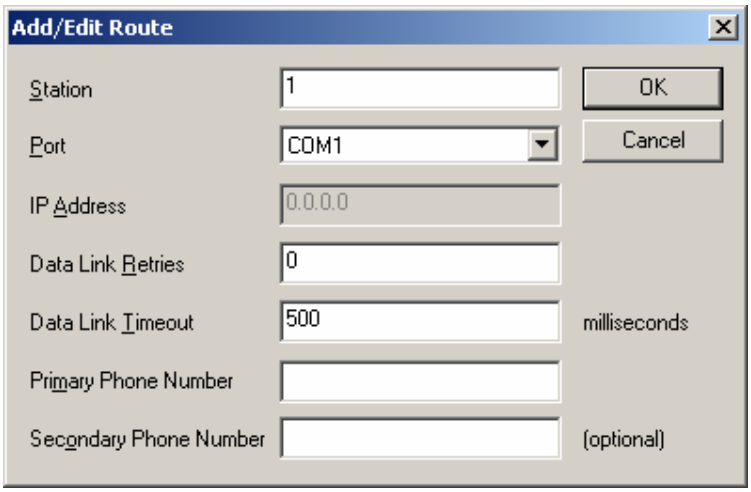
The **Delete** button removes the selected rows from the table. This button is disabled if there are no entries in the table.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click on the column headings to sort the data. Clicking once sorts the data in ascending order. Clicking again sorts the data in descending order.

5.6.1 Add/Edit DNP Route Dialog

This dialog is used to edit an entry or add a new entry in the DNP Routing table.



The **Station** edit control displays the address of the remote DNP station. Valid values for this field are from 0 to 65519.

The **Port** combo box displays the communications port, which should be used to communicate with the remote DNP station. This combo box contains list of the valid communications ports, which will depend on the type of controller. For SCADAPack 350, SCADAPack 32 and SCADAPack 32P controllers the list will contain DNP in TCP and DNP in UDP in addition to the serial port designations, COM1, COM2 etc.

The **IP Address** edit control is only enabled if the controller type is a SCADAPack 350, SCADAPack 32 or SCADAPack 32P. Enter the IP address of the remote DNP station.

The **Data Link Retries** edit control displays the maximum number of Data Link retries which should be used for this DNP station in the case of communication errors. This field overrides the

Data Link Retries field in the global DNP parameters set in the Data Link Layer configuration. Valid values for this field are 0 to 255.

The **Data Link Timeout** edit control displays the maximum time (in milliseconds) to wait for a Data Link response before retrying or failing the message. This field overrides the Data Link Timeout field in the global DNP parameters in the Data Link Layer configuration. Valid values for this field are 100 to 60000, in multiples of 100.

The phone number parameters allow automatic dialing for stations that use dial-up ports. The Phone Number parameters are enabled only when the Port selected is a serial port.

The **Primary Phone Number** is the dialing string that will be used for the primary connection to the station. The controller will make 1 or more attempts, as configured in the Application layer, to connect using this number. If this connection fails then the Secondary Phone Number will be dialed, if it is entered.

Valid values are any ASCII string. The maximum length is 32 characters. Leave this blank if you are not using a dial-up connection. The default value is blank. The serial port type must be set to RS-232 Modem for dial-up operation.

The **Secondary Phone Number** is the dialing string that will be used for the secondary connection to the station. The controller will make 1 or more attempts, as configured in the Application layer, to connect using this number. This number is used after the primary connection fails on all attempts.

Valid values are any ASCII string. The maximum length is 32 characters. Leave this blank if you are not using a dial-up connection. The default value is blank. The serial port type must be set to RS-232 Modem for dial-up operation.

The **OK** button checks the data for this table entry. If the data is valid the dialog is closed. If the table data entered is invalid, an error message is displayed and the dialog remains open. The table entry is invalid if any of the fields is out of range. The data is also invalid if it conflicts with another entry in the table.

The **Cancel** button closes the dialog without saving changes.

5.6.2 Dynamic Routing

In addition to the configured routing table, there is an internal *dynamic* routing entry. This entry is not shown in the routing table. The dynamic routing entry listens to incoming messages and learns the address of the remote station and the communication port used for communicating with it.

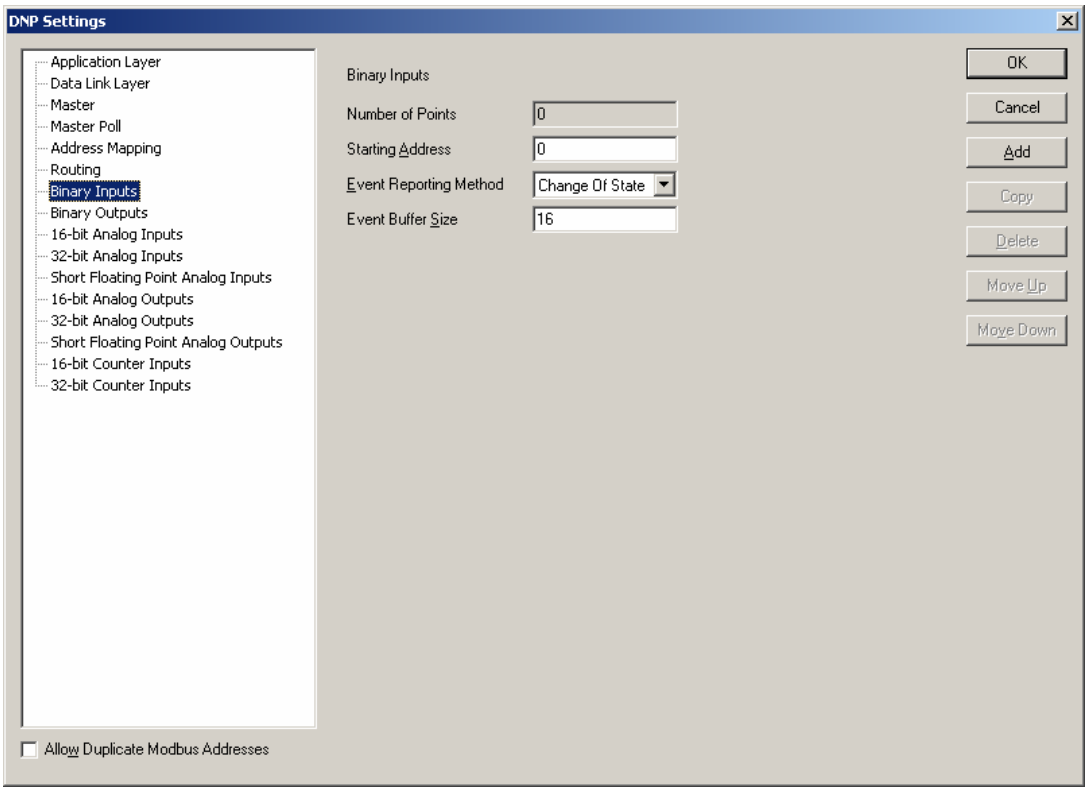
If there is no entry in the routing table, the RTU will use the dynamic routing entry to respond to a message on the same communication port as the incoming message.

The dynamic routing entry is not cleared on initialization. This is deliberate, and is important for controllers that need to be remotely reconfigured. In this case the host can initialize the controller without losing the communications link.

Note:	Dynamic routing should not be used in a master station. Configure all slave stations in the routing table.

5.7 Binary Inputs Configuration

The Binary Inputs property page is selected for editing by clicking Binary Inputs in the tree control section of the DNP Settings window. When selected the Binary Inputs property page is active.



Binary Inputs parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays number of binary inputs reported by this RTU. This value will increment with the addition of each configured Binary Input point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the starting DNP address of the first Binary Input point.

The **Event Reporting Method** selection specifies how binary input events are reported. A ***Change Of State*** event is an event object, without time, that is generated when the point changes state. Only one event is retained in the buffer for each point. If a subsequent event occurs for a point, the previous event object will be overwritten. The main purpose of this mode is to allow a master station to efficiently poll for changed data. A ***Log All Events*** is event object with absolute time will be generated when the point changes state. All events will be retained. The main purpose of this mode is to allow a master station to obtain a complete historical data log. The selections are:

- Change of State
- Log All Events

The **Event Buffer Size** is the maximum number of binary input change events, which can be buffered by the DNP driver. The buffer holds all binary input change events, regardless of the class to which they are assigned. If the buffer fills to 90 percent the RTU will send a buffer overflow event to the master station. If the buffer is completely full the RTU will lose the oldest events and retain the newest. The size of the event buffer should be at least equivalent to the number of Binary Inputs defined with a Class. This will allow all Binary Inputs to change simultaneously without losing any events. The value of this parameter is dependent on how often change events occur and the rate at

which the events are reported to the master station. The valid values for this parameter are 0 - 65535. Default value is 16.

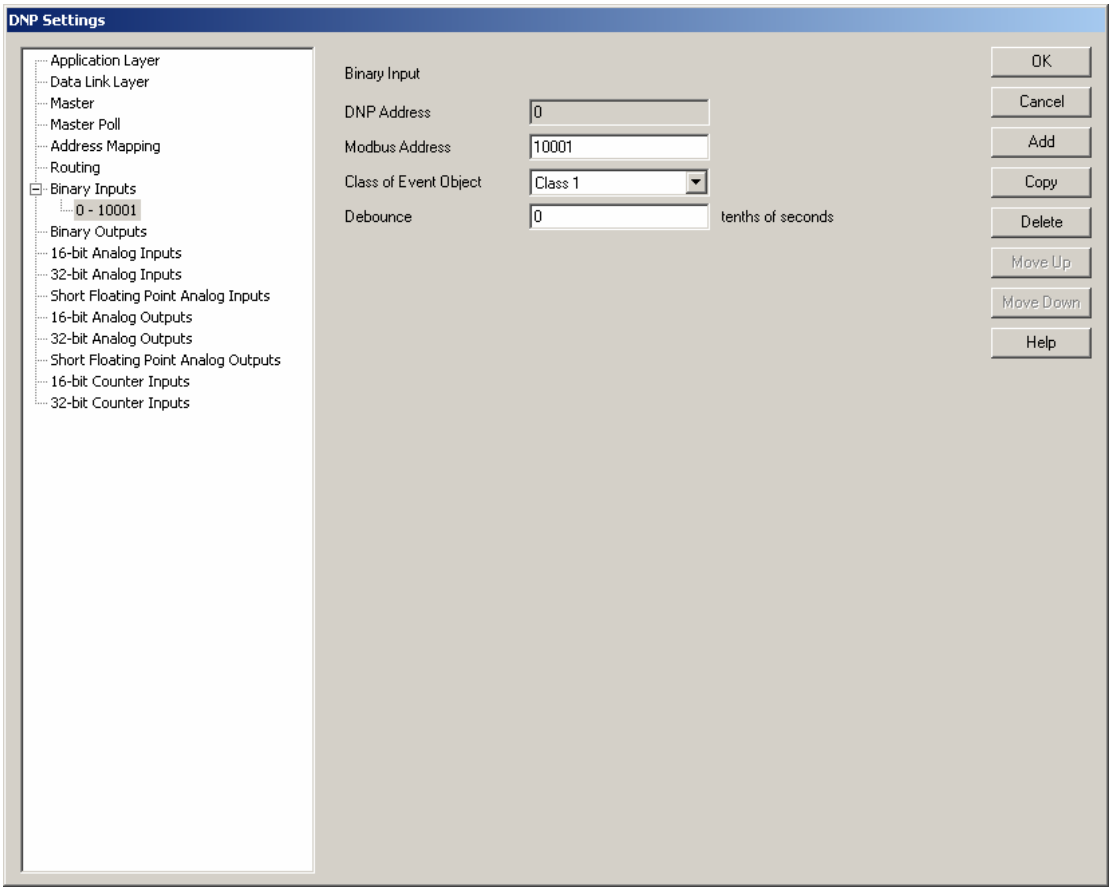
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.7.1 Adding Binary Inputs

Binary Inputs are added to the DNP configuration using the Binary Input property page. To add a Binary Input:

- Select **Binary Inputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the Binary Inputs property page.
- The **Binary Input** property page is now displayed.
- Edit the Binary Input parameters as required and then click the **Add** button.

As Binary Inputs are defined they are added as leaves to the Binary Inputs branch of the tree control. When Binary Inputs are defined the Binary Inputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined Binary Inputs.



The Binary Input parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP Binary Input address of the point. Each Binary Input is assigned a DNP address as they are defined. The DNP point address starts at the value defined in the Binary Inputs configuration dialog and increments by one with each defined Input.

The **Modbus Address** parameter specifies the Modbus address of the Binary Input assigned to the DNP Address. The SCADAPack and Micro16 controllers use Modbus addressing for all digital inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on digital input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 00001 through 09999
- 10001 through 19999

The **Class of Event Object** parameter specifies the event object class the Binary Input is assigned. The selections are:

- None
- Class 1
- Class 2
- Class 3

The **Debounce** parameter limits the frequency of change events. The input must remain in the same state for the debounce time for a change of state to be detected. Note that the input is sampled every 0.1s. Changes shorter than the sample time cannot be detected. Valid values are 0 to 65535 tenths of seconds. The value 0 means no debounce. The default value is 0.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the Binary Input parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current Binary Input to the DNP configuration.

Click the **Copy** button to copy the current Binary Input parameters to the next DNP Address.

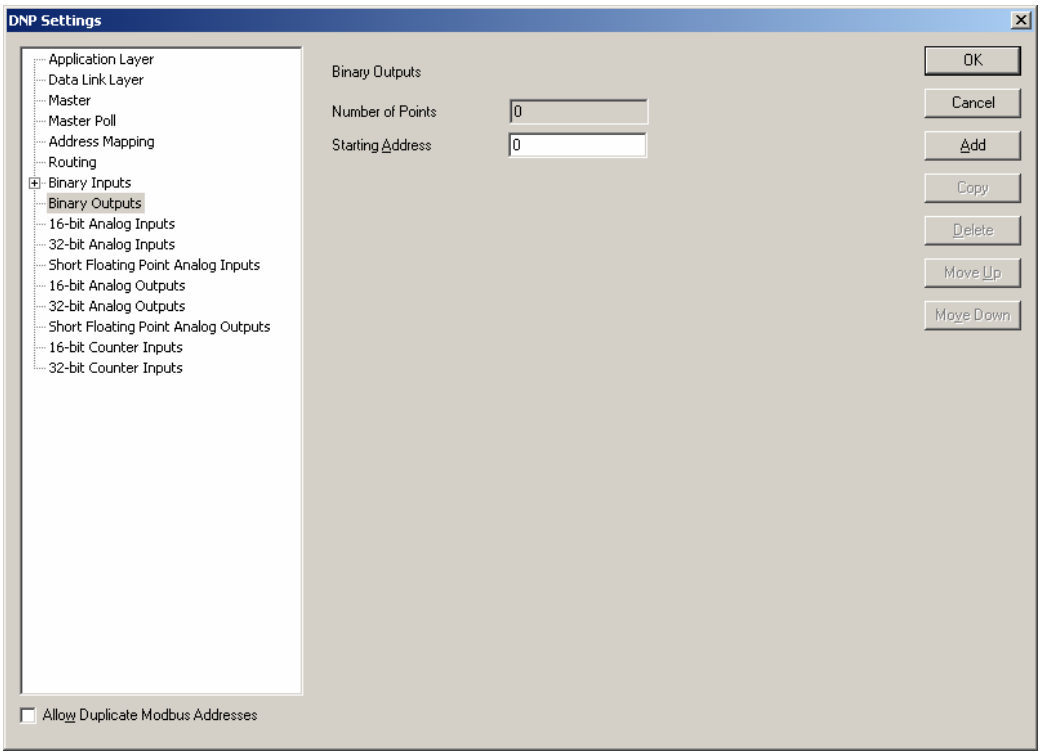
Click the **Delete** button to delete the current Binary Input.

Click the **Move Up** button to move the current Binary Input up one position in the tree control branch.

Click the **Move Down** button to move the current Binary Input down one position in the tree control branch.

5.8 Binary Outputs Configuration

The Binary Outputs property page is selected for editing by clicking Binary Outputs in the tree control section of the DNP Settings window. When selected the Binary Outputs property page is active.



Binary Outputs parameters are viewed in this property page.

The **Number of Points** displays the number of binary outputs reported by this RTU. This value will increment with the addition of each configured Binary Output point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the starting DNP address of the first Binary Output point.

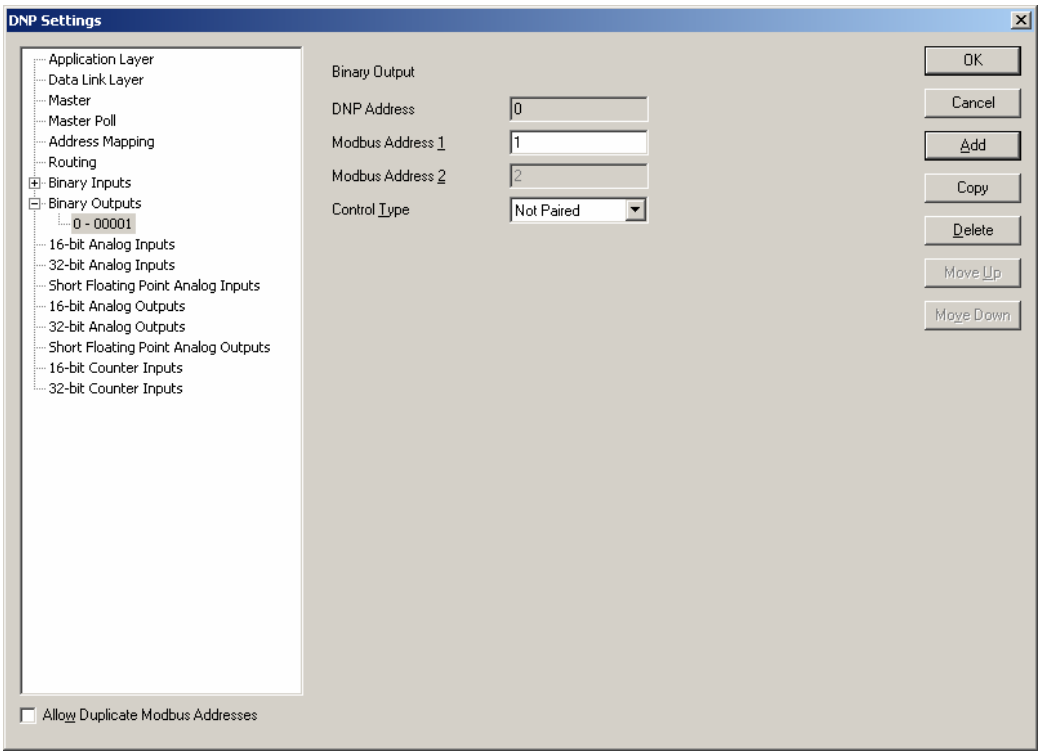
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.8.1 Adding Binary Outputs

Binary Outputs are added to the DNP configuration using the Binary Output property page. To add a Binary Output:

- Select **Binary Outputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the Binary Outputs property page.
- The Binary Output property page is now displayed.
- Edit the Binary Output parameters as required and then click the **Add** button.

As Binary Outputs are defined they are added as leaves to the Binary Outputs branch of the tree control. When Binary Outputs are defined the Binary Outputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined Binary Outputs.



The Binary Output parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP Binary Output address of the point. Each Binary Output is assigned a DNP address as they are defined. The DNP point address starts at the value defined in the Binary Outputs dialog and increments by one with each defined Output.

The **Modbus Address 1** parameter specifies the Modbus address of the Binary Output assigned to the DNP Address. The SCADAPack and Micro16 controllers use Modbus addressing for all digital outputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference Manual*** for complete information on digital output addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 00001 through 09999

The **Modbus Address 2** parameter specifies the second Modbus address of the second Binary Output assigned to the DNP Address when the Paired control type is selected. This selection is not active when the control type is Not Paired. Valid Modbus addresses are:

- 00001 through 09999

The **Control Type** parameter specifies whether the Binary Output is a paired control or not. If it is a paired control, i.e. trip/close output type, this means that the DNP address is associated to two physical control outputs and requires two Modbus addresses per DNP address. Control type selections are:

- Paired
- Not Paired

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the Binary Output parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current Binary Output to the DNP configuration.

Click the **Copy** button to copy the current Binary Output parameters to the next DNP Address.

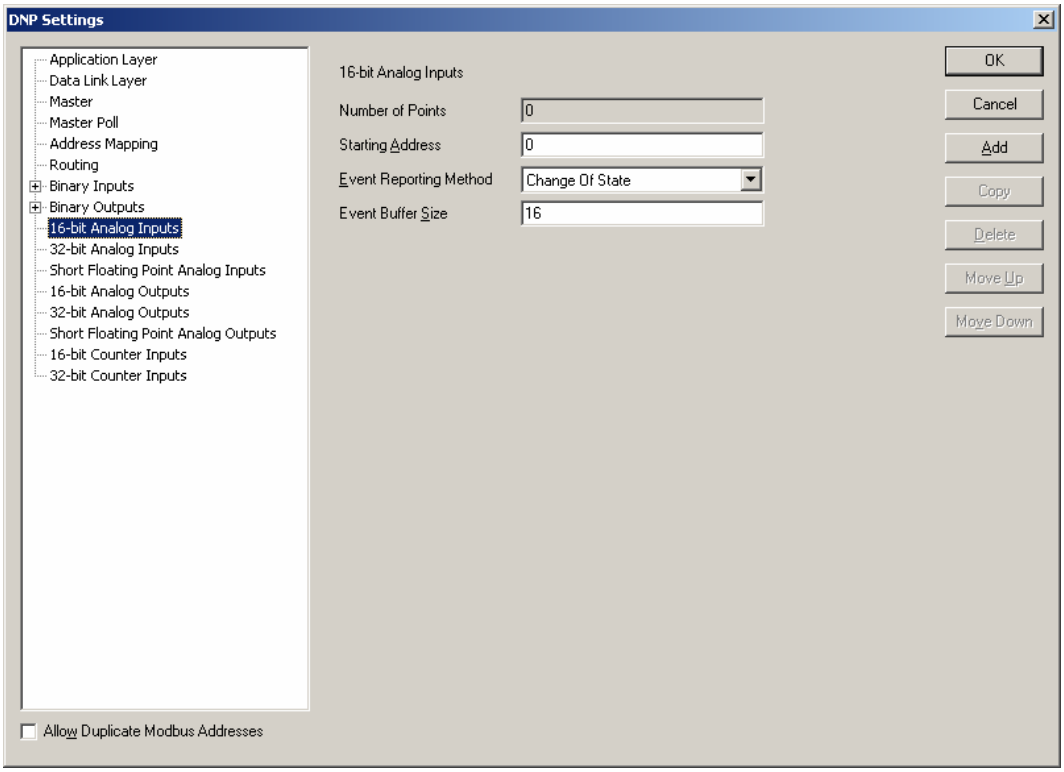
Click the **Delete** button to delete the current Binary Output.

Click the **Move Up** button to move the current Binary Output up one position in the tree control branch.

Click the **Move Down** button to move the current Binary Output down one position in the tree control branch.

5.9 16–Bit Analog Inputs Configuration

The 16-Bit Analog Inputs property page is selected for editing by clicking 16-Bit Analog Inputs in the tree control section of the DNP Settings window. When selected the 16-Bit Analog Inputs property page is active.



16-Bit Analog Inputs parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays the number of 16 bit analog inputs reported by the RTU. This value will increment with the addition of each configured 16-Bit Analog Input point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first 16-bit Analog Input point.

The **Event Reporting Method** selection specifies how 16-bit Analog Input events are reported. A ***Change Of State*** event is an event object, without time, that is generated when the point changes state. Only one event is retained in the buffer for each point. If a subsequent event occurs for a point, the previous event object will be overwritten. The main purpose of this mode is to allow a master station to efficiently poll for changed data. A ***Log All Events*** event object with absolute time will be generated when the point changes state. All events will be retained. The main purpose of this mode is to allow a master station to obtain a complete historical data log. The selections are:

- Change of State
- Log All Events

The **Event Buffer Size** parameter specifies the maximum number of 16-Bit Analog Input change without time events buffered by the RTU. The buffer holds all 16-Bit Analog Input events, regardless of the class to which they are assigned. If the buffer fills to 90 percent the RTU will send a buffer overflow event to the master station. If the buffer is completely full the RTU will lose the oldest events and retain the newest. The Event Buffer size should be at least equivalent to the number of 16-Bit Analog Inputs defined as Change of State type. That will allow all 16-Bit Analog Inputs to exceed the deadband simultaneously without losing any events. The value of this parameter is dependent on how often 16-Bit Analog Input events occur and the rate at which the events are reported to the master station. The valid values for this parameter are 0 - 65535. Default value is 16.

For SCADAPack 32 and SCADAPack 32P controllers analog input events are processed by the DNP driver at a rate of 100 events every 100 ms. If more than 100 analog input events need to be processed they are processed sequentially in blocks of 100 until all events are processed. This allows the processing of 1000 analog input events per second.

For SCADASense Series of controllers, SCADAPack 100, SCADAPack LP, SCADAPack and Micro16 controllers analog input events are processed by the DNP driver at a rate of 20 events every 100 ms. If more than 20 analog input events need to be processed they are processed sequentially in blocks of 20 until all events are processed. This allows the processing of 200 analog input events per second.

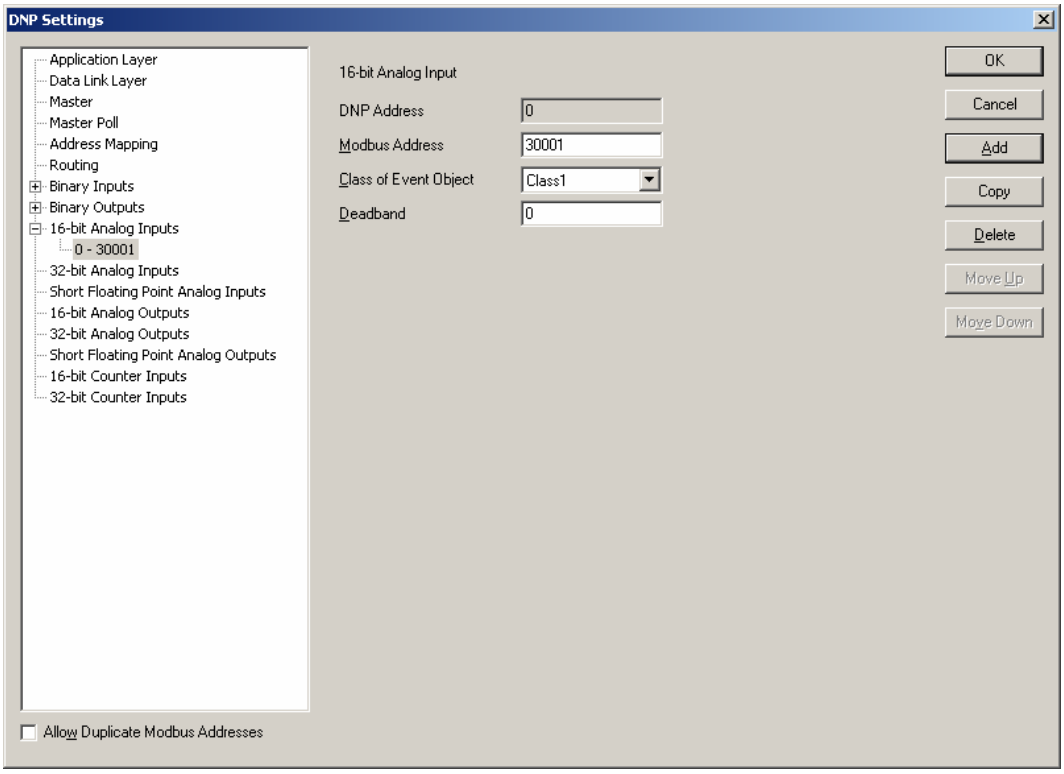
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.9.1 Adding 16-Bit Analog Inputs

16-Bit Analog Inputs are added to the DNP configuration using the 16-Bit Analog Input property page. To add a 16-Bit Analog Input:

- Select **16-Bit Analog Inputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the 16-Bit Analog Inputs property page.
- The **16-Bit Analog Input** property page is now displayed.
- Edit the 16-Bit Analog Input parameters as required and then click the **Add** button.

As 16-Bit Analog Inputs are defined they are added as leaves to the 16-Bit Analog Inputs branch of the tree control. When 16-Bit Analog Inputs are defined the 16-Bit Analog Inputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined 16-Bit Analog Inputs.



The 16-Bit Analog Input parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP 16-Bit Analog Input address of the point. Each 16-Bit Analog Input is assigned a DNP address as they are defined. The DNP point address starts at the value set in the 16-bit Analog Input configuration dialog and increments by one with each defined 16-Bit Analog Input.

The **Modbus Address** parameter specifies the Modbus address of the 16-Bit Analog Input assigned to the DNP Address. The SCADAPack and Micro16 controllers use Modbus addressing for all analog inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 30001 through 39999
- 40001 through 49999

The **Class of Event Object** parameter specifies the event object class assigned to the 16-Bit Analog Input is assigned. If Unsolicited reporting is not required for a point, it is recommended to set its Class to **None**. All data points automatically become members of Class 0 or **None** (static data). The selections are:

- None
- Class 1
- Class 2
- Class 3

The **Deadband** parameter specifies the minimum number of counts that the 16-Bit Analog Input must change since it was last reported in order to generate an event. Valid deadband values are 0 to 65535. A deadband of zero will cause any change to create an event.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the 16-Bit Analog Input parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current 16-Bit Analog Input to the DNP configuration.

Click the **Copy** button to copy the current 16-Bit Analog Input parameters to the next DNP Address.

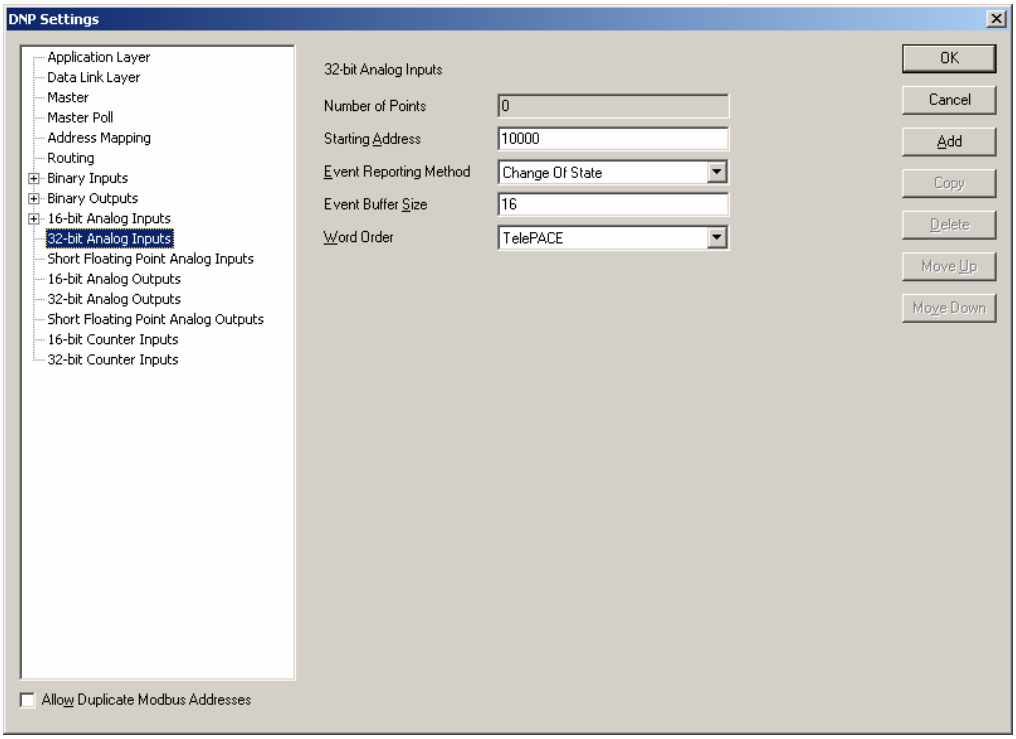
Click the **Delete** button to delete the current 16-Bit Analog Input.

Click the **Move Up** button to move the current 16-Bit Analog Input up one position in the tree control branch.

Click the **Move Down** button to move the current 16-Bit Analog Input down one position in the tree control branch.

5.10 32-Bit Analog Inputs Configuration

The 32-Bit Analog Inputs property page is selected for editing by clicking 32-Bit Analog Inputs in the tree control section of the DNP Settings window. When selected the 32-Bit Analog Inputs property page is active.



32-Bit Analog Inputs parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays the number of 32- bit analog inputs reported by the RTU. This value will increment with the addition of each configured 32-Bit Analog Input point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first 32-bit Analog Input point.

The **Event Reporting Method** selection specifies how 32-bit Analog Input events are reported. A ***Change Of State*** event is an event object, without time, that is generated when the point changes state. Only one event is retained in the buffer for each point. If a subsequent event occurs for a point, the previous event object will be overwritten. The main purpose of this mode is to allow a master station to efficiently poll for changed data. A ***Log All Events*** is event object with absolute time will be generated when the point changes state. All events will be retained. The main purpose of this mode is to allow a master station to obtain a complete historical data log. The selections are:

- Change of State
- Log All Events

The **Event Buffer Size** parameter specifies the maximum number of 32-Bit Analog Input change without time events buffered by the RTU. The buffer holds all 32-Bit Analog Input events, regardless of the class to which they are assigned. If the buffer fills to 90 percent the RTU will send a buffer overflow event to the master station. If the buffer is completely full the RTU will lose the oldest events and retain the newest. The Event Buffer size should be at least equivalent to the number of 32-Bit Analog Inputs defined as Change of State type. That will allow all 32-Bit Analog Inputs to exceed the deadband simultaneously without losing any events. The value of this parameter is dependent on how often 32-Bit Analog Input events occur and the rate at which the events are reported to the master station. The valid values for this parameter are 0 - 65535. Default value is 16.

For SCADAPack 32 and SCADAPack 32P controllers analog input events are processed by the DNP driver at a rate of 100 events every 100 ms. If more than 100 analog input events need to be processed they are processed sequentially in blocks of 100 until all events are processed. This allows the processing of 1000 analog input events per second.

For SCADASense Series of controllers, SCADAPack 100, SCADAPack LP, SCADAPack and Micro16 controllers analog input events are processed by the DNP driver at a rate of 20 events every 100 ms. If more than 20 analog input events need to be processed they are processed sequentially in blocks of 20 until all events are processed. This allows the processing of 200 analog input events per second.

The **Word Order** selection specifies the word order of the 32-bit value. The selections are:

- **TelePACE** Least Significant Word in first register.
- **ISaGRAF** Most Significant Word in first register.

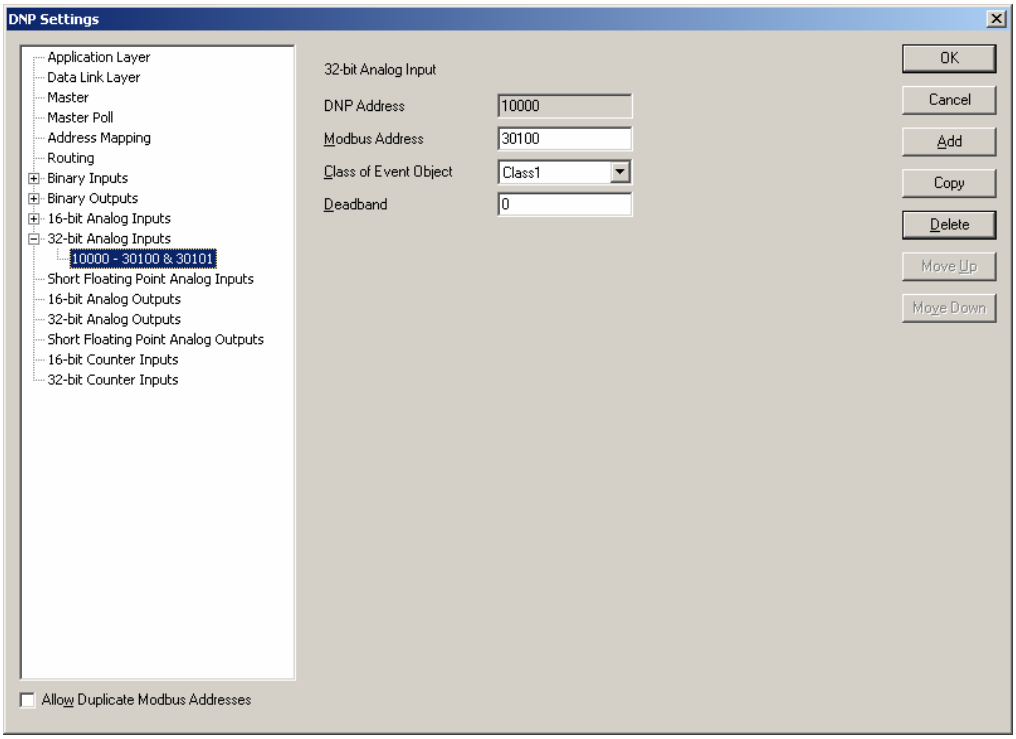
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.10.1 Adding 32-Bit Analog Inputs

32-Bit Analog Inputs are added to the DNP configuration using the 16-Bit Analog Input property page. To add a 32-Bit Analog Input:

- Select **32-Bit Analog Inputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the 32-Bit Analog Inputs property page.
- The **32-Bit Analog Input** property page is now displayed.
- Edit the 32-Bit Analog Input parameters as required and then click the **Add** button.

As 32-Bit Analog Inputs are defined they are added as leaves to the 32-Bit Analog Inputs branch of the tree control. When 32-Bit Analog Inputs are defined the 32-Bit Analog Inputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined 32-Bit Analog Inputs.



The 32-Bit Analog Input parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP 32-Bit Analog Input address of the point. Each 32-Bit Analog Input is assigned a DNP address as they are defined. The DNP point address starts at the value set in the 32-bit Analog Input configuration dialog and increments by one with each defined 32-Bit Analog Input.

The **Modbus Address** parameter specifies the Modbus addresses of the 32-Bit Analog Input assigned to the DNP Address. 32-Bit Analog Inputs use two consecutive Modbus registers for each assigned DNP Address, the address that is entered in this box and the next consecutive Modbus register. The SCADAPack and Micro16 controllers use Modbus addressing for all analog inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 30001 through 39998
- 40001 through 49998

The **Class of Event Object** parameter specifies the event object class the 32-Bit Analog Input is assigned. If Unsolicited reporting is not required for a DNP point, it is recommended to set its Class 0 or **None**. All data points automatically become members of Class 0 or **None** (static data).The selections are:

- None
- Class 1

- Class 2
- Class 3

The **Deadband** parameter specifies whether the RTU generates events. The value entered is the minimum number of counts that the 32-Bit Analog Input must change since it was last reported. Valid deadband values are 0 to 4,294,967,295. A deadband of zero will cause any change to create an event.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the 32-Bit Analog Input parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current 32-Bit Analog Input to the DNP configuration.

Click the **Copy** button to copy the current 32-Bit Analog Input parameters to the next DNP Address.

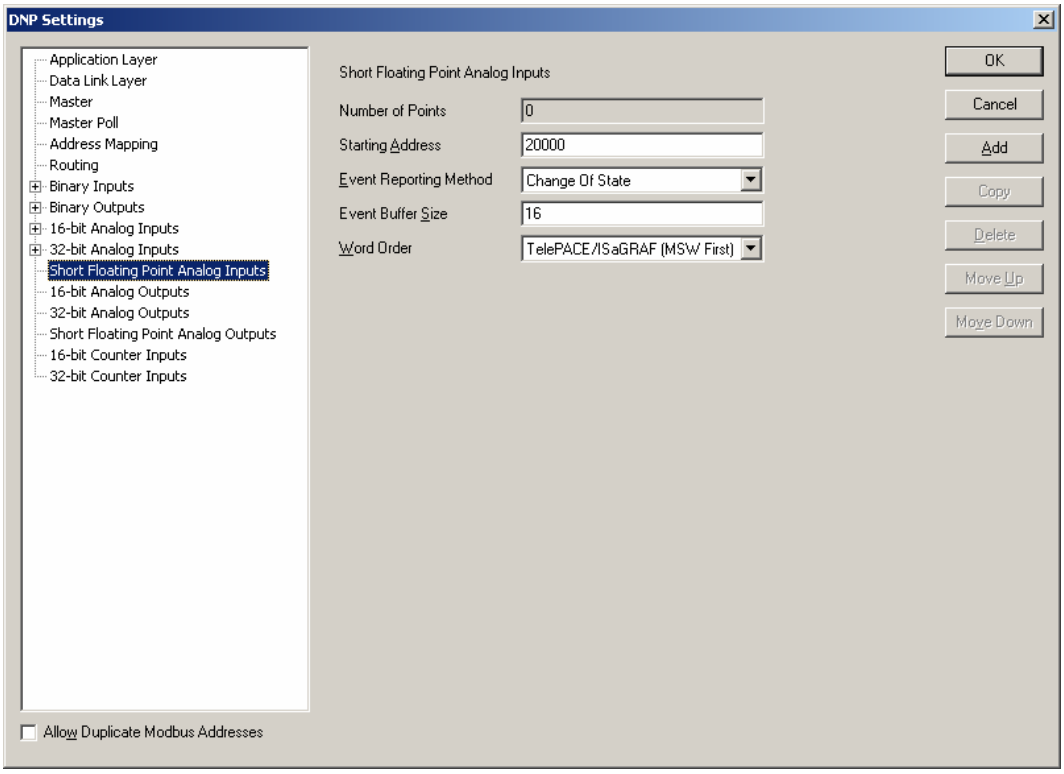
Click the **Delete** button to delete the current 32-Bit Analog Input.

Click the **Move Up** button to move the current 32-Bit Analog Input up one position in the tree control branch.

Click the **Move Down** button to move the current 32-Bit Analog Input down one position in the tree control branch.

5.11 Short Floating Point Analog Inputs

The Short Floating Point Analog Inputs property page is selected for editing by clicking Short Floating Point Analog Inputs in the tree control section of the DNP Settings window. When selected the Short Floating Point Analog Inputs property page is active.



Short Floating Point Analog Input parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays the number of Short Floating Point Analog Inputs reported by the RTU. This value will increment with the addition of each configured Short Floating Point Analog Input point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first Short Floating Point Analog Input point.

The **Event Reporting Method** selection specifies how Short Floating Point Analog Input events are reported. A ***Change Of State*** event is an event object, without time, that is generated when the point changes state. Only one event is retained in the buffer for each point. If a subsequent event occurs for a point, the previous event object will be overwritten. The main purpose of this mode is to allow a master station to efficiently poll for changed data. A ***Log All Events*** is event object with absolute time will be generated when the point changes state. All events will be retained. The main purpose of this mode is to allow a master station to obtain a complete historical data log. The selections are:

- Change of State
- Log All Events

The **Event Buffer Size** parameter specifies the maximum number of Short Floating Point Analog Input changes without time events buffered by the RTU. The buffer holds all Short Floating Point Analog Input events, regardless of the class to which they are assigned. If the buffer fills to 90 percent the RTU will send a buffer overflow event to the master station. If the buffer is completely full the RTU will lose the oldest events and retain the newest. The Event Buffer size should be at least equivalent to the number of Short Floating Point Analog Inputs defined as Change of State type. That will allow all Short Floating Point Analog Inputs to exceed the deadband simultaneously without losing any events. The value of this parameter is dependent on how often Short Floating

Point Analog Input events occur and the rate at which the events are reported to the master station. The valid values for this parameter are 0 - 65535. Default value is 16.

For SCADAPack 32 and SCADAPack 32P controllers analog input events are processed by the DNP driver at a rate of 100 events every 100 ms. If more than 100 analog input events need to be processed they are processed sequentially in blocks of 100 until all events are processed. This allows the processing of 1000 analog input events per second.

For SCADASense Series of controllers, SCADAPack 100, SCADAPack LP, SCADAPack and Micro16 controllers analog input events are processed by the DNP driver at a rate of 20 events every 100 ms. If more than 20 analog input events need to be processed they are processed sequentially in blocks of 20 until all events are processed. This allows the processing of 200 analog input events per second.

The **Word Order** selection specifies the word order of the 32-bit value. The selections are:

- **TelePACE / ISaGRAF (MSW First)** Most Significant Word in first register.
- **Reverse (LSW First)** Least Significant Word in first register.

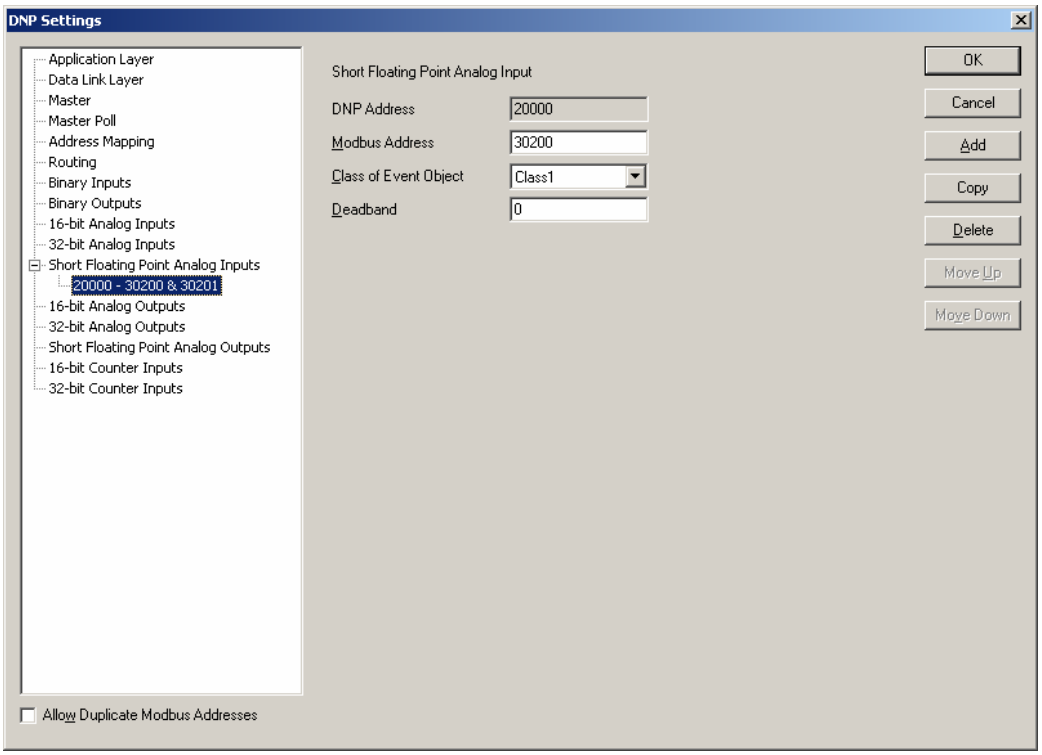
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.11.1 Adding Short Floating Point Analog Inputs

Short Floating Point Analog Inputs are added to the DNP configuration using the 16-Bit Analog Input property page. To add a Short Floating Point Analog Input:

- Select **Short Floating Point Analog Input** in the tree control section of the DNP Settings window.
- Click the **Add** button in the Short Floating Point Analog Inputs property page.
- The **Short Floating Point Analog Input** property page is now displayed.
- Edit the Short Floating Point Analog Input parameters as required and then click the **Add** button.

As Short Floating Point Analog Inputs are defined they are added as leaves to the Short Floating Point Analog Inputs branch of the tree control. When Short Floating Point Analog Inputs are defined the Short Floating Point Analog Inputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined Short Floating Point Analog Inputs.



The Short Floating Point Analog Input parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP Short Floating Point Analog Input address of the point. Each Short Floating Point Analog Input is assigned a DNP address as they are defined. The DNP point address starts at the value set in the Short Floating Point Analog Input configuration dialog and increments by one with each defined Short Floating Point Analog Input.

The **Modbus Address** parameter specifies the Modbus addresses of the Short Floating Point Analog Input assigned to the DNP Address. Short Floating Point Analog Inputs use two consecutive Modbus registers for each assigned DNP Address, the address that is entered in this box and the next consecutive Modbus register. The SCADAPack and Micro16 controllers use Modbus addressing for all analog inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 30001 through 39998
- 40001 through 49998

The Class of Event Object parameter specifies the event object class the Short Floating Point Analog Input is assigned. If Unsolicited reporting is not required for a DNP point, it is recommended to set its Class 0 or **None.** The selections are:

- None
- Class 1
- Class 2
- Class 3

The **Deadband** parameter specifies whether the RTU generates events. The value entered is the minimum number of counts that the Short Floating Point Analog Input must change since it was last

reported. Setting this value to zero disables generating events for the Short Floating Point Analog Inputs.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the Short Floating Point Analog Input parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current Short Floating Point Analog Input to the DNP configuration.

Click the **Copy** button to copy the current Short Floating Point Analog Input parameters to the next DNP Address.

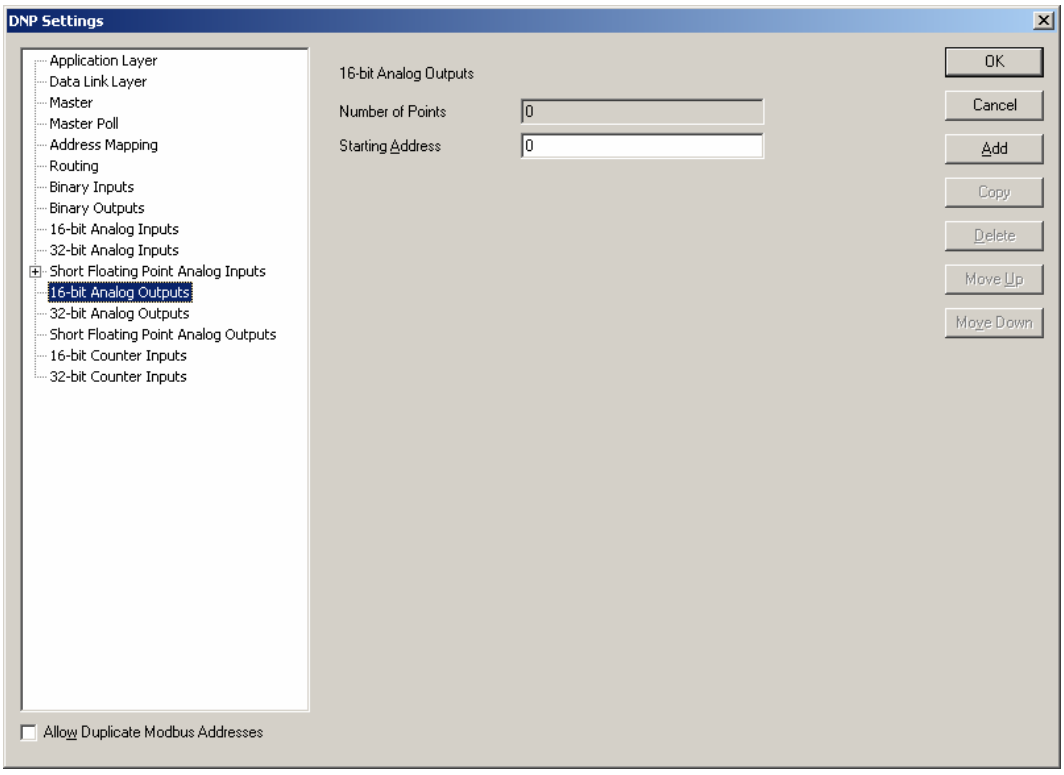
Click the **Delete** button to delete the current Short Floating Point Analog Input.

Click the **Move Up** button to move the current Short Floating Point Analog Input up one position in the tree control branch.

Click the **Move Down** button to move the current Short Floating Point Analog Input down one position in the tree control branch.

5.12 16-Bit Analog Outputs Configuration

The 16-Bit Analog Outputs property page is selected for editing by clicking 16-Bit Analog Outputs in the tree control section of the DNP Settings window. When selected the 16-Bit Analog Outputs property page is active.



16-Bit Analog Outputs parameters are viewed in this property page.

The **Number of Points** displays the number of 16-Bit Analog Outputs reported by this RTU. This value will increment with the addition of each configured 16-Bit Analog Input point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first 16-bit Analog Output point.

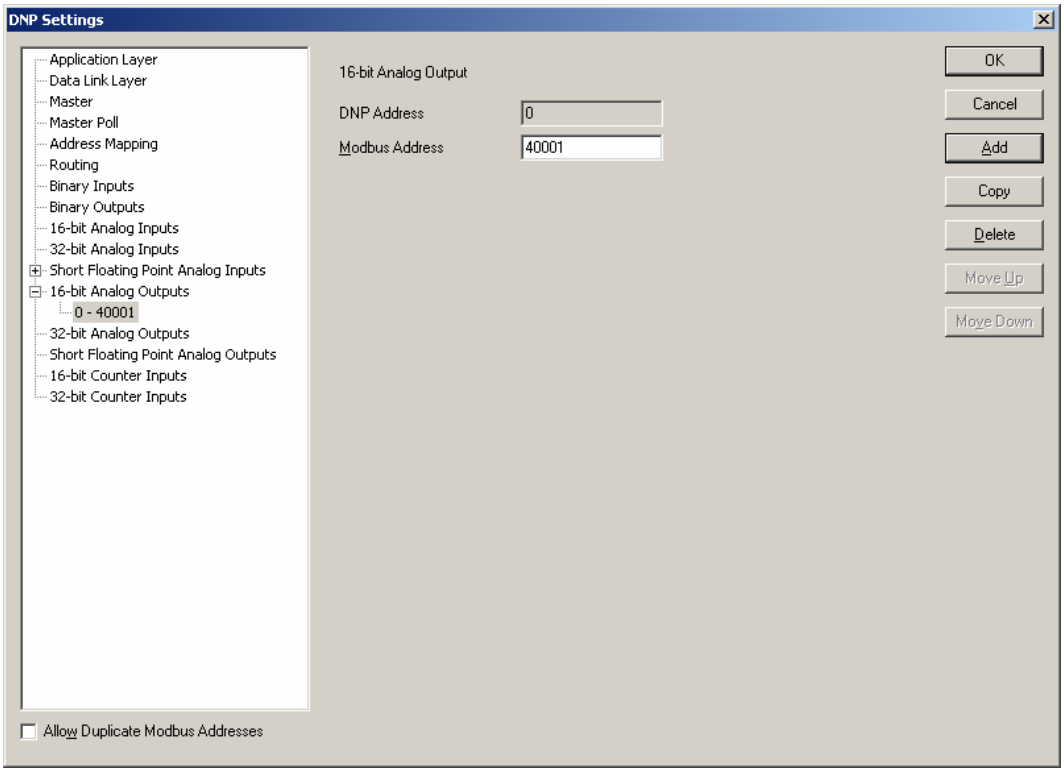
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.12.1 Adding 16-Bit Analog Outputs

16-Bit Analog Outputs are added to the DNP configuration using the 16-Bit Analog Outputs property page. To add a 16-Bit Analog Output:

- Select **16-Bit Analog Outputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the 16-Bit Analog Outputs property page.
- The **16-Bit Analog Output** property page is now displayed.
- Edit the 16-Bit Analog Outputs parameters as required and then click the **Add** button.

As 16-Bit Analog Outputs are defined they are added as leaves to the 16-Bit Analog Output branch of the tree control. When 16-Bit Analog Outputs are defined the 16-Bit Analog Outputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined 16-Bit Analog Outputs.



The 16-Bit Analog Outputs parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP 16-Bit Analog Output address of the point. Each 16-Bit Analog Output is assigned a DNP address as they are defined. The DNP point address starts at

the value set in the 16-bit Analog Output configuration dialog and increments by one with each defined 16-Bit Analog Output.

The **Modbus Address** parameter specifies the Modbus address of the 16-Bit Analog Output assigned to the DNP Address. The SCADAPack and Micro16 controllers use Modbus addressing for all analog outputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog output addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 40001 through 49999

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the 16-Bit Analog Output parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current 16-Bit Analog Output to the DNP configuration.

Click the **Copy** button to copy the current 16-Bit Analog Output parameters to the next DNP Address.

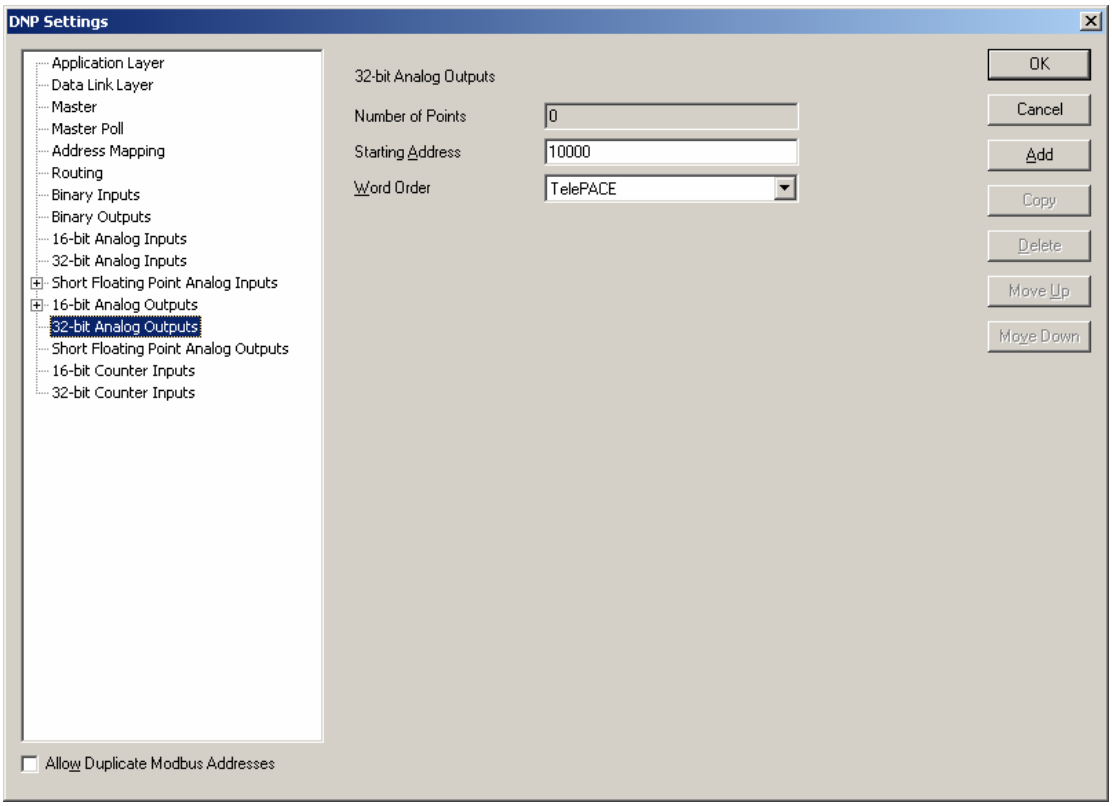
Click the **Delete** button to delete the current 16-Bit Analog Output.

Click the **Move Up** button to move the current 16-Bit Analog Output up one position in the tree control branch.

Click the **Move Down** button to move the current 16-Bit Analog Output down one position in the tree control branch.

5.13 32-Bit Analog Outputs Configuration

The 32-Bit Analog Outputs property page is selected for editing by clicking 32-Bit Analog Outputs in the tree control section of the DNP Settings window. When selected the 32-Bit Analog Outputs property page is active.



32-Bit Analog Outputs parameters are viewed in this property page.

The **Number of Points** displays the number of 32-Bit Analog Outputs reported by this RTU. This value will increment with the addition of each configured 32-Bit Analog Output point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first 16-bit Analog Output point.

The **Word Order** selection specifies the word order of the 32-bit value. The selections are:

- **TelePACE** Least Significant Word in first register.
- **ISaGRAF** Most Significant Word in first register.

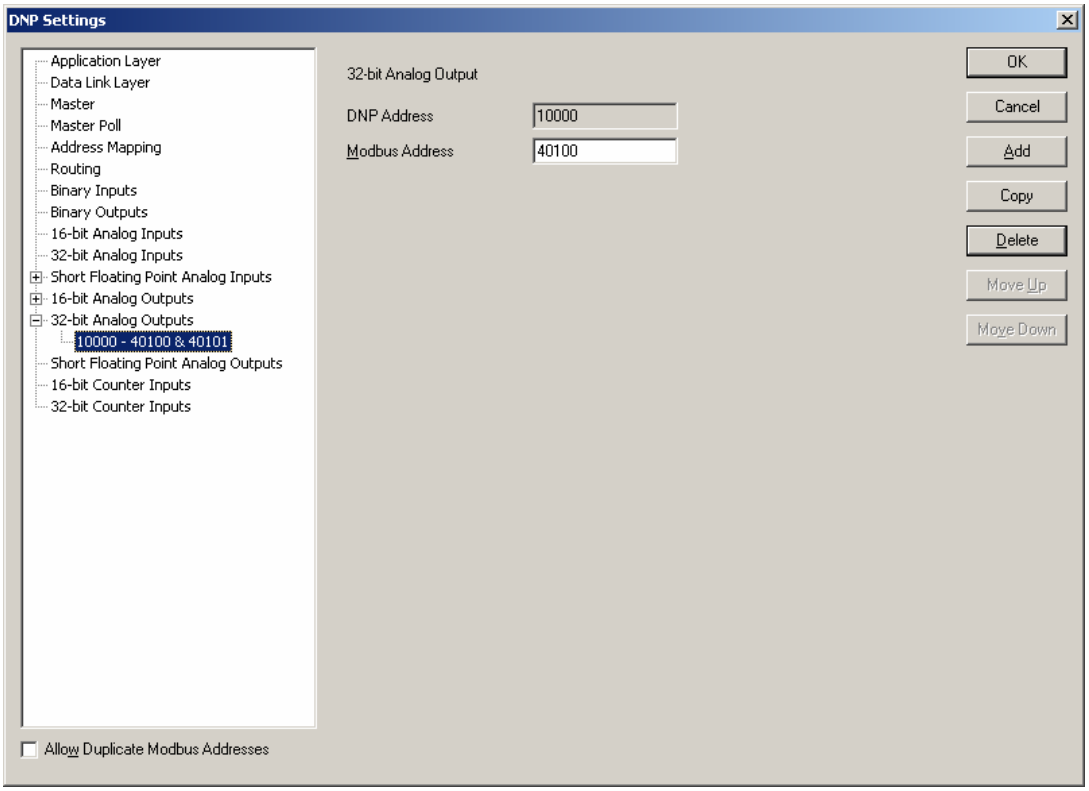
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.13.1 Adding 32-Bit Analog Outputs

32-Bit Analog Outputs are added to the DNP configuration using the 32-Bit Analog Outputs property page. To add a 32-Bit Analog Output:

- Select **32-Bit Analog Outputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the 16-Bit Analog Outputs property page.
- The **32-Bit Analog Output** property page is now displayed.
- Edit the 32-Bit Analog Outputs parameters as required and then click the **Add** button.

As 32-Bit Analog Outputs are defined they are added as leaves to the Binary Inputs branch of the tree control. When 32-Bit Analog Outputs are defined the 32-Bit Analog Outputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined 32-Bit Analog Outputs.



The 32-Bit Analog Outputs parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP 32-Bit Analog Output address of the point. Each 16-Bit Analog Output is assigned a DNP address s they are defined. The DNP point address starts at the value set in the 32-bit Analog Output configuration dialog and increments by one with each defined 32-Bit Analog Output.

The **Modbus Address** parameter specifies the Modbus address of the 32-Bit Analog Output assigned to the DNP Address. 32-Bit Analog Outputs use two consecutive Modbus registers for each assigned DNP Address, the address that is entered in this box and the next consecutive Modbus register. The SCADAPack and Micro16 controllers use Modbus addressing for all analog outputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog output addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 40001 through 49998

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the 16-Bit Analog Output parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current 32-Bit Analog Output to the DNP configuration.

Click the **Copy** button to copy the current 32-Bit Analog Output parameters to the next DNP Address.

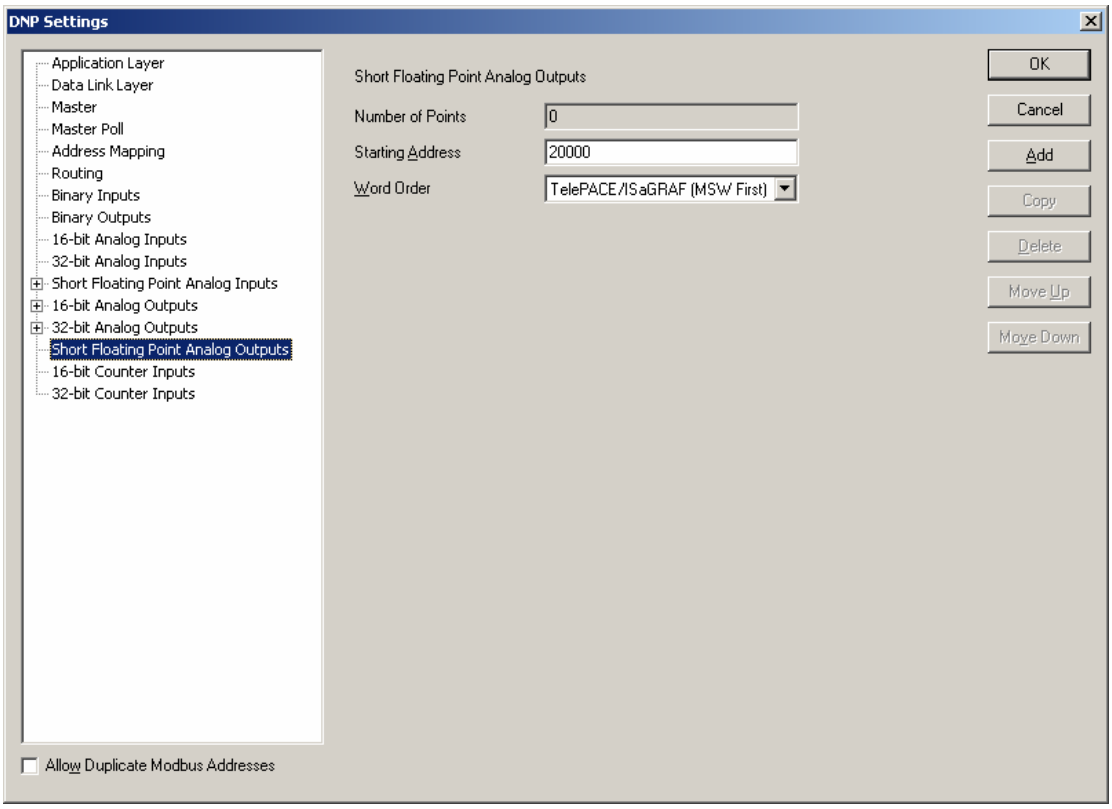
Click the **Delete** button to delete the current 32-Bit Analog Output.

Click the **Move Up** button to move the current 32-Bit Analog Output up one position in the tree control branch.

Click the **Move Down** button to move the current 32-Bit Analog Output down one position in the tree control branch.

5.14 Short Floating Point Analog Outputs

The Short Floating Point Analog Outputs property page is selected for editing by clicking Short Floating Point Analog Outputs in the tree control section of the DNP Settings window. When selected the Short Floating Point Analog Outputs property page is active.



Short Floating Point Analog Output parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays the number of Short Floating Point Analog Outputs reported by the RTU. This value will increment with the addition of each configured Short Floating Point Analog Input point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first Short Floating Point Analog Output point.

The **Word Order** selection specifies the word order of the 32-bit value. The selections are:

- **TelePACE / ISaGRAF (MSW First)** Most Significant Word in first register.
- **Reverse (LSW First)** Least Significant Word in first register.

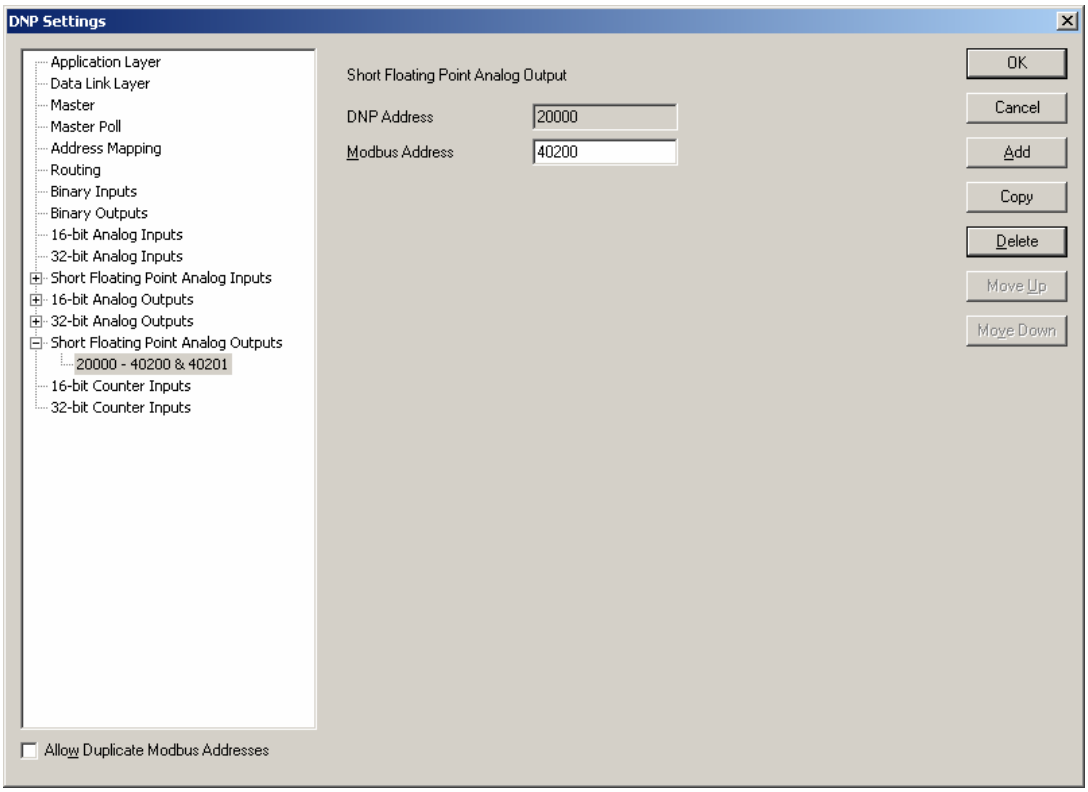
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.14.1 Adding Short Floating Point Analog Outputs

Short Floating Point Analog Outputs are added to the DNP configuration using the Short Floating Point Analog Output property page. To add a Short Floating Point Analog Output:

- Select **Short Floating Point Analog Output** in the tree control section of the DNP Settings window.
- Click the **Add** button in the Short Floating Point Analog Inputs property page.
- The **Short Floating Point Analog Output** property page is now displayed.
- Edit the Short Floating Point Analog Output parameters as required and then click the **Add** button.

As Short Floating Point Analog Outputs are defined they are added as leaves to the Short Floating Point Analog Outputs branch of the tree control. When Short Floating Point Analog Outputs are defined the Short Floating Point Analog Outputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined Short Floating Point Analog Outputs.



The Short Floating Point Analog Output parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP Short Floating Point Analog Output address of the point. Each Short Floating Point Analog Output is assigned a DNP address as they are defined. The

DNP point address starts at the value set in the Short Floating Point Analog Output configuration dialog and increments by one with each defined Short Floating Point Analog Output.

The **Modbus Address** parameter specifies the Modbus addresses of the Short Floating Point Analog Output assigned to the DNP Address. Short Floating Point Analog Outputs use two consecutive Modbus registers for each assigned DNP Address, the address that is entered in this box and the next consecutive Modbus register. The SCADAPack and Micro16 controllers use Modbus addressing for all analog inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 30001 through 39998
- 40001 through 49998

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the Short Floating Point Analog Input parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current Short Floating Point Analog Input to the DNP configuration.

Click the **Copy** button to copy the current Short Floating Point Analog Input parameters to the next DNP Address.

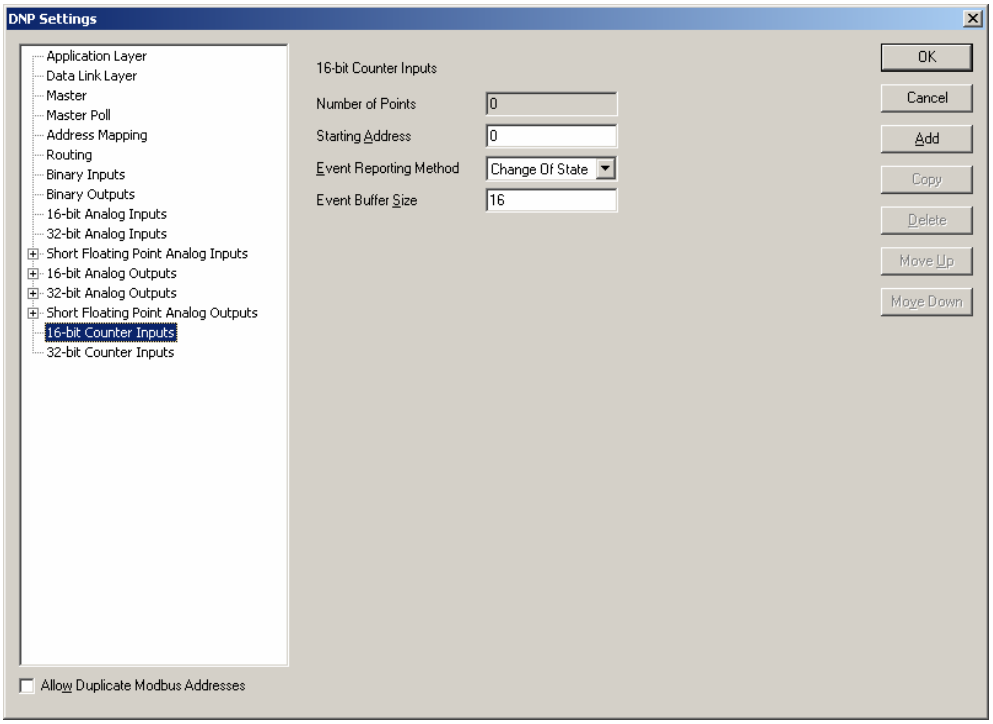
Click the **Delete** button to delete the current Short Floating Point Analog Input.

Click the **Move Up** button to move the current Short Floating Point Analog Input up one position in the tree control branch.

Click the **Move Down** button to move the current Short Floating Point Analog Input down one position in the tree control branch.

5.15 16–Bit Counter Inputs Configuration

The 16-Bit Counter Inputs property page is selected for editing by clicking 16-Bit Counter Inputs in the tree control section of the DNP Settings window. When selected the 16-Bit Counter Inputs property page is active.



16-Bit Counter Inputs parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays the number of 16-Bit Counter Inputs reported by the RTU. This value will increment with the addition of each configured 16-Bit Counter Inputs point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first 16-Bit Counter Input point.

The **Event Reporting Method** selection specifies how 16-Bit Counter Input events are reported. A ***Change Of State*** event is an event object, without time, that is generated when the point changes state. Only one event is retained in the buffer for each point. If a subsequent event occurs for a point, the previous event object will be overwritten. The main purpose of this mode is to allow a master station to efficiently poll for changed data. A ***Log All Events*** is event object with absolute time will be generated when the point changes state. All events will be retained. The main purpose of this mode is to allow a master station to obtain a complete historical data log. The selections are:

- Change of State
- Log All Events

The **Event Buffer Size** parameter specifies the maximum number of 16-Bit Counter Input change without time events buffered by the RTU. The buffer holds all 16-Bit Counter Input events, regardless of the class to which they are assigned. If the buffer fills to 90 percent the RTU will send a buffer overflow event to the master station. If the buffer is completely full the RTU will lose the oldest events and retain the newest. The Event Buffer size should be at least equivalent to the number of 16-Bit Analog Inputs defined as Change of State type. That will allow all 16-Bit Counter Inputs to exceed the threshold simultaneously without losing any events. The value of this parameter is dependent on how often 16-Bit Counter Input events occur and the rate at which the events are reported to the master station. The valid values for this parameter are 0 - 65535. Default value is 16.

For SCADAPack 32 and SCADAPack 32P controllers counter input events are processed by the DNP driver at a rate of 100 events every 100 ms. If more than 100 counter input events need to be processed they are processed sequentially in blocks of 100 until all events are processed. This allows the processing of 1000 counter input events per second.

For SCADASense Series of controllers, SCADAPack 100, SCADAPack LP, SCADAPack and Micro16 controllers counter input events are processed by the DNP driver at a rate of 20 events every 100 ms. If more than 20 counter input events need to be processed they are processed sequentially in blocks of 20 until all events are processed. This allows the processing of 200 counter input events per second.

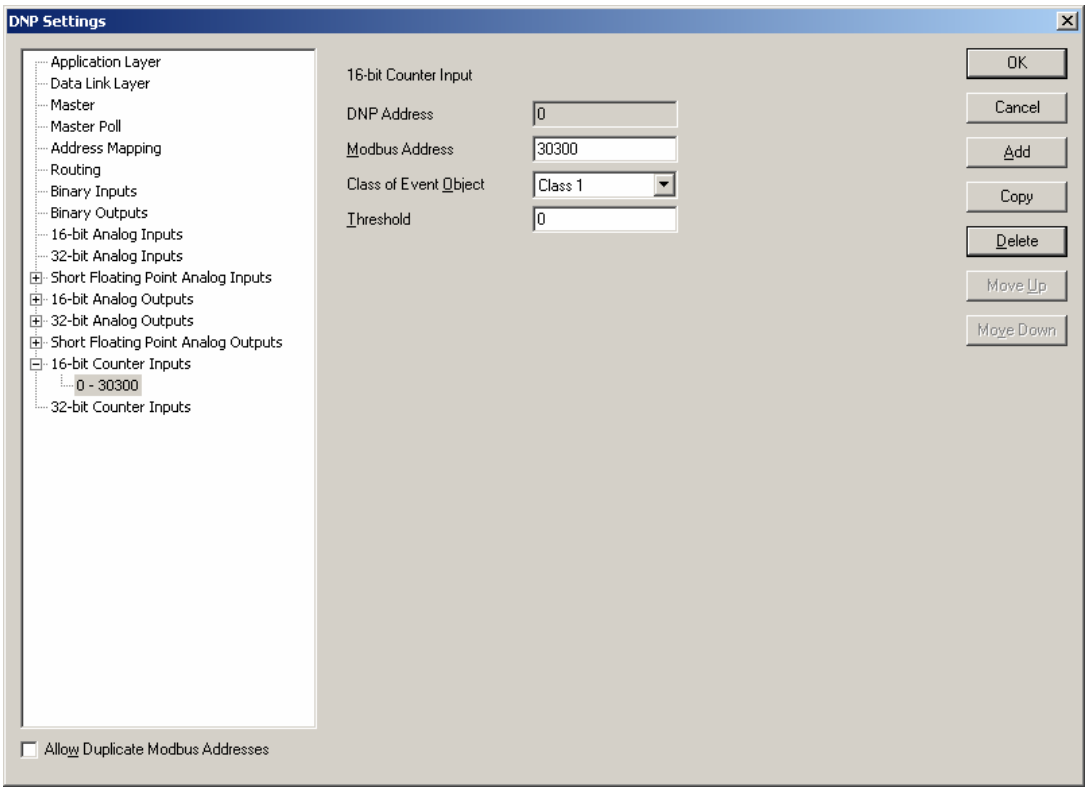
The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

5.15.1 Adding 16-Bit Counter Inputs

16-Bit Counter Inputs are added to the DNP configuration using the 16-Bit Counter Inputs property page. To add a 16-Bit Counter Input:

- Select **16-Bit Counter Inputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the 16-Bit Counter Inputs property page.
- The **16-Bit Counter Input** property page is now displayed.
- Edit the 16-Bit Counter Inputs parameters as required and then click the **Add** button.

As 16-Bit Counter Inputs are defined they are added as leaves to the 16-Bit Counter Inputs branch of the tree control. When 16-Bit Counter Inputs are defined the 16-Bit Counter Inputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined 16-Bit Counter Inputs.



The 16-Bit Counter Input parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP 16-Bit Counter Input address of the point. Each 16-Bit Counter Input is assigned a DNP address s they are defined. The DNP point address starts at the value set in the 16-Bit Counter Input configuration dialog and increments by one with each defined 16-Bit Counter Input.

The **Modbus Address** parameter specifies the Modbus address of the 16-Bit Counter Input assigned to the DNP Address. The SCADAPack and Micro16 controllers use Modbus addressing for all counter inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 30001 through 39999
- 40001 through 49999

The **Class of Event Object** parameter specifies the event object class the 16-Bit Counter Input is assigned. If Unsolicited reporting is not required for a DNP point, it is recommended to set its Class 0 or **None**. The selections are:

- None
- Class 1
- Class 2
- Class 3

The **Threshold** parameter specifies whether the RTU generates events. The value entered is the minimum number of counts that the 16-Bit Counter Input must change since it was last reported.

Setting this value to zero disables generating events for the 16-Bit Counter Input point. Valid deadband values are 0 to 65535.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the 16-Bit Analog Counter parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current 16-Bit Analog Input to the DNP configuration.

Click the **Copy** button to copy the current 16-Bit Analog Input parameters to the next DNP Address.

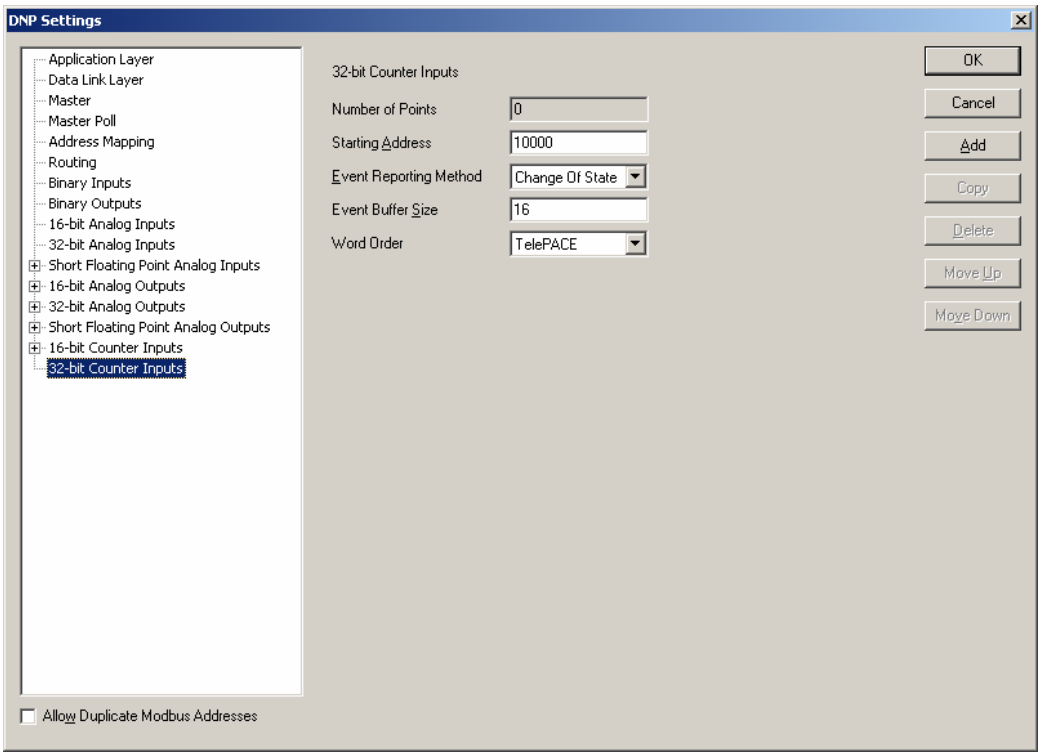
Click the **Delete** button to delete the current 16-Bit Analog Input.

