C-Control
Pro
Schalten, Steuern, Regeln
Integrated Development Environment
Integrierte Entwicklungsumgebung
www.c-control.de

C-Control Pro IDE

Table of Contents

Part 1

1 Important Notes

This chapter deals with important information's to warranty, support and operation of the C-Control-Pro hardware and software.

1.1 Introduction

The C-Control Pro Systems are based on the Atmel AVR32 and the Atmel Mega Series (Mega 32, Mega 128, AT90CAN) resp. These Microcontrollers are used in large numbers in a broad variety of devices from entertainment electronics through household appliances to various application facilities in the industries. There the controller takes charge of important control tasks. C-Control Pro offers this highly sophisticated technology to solve your controlling problems. You can acquire analog measuring values and switch positions and provide corresponding switching signals dependent on these input conditions, e. g. for Relais and servo motors. In conjunction with a DCF-77 radio antenna C-Control Pro can receive the time with atomic accuracy and thus take over precise time switch functions. Various hardware interfaces and bus systems allow the cross linking of C-Control Pro with sensors, actors and other control systems. We want to provide a broad user range with our technology. From our former work in C-Control service we know that also customers without any experience in electronics and programming but eager to learn are interested in C-Control. If you happen to belong to this user group please allow us to give you the following advice:

C-Control Pro is only of limited use for the entry into programming of micro computers and electronic circuit technique! We presuppose that you have at least a basic knowledge in a higher programming language such as BASIC, PASCAL, C, C++ or Java. Furthermore we presume that you are used to operating a PC under one of the Microsoft operating systems (2000/XP/Vista/Win7/Win8) . You should further be experienced in working with soldering irons, multimeters and electronic components. We have made every effort to formulate all descriptions as simple as possible. Unfortunately we were not able to do without the use of technical terms and expressions in an operating manual to the themes involved here. If need be please see the appropriate technical literature.

1.2 Reading this operating manual

Please read this operating manual thoroughly prior to putting the C-Control Pro Unit into operation. While several chapters are only of interest for the understanding of the deeper coherence's, others contain important information's whose non-compliance may lead to malfunctions or even damages.

➜ Chapters and paragraphs containing important themes are marked by a symbol.

Please read the entire manual prior to putting the unit into operation since it contains important notes for correct operation. In case of damages to material or personnel caused by improper handling or non-compliance to this operating manual the warranty claim will expire! We will further not take liability for consequential damages.

1.3 Handling

The C-Control Pro Unit contains sensitive components. These can be destroyed by electrostatic discharges! Please observe the general rules on handling electronic components. Please organize your working bench professionally. Ground your body prior to any work being done, e. g. by touching a grounded and conducting object (e. g. heating radiator). Avoid touching the connection pins of the C-Control Pro Unit.

1.4 Intended use

The C-Control Pro Unit is an electronic device in the sense of an integrated circuit. It serves the programmable controlling of electric and electronic equipment. Construction and operation of this equipment must be in conformance with the valid European licensing principles (CE).

The C-Control Pro must not be galvanically connected to voltages exceeding the directed Extra Low Protective Voltage. Coupling to systems with higher voltages must exclusively be performed by use of components having VDE qualification. In doing so the directed air and leakage paths must be observed as well as sufficient precautions for protection against touching dangerous voltages must be taken.

The PCB of the C-Control Pro Unit carries electronic components with high frequency clock signals and steep pulse slopes. Improper use of the unit may lead to the radiation of electro-magnetic interference signals. The adoption of proper measures (e. g. the use of chokes, limiting resistors, blocking capacitors and shielding's) to ensure the observance of legally directed maximum values lies in the responsibility of the user.

The maximum allowable length of connected wire lines is without additional precautions appr. 0.25 Meters (Exception: Serial Interface). Under influence of strong electro-magnetic alternating fields or interference pulses the function of the C-Control Pro Unit can be detracted. If need be a reset or a restart of the system may become necessary.

During connection of external sub-assemblies the maximum admissible current and voltage values of the particular pins must be observed. The connection of too high a voltage, a voltage of wrong polarity or an excessive current load may lead to immediate damage of the unit. Please keep the C-Control Pro Unit away from spray water or condensation dampness. Observe the safe operating temperature range in Item Technical Data in the attachment.

1.5 Warranty and Liability

For the C-Control Pro Unit Conrad Electronic grants a warranty period of 24 months from the date of billing. Within this time period faulty units will be replaced free of charge if the fault provable originates in faulty production or loss on goods in transit.

The software in the operating system of the Microcontroller as well as the PC software on CD-ROM is shipped in the form as is. Conrad Electronic can not guarantee that the performance features of this software will satisfy individual requirements and that this software will operate free of faults and interruptions. Conrad Electronic can further not be held liable for damages occurring directly by or consequently to the use of the C-Control Pro Unit. The use of the C-Control Pro Unit in systems directly or indirectly serving medical, health or life saving objectives is not authorized.

In case the C-Control Pro Unit incl. software does not satisfy your demands or if you do not agree to our warranty and liability conditions you are to make use of our 14 days money back guarantee. Please return the unit without use marks, in the undamaged original packaging and incl. all accessories within this time-limit to our address for refund or clearing of the value of goods!

1.6 Service

Conrad Electronic provides you with a team of experienced service technicians. If you have any question with regard to our C-Control Pro Unit you can reach our Technical Service by letter, tele-fax or e-mail.

By letter	Conrad Electronic SE Technical Inquiry Klaus-Conrad-Straße 2 D-92530 Wernberg-Köblitz
Fax-Nr.:	09604 / 40-8848
E-Mail:	webmaster@c-control.de

Please preferably use e-mail communication. If there is a problem possibly provide us with a sketch of your connection diagram in form of an attached picture file (jpg format) as well as the program source code reduced to the part referring to your problem (max. 20 lines). Further information's and current software for download please find on the C-Control homepage under www.c-control.de.

1.7 Open Source

When C-Control Pro was designed also open source software has come into operation:

ANTLR 2.73	http://www.antlr.org
Inno Setup 5.5.2	http://www.jrsoftware.org
GPP (Generic Preprocessor)	http://www.nothingisreal.com/gpp
avra-1.2.3a Assembler	http://avra.sourceforge.net/

In accordance with the rules of "LESSER GPL" (www.gnu.org/copyleft/lesser) during installation of the IDE also the original source code of the avra assembler, the generic pre-processor as well as the source text of the modified version is supplied, which is used with C-Control Pro. Both source texts are found in a ZIP file in the "GNU" sub-directory.

1.8 Demo Programs

You will find the actual demo programs in "C:\Documents and Settings\All Users\Documents\C-Control Pro Demos" (XP and earlier) or in "C:\Users\Public\Public Documents\C-Control Pro Demos" directory (Vista and later). The current demos are stored in the folder "Demos Ver 2.31". The old demo programs are thus not overwritten.

➔ There is an entry Demo Programs in the Help menu of the IDE that will open an Explorer window at the point where the demo programs are stored. Can also be opened with Open Demos directly from the Project menu.

➔ Please do not save your own programs in the area of the demo programs! Reinstalling the IDE will overwrite the files there.

1.9 History

⊟ Version 2.31 from 09/20/2013

New Features
- AVR32 support
- Ethernet Support (AVR32Bit)
- Webserver (AVR32Bit)
- Tab Interface for Editor
- new Communication routines
- direct access to COM Port in Toolbar
- turn on/off COM Ports in Toolbar

Error Corrections
- Documentation Update
- Partly wrong incrementation of Clock Variable in Interrupt context
- corrected error in type recognition of constants
- fixed error in Onewire_Read
- wrong definitions PORT_ON and PORT_OFF corrected

⊟ Version 2.13 from 04/04/2011

New Features
- overhauled all demo programs

Error Corrections
- Documentation Update
- error check in Linker improved
- corrected register usage in Mega32 interpreter
- all fields in project options are now correctly initialized
- corrected wrong behavior with setting PIN Codes
- Expressions like "a[fun(2)]=b" work again

⊟ Version 2.12 from 01/06/2011

New Features
- 32-Bit Integer (only Mega128)
- new multithreading with time slices
- #thread parameter syntax in source
- SD card support
- CAN-Bus Support (only C-Control Pro 128 CAN)
- direct access to Flash Arrays
- Array Tooltips in Debugger
- IDE Style changeable
- Vista and Win7 Theme support
- ask for transfer at program start option
- increased serial speed for module communication
- VT100 Emulation for Terminal
- rand(), srand() randomize functions

Error Corrections
- Documentation update
- Translation errors fixed

- Floats in tables now work
- Corrected negative values in tables
- Fixed constant expressions in parentheses
- Corrected function calls made in return statements
- "#pragma Warn" is now "'#pragma Warning"
- Wrong editor undo after save fixed
- Fixed bug in Serial_IRQ_Info
- Fixed bug in serial program transfer
- Problem in Servo-Routines corrected
- External Interrupt Acknowledge now in correct order
- Wrong upper limit at some TimerXTime() functions fixed
- Clear all Breakpoints now works every time
- Fixed problem crossing 64kb boundary
- Fixed stopping program in debugger >64kb code
- round() now works correctly
- Problem in BASIC For-loops fixed

⊟ Version 2.01 from 06/27/2009

New Features
- Added Search Function into Editor popupmenu

Error Corrections
- Documentation update
- Error at "unused Code Optimizer" corrected
- Fixed internal handling of data crossing 64kb boundary
- Fixed error when starting programs from Tools menu
- Corrected translation bugs in Search dialog
- Line offset fixed in Project Search
- Timeout in I2C Routines
- Fixed error message "...tbSetRowCount:new count too small"

⊟ Version 2.00 from 05/14/2009

New Features
- Assembler Support
- Enhanced Search Functions in the Editor
- New configurable GUI
- Todo List
- switchable Compiler Warnings
- Program Transfer of Bytecode without Project
- extended Program Info
- Fast Transfer if Interpreter already on Module
- Enhanced Auto-Completion of Keywords and Function Names
- Function Parameter help
- unused Code Optimizer
- Peephole Optimizer
- Support for predefined Arrays in Flash Memory
- Realtime Array Index check
- Optimized Array Access
- better verification of constant array indices
- call functions with string constants
- Enter binary numbers with 0b....

- Addition und Subtraction of Pointers
- Optimized Port OUT, PIN and DDR Access
- Direct Atmel Register Access
- Formatted String Output with Str_Printf()
- convert ASCII strings in numerical values
- ++/-- for BASIC
- Port toggle functions
- RC5 Send and Receive Routines
- Software Clock (Time & Date) with Quartz correction factor
- Servo Routines
- mathematical Round
- Atmel Mega Sleep Function

Error Corrections
- Initialization Timer_T0FRQ corrected
- Initialization Timer_T0PWM corrected
- Initialization Timer_T1FRQ corrected
- Initialization Timer_T1FRQX corrected
- Initialization Timer_T1PWM corrected
- Initialization Timer_T1PWMX corrected
- Initialization Timer_T1PWMXY corrected
- Initialization Timer_T3FRQ corrected
- Refresh for Array Window corrected
- Desktop Reset corrected
- Module Reset corrected
- Bug in Debugfiles >30000 Bytes corrected
- Bug in conditional valuation in CompactC fixed
- Bug in Timer_Disable() fixed

⊟ Version 1.72 from 10/22/2008

New Features
- added SPI functions
- RP6 AutoConnect

Error Corrections
- improved quality of serial transfers

⊟ Version 1.71 from 06/25/2008

New Features
- new Editor in IDE
- Editor shows all defined function names
- Editor supports code folding
- Simple serial Terminal
- Pulldownmenu to start your own programs (Tool Quickstart)
- Syntaxhighlighting of all standard library functions
- Configuration of Syntaxhighlighting
- Extension of Select .. Case in BASIC
- Automatic case correction for keywords and library function names
- Simple automatic lookup for keywords and library function names
- OneWire Library Functions
- Comments of Blocks in BASIC with /* , */

- New FTDI driver

Error Corrections
- Global For-Loop counter variables in BASIC work now correct
- Char variables work now correct with negative numbers
- "u" after an integer now defines unsigned number
- Project names now can contain special characters
- Thread_Wait() now supports thread parameter
- return command in CompactC without return parameter was working wrong
- Corrected swapped error messages when called functions with pointers
- Corrected error message at assignment, when function had no return parameter
- Nested switch/Select statements are working now
- Very long switch/Select statements are functioning properly now
- Better Error recovery when selected COM Port already in use
- No longer a crash if very huge amounts of faulty data where transferred over USB or COM Port
- "Exit" in BASIC For-Loops is working now
- Compiler error corrected in declaration of array variables

⊟ Version 1.63 from 12/21/2007

Error Corrections
- Documentation update

⊟ Version 1.62 from 12/08/2007

New Features
- Vista Compatibility

Error Corrections
- Brackets are working correctly
- The compiler is no longer crashing when variable names are not known
- There were sometimes incorrect syntax errors when opening some brace levels and a missing operand
- "Exit" don't worked correctly in BASIC For-Next loops
- The array window could only be opened 16 times, even when some array windows were closed
- Renamed the Text "Compiler" to "Compiler Defaults" in the Options Menu

⊟ Version 1.60 from 03/04/2007

New Features
- English language version of IDE - switchable at runtime
- English language Compiler messages
- English language version of help files and manual
- printing of source code from the IDE
- Print preview of source code
- Thread_Wait() extended with thread parameter
- ADC_Set() got a speedup
- DoubleClock mode can be activated in serial functions

Error Corrections
- ExtIntEnable() was only working correct with IRQ 0 and 4
- Serial_Init() und Serial_Init_IRQ() got wrongly a byte as divider instead of a word
- EPROM_WriteFloat und EEPROM_ReadFloat() sometimes worked incorrect

- Thread_Kill() worked erroneous when called from the main thread
- read accesses from globally defined floating point arrays were faulty
- The second serial interface was not working correctly
- EEPROM write accesses that used illegal addresses could overwrite reserved data in EEPROM
- There was a chance with a very low probability that the LCD display content could get corrup-ted

⊟ Version 1.50 from 11/08/2005

New Features

- IDE Support for Mega128
- Improved Cache Algorithm during IDE access to Transit Time Data in the Debugger
- New Library Routines for Timer 3 (Mega128)
- Programs using the extended (>64kb) Address Space (Mega128)
- Supporting the external 64kb SRAM
- Supporting the external Interrupts 3 - 7 (Mega128)
- Routines for the 2. Serial Interface (Mega128)
- Mathematical Functions (Mega128)
- Display of Memory Volume when Interpreter is started
- Internal RAM check for recognition when Global Variables too large for Main Memory
- Interner RAM check for recognition when Thread Configuration too large for Main Memory
- Transit Time Check if Stack Limits have been violated
- Source Files can be moved up and down in the Project Hierarchy
- Warning when Strings too long are assigned
- On demand the Compiler creates a Map File describing the volume of all Program Variables
- New Address model for Global Variables (the same Program runs at different RAM Volumes)
- Interrupt Routines for Serial Interface (up to 256 Byte Receiver Buffer / 256 Byte Transmitter Buffer)
- Fixed wired IRQ Routines to allow Periode Measurement of small time intervals
- Recursions are now usable without limits
- Arrays of any size can now be displayed in a separate Window in the Debugger
- Strings (character arrays) are now shown as Tooltip in the Debugger
- SPI can be switched off in order to use the pins for I/O
- The Serial Interface can be switched off in order to use the pins for I/O
- The Hex value is now additionally shown as Tooltip in the Debugger
- New Function Thread_MemFree()
- Additional EEPROM Routines for Word and Floating Point access
- Time Measurement with Timer_TickCount()
- #pragma Commands to create Errors or Warnings
- Pre-defined Symbol in Pre-Prozessor: __DATE__, __TIME__ __FILE__, __FUNCTION__, __LINE__
- Version Number in Splashscreen
- Extended Documentation
- Interactive Graphics at "Jumper Application Board" in Help File
- New Demo Programs
- Ctrl-F1 starts Context Help

Error Corrections

- An Error is created if the Return Command is missing at the end of a function
- Breakpoint Marks have not always been deleted
- Limits at EEPROM Access can now be checked closer (internal overflow seized)
- In the Debugger a single step can no longer depose the next command too early

Version 1.39 from 06/09/2005

New Features

- BASIC Support
- CompactC and BASIC can be mixed in a project
- Extended Documentation
- Loop Optimizing for For - Next in BASIC
- ThreadInfo Function
- New Demo Programs

Error Corrections

- Compiler does no longer break down at German Umlauts (ä, ö, ü)
- Internal Byte Code of command StoreRel32XT corrected
- Offset in String Table improved

Version 1.28 from 04/26/2005

- Initial Version

Part 2

2 Hardware

This chapter gives a description of the hardware coming into operation with the C-Control Pro series. The Modules C-Control Pro Mega32 and C-Control Pro Mega128 will be described. Further chapters will comment on construction and function of the accompanying application boards and LCD modules as well as the keyboard.

2.1 Mega Series

2.1.1 Installation

In this chapter the installation of hardware and software of the C-Control Pro Mega is described.

2.1.1.1 Software

To get the current development software, sample programs, the manual and useful information, please visit: www.c-control.de The manual is also available as a help file in the development environment of the C-Control PRO IDE and the PDF file is in the installation folder of the C-Control Pro in the "Manual" directory.

Direct IDE Download Link: http://www.c-control-pro.de/updates/C-ControlSetup.exe

➔ For the time of software and USB driver installations the user must be registered as administrator. During normal operation of C-Control Pro this is not necessary.

At the beginning of the installation first select the language in which the installation should take place. After that you can choose whether you want to install C-Control Pro into the standard path or whether you want to specify your own target directory. At the end of the installation process you will be asked if an icon should be created on your desktop.

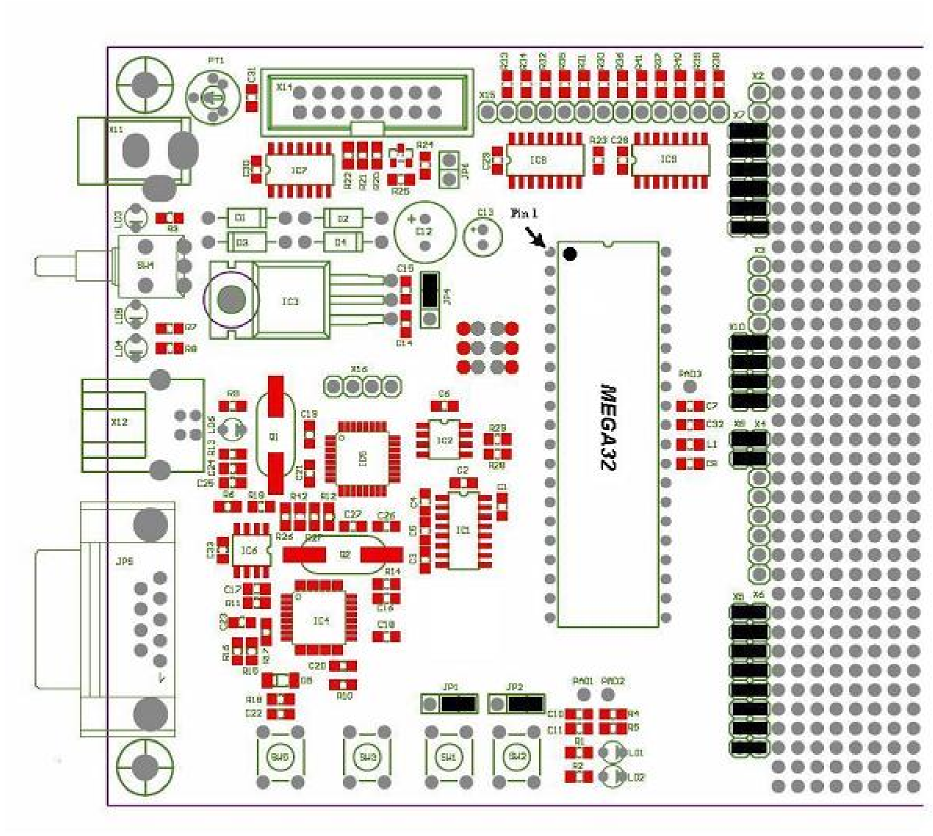
When the installation process is completed you can choose whether you want to see the "ReadMe" file, have the shortform introduction displayed or directly start the C-Control Pro design platform.

2.1.1.2 Hardware

Important Note on Inserting/ Retrieving a Mega Module

For the connection between Module and Application Board high quality connectors have been used in order to ensure intimate contacts. Mounting and dismounting of a Module should only take place during power-down condition (switched off voltage) since otherwise damages may occur to Application Board and/ or Module resp. Because of the high number of contacts (40/ 64 Pins) considerable force may be necessary to insert/ retrieve the Module. When inserting it must be ensured that the Module is pressed into the socket evenly, i. e. not out of line. To do this the Module should be placed onto an even surface. Mount the Module Mega32 in the correct orientation observing the marking for Pin 1. The label inscription will then point towards the control elements on the Application Board

Mounting Orientation of Module MEGA32



The connector of Module Mega32 has been designed in such a way that faulty insertion of the Module is not possible. The dismounting of the Module is performed by carefully lifting it from the socket by use of a suitable tool. In order to avoid bending the contacts the lifting of the Module should take place from various sides.

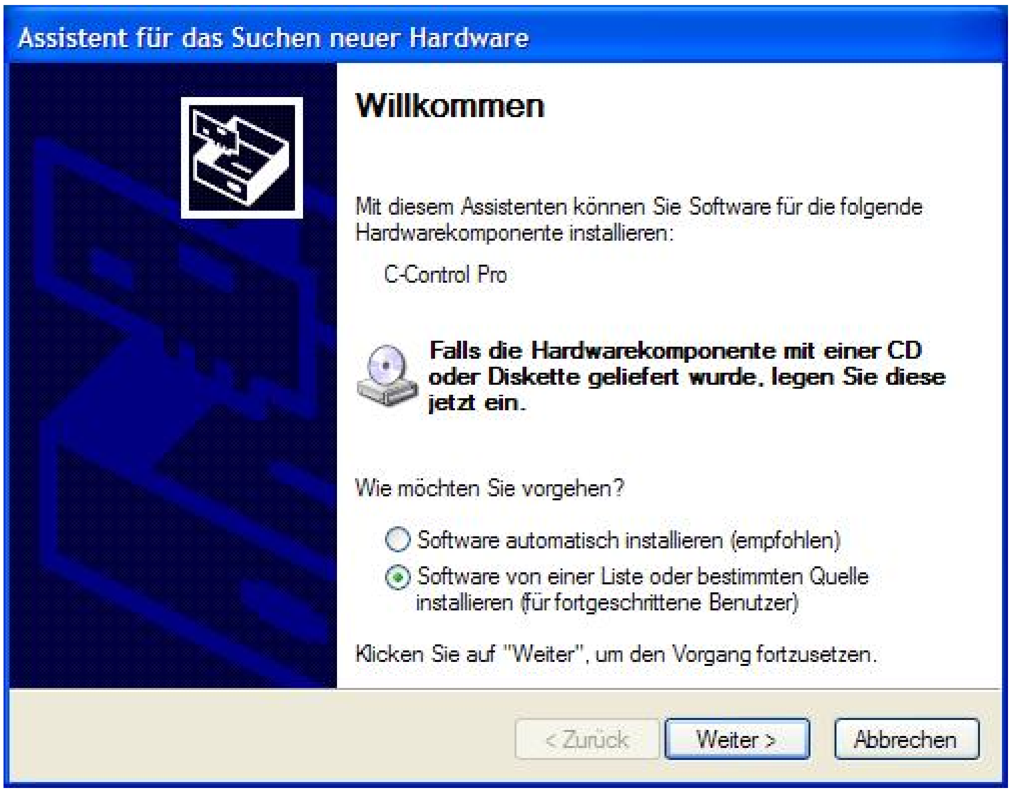
2.1.1.3 USB and serial

Installation of the USB Drivers

Please connect the Application Board to an appropriate power supply. A Standard 9V/ 250mA Mains Plug-in Power Supply will be sufficient. The polarity does not matter since it is automatically corrected by means of diodes. Depending on additionally used components it may later become necessary to use a power supply with higher output. Establish a connection between the Application Board and your PC by use of a USB cable. Switch on the Application Board.

➔ Driver and Software of the C-Control Pro environment support no Windows Operating System before Windows 2000.

If the Application Board is connected for the first time then there will be no driver for the FTDI chip. The following window will then be shown under Windows XP.


Assistent für das Suchen neuer Hardware

Willkommen

Mit diesem Assistenten können Sie Software für die folgende Hardwarekomponente installieren:

C-Control Pro

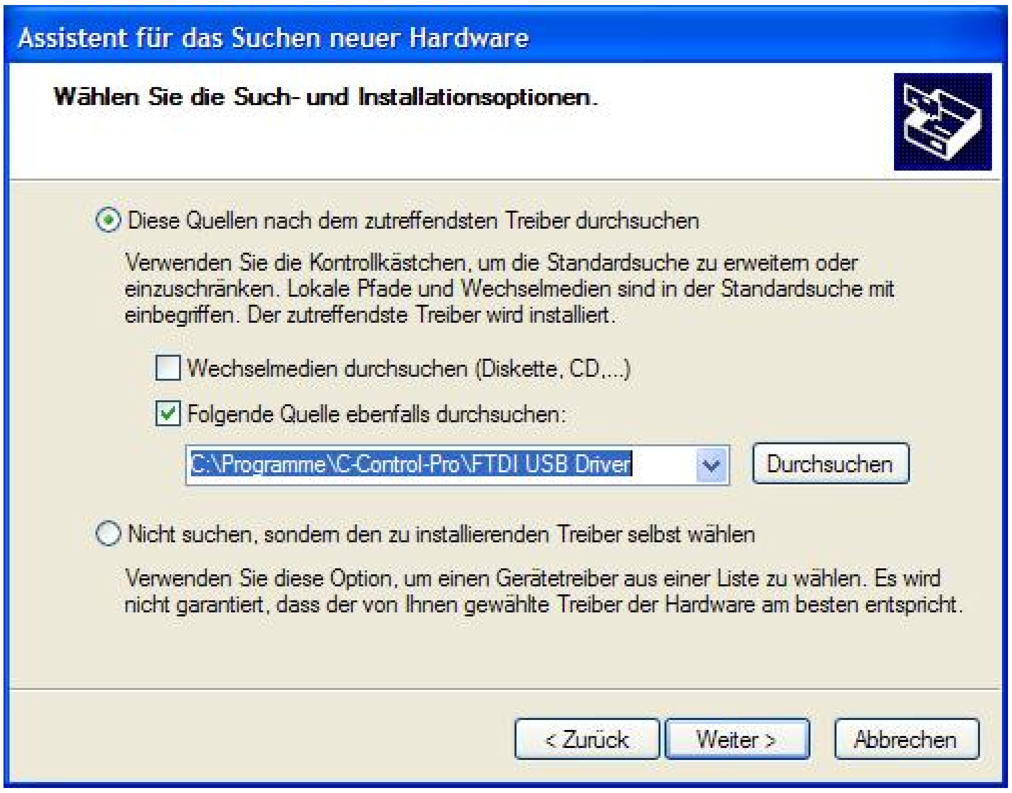
Falls die Hardwarekomponente mit einer CD oder Diskette geliefert wurde, legen Sie diese jetzt ein.

Wie möchten Sie vorgehen?

( ) Software automatisch installieren (empfohlen)
[✓ Software von einer Liste oder bestimmten Quelle installieren (für fortgeschrittene Benutzer)]

Klicken Sie auf "Weiter", um den Vorgang fortzusetzen.

From here select "Install software from a list or other source" and click "Next"..


Assistent für das Suchen neuer Hardware

Wählen Sie die Such- und Installationsoptionen.

[✓ Diese Quellen nach dem zutreffendsten Treiber durchsuchen]

Verwenden Sie die Kontrollkästchen, um die Standardsuche zu erweitern oder einzuschränken. Lokale Pfade und Wechselmedien sind in der Standardsuche mit einbegriffen. Der zutreffendste Treiber wird installiert.