Click the **Move Up** button to move the current 16-Bit Analog Input up one position in the tree control branch.

Click the **Move Down** button to move the current 16-Bit Analog Input down one position in the tree control branch.

5.16 32-Bit Counter Inputs Configuration

The 32-Bit Counter Inputs property page is selected for editing by clicking 32-Bit Counter Inputs in the tree control section of the DNP Settings window. When selected the 32-Bit Counter Inputs property page is active.



32-Bit Counter Inputs parameters are set in this property page. Each parameter is described in the following paragraphs.

The **Number of Points** displays the number of 32-Bit Counter Inputs reported by the RTU. This value will increment with the addition of each configured 32-Bit Counter Inputs point. The maximum number of points is 9999. The maximum number of actual points will depend on the memory available in the controller.

The **Starting Address** parameter specifies the DNP address of the first 32-Bit Counter Input point.

The **Event Reporting Method** selection specifies how 32-Bit Counter Input events are reported. A ***Change Of State*** event is an event object, without time, that is generated when the point changes state. Only one event is retained in the buffer for each point. If a subsequent event occurs for a point, the previous event object will be overwritten. The main purpose of this mode is to allow a master station to efficiently poll for changed data. A ***Log All Events*** is event object with absolute time will be generated when the point changes state. All events will be retained. The main purpose of this mode is to allow a master station to obtain a complete historical data log. The selections are:

- Change of State
- Log All Events

The **Event Buffer Size** parameter specifies the maximum number of 32-Bit Counter Input change without time events buffered by the RTU. The buffer holds all 32-Bit Counter Input events, regardless of the class to which they are assigned. If the buffer fills to 90 percent the RTU will send a buffer overflow event to the master station. If the buffer is completely full the RTU will lose the oldest events and retain the newest. The Event Buffer size should be at least equivalent to the number of 32-Bit Counter Inputs defined as Change of State type. That will allow all 32-Bit Counter Inputs to exceed the deadband simultaneously without losing any events. The value of this parameter is dependent on how often 32-Bit Analog Input events occur and the rate at which the events are reported to the master station. The valid values for this parameter are 0 - 65535. Default value is 16.

For SCADAPack 32 and SCADAPack 32P controllers counter input events are processed by the DNP driver at a rate of 100 events every 100 ms. If more than 100 counter input events need to be processed they are processed sequentially in blocks of 100 until all events are processed. This allows the processing of 1000 counter input events per second.

For SCADASense Series of controllers, SCADAPack 100, SCADAPack LP, SCADAPack and Micro16 controllers counter input events are processed by the DNP driver at a rate of 20 events every 100 ms. If more than 20 counter input events need to be processed they are processed sequentially in blocks of 20 until all events are processed. This allows the processing of 200 counter input events per second.

The **Word Order** selection specifies the word order of the 32-bit value. The selections are:

- **TelePACE** Least Significant Word in first register.
- **ISaGRAF** Most Significant Word in first register.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

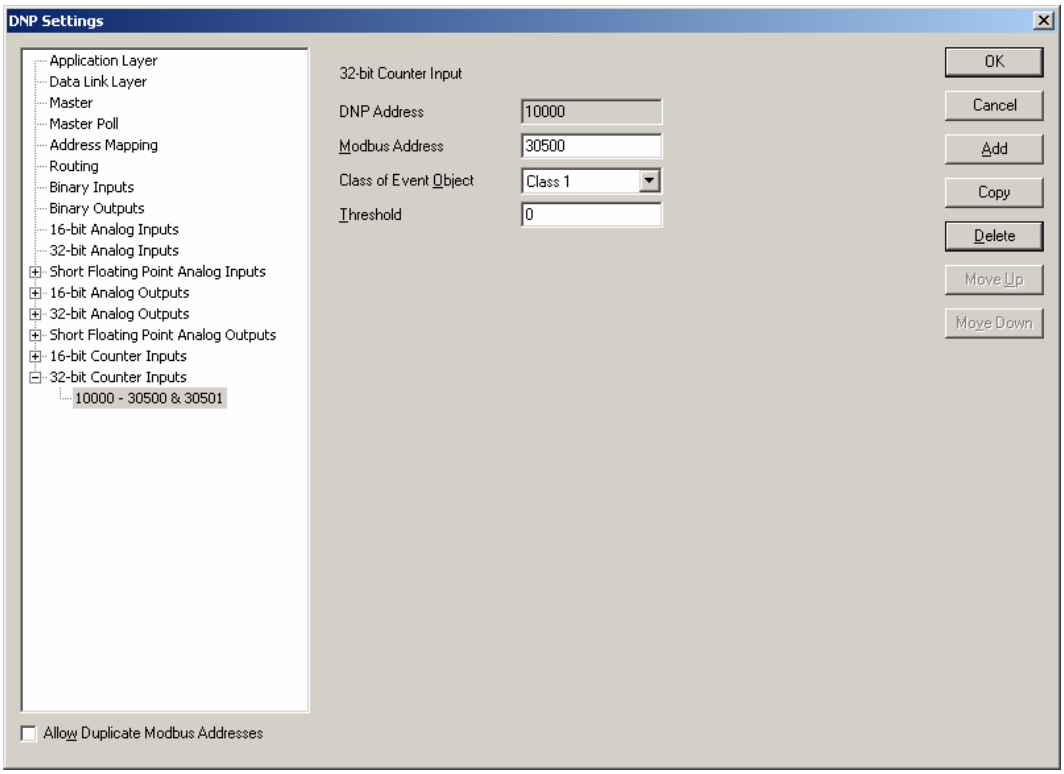
5.16.1 Adding 32-Bit Counter Inputs

32-Bit Counter Inputs are added to the DNP configuration using the 16-Bit Counter Input property page. To add a 32-Bit Analog Input:

- Select **32-Bit Counter Inputs** in the tree control section of the DNP Settings window.
- Click the **Add** button in the 32-Bit Counter Inputs property page.

- The **32-Bit Counter Input** property page is now displayed.
- Edit the 32-Bit Counter Input parameters as required and then click the **Add** button.

As 32-Bit Counter Inputs are defined they are added as leaves to the 32-Bit Counter Inputs branch of the tree control. When 32-Bit Counter Inputs are defined the 32-Bit Counter Inputs branch will display a collapse / expand control to the left of the branch. Click this control to display all defined 32-Bit Counter Inputs.



The 32-Bit Counter Input parameters are described in the following paragraphs.

The **DNP Address** window displays the DNP 32-Bit Counter Input address of the point. Each 32-Bit Counter Input is assigned a DNP address as they are defined. The DNP point address starts at the value set in the 32-Bit Counter Input configuration dialog and increments by one with each defined 32-Bit Counter Input.

The **Modbus Address** parameter specifies the Modbus addresses of the 32-Bit Counter Input assigned to the DNP Address. 32-Bit Counter Inputs use two consecutive Modbus registers for each assigned DNP Address, the address that is entered in this box and the next consecutive Modbus register. The SCADAPack and Micro16 controllers use Modbus addressing for all counter inputs. Refer to the ***I/O Database Registers*** section of the ***TelePACE Ladder Logic Reference and User Manual*** for complete information on analog input addressing in the SCADAPack and Micro16 controllers. Valid Modbus addresses are:

- 30001 through 39998
- 40001 through 49998

The **Class of Event Object** parameter specifies the event object class the 32-Bit Counter Input is assigned. If Unsolicited reporting is not required for a DNP point, it is recommended to set its Class 0 or **None**. The selections are:

- None
- Class 1
- Class 2
- Class 3

The **Threshold** parameter specifies whether the RTU generates events. The value entered is the minimum number of counts that the 32-Bit Counter Input must change since it was last reported. Setting this value to zero disables generating events for the 32-Bit Counter Input point. Valid threshold values are 0 to 4,294,967,295.

The **Allow Duplicate Modbus Addresses** checkbox determines if the Modbus I/O database addresses assigned to the DNP data points must be unique. Check this box if you want to allow more than one point to use the same Modbus address.

Click the **OK** button to accept the 32-Bit Counter Input parameters and close the DNP Settings dialog.

Click the **Cancel** button to close the dialog without saving any changes.

Click the **Add** button to add the current 32-Bit Counter Input to the DNP configuration.

Click the **Copy** button to copy the current 32-Bit Counter Input parameters to the next DNP Address.

Click the **Delete** button to delete the current 32-Bit Counter Input.

Click the **Move Up** button to move the current 32-Bit Counter Input up one position in the tree control branch.

Click the Move Down button to move the current 32-Bit Counter Input down one position in the tree control branch.

6 DNP Diagnostics

DNP Diagnostics provide Master station and Outstation DNP diagnostics. The diagnostics provide detailed information on the status of DNP communication and DNP data points. This information is useful when debugging DNP station and network problems that may arise.

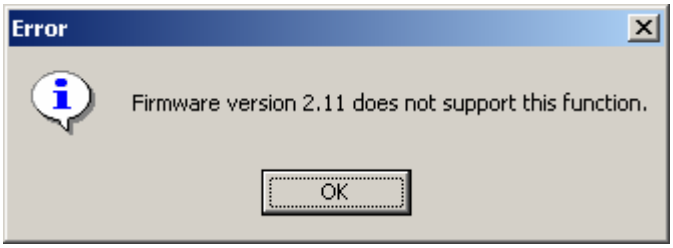
DNP diagnostics are available for local DNP information using the **DNP Status** command.

- For TelePACE applications select **Controller >> DNP Status** from the menu bar. See the section ***DNP Status*** for information on DNP Status diagnostics.
- For ISaGRAF applications select **Tools >> Controller >> DNP Status** from the program window menu bar. See the section ***DNP Status*** for information on DNP Status diagnostics.

SCADAPack 32 controllers support DNP master operations. DNP diagnostics are available for master stations using the **DNP Master Status** command.

- For TelePACE applications select **Controller >> DNP Master Status** from the menu bar. See the section ***DNP Master Status*** for information on DNP Master Status diagnostics.
- For ISaGRAF applications select **Tools >> Controller >> DNP Master Status** from the program window menu bar. See the section ***4.2- DNP Master Status*** for information on DNP Master Status diagnostics.

DNP Diagnostics require firmware version 2.20 or newer for SCADAPack controllers and firmware version 1.50 or newer for SCADAPack 32 controllers. When an attempt is made to select the DNP Status or DNP Master Status command for controllers with firmware that does not support the commands an error message is displayed. An example of the error message is shown below.



To enable the use of DNP diagnostics you will need to upgrade the firmware in the controller to the newer version.

6.1 DNP Status

When the DNP Status command is selected the DNP Status dialog is displayed. This dialog shows the run-time DNP diagnostics and current data values for the local DNP points.

The DNP Status dialog has a number of selectable tabs and opens with the Overview tab selected. The following tabs are displayed.

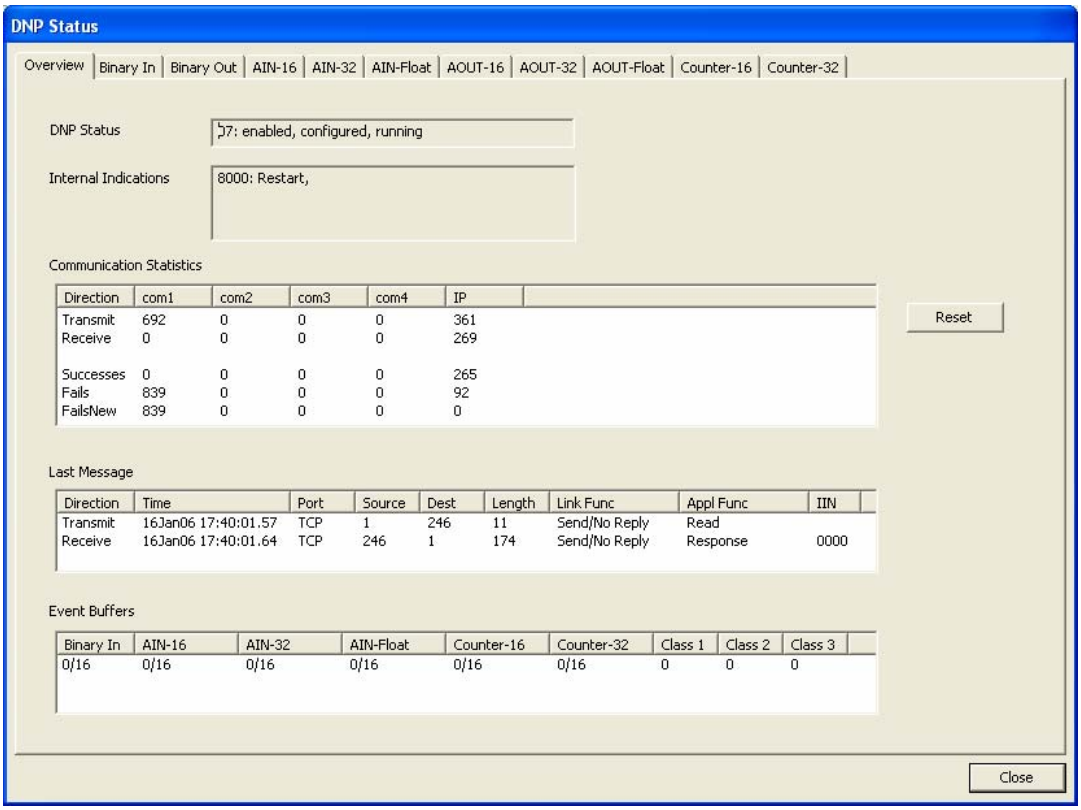
- Overview
- Binary In (binary inputs information)
- Binary Out (binary outputs information)
- AIN-16 (16-bit analog inputs information)
- AIN-32 (32-bit analog inputs information)
- AIN-Float (short float analog inputs information)

- AOUT-16 (16-bit analog outputs information)
- AOUT-32 (32-bit analog outputs information)
- AOUT-Float (short float analog outputs information)
- Counter-16 (16-bit counter inputs information)
- Counter-32 (32-bit counter inputs information)

Clicking on any tab opens the tab and displays the selected information.

6.1.1 Overview Tab

The Overview Tab displays the run-time diagnostics for the local DNP station. The Overview display is divided into five areas of diagnostic information: DNP Status, Internal Indications, Communication Statistics, Last Message and Event Buffer. Each of these is explained in the following paragraphs.



The **DNP Status** window provides information on the status of the DNP protocol running in the controller. Depending on the status the window may contain the following text.

- **Enabled** or **Disabled** indicates whether the controller firmware supports DNP protocol.
- **Configured** or **Not Configured** indicates whether the controller has been configured with DNP protocol on at least one communications port.
- **Running** or **Not Running** indicates whether the DNP tasks are running in the controller.

The **Internal Indications** window displays the current state of the DNP internal indications (IIN) flags in the controller. For a detailed description of the IIN flags see the section ***Internal Indication***

(IIN) Flags section of this manual. Note that bits 0 – 7 (the first octet) are displayed on the left, then bits 8 - 15 (second octet) on the right.

The **Communication Statistics** window displays the message statistics for each DNP communication port. The statistics include the total number of messages transmitted and received and the total number of successes, failures, and failures since last success (which will only be updated for messages sent by this controller) for each communication port. The counters increment whenever a new DNP message is sent or received on the port, and roll over after 65535 messages.

- Click the **Reset** button to reset the counters to zero.

The **Last Message** window displays information about the most recent DNP message. The information is updated each time a new message is received or transmitted. The Last Message window contains the following information.

- **Direction** displays whether the message was received or transmitted.
- **Time** displays the time at which the message was received or sent.
- **Port** displays which communication port was used for the message.
- **Source** displays the source DNP station address for the message.
- **Dest** displays the destination DNP station address for the message.
- **Length** displays the message length in bytes.
- **Link Func** displays the Link Layer function code.
- **Appl Func** displays the Application Layer function code.
- **IIN** displays the Internal indications received with the last message

The **Event Buffers** window displays the number of events in each type of event buffer and the allocated buffer size. The event buffers displayed are:

- Binary In (binary inputs)
- AIN-16 (16-bit analog inputs)
- AIN-32 (32-bit analog inputs)
- AIN-Float (floating point analog inputs)
- Counter-16 (16-bit counter inputs)
- Counter-32 (32-bit counter inputs)
- Class 1 (class 1 events)
- Class 2 (class 2 events)
- Class 3 (class 3 events)

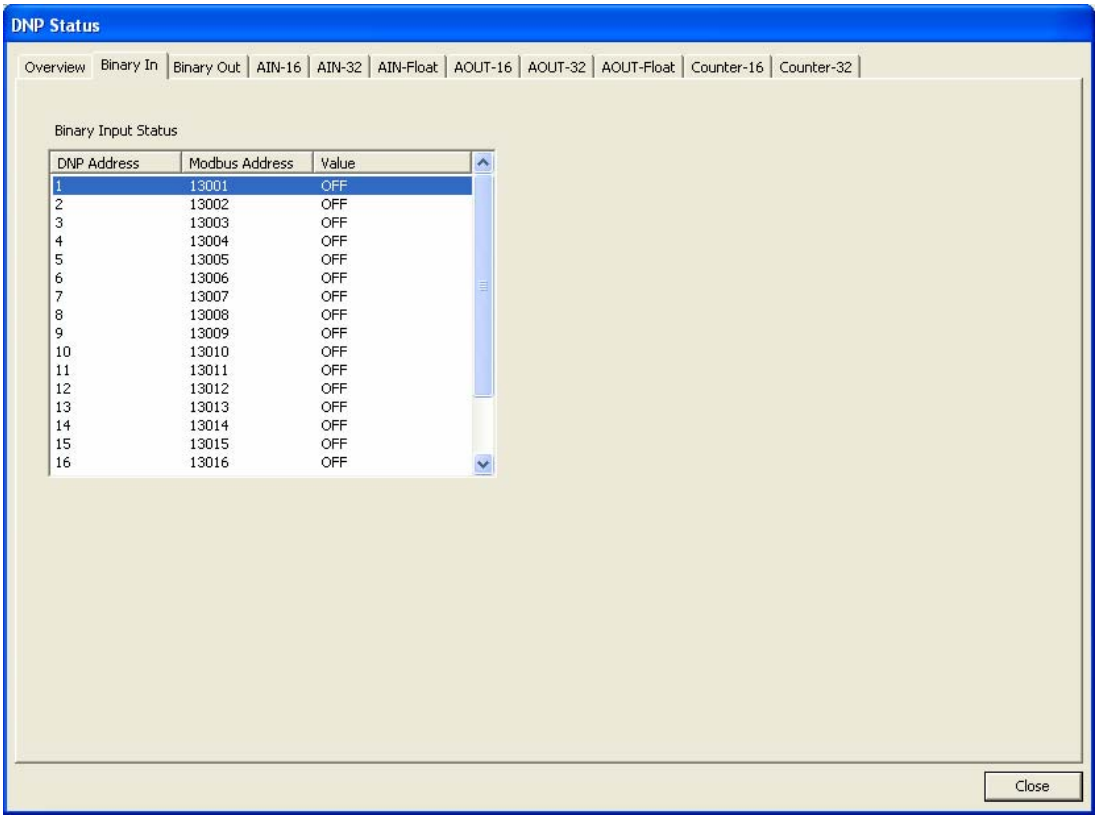
6.1.2 Point Status Tabs

The point status tabs display the state of each point of the selected type in the controller. The following tabs are displayed.

- Binary In (binary inputs information)
- Binary Out (binary outputs information)

- AIN-16 (16-bit analog inputs information)
- AIN-32 (32-bit analog inputs information)
- AIN-Float (short float analog inputs information)
- AOUT-16 (16-bit analog outputs information)
- AOUT-32 (32-bit analog outputs information)
- AOUT-Float (short float analog outputs information)
- Counter-16 (16-bit counter inputs information)
- Counter-32 (32-bit counter inputs information)

Each of the tabs displays information in the same format. The example below shows the appearance of the binary input page.



The **DNP Address** column shows the DNP address of the point.

The **Modbus Address** column shows the Modbus register address of the point.

The **Value** column shows the value of the point. Binary points are shown as OFF or ON. Numeric points show the numeric value of the point.

6.2 DNP Master Status

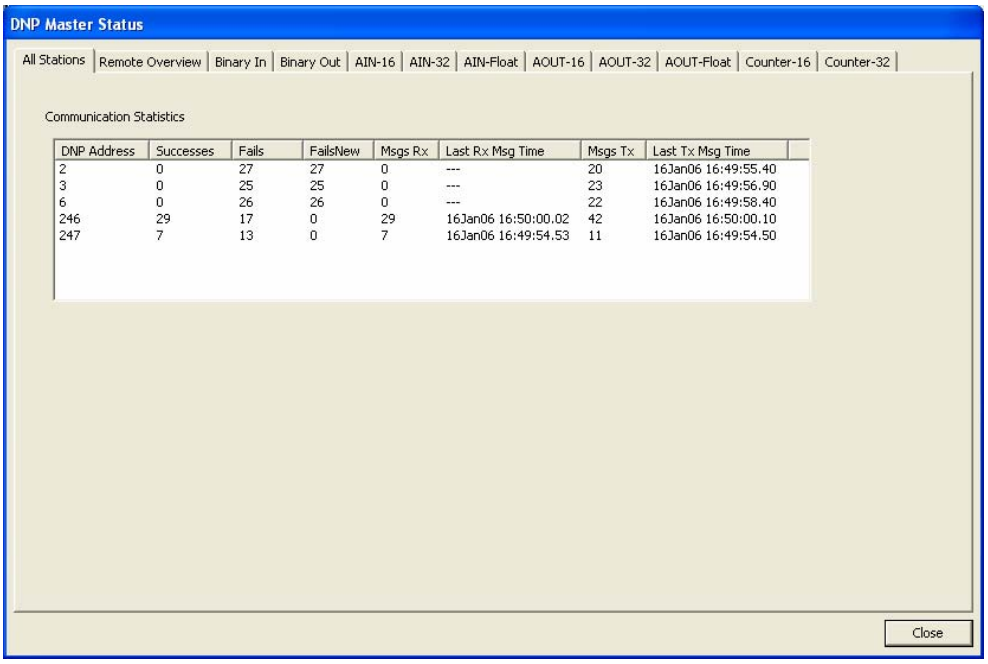
When the DNP Master Status command is selected the **DNP Master Status** dialog is displayed. This dialog shows the run-time DNP diagnostics and status of the DNP outstations and current data values for the DNP points in these outstations.

The DNP Master Status dialog has a number of selectable tabs and opens with the All Stations tab selected. The following tabs are displayed.

- All Stations
- Remote Overview
- Binary In (binary inputs information)
- Binary Out (binary outputs information)
- AIN-16 (16-bit analog inputs information)
- AIN-32 (32-bit analog inputs information)
- AIN-Float (short float analog inputs information)
- AOUT-16 (16-bit analog outputs information)
- AOUT-32 (32-bit analog outputs information)
- AOUT-Float (short float analog outputs information)
- Counter-16 (16-bit counter inputs information)
- Counter-32 (32-bit counter inputs information)

6.2.1 All Stations Tab

The **All Stations** tab displays the run-time communications diagnostics for all outstations polled by the master or outstations reporting unsolicited data to the master.



The **Communication Statistics** window displays a list of all outstations and the communication statistics for each station in the list. The statistics counters increment whenever a new DNP message is sent or received, and roll over after 65535 messages. The following statistics are displayed.

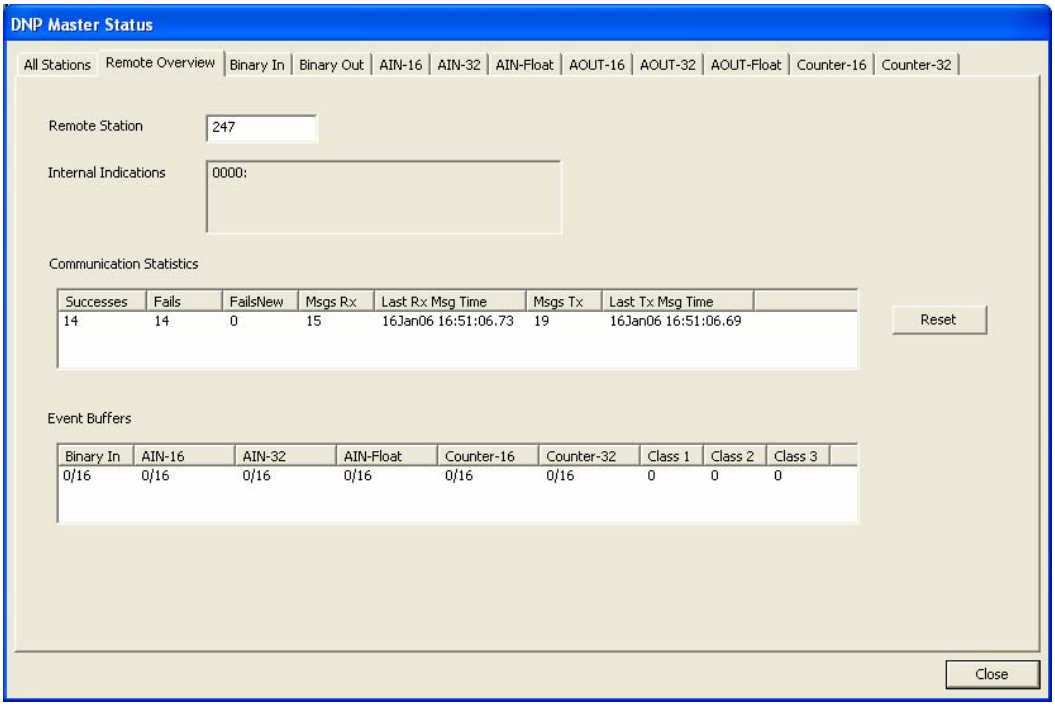
- **DNP Address** displays the DNP address of the outstation.

- **Successes** display the number of successful message transactions between this master and the corresponding remote station. This number includes master polls to the remote station and unsolicited responses from the outstation.
- **Fails** displays the number of failed message transactions between this master and the corresponding remote station. This counter increments by 1 for a failed message transaction irrespective of the number of application layer retries.
- **FailsNew** displays the number failed message transactions between this master and the corresponding remote station since the last successful poll.
- **Msgs Rx** displays the number of DNP packets (frames) received from the outstation station. This number includes frames containing unsolicited responses from the outstation.
- **Last Rx Msg Time** displays the time the last DNP packet (frame) was received from the outstation.
- **Msgs Tx** displays the number of DNP packets (frames) sent to the outstation.
- **Last Tx Msg Time** displays the time the last DNP packet (frame) was sent to the outstation.

Note: The **Msgs Tx** and **Msgs Rx** counters could be greater than or equal to the Successes and Fails counters.

6.2.2 Remote Overview Tab

The Remote Overview tab displays the run-time diagnostics and current data values for a selected remote station. The data shown is from the image of the data in the master station.



The **Remote Station** window is where the DNP address of the remote station is entered. When the Remote station field is changed all data fields on this tab and the following I/O tabs are updated with the values for the newly selected Remote Station.

The **Internal Indications** window displays the current state of the DNP internal indications (IIN) flags for the selected remote station. For a detailed description of the IIN flags see the section ***Internal Indication (IIN) Flags*** section of this manual.

The **Communication Statistics** window displays communication statistics for the remote station selected. The statistics counters increment whenever a new DNP message is sent or received, and roll over after 65535 messages. The following statistics are displayed.

- **Successes** displays the number of successful messages received in response to master polls sent to the station. This number includes unsolicited responses from the outstation.
- **Fails** displays the number of failed or no responses to master polls sent to the outstation.
- **FailsNew** displays the number failed or no responses to master polls sent to the outstation since the last successful poll.
- **Msgs Rx** displays the number of messages received from the outstation station. This number includes unsolicited responses from the outstation.
- **Last Rx Msg Time** displays the time the last message was received from the outstation.
- **Msgs Tx** displays the number of messages sent to the outstation station.
- **Last Tx Msg Time** displays the time the last message was sent to the outstation.

Click **Reset** to reset the counters to zero.

Event Buffers shows the number of events in each type of event buffer and the allocated buffer size. The buffers shown are for binary inputs, 16-bit analog inputs, 32-bit analog inputs, Floating point analog inputs, 16-bit counter inputs, and 32-bit counter inputs, and Class 1, 2, and 3 events.

The **Event Buffers** window displays the number of events in each type of event buffer and the allocated buffer size for the selected remote station. The event buffers displayed are:

- Binary In (binary inputs)
- AIN-16 (16-bit analog inputs)
- AIN-32 (32-bit analog inputs)
- AIN-Float (floating point analog inputs)
- Counter-16 (16-bit counter inputs)
- Counter-32 (32-bit counter inputs)
- Class 1 (class 1 events)
- Class 2 (class 2 events)
- Class 3 (class 3 events)

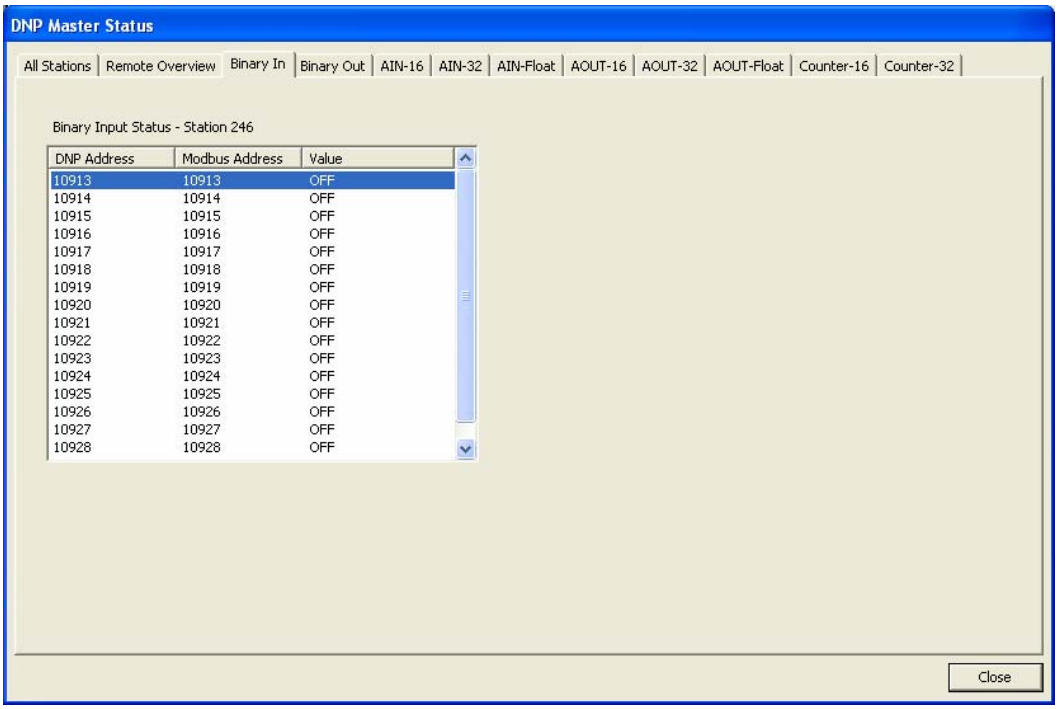
Note: Due to a limitation of the DNP3 protocol, an Unsolicited message from an outstation is not capable of including information stating which data class generated the message. As a result, all Unsolicited events when received by the master will be counted as Class 1 events. Events which are polled by the master, however, do contain class information and will be counted in the Event Buffer for the appropriate class.

6.2.3 Remote Point Status Tabs

The point status tabs show the state of each point of the selected type in the remote station selected on the Remote Overview tab. The values shown are from the image of the remote station in the master station.

Note:	Class 0 polling of an outstation must be enabled in the master in order to allow that outstation's DNP points to be listed on these tabs. This is the only way for the master to retrieve a complete list of all points in an outstation.

The example below shows the appearance of the Binary In tab.



The **DNP Address** column shows the DNP address of the point.

The **Modbus Address** column shows the Modbus register address of the point. This is only relevant for points that have an address mapping in the master station. For points that have an address mapping, this will show the Modbus register address of the point. For points which do not have an address mapping, this will show '---'.

The **Value** column shows the value of the point. Binary points are shows as OFF or ON. Numeric points show the numeric value of the point.

7 DNP Device Profile Document - Master

DNP v3.00

DEVICE PROFILE DOCUMENT

Vendor Name: Control Microsystems Inc.

Device Name: SCADAPack controllers

Highest DNP Level Supported:	Device Function:
For Requests 2	■ Master ☐ Slave
For Responses 2	

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

- Function code 14 (warm restart)
- Function code 20 (Enable Unsolicited Messages) for class 1, 2, 3 objects only.
- Function code 21 (Disable Unsolicited Messages) for class 1, 2, 3 objects only.
- Object 41, variation 1 (32-bit analog output block)

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted 292	Transmitted 2048
Received (must be 292)	Received 2048

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☐ None ☐ Fixed at ■ Configurable, range 0 to 255	☐ None ■ Configurable, range 0 to 255

Requires Data Link Layer Confirmation:

☐ Never
☐ Always
☐ Sometimes If 'Sometimes', when?

■ Configurable for Always or Never

Requires Application Layer Confirmation:

☐ Never
☐ Always (not recommended)
☐ When reporting Event Data (Slave devices only)
☐ When sending multi-fragment responses (Slave devices only)

☐ Sometimes If 'Sometimes', when?
_____

■Configurable for always or only when Reporting Event Data and Unsolicited Messages

Timeouts while waiting for:

Data Link Confirm	☐ None☐ Fixed at _____	☐ Variable	■ Configurable
Complete Appl. Fragment	☐ None☐ Fixed at _____	☐ Variable	■ Configurable
Application Confirm	☐ None☐ Fixed at _____	☐ Variable	■ Configurable
Complete Appl. Response	☐ None☐ Fixed at _____	☐ Variable	■ Configurable

Others _____

Sends/Executes Control Operations:

WRITE Binary Outputs	☐ Never	☐ Always	☐ Sometimes	■ Configurable
SELECT/OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE - NO ACK	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Count > 1	☐ Never	☐ Always	☐ Sometimes	■ Configurable

Pulse On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Pulse Off	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Latch On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Latch Off	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

■ Either time-tagged or non-time-tagged for a single event
☐ Both time-tagged and non-time-tagged for a single event
☐ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:

Reports Binary Input Change Events when no specific variation requested:

☐ Never
☐ Only time-tagged
☐ Only non-time-tagged
☐ Configurable to send both, one or the other (attach explanation)

Reports time-tagged Binary Input Change Events when no specific variation requested:

☐ Never
☐ Binary Input Change With Time
☐ Binary Input Change With Relative Time
☐ Configurable (attach explanation)

Sends Unsolicited Responses:

☐ Never
☐ Configurable by class
☐ Only certain objects
☐ Sometimes (attach explanation)

■ ENABLE/DISABLE UNSOLICITED

Sends Static Data in Unsolicited Responses:

☐ Never
☐ When Device Restarts
☐ When Status Flags Change

No other options are permitted.

Default Counter Object/Variation:

☐ No Counters Reported
☐ Configurable (attach explanation)
☐ Default Object 20
Default Variation 05

Counters Roll Over at:

☐ No Counters Reported
☐ Configurable (attach explanation)
☐ 16 Bits
☐ 32 Bits

☐ Point-by-point list attached	☐ 16 Bits for 16-bit counters 32 Bits for 32-bit counters ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ■ Yes ☐ No	

DNP V3.00
DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
1	0	Binary Input - All Variations	1	06		
1	1	Binary Input			129, 130	00, 01
1	2	Binary Input with Status			129, 130	00, 01
2	0	Binary Input Change - All Variations	1	06,07,08		
2	1	Binary Input Change without Time	1	06,07,08	129, 130	17, 28
2	2	Binary Input Change with Time	1	06,07,08	129, 130	17, 28
2	3	Binary Input Change with Relative Time	1	06,07,08	129, 130	17, 28
10	0	Binary Output - All Variations	1	06		
10	1	Binary Output				
10	2	Binary Output Status			129, 130	00, 01
12	0	Control Block - All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter - All Variations	1, 7, 8, 9, 10	06		
20	1	32-Bit Binary Counter			129, 130	00, 01
20	2	16-Bit Binary Counter			129, 130	00, 01
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter without Flag			129, 130	00, 01
20	6	16-Bit Binary Counter without Flag			129, 130	00, 01
20	7	32-Bit Delta Counter without Flag				

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
20	8	16-Bit Delta Counter without Flag				
21	0	Frozen Counter - All Variations	1	06		
21	1	32-Bit Frozen Counter			129, 130	00, 01
21	2	16-Bit Frozen Counter			129, 130	00, 01
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter with Time of Freeze				
21	6	16-Bit Frozen Counter with Time of Freeze				
21	7	32-Bit Frozen Delta Counter with Time of Freeze				
21	8	16-Bit Frozen Delta Counter with Time of Freeze				
21	9	32-Bit Frozen Counter without Flag			129, 130	00, 01
21	10	16-Bit Frozen Counter without Flag			129, 130	00, 01
21	11	32-Bit Frozen Delta Counter without Flag				
21	12	16-Bit Frozen Delta Counter without Flag				
22	0	Counter Change Event - All Variations	1	06,07,08		
22	1	32-Bit Counter Change Event without Time			129, 130	17, 28
22	2	16-Bit Counter Change Event without Time			129, 130	17, 28
22	3	32-Bit Delta Counter Change Event without Time				
22	4	16-Bit Delta Counter Change Event without Time				
22	5	32-Bit Counter Change Event with Time				
22	6	16-Bit Counter Change Event with Time				
22	7	32-Bit Delta Counter Change Event with Time				
22	8	16-Bit Delta Counter Change Event with Time				

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
23	0	Frozen Counter Event - All Variations				
23	1	32-Bit Frozen Counter Event without Time				
23	2	16-Bit Frozen Counter Event without Time				
23	3	32-Bit Frozen Delta Counter Event without Time				
23	4	16-Bit Frozen Delta Counter Event without Time				
23	5	32-Bit Frozen Counter Event with Time				
23	6	16-Bit Frozen Counter Event with Time				
23	7	32-Bit Frozen Delta Counter Event with Time				
23	8	16-Bit Frozen Delta Counter Event with Time				
30	0	Analog Input - All Variations	1	06		
30	1	32-Bit Analog Input			129, 130	00, 01
30	2	16-Bit Analog Input			129, 130	00, 01
30	3	32-Bit Analog Input without Flag			129, 130	00, 01
30	4	16-Bit Analog Input without Flag			129, 130	00, 01
30	5	Short Floating Point Analog Input			129, 130	00, 01
31	0	Frozen Analog Input - All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input with Time of Freeze				
31	4	16-Bit Frozen Analog Input with Time of Freeze				
31	5	32-Bit Frozen Analog Input without Flag				
31	6	16-Bit Frozen Analog Input without Flag				
32	0	Analog Change Event - All Variations	1	06,07,08		
32	1	32-Bit Analog Change Event without Time			129,130	17,28
32	2	16-Bit Analog Change Event without Time			129,130	17,28

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
32	3	32-Bit Analog Change Event with Time			129,130	17,28
32	4	16-Bit Analog Change Event with Time			129,130	17,28
32	5	Short Floating Point Analog Change Event without Time			129,130	17,28
33	0	Frozen Analog Event - All Variations				
33	1	32-Bit Frozen Analog Event without Time				
33	2	16-Bit Frozen Analog Event without Time				
33	3	32-Bit Frozen Analog Event with Time				
33	4	16-Bit Frozen Analog Event with Time				
40	0	Analog Output Status - All Variations	1	06		
40	1	32-Bit Analog Output Status			129, 130	00, 01
40	2	16-Bit Analog Output Status			129, 130	00, 01
40	3	Short Floating Point Analog Output Status			129, 130	00, 01
41	0	Analog Output Block - All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date - All Variations				
50	1	Time and Date	2 (see 4.14)	07 where quantity = 1		
50	2	Time and Date with Interval				
51	0	Time and Date CTO - All Variations				
51	1	Time and Date CTO			129, 130	07, quantity=1

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
51	2	Unsynchronized Time and Date CTO			129, 130	07, quantity=1
52	0	Time Delay - All Variations				
52	1	Time Delay Coarse			129	07, quantity=1
52	2	Time Delay Fine			129	07, quantity=1
60	0					
60	1	Class 0 Data	1	06		
60	2	Class 1 Data	1 20,21	06,07,08 06		
60	3	Class 2 Data	1 20,21	06,07,08 06		
60	4	Class 3 Data	1 20,21	06,07,08 06		
70	1	File Identifier				
80	1	Internal Indications	2	00 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT

This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
101	3	Large Packed Binary-Coded Decimal				
		No Object	13			
		No Object	14			
		No Object	23 (see 4.14)			

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TIME SYNCHRONISATION PARAMETERS

This table describes the worst-case time parameters relating to time synchronisation, as required by DNP Level 2 Certification Procedure section 8.7

PARAMETER	VALUE
Time base drift	+/- 1 minute/month at 25°C +1 / -3 minutes/month 0 to 50°C
Time base drift over a 10-minute interval	+/- 14 milliseconds at 25°C +14 / -42 milliseconds 0 to 50°C
Maximum delay measurement error	+/- 100 milliseconds
Maximum internal time reference error when set from the protocol	+/- 100 milliseconds
Maximum response time	100 milliseconds

8 DNP Device Profile Document - Slave

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DEVICE PROFILE DOCUMENT

Vendor Name: Control Microsystems Inc.

Device Name: SCADAPack controllers

Highest DNP Level Supported:	Device Function:
For Requests 2	☐ Master ■ Slave
For Responses 2	

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

Function code 14 (warm restart)
Function code 20 (Enable Unsolicited Messages) for class 1, 2, 3 objects only.
Function code 21 (Disable Unsolicited Messages) for class 1, 2, 3 objects only.
Object 41, variation 1 (32-bit analog output block)

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted 292	Transmitted 2048
Received (must be 292)	Received 2048

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☐ None ☐ Fixed at ■ Configurable, range 0 to 255	☐ None ■ Configurable, range 0 to 255

Requires Data Link Layer Confirmation:

☐ Never
☐ Always
☐ Sometimes If 'Sometimes', when?

■ Configurable for Always or Never

Requires Application Layer Confirmation:

☐ Never
☐ Always (not recommended)
☐ When reporting Event Data (Slave devices only)
☐ When sending multi-fragment responses (Slave devices only)

☐ Sometimes If 'Sometimes', when?
_____

■Configurable for always or only when Reporting Event Data and Unsolicited Messages

Timeouts while waiting for:

Data Link Confirm	☐ None	☐ Fixed at _____	☐ Variable	■ Configurable
Complete Appl. Fragment	☐ None	☐ Fixed at _____	☐ Variable	■ Configurable
Application Confirm	☐ None	☐ Fixed at _____	☐ Variable	■ Configurable
Complete Appl. Response	☐ None	☐ Fixed at _____	☐ Variable	■ Configurable

Others _____

Sends/Executes Control Operations:

WRITE Binary Outputs	☐ Never	☐ Always	☐ Sometimes	■ Configurable
SELECT/OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE - NO ACK	☐ Never	☐ Always	☐ Sometimes	■ Configurable

Count > 1	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Pulse On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Pulse Off	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Latch On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Latch Off	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

☐ Either time-tagged or non-time-tagged for a single event
☐ Both time-tagged and non-time-tagged for a single event
☐ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:

Reports Binary Input Change Events when no specific variation requested:

☐ Never
☐ Only time-tagged
■ Only non-time-tagged
☐ Configurable to send both, one or the other (attach explanation)

Reports time-tagged Binary Input Change Events when no specific variation requested:

■ Never
☐ Binary Input Change With Time
☐ Binary Input Change With Relative Time
☐ Configurable (attach explanation)

Sends Unsolicited Responses:

☐ Never
■ Configurable by class
☐ Only certain objects
☐ Sometimes (attach explanation)

■ ENABLE/DISABLE UNSOLICITED

Sends Static Data in Unsolicited Responses:

■ Never
☐ When Device Restarts
☐ When Status Flags Change

No other options are permitted.

Default Counter Object/Variation:

☐ No Counters Reported
☐ Configurable (attach explanation)
■ Default Object 20

Counters Roll Over at:

☐ No Counters Reported
☐ Configurable (attach explanation)
☐ 16 Bits

Default Variation 05 ☐ Point-by-point list attached	☐ 32 Bits ■ 16 Bits for 16-bit counters 32 Bits for 32-bit counters ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ■ Yes ☐ No	

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
1	0	Binary Input - All Variations	1	06		
1	1	Binary Input			129, 130	00, 01
1	2	Binary Input with Status			129, 130	00, 01
2	0	Binary Input Change - All Variations	1	06,07,08		
2	1	Binary Input Change without Time	1	06,07,08	129, 130	17, 28
2	2	Binary Input Change with Time	1	06,07,08	129, 130	17, 28
2	3	Binary Input Change with Relative Time	1	06,07,08	129, 130	17, 28
10	0	Binary Output - All Variations	1	06		
10	1	Binary Output				
10	2	Binary Output Status			129, 130	00, 01
12	0	Control Block - All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter - All Variations	1, 7, 8, 9, 10	06		
20	1	32-Bit Binary Counter			129, 130	00, 01
20	2	16-Bit Binary Counter			129, 130	00, 01
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter without Flag			129, 130	00, 01
20	6	16-Bit Binary Counter without Flag			129, 130	00, 01
20	7	32-Bit Delta Counter without Flag				

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
20	8	16-Bit Delta Counter without Flag				
21	0	Frozen Counter - All Variations	1	06		
21	1	32-Bit Frozen Counter			129, 130	00, 01
21	2	16-Bit Frozen Counter			129, 130	00, 01
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter with Time of Freeze				
21	6	16-Bit Frozen Counter with Time of Freeze				
21	7	32-Bit Frozen Delta Counter with Time of Freeze				
21	8	16-Bit Frozen Delta Counter with Time of Freeze				
21	9	32-Bit Frozen Counter without Flag			129, 130	00, 01
21	10	16-Bit Frozen Counter without Flag			129, 130	00, 01
21	11	32-Bit Frozen Delta Counter without Flag				
21	12	16-Bit Frozen Delta Counter without Flag				
22	0	Counter Change Event - All Variations	1	06,07,08		
22	1	32-Bit Counter Change Event without Time			129, 130	17, 28
22	2	16-Bit Counter Change Event without Time			129, 130	17, 28
22	3	32-Bit Delta Counter Change Event without Time				
22	4	16-Bit Delta Counter Change Event without Time				
22	5	32-Bit Counter Change Event with Time				
22	6	16-Bit Counter Change Event with Time				
22	7	32-Bit Delta Counter Change Event with Time				
22	8	16-Bit Delta Counter Change Event with Time				

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IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
23	0	Frozen Counter Event - All Variations				
23	1	32-Bit Frozen Counter Event without Time				
23	2	16-Bit Frozen Counter Event without Time				
23	3	32-Bit Frozen Delta Counter Event without Time				
23	4	16-Bit Frozen Delta Counter Event without Time				
23	5	32-Bit Frozen Counter Event with Time				
23	6	16-Bit Frozen Counter Event with Time				
23	7	32-Bit Frozen Delta Counter Event with Time				
23	8	16-Bit Frozen Delta Counter Event with Time				
30	0	Analog Input - All Variations	1	06		
30	1	32-Bit Analog Input			129, 130	00, 01
30	2	16-Bit Analog Input			129, 130	00, 01
30	3	32-Bit Analog Input without Flag			129, 130	00, 01
30	4	16-Bit Analog Input without Flag			129, 130	00, 01
30	5	Short Floating Point Analog Input			129, 130	00, 01
31	0	Frozen Analog Input - All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input with Time of Freeze				
31	4	16-Bit Frozen Analog Input with Time of Freeze				
31	5	32-Bit Frozen Analog Input without Flag				
31	6	16-Bit Frozen Analog Input without Flag				
32	0	Analog Change Event - All Variations	1	06,07,08		
32	1	32-Bit Analog Change Event without Time			129,130	17,28
32	2	16-Bit Analog Change Event without Time			129,130	17,28

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
32	3	32-Bit Analog Change Event with Time			129,130	17,28
32	4	16-Bit Analog Change Event with Time			129,130	17,28
32	5	Short Floating Point Analog Change Event without Time			129,130	17,28
33	0	Frozen Analog Event - All Variations				
33	1	32-Bit Frozen Analog Event without Time				
33	2	16-Bit Frozen Analog Event without Time				
33	3	32-Bit Frozen Analog Event with Time				
33	4	16-Bit Frozen Analog Event with Time				
40	0	Analog Output Status - All Variations	1	06		
40	1	32-Bit Analog Output Status			129, 130	00, 01
40	2	16-Bit Analog Output Status			129, 130	00, 01
40	3	Short Floating Point Analog Output Status			129, 130	00, 01
41	0	Analog Output Block - All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date - All Variations				
50	1	Time and Date	2 (see 4.14)	07 where quantity = 1		
50	2	Time and Date with Interval				
51	0	Time and Date CTO - All Variations				
51	1	Time and Date CTO			129, 130	07, quantity=1

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT
This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
51	2	Unsynchronized Time and Date CTO			129, 130	07, quantity=1
52	0	Time Delay - All Variations				
52	1	Time Delay Coarse			129	07, quantity=1
52	2	Time Delay Fine			129	07, quantity=1
60	0					
60	1	Class 0 Data	1	06		
60	2	Class 1 Data	1 20,21	06,07,08 06		
60	3	Class 2 Data	1 20,21	06,07,08 06		
60	4	Class 3 Data	1 20,21	06,07,08 06		
70	1	File Identifier				
80	1	Internal Indications	2	00 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				

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DEVICE PROFILE DOCUMENT

IMPLEMENTATION OBJECT

This table describes the objects, function codes and qualifiers used in the device:

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
101	3	Large Packed Binary-Coded Decimal				
		No Object	13			
		No Object	14			
		No Object	23 (see 4.14)			

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TIME SYNCHRONISATION PARAMETERS

This table describes the worst-case time parameters relating to time synchronization, as required by DNP Level 2 Certification Procedure section 8.7

PARAMETER	VALUE
Time base drift	+/- 1 minute/month at 25°C +1 / -3 minutes/month 0 to 50°C
Time base drift over a 10-minute interval	+/- 14 milliseconds at 25°C +14 / -42 milliseconds 0 to 50°C
Maximum delay measurement error	+/- 100 milliseconds
Maximum internal time reference error when set from the protocol	+/- 100 milliseconds
Maximum response time	100 milliseconds

TelePACE C Tools

User and Reference Manual

CONTROL MICROSYSTEMS

SCADA products... for the distance

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Kanata, Ontario
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Canada

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888-2CONTROL

TelePACE C Tools User and Reference Manual

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Table of Contents

TelePACE C Tools Overview

The TelePACE C Tools are ideal for engineers and programmers who require advanced programming tools for SCADA applications and process control. The SCADAPack, 4000 Series and TeleSAFE families of controllers execute ladder logic and C application programs simultaneously, providing you with maximum flexibility in implementing your control strategy.

This manual provides full documentation on the TelePACE C program loader and the library of C language process control and SCADA functions. We strongly encourage you to read it, and to notify us if you find any errors or additional items you feel should be included in our documentation.

We sincerely hope that the reliability and flexibility afforded by this fully programmable controller enable you and your company to solve your automation problems in a cost effective and efficient manner.

The TelePACE C Tools include an ANSI C cross compiler; a customized library of functions for industrial automation and data acquisition; a real time operating system; and the TelePACE C program loader. The C function library is similar to many other C implementations, but contains additional features for real time control, digital and analog I/O. An overview of the application development environment and its features follows.

Program Development

C programs are written using any text editor. The MCCM77 compiler is used to compile, assemble and link the programs on a personal computer.

The memory image, which results from this process may then be, loaded either into the RAM, committed to an EPROM, or both may be used together. Programs may be executed either manually or automatically at power up.

Modularity

Programs written in TelePACE C may be split into many separately compiled modules. These modules may be tested individually before being linked together in the final program. Command files specify how the various files are to be linked.

Assembly Language Code

Assembly language source code may be included directly within C programs. The #asm and #endasm statements are used to enclose in-line assembly language code, which is then assembled without passing through the compiler.

C programs are converted to assembly language by the MCCM77 compiler, and this code may be viewed and modified. The resulting code may also be combined with programs written directly in assembler.

Program Options

A C application program may reside in RAM or ROM. The normal method of program development has the program in RAM. The program may call library routines in the operating system ROM. The RAM is nonvolatile (battery backed), so the program may remain in RAM once development is completed and the unit is installed.

Application programs may also be committed to EPROM. The RAM is used for data storage in this case.

Supported Language Features

The TelePACE C Tools use the Microtec® MCCM77 C compiler. The compiler is ANSI C compliant, and provides a code optimizer and assembler.

In addition to the standard C operators, data types and library functions, the C tools provide a set of routines specifically designed for control applications. Some applications and the descriptions of these functions may be found on the following pages.

Serial Communication

An extensive serial communication library supports simple ASCII communication, communication protocols and serial port configuration. The default communication mode uses the TeleBUS RTU communication protocol. It supports access to the I/O database, serial port reconfiguration and program loading.

The application program can disable the TeleBUS protocol, and use the serial ports for other purposes.

TeleBUS protocols are compatible with the widely supported, Modbus ASCII and RTU protocols.

Clock/Calendar

The processor's hardware clock calendar is supported by the C Tools. The time, date and day of week can be read and set by the application software.

Timers

The controller provides 32 software timers. They are individually programmable for tick rates from ten per second to once every 25.5 seconds. Timers may be linked to digital outputs to cause external devices to turn on/off after a specified period. All timers operate in the background from a hardware interrupt generated by the main system clock.

Duty Cycle and Pulse Outputs

The digital I/O driver provides duty cycle and pulse train outputs. Duty cycle outputs generate continuous square waves. Pulse train outputs generate finite sequences of pulses. Outputs are generated independent of the application program.

Watchdog Timer

The controller supports a hardware watchdog timer to detect and respond to hardware or software failures. Watchdog timer trigger pulses may be generated by the user program or by the system clock.

Checksums

To simplify the implementation of self-checking communication algorithms, the C Tools provide four types of checksums: additive, CRC-16, CRC-CCITT, and byte-wise exclusive-OR. The CRC algorithms are particularly reliable, employing various polynomial methods to detect nearly all communication errors. Additional types of checksums are easily implemented using library functions.

Standard I/O Functions

The TelePACE C Tools are an enhanced version of standard C libraries. Most of the usual C programming techniques apply. However, with respect to I/O, there are some differences.

The C Tools function library supports all the standard I/O functions. There are no disk-drives or peripherals associated with the controller. Thus many file handling functions return fixed responses, indicating that the operation could not be performed.

All standard devices are opened automatically by the operating system and cannot be closed. The route function may be used to redirect `stdin`, `stdout` and `stderr`.

The TelePACE Program

TelePACE is an easy-to-use interface providing, among several other features, a C Program Loader and a Ladder Logic program editor. On-line help provides a full reference to all the features of the TelePACE program. TelePACE runs on the Microsoft Windows operating system.

This manual references only those features of TelePACE pertaining to the C Program Loader dialog. Please refer to the section ***TelePACE Program Reference*** for a complete description of TelePACE menus, which will be useful during C Program development.

Additional Documentation

Additional documentation on TelePACE Ladder Logic and the TeleSAFE and SCADAPack controllers is found in the following documents.

The on-line help for the TelePACE C program loader contains a complete reference to the operation of the loader. To display on-line help, select **Contents** from the **Help** menu.

The ***SCADAPack & Micro16 System Manual*** is a complete reference to controller and I/O modules used with SCADAPack and Micro16 controllers. It contains the ***SCADAPack Controller Hardware Manual,*** the ***TeleSAFE Micro16 System Manual*** and hardware manuals for all 5000 Series I/O modules.

The ***TelePACE Ladder Logic Reference and User Manual*** describes the creation of application programs in the Ladder Logic language.

The ***TeleBUS Protocols User Manual*** describes communication using Modbus compatible protocols.

The ***TelePACE PID Controller Reference Manual*** describes PID control concepts and provides examples using the PID functions.

Getting Started

This section of the C Tools User Manual describes the installation of C Tools and includes a Program Development Tutorial. The Program Development Tutorial leads the user through the steps involved in writing, compiling, linking and loading a C application program.

System Requirements

TelePACE requires the following minimum system configuration.

- Personal computer using 80386 or higher microprocessor.
- Microsoft Windows™ operating system versions including Windows 2000, NT and XP™ .
- Minimum 4 MB of memory.
- Mouse or compatible pointing device.
- Hard disk with approximately 2.5 Mbytes of free disk space.

Making Backup Disks

You should make a backup copy of the TelePACE disk and Microtec C compiler disks before using the software. A backup copy protects you against damage to the disk. Always work with the backup copy – if it fails, you can make a new copy from the original disk. Store the original disk in a safe location.

- In My Computer, click the icon for the disk you want to copy.
- On the File menu, click Copy Disk.
- Click the drive you want to copy from and the drive you want to copy to, and then click Start.

Installation of C Compiler

Install the Microtec C compiler as described in the installation manuals supplied with the system.

To run the Microtec Compiler and Linker from any directory, without the need to specify the full path, you will have to setup the following System Environmental Variables:

Variable	Value
mri_m77_bin	c:\mccm77;c:\asmm77
mri_m77_inc	c:\mccm77
mri_m77_lib	c:\mccm77
mri_m77_tmp	c:\mccm77\tmp

In addition you would need to add these values to the Path System Variable:

C:\MCCM77;C:\ASMM77;C:\XHSM77

Note that spaces are not tolerated in between entries in the Path value.

On a Windows XP Control Panel, select **System** | **Advanced** | **Environmental Variables** to access the dialog where the above variables need to be set.

Installation of TelePACE

Install TelePACE as described in the installation section of the *TelePACE Ladder Logic Reference and User Manual.*

Some virus checking software may interfere with Setup. If you experience problems with the Setup, disable your virus checker and run Setup again.

Installing C Tools as an Upgrade

If you are installing TelePACE as an upgrade to a previous C Tools installation for the Micro16, note that the C Tools are installed in the new directory `c:\telepace\ctools\520x` instead of the directory `c:\telepace\ctools\micro16`.

If the older version of C Tools is not needed, copy all user data files out of the micro16 directory and delete the directory and its contents.

When linking older programs you will need to modify all older linker command (`.cmd`) files to reference the new 520x directory instead of the micro16 directory, or see the sample linker file `appram.cmd` for the correct file contents.

The sample linker command file `appram.cmd` also loads the new `ctools.lib` library. This library contains the new C Tools functions defined in the header file `ctools.h`.

Program Development Tutorial

Program development consists of three stages: writing and editing; compiling and linking; and loading the program into the controller. Each uses separate tools. To demonstrate these steps a sample program will be prepared.

Refer to the **C Program Development** section for a full description of the program development process.

Traditionally, the first program that is run on a new C compiler is the *hello, world* program. It prints the message “hello, world”.

Writing and Editing

A controller C program is written using any text editor or word processor in text mode. The syntax should correspond to that described in the *Microtec MCCM77 Documentation Set*, and the ***C Program Development*** section of this manual. This chapter describes non-standard functions, which are unique to the controller. It should be read carefully to make full use of the special purpose routines available.

Using your text editor, open the file `hello.c` file. It is located in the `telepace\ctools\520x` directory. The program looks a little different from the traditional *hello, world* program.

```
/* ------------------------------------------
   hello.c
   SCADAPack and TeleSAFE Micro16 Test Program

   The infamous hello, world program.
   ------------------------------------------ */

#include <ctools.h>
```

```
void main(void)
{
   PROTOCOL_SETTINGS settings;

   /* Disable the protocol on serial port 1 */
   settings.type        = NO_PROTOCOL;
   settings.station     = 1;
   settings.mode        = AM_standard;
   settings.priority    = 3;
   settings.SFMessaging = FALSE;
   setProtocolSettings(com1, &settings);

   /* Print the message */
   fprintf(com1, "hello, world\r\n");

   /* Wait here forever */
   while (TRUE)
   {
      NULL;
   }
}
```

The “hello, world” message will be output to the *com1* serial port of the controller. A terminal connected to the port will display the message.

The controller normally communicates on all ports using the TeleBUS communication protocol. The first section of the program disables the *com1* protocol so the serial port can be used as a normal RS-232 port.

The `fprintf` function prints the message to the `com1` serial port.

When you have completed examining the program, close the `hello.c` file. It is now ready to be compiled and linked.

Compiling and Linking

Compiling and linking convert the source code into executable code for the controller. The TelePACE C Tools use a C cross compiler and linker from Microtec, a respected supplier of embedded system tools. The compiler produces tight, well-optimized code. The compiler and linker run under the Microsoft MS-DOS operating system.

The compiler has many command line options. The basic command line and options required to compile code for the controller are:

`mccm77 -v -nQ -Ml -c` *`filename`*`.c`

This should be repeated for each file in the application. Note that the command line options are case sensitive. The character following the M is a lower case l (ell).

Files are linked together using linker command files. To link a program execute the command:

`lnkm77 -c` *`filename`*`.cmd`

Sample command files for RAM and ROM based applications are located in the `telepace\ctools\520x` directory.

Example

The `hello.c` program is found in the `telepace\ctools\520x` directory. To compile and link the program:

- switch to the telepace\ctools\520x directory;

- enter the commands

```
mccm77 -v -nQ -Ml -c hello.c
lnkm77 -c hello.cmd
```

The file `hello.abs` contains the executable code in a format ready to load into the controller.

Loading and Executing

The TelePACE C Program Loader transfers executable files from a PC to the controller and controls execution of programs in the controller. The loader can also initialize program memory and serial port configuration.

Controller Initialization

The memory of the controller has to be initialized when beginning a new programming project or when it is desired to start from default conditions. It is not necessary to initialize the controller before every program load.

To initialize the controller, first perform a SERVICE boot. A SERVICE boot preserves programs and data in nonvolatile RAM, but does not start the programs running. Default communication parameters are used.

To perform a service boot:

- Remove power from the controller.
- Press and hold the LED POWER switch.
- Apply power to the controller.
- Wait until the STAT LED on the top of the board turns on.
- Release the LED POWER switch.

Second, initialize the program and data memory in the controller. A new controller will require all initializations to be performed. Selected initializations can be performed on a controller that is in use.

- Run the TelePACE program under Microsoft Windows.
- Connect the PC to the controller with the appropriate serial cable. The *hello, world* program will print data on the *com1* serial port. Therefore connect to the *com2* serial port on the controller. (All communication ports work the same. We use *com2* here because the sample program is using *com1.)*
- From the **Controller** menu, select under **Type** the controller type that is connected. A check mark appears beside the desired type when it is selected.
- From the **Controller** menu, select the **Initialize** command.
- Select all options: **Erase Ladder Logic Program, Erase C Program**, **Initialize Controller** and **Erase Register Assignment Table**.
- Click on the **OK** button.

The controller is now ready for a program.

Loading the Program

To load the *hello, world* program into the controller:

- Run the TelePACE program.
- From the **Controller** menu, select the **C Program Loader** command.
- Enter `hello.abs` in the edit box for the C Program file name.
- Select all write options: **C Program**, **Register Assignment** and **Serial port settings**.
- Click on the **Write** button. The file will be downloaded.
- A warning message about the empty register assignment will appear. Click on the **OK** button.

Executing the Program

- Connect a terminal to *com1* on the controller. It will display the output of the program. Set the communication parameters to 9600 baud, 8 data bits, 1 stop bit, and no parity.
- From the **C Program Loader** dialog, click on the **Run** button to execute the program. The “hello, world” message will be displayed on the terminal.

Serial Communication Parameters

When the controller is powered up in the SERVICE mode the serial ports are configured as:

- 9600 baud
- 8 data bits
- 1 stop bit
- no parity
- Modbus RTU protocol emulation
- station address = 1

A program may change these settings with the `set_port` function. When the controller is powered up in RUN position, the custom parameters, as stored by the most recent `save` function, are used.

C Program Development

Program Architecture

A C application program may be contained in a single file or in a number of separate files, called modules. A single file is simple to compile and link. It can become cumbersome to edit and time-consuming to compile as the file grows in size.

An application stored in separate modules by function is easier to edit, promotes function re-use, and is quicker to compile when only a few modules are changed. Compiled modules can be combined into object libraries and shared among users.

The TelePACE C Tools support both single file and multiple module programs. A C application program consists of support functions provided by the C Tools and the main() and other functions written by the user.

Main Function Structure

The program sample below shows a typical structure for the main() function.

```
void main(void)
{
   /* Perform initialization actions */
   /* Start support tasks */

   /* Main Loop*/
   while (TRUE)
   {
      /* Perform application functions */
   }
}
```

Initialization actions typically consist of variable declarations, variable initialization and one-time actions that must be performed when the program starts running.

Supporting tasks (see ***Real Time Operating System*** section) are typically created before the main loop of the program. Tasks can be created and ended dynamically during the execution of a program as well.

The main loop of a program is always an infinite loop that continually performs the actions required by the program. The main() function normally never returns.

Example

The following is an example of a three-module program. Each function is stored in a separate file. This program will be used in subsequent examples.

File: `func1.c`

```
#include <ctools.h>

void func1(void)
{
   fputs("This is function 1\r\n", com1);
}
```

File: func2.c

```
#include <ctools.h>

void func2(void)
{
   fputs("This is function 2\r\n", com1);
}
```

File: `main.c`

```
#include <ctools.h>

extern void func1(void);
extern void func2(void);

void main(void)
{
   func1();

   while (TRUE)
   {
      func2();
   }
}
```

Start-Up Function Structure

The user's main() function is called from the `appstart` function of the C Tools. It is not necessary to understand the `appstart` function to write programs. However it performs a number of useful functions that can be modified by the user.

The start-up code has five major functions:

- create and initialize the application program heap (for dynamic memory allocation);
- specify the number of stack blocks allocated to the main task;
- initialize application program variables;
- control execution of the protocol, ladder logic and background I/O tasks;
- execute the `main` function.

Source code for the function is supplied with the C Tools. The following discussion refers to statements found in the file `appstart.c`.

The heap is a section of memory used by dynamic memory allocation functions such as `malloc`. The heap starts at the end of RAM used by the program and continues to the end of physical RAM. The limit is set by the statement:

```
end_of_heap      .EQU     41ffffh
```

The limit is set by default to the smallest memory option available for the controller. If your controller has more memory, change the value of the constant according to the following table.

RAM Installed	C Application Program RAM Addresses
128 Kbytes	none (ladder logic only)
256 Kbytes	400000h – 41FFFFh
640 Kbytes	400000h – 47FFFFh
1024 Kbytes	388000h – 3E7FFFh 400000h – 47FFFFh

The application program signature section of the file contains a constant that determines the size of the stack allocated to the main task. The stack size is sufficient for most applications. It can be changed by modifying the statement:

```
.WORD 4     ;stack size in blocks
```

Refer to the ***Real Time Operating System*** section for more information on the stack required by tasks.

The `appstart` function begins by initializing the heap pointers, setting all non-initialized variables to zero, and initializing system variables.

It then starts the communication protocols for each serial port, according to the stored values in the EEPROM (or the standard values on a SERVICE boot). If your application program never uses the communication protocols, some or all of the following commands can be removed, to free the stack space used by the protocol tasks.[1]

```
start_protocol(com1);
start_protocol(com2);
start_protocol(com3);[2]
start_protocol(com4);[3]
```

The background I/O task is required for the timer functions, dial-up modem communications, and PID controller functions to operate. If you do not intend to use these functions, you can reduce the CPU load by changing TRUE to FALSE in the following statement:

```
runBackgroundIO(TRUE);
```

The ladder logic interpreter is required for ladder logic programs. If you do not intend to use ladder logic, you can reduce the CPU load by changing TRUE to FALSE in the following statement:

```
runLadderLogic(TRUE);
```

The final operation is execution of the `main` function. The `_initcopy` function copies the initial values for initialized variables from the `__INITDATA` section in the program to the variables. If there are no errors in the data then the user's application program runs. (An error is likely only if the program in RAM has been damaged or improperly linked.)

```
if (_initcopy() == 0)
{
   main();
}
```

If the `main` function returns, the task is ended. First, any modem control sessions started by the application are terminated.

```
abortAllDialupApps();
```

Then the task is ended. This will cause all other APPLICATION tasks created by main to be stopped as well.

```
taskStatus = getTaskInfo(0);
end_task(taskStatus.taskID);
```

[1] Stack space is required to create additional tasks. Refer to the create_task function for more information.

[2] com3 is used only in the SCADAPack and SCADAPack PLUS controllers.

[3] com4 is used only in the SCADAPack LIGHT and SCADAPack PLUS controllers.

Data Storage

All non-initialized variables (local and global) are initialized to zero on program startup by the Microtec C Compiler. The I/O database is the only section of memory that is not initialized to zero on startup. Data stored in the I/O database is maintained when power to the controller is lost, and remains until the controller is initialized from the TelePACE program.

In most cases the I/O database provides adequate space for data storage. However, if additional non-initialized memory is required, for example for an array of custom data structures, an non-initialized section of memory can be created as shown in the example below.

```
/* ---------------------------------------------------------------
datalog.c

This file contains the global variable definitions for a datalogger
database.

These global variables are placed in a non-initialized section
called "savedata". All data in these variables will be maintained
over powerup.
--------------------------------------------------------------- */
#include <datalog.h>

/* define a non-initialized section called savedata */
#pragma option -NZsavedata
#pragma option -Xp

/* Global variable definitions */

/* log index */
unsigned  logIndex;

/* log database */
struct dataLog   logData[DATA_LOG_SIZE];
```

Any variable defined in this file `datalog.c` will be placed in the non-initialized section arbitrarily named `savedata`. Code operating on these variables should be placed in a separate file, which references these global variables through external definitions placed in a header file (e.g. `datalog.h`).

The `#pragma option` directive is documented in the ***Microtec MCCM77 Documentation Set.***

Compiling Source Code

The C Compiler converts source code into object files. The basic command line and options required to compile code for the controller are:

```
mccm77 -v -nQ -Ml -c filename.c
```

A complete description of the command line options is given in the Microtec *MCCM77 User's Guide*. The options used here are:

Option	Description
`-v`	Issue warnings for features in source file. This option allows you to detect potential errors in your source code before running the program.
`-nQ`	Do not suppress diagnostic messages. This option provides additional warnings that allow you to detect potential errors in your source code before running the program.
`-Ml`	Compile for large memory model (note that the character following the

	M is a lower case ell).
-c	Compiler output is an object file.

The following options may be useful.

Option	Description
-Jdir	Specify the directory containing the standard include files. Adding -Jc:\telepace\ctools\520x to the command line allows you to locate your application program files in a different directory. This helps in organizing your files if you have more than one application program.
-O	Enable standard optimizations. This produces smaller and faster executable code.
-Ot	Optimize in favor of execution time rather than code size where a choice can be made.
-nOc	Pop the stack after each function call. This increases code size and execution time. This option should only be used if there is a large number of *consecutive* function calls in your program. A large number of consecutive calls requires a large stack allocation for a task. Since the number of stack blocks is limited, using this option can reduce the stack requirements for a task. See the description for the create_task function for more information.

Each module in an application should be compiled to produce an object file. The object files are then linked together to form an executable program.

Example

The following commands are required to compile the program described in the previous sections.

```
mccm77 -v -nQ -Ml -c main.c
mccm77 -v -nQ -Ml -c func1.c
mccm77 -v -nQ -Ml -c func2.c
```

This produces three output files: main.obj; func1.obj and func2.obj. In the next section these object files will be combined into an executable program.

Linking Object Files

The linker converts object files and object file libraries into an executable program. The basic command line and options to link a program are:

```
lnkm77 -c filename.cmd
```

Controller programs can execute from RAM, Flash or ROM. The linker command file determines the location of the program.

RAM Based Applications

A sample linker command file for a RAM based program is appram.cmd located in the telepace\ctools\520x directory.

The file begins by specifying the location and order of memory sections. The far_appcode section is the first section in all controller C programs. It contains the start-up code that calls the main() function. In a RAM based program, the start-up code is located at the start of C application program RAM. This address is fixed at 00400000h.

The order commands specify the order of the sections. The sections are grouped so all the code and static data sections are first. The variable data sections follow. The heap is the last section. It is allowed to grow from the end of the program data to the end of memory (see ***Start Up Function Structure*** section for more information).

The sections may be rearranged, and new sections added, according to the following rules:

- The `far_appcode` section must be first in the order listing.
- All code sections must follow the `far_appcode` section.
- The `far_endcode` section must be the last code section.
- All data sections must follow the code sections.
- The `heap` section must be last in the order listing.

```
; ---------------------------------------------
; Specify location and order of memory sections
; ---------------------------------------------
sect far_appcode = 00400000h
order far_appcode, far_code, (CODE), const
order strings, literals, __INITDATA, far_endcode
order far_zerovars, far_initvars, (DATA), heap
```

The next section of the command file creates initialized data sections. All variables in the specified section are initialized at start-up of the program. The linker creates a copy of the data in these sections and stores it in the __INITDATA section.

```
; ---------------------------------------------
; Create initialized variables section
; ---------------------------------------------
initdata far_initvars
```

The next section of the command file lists the application program object modules (files) to be included in the program. You may also include libraries of functions you create here. The sample command file includes one object module: `app.obj`.

```
; ---------------------------------------------
; Load application program object modules
; ---------------------------------------------
load app
```

The next section of the command file lists the start-up routines and standard libraries to be included. There are three object modules and two libraries:

Module	Description
`Appstart.obj`	This file contains the application program start up routine (see *Program Architecture* section above). If you modify the start-up routine for a particular application, be sure to specify the path to the modified routine.
`Romfunc.obj`	This file contains addresses of the jump table for calling functions in the operating system ROM. Only the symbols are loaded as only the addresses are needed.
`Ctools.lib`	This is the C Tools library, which contains C Tools functions not found in the operating system ROM.
`cm77islf.lib`	This is the standard Microtec floating point library.
`cm77islc.lib`	This is the standard Microtec function library.

```
; ---------------------------------------------
; Load start up and library routines
; ---------------------------------------------
load c:\telepace\ctools\520x\appstart
```

```
load_symbols c:\telepace\ctools\520x\romfunc
load c:\telepace\ctools\520x\ctools.lib
load c:\mccm77\cm77islf.lib
load c:\mccm77\cm77islc.lib
```

The final section of the command file specifies the output file format. The `listmap` command specifies what information is to be included in the map file. Refer to the Microtec manuals for more information on map files.

The `format` command specifies the executable output will be in Motorola S2 record format. The TelePACE C Program Loader requires this format.

```
; ------------------------------------------
; Specify output file formats and options
; ------------------------------------------
listmap nopublics, nointernals, nocrossref
format S2
```

Example

The standard command file must be modified to link the application described in the previous example. Copy the `appram.cmd` file to `myapp.cmd`. Modify the application object modules section to read:

```
; ------------------------------------------
; Load application program object modules
; ------------------------------------------
load main
load func1
load func2
```

Link the file with the command

```
lnkm77 -c myapp.cmd
```

This will produce one output file: `myapp.abs`. The next step is to load it into the controller using the TelePACE C Program Loader.

Flash Based Applications

A sample command file for a Flash based program is `appflash.cmd` located in the `telepace\ctools\520x` directory. This file is very similar to the command file for RAM based programs.

The file begins by specifying the location and order of memory sections. There are two types of sections in a Flash based program. The code and static data sections must be stored in the Flash. The variable data sections must be stored in RAM.

The `far_appcode` section is the first code section in all controller C programs. In a Flash based program, the `far_appcode` section is located at 110000h.

The `far_zerovars` section is the first data section. In a ROM based program it is normally located at the start of application program RAM (00400000h). It is possible to start this section at any RAM address, if your application requires it.

The order commands specify the order of the sections. The sections may be rearranged, and new sections added, according to the following rules:

- The `far_appcode` section must be first in the order listing.
- All code sections must follow the `far_appcode` section.
- The `far_endcode` section must be the last code section.

- The `far_zerovars` section must be the first data section.
- All other data sections must follow the `far_zerovars` section.
- The `heap` section must be the last data section.

```
; ---------------------------------------------
; Specify location and order of memory sections
; ---------------------------------------------
sect far_appcode  = 00110000h
sect far_zerovars = 00400000h
order far_appcode, far_code, (CODE), const
order strings, literals, __INITDATA, far_endcode
order far_zerovars, far_initvars, (DATA), heap
```

The remaining sections of the file are identical to the RAM command file. Refer to the ***RAM Based Applications*** section for a description.

The final section of the command file specifies the output file format. The default format command specifies the executable output will be in Motorola S2 record format. This is the format required by the TelePACE Flash Loader.

Example – C Program in Flash

The standard command file must be modified to link the application described in the previous example. Copy the `appflash.cmd` file to `myapp.cmd`. Modify the application object modules section to read:

```
; ---------------------------------------------
; Load application program object modules
; ---------------------------------------------
load main
load func1
load func2
```

Link the file with the command

```
lnkm77 -c myapp.cmd
```

This will produce one output file: `myapp.abs`. The next step is to write the file to the controller using TelePACE. Use the Flash Loader command on the Controller menu. Consult the TelePACE documentation for details.

ROM Based Applications

A ROM based program is very similar to a Flash based application. However, an EPROM programmer must be used to create the ROM. ROM based programs have access to more program (code) memory than Flash based applications.

It is recommended that Flash based programs be used, unless there is not enough program memory available.

If a ROM based program is created it should be stored in an EPROM. If a Flash based part is used the commands in TelePACE to erase Flash may not work as expected. Contact Control Microsystems for more information about this.

A sample command file for a ROM based program is `approm.cmd` located in the `telepace\ctools\520x` directory. This file is very similar to the command file for Flash based programs.

The file begins by specifying the location and order of memory sections. There are two types of sections in a ROM based program. The code and static data sections must be stored in the ROM. The variable data sections must be stored in RAM.

The `far_appcode` section is the first code section in all controller C programs. In a ROM based program, the `far_appcode` section can be located at any address that is a multiple of 100h in the application ROM. The start of application ROM is fixed at 100000h.

A C application program may share the application ROM space with a ladder logic program. If only a C program is stored in the ROM the `far_appcode` section is located at 100000h. If a ladder logic program is stored in ROM it must start at 100000h. The C application can start anywhere after the end of the ladder logic program. This location is determined by the size of the ladder logic program and is best determined by examining the memory image of the ladder logic program in your EPROM programmer.

The `far_zerovars` section is the first data section. In a ROM based program it is normally located at the start of application program RAM (00400000h). It is possible to start this section at any RAM address, if your application requires it.

The order commands specify the order of the sections. The sections may be rearranged, and new sections added, according to the following rules:

- The `far_appcode` section must be first in the order listing.
- All code sections must follow the `far_appcode` section.
- The `far_endcode` section must be the last code section.
- The `far_zerovars` section must be the first data section.
- All other data sections must follow the `far_zerovars` section.
- The `heap` section must be the last data section.

```
; ------------------------------------------
; Specify location and order of memory sections
;
; Note: the far_appcode section address must
;       be a multiple of 100h.
; ------------------------------------------
sect far_appcode  = 00100000h
sect far_zerovars = 00400000h
order far_appcode, far_code, (CODE), const
order strings, literals, __INITDATA, far_endcode
order far_zerovars, far_initvars, (DATA), heap
```

The remaining sections of the file are identical to the RAM command file. Refer to the ***RAM Based Applications*** section for a description.

The final section of the command file specifies the output file format. The default format command specifies the executable output will be in Motorola S2 record format. Your EPROM programmer may require a different output format. The following options are available. Refer to the Microtec Linker manual for a complete description.

Command	Description
`format ASCII`	Intel ASCII hex format. This is also known as Intel-86 or Extended Intel Hex format.
`format IEEE`	Microtec extended IEEE-695 format.
`format S1`	Motorola S1 record format.
`format S2`	Motorola S2 record format.

Example – C Program in ROM

The standard command file must be modified to link the application described in the previous example. Copy the `approm.cmd` file to `myapp.cmd`. Modify the application object modules section to read:

```
; ---------------------------------------------
; Load application program object modules
; ---------------------------------------------
load main
load func1
load func2
```

Link the file with the command

```
lnkm77 -c myapp.cmd
```

This will produce one output file: `myapp.abs`. The next step is to program an EPROM using this file.

Example – C and Ladder Logic Program in ROM

The C application program may share the ROM with a ladder logic program. The ladder logic program is always located at 100000h. The C program may start at any address that is a multiple of 100h following the ladder logic program.

The standard command file must be modified to link the application described in the previous examples. Copy the `approm.cmd` file to `myapp.cmd`.

Assume for this example that the ladder logic program ends at address 100417h. The next multiple of 100h after this address is 100500h. Modify the section locations to read:

```
; ---------------------------------------------
; Specify location and order of memory sections
;
; Note: the far_appcode section address must
;       be a multiple of 100h.
; ---------------------------------------------
sect far_appcode  = 00100500h
```

Modify the application object modules section to read:

```
; ---------------------------------------------
; Load application program object modules
; ---------------------------------------------
load main
load func1
load func2
```

Link the file with the command

```
lnkm77 -c myapp.cmd
```

This will produce one output file: `myapp.abs`. The next step is to program an EPROM using this file.

Controller Initialization

You should initialize the memory of the controller when beginning a new programming project or when you wish to start from default conditions. It is not necessary to initialize the controller before every program load.

To initialize the controller, first perform a SERVICE boot. A SERVICE boot preserves programs and data in nonvolatile RAM, but does not start the programs running. Default communication parameters are used.

To perform a service boot:

- Remove power from the controller.

- Press and hold the LED POWER switch.
- Apply power to the controller.
- Wait until the STAT LED on the top of the board turns on.
- Release the LED POWER switch.

Second, initialize the program and data memory in the controller. A new controller will require all initializations be performed. Selected initializations can be performed on a controller that is in use.

- Run the TelePACE program under Microsoft Windows.
- Connect the PC to the controller with the appropriate serial cable.
- From the **Controller** menu, select under **Type** the controller type that is connected. A check mark appears beside the desired type when it is selected.
- From the **Controller** menu, select the **Initialize** command.
- Select all options: **Erase Ladder Logic Program, Erase C Program**, **Initialize Controller** and **Erase Register Assignment Table**.
- Click on the **OK** button.

Loading Programs into RAM

The *C Program Loader* dialog transfers executable files from a PC to the controller.

To load a program into RAM:

- Initialize the controller (see ***Controller Initialization*** section above).
- Load the program into the controller:
- Run the TelePACE program.
- From the **Controller** menu, select the **C Program Loader** command.
- Enter the executable (`.abs`) file in the edit box for the C Program file name.
- Select the **C Program** write option and any other write options desired.
- Click on the **Write** button. The file will be downloaded.

A checksum is calculated for the complete C program. The checksum is verified each time the program is run. This prevents a damaged program from running.

Loading Programs into EPROM

The procedure for creating an EPROM depends on your EPROM programmer. In general you must follow these steps:

- Load the executable file into the programmer and program the EPROM.
- Install the EPROM in the controller.

The controller can accept the following EPROMs. Other EPROMs may be compatible. Contact Control Microsystems if you are considering using an EPROM not in this list.

Size (Kbytes)	Manufacturer	Part Number
64	AMD	AM27C512-70DC

64	SGS-Thomson	M27C512-80F1
128	AMD	AM27C010-70DC
128	Atmel	AT27C010-70PI (one time programmable)
128	SGS-Thomson	M27C1001-80F1
128	Toshiba	TC57H1000AD-85
256	AMD	AM27C020-70DC
256	SGS-Thomson	M27C2001-80F1

C Programs may be loaded into Flash memory or EPROM when using TelePACE firmware 1.64 or older.

TelePACE firmware 1.65 or newer no longer supports C Programs in Flash memory. C Programs may be loaded in RAM memory only.

Creating the EPROM

Load the executable (`.abs`) file into the memory of the EPROM programmer, according to the instructions for the programmer.

The first byte of the EPROM (offset 0 in the EPROM) maps to address 100000h when the EPROM is installed in the controller. The linker generates an executable file with address offsets starting at 100000h. These offsets must be removed with most programmers, so that the memory image can be placed at offset 0 in the EPROM itself. (Note that this does not affect the addresses in the program itself, just the address at which it loads.)

Consult your EPROM programmer documentation to determine how to remove the offset. This is typically done in one of two ways:

- Specify the data is to be loaded from file address 100000h. You may have to specify that the file is loaded to offset 0h.
- Or, specify a load offset of –100000h when reading the executable file. The programmer will add –100000h to all load addresses in the file, resulting in a memory image at offset 0h.

Program the EPROM according to the instructions for your programmer.

Installing the EPROM

Install the EPROM in the application ROM socket on the 5203 or 5204 controller board:

- Locate the socket labeled U14. This is the application ROM socket.
- Orient the EPROM so the notch on the EPROM is at the same end as the notch in the socket.
- Align all pins of the EPROM with the socket.
- Press the EPROM gently into the socket.
- Check that all pins are inserted correctly and that none are bent.

Initialize the controller (see ***Controller Initialization*** section above). The **Erase C Program** option must be specified. Other initializations may be performed if desired.

Executing Programs

C application programs are executed when a *run program* command is received from the TelePACE C Program Loader; or power is applied to the controller (except when a SERVICE boot is performed).

To start a program from the program loader:

- Run the TelePACE program.
- From the **C Program Loader** dialog, click on the **Run** button to execute the program.

The controller will execute either the program in RAM or the program in ROM. It chooses the program to execute in the following order:

- C application program in RAM;
- C application program in ROM;
- no C application (standard start-up sequence for other components).

This mode of operation is useful in the following scenario. A controller is installed with a program in ROM. If new features or corrections are required, a program can be downloaded into RAM, either locally or remotely. This program will take precedence over the program in ROM.

If the RAM program is lost or damaged, the ROM program will execute. The ROM program can be used as a fallback, performing minimal functions to maintain a process in a fail-safe condition.

Real Time Operating System

The real time operating system (RTOS) provides the programmer with tools for building sophisticated applications. The RTOS allows pre-emptive scheduling of event driven tasks to provide quick response to real-world events. Tasks multi-task cooperatively. Inter-task communication and event notification functions pass information between tasks. Resource functions facilitate management of non-sharable resources.

Task Management

The task management functions provide for the creation and termination of tasks. Tasks are independently executing routines. The RTOS uses a cooperative multi-tasking scheme, with pre-emptive scheduling of event driven tasks.

The initial task (the **main** function) may create additional tasks. The RTOS supports up to 16 tasks. There are 5 task priority levels to aid in scheduling of task execution.

Task Execution

SCADAPack controllers can execute one task at a time. The RTOS switches between the tasks to provide parallel execution of multiple tasks. The application program can be event driven, or tasks can execute round-robin (one after another).

Task execution is based upon the priority of tasks. There are 5 priority levels. Level 0 is reserved for the `null` task. This task runs when there are no other tasks available for execution. Application programs can use levels 1 to 4. The main task is created at priority level 1.

Tasks that are not running are held in queues. The Ready Queue holds all tasks that are ready to run. Event queues hold tasks that are waiting for events. Message queues hold tasks waiting for messages. Resource queues hold tasks that are waiting for resources. The envelope queue holds tasks that are waiting for envelopes.

Priority Inversion Prevention

When a higher priority task, Task H, requests a resource, which is already obtained by a lower priority task, Task L, the higher priority task, is blocked until Task L releases the resource. If Task L is unable to execute to the point where its releases the resource, Task H will remain blocked. This is called a Priority Inversion.

To prevent this from occurring, the prevention method known as Priority Inheritance has been implemented. In the example already described, the lower priority task, Task L, is promoted to the priority of Task H until it releases the needed resource. At this point Task L is returned to its original priority. Task H will obtain the resource now that it is available.

Note that this does not prevent deadlocks that occur when each task requests a resource that the other has already obtained. This “deadly embrace” is a design error in the application program.

Task Management Functions

There are five RTOS functions for task management. Refer to the ***Function Specification*** section for details on each function listed.

create_task	Create a task and make it ready to execute.
end_task	Terminate a task and free the resources and envelopes allocated to it.
end_application	Terminate all application program type tasks. This function is used by communication protocols to stop the application program prior to loading new code.
installExitHandler	Specify a function that is called when a task is ended with the end_task or end_application functions.
getTaskInfo	Return information about a task.

Task Management Macros

The **ctools.h** file defines the following macros used for task management. Refer to the ***C Tools Macros*** section for details on each macro listed.

RTOS_PRIORITIES	Number of RTOS task priorities.
RTOS_TASKS	Number of RTOS tasks.
STACK_SIZE	Size of the machine stack.
TS_EXECUTING	Task status indicating task is executing
TS_READY	Task status indicating task is ready to execute
TS_WAIT_RESOURCE	Task status indicating task is blocked waiting for a resource
TS_WAIT_ENVELOPE	Task status indicating task is blocked waiting for an envelope
TS_WAIT_EVENT	Task status indicating task is blocked waiting for an event
TS_WAIT_MESSAGE	Task status indicating task is blocked waiting for a message

Task Management Structures

The **ctools.h** file defines the structure **Task Information Structure** for task management information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Resource Management

The resource management functions arbitrate access to non-sharable resources. These resources include physical devices such as serial ports, and software that is not re-entrant.

The RTOS defines nine system resources, which are used by components of the I/O drivers, memory allocation functions and communication protocols.

An application program may define other resources as required. Care must be taken not to duplicate any of the resource numbers declared in **ctools.h** as system resources.

Resource Management Functions

There are three RTOS functions for resource management. Refer to the ***Function Specification*** section for details on each function listed.

request_resource	Request access to a resource and wait if the resource is not available.

poll_resource	Request access to a resource. Continue execution if the resource is not available
release_resource	Free a resource for use by other tasks.

IO_SYSTEM Resource

The IO_SYSTEM resource regulates access to all functions using the I/O system. C application programs, ladder logic programs, communication protocols and background I/O operations share the I/O system. It is imperative the resource is obtained to prevent a conflict, as protocols and background operations are interrupt driven. Do not retain control of the resource for more that 0.1 seconds, or background operations will not execute properly.

DYNAMIC_MEMORY Resource

The DYNAMIC_MEMORY resource regulates access to all memory allocation functions. These functions allocate memory from the system heap. The heap is shared amongst all tasks. The allocation functions are non-reentrant.

The DYNAMIC_MEMORY resource must be obtained before using any of the following functions.

calloc	allocates data space dynamically
free	frees dynamically allocated memory
malloc	allocates data space dynamically
realloc	changes the size of dynamically allocated space

AB_PARSER Resource

This resource is used by the DF1 communication protocol tasks to allocate access to the common message parser for each serial port. This resource is of no interest to an application program. However, an application program may not use the resource number assigned to it.

MODBUS_PARSER Resource

This resource is used by Modbus communication protocol drivers to allocate access to the common message parser by tasks for each serial port. This resource is of no interest to an application program.

Resource Management Macros

The **ctools.h** file defines the following macros used for resource management. Refer to the ***C Tools Macros*** section for details on each macro listed.

AB_PARSER	DF1 protocol message parser.
COM1_DIALUP	Resource for dialing functions on com1.
COM2_DIALUP	Resource for dialing functions on com2.
COM3_DIALUP	Resource for dialing functions on com3.
COM4_DIALUP	Resource for dialing functions on com4.
DYNAMIC_MEMORY	Memory allocation functions.
HART	HART modem resource.

IO_SYSTEM I/O system hardware functions.

MODBUS_PARSER Modbus protocol message parser.

RTOS_RESOURCES Number of RTOS resource flags.

Inter-task Communication

The inter-task communication functions pass information between tasks. These functions can be used for data exchange and task synchronization. Messages are queued by the RTOS until the receiving task is ready to process the data.

Inter-task Communication Functions

There are five RTOS functions for inter-task communication. Refer to the ***Function Specification*** section for details on each function listed.

send_message Send a message envelope to another task.

receive_message Read a received message from the task's message queue or wait if the queue is empty.

poll_message Read a received message from the task's message queue. Continue execution of the task if the queue is empty.

allocate_envelope Obtain a message envelope from free pool maintained by the RTOS, or wait if none is available.

deallocate_envelope Return a message envelope to the free pool maintained by the RTOS.

Inter-task Communication Macros

The **ctools.h** file defines the following macros used for inter-task communication. Refer to the ***C Tools Macros*** section for details on each macro listed.

MSG_DATA Specifies the data field in an envelope contains a data value.

MSG_POINTER Specifies the data field in an envelope contains a pointer.

RTOS_ENVELOPES Number of RTOS envelopes.

Inter-task Communication Structures

The **ctools.h** file defines the structure **Message Envelope Structure** for inter-task communication information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Event Notification

The event notification functions provide a mechanism for communicating the occurrence events without specifying the task that will act upon the event. This is different from inter-task communication, which communicates to a specific task.

Multiple occurrences of a single type of event are queued by the RTOS until a task waits for or polls the event.

Event Notification Functions

There are four RTOS functions for event notification. Refer to the ***Function Specification*** section for details on each function listed.

wait_event Wait for an event to occur.

poll_event Check if an event has occurred. Continue execution if one has not occurred.

signal_event Signal that an event has occurred.

interrupt_signal_event Signal that an event has occurred from an interrupt handler. This function must only be called from within an interrupt handler.

There are two support functions, which are not part of the RTOS that may be used with events.

startTimedEvent Enables signaling of an event at regular intervals.

endTimedEvent Terminates signaling of a regular event.

Event Notification Macros

The **ctools.h** file defines the following macro used for event notification. Refer to the ***C Tools Macros*** section for details.

RTOS_EVENTS Defines the number of available RTOS events.

System Events

The RTOS defines events for communication port management and background I/O operations. An application program may define other events as required. Care must be taken not to duplicate any of the event numbers declared in **ctools.h** as system events.

BACKGROUND This event triggers execution of the background I/O routines. An application program cannot use it.

COM1_RCVR This event is used by communication protocols to signal a character or message received on com1. It can be used in a custom character handler (see **install_handler**).

COM2_RCVR This event is used by communication protocols to signal a character or message received on com2. It can be used in a custom character handler (see **install_handler**).

COM3_RCVR This event is used by communication protocols to signal a character or message received on com3. It can be used in a custom character handler (see **install_handler**).

COM4_RCVR This event is used by communication protocols to signal a character or message received on com4. It can be used in a custom character handler (see **install_handler**).

FOXCOM_MSG_RECEIVED This event is used when a Foxcom message is received. An application program cannot use it.

FOXCOM_STARTED This event is used when Foxcom communication has been established with the sensor. An application program cannot use it.

NEVER This event is guaranteed never to occur. It can be used to disable a task by waiting for it to occur. However, to end a task it is better to use **end_task**. This frees all resources and stack space allocated to the task.

Error Reporting

Sharable I/O drivers to return error information to the calling task use the error reporting functions. These functions ensure that an error code generated by one task is not reported in another task. The **errno** global variable used by some functions may be modified by another task, before the current task can read it.

Error Reporting Functions

There are two RTOS functions for error reporting. Refer to the ***Function Specification*** section for details on each function listed.

check_error Check the error code for the current task.

report_error Set the error code for the current task.

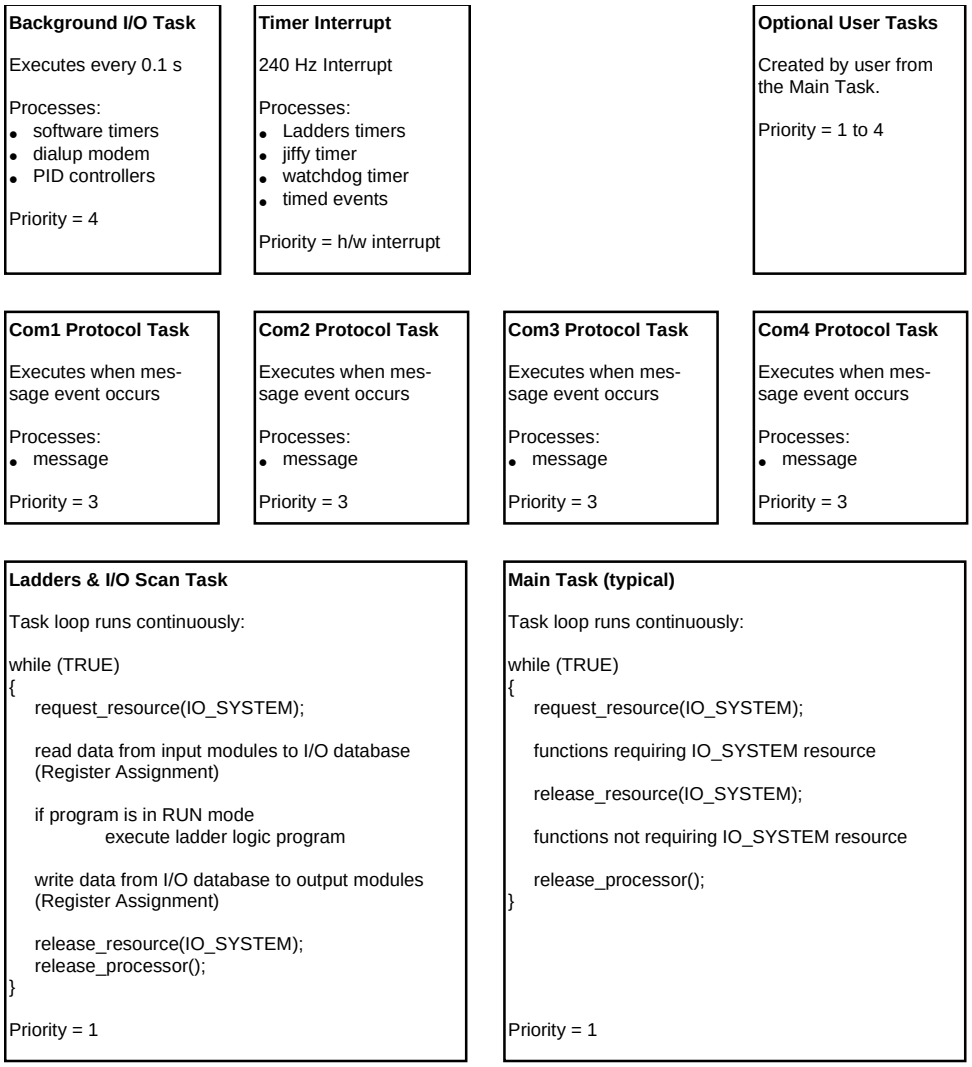
Error Reporting Macros

The **ctools.h** file defines the following macro used for error reporting. Refer to the C Tools Macros section for details.

NO_ERROR Error code indicating no error has occurred.

SCADAPack Task Architecture

The diagram shows the tasks present in the SCADAPack controller.



The highest priority routines that execute are hardware interrupt handlers. Most hardware interrupt handlers perform their functions transparently. The Timer Interrupt handler is important to application programs, because it updates several timers that can be used in application programs. It also triggers the background I/O task.

The background I/O task is the highest priority task in the system. It processes software timers, PID controllers and dialup modem control routines.

There is one protocol task for each serial port where a protocol is enabled. The protocol tasks wait for an event signaled by an interrupt handler. This event is signaled when a complete message is received. The protocol tasks process the received message and transmit a response when needed. Protocol tasks may be disabled and replaced with protocol tasks from the application program.

The Ladder Logic and I/O Scan task executes the Ladder Logic program and performs an I/O scan based on the register assignment. This task is the same priority as the main user application task.

The main task is the central task of the user application. It performs the functions required by the user. Typically, it executes at the same priority as the Ladder Logic and I/O Scan task. It may start other user tasks if needed.

RTOS Example Application Program

The following program is used in the explanation of the RTOS functions. It creates several simple tasks that demonstrate how tasks execute. A task is a C language function that has as its body an infinite loop so it continues to execute forever.

The `main` task creates two tasks. The `echoData` task is higher priority than `main`. The `auxiliary` task is the same priority as `main`. The `main` task then executes round robin with other tasks of the same priority.

The `auxiliary` task is a simple task that executes round robin with the other tasks of its priority. Only the code necessary for task switching is shown to simplify the example.

The `echoData` task waits for a character to be received on a serial port, then echoes it back out the port. It waits for the event of the character being received to allow lower priority tasks to execute. It installs a character handler function – `signalCharacter` – that signals an event each time a character is received. This function is hooked into the receiver interrupt handler for the serial port.

The execution of this program is explained in the ***Explanation of Task Execution*** section.

```
/* ---------------------------------------------------------------------
   SCADAPack Real Time Operating System Sample
   Copyright (c) 1998, Control Microsystems Inc.

   Version History
        version 1.00   Wayne Johnston        November 10, 1998
   --------------------------------------------------------------------- */

/* ---- Version 1.00 ------------------------------------------------

   This program creates several simple tasks for demonstration of the
   functionality of the real time operation system.
   --------------------------------------------------------------------- */

#include <mriext.h>
#include <stdio.h>
#include "ctools,h"

/* ---------------------------------------------------------------------
   Constants
   --------------------------------------------------------------------- */

#define CHARACTER_RECEIVED    10

/* ---------------------------------------------------------------------
   signalCharacter

   The signalCharacter function signals an event when a character is
   received. This function must be called from an interrupt handler.
   --------------------------------------------------------------------- */

void signalCharacter(unsigned character, unsigned error)
{
       /* If there was no error, signal that a character was received */
       if (error == 0)
              {
              interrupt_signal_event(CHARACTER_RECEIVED);
              }

       /* Prevent compiler unused variables warning (generates no code) */
       character;
}

/* ---------------------------------------------------------------------
```

```
   echoData

   The echoData function is a task that waits for a character
   to be received on com6 and echoes the character back. It installs
   a character handler for com6 to generate events on the reception
   of characters.
   ------------------------------------------------------------------- */

void echoData(void)
{
       struct prot_settings protocolSettings;
       struct pconfig portSettings;
       int character;

       /* Disable communication protocol */
       get_protocol(com6, &protocolSettings);
       protocolSettings.type = NO_PROTOCOL;
       set_protocol(com6, &protocolSettings);

       /* Set serial communication parameters */
       portSettings.baud      = BAUD9600;
       portSettings.duplex    = FULL;
       portSettings.parity    = NONE;
       portSettings.data_bits = DATA8;
       portSettings.stop_bits = STOP1;
       portSettings.flow_rx   = DISABLE;
       portSettings.flow_tx   = DISABLE;
       portSettings.type      = RS232;
       portSettings.timeout   = 600;
       set_port(com6, &portSettings);

       /* Install handler for received character */
       install_handler(com6, signalCharacter);

       while (TRUE)
              {
              /* Wait for a character to be received */
              wait_event(CHARACTER_RECEIVED);

              /* Echo the character back */
              character = fgetc(com6);
              fputc(character, com6);
              }
}


/* ------------------------------------------------------------------
   auxiliary

   The auxiliary function is a task that performs some action
   required by the program. It does not have specific function so
   that the real time operating system features are clearer.
   ------------------------------------------------------------------- */

void auxiliary(void)
{
       while (TRUE)
       {
              /* ... add application specific code here ... */

              /* Allow other tasks of this priority to run */
              release_processor();
              }
}

/* ------------------------------------------------------------------
   main

   This function creates two tasks: one at priority three and one at
   priority 1 to demonstrate the functions of the RTOS.
   ------------------------------------------------------------------- */

void main(void)
{
       /* Create serial communication task */
```

```
        create_task(echoData, 3, APPLICATION, 3);

        /* Create a task - same priority as main() task */
        create_task(auxiliary, 1, APPLICATION, 2);

        while (TRUE)                                          <-- 5
                {
                /* ... add application specific code here ... */

                /* Allow other tasks of this priority to execute */
                release_processor();
                }                                             <-- 6
}
```

Explanation of Task Execution

SCADAPack controllers can execute one task at a time. The Real Time Operating System (RTOS) switches between the tasks to provide parallel execution of multiple tasks. The application program can be event driven, or tasks can execute round-robin (one after another). This program illustrates both types of execution.

Task execution is based upon the priority of tasks. There are 5 priority levels. Level 0 is reserved for the `null` task. This task runs when there are no other tasks available for execution. Application programs can use levels 1 to 4. The main task is created at priority level 1.

Tasks that are not running are held in queues. The Ready Queue holds all tasks that are ready to run. Event queues hold tasks that are waiting for events. Message queues hold tasks waiting for messages. Resource queues hold tasks that are waiting for resources. The envelope queue holds tasks that are waiting for envelopes.

The execution of the tasks is illustrated by examining the state of the queues at various points in the program. These points are indicated on the program listing above. The examples show only the Ready queue, the Event 10 queue and the executing task. These are the only queues relevant to the example.

Execution Point 1

This point occurs just before the `main` task begins. The `main` task has not been created by the RTOS. The `null` task has been created, but is not running. No task is executing.

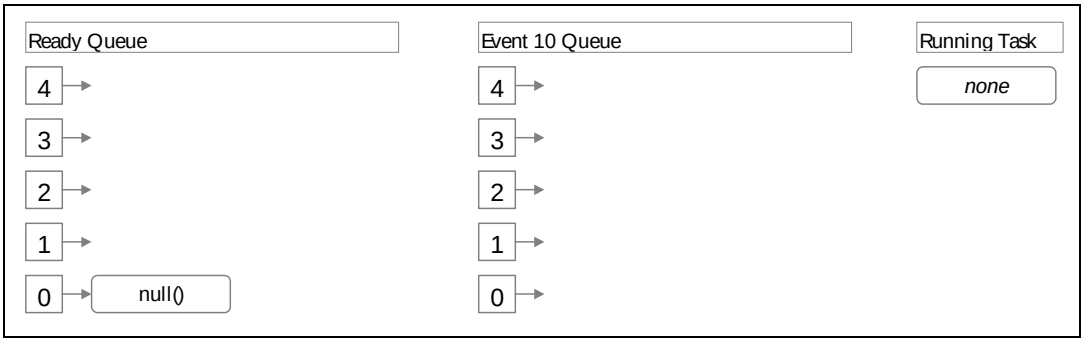


Figure 1: Queue Status before Execution of main Task

Execution Point 2

This point occurs just after the creation of the `main` task. It is the running task. On the next instruction it will create the `echoData` task.

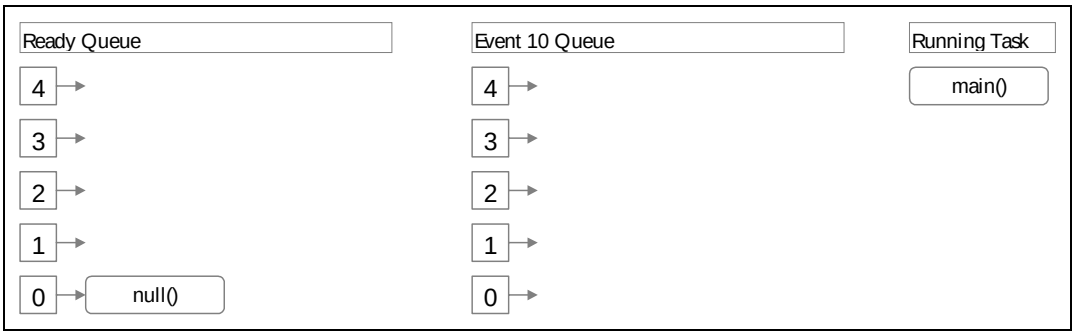


Figure 2: Queue Status at Start of `main` Task

Execution Point 3

This point occurs just after the `echoData` task is created. The `echoData` task is higher priority than the `main` task so it is made the running task. The `main` task is placed into the ready queue. It will execute when it becomes the highest priority task.

The `echoData` task initializes the serial port and installs the serial port handler function `signalCharacter`. It will then wait for an event. This will suspend the task until the event occurs.

The `signalCharacter` function will generate an event each time a character is received without an error.

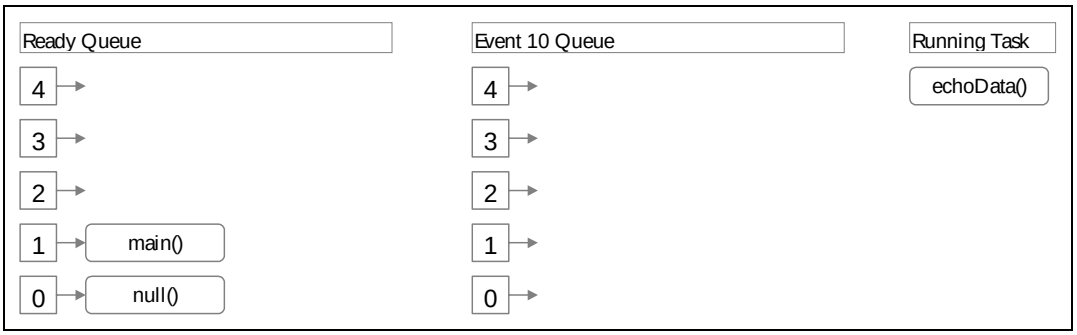


Figure 3: Queue Status after Creation of `echoData` Task

Execution Point 4

This point occurs just after the `echoData` task waits for event 10. It has been placed on the event queue for event 10.

The highest priority task on the ready queue was the `main` task. It is now running. On the next instruction it will create another task at the same priority as `main`.

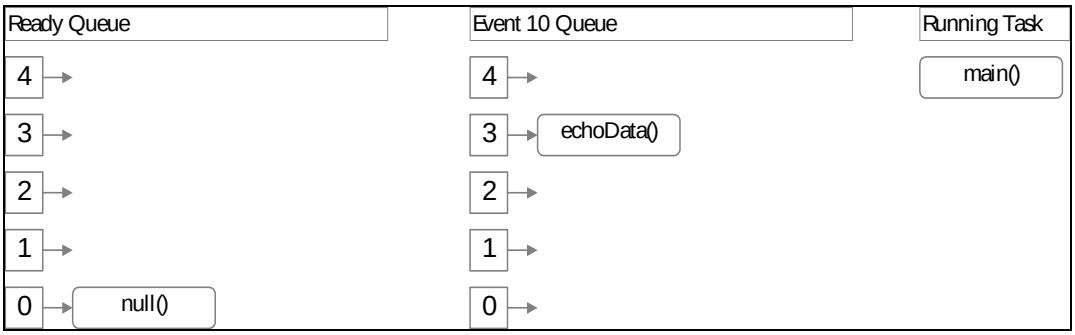


Figure 4: Queue Status After* `echoData` *Task Waits for Event

Execution Point 5

This point occurs just after the creation of the **auxiliary** task. This task is the same priority as the **main** task. Therefore the **main** task remains the running task. The **auxiliary** task is ready to run and it is placed on the Ready queue.

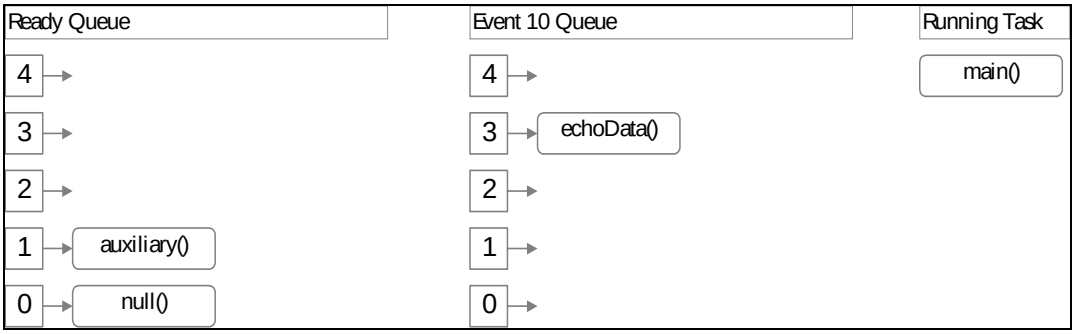


Figure 5 Queue Status after Creation of* `auxiliary` *Task

Execution Point 6

This point occurs just after the `main` task releases the processor, but before the next task is selected to run. The `main` task is added to the end of the priority 1 list in the Ready queue.

On the next instruction the RTOS will select the highest priority task in the Ready queue.

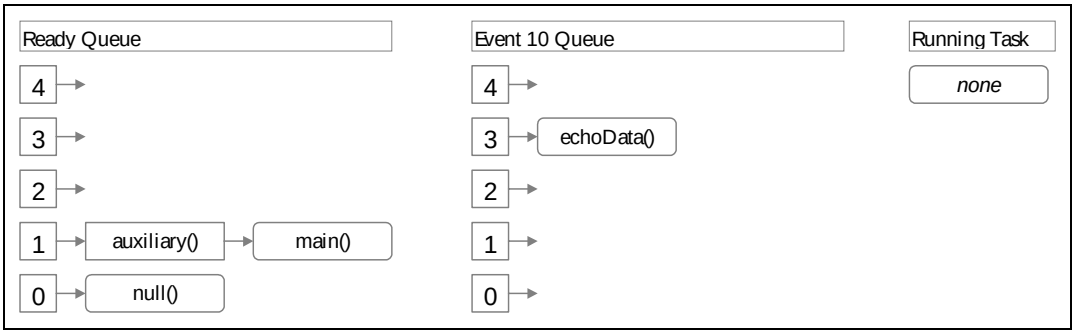


Figure 6: Queue Status After* `main` *Task Releases Processor

Execution Point 7

This point is just after the `auxiliary` task has started to run. The `main` and `auxiliary` tasks will continue to alternate execution, as each task releases the processor to the other.

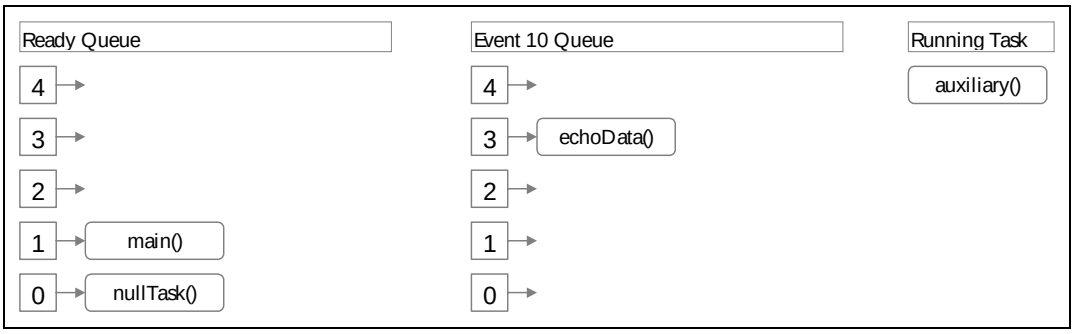


Figure 7: Queue Status at Start of* `auxiliary` *Task

Execution Point 8

This point occurs just after a character has been received. The `signalCharacter` function executes and signals an event. The RTOS checks the event queue for the event, and makes the highest priority task ready to execute. In this case the `echoData` task is made ready.

The RTOS then determines if the new task is higher priority than the executing task. Since the `echoData` task is higher priority than the `auxiliary` task, a task switch occurs. The `auxiliary` task is placed on the Ready queue. The `echoData` task executes.

Note the position of `auxiliary` in the Ready queue. The `main` task will execute before it at the next task switch.

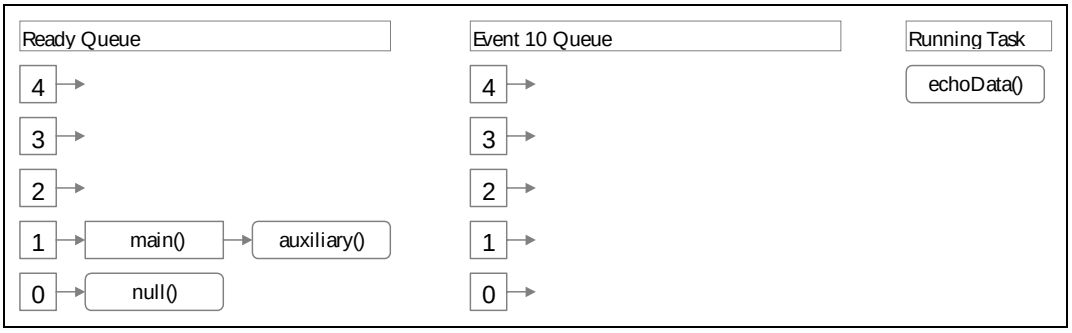


Figure 8: Queue Status after Character Received

Execution Point 9

This point occurs just after the `echoData` task waits for the character-received event. It is placed on the event 10 queue. The highest priority task on the ready queue – `main` – is given the processor and executes.

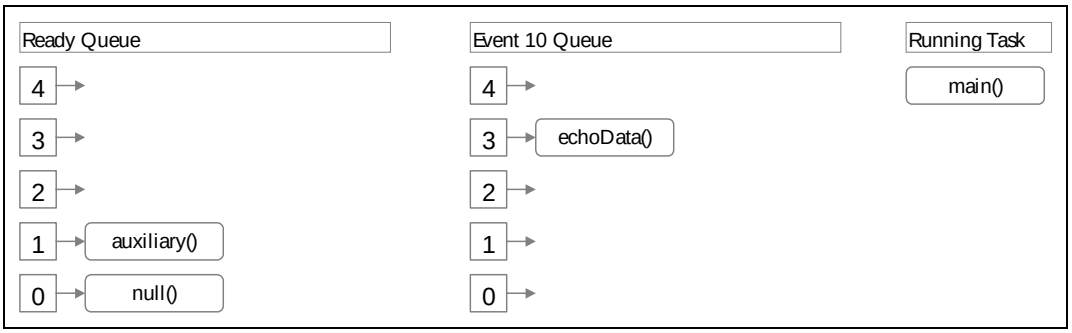


Figure 9: Queue Status after* `echoData` *Waits for Event

Overview of Programming Functions

This section of the User Manual provides and overview of the Functions, Macros, Structure and Types available to the user. The Functions, Macros, Structure and Types overview is separated into sections of related functions. Refer to the Function Specification, C Tools Macros and C Tools Structures and Types section of this manual for detailed explanations of the Functions, Macros, Structure and Types described here.

Controller Operation

This section of the manual provides an overview of the TelePACE functions relating to controller operation. These functions are provided in addition to the run-time library supplied with the Microtec C compiler.

Start Up Functions

There are two library functions related to the system or application start up task. Refer to the ***Function Specification*** section for details on each function listed.

startup_task Returns the address of the system start up routine.

system_start The default start up routine.

Start Up Macros

The **ctools.h** file defines the following macros for use with the start up task. Refer to the ***C Tools Macros*** section for details on each macro listed.

STARTUP_APPLICATION Specifies the application start up task.

STARTUP_SYSTEM Specifies the system start up task.

Start Up Task Info Structure

The **ctools.h** file defines the structure **Start Up Information Structure** for use with the startup_task function. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Program Status Information Functions

There are five library functions related to controller program status information. Refer to the ***Function Specification*** section for details on each function listed.

applicationChecksum Returns the application program checksum.

getBootType Returns the controller boot up status.

getProgramStatus Returns the application program execution status.

setBootType Sets the controller boot up status.

setProgramStatus Sets the application program execution status.

Program Status Information Macros

The **ctools.h** file defines the following macros for use with controller program information. Refer to the ***C Tools Macros*** section for details on each macro listed.

NEW_PROGRAM Application program is newly loaded.

PROGRAM_EXECUTED Application program has been executed.

COLD_BOOT Controller started in COLD BOOT mode.

RUN Controller started in RUN mode.

SERVICE Controller started in SERVICE mode.

REENTRY_BOOT

Controller Information Functions

There is one library function related to controller information. Refer to the ***Function Specification*** section for details on the function listed.

getControllerID Returns the controller ID string.

Controller Information Macros

The **ctools.h** file defines the following macros for use with controller information. Refer to the ***Function Specification*** section for details on each macro listed.

AB_PROTOCOL DF1 protocol firmware option

BASE_TYPE_MASK Controller type bit mask

FT_NONE Unknown firmware type

FT_TELEPACE TelePACE firmware type

FT_ISAGRAF ISaGRAF firmware type

GASFLOW Gas Flow calculation firmware option

RUNS_2 Set if Gas Flow supports two meter runs

SCADAPACK SCADAPack controller

SCADAPACK_LIGHT SCADAPack LIGHT controller

SCADAPACK_PLUS SCADAPack PLUS controller

UNKNOWN_CONTOLLER Unknown controller type

Firmware Version Information Functions

There is one function related to the controller firmware version. Refer to the ***Function Specification*** section for details.

getVersion Returns controller firmware version information.

Firmware Version Information Macros

The **ctools.h** file defines the following macros for use with the firmware version function. Refer to the ***C Tools Macros*** section for details on each macro listed.

VI_DATE_SIZE Number of characters in the version information date field.

VI_STRING_SIZE Number of characters in the version information copyright field.

Firmware Version Information Structure

The **ctools.h** file defines the structure **Version Information Structure** for controller firmware version information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Sleep Mode Functions

SCADAPack controllers are capable of extremely low power operation when in sleep mode. SCADAPack controllers enter the sleep mode under control of the application program. Refer to the ***SCADAPack System Hardware Manual*** for further information on controller sleep mode. The SCADAPack 100 and the SCADASesne series of controllers do not support sleep mode.

There are three library functions related to sleep mode. Refer to the ***Function Specification*** section for details on each function listed.

getWakeSource Gets wake up sources

setWakeSource Sets wake up sources

sleep Put controller into sleep mode

Sleep Mode Macros

The **ctools.h** file defines the following macros for use sleep mode. Refer to the ***C Tools Macros*** section for details on each macro listed.

SLEEP_MODE_SUPPORTED Defined if sleep function is supported

WS_ALL All wake up sources enabled

WS_COUNTER_0_OVERFLOW Bit mask to enable counter 0 overflow as wake up source

WS_COUNTER_1_OVERFLOW Bit mask to enable counter 1 overflow as wake up source

WS_COUNTER_2_OVERFLOW Bit mask to enable counter 2 overflow as wake up source

WS_INTERRUPT_INPUT Bit mask to enable interrupt input as wake up source

WS_LED_POWER_SWITCH Bit mask to enable LED power switch as wake up source

WS_NONE No wake up source enabled

WS_REAL_TIME_CLOCK Bit mask to enable real time clock as wake up source

WS_UNDEFINED Undefined wake up source

Power Management Functions

Under normal operation, the SCADAPack 350 operates on a CPU clock frequency of 32 MHz. However, the SCADAPack 350 controller is capable of operating on a reduced CPU clock frequency of 8 MHz, known as Reduced Power Mode.

Further power savings can be realized on the SCADAPack 350 controller by disabling the LAN or USB peripheral and host ports. Activation of Reduced Power mode as well as the deactivation of the communication ports can be performed by the application program.

The library functions associated with the aforementioned power management allows for the following:

- The CPU speed can be changed from full speed (32 MHz) to reduced speed (8 MHz).
- The LAN port can be enabled or disabled
- The USB peripheral port can be enabled or disabled
- The USB host port can be enabled or disabled.

The Power Mode LED blinks once a second when the controller is operating in Reduced Power Mode.

The library functions associated with the power management features are listed below. Refer to the ***Function Specification*** section for details on each function listed.

getPowerMode	Gets the current power mode
setPowerMode	Sets the power mode

Power Management Macros

The **ctools.h** file defines the following macros for use in the power management functions. Refer to the ***C Tools Macros*** section for details on each macro listed.

PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_UNAVAILABLE	The status of the device could not be read

Configuration Data EEPROM Functions

The EEPROM is nonvolatile memory used to store configuration parameters. The application program cannot store application data into this memory. It can cause the system configuration parameters to be written, using the **save** function.

The contents of the EEPROM are copied to RAM under two conditions: during a RUN boot of the controller; and when the application program executes the **load** function.

The following data is loaded on a RUN boot; otherwise default information is used:

- serial port configuration tables
- protocol configuration tables
- enable store and forward settings
- LED power settings
- mask for wake-up sources
- execution period on power-up for each PID

There are two library functions related to the configuration data EEPROM. Refer to the ***Function Specification*** section for details on each function listed.

Save	Writes configuration data from RAM to EEPROM
load	Reads configuration data from EEPROM into RAM

Configuration Data EEPROM Macros

The **ctools.h** file defines the following macros for use with the configuration data EEPROM. Refer to the ***C Tools Macros*** section for details on each macro listed.

EEPROM_EVERY	EEPROM section loaded to RAM on every CPU reboot.
EEPROM_RUN	EEPROM section loaded to RAM on RUN type boots only.
EEPROM_SUPPORTED	If defined, indicates that there is an EEPROM in the controller.

I/O Bus Communication Functions

The **ctools.h** file defines the following functions that access the I/O bus. The I/O bus is I^2C compatible. Refer to the ***Function Specification*** section for details on each function listed.

ioBusReadByte	Reads one byte from an I^2C slave device
ioBusReadLastByte	Reads one byte from an I^2C slave device and terminates read
ioBusReadMessage	Reads a message from an I^2C slave device
ioBusSelectForRead	Selects an I^2C slave device for reading
ioBusSelectForWrite	Selects an I^2C slave device for writing
ioBusStart	Issues an I^2C bus START condition
ioBusStop	Issues an I^2C bus STOP condition
ioBusWriteByte	Writes one byte to an I^2C slave device
ioBusWriteMessage	Writes a message to an I^2C slave device

I/O Bus Communication Macros

The **ctools.h** file defines the following macros for use with I/O Bus Communication. Refer to the ***C Tools Macros*** section for details on each macro listed.

The **ctools.h** file defines the following macros.

READSTATUS	enumeration type ReadStatus
WRITESTATUS	enumeration type WriteStatus

I/O Bus Communication Types

The **ctools.h** file defines the enumeration types **ReadStatus** and **WriteStatus**. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

System Functions

The **ctools.h** file defines the following functions for system initialization and for retrieving system information. Some of these functions are primarily used in the **appstart.c** routine, having limited use in an application program.

Refer to the ***Function Specification*** section for details on each function listed.

applicationChecksum Returns the application program checksum.

ioClear Clears all I/O points

ioDatabaseReset Resets the controller to default settings.

ioRefresh Refresh outputs with internal data

ioReset Reset all I/O modules

Controller I/O Hardware

This section of the manual provides an overview of the TelePACE C Tools functions relating to controller signal input and output (I/O). These functions are provided in addition to the run-time library supplied with the Microtec C compiler.

Analog Input Functions

The controller supports internal analog inputs and external analog input modules. Refer to the ***SCADAPack System Hardware Manual*** for further information on controller analog inputs and analog input modules.

There are several library functions related to internal analog inputs and analog input modules. Refer to the ***Function Specification*** section for details on each function listed.

readBattery Read the controller RAM battery voltage.

readThermistor Read the controller ambient temperature sensor.

readInternalAD Read the controller internal AD converter.

ioRead4Ain Read 4 analog inputs into I/O database.

ioRead8Ain **R**ead 8 analog inputs into I/O database.

IoRead4202Inputs Read the digital, counter and analog inputs from a SCADASense 4202 DR.

IoRead4202DSInputs Read the digital, counter and analog inputs from a SCADASense 4202 DS.

ioRead5505Inputs Read the digital and analog inputs from a 5505 I/O Module.

ioRead5506Inputs Read the digital and analog inputs from a 5506 I/O Module.

ioRead5601Inputs Read the digital and analog inputs from a SCADAPack 5601 I/O Module.

ioRead5602Inputs	Read the digital and analog inputs from a SCADAPack 5602 I/O Module.
ioRead5604Inputs	Read the digital and analog inputs from a SCADAPack 5604 I/O Module.
ioRead5606Inputs	Read the digital and analog inputs from a 5606 I/O Module.
ioReadLPInputs	Read the digital and analog inputs from the SCADAPack LP I/O.
ioReadSP100Inputs	Read the digital and analog inputs from the SCADAPack 100 I/O.

Analog Input Macros

The **ctools.h** file defines the following macros for use with controller analog inputs. Refer to the ***C Tools Macros*** section for details on each macro listed.

AD_BATTERY	Internal AD channel connected to lithium battery.
AD_THERMISTOR	Internal AD channel connected to thermistor.
T_CELSIUS	Specifies temperatures in degrees Celsius.
T_FAHRENHEIT	Specifies temperatures in degrees Fahrenheit.
T_KELVIN	Specifies temperatures in degrees Kelvin.
T_RANKINE	Specifies temperatures in degrees Rankine.

Analog Output Functions

The controller supports external analog output modules. Refer to the ***SCADAPack System Hardware Manual*** for further information on these modules.

There are three library functions related to analog output modules. Refer to the ***Function Specification*** section for details on each function listed.

ioWriteAout	Write to 4 analog outputs from I/O database.
ioWrite2Aout	Write to 2 analog outputs from I/O database.
ioWrite4Aout	Write to 4 analog outputs from I/O database.
IoWrite4202Outputs	Write to the analog outputs of a SCADASense 4202 DR.
IoWrite4202OutputsEx	Write to analog outputs of a SCADASense 4202 DR with extended IO (4202 DR with a digital output).
ioWrite5303Aout	Write to analog outputs of the 5303 module from I/O database**.**
ioWrite5606Outputs	Write to the digital and analog outputs of 5606 I/O Module.
ioWriteLPOutputs	Writes data to the digital and analog outputs of the SCADAPack LP I/O.

Digital Input Functions

The controller supports internal digital inputs and external digital input modules. Refer to the ***SCADAPack System Hardware Manual*** for further information on controller digital inputs and digital input modules.

There are several library functions related to digital inputs and external digital input modules. Refer to the ***Function Specification*** section for details on each function listed.

interruptInput	Read the controller interrupt input.

readCounterInput Read the status of the counter input points on the controller board.

ioRead8Din read 8 digital inputs into I/O database.

ioRead16Din read 16 digital inputs into I/O database.

IoRead32Din read 32 digital inputs into I/O database.

IoRead4202Inputs Read the digital, counter and analog inputs from a SCADASense 4202 DR.

IoRead4202DSInputs Read the digital, counter and analog inputs from a SCADASense 4202 DS.

ioRead5505Inputs Read the digital and analog inputs from a 5505 I/O Module.

ioRead5506Inputs Read the digital and analog inputs from a 5506 I/O Module.

ioRead5601Inputs Read the digital and analog inputs from a 5601 I/O Module.

ioRead5602Inputs Read the digital or analog inputs from a 5602 I/O Module.

ioRead5604Inputs Read the digital and analog inputs from a SCADAPack 5604 I/O Module.

ioRead5606Inputs Read the digital and analog inputs from a 5606 I/O Module.

ioReadLPInputs Read the digital and analog inputs from the SCADAPack LP I/O.

ioReadSP100Inputs Read the digital and analog inputs from the SCADAPack 100 I/O.

Digital Output Functions

The controller supports external digital output modules. Refer to the ***SCADAPack System Hardware Manual*** for further information on controller digital output modules.

There are several library functions related to digital output modules. Refer to the ***Function Specification*** section for details on each function listed.

interruptInput Read the controller interrupt input.

ioWrite16Dout Write data to any 16 point Digital output module.

IoWrite32Dout Write data to any 32 point Digital output module.

IoWrite4202OutputsEx Write to digital and analog outputs of the SCADASense 4202 DR with extended IO (with digital output) from I/O database.

IoWrite4202DSOutputs Write to digital outputs of the SCADASense 4202 DS from I/O database**.**

ioWrite5601Outputs Write to the digital and analog outputs of SCADAPack 5601 I/O Module.

ioWrite5602Outputs Write to the digital and analog outputs of SCADAPack 5602 I/O Module.

ioWrite5604Outputs Write to the digital and analog outputs of SCADAPack 5604 I/O Module.

ioWrite5606Outputs Write to the digital and analog outputs of 5606 I/O Module.

ioWrite8Dout Write data to any 8 point Digital output module.

ioWriteLPOutputs Writes data to the digital and analog outputs of the SCADAPack LP I/O.

ioWriteSP100utputs Writes data to the digital outputs of the SCADAPack 100 I/O.

Counter Input Functions

The controller supports internal counters and external counter modules. The counter registers are 32 bits, for a maximum count of 4,294,967,295. They roll over to 0 on the next count. The counter inputs measure the number of rising inputs. Refer to the ***SCADAPack System Hardware Manual*** for further information on controller counter inputs and counter input modules.

There are four library functions related to counters. Refer to the ***Function Specification*** section for details on each function listed.

readCounter	Read a SCADAPack, SCADAPack LP or SCADAPack 100 counter with or without automatic clearing of the counter register.
interruptCounter	Read the SCADAPack or SCADAPack LP interrupt input as a counter with or without automatic clearing of the counter value.
ioRead4Counter	Read any 4 point Counter input module.
IoRead4202Inputs	Read the digital, counter and analog inputs from a SCADASense 4202 DR.
IoRead4202DSInputs	Read the digital, counter and analog inputs from a SCADAense 4202 DS.

Counter Input Macros

The **ctools.h** file defines the following macro for use with counter inputs. Refer to the ***C Tools Macros*** section for details.

LOCAL_COUNTERS	Number of controller counter inputs.

Status LED and Output Functions

The status LED and output indicate alarm conditions. The STAT LED blinks and the STATUS output opens when an alarm occurs. The STAT LED turns off and the STATUS output closes when all alarms clear.

The STAT LED blinks a binary sequence indicating alarm codes. The sequences consist of long and short flashes, followed by an off delay of 1 second. The sequence then repeats. The sequence may be read as the Controller Status Code.

Refer to the ***SCADAPack System Hardware Manual*** for further information on the status LED and digital output. There is no status output on the SCADASense series of programmable controllers.

There are two library functions related to the status LED and digital output. Refer to the ***Function Specification*** section for details on each function listed.

clearStatusBit	Clears bits in controller status code.
setStatusBit	Sets the bits in controller status code.

Status LED and Output Macros

The **ctools.h** file defines the following macros for use with the status LED and digital output. Refer to the ***C Tools Macros*** section for details on each macro listed.

S_MODULE_FAILURE	Status LED code for I/O module communication failure
S_NORMAL	Status LED code for normal status

Options Switches Functions

The controller has three option switches located under the cover of the controller module. These switches are labeled OPTION 1,2 and 3. The option switches are user defined except when a SCADAPack I/O module or SCADAPack AOUT module used. In this case option switches 1 and 2 select the analog ranges. Refer to the ***SCADAPack System Hardware Manual*** for further information on option switches.

There are no option switches on the SCADAPack 100, SCADAPack LP or the SCADASense series of programmable controllers.

There is one library function related to the controller option switches. Refer to the ***Function Specification*** section for details.

optionSwitch	Read option switch states.

Option Switches Macros

The **ctools.h** file defines the following macros for use with option switches. Refer to the ***C Tools Macros*** section for details on each macro listed.

CLOSED	Specifies switch is in closed position
OPEN	Specifies switch is in open position

LED Indicators Functions

An application program can control three LED indicators.

The RUN LED indicates the execution status of the program. The LED can be on or off. It remains in the last state until changed.

The STAT LED indicates error conditions. It outputs an error code as a binary sequence. The sequence repeats until a new error code is output. If the error code is zero, the status LED turns off.

The FORCE LED indicates locked I/O variables. Use this function with caution in application programs.

There are three library functions related to the LED indicators. Refer to the ***Function Specification*** section for details on each function listed.

runLed	Controls the RUN LED status.
setStatus	Sets controller status code.
forceLed	Sets state of the force LED.

LED Indicators Macros

The **ctools.h** file defines the following macros for use with LED power control. Refer to the ***C Tools Macros*** section for details on each macro listed.

LED_OFF	Specifies LED is to be turned off.
LED_ON	Specifies LED is to be turned on.

LED Power Control Functions

The controller board can disable the LEDs on the controller board, the 5601, 5602 or 5604 I/O modules and the 5000 Series I/O modules to conserve power. This is particularly useful in solar powered or unattended installations. Refer to the ***SCADAPack System Hardware Manual*** for further information on LED power control.

There are four library functions related to LED power control. Refer to the ***Function Specification*** section for details on each function listed.

ledGetDefault	Get default LED power state
ledPower	Set LED power state
ledPowerSwitch	Read LED power switch
ledSetDefault	Set default LED power state

LED Power Control Macros

The **ctools.h** file defines the following macros for use with LED power control. Refer to the ***C Tools Macros*** section for details on each macro listed.

LED_OFF	Specifies LED is to be turned off.
LED_ON	Specifies LED is to be turned on.

LED Power Control Structure

The **ctools.h** file defines the structure **LED Power Control Structure** for LED power control information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Software Timer Functions

The controller provides 32 powerful software timers, which greatly simplify the task of programming time-related functions. Uses include:

- generation of time delays
- timing of process events such as tank fill times
- generation of time-based interrupts to schedule regular activities
- control of digital outputs by time periods

The 32 timers are individually programmable for tick rates from ten per second to once every 25.5 seconds. Time periods from 0.1 second to greater than nineteen days can be measured and controlled.

All timers operate in the background from a hardware interrupt generated by the main system clock. Once loaded, they count without intervention from the main program.

There are four library functions related to timers. Refer to the ***Function Specification*** section for details on each function listed.

interval	Set timer tick interval in tenths of seconds.
settimer	Set a timer. Timers count down from the set value to zero.
timer	Read the time period remaining in a timer.
read_timer_info	Read information about a software timer.

Software Timer Macros

The **ctools.h** file defines the following macros for use with timers. Refer to the ***C Tools Macros*** section for details on each macro listed.

NORMAL	Specifies normal count down timer.
TIMED_OUT	Specifies timer is has reached zero.
TIMER_BADINTERVAL	Error code indicating invalid timer interval.
TIMER_BADTIMER	Error code indicating invalid timer.
TIMER_BADVALUE	Error code indicating invalid time value.
TIMER_MAX	Number of last valid software timer.

Timer Information Structure

The **ctools.h** file defines the structure **Timer Information** for timer information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Timer Example Programs

Example 1: Turn on a digital output assigned to coil register 1 and wait 5 seconds before turning it off.

```
interval(0,10);  /* timer 0 tick rate = 1 second */
request_resource(IO_SYSTEM);
setdbase(MODBUS, 1, 1); /* turn on output */
release_resource(IO_SYSTEM);
settimer(0,5);   /* load timer 0 with 5 seconds */
while(timer(0))  /* wait until time expires */
{
   /* Allow other tasks to execute */
   release_processor();
}
request_resource(IO_SYSTEM);
setdbase(MODBUS, 1, 0);/* shut off output */
release_resource(IO_SYSTEM);
```

Example 2: Time the duration a contact is on but wait in loop to measure time. Contact is assigned to status register 10001.

```
interval(0,1);   /* tick rate = 0.1 second */
request_resource(IO_SYSTEM);
if (dbase(MODBUS, 10001)) /* test if contact is on */
{
   settimer(0,63000);  /* start timer */
   while(dbase(MODBUS, 10001)) /* wait for turn off */
   {
      /* Allow other tasks to execute */
      release_resource(IO_SYSTEM);
      release_processor();
      request_resource(IO_SYSTEM);
   }
   printf("time period = %u\r\n",63000-timer(0));
}
release_resource(IO_SYSTEM);
```

Example 3: Open valve to fill tank and print alarm message if not full in 1 minute. Contact is assigned to status register 10001. Valve is controlled by coil register 1.

```
interval(0,10);  /* timer 0 tick rate = 1 second */
request_resource(IO_SYSTEM);
setdbase(MODBUS, 1, 1);    /* open valve */
settimer(0,60);  /* set timer for 1 minute */

/* tank not full if contact is off */
while((dbase(MODBUS, 10001)== 0) && timer(0))
{
   /* Allow other tasks to execute */
   release_resource(IO_SYSTEM);
   release_processor();
   request_resource(IO_SYSTEM);
}

if (dbase(MODBUS, 10001)== 0)
   puts("tank is not filling!!\r\n");
else
   puts("tank full\r\n");

setdbase(MODBUS, 1, 0); /* close valve */
release_resource(IO_SYSTEM);
```

Real Time Clock Functions

The controller is provided with a hardware based real time clock that independently maintains the time and date for the operating system. The time and date remain accurate during power-off. This allows the controller to be synchronized to time of day for such functions as shift production reports, automatic instrument calibration, energy logging, etc. The calendar can be used to automatically take the controller off-line during weekends and holidays. The calendar automatically handles leap years.

There are eight library functions, which access the real-time clock. Refer to the ***Function Specification*** section for details on each function listed.

alarmIn	Returns absolute time of alarm given elapsed time
getclock	Read the real time clock.
getClockAlarm	Reads the real time clock alarm settings.
getClockTime	Read the real time clock.
installClockHandler	Installs a handler for real time clock alarms.
resetClockAlarm	Resets the real time clock alarm so it will recur at the same time next day.
setclock	Set the real time clock.
setClockAlarm	Sets real time clock alarm.

Real Time Clock Macros

The **ctools.h** file defines the following macros for real time clock alarms. Refer to the ***C Tools Macros*** section for details on each macro listed.

AT_ABSOLUTE	Specifies a fixed time of day alarm.
AT_NONE	Disables alarms

Real Time Clock Structures

The **ctools.h** file defines the structures **Real Time Clock Structure** and **Alarm Settings Structure** for real time clock information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Real Time Clock Program Example

The following program illustrates how the date and time can be set and displayed. All fields of the clock structure must be set with valid values for the clock to operate properly.

```
#include <ctools.h>

void main(void)
{
    struct clock now;

    /* Set to 12:01:00 on January 1, 1994 */

    now.hour      = 12;    /* set the time */
    now.minute    = 1;
    now.second    = 0;
    now.day       = 1;     /* set the date */
    now.month     = 1;
    now.year      = 94;
    now.dayofweek = 6;      /* day is Sat. */

    request_resource(IO_SYSTEM);
    setclock(&now);

    now = getclock();
    release_resource(IO_SYSTEM);

    /* Display current hour, minute and second */
    printf("%2d:%2d:%2d", now.hour, now.minute,
           now.second);
}
```

The Jiffy Clock

The jiffy clock is a counter that increments 60 times per second. The jiffy clock is useful for measuring execution times or generating delays where a fine time base is required. The clock is reset to zero each time power is applied to the controller. It rolls over to zero after it reaches a value of 5183999. This is the number of 1/60-second intervals in 24 hours.

There are two library functions, which access the real-time clock. Refer to the ***Function Specification*** *C Function Library* chapter for a complete description.

setjiffy	set the jiffy clock
jiffy	read the jiffy clock

Watchdog Timer Functions

A watchdog timer is a hardware device, which enables rapid detection of computer hardware or software problems. In the event of a major problem, the CPU resets and the application program restarts.

The controller provides an integral watchdog timer to ensure reliable operation. The watchdog timer resets the CPU if it detects a problem in either the hardware or system firmware. A user program can take control of the watchdog timer, so it will detect abnormal execution of the program.

A watchdog timer is a retriggerable, time delay timer. It begins a timing sequence every time it receives a reset pulse. The time delay is adjusted so that regular reset pulses prevent the timer from expiring. If the reset pulses cease, the watchdog timer expires and turns on its output, signifying a malfunction. The timer output in the controller resets the CPU and turns off all outputs at the I/O system.

The watchdog timer is normally reset by the operating system. This is transparent to the application program. Operating in such a fashion, the watchdog timer detects any hardware or firmware problems.

The watchdog timer can detect failure of an application program. The program takes control of the timer, and resets it regularly. If unexpected operation of the program occurs, the reset pulses cease, and the watchdog timer resets the CPU. The program restarts from the beginning.

There are three library functions related to the watchdog timer. Refer to the ***Function Specification*** section for details on each function listed.

wd_auto Gives control of the watchdog timer to the operating system (default).

wd_manual Gives control of the watchdog timer to an application program.

wd_pulse Generates a watchdog reset pulse.

A watchdog reset pulse must be generated at least every 500 ms. The CPU resets, and program execution starts from the beginning of the program, if the watchdog timer is not reset.

Watchdog Timer Program Example

The following program segment shows how the watchdog timer could be used to detect the failure of a section of a program.

```
wd_manual(); /* take control of watchdog timer */
do {
   /* program code */
   wd_pulse();      /* reset the watchdog timer */
}
while (condition)
wd_auto();          /* return control to OS */
```

Note: Always pass control of the watchdog timer back to the operating system before stopping a program, or switching to another task that expects the operating system to reset the timer.

Checksum Functions

To simplify the implementation of self-checking communication algorithms, the C Tools provide four types of checksums: additive, CRC-16, CRC-CCITT, and byte-wise exclusive-OR. The CRC algorithms are particularly reliable, employing various polynomial methods to detect nearly all communication errors. Additional types of checksums are easily implemented using library functions.

There are two library functions related to checksums. Refer to the ***Function Specification*** section for details on each function listed.

checksum Calculates additive, CRC-16, CRC-CCITT and exclusive-OR type checksums

crc_reverse Calculates custom CRC type checksum using reverse CRC algorithm.

Checksum Macros

The **ctools.h** file defines macros for specifying checksum types. Refer to the ***C Tools Macros*** section for details on each macro listed.

ADDITIVE	Additive checksum
BYTE_EOR	Byte-wise exclusive OR checksum
CRC_16	CRC-16 type CRC checksum (reverse algorithm)
CRC_CCITT	CCITT type CRC checksum (reverse algorithm)

Serial Communication

The SCADAPack family of controllers offers three or four RS-232 serial ports. The TeleSAFE Micro16 has two RS-232 serial communication ports. (com1 on all controllers is also available as an RS-485 port.) The ports are configurable for baud rate, data bits, stop bits, parity and communication protocol.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the ISaGRAF program.

For the SCADASense series of programmable controllers, com1 is not available for C applications.

Default Serial Parameters

All ports are configured at reset with default parameters when the controller is powered up in SERVICE mode. The ports use stored parameters when the controller is reset in the RUN mode. The default parameters are listed below.

Parameter	***com1***	***com2***	***Com3***	***Com4***
Baud rate	9600	9600	9600	9600
Parity	none	none	None	None
Data bits	8	8	8	8
Stop bits	1	1	1	1
Duplex	full	full	Half	Half
Protocol	Modbus RTU	Modbus RTU	Modbus RTU	Modbus RTU
Station	1	1	1	1
Rx flow control	off	off	Rx disable	Rx disable
Tx flow control	off	off	Off	Off
Serial time out	60 s	60 s	60 s	60 s
Type	RS-232	RS-232	RS-232	RS-232

Serial Communication Time Out

When the controller is transmitting data on the communication ports, the transmit buffer may become full due to receipt of an XOFF character, a slow baud rate, or improper hardware handshaking.

If the transmit buffers become full, the task transmitting data is blocked until space is available or the serial time out period expires. If no space is available at the conclusion of this time period, the transmit buffer is emptied. The task then continues execution.

Debugging Serial Communication

Serial communication can be difficult to debug. This section describes the most common causes of communication failures.

- To communicate, the controller and an external device must use the same communication parameters. Check the parameters in both units.
- If some but not all characters transmit properly, you probably have a parity or stop bit mismatch between the devices.

The connection between two RS-232 Data Terminal Equipment (DTE) devices is made with a null-modem cable. This cable connects the transmit data output of one device to the receive data input of the other device – and vice versa. The controller is a DTE device. This cable is described in the ***System Hardware Manual*** for your controller.

The connection between a DTE device and a Data Communication Equipment (DCE) device is made with a straight cable. The transmit data output of the DTE device is connected to the transmit data input of the DCE device. The receive data input of the DTE device is connected to the receive data output of the DCE device. Modems are usually DCE devices. This cable is described in the ***System Hardware Manual*** for your controller.

Many RS-232 devices require specific signal levels on certain pins. Communication is not possible unless the required signals are present. In the controller the CTS line must be at the proper level. The controller will not transmit if CTS is OFF. If the CTS line is not connected, the controller will force it to the proper value. If an external device controls this line, it must turn it ON for the controller to transmit.

Serial Communication Functions

The **ctools.h** file defines the following serial communication related functions. Refer to the ***Function Specification*** section for details on each function listed. Additional serial communication functions are included in the Microtec run-time library.

clear_errors	Clear serial port error counters.
clear_tx	Clear serial port transmit buffer.
get_port	Read serial port communication parameters.
GetPortCharacteristics	Read information about features supported by a serial port.
get_status	Read serial port status and error counters.
install_handler	Install serial port character received handler.
portConfiguration	Get pointer to port configuration table
portIndex	Get array index for serial port
portStream	Get serial port corresponding to index
queue_mode	Set serial port transmitter mode.
route	Redirect standard I/O streams.
setDTR	Control RS232 port DTR signal.
set_port	Set serial port communication parameters.

Serial Communication Macros

The **ctools.h** file defines macros for specifying serial communication parameters. Refer to the ***C Tools Macros*** section for details on each macro listed.

BAUD75	Specifies 75-baud port speed.
BAUD110	Specifies 110-baud port speed.
BAUD150	Specifies 150-baud port speed.

BAUD300	Specifies 300-baud port speed.
BAUD600	Specifies 600-baud port speed.
BAUD1200	Specifies 1200-baud port speed.
BAUD2400	Specifies 2400-baud port speed.
BAUD4800	Specifies 4800-baud port speed.
BAUD9600	Specifies 9600-baud port speed.
BAUD19200	Specifies 19200-baud port speed.
BAUD38400	Specifies 38400-baud port speed.
BAUD57600	Specifies 57600-baud port speed.
BAUD115200	Specifies 115200-baud port speed.
com1	Points to a file object for *com1* serial port.
com2	Points to a file object for *com2* serial port.
com3	Points to a file object for *com3* serial port.
com4	Points to a file object for *com4* serial port.
DATA7	Specifies 7 bit world length.
DATA8	Specifies 8 bit word length.
DISABLE	Specifies flow control is disabled.
ENABLE	Specifies flow control is enabled.
EVEN	Specifies even parity.
FULL	Specifies full duplex.
FOPEN_MAX	Redefinition of macro from stdio.h
HALF	Specifies half duplex.
NONE	Specifies no parity.
NOTYPE	Specifies serial port type is not known.
ODD	Specifies odd parity.
PC_FLOW_RX_RECEIVE_STOP	Receiver disabled after receipt of a message.
PC_FLOW_RX_XON_XOFF	Receiver Xon/Xoff flow control.
PC_FLOW_TX_IGNORE_CTS	Transmitter flow control ignores CTS.
PC_FLOW_TX_XON_XOFF	Transmitter Xon/Xoff flow control.
RS232	Specifies serial port is an RS-232 port.
RS232_MODEM	Specifies serial port is an RS-232 dial-up modem.
RS485_4WIRE	Specifies serial port is a 4 wire RS-485 port.
SERIAL_PORTS	Number of serial ports.
SIGNAL_CTS	I/O line bit mask: clear to send signal
SIGNAL_DCD	I/O line bit mask: carrier detect signal
SIGNAL_OFF	Specifies a signal is de-asserted
SIGNAL_OH	I/O line bit mask: off hook signal

SIGNAL_ON	Specifies a signal is asserted
SIGNAL_RING	I/O line bit mask: ring signal
SIGNAL_VOICE	I/O line bit mask: voice/data switch signal
STOP1	Specifies 1 stop bit.
STOP2	Specifies 2 stop bits.

Serial Communication Structures

The **ctools.h** file defines the structures **Serial Port Configuration**, **Serial Port Status** and **Serial Port Characteristics** for serial port configuration and information. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Microtec Serial I/O Functions

These library functions are related to serial communication. They are documented in the *Microtec MCCM77 Documentation Set*.

fgetc	reads a character from a stream
fgets	reads a string from a stream
fputc	writes a character to a stream
fputs	writes a string to a stream
fread	reads from a stream
fwrite	writes to a stream
getc	reads a character from a stream
getchar	reads a character from standard input device
gets	reads a string from a stream
initport	re-initializes serial port
printf	formatted output to a stream
putc	writes a character to a stream
putchar	reads a character to standard output device
puts	writes a string to a stream
scanf	formatted input from a stream

Dial-Up Modem Functions

These library functions provide control of dial-up modems. They are used with external modems connected to a serial port. An external modem normally connects to the RS-232 port with a DTE to DCE cable. Consult the ***System Hardware Manual*** for your controller for details. Refer to the ***Function Specification*** section for details on each function listed.

> **Note:** The SCADAPack 100 does not support dial up connections on com port 1. The SCADASense series of controllers do not support dial up connections.

modemInit	send initialization string to dial-up modem.
modemInitStatus	read status of modem initialization operation.

modemInitEnd	terminate modem initialization operation.
modemDial	connect with an external device using a dial-up modem.
modemDialStatus	read status of connection with external device using a dial-up modem.
modemDialEnd	terminate connection with external device using a dial-up modem.
modemAbort	unconditionally terminate connection with external device or modem initialization (used in task exit handler).
modemAbortAll	unconditionally terminate connections with external device or modem initializations (used in task exit handler).
modemNotification	notify the dial-up modem handler that an interesting event has occurred. This function is usually called whenever a message is received by a protocol.

Dial-Up Modem Macros

The **ctools.h** file defines the following macros of interest to a C application program. Refer to the ***C Tools Macros*** section for details on each macro listed.

MODEM_CMD_MAX_LEN	Maximum length of the modem initialization command string
PHONE_NUM_MAX_LEN	Maximum length of the phone number string

Dial-Up Modem Enumeration Types

The `ctools.h` file defines the enumerated types `DialError` and `DialState`. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Dial-up Modem Structures

The `ctools.h` file defines the structures `ModemInit` and `ModemSetup`**.** Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Modem Initialization Example

The following code shows how to initialize a modem. Typically, the modem initialization is used to prepare a modem to answer calls. The example sets up a Hayes modem to answer incoming calls.

```
#include <ctools.h>

void main(void)
{
struct ModemInit initSettings;
reserve_id portID;
enum DialError status;
enum DialState state;
struct pconfig portSettings;

/* Configure serial port 1 */
portSettings.baud      = BAUD1200;
portSettings.duplex    = FULL;
portSettings.parity    = NONE;
portSettings.data_bits = DATA8;
portSettings.stop_bits = STOP1;
portSettings.flow_rx   = DISABLE;
portSettings.flow_tx   = DISABLE;
```

```
portSettings.type      = RS232_MODEM;
portSettings.timeout   = 600;
request_resource(IO_SYSTEM);
set_port(com1, &portSettings);
release_resource(IO_SYSTEM);

/* Initialize Hayes modem to answer incoming calls */
initSettings.port = com1;
strcpy(initSettings.modemCommand, " F1Q0V1X1 S0=1");
if (modemInit(&initSettings, &portID) == DE_NoError)
{
    do
    {
        /* Allow other tasks to execute */
        release_processor();

        /* Wait for the initialization to complete */
        modemInitStatus(com1, portID, &status, &state);
    }
    while (state == DS_Calling);

    /* Terminate the initialization */
    modemInitEnd(com1, portID, &status);
}
}
```

Connecting with a Remote Controller Example

The following code shows how to connect to a remote controller using a modem. The example uses a US Robotics modem. It also demonstrates the use of the modemAbort function in an exit handler.

```
#include <ctools.h>

/* ------------------------------------------
   The shutdown function aborts any active
   modem connections when the task is ended.
   ------------------------------------------ */
void shutdown(void)
{
    modemAbort(com1);
}

void main(void)
{
struct ModemSetup dialSettings;
reserve_id portID;
enum DialError status;
enum DialState state;
struct pconfig portSettings;
TASKINFO taskStatus;

/* Configure serial port 1 */
portSettings.baud      = BAUD19200;
portSettings.duplex    = FULL;
portSettings.parity    = NONE;
portSettings.data_bits = DATA8;
portSettings.stop_bits = STOP1;
portSettings.flow_rx   = DISABLE;
portSettings.flow_tx   = DISABLE;
portSettings.type      = RS232_MODEM;
portSettings.timeout   = 600;
request_resource(IO_SYSTEM);
set_port(com1, &portSettings);
release_resource(IO_SYSTEM);

/* Configure US Robotics modem */
dialSettings.port         = com1;
dialSettings.dialAttempts = 3;
dialSettings.detectTime   = 60;
dialSettings.pauseTime    = 30;
dialSettings.dialmethod   = 0;
strcpy(dialSettings.modemCommand, "&F1 &A0 &K0 &M0 &B1");
```

```
strcpy(dialSettings.phoneNumber, "555-1212");

/* set up exit handler for this task */
taskStatus = getTaskInfo(0);
installExitHandler(taskStatus.taskID, shutdown);

/* Connect to the remote controller */
if (modemDial(&dialSettings, &portID) == DE_NoError)
{
    do
    {
        /* Allow other tasks to execute */
        release_processor();

        /* Wait for initialization to complete */
        modemDialStatus(com1, portID, &status, &state);
    }
    while (state == DS_Calling);

    /* If the remote controller connected */
    if (state == DS_Connected)
    {
        /* Talk to remote controller here */
    }

    /* Terminate the connection */
    modemDialEnd(com1, portID, &status);
}
}
```

Note that a pause of a few seconds is required between terminating a connection and initiating a new call. This pause allows the external modem time to hang up.

Communication Protocols

The TeleBUS protocols are compatible with the widely used Modbus RTU and ASCII protocols. The TeleBUS communication protocols provide a standard communication interface to SCADAPack controllers. Additional TeleBUS commands provide remote programming and diagnostics capability.

The TeleBUS protocols provide full access to the I/O database in the controller. The I/O database contains user-assigned registers and general purpose registers. Assigned registers map directly to the I/O hardware or system parameter in the controller. General purpose registers can be used by ladder logic and C application programs to store processed information, and to receive information from a remote device.

The TeleBUS protocols operate on a wide variety of serial data links. These include RS-232 serial ports, RS-485 serial ports, radios, leased line modems, and dial up modems. The protocols are generally independent of the communication parameters of the link, with a few exceptions.

Application programs can initiate communication with remote devices. A multiple port controller can be a data concentrator for remote devices, by polling remote devices on one port(s) and responding as a slave on another port(s).

The protocol type, communication parameters and station address are configured separately for each serial port on a controller. One controller can appear as different stations on different communication networks. The port configuration can be set from an application program, from the TelePACE programming software, or from another Modbus or DF1 compatible device.

Protocol Type

The protocol type may be set to emulate the Modbus ASCII and Modbus RTU protocols, or it may be disabled. When the protocol is disabled, the port functions as a normal serial port.

The DF1 option enables the emulation of the DF1 protocols.

The DNP (Distributed Network Protocol) option enables DNP. See the ***DNP Communication Protocol*** section for details on this protocol.

Station Number

The TeleBUS protocol allows up to 254 devices on a network using standard addressing and up to 65534 devices using extended addressing. Station numbers identify each device. A device responds to commands addressed to it, or to commands broadcast to all stations.

The station number is in the range 1 to 254 for standard addressing and 1 to 65534 for extended addressing. Address 0 indicates a command broadcast to all stations, and cannot be used as a station number. Each serial port may have a unique station number.

The TeleBUS DF1 protocols allow up to 255 devices on a network. Station numbers identify each device. A device responds to commands addressed to it, or to commands broadcast to all stations. The station number is in the range 0 to 254. Address 255 indicates a command broadcast to all stations, and cannot be used as a station number. Each serial port may have a unique station number.

Store and Forward Messaging

Store and forward messaging re-transmits messages received by a controller. Messages may be re-transmitted on any serial port, with or without station address translation. A user-defined translation table determines actions performed for each message. Store and forward messaging may be enabled or disabled on each port. It is disabled by default.

Store and forward messaging is not supported by DNP or TeleBUS DF1 protocol.

Communication Protocols Functions

There are several library functions related to TeleBUS communication protocol. Refer to the ***Function Specification*** section for details on each function listed.

checkSFTranslationTable	Check translation table for invalid entries.
clear_protocol_status	Clears protocol message and error counters.
clearSFTranslationTable	Clear all store and forward translation table entries.
enronInstallCommandHandler	Installs handler for Enron Modbus commands.
getABConfiguration	Reads DF1 protocol configuration parameters.
get_protocol	Reads protocol parameters.
getProtocolSettings	Reads extended addressing protocol parameters for a serial port.
getProtocolSettingsEx	Reads extended addressing and Enron Modbus protocol parameters for a serial port.
get_protocol_status	Reads protocol message and error counters.
getSFMapping	This function is a stub and no longer performs a necessary operation.
getSFTranslation	Read store and forward translation table entry.
installModbusHandler	This function allows user-defined extensions to standard Modbus protocol.

master_message	Sends a protocol message to another device.
modbusExceptionStatus	Sets response for the read exception status function.
modbusSlaveID	Sets response for the read slave ID function.
pollABSlave	Requests a response from a slave controller using the half-duplex version of the protocol.
resetAllABSlaves	Clears responses from the response buffers of half-duplex slave controllers.
setABConfiguration	Defines DF1 protocol configuration parameters.
set_protocol	Sets protocol parameters and starts protocol.
setProtocolSettings	Sets extended addressing protocol parameters for a serial port.
setProtcolSettingEx	Sets extended addressing and Enron Modbus protocol parameters for a serial port.
setSFMapping	This function is a stub and no longer performs a necessary operation.
setSFTranslation	Write store and forward translation table entry.
start_protocol	Starts protocol execution based on stored parameters.

Communication Protocols Macros

The **ctools.h** file defines macros for specifying communication protocol parameters. Refer to the ***C Tools Macros*** section for details on each macro listed.

AB_FULL_BCC	Specifies the DF1 Full Duplex protocol emulation for the serial port. (BCC checksum)
AB_FULL_CRC	Specifies the DF1 Full Duplex protocol emulation for the serial port. (CRC checksum)
AB_HALF_BCC	Specifies the DF1 Half Duplex protocol emulation for the serial port. (BCC checksum)
AB_HALF_CRC	Specifies the DF1 Half Duplex protocol emulation for the serial port. (CRC checksum)
FORCE_MULTIPLE_COILS	Modbus function code
FORCE_SINGLE_COIL	Modbus function code
LOAD_MULTIPLE_REGISTERS	Modbus function code
LOAD_SINGLE_REGISTER	Modbus function code
MM_BAD_ADDRESS	Master message status: invalid database address
MM_BAD_FUNCTION	Master message status: invalid function code
MM_BAD_LENGTH	Master message status: invalid message length
MM_BAD_SLAVE	Master message status: invalid slave station address
MM_NO_MESSAGE	Master message status: no message was sent.
MM_PROTOCOL_NOT_SUPPORTED	Master message status: selected protocol is not supported.
MM_RECEIVED	Master message status: response was received.

MM_SENT	Master message status: message was sent.
MM_EOT	Master message status: DF1 slave response was an EOT message
MM_WRONG_RSP	Master message status: DF1 slave response did not match command sent
MM_CMD_ACKED	Master message status: DF1 half duplex command has been acknowledged by slave – Master may now send poll command
MM_EXCEPTION_FUNCTION	Master message status: Modbus slave returned a function exception
MM_EXCEPTION_ADDRESS	Master message status: Modbus slave returned an address exception
MM_EXCEPTION_VALUE	Master message status: Modbus slave returned a value exception
MM_RECEIVED_BAD_LENGTH	Master message status: response received with incorrect amount of data.
MODBUS_ASCII	Specifies the Modbus ASCII protocol emulation for the serial port.
MODBUS_RTU	Specifies the Modbus RTU protocol emulation for the serial port.
NO_PROTOCOL	Specifies no communication protocol for the serial port.
READ_COIL_STATUS	Modbus function code
READ_EXCEPTION_STATUS	Modbus function code
READ_HOLDING_REGISTER	Modbus function code
READ_INPUT_REGISTER	Modbus function code
READ_INPUT_STATUS	Modbus function code
REPORT_SLAVE_ID	Modbus function code
SF_ALREADY_DEFINED	Result code: translation is already defined in the table
SF_INDEX_OUT_OF_RANGE	Result code: invalid translation table index
SF_NO_TRANSLATION	Result code: entry does not define a translation
SF_PORT_OUT_OF_RANGE	Result code: serial port is not valid
SF_STATION_OUT_OF_RANGE	Result code: station number is not valid
SF_TABLE_SIZE	Number of entries in the store and forward table
SF_VALID	Result code: translation is valid

Communication Protocols Enumeration Types

The **ctools.h** file defines the enumeration type **ADDRESS_MODE**. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Communication Protocols Structures

The **ctools.h** file defines the structures **Protocol Status Information**, **Protocol Settings**, **Extended Protocol Settings**, **Store and Forward Message** and **Store and Forward Status**. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

DNP Communication Protocol

DNP, the Distributed Network Protocol, is a standards-based communications protocol developed to achieve interoperability among systems in the electric utility, oil & gas, water/waste water and security industries. This robust, flexible non-proprietary protocol is based on existing open standards to work within a variety of networks. The IEEE has recommended DNP for remote terminal unit to intelligent electronic device messaging. DNP can also be implemented in any SCADA system for efficient and reliable communications between substation computers, RTUs, IEDs and master stations; over serial or LAN-based systems.

DNP offers flexibility and functionality that go far beyond conventional communications protocols. Among its robust and flexible features DNP 3.0 includes:

- Output options
- Addressing for over 65,000 devices on a single link
- Time synchronization and time-stamped events
- Broadcast messages
- Data link and application layer confirmation

DNP 3.0 was originally designed based on three layers of the OSI seven-layer model: application layer, data link layer and physical layer. The application layer is object-based with objects provided for most generic data formats. The data link layer provides for several methods of retrieving data such as polling for classes and object variations. The physical layer defines most commonly a simple RS-232 or RS-485 interface.