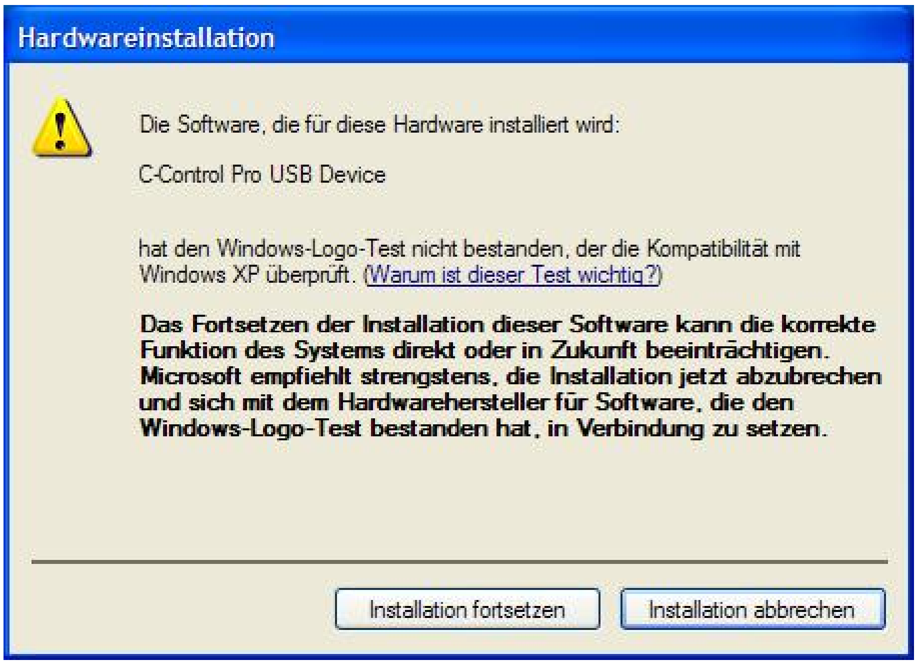
- [ ] Wechselmedien durchsuchen (Diskette, CD,...)
- [✓] Folgende Quelle ebenfalls durchsuchen:

C:\Programme\C-Control-Pro\FTDI USB Driver

Nicht suchen, sondern den zu installierenden Treiber selbst wählen

Verwenden Sie diese Option, um einen Gerätetreiber aus einer Liste zu wählen. Es wird nicht garantiert, dass der von Ihnen gewählte Treiber der Hardware am besten entspricht.

Then type in the path to the driver's directory. If the software has been installed to "C:\Programs" it will be path "C:\Programs\C-Control-Pro\FTDI USB Driver".


Hardwareinstallation

Die Software, die für diese Hardware installiert wird:

C-Control Pro USB Device

hat den Windows-Logo-Test nicht bestanden, der die Kompatibilität mit Windows XP überprüft. (Warum ist dieser Test wichtig?)

Das Fortsetzen der Installation dieser Software kann die korrekte Funktion des Systems direkt oder in Zukunft beeinträchtigen. Microsoft empfiehlt strengstens, die Installation jetzt abzubrechen und sich mit dem Hardwarehersteller für Software, die den Windows-Logo-Test bestanden hat, in Verbindung zu setzen.

The message "C-Control Pro USB Device has not passed the Windows Logo Test ...." will normally appear. This does **not** mean that the driver has failed during the Windows Logo Test. It merely means that the driver has not taken part in the (quite costly) Redmond Test.

Here click "Continue Installation". The USB driver should then be installed after a few seconds.

In the PC software click on IDE in menu Options and select the area Interfaces. Here select the communication port "USB0".

The FTDI driver supports 32 bit and 64 bit operating systems. The specific drivers are located in the "FTDI USB Driver\i386" and "FTDI USB Driver\amd64".

Serial Connection

Due to the slow transmitting speed of the serial interface the USB connection should preferably be used. If however due to hardware grounds the USB interface is not available then the Bootloader can be switched into the Serial Mode.

To do this the key SW1 has to be kept pressed during power-up of the Application Board. After this the Serial Bootloader Mode will be activated.

Select in the IDE the correct COM Interface.

2.1.2 Firmware

The operating system of C-Control Pro consists of the following components:

- *Bootloader*
- *Interpreter*

Bootloader

The Bootloader is available at any time. It serves the serial or USB communication with the IDE. By use of command line commands the Interpreter and the user program can be transferred from the PC to the Atmel Risc Chip. If a program is compiled and transferred to the Mega Chip the current Interpreter is also transferred at the same time.

If instead of the USB interface a serial connection should be set up from the IDE to the C-Control Pro module then the push button SW1 (Port **M32**:D.2 and **M128**:E.4 resp. at low level) must be held pressed during power-up of the module. In this mode any communication will be directed through the serial interface. This is useful when the module has already been incorporated into the hardware application and the application board is thus not available. The serial communication however is considerably slower than the USB connection. In serial mode the USB pins are not used and are thus available to the user for other tasks.

Since SW1 initiates the serial Bootloader during module start there should be no signal on Port **M32**:D.2 and **M128**:E.4, resp. during power-up of the application since these ports are also usable as outputs.

SPI Switch Off (only Mega128)

A signal on the SPI interface during switch on can activate USB communication. In order to avoid this PortG.4 (LED 2) can be set LOW during switch on. The SPI interface will then not be activated. The SPI interface can also be manually be switched off by the Interpreter later on using SPI_Disable ().

Interpreter

The Interpreter consists of the following components:

- Bytecode Interpreter
- Multithreading Support
- Interrupt Processing
- User Functions
- RAM and EEPROM Interface

In general the Interpreter processes the bytecode generated by the Compiler. Further most library functions are integrated into it in order to allow access of the bytecode program to e. g. the hardware ports. The RAM and EEPROM Interfaces are used by the IDE's Debugger to get access to the variables when the Debugger is stopped at any Breakpoint.

Autostart

If no USB interface is connected and if SW1 has not been pressed during power-up in order to reach the serial Bootloader mode then the Bytecode (if available) is started in the Interpreter. This means that in case that the module is inserted into a hardware application the mere connection of the operating voltage will suffice to automatically start the user program.

➔ A signal on Mega32: INT_0 resp. mega128: INT_4 when the C-Control Pro module is turned on, can disrupt the startup behavior. Corresponding to the pin assignment of M32 and M128 the pin INT_0 (resp. INT_4) are the same pin as SW1. When SW1 is pressed when the module is turned on, this will lead to the activation of the serial bootloader mode, and the program is not started automatically.

2.1.3 Mega32 Module

Module Memory

The C-Control Pro Module provides 32kB FLASH, 1kB EEPROM and 2kB SRAM. A supplementary EEPROM with an 8kB memory depth is mounted on the application board. The latter can be addressed by an I2C interface.

Note: Detailed information can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

ADC-Reference Voltage Generation

The Micro Controller is equipped with an analog-to-digital converter with a 10 Bit resolution. This means that measured voltages can be represented by integral numbers from 0 through 1023. The reference voltage for the lower limit is GND level, i. e. 0V. The reference voltage for the upper limit can be selected by the user:

- 5V Operating Voltage (VCC)
- Internal Reference Voltage of 2.56V
- External Reference Voltage e. g. 4,096V generated by a Reference Voltage IC.

If *x* is a digital measuring value then the corresponding voltage value u is computed as follows:

u = *x* * Reference Voltage / 1024

Clock Generation

Clock generation takes place by a 14.7456MHz Quartz Oscillator. All time dependent actions within the controller are derived from this clock frequency.

Reset

A Reset initiates the return of the Micro Controller system to a defined starting condition. In gerneral the C-Control Pro Module knows two reset sources:

- Power-On-Reset: is automatically executed after switch on of the operating voltage.
- Hardware-Reset: is executed when the Module's RESET (Pin 9) is pulled to "low" and released again by e. g. shortly pressing the connected reset key RESET1 (SW3).

A "Brown-Out-Detection" avoids that the Controller can enter undefined conditions in case of dropping operating voltages.

Digital Ports (PortA, PortB, PortC, PortD)

The C-Control Pro Module provides four digital ports at 8 pins each. To the digital ports it is possible to connect e. g. pushbuttons with pull-up resistors, digital IC's, opto couples or driver circuits for relais. The ports can be addressed either separatly, i.e. pin by pin or byte by byte. Each pin can either be input or output.

➔ Never connect two ports directly together which should simultaneously work as outputs!

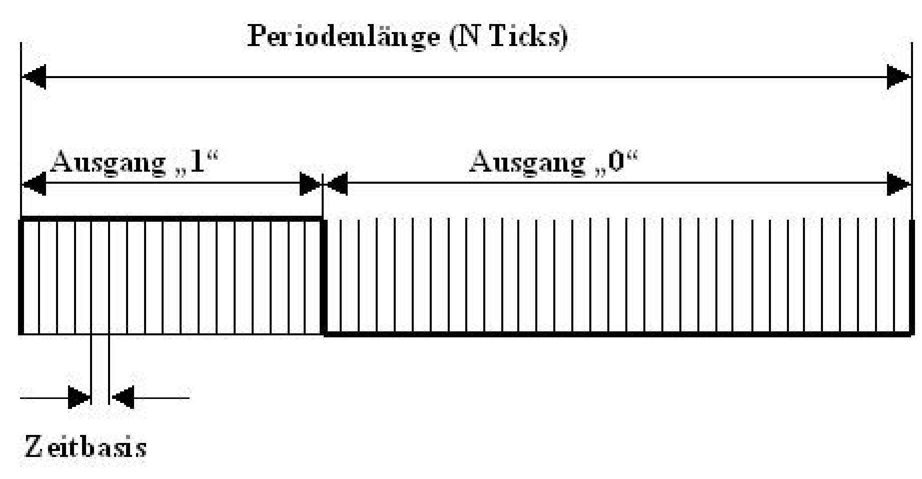
Digital input pins are high-impedance or wired to internal pull-up resistors and transform an applied voltage signal into a logical value. For this it is required that the voltage signal is within the limits defined for TTL and CMOS IC's high or low levels. During further processing in the program the logical values on the respective input ports are represented as 0 ("low") or 1 ("high"). Pins will take on the values 0 or 1, Bytes from 0 to 255. Output ports are able to give out digital voltage signals by use of an internal driver circuit. Connected circuits can draw (at high level) or feed (at low level) a specific current from or to the ports.

➔ Pay attention to the maximum admissable load current for a single port or for all ports in total. Exceeding the maximal values may lead to destruction of the C-Control Pro Module. After a reset each port is initially configured as input port. By certain commands the direction of data transport can be toggled.

It is important to closely study the pin assignment of M32 and M128 prior to programming since important functions of the program design (e. g. the USB interface of the application board) will apply to specific ports. If these ports are re-programmed or if the matching jumpers on the application board are no longer set then it may happen that the design platform can no longer transfer any programs to the C-Control Pro. Timer inputs and outputs, A/D converter, I2C as well as serial interface are also connected to various port pins.

PLM-Ports

There are two timers available for PLM. These are *Timer_0* with 8 bits and *Timer_1* with 16 bits. They can be used for D/A conversion, to control servo motors in pattern making and to output audio frequencies. A pulse length modulated signal has a period of N so called "Ticks". The duration of one tick is the time base. If the output value of a PLM port is set to X then the port will hold high level for X ticks of one period and will then for the balance of the period drop to low level. For programming of the PLM channels see Timer.



The PLM channels for *Timer_0* and *Timer_1* have independent time base and period length. In applications for pulse width modulated digital to analog conversion the time base and period length are set once and then only the output value is varied. According to their electrical properties the PLM ports are digital ports. Please observe the technical boundary conditions for digital ports (max. current).

Technical Data Module

Note: Detailed information can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

All voltage specifications apply to direct current (DC).

Environmental Conditions	
Range of admissable ambient temperature	0°C … 70°C
Range of admissable ambient relative humidity	20% … 60%
Power Supply	
Range of admissable supply voltage	4,5V … 5,5V
Power reqirement of the module without external loads	appr. 20mA

Clock	
Clock Frequency (Quartz Oscillator)	14.7456MHz
Mechanics	
Overall measurements less pins, appr.	53 mm x 21mm x 8 mm
Weight	appr. 90g
Pin pitch	2.54mm
Number of pins (two rows)	40
Distance between rows	15.24mm

Ports	
Max. adimissable current from digital ports	± 20 mA
Admissable current total on digital ports	200mA
Admissable input voltage on port pins (digital and A/D)	–0.5V … 5.5V
Internal pull-up resistors (disconnectable)	20 - 50 kOhm

2.1.3.1 CPU

Mega32 Overview

The Micro Controller ATmega32 originates from the AVR family by ATMEL. It is a low-power Micro Controller with Advanced RISC Architecture. In the following see a short summary of its hardware resources:

- **131 Powerful Instructions – Most Single-clock Cycle Execution**
- **32 x 8 General Purpose Working Registers**
- **Up to 16 MIPS Throughput at 16 MHz**

- **Nonvolatile Program and Data Memories**

32K Bytes of In-System Self-Programmable Flash
Endurance: 10,000 Write/Erase Cycles
In-System Programming by On-chip Boot Program

- 1024 Bytes EEPROM
- 2K Byte Internal SRAM

- Peripheral Features:
  Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  Four PWM Channels
  8-channel, 10-bit ADC
  8 Single-ended Channels
  2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  Byte-oriented Two-wire Serial Interface (I2C)
  Programmable Serial USART
  On-chip Analog Comparator
  External and Internal Interrupt Sources
  32 Programmable I/O Lines

- 40-pin DIP
- Operating Voltages 4.5 - 5.5V

2.1.3.2 Pin Assignment

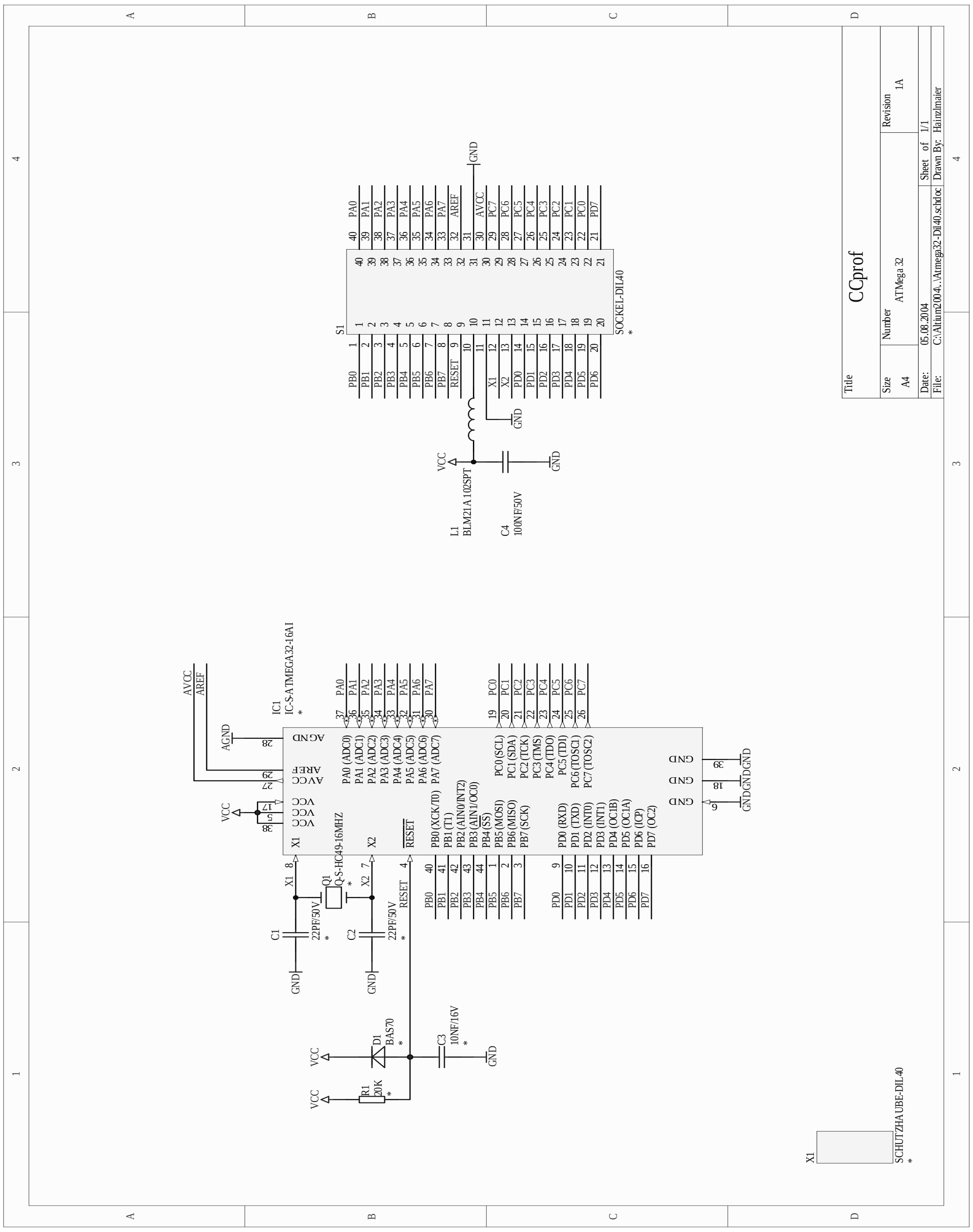
PortA through PortD are for direct pin functions (e. g. Port_WriteBit) counted from 0 through 31, see "PortBit".

Pin Assignment for Application Board Mega32

M32 PIN	Port	Port	PortBit	Name	Layout	Remarks
1	PB0	PortB.0	8	T0		Input Timer/Counter0
2	PB1	PortB.1	9	T1		Input Timer/Counter1
3	PB2	PortB.2	10	INT2/AIN0		(+)Analog Comparator, external In-terrupt2
4	PB3	PortB.3	11	OT0/AIN1		(-)Analog Comparator, Output Timer0
5	PB4	PortB.4	12		SS	USB-Communication
6	PB5	PortB.5	13		MOSI	USB-Communication
7	PB6	PortB.6	14		MISO	USB-Communication
8	PB7	PortB.7	15		SCK	USB-Communication
9				RESET		
10				VCC		
11				GND		
12				XTAL2		Oscillator : 14,7456MHz
13				XTAL1		Oscillator : 14,7456MHz
14	PD0	PortD.0	24	RXD	EXT-RXD	RS232, serial Interface
15	PD1	PortD.1	25	TXD	EXT-TXD	RS232, serial Interface
16	PD2	PortD.2	26	INT0	EXT-T1	SW1 (Taster1); external Interrupt0
17	PD3	PortD.3	27	INT1	EXT-T2	SW2 (Taster2); external Interrupt1
18	PD4	PortD.4	28	OT1B	EXT-A1	Output B Timer1
19	PD5	PortD.5	29	OT1A	EXT-A2	Output A Timer1

20	PD6	PortD.6	30	ICP	LED1	LED; Input Capture Pin for Pulse/ Period Measurement
21	PD7	PortD.7	31		LED2	LED
22	PC0	PortC.0	16	SCL	EXT-SCL	I2C-Interface
23	PC1	PortC.1	17	SDA	EXT-SDA	I2C-Interface
24	PC2	PortC.2	18			
25	PC3	PortC.3	19			
26	PC4	PortC.4	20			
27	PC5	PortC.5	21			
28	PC6	PortC.6	22			
29	PC7	PortC.7	23			
30				AVCC		
31				GND		
32				AREF		
33	PA7	PortA.7	7	ADC7	RX_BUSY	ADC7 Input; USB-Communication
34	PA6	PortA.6	6	ADC6	TX_REQ	ADC6 Input; USB-Communication
35	PA5	PortA.5	5	ADC5	KEY_EN	ADC5 Input; LCD/Keyboard Inter-face
36	PA4	PortA.4	4	ADC4	LCD_EN	ADC4 Input; LCD/Keyboard Inter-face
37	PA3	PortA.3	3	ADC3	EXT_SCK	ADC3 Input; LCD/Keyboard Inter-face
38	PA2	PortA.2	2	ADC2	EXT_DATA	ADC2 Input; LCD/Keyboard Inter-face
39	PA1	PortA.1	1	ADC1		ADC1 Input
40	PA0	PortA.0	0	ADC0		ADC0 Input

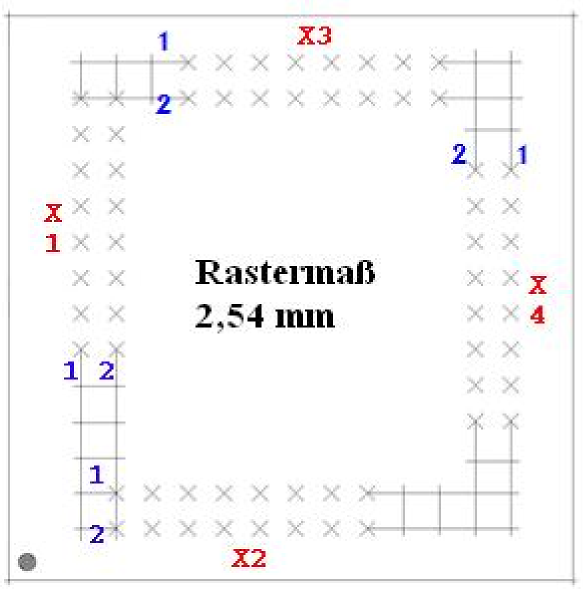
2.1.3.3 Connection Diagram



2.1.4 Mega128 Module

Pin Layout of the Module

The Mega128 Module is shipped on 4 dual row (2x8) square pins. For hardware application the corresponding socket strips must be organized in the following pitch format:



In the graph the socket strip X1-X4 and then the first two pins of the socket strip can be seen. Pin 1 of strip X1 corresponds to terminal X1_1 (see Mega128 Pinzuordnung).

Module Memory

The C-Control Pro 128 Module provides 128kB FLASH, 4kB EEPROM and 4kB SRAM. A supplementary EEPROM with an 8kB memory depth and an SRAM with a 64kB memory depth is mounted on the application board. The EEPROM can be addressed by an I2C interface.

Note: Detailed information can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

ADC Reference Voltage Generation

The Micro Controller is equipped with an analog-to-digital converter with a 10 Bit resolution. This means that measured voltages can be represented by integral numbers from 0 through 1023. The reference voltage for the lower limit is GND level, i. e. 0V. The reference voltage for the upper limit can be selected by the user:

- 5V Operating Voltage (VCC)
- Internal Reference Voltage of 2.56V
- External Reference Voltage e. g. 4.096V generated by a Reference Voltage IC.

If *x* is a digital measuring value then the corresponding voltage value u is computed as follows:

u = *x* * Reference Voltage / 1024

Clock Generation

Clock generation takes place by a 14.7456MHz Quartz Oscillator. All time dependent actions within the controller are derived from this clock frequency.

Reset

A Reset initiates the return of the Micro Controller system to a defined starting condition. In gerneral the C-Control Pro Module knows two reset sources:

- Power-On-Reset: is automatically executed after the operating voltage is switched on.
- Hardware-Reset: is executed when the Module’s RESET (X2_3) is pulled to "low" and released again by e. g. shortly pressing the connected Reset push button RESET1 (SW3).

A "Brown-Out-Detection" avoids that the Controller can enter undefined conditions in case of dropping operating voltages.

Digital Ports (PortA, PortB, PortC, PortD, PortE, PortF, PortG)

The C-Control Pro Module provides 6 digital ports at 8 pins each and one digital port with 5 pins. To the digital ports it is possible to connect e. g. push buttons with pull-up resistors, digital IC’s, opto couples or driver circuits for relais. The ports can be addressed either separatly, i.e. pin by pin or byte by byte. Each pin can either be input or output.

➡ Note: Never connect two ports directly together which should simultaneously work as outputs!

Digital input pins are high-impedance or wired to internal pull-up resistors and transform an applied voltage signal into a logical value. For this it is required that the voltage signal is within the limits defined for TTL and CMOS ICs high or low levels. During further processing in the program the logical values on the respective input ports are represented as 0 ("low") oder -1 ("high). Pins will take on the values 0 or 1, Bytes from 0 to 255. Output ports are able to give out digital voltage signals by use of an internal driver circuit. Connected circuits can draw (at high level) or feed (at low level) a specific current from or to the ports.

➡ Pay attention to the Maximum Admissible Load Current for a single port or for all ports in total. Exceeding the maximal values may lead to destruction of the C-Control Pro Module. After a reset each port is initially configured as input port. By certain commands the direction of data transport can be toggled.

➡ It is important to closely study the pin assignment of M32 and M128 prior to programming since important functions of the program design (e. g. the USB interface of the application board) will apply to specific ports. If these ports are re-programmed or if the matching jumpers on the application board are no longer set then it may happen that the design platform can no longer transfer any programs to the C-Control Pro. Timer inputs and outputs, A/D converter, I2C as well as serial interface are also connected to various port pins.

PLM Ports

There are three timers available for PLM. These are *Timer_0* with 8 bits and *Timer_1* as well as

Timer_3 with 16 bits each. They can be used for D/A conversion, to control servo motors in pattern making and to output audio frequencies. A pulse length modulated signal has a period of N so called "Ticks". The duration of one tick is the time base. If the output value of a PLM port is set to X then the port will hold high level for X ticks of one period and will then for the balance of the period drop to low level. For programming of the PLM channels see Timer.

The PLM channels for *Timer_0*, *Timer_1* and *Timer_3* have independent time base and period length. In applications for pulse width modulated digital to analog conversion the time base and period length are set once and then only the output value is varied. According to their electrical properties the PLM ports are digital ports. Please observe the technical boundary conditions for digital ports (max. current).

Technical Data Module

Note: Detailed information can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

All voltage specifications apply to direct current (DC).

Environmental Conditions	
Range of admissible ambient temperature	0°C … 70°C
Range of admissible relative ambient humidity	20% … 60%
Power Supply	
Range of admissible operating voltage	4.5V … 5.5V
Power consumption of the module without external loads	appr. 20mA

Clock	
Clock Frequency (Quartz Oscillator)	14.7456MHz
Mechanics	
Overall measurements less pins, appr.	40 mm x 40mm x 8 mm
Weight	appr. 90g
Pin pitch	2.54mm
Number of pins (two rows)	64

Ports	
Max. admissible current from digital ports	± 20 mA
Admissible current total on digital ports	200mA
Admissible input voltage on port pins (digital and A/D)	–0.5V ... 5.5V
Internal pull-up resistors (disconnectable)	20 - 50 kOhm

2.1.4.1 CPU

The Micro Controller Atmega128 originates from the AVR family by ATMEL. It is a low-power Micro Controller with Advanced RISC Architecture. In the following see a short summary of its hardware resources:

- **133 Powerful Instructions – Most Single Clock Cycle Execution**
- **32 x 8 General Purpose Working Registers + Peripheral Control Registers**
- **Fully Static Operation**
- **Up to 16 MIPS Throughput at 16 MHz**
- **On-chip 2-cycle Multiplier**

- **Nonvolatile Program and Data Memories**
  128K Bytes of In-System Reprogrammable Flash
  Endurance: 10,000 Write/Erase Cycles
  Optional Boot Code Section with Independent Lock Bits
  In-System Programming by On-chip Boot Program

- **True Read-While-Write Operation**
  4K Bytes EEPROM
  Endurance: 100,000 Write/Erase Cycles
  4K Bytes Internal SRAM
  Up to 64K Bytes Optional External Memory Space
  Programming Lock for Software Security
  SPI Interface for In-System Programming

- **JTAG (IEEE std. 1149.1 Compliant) Interface**
  Boundary-scan Capabilities According to the JTAG Standard
  Extensive On-chip Debug Support
  Programming of Flash, EEPROM, Fuses and Lock Bits through the JTAG Interface

- **Peripheral Features**
  Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  Two Expanded 16-bit Timer/Counters with Separate Prescaler, Compare Mode and Capture Mode
  Real Time Counter with Separate Oscillator
  Two 8-bit PWM Channels
  6 PWM Channels with Programmable Resolution from 2 to 16 Bits
  Output Compare Modulator
  8-channel, 10-bit ADC
  8 Single-ended Channels

7 Differential Channels
2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
Byte-oriented Two-wire Serial Interface
Dual Programmable Serial USARTs
Master/Slave SPI Serial Interface
Programmable Watchdog Timer with On-chip Oscillator
On-chip Analog Comparator

- Special Microcontroller Features
  Power-on Reset and Programmable Brown-out Detection
  Internal Calibrated RC Oscillator
  External and Internal Interrupt Sources
  Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
  Software Selectable Clock Frequency
  ATmega103 Compatibility Mode Selected by a Fuse
  Global Pull-up Disable

- I/O and Packages
  53 Programmable I/O Lines
  64-lead TQFP and 64-pad MLF

- Operating Voltages
  2.7 - 5.5V for ATmega128L

4.5 - 5.5V for ATmega128

2.1.4.2 Pin Assignment

PortA through PortG are for direct pin functions (e. g. Port_WriteBit) counted from 0 through 52, see "PortBit".