Refer to the **DNP User Manual** for complete information on DNP protocol, including the **Device Profile Document**.

DNP Communication Protocols Functions

There are several library functions related to DNP communication protocol. Refer to the ***Function Specification*** section for details on each function listed.

dnpInstallConnectionHandler	Configures the connection handler for DNP.
dnpClearEventLog	Deletes all change events from the DNP change event buffers.
dnpConnectionEvent	Report a DNP connection event
dnpCreateRoutingTable	Allocates memory for a new routing table.
dnpGenerateEventLog	Generates a change event for the DNP point.
dnpGetConfiguration	Reads the DNP protocol configuration.
dnpGetConfigurationEx	Reads the extended DNP configuration parameters.
dnpSaveConfiguration	Writes the DNP protocol configuration parameters.
dnpSaveConfigurationEx	Writes the extended DNP configuration parameters

dnpGetBIConfig	Reads the configuration of a DNP binary input point.
dnpSaveBIConfig	Writes the configuration of a DNP binary input point.
dnpSaveBIConfigEx	Writes the configuration of an extended DNP Binary Input point
dnpGetBOConfig	Reads the configuration of a DNP binary output point.
dnpGetBIConfigEx	Reads the configuration of an extended DNP Binary Input point.
dnpSaveBOConfig	Sets the configuration of a DNP binary output point.
dnpGetAI16Config	Reads the configuration of a DNP 16-bit analog input point.
dnpSaveAI16Config	Sets the configuration of a DNP 16-bit analog input point.
dnpGetAI32Config	Reads the configuration of a DNP 32-bit analog input point.
dnpSaveAISFConfig	Sets the configuration of a DNP 32-bit short floating analog input point
dnpGetAISFConfig	Reads the configuration of a DNP 32-bit short floating analog input point.
dnpSaveAI32Config	Sets the configuration of a DNP 32-bit analog input point.
dnpGetAO16Config	Reads the configuration of a DNP 16-bit analog output point.
dnpSaveAO16Config	Sets the configuration of a DNP 32-bit analog output point.
dnpGetAO32Config	Reads the configuration of a DNP 32-bit analog output point.
dnpSaveAO32Config	Sets the configuration of a DNP 32-bit analog output point.
dnpSaveAOSFConfig	Sets the configuration of a DNP 32-bit short floating analog output point.
dnpGetAOSFConfig	Sets the configuration of a DNP 32-bit short floating analog output point.
dnpGetCI16Config	Reads the configuration of a DNP 16-bit counter input point.
dnpSaveCI16Config	Sets the configuration of a DNP 16-bit counter input point.
dnpGetCI32Config	Reads the configuration of a DNP 32-bit counter input point.
dnpSaveCI32Config	Sets the configuration of a DNP 32-bit counter input point.
dnpGetRuntimeStatus	Reads the current status of all DNP change event buffers.
dnpSendUnsolicited	Sends an ‘Unsolicited Response’ message in DNP protocol.
dnpSendUnsolicitedResponse	Sends an Unsolicited Response message in DNP, with data from the specified classes.
dnpWriteRoutingTableEntry	Wwrites an entry in the DNP routing table.
dnpReadRoutingTableEntry	Reads an entry from the routing table.
dnpReadRoutingTableSize	Reads the total number of entries in the routing table.
dnpSearchRoutingTable	Searches the routing table for a specific DNP address.
dnpWriteRoutingTableDialStrings	Writes a primary and secondary dial string into an entry in the DNP routing table.

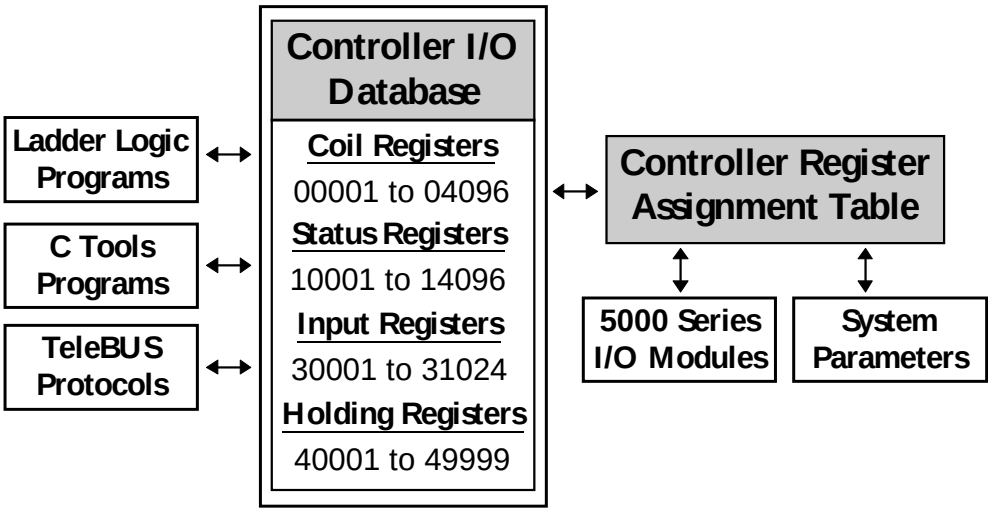
dnpReadRoutingTableDialStrings Reads a primary and secondary dial string from an entry in the DNP routing table.

DNP Communication Protocol Structures and Types

The **ctools.h** file defines the structures **DNP Configuration**, **Binary Input Point**, **Binary Output Point**, **Analog Input Point**, **Analog Output Point** and **Counter Input Point**. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

I/O Database

The I/O database allows data to be shared between C programs, Ladder Logic programs and communication protocols. A simplified diagram of the I/O Database is shown below.



The I/O database contains general purpose and user-assigned registers. General purpose registers may be used by Ladder Logic and C application programs to store processed information and to receive information from a remote device. Initially all registers in the I/O Database are general purpose registers.

User-assigned registers are mapped directly from the I/O database to physical I/O hardware, or to controller system configuration and diagnostic parameters. The Register Assignment performs the mapping of registers from the I/O database to physical I/O hardware and system parameters.

User-assigned registers are initialized to the default hardware state or system parameter when the controller is reset. Assigned output registers do not maintain their values during power failures. Assigned output registers do retain their values during application program loading.

General purpose registers retain their values during power failures and application program loading. The values change only when written by an application program or a communication protocol.

The TeleBUS communication protocols provide a standard communication interface to the controller. The TeleBUS protocols are compatible with the widely used Modbus RTU and ASCII protocols and provide full access to the I/O database in the controller.

I/O Database Register Types

The I/O database is divided into four types of I/O registers. Each of these types are initially configured as general purpose registers by the controller.

Coil Registers

Coil registers are single bit registers located in the digital output section of the I/O database. Coil, or digital output, database registers may be assigned to 5000 Series digital output modules or SCADAPack I/O modules through the Register Assignment. Coil registers may also be assigned to controller on-board digital outputs and to system configuration modules.

There are 4096 coil registers numbered 00001 to 04096. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

Status Registers

Status registers are single bit registers located in the digital input section of the I/O database. Status, or digital input, database registers may be assigned to 5000 Series digital input modules or SCADAPack I/O modules through the Register Assignment. Status registers may also be assigned to controller on-board digital inputs and to system diagnostic modules.

There are 4096 status registers are numbered 10001 to 14096. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language application programs can read data from and write data to these registers.

Input Registers

Input registers are 16 bit registers located in the analog input section of the I/O database. Input, or analog input, database registers may be assigned to 5000 Series analog input modules or SCADAPack I/O modules through the Register Assignment. Input registers may also be assigned to controller internal analog inputs and to system diagnostic modules.

There are 1024 input registers numbered 30001 to 31024. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language application programs can read data from and write data to these registers.

The I/O database for the SCADAPack 100 controller has 512 input registers numbered 30001 to 30512. Ladder logic programs and the TeleBUS protocols can only read from these registers. C language programs can read data from and write data to these registers.

Holding Registers

Holding registers are 16 bit registers located in the analog output section of the I/O database. Holding, or analog output, database registers may be assigned to 5000 Series analog output modules or SCADAPack analog output modules through the Register Assignment. Holding registers may also be assigned to system diagnostic and configuration modules.

There are 9999 input registers numbered 40001 to 49999. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

The I/O database for the SCADAPack 100 controller has 4000 holding registers numbered 40001 to 44000. Ladder logic programs, C language programs, and the TeleBUS protocols can read from and write to these registers.

I/O Database Functions

There are two library functions related to the I/O database. Refer to the ***Function Specification*** section for details on each function listed.

dbase	Reads a value from the I/O database.
setdbase	W**r**ites a value to the I/O database.

I/O Database Macros

The **ctools.h** file defines library functions for the I/O database. Refer to the ***C Tools Macros*** section for details on each macro listed.

AB	Specifies Allan-Bradley database addressing.
DB_BADSIZE	Error code: out of range address specified
DB_BADTYPE	Error code: bad database addressing type specified
DB_OK	Error code: no error occurred
LINEAR	Specifies linear database addressing.
MODBUS	Specifies Modbus database addressing.
NUMAB	Number of registers in the Allan-Bradley database.
NUMCOIL	Number of registers in the Modbus coil section.
NUMHOLDING	Number of registers in the Modbus holding register section.
NUMINPUT	Number of registers in the Modbus input registers section.
NUMLINEAR	Number of registers in the linear database.
NUMSTATUS	Number of registers in the Modbus status section.
START_COIL	Start of the coil section in the linear database.
START_HOLDING	Start of the holding registers section in the linear database.
START_INPUT	Start of the input register section in the linear database.
START_STATUS	Start of the status section in the linear database.

Register Assignment Functions

All I/O hardware that is used by the controller must be assigned to I/O database registers in order for these I/O points to be scanned continuously. I/O data may then be accessed through the I/O database within the C program. C programs may read data from, or write data to the I/O hardware through user- assigned registers in the I/O database.

The Register Assignment assigns I/O database registers to user-assigned registers using I/O modules. An I/O Module can refer to an actual I/O hardware module (e.g. *5401 Digital Input Module*) or it may refer to a set of controller parameters, such as serial port settings.

The chapter *Register Assignment Reference* of the ***TelePACE Ladder Logic Reference and User Manual*** contains a description of what each module is used for and the register assignment requirements for the I/O module.

Register assignments configured using the TelePACE *Register Assignment* dialog may be stored in the TelePACE program file or downloaded directly to the controller. To obtain error checking that prevents invalid register assignments, use the *TelePACE Register Assignment* dialog to initially build the Register Assignment. The Register Assignment can then be saved in a Ladder Logic file (e.g. filename.lad) and downloaded with the C program.

There are several library functions related to register assignment. Refer to the ***Function Specification*** section for details on each function listed.

clearRegAssignment	Erases the current Register Assignment.
addRegAssignment	Adds one I/O module to the current Register Assignment.
getIOErrorIndication	Gets the control flag for the I/O module error indication
getOutputsInStopMode	Gets the control flags for state of Outputs in Ladders Stop Mode
setIOErrorIndication	Sets the control flag for the I/O module error indication
setOutputsInStopMode	Sets the control flags for state of Outputs in Ladders Stop Mode

Register Assignment Enumeration Types

The **ctools.h** file defines one enumeration type. The **ioModules** enumeration type defines a list of results of sending a command. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

Register Assignment Structure

The **ctools.h** file defines the structure **RegAssign.** Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

HART Communication

The HART ® protocol is a field bus protocol for communication with smart transmitters.

The HART protocol driver provides communication between TeleSAFE Micro16 and SCADAPack controllers and HART devices. The protocol driver uses the model 5904 HART modem for communication. Four HART modem modules are supported per controller.

The driver allows HART transmitters to be used with C application programs and with RealFLO. The driver can read data from HART devices.

HART Command Functions

The **ctools.h** file defines the following HART command related functions. Refer to the ***Function Specification*** section for details on each function listed.

hartIO	Reads data from the 5904 interface module, processes HART responses, processes HART commands, and writes commands and configuration data to the 5904 interface module.
hartCommand	send a HART command string and specify a function to handle the response
hartCommand0	read unique identifier using short-address algorithm
hartCommand1	read primary variable
hartCommand2	read primary variable current and percent of span
hartCommand3	read primary variable current and dynamic variables
hartCommand11	read unique identifier associated with tag
hartCommand33	read specified transmitter variables

hartStatus	return status of last HART command sent
hartGetConfiguration	read HART module settings
hartSetConfiguration	write HART module settings
hartPackString	convert string to HART packed string
hartUnpackString	convert HART packed string to string

HART Command Macros

The **ctools.h** file defines the following macro of interest to a C application program. Refer to the ***C Tools Macros*** section for details.

DATA_SIZE	Maximum length of the HART command or response field.

HART Command Enumeration Types

The **ctools.h** file defines one enumeration type. The **HART_RESULT** enumeration type defines a list of results of sending a command. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

HART Command Structures

The **ctools.h** file defines five structures. Refer to the ***C Tools Structures and Types*** section for complete information on structures and enumeration types.

The HART_DEVICE type is a structure containing information about the HART device.

The HART_VARIABLE type is a structure containing a variable read from a HART device.

The HART_SETTINGS type is a structure containing the configuration for the HART modem module.

The HART_COMMAND type is a structure containing a command to be sent to a HART slave device.

The HART_RESPONSE type is a structure containing a response from a HART slave device.

PID Control

TelePACE C Tools provides a total of 32 independent PID (Proportional, Integral, and Derivative) controllers. PID control blocks operate independent of application programs. An elaborate control program need not be written to use the control blocks. A simple program to set up the control blocks is all that is required.

The PID control blocks are not limited to the PID control algorithm. They also provide ratio control, ratio/bias control, alarm scanning and square root functions. Control blocks may be interconnected to exchange setpoints, output limits, and other parameters.

Refer to the PID Controllers section of the TelePACE Ladder Logic User Manual for complete information on configuring and using PID controllers.

PID Control Functions

The **ctools.h** file defines the following PID control related functions. Refer to the ***Function Specification*** section for details on each function listed.

auto_pid	Set a PID block to execute automatically at the specified rate.

clear_pid	Set all PID block variables to zero.
get_pid	This function returns the value of a PID control block variable.
set_pid	This function assigns *value* to a PID control block variable.

PID Control Macros

The **ctools.h** file defines the following macros for PID block access. Refer to the ***C Tools Macros*** section for details on each function listed.

AO	Variable name: alarm output address
CA	Variable name: cascade setpoint source
CR	Variable name: control register
DB	Variable name: deadband
DO	Variable name: decrease output
ER	Variable name: error
EX	Variable name: automatic execution period
FS	Variable name: full scale output limit
GA	Variable name: gain
HI	Variable name: high alarm setpoint
IB	Variable name: input bias
IH	Variable name: inhibit execution address
IN	Variable name: integrated error
IO	Variable name: increase output
IP	Variable name: input source
LO	Variable name: low alarm setpoint
OB	Variable name: output bias
OP	Variable name: output
PE	Variable name: period
PID_ALARM	Control register mask: alarms enabled
PID_ALARM_ABS	Control register mask: absolute alarms
PID_ALARM_ACK	Status register mask: alarm acknowledged
PID_ALARM_DEV	Control register mask: deviation alarms
PID_ALARM_ONLY	Control register mask: alarm only block
PID_ALARM_RATE	Control register mask: rate alarms
PID_ANALOG_IP	Control register mask: analog input
PID_ANALOG_OP	Control register mask: analog output
PID_BAD_BLOCK	Return code: bad block number specified.
PID_BAD_IO_IP	Status register mask: I/O failure on block input
PID_BAD_IO_OP	Status register mask: I/O failure on block output

PID_BLOCK_IP	Control register mask: input from output of another block
PID_BLOCKS	Number of PID blocks.
PID_CLAMP_FULL	Status register mask: output is clamped at full scale
PID_CLAMP_ZERO	Status register mask: output is clamped at zero scale
PID_ER_SQR	Control register mask: take square root of error
PID_HI_ALARM	Status register mask: high alarm detected
PID_INHIBIT	Status register mask: external inhibit input is on
PID_LO_ALARM	Status register mask: low alarm detected
PID_MANUAL	Status register mask: block is in manual mode
PID_MODE_AUTO	Control register mask: automatic mode
PID_MODE_MANUAL	Control register mask: manual mode
PID_MOTOR_OP	Control register mask: motor pulse duration output
PID_NO_ALARM	Control register mask: alarms disabled
PID_NO_ER_SQR	Control register mask: normal error
PID_NO_IP	Control register mask: no input (other than IP)
PID_NO_OP	Control register mask: no output
PID_NO_PV_SQR	Control register mask: normal PV
PID_NO_SP_TRACK	Control register mask: setpoint tracking disabled
PID_OK	Return code: operation completed successfully.
PID_OUT_DB	Status register mask: PID controller outside of deadband
PID_PID	Control register mask: PID control block
PID_PULSE_OP	Control register mask: pulse duration output
PID_PV_SQR	Control register mask: take square root of PV
PID_RATE_CLAMP	Status register mask: rate gain clamed at maximum
PID_RATIO_BIAS	Control register mask: ratio/bias control block
PID_RUNNING	Status register mask: block is executing
PID_SP_CASCADE	Control register mask: cascade setpoint
PID_SP_NORMAL	Control register mask: setpoint stored in SP
PID_SP_TRACK	Control register mask: setpoint tracking enabled
PV	Variable name: process value
RA	Variable name: rate time
RE	Variable name: reset time
SP	Variable name: setpoint
SR	Variable name: status register
ZE	Variable name: zero scale output limit

Backward Compatibility Functions

The following functions are provided for backward compatibility. They cannot access all 5000 series I/O modules. It is recommended that these functions not be used in new programs. Instead use Register Assignment or call the specific I/O module driver function directly.

These functions are defined in **ctools.h** for backward compatibility with these programs.

ain	Reads analog input
aioError	Reads analog I/O communication status
aout	Writes analog output
counter	Reads counter module input channel
counterError	Reads counter module error flag
din	Reads digital input channel (8 I/O points)
dout	Writes digital output channel (8 I/O points)
off	Tests If one digital I/O point is OFF
on	Tests If one digital I/O point is ON
pulse	Generates a square wave on a digital output point
pulse_train	Generates a series of pulses on a digital output point
timeout	Performs time delayed action on a digital output point
turnoff	Writes one digital output point to OFF status
turnon	Writes one digital output point to ON status

Backward Compatibility Macros

The following macros may have been used in C programs written for a controller with firmware version 1.22 or older to support the functions: ain, aioError, aout, counter, counterError, din, dout, off, on, pulse, pulse_train, timeout, turnoff or turnon.

These macros are defined in **ctools.h** for backward compatibility with these programs.

AIN_END	Number of last analog input channel.
AIN_START	Number of first analog input channel.
AIO_BADCHAN	Error code: bad analog input channel specified.
AIO_TIMEOUT	Error code: input device did not respond.
AIO_SUPPORTED	If defined indicates analog I/O supported.
AOUT_END	Number of last analog output channel.
AOUT_START	Number of first analog output channel.
COUNTER_CHANNELS	Specifies number of 5000 Series counter input channels
COUNTER_END	Number of last counter input channel
COUNTER_START	Number of first counter input channel
COUNTER_SUPPORTED	If defined indicates counter I/O hardware supported.
DIN_END	Number of last regular digital input channel.

DIN_START	Number of first regular digital input channel
DIO_SUPPORTED	If defined indicates digital I/O hardware supported.
DOUT_END	Number of last regular digital output channel.
DOUT_START	Number of first regular digital output channel
DUTY_CYCLE	Specifies timer is generating square wave output.
EXTENDED_DIN_END	Number of last extended digital input channel.
EXTENDED_DIN_START	Number of first extended digital input channel
EXTENDED_DOUT_END	Number of last extended digital output channel.
EXTENDED_DOUT_START	Number of first extended digital output channel
NORMAL	Specifies normal count down timer.
PULSE_TRAIN	Specifies timer is generating pulse train output.
TIMEOUT	Specifies timer is generating timed output change.
TIMER_BADADDR	Error code: invalid digital I/O address.

TelePACE C Tools Function Specifications

The controller C function specifications are formatted as follows. The functions are listed alphabetically.

Name	Each specification begins with the name of the function and a brief description.
Syntax	The syntax shows a prototype for the function, indicating the return type and the types of its arguments. Any necessary header files are listed.
Description	This defines the calling parameters for the function and its return values.
Notes	This section contains additional information on the function, and considerations for its use.
See Also	This section lists related functions.
Example	The example gives a brief sample of the use of the function.

addRegAssignment

Add Register Assignment

Syntax

```
#include <ctools.h>
unsigned addRegAssignment(
       unsigned moduleType,
       unsigned moduleAddress,
       unsigned startingRegister1,
       unsigned startingRegister2,
       unsigned startingRegister3,
       unsigned startingRegister4);
```

Description

The **addRegAssignment** function adds one I/O module to the current Register Assignment of type *moduleType*. The following symbolic constants are valid values for *moduleType*:

```
AIN_520xTemperature          DIAG_forceLED
AIN_520xRAMBattery           DIAG_IPConnections
AIN_5501                     DIAG_ModbusStatus
AIN_5502                     DIAG_protocolStatus
AIN_5503                     DIN_520xDigitalInputs
AIN_5504                     DIN_520xInterruptInput
AIN_5521                     DIN_520xOptionSwitches
AIN_generic8                 DIN_5401
AOUT_5301                    DIN_5402
AOUT_5302                    DIN_5403
AOUT_5304                    DIN_5404
AOUT_generic2                DIN_5405
AOUT_generic4                DIN_5421
CNFG_5904Modem               DIN_generic16
CNFG_clearPortCounters       DIN_generic8
CNFG_clearProtocolCounters   DIN_SP32OptionSwitches
CNFG_IPSettings              DOUT_5401
CNFG_LEDPower                DOUT_5402
CNFG_MTCPIfSettings          DOUT_5406
CNFG_MTCPSettings            DOUT_5407
CNFG_PIDBlock                DOUT_5408
CNFG_portSettings            DOUT_5409
CNFG_protocolExtended        DOUT_5411
CNFG_protocolExtendedEx      DOUT_generic16
CNFG_protocolSettings        DOUT_generic8
CNFG_realTimeClock           SCADAPack_AOUT
CNFG_saveToEEPROM            SCADAPack_lowerIO
CNFG_setSerialPortDTR        SCADAPack_upperIO
CNFG_storeAndForward         SCADAPack_LPIO
CNTR_520xCounterInputs       SCADAPack_100IO
CNTR_5410                    SCADAPack_5604IO
CNTR_520xInterruptInput      GFC_4202IO
DIAG_commStatus              GFC_4202IOEx
DIAG_controllerStatus        GFC_4202DSIO
DIAG_LogicStatus
```

moduleAddress specifies a unique address for the module. For the valid range for *moduleAddress* refer to the list of modules in the chapter *Register Assignment Reference* of the ***TelePACE Ladder Logic Reference and User Manual***. For module addresses com1,

com2, com3 or com4 specify 0, 1, 2 or 3 respectively for *moduleAddress*. For module types that have no module address (e.g. CNFG_LEDPower) specify -1 for *moduleAddress.* For SCADAPack module types that have a module address fixed at 0, specify 0 for *moduleAddress.*

startingRegister1 specifies the first register of any unused block of consecutive registers. Refer to the list of modules in the *Register Assignment Reference* for the type and number of registers required for this block. Data read from or written to the module is stored in this block of registers.

If the module type specified has more than one type of I/O, use *startingRegister2*, *startingRegister3*, and *startingRegister4* as applicable. Each start register specifies the first register of an unused block of consecutive registers for each type of input or output on the module. Refer to the list of modules in the *Register Assignment Reference* for the module I/O types. Specify 0 for *startingRegister2*, *startingRegister3*, or *startingRegister4* if not applicable.

Notes

Up to 150 modules may be added to the Register Assignment. If the Register Assignment is full or if an incorrect value is specified for any argument this function returns FALSE; otherwise TRUE is returned.

Output registers specified for certain CNFG type modules are initialized with the current parameter values when the module is added to the Register Assignment (e.g. CNFG_realTimeClock).

Call **clearRegAssignment** first before using the **addRegAssignment** function when creating a new Register Assignment.

Duplicate or overlapping register assignments are not checked for by this function. Overlapping register assignments may result in unpredictable I/O activity.

To obtain error checking that prevents invalid register assignments such as these, use the *TelePACE Register Assignment* dialog to build the Register Assignment. Then save the Register Assignment in a Ladder Logic file (e.g. `filename.lad`) and download it with the C program, or transfer the Register Assignment to the C program using the **clearRegAssignment** and **addRegAssignment** functions.

The IO_SYSTEM resource must be requested before calling this function.

See Also

clearRegAssignment

Example

```
#include <primitiv.h>

void main(void)
{
       request_resource(IO_SYSTEM);

       /* Create the Register Assignment */
       clearRegAssignment();

       addRegAssignment(SCADAPack_lowerIO, 0, 1,
          10001, 30001, 0);
       addRegAssignment(SCADAPack_AOUT, 0, 40001, 0,
          0, 0);
       addRegAssignment(AOUT_5302, 1, 40003, 0, 0, 0);
```

```
        addRegAssignment(DIAG_forceLED, -1, 10017, 0,
            0, 0);
        addRegAssignment(DIAG_controllerStatus, -1,
            30009, 0, 0, 0);
        addRegAssignment(DIAG_protocolStatus, 2, 30010,
            0, 0, 0);

        release_resource(IO_SYSTEM);
}
```

addRegAssignmentEx

Add Register Assignment

Syntax

```
#include <ctools.h>
BOOLEAN addRegAssignmentEx(
       UINT16 moduleType,
       UINT16 moduleAddress,
       UINT16 startingRegister1,
       UINT16 startingRegister2,
       UINT16 startingRegister3,
       UINT16 startingRegister4,
       UINT16 parameters[16]
);
```

Description

The **addRegAssignmentEx** function adds one I/O module to the current Register Assignment of type *moduleType*. The following symbolic constants are valid values for *moduleType*:

```
AIN_5209Temperature
AIN_5209RAMBattery
AIN_5501
AIN_5502
AIN_5503
AIN_5504
AIN_5505
AIN_5506
AIN_5521
AIN_generic8
AOUT_5301
AOUT_5302
AOUT_5304
AOUT_generic2
AOUT_generic4
CNFG_5904Modem
CNFG_clearPortCounters
CNFG_clearProtocolCounters
CNFG_IPSettings
CNFG_LEDPower
CNFG_modbusIpProtocol
CNFG_MTCPIfSettings
CNFG_MTCPSettings
CNFG_PIDBlock
CNFG_portSettings
CNFG_protocolExtended
CNFG_protocolExtendedEx
CNFG_protocolSettings
CNFG_realTimeClock
CNFG_saveToEEPROM
CNFG_setSerialPortDTR
CNFG_storeAndForward
CNTR_5209CounterInputs
CNTR_5410
CNTR_5209InterruptInput
DIAG_commStatus
DIAG_controllerStatus
DIAG_forceLED
DIAG_IPConnections
DIAG_ModbusStatus
DIAG_protocolStatus
DIN_5209DigitalInputs
DIN_5209InterruptInput
DIN_5401
DIN_5402
DIN_5403
DIN_5404
DIN_5405
DIN_5421
DIN_generic16
DIN_generic8
DOUT_5401
DOUT_5402
DOUT_5406
DOUT_5407
DOUT_5408
DOUT_5409
DOUT_5411
DOUT_generic16
DOUT_generic8
SCADAPack_AOUT
SCADAPack_lowerIO
SCADAPack_upperIO
SCADAPack_LPIO
SCADAPack_100IO
SCADAPack_5209IO
SCADAPack_5606IO
```

moduleAddress specifies a unique address for the module. For the valid range for *moduleAddress* refer to the list of modules in the chapter *Register Assignment Reference* of the ***TelePACE Ladder Logic Reference and User Manual***. For module addresses com1, com2, com3 or com4 specify 0, 1, 2 or 3 respectively for *moduleAddress*. For module address Ethernet1 specify 4 for *moduleAddress*. For module types that have no module address (e.g. CNFG_LEDPower) specify -1 for *moduleAddress.* For SCADAPack module types that have a module address fixed at 0, specify 0 for *moduleAddress.*

startingRegister1 specifies the first register of any unused block of consecutive registers. Refer to the list of modules in the *Register Assignment Reference* for the type and number of registers required for this block. Data read from or written to the module is stored in this block of registers.

If the module type specified has more than one type of I/O, use *startingRegister2*, *startingRegister3*, and *startingRegister4* as applicable. Each start register specifies the first register of an unused block of consecutive registers for each type of input or output on the module. Refer to the list of modules in the *Register Assignment Reference* for the module I/O types. Specify 0 for *startingRegister2*, *startingRegister3*, or *startingRegister4* if not applicable.

`parameters` is an array of configuration parameters for the register assignment module. Most modules do not use the parameters. Use the **addRegAssignment** function to configure these modules. Use parameters with the following modules.

5505 I/O Module: `parameters[0]` to `[3]` define the analog input type for the corresponding input. Valid values are:

- 0 = RTD in deg Celsius
- 1 = RTD in deg Fahrenheit
- 2 = RTD in deg Kelvin
- 3 = resistance measurement in ohms.

5505 I/O Module: `parameter[4]` defines the analog input filter. Valid values are:

- 0 = 0.5 s (minimum)
- 1 = 1 s
- 2 = 2 s
- 3 = 4 s (maximum)

5506 I/O Module: `parameters[0]` to `[7]` define the analog input type for the corresponding input. Valid values are:

- 0 = 0 to 5 V input
- 1 = 1 to 5 V input
- 2 = 0 to 20 mA input
- 3 = 4 to 20 mA input

5506 I/O Module: `parameter[8]` defines the analog input filter. Valid values are:

- 0 = < 3 Hz (maximum filter)
- 1 = 6 Hz
- 2 = 11 Hz
- 3 = 30 Hz (minimum filter)

5506 I/O Module: `parameter[9]` defines the scan frequency. Valid values are:

- 0 = 60 Hz
- 1 = 50 Hz

5606 I/O Module: `parameters[0]` to `[7]` define the analog input type for the corresponding input. Valid values are:

- 0 = 0 to 5 V input
- 1 = 1 to 5 V input
- 2 = 0 to 20 mA input
- 3 = 4 to 20 mA input

5606 I/O Module: `parameter[8]` defines the analog input filter. Valid values are:

- 0 = < 3 Hz (maximum filter)
- 1 = 6 Hz
- 2 = 11 Hz
- 3 = 30 Hz (minimum filter)

5606 I/O Module: `parameter[9]` defines the scan frequency. Valid values are:

- 0 = 60 Hz
- 1 = 50 Hz

5606 I/O Module: `parameter[10]` defines the analog output type. Valid values are:

- 0 = 0 to 20 mA output
- 1 = 4 to 20 mA output

Notes

Up to 150 modules may be added to the Register Assignment. If the Register Assignment is full or if an incorrect value is specified for any argument this function returns `FALSE`; otherwise `TRUE` is returned.

Output registers specified for certain CNFG type modules are initialized with the current parameter values when the module is added to the Register Assignment (e.g. `CNFG_realTimeClock`).

Call `clearRegAssignment` first before using the `addRegAssignmentEx` function when creating a new Register Assignment.

Duplicate or overlapping register assignments are not checked for by this function. Overlapping register assignments may result in unpredictable I/O activity.

To obtain error checking that prevents invalid register assignments such as these, use the *TelePACE Register Assignment* dialog to build the Register Assignment. Then save the Register Assignment in a Ladder Logic file (e.g. `filename.lad`) and download it with the C program, or transfer the Register Assignment to the C program using the `clearRegAssignment` and `addRegAssignmentEx` functions.

The `IO_SYSTEM` resource must be requested before calling this function.

See Also

addRegAssignment, **clearRegAssignment**

ain

Read an Analog Input

Syntax

```
#include <ctools.h>
int ain(unsigned channel);
```

Description

The **ain** function reads from the analog input or output specified by *channel*. Input channels read from the analog input hardware. Output channels read the value output to the channel with the **aout** function.

The valid range for *channel* is 0 to **AIO_MAX**. If an invalid channel is selected, the **ain** function returns **INT_MIN** and the current task's error code is set to **AIO_BADCHAN.** The error code is obtained with the **check_error** function.

The **ain** function normally returns a value in the range –32767 to +32767.

Notes

Use offsets from the symbolic constants AIN_START, AIN_END, AOUT_START and AOUT_END to reference analog channels. The constants make programs more portable and protect against future changes to the analog I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead8Ain** directly.

See also

aout, check_error, ioRead8Ain

Example

```
#include <ctools.h>

void main(void)
{
       request_resource(IO_SYSTEM);
       printf("ain(%d)=%d\r\n", 2, ain(2));
       release_resource(IO_SYSTEM);
}
```

aioError

Read Analog I/O Error Flags

Syntax

```
#include <ctools.h>
int aioError(unsigned channel);
```

Description

The **aioError** function reads the I/O error flag for an analog channel.

It returns the error flag for the channel, if the channel number is valid; otherwise it returns INT_MIN. A value of 0 indicates no error occurred. A positive value indicates an error.

Notes

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead8Ain** directly.

See Also

aout, check_error, ioRead8Ain

alarmIn

Determine Alarm Time from Elapsed Time

Syntax

```
#include <ctools.h>
ALARM_SETTING alarmIn(unsigned hours, unsigned minutes, unsigned seconds);
```

Description

The **alarmIn** function calculates the alarm settings to configure a real time clock alarm to occur in *hours*, *minutes* and *seconds* from the current time.

The function returns an ALARM_SETTING structure suitable for passing to the **setClockAlarm** function. The structure specifies an absolute time alarm at the time offset specified by the call to **alarmIn**. Refer to the **Structures and Types** section for a description of the fields in the ALARM_SETTING structure.

Notes

If *second* is greater than 60 seconds, the additional time is rolled into the minutes. If *minute* is greater than 60 minutes, the additional time is rolled into the hours.

If the offset time is greater that one day, then the alarm time will roll over within the current day.

The IO_SYSTEM resource must be requested before calling this function.

See Also

getClockAlarm, setClockAlarm,

Example

```
#include <ctools.h>

/* ----------------------------------------
   conservePower

   The conservePower function places the
   controller into sleep mode for 10 minutes.
   ---------------------------------------- */
void conservePower(void)
{
       ALARM_SETTING alarm;

       request_resource(IO_SYSTEM);

       /* Alarm in 10 minutes */
       alarm = alarmIn(0, 10, 0);
       setClockAlarm(alarm)

       /* Put controller in low power mode */
       sleep();
       release_resource(IO_SYSTEM);
}
```

allocate_envelope

Obtain an Envelope from the RTOS

Syntax

```
#include <ctools.h>envelope *allocate_envelope(void);
```

Description

The **allocate_envelope** function obtains an envelope from the operating system. If no envelope is available, the task is blocked until one becomes available.

The **allocate_envelope** function returns a pointer to the envelope.

Notes

Envelopes are used to send messages between tasks. The RTOS allocates envelopes from a pool of free envelopes. It returns envelopes to the pool when they are de-allocated.

An application program must ensure that unneeded envelopes are de-allocated. Envelopes may be reused.

See Also

deallocate_envelope

Example

```
#include <ctools.h>
extern unsigned other_task_id;

void task1(void)
{
       envelope *letter;

       /* send a message to another task */
       /* assume it will deallocate the envelope */

       letter = allocate_envelope();
       letter->destination = other_task_id;
       letter->type = MSG_DATA;
       letter->data = 5;
       send_message(letter);

       /* receive a message from any other task */

       letter = receive_message();
       /* ... process the data here */
       deallocate_envelope(letter);

       /* ... the rest of the task */
}
```

aout

Write to Analog Output

Syntax

```
#include <ctools.h>
int aout(unsigned channel, int value);
```

Description

The **aout** function writes *value* to the analog output specified by *channel*. The range for *channel* is **AOUT_START** to **AOUT_END** inclusive. The range for *value* is -32767 to 32767.

aout returns the value written to the hardware, or -1 if the channel is not an analog output.

Notes

The *value* output may be limited by the analog output module.

Use offsets from the symbolic constants AIN_START, AIN_END, AOUT_START and AOUT_END to reference analog channels. The constants make programs more portable and protect against future changes to the analog I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite4Aout** directly.

See Also

addRegAssignment, ioWrite4Aout

Example

```
#include <ctools.h>
void main(void)
{
       int value;

       /* ramp output from zero to full scale */
       for (value = 0; value < 32767; value++)
       {
          request_resource(IO_SYSTEM);
          aout(AOUT_START, value);
          release_resource(IO_SYSTEM);
       }
}
```

auto_pid

Execute a PID Block Automatically

Syntax

```
#include <ctools.h>
void auto_pid(unsigned block, unsigned period);
```

Description

The **auto_pid** routine configures a PID control block to execute automatically at the specified period. *period* is measured in 0.1 second increments. *block* must be in the range 0 to **PID_BLOCKS** – 1.

Setting the period to 0 stops execution of the control block.

Notes

See the ***TelePACE PID Controllers Reference Manual*** for a detailed description of PID control.

The control block must be configured properly before it is engaged, or indeterminate operation may result.

The IO_SYSTEM resource must be requested before calling this function.

See Also

set_pid, getPowerMode

Get Current Power Mode

Syntax

```
#include <ctools.h>
BOOLEAN getPowerMode(UCHAR* cpuPower, UCHAR* lan, UCHAR* usbPeripheral,
UCHAR* usbHost);
```

Description

The **getPowerMode** function places the current state of the CPU, LAN, USB peripheral port, and USB host port in the passed parameters. The following table lists the possible return values and their meaning.

Macro	***Meaning***
PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_UNAVAILABLE	The status of the device could not be read.

TRUE is returned if the values placed in the passed parameters are valid, otherwise FALSE is returned.

The application program may set the current power mode with the setPowerMode function.

See Also

setPowerMode, setWakeSource, getWakeSource

get_pid**, clear_pid**

check_error

Get Error Code for Current Task

Syntax

```
#include <ctools.h>
int check_error(void);
```

Description

The **check_error** function returns the error code for the current task. The error code is set by various I/O routines, when errors occur. A separate error code is maintained for each task.

Notes

Some routines in the standard C library, return errors in the global variable **errno**. This variable is not unique to a task, and may be modified by another task, before it can be read.

See Also

report_error

checksum

Calculate a Checksum

Syntax

```
#include <ctools.h>
unsigned checksum(unsigned char *start, unsigned char *end, unsigned
   algorithm);
```

Description

The **checksum** function calculates a checksum on memory. The memory starts at the byte pointed to by *start*, and ends with the byte pointed to by *end*. The *algorithm* may be one of:

ADDITIVE	16 bit byte-wise sum
CRC_16	CRC-16 polynomial checksum
CRC_CCITT	CRC-CCITT polynomial checksum
BYTE_EOR	8 bit byte-wise exclusive OR

The CRC checksums use the **crc_reverse** function.

See Also

crc_reverse

Example

This function displays two types of checksums.

```
#include <ctools.h>

void checksumExample(void)
{
       char str[] = "This is a test";
       unsigned sum;

       /* Display additive checksum */
       sum = checksum(str, str+strlen(str), ADDITIVE);
       printf("Additive checksum: %u\r\n", sum);

       /* Display CRC-16 checksum */
       sum = checksum(str, str+strlen(str), CRC_16);
       printf("CRC-16 checksum: %u\r\n", sum);
}
```

checkSFTranslationTable

Test for Store and Forward Configuration Errors

Syntax

```
#include <ctools.h>
struct SFTranslationStatus checkSFTranslationTable(void);
```

Description

The **checkSFTranslationTable** function checks all entries in the address translation table for validity. It detects the following errors:

The function returns a *SFTranslationStatus* structure. Refer to the **Structures and Types** section for a description of the fields in the *SFTranslationStatus* structure. The *code* field of the structure is set to one of the following. If there is an error, the *index* field is set to the location of the translation that is not valid.

Result code	Meaning
SF_VALID	All translations are valid
SF_NO_TRANSLATION	The entry defines re-transmission of the same message on the same port
SF_PORT_OUT_OF_RANGE	One or both of the serial port indexes is not valid
SF_STATION_OUT_OF_RANGE	One or both of the stations is not valid

Notes

The ***TeleBUS Protocols User Manual*** describes store and forward messaging mode.

See Also

getSFTranslation, setSFTranslation, checkSFTranslationTable

Example

See the example for the **setSFTranslation** function.

clearAllForcing

Clear All Forcing

Syntax

```
#include <ctools.h>
void clearAllForcing(void);
```

Description

The **clearAllForcing** function removes all forcing conditions from all I/O database registers.

The IO_SYSTEM resource must be requested before calling this function.

See Also

setForceFlag, overrideDbase

clear_errors

Clear Serial Port Error Counters

Syntax

```
#include <ctools.h>
void clear_errors(FILE *stream);
```

Description

The **clear_errors** function clears the serial port error counters for the serial port specified by *stream*. If *stream* does not point to a valid serial port the function has no effect.

The IO_SYSTEM resource must be requested before calling this function.

See Also

get_status

clear_pid

Clear PID Block Variables

Syntax

```
#include <ctools.h>
void clear_pid(unsigned block);
```

Description

The **clear_pid** routine sets all variables in the specified control block to 0. **clear_pid** is normally used as the first step of control block configuration. *block* must be in the range 0 to **PID_BLOCKS** – 1.

Notes

See the ***TelePACE PID Controllers Reference Manual*** for a detailed description of PID control.

Values stored in PID blocks are not initialized when a program is run, and are guaranteed to retain their values during power failures and program loading. PID block variables must always be initialized by the user program.

The IO_SYSTEM resource must be requested before calling this function.

See Also

set_pid, getPowerMode

Get Current Power Mode

Syntax

```
#include <ctools.h>
BOOLEAN getPowerMode(UCHAR* cpuPower, UCHAR* lan, UCHAR* usbPeripheral,
UCHAR* usbHost);
```

Description

The **getPowerMode** function places the current state of the CPU, LAN, USB peripheral port, and USB host port in the passed parameters. The following table lists the possible return values and their meaning.

Macro	***Meaning***
PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_UNAVAILABLE	The status of the device could not be read.

TRUE is returned if the values placed in the passed parameters are valid, otherwise FALSE is returned.

The application program may set the current power mode with the setPowerMode function.

See Also

setPowerMode, setWakeSource, getWakeSource

get_pid**, auto_pid**

clear_protocol_status

Clear Protocol Counters

Syntax

```
#include <ctools.h>
void clear_protocol_status(FILE *stream);
```

Description

The **clear_protocol_status** function clears the error and message counters for the serial port specified by *stream*. If *stream* does not point to a valid serial port the function has no effect.

The IO_SYSTEM resource must be requested before calling this function.

See Also

get_protocol_status

clearRegAssignment

Clear Register Assignment

Syntax

```
#include <ctools.h>
void clearRegAssignment(void);
```

Description

The **clearRegAssignment** function erases the current Register Assignment. Call this function first before using the **addRegAssignment** function to create a new Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

addRegAssignment

Example

See example for **addRegAssignment**.

clearSFTranslationTable

Clear Store and Forward Translation Configuration

Syntax

```
#include <ctools.h>
void clearSFTranslationTable(void);
```

Description

The **clearSFTranslationTable** function clears all entries in the store and forward translation table.

Notes

The ***TeleBUS Protocols User Manual*** describes store and forward messaging mode.

The IO_SYSTEM resource must be requested before calling this function.

See Also

getSFTranslation, setSFTranslation, checkSFTranslationTable

Example

See the example for the **setSFTranslation** function.

clearStatusBit

Clear Bits in Controller Status Code

Syntax

```
#include <ctools.h>
unsigned clearStatusBit(unsigned bitMask);
```

Description

The **clearStatusBit** function clears the bits indicated by *bitMask* in the controller status code. When the status code is non-zero, the STAT LED blinks a binary sequence corresponding to the code. If *code* is zero, the STAT LED turns off.

The function returns the value of the status register.

Notes

The status output opens if *code* is non-zero. Refer to the ***System Hardware Manual*** for more information.

The binary sequence consists of short and long flashes of the error LED. A binary zero is indicated by a short flash of 1/10th of a second. A longer flash of approximately 1/2 of a second indicates a binary one. The least significant digit is output first. As few bits as possible are displayed – all leading zeros are ignored. There is a two-second delay between repetitions.

The STAT LED is the LED located on the top left hand corner of the 5203 or 5204 controller board.

Bits 0 and 1 of the status code are used by the Register Assignment.

See Also

setStatusBit, setStatus, getStatusBit

clear_tx

Clear Serial Port Transmit Buffer

Syntax

```
#include <ctools.h>
void clear_tx(FILE *stream);
```

Description

The **clear_tx** function clears the transmit buffer for the serial port specified by *stream*. If *stream* does not point to a valid serial port the function has no effect.

See Also

get_status

counter

Read Counter Input Module

Syntax

```
#include <ctools.h>
long counter(unsigned counter);
```

Description

The **counter** function reads data from the counter input specified by *channel*. If the channel number is not valid a COUNTER_BADCOUNTER error is reported for the current task. The value returned by **counter** is not valid.

Notes

Refer to the ***TelePACE Ladder Logic User Manual*** for an explanation of counter input channel assignments.

Use offsets from the symbolic constants COUNTER_START and COUNTER_END to reference counter channels. The constants make programs more portable and protect against future changes to the counter input channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead4Counter** directly.

See Also

counterError, check_error, request_resource, release_resource, ioRead4Counter

counterError

Read Counter Input Error Flag

Syntax

```
#include <ctools.h>
long counterError(unsigned counter);
```

Description

The **counterError** function returns the I/O error flag for a counter channel. It returns TRUE if an error occurred and FALSE if no occurred on the last read of the input module.

If the channel number is not valid a COUNTER_BADCOUNTER error is reported for the current task. The value returned is not valid.

Notes

Refer to the ***TelePACE Ladder Logic User Manual*** for a explanation of counter input channel assignments.

Use offsets from the symbolic constants COUNTER_START and COUNTER_END to reference counter channels. The constants make programs more portable and protect against future changes to the counter input channel numbering.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead4Counter** directly.

See Also

counter, check_error, ioRead4Counter

crc_reverse

Calculate a CRC Checksum

Syntax

```
#include <ctools.h>
unsigned crc_reverse(unsigned char *start, unsigned char *end, unsigned
   poly, unsigned initial);
```

Description

The **crc_reverse** function calculates a CRC type checksum on memory using the reverse algorithm. The memory starts at the byte pointed to by *start*, and ends with the byte pointed to by *end*. The generator polynomial is specified by *poly*. *poly* may be any value, but must be carefully chosen to ensure good error detection. The checksum accumulator is set to *initial* before the calculation is started.

Notes

The reverse algorithm is named for the direction bits are shifted. In the reverse algorithm, bits are shifted towards the least significant bit. This produces different checksums than the classical, or forward algorithm, using the same polynomials.

See Also

checksum

create_task

Create a New Task

Syntax

```
#include <ctools.h>
int create_task(void *function, unsigned priority, unsigned type, unsigned
   stack);
```

Description

The **create_task** function allocates stack space for a task and places the task on the ready queue. *function* specifies the start address of the routine to be executed. The task will execute immediately if its priority is higher than the current task.

priority is an execution priority between 1 and 4 for the created task. The 4 task priority levels aid in scheduling task execution.

type specifies if the task is ended when an application program is stopped. Valid values for *type* are:

SYSTEM system tasks do not terminate when the program stops

APPLICATION application tasks terminate when the program stops

It is recommended that only **APPLICATION** type tasks be created.

The *stack* parameter specifies how many stack blocks are allocated for the task. Each stack block is 256 bytes.

The **create_task** function returns the task ID (TID) of the task created. If an error occurs, -1 is returned.

Notes

Refer to the **Real Time Operating System** section for more information on tasks.

Note that the **main** task and the Ladder Logic and I/O scanning task have a priority of 1. If the created task is continuously running processing code, create the task with a priority of 1 and call **release_processor** periodically; otherwise the remaining priority 1 tasks will be blocked from executing.

For tasks such as a protocol handler, that wait for an event using the **wait_event** or **receive_message** function, a priority greater than 1 may be selected without blocking other lower priority tasks.

The number of stack blocks required depends on the functions called within the task, and the size of local variables created. Most tasks require 2 stack blocks. If any of the **printf** functions are used, then at least 4 stack blocks are required. Add local variable usage to these limits, if large local arrays or structures are created. Large structures and arrays are usually best handled as static global variables within the task source file. (The variables are global to all functions in the task, but cannot be seen by functions in other files.)

Additional stack space may be made available by disabling unused protocol tasks. See the section **Program Development** or the set_protocol() function for more information.

See Also

end_task

Example

```
#include <ctools.h>

#define   TIME_TO_PRINT    20

void task1(void)
{
       int a, b;

       while (TRUE)
       {
          /* body of task 1 loop - processing I/O */

          request_resource(IO_SYSTEM);
          a = dbase(MODBUS, 30001);
          b = dbase(MODBUS, 30002);
          setdbase(MODBUS, 40020, a * b);
          release_resource(IO_SYSTEM);

          /* Allow other tasks to execute */
          release_processor();
       }
}

void task2(void)
{
       while(TRUE)
       {
          /* body of task 2 loop - event handler */
          wait_event(TIME_TO_PRINT);
          printf("It's time for a coffee break\r\n");
       }
}
/* -----------------------------------------
   The shutdown function stops the signalling
   of TIME_TO_PRINT events when application is
       stopped.
   ----------------------------------------- */
void shutdown(void)
{
       endTimedEvent(TIME_TO_PRINT);
}
void main(void)
{
       TASKINFO taskStatus;

       /* continuos processing task at priority 1 */
       create_task(task1, 1, APPLICATION, 2);

       /* event handler needs larger stack for printf function */
       create_task(task2, 3, APPLICATION, 4);

       /* set up task exit handler to stop
          signalling of events when this task ends */
       taskStatus = getTaskInfo(0);
   installExitHandler(taskStatus.taskID, shutdown);

       /* start timed event to occur every 10 sec */
       startTimedEvent(TIME_TO_PRINT, 100);

       interval(0, 10);
       while(TRUE)
       {
          /* body of main task loop */
          /* other processing code */
          /* Allow other tasks to execute */
```

```
            release_processor();
        }
    }
```

databaseRead

Read Value from I/O Database

Syntax

```
#include <ctools.h>
BOOLEAN databaseRead(UINT16 type, UINT16 address, INT16* value)
```

Description

The **databaseRead** function reads a value from the database. The value is written to the variable pointed to by `value`. The variable is not changed if type and address are not valid.

The function has three parameters. `type` specifies the method of addressing the database. Valid values are `MODBUS` and `LINEAR`. `address` specifies the location in the database. `value` is a pointer to a variable to hold the result.

The function returns `TRUE` if the specified address is valid and FALSE if the register does not exist.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

databaseWrite

Example

```
#include <ctools.h>
void main(void)
{
       INT16 value;
       BOOLEAN status;

       request_resource(IO_SYSTEM);

       /* Read Modbus status input point */
       status = databaseRead(MODBUS, 10001, &value);

       /* Read 16 bit register */
       status = databaseRead(LINEAR, 3020, &value);

       release_resource(IO_SYSTEM);
}
```

databaseWrite

Write Value to I/O Database

Syntax

```
#include <ctools.h>
BOOLEAN databaseWrite(UINT16 type, UINT16 address, INT16 value)
```

Description

The **databaseWrite** function writes `value` to the I/O database.

The function has three parameters. `type` specifies the method of addressing the database. Valid values are `MODBUS` and `LINEAR`. `address` specifies the location in the database. `value` is the data to write.

The function returns TRUE if the value was written. The function returns FALSE if

- the type is invalid
- the address is not valid for the controller
- the address is read only on the SCADASense 4202 controller (some registers in the range 40001 to 40499).
- the data is not valid for the address on the SCADASense 4202 controller (some registers in the range 40001 to 40499).
- the hardware write protect is installed on the SCADASense 4202 controller (registers in the range 40001 to 40499).
- the flow computer is running on the SCADASense 4202 controller (registers in the range 40001 to 40499).

Notes

When writing to LINEAR digital addresses, *value* is a bit mask which writes data to 16 1-bit registers at once. If any of these 1-bit registers is invalid, only the valid registers are written and FALSE is returned.

The IO_SYSTEM resource must be requested before calling this function.

See Also

databaseRead

Example

```
#include <ctools.h>

void main(void)
{
       BOOLEAN status;
       request_resource(IO_SYSTEM);

       status = databaseWrite(MODBUS, 40001, 102);

       /* Turn ON the first 16 coils */
       status = databaseWrite(LINEAR, 0, 255);
```

```
        /* Write to a 16 bit register */
        status = databaseWrite(LINEAR, 3020, 240);

        release_resource(IO_SYSTEM);
}
```

datalogCreate

Create Data Log Function

Syntax

```
#include <ctools.h>
DATALOG_STATUS datalogCreate(
UINT16 logID,
DATALOG_CONFIGURATION * pLogConfiguration
);
```

Description

This function creates a data log with the specified configuration. The data log is created in the data log memory space.

The function has two parameters. `logID` specifies the data log to be created. The valid range is 0 to 15. `pLogConfiguration` points to a structure with the configuration for the data log.

The function returns the status of the operation.

Notes

The configuration of an existing data log cannot be changed. The log must be deleted and recreated to change the configuration.

All data logs are stored in memory from a pool for all data logs. If there is insufficient memory the creation operation fails. The function returns `DLS_NOMEMORY`.

If the data log already exists the creation operation fails. The function returns `DLS_EXISTS`.

If the log ID is not valid the creation operation fails. The function returns `DLS_BADID`.

If the configuration is not valid the creation operation fails. The function returns `DLS_BADCONFIG`.

See Also

datalogDelete datalogSettings

Example

```
/*-----------------------------------------------
  The following code shows how to create a
  data log and how to write one record into it.
  -----------------------------------------------*/
#include "ctools.h"
/*---------------------------------
  Structure used only to copy one
  record into data log
---------------------------------*/
struct dataRecord
{
      UINT16      value1;
      int         value2;
      double      value3;
      float       value4;
```

```
      float       value5;
};
int logID;
/*---------------------------------
  Declare a structure for the log
---------------------------------*/
DATALOG_CONFIGURATION dLogConfig;
/*---------------------------------
  Declare a struture to hold the
  data that will be copied in log
---------------------------------*/
struct dataRecord data;
/*----------------------
  Function declaration
----------------------*/
void ConfigureLog(void);
void InitRecord(void);

void main(void)
{
      ConfigureLog();         /* function call to cofigure log */
      InitRecord();

      if(datalogCreate(logID, &dLogConfig) == DLS_CREATED)
      {
            /* Start writing records in log */
            if( datalogWrite(logID, (UINT16 *)&data) )
            {
                  /* one record was written in data log */
            }
      }
}

/* Log configuration */
void ConfigureLog(void)
{
      /* Assign a number to the data log */
      logID = 10;

      /* Fill in the log configuration structure */
      dLogConfig.records = 200;
      dLogConfig.fields = 5;
      dLogConfig.typesOfFields[0] = DLV_UINT16;
      dLogConfig.typesOfFields[1] = DLV_INT32;
      dLogConfig.typesOfFields[2] = DLV_DOUBLE;
      dLogConfig.typesOfFields[3] = DLV_FLOAT;
      dLogConfig.typesOfFields[4] = DLV_FLOAT;
}

/* One record initialization */
void InitRecord(void)
{
      /* Assign some data for the log */
      data.value1 = 100;
      data.value2 = 200;
      data.value3 = 30000;
      data.value4 = 40.3;
      data.value5 = 50.75;
}
```

datalogDelete

Delete Data Log Function

Syntax

```
#include <ctools.h>
BOOLEAN datalogDelete(
UINT16 logID
);
```

Description

This function destroys the specified data log. The memory used by the data log is returned to the freed.

The function has one parameter. `logID` specifies the data log to be deleted. The valid range is 0 to 15.

The function returns TRUE if the data log was deleted. The function returns FALSE if the log ID is not valid or if the log had not been created.

See Also

datalogCreate

Example

```
/* The following code shows the only way to
   change the configuration of an existing log
   is to delete the log and recreate the data
   log                                          */

#include <ctools.h>

int logID;

/* Declare a structure for the log */
DATALOG_CONFIGURATION dLogConfig;

/* Select logID #10 */
logID = 10;

/* Read the configuration of logID #10 */
if( datalogSettings( logID,  &dLogConfig ) )
{
  if(dLogConfig.typesOfFields[0] == DLV_INT16)
  {
    /* Wrong type.  Delete whole log and start from scratch */
    if(datalogDelete(logID) )
    {
      /* Re-enter the log configuration */
      dLogConfig.records = 200;
      dLogConfig.fields = 5;
      dLogConfig.typesOfFields[0] = DLV_UINT16;
      dLogConfig.typesOfFields[1] = DLV_INT32;
      dLogConfig.typesOfFields[2] = DLV_DOUBLE;
      dLogConfig.typesOfFields[3] = DLV_FLOAT;
```

```
      dLogConfig.typesOfFields[4] = DLV_FLOAT;
      datalogCreate(logID, &dLogConfig);
    }
    else
    {
      /* could not delete log */
    }
  }
}
else
{
  /* Could not read settings */
}
```

datalogPurge

Purge Data Log Function

Syntax

```
#include <ctools.h>
BOOLEAN datalogPurge(
UINT16 logID,
BOOLEAN purgeAll,
UINT32 sequenceNumber
);
```

Description

This function removes records from a data log. The function can remove all the records, or a group of records starting with the oldest in the log.

The function has three parameters. `logID` specifies the data log. The valid range is 0 to 15. If `purgeAll` is TRUE, all records are removed, otherwise the oldest records are removed. `sequenceNumber` specifies the sequence number of the most recent record to remove. All records up to and including this record are removed. This parameter is ignored if `purgeAll` is TRUE.

The function returns TRUE if the operation succeeds. The function returns FALSE if the log ID is invalid, if the log has not been created, or if the sequence number cannot be found in the log.

Notes

Purging the oldest records in the log is usually done after reading the log. The sequence number used is that of the last record read from the log. This removes the records that have been read and leaves any records added since the records were read.

If the sequence number specifies a record that is not in the log, no records are removed.

See Also

datalogReadStart datalogReadNext datalogWrite

Example

```
#include <ctools.h>

int logID, sequenceNumber;

/* Declare flag to purge entire of data log or part of it */
BOOLEAN purgeAll;

/* Which data log to purge? */
logID = 10;

/* Set flag to purge only part of data log */
purgeAll = FALSE;

/* How many of the oldest records to purge */
sequenceNumber = 150;
```

```
if( datalogPurge(logID, purgeAll, sequenceNumber) )
{
      /* Successful at purging the first 150 records of log */
      /* Start writing records again */
}

/* To purge the entire data log, simply set flag to TRUE */
purgeAll = TRUE;

/* Call up function with same parameters */
if( datalogPurge(logID, purgeAll, sequenceNumber) )
{
      /* Successful at purging the entire data log */
      /* Start writing records again */
}
```

datalogReadNext

Read Data Log Next Function

This function returns the next record in the data log.

Syntax

```
#include <ctools.h>
BOOLEAN datalogReadNext(
UINT16 logID,
UINT32 sequenceNumber,
UINT32 * pSequenceNumber,
UINT32 * pNextSequenceNumber,
UINT16 * pData
);
```

Description

This function reads the next record from the data log starting at the specified sequence number. The function returns the record with the specified sequence number if it is present in the log. If the record no longer exists it returns the next record in the log.

The function has five parameters. `logID` specifies the data log. The valid range is 0 to 15. `sequenceNumber` is sequence number of the record to be read. `pSequenceNumber` is a pointer to a variable to hold the sequence number of the record read. `pNextSequenceNumber` is a pointer to a variable to hold the sequence number of the next record in the log. This is normally used for the next call to this function. `pData` is a pointer to memory to hold the data read from the log.

The function returns TRUE if a record is read from the log. The function returns FALSE if the log ID is not valid, if the log has not been created or if there are no more records in the log.

Notes

Use the `datalogReadStart` function to obtain the sequence number of the oldest record in the data log.

The `pData` parameter must point to memory of sufficient size to hold all the data in a record.

It is normally necessary to call this function until it returns FALSE in order to read all the data from the log. This accommodates cases where data is added to the log while it is being read.

If data is read from the log at a slower rate than it is logged, it is possible that the sequence numbers of the records read will not be sequential. This indicates that records were overwritten between calls to read data.

The sequence number rolls over after reaching its maximum value.

See Also

datalogReadStart datalogPurge datalogWrite

Example

See the example for **datalogReadStart**.

datalogReadStart

Read Data Log Start Function

Syntax

```
#include <ctools.h>
BOOLEAN datalogReadStart(
UINT16 logID,
UINT32 * pSequenceNumber
);
```

Description

This function returns the sequence number of the record at the start of the data log. This is the oldest record in the log.

The function has two parameters. `logID` specifies the data log. The valid range is 0 to 15. `pSequenceNumber` is a pointer to a variable to hold the sequence number.

The function returns TRUE if the operation succeeded. The function returns FALSE if the log ID is not valid or if the log has not been created.

Notes

Use the `datalogReadNext` function to read records from the log.

The function will return a sequence number even if the log is empty. In this case the next call to `datalogReadNext` will return no data.

See Also

datalogReadNext datalogPurge datalogWrite

Example

```
/*********************************************
  The following code shows how to read records
  from data log.
*********************************************/

#include "ctools.h"
#include <stdlib.h>

UINT16 recordSize,
       logID,
       *pData; /* Pointer to memory to hold data read from log. */

UINT32 sequenceNumber,/* Sequence number of record to be read. */
        nextSequenceNumber; /* Sequence number of next record.  */

void main(void)
{
  /* Select data log #10 */
  logID = 10;

  /* Find first record in data log #10 and store
    its sequence number into sequenceNumber */
```

```
  if( datalogReadStart(logID, &sequenceNumber) )
    {
      /* Get the size of this record */
      if( datalogRecordSize(logID, &recordSize) )
        {
        /* Allocate memory of size recordSize */
        pData = (UINT16 *) malloc(recordSize);

        /* Read all records from data log #10. */
          while( datalogReadNext(logID, sequenceNumber,
&sequenceNumber, &nextSequenceNumber, pData) )
            {
                 /* Use pData and its contents.
                   Set next sequence number of record to be read. */

                 sequenceNumber =  nextSequenceNumber;
             }
          }
      }
  }
```

datalogRecordSize

Data Log Record Size Function

Syntax

```
#include < ctools.h >
BOOLEAN datalogRecordSize(
UINT16 logID,
UINT16 * pRecordSize;
);
```

Description

This function returns the size of a record for the specified data log. The log must have been previously created with the `datalogCreate` function.

The function has two parameters. `logID` specifies the data log. The valid range is 0 to 15. `pRecordSize` points to a variable that will hold the size of a record in the log.

The function returns TRUE if the operation succeeded. The function returns FALSE if the log ID is invalid or if the data log does not exist.

Notes

This function is useful in determining how much memory must be allocated for a call to `datalogReadNext` or `datalogWrite`.

See Also

datalogSettings

Example

See the example for **datalogReadStart**.

datalogSettings

Data Log Settings Function

Syntax

```
#include < ctools.h >
BOOLEAN datalogSettings(
UINT16 logID,
DATALOG_CONFIGURATION * pLogConfiguration
);
```

Description

This function reads the configuration of the specified data log. The log must have been previously created with the `datalogCreate` function.

The function has two parameters. `logID` specifies the data log. The valid range is 0 to 15. `pLogConfiguration` points to a structure that will hold the data log configuration.

The function returns TRUE if the operation succeeded. The function returns FALSE if the log ID is invalid or if the data log does not exist.

Notes

The configuration of an existing data log cannot be changed. The log must be deleted and recreated to change the configuration.

See Also

datalogRecordSize

Example

See example for **datalogDelete**.

datalogWrite

Write Data Log Function

Syntax

```
#include <ctools.h>
BOOLEAN datalogWrite(
UINT16 logID,
UINT16 * pData
);
```

Description

This function writes a record to the specified data log. The log must have been previously created with the `datalogCreate` function.

The function has two parameters. `logID` specifies the data log. The valid range is 0 to 15. `pData` is a pointer to the data to be written to the log. The amount of data copied using the pointer is determined by the configuration of the data log.

The function returns TRUE if the data is added to the log. The function returns FALSE if the log ID is not valid or if the log does not exist.

Notes

Refer to the `datalogCreate` function for details on the configuration of the data log.

If the data log is full, then the oldest record in the log is replaced with this record.

See Also

datalogReadStart datalogReadNext datalogPurge

Example

See the example for **datalogDelete**.

dbase

Read Value from I/O Database

Syntax

```
#include <ctools.h>
int dbase(unsigned type, unsigned address);
```

Description

The **dbase** function reads a value from the I/O database. *type* specifies the method of addressing the database. *address* specifies the location in the database. The table below shows the valid address types and ranges

Type	Address Ranges	Register Size
MODBUS	00001 to NUMCOIL 10001 to 10000 + NUMSTATUS 30001 to 30000 + NUMINPUT 40001 to 40000 + NUMHOLDING	1 bit 1 bit 16 bit 16 bit
LINEAR	0 to NUMLINEAR-1	16 bit

Notes

Refer to the *I/O Database and Register Assignment* chapter for more information.

If the specified register is currently forced, **dbase** returns the forced value for the register.

The I/O database is not modified when the controller is reset. It is a permanent storage area, which is maintained during power outages.

The IO_SYSTEM resource must be requested before calling this function.

See Also

setdbase

Example

```
#include <ctools.h>

void main(void)
{
       int a;

       request_resource(IO_SYSTEM);

       /* Read Modbus status input point */
       a = dbase(MODBUS, 10001);

       /* Read 16 bit register */
       a = dbase(LINEAR, 3020);

       /* Read 16 bit register beginning at first
       status register */
       a = dbase(LINEAR, START_STATUS);

       /* Read 6th input register */
       a = dbase(LINEAR, START_INPUT + 5);
```

```
        release_resource(IO_SYSTEM);
}
```

deallocate_envelope

Return Envelope to the RTOS

Syntax

```
#include <ctools.h>
void deallocate_envelope(envelope *penv);
```

Description

The **deallocate_envelope** function returns the envelope pointed to by *penv* to the pool of free envelopes maintained by the operating system.

See Also

allocate_envelope

Example

See the example for the **allocate_envelope** function.

din

Read Digital I/O

Syntax

```
#include <ctools.h>
int din(unsigned channel);
```

Description

The **din** function reads the value of a digital input or output channel. Reading an input channel returns data read from a digital input module. Reading an output channel returns the last value written to the output module.

The **din** function returns a value corresponding to the sum of the binary states of all 8 bits of the channel.

Notes

The **din** function reads the status of digital input signals, and digital output modules.

The **din** function may be used to read the current values in the I/O disable, forced status and I/O form tables, and I/O type tables.

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START, DOUT_END, EXTENDED_DIN_START, EXTENDED_DIN_END, EXTENDED_DOUT_START and EXTENDED_DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead8Din** directly.

See Also

pulse, timeout, turnon, turnoff, on, off

Example

This program displays the first 8 digital inputs in binary.

```
#include <ctools.h>

void main(void)
{
       int loop, value;

       /* Read the first digital input channel */
       request_resource(IO_SYSTEM);
       value = din(DIN_START);
       release_resource(IO_SYSTEM);

       printf("Channel =");

       /* For each bit in the channel */
       for(loop = 8; loop; loop--)
```

```
        {
            putchar((value & 0x80) ? '1' :'0')

            /* Select the next bit */
            value <<= 1;
        }
        puts( "\r\n" );
}
```

dnpInstallConnectionHandler

Configures the connection handler for DNP.

Syntax

```
#include <ctools.h>
void dnpInstallConnectionHandler(void (* function)
(DNP_CONNECTION_EVENT event));
```

Description

This function installs a handler that will permit user-defined actions to occur when DNP requires a connection, message confirmation is received, or a timeout occurs.

`function` is a pointer to the handler function. If function is NULL the handler is disabled.

The function has no return value.

Notes

The handler function must process the event and return immediately. If the required action involves waiting this must be done outside of the handler function. See the example below for one possible implementation.

The application must disable the handler when the application ends. This prevents the protocol driver from calling the handler while the application is stopped. Call the `dnpInstallConnectionHandler` with a NULL pointer. The usual method is to create a task exit handler function to do this. See the example below for details.

The handler function has one parameter.

- `event` is DNP event that has occurred. It may be one of `DNP_CONNECTION_REQUIRED`, `DNP_MESSAGE_COMPLETE`, or `DNP_MESSAGE_TIMEOUT`. See the structure definition for the meaning of these events.

The handler function has no return value.

By default no connection handler is installed and no special steps are taken when DNP requires a connection, receives a message confirmation, or a timeout occurs.

See Also

`dnpConnectionEvent`

Example

This example shows how a C application can handle the events and inform a logic application of the events. The logic application is responsible for making and ending the dial-up connection.

The program uses the following registers.

- 10001 turns on when a connection is requested by DNP for unsolicited reporting.
- 10002 turns on when the unsolicited report is complete.
- 10003 turns on when the unsolicited report is fails.

- The ladder logic program turns on register 1 when the connection is complete and turns off the register when the connection is broken.

```
/* ---------------------------------------------------------------------
   dnp.c
   Demonstration program for using the DNP connection handler.

   Copyright 2001, Control Microsystems Inc.
   --------------------------------------------------------------------- */

/* ---------------------------------------------------------------------
   Include Files
   --------------------------------------------------------------------- */
#include <ctools.h>

/* ---------------------------------------------------------------------
   Constants
   --------------------------------------------------------------------- */
#define CONNECTION_REQUIRED  10001    /* register for signaling connection required */
#define MESSAGE_COMPLETE     10002    /* register for signaling unsolicited message is
                                         complete */
#define MESSAGE_FAILED       10003    /* register for signaling unsolicited message
                                         failed */
#define CONNECTION_STATUS    1        /* connection status register */

/* ---------------------------------------------------------------------
   Private Functions
   --------------------------------------------------------------------- */

/* ---------------------------------------------------------------------
   sampleDNPHandler

   This function is the user defined DNP connection handler.  It will be
   called by internal DNP routines when a connection is required, when
   confirmation of a message is received, and when a communication timeout
   occurs.

   The function takes a variable of type DNP_CONNECTION_EVENT as an input.
   This input instructs the handler as to what functionality is required.
   The valid choices are connection required (DNP_CONNECTION_REQUIRED),
   message confirmation received (DNP_MESSAGE_COMPLETE), and timeout occurred
   (DNP_MESSAGE_TIMEOUT).

   The function does not return any values.
   --------------------------------------------------------------------- */
static void sampleDNPHandler(DNP_CONNECTION_EVENT event)
{
       /* Determine what connection event is required or just occurred */
       switch(event)
       {
              case DNP_CONNECTION_REQUIRED:
                     /* indicate connection is needed and clear other bits */
                     request_resource(IO_SYSTEM);
                     setdbase(MODBUS, CONNECTION_REQUIRED, 1);
                     setdbase(MODBUS, MESSAGE_COMPLETE, 0);
                     setdbase(MODBUS, MESSAGE_FAILED, 0);
                     release_resource(IO_SYSTEM);
                     break;

              case DNP_MESSAGE_COMPLETE:
                     /* indicate message sent and clear other bits */
                     request_resource(IO_SYSTEM);
                     setdbase(MODBUS, CONNECTION_REQUIRED, 0);
                     setdbase(MODBUS, MESSAGE_COMPLETE, 1);
                     setdbase(MODBUS, MESSAGE_FAILED, 0);
                     release_resource(IO_SYSTEM);
                     break;

              case DNP_MESSAGE_TIMEOUT:
                     /* indicate message failed and clear other bits */
                     request_resource(IO_SYSTEM);
                     setdbase(MODBUS, CONNECTION_REQUIRED, 0);
                     setdbase(MODBUS, MESSAGE_COMPLETE, 0);
                     setdbase(MODBUS, MESSAGE_FAILED, 1);
                     release_resource(IO_SYSTEM);
```

```
                        break;

                default:
                        /* ignore invalid requests */
                        break;
        }
}

/* ---------------------------------------------------------------------
   Public Functions
   --------------------------------------------------------------------- */

/* ---------------------------------------------------------------------
   main

   This function is the main task of a user application. It monitors a
   register from the ladder logic application. When the register value
   changes, the function signals DNP events.

   The function has no parameters.

   The function does not return.
   --------------------------------------------------------------------- */
void main(void)
{
        int lastConnectionState;      /* last state of connection register */
        int currentConnectionState;   /* current state of connection register */

        /* install DNP connection handler */
        dnpInstallConnectionHandler(sampleDNPHandler);

        /* get the current connection state */
        lastConnectionState = dbase(MODBUS, CONNECTION_STATUS);

        /* loop forever */
        while (TRUE)
        {
                request_resource(IO_SYSTEM);

                /* get the current connection state */
                currentConnectionState = dbase(MODBUS, CONNECTION_STATUS);

                /* if the state has changed */
                if (currentConnectionState != lastConnectionState)
                {
                        /* if the connection is active */
                        if (currentConnectionState)
                        {
                                /* Inform DNP that a connection exists */
                                dnpConnectionEvent(DNP_CONNECTED);

                                /* clear the request flag */
                                setdbase(MODBUS, CONNECTION_REQUIRED, 0);
                        }
                        else
                        {
                                /* Inform DNP that the connection is closed */
                                dnpConnectionEvent(DNP_DISCONNECTED);

                                /* clear the message flags */
                                setdbase(MODBUS, MESSAGE_COMPLETE, 0);
                                setdbase(MODBUS, MESSAGE_FAILED, 0);
                        }

                        /* save the new state */
                        lastConnectionState = currentConnectionState;
                }

                /* release the processor so other tasks can run */
                release_resource(IO_SYSTEM);
                release_processor();
        }
}
```

dnpClearEventLog

Clear DNP Event Log

Syntax:

```
#include <ctools.h>
BOOLEAN dnpClearEventLog(void);
```

Description:

The **dnpClearEventLogs** function deletes all change events from the DNP change event buffers, for all point types.

Example:

See the example in the section **dnpSendUnsolicited**.

dnpConnectionEvent

Report a DNP connection event

Syntax

```
#include <ctools.h>
void dnpConnectionEvent(DNP_CONNECTION_EVENT event);
```

Description

`dnpConnectionEvent` is used to report a change in connection status to DNP. This function is only used if a custom DNP connection handler has been installed.

`event` is current connection status. The valid connection status settings are `DNP_CONNECTED`, and `DNP_DISCONNECTED`.

See Also

`dnpInstallConnectionHandler`

Example

See the `dnpInstallConnectionHandler` example.

dnpCreateRoutingTable

Create Routing Table

Syntax

```
#include <ctools.h>
BOOLEAN createRoutingTable (UINT16 size);
```

Description

This function destroys any existing DNP routing table, and allocates memory for a new routing table according to the ‘size’ parameter.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

The function returns TRUE if successful, FALSE otherwise.

Example

See the example in the section **dnpSendUnsolicited**.

dnpGenerateEventLog

Generate DNP Event Log

Syntax

```
#include <ctools.h>
BOOLEAN dnpGenerateEventLog(
   UINT16 pointType,
   UINT16 pointAddress
);
```

Description

The `dnpGenerateEventLog` function generates a change event for the DNP point specified by `pointType` and `pointAddress`.

`pointType` specifies the type of DNP point. Allowed values are:

BI_POINT	binary input
AI16_POINT	16 bit analog input
AI32_POINT	32 bit analog input
AISF_POINT	short float analog input
CI16_POINT	16 bit counter output
CI32_POINT	32 bit counter output

`pointAddress` specifies the DNP address of the point.

A change event is generated for the specified point (with the current time and current value), and stored in the DNP event buffer.

The format of the event will depend on the Event Reporting Method and Class of Event Object that have been configured for the point.

The function returns TRUE if the event was generated. It returns FALSE if the DNP point is invalid, or if the DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

Example

See the example in the section **dnpSendUnsolicited**.

dnpGetAI16Config

Get DNP 16-bit Analog Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetAI16Config(
      UINT16 point,
      dnpAnalogInput * pAnalogInput
      );
```

Description

This function reads the configuration of a DNP 16-bit analog input point.

The function has two parameters: the point number; and a pointer to an analog input point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveAI16Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetAI32Config

Get DNP 32-bit Analog Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetAI32Config(
      UINT32 point,
      dnpAnalogInput * pAnalogInput
      );
```

Description

This function reads the configuration of a DNP 32-bit analog input point.

The function has two parameters: the point number; and a pointer to an analog input point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveAI32Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetAISFConfig

Get Short Floating Point Analog Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetAISFConfig (
      UINT16 point,
      dnpAnalogInput *pAnalogInput;
);
```

Description

This function reads the configuration of a DNP short floating point analog input point.

The function has two parameters: the point number, and a pointer to a configuration structure.

The function returns TRUE if the configuration was successfully read, or FALSE otherwise (if the point number is not valid, or pointer is NULL, or if the DNP configuration has not been created).

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

dnpGetAO16Config

Get DNP 16-bit Analog Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetAO16Config(
      UINT16 point,
      dnpAnalogOutput * pAnalogOutput
      );
```

Description

This function reads the configuration of a DNP 16-bit analog output point.

The function has two parameters: the point number; and a pointer to an analog output point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveAO16Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetAO32Config

Get DNP 32-bit Analog Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetAO32Config(
      UINT32 point,
      dnpAnalogOutput * pAnalogOutput
      );
```

Description

This function reads the configuration of a DNP 32-bit analog output point.

The function has two parameters: the point number; and a pointer to an analog output point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveAO32Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetAOSFConfig

Get Short Floating Point Analog Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetAOSFConfig (
      UINT16 point,
      dnpAnalogOutput *pAnalogOutput;
);
```

Description

This function reads the configuration of a DNP short floating point analog output point.

The function has two parameters: the point number, and a pointer to a configuration structure.

The function returns TRUE if the configuration was successfully read, or FALSE otherwise (if the point number is not valid, or pointer is NULL, or if the DNP configuration has not been created).

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

dnpGetBIConfig

Get DNP Binary Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetBIConfig(
      UINT16 point,
      dnpBinaryInput * pBinaryInput
      );
```

Description

This function reads the configuration of a DNP binary input point.

The function has two parameters: the point number; and a pointer to a binary input point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveBIConfig

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetBIConfigEx

Read DNP Binary Input Extended Point

Syntax

```
BOOLEAN dnpGetBIConfigEx(
      UINT16 point,
      dnpBinaryInputEx *pBinaryInput
);
```

Description

This function reads the configuration of an extended DNP Binary Input point.

The function has two parameters: the point number, and a pointer to an extended binary input point configuration structure.

The function returns TRUE if the configuration was successfully read. It returns FALSE if the point number is not valid, if the configuration is not valid, or if the DNP configuration has not been created.

This function supersedes `dnpSaveBIConfig`.

dnpGetBOConfig

Get DNP Binary Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetBOConfig(
      UINT16 point,
      dnpBinaryOutput * pBinaryOutput
      );
```

Description

This function reads the configuration of a DNP binary output point.

The function has two parameters: the point number; and a pointer to a binary output point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetCI16Config

Get DNP 16-bit Counter Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetCI16Config(
      UINT16 point,
      dnpCounterInput * pCounterInput
      );
```

Description

This function reads the configuration of a DNP 16-bit counter input point.

The function has two parameters: the point number; and a pointer to a counter input point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveCI16Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetCI32Config

Get DNP 32-bit Counter Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetCI32Config(
      UINT32 point,
      dnpCounterInput * pCounterInput
      );
```

Description

This function reads the configuration of a DNP 32-bit counter input point.

The function has two parameters: the point number; and a pointer to a counter input point configuration structure.

The function returns TRUE if the configuration was read. It returns FALSE if the point number is not valid, if the pointer is NULL, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpSaveCI32Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpGetConfiguration

Get DNP Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpGetConfiguration(
      dnpConfiguration * pConfiguration
      );
```

Description

This function reads the DNP configuration.

The function has one parameter: a pointer to a DNP configuration structure.

The function returns TRUE if the configuration was read and FALSE if an error occurred.

See Also

dnpSaveConfiguration

Example

The following program demonstrates how to configure DNP for operation on com2. To illustrate creation of points it uses a sequential mapping of Modbus registers to points. This is not required. Any mapping may be used.