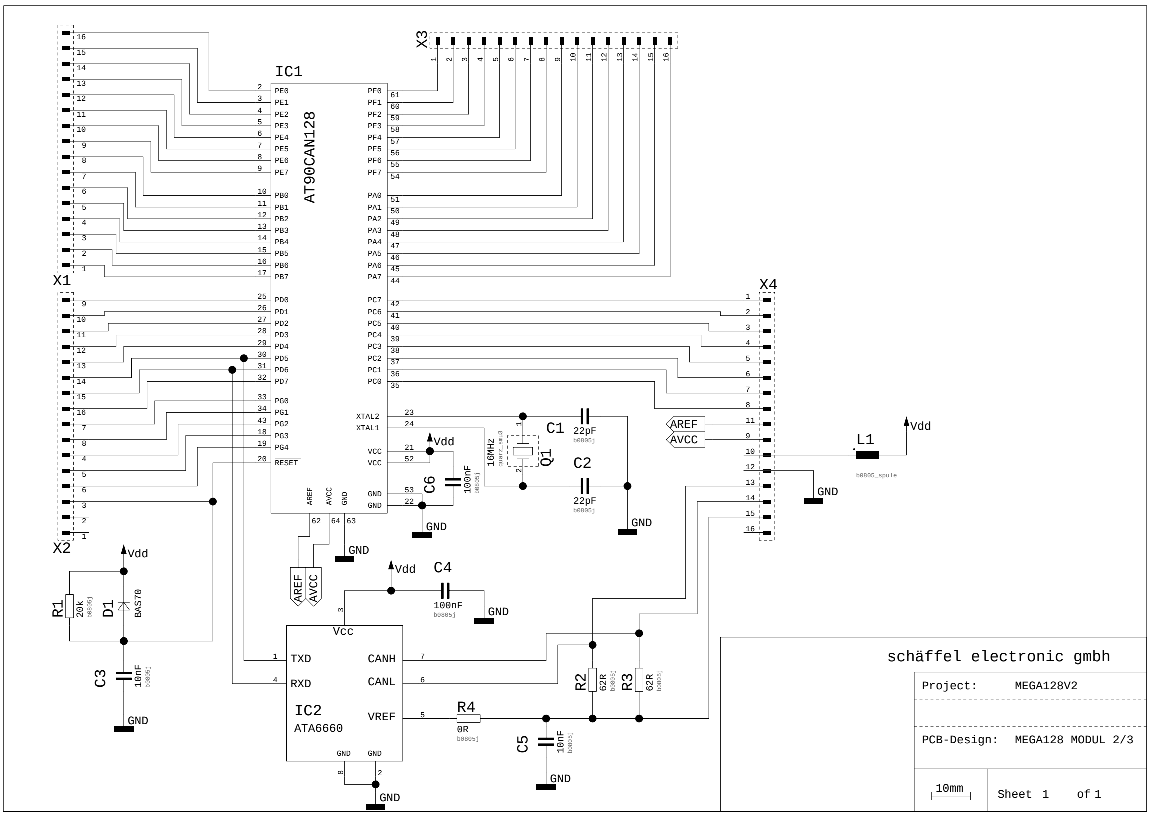
Pin Assignment for Application Board Mega128

Module	M128	Port	Port #	PortBit	Name1	Name2	Internal	Remarks
	1				PEN			prog. Enable
X1_16	2	PE0	4	32	RXD0	PDI	EXT-RXD0	RS232
X1_15	3	PE1	4	33	TXD0	PDO	EXT-TXD0	RS232
X1_14	4	PE2	4	34	AIN0	XCK0		Analog Comparator
X1_13	5	PE3	4	35	AIN1	OC3A		Analog Comparator
X1_12	6	PE4	4	36	INT4	OC3B	EXT-T1	Switch 1
X1_11	7	PE5	4	37	INT5	OC3C	TX-REQ	SPI_TX_REQ
X1_10	8	PE6	4	38	INT6	T3	EXT-T2	Switch 2 / Input Timer 3
X1_9	9	PE7	4	39	INT7	IC3	EXT-DATA	LCD_Interface
X1_8	10	PB0	1	8	SS			SPI
X1_7	11	PB1	1	9	SCK			SPI
X1_6	12	PB2	1	10	MOSI			SPI
X1_5	13	PB3	1	11	MISO			SPI
X1_4	14	PB4	1	12	OC0		RX-BUSY	SPI_RX_BUSY
X1_3	15	PB5	1	13	OC1A		EXT-A1	DAC1
X1_2	16	PB6	1	14	OC1B		EXT-A2	DAC2
X1_1	17	PB7	1	15	OC1C	OC2	EXT-SCK	LCD_Interface
X2_5	18	PG3	6	51	TOSC2		LED1	LED

X2_6	19	PG4	6	52	TOSC1		LED2	LED
X2_3	20				RESET			
X4_10	21				VCC			
X4_12	22				GND			
	23				XTAL2			Oscillator
	24				XTAL1			Oscillator
X2_9	25	PD0	3	24	INT0	SCL	EXT-SCL	I2C
X2_10	26	PD1	3	25	INT1	SDA	EXT-SDA	I2C
X2_11	27	PD2	3	26	INT2	RXD1	EXT-RXD1	RS232
X2_12	28	PD3	3	27	INT3	TXD1	EXT-TXD1	RS232
X2_13	29	PD4	3	28	IC1	A16		IC Timer 1, SRAM bank se-lect
X2_14	30	PD5	3	29	XCK1		LCD-E	LCD_Interface
X2_15	31	PD6	3	30	T1			Input Timer 1
X2_16	32	PD7	3	31	T2		KEY-E	LCD_Interface / Input Timer 2
X2_7	33	PG0	6	48	WR			WR SRAM
X2_8	34	PG1	6	49	RD			RD SRAM
X4_8	35	PC0	2	16	A8			ADR SRAM
X4_7	36	PC1	2	17	A9			ADR SRAM
X4_6	37	PC2	2	18	A10			ADR SRAM
X4_5	38	PC3	2	19	A11			ADR SRAM
X4_4	39	PC4	2	20	A12			ADR SRAM
X4_3	40	PC5	2	21	A13			ADR SRAM
X4_2	41	PC6	2	22	A14			ADR SRAM
X4_1	42	PC7	2	23	A15			ADR SRAM
X2_4	43	PG2	6	50	ALE			Latch
X3_16	44	PA7	0	7	AD7			A/D SRAM
X3_15	45	PA6	0	6	AD6			A/D SRAM
X3_14	46	PA5	0	5	AD5			A/D SRAM
X3_13	47	PA4	0	4	AD4			A/D SRAM
X3_12	48	PA3	0	3	AD3			A/D SRAM
X3_11	49	PA2	0	2	AD2			A/D SRAM
X3_10	50	PA1	0	1	AD1			A/D SRAM
X3_9	51	PA0	0	0	AD0			A/D SRAM
X4_10	52				VCC			
X4_12	53				GND			
X3_8	54	PF7	5	47	ADC7	TDI-JTAG		
X3_7	55	PF6	5	46	ADC6	TDO-JTAG		
X3_6	56	PF5	5	45	ADC5	TMS-JTAG		
X3_5	57	PF4	5	44	ADC4	TCK-JTAG		
X3_4	58	PF3	5	43	ADC3			
X3_3	59	PF2	5	42	ADC2			
X3_2	60	PF1	5	41	ADC1			
X3_1	61	PF0	5	40	ADC0			
X4_11	62				AREF			
X4_12	63				GND			
X4_9	64				AVCC			

2.1.4.3 Connection Diagram

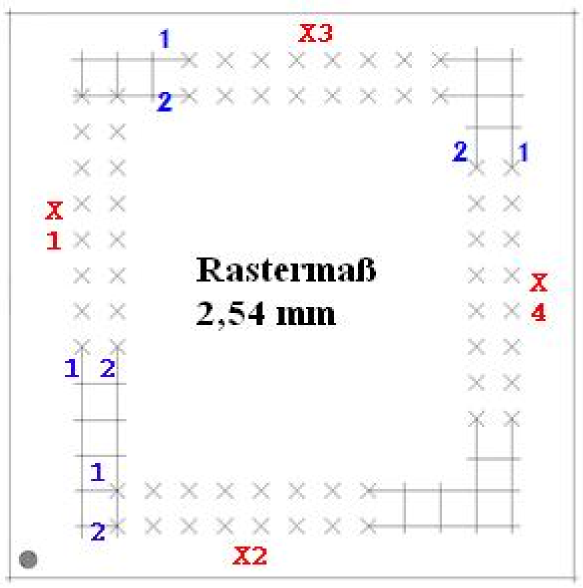
The shown connection diagram shows the planned C-Control Pro Module with CAN Bus interface. This Module has not been built. Inside the C-Control Pro 128 Module is working a Mega 128 processor, and not a AT90CAN128 like shown in this diagram. Therefore there is also no ATA6660 CAN-Bus Transceiver inside the C-Control Module.



2.1.5 Mega128 CAN Module

Pin Layout of the Module

The Mega128 CAN Module is shipped on 4 dual row (2x8) square pins. For hardware application the corresponding socket strips must be organized in the following pitch format:



In the graph the socket strip X1-X4 and then the first two pins of the socket strip can be seen. Pin 1 of strip X1 corresponds to terminal X1_1 (see Mega128 Pinzuordnung).

To enable the simultaneous access of the CAN Bus and the LCD-Display with the C-Control Mega128 CAN Module, the connections PD5 and PF7 were exchanged! At the C-Control Mega128 CAN pin PD5 is connected with X3_8 and PF7 is connected with X2_14!

Module Memory

The C-Control Pro 128 Module provides 128kB FLASH, 4kB EEPROM and 4kB SRAM. A supplementary EEPROM with an 8kB memory depth and an SRAM with a 64kB memory depth is mounted on the application board. The EEPROM can be addressed by an I2C interface.

Note: Detailed information can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

ADC Reference Voltage Generation

The Micro Controller is equipped with an analog-to-digital converter with a 10 Bit resolution. This means that measured voltages can be represented by integral numbers from 0 through 1023. The reference voltage for the lower limit is GND level, i. e. 0V. The reference voltage for the upper limit can be selected by the user:

- 5V Operating Voltage (VCC)
- Internal Reference Voltage of 2.56V
- External Reference Voltage e. g. 4.096V generated by a Reference Voltage IC.

If *x* is a digital measuring value then the corresponding voltage value u is computed as follows:

u = *x* * Reference Voltage / 1024

Clock Generation

Clock generation takes place by a 16MHz Quartz Oscillator. All time dependent actions within the controller are derived from this clock frequency.

Reset

A Reset initiates the return of the Micro Controller system to a defined starting condition. In gerneral the C-Control Pro Module knows two reset sources:

- Power-On-Reset: is automatically executed after the operating voltage is switched on.
- Hardware-Reset: is executed when the Module’s RESET (X2_3) is pulled to "low" and released again by e. g. shortly pressing the connected Reset push button RESET1 (SW3).

A "Brown-Out-Detection" avoids that the Controller can enter undefined conditions in case of dropping operating voltages.

Digital Ports (PortA, PortB, PortC, PortD, PortE, PortF, PortG)

The C-Control Pro Module provides 6 digital ports at 8 pins each and one digital port with 5 pins. To the digital ports it is possible to connect e. g. push buttons with pull-up resistors, digital IC’s, opto couples or driver circuits for relais. The ports can be addressed either separatly, i.e. pin by pin or byte by byte. Each pin can either be input or output.

➔ Note: Never connect two ports directly together which should simultaneously work as outputs!

Digital input pins are high-impedance or wired to internal pull-up resistors and transform an applied voltage signal into a logical value. For this it is required that the voltage signal is within the limits defined for TTL and CMOS ICs high or low levels. During further processing in the program the logical values on the respective input ports are represented as 0 ("low") oder -1 ("high). Pins will take on the values 0 or 1, Bytes from 0 to 255. Output ports are able to give out digital voltage signals by use of an internal driver circuit. Connected circuits can draw (at high level) or feed (at low level) a specific current from or to the ports.

➔ Pay attention to the Maximum Admissible Load Current for a single port or for all ports in total. Exceeding the maximal values may lead to destruction of the C-Control Pro Module. After a reset each port is initially configured as input port. By certain commands the direction of data transport can be toggled.

➔ It is important to closely study the pin assignment of M32 and M128 prior to programming since important functions of the program design (e. g. the USB interface of the application board) will apply to specific ports. If these ports are re-programmed or if the matching jumpers on the application board are no longer set then it may happen that the design platform can no longer transfer any programs to the C-Control Pro. Timer inputs and outputs, A/D converter, I2C as well as serial interface are also connected to various port pins.

PLM Ports

There are three timers available for PLM. These are *Timer_0* with 8 bits and *Timer_1* as well as *Timer_3* with 16 bits each. They can be used for D/A conversion, to control servo motors in pattern making and to output audio frequencies. A pulse length modulated signal has a period of N so called "Ticks". The duration of one tick is the time base. If the output value of a PLM port is set to X then the port will hold high level for X ticks of one period and will then for the balance of the period drop to low level. For programming of the PLM channels see Timer.

The PLM channels for *Timer_0*, *Timer_1* and *Timer_3* have independent time base and period length. In applications for pulse width modulated digital to analog conversion the time base and period length are set once and then only the output value is varied. According to their electrical properties the PLM ports are digital ports. Please observe the technical boundary conditions for digital ports (max. current).

Technical Data Module

Note: Detailed information can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

All voltage specifications apply to direct current (DC).

Environmental Conditions	
Range of admissible ambient temperature	0°C … 70°C
Range of admissible relative ambient humidity	20% … 60%
Power Supply	
Range of admissible operating voltage	4.5V … 5.5V
Power consumption of the module without external loads	appr. 20mA

Clock	
Clock Frequency (Quartz Oscillator)	16MHz
Mechanics	
Overall measurements less pins, appr.	40 mm x 40mm x 8 mm
Weight	appr. 90g
Pin pitch	2.54mm
Number of pins (two rows)	64

Ports	
Max. admissible current from digital ports	± 20 mA
Admissible current total on digital ports	200mA
Admissible input voltage on port pins (digital and A/D)	–0.5V ... 5.5V
Internal pull-up resistors (disconnectable)	20 - 50 kOhm

2.1.5.1 CPU

AT90CAN Overview

The Micro Controller AT90CAN originates from the AVR family by ATMEL. It is a low-power Micro Controller with Advanced RISC Architecture. In the following see a short summary of its hardware resources:

- **Advanced RISC Architecture**
  133 Powerful Instructions – Most Single Clock Cycle Execution
  32 x 8 General Purpose Working Registers + Peripheral Control Registers
  Fully Static Operation
  Up to 16 MIPS Throughput at 16 MHz
  On-chip 2-cycle Multiplier

- **Non volatile Program and Data Memories**
  32K/64K/128K Bytes of In-System Reprogrammable Flash (AT90CAN32/64/128)
  • Endurance: 10,000 Write/Erase Cycles
  Optional Boot Code Section with Independent Lock Bits
  • Selectable Boot Size: 1K Bytes, 2K Bytes, 4K Bytes or 8K Bytes
  • In-System Programming by On-Chip Boot Program (CAN, UART, ...)
  • True Read-While-Write Operation
  1K/2K/4K Bytes EEPROM (Endurance: 100,000 Write/Erase Cycles) (AT90CAN32/64/128)
  2K/4K/4K Bytes Internal SRAM (AT90CAN32/64/128)
  Up to 64K Bytes Optional External Memory Space
  Programming Lock for Software Security

- **JTAG (IEEE std. 1149.1 Compliant) Interface**
  Boundary-scan Capabilities According to the JTAG Standard
  Programming Flash (Hardware ISP), EEPROM, Lock & Fuse Bits
  Extensive On-chip Debug Support

- **CAN Controller 2.0A & 2.0B - ISO 16845 Certified** (1)
  15 Full Message Objects with Separate Identifier Tags and Masks
  Transmit, Receive, Automatic Reply and Frame Buffer Receive Modes
  1Mbits/s Maximum Transfer Rate at 8 MHz
  Time stamping, TTC & Listening Mode (Spying or Autobaud)

- **Peripheral Features**
  Programmable Watchdog Timer with On-chip Oscillator
  8-bit Synchronous Timer/Counter-0

• 10-bit Prescaler
• External Event Counter
• Output Compare or 8-bit PWM Output
8-bit Asynchronous Timer/Counter-2
• 10-bit Prescaler
• External Event Counter
• Output Compare or 8-Bit PWM Output
• 32Khz Oscillator for RTC Operation
Dual 16-bit Synchronous Timer/Counters-1 & 3
• 10-bit Prescaler
• Input Capture with Noise Canceler
• External Event Counter
• 3-Output Compare or 16-Bit PWM Output
• Output Compare Modulation
8-channel, 10-bit SAR ADC
• 8 Single-ended Channels
• 7 Differential Channels
• 2 Differential Channels With Programmable Gain at 1x, 10x, or 200x
On-chip Analog Comparator
Byte-oriented Two-wire Serial Interface
Dual Programmable Serial USART
Master/Slave SPI Serial Interface
• Programming Flash (Hardware ISP)

- **Special Microcontroller Features**
  Power-on Reset and Programmable Brown-out Detection
  Internal Calibrated RC Oscillator
  8 External Interrupt Sources
  5 Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down & Standby
  Software Selectable Clock Frequency
  Global Pull-up Disable

- **I/O and Packages**
  53 Programmable I/O Lines
  64-lead TQFP and 64-lead QFN

- **Operating Voltages: 2.7 - 5.5V**

- **Operating temperature: Industrial (-40°C to +85°C)**

- **Maximum Frequency: 8 MHz at 2.7V, 16 MHz at 4.5V**

2.1.5.2 Pin Assignment

PortA through PortG are for direct pin functions (e. g. Port_WriteBit) counted from 0 through 52, see "PortBit".

➡ To enable the simultaneous access of the CAN Bus and the LCD-Display with the C-Control Mega128 CAN Module, the connections PD5 and PF7 were exchanged! At the C-Control Mega128 CAN pin PD5 is connected with X3_8 and PF7 is connected with X2_14!

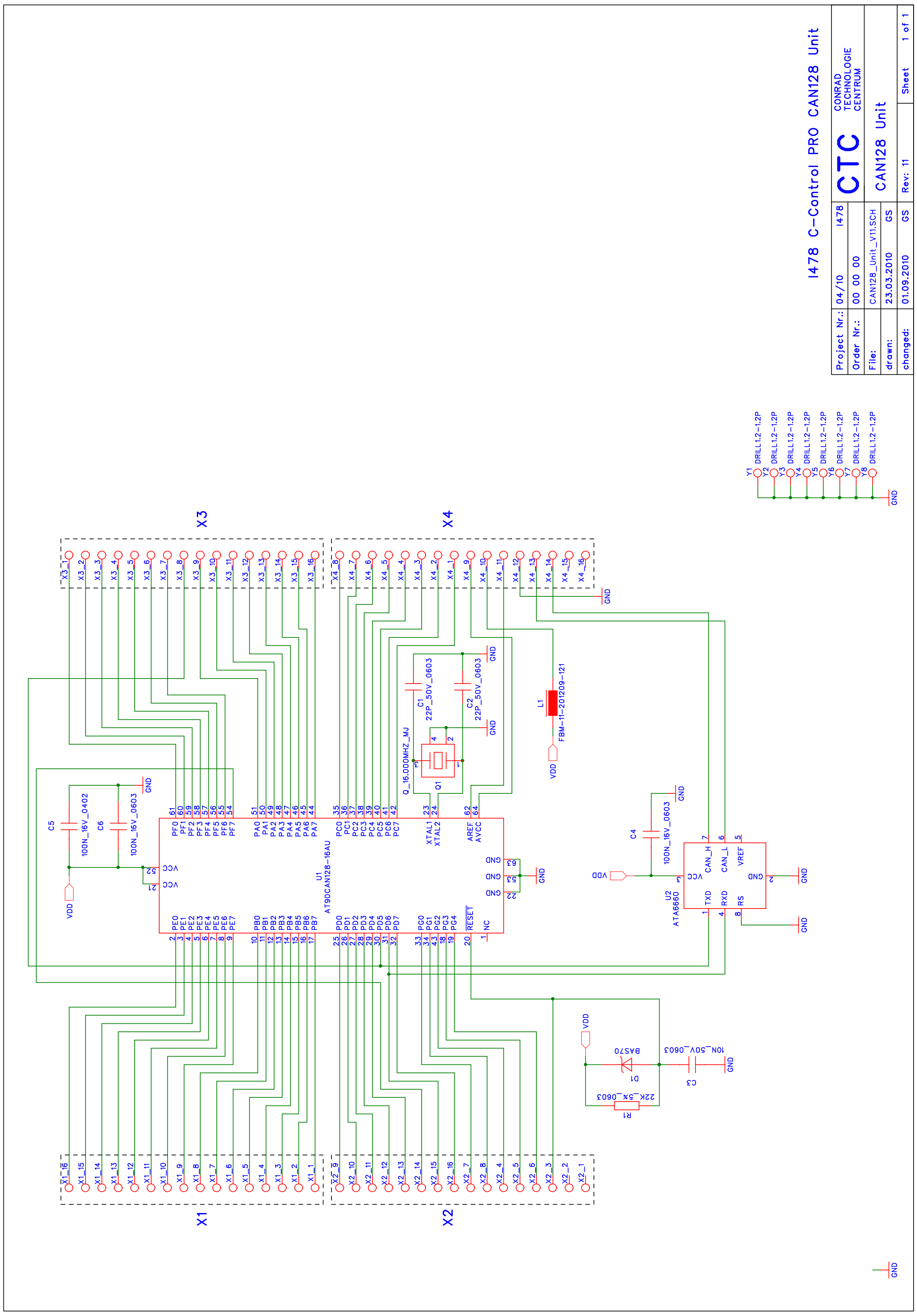
Pin Assignment for Application Board Mega128 CAN

Module	M128	Port	Port #	PortBit	Name1	Name2	Internal	Remarks
	1				PEN			prog. Enable
X1_16	2	PE0	4	32	RXD0	PDI	EXT-RXD0	RS232
X1_15	3	PE1	4	33	TXD0	PDO	EXT-TXD0	RS232
X1_14	4	PE2	4	34	AIN0	XCK0		Analog Comparator
X1_13	5	PE3	4	35	AIN1	OC3A		Analog Comparator
X1_12	6	PE4	4	36	INT4	OC3B	EXT-T1	Switch 1
X1_11	7	PE5	4	37	INT5	OC3C	TX-REQ	SPI_TX_REQ
X1_10	8	PE6	4	38	INT6	T3	EXT-T2	Switch 2 / Input Timer 3
X1_9	9	PE7	4	39	INT7	IC3	EXT-DATA	LCD_Interface
X1_8	10	PB0	1	8	SS			SPI
X1_7	11	PB1	1	9	SCK			SPI
X1_6	12	PB2	1	10	MOSI			SPI
X1_5	13	PB3	1	11	MISO			SPI
X1_4	14	PB4	1	12	OC0		RX-BUSY	SPI_RX_BUSY
X1_3	15	PB5	1	13	OC1A		EXT-A1	DAC1
X1_2	16	PB6	1	14	OC1B		EXT-A2	DAC2
X1_1	17	PB7	1	15	OC1C	OC2	EXT-SCK	LCD_Interface
X2_5	18	PG3	6	51	TOSC2		LED1	LED
X2_6	19	PG4	6	52	TOSC1		LED2	LED
X2_3	20				RESET			
X4_10	21				VCC			
X4_12	22				GND			
	23				XTAL2			Oscillator
	24				XTAL1			Oscillator
X2_9	25	PD0	3	24	INT0	SCL	EXT-SCL	I2C
X2_10	26	PD1	3	25	INT1	SDA	EXT-SDA	I2C
X2_11	27	PD2	3	26	INT2	RXD1	EXT-RXD1	RS232
X2_12	28	PD3	3	27	INT3	TXD1	EXT-TXD1	RS232
X2_13	29	PD4	3	28	IC1	A16		IC Timer 1, SRAM bank se-lect
X3_8	30	PD5	3	29	XCK1	TXCAN	LCD-E	LCD_Interface
X2_15	31	PD6	3	30	T1	RXCAN		Input Timer 1
X2_16	32	PD7	3	31	T2		KEY-E	LCD_Interface / Input Timer 2
X2_7	33	PG0	6	48	WR			WR SRAM
X2_8	34	PG1	6	49	RD			RD SRAM
X4_8	35	PC0	2	16	A8			ADR SRAM
X4_7	36	PC1	2	17	A9			ADR SRAM
X4_6	37	PC2	2	18	A10			ADR SRAM
X4_5	38	PC3	2	19	A11			ADR SRAM
X4_4	39	PC4	2	20	A12			ADR SRAM
X4_3	40	PC5	2	21	A13			ADR SRAM
X4_2	41	PC6	2	22	A14			ADR SRAM
X4_1	42	PC7	2	23	A15			ADR SRAM
X2_4	43	PG2	6	50	ALE			Latch
X3_16	44	PA7	0	7	AD7			A/D SRAM
X3_15	45	PA6	0	6	AD6			A/D SRAM
X3_14	46	PA5	0	5	AD5			A/D SRAM

X3_13	47	PA4	0	4	AD4			A/D SRAM
X3_12	48	PA3	0	3	AD3			A/D SRAM
X3_11	49	PA2	0	2	AD2			A/D SRAM
X3_10	50	PA1	0	1	AD1			A/D SRAM
X3_9	51	PA0	0	0	AD0			A/D SRAM
X4_10	52				VCC			
X4_12	53				GND			
X2_14	54	PF7	5	47	ADC7	TDI-JTAG		in CAN Modul exchanged with X3_8
X3_7	55	PF6	5	46	ADC6	TDO-JTAG		
X3_6	56	PF5	5	45	ADC5	TMS-JTAG		
X3_5	57	PF4	5	44	ADC4	TCK-JTAG		
X3_4	58	PF3	5	43	ADC3			
X3_3	59	PF2	5	42	ADC2			
X3_2	60	PF1	5	41	ADC1			
X3_1	61	PF0	5	40	ADC0			
X4_11	62				AREF			
X4_12	63				GND			
X4_9	64				AVCC			
X4_13					CAN-L			
X4_14					CAN-H			

2.1.5.3 Connection Diagram

➡ The connection diagram shows the new C-Control Pro Mega128 CAN module **with** CAN bus.


I478 C-Control PRO CAN128 Unit
Project Nr.: 04/10 I478
Order Nr.: 00 00 00
File: CAN128_Unit_V11.SCH
drawn: 23.03.2010 GS
changed: 01.09.2010 GS
CTC
CONRAD TECHNOLOGIE CENTRUM
CAN128 Unit
Rev: 11
Sheet 1 of 1
U1
AT90CAN128-16AU
U2
ATA6660
Q1
Q_16.000MHZ_MJ
C1
22P_50V_0603
C2
22P_50V_0603
C3
10N_50V_0603
C4
100N_16V_0603
C5
100N_16V_0402
C6
100N_16V_0603
L1
FBM-11-201209-121
D1
BAS70
R1
22K_5%_0603
X1
X2
X3
X4
VDD
GND
DRILL1.2-1.2P

2.1.6 Mega32 Application Board

USB

The "C-Control Pro Application Board MEGA 32" (Conrad Item no. 198245) provides a USB interface for the program’s loading and debugging. Because of the high data rate of this interface data transmission times are considerably shorter compared to the serial interface. Communication takes place through a USB Controller by FTDI and an AVR Mega8 Controller. The Mega8 provides its own Reset push button (SW5). During USB operation the status of the interface is indicated by two light emitting diodes (LD4 red, LD5 green). When only the green LED lights up the USB interface is ready for operation. During data transmission both LED’s will light up. This also applies to the Debug mode. Flashing of the red LED indicates an error condition. Is a program started in the Interpreter, the red LED is turned on during the runtime. For USB communication the SPI interface of Mega32 is used (PortB.4 through PortB.7, PortA.6, PortA.7), which must be connected by their respective jumpers.

Note: Detailed information on the Mega32 can be found in the IC manufacturer’s PDF files on the C-Control Pro Software CD-ROM.

On-Off Switch

The switch SW4 is located on the front of the application board and serves the power-up (On) or power-down (Off) of the voltage supply.

Light Emitting Diodes (LED)

There are 5 light emitting diodes (LEDs). The LD3 (green) is located on the front below the DC terminals and lights up when supply voltage is applied. LD4 and LD5 indicate the status of the USB interface (see Section USB). The green LEDs LD1 and LD2 are located next to the four push buttons and are freely available to the user. They are connected to VCC through a dropping resistor. By means of jumpers LD1 can be connected to PortD.6 and LD2 to PortD.7. The LEDs will light up when the corresponding pin port is low (GND).

Push Buttons

There are four push buttons provided for. SW3 (RESET1) will initiate a reset with Mega32 while SW3 (RESET2) will do the same with Mega8. The push buttons SW1 and SW2 are freely available to the user. Through jumpers SW1 can be connected to PortD.2 and accordingly SW2 to PortD.3. There is the possibility to connect switches SW1/2 to either GND or VCC. The possibilities to choose from are determined by JP1 and JP2 resp. In order to have a defined level at the input port while the push button is open the corresponding pull-up should be switched on (see Section Digitalports).

➡ Pressing SW1 during power-up of the board will activate the Serial Bootloader Mode.

LCD

An LCD module can be plugged onto the application board. It displays 2 lines at 8 characters each. In general also differently organized displays can be operated through this interface. Each character consists of a monochrome matrix of 5x7 pixels. A flashing cursor below any one of the characters will indicate the current output position. The operating system provides a simple software interface for output on the display. This display is connected to connector X14 (16 poles, double row). By means of a mechanical protection a faulty connection and thus the confusing of poles is avoided.

The LCD module used is of type Hantronix HDM08216L-3. Further information can be found on the Hantronix Webseite http://www.hantronix.com and in the data sheet list on the CD-ROM.

The display is operated in the 4-Bit data mode. Data bits are set to the EXT-Data output, and then clocked into the 74HC164 shift register with triggering EXT-SCK. When LCD-E is set, the 4 Bits are applied to the display.

LCD Contrast (LCD ADJ)

Direct frontal view will allow best readability of the LCD characters. If necessary the contrast must be trivially re-adjusted. The contrast can be adjusted by means of potentiometer PT1.

Keyboard

For user inputs a 12 character keyboard (0..9,*,#) is provided (X15: 13 pole connector). The keyboard is organized 1 out of 12, i. e. there is one line assigned to each key. The keyboard information is read-in serially through a shift register. If no keyboard is used the 12 inputs can be used as additional digital inputs. The keyboard uses a 13 pole terminal (single row) and is plugged to X15 in such a way that the keys will point towards the application board.

With activating the PL (parallel load - KEY-E) input of the 74HC165 all 12 keyboard wires are transferred in the 74HC165 shift register. After that all information bits are latched to Q7 with triggering of CP (clock input - EXT-SCK). There they can be read with the EXT-Data Port. Since one 74HC165 holds only 8 Bit information, Q7 of the 1st 74HC165 is connected with DS of the 2nd 74HC165.

I2C Interface

Through this interface serial data can be transmitted at high speed. To do this only two signal lines are necessary. Data transmission takes place according to the I2C protocol. To effectively use this interface special functions are provided (see Software Description I2C).

I2C SCL	I2C Bus Clock Line	PortC.0
I2C SDA	I2C Bus Data Line	PortC.1

Power Supply (POWER, 5 Volts, GND)

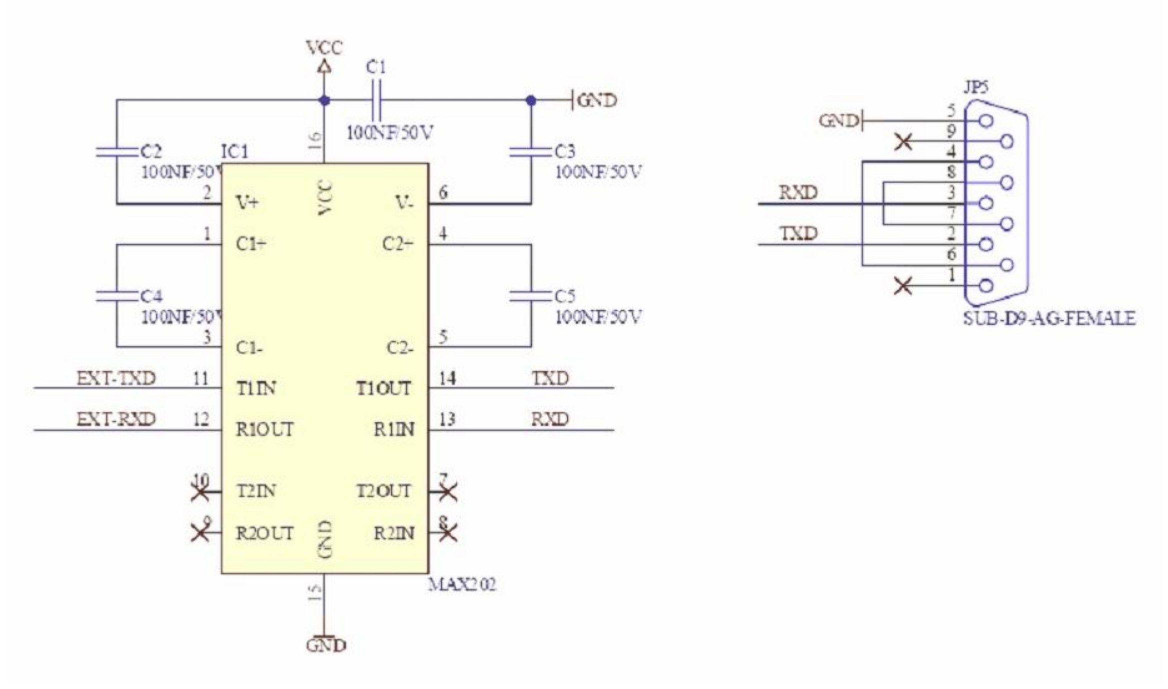
Power is provided to the application board by means of a 9V/ 250mA Mains Plug-in Power Supply. Depending on additionally used components it may later become necessary to use a power supply with higher power rating. A fixed voltage control generates an internally stabilized 5V supply voltage. This voltage is provided to all circuit components on the application board. Due to the power reserve of the Plug-In Power Supply this voltage can also be used to power external ICs.

➔ Please observe the Maximum Drawable Current. Exceeding this current may lead to immediate destruction! Because of the relativelly high current consumption of the application board in the vicinity of 125mA it is not recommended for use in devices consistently battery operated. Please see the note on short time breakdowns of the power supply (see Reset Characteristics).

➜ If you turn the application board to a position where the interface connectors (USB and serial) show to the upper side, the leftmost column on the breadboard is GND and the rightmost column is VCC.

Serial Interfaces

The Micro Controller Atmega32 contains in its hardware an asynchronous serial interface according to RS232 standards. The format (Data Bits, Parity Bit, Stop Bit) can be determined during initialization of the interface. The application board contains a high value level conversion IC to transform the digital bit streams to Non Return Zero Signals in accordance with the RS232 standards (positive voltage for low bits, negative voltage for high bits). The level conversion IC makes use of an improved protection against voltage transients. Voltage transients can in electro-magnetically loaded surroundings (e. g. in industrial applications) be induced in the interface cables and thus destroy connected electrical circuits. By means of jumpers the data lines RxD and TxD can be connected to the Controller PortD.0 and PortD.1. During quiescent condition (no active data transmission) a negative voltage of several volts can be measured on Pin TxD against GND. RxD is of high impedance. The 9 pole SUB-D socket of the application board carries RxD on Pin 3 and TxD on Pin 2. Pin 5 is the GND connection. No handshake signals are being used for serial data transmission.



The cable with connection to the NRZ Pins TxD, RxD and RTS may have a length of up to 10 meters. It is recommended to use shielded standard cables. When using longer lines or non-shielded cables interferences may detract correct data transmission. Only use cables of which the pin assignments are known.

➜ Never connect the serial transmission outputs of two devices directly together! Transmission outputs can usually be identified by their negative output voltage in quiescent condition.

Testing Interfaces

The 4 pole pin strip X16 is to be used for testing purposes only and will not necessarily be armed with components of any kind on every application board. For the user this pin strip is of no importance.

One further testing interface is the 6 pole pin strip (two rows at 3 pins each) at JP4. This pin strip too is only meant for internal use and may likely no longer be fitted with components in future board series.

Technical Data Application Board

Note: Detailed information's can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.
All voltage specifications are referring to direct current (DC).

Mechanics	
Overall measurements, appr.	160 mm x 100 mm
Pin pitch wiring field	2.54 mm
Environmental Conditions	
Range of admissible ambient temperature	0°C ... 70°C
Range of admissible relative ambient humidity	20% ... 60%

Power Supply	
Range of admissibly operating voltage	8V ... 24V
Power consumption without external loads	appr. 125mA
Max. admissibly permanent current from a stabilized 5V power supply	200mA

2.1.6.1 Jumper Application Board

Jumper

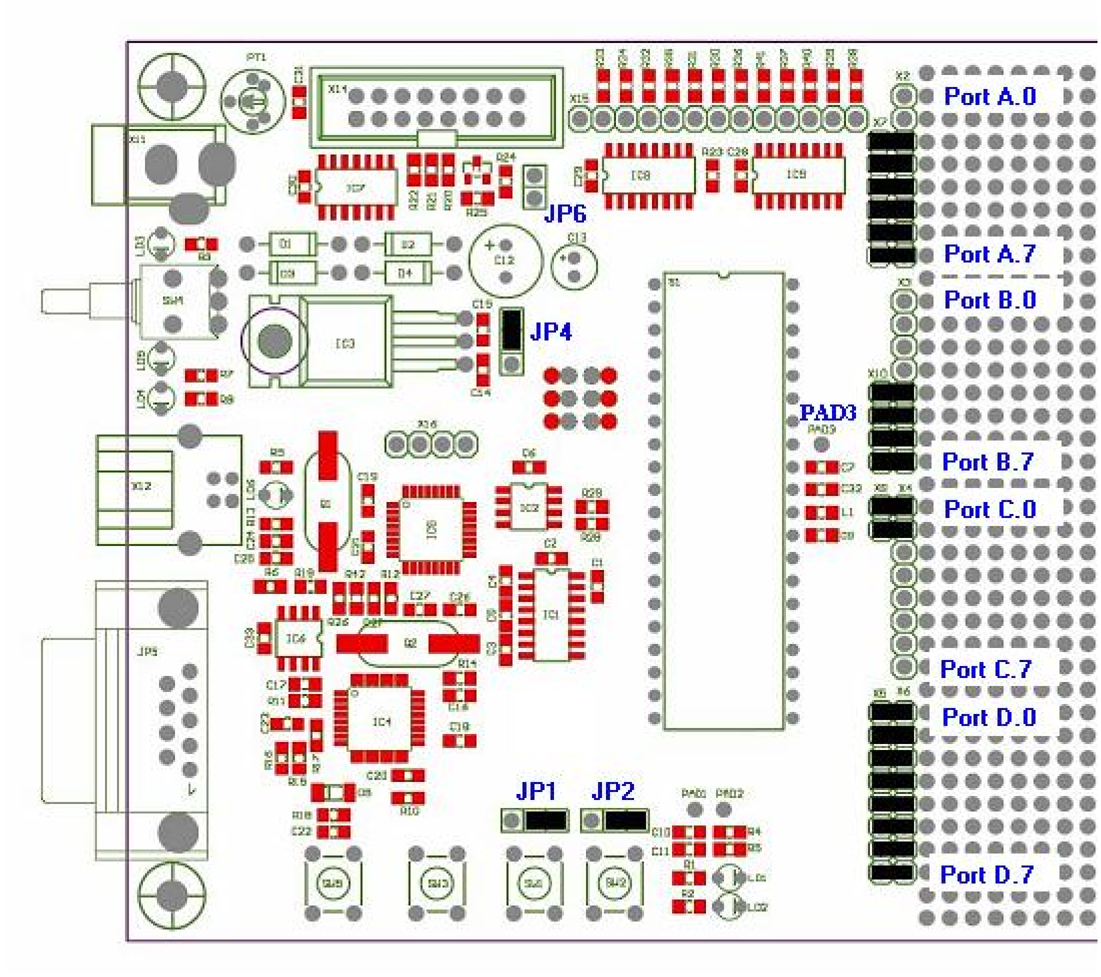
By use of jumpers certain options can be selected. This applies to several ports which are provided with special functions (see Pin Assignment Table for M32). E. g. the serial interface is relized through Pins PortD.0 and PortD.1. If the serial interface is not being used then the corresponding jumpers can be removed and these pins will then be available for other functions. Besides the port jumpers there are additional jumpers which are described in the following.

Ports A through D

The ports available with the Mega32 Module are inscribed in this graph. Here the right side is connected to the module while the left side connects to the components of the application board. If any jumper is pulled then the connection to the application board is suspended. This may lead to obstructions of USB, RS232, etc. on the board.

JP1 and JP2

These jumpers are assigned to push buttons SW1 and SW2. There is the possibility to operate the push button against both GND or VCC. In the basic setting the push buttons are switching to GND.



Jumperpositions at delivery

JP4

JP4 serves to toggle the operating voltage (Mains Plug-In Power Supply or USB). The application board should be operated using Plug-In Power Supply and voltage control (Shipping Condition). The maximum current to be drawn from the USB interface is lower than from the Plug-In Power Supply. Exceeding this current can lead to damage on the USB interface of the computer.

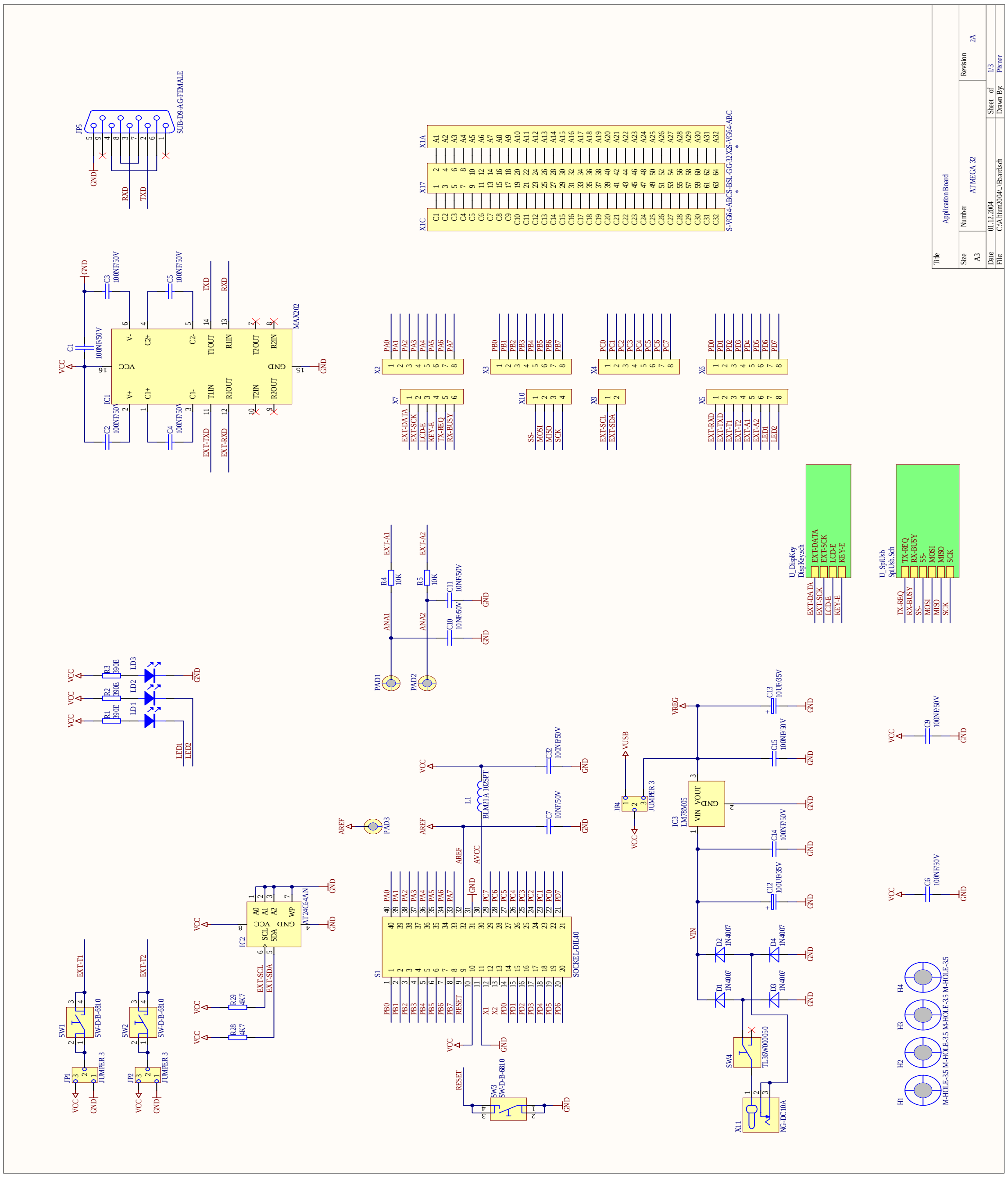
JP6

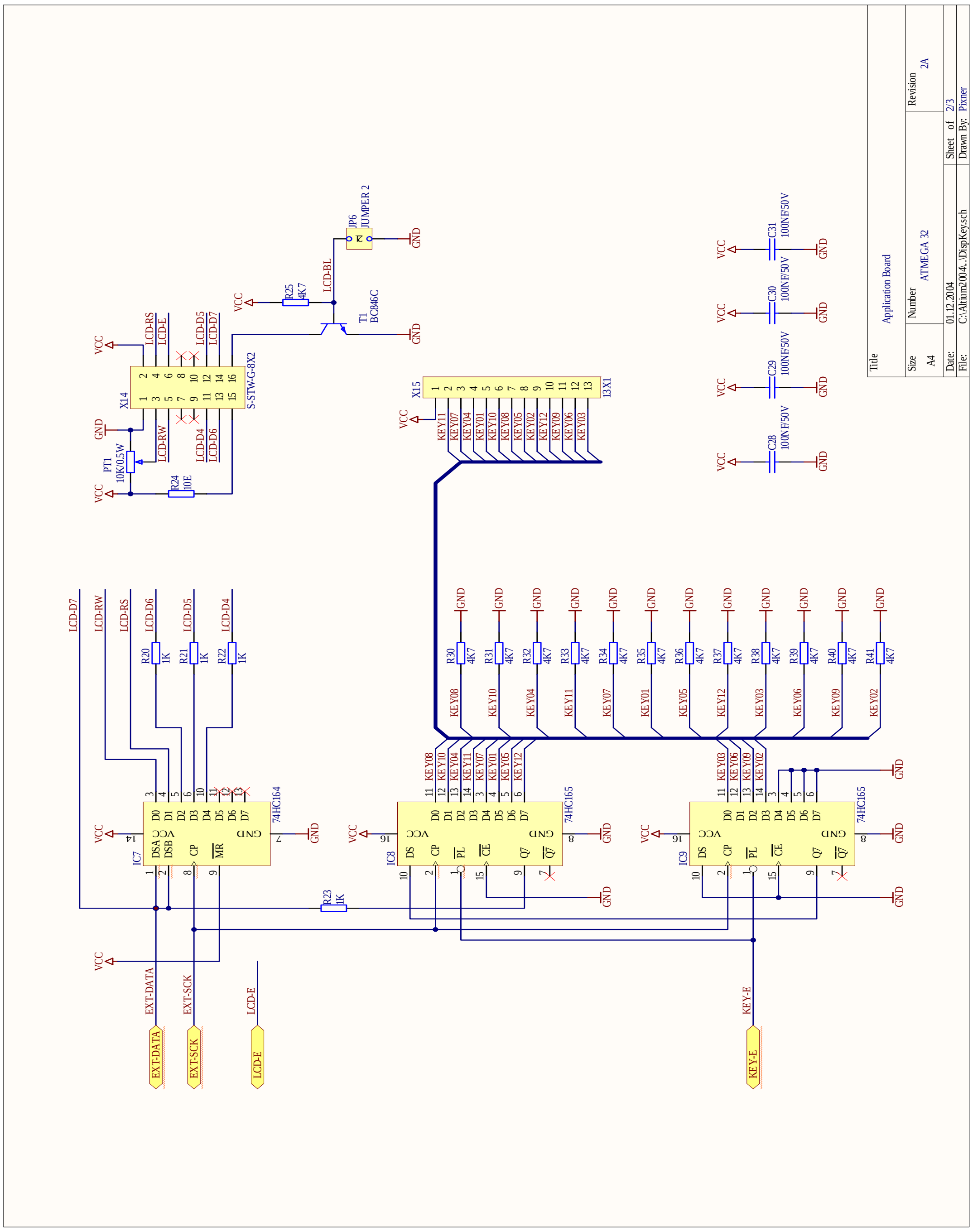
When using the displays the LED back lighting can be switched off by use of JP6.

PAD3

PAD3 (to the right of the module, below the blue inscription) is required as ADC_VREF_EXT for functions ADC_Set and ADC_SetInt.

2.1.6.2 Connection Diagram

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Size A4
Number ATMEGA 32
Revision 2A
Date: 01.12.2004
Sheet of 2/3
File: C:\Altium2004..\DispKey.sch
Drawn By: Pixner
IC7 74HC164
IC8 74HC165
IC9 74HC165
X14 S-STW-G-8X2
X15 13X1
T1 BC846C
JP6 JUMPER 2
PT1 10K/0,5W
R24 10E
R25 4K7
R23 1K
R20 1K
R21 1K
R22 1K
R30 4K7
R31 4K7
R32 4K7
R33 4K7
R34 4K7
R35 4K7
R36 4K7
R37 4K7
R38 4K7
R39 4K7
R40 4K7
R41 4K7
C28 100NF/50V
C29 100NF/50V
C30 100NF/50V
C31 100NF/50V
EXT-DATA
EXT-SCK
LCD-E
KEY-E
LCD-BL
LCD-RS
LCD-RW
LCD-D4
LCD-D5
LCD-D6
LCD-D7
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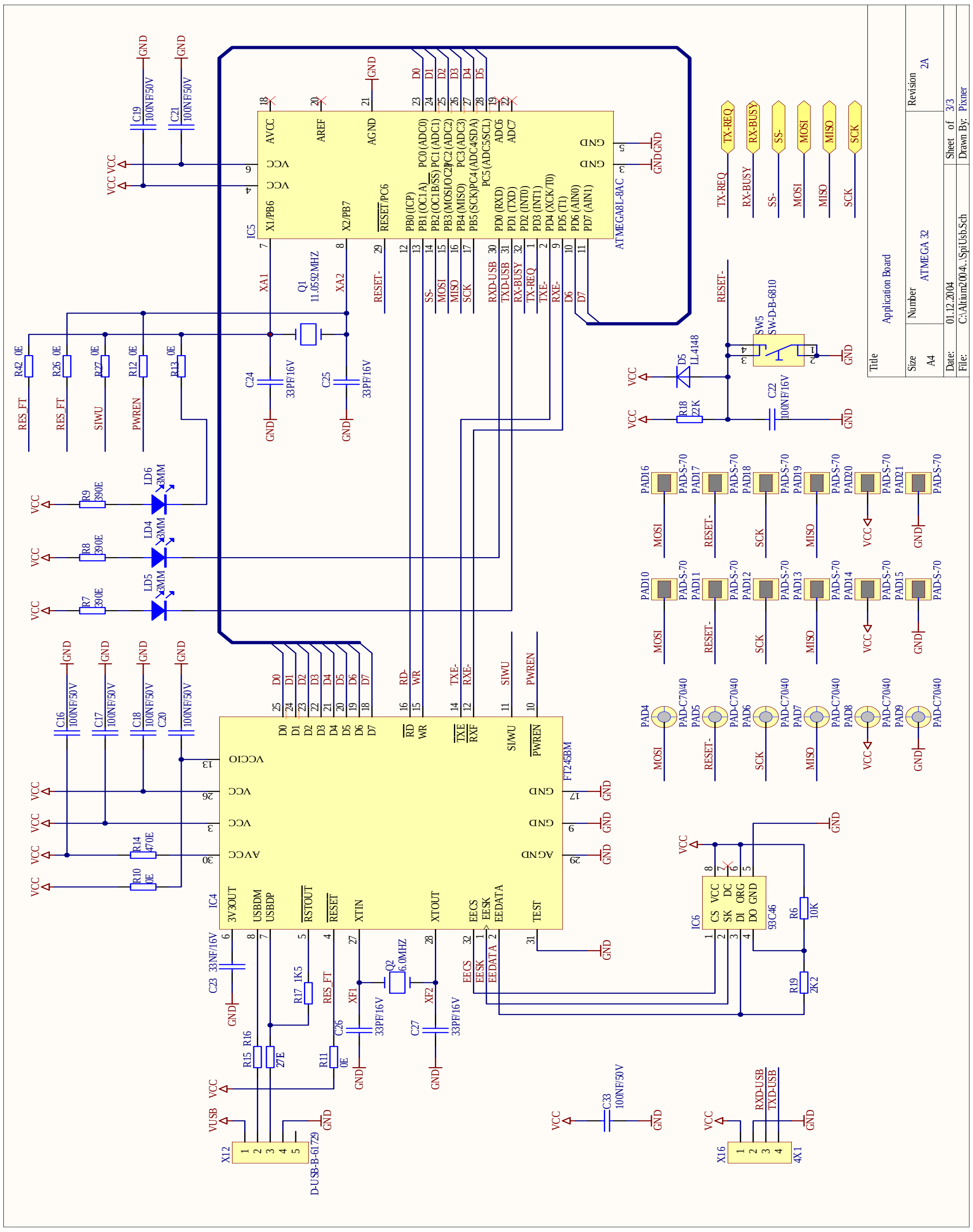
KEY09
KEY10
KEY11
KEY12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Size A4
Sheet 3/3
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Drawn By: Pixner
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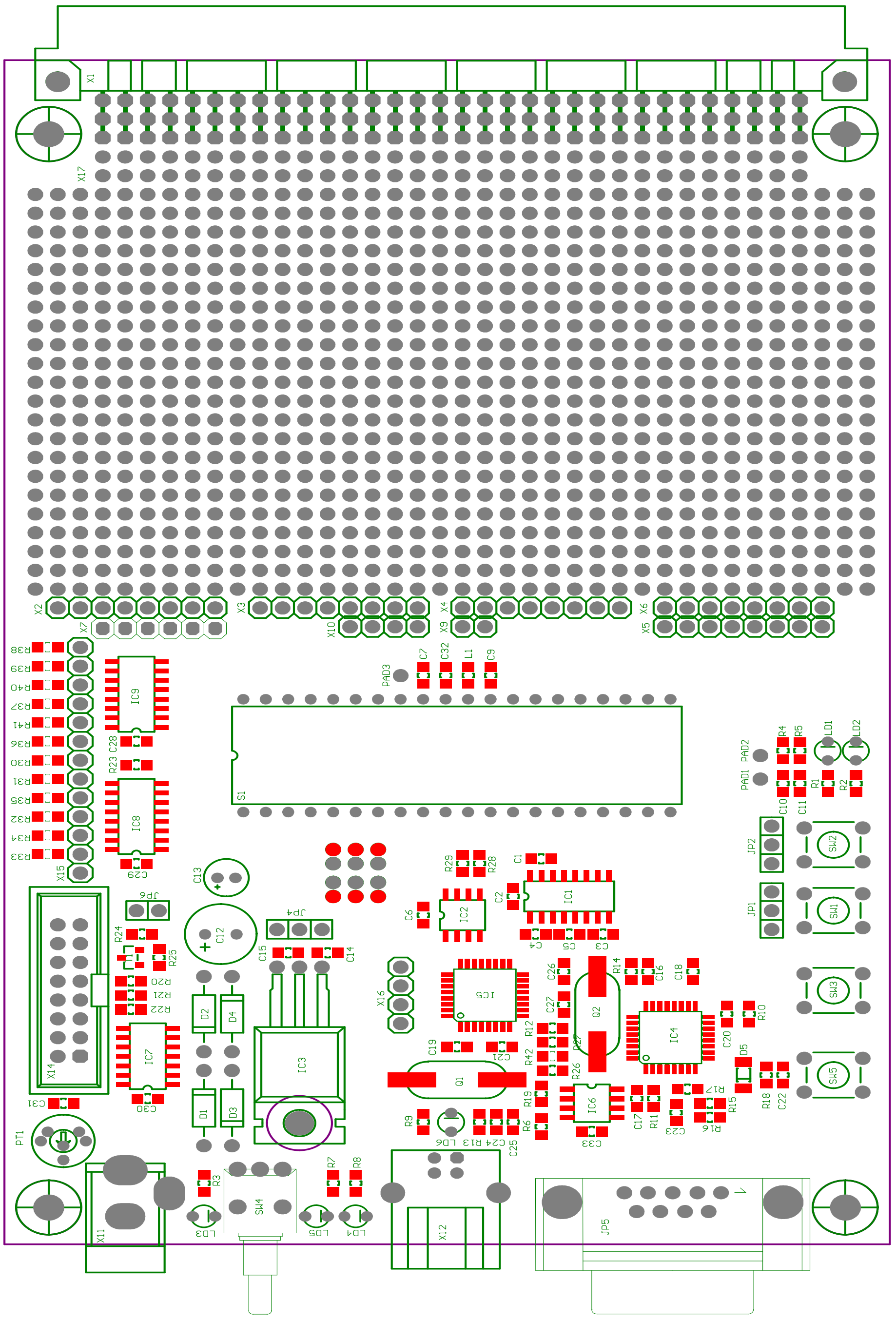
IC5 ATMEGA8L-8AC
IC4 FT245BM
IC6 93C46
Q1 11.0592MHZ
Q2 6.0MHZ
X12 D-USB-B-61729
X16 4X1
SW5 SW-D-B-6810
D5 LL4148
TX-REQ
RX-BUSY
SS-
MOSI
MISO
SCK
RESET-
VCC
GND
VUSB

2.1.6.3 Component Parts Plan



2.1.7 Mega128 Application Board

USB

The "C-Control Pro Application Board MEGA 128" (Conrad Item no. 198258) provides a USB interface for the program's loading and debugging. Because of the high data rate of this interface data transmission times are considerably shorter compared to the serial interface. Communication takes place through a USB Controller by FTDI and an AVR Mega8 Controller. The Mega8 provides its own Reset push button (SW5). During USB operation the status of the interface is indicated by two light emitting diodes (LD4 red, LD5 green). When only the green LED lights up the USB interface is ready for operation. During data transmission both LEDs will light up. This also applies to the Debug mode. Flashing of the red LED indicates an error condition. Is a program started in the Interpreter, the red LED is turned on during the runtime. For USB communication the SPI interface of Mega128 is used (PortB.0 through PortB.4, PortE.5), which must be connected by their respective jumpers.