```
void main(void)
{
       UINT16 index;                        /* loop index */
       struct prot_settings settings;       /* protocol settings */
       dnpConfiguration configuration;      /* configuration settings */
       dnpBinaryInput binaryInput;          /* binary input settings */
       dnpBinaryOutput binaryOutput;        /* binary output settings */
       dnpAnalogInput analogInput;          /* analog input settings */
       dnpAnalogOutput analogOutput;        /* analog output settings */
       dnpCounterInput counterInput;        /* counter input settings */

       /* Stop any protocol currently active on com port 2 */
       get_protocol(com2,&settings);
       settings.type = NO_PROTOCOL;
       set_protocol(com2,&settings);

       /* Load the Configuration Parameters */
       configuration.masterAddress         = DEFAULT_DNP_MASTER;
       configuration.rtuAddress            = DEFAULT_DNP_RTU;
       configuration.datalinkConfirm       = TRUE;
       configuration.datalinkRetries       = DEFAULT_DLINK_RETRIES;
       configuration.datalinkTimeout       = DEFAULT_DLINK_TIMEOUT;

       configuration.operateTimeout        = DEFAULT_OPERATE_TIMEOUT;
       configuration.applicationConfirm    = TRUE;
       configuration.maximumResponse       = DEFAULT_MAX_RESP_LENGTH;
       configuration.applicationRetries    = DEFAULT_APPL_RETRIES;
       configuration.applicationTimeout    = DEFAULT_APPL_TIMEOUT;
       configuration.timeSynchronization   = TIME_SYNC;

       configuration.BI_number             = 8;
       configuration.BI_cosBufferSize      = DEFAULT_COS_BUFF;
       configuration.BI_soeBufferSize      = DEFAULT_SOE_BUFF;
       configuration.BO_number             = 8;
       configuration.CI16_number           = 24;
       configuration.CI16_bufferSize       = 48;
       configuration.CI32_number           = 12;
```

```
configuration.CI32_bufferSize       = 24;
configuration.AI16_number           = 24;
configuration.AI16_reportingMethod  = CURRENT_VALUE;
configuration.AI16_bufferSize       = 24;
configuration.AI32_number           = 12;
configuration.AI32_reportingMethod  = CURRENT_VALUE;
configuration.AI32_bufferSize       = 12;
configuration.AO16_number           = 8;
configuration.AO32_number           = 8;

configuration.unsolicited           = TRUE;

configuration.holdTime              = DEFAULT_HOLD_TIME;
configuration.holdCount             = DEFAULT_HOLD_COUNT;

dnpSaveConfiguration(&configuration);

/* Start DNP protocol on com port 2 */
get_protocol(com2,&settings);
settings.type = DNP;
set_protocol(com2,&settings);

/* Save port settings so DNP protocol will automatically start */
request_resource(IO_SYSTEM);
save(EEPROM_RUN);
release_resource(IO_SYSTEM);

/* Configure Binary Output Points */
for (index = 0; index < configuration.BO_number; index++)
{
       binaryOutput.modbusAddress1 = 1 + index;
       binaryOutput.modbusAddress2 = 1 + index;
       binaryOutput.controlType    = NOT_PAIRED;

       dnpSaveBOConfig(index, &binaryOutput);
}

/* Configure Binary Input Points */
for (index = 0;index < configuration.BI_number; index++)
{
       binaryInput.modbusAddress = 10001 + index;
       binaryInput.class         = CLASS_1;
       binaryInput.eventType     = COS;

       dnpSaveBIConfig(index, &binaryInput);
}

/* Configure 16 Bit Analog Input Points */
for (index = 0; index < configuration.AI16_number; index++)
{
       analogInput.modbusAddress  = 30001 + index;
       analogInput.class          = CLASS_2;
       analogInput.deadband       = 1;

       dnpSaveAI16Config(index, &analogInput);
}

/* Configure32 Bit Analog Input Points */
for (index = 0; index < configuration.AI32_number; index++)
{
       analogInput.modbusAddress  = 30001 + index * 2;
       analogInput.class          = CLASS_2;
       analogInput.deadband       = 1;

       dnpSaveAI32Config(index,&analogInput);
}

/* Configure 16 Bit Analog Output Points */
for (index = 0;index < configuration.AO16_number; index++)
{
       analogOutput.modbusAddress = 40001 + index;

       dnpSaveAO16Config(index, &analogOutput);
}
```

```
        /* Configure 32 Bit Analog Output Points */
        for (index = 0; index < configuration.AO32_number; index++)
        {
                analogOutput.modbusAddress = 40101 + index * 2;

                dnpSaveAO32Config(index, &analogOutput);
        }

        /* Configure 16 Bit Counter Input Points */
        for (index = 0; index < configuration.CI16_number; index++)
        {
                counterInput.modbusAddress = 30001 + index;
                counterInput.class         = CLASS_3;
                counterInput.threshold     = 1;

                dnpSaveCI16Config(index, &counterInput);
        }

        /* Configure 32 bit Counter Input Points */
        for (index = 0; index < configuration.CI32_number; index++)
        {
                counterInput.modbusAddress = 30001 + index * 2;
                counterInput.class         = CLASS_3;
                counterInput.threshold     = 1;

                dnpSaveCI32Config(index, &counterInput);
        }

        /* add additional initialization code for your application here ... */

        /* loop forever */
        while (TRUE)
        {
                /* add additional code for your application here ... */

                /* allow other tasks of this priority to execute */
                release_processor();
        }
        return;
}
```

dnpGetConfigurationEx

Read DNP Extended Configuration

Syntax

```
BOOLEAN dnpGetConfigurationEx (
      dnpConfigurationEx *pDnpConfigurationEx
);
```

Description

This function reads the extended DNP configuration parameters.

The function has one parameter: a pointer to the DNP extended configuration structure.

The function returns TRUE if the configuration was successfully read, or FALSE otherwise (if the pointer is NULL, or if the DNP configuration has not been created).

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

This function supersedes the `dnpGetConfiguration` function.

dnpGetRuntimeStatus

Get DNP Runtime Status

Syntax:

```
#include <ctools.h>
BOOLEAN dnpGetRuntimeStatus(
   DNP_RUNTIME_STATUS *status
);
```

Description:

The **dnpGetRuntimeStatus** function reads the current status of all DNP change event buffers, and returns information in the status structure.

DNP must be enabled before calling this function in order to create the DNP configuration.

Example:

See the example in the section **dnpSendUnsolicited**.

dnpReadRoutingTableDialStrings

Read DNP Routing Table Entry Dial Strings

Syntax

```
BOOLEAN dnpReadRoutingTableDialStrings(
      UINT16 index,
      UINT16 maxPrimaryDialStringLength,
      CHAR *primaryDialString,
      UINT16 maxSecondaryDialStringLength,
      CHAR *secondaryDialString
);
```

Description

This function reads a primary and secondary dial string from an entry in the DNP routing table.

`index` specifies the index of an entry in the DNP routing table.

`maxPrimaryDialStringLength` specifies the maximum length of `primaryDialString` excluding the null-terminator character. The function uses this to limit the size of the returned string to prevent overflowing the storage passed to the function.

`primaryDialString` returns the primary dial string of the target station. It must point to an array of size `maxPrimaryDialStringLength.`

`maxSecondaryDialStringLength` specifies the maximum length of `secondaryDialString` excluding the null-terminator character. The function uses this to limit the size of the returned string to prevent overflowing the storage passed to the function.

`secondaryDialString` returns the secondary dial string of the target station. It must point to an array of size `maxSecondaryDialStringLength.`

Notes

This function must be used in conjunction with the `dnpReadRoutingTableEntry` function to read a complete entry in the DNP routing table.

dnpReadRoutingTableEntry

Read Routing Table entry

Syntax

```
#include <ctools.h>
BOOLEAN dnpReadRoutingTableEntry (
      UINT16 index,
      routingTable *pRoute
);
```

Description

This function reads an entry from the routing table.

pRoute is a pointer to a table entry; it is written by this function.

The return value is TRUE if pRoute was successfully written or FALSE otherwise.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

The function returns the total number of entries in the DNP routing table.

dnpReadRoutingTableSize

Read Routing Table size

Syntax

```
#include <ctools.h>
UINT16 dnpReadRoutingTableSize (void);
```

Description

This function reads the total number of entries in the routing table.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

The function returns the total number of entries in the routing table.

dnpSaveAI16Config

Save DNP 16-Bit Analog Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveAI16Config(
      UINT16 point,
      dnpAnalogInput * pAnalogInput
      );
```

Description

This function sets the configuration of a DNP 16-bit analog input point.

The function has two parameters: the point number; and a pointer to an analog input point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpGetAI16Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveAI32Config

Save DNP 32-Bit Analog Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveAI32Config(
      UINT32 point,
      dnpAnalogInput * pAnalogInput
      );
```

Description

This function sets the configuration of a DNP 32-bit analog input point.

The function has two parameters: the point number; and a pointer to an analog input point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpGetAI32Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveAISFConfig

Save Short Floating Point Analog Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveAISFConfig (
      UINT16 point,
      dnpAnalogInput *pAnalogInput;
);
```

Description

This function sets the configuration of a DNP short floating point analog input point.

The function has two parameters: the point number, and a pointer to a configuration structure.

The function returns TRUE if the configuration was successfully written, or FALSE otherwise (if the point number is not valid, or the configuration is not valid, or if the DNP configuration has not been created).

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

dnpSaveAO16Config

Save DNP 16-Bit Analog Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveAO16Config(
      UINT16 point,
      dnpAnalogOutput * pAnalogOutput
      );
```

Description

This function sets the configuration of a DNP 16-bit analog output point.

The function has two parameters: the point number; and a pointer to an analog output point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveAO32Config

Save DNP 32-Bit Analog Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveAO32Config(
      UINT32 point,
      dnpAnalogOutput * pAnalogOutput
      );
```

Description

This function sets the configuration of a DNP 32-bit analog output point.

The function has two parameters: the point number; and a pointer to an analog output point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpGetAO32Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveAOSFConfig

Save Short Floating Point Analog Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveAOSFConfig (
      UINT16 point,
      dnpAnalogOutput *pAnalogOutput;
);
```

Description

This function sets the configuration of a DNP short floating point analog output point.

The function has two parameters: the point number, and a pointer to a configuration structure.

The function returns TRUE if the configuration was successfully written, or FALSE otherwise (if the point number is not valid, or the configuration is not valid, or if the DNP configuration has not been created).

Notes

DNP must be enabled before calling this function in order to create the DNP

dnpSaveBIConfig

Save DNP Binary Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveBIConfig(
      UINT16 point,
      dnpBinaryInput * pBinaryInput
      );
```

Description

This function sets the configuration of a DNP binary input point.

The function has two parameters: the point number; and a pointer to a binary input point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveBIConfigEx

Write DNP Binary Input Extended Point

Syntax

```
BOOLEAN dnpSaveBIConfigEx(
      UINT16 point,
      dnpBinaryInputEx *pBinaryInput
);
```

Description

This function writes the configuration of an extended DNP Binary Input point.

The function has two parameters: the point number, and a pointer to an extended binary input point configuration structure.

The function returns TRUE if the configuration was successfully written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if the DNP configuration has not been created.

This function supersedes `dnpSaveBIConfig`.

dnpSaveBOConfig

Save DNP Binary Output Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveBOConfig(
      UINT16 point,
      dnpBinaryOutput * pBinaryOutput
      );
```

Description

This function sets the configuration of a DNP binary output point.

The function has two parameters: the point number; and a pointer to a binary output point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveCI16Config

Save DNP 16-Bit Counter Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveCI16Config(
      UINT16 point,
      dnpCounterInput * pCounterInput
      );
```

Description

This function sets the configuration of a DNP 16-bit counter input point.

The function has two parameters: the point number; and a pointer to a counter input point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpGetCI16Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveCI32Config

Save DNP 32-Bit Counter Input Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveCI32Config(
      UINT32 point,
      dnpCounterInput * pCounterInput
      );
```

Description

This function sets the configuration of a DNP 32-bit counter input point.

The function has two parameters: the point number; and a pointer to a counter input point configuration structure.

The function returns TRUE if the configuration was written. It returns FALSE if the point number is not valid, if the configuration is not valid, or if DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

See Also

dnpGetCI32Config

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveConfiguration

Save DNP Configuration

Syntax

```
#include <ctools.h>
BOOLEAN dnpSaveConfiguration(
      dnpConfiguration * pConfiguration
      );
```

Description

This function sets the DNP configuration.

The function has one parameter: a pointer to a DNP configuration structure.

The function returns TRUE if the configuration was updated and FALSE if an error occurred. No changes are made to any parameters if an error occurs.

Notes

This function must be called before enabling DNP.

The following parameters cannot be changed if DNP is enabled. The function will not make any changes and will return FALSE if this is attempted. The protocol must be disabled in order to make a change involving these parameters.

- `BI_number`
- `BI_cosBufferSize`
- `BI_soeBufferSize`
- `BO_number`
- `CI16_number`
- `CI16_bufferSize`
- `CI32_number`
- `CI32_bufferSize`
- `AI16_number`
- `AI16_reportingMethod`
- `AI16_bufferSize`
- `AI32_number`
- `AI32_reportingMethod`
- `AI32_bufferSize`
- `AO16_number`
- `AO32_number`

The following parameters can be changed when DNP is enabled.

- `masterAddress;`
- `rtuAddress;`
- `datalinkConfirm;`
- `datalinkRetries;`
- `datalinkTimeout;`
- `operateTimeout`
- `applicationConfirm`

- `maximumResponse`
- `applicationRetries`
- `applicationTimeout`
- `timeSynchronization`
- `unsolicited`
- `holdTime`
- `holdCount`

See Also

dnpGetConfiguration

Example

See example in the ***dnpGetConfiguration*** function section.

dnpSaveConfigurationEx

Write DNP Extended Configuration

Syntax

```
BOOLEAN dnpSaveConfigurationEx (
      dnpConfigurationEx *pDnpConfigurationEx
);
```

Description

This function writes the extended DNP configuration parameters.

The function has one parameter: a pointer to the DNP extended configuration structure.

The function returns TRUE if the configuration was successfully written, or FALSE otherwise (if the pointer is NULL, or if the DNP configuration has not been created).

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

This function supersedes the `dnpSaveConfiguration` function.

dnpSearchRoutingTable

Search Routing Table

Syntax

```
#include <ctools.h>
BOOLEAN dnpSearchRoutingTable (
      UINT16 Address
      routingTable  *pRoute
);
```

Description

This function searches the routing table for a specific DNP address.

pRoute is a pointer to a table entry; it is written by this function.

The return value is TRUE if pRoute was successfully written or FALSE otherwise.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

dnpSendUnsolicited

Send DNP Unsolicited Response

Syntax

```
#include <ctools.h>
UINT16 dnpSendUnsolicitedResponse(
   UINT16 classFlags
);
```

Description

The **dnpSendUnsolicitedResponse** function sends an 'Unsolicited Response' message in DNP protocol, with data from the specified class(es).

- *class* specifies the class(es) of event data to include in the message.
- Allowed values are

```
#define CLASS0_FLAG 0x01     /* flag for enabling Class 0 Unsolicited Responses
*/

#define CLASS1_FLAG 0x02     /* flag for enabling Class 1 Unsolicited Responses
*/

#define CLASS2_FLAG 0x04     /* flag for enabling Class 2 Unsolicited Responses
*/

#define CLASS3_FLAG 0x08     /* flag for enabling Class 3 Unsolicited Responses
*/
```

DNP must be enabled before calling this function in order to create the DNP configuration.

Example

```
/* ------------------------------------------------------------------
   SCADAPack 32 C++ Application Main Program
   Copyright 2001 - 2002, Control Microsystems Inc.

   Test application for new DNP API Functions.
   written by James Wiles May 2003

   This app was written for a ScadaPack 32P, running DNP on comm port
   4.

   ------------------------------------------------------------------ */
#include <ctools.h>
#include <string.h>


/* ------------------------------------------------------------------
   Constants
   ------------------------------------------------------------------ */

/*
 * Event Triggers :
 * This application detects when these registers have been set,
 * then performs the specified action and clears the register.
 */
#define CLEAR_EVENTS       100/* Clear all DNP Event Log Buffers */
#define GENERATE_BI_EVENT  101/* Generate a change event for BI
channel 0 */
```

```
#define GENERATE_AI16_EVENT   102 /* Generate a change event for 16-
bit AI channel 0 */
#define CLASS0_REPORT      103 /* Send an unsolicited report of Class
0 data */

/*
 * Status Flags
 */
#define EVENTS_CLASS1      110
#define EVENTS_CLASS2      111
#define EVENTS_CLASS3      112

/*
 * Status Registers
 */
#define EVENT_COUNT_AI16   40102
#define EVENT_COUNT_BI     40104
#define EVENT_COUNT_CLASS1 40106
#define EVENT_COUNT_CLASS2 40108
#define EVENT_COUNT_CLASS3 40110


/* ----------------------------------------------------------------
   main

   This routine is the main application loop.
   ---------------------------------------------------------------- */
void main(void)
{
   UINT16 index;              /* loop index */
   struct prot_settings protocolSettings;  /* protocol settings */
   dnpConfiguration configuration;
   dnpBinaryInput binaryInput;
   dnpAnalogInput analogInput;
   DNP_RUNTIME_STATUS dnpStatus;
   int clear_events_flag;
   int bi_event_flag;
   int ai16_event_flag;
   int class0_report_flag;


   /* Set DNP Configuration */
   configuration.masterAddress         = 100;
   configuration.rtuAddress            = 1;
   configuration.datalinkConfirm       = FALSE;
   configuration.datalinkRetries       = DEFAULT_DLINK_RETRIES;
   configuration.datalinkTimeout       = DEFAULT_DLINK_TIMEOUT;

   configuration.operateTimeout        = DEFAULT_OPERATE_TIMEOUT;
   configuration.applicationConfirm    = FALSE;
   configuration.maximumResponse       = DEFAULT_MAX_RESP_LENGTH;
   configuration.applicationRetries    = DEFAULT_APPL_RETRIES;
   configuration.applicationTimeout    = DEFAULT_APPL_TIMEOUT;
   configuration.timeSynchronization   = NO_TIME_SYNC;

   configuration.BI_number             = 2;
   configuration.BI_startAddress       = 0;
   configuration.BI_reportingMethod    = REPORT_ALL_EVENTS;
   configuration.BI_soeBufferSize      = 1000;
   configuration.BO_number             = 0;
   configuration.BO_startAddress       = 0;
   configuration.CI16_number           = 0;
   configuration.CI16_startAddress     = 0;
   configuration.CI16_reportingMethod  = REPORT_ALL_EVENTS;
   configuration.CI16_bufferSize       = 0;
   configuration.CI32_number           = 0;
   configuration.CI32_startAddress     = 100;
```

```
   configuration.CI32_reportingMethod  = REPORT_ALL_EVENTS;
   configuration.CI32_bufferSize       = 0;
   configuration.CI32_wordOrder        = MSW_FIRST;
   configuration.AI16_number           = 2;
   configuration.AI16_startAddress     = 0;
   configuration.AI16_reportingMethod  = REPORT_ALL_EVENTS;
   configuration.AI16_bufferSize       = 1000;
   configuration.AI32_number           = 0;
   configuration.AI32_startAddress     = 100;
   configuration.AI32_reportingMethod  = REPORT_ALL_EVENTS;
   configuration.AI32_bufferSize       = 0;
   configuration.AI32_wordOrder        = MSW_FIRST;
   configuration.AISF_number           = 0;
   configuration.AISF_startAddress     = 200;
   configuration.AISF_reportingMethod  = REPORT_CHANGE_EVENTS;
   configuration.AISF_bufferSize       = 0;
   configuration.AISF_wordOrder        = MSW_FIRST;
   configuration.AO16_number           = 0;
   configuration.AO16_startAddress     = 0;
   configuration.AO32_number           = 0;
   configuration.AO32_startAddress     = 100;
   configuration.AO32_wordOrder        = MSW_FIRST;
   configuration.AOSF_number           = 0;
   configuration.AOSF_startAddress     = 200;
   configuration.AOSF_wordOrder        = MSW_FIRST;

   configuration.autoUnsolicitedClass1 = TRUE;
   configuration.holdTimeClass1        = 10;
   configuration.holdCountClass1       = 3;
   configuration.autoUnsolicitedClass2 = TRUE;
   configuration.holdTimeClass2        = 10;
   configuration.holdCountClass2       = 3;
   configuration.autoUnsolicitedClass3 = TRUE;
   configuration.holdTimeClass3        = 10;
   configuration.holdCountClass3       = 3;

   dnpSaveConfiguration(&configuration);

   /* Start DNP protocol on com port 4 */
   get_protocol(com4, &protocolSettings);
   protocolSettings.type = DNP;
   set_protocol(com4, &protocolSettings);


   /* Configure Binary Input Points */
   for (index = 0;index < configuration.BI_number; index++)
   {
      binaryInput.modbusAddress = 10001 + index;
      binaryInput.eventClass    = CLASS_1;
      dnpSaveBIConfig(configuration.BI_startAddress + index,
&binaryInput);
   }

   /* Configure 16 Bit Analog Input Points */
   for (index = 0; index < configuration.AI16_number; index++)
   {
      analogInput.modbusAddress  = 40002 + index * 2;
      analogInput.eventClass     = CLASS_2;
      analogInput.deadband       = 1;
      dnpSaveAI16Config(configuration.AI16_startAddress + index,
&analogInput);
   }

   /*
    * Configure DNP Routing Table :
    * station 100 via com4
    * station 101 via com4
```

```
     */
    dnpCreateRoutingTable(2);
    dnpWriteRoutingTableEntry(0, 100, CIF_Com4, DEFAULT_DLINK_RETRIES,
DEFAULT_DLINK_TIMEOUT);
    dnpWriteRoutingTableEntry(1, 101, CIF_Com4, DEFAULT_DLINK_RETRIES,
DEFAULT_DLINK_TIMEOUT);


    /*
     * main loop
     */
    while (TRUE)
    {
        /* request IO resource */
        request_resource(IO_SYSTEM);

        /* read DNP status */
        dnpGetRuntimeStatus(&dnpStatus);
        setdbase(MODBUS, EVENTS_CLASS1, dnpStatus.eventCountClass1 ? 1
: 0);
        setdbase(MODBUS, EVENTS_CLASS2, dnpStatus.eventCountClass2 ? 1
: 0);
        setdbase(MODBUS, EVENTS_CLASS3, dnpStatus.eventCountClass3 ? 1
: 0);
        setdbase(MODBUS, EVENT_COUNT_AI16, dnpStatus.eventCountAI16);
        setdbase(MODBUS, EVENT_COUNT_BI, dnpStatus.eventCountBI);
        setdbase(MODBUS, EVENT_COUNT_CLASS1,
dnpStatus.eventCountClass1);
        setdbase(MODBUS, EVENT_COUNT_CLASS2,
dnpStatus.eventCountClass2);
        setdbase(MODBUS, EVENT_COUNT_CLASS3,
dnpStatus.eventCountClass3);
        release_resource(IO_SYSTEM);

        clear_events_flag = FALSE;
        bi_event_flag = FALSE;
        ai16_event_flag = FALSE;
        class0_report_flag = FALSE;

        /* Read Event Triggers */
        if (dbase(MODBUS, CLEAR_EVENTS))
        {
            setdbase(MODBUS, CLEAR_EVENTS, 0);
            clear_events_flag = TRUE;
        }

        if (dbase(MODBUS, GENERATE_BI_EVENT))
        {
            setdbase(MODBUS, GENERATE_BI_EVENT, 0);
            bi_event_flag = FALSE;
        }

        if (dbase(MODBUS, GENERATE_AI16_EVENT))
        {
            setdbase(MODBUS, GENERATE_AI16_EVENT, 0);
            ai16_event_flag = FALSE;
        }

        if (dbase(MODBUS, CLASS0_REPORT))
        {
            setdbase(MODBUS, CLASS0_REPORT, 0);
            class0_report_flag = FALSE;
        }

        /* release IO resource */
        release_resource(IO_SYSTEM);
```

```
        /* Clear DNP Event Log buffer if requested */
        if (clear_events_flag)
        {
            dnpClearEventLog();
        }

        /* Generate a DNP Change Event for BI Point 0 if requested */
        if (bi_event_flag)
        {
            dnpGenerateEventLog(BI_POINT, 0);
        }

        /* Generate a DNP Change Event for 16-bit AI Point 0 if
requested */
        if (ai16_event_flag)
        {
            dnpGenerateEventLog(AI16_POINT, 0);
        }

        /* Send DNP Class 0 Unsolicited Report if requested */
        if (class0_report_flag)
        {
            dnpSendUnsolicitedResponse(CLASS0_FLAG);
        }

        /* release processor to other tasks */
        release_processor();
    }
}
```

dnpSendUnsolicitedResponse

Send DNP Unsolicited Response

Syntax

```
BOOLEAN dnpSendUnsolicitedResponse(
      UINT16 classFlags
);
```

Description

The `dnpSendUnsolicitedResponse` function sends an Unsolicited Response message in DNP, with data from the specified classes.

`class` specifies the class or classes of event data to include in the message. It can contain any combination of the following values; if multiple values are used they should be ORed together:

CLASS0_FLAG	enables Class 0 Unsolicited Responses
CLASS1_FLAG	enables Class 1 Unsolicited Responses
CLASS2_FLAG	enables Class 2 Unsolicited Responses
CLASS3_FLAG	enables Class 3 Unsolicited Responses

The function returns TRUE if the DNP unsolicited response message was successfully triggered. It returns FALSE if an unsolicited message of the same class is already pending, or if the DNP configuration has not been created.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

If no events are pending an empty unsolicited message will be sent.

dnpWriteRoutingTableEntry

Write Routing Table Entry

Syntax

```
#include <ctools.h>
BOOLEAN dnpWriteRoutingTableEntry (
      UINT16 index,
      UINT16 dnpAddress,
      UINT16 commPort,
      UINT16 DataLinkRetries,
      UINT16 DataLinkTimeout
);
```

Description

This function writes an entry in the DNP routing table.

Notes

DNP must be enabled before calling this function in order to create the DNP configuration.

The function returns TRUE if successful, FALSE otherwise.

Example

See the example in the section **dnpSendUnsolicited**.

dnpWriteRoutingTableDialStrings

Write DNP Routing Table Entry Dial Strings

Syntax

```
BOOLEAN dnpWriteRoutingTableDialStrings(
      UINT16 index,
      UINT16 primaryDialStringLength,
      CHAR *primaryDialString,
      UINT16 secondaryDialStringLength,
      CHAR *secondaryDialString
);
```

Description

This function writes a primary and secondary dial string into an entry in the DNP routing table.

`index` specifies the index of an entry in the DNP routing table.

`primaryDialStringLength` specifies the length of `primaryDialString` excluding the null-terminator character.

`primaryDialString` specifies the dial string used when dialing the target station. This string is used on the first attempt.

`secondaryDialStringLength` specifies the length of `secondaryDialString` excluding the null-terminator character.

`secondaryDialString` specifies the dial string to be used when dialing the target station. It is used for the next attempt if the first attempt fails.

Notes

This function must be used in conjunction with the `dnpWriteRoutingTableEntry` function to write a complete entry in the DNP routing table.

dout

Write Digital Outputs

Syntax

```
#include <ctools.h>
int dout(unsigned channel, unsigned value);
```

Description

The **dout** function outputs *value* to the digital input or output specified by *channel*. It sets the status of 8 digital points.

The **dout** function returns the value output to the channel, as modified by the channel configuration tables. If channel is not valid, –1 is returned.

Notes

The **dout** function modifies all 8 bits (points) in a channel. Use the **turnon** and **turnoff** functions to write to single bits.

Use offsets from the symbolic constants DIN_START, DIN_END, EXTENDED_DIN_START, EXTENDED_DIN_END, DOUT_START, DOUT_END, EXTENDED_DOUT_START and EXTENDED_DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite8Dout** directly.

See Also

ioWrite8Dout, din, pulse, timeout, turnon, turnoff, on, off

Example

This program sends all bit combinations to the second digital output channel.

```
#include <ctools.h>
void main(void)
{
       unsigned value;         /* output values */
       for (value = 0; value; value++)
       {
          request_resource(IO_SYSTEM);
          dout(DOUT_START + 1, value);
          release_resource(IO_SYSTEM);
       }
}
```

end_application

Terminates all Application Tasks

Syntax

```
#include <ctools.h>
void end_application(void);
```

Description

The **end_application** function terminates all **APPLICATION** type tasks created with the **create_task** function. Stack space and resources used by the tasks are freed.

Notes

This function is used normally by communication protocols to stop an executing application program, prior to loading a new program into memory.

See Also

create_task, end_task

end_task

Terminate a Task

Syntax

```
#include <ctools.h>
void end_task(unsigned task_ID);
```

Description

The **end_task** function terminates the task specified by *task_ID*. Stack space and resources used by the task are freed. The **end_task** function terminates both **APPLICATION** and **SYSTEM** type tasks.

See Also

create_task, end_application, getTaskInfo

endTimedEvent

Terminate Signaling of a Regular Event

Syntax

```
#include <ctools.h>
unsigned endTimedEvent(unsigned event);
```

Description

This **endTimedEvent** function cancels signaling of a timed event, initialized by the startTimedEvent function.

The function returns TRUE if the event signaling was canceled.

The function returns FALSE if the event number is not valid, or if the event was not previously initiated with the startTimedEvent function. The function has no effect in these cases.

Notes

Valid events are numbered 0 to RTOS_EVENTS - 1. Any events defined in ctools.h are not valid events for use in an application program.

Example

See the examples for **startTimedEvent**.

See Also

startTimedEvent

enronInstallCommandHandler

Installs handler for Enron Modbus commands.

Syntax

```
#include <ctools.h>
void enronInstallCommandHandler(
      UINT16 (* function)(
            UINT16   length,
            UCHAR  * pCommand,
            UINT16   responseSize,
            UINT16 * pResponseLength,
            UCHAR  * pResponse
            )
      );
```

Description

This function installs a handler function for Enron Modbus commands. The protocol driver calls this handler function each time a command is received for the Enron Modbus station.

`function` is a pointer to the handler function. If function is NULL the handler is disabled.

The function has no return value.

Notes

The application must disable the handler when the application ends. This prevents the protocol driver from calling the handler while the application is stopped. Call the `enronInstallCommmandHandler` with a NULL pointer. The usual method is to create a task exit handler function to do this. See the example below for details.

The handler function has five parameters.

- `length` is the number of characters in the command message.
- `pCommand` is a pointer to the command message. The first byte in the message is the function code, followed by the Enron Modbus message. See the Enron Modbus protocol specification for details on the message formats.
- `responseSize` is the size of the response buffer in characters.
- `pResponseLength` is a pointer to a variable that will hold the number of characters in the response. If the handler returns TRUE, it must set this variable.
- `pResponse` is a pointer to a buffer that will hold the response message. The buffer size is `responseSize` characters. The handler must not write beyond the end of the buffer. If the handler returns TRUE, it must set this variable. The data must start with the function code and end with the last data byte. The protocol driver will add the station address, checksum, and message framing to the response.

The handler function returns the following values.

Value	Description
`NORMAL`	Indicates protocol handler should send a normal response message. Data are returned using `pResponse` and `pResponseLength.`
`ILLEGAL_FUNCTION`	Indicates protocol handler should send an Illegal Function exception response message. This

Value	Description
	response should be used when the function code in the command is not recognised.
ILLEGAL_DATA_ADDRESS	Indicates protocol handler should send an Illegal Data Address exception response message. This response should be used when the data address in the command is not recognised.
ILLEGAL_DATA_VALUE	Indicates protocol handler should send an Illegal Data Value exception response message. This response should be used when invalid data is found in the command.

If the function returns NORMAL then the protocol driver sends the response message in the buffer pointed to by pResponse. If the function returns an exception response protocol driver returns the exception response to the caller. The buffer pointed to by pResponse is not used.

Example

This program installs a simple handler function.

```
#include <ctools.h>

/* ------------------------------------------------------
   This function processes Enron Modbus commands.
   ------------------------------------------------------ */
UINT16 commandHandler(
      UINT16   length,
      UCHAR  * pCommand,
      UINT16   responseSize,
      UINT16 * pResponseLength,
      UCHAR  * pResponse
      )
{
      UCHAR command;
      UINT16 result;

      /* if a command byte was received */
      if (length >= 1)
      {
            /* get the command byte */
            command = pCommand[0];
            switch (command)
            {
            /* read unit status command */
            case 7:
                  /* if the response buffer is large enough */
                  if (responseSize > 2)
                  {
                        /* build the response header */
                        pResponse[0] = pCommand[0];

                        /* set the unit status */
                        pResponse[1] = 17;

                        /* set response length */
                        *pResponseLength = 2;
```

```
                        /* indicate the command worked */
                        result = NORMAL;
                  }
                  else
                  {
                        /* buffer is to small to respond */
                        result = ILLEGAL_FUNCTION;
                  }
                  break;

            /* add cases for other commands here */

            default:
                  /* command is invalid */
                  result = ILLEGAL_FUNCTION;
            }
      }
      else
      {
            /* command is too short so return error */
            result = ILLEGAL_FUNCTION;
      }
      return result;
}

/* -----------------------------------------------------
   This function unhooks the protocol handler when the
   main task ends.
   ----------------------------------------------------- */
void mainExitHandler(void)
{
      /* unhook the handler function */
      enronInstallCommandHandler(NULL);
}

void main(void)
{
      TASKINFO thisTask;

      /* install handler to execute when this task ends */
      thisTask = getTaskInfo(0);
      installExitHandler(thisTask.taskID, mainExitHandler);

      /* install handler for Enron Modbus */
      enronInstallCommandHandler(commandHandler);

      /* infinite loop of main task */
      while (TRUE)
      {
            /* add application code here */
      }
}
```

forceLed

Set State of Force LED

Syntax

```
#include <ctools.h>
void forceLed(unsigned state);
```

Description

The **forceLed** function sets the state of the FORCE LED. *state* may be either LED_ON or LED_OFF.

Notes

The FORCE LED is used to indicate forced I/O. Use this function with caution in application programs.

See Also

setStatus

getABConfiguration

Get DF1 Protocol Configuration

Syntax

```
#include <ctools.h>
struct ABConfiguration *getABConfiguration(FILE *stream, struct
ABConfiguration *ABConfig);
```

Description

The **getABConfiguration** function gets the DF1 protocol configuration parameters for the *stream*. If *stream* does not point to a valid serial port the function has no effect. *ABConfig* must point to an DF1 protocol configuration structure.

The **getABConfiguration** function copies the DF1 configuration parameters into the *ABConfig* structure and returns a pointer to it.

Example

This program displays the DF1 configuration parameters for **com1**.

```
#include <ctools.h>


void main(void)
{
   struct ABConfiguration ABConfig;

   getABConfiguration(com1, &ABConfig);
   printf("Min protected address:     %u\r\n",
      ABConfig.min_protected_address);
   printf("Max protected address:     %u\r\n",
      ABConfig.max_protected_address);
}
```

getBootType

Get Controller Boot Up State

Syntax

```
#include <ctools.h>
unsigned getBootType(void);
```

Description

The **getBootType** function returns the boot up state of the controller. The possible return values are:

SERVICE	controller started in SERVICE mode
RUN	controller started in RUN mode

Example

```
#include <ctools.h>

void main(void)
{
       struct prot_settings settings;

       /* Disable the protocol on serial port 1 */
       settings.type = NO_PROTOCOL;
       settings.station = 1;
       settings.priority = 3;
       settings.SFMessaging = FALSE;
       request_resource(IO_SYSTEM);
       set_protocol(com1, &settings);
       release_resource(IO_SYSTEM);

       /* Display the boot status information */
       printf("Boot type: %d\r\n", getBootType());
}
```

getclock

Read the Real Time Clock

Syntax

```
#include <rtc.h>
struct clock getclock(void);
```

Description

The **getclock** function reads the time and date from the real time clock hardware.

The **getclock** function returns a `struct clock` containing the time and date information.

Notes

The time format returned by the **getclock** function is not compatible with the standard UNIX style functions supplied by Microtec.

The IO_SYSTEM resource must be requested before calling this function.

See Also

setclock, getClockTime

Example

This program displays the current date and time.

```
#include <ctools.h>
main(void)
{
       struct clock now;

       request_resource(IO_SYSTEM);
       now = getclock();          /* read the clock */
       release_resource(IO_SYSTEM);
       printf("%2d/%2d/%2d", now.day,
              now.month, now.year);
       printf("%2d:%2d\r\n",now.hour, now.minute);
}
```

getClockAlarm

Read the Real Time Clock Alarm Settings

Syntax

```
#include <ctools.h>
ALARM_SETTING getClockAlarm(void);
```

Description

The **getClockAlarm** function returns the alarm setting in the real time clock. The alarm is used to wake the controller from sleep mode.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

alarmIn, setClockAlarm

getClockTime

Read the Real Time Clock

Syntax

```
#include <ctools.h>
void getClockTime(long * pDays, long * pHundredths);
```

Description

The getClockTime function reads the read time clock and returns the value as the number of whole days since 01/01/97 and the number of hundredths of a second since the start of the current day. The function works for 100 years from 01/01/97 to 12/31/96 then rolls over.

The function has two parameters: a pointer to the variable to hold the days; and a pointer to a variable to hold the hundredths of a second.

The function has no return value.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

setclock, getclock

getControllerID

Get Controller ID

Syntax

```
#include <ctools.h>
void getControllerID(CHAR * pID)
```

Description

This function writes the Controller ID to the string pointed to by *pID*. The Controller ID is a unique ID for the controller set at the factory. The pointer *pID* must point to a character string of length CONTROLLER_ID_LEN.

Example

This program displays the Controller ID.

```
#include <ctools.h>

void main(void)
{
       char     ctlrID[CONTROLLER_ID_LEN];
       UINT16 index;

       getControllerID(ctlrID);

       fprintf(com1, "\r\nController ID : ");
       for (index=0; index<CONTROLLER_ID_LEN; index++)
       {
           fputc(ctlrID[index], com1);
       }
}
```

getForceFlag

Get Force Flag State for a Register

Syntax

```
#include <ctools.h>
unsigned getForceFlag(unsigned type, unsigned address, unsigned *value);
```

Description

The **getForceFlag** function copies the value of the force flag for the specified database register into the integer pointed to by *value*. The valid range for *address* is determined by the database addressing *type*.

The force flag value is either 1 or 0, or a 16-bit mask for LINEAR digital addresses.

If the *address* or addressing *type* is not valid, FALSE is returned and the integer pointed to by *value* is 0; otherwise TRUE is returned. The table below shows the valid address types and ranges.

Type	Address Ranges	Register Size
MODBUS	00001 to NUMCOIL 10001 to 10000 + NUMSTATUS 30001 to 30000 + NUMINPUT 40001 to 40000 + NUMHOLDING	1 bit 1 bit 16 bit 16 bit
LINEAR	0 to NUMLINEAR-1	16 bit

Notes

Force Flags are not modified when the controller is reset. Force Flags are in a permanent storage area, which is maintained during power outages.

Refer to the *I/O Database and Register Assignment* chapter for more information.

See Also

setForceFlag, clearAllForcing, overrideDbase

Example

This program obtains the force flag state for register 40001, for the 16 status registers at linear address 302 (i.e. registers 10737 to 10752), and for the holding register at linear address 1540 (i.e. register 40005).

```
#include <ctools.h>

void main(void)
{
       unsigned flag, bitmask;

       getForceFlag(MODBUS, 40001, &flag);
       getForceFlag(LINEAR, 302, &bitmask);
       getForceFlag(LINEAR, 1540, &flag);
}
```

getIOErrorIndication

Get I/O Module Error Indication

Syntax

```
#include <ctools.h>
unsigned getIOErrorIndication(void);
```

Description

The **getIOErrorIndication** function returns the state of the I/O module error indication. TRUE is returned if the I/O module communication status is currently reported in the controller status register and Status LED. FALSE is returned if the I/O module communication status is not reported.

Notes

Refer to the ***5203/4 System Manual*** or the ***SCADAPack System Manual*** for further information on the Status LED and Status Output.

See Also

setIOErrorIndication

getOutputsInStopMode

Get Outputs In Stop Mode

Syntax

```
#include <ctools.h>
void getOutputsInStopMode( unsigned *doutsInStopMode, unsigned
   *aoutsInStopMode);
```

Description

The **getOutputsInStopMode** function copies the values of the output control flags into the integers pointed to by *doutsInStopMode* and *aoutsInStopMode*.

If the value pointed to by *doutsInStopMode* is TRUE, then digital outputs are held at their last state when the Ladder Logic program is stopped.

If the value pointed to by *doutsInStopMode* is FALSE, then digital outputs are turned OFF when the Ladder Logic program is stopped.

If the value pointed to by a*outsInStopMode* is TRUE, then analog outputs are held at their last value when the Ladder Logic program is stopped.

If the value pointed to by a*outsInStopMode* is FALSE, then analog outputs go to zero when the Ladder Logic program is stopped.

See Also

setOutputsInStopMode

Example

See the example for **setOutputsInStopMode** function.

getPortCharacteristics

Get Serial Port Characteristics

Syntax

```
#include <ctools.h>
unsigned getPortCharacteristics(FILE *stream, PORT_CHARACTERISTICS
   *pCharacteristics);
```

Description

The **getPortCharacteristics** function gets information about features supported by the serial port pointed to by *stream*. If *stream* does not point to a valid serial port the function has no effect and FALSE is returned; otherwise TRUE is returned.

The **getPortCharacteristics** function copies the serial port characteristics into the structure pointed to by *pCharacteristics*.

Notes

Refer to the **Overview of Functions** section for detailed information on serial ports.

Refer to the **Structures and Types** section for a description of the fields in the PORT_CHARACTERISTICS structure.

See Also

get_port

Example

```
#include <ctools.h>
void main(void)
{
       PORT_CHARACTERISTICS options;

       getPortCharacteristics(com3, &options);
       fprintf(com1, "Dataflow options: %d\r\n",
          options.dataflow);
       fprintf(com1, "Protocol options: %d\r\n",
          options.protocol);
}
```

getPowerMode

Get Current Power Mode

Syntax

```
#include <ctools.h>
BOOLEAN getPowerMode(UCHAR* cpuPower, UCHAR* lan, UCHAR* usbPeripheral,
UCHAR* usbHost);
```

Description

The **getPowerMode** function places the current state of the CPU, LAN, USB peripheral port, and USB host port in the passed parameters. The following table lists the possible return values and their meaning.

Macro	*Meaning*
PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_UNAVAILABLE	The status of the device could not be read.

TRUE is returned if the values placed in the passed parameters are valid, otherwise FALSE is returned.

The application program may set the current power mode with the s**etPowerMode** function.

See Also

setPowerMode, setWakeSource, getWakeSource

get_pid

Get PID Variable

Syntax

```
#include <ctools.h>
int get_pid(unsigned name, unsigned block);
```

Description

The **get_pid** function returns the value of a PID control block variable. *name* must be specified by one of the variable name macros in **pid.h**. *block* must be in the range 0 to **PID_BLOCKS-1**.

Notes

See the ***TelePACE PID Controllers Manual*** for a detailed description of PID control.

Values stored in PID blocks are not initialized when a program is run, and are guaranteed to retain their values during power failures and program loading. The user program must always initialize PID block variables.

The IO_SYSTEM resource must be requested before calling this function.

See Also

set_pid, auto_pid, clear_pid

get_port

Get Serial Port Configuration

Syntax

```
#include <ctools.h>
struct pconfig *get_port(FILE *stream, struct pconfig *settings);
```

Description

The **get_port** function gets the serial port configuration for the *stream*. If *stream* does not point to a valid serial port the function has no effect.

The **get_port** function copies the serial port settings into the structure pointed to by *settings* and returns a pointer to the structure.

Notes

Refer to the **Overview of Functions** section for detailed information on serial ports.

Refer to the **Structure and Types** section for a description of the fields in the *pconfig* structure.

See Also

set_port

Example

```
#include <ctools.h>

void main(void)
{
       struct pconfig settings;

       get_port(com1, &settings);
       printf("Baud rate: %d\r\n", settings.baud);
       printf("Duplex:    %d\r\n", settings.duplex);
}
```

getProgramStatus

Get Program Status Flag

Syntax

```
#include <ctools.h>
unsigned getProgramStatus( void );
```

Description

The **getProgramStatus** function returns the application program status flag. The status flag is set to **NEW_PROGRAM** when the C program is erased or downloaded to the controller from the program loader.

The application program may modify the status flag with the **setProgramStatus** function.

See Also

setPowerMode

Set Current Power Mode

Syntax

```
#include <ctools.h>
BOOLEAN setPowerMode(UCHAR cpuPower, UCHAR lan, UCHAR usbPeripheral, UCHAR
usbHost);
```

Description

The **setPowerMode** function returns TRUE if the new settings were successfully applied. The setPowerMode function allows for power savings to be realized by controlling the power to the LAN port, changing the clock speed, and individually controlling the host and peripheral USB power. The following table of macros summarizes the choices available.

Macro	*Meaning*
PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_NO_CHANGE	The current value will be used

TRUE is returned if the requested change was made, otherwise FALSE is returned.

The application program may view the current power mode with the **getPowerMode** function.

See Also

getPowerMode, setWakeSource, getWakeSource

Example

This program stores a default alarm limit into the I/O database the first time it is run. On subsequent executions, it uses the limit in the database. The limit in the database can be modified by a communication protocol during execution.

```
#include <ctools.h>

#define HI_ALARM    41000
#define ALARM_OUTPUT   1026

void main( void )
{
       int inputValue;

       if (getProgramStatus() == NEW_PROGRAM)
       {
          /* Set default alarm limit */
          request_resource(IO_SYSTEM);
          setdbase(MODBUS, HI_ALARM, 4000);
          release_resource(IO_SYSTEM);

          /* Use values in database from now on */
          setProgramStatus(PROGRAM_EXECUTED);
       }
       while (TRUE)
       {
          request_resource(IO_SYSTEM);

          /* Test input against alarm limits */
          if (ain(INPUT) > dbase(MODBUS, HI_ALARM))
             setdbase(MODBUS, ALARM_OUTPUT, 1);
          else
             setdbase(MODBUS, ALARM_OUTPUT, 0);

          release_resource(IO_SYSTEM);

          /* Allow other tasks to execute */
          release_processor();
       }
}
```

get_protocol

Get Protocol Configuration

Syntax

```
#include <ctools.h>
struct prot_settings *get_protocol(FILE *stream, struct prot_settings
   *settings);
```

Description

The **get_protocol** function gets the communication protocol configuration for the *stream*. If *stream* does not point to a valid serial port the function has no effect. *settings* must point to a protocol configuration structure, *prot_settings*.

The **get_protocol** function copies the protocol settings into the structure pointed to by *settings* and returns a pointer to that structure.

Refer to the *ctools.h* file for a description of the fields in the *prot_settings* structure.

Refer to the **Overview of Functions** section for detailed information on communication protocols.

See Also

set_protocol

Example

This program displays the protocol configuration for **com1**.

```
#include <ctools.h>

void main(void)
{
       struct prot_settings settings;

       get_protocol(com1, &settings);
       printf("Type:     %d\r\n", settings.type);
       printf("Station:  %d\r\n", settings.station);
       printf("Priority: %d\r\n", settings.priority);
}
```

getProtocolSettings

Get Protocol Extended Addressing Configuration

Syntax

```
#include <ctools.h>
BOOLEAN getProtocolSettings(
      FILE * stream,
      PROTOCOL_SETTINGS * settings
      );
```

Description

The getProtocolSettings function reads the protocol parameters for a serial port. This function supports extended addressing.

The function has two parameters: *stream* is one of com1, com2, com3 or com4; and *settings,* a pointer to a PROTOCOL_SETTINGS structure. Refer to the description of the structure for an explanation of the parameters.

The function returns **TRUE** if the structure was changed. It returns **FALSE** if the stream is not valid.

Notes

Extended addressing is available on the Modbus RTU and Modbus ASCII protocols only. See the *TeleBUS Protocols User Manual* for details.

Refer to the ***TeleBUS Protocols User Manual*** section for detailed information on communication protocols.

See Also

setProtocolSettings, get_protocol

Example

This program displays the protocol configuration for com1.

```
#include <ctools.h>

void main(void)
{
       PROTOCOL_SETTINGS settings;

       if (getProtocolSettings(com1, &settings)
       {
           printf("Type: %d\r\n", settings.type);
           printf("Station: %d\r\n", settings.station);
           printf("Address Mode: %d\r\n", settings.mode);
           printf("SF Messaging: %d\r\n", settings.SFMessaging);
           printf("Priority: %d\r\n", settings.priority);
       }
       else
       {
           printf(“Serial port is not valid\r\n”);
       }
}
```

getProtocolSettingsEx

Reads extended protocol settings for a serial port.

Syntax

```
#include <ctools.h>
BOOLEAN getProtocolSettingsEx(
      FILE * stream,
      PROTOCOL_SETTINGS_EX * pSettings
);
```

Description

The `setProtocolSettingsEx` function sets protocol parameters for a serial port. This function supports extended addressing and Enron Modbus parameters.

The function has two arguments:

- `stream` specifies the serial port. It is one of com1, com2, com3 or com4.
- `pSettings` is a pointer to a `PROTOCOL_SETTINGS_EX` structure. Refer to the description of the structure for an explanation of the parameters.

The function returns `TRUE` if the settings were retrieved. It returns `FALSE` if the stream is not valid.

Notes

Extended addressing and the Enron Modbus station are available on the Modbus RTU and Modbus ASCII protocols only. See the *TeleBUS Protocols User Manual* for details.

See Also

`setProtocolSettingsEx`

Example

This program displays the protocol configuration for com1.

```
#include <ctools.h>
void main(void)
{
      PROTOCOL_SETTINGS_EX settings;
      if (getProtocolSettingsEx(com1, &settings)
      {
            printf("Type: %d\r\n", settings.type);
            printf("Station: %d\r\n", settings.station);
            printf("Address Mode: %d\r\n", settings.mode);
            printf("SF: %d\r\n", settings.SFMessaging);
            printf("Priority: %d\r\n", settings.priority);
            printf("Enron: %d\r\n", settings.enronEnabled);
            printf("Enron station: %d\r\n",
                  settings.enronStation);
      }
      else
      {
            printf(“Serial port is not valid\r\n”);
      }
```

```
}
```

get_protocol_status

Get Protocol Information

Syntax

```
#include <ctools.h>
struct prot_status get_protocol_status(FILE *stream);
```

Description

The **get_protocol_status** function returns the protocol error and message counters for *stream*. If *stream* does not point to a valid serial port the function has no effect.

Refer to the **Overview of Functions** section for detailed information on communication protocols.

See Also

clear_protocol_status

Example

This program displays the checksum error counter for **com2**.

```
#include <ctools.h>

void main(void)
{
       struct prot_status status;

       status = get_protocol_status(com2);
       printf("Checksum: %d\r\n",
          status.checksum_errors);
}
```

getSFMapping

Read Translation Table Mapping Control

Syntax

```
#include <ctools.h>
unsigned getSFMapping(void);
```

Description

The **getSFMapping** and **setSFMapping** functions no longer perform any useful function but are maintained as stubs for backward compatibility. Include the CNFG_StoreAndForward module in the Register Assignment to assign a store and forward table to the I/O database.

Notes

The ***TeleBUS Protocols User Manual*** describes store and forward messaging mode.

See Also

addRegAssignment

getSFTranslation

Read Store and Forward Translation

Syntax

```
#include <ctools.h>
struct SFTranslation getSFTranslation(unsigned index);
```

Description

The **getSFTranslation** function returns the entry at *index* in the store and forward address translation table. If *index* is invalid, a disabled table entry is returned.

The function returns a SFTranslation structure. It is described in the **Structures and Types** section.

Notes

The ***TeleBUS Protocols User Manual*** describes store and forward messaging mode.

See Also

setSFTranslation, clearSFTranslationTable, checkSFTranslationTable

Example

See the example for the **setSFTranslation** function.

get_status

Get Serial Port Status

Syntax

```
#include <ctools.h>
struct pstatus *get_status(FILE *stream, struct pstatus *status);
```

Description

The **get_status** function returns serial port error counters, I/O lines status and I/O driver buffer information for *stream*. If *stream* does not point to a valid serial port the function has no effect. *status* must point to a valid serial port status structure, *pstatus*.

The **get_status** function copies the serial port status into the structure pointed to by *status* and returns a pointer to that structure *settings*.

Refer to the **Overview of Functions** section for detailed information on serial ports.

See Also

clear_errors

Example

This program displays the framing and parity errors for **com1**.

```
#include <ctools.h>

void main(void)
{
       struct pstatus status;

       get_status(com1, &status);
       printf("Framing: %d\r\n", status.framing);
       printf("Parity:  %d\r\n", status.parity);
}
```

getStatusBit

Read Bits in Controller Status Code

Syntax

```
#include <ctools.h>
unsigned getStatusBit(unsigned bitMask);
```

Description

The **getStatusBit** function returns the values of the bits indicated by *bitMask* in the controller status code.

See Also

setStatusBit, setStatus, clearStatusBit

getTaskInfo

Get Information on a Task

Syntax

```
#include <ctools.h>
TASKINFO getTaskInfo(unsigned taskID);
```

Description

The **getTaskInfo** function returns information about the task specified by *taskID*. If *taskID* is 0 the function returns information about the current task.

Notes

If the specified task ID does not identify a valid task, all fields in the return data are set to zero. The calling function should check the taskID field in the TASKINFO structure: if it is zero the remaining information is not valid.

Refer to the **Structures and Types** section for a description of the fields in the TASKINFO structure.

Example

The following program displays information about all valid tasks.

```
#include <string.h>
#include <ctools.h>

void main(void)
{
        struct prot_settings settings;
        TASKINFO taskStatus;
        unsigned task;
        char state[6][20];
        char type[2][20];

        /* Set up state strings */
        strcpy(state[TS_READY], "Ready");
        strcpy(state[TS_EXECUTING], "Executing");
        strcpy(state[TS_WAIT_ENVELOPE], "Waiting for Envelope");
        strcpy(state[TS_WAIT_EVENT], "Waiting for Event");
        strcpy(state[TS_WAIT_MESSAGE], "Waiting for Message");
        strcpy(state[TS_WAIT_RESOURCE], "Waiting for Resource");

        /* Set up type strings */
        strcpy(type[APPLICATION], "Application");
        strcpy(type[SYSTEM], "System");

        /* Disable the protocol on serial port 1 */
        settings.type = NO_PROTOCOL;
        settings.station = 1;
        settings.priority = 3;
        settings.SFMessaging = FALSE;
        request_resource(IO_SYSTEM);
        set_protocol(com1, &settings);
        release_resource(IO_SYSTEM);

        /* display information about all tasks */
        for (task = 0; task <= RTOS_TASKS; task++)
        {
            taskStatus = getTaskInfo(task);
            if (taskStatus.taskID != 0)
            {
                /* show information for valid task */
```

```
                fprintf(com1, "\r\n\r\nInformation about task %d:\r\n", task);
                fprintf(com1, "    Task ID:  %d\r\n", taskStatus.taskID);
                fprintf(com1, "    Priority: %d\r\n", taskStatus.priority);
                fprintf(com1, "    Status:   %s\r\n", state[taskStatus.status]);
                if (taskStatus.status == TS_WAIT_EVENT)
                {
                    fprintf(com1, "    Event:    %d\r\n", taskStatus.requirement);
                }
                if (taskStatus.status == TS_WAIT_RESOURCE)
                {
                    fprintf(com1, "    Resource: %d\r\n", taskStatus.requirement);
                }
                fprintf(com1, "    Error:    %d\r\n", taskStatus.error);
                fprintf(com1, "    Type:     %s\r\n", type[taskStatus.type]);
            }
        }

        while (TRUE)
        {
            /* Allow other tasks to execute */
            release_processor();
        }
}
```

getVersion

Get Firmware Version Information

Syntax

```
#include <ctools.h>
VERSION getVersion(void);
```

Description

The **getVersion** function obtains firmware version information. It returns a VERSION structure. Refer to the **Structures and Types** section for a description of the fields in the VERSION structure.

Notes

The version information can be used to adapt a program to a specific type of controller or version of firmware. For example, a bug work-around could be executed only if older firmware is detected.

Example

This program displays the version information.

```
#include <ctools.h>
void main(void)
{
       struct prot_settings settings;
       VERSION versionInfo;

       /* Disable the protocol on serial port 1 */
       settings.type =        NO_PROTOCOL;
       settings.station =     1;
       settings.priority =    3;
       settings.SFMessaging = FALSE;
       request_resource(IO_SYSTEM);
       set_protocol(com1, &settings);
       release_resource(IO_SYSTEM);

       /* Display the ROM version information */
       versionInfo = getVersion();
       fprintf(com1, "\r\nFirmware Information\r\n");

       fprintf(com1, "  Controller type:  %d\r\n", versionInfo.controller &
       BASE_TYPE_MASK);
       fprintf(com1, "  Firmware version: %d\r\n", versionInfo.version);
       fprintf(com1, "  Creation date:    %s\r\n", versionInfo.date);
       fprintf(com1, "  Copyright:        %s\r\n", versionInfo.copyright);
}
```

getWakeSource

Gets Conditions for Waking from Sleep Mode

Syntax

```
#include <ctools.h>
unsigned getWakeSource(void);
```

Description

The **getWakeSource** function returns a bit mask of the active wake up sources. Valid wake up sources are listed below.

- WS_REAL_TIME_CLOCK
- WS_INTERRUPT_INPUT
- WS_LED_POWER_SWITCH
- WS_COUNTER_0_OVERFLOW
- WS_COUNTER_1_OVERFLOW
- WS_COUNTER_2_OVERFLOW

See Also

setWakeSource, sleep

Example

The following code fragment displays the enabled wake up sources.

```
unsigned enabled;

enabled = getWakeSource();
fputs("Enabled wake up sources:\r\n", com1);
if (enabled & WS_REAL_TIME_CLOCK)
       fputs("  Real Time Clock\r\n", com1);
if (enabled & WS_INTERRUPT_INPUT)
       fputs("  Interrupt Input\r\n", com1);
if (enabled & WS_LED_POWER_SWITCH)
       fputs("  LED Power Switch\r\n", com1);
if (enabled & WS_COUNTER_0_OVERFLOW)
       fputs("  Counter 0 Overflow\r\n", com1);
if (enabled & WS_COUNTER_1_OVERFLOW)
       fputs("  Counter 1 Overflow\r\n", com1);
if (enabled & WS_COUNTER_2_OVERFLOW)
       fputs("  Counter 2 Overflow\r\n", com1);
```

hartIO

Read and Write 5904 HART Interface Module

Syntax

```
#include <ctools.h>
BOOLEAN hartIO(unsigned module);
```

Description

This function reads the specified 5904 interface module. It checks if a response has been received and if a corresponding command has been sent. If so, the response to the command is processed.

This function writes the specified 5904 interface module. It checks if there is a new command to send. If so, this command is written to the 5904 interface.

The function has one parameter: the module number of the 5904 interface (0 to 3).

The function returns TRUE if the 5904 interface responded and FALSE if it did not or if the module number is not valid.

Notes

This function is called automatically if the 5904 module is in the register assignment. Use this function to implement communication with the 5904 if register assignment is not used.

See Also

hartSetConfiguration, hartGetConfiguration, hartCommand

hartIOFromDbase

Read and Write 5904 HART Interface Module with Settings from Database

Syntax

```
#include <ctools.h>
BOOLEAN hartIOFromDbase(unsigned module, unsigned firstRegister);
```

Description

This function reads the specified 5904 interface module. It checks if a response has been received and if a corresponding command has been sent. If so, the response to the command is processed.

This function writes configuration and commands to the specified 5904 interface module. Configuration data is read from the I/O database. It checks if there is a new command to send. If so, this command is written to the 5904 interface.

The function has two parameters: the module number of the 5904 interface (0 to 3); and the address of the first register of a group of four containing the HART interface configuration.

The function returns TRUE if the 5904 interface responded and FALSE if it did not or if the module number is not valid or there is an error in the settings.

See Also

hartIO, hartSetConfiguration

hartCommand

Send Command using HART Interface Module

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand(
       unsigned module,
       HART_DEVICE * const device,
       HART_COMMAND * const command,
       void (* processResponse)( unsigned,
       HART_RESPONSE)
       );
```

Description

This function sends a command to a HART slave device using a HART interface module. This function can be used to implement HART commands not provided by the Network Layer API.

The function has four parameters. The first is the module number of the 5904 interface (0 to 3). The second is the device to which the command is to be sent.

The third parameter is a structure describing the command to send. This contains the command number, and the data field of the HART message. See the HART protocol documentation for your device for details.

The fourth parameter is a pointer to a function that will process the response. This function is called when a response to the command is received by the HART interface. The function is defined as follows:

```
void function_name(HART_RESPONSE response)
```

The single parameter is a structure containing the response code and the data field from the message.

The function returns TRUE if the 5904 interface responded and FALSE if it did not or if the module number is not valid or there is an error in the command.

Notes

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

A program must initialize the link before executing any other commands.

The function determines if long or short addressing is to be used by the command number. Long addressing is used for all commands except commands 0 and 11.

The functions hartCommand0, hartCommand1, etc. are used to send commands provided by the Network Layer.

See Also

hartStatus, hartSetConfiguration, hartCommand0, hartCommand1

hartCommand0

Read Unique Identifier

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand0(unsigned module, unsigned address, HART_DEVICE * const
device);
```

Description

This function reads the unique identifier of a HART device using command 0 with a short-form address. This is a link initialization function.

The function has three parameters: the module-number of the 5904 module (0 to 3); the short-form address of the HART device (0 to 15); and a pointer to a HART_DEVICE structure. The information read by command 0 is written into the HART_DEVICE structure when the response is received by the 5904 interface.

The function returns TRUE if the command was sent. The function returns FALSE if the module number is invalid, or if the device address is invalid.

Notes

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

A program must initialize the link before executing any other commands.

See Also

hartCommand11, hartStatus, hartSetConfiguration

hartCommand1

Read Primary Variable

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand1(unsigned module, HART_DEVICE * const device,
HART_VARIABLE * primaryVariable);
```

Description

This function reads the primary variable of a HART device using command 1.

The function has three parameters: the module-number of the 5904 module (0 to 3); the device to be read; and a pointer to the primary variable. The variable pointed to by primaryVariable is updated when the response is received by the 5904 interface.

The primaryVariable must be a static modular or global variable. A primaryVariable should be declared for each HART I/O module in use. A local variable or dynamically allocated variable may not be used because a late command response received after the variable is freed will write data over the freed variable space.

The function returns TRUE if the command was sent. The function returns FALSE if the module number is invalid.

Notes

The HART_DEVICE structure must be initialized using hartCommand0 or hartCommand11.

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

The code field of the HART_VARIABLE structure not changed. Command 1 does not return a variable code.

See Also

hartCommand2, hartStatus, hartSetConfiguration

hartCommand2

Read Primary Variable Current and Percent of Range

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand2(unsigned module, HART_DEVICE * const device,
HART_VARIABLE * pvCurrent, HART_VARIABLE * pvPercent);
```

Description

This function reads the primary variable (PV), as current and percent of range, of a HART device using command 2.

The function has four parameters: the module-number of the 5904 module (0 to 3); the device to be read; a pointer to the PV current variable; and a pointer to the PV percent variable. The pvCurrent and pvPercent variables are updated when the response is received by the 5904 interface.

The pvCurrent and pvPercent variables must be static modular or global variables. A pvCurrent and pvPercent variable should be declared for each HART I/O module in use. A local variable or dynamically allocated variable may not be used because a late command response received after the variable is freed will write data over the freed variable space.

The function returns TRUE if the command was sent. The function returns FALSE if the module number is invalid.

Notes

The HART_DEVICE structure must be initialized using hartCommand0 or hartCommand11.

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

The code field of both HART_VARIABLE structures is not changed. The response from the HART device to command 2 does not include variable codes.

The units field of the pvCurrent variable is set to 39 (units = mA). The units field of the pvPercent variable is set to 57 (units = percent). The response from the HART device to command 2 does not include units.

See Also

hartCommand1, hartStatus, hartSetConfiguration

hartCommand3

Read Primary Variable Current and Dynamic Variables

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand3(unsigned module, HART_DEVICE * const device,
HART_VARIABLE * variables);
```

Description

This function reads dynamic variables and primary variable current from a HART device using command 3.

The function has three parameters: the module number of the 5904 module (0 to 3); the device to be read; and a pointer to an array of five HART_VARIABLE structures.

The variables array must be static modular or global variables. An array of variables should be declared for each HART I/O module in use. A local variable or dynamically allocated variable may not be used because a late command response received after the variable is freed will write data over the freed variable space.

The variables array is updated when the response is received by the 5904 interface as follows.

Variable	Contains
variables[0]	primary variable current
variables[1]	primary variable
variables[2]	secondary variable
variables[3]	tertiary variable
variables[4]	fourth variable

The function returns TRUE if the command was sent. The function returns FALSE if the module number is invalid.

Notes

The HART_DEVICE structure must be initialized using hartCommand0 or hartCommand11.

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

Not all devices return primary, secondary, tertiary and fourth variables. If the device does not support a variable, zero is written into the value and units code for that variable.

The code field of both HART_VARIABLE structures is not changed. The response from the HART device to command 3 does not include variable codes.

The units field of variable[0] is set to 39 (units = mA). The response from the HART device to command 3 does not include units.

See Also

hartCommand33, hartStatus, hartSetConfiguration

hartCommand11

Read Unique Identifier Associated with Tag

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand11(unsigned module, char * deviceTag, HART_DEVICE *
device);
```

Description

This function reads the unique identifier of a HART device using command 11. This is a link initialization function.

The function has three parameters: the module number of the 5904 module (0 to 3); a pointer to a null terminated string containing the tag of the HART device; and a pointer to a HART_DEVICE structure. The information read by command 11 is written into the HART_DEVICE structure when the response is received by the 5904 interface.

The function returns TRUE if the command was sent. The function returns FALSE if the module number is invalid.

Notes

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

A program must initialize the link before executing any other commands.

See Also

hartCommand0, hartStatus, hartSetConfiguration

hartCommand33

Read Transmitter Variables

Syntax

```
#include <ctools.h>
BOOLEAN hartCommand33(unsigned module, HART_DEVICE * const device, unsigned
variableCode[4], HART_VARIABLE * variables);
```

Description

This function reads selected variables from a HART device using command 33.

The function has four parameters: the module number of the 5904 module (0 to 3); the device to be read; an array of codes; and a pointer to an array of four HART_VARIABLE structures.

The variables array must be static modular or global variables. An array of variables should be declared for each HART I/O module in use. A local variable or dynamically allocated variable may not be used because a late command response received after the variable is freed will write data over the freed variable space.

The variableCode array specifies which variables are to be read from the transmitter. Consult the documentation for the transmitter for valid values.

The variables array is updated when the response is received by the 5904 interface as follows.

Variable	Contains
variables[0]	transmitter variable, code and units specified by variableCode[0]
variables[1]	transmitter variable, code and units specified by variableCode[1]
variables[2]	transmitter variable, code and units specified by variableCode[2]
variables[3]	transmitter variable, code and units specified by variableCode[3]

The function returns TRUE if the command was sent. The function returns FALSE if the module number is invalid.

Notes

The HART_DEVICE structure must be initialized using hartCommand0 or hartCommand11.

The pointer variables must point to an array with at least four elements.

The function returns immediately after the command is sent. The calling program must wait for the response to be received. Use the hartStatus command to read the status of the command.

The number of attempts and the number of preambles sent are set with the hartSetConfiguration command.

The function always requests four variables and expects four variables in the response.

See Also

hartCommand3, hartStatus, hartSetConfiguration

hartStatus

Return Status of Last HART Command Sent

Syntax

```
#include <ctools.h>
BOOLEAN hartStatus(unsigned module, HART_RESULT * status, unsigned * code);
```

Description

This function returns the status of the last HART command sent by a 5904 module (0 to 3). Use this function to determine if a response has been received to a command sent.

The function has three parameters: the module number of the 5904 module; a pointer to the status variable; and a pointer to the additional status code variable. The status and code variables are updated with the following information.

Result	Status	code
HART interface module is not communicating	HR_NoModuleResponse	not used
Command ready to be sent	HR_CommandPending	not used
Command sent to device	HR_CommandSent	current attempt number
Response received	HR_Response	response code from HART device (see Notes)
No valid response received after all attempts made	HR_NoResponse	0=no response from HART device. Other = error response code from HART device (see Notes)
HART interface module is not ready to transmit	HR_WaitTransmit	not used

The function returns TRUE if the status was read. The function returns FALSE if the module number is invalid.

Notes

The response code from the HART device contains communication error and status information. The information varies by device, but there are some common values.

- If bit 7 of the high byte is set, the high byte contains a communication error summary. This field is bit-mapped. The table shows the meaning of each bit as defined by the HART protocol specifications. Consult the documentation for the HART device for more information.

Bit	Description
6	vertical parity error
5	overrun error
4	framing error
3	longitudinal parity error
2	reserved – always 0
1	buffer overflow
0	Undefined

- If bit 7 of the high byte is cleared, the high byte contains a command response summary. The table shows common values. Other values may be defined for specific commands. Consult the documentation for the HART device.

Code	Description
32	Busy – the device is performing a function that cannot be interrupted by this command
64	Command not Implemented – the command is not defined for this device.

- The low byte contains the field device status. This field is bit-mapped. The table shows the meaning of each bit as defined by the HART protocol specifications. Consult the documentation for the HART device for more information.

Bit	Description
7	field device malfunction
6	configuration changed
5	cold start
4	more status available (use command 48 to read)
3	primary variable analog output fixed
2	primary variable analog output saturated
1	non-primary variable out of limits
0	primary variable out of limits

See Also

hartSetConfiguration

hartGetConfiguration

Read HART Module Settings

Syntax

```
#include <ctools.h>
BOOLEAN hartGetConfiguration(unsigned module, HART_SETTINGS * settings);
```

Description

This function returns the configuration settings of a 5904 module.

The function has two parameters: the module number of the 5904 module (0 to 3); and a pointer to the settings structure.

The function returns TRUE if the settings were read. The function returns FALSE if the module number is invalid.

See Also

hartSetConfiguration

hartSetConfiguration

Write HART Module Settings

Syntax

```
#include <ctools.h>
BOOLEAN hartSetConfiguration(unsigned module, HART_SETTINGS settings);
```

Description

This function writes configuration settings to a 5904 module.

The function has two parameters: the module number of the 5904 module (0 to 3); and a settings structure.

The function returns TRUE if the settings were written. The function returns FALSE if the module number or the settings are invalid.

Notes

The configuration settings are stored in the EEPROM_RUN section of the EEPROM. The user-defined settings are used when the controller is reset in the RUN mode. Default settings are used when the controller is reset in the SERVICE or COLD BOOT modes.

If a **CNFG 5904 HART Interface** module is in the register assignment, forced registers from it take precedence over the settings supplied here.

See Also

hartGetConfiguration

hartPackString

Convert String to HART Packed String

Syntax

```
#include <ctools.h>
void hartPackString(char * pPackedString, const char * pString, unsigned
sizePackedString);
```

Description

This function stores an ASCII string into a HART packed ASCII string.

The function has three parameters: a pointer to a packed array; a pointer to an unpacked array; and the size of the packed array. The packed array must be a multiple of three in size. The unpacked array must be a multiple of four in size. It should be padded with spaces at the end if the string is not long enough.

The function has no return value.

See Also

hartUnpackString

hartUnpackString

Convert HART Packed String to String

Syntax

```
#include <ctools.h>
void hartUnpackString(char * pString, const char * pPackedString, unsigned
sizePackedString);
```

Description

This function unpacks a HART packed ASCII string into a normal ASCII string.

The function has three parameters: a pointer to an unpacked array; a pointer to a packed array; and the size of the packed array. The packed array must be a multiple of three in size. The unpacked array must be a multiple of four in size.

The function has no return value.

See Also

hartPackString

install_handler

Install Serial Port Handler

Syntax

```
#include <ctools.h>
void install_handler(FILE *stream, void *function(unsigned, unsigned));
```

Description

The **install_handler** function installs a serial port character handler function. The serial port driver calls this function each time it receives a character. If *stream* does not point to a valid serial port the function has no effect.

function specifies the handler function, which takes two arguments. The first argument is the received character. The second argument is an error flag. A non-zero value indicates an error. If *function* is **NULL**, the default handler for the port is installed. The default handler does nothing.

Notes

The **install_handler** function can be used to write custom communication protocols.

The handler is called at the completion of the receiver interrupt handler. RTOS calls (see functions listed in the section *Real Time Operating System Functions* at the start of this chapter) may not be made within the interrupt handler, with one exception. The **interrupt_signal_event** RTOS call can be used to signal events.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

Example

```
#include <ctools.h>

#define CHAR_RECEIVED 11


/* ------------------------------------------
   signal

   This routine signals an event when a character
   is received on com1. If there is an error, the
   character is ignored.
   ------------------------------------------ */

void signal(unsigned character, unsigned error)
{
       if (error == 0)
           interrupt_signal_event( CHAR_RECEIVED );

       character;
}

/* ------------------------------------------
   main

   This program displays all characters received
   on com1 using an installed handler to signal
```

```
   the reception of a character.
   ---------------------------------------- */

void main(void)
{
       struct prot_settings protocolSettings;
       int character;

       /* Disable protocol */
       get_protocol(com1, &protocolSettings);
       protocolSettings.type = NO_PROTOCOL;
       request_resource(IO_SYSTEM);
       set_protocol(com1, &protocolSettings);
       release_resource(IO_SYSTEM);

       /* Enable character handler */
       install_handler(com1, signal);

       /* Print each character as it is recevied */
       while (TRUE)
       {
          wait_event(CHAR_RECEIVED);
          character = fgetc(com1);
          fputs("character: ", com1);
          fputc(character, com1);
          fputs("\r\n", com1);
       }
}
```

installClockHandler

Install Handler for Real Time Clock

Syntax

```
#include <ctools.h>
void installClockHandler(void (*function)(void));
```

Description

The **installClockHandler** function installs a real time clock alarm handler function. The real time clock alarm function calls this function each time a real time clock alarm occurs.

function specifies the handler function. If *function* is **NULL**, the handler is disabled.

Notes

RTOS calls (see functions listed in the section *Real Time Operating System Functions* at the start of this chapter) may not be made within the interrupt handler, with one exception. The **interrupt_signal_event** RTOS call can be used to signal events.

See Also

setClockAlarm

Example

```
/* ------------------------------------------
   This program demonstrates how to call a
   function at a specific time of day.
   ------------------------------------------ */

#include <ctools.h>

#define   ALARM_EVENT      20

/* ------------------------------------------
       This function signals an event when the alarm
       occurs.
------------------------------------------ */
void alarmHandler(void)
{
       interrupt_signal_event( ALARM_EVENT );
}

/* ------------------------------------------
   This task processes alarms signaled by the
       clock handler
------------------------------------------ */
void processAlarms(void)
{
       while(TRUE)
       {
          wait_event(ALARM_EVENT);

          /* Reset the alarm for the next day */
          request_resource(IO_SYSTEM);
          resetClockAlarm();
          release_resource(IO_SYSTEM);
```

```
            fprintf(com1, "It's quitting time!\r\n");
        }
}

void main(void)
{
        struct prot_settings settings;
        ALARM_SETTING alarm;

        /* Disable the protocol on serial port 1 */
        settings.type = NO_PROTOCOL;
        settings.station = 1;
        settings.priority = 3;
        settings.SFMessaging = FALSE;
        request_resource(IO_SYSTEM);
        set_protocol(com1, &settings);
        release_resource(IO_SYSTEM);

        /* Install clock handler function */
        installClockHandler(alarmHandler);

        /* Create task for processing alarm events */
        create_task(processAlarms, 3, APPLICATION, 4);

        /* Set real time clock alarm */
        alarm.type   = AT_ABSOLUTE;
        alarm.hour   = 16;
        alarm.minute = 0;
        alarm.second = 0;

        request_resource(IO_SYSTEM);
        setClockAlarm(alarm);
        release_resource(IO_SYSTEM);

        while(TRUE)
        {
            /* body of main task loop */

            /* other processing code */

            /* Allow other tasks to execute */
            release_processor();
        }
}
```

installExitHandler

Install Handler Called when Task Ends

Syntax

```
#include <ctools.h>
unsigned installExitHandler(unsigned taskID, void (*function)(void));
```

Description

The **installExitHandler** function defines a function that is called when the task, specified by *taskID*, is ended. *function* specifies the handler function. If *function* is **NULL**, the handler is disabled.

Notes

The exit handler function will be called when:

- the task is ended by the end_task function
- the end_application function is executed and the function is an APPLICATION type function
- the program is stopped from the TelePACE program and the task is an APPLICATION type function
- the C program is erased by the TelePACE program.

The exit handler function is not called if power to the controller is removed. In this case all execution stops when power fails. The application program starts from the beginning when power is reapplied.

Do not call any RTOS functions from the exit handler.

Example

See the example for **startTimedEvent**.

installModbusHandler

Install User Defined Modbus Handler

Syntax

```
#include <ctools.h>
void installModbusHandler(
unsigned (* handler)(unsigned char *, unsigned,
                     unsigned char *, unsigned *)
      );
```

Description

The installModbusHandler function allows user-defined extensions to standard Modbus protocol. This function specifies a function to be called when a Modbus message is received for the station, but is not understood by the standard Modbus protocol. The installed handler function is called only if the message is addressed to the station, and the message checksum is correct.

The function has one parameter: a pointer to a function to handle the messages. See the section **Handler Function** for a full description of the function and it's parameters. If the pointer is NULL, no function is called for non-standard messages.

The function has no return value.

Notes

This function is used to create a user-defined extension to the standard Modbus protocol.

Call this function with the NULL pointer to disable processing of non-standard Modbus messages. This must be done when the application program is ended with an exit handler. Use the installExitHandler function to install the exit handler.

If the Modbus handler is not disabled within an exit handler, it will remain installed and continue to operate until the controller power is cycled. Changing the protocol type or *Erasing the C Program* from TelePACE Initialize dialog will not remove the Modbus handler. If the handler is located in a RAM-based application and left enabled while a different C application is downloaded, the original handler will be corrupted and the system will likely crash.

See Also

installExitHandler, Handler Function

Handler Function

User Specified Handler Function

The handler function is a user-specified function that handles processing of Modbus messages not recognized by the protocol. The function can have any name; *handler* is used in the description below.

Syntax

```
#include <ctools.h>
unsigned handler(
       unsigned char * message,
       unsigned messageLength,
       unsigned char * response,
       unsigned * responseLength
       );
```

Description

This function *handler* is a user-defined handler for processing Modbus messages. The function is called for each Modbus message with a function code that is not recognized by the standard Modbus protocol.

The *handler* function should process the message string and create a response string. IF the message is not understood, one of the error codes should be returned.

The function has four parameters.

- The *message* parameter is a pointer to the first character of the received message. The first character of the message is the function code. The format of the data after the function code is defined by the function code.
- The *messageLength* parameter is the number of characters in the message.
- The *response* parameter is a pointer to the first character of a buffer to hold the response. The function should write the response into this buffer. The buffer is 253 characters long. The first character of the buffer is the function code of the message. The format of the data after the function code is defined by the function code.
- The *responseLength* parameter is a pointer to the length of the response. The function should set the length of the response using this pointer. The length is the number of characters placed into the response buffer.

The function must return one of four values. The first causes a normal response to be sent. The others cause an exception response to be sent.

- NORMAL indicates the response and responseLength have been set to valid values. The Modbus protocol will add the station address and checksum to this string and transmit the reply to the master station.
- ILLEGAL_FUNCTION indicates the function code in the message was not understood. The *handler* function must return this value for all function codes it does not process. The Modbus protocol will return an Illegal Function exception response.
- ILLEGAL_DATA_ADDRESS indicates the function code in the message was understood, but that the command referenced an address that is not valid. The Modbus protocol will return an Illegal Data Address exception response.

- ILLEGAL_DATA_VALUE indicates the function code in the message was understood, but that the command included data that is not valid. The Modbus protocol will return an Illegal Data Address exception response.

Function Codes Used

The following function codes are currently used by the TeleBUS Modbus-compatible protocol. All other function codes are available for use. For maximum compatibility with other Modbus and Modbus-compatible devices it is recommended that codes in the user-defined function code range be used first.

Code	Type	Description
1	Modbus standard	Read coil registers from I/O database
2	Modbus standard	Read status registers from I/O database
3	Modbus standard	Read holding registers from I/O database
4	Modbus standard	Read input registers from I/O database
5	Modbus standard	Write a single coil register
6	Modbus standard	Write a single holding register
7	Modbus standard	Read exception status
15	Modbus standard	Write multiple coil registers
16	Modbus standard	Write multiple holding registers
17	Modbus standard	Report slave identification string
65	TeleBUS extension	Used by TelePACE
66	TeleBUS extension	Used by TelePACE
67	TeleBUS extension	Used by TelePACE
68	TeleBUS extension	Used by TelePACE
69	TeleBUS extension	Used by TelePACE
70	TeleBUS extension	Used by TelePACE

Notes

One *handler* function is used for all serial ports. Only one port will be active at any time. Therefore, the function does not have to be re-entrant.

The *handler* function is called from the Modbus protocol task. This task may pre-empt the execution of another task. If there are shared resources, the *handler* function must request and release the appropriate resources to ensure proper operation.

The station address is not included in the message or response string. It will be added to the response string before sending the reply.

The checksum is not included in the message or the response string. It will be added to the response string before sending the reply.

The maximum size of the response string is 253 bytes. If a longer response length is returned, the Modbus protocol will report an ILLEGAL_DATA_VALUE exception. The response will not be returned.

See Also

installModbusHandler

Example

```
/* ---------------------------------------------
   handler.c
```

```
   This is a sample program for the  InstallModbusHandler function. This
sample    program uses function code 71 to demonstrate a    simple method
for using the    installModbusHandler function.
   When the handler is installed Modbus ASCII  messages using function code
71 that are  received on com2 of the controller will
   be processed as shown in the program text.