Note: Detailed information on the Mega8 can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.

On-Off Switch

The switch SW4 is located on the front of the application board and serves the power-up (On) or power-down (Off) of the voltage supply.

Light Emitting Diodes (LED)

There are 5 light emitting diodes (LEDs). The LD3 (green) is located on the front below the DC terminals and lights up when supply voltage is applied. LD4 and LD5 indicate the status of the USB interface (see Section USB). The green LEDs LD1 and LD2 are located next to the four push buttons and are freely available to the user. They are connected to VCC through a dropping resistor. By means of jumpers LD1 can be connected to PortG.3 and LD2 to PortG.4. The LEDs will light up when the corresponding pin port is low (GND).

Push Buttons

There are four push buttons provided for. SW3 (RESET1) will initiate a reset with Mega128 while SW5 (RESET2) will do the same with Mega8. The push button SW1 and SW2 are freely available to the user. Through jumpers SW1 can be connected to PortE.4 and accordingly SW2 to PortE.6. There is the possibility to connect switches SW1/2 to either GND or VCC. The possibilities to choose from are determined by JP1 and JP2 resp. In order to have a defined level at the input port while the push button is open the corresponding pull-up should be switched on (see Section Digital-ports).

Pressing SW1 during power-up of the board will activate the Serial Bootloader Mode.

LCD

An LCD module can be plugged onto the application board. It displays 2 lines at 8 characters each. In general also differently organized displays can be operated through this interface. Each character consists of a monochrome matrix of 5x7 pixels. A flashing cursor below any one of the characters will indicate the current output position. The operating system provides a simple software interface for output on the display. This display is connected to connector X14 (16 poles, double row). By means of a mechanical protection a faulty connection and thus the confusing of poles is avoided.

The LCD module used is of type Hantronix HDM08216L-3. Further information can be found on the Hantronix Webseite http://www.hantronix.com and in the data sheet list on the CD-ROM.

The display is operated in the 4-Bit data mode. Data bits are set to the EXT-Data output, and then clocked into the 74HC164 shift register with triggering EXT-SCK. When LCD-E is set, the 4 Bits are applied to the display.

LCD Contrast (LCD ADJ)

Direct frontal view will allow best readability of the LCD characters. If necessary the contrast must be trivially re-adjusted. The contrast can be adjusted by means of potentiometer PT1.

Keyboard

For user inputs a 12 character keyboard (0..9,*,#) is provided (X15: 13 pole connector). The keyboard is organized 1 out of 12, i. e. there is one line assigned to each key. The keyboard information is read-in serially through a shift register. If no keyboard is used the 12 inputs can be used as additional digital inputs. The keyboard uses a 13 pole terminal (single row) and is plugged to X15 in such a way that the keys will point towards the application board.

With activating the PL (parallel load - KEY-E) input of the 74HC165 all 12 keyboard wires are transferred in the 74HC165 shift register. After that all information bits are latched to Q7 with triggering of CP (clock input - EXT-SCK). There they can be read with the EXT-Data Port. Since one 74HC165 holds only 8 Bit information, Q7 of the 1st 74HC165 is connected with DS of the 2nd 74HC165.

SRAM

The application board holds an SRAM chip (K6X1008C2D) made by Samsung. By using this the available SRAM memory is extended to 64kByte. Mentioned SRAM uses Ports A, C and partly G for triggering. If the SRAM is not used then it can be de-activated by JP7 and then these ports become available to the user.

➔ To deactivate the SRAM the jumper JP7 has to be moved to the left side (orientation: serial interface shows to the left), such that the left pins of JP7 are connected.
➔ Even though the used RAM chip has a capacity of 128kb only 64kb can be used for reason of the memory model.

I2C Interface

Through this interface serial data can be transmitted at high speed. To do this only two signal lines are necessary. Data transmission takes place according to the I2C protocol. To effectively use this interface special functions are provided (see Software Description I2C).

I2C SCL	I2C Bus Clock Line	PortD.0
I2C SDA	I2C Bus Data Line	PortD.1

Power Supply (POWER, 5 Volt, GND)

Power is provided to the application board by means of a 9V/ 250mA Mains Plug-in Power Supply. Depending on additionally used components it may later become necessary to use a power supply with higher power rating. A fixed voltage control generates an internally stabilized 5V supply voltage. This voltage is provided to all circuit components on the application board. Due to the power reserve of the Plug-In Power Supply this voltage can also be used to power external ICs.

➡ Please observe the Maximum Drawable Current. Exceeding this current may lead to immediate destruction! Because of the relativelly high current consumption of the application board in the vicinity of 125mA it is not recommended for use in devices consistently battery operated. Please see the note on short time breakdowns of the power supply (see Reset Characteristics).

➡ If you turn the application board to a position where the interface connectors (USB and serial) show to the upper side, the leftmost column on the breadboard is GND and the rightmost column is VCC.

Serial Interfaces

The Micro Controller Atmega128 contains in its hardware two asynchronous serial interfaces according to RS232 standards. The format (Data Bits, Parity Bit, Stop Bit) can be determined during initialization of the interface. The application board contains a high value level conversion IC for both interfaces to transform the digital bit streams to Non Return Zero Signals in accordance with the RS232 standards (positive voltage for low bits, negative voltage for high bits). The level conversion IC makes use of an improved protection against voltage transients. Voltage transients can in electro-magnetically loaded surroundings (e. g. in industrial applications) be induced in the interface cables and thus destroy connected electrical circuits. By means of jumpers the data lines RxD0 (PortE.0), TxD0 (PortE.1) and RxD1 (PortD.2), TxD1 (PortD.3) can through the Controller be connected to the level converter. During quiescent condition (no active data transmission) a negative voltage of several volts can be measured on Pin TxD against GND. RxD is of high impedance. The 9 pole SUB-D socket of the application board carries RxD0 on Pin 3 and TxD0 on Pin 2. Pin 5 is the GND connection. No handshake signals are being used for serial data transmission. The second serial interface is lead to a 3 pole pin strip. Here RxD1 occupies Pin 2, TxD1 occupies Pin 1 while Pin 3 is GND.

The cable with connection to the NRZ Pins TxD, RxD and RTS may have a length of up to 10 meters. It is recommended to use shielded standard cables. When using longer lines or non-shielded cables interferences may detract correct data transmission. Only use cables of which the pin assignments are known.

➔ Never connect the serial transmission outputs of two devices directly together! Transmission outputs can usually be identified by their negative output voltage in quiescent condition.

Testing Interfaces

The 4 pole pin strip X16 is to be used for testing purposes only and will not necessarily be armed with components of any kind on every application board. For the user this pin strip is of no importance.

One further testing interface is the 6 pole pin strip (two rows at 3 pins each) at the lower right next to JP4. This pin strip too is only meant for internal use and may likely no longer be fitted with components in future board series.

Technical Data Application Board

Note: Detailed information's can be found in the IC manufacturer's PDF files on the C-Control Pro Software CD-ROM.
All voltage specifications are referring to direct current (DC).

Mechanics	
Overall measurements, appr.	160 mm x 100 mm
Pin pitch wiring field	2.54 mm
Environmental Conditions	
Range of admissible ambient temperature	0°C ... 70°C
Range of admissible relative ambient humidity	20% ... 60%

Power Supply	
Range of admissibly operating voltage	8V ... 24V
Power consumption without external loads	appr. 125mA
Max. admissibly permanent current from a stabilized 5V power supply	200mA

2.1.7.1 External RAM

The Application Board of **Mega128** carries external RAM. This RAM is automatically recognized by the Interpreter and used for the program to be carried out. For this reason a program memory of appr. 63848 Bytes rather than appr. 2665 Bytes is available. For this it is not necessary to newly compile the program.

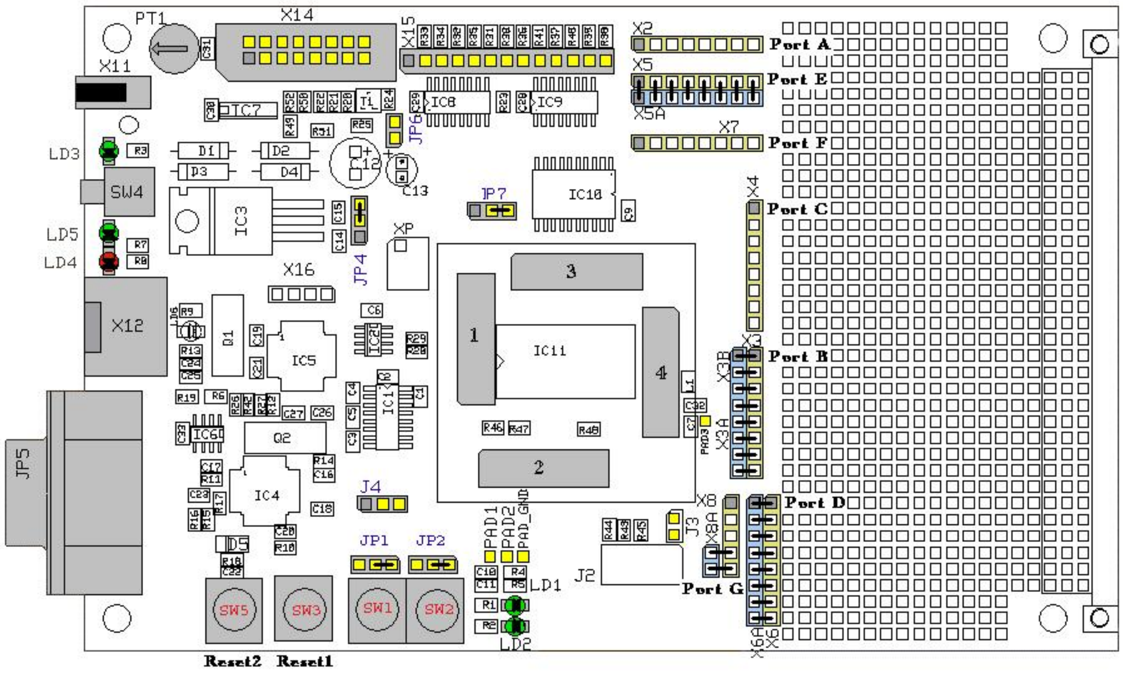
➔ If the SRAM is not needed it can be deactivated by JP7 and the ports will be free for other uses.

To deactivate the SRAM the jumper JP7 has to be moved to the left side (orientation: serial interface shows to the left), such that the left pins of JP7 are connected.

2.1.7.2 Jumper Application Board

Jumper

By use of jumpers certain options can be selected. This applies to several ports which are provided with special functions (see Pin Assignment Table for M128). E. g. the serial interface is realized through Pins PortE.0 and PortE.1. If the serial interface is not being used then the corresponding jumpers can be removed and these pins will then be available for other functions. Besides the port jumpers there are additional jumpers which are described in the following.



Jumperpositionen im Auslieferzustand

Ports A through G

The ports available with the Mega128 Module are inscribed in this graph. Here the yellow side is connected to the module while the light blue side connects to the components of the application board. If any jumper is pulled then the connection to the application board is suspended. This may lead to obstructions of USB, RS232, etc. on the board. The gray marking indicates the first Pin (Pin 0) of the Port.

JP1 and JP2

These jumpers are assigned to push buttons SW1 and SW2. There is the possibility to operate the push button against both GND or VCC. In the basic setting the push buttons are switching to GND.

JP4

JP4 serves to toggle the operating voltage (Mains Plug-In Power Supply or USB). The application board should be operated using Plug-In Power Supply and voltage control (Shipping Condition). The maximum current to be drawn from the USB interface is lower than from the Plug-In Power Supply. Exceeding this current can lead to damage on the USB interface of the computer.

JP6

When using the displays the LED back lighting can be switched off by use of JP6.

JP7

If the SRAM on the application board is not needed it can be de-activated by use of JP7. These ports will then be available to the user.

➔ To deactivate the SRAM the jumper has to be moved to the left side (orientation: serial interface shows to the left), such that the left pins of JP7 are connected.

J4

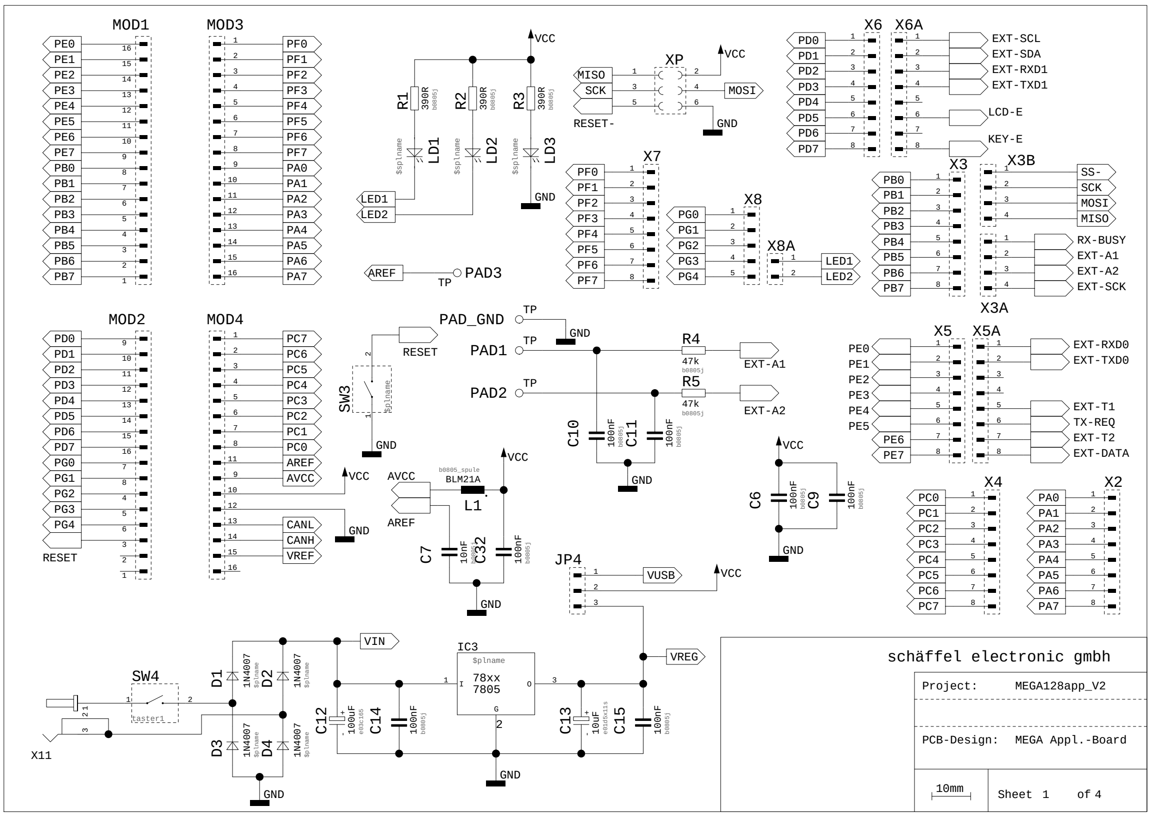
To jumper J4 the second serial interface of the Mega128 is connected through a level converter.

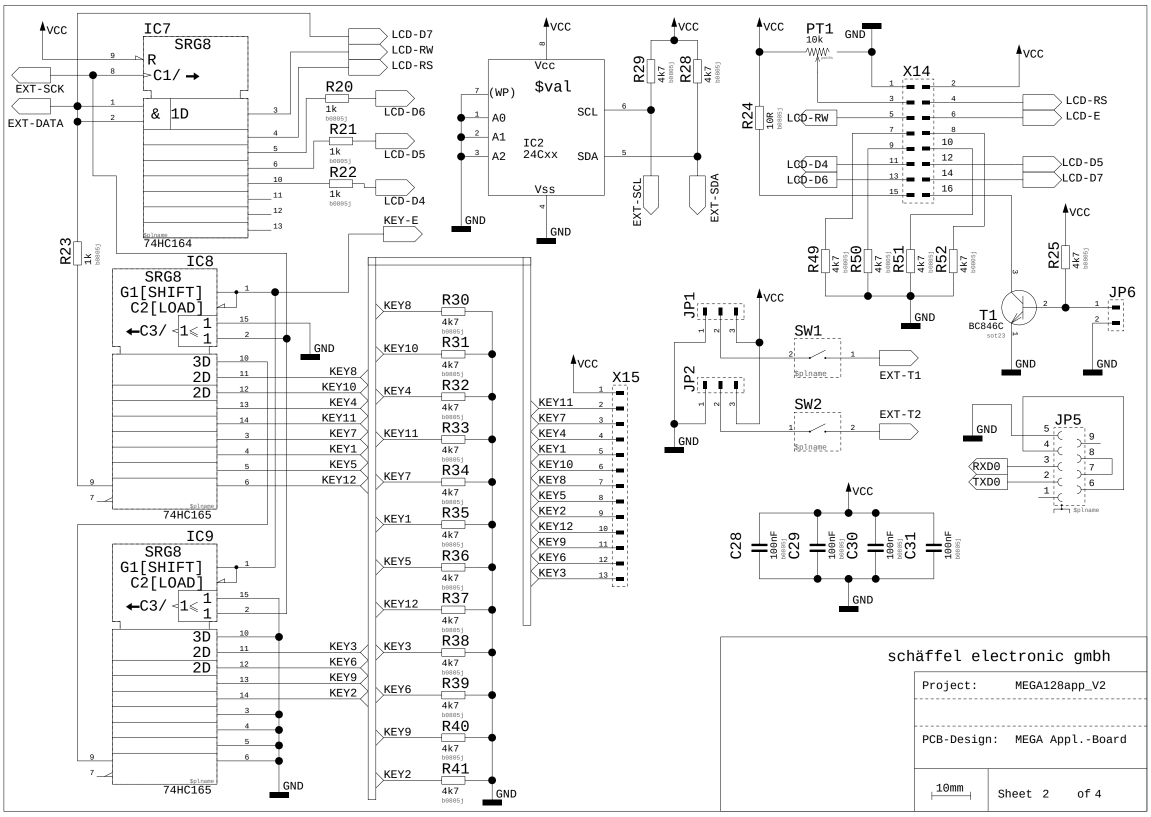
Pin 1 (left, gray)	**TxD**
Pin 2 (center)	**RxD**
Pin 3 (right)	**GND**

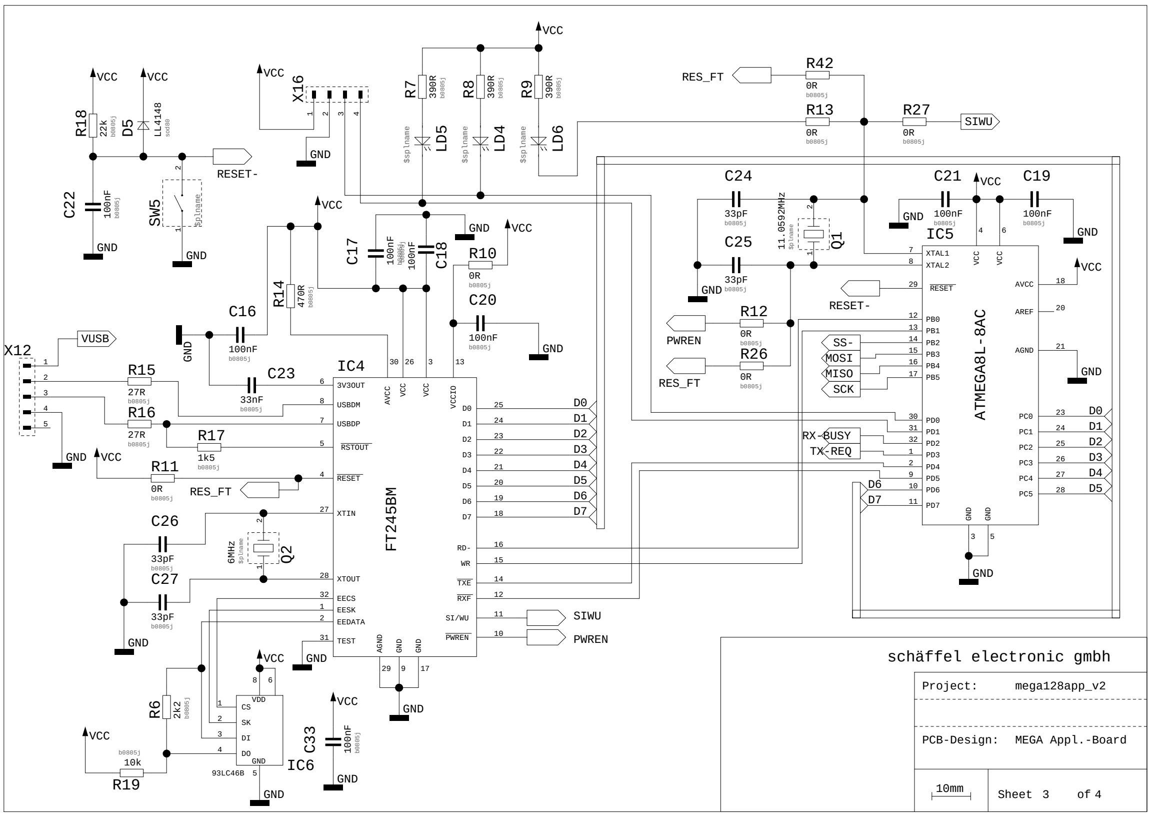
PAD3

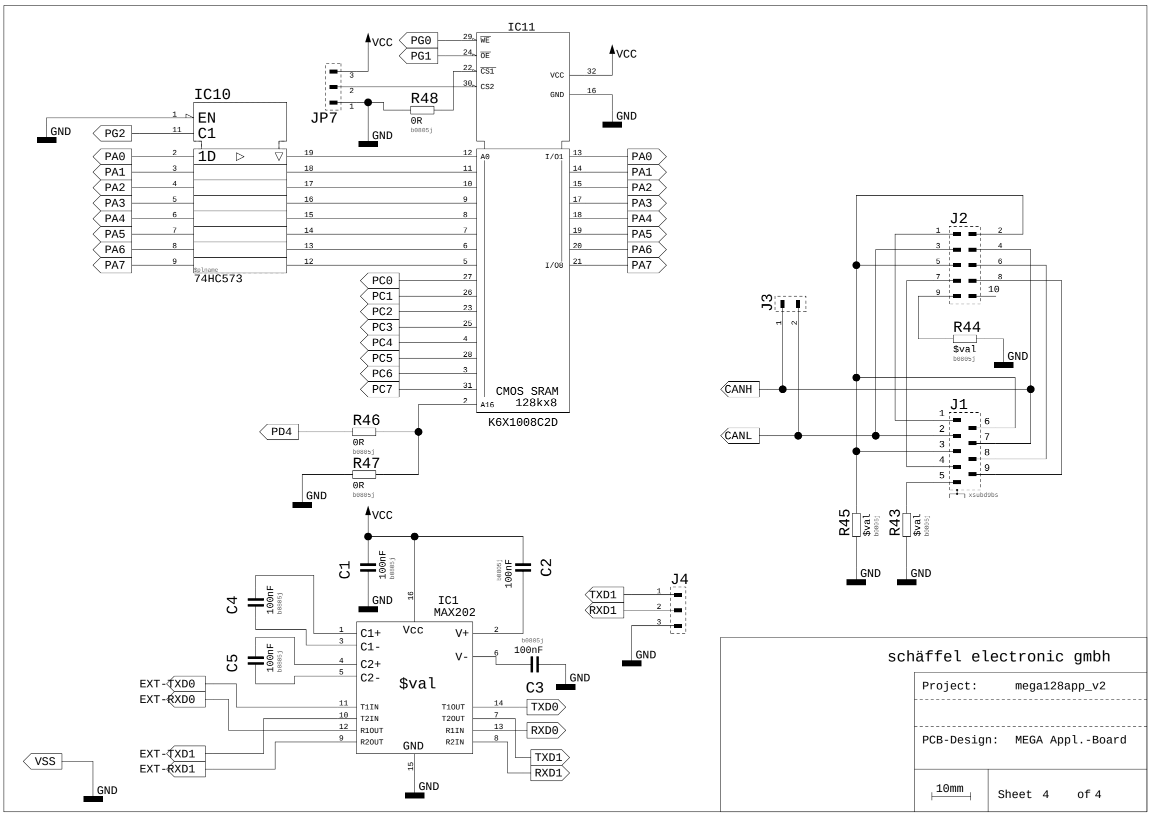
PAD3 (to the right of the module) is required as ADC_VREF_EXT for functions ADC_Set and ADC_SetInt.