   To turn on digital output 00001:
   From a terminal send the ASCII command  :014701B7
   Where;
       01 is the station address
       47 is the function code in hex
       01 is the command for the function code
       B7 is the message checksum

   To turn off digital output 00001:
   From a terminal send the ASCII command  :014700B8
   Where;
       01 is the station address
       47 is the function code in hex
       00 is the command for the function code
       B8 is the message checksum
   ------------------------------------------ */
#include <ctools.h>

static unsigned myModbusHandler(
       unsigned char * message,
       unsigned  messageLength,
       unsigned char * response,
       unsigned * responseLength
       )
{
       unsigned char * pMessage;
       unsigned char * pResponse;

       pMessage = message;

       if (*pMessage == 71)
       {
          /* Action for command data */
          pMessage++;

           if (*pMessage == 0)
          {
             request_resource(IO_SYSTEM);
             setdbase(MODBUS, 1, 0);
             release_resource(IO_SYSTEM);

             pResponse = response;

             *pResponse   = 71;
             pResponse++;
             *pResponse   = 'O';
             pResponse++;
             *pResponse   = 'F';
             pResponse++;
             *pResponse   = 'F';
             pResponse++;

             *responseLength = 4;

             return NORMAL;
          }

          if (*pMessage == 1)
          {
```

```
            request_resource(IO_SYSTEM);
            setdbase(MODBUS, 1, 1);
            release_resource(IO_SYSTEM);

            pResponse = response;
            *pResponse   = 71;
            pResponse++;
            *pResponse   = 'O';
            pResponse++;
            *pResponse   = 'N';
            pResponse++;
            *responseLength = 3;

            return NORMAL;
         }

      }
}

static void shutdown(void)
{
      installModbusHandler(NULL);
}

/* ---------------------------------------------
   main

   This routine is the modbus slave application.
   Serial port com2 is configured for Modbus ASCII   protocol.
   Register Assignment is configured.
   The modbus handler is installed.
   The exit handler is installed.
   ------------------------------------------- */
void main(void)
{
      TASKINFO taskStatus;

      struct pconfig portSettings;
      struct prot_settings protSettings;

      portSettings.baud      = BAUD9600;
      portSettings.duplex    = FULL;
      portSettings.parity    = NONE;
      portSettings.data_bits = DATA7;
      portSettings.stop_bits = STOP1;
      portSettings.flow_rx   = DISABLE;
      portSettings.flow_tx   = DISABLE;
      portSettings.type      = RS232;
      portSettings.timeout   = 600;
      set_port(com2, &portSettings);

      get_protocol(com2, &protSettings);
      protSettings.station     = 1;
      protSettings.type       = MODBUS_ASCII;
      set_protocol(com2, &protSettings);

      /* Configure Register Assignment */
      clearRegAssignment();
      addRegAssignment(DIN_generic8, 0, 10017, 0, 0, 0);
      addRegAssignment(SCADAPack_lowerIO,0, 1, 10001, 30001, 0);
      addRegAssignment(DIAG_protocolStatus,1,31000, 0, 0, 0);

      /* Install Modbus Handler */
      request_resource(IO_SYSTEM);
      installModbusHandler(myModbusHandler);
      release_resource(IO_SYSTEM);
```

```
    /* Install Exit Handler */
       taskStatus = getTaskInfo(0);
       installExitHandler(taskStatus.taskID, shutdown);

       while(TRUE)
       {
          release_processor();
       }
}
```

installRTCHandler

Install User Defined Real-Time-Clock Handler

Syntax

```
#include <ctools.h>
void installRTCHandler(
void (* rtchandler)(TIME *now,
                    TIME *new)
      );
```

Description

The installRTCHandler function allows an application program to override Modbus protocol and DNP protocol commands to set the real time clock. This function specifies a function to be called when a Modbus or DNP message is received for the station. The installed handler function is called only if the message is intended to set the real time clock.

The function has one parameter: a pointer to a function to handle the messages. See the section **RTCHandler Function** for a full description of the function and its parameters. If the pointer is NULL, no function is called for set the real time clock commands, and the default method is used set the real time clock.

The function has no return value.

Notes

Call this function with the NULL pointer to disable processing of *Set Real Time Clock* messages. This must be done when the application program is ended with an exit handler. Use the installExitHandler function to install the exit handler.

If the RTC handler is not disabled within an exit handler, it will remain installed and continue to operate until the controller power is cycled. Changing the protocol type or *Erasing the C Program* from the TelePACE Initialize dialog will not remove the handler. If the handler is located in a RAM-based application and left enabled while a different C application is downloaded, the original handler will be corrupted and the system will likely crash.

See Also

RTCHandler Function, installExitHandler

RTCHandler Function

User Specified Real Time Clock Handler Function

The handler function is a user-specified function that handles processing of Modbus messages or DNP messages for setting the real time clock. The function can have any name; *rtchandler* is used in the description below.

Syntax

```
#include <ctools.h>
void rtchandler(
       TIME *now,
       TIME *new
       );
```

Description

This function *rtchandler* is a user-defined handler for processing Modbus messages or DNP messages. The function is called only for messages that set the real time clock.

The *rtchandler* function should set the real time clock to the requested time. If there is a delay before this can be done, the time when the message was received is provided so that a correction to the requested time can be made.

The function has two parameters.

- The *now* parameter is a pointer to the structure containing the time when the message was received.
- The *new* parameter is a pointer to the structure containing the requested time.

The function does not return a value.

Notes

The IO_SYSTEM resource has already been requested before calling this function. If this function calls other functions that require the IO_SYSTEM resource (e.g. setclock), there is no need to request or release the resource.

This function must not request or release the IO_SYSTEM resource.

See Also

installRTCHandler

interruptCounter

Read Interrupt Input Counter

Syntax

```
#include <ctools.h>
unsigned long interruptCounter(unsigned clear);
```

Description

The interruptCounter routine reads the interrupt input as a counter. If *clear* is TRUE the counter is cleared after reading; otherwise if it is FALSE the counter continues to accumulate.

Notes

The interrupt input is located on the 5203 or 5204 controller board. Refer to the ***System Hardware Manual*** for more information on the hardware.

The counter increments on the rising edge of the input signal.

The maximum input frequency that can be counted by the interrupt input is 200 Hz.

See Also

interruptInput, readCounter

interruptInput

Read State of Interrupt Digital Input

Syntax

```
#include <ctools.h>
unsigned interruptInput(void);
```

Description

The **interruptInput** function reads the status of the interrupt input point on the controller. It returns **TRUE** if the input is energized and **FALSE** if it is not.

Notes

The interrupt input can be used as wake up source for the controller or as an additional a digital input. Refer to the ***System Hardware Manual*** for wiring details.

See Also

installRTCHandler

Install User Defined Real-Time-Clock Handler

Syntax

```
#include <ctools.h>
void installRTCHandler(
void (* rtchandler)(TIME *now,
                    TIME *new)
       );
```

Description

The installRTCHandler function allows an application program to override Modbus protocol and DNP protocol commands to set the real time clock. This function specifies a function to be called when a Modbus or DNP message is received for the station. The installed handler function is called only if the message is intended to set the real time clock.

The function has one parameter: a pointer to a function to handle the messages. See the section **RTCHandler Function** for a full description of the function and its parameters. If the pointer is NULL, no function is called for set the real time clock commands, and the default method is used set the real time clock.

The function has no return value.

Notes

Call this function with the NULL pointer to disable processing of *Set Real Time Clock* messages. This must be done when the application program is ended with an exit handler. Use the installExitHandler function to install the exit handler.

If the RTC handler is not disabled within an exit handler, it will remain installed and continue to operate until the controller power is cycled. Changing the protocol type or *Erasing the C Program* from the TelePACE Initialize dialog will not remove the handler. If the handler is located in a RAM-based application and left enabled while a different C application is downloaded, the original handler will be corrupted and the system will likely crash.

See Also

RTCHandler Function, installExitHandler

RTCHandler Function

User Specified Real Time Clock Handler Function

The handler function is a user-specified function that handles processing of Modbus messages or DNP messages for setting the real time clock. The function can have any name; *rtchandler* is used in the description below.

Syntax

```
#include <ctools.h>
void rtchandler(
       TIME *now,
       TIME *new
       );
```

Description

This function *rtchandler* is a user-defined handler for processing Modbus messages or DNP messages. The function is called only for messages that set the real time clock.

The *rtchandler* function should set the real time clock to the requested time. If there is a delay before this can be done, the time when the message was received is provided so that a correction to the requested time can be made.

The function has two parameters.

- The *now* parameter is a pointer to the structure containing the time when the message was received.
- The *new* parameter is a pointer to the structure containing the requested time.

The function does not return a value.

Notes

The IO_SYSTEM resource has already been requested before calling this function. If this function calls other functions that require the IO_SYSTEM resource (e.g. setclock), there is no need to request or release the resource.

This function must not request or release the IO_SYSTEM resource.

See Also

installRTCHandler

interruptCounter

interrupt_signal_event

Signal Event in Interrupt Handler

Syntax

```
#include <ctools.h>
void interrupt_signal_event(unsigned event_number);
```

Description

The **interrupt_signal_event** function is used in an interrupt handler to signal events. The function signals that the *event_number* event has occurred.

If there are tasks waiting for the event, the highest priority task is made ready to execute. Otherwise the event flag is incremented. Up to 255 occurrences of an event will be recorded. The current task is blocked of there is a higher priority task waiting for the event.

Notes

Refer to the **Real Time Operating System** section for more information on events.

This function must only be used within an interrupt handler.

Valid events are numbered 0 to RTOS_EVENTS - 1. Any events defined in ctools.h. are not valid events for use in an application program.

See Also

signal_event, startTimedEvent, installClockHandler

interval

Set Timer Tick Interval

Syntax

```
#include <ctools.h>
void interval(unsigned timer, unsigned value);
```

Description

The **interval** function sets the tick interval for *timer* to *value*. Tick intervals are measured in multiples of 0.1 second.

If the timer number is invalid, the task's error code is set to **TIMER_BADTIMER**.

Notes

The default timer tick interval is 1/10 second.

See Also

settimer, read_timer_info, check_error

Example

Set timer 5 to count 12 seconds using 1.0 s ticks.

```
interval(5, 10);    /* 1.0 s ticks */
settimer(5, 12);    /* time = 12 seconds */
```

Set timer 5 to count 12 seconds using 0.1 s ticks.

```
interval(5, 1);     /* 0.1 s ticks */
settimer(5, 120);       /* time = 12 seconds */
```

ioBusReadByte

Read One Byte from I²C Slave Device

Syntax

```
#include <ctools.h>
unsigned char ioBusReadByte(void);
```

Description

The **ioBusReadByte** function returns one byte read from an I²C slave device. The byte is acknowledged by the master receiver. This function can be used multiple times in sequence to read data from a slave device. The last byte read from the slave must be read with the **ioBusReadLastByte** function.

If only one byte is to be read from a device, the **ioBusReadLastByte** function must be used instead of this function.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusStop, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteByte, ioBusWriteMessage

Example

```
#include <ctools.h>

void main(void)
{
       unsigned char data[3];
       unsigned char ioBusAddress = 114;

       request_resource(IO_SYSTEM);

       ioBusStart();
       if (ioBusSelectForRead(ioBusAddress))
       {
          data[0] = ioBusReadByte();
          data[1] = ioBusReadByte();
          /* reading the last byte terminates read */
          data[2] = ioBusReadLastByte();
       }
       ioBusStop();

       release_resource(IO_SYSTEM);
}
```

ioBusReadLastByte

Read Last Byte from I²C Slave Device

Syntax

```
#include <ctools.h>
unsigned char ioBusReadLastByte(void);
```

Description

The **ioBusReadLastByte** function returns one byte read from an I²C slave device and terminates reading from the slave. The byte is not acknowledged by the master receiver. This signals to the slave device that the read is complete. This function must be used once at the end of a read.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusStop, ioBusReadByte, ioBusReadMessage, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteByte, ioBusWriteMessage

Example

See example for **ioBusReadByte**.

ioBusReadMessage

Read Message from I²C Slave Device

Syntax

```
#include <ctools.h>
READSTATUS ioBusReadMessage(unsigned address, unsigned numberBytes, unsigned
    char *message);
```

Description

The **ioBusReadMessage** function reads a specified number of bytes from an I²C slave device.

The function issues a START condition, selects the device for reading, reads the specified number of bytes, and issues a STOP condition. It detects if the device cannot be selected and, if so, aborts the read.

The function has three parameters: the *address* of the device; the number of bytes to read, *numberBytes*; and a pointer to a buffer, *message*, capable of holding the data read.

The function returns the status of the read:

Value	Description
RS_success	read was successful
RS_selectFailed	slave device could not be selected

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusWriteMessage, ioBusStart, ioBusStop, ioBusReadByte ioBusReadLastByte, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteByte, ioBusWriteMessage

Example

```
#include <ctools.h>
void main(void)
{
       unsigned char message[10];
       unsigned char ioBusAddress = 114;
       READSTATUS    status;
       request_resource(IO_SYSTEM);

       /* Read a 10 byte message from I2C device */
       status = ioBusReadMessage(ioBusAddress, 10,
          message);
       release_resource(IO_SYSTEM);

       if (status != RS_success)
       {
          fprintf(com1, "I/O error = %d\n\r", status);
       }
}
```

ioBusSelectForRead

Select I²C Slave Device for Reading

Syntax

```
#include <ctools.h>
unsigned ioBusSelectForRead(unsigned char address);
```

Description

The **ioBusSelectForRead** function selects an I^2C slave device for reading. It writes the slave device address with the read/write bit set to the read state. The function handles the formatting of the address byte.

The function has one parameter, the *address* of the device. It returns TRUE if the write succeeded, that is the byte was acknowledged by the slave. It returns FALSE if the write failed, that is the byte was not acknowledged by the slave.

Notes

This function can only be used immediately after a START condition, e.g. **ioBusStart**.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusStop, ioBusReadByte, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForWrite, ioBusWriteByte, ioBusWriteMessage

Example

See example for **ioBusReadByte**.

ioBusSelectForWrite

Select I²C Slave Device for Writing

Syntax

```
#include <ctools.h>
unsigned ioBusSelectForWrite(unsigned char address);
```

Description

The **ioBusSelectForWrite** function selects an I^2C slave device for writing. It writes the slave device address with the read/write bit set to the write state. The function handles the formatting of the address byte.

The function has one parameter, the *address* of the device. It returns TRUE if the write succeeded, that is the byte was acknowledged by the slave. It returns FALSE if the write failed, that is the byte was not acknowledged by the slave.

Notes

This function can only be used immediately after a START condition, e.g. **ioBusStart**.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusStop, ioBusReadByte, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForRead, ioBusWriteByte, ioBusWriteMessage

Example

See example for **ioBusWriteByte**.

ioBusStart

Issue an I²C Bus START Condition

Syntax

```
#include <ctools.h>
void ioBusStart(void);
```

Description

The **ioBusStart** function issues an I²C bus START condition.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStop, ioBusReadByte, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteByte, ioBusWriteMessage

Example

See example for **ioBusReadByte**.

ioBusStop

Issue an I²C Bus STOP Condition

Syntax

```
#include <ctools.h>
void ioBusStop(void);
```

Description

The **ioBusStop** function issues an I²C bus STOP condition.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusReadByte, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteByte, ioBusWriteMessage

Example

See example for **ioBusReadByte**.

ioBusWriteByte

Write One Byte to I²C Slave Device

Syntax

```
#include <ctools.h>
unsigned ioBusWriteByte(unsigned char byte);
```

Description

The **ioBusWriteByte** function writes one byte to an I²C slave device and returns the acknowledge signal from the slave. It returns TRUE if the write succeeded, that is the byte was acknowledged by the slave. It returns FALSE if the write failed, that is the byte was not acknowledged by the slave.

This function can be used multiple times in sequence to write data to a device.

Notes

ioBusWriteByte can be used to write the address selection byte at the start of an I²C message; however, the **ioBusSelectForRead** and **ioBusSelectForWrite** functions provide a more convenient interface for doing this.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusStop, ioBusReadByte, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteMessage

Example

```
#include <ctools.h>

void main(void)
{
       unsigned char data[2];
       unsigned char ioBusAddress = 114;

       request_resource(IO_SYSTEM);

       ioBusStart();
       if (ioBusSelectForWrite(ioBusAddress))
       {
          ioBusWriteByte(data[0]);
          ioBusWriteByte(data[1]);
       }
       ioBusStop();

       release_resource(IO_SYSTEM);
}
```

ioBusWriteMessage

Write Message to I²C Slave Device

Syntax

```
#include <ctools.h>
WRITESTATUS ioBusWriteMessage(unsigned address, unsigned numberBytes,
   unsigned char *message);
```

Description

The **ioBusWriteMessage** function writes a specified number of bytes to an I²C slave device.

The function issues the START condition, selects the device for writing, writes the specified number of bytes, and issues a STOP condition. If the slave fails to acknowledge the selection or any data written to it, the write is aborted immediately.

The function has three parameters: the *address* of the device; the number of bytes to write, *numberBytes*; and a pointer to the buffer, *message*, containing the data.

The function returns the status of the write:

Value	Description
WS_success	write was successful
WS_selectFailed	slave could not be selected
WS_noAcknowledge	slave failed to acknowledge data

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioBusStart, ioBusStop, ioBusReadByte, ioBusReadLastByte, ioBusReadMessage, ioBusSelectForRead ioBusSelectForWrite, ioBusWriteByte

Example

```
#include <ctools.h>

void main(void)
{
       unsigned char    message[10];
       unsigned char    ioBusAddress = 114;
       WRITESTATUS      status;

       request_resource(IO_SYSTEM);

       /* Write a 10 byte message to I2C device */
       status = ioBusWriteMessage(ioBusAddress, 10,
          message);

       release_resource(IO_SYSTEM);

       if (status != WS_success)
       {
          fprintf(com1, "I/O error = %d\n\r", status);
       }
}
```

ioClear

Turn Off all Outputs

Syntax

```
#include <ctools.h>
void ioClear(void);
```

Description

The **ioClear** function turns off all outputs in the current Register Assignment as follows.

- analog outputs are set to 0;
- digital outputs are turned set to 0 (turned off).

If the Register Assignment is empty, all outputs are turned off for all possible I/O modules that exist under the fixed I/O hardware mapping of firmware versions 1.22 or older.

Also, all delayed digital I/O actions started by the **pulse**, **pulse_train** and **timeout** functions are always canceled.

Notes

Timers referenced by the **pulse**, **pulse_train** and **timeout** functions are set to 0. All other timers are not affected.

The IO_SYSTEM resource must be requested before calling this function.

ioDatabaseReset

Initialize I/O Database with Default Values

Syntax

```
#include <ctools.h>
void ioDatabaseReset(void);
```

Description

The **ioDatabaseReset** function resets all I/O database values to their defaults:

- Configuration parameters are reset to default values. All registers assigned to configuration parameters through the Register Assignment are also reset to default values.
- All other registers are set to zero. I/O hardware assigned to these registers through the Register Assignment are also set to zero.
- All forcing is removed.
- Locked variables are unlocked.
- Set all database locations to zero
- Clear real time clock alarm settings
- Clear serial port event counters
- Clear store and forward configuration
- Enable LED power by default and return to default state after 5 minutes
- Set Outputs on Stop settings to Hold
- Set 5904 HART modem configuration for all modems
- Set Modbus/TCP default configuration
- Write new default data to Flash

Notes

This function can be used to restore the controller to its default state. **ioDatabaseReset** has the same effect as selecting the **Initialize Controller** option from the **Initialize** command in the TelePACE program.

Use this function carefully as it erases any data stored in the I/O database.

The IO_SYSTEM resource must be requested before calling this function.

Example

```
#include <ctools.h>

void main(void)
{
       /* Power Up Initialization */
       request_resource(IO_SYSTEM);
       ioDatabaseReset();
       release_resource(IO_SYSTEM);

       /* ... the rest of the program */
}
```

ioRead16Din

Read 16 Digital Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead16Din(unsigned moduleAddress, unsigned startStatusRegister);
```

Description

The **ioRead16Din** function reads any 16 point Digital Input Module at the specified *moduleAddress*. Data is read from all 16 digital inputs and copied to 16 consecutive status registers beginning at *startStatusRegister*.

The function returns FALSE if the *moduleAddress* or *startStatusRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startStatusRegister* is any valid Modbus status register between 10001 and (10000 + NUMSTATUS - 15).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead8Din

Example

This program displays the values of the 16 digital inputs read from a 16 point Digital Input Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Read data from digital input module and  write it to I/O database
*/
       ioRead16Din(0, 10001);

       /* Print data from I/O database */
       fprintf(com1, "Register    Value");
       for (reg = 10001; reg <= 10016; reg++)
       {
          fprintf(com1, "\n\r%d   ", reg);
          putchar( dbase(MODBUS, reg) ? '1' :'0');
       }
```

```
        release_resource(IO_SYSTEM);
}
```

ioRead32Din

Read 32 Digital Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead32Din(
      UINT16 moduleAddress,
      UINT16 startStatusRegister);
```

Description

The `ioRead32Din` function reads any 32 point Digital Input Module at the specified `moduleAddress`. Data is read from all 32 digital inputs and copied to 32 consecutive status registers beginning at `startStatusRegister`.

The function returns FALSE if the `moduleAddress` or `startStatusRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for `moduleAddress` is 0 to 15. `startStatusRegister` is any valid Modbus status register between 10001 and (10001 + NUMSTATUS - 32).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the `ctools.lib` library. Load this library in you linker command (`.cmd`) file as shown in the sample file `appram.cmd` in your `ctools` directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead8Din, **ioRead16Din**

Example

This program displays the values of the 32 digital inputs read from a 32 point Digital Input Module at module address 0.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Read data from module and write to I/O database */
      ioRead32Din(0, 10001);

      /* Print data from I/O database */
      fprintf(com1, "Register       Value");
      for (reg = 10001; reg <= 10032; reg++)
      {
```

```
            fprintf(com1, "\n\r%d   ", reg);
            putchar( dbase(MODBUS, reg) ? '1' :'0');
        }

        release_resource(IO_SYSTEM);
    }
```

ioRead4Ain

Read 4 Analog Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead4Ain(unsigned moduleAddress, unsigned startInputRegister);
```

Description

The **ioRead4Ain** function reads any 4 point Analog Input Module at the specified *moduleAddress*. Data is read from all 4 analog inputs and copied to 4 consecutive input registers beginning at *startInputRegister*.

The function returns FALSE if the *moduleAddress* or *startInputRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startInputRegister* is any valid Modbus input register between 30001 and (30000 + NUMINPUT - 3).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead8Ain

Example

This program displays the values of the 4 analog inputs read from a 4 point Analog Input Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Read data from digital input module and  write it to I/O database
*/
       ioRead4Ain(0, 30001);

       /* Print data from I/O database */
       fprintf(com1, "Register    Value\n\r");
       for(reg = 30001; reg <= 30004; reg++)
       {
          fprintf(com1, "%d   %d\n\r", reg,          dbase(MODBUS, reg));
       }

       release_resource(IO_SYSTEM);
```

```
}
```

ioRead4Counter

Read 4 Counter Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead4Counter(unsigned moduleAddress, unsigned
   startInputRegister);
```

Description

The **ioRead4Counter** function reads any 4 point Counter Input Module at the specified *moduleAddress*. Data is read from all 4 counter inputs and copied to 8 consecutive input registers beginning at *startInputRegister*.

Each counter is a 32 bit number, stored in two input registers. The first register holds the least significant 16 bits of the counter. The second register holds the most significant 16 bits of the counter.

The maximum count is 4,294,967,295. Counters roll back to 0 when the maximum count is exceeded.

The function returns FALSE if the *moduleAddress* or *startInputRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startInputRegister* is any valid Modbus input register between 30001 and (30000 + NUMINPUT - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

Example

This program displays the values of the 4 counter inputs read from a 4 point Counter Input Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned counter, reg;
       unsigned long    value;

       request_resource(IO_SYSTEM);

       /* Read data from counter input module and
       write it to I/O database */
       ioRead4Counter(0, 30001);

       /* Print data from I/O database */
       fprintf(com1, "Counter  Value\n\r");
       counter = 0;
```

```
        for(reg = 30001; reg <= 30008; reg+=2)
        {
            value = dbase(MODBUS, reg) +
                ((long) dbase(MODBUS, reg+1)<<16);
            fprintf(com1, "%d   %ld\n\r", counter++,
            value);
        }

        release_resource(IO_SYSTEM);
}
```

ioRead4202Inputs

Read SCADASense 4202 DR Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead4202Inputs(
      unsigned startStatusRegister,
      unsigned startInputRegister
      );
```

Description

The `ioRead4202Inputs` function reads the digital, counter, and analog inputs from the SCADASense 4202 DR I/O. Data are read from 1 digital input and copied to 1 consecutive status registers beginning at `startStatusRegister`. Data is read from the analog input and copied to 1 input register beginning at `startInputRegister`. Data are read from the counter inputs and copied to 4 consecutive input registers beginning at `startInputRegister + 1`.

`startStatusRegister` is any valid Modbus status register between `10001` and `(10000 + NUMSTATUS - 1)`. `startInputRegister` is any valid Modbus input register between `30001` and `(30000 + NUMINPUT - 4)`.

The function returns FALSE if `startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

Notes

When this function reads data from the transnmitter (controller), it also processes the receiver buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

Digital inputs can also be read with the `readCounterInput` function.

Counters can also be read with the `readCounter` function.

Analog inputs can also be read with the `readInternalAD` function.

See Also

ioWrite4202Outputs, readCounter, readCounterInput

Example

This program displays the values of the 1 digital input, 2 counter inputs and 1 analog input read from SCADASense 4202 DR I/O.

```
#include <ctools.h>

void main(void)
{
```

```
        request_resource(IO_SYSTEM);

        /* Read 4202 DR inputs and write to I/O database */
        ioRead4202Inputs (10001, 30001);

        /* Print digital inputy */
        fprintf(com2, "Register       Value");
        fprintf(com2, "\n\r%d   ", 10001);
        putchar( dbase(MODBUS, 10001) ? '1' :'0');

        /* print analog input */
        fprintf(com2, "\n\r%d   %d", reg, dbase(MODBUS, 30001));

        /* print counter inputs */
        fprintf(com2, "Counter  Value\n\r");
        counter = 0;
        for(reg = 30002; reg <= 30005; reg+=2)
        {
              value = dbase(MODBUS, reg) +
                      ((long) dbase(MODBUS, reg+1)<<16);
              fprintf(com2, "%d %ld\n\r", counter++, value);
        }

        release_resource(IO_SYSTEM);
}
```

ioRead4202DSInputs

Read SCADASense 4202 DS Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead4202DSInputs(
      unsigned startStatusRegister,
      unsigned startInputRegister
      );
```

Description

The `ioRead4202DSInputs` function reads the digital, counter, and analog inputs from the SCADASense 4202 DS I/O. Data are read from 1 digital input and copied to 1 consecutive status registers beginning at `startStatusRegister`. Data is read from three analog inputs and copied to 3 input register beginning at `startInputRegister`. Data are read from the counter inputs and copied to 4 consecutive input registers beginning at `startInputRegister + 4`.

`startStatusRegister` is any valid Modbus status register between `10001` and `(10000 + NUMSTATUS)`.

`startInputRegister` is any valid Modbus input register between `30001` and `(30000 + NUMINPUT - 6)`.

The function returns FALSE if `startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

Notes

When this function reads data from the SCADASense 4202 DS I/O it also processes the receiver buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

The digital input can also be read with the `readCounterInput` function.

Counters can also be read with the `readCounter` function.

Analog inputs can also be read with the `readInternalAD` function.

See Also

ioWrite4202DSOutputs, **readCounter**, **readCounterInput**, **readInternalAD**

Example

This program displays the values of the digital input, 2 counter inputs and 3 analog inputs read from the SCADASense 4202 DS I/O.

```
#include <ctools.h>
```

```
void main(void)
{
      request_resource(IO_SYSTEM);

      /* Read 4202 DS inputs and write to I/O database */
      ioRead4202DSInputs (10001, 30001);

      /* Print digital input */
      fprintf(com2, "Register       Value");
      fprintf(com2, "\n\r%d   ", 10001);
      putchar( dbase(MODBUS, 10001) ? '1' :'0');

      /* print analog inputs */
      fprintf(com2, "\n\r%d   %d",30001,dbase(MODBUS, 30001));
      fprintf(com2, "\n\r%d   %d",30002,dbase(MODBUS, 30002));
      fprintf(com2, "\n\r%d   %d",30003,dbase(MODBUS, 30003));

      /* print counter inputs */
      fprintf(com12 "Counter  Value\n\r");
      counter = 0;
      for(reg = 30004; reg <= 30007; reg+=2)
      {
            value = dbase(MODBUS, reg) +
                  ((long) dbase(MODBUS, reg+1)<<16);
            fprintf(com2, "%d %ld\n\r", counter++, value);
      }

      release_resource(IO_SYSTEM);
}
```

ioRead5505Inputs

Read 5505 Inputs into I/O Database

Syntax

```
#include <ctools.h>
UINT16 ioRead5505Inputs(
      UINT16 moduleAddress,
      UINT16 startStatusRegister,
      UINT16 startInputRegister);
```

Description

The **ioRead5505Inputs** function reads the digital and analog inputs from the 5505 I/O. Data is read from all 16 digital inputs and copied to 16 consecutive status registers beginning at `startStatusRegister`. Data is read from all 4 analog inputs and copied to 8 consecutive input registers in floating point format beginning at `startInputRegister`.

The function of the 16 digital inputs is described in the table below.

Point Offset	Function
0	OFF = channel 0 RTD is good ON = channel 0 RTD is open or PWR input is off
1	OFF = channel 0 data in range ON = channel 0 data is out of range
2	OFF = channel 0 RTD is using 3-wire measurement ON = channel 0 RTD is using 4-wire measurement
3	reserved for future use
4	OFF = channel 1 RTD is good ON = channel 1 RTD is open or PWR input is off
5	OFF = channel 1 data in range ON = channel 1 data is out of range
6	OFF = channel 1 RTD is using 3-wire measurement ON = channel 1 RTD is using 4-wire measurement
7	reserved for future use
8	OFF = channel 2 RTD is good ON = channel 2 RTD is open or PWR input is off
9	OFF = channel 2 data in range ON = channel 2 data is out of range
10	OFF = channel 2 RTD is using 3-wire measurement ON = channel 2 RTD is using 4-wire measurement
11	reserved for future use
12	OFF = channel 3 RTD is good ON = channel 3 RTD is open or PWR input is off
13	OFF = channel 3 data in range ON = channel 3 data is out of range
14	OFF = channel 3 RTD is using 3-wire measurement ON = channel 3 RTD is using 4-wire measurement
15	reserved for future use

The function returns FALSE if the `moduleAddress, startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

`moduleAddress` is the address of the 5505 module. Valid values are 0 to 15.

`startStatusRegister` is any valid Modbus status register between `10001` and (10001 + `NUMSTATUS` - 15).

`startInputRegister` is any valid Modbus input register between `30001` and (30001 + `NUMINPUT` - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

Example

This program displays the values of the 16 digital inputs and 4 analog inputs read from 5505 I/O at module address 3.

```
#include <ctools.h>
void main(void)
{
      UINT16 reg;
      typedef union
      {
            UINT16 intValue[2];
            float  floatValue;
      } UF_UNION;
      UF_UNION value;

      request_resource(IO_SYSTEM);

      /* Read data from 5505 I/O into I/O database */
      ioRead5505Inputs(3, 10001, 30001);
      /* Print data from I/O database */
      fprintf(com1, "Register       Value");
      for (reg = 10001; reg <= 10016; reg++)
      {
            fprintf(com1, "\n\r%d   ", reg);
            putchar(dbase(MODBUS, reg) ? '1' :'0');
      }

      for(reg = 30001; reg <= 30008; reg+2)
      {
            value.intValue[1] = dbase(MODBUS, reg);
            value.intValue[0] = dbase(MODBUS, reg + 1);
            fprintf(com1, "\n\r%d   %d", reg, value.floatValue);
      }

      release_resource(IO_SYSTEM);
}
```

ioRead5506Inputs

Read 5506 Inputs into I/O Database

Syntax

```
#include <ctools.h>
UINT16 ioRead5506Inputs(
      UINT16 moduleAddress,
      UINT16 startStatusRegister,
      UINT16 startInputRegister);
```

Description

The **ioRead5506Inputs** function reads the digital and analog inputs from the 5506 I/O. Data is read from all 8 digital inputs and copied to 8 consecutive status registers beginning at `startStatusRegister`. Data is read from all 8 analog inputs and copied to 8 consecutive input registers beginning at `startInputRegister`.

The function returns FALSE if the `moduleAddress, startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

`moduleAddress` is the address of the 5506 module. Valid values are 0 to 15.

`startStatusRegister` is any valid Modbus status register between `10001` and (10001 + `NUMSTATUS` - 7).

`startInputRegister` is any valid Modbus input register between `30001` and (30001 + `NUMINPUT` - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite5606Outputs

Example

This program displays the values of the 8 digital inputs and 8 analog inputs read from 5506 I/O at module address 3.

```
#include <ctools.h>

void main(void)
{
      UINT16 reg;

      request_resource(IO_SYSTEM);

      /* Read data from 5506 I/O into I/O database */
      ioRead5506Inputs(3, 10001, 30001);
```

```
        /* Print data from I/O database */
        fprintf(com1, "Register       Value");
        for (reg = 10001; reg <= 10008; reg++)
        {
              fprintf(com1, "\n\r%d   ", reg);
              putchar(dbase(MODBUS, reg) ? '1' :'0');
        }

        for(reg = 30001; reg <= 30008; reg++)
        {
              fprintf(com1, "\n\r%d   %d", reg,
              dbase(MODBUS, reg));
        }

        release_resource(IO_SYSTEM);
}
```

ioRead5601Inputs

Read 5601 Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead5601Inputs(unsigned startStatusRegister, unsigned
   startInputRegister);
```

Description

The **ioRead5601Inputs** function reads the digital and analog inputs from a 5601 I/O Module. Data is read from all 16 digital inputs and copied to 16 consecutive status registers beginning at *startStatusRegister*. Data is read from all 8 analog inputs and copied to 8 consecutive input registers beginning at *startInputRegister*.

The function returns FALSE if *startStatusRegister* or *startInputRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

startStatusRegister is any valid Modbus status register between 10001 and (10000 + NUMSTATUS - 15). *startInputRegister* is any valid Modbus input register between 30001 and (30000 + NUMINPUT - 7).

Notes

Note that when this function reads data from the 5601 it also processes the receiver buffer for the com3 serial port. If the controller type is a SCADAPack or SCADAPack PLUS, the com3 serial port is also continuously processed automatically.

The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite5601Outputs

Example

This program displays the values of the 16 digital inputs and 8 analog inputs read from a 5601 I/O Module.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Read data from 5601 I/O module and write it
```

```
        to I/O database */
        ioRead5601Inputs(10001, 30001);

        /* Print data from I/O database */
        fprintf(com1, "Register    Value");
        for (reg = 10001; reg <= 10016; reg++)
        {
           fprintf(com1, "\n\r%d   ", reg);
           putchar( dbase(MODBUS, reg) ? '1' :'0');
        }

        for(reg = 30001; reg <= 30008; reg++)
        {
           fprintf(com1, "\n\r%d   %d", reg,
           dbase(MODBUS, reg));
        }

        release_resource(IO_SYSTEM);
}
```

ioRead5602Inputs

Read 5602 Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead5602Inputs(unsigned startStatusRegister, unsigned
   startInputRegister);
```

Description

The **ioRead5602Inputs** function reads the inputs from a 5602 I/O Module as digital or analog inputs. Data is read from all 5 analog inputs and copied to 5 consecutive input registers beginning at *startInputRegister*. The same 5 analog inputs are also read as 5 digital inputs and copied to 5 consecutive status registers beginning at *startStatusRegister*.

A digital input is ON if the corresponding filtered analog input value is greater than or equal to 20% of its full scale value, otherwise it is OFF. Analog input 0 to 4 correspond to digital inputs 0 to 4.

The function returns FALSE if *startStatusRegister* or *startInputRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

startStatusRegister is any valid Modbus status register between 10001 and (10000 + NUMSTATUS - 4). *startInputRegister* is any valid Modbus input register between 30001 and (30000 + NUMINPUT - 4).

Notes

Note that when this function reads data from the 5602 it also processes the receiver buffer for the com4 serial port. If the controller type is a SCADAPack LIGHT or SCADAPack PLUS, the com4 serial port is also continuously processed automatically.

The additional service to the com4 receiver caused by this function does not affect the normal automatic operation of com4.

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite5602Outputs

Example

This program displays the values of the 5 inputs read from a 5602 I/O Module as both digital and analog inputs.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;
```

```
        request_resource(IO_SYSTEM);

        /* Read data from 5602 I/O module and write it
        to I/O database */
        ioRead5602Inputs(10001, 30001);

        /* Print data from I/O database */
        fprintf(com1, "Register    Value");
        for (reg = 10001; reg <= 10005; reg++)
        {
           fprintf(com1, "\n\r%d   ", reg);
           putchar( dbase(MODBUS, reg) ? '1' :'0');
        }

        for(reg = 30001; reg <= 30005; reg++)
        {
           fprintf(com1, "\n\r%d   %d", reg,
           dbase(MODBUS, reg));
        }
        release_resource(IO_SYSTEM);
}
```

ioRead5604Inputs

Read 5604 Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead5604Inputs(
      unsigned startStatusRegister,
      unsigned startInputRegister);
```

Description

The `ioRead5604Inputs` function reads the digital and analog inputs from the 5604 I/O. Data is read from all 35 digital inputs and copied to 35 consecutive status registers beginning at `startStatusRegister`. Data is read from all 10 analog inputs and copied to 10 consecutive input registers beginning at `startInputRegister`.

The function returns `FALSE` if `startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

`startStatusRegister` is any valid Modbus status register between `10001` and (10001 + `NUMSTATUS` - 35).

`startInputRegister` is any valid Modbus input register between `30001` and (30001 + `NUMINPUT` - 10).

Notes

When this function reads data from the 5604 I/O it also processes the receiver buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite5604Outputs

Example

This program displays the values of the 35 digital inputs and 10 analog inputs read from 5604 I/O.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Read data from 5604 I/O into I/O database */
      ioRead5604Inputs(10001, 30001);
```

```
        /* Print data from I/O database */
        fprintf(com1, "Register       Value");
        for (reg = 10001; reg <= 10035; reg++)
        {
              fprintf(com1, "\n\r%d   ", reg);
              putchar(dbase(MODBUS, reg) ? '1' :'0');
        }

        for(reg = 30001; reg <= 30010; reg++)
        {
              fprintf(com1, "\n\r%d   %d", reg,
              dbase(MODBUS, reg));
        }

        release_resource(IO_SYSTEM);
}
```

ioRead5606Inputs

Read 5606 Inputs into I/O Database

Syntax

```
#include <ctools.h>
UINT16 ioRead5606Inputs(
      UINT16 moduleAddress,
      UINT16 startStatusRegister,
      UINT16 startInputRegister);
```

Description

The **ioRead5606Inputs** function reads the digital and analog inputs from the 5606 I/O. Data is read from all 40 digital inputs and copied to 40 consecutive status registers beginning at `startStatusRegister`. Data is read from all 8 analog inputs and copied to 8 consecutive input registers beginning at `startInputRegister`.

The function returns FALSE if the `moduleAddress, startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

`moduleAddress` is the address of the 5606 module. Valid values are 0 to 7.

`startStatusRegister` is any valid Modbus status register between `10001` and (10001 + `NUMSTATUS` - 39).

`startInputRegister` is any valid Modbus input register between `30001` and (30001 + `NUMINPUT` - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite5606Outputs

Example

This program displays the values of the 40 digital inputs and 8 analog inputs read from 5606 I/O at module address 3.

```
#include <ctools.h>

void main(void)
{
      UINT16 reg;

      request_resource(IO_SYSTEM);

      /* Read data from 5606 I/O into I/O database */
      ioRead5606Inputs(3, 10001, 30001);
```

```
        /* Print data from I/O database */
        fprintf(com1, "Register       Value");
        for (reg = 10001; reg <= 10040; reg++)
        {
              fprintf(com1, "\n\r%d   ", reg);
              putchar(dbase(MODBUS, reg) ? '1' :'0');
        }

        for(reg = 30001; reg <= 30008; reg++)
        {
              fprintf(com1, "\n\r%d   %d", reg,
              dbase(MODBUS, reg));
        }

        release_resource(IO_SYSTEM);
}
```

ioRead8Ain

Read 8 Analog Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead8Ain(unsigned moduleAddress, unsigned startInputRegister);
```

Description

The **ioRead8Ain** function reads any 8 point Analog Input Module at the specified *moduleAddress*. Data is read from all 8 analog inputs and copied to 8 consecutive input registers beginning at *startInputRegister*.

The function returns FALSE if the *moduleAddress* or *startInputRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startInputRegister* is any valid Modbus input register between 30001 and (30000 + NUMINPUT - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead4Ain

Example

This program displays the values of the 8 analog inputs read from an 8 point Analog Input Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Read data from digital input module and  write it to I/O database
*/
       ioRead8Ain(0, 30001);

       /* Print data from I/O database */
       fprintf(com1, "Register    Value\n\r");
       for(reg = 30001; reg <= 30008; reg++)
       {
          fprintf(com1, "%d   %d\n\r", reg,          dbase(MODBUS, reg));
       }

       release_resource(IO_SYSTEM);
```

```
}
```

ioRead8Din

Read 8 Digital Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioRead8Din(unsigned moduleAddress, unsigned startStatusRegister);
```

Description

The **ioRead8Din** function reads any 8 point Digital Input Module at the specified *moduleAddress*. Data is read from all 8 digital inputs and copied to 8 consecutive status registers beginning at *startStatusRegister*.

The function returns FALSE if the *moduleAddress* or *startStatusRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startStatusRegister* is any valid Modbus status register between 10001 and (10000 + NUMSTATUS - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead16Din

Example

This program displays the values of the 8 digital inputs read from an 8 point Digital Input Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Read data from digital input module and  write it to I/O database
*/
       ioRead8Din(0, 10001);

       /* For each digital input on the module */
       fprintf(com1, "Register    Value");
       for (reg = 10001; reg <= 10008; reg++)
       {
          fprintf(com1, "\n\r%d   ", reg);

          putchar( dbase(MODBUS, reg) ? '1' :'0');
       }
```

```
        release_resource(IO_SYSTEM);
}
```

ioReadLPInputs

Read SCADAPack LP Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioReadLPInputs (unsigned startStatusRegister, unsigned
startInputRegister);
```

Description

The `ioReadLPInputs` function reads the digital and analog inputs from the SCADAPack LP I/O. Data is read from all 16 digital inputs and copied to 16 consecutive status registers beginning at `startStatusRegister`. Data is read from all 8 analog inputs and copied to 8 consecutive input registers beginning at `startInputRegister`.

The function returns `FALSE` if `startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

`startStatusRegister` is any valid Modbus status register between 10001 and (10000 + `NUMSTATUS` - 15). `startInputRegister` is any valid Modbus input register between 30001 and (30000 + `NUMINPUT` - 7).

Notes

When this function reads data from the SCADAPack LP I/O it also processes the receiver buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

Data is not copied to the I/O database for registers that are currently forced.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

Example

This program displays the values of the 16 digital inputs and 8 analog inputs read from SCADAPack LP I/O.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Read data from LP I/O and write it to I/O database */
      ioReadLPInputs (10001, 30001);

      /* Print data from I/O database */
      fprintf(com1, "Register       Value");
      for (reg = 10001; reg <= 10016; reg++)
      {
            fprintf(com1, "\n\r%d   ", reg);
            putchar( dbase(MODBUS, reg) ? '1' :'0');
```

```
        }

        for(reg = 30001; reg <= 30008; reg++)
        {
              fprintf(com1, "\n\r%d   %d", reg,
              dbase(MODBUS, reg));
        }

        release_resource(IO_SYSTEM);
}
```

ioReadSP100Inputs

Read SCADAPack 100 Inputs into I/O Database

Syntax

```
#include <ctools.h>
unsigned ioReadSP100Inputs(unsigned startStatusRegister, unsigned
startInputRegister);
```

Description

The `ioReadSP100Inputs` function reads the digital and analog inputs from the SCADAPack 100 I/O. Data is read from all 6 digital inputs and copied to 6 consecutive status registers beginning at `startStatusRegister`. Data is read from all 6 analog inputs and one counter input, and copied to 8 consecutive input registers beginning at `startInputRegister`.

The function returns FALSE if `startStatusRegister` or `startInputRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

`startStatusRegister` is any valid Modbus status register between 10001 and (10000 + `NUMSTATUS` - 5). `startInputRegister` is any valid Modbus input register between 30001 and (30000 + `NUMINPUT` - 7).

Notes

Data is not copied to the I/O database for registers that are currently forced.

Data from the four external analog inputs is copied to the first four input registers.

Data from the temperature sensor is copied to the fifth input register.

Data from the battery voltage sensor is copied to the sixth input register.

Data from the counter input is copied to the seventh and eighth input registers.

To read data from an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWriteSP100Outputs

Example

This program displays the values of the 6 digital inputs, 6 analog inputs, and the counter input read from SCADAPack 100 I/O.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;
      unsigned long count;

      request_resource(IO_SYSTEM);

      /* Read data from I/O and write it to I/O database */
```

```
        ioReadSP100Inputs(10001, 30001);

        /* Print digital data from I/O database */
        for (reg = 10001; reg <= 10006; reg++)
        {
              fprintf(com1, "Register %d = %d\r\n", reg,
              dbase(MODBUS, reg));
        }
        fprintf(com1, "\r\n");

        /* Print analog data from I/O database */
        for(reg = 30001; reg <= 30006; reg++)
        {
              fprintf(com1, "Regsiter %d = %d\n\r", reg,
              dbase(MODBUS, reg));
        }
        fprintf(com1, "\r\n");

        /* Print counter data from I/O database */
        count = dbase(MODBUS, 30006);
        count += ((unsigned long) dbase(MODBUS, reg)) << 16;

        fprintf(com1, "Registers 30006 & 30007 = %ul\r\n", reg,
        count);

        release_resource(IO_SYSTEM);
}
```

ioRefresh

Update Outputs with Internal Data

Syntax

```
#include <ctools.h>
void ioRefresh(void);
```

Description

The **ioRefresh** function resets devices on the 5000 series I/O bus. Input channels are scanned to update their values from the I/O hardware. Output channels are scanned to write their values from output tables in memory.

Notes

This function is normally only used by the sleep function to restore output states when the controller wakes.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioClear, ioReset

ioReset

Reset 5000 Series I/O Modules

Syntax

```
#include <ctools.h>
void ioReset(unsigned state);
```

Description

The **ioReset** function sets the state of the 5000 Series I/O bus reset signal. *state* may be TRUE or FALSE.

The reset signal restarts all devices on the 5000 Series I/O bus. Output modules clear all their output points. Input modules restart their input scanning. All modules remain in the reset state until the reset signal is set to FALSE.

Notes

Do not leave the reset signal in the TRUE state. This will disable I/O.

The **ioClear** function provides a more effective method of resetting the I/O system.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioClear

ioWrite16Dout

Write to 16 Digital Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite16Dout(unsigned moduleAddress, unsigned startCoilRegister);
```

Description

The **ioWrite16Dout** function writes data to any 16 point Digital Output Module at the specified *moduleAddress*. Data is read from 16 consecutive coil registers beginning at *startCoilRegister*, and written to the 16 digital outputs.

The function returns FALSE if the *moduleAddress* or *startCoilRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startCoilRegister* is any valid Modbus coil register between 00001 and (NUMCOIL - 15).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the ctools.lib library. Load this library in you linker command (.cmd) file as shown in the sample file appram.cmd in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite8Dout

Example

This program turns ON all 16 digital outputs of a 16 point Digital Output Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       for (reg = 1; reg <= 16; reg++)
       {
          setdbase(MODBUS, reg, 1);
       }

       /* Write data from I/O database to digital
       output module */
       ioWrite16Dout(0, 1);

       release_resource(IO_SYSTEM);
```

```
}
```

ioWrite32Dout

Write to 32 Digital Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite32Dout(
      UINT16 moduleAddress,
      UINT16 startCoilRegister);
```

Description

The `ioWrite32Dout` function writes data to any 32-point Digital Output Module at the specified `moduleAddress`. Data is read from 32 consecutive coil registers beginning at `startCoilRegister`, and written to the 32 digital outputs.

The function returns FALSE if the `moduleAddress` or `startCoilRegister` is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for `moduleAddress` is 0 to 15. `startCoilRegister` is any valid Modbus coil register between 00001 and (NUMCOIL - 31).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment.

This function is contained in the `ctools.lib` library. Load this library in you linker command (`.cmd`) file as shown in the sample file `appram.cmd` in your `ctools` directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite8Dout, **ioWrite16Dout**

Example

This program turns ON all 32 digital outputs of a 32 point Digital Output Module at module address 0.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Write data to I/O database */
      for (reg = 1; reg <= 32; reg++)
      {
            setdbase(MODBUS, reg, 1);
      }

      /* Write data from I/O database to digital
      output module */
      ioWrite32Dout(0, 1);
```

```
        release_resource(IO_SYSTEM);
}
```

ioWrite8Dout

Write to 8 Digital Outputs from I/O Database

Syntax

```
#include <iomodule.h>
unsigned ioWrite8Dout(unsigned moduleAddress, unsigned startCoilRegister);
```

Description

The **ioWrite8Dout** function writes data to any 8 point Digital Output Module at the specified *moduleAddress*. Data is read from 8 consecutive coil registers beginning at *startCoilRegister*, and written to the 8 digital outputs.

The function returns FALSE if the *moduleAddress* or *startCoilRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startCoilRegister* is any valid Modbus coil register between 00001 and (NUMCOIL - 7).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite16Dout

Example

This program turns ON all 8 digital outputs of an 8 point Digital Output Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       for (reg = 1; reg <= 8; reg++)
       {
          setdbase(MODBUS, reg, 1);
       }

       /* Write data from I/O database to digital
       output module */
       ioWrite8Dout(0, 1);

       release_resource(IO_SYSTEM);
}
```

ioWrite2Aout

Write to 2 Analog Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite2Aout(unsigned moduleAddress, unsigned
   startHoldingRegister);
```

Description

The **ioWrite2Aout** function writes data to any 2 point Analog Output Module at the specified *moduleAddress*. Data is read from 2 consecutive holding registers beginning at *startHoldingRegister*, and written to the 2 analog outputs.

The function returns FALSE if the *moduleAddress* or *startHoldingRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startHoldingRegister* is any valid Modbus holding register between 40001 and (40000 + NUMHOLDING - 1).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite4Aout, ioWrite5303Aout

Example

This program sets both analog outputs to half scale on a 2 point Analog Output Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       setdbase(MODBUS, 40001, 16384);
       setdbase(MODBUS, 40002, 16384);

       /* Write data from I/O database to analog
       output module */
       ioWrite2Aout(0, 40001);

       release_resource(IO_SYSTEM);
}
```

ioWrite4Aout

Write to 4 Analog Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite4Aout(unsigned moduleAddress, unsigned
   startHoldingRegister);
```

Description

The **ioWrite4Aout** function writes data to any 4 point Analog Output Module at the specified *moduleAddress*. Data is read from 4 consecutive holding registers beginning at *startHoldingRegister*, and written to the 4 analog outputs.

The function returns FALSE if the *moduleAddress* or *startHoldingRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

The valid range for *moduleAddress* is 0 to 15. *startHoldingRegister* is any valid Modbus holding register between 40001 and (40000 + NUMHOLDING - 3).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the ctools.lib library. Load this library in you linker command (.cmd) file as shown in the sample file appram.cmd in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite2Aout, ioWrite5303Aout

Example

This program sets all 4 analog outputs to half scale on a 4 point Analog Output Module at module address 0.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       for (reg = 40001; reg <= 40004; reg++)
       {
          setdbase(MODBUS, reg, 16384);
       }
       /* Write data from I/O database to analog
       output module */
       ioWrite4Aout(0, 40001);

       release_resource(IO_SYSTEM);
}
```

ioWrite4AoutChecksum

Write to 4 Point Analog Output Module with Checksum

Syntax

```
#include <ctools.h>
UINT16 ioWrite4AoutChecksum(
      UINT16 moduleAddress,
      UINT16 startHoldingRegister
      )
```

Description

The `ioWrite4AoutChecksum` function writes data to a 4-point analog output module with checksum support. Output data comes from the I/O database. The function can be used with 5304 analog output modules. Use the `isaWrite4Aout` function for all other analog output modules.

The function has two parameters.

- `moduleAddress` is the address of the module. The valid range is 0 to 15.
- Data are read from 4 consecutive holding registers and written to 4 analog outputs. `startHoldingRegister` is any valid Modbus holding register between 40001 and (40001 + NUMHOLDING - 4).

The function returns FALSE if the `moduleAddress` or `startHoldingRegister` is invalid, or if an I/O error occurs; otherwise TRUE is returned.

Notes

The IO_SYSTEM resource must be requested before calling this function.

This function is contained in the `ctools.lib` library. Load this library in you linker command (`.cmd`) file as shown in the sample file `appram.cmd` in your `ctools` directory.

To write data to an I/O Module continuously, add the module to the Register Assignment.

See Also

ioWrite2Aout, **ioWrite4Aout**, **ioWrite5303Aout**

Example

This program sets all 4 analog outputs to half scale on a 5304 Analog Output Module at module at address 0.

```
#include <ctools.h>

void main(void)
{
      UINT16 reg;
      request_resource(IO_SYSTEM);

      /* Write data to I/O database */
      for (reg = 40001; reg <= 40004; reg++)
      {
            setdbase(MODBUS, reg, 16384);
```

```
        }
        /* Write I/O database to 5304 analog output module */
        ioWrite4AoutChecksum(0, 40001);

        release_resource(IO_SYSTEM);
}
```

ioWrite4202Outputs

Write to SCADASense 4202 DR Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite4202Outputs(
      unsigned startHoldingRegister
      );
```

Description

The `ioWrite4202Outputs` function writes data to the analog output of the SCADASense 4202 DR I/O. Analog data is read from 1 holding register beginning at `startHoldingRegister` and written to the analog output.

`startHoldingRegister` is any valid Modbus holding register between 40001 and (4000 + `NUMHOLDING`).

The function returns `FALSE` if `startHoldingRegister` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

Notes

When this function writes data to the SCADASense 4202 DR I/O it also processes the transmit buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead4202Inputs, ioWrite4202OutputsEx

Example

This program sets the analog output to full scale.

```
#include <ctools.h>

void main(void)
{
      request_resource(IO_SYSTEM);

      /* Write analog data to I/O database */
      setdbase(MODBUS, 40001, 32767);

      /* Write data from I/O database to 4202 DR output */
      ioWrite4202Outputs(40001);

      release_resource(IO_SYSTEM);
}
```

ioWrite4202OutputsEx

Write to SCADASense 4202 DR with Extended Outputs, from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite4202OutputsEx(
      unsigned startCoilRegister,
      unsigned startHoldingRegister
      );
```

Description

The `ioWrite4202OutputsEx` function writes data to the outputs of the SCADASense 4202 DR with Extended I/O (digital output). Digital data is read from one coil register starting at `startCoilRegister` and written to the digital output. Analog data is read from 1 holding register beginning at `startHoldingRegister` and written to the analog output.

`startCoilRegister` is any valid Modbus coil register between 1 and (`NUMCOIL`).

`startHoldingRegister` is any valid Modbus holding register between 40001 and (4000 + `NUMHOLDING`).

The function returns FALSE if `startCoilRegister` or `startHoldingRegister` are invalid, or if an I/O error has occurred; otherwise TRUE is returned.

Notes

When this function writes data to the SCADASense 4202 DR I/O it also processes the transmit buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

To write data to an I/O Module continuously, add the module to the Register Assignment.

The `IO_SYSTEM` resource must be requested before calling this function.

See Also

ioRead4202Inputs

Example

This program sets the analog output to full scale and turns on the digital output.

```
#include <ctools.h>
void main(void)
{
      request_resource(IO_SYSTEM);

      /* Write output data to I/O database */
      setdbase(MODBUS, 1, 1);
      setdbase(MODBUS, 40001, 32767);

      /* Write data from I/O database to 4202 DR outputs */
      ioWrite4202OutputsEx(1, 40001);

      release_resource(IO_SYSTEM);
}
```

ioWrite4202DSOutputs

Write to SCADASense 4202 DS Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite4202DSOutputs(
      unsigned startCoilRegister
      );
```

Description

The ioWrite4202DSOutputs function writes data to the outputs of the SCADASense 4202 DS I/O module. Digital data is read from two coil registers starting at `startCoilRegister` and written to the digital outputs.

`startCoilRegister` is any valid Modbus coil register between 1 and (`NUMCOIL` - 1).

The function returns FALSE if `startCoilRegister` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

Notes

When this function writes data to the SCADASense 4202 DS I/O it also processes the transmit buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

To write data to an I/O Module continuously, add the module to the Register Assignment.

The `IO_SYSTEM` resource must be requested before calling this function.

See Also

ioRead4202DSInputs

Example

This program turns on the digital outputs.

```
#include <ctools.h>

void main(void)
{
      request_resource(IO_SYSTEM);

      /* Write output data to I/O database */
      setdbase(MODBUS, 1, 1);
      setdbase(MODBUS, 2, 1);

      /* Write data from I/O database to 4202 DS outputs */
      ioWrite4202DSOutputs(1);

      release_resource(IO_SYSTEM);
}
```

ioWrite5303Aout

Write to 5303 Analog Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite5303Aout(unsigned startHoldingRegister);
```

Description

The **ioWrite5303Aout** function writes data to the 2 points on a 5303 SCADAPack Analog Output Module. Data is read from 2 consecutive holding registers beginning at *startHoldingRegister*, and written to the 2 analog outputs.

The function returns FALSE if *startHoldingRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

startHoldingRegister is any valid Modbus holding register between 40001 and (40000 + NUMHOLDING - 1).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section *I/O Database and Register Assignment* for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioWrite2Aout, ioWrite5303Aout

Example

This program sets both analog outputs to half scale on a 5303 Analog Output Module.

```
#include <ctools.h>

void main(void)
{
       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       setdbase(MODBUS, 40001, 16384);
       setdbase(MODBUS, 40002, 16384);

       /* Write data from I/O database to analog
       output module */
       ioWrite5303Aout(40001);

       release_resource(IO_SYSTEM);
}
```

ioWrite5505Outputs

Write to 5505 Configuration from I/O Database

Syntax

```
#include <ctools.h>
UINT16 ioWrite5505Outputs(
      UINT16 moduleAddress,
      UINT16 inputType[4],
      UINT16 inputFilter
);
```

Description

The `ioWrite5505Outputs` function writes configuration data to the 5505 I/O module.

The function returns FALSE if `moduleAddress` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

`moduleAddress` is the address of the 5505 module. Valid values are 0 to 15.

`inputType` is an array of 4 values indicating the input range for the corresponding analog input. Valid values are

- 0 = RTD in deg Celsius
- 1 = RTD in deg Fahrenheit
- 2 = RTD in deg Kelvin
- 3 = resistance measurement in ohms.

`inputFilter` is the analog input filter setting. Valid values are.

- 0 = 0.5 s
- 1 = 1 s
- 2 = 2 s
- 3 = 4 s

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

Example

This program writes configuration data to a 5505 I/O module at module address 5.

```
#include <ctools.h>

void main(void)
{
      UINT16 index;
      UINT16 inputType[4];
      UINT16 inputFilter;

      request_resource(IO_SYSTEM);

      /* set the input types */
      for (index = 0; index < 4; index++)
```

```
        {
              inputType[index] = 1; // RTD in deg F
        }

        /* set filter */
        inputFilter = 3;        // maximum filter

        /* Write configuration data to 5505 I/O module */
        ioWrite5505Outputs(5, inputType, inputFilter);

        release_resource(IO_SYSTEM);
}
```

ioWrite5506Outputs

Write to 5506 Configuration from I/O Database

Syntax

```
#include <ctools.h>
UINT16 ioWrite5506Outputs(
      UINT16 moduleAddress,
      UINT16 inputType[8],
      UINT16 inputFilter,
      UINT16 scanFrequency
);
```

Description

The **ioWrite5506Outputs** function writes configuration data to the 5506 I/O module.

The function returns FALSE if `moduleAddress` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

`moduleAddress` is the address of the 5506 module. Valid values are 0 to 15.

`inputType` is an array of 8 values indicating the input range for the corresponding analog input. Valid values are

- 0 = 0 to 5 V
- 1 = 1 to 5 V
- 2 = 0 to 20 mA
- 3 = 4 to 20 mA.

`inputFilter` is the analog input filter setting. Valid values are.

- 0 = 3 Hz
- 1 = 6 Hz
- 2 = 11 Hz
- 3 = 30 Hz

`scanFrequency` is the scan frequency setting. Valid values are.

- 0 = 60 Hz
- 1 = 50 Hz

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead5606Inputs

Example

This program writes configuration data to a 5506 I/O module at module address 5.

```
#include <ctools.h>

void main(void)
{
      UINT16 index;
      UINT16 inputType[8];
      UINT16 inputFilter;
      UINT16 scanFrequency;

      request_resource(IO_SYSTEM);

      /* set the input types */
      for (index = 0; index < 8; index++)
      {
            inputType[index] = 1; // 1 to 5 V
      }

      /* set filter and frequency */
      inputFilter = 3;        // minimum filter
      scanFrequency = 0;      // 60 Hz

      /* Write configuration data to 5506 I/O module */
      ioWrite5506Outputs(5, inputType, inputFilter, scanFrequency);

      release_resource(IO_SYSTEM);
}
```

ioWrite5601Outputs

Write to 5601 Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite5601Outputs(unsigned startCoilRegister);
```

Description

The **ioWrite5601Outputs** function writes data to the digital outputs of a 5601 I/O Module. Data is read from 12 consecutive coil registers beginning at *startCoilRegister*, and written to the 12 digital outputs.

The function returns FALSE if *startCoilRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

startCoilRegister is any valid Modbus coil register between 00001 and (NUMCOIL - 11).

Notes

Note that when this function writes data to the 5601 it also services to the transmit buffer of the com3 serial port. If the controller type is a SCADAPack or SCADAPack PLUS, the com3 serial port is also continuously processed automatically.

The additional service to the com3 transmitter caused by this function does not affect the normal automatic operation of com3.

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead5601Inputs

Example

This program turns ON all 12 digital outputs of a 5601 I/O Module.

```
#include <ctools.h>

void main(void)
{
       unsigned reg;

       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       for (reg = 1; reg <= 12; reg++)
       {
          setdbase(MODBUS, reg, 1);
       }

       /* Write data from I/O database to 5601 */
       ioWrite5601Outputs(1);
```

```
        release_resource(IO_SYSTEM);
}
```

ioWrite5602Outputs

Write to 5602 Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite5602Outputs(unsigned startCoilRegister);
```

Description

The **ioWrite5602Outputs** function writes data to the digital outputs of a 5602 I/O Module. Data is read from 2 consecutive coil registers beginning at *startCoilRegister*, and written to the 2 digital outputs.

The function returns FALSE if *startCoilRegister* is invalid or if an I/O error has occurred; otherwise TRUE is returned.

startCoilRegister is any valid Modbus coil register between 00001 and (NUMCOIL - 1).

Notes

Note that when this function writes data to the 5602 it also services to the transmit buffer of the com4 serial port. If the controller type is a SCADAPack LIGHT or SCADAPack PLUS, the com4 serial port is also continuously processed automatically.

The additional service to the com4 transmitter caused by this function does not affect the normal automatic operation of com4.

To write data to an I/O Module continuously, add the module to the Register Assignment. Refer to the section **Overview of Functions** for details.

This function is contained in the *ctools.lib* library. Load this library in you linker command (.cmd) file as shown in the sample file *appram.cmd* in your ctools directory.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead5602Inputs

Example

This program turns ON both digital outputs of a 5602 I/O Module.

```
#include <ctools.h>
void main(void)
{
       unsigned reg;
       request_resource(IO_SYSTEM);

       /* Write data to I/O database */
       setdbase(MODBUS, 1, 1);
       setdbase(MODBUS, 2, 1);

       /* Write data from I/O database to 5602 */
       ioWrite5602Outputs(1);

       release_resource(IO_SYSTEM);
}
```

ioWrite5604Outputs

Write to 5604 Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWrite5604Outputs(
      unsigned startCoilRegister,
      unsigned startHoldingRegister);
```

Description

The `ioWrite5604Outputs` function writes data to the digital and analog outputs of the 5604 I/O. Digital data is read from 36 consecutive coil registers beginning at `startCoilRegister`, and written to the 36 digital outputs. Analog data is read from 2 consecutive holding registers beginning at `startHoldingRegister` and written to the 2 analog outputs.

The function returns FALSE if `startCoilRegister` is invalid, if `startHoldingRegister` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

`startCoilRegister` is any valid Modbus coil register between `00001` and `(1 + NUMCOIL - 36)`.

`startHoldingRegister` is any valid Modbus holding register between `40001` and `(40001 + NUMHOLDING - 2)`.

Notes

When this function writes data to the 5604 I/O it also processes the transmit buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 transmitter caused by this function does not affect the normal automatic operation of com3.

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead5604Inputs

Example

This program turns on all 32 external digital outputs and sets the analog outputs to full scale. The internal digital outputs are turned off.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Write digital data to I/O database */
      for (reg = 1; reg <= 32; reg++)
```

```
        {
              setdbase(MODBUS, reg, 1);
        }

        for (reg = 33; reg <= 36; reg++)
        {
              setdbase(MODBUS, reg, 0);
        }

        /* Write analog data to I/O database */
        for (reg = 40001; reg <= 40002; reg++)
        {
              setdbase(MODBUS, reg, 32767);
        }

        /* Write data from I/O database to 5604 I/O */
        ioWrite5604Outputs(1, 40001);

        release_resource(IO_SYSTEM);
}
```

ioWrite5606Outputs

Write to 5606 Outputs from I/O Database

Syntax

```
#include <ctools.h>
UINT16 ioWrite5606Outputs(
      UINT16 moduleAddress,
      UINT16 startCoilRegister,
      UINT16 startHoldingRegister,
      UINT16 inputType[8],
      UINT16 inputFilter,
      UINT16 scanFrequency,
      UINT16 outputType
);
```

Description

The **ioWrite5606Outputs** function writes data to the digital and analog outputs of the 5606 I/O. Digital data is read from 16 consecutive coil registers beginning at `startCoilRegister`, and written to the 16 digital outputs. Analog data is read from 2 consecutive holding registers beginning at `startHoldingRegister` and written to the 2 analog outputs.

The function returns FALSE if `moduleAddress, startCoilRegister` or `startHoldingRegister` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

`moduleAddress` is the address of the 5606 module. Valid values are 0 to 7.

`startCoilRegister` is any valid Modbus coil register between `00001` and `(1 + NUMCOIL - 15)`.

`startHoldingRegister` is any valid Modbus holding register between `40001` and `(40001 + NUMHOLDING - 1)`.

`inputType` is an array of 8 values indicating the input range for the corresponding analog input. Valid values are

- 0 = 0 to 5V
- 1 = 0 to 10 V
- 2 = 0 to 20 mA
- 3 = 4 to 20 mA.

`inputFilter` is the analog input filter setting. Valid values are.

- 0 = 3 Hz
- 1 = 6 Hz
- 2 = 11 Hz
- 3 = 30 Hz

`scanFrequency` is the scan frequency setting. Valid values are.

- 0 = 60 Hz
- 1 = 50 Hz

`outputType` selects the type of analog outputs on the module. Valid values are

- 0 = 0 to 20 mA
- 1 = 4 to 20 mA.

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioRead5606Inputs

Example

This program turns on all 16 external digital outputs and sets the analog outputs to full scale. The internal digital outputs are turned off. The module address is 5.

```
#include <ctools.h>

void main(void)
{
      UINT16 index;
      UINT16 inputType[8];
      UINT16 inputFilter;
      UINT16 scanFrequency;
      UINT16 outputType;

      request_resource(IO_SYSTEM);

      /* Write digital data to I/O database */
      for (index = 1; index <= 16; index ++)
      {
            setdbase(MODBUS, index, 1);
      }

      /* Write analog data to I/O database */
      for (index = 40001; index <= 40002; index ++)
      {
            setdbase(MODBUS, index, 32767);
      }

      /* set the input types */
      for (index = 0; index < 8; index++)
      {
            inputType[index] = 1; // 0 to 10 V
      }

      /* set filter and frequency */
      inputFilter = 3;        // minimum filter
      scanFrequency = 0;      // 60 Hz

      /* set analog output type to 4-20 mA */
      outputType = 1;

      /* Write data from I/O database to 5606 I/O */
```

```
            ioWrite5606Outputs(5, 1, 40001, inputType, inputFilter,
        scanFrequency, outputType);

        release_resource(IO_SYSTEM);
    }
```

ioWriteLPOutputs

Write to SCADAPack LP Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWriteLPOutputs (unsigned startCoilRegister, unsigned
startHoldingRegister);
```

Description

The `ioWriteLPOutputs`function writes data to the digital and analog outputs of the SCADAPack LP I/O. Digital data is read from 12 consecutive coil registers beginning at `startCoilRegister`, and written to the 12 digital outputs. Analog data is read from 2 consecutive holding registers beginning at `startHoldingRegister` and written to the 2 analog outputs.

The function returns `FALSE` if `startCoilRegister` is invalid, if `startHoldingRegister` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

`startCoilRegister` is any valid Modbus coil register between 00001 and (`NUMCOIL` - 11).

`startHoldingRegister` is any valid Modbus holding register between 40001 and (`NUMHOLDING` - 2).

Notes

When this function writes data to the SCADAPack LP I/O it also processes the transmit buffer for the com3 serial port. The com3 serial port is also continuously processed automatically. The additional service to the com3 receiver caused by this function does not affect the normal automatic operation of com3.

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioReadLPInputs

Example

This program turns on all 12 digital outputs and sets the analog outputs to full scale.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Write digital data to I/O database */
      for (reg = 1; reg <= 12; reg++)
      {
            setdbase(MODBUS, reg, 1);
      }
```

```
        /* Write analog data to I/O database */
        for (reg = 40001; reg <= 40002; reg++)
        {
              setdbase(MODBUS, reg, 32767);
        }

        /* Write data from I/O database to SCADAPack LP I/O */
        ioWriteLPOutputs (1, 40001);

        release_resource(IO_SYSTEM);
}
```

ioWriteSP100Outputs

Write to SCADAPack 100 Outputs from I/O Database

Syntax

```
#include <ctools.h>
unsigned ioWriteSP100Outputs(unsigned startCoilRegister);
```

Description

The `ioWriteSP100Outputs` function writes data to the digital outputs of the SCADAPack 100 I/O. Digital data is read from 6 consecutive coil registers beginning at `startCoilRegister`, and written to the 6 digital outputs.

The function returns FALSE if `startCoilRegister` is invalid, or if an I/O error has occurred; otherwise TRUE is returned.

`startCoilRegister` is any valid Modbus coil register between 00001 and (`NUMCOIL - 5`).

Notes

To write data to an I/O Module continuously, add the module to the Register Assignment.

The IO_SYSTEM resource must be requested before calling this function.

See Also

ioReadSP100Inputs

Example

This program turns on all 6 digital outputs.

```
#include <ctools.h>

void main(void)
{
      unsigned reg;

      request_resource(IO_SYSTEM);

      /* Write digital data to I/O database */
      for (reg = 1; reg <= 6; reg++)
      {
            setdbase(MODBUS, reg, 1);
      }

      /* Write data from I/O database to SCADAPack 100 I/O */
      ioWriteSP100Outputs(1);

      release_resource(IO_SYSTEM);
}
```

jiffy

Read System Clock

Syntax

```
#include <ctools.h>
unsigned long jiffy(void);
```

Description

The **jiffy** function returns the current value of the system jiffy clock. The jiffy clock increments every 1/60 second. The jiffy clock rolls over to 0 after 5183999. This is the number of 1/60 second intervals in a day.

Notes

The real time clock and the jiffy clock are not related. They may drift slightly with respect to each other over several days.

Use the jiffy clock to measure times with resolution better than the 1/10th resolution provided by timers.

See Also

interval, setjiffy

Example

This program uses the jiffy timer to determine the execution time of a section of code. The section is run 10 times to provide a longer time base for the measurement.

```
#include <ctools.h>
void main(void)
{
       int iterations = 10;
       int i;

       setjiffy(0UL);
       for(i=0; i<=iterations; i++)
       {
          /* statements to time */
       }
       printf("average time=%ld jiffies",
          jiffy()/iterations);
}
```

ledGetDefault

Read LED Power Control Parameters

Syntax

```
#include <ctools.h>
struct ledControl_tag ledGetDefault(void);
```

Description

The **ledGetDefault** routine returns the default LED power control parameters. The controller controls LED power to 5000 series I/O modules. To conserve power, the LEDs can be disabled.

The user can change the LED power setting with the LED POWER switch on the controller. The LED power returns to its default state after a user specified time period.

Example

See the example for the **ledSetDefault** function.

ledPower

Set LED Power State

Syntax

```
#include <ctools.h>
unsigned ledPower(unsigned state);
```

Description

The **ledPower** function sets the LED power state. The LED power will remain in the state until the default time-out period expires. *state* must be LED_ON or LED_OFF.

The function returns TRUE if state is valid and FALSE if it is not.

Notes

The LED POWER switch also controls the LED power. A user may override the setting made by this function.

The **ledSetDefault** function sets the default state of the LED power. This state overrides the value set by this function.

See Also

ledPowerSwitch, ledGetDefault, ledSetDefault

ledPowerSwitch

Read State of the LED Power Switch

Syntax

```
#include <ctools.h>
unsigned ledPowerSwitch(void);
```

Description

The ledPowerSwitch function returns the status of the led power switch. The function returns FALSE if the switch is released and TRUE if the switch is pressed.

Notes

This switch may be used by the program for user input. However, pressing the switch will have the side effect of changing the LED power state.

See Also

ledPower, ledSetDefault, ledGetDefault

ledSetDefault

Set Default Parameters for LED Power Control

Syntax

```
#include <ctools.h>
unsigned ledSetDefault(struct ledControl_tag ledControl);
```

Description

The **ledSetDefault** routine sets default parameters for LED power control. The controller controls LED power to 5000 series I/O modules. To conserve power, the LEDs can be disabled.

The LED power setting can be changed by the user with the LED POWER switch on the controller. The LED power returns to its default state after a user specified time period.

The *ledControl* structure contains the default values. Refer to the **Structures and Types** section for a description of the fields in the *ledControl_tag* structure. Valid values for the *state* field are LED_ON and LED_OFF. Valid values for the *time* field are 1 to 65535 minutes.

The function returns TRUE if the parameters are valid and false if they are not. If either parameter is not valid, the default values are not changed.

The IO_SYSTEM resource must be requested before calling this function.

Example

```
#include <ctools.h>

void main(void)
{
       struct ledControl_tag ledControl;

       request_resource(IO_SYSTEM);

       /* Turn LEDS off after 20 minutes */
       ledControl.time  = 20;
       ledControl.state = LED_OFF;
       ledSetDefault(ledControl);

       release_resource(IO_SYSTEM);

       /* ... the reset of the program */
}
```

load

Read Parameters from EEPROM

Syntax

```
#include <ctools.h>
void load(unsigned section);
```

Description

The **load** function reads data from the specified *section* of the EEPROM into RAM.. Valid values for *section* are **EEPROM_EVERY** and **EEPROM_RUN**.

The **save** function writes data to the EEPROM.

Notes

The IO_SYSTEM resource must be requested before calling this function.

The **EEPROM_EVERY** section is not used.

The **EEPROM_RUN** section is loaded from EEPROM to RAM when the controller is reset and the Run/Service switch is in the RUN position. Otherwise default information is used for this section. This section contains:

- serial port configuration tables
- protocol configuration tables

See Also

save

master_message

Send Protocol Command

Syntax

```
#include <ctools.h>
extern unsigned master_message(FILE *stream, unsigned function, unsigned
slave_station, unsigned slave_address, unsigned master_address, unsigned
length);
```

Description

The **master_message** function sends a command using a communication protocol. The communication protocol task waits for the response from the slave station. The current task continues execution.

- *stream* specifies the serial port.
- *function* specifies the protocol function code. Refer to the communication protocol manual for supported function codes.
- *slave* specifies the network address of the slave station. This is also known as the slave station number.
- *address* specifies the location of data in the slave station. Depending on the protocol function code, data may be read or written at this location.
- *master_address* specifies the location of data in the master (this controller). Depending on the protocol function code, data may be read or written at this location.
- *length* specifies the number or registers.

The **master_message** function returns the command status from the protocol driver.

Value	Description
MM_SENT	message transmitted to slave
MM_BAD_FUNCTION	function is not recognized
MM_BAD_SLAVE	slave station number is not valid
MM_BAD_ADDRESS	slave or master database address not valid
MM_BAD_LENGTH	too many or too few registers specified
MM_EOT	Master message status: DF1 slave response was an EOT message
MM_WRONG_RSP	Master message status: DF1slave response did not match command sent.
MM_CMD_ACKED	Master message status: DF1half duplex command has been acknowledged by slave – Master may now send poll command.
MM_EXCEPTION_FUNCTION	Master message status: Modbus slave returned a function exception.
MM_EXCEPTION_ADDRESS	Master message status: Modbus slave returned an address exception.
MM_EXCEPTION_VALUE	Master message status: Modbus slave returned a value exception.
MM_RECEIVED	Master message status: response received.
MM_RECEIVED_BAD_LENGTH	Master message status: response received with incorrect amount of data.

The calling task monitors the status of the command sent using the **get_protocol_status** function. The `command` field of the `prot_status` structure is set to **MM_SENT** if a master message is sent. It will be set to **MM_RECEIVED** when the response to the message is received with the proper length. It will be set to **MM_RECEIVED_BAD_LENGTH** when a response to the message is received with the improper length.

Notes

Refer to the communication protocol manual for more information.

Users of TeleSAFE BASIC and the TeleSAFE 6000 C compiler should note that the address parameter now specifies the actual database address, when used with the Modbus protocol. This parameter specified the address offset on these older TeleSAFE products.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

The IO_SYSTEM resource must be requested before calling this function.

See Also

clear_protocol_status

Example Using Modbus Protocol

This program sends a master message, on **com2**, using the Modbus protocol, then waits for a response from the slave. The number of good and failed messages is printed to **com1**.

```
/* ----------------------------------------
   poll.c
   Polling program for Modbus slave.
   ---------------------------------------- */

#include <ctools.h>

/* ----------------------------------------
   wait_for_response

   The wait_for_response function waits for a
   response to be received to a master_message on
   the serial port specified by stream. It returns
   when a response is received, or when the period
   specified by time (in tenths of a second)
   expires.
   ---------------------------------------- */

void wait_for_response(FILE *stream, unsigned time)
{
       struct prot_status status;
       static unsigned long good, bad;

       interval(0, 1);
       settimer(0, time);
       do {
          /* Allow other tasks to execute */
          release_processor();

          status = get_protocol_status(stream);
       }
       while (timer(0) && status.command == MM_SENT);

       if (status.command == MM_RECEIVED)
```

```
            good++;
        else
            bad++;
        fprintf(com1, "Good: %8lu  Bad: %8lu\r", good,
              bad);
}
/* ----------------------------------------
        main

    The main function sets up serial ports then
    sends commands to a Modbus slave.
    ---------------------------------------- */
void main(void)
{
        struct prot_settings settings;
        struct pconfig portset;

        request_resource(IO_SYSTEM);

        /* disable protocol on serial port 1 */
        settings.type = NO_PROTOCOL;
        settings.station = 1;
        settings.priority = 3;
        settings.SFMessaging = FALSE;
        set_protocol(com1, &settings);

        /* Set communication parameters for port 1 */
        portset.baud      = BAUD9600;
        portset.duplex    = FULL;
        portset.parity    = NONE;
        portset.data_bits = DATA8;
        portset.stop_bits = STOP1;
        portset.flow_rx   = DISABLE;
        portset.flow_tx   = DISABLE;
        portset.type      = RS232;
        portset.timeout   = 600;
        set_port(com1, &portset);

        /* enable Modbus protocol on serial port 2 */
        settings.type = MODBUS_ASCII;
        settings.station = 2;
        settings.priority = 3;
        settings.SFMessaging = FALSE;
        set_protocol(com2, &settings);

        /* Set communication parameters for port 2 */
        portset.baud      = BAUD9600;
        portset.duplex    = HALF;
        portset.parity    = NONE;
        portset.data_bits = DATA8;
        portset.stop_bits = STOP1;
        portset.flow_rx   = DISABLE;
        portset.flow_tx   = DISABLE;
        portset.type      = RS485_2WIRE;
        portset.timeout   = 600;
        set_port(com2, &portset);

        release_resource(IO_SYSTEM);
```

```
        /* Main communication loop */
        while (TRUE)
        {
            /* Transfer slave inputs to outputs */
            request_resource(IO_SYSTEM);
            master_message(com2, 2, 1, 10001, 17, 8);
            release_resource(IO_SYSTEM);
            wait_for_response(com2, 10);

            /* Transfer inputs to slave outputs */
            request_resource(IO_SYSTEM);
            master_message(com2, 15, 1, 1, 10009, 8);
            release_resource(IO_SYSTEM);
            wait_for_response(com2, 10);

            /* Allow other tasks to execute */
            release_processor();
        }
}
```

Examples using DF1 Protocol

Full Duplex

Using the same example program above, apply the following calling format for the master_message function.

This code fragment uses the protected write command (*function*=0) to transmit 13 (*length*=13) 16-bit registers to slave station 10 (*slave*=10). The data will be read from registers 127 to 139 (*master_address*=127), and stored into registers 180 to 192 (*address*=180) in the slave station. The command will be transmitted on com2 (*stream*=com2).

```
master_message(com2, 0, 10, 180, 127, 13);
```

This code fragment uses the unprotected read command (*function*=1) to read 74 (*length*=74) 16-bit registers from slave station 37 (*slave*=37). The data will be read from registers 300 to 373 in the slave (*address*=300), and stored in registers 400 to 473 in the master (*master_address*=400). The command will be transmitted on com2 (*stream*=com2).

```
master_message(com2, 1, 37, 300, 400, 74);
```

This code fragment will send specific bits from a single 16-bit register in the master to slave station 33. The unprotected bit write command (*function*=5) will be used. Bits 0,1,7,12 and 15 of register 100 (*master_address*=100) will be sent to register 1432 (*address*=1432) in the slave. The *length* parameter is used as a bit mask and is evaluated as follows:

it mask = 1001 0000 1000 0011 in binary

= 9083 in hexadecimal

= 36,995 in decimal

Therefore the command, sent on com2, is:

```
master_message(com2, 5, 33, 1432, 100, 36995);
```

Half Duplex

The example program is the same as for Full Duplex except that instead of waiting for a response after calling master_message, the slave must be polled for a response. Add the following function **poll_for_response** to the example program above and call it instead of wait_for_response:

```
/* ----------------------------------------
```

```
   poll_for_response

   The poll_for_response function polls the
   specified slave for a response to a master
   message sent on the serial port specified by
   stream. It returns when the correct response
   is received, or when the period specified by
   time (in tenths of a second) expires.
   ------------------------------------------ */
unsigned poll_for_response(FILE *stream, unsigned slave, unsigned
time)
{
   struct prot_status status;
   unsigned done;
   static unsigned long good, bad;

   /* set timeout timer */
   interval( 0, 10 );
   settimer( 0, time );
   do
   {
      /* wait until command status changes or
      timer expires */
      do
      {
         status = get_protocol_status( stream );
         release_processor();
      }
      while(timer(0)&& (status.command==MM_SENT));

      /* command has been ACKed, send poll */
      if (status.command == MM_CMD_ACKED)
      {
         pollABSlave(stream, slave);
         done = FALSE;
      }

      /* response/command mismatch, poll again */
      else if (status.command == MM_WRONG_RSP)
      {
         pollABSlave(stream, slave);
         done = FALSE;
      }

      /* correct response was received */
      else if (status.command == MM_RECEIVED)
      {
         good++;
         done = TRUE;
      }

      /* timer has expired or status is MM_EOT */
      else
      {
         bad++;
         done = TRUE;
      }
   } while (!done);

   fprintf(com1, "Good: %8lu  Bad: %8lu\r", good,
   bad);
}
```

modbusExceptionStatus

Set Response to Protocol Command

Syntax

```
#include <ctools.h>
void modbusExceptionStatus(unsigned char status);
```

Description

The **modbusExceptionStatus** function is used in conjunction with the Modbus compatible communication protocol. It sets the result returned in response to the Read Exception Status command. This command is provided for compatibility with some Modbus protocol drivers for host computers.

The value of *status* is determined by the requirements of the host computer.

Notes

The specified result will be sent each time that the protocol command is received, until a new result is specified.

The result is cleared when the controller is reset. The application program must initialize the status each time it is run.

See Also

modbusSlaveID

modbusSlaveID

Set Response to Protocol Command

Syntax

```
#include <ctools.h>
void modbusSlaveID(unsigned char *string, unsigned length);
```

Description

The **modbusSlaveID** function is used in conjunction with the Modbus compatible communication protocol. It sets the result returned in response to the Report Slave ID command. This command is provided for compatibility with some Modbus protocol drivers for host computers.

string points to a string of at least *length* characters. The contents of the string is determined by the requirements of the host computer. The string is not NULL terminated and may contain multiple NULL characters.

The *length* specifies how many characters are returned by the protocol command. *length* must be in the range 1 to **REPORT_SLAVE_ID_SIZE**. If *length* is too large only the first **REPORT_SLAVE_ID_SIZE** characters of the string will be sent in response to the command.

Notes

The specified result will be sent each time that the protocol command is received, until a new result is specified.

The function copies the data pointed to by *string*. *string* may be modified after the function is called.

The result is cleared when the controller is reset. The application program must initialize the salve ID string each time it is run.

See Also

modbusExceptionStatus

modbusProcessCommand Function

Process a Modbus command and return the response.

Syntax

```
#include <ctools.h>
BOOLEAN processModbusCommand(
      FILE * stream,
      UCHAR * pCommand,
      UINT16 commandLength,
      UINT16 responseSize,
      UCHAR * pResponse,
      UINT16 * pResponseLength
      )
```

Description

The `processModbusCommand` function processes a Modbus protocol command and returns the response. The function can be used by an application to encapsulate Modbus RTU commands in another protocol.

`stream` is a FILE pointer that identifies the serial port where the command was received. This is used for to accumulate statistics for the serial port.

`pCommand` is a pointer to a buffer containing the Modbus command. The contents of the buffer must be a standard Modbus RTU message. The Modbus RTU checksum is not required.

`commandLength` is the number of bytes in the Modbus command. The length must include all the address and data bytes. It must not include the checksum bytes, if any, in the command buffer.

`responseSize` is the size of the response buffer in bytes. A 300-byte buffer is recommended. If this is not practical in the application, a smaller buffer may be supplied. Some responses may be truncated if a smaller buffer is used.

`pResponse` is a pointer to a buffer to contain the Modbus response. The function will store the response in this buffer in standard Modbus RTU format including two checksum bytes at the end of the response.

`pResponseLength` is a pointer to a variable to hold response length. The function will store the number of bytes in the response in this variable. The length will include two checksum bytes.

The function returns TRUE if the response is valid and can be used. It returns FALSE if the response is too long to fit into the supplied response buffer.

Notes

To use the function on a serial port, a protocol handler must be created for the encapsulating protocol. Set the protocol type for the port to NO_PROTOCOL to allow the custom handler to be used.

The function supports standard and extended addressing. Configure the protocol settings for the serial port for the appropriate protocol.

The Modbus RTU checksum is not required in the command so the encapsulating protocol may omit them if they are not needed. This may be useful in host devices that don't create a Modbus RTU message with checksum prior to encapsulation.

The Modbus RTU checksum is included in the response to support encapsulating a complete Modbus RTU format message. If the checksum is not needed by the encapsulating protocol the checksum bytes may be ignored.

See Also

set_protocol

Example

This example is taken from a protocol driver than encapsulates Modbus RTU messages in another protocol. It shows how to pass the Modbus RTU command to the Modbus driver, and obtain the response.

The example assumes the Modbus RTU messages are transmitted with the checksum. The length of the checksum is subtracted when calling the `processModbusCommand` function. The checksum is included when responding.

```
/* receive the packet in the encapsulating protocol */
/* verify the packet is valid */

/* locate the Modbus RTU command in the command buffer */
pCommandData = commandBuffer + PROTOCOL_HEADER_SIZE;

/* get length of Modbus RTU command from the packet header */
commandLength = commandBuffer[DATA_SIZE] - 2;

/* locate the Modbus RTU response in the response buffer leaving
room for the packet header */
pResponseData = responseBuffer + PROTOCOL_HEADER_SIZE;

/* process the Modbus message */
if (processModbusCommand(
      stream,
      pCommandData,
      commandLength,
      MODBUS_BUFFER_SIZE,
      pResponseData,
      &responseLength))
{
      /* put the response length in the header */
      responseBuffer[DATA_SIZE] = responseLength;

      /* fill in rest of packet header */
      /* transmit the encapsulated response */
}
```

modemAbort

Unconditionally Terminate Dial-up Connection

Syntax

```
#include <ctools.h>
void modemAbort(FILE *port);
```

Description

The **modemAbort** function unconditionally terminates a dial-up connection, connection in progress or modem initialization started by the C application. *port* specifies the serial port the where the modem is installed.

The connection or initialization is terminated only if it was started from a C application. Connections made from a Ladder Logic application and answered calls are not terminated.

This function can be used in a task exit handler.

Notes

The serial port type must be set to RS232_MODEM.

Note that a pause of a few seconds is required between terminating a connection and initiating a new call. This pause allows the external modem time to hang up.

Use this function in a task exit handler to clean-up any open dial-up connections or modem initializations. If a task is ended by executing end_task from another task, modem connections or initializations must be aborted in the exit handler. Otherwise, the reservation ID for the port remains valid. No other task or Ladder Logic program may use modem functions on the port. Failing to call **modemAbort** or **modemAbortAll** in the task exit handler may result in the port being unavailable to any programs until the controller is reset.

The modem connection or initialization is automatically terminated when TelePACE stops the C application and when the controller is rebooted.

All reservation IDs returned by the **modemDial** and **modemInit** functions on this port are invalid after calling **modemAbort**.

See Also

modemAbortAll, modemDial, modemDialEnd, modemDialStatus, modemInit, modemInitEnd, modemInitStatus, modemNotification

Example

Refer to the examples in the **Functions Overview** section.

modemAbortAll

Unconditionally Terminate All Dial-up Connections

Syntax

```
#include <ctools.h>
void modemAbort(void);
```

Description

The **modemAbortAll** function unconditionally terminates all dial-up connections, connections in progress or modem initializations started by the C application.

The connections or initializations are terminated only if they were started from a C application. Connections made from a Ladder Logic application and answered calls are not terminated.

This function can be used in a task exit handler.

Notes

Note that a pause of a few seconds is required between terminating a connection and initiating a new call. This pause allows the external modem time to hang up.

Use this function in a task exit handler to clean-up any open dial-up connections or modem initializations. If executing end_task from another task ends a task, modem connections or initializations must be aborted in the exit handler. Otherwise, the reservation ID for the port remains valid. No other task or Ladder Logic program may use modem functions on the port. Failing to call **modemAbort** or **modemAbortAll** in the task exit handler may result in the port being unavailable to any programs until the controller is reset.

The modem connection or initialization is automatically terminated when TelePACE stops the C application and when the controller is rebooted.

This function will terminate all open dial-up connections or modem initializations started by the C application - even those started by other tasks. The exit handler can safely call this function instead of multiple calls to **modemAbort** if all the connections or initializations were started from the same task.

All reservation IDs returned by the **modemDial** and **modemInit** functions are invalid after calling **modemAbort**.

See Also

modemDial, modemDialEnd, modemDialStatus, modemInit, modemInitEnd, modemInitStatus, modemNotification

Example

This program installs an exit handler for the main task that terminates any dial-up connections made by the task. This handler is not strictly necessary if TelePACE ends the main task. However, it demonstrates how to use the modemAbortAll function and an exit handler for another task in a more complex program.

```
#include <ctools.h>

/* ------------------------------------------
   The shutdown function aborts any active
```

```
   modem connections when the task is ended.
   ----------------------------------------- */
void shutdown(void)
{
      modemAbortAll();
}

void main(void)
{
      TASKINFO taskStatus;

      /* set up exit handler for this task */
      taskStatus = getTaskInfo(0);
   installExitHandler(taskStatus.taskID, shutdown);

      while(TRUE)
      {
         /* rest of main task here */

         /* Allow other tasks to execute */
         release_processor();
      }
}
```

modemDial

Connect to a Remote Dial-up Controller

Syntax

```
#include <ctools.h>
enum DialError modemDial(struct ModemSetup *configuration, reserve_id *id);
```

Description

The **modemDial** function connects a controller to a remote controller using an external dial-up modem. One **modemDial** function may be active on each serial port. The **modemDial** function handles all port sharing and multiple dialing attempts.

The *ModemSetup* structure specified by *configuration* defines the serial port, dialing parameters, modem initialization string and the phone number to dial. Refer to the **Structures and Types** section for a description of the fields in the *ModemSetup* structure.

id points to a reservation identifier for the serial port. The identifier ensures that no other modem control function can access the serial port. This parameter must be supplied to the **modemDialEnd** and **modemDialStatus** functions.

The function returns an error code. DE_NoError indicates that the connect operation has begun. Any other code indicates an error. Refer to the *dialup.h* section for a complete description of error codes.

Notes

The serial port type must be set to RS232_MODEM.

Note:	The SCADAPack 100 does not support dial up connections on com port 1. The SCADASense series controllers do not support dial up connections.

The **modemDialStatus** function returns the status of the connection attempt initiated by modemDial.

The **modemDialEnd** function terminates the connection to the remote controller. Note that a pause of a few seconds is required between terminating a connection and initiating a new call. This pause allows the external modem time to hang up.

If a communication protocol is active on the serial port when a connection is initiated, the protocol will be disabled until the connection is made, then re-enabled. This allows the controller to communicate with the external modem on the port. The protocol settings will also be restored when a connection is terminated with the **modemDialEnd** function.

If a **modemInit** function or an incoming call is active on the port, the **modemDial** function cannot access the port and will return an error code of DE_NotInControl. If communication stops for more than five minutes, then outgoing call requests are allowed to end the incoming call. This prevents problems with the modem or the calling application from permanently disabling outgoing calls.

The reservation identifier is valid until the call is terminated and another modem function or an incoming call takes control of the port.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

Do not call this function in a task exit handler.

See Also

modemAbortAll, modemDialEnd, modemDialStatus, modemInit, modemInitEnd, modemInitStatus, modemNotification

Example

Refer to the examples in the **Functions Overview** section.

modemDialEnd

Terminate Dial-up Connection

Syntax

```
#include <ctools.h>
void modemDialEnd(FILE *port, reserve_id id, enum DialError *error);
```

Description

The **modemDialEnd** function terminates a dial-up connection or connection in progress. *port* specifies the serial port the where the modem is installed. *id* is the port reservation identifier returned by the modemDial function.

The function sets the variable pointed to by *error*. If no error occurred DE_NoError is returned. Any other value indicates an error. Refer to the **Structures and Types** section for a complete description of error codes.

Notes

The serial port type must be set to RS232_MODEM.

A connection can be terminated by any of the following events. Once terminated another modem function or incoming call can take control of the serial port.

- Execution of the modemDialEnd function.
- Execution of the modemAbort or modemAbortAll functions.
- The remote device hangs up the phone line.
- An accidental loss of carrier occurs due to phone line problems.

Note that a pause of a few seconds is required between terminating a connection and initiating a new call. This pause allows the external modem time to hang up.

The reservation identifier is valid until the call is terminated and another modem function or an incoming call takes control of the port. The **modemDialEnd** function returns a DE_NotInControl error code, if another modem function or incoming call is in control of the port.

Do not call this function in a task exit handler. Use modemAbort instead.

See Also

modemAbortAll, modemDial, modemDialStatus, modemInit, modemInitEnd, modemInitStatus, modemNotification

modemDialStatus

Return Status of Dial-up Connection

Syntax

```
#include <ctools.h>
void modemDialStatus(FILE *port, reserve_id id, enum DialError * error, enum
   DialState *state);
```

Description

The **modemDialStatus** function returns the status of a remote connection initiated by the **modemDial** function. *port* specifies the serial port where the modem is installed. *id* is the port reservation identifier returned by the **modemDial** function.

The function sets the variable pointed to by *error*. If no error occurred DE_NoError is returned. Any other value indicates an error. Refer to the **Structures and Types** section for a complete description of error codes.

The function sets the variable pointed to by *state* to the current execution state of dialing operation. The state value is not valid if the error code is DE_NotInControl. Refer to the *dialup.h* section for a complete description of state codes.

Notes

The serial port type must be set to RS232_MODEM.

The reservation identifier is valid until the call is terminated and another modem function or an incoming call takes control of the port. The **modemDialStatus** function will return a DE_NotInControl error code, if another dial function or incoming call is now in control of the port.

Do not call this function in a task exit handler.

modemInit

Initialize Dial-up Modem

Syntax

```
#include <ctools.h>
enum DialError modemInit(struct ModemInit *configuration, reserve_id *id);
```

Description

The **modemInit** function sends an initialization string to an external dial-up modem. It is typically used to set up a modem to answer incoming calls. One modemInit function may be active on each serial port. The modemInit function handles all port sharing and multiple dialing attempts.

The ModemInit structure pointed to by *configuration* defines the serial port and modem initialization string. Refer to the **Structures and Types** section for a description of the fields in the *ModemInit* structure.

The *id* variable is set to a reservation identifier for the serial port. The identifier ensures that no other modem control function can access the serial port. This parameter must be supplied to the modemInitEnd and modemInitStatus functions.

The function returns an error code. DE_NoError indicates that the initialize operation has begun. Any other code indicates an error. Refer to the **Structures and Types** section for a complete description of error codes.

Notes

The serial port type must be set to RS232_MODEM.

The **modemInitStatus** function returns the status of the connection attempt initiated by modemInit.

The **modemInitEnd** function terminates initialization of the modem.

If a communication protocol is active on the serial port, the protocol will be disabled until the initialization is complete then re-enabled. This allows the controller to communicate with the external modem on the port. The protocol settings will also be restored when initialization is terminated with the **modemInitEnd** function.

If a **modemDial** function or an incoming call is active on the port, the **modemInit** function cannot access the port and will return an error code of DE_NotInControl.

The reservation identifier is valid until the call is terminated and another modem function or an incoming call takes control of the port.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

Do not call this function in a task exit handler.

See Also

modemAbortAll, modemDial, modemDialEnd, modemDialStatus, modemInitEnd, modemInitStatus, modemNotification

Example

Refer to the example in the **Functions Overview** section.

modemInitEnd

Abort Initialization of Dial-up Modem

Syntax

```
#include <ctools.h>
void modemInitEnd(FILE *port, reserve_id id, enum DialError *error);
```

Description

The **modemInitEnd** function terminates a modem initialization in progress. *port* specifies the serial port where the modem is installed. *id* is the port reservation identifier returned by the **modemInit** function.

The function sets the variable pointed to by *error*. If no error occurred DE_NoError is returned. Any other value indicates an error. Refer to the *dialup.h* section for a complete description of error codes.

Notes

The serial port type must be set to RS232_MODEM.

Normally this function should be called once the **modemInitStatus** function indicates the initialization is complete.

The reservation identifier is valid until the initialization is complete or terminated, and another modem function or an incoming call takes control of the port. The **modemInitEnd** function returns a DE_NotInControl error code, if another modem function or incoming call is in control of the port.

Do not call this function in a task exit handler. Use modemAbort instead.

See Also

modemAbortAll, modemDial, modemDialEnd, modemDialStatus, modemInit, modemInitStatus, modemNotification

modemInitStatus

Return Status of Dial-up Modem Initialization

Syntax

```
#include <ctools.h>
void modemInitStatus(FILE *port, reserve_id id, enum DialError *error, enum
   DialState *state);
```

Description

The **modemInitStatus** function returns the status a modem initialization started by the **modemInit** function. *port* specifies the serial port where the modem is installed. *id* is the port reservation identifier returned by the **modemInit** function.

The function sets the variable pointed to by *error*. If no error occurred DE_NoError is returned. Any other value indicates an error. Refer to the **Structures and Types** section for a complete description of error codes.

The function sets the variable pointed to by *state* to the current execution state of dialing operation. The state value is not valid if the error code is DE_NotInControl. Refer to the *dialup.h* section for a complete description of state codes.

Notes

The serial port type must be set to RS232_MODEM.

The port will remain in the DS_Calling state until modem initialization is complete or fails. The application should wait until the state is not DS_Calling before calling the **modemInitEnd** function.

The reservation identifier is valid until the initialization is complete or terminated, and another modem function or an incoming call takes control of the port.

Do not call this function in a task exit handler.

See Also

modemAbortAll, modemDial, modemDialEnd, modemDialStatus, modemInit, modemInitEnd, modemNotification

modemNotification

Notify the modem handler of an important event

Syntax

```
#include <ctools.h>
void modemNotification(UINT16 port_index);
```

Description

The `modemNotification` function notifies the dial-up modem handler that an interesting event has occurred. This informs the modem handler not to disconnect an incoming call when an outgoing call is requested with `modemDial`.

This function is used with custom communication protocols. The function is usually called when a message is received by the protocol, although it can be called for other reasons.

The `port_index` indicates the serial port that received the message.

Notes

The serial port type must be set to RS232_MODEM.

Use the `portIndex` function to obtain the index of the serial port.

The dial-up connection handler prevents outgoing calls from using the serial port when an incoming call is in progress and communication is active. If communication stops for more than five minutes, then outgoing call requests are allowed to end the incoming call. This prevents problems with the modem or the calling application from permanently disabling outgoing calls.

The function is used with programs that dial out through an external modem using the `modemDial` function. It is not required where the modem is used for dialing into the controller only.

See Also

modemAbortAll, modemDial, modemDialEnd, modemDialStatus, modemInit, modemInitEnd, modemInitStatus

off

Test Digital I/O Bit

Syntax

```
#include <ctools.h>
int off(unsigned channel, unsigned bit);
```

Description

The **off** function tests the status of the digital I/O point at *channel* and *bit*. *channel* must be in the range 0 to **DIO_MAX**. *bit* must be in the range 0 to 7.

The **off** function returns **TRUE** if the bit is off, **FALSE** if the bit is on, and –1 if *channel* or *bit* is invalid.

Notes

The **off** function may be used to check the status of digital inputs, outputs and configuration tables.

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START and DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead8Din** directly.

See Also

ioRead8Din, turnoff, turnon, on

Example

This code fragment inverts the digital output point at the first digital output channel, bit 3.

```
request_resource(IO_SYSTEM);
if (off(DOUT_START, 3))
      turnon(DOUT_START, 3);
else
      turnoff(DOUT_START, 3);
release_resource(IO_SYSTEM);
```

on

Test Digital I/O Bit

Syntax

```
#include <ctools.h>
int on(unsigned channel, unsigned bit);
```

Description

The **on** function tests the status of the digital I/O point at *channel* and *bit*. *channel* must be in the range 0 to **DIO_MAX**. *bit* must be in the range 0 to 7.

The **on** function returns **TRUE** if the bit is on, **FALSE** if the bit is off, and –1 if *channel* or *bit* is invalid.

Notes

The **on** function may be used to check the status of digital inputs, outputs and configuration tables.

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START and DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioRead8Din** directly.

See Also

ioRead8Din, turnoff, turnon, off

optionSwitch

Read State of Controller Option Switches

Syntax

```
#include <ctools.h>
unsigned optionSwitch(unsigned option);
```

Description

The **optionSwitch** function returns the state of the controller option switch specified by *option*. *option* may be 1, 2 or 3.

The function returns OPEN if the switch is in the open position. It returns CLOSED if the switch is in the closed position.

Notes

The option switches are located under the cover of the controller module. The SCADAPack LP, SCADAPack 100 and SCADASense series of controllers do not have option switches.

All options are user defined.

However, when a SCADAPack I/O module is placed in the Register Assignment, option switch 1 selects the input range for analog inputs on this module. When the SCADAPack AOUT module is placed in the Register Assignment, option switch 2 selects the output range for analog outputs on this module. Refer to the ***SCADAPack System Hardware Manual*** for further information on option switches.

overrideDbase

Overwrite Value in Forced I/O Database

Syntax

```
#include <ctools.h>
unsigned overrideDbase(unsigned type, unsigned address, int value);
```

Description

The **overrideDbase** function writes *value* to the I/O database even if the database register is currently forced. *type* specifies the method of addressing the database. *address* specifies the location in the database.

If the register is currently forced, the register remains forced but forced to the new *value.*

If the *address* or addressing *type* is not valid, the I/O database is left unchanged and FALSE is returned; otherwise TRUE is returned. The table below shows the valid address types and ranges.

Type	Address Ranges	Register Size
MODBUS	00001 to NUMCOIL 10001 to 10000 + NUMSTATUS 30001 to 30000 + NUMINPUT 40001 to 40000 + NUMHOLDING	1 bit 1 bit 16 bit 16 bit
LINEAR	0 to NUMLINEAR-1	16 bit

Notes

When writing to LINEAR digital addresses, *value* is a bit mask which writes data to 16 1-bit registers at once.

The I/O database is not modified when the controller is reset. It is a permanent storage area, which is maintained during power outages.

Refer to the **Functions Overview** chapter for more information.

The IO_SYSTEM resource must be requested before calling this function.

See Also

setdbase, setForceFlag

Example

```
#include <ctools.h>
void main(void)
{
       request_resource(IO_SYSTEM);

       overrideDbase(MODBUS, 40001, 102);
       overrideDbase(LINEAR, 302, 330);

       release_resource(IO_SYSTEM);
}
```

pollABSlave

Poll DF1 Slave for Response

Syntax

```
#include <ctools.h>
unsigned pollABSlave(FILE *stream, unsigned slave);
```

Description

The **pollABSlave** function is used to send a poll command to the slave station specified by *slave* in the DF1 Half Duplex protocol configured for the specified port. *stream* specifies the serial port.

The function returns **FALSE** if the slave number is invalid, or if the protocol currently installed on the specified serial port is not an DF1 Half Duplex protocol. Otherwise it returns **TRUE** and the protocol command status is set to **MM_SENT**.

Notes

See the example using the **pollABSlave** function in the sample polling function "poll_for_response" shown in the example for the **master_message** function.

See Also

master_message

Example

This program segment polls slave station 9 for a response communicating on the **com2** serial port.

```
#include <ctools.h>

pollABSlave(com2, 9);
```

poll_event

Test for Event Occurrence

Syntax

```
#include <ctools.h>
int poll_event(int event);
```

Description

The **poll_event** function tests if an event has occurred.

The **poll_event** function returns **TRUE,** and the event counter is decrements, if the event has occurred. Otherwise it returns **FALSE**.

The current task always continues to execute.

Notes

Refer to the **Real Time Operating System** section for more information on events.

Valid events are numbered 0 to RTOS_EVENTS - 1. Any events defined in primitiv.h are not valid events for use in an application program.

See Also

signal_event, wait_event, startTimedEvent

Example

This program implements a somewhat inefficient transfer of data between **com1** and **com2**. (It would be more efficient to test for EOF from getc).

```
#include <ctools.h>

void main(void)
{
       while(TRUE)
       {
           if (poll_event(COM1_RCVR))
               fputc(getc(com1), com2);
           if (poll_event(COM2_RCVR))
               fputc(getc(com2), com1);

           /* Allow other tasks to execute */
           release_processor();
       }
}
```

poll_message

Test for Received Message

Syntax

```
#include <ctools.h>
envelope *poll_message(void);
```

Description

The **poll_message** function tests if a message has been received by the current task.

The **poll_message** function returns a pointer to an envelope if a message has been received. It returns **NULL** if no message has been received.

The current task always continues to execute.

Notes

Refer to the **Real Time Operating System** section for more information on messages.

See Also

send_message, receive_message

Example

This task performs a function continuously, and processes received messages (from higher priority tasks) when they are received.

```
#include <ctools.h>

void task(void)
{
       envelope *letter;

       while(TRUE)
       {
           letter=poll_message();
           if (letter != NULL)
               /* process the message now */

           /* more code here */
       }
}
```

poll_resource

Test Resource Availability

Syntax

```
#include <ctools.h>
int poll_resource(int resource);
```

Description

The **poll_resource** function tests if the resource specified by *resource* is available. If the resource is available it is given to the task.

The **poll_resource** function returns **TRUE** if the resource is available. It returns **FALSE** if it is not available.

The current task always continues to execute.

Notes

Refer to the **Real Time Operating System** section for more information on resources.

See Also

request_resource, release_resource

portConfiguration

Get Pointer to Port Configuration Structure

Syntax

```
#include <ctools.h>
struct pconfig *portConfiguration(FILE *stream);
```

Description

The **portConfiguration** function returns a pointer to the configuration structure for *stream*. A NULL pointer is returned if *stream* is not valid.

Notes

It is recommended the **get_port** and **set_port** functions be used to access the configuration table.

portIndex

Get Index of Serial Port

Syntax

```
#include <ctools.h>
unsigned portIndex(FILE *stream);
```

Description

The **portIndex** function returns an array index for the serial port specified by *stream*. It is guaranteed to return a value suitable for an array index, in increasing order of external serial port numbers, if no error occurs.

If the stream is not recognized, SERIAL_PORTS is returned, to indicate an error.

See Also

portStream

portStream

Get Serial Port Corresponding to Index

Syntax

```
#include <ctools.h>
FILE *portStream(unsigned index);
```

Description

The **portStream** function returns the file pointer corresponding to *index*. This function is the inverse of the **portIndex** function. If the index is not valid, the NULL pointer is returned.

See Also

portIndex

processModbusCommand

Process a Modbus Command and Return the Response

Syntax

```
#include <ctools.h>
BOOLEAN processModbusCommand(
       FILE * stream,
       UCHAR * pCommand,
       UINT16 commandLength,
       UINT16 responseSize,
       UCHAR * pResponse,
       UINT16 * pResponseLength
       )
```

Description

The `processModbusCommand` function processes a Modbus protocol command and returns the response. The function can be used by an application to encapsulate Modbus RTU commands in another protocol.

`stream` is a FILE pointer that identifies the serial port where the command was received. This is used for to accumulate statistics for the serial port.

`pCommand` is a pointer to a buffer containing the Modbus command. The contents of the buffer must be a standard Modbus RTU message. The Modbus RTU checksum is not required.

`commandLength` is the number of bytes in the Modbus command. The length must include all the address and data bytes. It must not include the checksum bytes, if any, in the command buffer.

`responseSize` is the size of the response buffer in bytes. A 300-byte buffer is recommended. If this is not practical in the application, a smaller buffer may be supplied. Some responses may be truncated if a smaller buffer is used.

`pResponse` is a pointer to a buffer to contain the Modbus response. The function will store the response in this buffer in standard Modbus RTU format including two checksum bytes at the end of the response.

`pResponseLength` is a pointer to a variable to hold response length. The function will store the number of bytes in the response in this variable. The length will include two checksum bytes.

The function returns TRUE if the response is valid and can be used. It returns FALSE if the response is too long to fit into the supplied response buffer.

Notes

To use the function on a serial port, a protocol handler must be created for the encapsulating protocol. Set the protocol type for the port to NO_PROTOCOL to allow the custom handler to be used.

The function supports standard and extended addressing. Configure the protocol settings for the serial port for the appropriate protocol.

The Modbus RTU checksum is not required in the command so the encapsulating protocol may omit them if they are not needed. This may be useful in host devices that don't create a Modbus RTU message with checksum prior to encapsulation.

The Modbus RTU checksum is included in the response to support encapsulating a complete Modbus RTU format message. If the checksum is not needed by the encapsulating protocol the checksum bytes may be ignored.

See Also

`setProtocolSettings`

Example

This example is taken from a protocol driver than encapsulates Modbus RTU messages in another protocol. It shows how to pass the Modbus RTU command to the Modbus driver, and obtain the response.

The example assumes the Modbus RTU messages are transmitted with the checksum. The length of the checksum is subtracted when calling the `processModbusCommand` function. The checksum is included when responding.

Contact Control Microsystems technical support department for a complete program that uses this function.

```
/* receive the packet in the encapsulating protocol */
/* verify the packet is valid */

/* locate the Modbus RTU command in the command buffer */
pCommandData = commandBuffer + PROTOCOL_HEADER_SIZE;

/* get length of Modbus RTU command from the packet header */
commandLength = commandBuffer[DATA_SIZE] - 2;

/* locate the Modbus RTU response in the response buffer leaving room for
the packet header */
pResponseData = responseBuffer + PROTOCOL_HEADER_SIZE;

/* process the Modbus message */
if (processModbusCommand(
       stream,
       pCommandData,
       commandLength,
       MODBUS_BUFFER_SIZE,
       pResponseData,
       &responseLength))
{
       /* put the response length in the header */
       responseBuffer[DATA_SIZE] = responseLength;

       /* fill in rest of packet header */
       /* transmit the encapsulated response */
}
```

pulse

Generate a Square Wave

Syntax

```
#include <ctools.h>
void pulse(unsigned channel, unsigned bit, unsigned timer, unsigned on,
   unsigned period);
```

Description

The **pulse** function generates a square wave with a specified duty cycle on a digital output point.

- *channel* specifies the digital output channel;
- *bit* specified the digital output bit;
- *timer* specifies the timer used to generate the square wave;
- *on* specifies the time the output will be on, measured in timer ticks;
- *period* specifies the period of the wave (on time plus off time), measured in timer ticks.

If an error occurs, the current task's error code is set as follows.

TIMER_BADTIMER	if the timer number is invalid
TIMER_BADVALUE	if the period is less than the on time
TIMER_BADADDR	if the digital channel or bit is invalid

Notes

The length of a timer tick is set with the **interval** function. The default value is 0.1 seconds.

To stop the square wave, set the *timer* to 0 with the **settimer** function. The square wave will stop if the controller is reset.

To ensure an orderly start of the duty cycle, use the following sequence:

```
settimer(t, 0);         /* stop the timer */
request_resource(IO_SYSTEM);
turnoff(c, b);          /* start with a rising edge */
release_resource(IO_SYSTEM);
pulse(c, b, t, o, p);   /* start pulses */
```

If the specified I/O point is on when the **pulse** function is executed, the square wave will start with the off portion of the cycle.

Use the **timeout** function to generate irregular or non-repeating sequences.

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START and DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite8Dout** directly.

See Also

pulse_train, settimer, timeout, ioWrite8Dout

Example

This code fragment generates a 60% duty cycle output with a period of 5 seconds. Bit 7 of channel 3 is controlled. Timer 10 generates the square wave.

```
settimer(10, 0);    /* stop timer */

request_resource(IO_SYSTEM);
turnoff(3, 7);      /* turn off the bit  */
release_resource(IO_SYSTEM);

interval(10, 10);   /* set tick rate to 1.0 s */
pulse(3, 7, 10, 3, 5);     /* on = 60% of 5 = 3 */
```

pulse_train

Generate Finite Number of Pulses

Syntax

```
#include <ctools.h>
void pulse_train(unsigned channel, unsigned bit, unsigned timer, unsigned
   pulses);
```

Description

The **pulse_train** function generates a specified number of pulses on a digital output point. The output is a square wave with a 50% duty cycle and a period of 200 milliseconds (5 Hz).

- *channel* specifies the digital output channel.
- *bit* specified the digital output bit.
- *timer* specifies the timer used to generate the square wave.
- *pulses* specifies the number of pulses. The timer interval acts as a multiplier of the number of pulses. The total number of pulses is *pulses* * interval.

If an error occurs, the current task's error code is set as follows.

TIMER_BADTIMER	if the timer number is invalid
TIMER_BADVALUE	if the period is less than the on time
TIMER_BADADDR	if the digital channel or bit is invalid

Notes

To stop the square wave, set the *timer* to 0 with the **settimer** function. The square wave will stop if the controller is reset.

To ensure an orderly start to the pulses, use the following sequence:

```
settimer(t, 0);     /* stop the timer */
request_resource(IO_SYSTEM);
turnoff(c, b);      /* start with a rising edge */
release_resource(IO_SYSTEM);
pulse_train(c, b, timer, pulses);
```

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START and DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite8Dout** directly.

See Also

pulse, settimer, timeout, ioWrite8Dout

Example

This code fragment generates 300 pulses on channel 3, bit 4.

```
interval(2, 1);           /* multiplier = 1 */
pulse_train(3, 4, 2, 300); /* 300 pulses */
```

This code fragment also generates 300 pulses on channel 3, bit 4. It shows the use of a multiplier.

```
interval(2, 100);          /* multiplier = 100 */
pulse_train(3, 4, 2, 3);   /* 300 pulses */
```

queue_mode

Control Serial Data Transmission

Syntax

```
#include <ctools.h>
void queue_mode(FILE *stream, int mode);
```

Description

The **queue_mode** function controls transmission of the serial data. Normally data output to a serial port are placed in the transmit buffer and transmitted as soon as the hardware is ready. If queuing is enabled, the characters are held in the transmit buffer until queuing is disabled. If the buffer fills, queuing is disabled automatically.

stream specifies the serial port. If it is not valid the function has no effect.

mode specifies the queuing control. It may be **DISABLE** or **ENABLE**.

Notes

Queuing is most often used with communication protocols that use character timing for message framing. Its uses in an application program are limited.

readCounter

Read Accumulator Input

Syntax

```
#include <ctools.h>
unsigned long readCounter(unsigned counter, unsigned clear);
```

Description

The readCounter routine reads the digital input counter specified by *counter*. The *counter* may be 0, 1 or 2. If *clear* is TRUE the counter is cleared after reading; otherwise if it is FALSE the counter continues to accumulate.

If counter is not valid, a BAD_COUNTER error is reported for the current task.

Notes

The three DIN/counter inputs are located on the SCADAPack, SCADAPack LP or SCADAPack 100. Refer to the ***System Hardware Manual*** for more information on the hardware.

The counter increments on the rising edge of the input signal.

See Also

readCounterInput, check_error

readCounterInput

Read Counter Input Status

Syntax

```
#include <ctools.h>
unsigned readCounterInput(unsigned input)
```

Description

The readCounterInput function returns the status of the DIN/counter input point specified by *input*. It returns TRUE if the input is ON and FALSE if the input is OFF.

If input is not valid, the function returns FALSE.

Notes

The three DIN/counter inputs are located on the 5203 or 5204 controller board. Refer to the ***System Hardware Manual*** for more information on the hardware.

See Also

readCounter

readBattery

Read Lithium Battery Voltage

Syntax

```
#include <ctools.h>
int readBattery(void);
```

Description

The **readBattery** function returns the RAM backup battery voltage in millivolts. The range is 0 to 5000 mV. A normal reading is about 3600 mV.

Example

```
#include <ctools.h>

if (readBattery() < 2500)
{
       fprintf(com1, “Battery Voltage is low\r\n”);
}
```

readInternalAD

Read Controller Internal Analog Inputs

Syntax

```
#include <ctools.h>
int readInternalAD(unsigned channel);
```

Description

The **readInternalAD** function reads analog inputs connected to the internal AD converter. *channel* may be 0 to 7.

The function returns a value in the range 0 to 32767.

Notes

There are only two channels with signals connected to them.

- AD_THERMISTOR reads the thermistor input.
- AD_BATTERY reads the battery input

See Also

readBattery

readStopwatch

Read Stopwatch Timer

Syntax

```
#include <ctools.h>
unsigned long readStopwatch(void)
```

Description

The **readStopwatch** function reads the stopwatch timer. The stopwatch time is in ms and has a resolution of 10 ms. The stopwatch time rolls over to 0 when it reaches the maximum value for an unsigned long integer: 4,294,967,295 ms (or about 49.7 days).

See Also

settimer, **timer**

Example

This program measures the execution time in ms of an operation.

```
#include <ctools.h>

void main(void)
{
    unsigned long startTime, endTime;

    startTime = readStopwatch();
    /* operation to be timed */
    endTime = readStopwatch();

    printf("Execution time = %lu ms\r\n", endTime - startTime);
}
```

readThermistor

Read Controller Ambient Temperature

Syntax

```
#include <ctools.h>
int readThermistor(unsigned scale);
```

Description

The **readThermistor** function returns the temperature measured at the main board in the specified temperature *scale*. If the temperature scale is not recognized, the temperature is returned in Celsius. The *scale* may be T_CELSIUS, T_FAHRENHEIT, T_KELVIN or T_RANKINE.

The temperature is rounded to the nearest degree.

Example

```
#include <ctools.h>

void checkTemperature(void)
{
       int temperature;

       temperature = readThermistor(T_FAHREHEIT);
       if (temperature < 0)
          fprintf(com1, “It’s COLD!!!\r\n”);
       else if (temperature > 90)
          fprintf(com1, “It’s HOT!!!\r\n”);
}
```

read_timer_info

Get Timer Status

Syntax

```
#include <ctools.h>
struct timer_info read_timer_info(unsigned timer);
```

Description

The **read_timer_info** function gets status information for the timer specified by *timer*.

The **read_timer_info** function returns a `timer_info` structure with information about the specified timer. Refer to the description of the `timer_info` structure for information about the fields.

See Also

settimer, pulse, pulse_train, timeout

Example

This program starts a pulse train and displays timer information.

```
#include <ctools.h>
void main(void)
{
       struct timer_info tinfo;

       /* Start Pulse Train */
       interval(10, 1);           /* multiplier = 1 */
       pulse_train(3, 5, 10, 500);
       while (timer(10) > 100)/* wait a while */
       {
          /* Allow other tasks to execute */
          release_processor();
       }
       /* Display Status of Pulse Train */
       tinfo = read_timer_info(10);
       printf("Pulses Remaining: %d\r\n",
              tinfo.time/2);
       printf("Output Channel:   %d\r\n",
              tinfo.channel);
       printf("Output Bit:       %d\r\n", tinfo.bit);
}
```

receive_message

Receive a Message

Syntax

```
#include <ctools.h>
envelope *receive_message(void);
```

Description

The **receive_message** function reads the next available envelope from the message queue for the current task. If the queue is empty, the task is blocked until a message is sent to it.

The **receive_message** function returns a pointer to an `envelope` structure.

Notes

Refer to the **Real Time Operating System** section for more information on messages.

See Also

send_message, poll_message

Example

This task waits for messages, then prints their contents. The envelopes received are returned to the operating system.

```
#include <ctools.h>

void show_message(void)
{
       envelope *msg;
       while (TRUE)
       {
          msg = receive_message();
          printf("Message data %ld\r\n", msg->data);
          deallocate_envelope(msg);
       }
}
```

release_processor

Release Processor to other Tasks

Syntax

```
#include <ctools.h>
void release_processor(void);
```

Description

The **release_processor** function releases control of the CPU to other tasks. Other tasks of the same priority will run. Tasks of the same priority run in a round-robin fashion, as each releases the processor to the next.

Notes

The **release_processor** function must be called in all idle loops of a program to allow other tasks to execute.

Release all resources in use by a task before releasing the processor.

Refer to the **Real Time Operating System** section for more information on tasks and task scheduling.

See Also

release_resource

release_resource

Release Control of a Resource

Syntax

```
#include <ctools.h>
void release_resource(int resource);
```

Description

The **release_resource** function releases control of the resource specified by *resource*.

If other tasks are waiting for the resource, the highest priority of these tasks, is given the resource and is made ready to execute. If no tasks are waiting the resource is made available, and the current task continues to run.

Notes

Refer to the **Real Time Operating System** section for more information on resources.

See Also

request_resource, poll_resource

Example

See the example for the **request_resource** function.

report_error

Set Task Error Code

Syntax

```
#include <ctools.h>
void report_error(int error);
```

Description

The **report_error** functions sets the error code for the current task to *error*. An error code is maintained for each executing task.

Notes

This function is used in sharable I/O routines to return error codes to the task using the routine.

Some functions supplied with the Microtec C compiler report errors using the global variable **errno**. The error code in this variable may be written over by another task before it can be used.

See also

check_error

request_resource

Obtain Control of a Resource

Syntax

```
#include <ctools.h>
void request_resource(int resource);
```

Description

The **request_resource** function obtains control of the resource specified by *resource*. If the resource is in use, the task is blocked until it is available.

Notes

Use the **request_resource** function to control access to non-sharable resources. Refer to the **Real Time Operating System** section for more information on resources.

See Also

release_resource, poll_resource

Example

This code fragment obtains the dynamic memory resource, allocates some memory, and releases the resource.

```
#include <ctools.h>

void task(void)
{
       unsigned *ptr;

       /* ... code here */

       request_resource(DYNAMIC_MEMORY);
       ptr = (unsigned *)malloc((size_t)100);
       release_resource(DYNAMIC_MEMORY);

       /* ... more code here */
}
```

resetAllABSlaves

Erase All DF1 Slave Responses

Syntax

```
#include <ctools.h>
unsigned resetAllABSlaves(FILE *stream);
```

Description

The **resetAllABSlaves** function is used to send a protocol message to all slaves communicating on the specified port to erase all responses not yet polled. *stream* specifies the serial port.

This function applies to the DF1 Half Duplex protocols only. The function returns **FALSE** if the protocol currently installed on the specified serial port is not an DF1 Half Duplex protocol, otherwise it returns **TRUE**.

Notes

The purpose of this command is to re-synch slaves with the master if the master has lost track of the order of responses to poll. This situation may exist if the master has been power cycled, for example. This function should not normally be needed if polling is done using the sample polling function "poll_for_response" shown in the example for the **master_message** function.

Example

This program segment will cause all slaves communicating on the **com2** serial port to erase all pending responses.

```
#include <protocol.h>

resetAllABSlaves(com2);
```

resetClockAlarm

Acknowledge and Reset Real Time Clock Alarm

Syntax

```
#include <ctools.h>
void resetClockAlarm(void);
```

Description

Real time clock alarms occur once after being set. The alarm setting remains in the real time clock. The alarm must be acknowledged before it can occur again.

The **resetClockAlarm** function acknowledges the last real time clock alarm and re-enables the alarm. Calling the function after waking up from an alarm will reset the alarm for 24 hours after the current alarm.

Notes

This function should be called after a real time clock alarm occurs. This includes after returning from the **sleep** function with a return code of WS_REAL_TIME_CLOCK.

The alarm time is not changed by this function.

The IO_SYSTEM resource must be requested before calling this function.

See Also

setClockAlarm, getClockAlarm, alarmIn

Example

See the example for the **installClockHandler** function.

route

Redirect Standard I/O Streams

Syntax

```
#include <ctools.h>
void route(FILE *logical, FILE *hardware);
```

Description

The **route** function redirects the I/O streams associated with `stdout`, `stdin`, and `stderr`. These streams are routed to the com1 serial port. *logical* specifies the stream to redirect. *hardware* specifies the hardware device which will output the data. It may be one of com1, com2, com3 or com4.

Notes

This function has a global effect, so all tasks must agree on the routing.

Output streams must be redirected to a device that supports output. Input streams must be redirected to a device that supports input.

Example

This program segment will redirect all input, output and errors to the **com2** serial port.

```
#include <ctools.h>

route(stderr, com2);    /* send errors to com2 */
route(stdout, com2);    /* send output to com2 */
route(stdin, com2);     /* get input from com2 */
```

runLed

Control Run LED State

Syntax

```
#include <ctools.h>
void runLed(unsigned state);
```

Description

The **runLed** function sets the run light LED to the specified state. *state* may be one of the following values.

LED_ON turn on run LED
LED_OFF turn off run LED

The run LED remains in the specified state until changed, or until the controller is reset.

Notes

The ladder logic interpreter controls the state of the RUN LED. If ladder logic is installed in the controller, a C program should not use this function.

The SCADASense series of programmable controllers do not have a RUN led.

Example

```
#include <ctools.h>

void main(void)
{
       runLed(LED_ON);     /* program is running */
       /* ... the rest of the code */
}
```

save

Write Parameters to EEPROM

Syntax

```
#include <ctools.h>
void save(unsigned section);
```

Description

The **save** function writes data from RAM to the specified section of the EEPROM. Valid values for *section* are **EEPROM_EVERY** and **EEPROM_RUN**.

Notes

The **EEPROM_EVERY** section is loaded whenever the controller is reset. It is not used.

The **EEPROM_RUN** section is loaded from EEPROM to RAM when the controller is reset and the Run/Service switch is in the RUN position. Otherwise default information is used for this section. This section contains:

- serial port configuration tables
- protocol configuration tables
- store and forward enable flags
- LED power settings
- make for wake-up sources
- execution period on power-up for PID controllers
- HART modem settings

The IO_SYSTEM resource must be requested before calling this function.

See Also

load

Example

This code fragment saves all parameters.

```
request_resource(IO_SYSTEM);
save(EEPROM_RUN);
release_resource(IO_SYSTEM);
```

send_message

Send a Message to a Task

Syntax

```
#include <ctools.h>
void send_message(envelope *penv);
```

Description

The **send_message** function sends a message to a task. The envelope specified by *penv* contains the message destination, type and data.

The envelope is placed in the destination task's message queue. If the destination task is waiting for a message it is made ready to execute.

The current task is not blocked by the **send_message** function.

Notes

Envelopes are obtained from the operating system with the **allocate_envelope** function.

See Also

receive_message, poll_message, allocate_envelope

Example

This program creates a task to display a message and sends a message to it.

```
#include <ctools.h>

void showIt(void)
{
       envelope *msg;

       while (TRUE)
       {
          msg = receive_message();
          printf("Message data %ld\r\n", msg->data);
          deallocate_envelope(msg);
       }
}

void main(void)
{
       envelope *msg;      /* message pointer */
       unsigned tid;       /* task ID */

       tid = create_task(showIt, 2, APPLICATION, 1);
       msg = allocate_envelope();
       msg->destination = tid;
       msg->type        = MSG_DATA;
       msg->data        = 1002;
       send_message(msg);

       /* wait for ever so that main and other
       APPLICATION tasks won't end */
       while(TRUE)
       {
          /* Allow other tasks to execute */
```

```
            release_processor();
        }
    }
```

setABConfiguration

Set DF1 Protocol Configuration

Syntax

```
#include <ctools.h>
int setABConfiguration(FILE *stream, struct    ABConfiguration *ABConfig);
```

Description

The **setABConfiguration** function sets DF1 protocol configuration parameters. *stream* specifies the serial port. *ABConfig* references an DF1protocol configuration structure. Refer to the description of the `ABConfiguration` structure for an explanation of the fields.

The **setABConfiguration** function returns **TRUE** if the settings were changed. It returns **FALSE** if *stream* does not point to a valid serial port.

Example

This code fragment changes the maximum protected address to 7000. This is the maximum address accessible by protected DF1 commands received on com2.

```
#include <ctools.h>
struct ABConfiguration ABConfig;

getABConfiguration(com2, &ABConfig);
ABConfig.max_protected_address = 7000;
setABConfiguration(com2, &ABConfig);
```

setBootType

Set Controller Boot Up State

Syntax

```
#include <ctools.h>
void setBootType(unsigned type);
```

Description

The **setBootType** function defines the controller boot up type code. This function is used by the operating system start up routines. It should not be used in an application program.

Notes

The value set with this function can be read with the **getBootType** function.

setclock

Set Real Time Clock

Syntax

```
#include <ctools.h>
void setclock(struct clock *now);
```

Description

The **setclock** function sets the real time clock. *now* references a clock structure containing the time and date to be set.

Refer to the **Structures and Types** section for a description of the fields. All fields of the clock structure must be set with valid values for the clock to operate properly.

Notes

The IO_SYSTEM resource must be requested before calling this function.

See Also

getclock

Example

This function switches the clock to daylight savings time.

```
#include <ctools.h>
#include <primitiv.h>

void daylight(void)
{
       struct clock now;

       request_resource(IO_SYSTEM);
       now = getclock();
       now.hour = now.hour + 1 % 24;
       setclock(&now);
       request_resource(IO_SYSTEM);
}
```

setClockAlarm

Set the Real Time Clock Alarm

Syntax

```
#include <ctools.h>
unsigned setClockAlarm(ALARM_SETTING alarm);
```

Description

The **setClockAlarm** function configures the real time clock to alarm at the specified alarm setting. The ALARM_SETTING structure *alarm* specifies the time of the alarm. Refer to the *rtc.h* section for a description of the fields in the structure.

The function returns TRUE if the alarm can be configured, and FALSE if there is an error in the alarm setting. No change is made to the alarm settings if there is an error.

Notes

An alarm will occur only once, but remains set until disabled. Use the **resetClockAlarm** function to acknowledge an alarm that has occurred and re-enable the alarm for the same time.

Set the alarm type to AT_NONE to disable an alarm. It is not necessary to specify the hour, minute and second when disabling the alarm.

The IO_SYSTEM resource must be requested before calling this function.

See Also

alarmIn, getclock

Example

```
#include <ctools.h>

/* ----------------------------------------
   wakeUpAtEight

       The wakeUpAtEight function sets an alarm
       for 08:00 AM and puts the controller into
       sleep mode.
   ---------------------------------------- */

void wakeUpAtEight(void)
{
       ALARM_SETTING alarm;
       unsigned wakeSource;

       /* Set alarm for 08:00 */
       alarm.type   = AT_ABSOLUTE;
       alarm.hour   = 8;
       alarm.minute = 0;
       alarm.second = 0;

       /* Set the alarm */
       request_resource(IO_SYSTEM);
       setClockAlarm(alarm)
       release_resource(IO_SYSTEM);
```

```
        /* Sleep until alarm ignoring other wake ups */
        do
        {
           request_resource(IO_SYSTEM);
           wakeSource = sleep();
           release_resource(IO_SYSTEM);
        } until (wakeSource == WS_REAL_TIME_CLOCK);

        /* Disable the alarm */
        alarm.type = AT_NONE;
        request_resource(IO_SYSTEM);
        setClockAlarm(alarm);
        release_resource(IO_SYSTEM);
}
```

setdbase

Write Value to I/O Database

Syntax

```
#include <ctools.h>
void setdbase(unsigned type, unsigned address, int value);
```

Description

The **setdbase** function writes *value* to the I/O database. *type* specifies the method of addressing the database. *address* specifies the location in the database. The table below shows the valid address types and ranges

Type	Address Ranges	Register Size
MODBUS	00001 to NUMCOIL 10001 to 10000 + NUMSTATUS 30001 to 30000 + NUMINPUT 40001 to 40000 + NUMHOLDING	1 bit 1 bit 16 bit 16 bit
LINEAR	0 to NUMLINEAR-1	16 bit

Notes

If the specified register is currently forced, the I/O database remains unchanged.

When writing to LINEAR digital addresses, *value* is a bit mask which writes data to 16 1-bit registers at once. If any of these 1-bit registers is currently forced, only the forced registers remain unchanged.

The I/O database is not modified when the controller is reset. It is a permanent storage area, which is maintained during power outages.

Refer to the **Functions Overview** section for more information.

The IO_SYSTEM resource must be requested before calling this function.

See Also

overrideDbase, setForceFlag

Example

```
#include <ctools.h>

void main(void)
{
       request_resource(IO_SYSTEM);

       setdbase(MODBUS, 40001, 102);

       /* Turn ON the first 16 coils */
       setdbase(LINEAR, START_COIL, 255);

       /* Write to a 16 bit register */
       setdbase(LINEAR, 3020, 240);

       /* Write to the 12th holding register */
       setdbase(LINEAR, START_HOLDING, 330);
```

```
        /* Write to the 12th holding register */
        setdbase(LINEAR, START_HOLDING, 330);

        release_resource(IO_SYSTEM);
}
```

setDTR

Control RS232 Port DTR Signal

Syntax

```
#include <ctools.h>
void setDTR(FILE *stream, unsigned state);
```

Description

The **setDTR** function sets the status of the DTR signal line for the communication port specified by *stream*. When *state* is SIGNAL_ON the DTR line is asserted. When *state* is SIGNAL_OFF the DTR line is de-asserted.

Notes

The DTR line follows the normal RS232 voltage levels for asserted and de-asserted states.

This function is only useful on RS232 ports. The function has no effect if the serial port is not an RS232 port.

setForceFlag

Set Force Flag State for a Register

Syntax

```
#include <ctools.h>
unsigned setForceFlag(unsigned type, unsigned address, unsigned value);
```

Description

The **setForceFlag** function sets the force flag(s) for the specified database register(s) to *value*. *value* is either 1 or 0, or a 16-bit mask for LINEAR digital addresses. The valid range for *address* is determined by the database addressing *type*.

If the *address* or addressing *type* is not valid, force flags are left unchanged and FALSE is returned; otherwise TRUE is returned. The table below shows the valid address types and ranges.

Type	Address Ranges	Register Size
MODBUS	00001 to NUMCOIL 10001 to 10000 + NUMSTATUS 30001 to 30000 + NUMINPUT 40001 to 40000 + NUMHOLDING	1 bit 1 bit 16 bit 16 bit
LINEAR	0 to NUMLINEAR-1	16 bit

Notes

When a register's force flag is set, the value of the I/O database at that register is forced to its current value. This register's value can only be modified by using the **overrideDbase** function or the *Edit/Force Register dialog.* While forced this value can not be modified by the **setdbase** function, protocols, or Ladder Logic programs.

Force Flags are not modified when the controller is reset. Force Flags are in a permanent storage area, which is maintained during power outages.

The IO_SYSTEM resource must be requested before calling this function.

See Also

clearAllForcing, overrideDbase

Example

This program clears the force flag for register 40001 and sets the force flags for the 16 registers at linear address 302 (i.e. registers 10737 to 10752).

```
#include <ctools.h>

void main(void)
{
       request_resource(IO_SYSTEM);

       setForceFlag(MODBUS, 40001, 0);
       setForceFlag(LINEAR, 302, 255);

       release_resource(IO_SYSTEM);
}
```

setIOErrorIndication

Set I/O Module Error Indication

Syntax

```
#include <ctools.h>
void setIOErrorIndication(unsigned state);
```

Description

The **setIOErrorIndication** function sets the I/O module error indication to the specified *state*. If set to TRUE, the I/O module communication status is reported in the controller status register and Status LED. If set to FALSE, the I/O module communication status is not reported.

Notes

Refer to the ***5203/4 System Manual*** or the ***SCADAPack System Manual*** for further information on the Status LED and Status Output.

See Also

getIOErrorIndication

setjiffy

Set the Jiffy Clock

Syntax

```
#include <ctools.h>
void setjiffy(unsigned long value);
```

Description

The **setjiffy** function sets the system jiffy clock. The jiffy clock increments every 1/60 second. The jiffy clock rolls over to 0 after 5183999. This is the number of 1/60-second intervals in a day.

Notes

The real time clock and the jiffy clock are not related. They may drift slightly with respect to each other over several days.

Use the jiffy clock to measure times with resolution better than the 1/10th resolution provided by timers.

See Also

interval

Example

See the example for the **jiffy** function.

setOutputsInStopMode

Set Outputs In Stop Mode

Syntax

```
#include <ctools.h>
void setOutputsInStopMode( unsigned doutsInStopMode, unsigned
   aoutsInStopMode);
```

Description

The **setOutputsInStopMode** function sets the *doutsInStopMode* and *aoutsInStopMode* control flags to the specified state.

If *doutsInStopMode* is set to TRUE, then digital outputs are held at their last state when the Ladder Logic program is stopped. If *doutsInStopMode* is FALSE, then digital outputs are turned OFF when the Ladder Logic program is stopped.

If a*outsInStopMode* is TRUE, then analog outputs are held at their last value when the Ladder Logic program is stopped. If a*outsInStopMode* is FALSE, then analog outputs go to zero when the Ladder Logic program is stopped.

See Also

getOutputsInStopMode

Example

This program changes the output conditions to hold analog outputs at their last value when the Ladder Logic program is stopped.

```
#include <ctools.h>

void main(void)
{
       unsigned holdDoutsOnStop;
       unsigned holdAoutsOnStop;
       getOutputsInStopMode( &holdDoutsOnStop, &holdAoutsOnStop);
       holdAoutsOnStop = TRUE;
       setOutputsInStopMode( holdDoutsOnStop,  holdAoutsOnStop);
}
```

set_pid

Write PID Block Variable

Syntax

```
#include <ctools.h>
void set_pid(unsigned name, unsigned block, int value);
```

Description

The **set_pid** function assigns *value* to a PID control block variable. *name* must be specified by one of the variable name macros in **pid.h**. *block* must be in the range 0 to **PID_BLOCKS**-1.

Notes

See the ***TelePACE PID Controllers Manual*** for a detailed description of PID control.

Values stored in PID blocks are not initialized when a program is run, and are guaranteed to retain their values during power failures and program loading. PID block variables must always be initialized by the user program.

The IO_SYSTEM resource must be requested before calling this function.

See Also

auto_pid, clear_pid, getPowerMode

Get Current Power Mode

Syntax

```
#include <ctools.h>
BOOLEAN getPowerMode(UCHAR* cpuPower, UCHAR* lan, UCHAR* usbPeripheral,
UCHAR* usbHost);
```

Description

The **getPowerMode** function places the current state of the CPU, LAN, USB peripheral port, and USB host port in the passed parameters. The following table lists the possible return values and their meaning.

Macro	***Meaning***
PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_UNAVAILABLE	The status of the device could not be read.

TRUE is returned if the values placed in the passed parameters are valid, otherwise FALSE is returned.

The application program may set the current power mode with the setPowerMode function.

See Also

setPowerMode, setWakeSource, getWakeSource

get_pid

set_port

Set Serial Port Configuration

Syntax

```
#include <ctools.h>
void set_port(FILE *stream, struct pconfig *settings);
```

Description

The **set_port** function sets serial port communication parameters. *stream* must specify one of **com1**, **com2**, **com3** or **com4**. *settings* references a serial port configuration structure. Refer to the description of the `pconfig` structure for an explanation of the fields.

Notes

If the serial port settings are the same as the current settings, this function has no effect.

The serial port is reset when settings are changed. All data in the receive and transmit buffers are discarded.

To optimize performance, minimize the length of messages on com3 and com4. Examples of recommended uses for com3 and com4 are for local operator display terminals, and for programming and diagnostics using the TelePACE program.

The IO_SYSTEM resource must be requested before calling this function.

See Also

get_port

Example

This code fragment changes the baud rate on com2 to 19200 baud.

```
#include <ctools.h>
struct pconfig settings;

get_port(com2, &settings);
settings.baud = BAUD19200;
request_resource(IO_SYSTEM);
set_port(com2, &settings);
release_resource(IO_SYSTEM);
```

This code fragment sets com2 to the same settings as com1.

```
#include <serial.h>
#include <primitiv.h>
struct pconfig settings;

request_resource(IO_SYSTEM);
set_port(com2, get_port(com1, &settings));
release_resource(IO_SYSTEM);
```

setPowerMode

Set Current Power Mode

Syntax

```
#include <ctools.h>
BOOLEAN setPowerMode(UCHAR cpuPower, UCHAR lan, UCHAR usbPeripheral, UCHAR
usbHost);
```

Description

The **setPowerMode** function returns TRUE if the new settings were successfully applied. The setPowerMode function allows for power savings to be realized by controlling the power to the LAN port, changing the clock speed, and individually controlling the host and peripheral USB power. The following table of macros summarizes the choices available.

Macro	***Meaning***
PM_CPU_FULL	The CPU is set to run at full speed
PM_CPU_REDUCED	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_NO_CHANGE	The current value will be used

TRUE is returned if the requested change was made, otherwise FALSE is returned.

The application program may view the current power mode with the **getPowerMode** function.

See Also

getPowerMode, **setWakeSource**, **getWakeSource**

setProgramStatus

Set Program Status Flag

Syntax

```
#include <ctools.h>
void setProgramStatus( unsigned status );
```

Description

The **setProgramStatus** function sets the application program status flag. The status flag is set to **NEW_PROGRAM** when a cold boot of the controller is performed, or a program is downloaded to the controller from the program loader.

Notes

There are two pre-defined values for the flag. However the application program may make whatever use of the flag it sees fit.

NEW_PROGRAM	indicates the program is newly loaded.
PROGRAM_EXECUTED	indicates the program has been executed.

See Also

getProgramStatus

Example

See the example for **getProgramStatus**.

set_protocol

Set Communication Protocol Configuration

Syntax

```
#include <ctools.h>
int set_protocol(FILE *stream, struct prot_settings *settings);
```

Description

The **set_protocol** function sets protocol parameters. *stream* must specify one of **com1**, **com2**, **com3** or **com4**. *settings* references a protocol configuration structure. Refer to the description of the `prot_settings` structure for an explanation of the fields.

The **set_protocol** function returns **TRUE** if the settings were changed. It returns **FALSE** if there is an error in the settings or if the protocol fails to start.

The IO_SYSTEM resource must be requested before calling this function.

Notes

Setting the protocol type to NO_PROTOCOL ends the protocol task and frees the stack resources allocated to it.

Be sure to add a call to `modemNotification` when writing a custom protocol.

See Also

get_protocol, start_protocol, modemNotification

Example

This code fragment changes the station number of the com2 protocol to 4.

```
#include <ctools.h>
struct prot_settings settings;

get_protocol(com2, &settings);
settings.station = 4;
request_resource(IO_SYSTEM);
set_protocol(com2, &settings);
release_resource(IO_SYSTEM);
```

setProtocolSettings

Set Protocol Extended Addressing Configuration

Syntax

```
#include <ctools.h>
BOOLEAN setProtocolSettings(
      FILE * stream,
      PROTOCOL_SETTINGS * settings
      );
```

Description

The setProtocolSettings function sets protocol parameters for a serial port. This function supports extended addressing.

The function has two arguments: *stream* is one of com1, com2, com3 or com4; and *settings,* a pointer to a PROTOCOL_SETTINGS structure. Refer to the description of the structure for an explanation of the parameters.

The function returns **TRUE** if the settings were changed. It returns **FALSE** if the stream is not valid, or if the protocol fails to start.

The IO_SYSTEM resource must be requested before calling this function.

Notes

Setting the protocol type to NO_PROTOCOL ends the protocol task and frees the stack resources allocated to it.

Be sure to add a call to `modemNotification` when writing a custom protocol.

Extended addressing is available on the Modbus RTU and Modbus ASCII protocols only. See the *TeleBUS Protocols User Manual* for details.

See Also

getProtocolSettings, start_protocol, get_protocol, set_protocol, modemNotification

Example

This code fragment sets protocol parameters for the com2 serial port.

```
#include <ctools.h>
PROTOCOL_SETTINGS settings;

settings.type        = MODBUS_RTU;
settings.station     = 1234;
settings.priority    = 3;
settings.SFMessaging = FALSE;
settings.mode        = AM_extended;

request_resource(IO_SYSTEM);
setProtocolSettings(com2, &settings);
release_resource(IO_SYSTEM);
```

setProtocolSettingsEx

Sets extended protocol settings for a serial port.

Syntax

```
#include <ctools.h>
BOOLEAN setProtocolSettingsEx(
      FILE * stream,
      PROTOCOL_SETTINGS_EX * pSettings
      );
```

Description

The `setProtocolSettingsEx` function sets protocol parameters for a serial port. This function supports extended addressing and Enron Modbus parameters.

The function has two arguments:

- `stream` specifies the serial port. It is one of com1, com2, com3 or com4.
- `pSettings` is a pointer to a `PROTOCOL_SETTINGS_EX` structure. Refer to the description of the structure for an explanation of the parameters.

The function returns `TRUE` if the settings were changed. It returns `FALSE` if the stream is not valid, or if the protocol fails to start.

Notes

The IO_SYSTEM resource must be requested before calling this function.

Setting the protocol type to NO_PROTOCOL ends the protocol task and frees the stack resources allocated to it.

Be sure to add a call to `modemNotification` when writing a custom protocol.

Extended addressing and the Enron Modbus station are available on the Modbus RTU and Modbus ASCII protocols only. See the *TeleBUS Protocols User Manual* for details.

See Also

`getProtocolSettingsEx`

Example

This code fragment sets protocol parameters for the com2 serial port.

```
#include <ctools.h>
PROTOCOL_SETTINGS_EX settings;

settings.type =         MODBUS_RTU;
settings.station =      1;
settings.priority =     3;
settings.SFMessaging =  FALSE;
settings.mode =         AM_standard;
settings.enronEnabled = TRUE;
settings.enronStation = 4;

request_resource(IO_SYSTEM);
```

```
setProtocolSettingsEx(com2, &settings);
release_resource(IO_SYSTEM);
```

setSFMapping

Control Translation Table Mapping

Syntax

```
#include <ctools.h>
void setSFMapping(unsigned flag);
```

Description

The s**etSFMapping** and **getSFMapping** functions no longer perform any useful function but are maintained as stubs for backward compatibility. Include the CNFG_StoreAndForward module in the Register Assignment to assign a store and forward table to the I/O database.

Notes

The ***TeleBUS Protocols User Manual*** describes store and forward messaging mode.

See Also

getSFMapping

setSFTranslation

Write Store and Forward Translation

Syntax

```
#include <ctools.h>
struct SFTranslationStatus setSFTranslation(unsigned index, struct
   SFTranslation translation);
```

Description

The **setSFTranslation** function writes *translation* into the store and forward address translation table at the location specified by *index*. *translation* consists of two port and station address pairs. The function checks for invalid translations; if the translation is not valid it is not stored.

The function returns a SFTranslationStatus structure. It is described in the **Structures and Types** section. The *code* field of the structure is set to one of the following. If there is an error, the *index* field is set to the location of the translation that is not valid.

Result code	Meaning
SF_VALID	All translations are valid
SF_NO_TRANSLATION	The entry defines re-transmission of the same message on the same port
SF_PORT_OUT_OF_RANGE	One or both of the serial port indexes is not valid
SF_STATION_OUT_OF_RANGE	One or both of the stations is not valid
SF_ALREADY_DEFINED	The translation already exists in the table
SF_INDEX_OUT_OF_RANGE	The entry referenced by *index* does not exist in the table

Notes

The ***TeleBUS Protocols User Manual*** describes store and forward messaging mode.

Writing a translation with both stations set to station 256 can clear a translation in the table. Station 256 is not a valid station.

The protocol type and communication parameters may differ between serial ports. The store and forward messaging will translate the protocol messages.

The IO_SYSTEM resource must be requested before calling this function.

See Also

getSFTranslation, clearSFTranslationTable, checkSFTranslationTable

Example

This program enables store and forward messaging on com1 and com2. Two entries are placed into the store and forward table.

Note that the communication parameters and protocol type on com2 are different from com1.

```
#include <ctools.h>
void main(void)
{
       struct prot_settings settings;
```

```
struct pconfig portset;
struct SFTranslation translation;
struct SFTranslationStatus status;

request_resource(IO_SYSTEM);

/* Set communication parameters for port 1 */
portset.baud      = BAUD9600;
portset.duplex    = FULL;
portset.parity    = NONE;
portset.data_bits = DATA8;
portset.stop_bits = STOP1;
portset.flow_rx   = DISABLE;
portset.flow_tx   = DISABLE;
portset.type      = RS232;
portset.timeout   = 600;
set_port(com1, &portset);

/* Set communication parameters for port 2 */
portset.baud      = BAUD1200;
portset.duplex    = HALF;
portset.parity    = NONE;
portset.data_bits = DATA8;
portset.stop_bits = STOP1;
portset.flow_rx   = DISABLE;
portset.flow_tx   = DISABLE;
portset.type      = RS232;
portset.timeout   = 600;
set_port(com2, &portset);

/* Set up the translation table */
clearSFTranslationTable();

translation.portA    = portIndex(com1);
translation.stationA = 2;
translation.portB    = portIndex(com2);
translation.stationB = 3;
setSFTranslation(0, translation);

translation.portA    = portIndex(com1);
translation.stationA = 4;
translation.portB    = portIndex(com2);
translation.stationB = 5;
setSFTranslation(1, translation);

/* Enable store and forward messaging */
settings.type        = MODBUS_RTU;
settings.station     = 1;
settings.priority    = 3;
settings.SFMessaging = TRUE;
set_protocol(com1, &settings);

settings.type        = MODBUS_ASCII;
settings.station     = 1;
settings.priority    = 3;
settings.SFMessaging = TRUE;
set_protocol(com2, &settings);

release_resource(IO_SYSTEM);

/* Check if everything is correct */
status = checkSFTranslationTable();
if (status.code != SF_VALID)
{
   /* Blink the error code on the status LED */
   setStatus(status.code);
}
```

```
        else
        {
           setStatus(0);
        }

        while (TRUE)
        {
           /* main loop of application program */
        }
}
```

setStatus

Set Controller Status Code

Syntax

```
#include <ctools.h>
void setStatus(unsigned code);
```

Description

The **setStatus** function sets the controller status code. When the status code is non-zero, the STAT LED blinks a binary sequence corresponding to the code. If *code* is zero, the STAT LED turns off.

Notes

The status output opens if *code* is non-zero. Refer to the ***System Hardware Manual*** for more information. Note that there is no status output on the SCADASense seires of programmable controllers.

The binary sequence consists of short and long flashes of the error LED. A short flash of 1/10th of a second indicates a binary zero. A binary one is indicated by a longer flash of approximately 1/2 of a second. The least significant digit is output first. As few bits as possible are displayed – all leading zeros are ignored. There is a two second delay between repetitions.

The Register Assignment uses bits 0 and 1 of the status code. It is recommended that the **setStatusBit** function be used instead of **setStatus** to prevent modification of these bits.

See Also

setStatusBit, clearStatusBit, getStatusBit

setStatusBit

Set Bits in Controller Status Code

Syntax

```
#include <ctools.h>
unsigned setStatusBit(unsigned bitMask);
```

Description

The **setStatusBit** function sets the bits indicated by *bitMask* in the controller status code. When the status code is non-zero, the STAT LED blinks a binary sequence corresponding to the code. If *code* is zero, the STAT LED turns off.

The function returns the value of the status register.

Notes

The status output opens if *code* is non-zero. Refer to the ***System Hardware Manual*** for more information. Note that there is no status output on the SCADASense series of controllers.

The binary sequence consists of short and long flashes of the STAT LED. A short flash of 1/10th of a second indicates a binary zero. A binary one is indicated by a longer flash of approximately 1/2 of a second. The least significant digit is output first. As few bits as possible are displayed – all leading zeros are ignored. There is a two second delay between repetitions.

The Register Assignment uses bits 0 and 1 of the status code.

See Also

clearStatusBit, clearStatusBit, getStatusBit

settimer

Set a Timer

Syntax

```
#include <ctools.h>
void settimer(unsigned timer, unsigned value);
```

Description

The **settimer** function loads *value* into timer *specified by timer*. The timer counts down at the timer interval frequency.

The **settimer** function can reset a timer before it has finished counting down.

Notes

The **settimer** function cancels delayed digital I/O actions started with the **timeout**, **pulse** and **pulse_train** functions..

See Also

interval

Example

This code fragment sets timer 8 for 10 seconds, using an interval of 0.5 seconds.

```
interval(8, 5);  /* interval = 1/2 second */
settimer(8, 20); /* 10 second timer */
```

This code fragment sets timer 9 for 60 seconds using an interval of 1.0 seconds.

```
interval(9, 10); /* interval = 1 second */
settimer(9, 60); /* 60 second timer */
```

setWakeSource

Sets Conditions for Waking from Sleep Mode

Syntax

```
#include <ctools.h>
void setWakeSource(unsigned enableMask);
```

Description

The setWakeSource routine enables and disables sources that will wake up the processor. It enables all sources specified by *enableMask*. All other sources are disabled.

Valid wake up sources are listed below. Multiple sources may be ORed together.

- WS_NONE
- WS_ALL
- WS_REAL_TIME_CLOCK
- WS_INTERRUPT_INPUT
- WS_LED_POWER_SWITCH
- WS_COUNTER_0_OVERFLOW
- WS_COUNTER_1_OVERFLOW
- WS_COUNTER_2_OVERFLOW

Notes

Specifying WS_NONE as the wake up source will prevent the controller from waking, except by a power on reset.

See Also

getWakeSource, sleep

Example

The code fragments below show how to enable and disable wake up sources.

```
/* Wake up on all sources */
setWakeSource(WS_ALL);

/* Enable wake up on real time clock only */
setWakeSource(WS_REAL_TINE_CLOCK);
```

signal_event

Signal Occurrence of Event

Syntax

```
#include <ctools.h>
void signal_event(int event_number);
```

Description

The **signal_event** function signals that the *event_number* event has occurred.

If there are tasks waiting for the event, the highest priority task is made ready to execute. Otherwise the event flag is incremented. Up to 255 occurrences of an event will be recorded. The current task is blocked of there is a higher priority task waiting for the event.

Notes

Refer to the **Real Time Operating System** section for more information on events.

Valid events are numbered 0 to RTOS_EVENTS - 1. Any events defined in ctools.h are not valid events for use in an application program.

See Also

wait_event

Example

This program creates a task to wait for an event, then signals the event.

```
#include <ctools.h>

void task1(void)
{
       while(TRUE)
       {
          wait_event(20);
          printf("Event 20 occurred\r\n");
       }
}

void main(void)
{
       create_task(task1, 3, APPLICATION, 4);

       while(TRUE)
       {
          /* body of main task loop */
          /* The body of this main task is intended solely for signaling the
          event waited for by task1. Normally main would be busy with more
          important things to do otherwise the code in task1 could be
          executed within main's wait loop */

          settimer(0, 10);    /* 1 second interval */
          while (timer(0))    /* wait for 1 s */
          {
             /* Allow other tasks to execute */
             release_processor();
          }
          signal_event(20);
```

```
            }
        }
```

sleep

Suspend Controller Operation

Syntax

```
#include <ctools.h>
unsigned sleep(void);
```

Description

The **sleep** function puts the controller into a sleep mode. Sleep mode reduces the power consumption to a minimum by halting the microprocessor clock and shutting down the power supply. All programs halt until the controller resumes execution. All output points turn off while the controller is in sleep mode.

The sleep function does not work with the SCADAPack 100 or SCADASense series of programmable controllers. These controllers do not support sleep mode.

The controller resumes execution under the conditions shown in the table below. The application program may disable some wake up conditions. If a wake up condition is disabled the controller will not resume execution when the condition occurs. The table below shows the effect of disabling the various wake up conditions. All wake up conditions will be enabled by default. Refer to the description of the **setWakeSource** function for details.

Condition	Wake Up Effects	Disable Allowed	Disable Effect
Hardware Reset	Application programs execute from start of program.	No	Not applicable.
External Interrupt	Program execution continues from point sleep function was executed.	Yes	Interrupt input ignored
Real Time Clock Alarm	Program execution continues from point sleep function was executed.	Yes	Alarm ignored
LED Power Button	Program execution continues from point sleep function was executed.	Yes	LED power button ignored
Hardware Counter Rollover	Software portion of counter is incremented. Program execution continues from point sleep function was executed.	Yes	Software portion of counter is incremented. Controller returns to sleep mode.

The **sleep** function returns a wake up code indicating which condition caused the controller to resume execution.

Return Code	Condition
WS_REAL_TIME_CLOCK	real time clock alarm
WS_INTERRUPT_INPUT	rising edge of interrupt input
WS_LED_POWER_SWITCH	LED Power switch pushed

Return Code	Condition
WS_COUNTER_0_OVERFLOW	roll over of low word of counter 0 (every 65536 transitions)
WS_COUNTER_1_OVERFLOW	roll over of low word of counter 1 (every 65536 transitions)
WS_COUNTER_2_OVERFLOW	roll over of low word of counter 2 (every 65536 transitions)

Notes

The sleep function does not work with the SCADAPack 100 or SCADASense controller firmware. These controllers do not support sleep mode.

The IO_SYSTEM resource must be requested before calling this function.

See Also

setclock, alarmIn, setWakeSource, getWakeSource

Example

See the examples for the **setClockAlarm** and **alarmIn** functions.

start_protocol

Enable Protocol Task

Syntax

```
#include <ctools.h>
int start_protocol(FILE *stream);
```

Description

The **start_protocol** function enables a protocol task on the port specified by *stream*. The protocol configuration settings stored in memory are used.

The **start_protocol** function returns **TRUE** if the protocol started and **FALSE** if there was an error.

Notes

The **start_protocol** function is used by the system start up routine. Application programs should use the **set_protocol** function to control protocol operation.

See Also

get_protocol, set_protocol

startup_task

Identify Start Up Task

Syntax

```
#include <ctools.h>
void *startup_task(void);
```

Description

The **startup_task** function returns the address of the system or application start up task.

Notes

This function is used by the reset routine. It is normally not used in an application program.

startTimedEvent

Enable Signaling of a Regular Event

Syntax

```
#include <ctools.h>
unsigned startTimedEvent(unsigned event, unsigned interval);
```

Description

The **startTimedEvent** function causes the specified *event* to be signaled at the specified *interval*. *interval* is measured in multiples of 0.1 seconds. The task that is to receive the events should use the **wait_event** or **poll_event** functions to detect the event.

The function returns TRUE if the event can be signaled. If interval is 0 or if the event number is not valid, the function returns FALSE and no change is made to the event signaling (a previously enabled event will not be changed).

Notes

Valid events are numbered 0 to RTOS_EVENTS - 1. Any events defined in primitiv.h are not valid events for use in an application program.

The application program should stop the signaling of timed events when the task which waits for the events is ended. If the event signaling is not stopped, events will continue to build up in the queue until a function waits for them. The example below shows a simple method using the **installExitHandler** function.

See Also

endTimedEvent, signal_event, wait_event

Example

The program prints the time every 10 seconds.

```
#include <string.h>
#include <ctools.h>

#define TIME_TO_PRINT  15

/* ----------------------------------------
   The shutdown function stops the signalling
   of TIME_TO_PRINT events.
   ---------------------------------------- */
void shutdown(void)
{
       endTimedEvent(TIME_TO_PRINT);
}

/* ----------------------------------------
   The main function sets up signalling of
   a timed event, then waits for that event.
   The time is printed each time the event
   occurs.
   ---------------------------------------- */
void main(void)
{
       struct prot_settings settings;
       struct clock now;
```

```
        TASKINFO taskStatus;

        /* Disable the protocol on serial port 1 */
        settings.type = NO_PROTOCOL;
        settings.station = 1;
        settings.priority = 3;
        settings.SFMessaging = FALSE;
        request_resource(IO_SYSTEM);
        set_protocol(com1, &settings);
        release_resource(IO_SYSTEM);

        /* set up task exit handler to stop
           signalling of events when this task ends */
        taskStatus = getTaskInfo(0);
    installExitHandler(taskStatus.taskID, shutdown);

        /* start timed event */
        startTimedEvent(TIME_TO_PRINT, 100);

        while (TRUE)
        {
           wait_event(TIME_TO_PRINT);
           request_resource(IO_SYSTEM);
           now = getclock();
           release_resource(IO_SYSTEM);
           fprintf(com1, "Time %02u:%02u:%02u\r\n", now.hour, now.minute,
        now.second);
        }
}
```

timeout

Delayed Digital Output

Syntax

```
#include <ctools.h>
void timeout(unsigned channel, unsigned bit, unsigned timer, unsigned
   delay);
```

Description

The **timeout** function initiates a delayed control action on a digital output. The output changes state when the delay expires.

- *channel* specifies the digital output channel.
- *bit* specifies the output point within *channel*.
- *timer* specifies the timer used to measure the delay. It must be in the range 0 to 31.
- *delay* specifies the delay in timer ticks. The **interval** function sets the length of a timer tick.

If an error occurs, the current task's error code is set as follows:

TIMER_BADTIMER	if the timer number is invalid
TIMER_BADADDR	if the digital channel or bit is invalid

Notes

To cancel a timeout, set the timer to zero.

Use the **pulse** function to generate a repeating square wave.

The **timeout** function may start a new timeout sequence before the previous one completes. In this case, the previous timeout sequence is canceled and the new one begins.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite8Dout** directly.

See Also

interval, ioWrite8Dout, turnoff, turnon, settimer, pulse

timeoutCancel

Cancel Timeout Notification Function

Syntax

```
#include <ctools.h>
unsigned timeoutCancel(unsigned timeoutID);
```

Description

This function cancels a timeout notification that was requested with the `timeoutRequest` function. No notification will be sent. The envelope provided when the request was made is de-allocated.

The function has one parameter: the ID of the timeout request. This is the value returned by the `timeoutRequest` function.

The function returns TRUE if the request was cancelled and FALSE if the timeout ID is not currently active.

Notes

The function will return FALSE if the timeout notification has already been made. In this case the envelope will not be de-allocated as it has already been given to the destination task. That task is responsible for de-allocating the envelope.

This function cannot be called from a task exit handler. See `installExitHandler` function for details of exit handlers.

See Also

timeoutRequest

Example

See the example for the `timeoutRequest` function.

timeoutRequest

Request Timeout Notification Function

Syntax

```
#include <ctools.h>
unsigned timeoutRequest(unsigned delay, envelope * pEnvelope);
```

Description

This function requests a timeout notification. A message is sent to the task specified in the envelope after the specified delay.

A task receives the message using the `receive_message` or `poll_message` function. The envelope received by the receiving task has the following characteristics.

- The source field is set to the task ID of the task that called `timeoutRequest`.
- The message type field is set to `MSG_TIMEOUT`.
- The message data is set to the timeout ID.

The function has two parameters: the length of time in tenths of a second before the timeout occurs, and a pointer to an envelope. The resolution of the delay is –0.1/+0 seconds. The notification message is sent delay-1 to delay tenths of a second after the function call.

The function returns the ID of the timeout request. This can be used to identify and cancel the timeout. The timeout ID changes with each call to the function. Although the ID will eventually repeat, it is sufficiently unique to allow the timeout notification to be identified. This can be useful in identifying notifications received by a task and matching them with requests.

Notes

Do not de-allocate the envelope passed to `timeoutRequest` in the calling function. After a call to `timeoutRequest` either use `timeoutCancel` to free the envelope if the timeout has not occurred yet, or call `deallocate_envelope` in the destination task after the envelope has been delivered.

The timeout may be cancelled using the `timeoutCancel` function.

The task that receives the notification message must de-allocate the envelope after receiving it.

No checking is done on the task ID. The caller must ensure it is valid.

If the delay is zero, the message is sent immediately, provided an envelope is available.

This function cannot be called from a task exit handler. See `installExitHandler` function for details of exit handlers.

See Also

timeoutCancel

Example

This example shows a task that acts on messages received from other tasks and when a timeout occurs. The task waits for a message for up to 10 seconds. If it does not receive one, it proceeds with other processing anyway.

The task shows how to deal with notifications from older timeout requests. These occur when the notification was send before the timeout was cancelled. The task ignores timeout notifications that don't match the last timeout request.

```
#include <mriext.h>
#include <ctools.h>

void aTask(void)
{
envelope * pEnvelope;
TASKINFO thisTask;
unsigned timeoutID;
unsigned done;

/* get the task ID for this task */
thisTask = getTaskInfo(0);

while (TRUE)
      {
      /* allocate an envelope and address it to this task */
      pEnvelope = allocate_envelope();
      pEnvelope->destination = thisTask.taskID;

      /* request a timeout in 10 seconds */
      timeoutID = timeoutRequest(100, pEnvelope);

      done = FALSE;
      while (!done)
            {
            /* wait for a message or a timeout */
            pEnvelope = receive_message();

            /* determine the message type */
            if (pEnvelope->type == MSG_TIMEOUT)
                  {
                  /* does it match the last request? */
                  if (pEnvelope->data == timeoutID)
                        {
                        /* accept the timeout */
                        done = TRUE;
                        }
                  }
            else
                  {
                  /* cancel the timeout */
                  timeoutCancel(timeoutID);
                  done = TRUE;

                  /* process message from other task here */
                  }

            /* return the envelope to the RTOS */
            deallocate_envelope(pEnvelope);
            }
```

```
        /* proceed with rest of task's actions here */
        }
}
```

timer

Read a Timer

Syntax

```
#include <ctools.h>
unsigned timer(unsigned timer);
```

Description

The **timer** function returns the time remaining in *timer*. *timer* must be in the range 0 to 31. A zero value means that the timer has finished counting down.

If the timer number is invalid, the function returns 0 and the task's error code is set to **TIMER_BADTIMER**.

Notes

See Also

interval, settimer, timeout, read_timer_info, pulse

Example

This code fragment sets a timer, then displays the time remaining until it reaches 0.