2.1.7.3 Connection Diagram

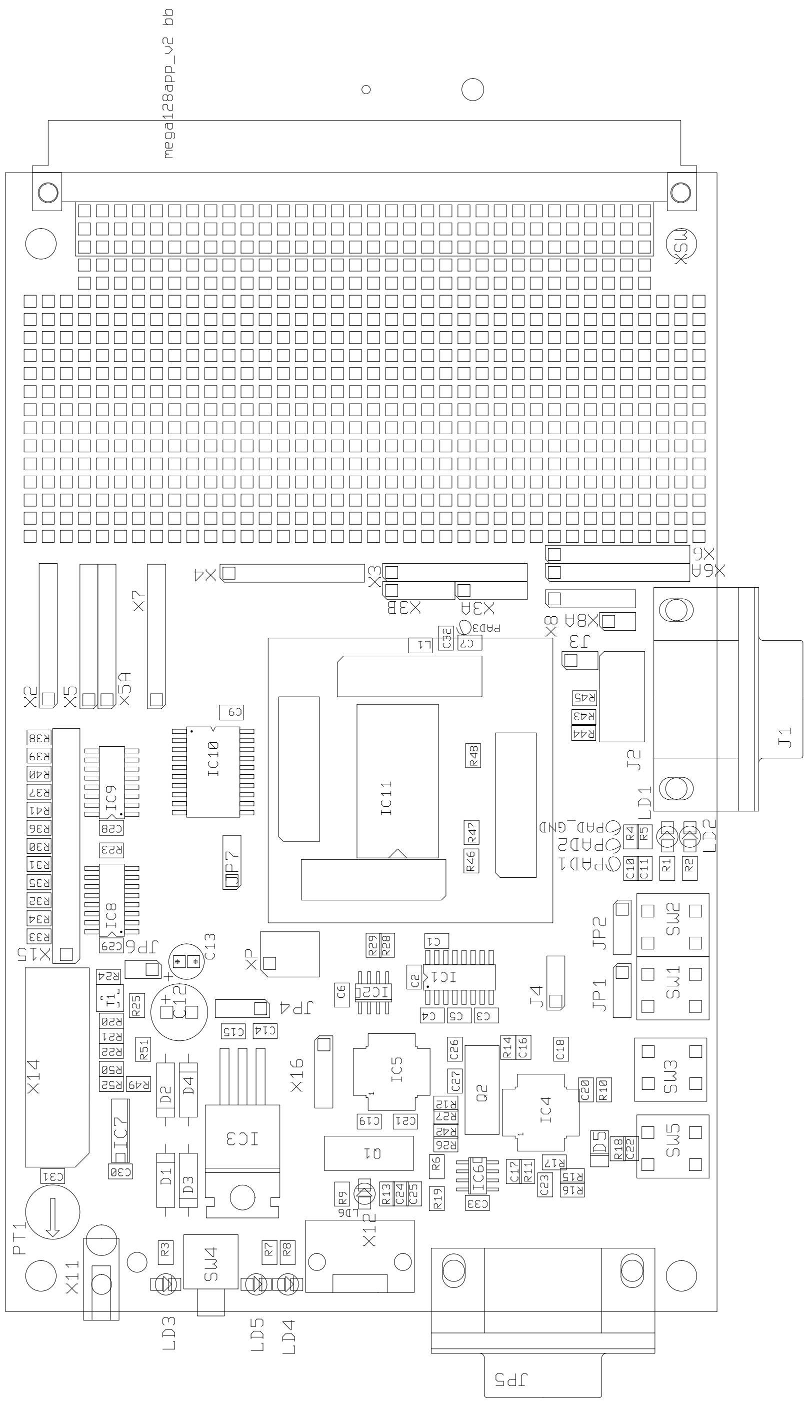





schäffel electronic gmbh
Project: mega128app_v2
PCB-Design: MEGA Appl.-Board
10mm
Sheet 3 of 4
FT245BM
IC4
ATMEGA8L-8AC
IC5
93LC46B
IC6
X12
X16
VUSB
RESET-
RES_FT
SIWU
PWREN
RX-BUSY
TX-REQ
SS-
MOSI
MISO
SCK
D0
D1
D2
D3
D4
D5
D6
D7
6MHz
11.0592MHz
VCC
GND

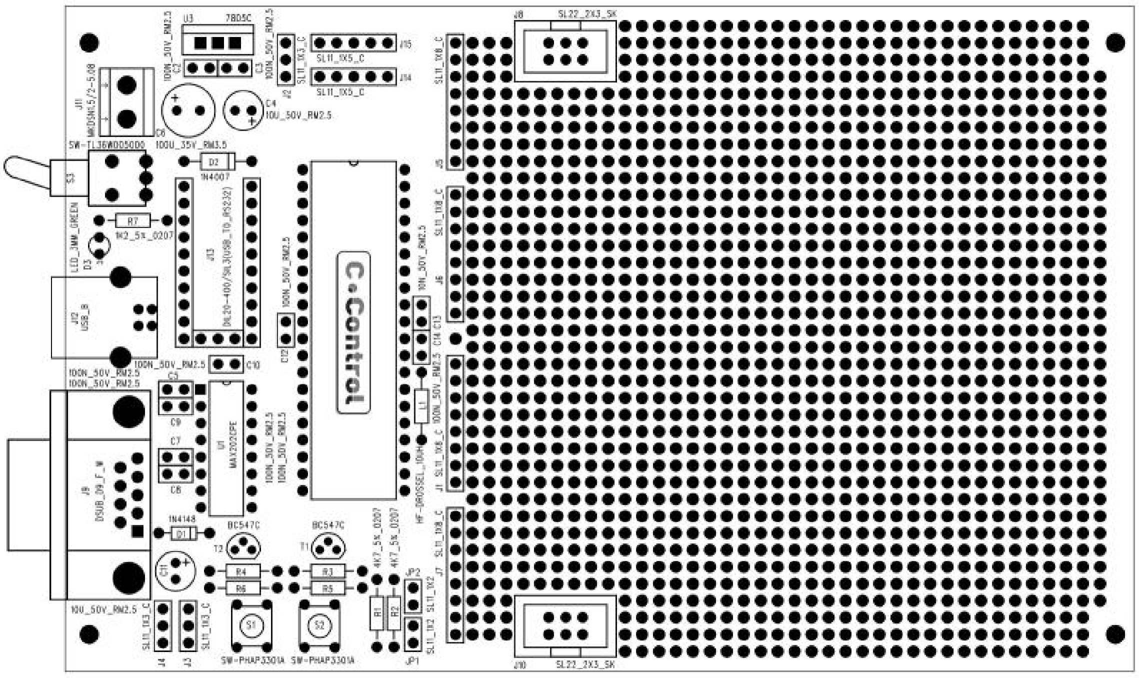

schäffel electronic gmbh
Project: mega128app_v2
PCB-Design: MEGA Appl.-Board
10mm
Sheet 4 of 4
IC10
74HC573
IC11
CMOS SRAM 128kx8
K6X1008C2D
IC1
MAX202
JP7
J1
J2
J3
J4
CANH
CANL
EXT-TXD0
EXT-RXD0
EXT-TXD1
EXT-RXD1
TXD0
RXD0
TXD1
RXD1
VSS
PD4
PG0
PG1
PG2
VCC
GND

2.1.7.4 Component Parts Plan



2.1.8 Mega32 Projectboard

The C-Control Projectboard PRO32 (Conrad Item no. 197287) provides a economic alternative to the application board MEGA32 (Conrad-Order no. 198 245). Compared to the C-Control Pro application board, it's range of functions is significantly limited, and is used mainly for own hardware developments related to the MEGA32 UNIT. The Projectboard includes the most important components needed to operate the MEGA32 UNIT. Furthermore, the Projectboard features a power supply (USB / AC adapter), a interface converter (RS232) and a large prototype area available for own development. By default, the Projectboard is designed for programming via RS232. Optionally, the RS232-USB converter (Conrad-Order no. 197 257) can be used for programming the MEGA32 UNIT via USB. In this case the programming is done via the serial connection of the MEGA32 UNIT (UART), so the program transfer is not as fast as the USB transfer on the application board MEGA32.



- The MEGA32 UNIT is so plugged that the signature of the UNIT is readable, if the programming and power connectors show out to you.

- In the baseline condition with no-USB-RS232 converters the jumpers J4/J3 are put like shown in the figure.

➔ When using the RS232-USB converter (not included), the jumper must be reconnected to USB.

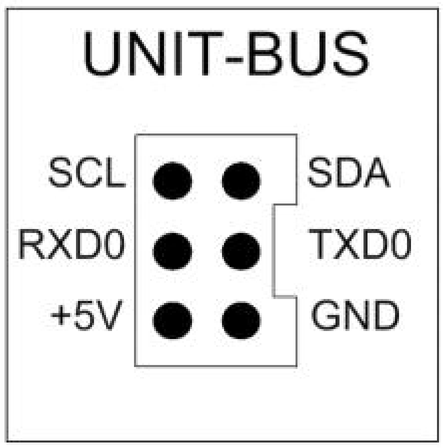
- The jumper J2 is used to select the supply voltage. With the jumper set to "network", the clamps J11 are used for the power supply (stabilized DC power supply or power adapter min. 100mA, depending on application). If the jumper J2 is replugged to USB, the board can be operated via the USB power supply of the computer.

➔ Attention! A maximum current of 100mA through USB should not be exceeded!

- The switch S3 and the power supply pin headers JP7/JP5 and the pins for Vcc / GND on the prototype area are no longer energized when using USB operation. This supply is used only for test applications, when there is no external power supply available.

- The appropriate COM port (serial port) must be selected in the C-Control Pro IDE software. Also the programming via USB is made through the serial interface of the C-Control PRO32 UNIT. Prior to that check, when necessary, the Windows device manager, which COM ports are available, or which was installed by the RS232-USB converter.

- If the I2C bus is used, the jumper JP2 and JP1 have to be inserted, if you provide no external pull-up resistors by your own.



- The bus unit is used to connect I2C-bus expansion modules of the CC1-family and can be used for custom applications. The interface layout can be found in the figure.

- The ports of the MEGA32 UNIT are passed out on headers J1, J5, J6 and J7.

- Before you can transfer a program in the unit, the key (BOOT / STOP) must be pressed, to switch the C-Control PRO32 into programming mode.

- When the voltage is supplied, the user program stored in the memory of the C-Control MEGA32 is started automatically. This program can be stopped with the (BOOT/STOP) button. Then the C-Control PRO32 is in BOOT mode, which is required for program transmission.

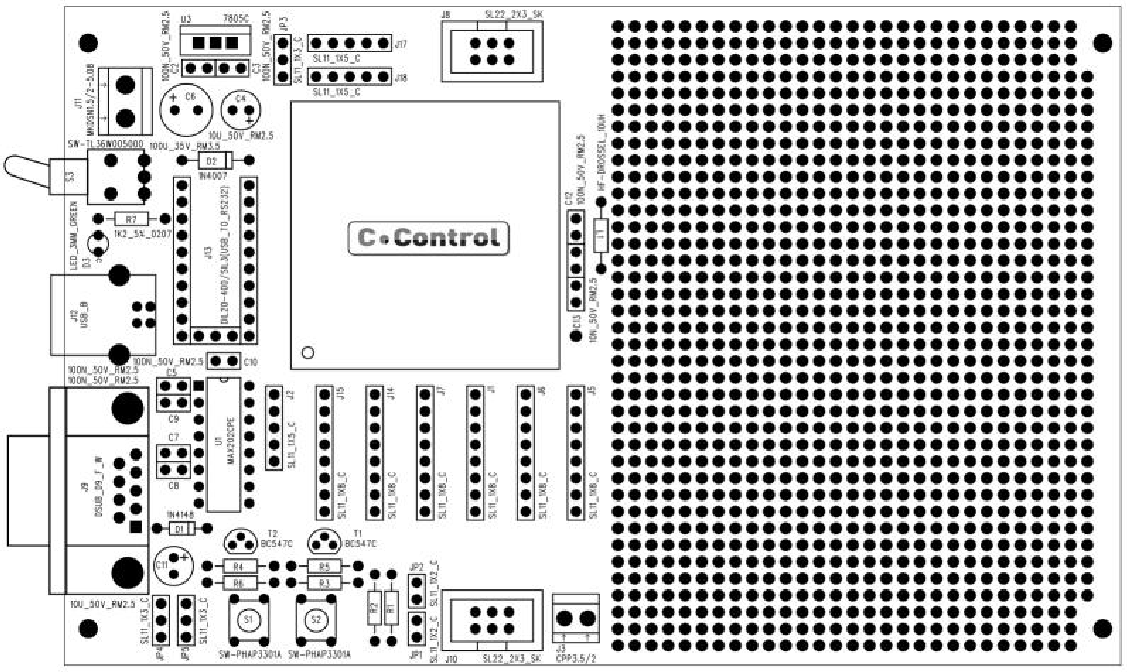
- The program start can be triggered via the IDE or on the button (RESET / START).

- When using Msg_Write... to output variables, it is advisable to use the software start from the IDE.

Technical data
Operating voltage: 8 - 16V DC
Current consumption without load and without external USB-RS232 Converter: about 40mA
Max continuous current from the stabilized 5V voltage: 100mA (without cooling)
Prototype area: 2.54 mm
Range of the permissible ambient temperature: 0 ° C to 70 ° C
Admissible relative humidity environment .. 20-60% non-condensing
Dimensions: 60 * 100 * 21mm (including MEGA32 UNIT)

2.1.9 Mega128 Projectboard

The "C-Control PRO 128 Projectboard" (Conrad Item no. 197313) provides a economic alternative to the "Application-Board MEGA128" (Conrad-Order no. 198258). Compared to the C-Control Pro application board, it's range of functions is significantly limited, and is used mainly for own hardware developments related to the "MEGA128 UNIT" and the "MEGA128CAN UNIT". The Projectboard also offers a connector "J3", which provides the CAN bus interface of the "MEGA128CAN". On the Projectboard the "MEGA128" or the "MEGA128CAN" can optionally be used. The Projectboard PRO 128 includes the most important components needed to operate the "MEGA128 UNIT". Furthermore, the Projectboard features a power supply (USB/AC adapter), a interface converter (RS232) and a large prototype area available for your own development. By default, the Project Board is designed for programming via RS232. Optionally, the RS232-USB converter (Conrad-Order no. 197257) can be used for programming the "MEGA128 UNIT" via USB. In this case the programming is done via the serial connection of the "MEGA128 UNIT" (UART), so the program transfer is not as fast as the USB transfer on the "Application-Board MEGA128".



- The "MEGA128 UNIT" is so plugged that the signature of the UNIT is readable, if the (RESET/RUN & BOOT/STOP) button shows to you.

- In the baseline condition with no-USB-RS232 converters the jumpers JP4/JP5 are put like shown in the figure.

➡ When using the RS232-USB converter (not included), the jumper must be reconnected to USB.

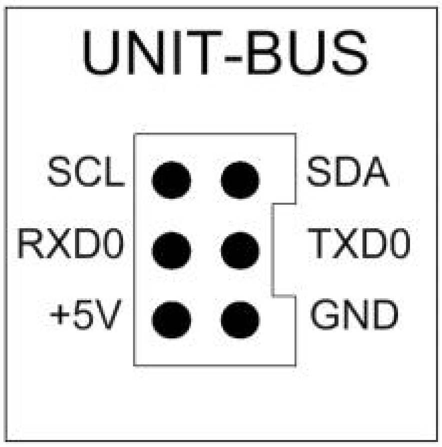
- The jumper J2 is used to select the supply voltage. With the jumper set to "network", the clamps J11 are used for the power supply (stabilized DC power supply or power adapter min. 100mA, depending on application). If the jumper J2 is replugged to USB, the board can be operated via the USB power supply of the computer.

➡ Attention! A maximum current of 100mA through USB should not be exceeded!

- The switch S3 and the power supply pin headers J17/J18 and the pins for Vcc / GND on the prototype area are no longer energized when using USB operation. This supply is used only for test applications, when there is no external power supply available.

- The appropriate COM port (serial port) must be selected in the C-Control Pro IDE software. Also the programming via USB is made through the serial interface of the C-Control "MEGA128 UNIT". Prior to that check, when necessary, the Windows device manager, which COM ports are available, or which was installed by the RS232-USB converter.

- If the I2C bus is used, the jumper JP2 and JP1 have to be inserted, if you provide no external pull-up resistors by your own.



- The bus unit is used to connect I2C-bus expansion modules of the CC1-family and can be used for custom applications. The interface layout can be found in the figure.

- The ports of the "MEGA128 UNIT" are passed out on headers J1, J2, J5, J6, J7, J14 and J15.

➡ For more information on the exact characteristics of the ports, see the documentation/help file in the C-Control Pro software.

- Before you can transfer a program in the unit, the button (BOOT/STOP) must be pressed, to switch the "MEGA128 UNIT" into programming mode.

- When the voltage is supplied, the user program stored in the memory of the "MEGA128 UNIT" is started automatically. This program can be stopped with the (BOOT/STOP) button. Then the "MEGA128 UNIT" is in BOOT mode, which is required for program transmission.

- The program start can be triggered via the IDE or on the button (RESET/START).

- When using Msg_Write... to output variables, it is advisable to use the software start from the IDE.

Technical data
Operating voltage: 8 - 16V DC
Current consumption without load and without external RS232-USB converter: 50 mA

Max continuous current from the stabilized 5V voltage: 100 mA (without cooling)
Prototype area: 2.54 mm
Range of the permissible ambient temperature: 0 ° C to +70 ° C
Admissible relative humidity environment .. 20 - 60% non-condensing
Dimensions: 160 x 100 x 23 mm (including "MEGA128 UNIT" or "MEGA128CAN UNIT)

2.2 AVR32Bit

2.2.1 Installation

In this chapter the installation of hardware and software of the C-Control Pro AVR32Bit is described.

➔ On delivery, the Autostart jumper is set. Please remove, otherwise no program transfer is possible.

2.2.1.1 Software

To get the current development software, sample programs, the manual and useful information, please visit: www.c-control.de The manual is also available as a help file in the development environment of the C-Control PRO IDE and the PDF file is in the installation folder of the C-Control Pro in the "Manual" directory.

Direct IDE Download Link: http://www.c-control-pro.de/updates/C-ControlSetup.exe

➔ For the time of software and USB driver installations the user must be registered as administrator. During normal operation of the C-Control Pro this is not necessary.

At the beginning of the installation first select the language in which the installation should take place. After that you can choose whether you want to install C-Control Pro into the standard path or whether you want to specify your own target directory. At the end of the installation process you will be asked if an icon should be created on your desktop.

When the installation process is completed you can choose whether you want to see the "ReadMe" file, have the shortform introduction displayed or directly start the C-Control Pro design platform.

MAC Address

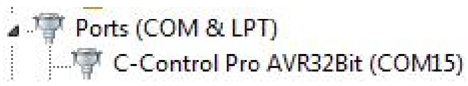
To avoid connection problems, the MAC address should be set to a new value in the C-Control Configuration before switching on the Ethernet support. To this end, its own MAC address is generated and supplied on a label for each C-Control Pro AVR32Bit. This label is located on the bottom of the UNIT.

See figure:

2.2.1.2 USB

Driver Installation

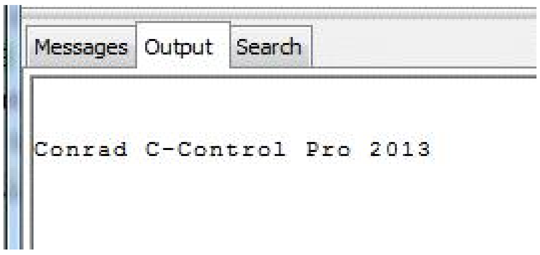
- Now connect the Unit with the supplied mini-USB cable to the PC (the cable is enclosed the Applicationboard or Mainboard). The PC is trying to install a driver for a "C-Control Pro AVR32" device. You can find the appropriate driver in the directory USB Driver\ AVR32 USB Driver in the installation directory of the C-Control Pro IDE.
- If all the connections are made, start the IDE.
- In the IDE the corresponding COM port (virtual serial port) must be selected. Check first in the windows device manager, which was the assigned COM port number (see illustration).


Ports (COM & LPT)
C-Control Pro AVR32Bit (COM15)

Picture device manager Comport

Drivers and software for the C-Control Pro do not support Windows operating system before Windows 2000.

Press the reset button on the C-Control PRO AVR32Bit UNIT. In the output of the IDE should now appear the following message:



```
Conrad C-Control Pro 2013
```

C-Control PRO IDE output after successful installation of the UNIT

Now you can already transfer a program to the Unit. The demo programs can be found if you click in the IDE under "Help" on "Demo Programs".

2.2.2 Firmware

The operating system of the C-Control Pro consists of the following components:

- *Bootloader*
- *Interpreter*

Bootloader

The boot loader is always available. It starts the interpreter or performs an upload when a new version of the interpreter is available.

- A power-on reset (turn power switch off and on) module brings the AVR32Bit always first in the boot loader (if the Autostart-Jumper is not set). This is a safety feature to always allow access, even if the interpreter should work incorrectly. In this state the UNIT can always be brought to its original condition with a "Reset Module".
- Pressing the reset button brings the module directly from the bootloader in the firmware when a valid interpreter is loaded. As a result, the number of USB driver interruptions are minimized during normal development.

Interpreter

The interpreter consists of several components:

- Bytecode Interpreter
- Multithreading support
- Interrupt processing
- User functions
- RAM and EEPROM interface

In the main, the interpreter executes the byte code that was generated by the compiler. Further, most library functions are integrated in interpreter so that the byte code program can e.g. access hardware ports. The RAM and EEPROM interface is used by the IDE debugger to get access to variables when the debugger has stopped at a breakpoint.

2.2.2.1 Autostart

Autostart

If the Autostart Jumper is set (J1 on AVR32Bit UNIT), the user program is started directly after a reset or a power on. Since the Autostart-Jumper bridges the connection to the Start/Stop button permanently, the Start/Stop button has no effect if the jumper is set.

➔ The library function ForceBootloader(), as well as a change in the "C-Control Configuration" AVR32Bit Unit options lead to an internal reset, where the Autostart behavior is ignored. This is done on purpose in order to make remote maintenance possible. In this case the user program can also be launched from the IDE, or a pressure on the reset button triggers Autostart again.

➔ On delivery, the Autostart jumper is set. Please remove, otherwise no program transfer is possible.

Remote Maintenance

To service an application with the AVR32Bit from afar, the application can use ForceBootloader() to jump into the bootloader. If the Autostart-Jumper is set, an update of the application would again start the program. You can prevent this, if you activate the Disable Autostart option in the C-Control configuration after a ForceBootloader. When the application update and the desired option changes are done, set Disable Autostart to off and restart the application from the IDE.

2.2.2.2 USB Troubleshooting

The USB Support C-Pro AVR32Bit Control is executed by the microcontroller itself, and not by an external chip, like e.g. on the C-Control Pro Mega Applicationboard. This is problematic as far as the Windows operating system does not always process interruptions of the USB system correctly. You will notice this in everyday life, when sometimes a USB device (stick, hard disk or USB-to-serial converter) only works when you plug it in a second time. To counteract this, several measures have been taken to minimize the number of USB restarts:

- The C-Control Pro AVR32Bit unit stays as long as possible in the firmware and seldom jumps to the bootloader like the C-Control Pro Mega Units.
- You can use the Start/Stop button to stop the Unit without having to perform a reset.
- Pressing the reset button skips the USB initialization in the boot loader, and starts the firmware directly. Only a power-on reset leaves the AVR32Bit module in the bootloader (if the Autostart-Jumper is not set).

➔ In rare cases, it may happen that the unit is not detected at power-on. This can be seen in the Windows device manager, if there C-Control AVR32Bit COM port does not appear when you turn on the unit. Please detach from the USB Hub (if any) and replug in, or if that does not help, perform a restart of Windows. Then the C-Control Pro Unit is recognized again.

➔ If the user program is started directly by a Autostart, no message "Interpreter started" is issued. The reason is that the USB subsystem needs up to 2 seconds to activate the virtual COM port. Since the user program starts running immediately, all the outputs of the first 2 seconds are lost. Also debug messages are not visible in this time with an active Autostart. A start of the program through the start button when the unit is in bootloader (e.g. after a power-on reset), behaves like a Autostart. Therefore, there are also no outputs in the first 2 seconds.

IDE does not respond

During the execution of programs on the AVR32Bit, overwriting foreign memory can have an impact to the IDE. In this case, the USB CDC protocol is no longer performed error-free by the AVR32, and the virtual COM port on the PC can get into a blocking state, that will the IDE only allow to accept data with delays (timeouts) . The IDE then no longer works properly. In normal case the IDE can be get out of this situation by pressing the reset button on the AVR32Bit module, but sometimes it just helps to quit the IDE with the Windows Task Manager.

2.2.3 Module

The C-Control Pro AVR32Bit UNIT (Conrad Order No.: 192573) is currently the fastest microcontroller unit of the C-Control Pro family (Atmel AT32UC3C1512C). The unit is equipped with a powerful AVR32 32-bit DSP microcontroller with FPU (Floating Point Unit) for the calculation of floating point numbers. This microcontroller has been specially designed for industrial and automotive applications, thus meeting a high standard of performance and reliability. The C-Control Pro AVR32Bit UNIT has already a wealth of facilities to peripheral, a web server, CAN-, µSD-, USB interface and much more is included for programming and debugging on this small unit.

To operate the UNIT you only need a stabilized 3.3V / 200mA power supply and a mini-USB cable to the Unit to connect to your PC. The easiest way to do this for development purposes is with the optional application board (Conrad Order No.: 192587). This board is specifically designed for the development of hardware and software and provides already a variety of additional peripherals.

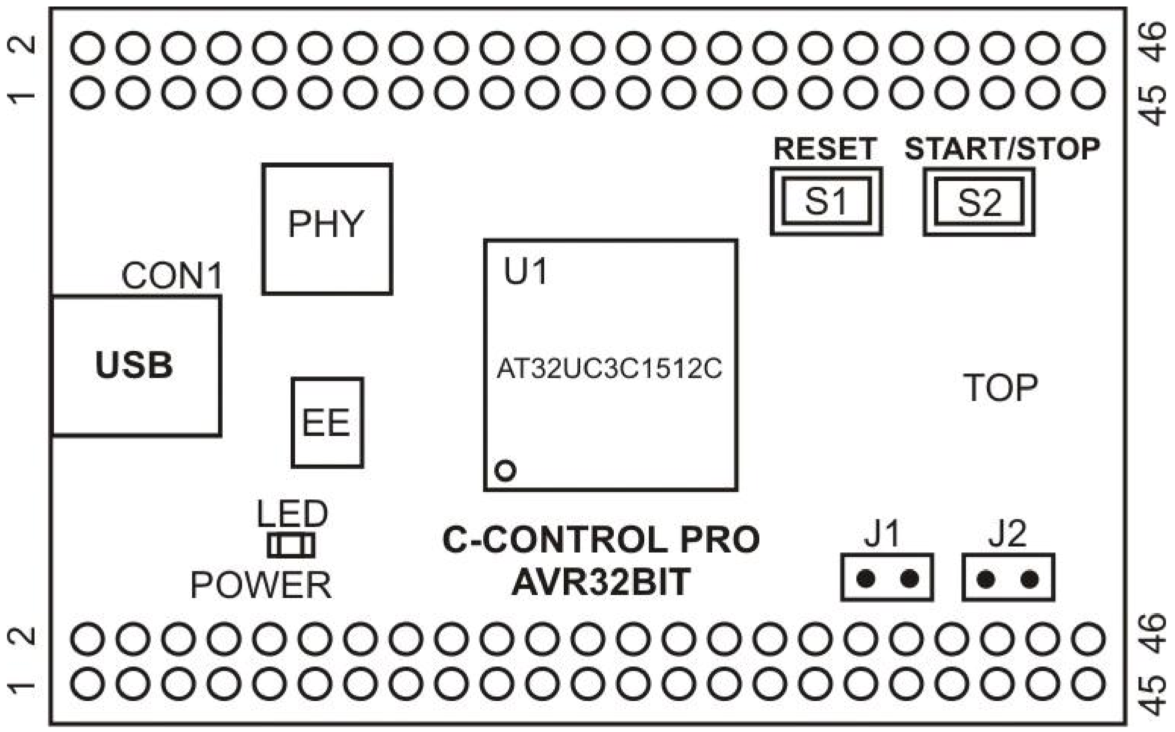
For rapid prototyping and small series also the AVR32Bit Mainboard (Conrad Order No.: 192702) can be used. This board can be expanded with additional boards depending on the application.

The programming of the AVR32Bit UNIT is made in the for several years proven and constantly improved C-Control Pro development environment in Basic, CompactC and graphically.