```
#include <ctools.h>

interval(0, 1);
settimer(0, 10);
while (timer(0))
       printf("Time %d\r\n", timer(0));
```

turnoff

Turn Off a Digital Output

Syntax

```
#include <ctools.h>
int turnoff(unsigned channel, unsigned bit);
```

Description

The **turnoff** function turns off the digital output specified by *channel* and *bit*.

The **turnoff** function returns the value written to the channel if successful. If *channel* or *bit* is invalid, it returns –1.

Notes

The **turnoff** function has no effect if the specified point is configured as a digital input.

The state of the physical output is modified by the values in the I/O form, disable, and force status tables.

Multiple bits in the same channel can be set with the **dout** function.

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START and DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite8Dout** directly.

See Also

ioWrite8Dout, turnon

turnon

Turn On a Digital Output

Syntax

```
#include <ctools.h>
int turnon(unsigned channel, unsigned bit);
```

Description

The **turnon** function turns on the digital output specified by *channel* and *bit*.

The **turnon** function returns the value written to the channel if successful. If *channel* or *bit* is invalid, it returns –1.

Notes

The **turnon** function has no effect if the specified point is configured as a digital input.

The state of the physical output is modified by the values in the I/O form, disable, and force status tables.

Multiple bits in the same channel can be set with the **dout** function.

Use offsets from the symbolic constants DIN_START, DIN_END, DOUT_START and DOUT_END to reference digital channels. The constants make programs more portable and protect against future changes to the digital I/O channel numbering.

The IO_SYSTEM resource must be requested before calling this function.

This function is provided for backward compatibility. It cannot access all 5000 series I/O modules. It is recommended that this function not be used in new programs. Instead use Register Assignment or call the I/O driver **ioWrite8Dout** directly.

See Also

ioWrite8Dout, turnoff

wait_event

Wait for an Event

Syntax

```
#include <ctools.h>
void wait_event(int event);
```

Description

The **wait_event** function tests if an event has occurred. If the event has occurred, the event counter is decrements and the function returns. If the event has not occurred, the task is blocked until it does occur.

Notes

Refer to the **Real Time Operating System** section for more information on events.

Valid events are numbered 0 to RTOS_EVENTS - 1. Any events defined in primitiv.h are not valid events for use in an application program.

See Also

signal_event, startTimedEvent

Example

See the example for the **signal_event** function.

wd_auto

Automatic Watchdog Timer Mode

Syntax

```
#include <ctools.h>
void wd_auto(void);
```

Description

The **wd_auto** function gives control of the watchdog timer to the operating system. The timer is automatically updated by the system.

Notes

Refer to the **Functions Overview** section for more information.

See Also

wd_manual, wd_pulse

Example

See the example for the **wd_manual** function

wd_manual

Manual Watchdog Timer Mode

Syntax

```
#include <ctools.h>
void wd_manual(void);
```

Description

The **wd_manual** function takes control of the watchdog timer.

Notes

The application program must retrigger the watchdog timer at least every 0.5 seconds using the **wd_pulse** function, to prevent an controller reset.

Refer to the **Functions Overview** section for more information.

See Also

wd_auto, wd_pulse

Example

This program takes control of the watchdog timer for a critical section of code, then returns it to the control of the operating system.

```
       #include <ctools.h>

void main(void)
{
       wd_manual();
       wd_pulse();
       /* ... code executing in less than 0.5 s */
       wd_pulse();
       /* ... code executing in less than 0.5 s */
       wd_auto()
       /* ... as much code as you wish */
}
```

wd_pulse

Retrigger Watchdog Timer

Syntax

```
#include <ctools.h>
void wd_pulse(void);
```

Description

The **wd_pulse** function retriggers the watchdog timer.

Notes

The **wd_pulse** function must execute at least every 0.5 seconds, to prevent an controller reset, if the **wd_manual** function has been executed.

Refer to the **Functions Overview** section for more information.

See Also

wd_auto, wd_manual

Example

See the example for the **wd_manual** function

TelePACE C Tools Macro Definitions

A

Macro	*Definition*
AB	Specifies Allan-Bradley database addressing.
AB_PARSER	System resource: DF1 protocol message parser.
AB_FULL_BCC	Specifies the DF1 Full Duplex protocol emulation for the serial port. (BCC checksum)
AB_FULL_CRC	Specifies the DF1 Full Duplex protocol emulation for the serial port. (CRC checksum)
AB_HALF_BCC	Specifies the DF1 Half Duplex protocol emulation for the serial port. (BCC checksum)
AB_HALF_CRC	Specifies the DF1 Half Duplex protocol emulation for the serial port. (CRC checksum)
AB_PROTOCOL	DF1 protocol firmware option
AD_BATTERY	Internal AD channel connected to lithium battery
AD_THERMISTOR	Internal AD channel connected to thermistor
ADDITIVE	Additive checksum
AIN_END	Number of last analog input channel.
AIN_START	Number of first analog input channel.
AIO_BADCHAN	Error code: bad analog input channel specified.
AIO_SUPPORTED	If defined indicates analog I/O supported.
AIO_TIMEOUT	Error code: input device did not respond.
AO	Variable name: alarm output address
AOUT_END	Number of last analog output channel.
AOUT_START	Number of first analog output channel.
APPLICATION	Specifies an application type task. All application tasks are terminated by the end_application function.
AT_ABSOLUTE	Specifies a fixed time of day alarm.
AT_NONE	Disables alarms

B

Macro	*Definition*
BACKGROUND	System event: background I/O requested. The background I/O task uses this event. It should not be used in an application program.
BASE_TYPE_MASK	Controller type bit mask
BAUD110	Specifies 110-baud port speed.
BAUD115200	Specifies 115200-baud port speed.
BAUD1200	Specifies 1200-baud port speed.
BAUD150	Specifies 150-baud port speed.
BAUD19200	Specifies 19200-baud port speed.
BAUD2400	Specifies 2400-baud port speed.
BAUD300	Specifies 300-baud port speed.

Macro	*Definition*
BAUD38400	Specifies 38400-baud port speed.
BAUD4800	Specifies 4800-baud port speed.
BAUD57600	Specifies 57600-baud port speed.
BAUD600	Specifies 600-baud port speed.
BAUD75	Specifies 75-baud port speed.
BAUD9600	Specifies 9600-baud port speed.
BYTE_EOR	Byte-wise exclusive OR checksum

C

Macro	*Definition*
CA	Variable name: cascade setpoint source
CLASS0_FLAG	specifies a flag for enabling DNP Class 0 data
CLASS1_FLAG	specifies a flag for enabling DNP Class 1 data
CLASS2_FLAG	specifies a flag for enabling DNP Class 2 data
CLASS3_FLAG	specifies a flag for enabling DNP Class 3 data
CLOSED	Specifies switch is in closed position
COLD_BOOT	Cold-boot switch depressed when CPU was reset.
com1	Points to a file object for the com1 serial port.
COM1_RCVR	System event: indicates activity on com1 receiver. The meaning depends on the character handler installed.
com2	Points to a file object for the com2 serial port.
COM2_RCVR	System event: indicates activity on com2 receiver. The meaning depends on the character handler installed.
com3	Points to a file object for the com3 serial port.
COM3_RCVR	System event: indicates activity on com3 receiver. The meaning depends on the character handler installed.
com4	Points to a file object for the com4serial port.
COM4_RCVR	System event: indicates activity on com4 receiver. The meaning depends on the character handler installed.
COUNTER_CHANNELS	Specifies number of 5000 Series counter input channels
COUNTER_END	Number of last counter input channel
COUNTER_START	Number of first counter input channel
COUNTER_SUPPORTED	If defined indicates counter I/O hardware supported.
CPU_CLOCK_RATE	Frequency of the system clock in cycles per second
CR	Variable name: control register
CRC_16	CRC-16 type CRC checksum (reverse algorithm)
CRC_CCITT	CCITT type CRC checksum (reverse algorithm)

D

Macro	*Definition*
DATA_SIZE	Maximum length of the HART command or response field.
DATA7	Specifies 7 bit world length.
DATA8	Specifies 8 bit word length.
DB	Variable name: deadband
DB_BADSIZE	Error code: out of range address specified

Macro	*Definition*
DB_BADTYPE	Error code: bad database addressing type specified
DB_OK	Error code: no error occurred
DE_BadConfig	The modem configuration structure contains an error
DE_BusyLine	The phone number called was busy
DE_CallAborted	A call in progress was aborted by the user
DE_CarrierLost	The connection to the remote site was lost (modem reported NO CARRIER). Carrier is lost for a time exceeding the S10 setting in the modem. Phone lines with call waiting are very susceptible to this condition.
DE_FailedToConnect	The modem could not connect to the remote site
DE_InitError	Modem initialization failed (the modem may be turned off)
DE_NoDialTone	Modem did not detect a dial tone or the S6 setting in the modem is too short.
DE_NoError	No error has occurred
DE_NoModem	The serial port is not configured as a modem (port type must be RS232_MODEM). Or no modem is connected to the controller serial port.
DE_NotInControl	The serial port is in use by another modem function or has answered an incoming call.
DIN_END	Number of last regular digital input channel.
DIN_START	Number of first regular digital input channel
DIO_SUPPORTED	If defined indicates digital I/O hardware supported.
DISABLE	Specifies flow control is disabled.
DNP	Specifies the DNP protocol for the serial port
DO	Variable name: decrease output
DOUT_END	Number of last regular digital output channel.
DOUT_START	Number of first regular digital output channel
DS_Calling	The controller is making a connection to a remote controller
DS_Connected	The controller is connected to a remote controller
DS_Inactive	The serial port is not in use by a modem
DS_Terminating	The controller is ending a connection to a remote controller.
DUTY_CYCLE	Specifies timer is generating square wave output.
DYNAMIC_MEMORY	System resource: all memory allocation functions such as `malloc`, `alloc`, and `zalloc`.

E

Macro	*Definition*
EEPROM_EVERY	EEPROM section loaded to RAM on every CPU reboot
EEPROM_RUN	EEPROM section loaded to RAM on RUN type boots only.
EEPROM_SUPPORTED	If defined, indicates that there is an EEPROM in the controller.
ENABLE	Specifies flow control is enabled.
ER	Variable name: error
EVEN	Specifies even parity.
EX	Variable name: automatic execution period

Macro	*Definition*
EXTENDED_DIN_END	Number of last extended digital input channel.
EXTENDED_DIN_START	Number of first extended digital input channel
EXTENDED_DOUT_END	Number of last extended digital output channel.
EXTENDED_DOUT_START	Number of first extended digital output channel

F

Macro	*Definition*
FOPEN_MAX	Redefinition of macro from stdio.h
FORCE_MULTIPLE_COILS	Modbus function code
FORCE_SINGLE_COIL	Modbus function code
FOXCOM_MESSAGE_RECEIVED	This event is used when a Foxcom message is received. An application program cannot use this event.
FOXCOM_STARTED	This event is used when Foxcom communication has been established with a sensor. An application program cannot use this event.
FS	Variable name: full scale output limit
FULL	Specifies full duplex.

G

Macro	*Definition*
GA	Variable name: gain
GASFLOW	Gas Flow calculation firmware option
GFC_4202	SCADASense 4202 DR controller
GFC_4202DS	SCADASense 4202 DS controller

H

Macro	*Definition*
HALF	Specifies half duplex.
HI	Variable name: high alarm setpoint

I

Macro	*Definition*
IB	Variable name: input bias
IH	Variable name: inhibit execution address
IN	Variable name: integrated error
IO	Variable name: increase output
IO_SYSTEM	System resource for all I/O hardware functions.
IP	Variable name: input source

L

Macro	*Definition*
LED_OFF	Specifies LED is to be turned off.
LED_ON	Specifies LED is to be turned on.
LINEAR	Specifies linear database addressing.
LO	Variable name: low alarm setpoint
LOAD_MULTIPLE_REGISTERS	Modbus function code
LOAD_SINGLE_REGISTER	Modbus function code
LOCAL_COUNTERS	Number of 5203/4 counter inputs

M

Macro	*Definition*
MAX_PRIORITY	The maximum task priority.
MM_BAD_ADDRESS	Master message status: invalid database address
MM_BAD_FUNCTION	Master message status: invalid function code
MM_BAD_LENGTH	Master message status: invalid message length
MM_BAD_SLAVE	Master message status: invalid slave station address
MM_NO_MESSAGE	Master message status: no message was sent.
MM_PROTOCOL_NOT_SUPPORTED	Master message status: selected protocol is not supported.
MM_RECEIVED	Master message status: response received.
MM_RECEIVED_BAD_LENGTH	Master message status: response received with the incorrect amount of data.
MM_SENT	Master message status: message was sent.
MODBUS	Specifies Modbus database addressing.
MM_EOT	Master message status: DF1 slave response was an EOT message
MM_WRONG_RSP	Master message status: DF1slave response did not match command sent.
MM_CMD_ACKED	Master message status: DF1half duplex command has been acknowledged by slave – Master may now send poll command.
MM_EXCEPTION_ADDRESS	Master message status: Modbus slave returned an address exception.
MM_EXCEPTION_DEVICE_BUSY	Master message status: Modbus slave returned a Device Busy exception.
MM_EXCEPTION_DEVICE_FAILURE	Master message status: Modbus slave returned a Device Failure exception
MM_EXCEPTION_FUNCTION	Master message status: Modbus slave returned a function exception.
MM_EXCEPTION_VALUE	Master message status: Modbus slave returned a value exception.
MODBUS_ASCII	Specifies the Modbus ASCII protocol emulation for the serial port.
MODBUS_PARSER	System resource: Modbus protocol message parser.

Macro	*Definition*
MODBUS_RTU	Specifies the Modbus RTU protocol emulation for the serial port.
MODEM_CMD_MAX_LEN	Maximum length of the modem initialization command string
MODEM_MSG	System event: new modem message generated.
MSG_DATA	Specifies the data field in an envelope contains a data value.
MSG_POINTER	Specifies the data field in an envelope contains a pointer.

N

Macro	*Definition*
NEVER	System event: this event will never occur.
NEW_PROGRAM	Application program is newly loaded.
NO_ERROR	Error code: indicates no error has occurred.
NO_PROTOCOL	Specifies no communication protocol for the serial port.
NONE	Specifies no parity.
NORMAL	Specifies normal count down timer.
NORMAL	Specifies normal count down timer.
NOTYPE	Specifies serial port type is not known.
NUMAB	Number of registers in the Allan-Bradley database.
NUMCOIL	Number of registers in the Modbus coil section.
NUMHOLDING	Number of registers in the Modbus holding register section.
NUMINPUT	Number of registers in the Modbus input register section.
NUMLINEAR	Number of registers in the linear database.
NUMSTATUS	Number of registers in the Modbus status section.

O

Macro	*Definition*
OB	Variable name: output bias
ODD	Specifies odd parity.
OB	Variable name: output bias
OP	Variable name: output
OPEN	Specifies switch is in open position

P

Macro	*Definition*
PC_FLOW_RX_RECEIVE_STOP	Receiver disabled after receipt of a message.
PC_FLOW_RX_XON_XOFF	Receiver Xon/Xoff flow control.
PC_FLOW_TX_IGNORE_CTS	Transmitter flow control ignores CTS.
PC_FLOW_TX_XON_XOFF	Transmitter Xon/Xoff flow control.

Macro	*Definition*
PC_PROTOCOL_RTU_FRAMING	Modbus RTU framing.
PID_ALARM	Control register mask: alarms enabled
PID_ALARM_ABS	Control register mask: absolute alarms
PID_ALARM_ACK	Status register mask: alarm acknowledged
PID_ALARM_DEV	Control register mask: deviation alarms
PID_ALARM_ONLY	Control register mask: alarm only block
PID_ALARM_RATE	Control register mask: rate alarms
PID_ANALOG_IP	Control register mask: analog input
PID_ANALOG_OP	Control register mask: analog output
PID_BAD_BLOCK	Return code: bad block number specified.
PID_BAD_IO_IP	Status register mask: I/O failure on block input
PID_BAD_IO_OP	Status register mask: I/O failure on block output
PID_BLOCK_IP	Control register mask: input from output of another block
PID_BLOCKS	Number of PID blocks.
PID_CLAMP_FULL	Status register mask: output is clamped at full scale
PID_CLAMP_ZERO	Status register mask: output is clamped at zero scale
PID_ER_SQR	Control register mask: take square root of error
PID_HI_ALARM	Status register mask: high alarm detected
PID_INHIBIT	Status register mask: external inhibit input is on
PID_LO_ALARM	Status register mask: low alarm detected
PID_MANUAL	Status register mask: block is in manual mode
PID_MODE_AUTO	Control register mask: automatic mode
PID_MODE_MANUAL	Control register mask: manual mode
PID_MOTOR_OP	Control register mask: motor pulse duration output
PID_NO_ALARM	Control register mask: alarms disabled
PID_NO_ER_SQR	Control register mask: normal error
PID_NO_IP	Control register mask: no input (other than IP)
PID_NO_OP	Control register mask: no output
PID_NO_PV_SQR	Control register mask: normal PV
PID_NO_SP_TRACK	Control register mask: setpoint tracking disabled
PID_OK	Return code: operation completed successfully.
PID_OUT_DB	Status register mask: PID controller outside of deadband
PID_PID	Control register mask: PID control block
PID_PULSE_OP	Control register mask: pulse duration output
PID_PV_SQR	Control register mask: take square root of PV
PID_RATE_CLAMP	Status register mask: rate gain clamed at maximum
PID_RATIO_BIAS	Control register mask: ratio/bias control block
PID_RUNNING	Status register mask: block is executing
PID_SP_CASCADE	Control register mask: cascade setpoint
PID_SP_NORMAL	Control register mask: setpoint stored in SP
PID_SP_TRACK	Control register mask: setpoint tracking enabled
PE	Variable name: period
PHONE_NUM_MAX_LEN	Maximum length of the phone number string
PROGRAM_EXECUTED	Application program has been executed.
PULSE_TRAIN	Specifies timer is generating pulse train output.
PV	Variable name: process value
PM_CPU_FULL_CLOCK	The CPU is set to run at full speed
PM_CPU_REDUCED_CLOCK	The CPU is set to run at a reduced speed
PM_CPU_SLEEP	The CPU is set to sleep mode

Macro	*Definition*
PM_LAN_ENABLED	The LAN is enabled
PM_LAN_DISABLED	The LAN is disabled
PM_USB_PERIPHERAL_ENABLED	The USB peripheral port is enabled
PM_USB_PERIPHERAL_DISABLED	The USB peripheral port is disabled
PM_USB_HOST_ENABLED	The USB host port is enabled
PM_USB_HOST_DISABLED	The USB host port is disabled
PM_UNAVAILABLE	The status of the device could not be read.
PM_NO_CHANGE	The current value will be used

R

Macro	*Definition*
RA	Variable name: rate time
RE	Variable name: reset time
READ_COIL_STATUS	Modbus function code
READ_EXCEPTION_STATUS	Modbus function code
READ_HOLDING_REGISTER	Modbus function code
READ_INPUT_REGISTER	Modbus function code
READ_INPUT_STATUS	Modbus function code
READSTATUS	enum ReadStatus
REPORT_SLAVE_ID	Modbus function code
RS232	Specifies serial port is an RS-232 port.
RS232_COLLISION_AVOIDANCE	Specifies serial port is RS232 and uses CD for collision avoidance.
RS232_MODEM	Specifies serial port is an RS-232 dial-up modem.
RS485_4WIRE	Specifies serial port is a 4 wire RS-485 port.
RTOS_ENVELOPES	Number of RTOS envelopes.
RTOS_EVENTS	Number of RTOS events.
RTOS_PRIORITIES	Number of RTOS task priorities.
RTOS_RESOURCES	Number of RTOS resource flags.
RTOS_TASKS	Number of RTOS tasks.
RUN	Run/Service switch is in RUN position.

S

Macro	*Definition*
SP	Variable name: setpoint
SR	Variable name: status register
S_MODULE_FAILURE	Status LED code for I/O module communication failure
S_NORMAL	Status LED code for normal status
SCADAPACK	SCADAPack controller
SCADAPACK_LIGHT	SCADAPack LIGHT controller
SCADAPACK_PLUS	SCADAPack PLUS controller
SERIAL_PORTS	Number of serial ports.
SERVICE	Run/Service switch is in SERVICE position.
SF_ALREADY_DEFINED	Result code: translation is already defined in the table
SF_INDEX_OUT_OF_RANGE	Result code: invalid translation table index
SF_NO_TRANSLATION	Result code: entry does not define a translation

Macro	*Definition*
SF_PORT_OUT_OF_RANGE	Result code: serial port is not valid
SF_STATION_OUT_OF_RANGE	Result code: station number is not valid
SF_TABLE_SIZE	Number of entries in the store and forward table
SF_VALID	Result code: translation is valid
SIGNAL_CTS	I/O line bit mask: clear to send signal
SIGNAL_CTS	Matches status of CTS input.
SIGNAL_DCD	I/O line bit mask: carrier detect signal
SIGNAL_DCD	Matches status of DCD input.
SIGNAL_OFF	Specifies a signal is de-asserted
SIGNAL_OH	I/O line bit mask: off hook signal
SIGNAL_OH	Not supported – forced low (1).
SIGNAL_ON	Specifies a signal is asserted
SIGNAL_RING	I/O line bit mask: ring signal
SIGNAL_RING	Not supported – forced low (0).
SIGNAL_VOICE	I/O line bit mask: voice/data switch signal
SIGNAL_VOICE	Not supported – forced low (0).
SLEEP_MODE_SUPPORTED	Defined if sleep function is supported
SMARTWIRE_5201_5202	SmartWIRE 5201 and 5202 controllers
SP	Variable name: setpoint
SR	Variable name: status register
STACK_SIZE	Size of the machine stack.
START_COIL	Start of the coils section in the linear database.
START_HOLDING	Start of the holding register section in the linear database.
START_INPUT	Start of the input register section in the linear database.
START_STATUS	Start of the status section in the linear database.
STARTUP_ APPLICATION	Specifies the application start up task.
STARTUP_SYSTEM	Specifies the system start up task.
STOP1	Specifies 1 stop bit.
STOP2	Specifies 2 stop bits.
SYSTEM	Specifies a system type task. System tasks are not terminated by the end_application function.

T

Macro	*Definition*
T_CELSIUS	Specifies temperatures in degrees Celsius
T_FAHRENHEIT	Specifies temperatures in degrees Fahrenheit
T_KELVIN	Specifies temperatures in degrees Kelvin
T_RANKINE	Specifies temperatures in degrees Rankine
TELESAFE_6000_16EX	TeleSAFE 6000-16EX controller
TELESAFE_MICRO_16	TeleSAFE Micro16 controller
TIMED_OUT	Specifies timer is has reached zero.
TIMEOUT	Specifies timer is generating timed output change.
TIMER_BADADDR	Error code: invalid digital I/O address
TIMER_BADINTERVAL	Error code: invalid timer interval
TIMER_BADTIMER	Error code: invalid timer
TIMER_BADVALUE	Error code: invalid time value

Macro	*Definition*
TIMER_MAX	Number of last valid software timer.
TS_EXECUTING	Task status indicating task is executing.
TS_READY	Task status indicating task is ready to execute
TS_WAIT_ RESOURCE	Task status indicating task is blocked waiting for a resource
TS_WAIT_ENVELOPE	Task status indicating task is blocked waiting for an envelope
TS_WAIT_EVENT	Task status indicating task is blocked waiting for an event
TS_WAIT_MESSAGE	Task status indicating task is blocked waiting for a message

V

Macro	*Definition*
VI_DATE_SIZE	Number of characters in version information date field

W

Macro	*Definition*
WRITESTATUS	enum WriteStatus
WS_ALL	All wake up sources enabled
WS_COUNTER_0_OVERFLOW	Bit mask to enable counter 0 overflow as wake up source
WS_COUNTER_1_OVERFLOW	Bit mask to enable counter 1 overflow as wake up source
WS_COUNTER_2_OVERFLOW	Bit mask to enable counter 2 overflow as wake up source
WS_INTERRUPT_INPUT	Bit mask to enable interrupt input as wake up source
WS_LED_POWER_SWITCH	Bit mask to enable LED power switch as wake up source
WS_NONE	No wake up source enabled
WS_REAL_TIME_CLOCK	Bit mask to enable real time clock as wake up source
WS_UNDEFINED	Undefined wake up source

Z

Macro	*Definition*
ZE	Variable name: zero scale output limit

TelePACE C Tools Structures and Types

ABConfiguration

The ABConfiguration structure defines settings for DF1 communication protocol.

```
/* DF1 Protocol Configuration */
struct ABConfiguration {
   unsigned min_protected_address;
   unsigned max_protected_address;
   };
```

- `min_protected_address` is the minimum allowable DF1 physical 16-bit address allowed in all protected commands. The default value is 0.
- `max_protected_address` is the maximum allowable DF1 physical 16-bit address allowed in all protected commands. The default value is NUMAB.

ADDRESS_MODE

The ADDRESS_MODE enumerated type describes addressing modes for communication protocols.

```
typedef enum addressMode_t
      {
      AM_standard = 0,
      AM_extended
      }
      ADDRESS_MODE;
```

- `AM_standard` returns standard Modbus addressing. Standard addressing allows 255 stations and is compatible with standard Modbus devices
- `AM_extended` returns extended addressing. Extended addressing allows 65534 stations.

ALARM_SETTING

The ALARM_SETTING structure defines a real time clock alarm setting.

```
typedef struct alarmSetting_tag {
      UINT16 type;
      UINT16 hour;
      UINT16 minute;
      UINT16 second;
      } ALARM_SETTING;
```

- `type` specifies the type of alarm. It may be the AT_NONE or AT_ABSOLUTE macro.
- `hour` specifies the hour at which the alarm will occur.
- `minute` specifies the minute at which the alarm will occur.
- `second` specifies the second at which the alarm will occur.

clock

The clock structure contains time and date for reading or writing the real time clock.

```
struct clock {
    UINT16 year;
    UINT16 month;
    UINT16 day;
    UINT16 dayofweek;
    UINT16 hour;
    UINT16 minute;
    UINT16 second;
    };
```

- `year` is the current year. It is two digits in the range 00 to 99.
- `month` is the current month. It is in the range 1 to 12.
- `day` is the current day. It is in the range 1 to 31.
- `dayofweek` is the current day of the week. It is in the range 1 to 7. 1 = Sunday, 2 = Monday…7 = Saturday.
- `hour` is the current hour. It is in the range 00 to 23.
- `minute` is the current minute. It is in the range 00 to 59.
- `second` is the current second. It is in the range 00 to 59.

DATALOG_CONFIGURATION

The data log configuration structure holds the configuration of the data log. Each record in a data log may hold up to eight fields. Not all the fields are used if fewer than eight variables are declared.

The amount of memory used for a record depends on the number of fields in the record and the size of each field. Use the `datalogRecordSize` function to determine the memory needed for each record.

```
typedef struct datalogConfig_type {
      UINT16 records;   /* # of records */
      UINT16 fields;    /* # of fields per record */
      DATALOG_VARIABLE typesOfFields[MAX_NUMBER_OF_FIELDS];
} DATALOG_CONFIGURATION;
```

DATALOG_STATUS

The data log status enumerated type is used to report status information.

```
typedef enum {
      DLS_CREATED,      /* data log created */
      DLS_BADID,  /* invalid log ID */
      DLS_EXISTS, /* log already exists */
      DLS_NOMEMORY,     /* insufficient memory for log */
      DLS_BADCONFIG     /* invalid configuration */
      DLS_BADSEQUENCE   /* sequence number not in use */
} DATALOG_STATUS;
```

DATALOG_VARIABLE

The data log variable enumerated type is specify the type and size of variables to be recorded in the log.

```
typedef enum {
      DLV_UINT16 = 0,   /* 16 bit unsigned integer */
      DLV_INT16,        /* 16 bit signed integer */
      DLV_UINT32,       /* 32 bit unsigned integer */
      DLV_INT32,        /* 32 bit signed integer */
      DLV_FLOAT,        /* 32 bit floating point */
      DLV_CMITIME,      /* 64 bit time */
      DLV_DOUBLE        /* 64 bit floating point */
} DATALOG_VARIABLE;
```

DialError

The `DialError` enumerated type defines error responses from the dial-up modem functions and may have one of the following values.

```
enum DialError
{
      DE_NoError = 0,
      DE_BadConfig,
      DE_NoModem,
      DE_InitError,
      DE_NoDialTone,
      DE_BusyLine,
      DE_CallAborted,
      DE_FailedToConnect,
      DE_CarrierLost,
      DE_NotInControl
      DE_CallCut
};
```

- `DE_NoError` returns no error has occurred
- `DE_BadConfig` returns the modem configuration structure contains an error
- `DE_NoModem` returns the serial port is not configured as a modem (port type must be RS232_MODEM). Or no modem is connected to the controller serial port.
- `DE_InitError` returns modem initialization failed (the modem may be turned off)
- `DE_NoDialTone` returns modem did not detect a dial tone or the S6 setting in the modem is too short.
- `DE_BusyLine` returns the phone number called was busy
- `DE_CallAborted` returns a call in progress was aborted by the user
- `DE_FailedToConnect` returns the modem could not connect to the remote site
- `DE_CarrierLost` returns the connection to the remote site was lost (modem reported NO CARRIER). Carrier is lost for a time exceeding the S10 setting in the modem. Phone lines with call waiting are very susceptible to this condition.
- `DE_NotInControl` returns the serial port is in use by another modem function or has answered an incoming call.
- `DE_CallCut` returns an incoming call was disconnected while attempting to dial out.

DialState

The `DialState` enumerated type defines the state of the `modemDial` operation and may have one of the following values.

```
enum DialState
{
```

```
      DS_Inactive,
      DS_Calling,
      DS_Connected,
      DS_Terminating
};
```

- DS_Inactive returns the serial port is not in use by a modem
- DS_Calling returns the controller is making a connection to a remote controller
- DS_Connected returns the controller is connected to a remote controller
- DS_Terminating returns the controller is ending a connection to a remote controller.

dnpAnalogInput

The dnpAnalogInput type describes a DNP analog input point. This type is used for both 16-bit and 32-bit points.

```
typedef struct dnpAnalogInput_type
{
      UINT16 modbusAddress;
      UCHAR  class;
      UINT32 deadband;
 } dnpAnalogInput;
```

- modbusAddress is the address of the Modbus register number associated with the point.
- class is the reporting class for the object. It may be set to CLASS_1, CLASS_2 or CLASS_3.
- deadband is the amount by which the analog input value must change before an event will be reported for the point.

dnpAnalogOutput

The dnpAnalogOutput type describes a DNP analog output point. This type is used for both 16-bit and 32-bit points.

```
typedef struct dnpAnalogOutput_type
{
      UINT16 modbusAddress;
} dnpAnalogOutput;
```

- modbusAddress is the address of the Modbus register associated with the point.

dnpBinaryInput

The dnpBinaryInput type describes a DNP binary input point.

```
typedef struct dnpBinaryInput_type
{
      UINT16 modbusAddress;
      UCHAR  class;
} dnpBinaryInput;
```

- modbusAddress is the address of the Modbus register associated with the point.
- class is the reporting class for the object. It may be set to CLASS_1, CLASS_2 or CLASS_3.

DNP Binary Input Extended Point

The dnpBinaryInputEx type describes an extended DNP Binary Input point.

```
typedef struct dnpBinaryInputEx_type
{
      UINT16 modbusAddress;
      UCHAR  eventClass;
      UCHAR  debounce;
} dnpBinaryInputEx;
```

- modbusAddress is the address of the Modbus register associated with the point.
- class is the reporting class for the object. It may be set to CLASS_1, CLASS_2 or CLASS_3.
- debounceTime is the debounce time for thebinary input.

dnpBinaryOutput

The dnpBinaryOutput type describes a DNP binary output point.

```
typedef struct dnpBinaryOutput_type
{
      UINT16 modbusAddress1;
      UINT16 modbusAddress2;
      UCHAR  controlType;
 } dnpBinaryOutput;
```

- modbusAddress1 is the address of the first Modbus register associated with the point. This field is always used.
- modbusAddress2 is the address of the second Modbus register associated with the point. This field is used only with paired outputs. See the controlType field.
- controlType determines if one or two outputs are associated with this output point. It may be set to PAIRED or NOT_PAIRED.
    - A paired output uses two Modbus registers for output. The first output is the Trip output and the second is the Close output. This is used with Control Relay Output Block objects.
    - A non-paired output uses one Modbus register for output. This is used with Binary Output objects.

DNP_CONNECTION_EVENT Type

This enumerated type lists DNP events.

```
typedef enum dnpConnectionEventType
{
      DNP_CONNECTED=0,
      DNP_DISCONNECTED,
      DNP_CONNECTION_REQUIRED,
      DNP_MESSAGE_COMPLETE,
      DNP_MESSAGE_TIMEOUT
} DNP_CONNECTION_EVENT;
```

- The DNP_CONNECTED event indicates that the handler has connected to the master station. The application sends this event to DNP. When DNP receives this event it will send unsolicited messages.

- The DNP_DISCONNECTED event indicates that the handler has disconnected from the master station. The application sends this event to DNP. When DNP receives this event it will request a new connection before sending unsolicited messages.
- The DNP_CONNECTION_REQUIRED event indicates that DNP wishes to connect to the master station. DNP sends this event to the application. The application should process this event by making a connection.
- The DNP_MESSAGE_COMPLETE event indicates that DNP has received confirmation of unsolicited messages from the master station. DNP sends this event to the application. The application should process this event by disconnecting. In many applications a short delay before disconnecting is useful as it allows the master station to send commands to the slave after the unsolicited reporting is complete.
- The DNP_MESSAGE_TIMEOUT event indicates that DNP has attempted to send an unsolicited message but did not receive confirmation after all attempts. This usually means there is a communication problem. DNP sends this event to the application. The application should process this event by disconnecting.

dnpConfiguration

The `dnpConfiguration` type describes the DNP parameters.

```
typedef struct dnpConfiguration_type
{
      UINT16 masterAddress;
      UINT16 rtuAddress;
      CHAR   datalinkConfirm;
      CHAR   datalinkRetries;
      UINT16 datalinkTimeout;
      UINT16 operateTimeout;
      UCHAR  applicationConfirm;
      UINT16 maximumResponse;
      UCHAR  applicationRetries;
      UINT16 applicationTimeout;
      INT16  timeSynchronization;
      UINT16 BI_number;
      UINT16 BI_startAddress;
      CHAR   BI_reportingMethod;
      UINT16 BI_soebufferSize;
      UINT16 BO_number;
      UINT16 BO_startAddress;
      UINT16 CI16_number;
      UINT16 CI16_startAddress;
      CHAR   CI16_reportingMethod;
      UINT16 CI16_bufferSize;
      UINT16 CI32_number;
      UINT16 CI32_startAddress;
      CHAR   CI32_reportingMethod;
      UINT16 CI32_bufferSize;
      CHAR   CI32_wordOrder;
      UINT16 AI16_number;
      UINT16 AI16_startAddress;
      CHAR   AI16_reportingMethod;
      UINT16 AI16_bufferSize;
      UINT16 AI32_number;
      UINT16 AI32_startAddress;
      CHAR   AI32_reportingMethod;
      UINT16 AI32_bufferSize;
```

```
        CHAR   AI32_wordOrder;
        UINT16 AISF_number;
        UINT16 AISF_startAddress;
        CHAR   AISF_reportingMethod;
        UINT16 AISF_bufferSize;
        CHAR   AISF_wordOrder;
        UINT16 AO16_number;
        UINT16 AO16_startAddress;
        UINT16 AO32_number;
        UINT16 AO32_startAddress;
        CHAR   AO32_wordOrder;
        UINT16 AOSF_number;
        UINT16 AOSF_startAddress;
        CHAR   AOSF_wordOrder;
        UINT16 autoUnsolicitedClass1;
        UINT16 holdTimeClass1;
        UINT16 holdCountClass1;
        UINT16 autoUnsolicitedClass2;
        UINT16 holdTimeClass2;
        UINT16 holdCountClass2;
        UINT16 autoUnsolicitedClass3;
        UINT16 holdTimeClass3;
        UINT16 holdCountClass3;
} dnpConfiguration;
```

- `masterAddress` is the address of the master station. Unsolicited messages are sent to this station. Solicited messages must come from this station. Valid values are 0 to 65534.
- `rtuAddress` is the address of the RTU. The master station must send messages to this address. Valid values are 0 to 65534.
- `datalinkConfirm` enables requesting data link layer confirmations. Valid values are TRUE and FALSE.
- `datalinkRetries` is the number of times the data link layer will retry a failed message. Valid values are 0 to 255.
- `datalinkTimeout` is the length of time the data link layer will wait for a response before trying again or aborting the transmission. The value is measured in milliseconds. Valid values are 100 to 60000 in multiples of 100 milliseconds.
- `operateTimeout` is the length of time an operate command is valid after receiving a select command. The value is measured in seconds. Valid values are 1 to 6500.
- `applicationConfirm` enables requesting application layer confirmations. Valid values are TRUE and FALSE.
- `maximumResponse` is the maximum length of an application layer response. Valid values are 20 to 2048. The recommended value is 2048 unless the master cannot handle responses this large.
- `applicationRetries` is the number of times the application layer will retry a transmission. Valid values are 0 to 255.
- `applicationTimeout` is the length of time the application layer will wait for a response before trying again or aborting the transmission. The value is measured in milliseconds. Valid values are 100 to 60000 in multiples of 100 milliseconds. This value must be larger than the data link timeout.

- timeSynchronization defines how often the RTU will request a time synchronization from the master.
  - Set this to NO_TIME_SYNC to disable time synchronization requests.
  - Set this to STARTUP_TIME_SYNC to request time synchronization at start up only.
  - Set this to 1 to 32767 to set the time synchronization period in seconds.
- BI_number is the number of binary input points. Valid values are 0 to 9999.
- BI_startAddress is the DNP address of the first Binary Input point.
- BI_reportingMethod determines how binary inputs are reported either Change Of State or Log All Events.
- BI_bufferSize is the Binary Input Change Event Buffer Size.
- BO_number is the number of binary output points. Valid values are 0 to 9999.
- BO_startAddress is the DNP address of the first Binary Output point.
- CI16_number is the number of 16-bit counter input points. Valid values are 0 to 9999.
- CI16_startAddress is the DNP address of the first CI16 point.
- CI16_reportingMethod determines how CI16 inputs are reported either Change Of State or Log All Events.
- CI16_bufferSize is the number of events in the 16-bit counter change buffer. Valid values are 0 to 9999.
- CI32_number is the number of 32-bit counter input points. Valid values are 0 to 9999.
- CI32_startAddress is the DNP address of the first CI32 point.
- CI32_reportingMethod determines how CI32 inputs are reported either Change Of State or Log All Events.
- CI32_bufferSize is the number of events in the 32-bit counter change buffer. Valid values are 0 to 9999.
- CI32_wordOrder is the Word Order of CI32 points (0=LSW first, 1=MSW first).
- AI16_number is the number of 16-bit analog input points. Valid values are 0 to 9999.
- AI16_startAddress is the DNP address of the first AI16 point.
- AI16_reportingMethod determines how 16-bit analog changes are reported.
  - Set this to FIRST_VALUE to report the value of the first change event measured.
  - Set this to CURRENT_VALUE to report the value of the latest change event measured.
- AI16_bufferSize is the number of events in the 16-bit analog input change buffer. Valid values are 0 to 9999.
- AI32_number is the number of 32-bit analog input points. Valid values are 0 to 9999.
- AI32_startAddress is the DNP address of the first AI32 point.
- AI32_reportingMethod determines how 32-bit analog changes are reported.
  - Set this to FIRST_VALUE to report the value of the first change event measured.

    - Set this to CURRENT_VALUE to report the value of the latest change event measured.
- AI32_bufferSize is the number of events in the 32-bit analog input change buffer. Valid values are 0 to 9999.
- AI32_wordOrder is the Word Order of AI32 points (0=LSW first, 1=MSW first)
- AO16_number is the number of 16-bit analog output points. Valid values are 0 to 9999.
- AO16_startAddress is the DNP address of the first AO16 point.
- AO32_number is the number of 32-bit analog output points. Valid values are 0 to 9999.
- AO32_startAddress is the DNP address of the first AO32 point.
- AO32_wordOrder is the Word Order of AO32 points (0=LSW first, 1=MSW first)
- AOSF_number is the number of short float Analog Outputs.
- AOSF_startAddress is the DNP address of first AOSF point.
- AOSF_wordOrder is the Word Order of AOSF points (0=LSW first, 1=MSW first).
- autoUnsolicitedClass1 enables or disables automatic Unsolicited reporting of Class 1 events.
- holdTimeClass1 is the maximum period to hold Class 1 events before reporting
- holdCountClass1 is the maximum number of Class 1 events to hold before reporting.
- autoUnsolicitedClass2 enables or disables automatic Unsolicited reporting of Class 2 events.
- holdTimeClass2 is the maximum period to hold Class 2 events before reporting
- holdCountClass2 is the maximum number of Class 2 events to hold before reporting.
- autoUnsolicitedClass3 enables or disables automatic Unsolicited reporting of Class 3 events.
- holdTimeClass3 is the maximum period to hold Class 3 events before reporting.
- holdCountClass2 is the maximum number of Class 3 events to hold before reporting.

dnpConfigurationEx

The dnpConfigurationEx type includes extra parameters in the DNP Configuration.

```
typedef struct dnpConfigurationEx_type
{
      UINT16 rtuAddress;
      UCHAR  datalinkConfirm;
      UCHAR  datalinkRetries;
      UINT16 datalinkTimeout;
      UINT16 operateTimeout;
      UCHAR  applicationConfirm;
      UINT16 maximumResponse;
      UCHAR  applicationRetries;
      UINT16 applicationTimeout;
      INT16  timeSynchronization;
      UINT16 BI_number;
      UINT16 BI_startAddress;
```

```
    UCHAR  BI_reportingMethod;
    UINT16 BI_soeBufferSize;
    UINT16 BO_number;
    UINT16 BO_startAddress;
    UINT16 CI16_number;
    UINT16 CI16_startAddress;
    UCHAR  CI16_reportingMethod;
    UINT16 CI16_bufferSize;
    UINT16 CI32_number;
    UINT16 CI32_startAddress;
    UCHAR  CI32_reportingMethod;
    UINT16 CI32_bufferSize;
    UCHAR  CI32_wordOrder;
    UINT16 AI16_number;
    UINT16 AI16_startAddress;
    UCHAR  AI16_reportingMethod;
    UINT16 AI16_bufferSize;
    UINT16 AI32_number;
    UINT16 AI32_startAddress;
    UCHAR  AI32_reportingMethod;
    UINT16 AI32_bufferSize;
    UCHAR  AI32_wordOrder;
    UINT16 AISF_number;
    UINT16 AISF_startAddress;
    UCHAR  AISF_reportingMethod;
    UINT16 AISF_bufferSize;
    UCHAR  AISF_wordOrder;
    UINT16 AO16_number;
    UINT16 AO16_startAddress;
    UINT16 AO32_number;
    UINT16 AO32_startAddress;
    UCHAR  AO32_wordOrder;
    UINT16 AOSF_number;
    UINT16 AOSF_startAddress;
    UCHAR  AOSF_wordOrder;
    UINT16 autoUnsolicitedClass1;
    UINT16 holdTimeClass1;
    UINT16 holdCountClass1;
    UINT16 autoUnsolicitedClass2;
    UINT16 holdTimeClass2;
    UINT16 holdCountClass2;
    UINT16 autoUnsolicitedClass3;
    UINT16 holdTimeClass3;
    UINT16 holdCountClass3;
    UINT16 enableUnsolicitedOnStartup;
    UINT16 sendUnsolicitedOnStartup;
    UINT16 level2Compliance;
    UINT16 masterAddressCount;
    UINT16 masterAddress[8];
    UINT16 maxEventsInResponse;
    UINT16 dialAttempts;
    UINT16 dialTimeout;
    UINT16 pauseTime;
    UINT16 onlineInactivity;
    UINT16 dialType;
    Char   modemInitString[64];
} dnpConfigurationEx;
```

- `rtuAddress` is the address of the RTU. The master station must send messages to this address. Valid values are 0 to 65534.

- `datalinkConfirm` enables requesting data link layer confirmations. Valid values are TRUE and FALSE.
- `datalinkRetries` is the number of times the data link layer will retry a failed message. Valid values are 0 to 255.
- `datalinkTimeout` is the length of time the data link layer will wait for a response before trying again or aborting the transmission. The value is measured in milliseconds. Valid values are 100 to 60000 in multiples of 100 milliseconds.
- `operateTimeout` is the length of time an operate command is valid after receiving a select command. The value is measured in seconds. Valid values are 1 to 6500.
- `applicationConfirm` enables requesting application layer confirmations. Valid values are TRUE and FALSE.
- `maximumResponse` is the maximum length of an application layer response. Valid values are 20 to 2048. The recommended value is 2048 unless the master cannot handle responses this large.
- `applicationRetries` is the number of times the application layer will retry a transmission. Valid values are 0 to 255.
- `applicationTimeout` is the length of time the application layer will wait for a response before trying again or aborting the transmission. The value is measured in milliseconds. Valid values are 100 to 60000 in multiples of 100 milliseconds. This value must be larger than the data link timeout.
- `timeSynchronization` defines how often the RTU will request a time synchronization from the master.
  - Set this to `NO_TIME_SYNC` to disable time synchronization requests.
  - Set this to `STARTUP_TIME_SYNC` to request time synchronization at start up only.
  - Set this to 1 to 32767 to set the time synchronization period in seconds.
- `BI_number` is the number of binary input points. Valid values are 0 to 9999.
- `BI_startAddress` is the DNP address of the first Binary Input point.
- `BI_reportingMethod` determines how binary inputs are reported either Change Of State or Log All Events.
- `BI_soebufferSize` is the Binary Input Change Event Buffer Size.
- `BO_number` is the number of binary output points. Valid values are 0 to 9999.
- `BO_startAddress` is the DNP address of the first Binary Output point.
- `CI16_number` is the number of 16-bit counter input points. Valid values are 0 to 9999.
- `CI16_startAddress` is the DNP address of the first CI16 point.
- `CI16_reportingMethod` determines how CI16 inputs are reported either Change Of State or Log All Events.
- `CI16_bufferSize` is the number of events in the 16-bit counter change buffer. Valid values are 0 to 9999.
- `CI32_number` is the number of 32-bit counter input points. Valid values are 0 to 9999.
- `CI32_startAddress` is the DNP address of the first CI32 point.

- CI32_reportingMethod determines how CI32 inputs are reported either Change Of State or Log All Events.
- CI32_bufferSize is the number of events in the 32-bit counter change buffer. Valid values are 0 to 9999.
- CI32_wordOrder is the Word Order of CI32 points (0=LSW first, 1=MSW first).
- AI16_number is the number of 16-bit analog input points. Valid values are 0 to 9999.
- AI16_startAddress is the DNP address of the first AI16 point.
- AI16_reportingMethod determines how 16-bit analog changes are reported.
  - Set this to FIRST_VALUE to report the value of the first change event measured.
  - Set this to CURRENT_VALUE to report the value of the latest change event measured.
- AI16_bufferSize is the number of events in the 16-bit analog input change buffer. Valid values are 0 to 9999.
- AI32_number is the number of 32-bit analog input points. Valid values are 0 to 9999.
- AI32_startAddress is the DNP address of the first AI32 point.
- AI32_reportingMethod determines how 32-bit analog changes are reported.
  - Set this to FIRST_VALUE to report the value of the first change event measured.
  - Set this to CURRENT_VALUE to report the value of the latest change event measured.
- AI32_bufferSize is the number of events in the 32-bit analog input change buffer. Valid values are 0 to 9999.
- AI32_wordOrder is the Word Order of AI32 points (0=LSW first, 1=MSW first)
- AISF_number is the number of short float Analog Inputs.
- AISF_startAddress is the DNP address of first AISF point.
- AISF_reportingMethod is the event reporting method, Change Of State or Log All Events.
- AISF_bufferSize is the short float Analog Input Event Buffer Size.
- AISF_wordOrder is the word order of AISF points (0=LSW first, 1=MSW first) */
- AO16_number is the number of 16-bit analog output points. Valid values are 0 to 9999.
- AO16_startAddress is the DNP address of the first AO16 point.
- AO32_number is the number of 32-bit analog output points. Valid values are 0 to 9999.
- AO32_startAddress is the DNP address of the first AO32 point.
- AO32_wordOrder is the Word Order of AO32 points (0=LSW first, 1=MSW first)
- AOSF_number is the number of short float Analog Outputs.
- AOSF_startAddress is the DNP address of first AOSF point.
- AOSF_wordOrder is the Word Order of AOSF points (0=LSW first, 1=MSW first).

- `autoUnsolicitedClass1` enables or disables automatic Unsolicited reporting of Class 1 events.
- `holdTimeClass1` is the `maximum period to hold Class 1 events before reporting`
- `holdCountClass1` is the maximum number of Class 1 events to hold before reporting.
- `autoUnsolicitedClass2` enables or disables automatic Unsolicited reporting of Class 2 events.
- `holdTimeClass2` is the maximum period to hold Class 2 events before reporting
- `holdCountClass2` is the maximum number of Class 2 events to hold before reporting.
- `autoUnsolicitedClass3` enables or disables automatic Unsolicited reporting of Class 3 events.
- `holdTimeClass3` is the maximum period to hold Class 3 events before reporting.
- `HoldCountClass3` is the maximum number of Class 3 events to hold before reporting.
- `EnableUnsolicitedOnStartup` enables or disables unsolicited reporting at start-up.
- `SendUnsolicitedOnStartup` sends an unsolicited report at start-up.
- `level2Compliance` reports only level 2 compliant data types (excludes floats, AO-32).
- `MasterAddressCount` is the number of master stations.
- `masterAddress[8]` is the number of master station addresses.
- `MaxEventsInResponse` is the maximum number of change events to include in read response.
- `PSTNDialAttempts` is the maximum number of dial attempts to establish a PSTN connection.
- `PSTNDialTimeout` is the maximum time after initiating a PSTN dial sequence to wait for a carrier signal.
- `PSTNPauseTime` is the pause time between dial events.
- `PSTNOnlineInactivity` is the maximum time after message activity to leave a PSTN connection open before hanging up.
- `PSTNDialType` is the dial type: tone or pulse dialling.
- `modemInitString[64]` is the initialization string to send to the modem.

dnpCounterInput

The `dnpCounterInput` type describes a DNP counter input point. This type is used for both 16-bit and 32-bit points.

```
typedef struct dnpCounterInput_type
{
      UINT16 modbusAddress;
      UCHAR  class;
      UINT32 threshold;
 } dnpCounterInput;
```

- `modbusAddress` is the address of the Modbus register number associated with the point.

- `class` is the reporting class for the object. It may be set to `CLASS_1`, `CLASS_2` or `CLASS_3`.
- `threshold` is the amount by which the counter input value must change before an event will be reported for the point.

dnpPointType

The enumerated type `DNP_POINT_TYPE` includes all allowed DNP data point types.

```
typedef enum dnpPointType
{
      BI_POINT=0,       /* binary input */
      AI16_POINT,       /* 16 bit analog input */
      AI32_POINT,       /* 32 bit analog input */
      AISF_POINT,       /* short float analog input */
      AILF_POINT,       /* long float analog input */
      CI16_POINT,       /* 16 bit counter output */
      CI32_POINT,       /* 32 bit counter output */
      BO_POINT,         /* binary output */
      AO16_POINT,       /* 16 bit analog output */
      AO32_POINT,       /* 32 bit analog output */
      AOSF_POINT,       /* short float analog output */
      AOLF_POINT        /* long float analog output */
} DNP_POINT_TYPE;
```

DNP_RUNTIME_STATUS

The DNP_RUNTIME_STATUS type describes a structure for holding status information about DNP event log buffers.

```
/* DNP Runtime Status */
typedef struct dnp_runtime_status
{
    UINT16 eventCountBI;
    UINT16 eventCountCI16;
    UINT16 eventCountCI32;
    UINT16 eventCountAI16;
    UINT16 eventCountAI32;
    UINT16 eventCountAISF;
    UINT16 eventCountClass1;
    UINT16 eventCountClass2;
    UINT16 eventCountClass3;
} DNP_RUNTIME_STATUS;
```

- `eventCountBI` is number of binary input events.
- `eventCountCI16` is number of 16-bit counter events.
- `eventCountCI32` is number of 32-bit counter events.
- `eventCountAI16` is number of 16-bit analog input events.
- `eventCountAI32` is number of 32-bit analog input events.
- `eventCountAISF` is number of short floating-point analog input events.
- `eventCountClass1` is the class 1 event counter.
- `eventCountClass2` is the class 2 event counter.

- `eventCountClass3` is the class 3 event counter.

envelope

The envelope type is a structure containing a message envelope. Envelopes are used for inter-task communication.

```
typedef struct env {
    struct env    *link;
    unsigned      source;
    unsigned      destination;
    unsigned      type;
    unsigned long data;
    unsigned      owner;
    }
    envelope;
```

- `link` is a pointer to the next envelope in a queue. This field is used by the RTOS. It is of no interest to an application program.
- `source` is the task ID of the task sending the message. This field is specified automatically by the `send_message` function. The receiving task may read this field to determine the source of the message.
- `destination` is the task ID of the task to receive the message. It must be specified before calling the `send_message` function.
- `type` specifies the type of data in the data field. It may be MSG_DATA, MSG_POINTER, or any other value defined by the application program. This field is not required.
- `data` is the message data. The field may contain a datum or pointer. The application program determines the use of this field.
- `owner` is the task that owns the envelope. This field is set by the RTOS and must not be changed by an application program.

HART_COMMAND

The HART_COMMAND type is a structure containing a command to be sent to a HART slave device. The command field contains the HART command number. The length field contains the length of the data string to be transmitted (the byte count in HART documentation). The data field contains the data to be sent to the slave.

```
typedef struct hartCommand_t
      {
      unsigned command;
      unsigned length;
      char     data[DATA_SIZE];
      }
      HART_COMMAND;
```

- `command` is the HART command number.
- `length` is the number of characters in the data string.
- `data[DATA_SIZE]` is the data field for the command.

HART_DEVICE

The HART_DEVICE type is a structure containing information about the HART device. The information is read from the device using command 0 or command 11. The fields are identical to those read by the commands. Refer to the command documentation for more information.

```
typedef struct hartDevice_t
       {
       unsigned char manufacturerID;
       unsigned char manufacturerDeviceType;
       unsigned char preamblesRequested;
       unsigned char commandRevision;
       unsigned char transmitterRevision;
       unsigned char softwareRevision;
       unsigned char hardwareRevision;
       unsigned char flags;
       unsigned long deviceID;
       }
       HART_DEVICE;
```

HART_RESPONSE

The HART_RESPONSE type is a structure containing a response from a HART slave device. The command field contains the HART command number. The length field contains the length of the data string to be transmitted (the byte count in HART documentation). The data field contains the data to be sent to the slave.

```
typedef struct hartResponse_t
       {
       unsigned responseCode,
       unsigned length,
       char     data[DATA_SIZE];
       }
       HART_RESPONSE;
```

- `response` is the response code from the device.
- `length` is the length of response data.
- `data[DATA_SIZE]` is the data field for the response.

HART_RESULT

The HART_RESULT enumeration type defines a list of results of sending a command.

```
typedef enum hartResult_t
       {
       HR_NoModuleResponse=0,
       HR_CommandPending,
       HR_CommandSent,
       HR_Response,
       HR_NoResponse,
       HR_WaitTransmit
       }
       HART_RESULT;
```

- `HR_NoModuleResponse` returns no response from HART modem module.
- `HR_CommandPending` returns command ready to be sent, but not sent.
- `HR_CommandSent` returns command sent.

- HR_Response returns response received.
- HR_NoResponse returns no response after all attempts.
- HR_WaitTransmit returns modem is not ready to transmit.

HART_SETTINGS

The HART_SETTINGS type is a structure containing the configuration for the HART modem module. The useAutoPreamble field indicates if the number of preambles is set by the value in the HART_SETTINGS structure (FALSE) or the value in the HART_DEVICE structure (TRUE). The deviceType field determines if the 5904 modem is a HART primary master or secondary master device (primary master is the recommended setting).

```
typedef struct hartSettings_t
      {
      unsigned attempts;
      unsigned preambles;
      BOOLEAN  useAutoPreamble;
      unsigned deviceType;
      }
      HART_SETTINGS;
```

- attempts is the number of command attempts (1 to 4).
- preambles is the number of preambles to send (2 to 15).
- useAutoPreamble is a flag to use the requested preambles.
- deviceType is the type of HART master (1 = primary; 0 = secondary).

HART_VARIABLE

The HART_VARIABLE type is a structure containing a variable read from a HART device. The structure contains three fields that are used by various commands. Note that not all fields will be used by all commands. Refer to the command specific documentation.

```
typedef struct hartVariable_t
      {
      float    value;
      unsigned units;
      unsigned variableCode;
      }
      HART_VARIABLE;
```

- value is the value of the variable.
- units are the units of measurement.
- variableCode is the transmitter specific variable ID.

ioModules

The ioModules enumerated type describes I/O modules used with register assignment.

```
enum ioModules
{
      DOUT_generic8 = 0,
      DOUT_generic16,
      DOUT_5401,
      DOUT_5402,
      DOUT_5406,
```

```
DOUT_5407,
DOUT_5408,
DOUT_5409,
DOUT_5411,
CNFG_clearPortCounters,
CNFG_clearProtocolCounters,
CNFG_saveToEEPROM,
CNFG_LEDPower,

SCADAPack_lowerIO,
SCADAPack_upperIO,

DIN_generic8,
DIN_generic16,
DIN_5401,
DIN_5402,
DIN_5403,
DIN_5404,
DIN_5405,
DIN_5421,
DIN_520xDigitalInputs,
DIN_520xOptionSwitches,
DIN_520xInterruptInput,
DIAG_forceLED,

AIN_generic8,
AIN_5501,
AIN_5503,
AIN_5504,
AIN_5521,
CNTR_5410,
CNTR_520xCounterInputs,
AIN_520xTemperature,
AIN_520xRAMBattery,
DIAG_controllerStatus,
DIAG_commStatus,
DIAG_protocolStatus,

AOUT_generic2,
AOUT_generic4,
AOUT_5301,
AOUT_5302,
SCADAPack_AOUT,
CNFG_portSettings,
CNFG_protocolSettings,
CNFG_realTimeClock,
CNFG_PIDBlock,
CNFG_storeAndForward,
CNFG_5904Modem,
CNFG_protocolExtended,
AIN_5502,
CNTR_520xInterruptInput,
CNFG_setSerialPortDTR,
SCADAPack_LPIO,
SCADAPack_10
CNFG_protocolExtendedEx,
SCADAPack_5604IO,
AOUT_5304,
GFC_4202IO
};
```

ledControl_tag

The ledControl_tag structure defines LED power control parameters.

```
struct ledControl_tag {
       unsigned state;
       unsigned time;
       };
```

- state is the default LED state. It is either the LED_ON or LED_OFF macro.
- time is the period, in minutes, after which the LED power returns to its default state.

ModemInit

The ModemInit structure specifies modem initialization parameters for the modemInit function.

```
struct ModemInit
{
       FILE * port;
       char   modemCommand[MODEM_CMD_MAX_LEN + 2];
};
```

- port is the serial port where the modem is connected.
- modemCommand is the initialization string for the modem. The characters AT will be prefixed to the command, and a carriage returned suffixed to the command when it is sent to the modem. Refer to the section **Modem Commands** for suggested command strings for your modem.

ModemSetup

The ModemSetup structure specifies modem initialization and dialing control parameters for the modemDial function.

```
struct ModemSetup
{
       FILE * port;
       unsigned short   dialAttempts;
       unsigned short   detectTime;
       unsigned short   pauseTime;
       unsigned short   dialmethod;
       char modemCommand[MODEM_CMD_MAX_LEN + 2];
       char phoneNumber[PHONE_NUM_MAX_LEN + 2];
};
```

- port is the serial port where the modem is connected.
- dialAttempts is the number of times the controller will attempt to dial the remote controller before giving up and reporting an error.
- detectTime is the length of time in seconds that the controller will wait for carrier to be detected. It is measured from the start of the dialing attempt.
- pauseTime is the length of time in seconds that the controller will wait between dialing attempts.
- dialmethod selects pulse or tone dialing. Set dialmethod to 0 for tone dialing or 1 for pulse dialing.
- modemCommand is the initialization string for the modem. The characters AT will be prepended to the command, and a carriage returned appended to the command when it

is sent to the modem. Refer to the section **Modem Commands** for suggested command strings for your modem.

- `phoneNumber` is the phone number of the remote controller. The characters ATD and the dialing method will be prepended to the command, and a carriage returned appended to the command when it is sent to the modem.

PROTOCOL_SETTINGS

The Extended Protocol Settings structure defines settings for a communication protocol. This structure differs from the standard settings in that it allows additional settings to be specified.

```
typedef struct protocolSettings_t
      {
      unsigned char type;
      unsigned station;
      unsigned char priority;
      unsigned SFMessaging;
      ADDRESS_MODE mode;
      }
      PROTOCOL_SETTINGS;
```

- `type` is the protocol type. It may be one of NO_PROTOCOL, MODBUS_RTU, or MODBUS_ASCII macros.
- `station` is the station address of the controller. Note that each serial port may have a different address. The valid values are determined by the communication protocol. This field is not used if the protocol type is NO_PROTOCOL.
- `priority` is the task priority of the protocol task. This field is not used if the protocol type is NO_PROTOCOL.
- `SFMessaging` is the enable Store and Forward messaging control flag.
- `ADDRESS_MODE` is the addressing mode, standard or extended.

PROTOCOL_SETTINGS_EX Type

This structure contains serial port protocol settings including Enron Modbus support.

```
typedef struct protocolSettingsEx_t
      {
      UCHAR type;
      UINT16 station;
      UCHAR priority;
      UINT16 SFMessaging;
      ADDRESS_MODE mode;
      BOOLEAN enronEnabled;
      UINT16 enronStation;
      }
      PROTOCOL_SETTINGS_EX;
```

- `type` is the protocol type. It may be one of `NO_PROTOCOL`, `MODBUS_RTU`, or `MODBUS_ASCII`.
- `station` is the station address of the controller. Note that each serial port may have a different address. The valid values are determined by the communication protocol. This field is not used if the protocol type is `NO_PROTOCOL`.

- priority is the task priority of the protocol task. This field is not used if the protocol type is NO_PROTOCOL.
- SFMessaging is the enable Store and Forward messaging control flag.
- ADDRESS_MODE is the addressing mode, AM_standard or AM_extended.
- enronEnabled determines if the Enron Modbus station is enabled. It may be TRUE or FALSE.
- enronStation is the station address for the Enron Modbus protocol. It is used if enronEnabled is set to TRUE. Valid values are 1 to 255 for standard addressing, and 1 to 65534 for extended addressing.

prot_settings

The Protocol Settings structure defines settings for a communication protocol. This structure differs from the extended settings in that it allows fewer settings to be specified.

```
struct prot_settings {
    unsigned char type;
    unsigned char station;
    unsigned char priority;
    unsigned SFMessaging;
    };
```

- type is the protocol type. It may be one of NO_PROTOCOL, MODBUS_RTU, MODBUS_ASCII, AB_FULL_BCC, AB_HALF_BCC, AB_FULL_CRC, AB_HALF_CRC or DNP macros.
- station is the station address of the controller. Note that each serial port may have a different address. The valid values are determined by the communication protocol. This field is not used if the protocol type is NO_PROTOCOL.
- priority is the task priority of the protocol task. This field is not used if the protocol type is NO_PROTOCOL.
- SFMessaging is the enable Store and Forward messaging control flag.

prot_status

The prot_status structure contains protocol status information.

```
struct prot_status {
    unsigned command_errors;
    unsigned format_errors;
    unsigned checksum_errors;
    unsigned cmd_received;
    unsigned cmd_sent;
    unsigned rsp_received;
    unsigned rsp_sent;
    unsigned command;
    int      task_id;
    unsigned stored_messages;
    unsigned forwarded_messages;
    };
```

- command_errors is the number of messages received with invalid command codes.
- format_errors is the number of messages received with bad message data.
- checksum_errors is the number of messages received with bad checksums.

- `cmd_received` is the number of commands received.
- `cmd_sent` is the number of commands sent by the `master_message` function.
- `rsp_received` is the number of responses received by the `master_message` function.
- `rsp_sent` is the number of responses sent.
- `command` is the status of the last protocol command sent.
- `task_id` is the ID of the protocol task. This field is used by the `set_protocol` function to control protocol execution.
- `stored_messages` is the number of messages stored for forwarding.
- `forwarded_messages` is the number of messages forwarded.

pconfig

The `pconfig` structure contains serial port settings.

```
struct pconfig {
    unsigned baud;
    unsigned duplex;
    unsigned parity;
    unsigned data_bits;
    unsigned stop_bits;
    unsigned flow_rx;
    unsigned flow_tx;
    unsigned type;
    unsigned timeout;
    };
```

- `baud` is the communication speed. It is one of the `BAUD_xxx` macros.
- `duplex` is either the FULL or HALF macro.
- `parity` is one of NONE, EVEN or ODD macros.
- `data_bits` is the word length. It is either the DATA7 or DATA8 macro.
- `stop_bits` in the number of stop bits transmitted. It is either the STOP1 or STOP2 macro.
- `flow_rx` specifies flow control on the receiver. It is either the DISABLE or ENABLE macro.
  - For com1 and com2 setting this parameter selects XON/XOFF flow control. It may be enabled or disabled.

    If any protocol, other than Modbus ASCII, is used on the port you must set `flow_rx` to DISABLE. If Modbus ASCII or no protocol is used, you can set `flow_rx` to ENABLE or DISABLE. In most cases DISABLE is recommended.
  - For com3 and com4 setting this parameter selects Receiver Disable after message reception. This is used with the Modbus RTU protocol only. If the Modbus RTU protocol is used, set `flow_rx` to ENABLE. Otherwise set `flow_rx` to DISABLE.
- `flow_tx` specifies flow control on the transmitter. It is either the DISABLE or ENABLE macro.
  - For com1 and com2 setting this parameter selects XON/XOFF flow control. It may be enabled or disabled.

If any protocol, other than Modbus ASCII, is used on the port you must set `flow_tx` to DISABLE. If Modbus ASCII or no protocol is used, you can set `flow_tx` to ENABLE or DISABLE. In most cases DISABLE is recommended.

- For com3 and com4 setting this parameter indicates if the port should ignore the CTS signal. Setting the parameter to ENABLE causes the port to ignore the CTS signal.

- `type` specifies the serial port type. It is one of NOTYPE, RS232, RS232_MODEM, RS485, or RS232_COLLISION_AVOID macros.
- `timeout` specifies the time the driver will wait when the transmit buffer fills, before it clears the buffer.

PORT_CHARACTERISTICS

The PORT_CHARACTERISTICS type is a structure that contains serial port characteristics.

```
typedef struct portCharacteristics_tag {
      unsigned dataflow;
      unsigned buffering;
      unsigned protocol;
      unsigned long options;
      } PORT_CHARACTERISTICS;
```

- `dataflow` is a bit mapped field describing the data flow options supported on the serial port. ANDing can isolate the options with the PC_FLOW_RX_RECEIVE_STOP, PC_FLOW_RX_XON_XOFF, PC_FLOW_TX_IGNORE_CTS or PC_FLOW_TX_XON_XOFF macros.
- `buffering` describes the buffering options supported. No buffering options are currently supported.
- `protocol` describes the protocol options supported. The macro, PC_PROTOCOL_RTU_FRAMING is the only option supported.
- `options` describes additional options supported. No additional options are currently supported.

pstatus

The `pstatus` structure contains serial port status information.

```
struct pstatus {
    unsigned framing;
    unsigned parity;
    unsigned c_overrun;
    unsigned b_overrun;
    unsigned rx_buffer_size;
    unsigned rx_buffer_used;
    unsigned tx_buffer_size;
    unsigned tx_buffer_used;
    unsigned io_lines;
    };
```

- `framing` is the number of received characters with framing errors.
- `parity` is the number of received characters with parity errors.
- `c_overrun` is the number of received character overrun errors.
- `b_overrun` is the number of receive buffer overrun errors.

- rx_buffer_size is the size of the receive buffer in characters.
- rx_buffer_used is the number of characters in the receive buffer.
- tx_buffer_size is the size of the transmit buffer in characters.
- tx_buffer_used is the number of characters in the transmit buffer.
- io_lines is a bit mapped field indicating the status of the I/O lines on the serial port. The values for these lines differ between serial ports (see tables below). ANDing can isolate the signals with the SIGNAL_CTS, SIGNAL_DCD, SIGNAL_OH, SIGNAL_RING or SIGNAL_VOICE macros.

READSTATUS

The READSTATUS enumerated type indicates the status of an I^2C bus message read and may have one of the following values.

```
enum ReadStatus {
       RS_success,
       RS_selectFailed
       };
typedef enum ReadStatus READSTATUS;
```

- RS_success returns read was successful.
- RS_selectFailed returns slave device could not be selected

regAssign

The regAssign structure is used to construct a register assignment. It is one entry in the register assignment.

```
struct regAssign {
      unsigned    ioDriverType;
      unsigned    moduleAddress;
      unsigned    startingRegister1;
      unsigned    startingRegister2;
      unsigned    startingRegister3;
      unsigned    startingRegister4;
      unsigned    moduleType;
      unsigned    modbusStartReg1;
      unsigned    modbusStartReg2;
      unsigned    modbusStartReg3;
      unsigned    modbusStartReg4;
      };
```

- ioDriverType is the i/o module driver type
- moduleAddress is the address or group index for module
- startingRegister1 is the starting linear address of 1st group of consecutive registers mapped to module
- startingRegister2 is the starting linear address of 2nd group of registers
- startingRegister3 is the starting linear address of 3rd group of registers
- startingRegister4 is the starting linear address of 4th group of registers
- moduleType is the hardware or pseudo module type

- modbusStartReg1 is the starting Modbus register of 1st group
- modbusStartReg2 is the starting Modbus register of 2nd group
- modbusStartReg3 is the starting Modbus register of 3rd group
- modbusStartReg4 is the starting Modbus register of 4th group

routingTable

The routingTable type describes an entry in the DNP Routing Table.

Note that the DNP Routing Table is a list of routes, which are maintained in ascending order of DNP addresses.

```
typedef struct RoutingTable_type
{
      UINT16 address;               /* station address */
      UINT16 comPort;               /* com port interface */
      UINT16 retries;               /* number of retries */
      UINT16 timeout;               /* timeout in milliseconds */
} routingTable;
```

- adress is the DNP address.
- comPort is the serial port interface.
- retries is the number of data link retires for this table entry.
- timeout is the timeout in milliseconds.

SFTranslation

The SFTranslation structure contains Store and Forward Messaging translation information. This is used to define an address and port translation.

```
struct SFTranslation {
       unsigned portA;
       unsigned stationA;
       unsigned portB;
       unsigned stationB;
       };
```

- portA is the index of the first serial port. The index is obtained with the portIndex function.
- stationA is the station address of the first station.
- portB is the index of the second serial port. The index is obtained with the portIndex function.
- stationB is the station address of the second station.

SFTranslationStatus

The SFTranslationStatus structure contains information about a Store and Forward Translation table entry. It is used to report information about specific table entries.

```
struct SFTranslationStatus {
       unsigned index;
```

```
unsigned code;
};
```

- `index` is the location in the store and forward table to which the status code applies.
- `code` is the status code. It is one of SF_VALID, SF_INDEX_OUT_OF_RANGE, SF_NO_TRANSLATION, SF_PORT_OUT_OF_RANGE, SF_STATION_OUT_OF_RANGE, or SF_ALREADY_DEFINED macros.

TASKINFO

The TASKINFO type is a structure containing information about a task.

```
/* Task Information Structure */
typedef struct taskInformation_tag {
   unsigned taskID;
   unsigned priority;
   unsigned status;
   unsigned requirement;
   unsigned error;
   unsigned type;
   } TASKINFO;
```

- `taskID` is the identifier of the task.
- `priority` is the execution priority of the task.
- `status` is the current execution status the task. This may be one of TS_READY, TS_EXECUTING, TS_WAIT_ENVELOPE, TS_WAIT_EVENT, TS_WAIT_MESSAGE, or TS_WAIT_RESOURCE macros.
- `requirement` is used if the task is waiting for an event or resource. If the `status` field is TS_WAIT_EVENT, then `requirement` indicates on which event it is waiting. If the `status` field is TS_WAIT_RESOURCE then `requirement` indicates on which resource it is waiting.
- `error` is the task error code. This is the same value as returned by the `check_error` function.
- `type` is the task type. It will be either SYSTEM or APPLICATION.

taskInfo_tag

The `taskInfo_tag` structure contains start up task information.

```
struct taskInfo_tag {
       void *address;
       unsigned stack;
       unsigned identity;
       };
```

- `address` is the pointer to the start up routine.
- `stack` is the required stack size for the routine
- `identity` is the type of routine found (STARTUP_APPLICATION or STARTUP_SYSTEM)

timer_info

The `timer_info` structure contains information about a timer.

```
struct timer_info {
    unsigned time;
    unsigned interval;
    unsigned interval_remaining;
    unsigned flags;
    unsigned duty_on;
    unsigned duty_period;
    unsigned channel;
    unsigned bit;
    };
```

- `time` is the time remaining in the timer in ticks.
- `interval` is the length of a timer tick in 10ths of a second.
- `interval_remaining` is the time remaining in the interval count down register in 10ths of a second.
- `flags` is the timer type and status bits (NORMAL, PULSE TRAIN, DUTY_CYCLE, TIMEOUT, and TIMED_OUT). More than one condition may be true at any time.
- `duty_on` is the length of the on high portion of the square wave output. This is used only by the **pulse** function.
- `duty_period` is the period of the square wave output This is used only by the **pulse** function.
- `channel` and `bit` specify the digital output point. This is used by **pulse**, **pulse_train** and **timeout** functions.

VERSION

The Firmware Version Information Structure holds information about the firmware.

```
typedef struct versionInfo_tag {
       unsigned version;
       unsigned controller;
       char date[VI_DATE_SIZE + 1];
       char copyright[VI_STRING_SIZE + 1];
       } VERSION;
```

- `version` is the firmware version number.
- `controller` is target controller for the firmware.
- `date` is a string containing the date the firmware was created.
- `copyright` is a string containing Control Microsystems copyright information.

WRITESTATUS

The WRITESTATUS enumerated type indicates the status of an I^2C bus message read and may have one of the following values.

```
enum WriteStatus {
       WS_success,
       WS_selectFailed,
       WS_noAcknowledge
       };
typedef enum WriteStatus WRITESTATUS;
```

- `WS_success` returns write was successful
- `WS_selectFailed` returns slave could not be selected

- `WS_noAcknowledge` returns slave failed to acknowledge data

C Compiler Known Problems

The C compiler supplied with the TelePACE C Tools is a product of Microtec. There are two known problems with the compiler.

Use of Initialized Static Local Variables

The compiler incorrectly allocates storage for initialized static local variables. The storage is allocated incorrectly in memory reserved for constant string data. The storage should be allocated in memory for initialized variables.

Problems Caused

A program loaded in ROM cannot modify a variable declared in this fashion.

A program loaded in RAM can modify the variable. However, the variable is in a section of program memory that the operating system expects to remain constant. Modifying the variable causes the operating system to think the program has been modified. The program continues to run correctly, but will not run again if it is stopped by the C Program Loader or if the controller is reset. The operating system detects that the program memory is corrupt and does not execute the program.

Example

The compiler generates incorrect code for the following example. Storage for the variable a is allocated in the *strings* section. It should be in the *initvars* section.

If the program is loaded in ROM, it cannot modify the variable a.

If the program is loaded in RAM, it can be run once after being written to a controller memory. All subsequent attempts to run the program will fail.

```
void main(void)
{
      static int a = 1;

      a++;
      /* other code here */
}
```

Working Around the Problem

There are two ways to work around the problem.

1. Use global variable instead of a local variable. For example:

```
static int a = 1;

void main(void)
{
   a++;
   /* other code here */
}
```

2. If the local variable is to be initialized to zero, then a non-initialized static local variable can be used. For example:

```
void main(void)
{
   static int a;

   a++;
   /* other code here */
}
```

In this example the declaration:

```
static int a;
```

is the same as the following:

```
static int a = 0;
```

The operating systems sets non-initialized variables (stored in the `zerovars` section) to zero before running the program.

Correction to the Problem

This problem exists with the C Compiler supplied by Microtec. It will not be corrected. Users must work around the problem as described above.

Use of pow Function

The compiler sometimes incorrectly evaluates expressions involving the pow function with other arithmetic.

Also, a task calling the pow function requires at least 5 stack blocks. The need for more stack space by the pow function is not a compiler problem, it is simply a requirement of pow.

Problems Caused

Some arithmetic expressions involving the pow function may result in incorrect results. When testing expressions that call pow, if the result is found to be incorrect, it will be consistently incorrect for all values used by variables in the expression.

The pow function requires at least 5 stack blocks. If 4 or less stack blocks are used by the task calling pow, the controller will overflow its stack space. When the stack space overflows the behavior is unpredictable, and will most likely cause the controller to reset.

Example

The compiler generates incorrect code for the following example. The result of this expression is incorrect for all values used for its variables.

```
void main(void)
{
      double a, b, c, d, e;

      a = pow(b, c) * (d + e);

      /* other code here */
}
```

Working Around the Problem

There are two ways to work around the problem.

1. To work around the problem compute the pow result on a separate line and use the result in the arithmetic expression afterwards. For example:

```
void main(void)
{
   double a, b, c, d, e, result;

   result = pow(b, c);
   a = result * (d + e);

   /* other code here */
}
```

   Note that when a task calls the pow function it requires at least 5 stack blocks. The default stack space allocated to the main task is only 4 blocks. To modify the number of stack blocks allocated to the main task refer to the section *Start-Up Function Structure* for details on editing *appstart.c*. See the function create_task to specify the stack used by other tasks.

2. The powf function may be used instead of pow where double precision is not required.

Correction to the Problem

This problem exists with the C Compiler supplied by Microtec. It will not be corrected. Users must work around the problem as described above.

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TelePACE Ladder Logic

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Modem Commands

The DIAL and INIM elements, and the TelePACE program dial-up connection operate with Hayes AT command set compatible external modems. The commands specify how the modem behaves. Each modem manufacturer has a different set of modem commands required to initialize the modem.

This appendix lists modem initialization command strings for a number of modems. If your modem is not on the list try the generic modem settings.

Modem Settings

If generic modem settings do not work, fill out the table below by looking up the commands in your modem manual. Construct a command string from the results. Your modem may not require all the commands or may require additional commands. Please contact our Technical Support department if you require assistance.

Command	***Description***
	reset modem to factory or default settings (This command should be sent first.)
	select extended result code set
	return verbal responses
	do not echo characters in command state
	return actual state of carrier detect (CD) signal
	hang up when DTR signal is dropped
	disable (local) flow control
	Communicate at a constant speed between DTE and modem
	answer incoming calls on the first ring
	carrier wait time = 50 seconds

Note that command strings do not begin with AT. The AT will be inserted automatically when the commands are sent to the modem.

Generic Modem

This command string works with many Hayes compatible modems.

String	X4 V1 E0 &C1 &D2 S0=1 S7=50
Command	***Description***
X4	select extended result code set
V1	return verbal responses
E0	do not echo characters in command state
&C1	return actual state of carrier detect (CD) signal
&D2	hang up when DTR signal is dropped
S0=1	answer incoming calls on the first ring
S7=50	carrier wait time = 50 seconds

5901 High Speed Dial-up Modem

Command	***Description***
&F0	reset modem to factory or default settings (This command should be sent first.)
X4	select extended result code set
V1	return verbal responses
E0	do not echo characters in command state
&C1	return actual state of carrier detect (CD) signal
&D2	hang up when DTR signal is dropped
&K0	disable (local) flow control
Nn and S37 see user manual	Communicate at a constant speed between DTE and modem
S0=1	answer incoming calls on the first ring
S7=50	carrier wait time = 50 seconds

ATI 14400 ETC-Express

String	&F0 X4 &C1 &D2 &K0 &Q0
Command	***Description***
&F0	recall factory (configuration) profile 0
X4	select extended result code set
&C1	return actual state of carrier detect (CD) signal
&D2	hang up when DTR signal is dropped
&K0	disable flow control
&Q0	select direct asynchronous operation

ATI 14400 ETC-E, ETC-I

String	&F0 &B1 &C1 &D2 &E0
Command	***Description***
&F0	recall factory (configuration) profile 0
&B1	DTE speed equals default value or the AT command speed
&C1	return actual state of carrier detect (CD) signal
&D2	hang up when DTR signal is dropped
&E0	Automatic retrying disabled

Hayes Smartmodem 1200

String	F1 Q0 V1 X1
Command	***Description***
F1	full duplex
Q0	result codes sent
V1	result codes transmitted as words (verbal)
X1	extended result code set

Hayes ACCURA 96, 144 and 288 Modems

String	&F &C1 &D2 &K0 &Q6
Command	***Description***
&F	recall factory configuration
&C1	return actual state of carrier detect (CD) signal
&D2	hang up when DTR signal is dropped
&K0	disable local flow control
&Q6	Communicate in asynchronous mode with automatic speed buffering (constant speed between DTE and modem)

Kama 2400 EI

String	&F &C1 &D2
Command	***Description***
&F	factory settings
&C1	DCD asserted when carrier detected
&D2	DTR controls the modem

Megahertz XJ4288 28.8 PC Card Modem

String	&F0 &Q0 %C0 S7=60
Command	***Description***
&F0	recall factory profile 0
&Q0	select direct asynchronous mode
%C0	disable data compression
S7=60	wait time for carrier = 60 seconds

Multitech 224E7B

String	F Q0 V1 X4 &C1 &D2 &E3
Command	***Description***
F	factory settings
Q0	send result codes
V1	verbal result codes
X4	extended result code set
&C1	DCD asserted when carrier detected
&D2	DTR controls the modem
&E3	no flow control correction

TeleSAFE 6901 Bell 212 Modem

String		
Command	***Description***	***Default***
S0 register	Rings to answer	1
S2 register	CTS-on delay measured in units of 8.3 ms.	14 (116 ms)
S3 register	Anti-streaming timer measured in 10's of seconds.	0 (disabled)
S4 register	CTS-off delay measured in units of 8.3 ms.	4 (33 ms)
S6 register	Dial tone wait time measured in 10ths of a second.	30 (3 seconds)
S7 register	Carrier wait time measured in seconds.	15 (15 seconds)
S9 register	Carrier detect delay time measured in units of 8.3 ms.	10 (83 ms)
S10 register	Carrier loss time measured in units of 8.3 ms.	10 (83 ms)
S11 register	Tone dial speed measured in 0.050 seconds.	2 (5 p/p second)

US Robotics Sportster 28,800

String	&F1 &A0 &H0 &K0 &M0 &R1 &B1 S0=1
Command	***Description***
&F1	generic factory configuration
&A0	ARQ result codes disabled
&K0	data compression disabled
&M0	error control (ARQ) disabled
&B1	fixed serial port rate
&H0	Flow control disabled
&R1	Modem ignores RTS
S0=1	answer phone on first ring (optional)