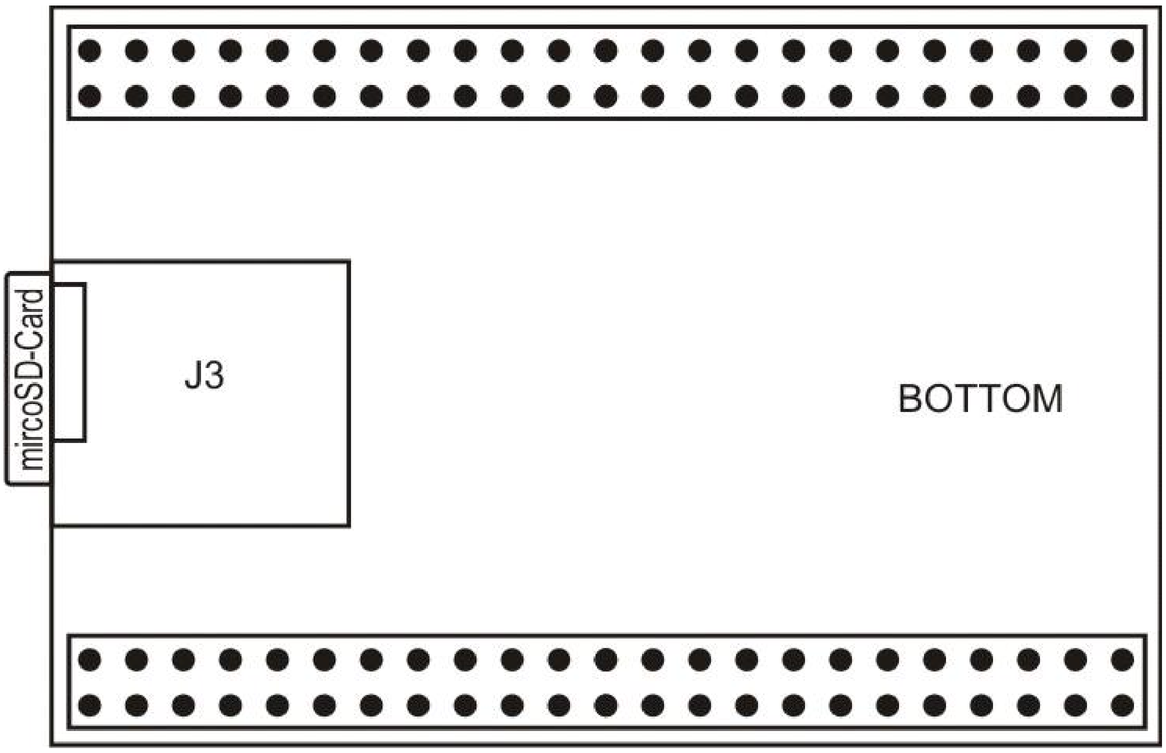
The Unit provides the following features:

- Powerful 32-bit microcontroller (91MIPS internal) 66 MHz clock
- 512 KB high-speed FLASH (160 KB reserved for interpreter)
- 64 KB high-speed SRAM (14 KB reserved for interpreter)
- 1x CAN bus (2.0A & 2.0B) with CAN driver + jumper enabled terminator
- 2x SPI interfaces
- 1x I2C (TWI)
- 2x voltage reference input for ADC
- 1x 16-channel 12-bit ADC
- 1x USB interface (Mini USB) for programming and debugging
- 3x USART interface (serial interface)
- 1x External I2C EEPROM 512 Kbit
- 1x Real Time Clock (RTC) with 32.768 kHz clock crystal
- 1x LAN interface (external LAN port)
- 1x µSD card holder (supports SDHC)
- 1x reference voltage input for DAC
- 2x Analog comparator
- 1x 4-channel 20-bit PWM Controller
- 2x 16-bit timer with 3 channels
- 7x interrupt inputs
- 57x digital inputs outputs (depending on the use of the other functions)
- Jumper selectable Autostart option
- Start-stop button
- Reset button
- 2 pin connectors, each with 2x23 pins in pitch 2.54mm
- Pinout in pitch 2.54mm, also ideal for breadboards

Scheme of the AVR32Bit Unit



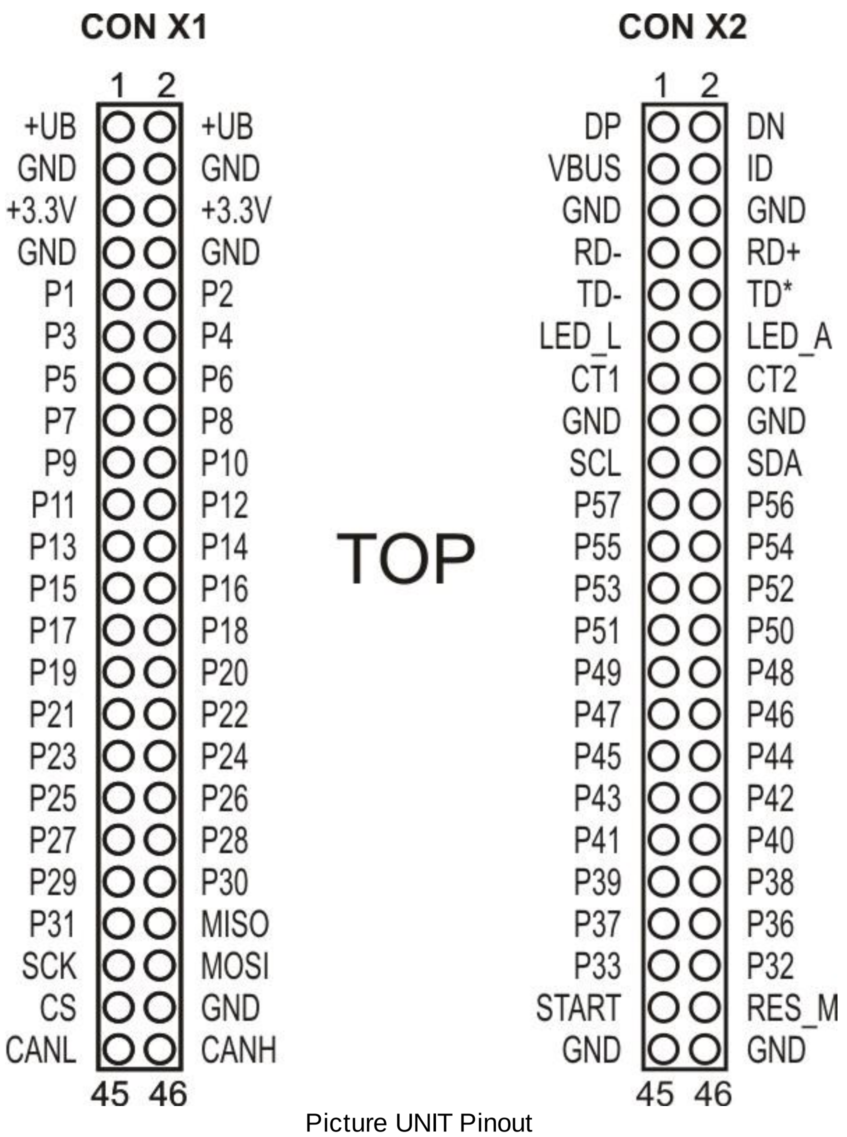
Picture UNIT (view from above)



Picture UNIT (view from below)

Jumper:
J1: enables Autostart of user application
J2: enables CAN 120Ohm terminator

Pin layout of the Module



Picture UNIT Pinout

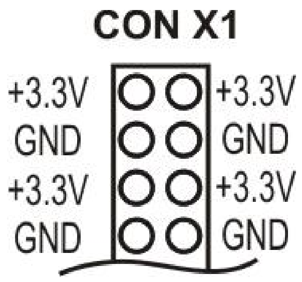
For a port list, see the chapter Pin Assignment.

Power Supply

The CON X1 Unit pins 3.3V and GND must be connected to a stabilized supply voltage. The four

3.3V and the GND pins are connected to each other! The "POWER" LED indicates that the Unit is receiving power.

The C-Control PRO UNIT has no inverse polarity protection, so the UNIT is destroyed by reversed polarity of the power supply!



Picture UNIT Power Supply

USB

Through the mini-USB connector, the C-Control Pro AVR32Bit module is connected to the PC. The USB port is used for programming and debugging of user software. All C-Control Pro UNIT's have a debugger. The debugger can set breakpoints and variables can be monitored and analyzed at runtime.

The module is not supplied with power via USB!

Reset

A reset causes the return of the micro-controller system in an initial state. The C-Control Pro Module AVR32Bit knows basically three sources of reset:

- Power-on reset: Executed automatically after switching on the operating voltage. The UNIT is then again in bootloader mode. It can be reset or a new module is transferred to the interpreter unit.
- Brown-out Reset: Automatically runs when the core voltage is less than 1.65V. This prevents the controller unit to get in undefined states at a drop of the supply voltage. If the voltage is significantly higher again, then the module starts anew.
- Hardware reset: Executed when the RESET button of the module is pressed.

Start/Stop Button

With the start/stop button, the program will start. In a renewed pressure, the program is stopped. A stop with this is preferable to the reset button, as with a reset, the USB subsystem is started again from scratch and the connection is renegotiated. Is the Autostart Jumper (J1) is inserted, the application is started directly after a reset and the start/stop button remains without effect.

Autostart

If the Autostart Jumper (J1) is inserted, the user program immediately restarts after a reset.

➡ On delivery, the Autostart jumper is set. Please remove, otherwise no program transfer is possible.

Clock Generation

The clock generation of the microcontroller is performed by a 12 MHz quartz crystal. In the controller the 12 MHz are clocked up to 66Mhz with a PLL-oscillator. All timings of the controller, as well as the 48Mhz of the USB subsystem are derived from this clock.

Real-Time Clock

The C-Control Pro AVR32Bit Unit has a separate oscillator with a 32.768 kHz clock crystal. This precise quartz watch can be set and read by software. This clock is ideal for applications such as time-accurate timers, etc.

Digital Ports

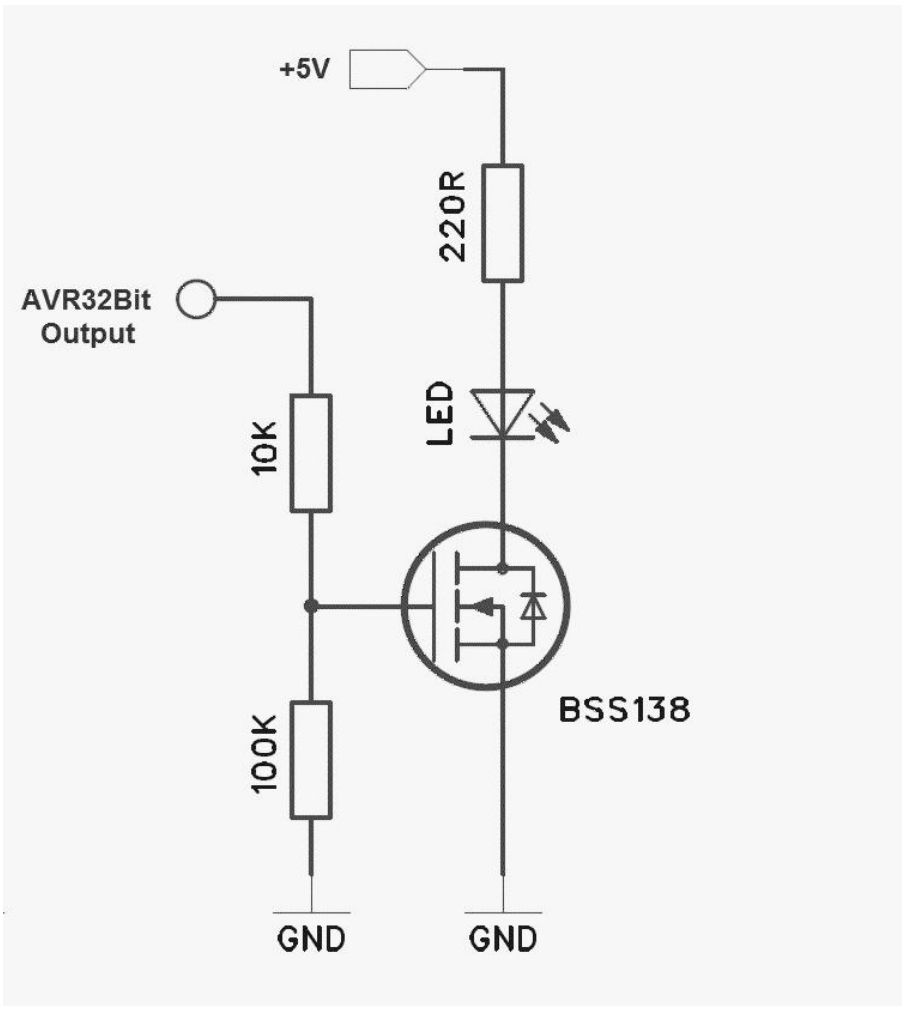
The C-Control Pro AVR32Bit module has 57 digital inputs and outputs that can be used with special functions such as PWM, ADC, etc. depending on the configuration. You can connect the digital inputs/outputs to for e.g. buttons with pull-up/pull-down resistors, digital ICs, optocouplers or driver circuits that are connected to relays. The pins are addressed individually, bitwise in each port. Each pin can be either input or output.

➡ **Never connect two pins that are configured as outputs at the same time. This can destroy the C-Control Pro AVR32Bit UNIT!**

Digital input pins are high impedance or connected with an internal pull-up/pull-down resistors and lead an applied voltage signal to a logical value. The prerequisite is that the signal voltage is within the specified range for low or high level. In the further processing of the program, the logical values of individual input pins are represented as 0 ("low"), or 1 ("high"). Output ports can output digital voltage signals via an internal driver circuit. Connected circuits can draw a certain current of the ports (at high level) or supply in these (at low level).

➡ **Never connect a voltage greater than 3.6V to one of the pins of the C-Control Pro AVR32Bit UNIT!**

Note the maximum load current for a single port and for all ports in total. Exceeding the maximum values can lead to the destruction of the C-Control Pro AVR32Bit module. After a reset each pin is initially configured as input. Use certain functions to change the data direction.



Since the outputs of the AVR32Bit Unit can not be overly stressed, a small driver stage should always (see picture) be used downstream. In the example an LED is driven, according to consumer a corresponding FET or transistor must be used. This circuit is used for loads up to 100mA. For inductive loads a freewheeling diode must be connected in parallel to the load.

➡ **With the C-Control Pro AVR32Bit UNIT pins are no longer configured with "Port_DataDir" or "Port_DataDirBit"! Since the AVR32Bit UNIT offers more options to configure the pins, here the function "Port_Attribute" is introduced.**

➡ **It is important to study the pin assignment of the AVR32Bit before programming, since important functions of the program development (eg, LAN, USB) are on certain pins.**

ADC Reference Voltage

The microcontroller has an Analog-to-Digital converter with a selectable resolution of 8/10/12 bits. This means that measured voltages can be represented as whole numbers from -2048 to 2048, since the AD-converter always works differential. In addition, an ADC preamplifier gain of 1, 2, 4, 8, 16, 32, 64 can be set by software.

The following reference voltage sources are available:

- 0,6 * VDDANA internal (0,6 * 3.3V = 1,98V)
- internal reference voltage of 1V
- two external reference voltage inputs, e.g. 2.048V generated by reference-voltage-IC

If "x" is a digital measurement value, calculate the corresponding voltage value "u" as follows:
The resolution depends on the configuration of the ADC.

Resolution	Maximal Value
8 Bit	-128 to +127
10 Bit	-512 to +511
12 Bit	-2048 to +2047

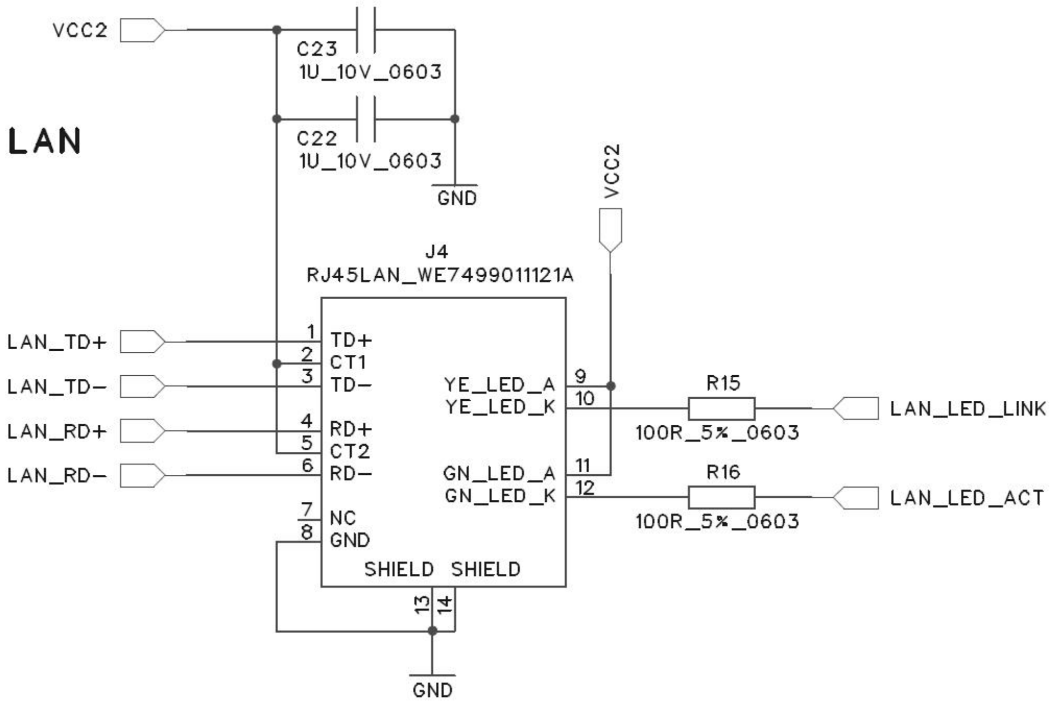
Formula for calculating the present ADC voltage:
u = x * reference voltage / resolution

CAN Terminating Resistor

Jumper (J2) enables the CAN bus 120 ohm termination resistorus. For more information on CAN-BUS and its properties, see the chapter CAN bus!

LAN

On pins VCC2 (+3.3 V), GND, RD, RD +, RD, TD +, LED_L and LEDA the connections for the LAN port are lead through. On the Applicationboard or Mainboard a LAN socket is already present, which is hardwired to the connectors of the UNIT. In their own applications, where the UNIT is used "stand alone", the user can retrofit an Ethernet jack himself like shown in the below diagram.



Technical Data

power supply VCC	3 to 3.6V Nominal 3.3V / >200mA (stabilized)
maximum voltage at the pins	-0.3V to 3.6V
maximum voltage at all pins (sum)	120mA
R_{PULLUP} I/O	5 to 26 kOhm
$R_{PULLDOWN}$ I/O	2 to 16 kOhm
input Low-level voltage I/O	0.3 * VCC
input high-level voltage I/O	0.7 * VCC
output low-level voltage I/O	-3.5 to -14mA dependent on configuration(1)
output high-level voltage I/O	3.5 to 14mA dependent on configuration(1)
deviation RTC	+/- 20ppm
environmental temperature (Ta)	0 to 70°C
dimensions	60x40x8mm (without pin connectors)
weight	approx. 18g

(1) *-3.5/ 3.5mA and Pins are*: **PB02** (P57), **PC04** (P34), **PC05** (P35), **PC06** (P33).
-7/ 7mA and -14/ 14mA able Pins are: **PB06** (P7), **PB21** (P29), **PD02** (SPI0-SCK).
The remaining pins PAxx, PBxx, PCxx, PDxx work with -3.5/3.5 mA resp. -7/ 7mA. The pin

output driver strength is programmable with the Port_Attribute() function.

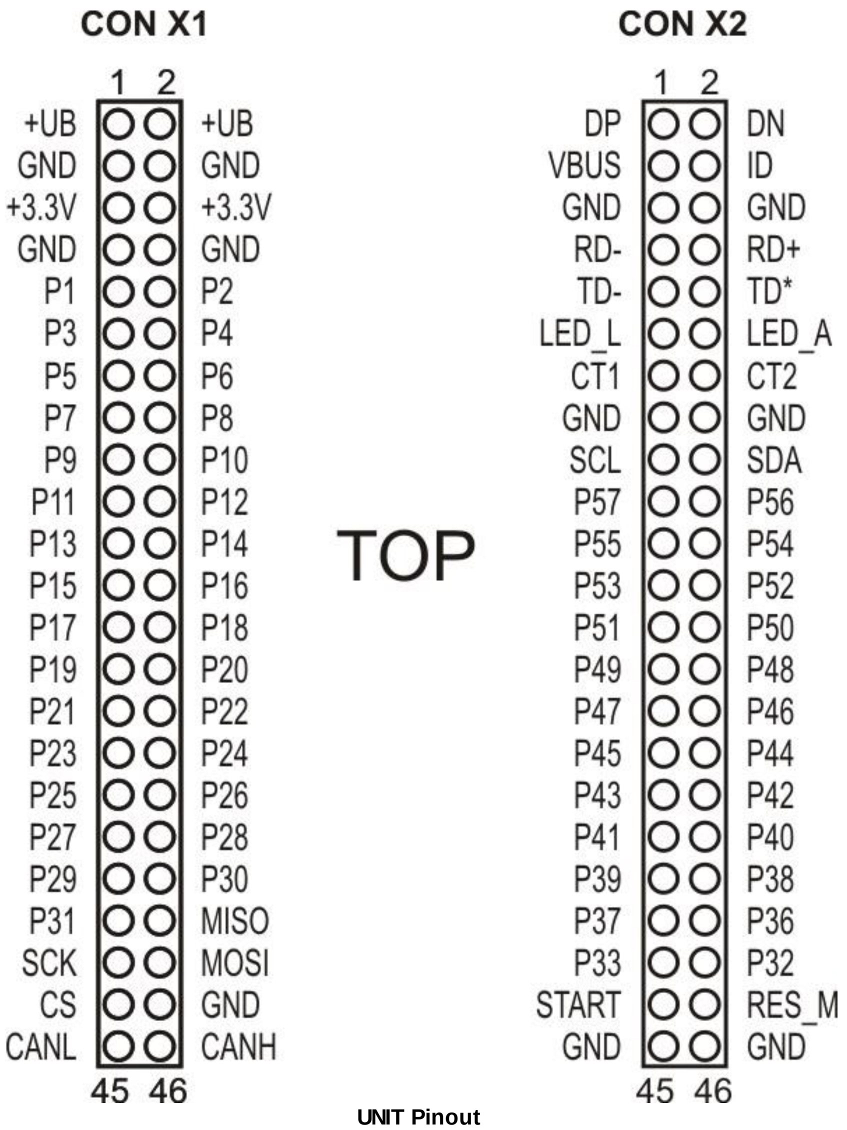
2.2.3.1 Pin Assignment

Port A through Port D are for direct pin functions (e. g. Port_WriteBit) counted from 0 through 127, see "PortBit".

Pin Assignment for C-Control Pro AVR32Bit Unit and Application Board

C-Control Unit Name	C-Control Module Pin	AVR32 Port Name	TQFP 100	GPIO	Function1	Function2	Appl. Board Function
P1	X1.09	PA00	1	0	CAN1-TX		
P2	X1.10	PA01	2	1	CAN1-RX		
P3	X1.11	PA02	3	2			
P4	X1.12	PA03	4	3		Ext Int1	
P5	X1.13	PB04	7	36	SPI1-MOSI		
P6	X1.14	PB05	8	37	SPI1-MISO		
P7	X1.15	PB06	9	38	SPI1-SCK		
P8	X1.16	PA16	22	16		ADCREF0	
P9	X1.17	PA04	10	4	ADC0		
P10	X1.18	PA05	11	5	ADC1		
P11	X1.19	PA06	12	6	ADC2	AC1AP1	
P12	X1.20	PA07	13	7	ADC3	AC1AN1	
P13	X1.21	PA08	14	8	ADC4	Ext Int2 AC1BP1	
P14	X1.22	PA09	15	9	ADC5		
P15	X1.23	PA10	16	10	ADC6	Ext Int4	
P16	X1.24	PA11	17	11	ADC7	ADCREF1	
P17	X1.25	PA19	25	19	ADC8		
P18	X1.26	PA20	28	20	ADC9	AC0AP0	
P19	X1.27	PA21	29	21	ADC10		
P20	X1.28	PA22	30	22	ADC11	AC0AN0	
P21	X1.29	PA23	31	23	ADC12	AC0BP0	
P22	X1.30	PA24	32	24	ADC13		
P23	X1.31	PA25	33	25	ADC14		
P24	X1.32	PA13	19	13	ADC15	AC1AN0	
P25	X1.33	PA12	18	12		AC1AP0	
P26	X1.34	PA14	20	14		AC1BP0	
P27	X1.35	PA15	21	15			

P28	X1.36	PB20	43	52	TIMER0-B		
P29	X1.37	PB21	44	53	COUNTA-1		
P30	X1.38	PB22	45	54	TIMER2-A		
P31	X1.39	PB23	46	55	TIMER2-B		
P32	X2.42	PC01	50	65	TIMER5-A		
P33	X2.41	PC06	57	70	COUNTA-2		
P34	X2.18	PC04	55	68	SDA (I2C)	Ext Int3	
P35	X2.17	PC05	56	69	SCL (I2C)		
P36	X2.40	PC17	65	81	USART3-TX	PWMH_0	
P37	X2.39	PC18	66	82	USART3-RX	PWML_0	
P38	X2.38	PC15	63	79	USART0-RX	PWMH_1	
P39	X2.37	PC16	64	80	USART0-TX	PWML_1	
P40	X2.36	PC19	67	83		PWML_2	
P41	X2.35	PC20	68	84		PWMH_2	PORT_T1
P42	X2.34	PC12	60	76		PWML_3	PORT_T2
P43	X2.33	PC11	59	75	COUNTA-0	PWMH_3	PORT_T3
P44	X2.32	PC13	61	77		Ext Int7	PORT_T4
P45	X2.31	PC14	62	78			PORT_T5
P46	X2.30	PC21	69	85			
P47	X2.29	PC22	70	86			
P48	X2.28	PC23	71	87			PORT_LED1
P49	X2.27	PC24	72	88			PORT_LED2
P50	X2.26	PC31	73	95	TIMER1-B		
P51	X2.25	PD07	78	103	USART4-TX	Ext Int5	
P52	X2.24	PD08	79	104	USART4-RX COUNTB-2	Ext Int6	
P53	X2.23	PD21	88	117			
P54	X2.22	PD22	89	118	TIMER4-A		
P55	X2.21	PD23	90	119			
P56	X2.20	PB19	42	51	TIMER0-A		
P57	X2.19	PB02	99	34	TIMER3-A		
---	X1.43	PD03	77	99			



UNIT Pinout

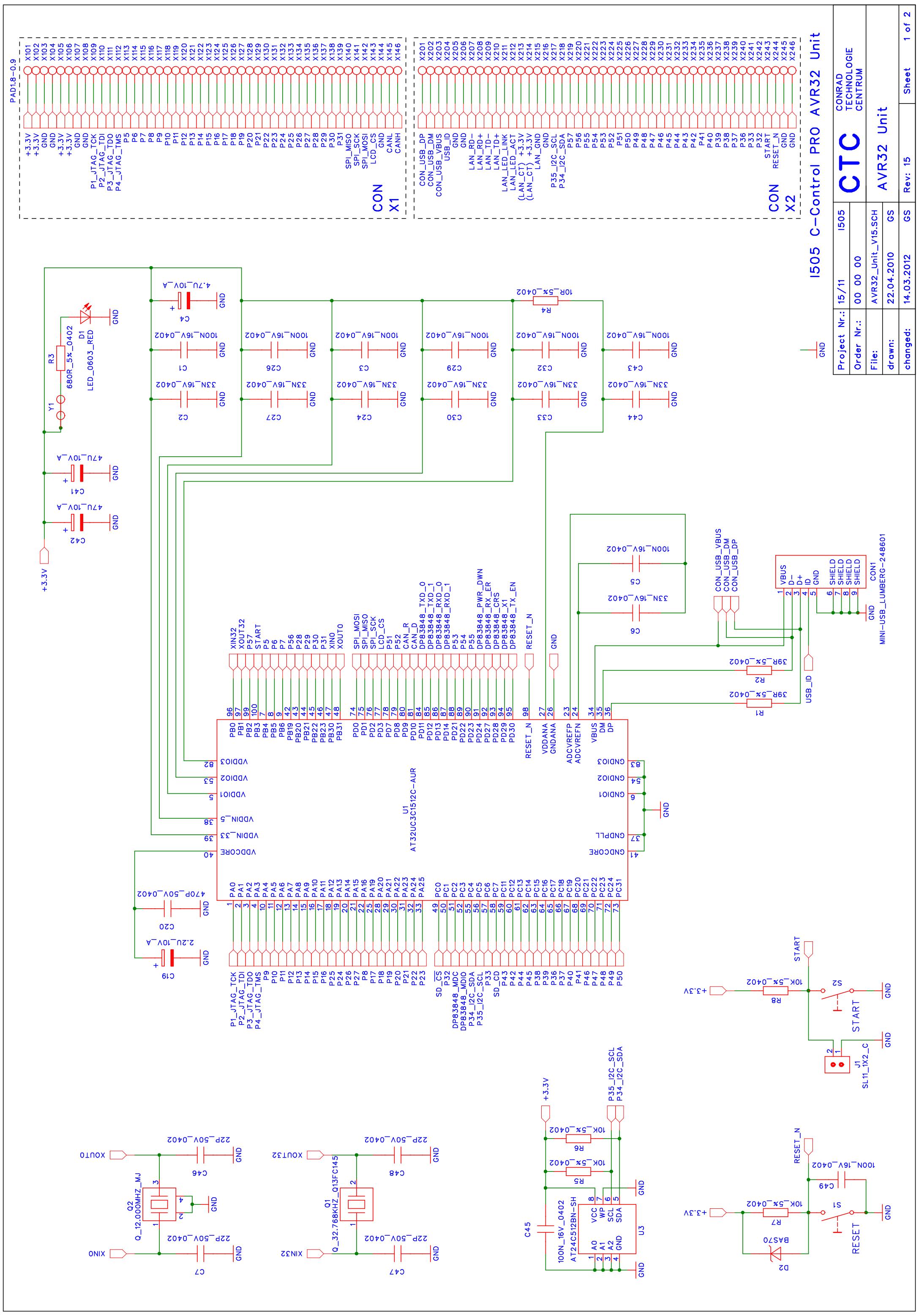
Hardwired Pins

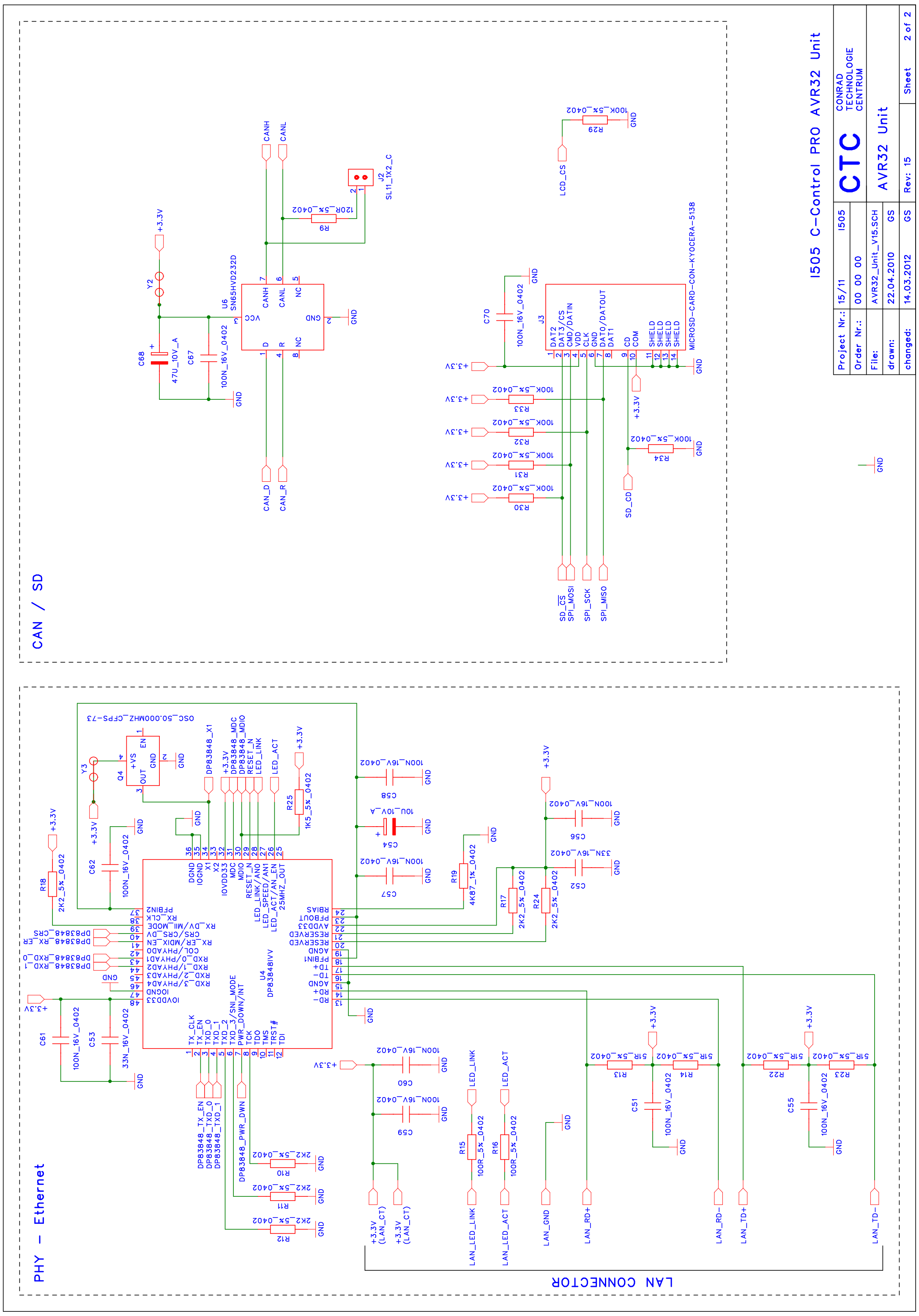
C-Control Module Pin	TQFP 100	AVR32 Port Name	GPIO	Function	I/O
X1.05, X1.06	5	VDDIO1			3,3V
X1.07, X1.08	6	GNDIO1			GND
	23	ADCVREFP			REF
	24	ADCVREFN			REF
	27	VDDANA			3,3V
	26	GNDANA			GND
	37	GNDPLL			GND
	38	VDDIN_5			3,3V

	39	VDDIN_33			3,3V
	40	VDDCORE			3,3V
	41	GNDCORE			GND
	53	VDDIO2			3,3V
	54	GNDIO2			GND
	82	VDDIO3			3,3V
	83	GNDIO			GND
	96	PB00	32	RTC	Xin32
	97	PB01	33	RTC	Xout32
	47	PB30	62	System Clock	Xin0
	48	PB31	63	System Clock	Xout0
X2.03	34	VBUS			USB-Debug
X2.02	35	DM			USB-Debug
X2.01	36	DP			USB-Debug
X2.43	100	PB03	35		Start-Button
X2.44	98	Reset_n			Reset-Button
	58	PC07	71	SD card	Card-Detect
X1.42	74	PD00	96	SPI	SPI0-MOSI
X1.40	75	PD01	97	SPI	SPI0-MISO
X1.41	76	PD02	98	SPI	SPI0-SCK
	49	PC00	64	SD-Card	SPI0-NPCS[1]
	93	PD28	124	MAC	MACB_CRS
	95	PD30	126	MAC	MACB_TX_EN
	51	PC02	66	MAC	MACB_MDC
	52	PC03	67	MAC	MACB_MDIO
	84	PD11	107	MAC	MACB_TXD[0]
	86	PD13	109	MAC	MACB_RXD[0]
	85	PD12	108	MAC	MACB_TXD[1]
	87	PD14	110	MAC	MACB_RXD[1]
	91	PD24	120	MAC	POWER_DOWN
	92	PD27	123	MAC	MACB_RX_ER
	94	PD29	125	MAC	MACB_TX_CLK
	80	PD09	105	CAN	CAN0_RX
	81	PD10	106	CAN	CAN0_TX
X1.45				CAN Driver	CAN0_LO

X1.46				CAN Driver	CAN0_HI
X2.07				PHY	LAN_RD-
X2.08				PHY	LAN_RD+
X2.09				PHY	LAN_TD-
X2.10				PHY	LAN_TD+
X2.11				PHY	LAN_LED_LNK
X2.12				PHY	LAN_LED_ACT
X2.13, X2.14				PHY	+3.3V (LAN_CT)
X2.15				PHY	LAN_GND

2.2.3.2 Connection Diagram


I505 C-Control PRO AVR32 Unit
CTC
CONRAD TECHNOLOGIE CENTRUM
AVR32 Unit
U1 AT32UC3C1512C-AUR
CON X1
CON X2
CON1 MINI-USB_LUMBERG-248601
U3 AT24C512BN-SH
START
RESET

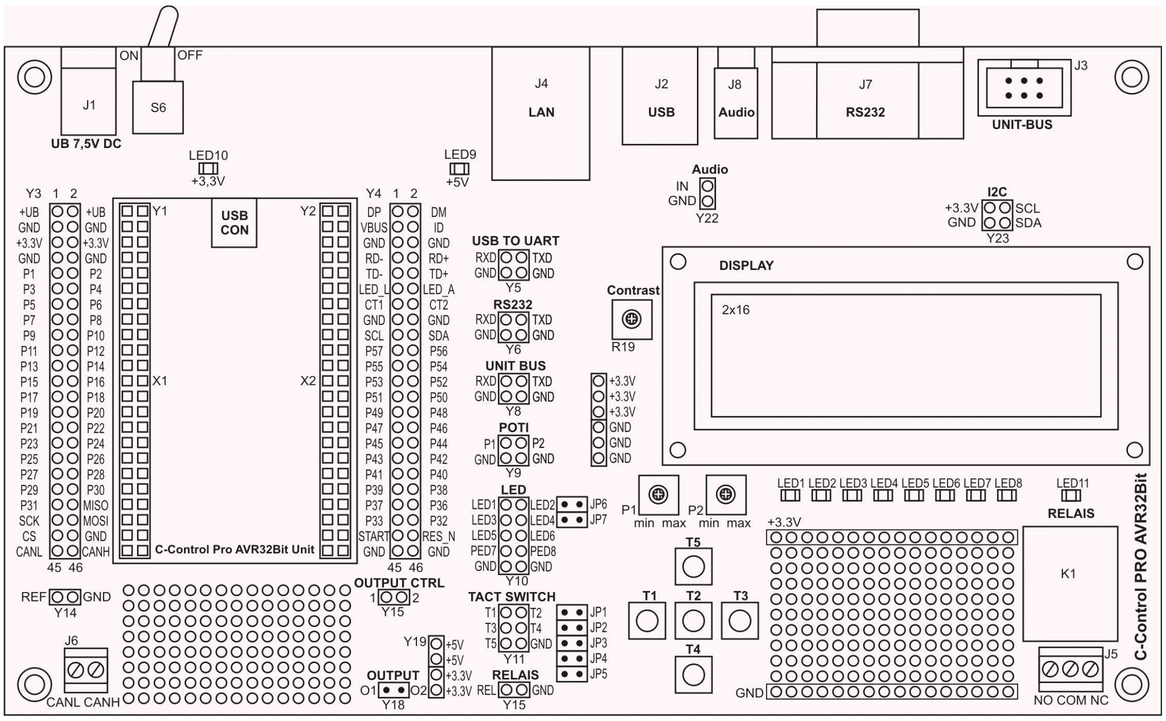

I505 C-Control PRO AVR32 Unit
CTC
CONRAD TECHNOLOGIE CENTRUM
AVR32 Unit
Project Nr.: 15/11 I505
Order Nr.: 00 00 00
File: AVR32_Unit_V15.SCH
drawn: 22.04.2010 GS
changed: 14.03.2012 GS
Rev: 15
Sheet 2 of 2
CAN / SD
PHY - Ethernet
LAN CONNECTOR
U6 SN65HVD232D
U4 DP83848IVV
J3 MICROSD-CARD-CON-KYOCERA-5138
OSC_50.000MHZ_CFPS-73

2.2.4 Applicationboard

The C-Control PRO AVR32Bit Applicationboard (Conrad Order No.: 192587) is the standard development board for the C-Control PRO AVR32Bit UNIT. The application board contains all the components that are needed to operate the C-Control PRO AVR32Bit UNIT. In addition, the board has a very good and comprehensive peripheral equipment.

The board offers the following features:

- 1x power supply (3.3V & 5V)
- 1x on/off switch
- 1x LAN connector (RJ45)
- 1x 2.048V voltage reference
- 1x CAN port
- 1x Dual Power MOS-FET (2x Open Drain)
- 1x directional keys (5 buttons)
- 2x analog sensor (trimmer)
- 2x16 character LC display (blue/white)
- 1x contrast control for LCD
- 8x LED's with driver for signaling
- 1x power relay (24V/ 7A)
- 1x USB to UART converter
- 1x RS232 to UART converter
- 1x audio amplifier
- 1x UNIT-Bus (3.3V to 5V)
- 2x breadboard for custom circuitry



Applicationboard with Component markings

Installation / Commissioning

- The C-Control PRO AVR32Bit UNIT is attached that the mini-USB socket of the Unit shows in the direction of the on/off switch (see mark on Applicationboard).
- In base condition, the jumper (JP1 to JP7) for LED1, LED2 and keyboard are not plugged.
- The power supply of the Applicationboard occurs via a stabilized power supply or a laboratory power supply with an output voltage of 7.5V and a minimum current of 500mA.
- Install the C-Control PRO Development Environment "IDE" (Integrated Development Environment). See installation software.
- Install the USB driver.

Power Supply

The Applicationboard is powered by a stabilized plug-in or laboratory power supply (7.5 V/500mA). Depending on the additional circuitry of the application motherboards it may be necessary later to use a mains adapter with a higher power. Two fixed voltage regulators on the application board generate the stabilized internal supply voltage of 3.3V and 5V. The two LEDs LED9 and LED10 indicate the functionality of the power supply. All circuit components on the application board are supplied with these voltages (see diagram). On the board, some ports are available to allow you to tap out the different voltages. Make sure that the two voltage regulators are not getting too hot when using custom circuitry with higher loads. For larger loads, it is recommended to feed them externally!

The mass between external circuitry (power supply) and the Applicationboard must be the same!

The cooling surface of the voltage regulator is warm to hot during operation, depending on the connected consumer!

On/Off Switch

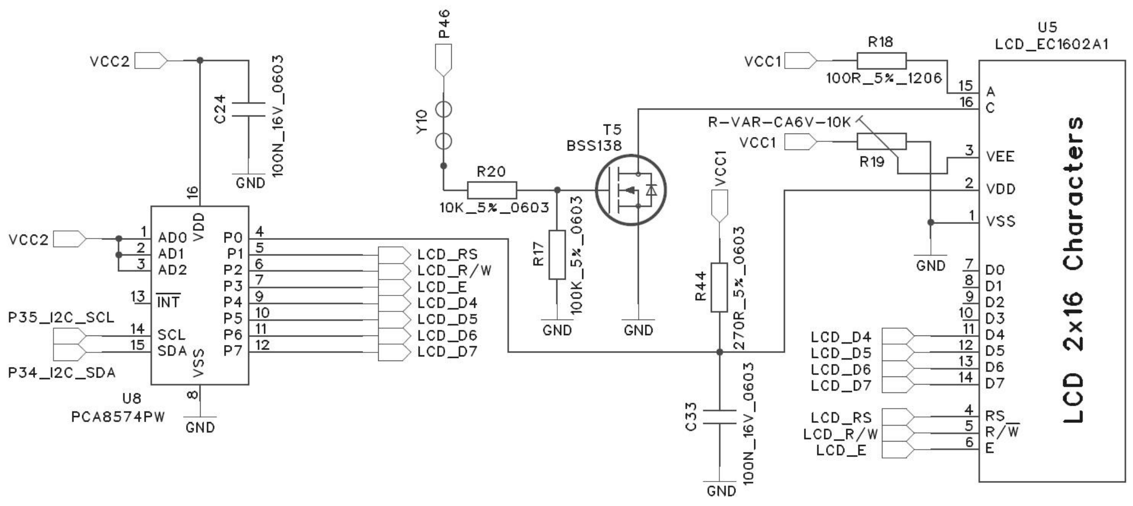
The switch S6 is located at the back, next to the power supply socket of the Applicationboard and is used to turn on/off the main power supply.

Jumper

The jumper JP1 to JP5 connect the buttons of the keyboard to the pins of the UNIT (T1 = P41, P42 = T2, T3 = P43, P44 = T4, T5 = P45). The jumpers JP6 and JP7 connect the LEDs LED1 and LED2 to the pins of the UNIT (P48 = LED1, LED2 = P49). See also Pin Assignment in AVR32Bit Module chapter.

LC-Display

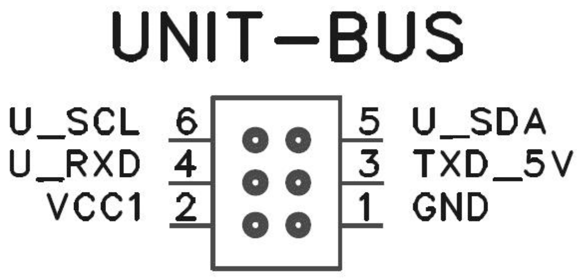
The LCD display is used to represent variables and characters. It is controlled via the I2C bus. A port expander (PCA8574) is available on the application board, which is responsible for communication between UNIT and LCD display over the I2C bus. The display is operated in 4-bit mode. Port P46 is responsible to turn the backlight on/off. The operating system provides a simple software interface for outputs to the display. The small circuit for driving the LCD can easily be applied to your own circuits. It will support most "standard dot matrix" LCD's. (see connection diagram and LCD data sheet).



Connection Diagram cutout of I2C-LCD

LC-Display contrast control

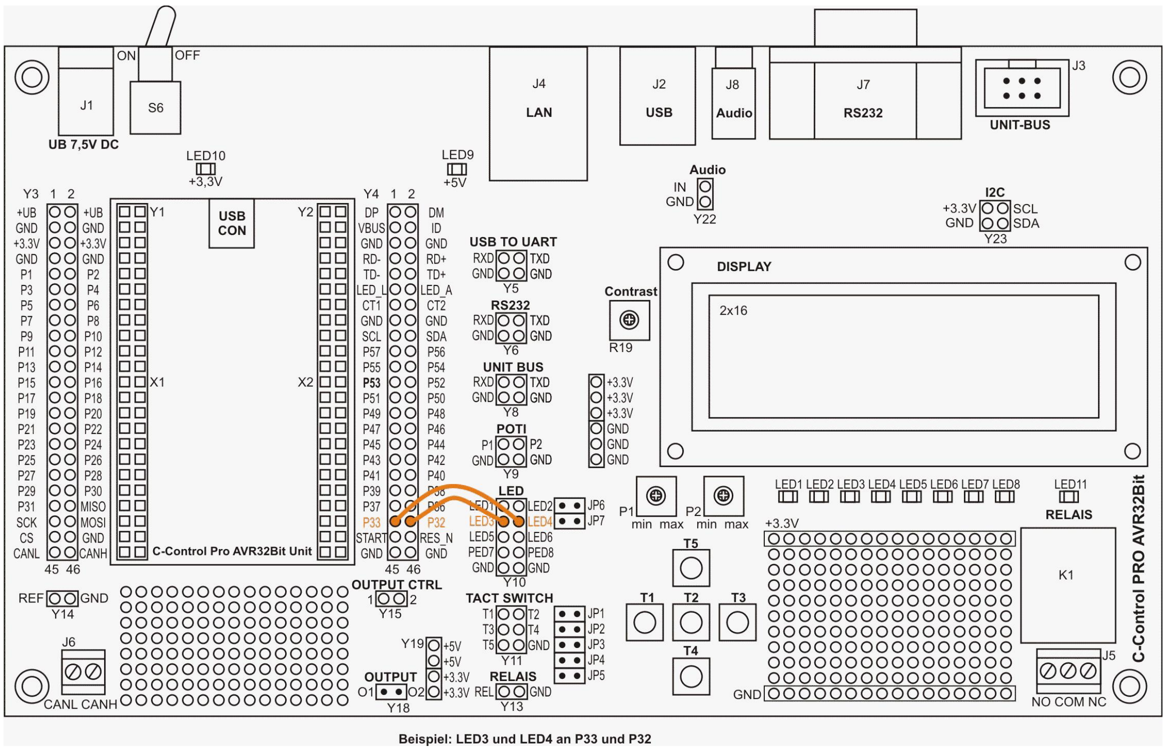
The best visibility of the LCD character arises in frontal view. If necessary, the contrast needs to be adjusted. The contrast can be set with the trimmer R19 ("Contrast" to the left of the LCD screen).



UNIT-BUS Pin Configuration

I2C and UNIT-Bus

The pins on the socket connector Y23 (Block 4) are permanently connected to the pins P34 (SDA) and P35 (SCL). At the pins on the socket connector Y8 (4 pin) a free UART interface can be assigned to the UNIT-bus. The UNIT-bus levels the 3.3V of the UNIT to 5V and 5V signals to 3.3V (bi-directional level shifter). C-Control I peripheral like I2C modules and other 5V circuitry can be connected to this bus.



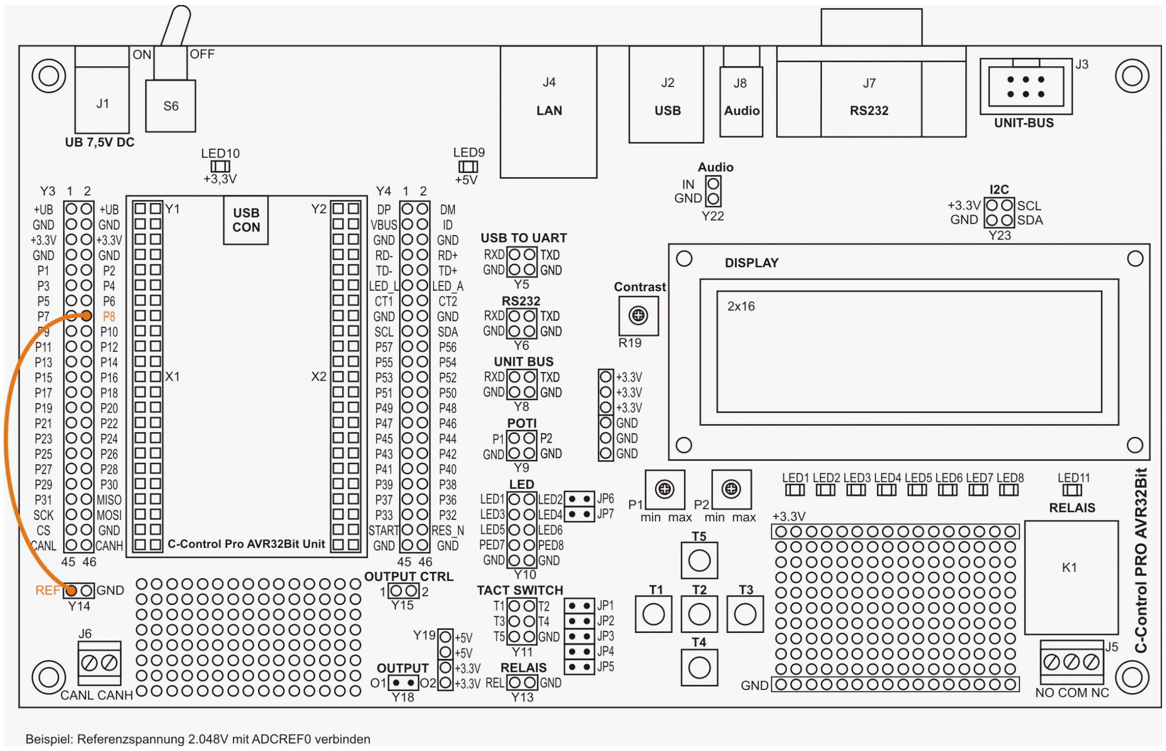
Exampleł connect LED3 and LED4 to P32 and P33

LED's

The pins of the connector strips Y10 (10 pin) are permanently connected to the LED's LED1 to LED8. The LED's are driven via a high impedance FET (about 100K). So that the port can also be used for other purposes, and the LED's signal the port status in addition. The jumpers JP6 and JP7 wire the first two LED's LED1, LED2 to the pins of the UNIT P48 and P49.

Reference Voltage

The pins on the socket connector Y14 provide a stable reference voltage for the ADC (Analog Digital Converter). They can be connected to the ADCREFx inputs of the UNIT. This allows you to provide a stable external reference voltage to the ADC.



Example connect reference voltage to ADCREF0

CAN Bus

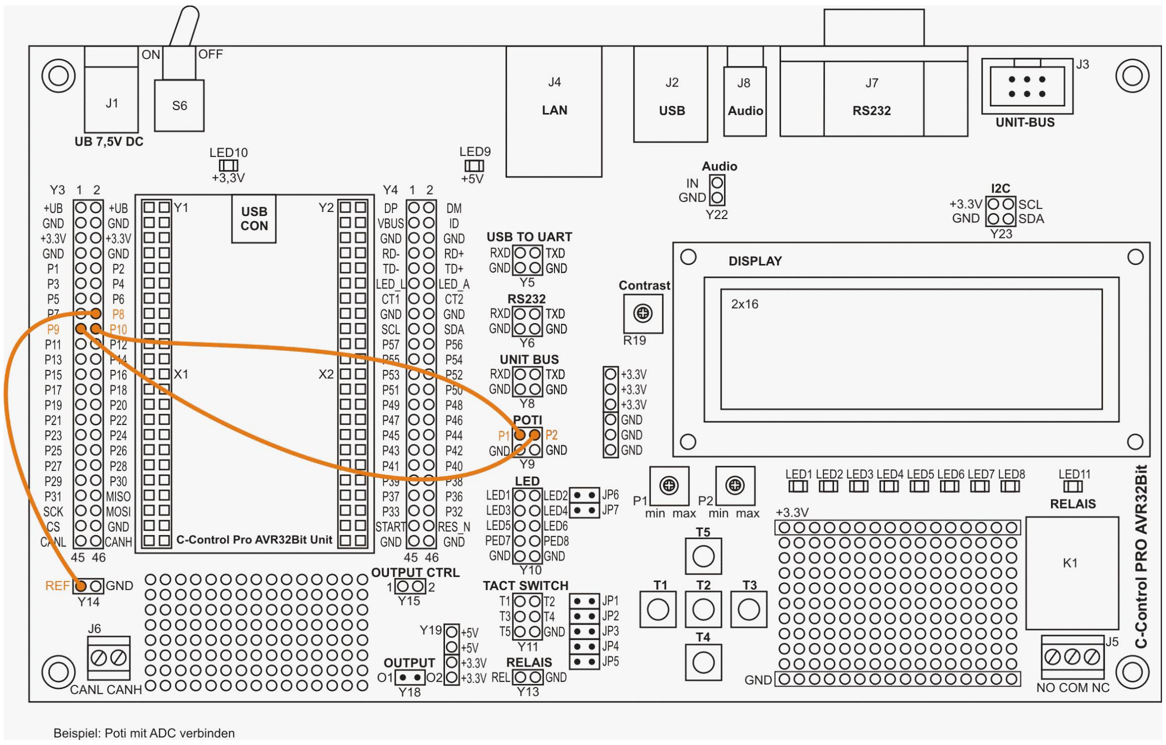
At clamp J6 the CAN bus (CAN0) is led out of the UNIT and can be used directly. It must be followed by no driver, since it is a driver already available on the UNIT.

Audio Amplifier

At the pins on the socket connector Y22 a PWM signal can be connected directly from the UNIT to the audio output. Headphones, small speakers (min. 8 Ohms) or an active speaker can be connected to the jack. Please note that the audio can be very noisy depending on the signal, and improper use can lead to hearing damage!

Analog Sensor

The pins on the socket connector Y9 (4 pin) are connected to the trimmer P1 and P2. The trimmers are connected as a variable voltage divider and fed from the 2.048V reference voltage. Thus, an output voltage can be set between 0 and 2.048V. The outputs of the female connector can be connected directly to the analog inputs of the UNIT.



Example connect trimmer to ADC0 and ADC1 with external reference voltage 2.048V

Keypad

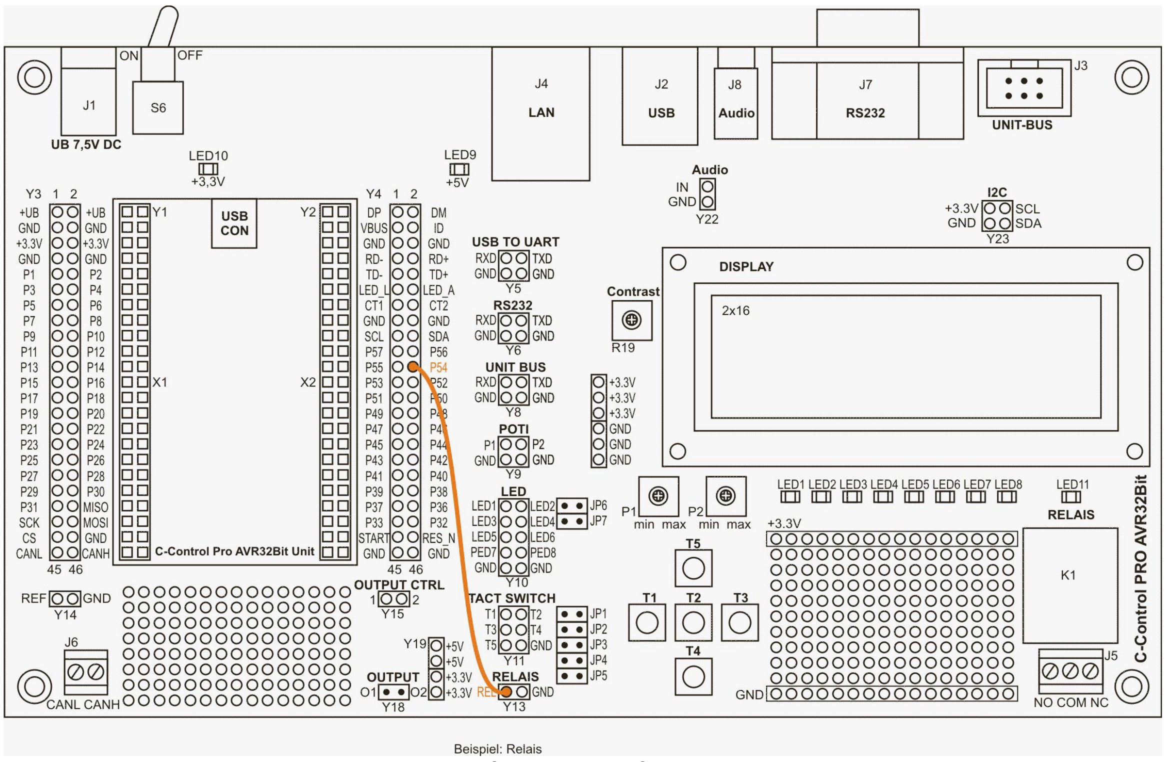
For user inputs a 5-button keypad (key cross) is available. The pins on the socket connector Y11 (6 pin) are connected to the switches T1 to T5. Through the jumper JP1 to JP5 the buttons T1 to T5 can be connected directly to the pins of the UNIT (P41 to P45). If another assignment is desired, the jumper must be removed and the button are connected via jump wire from the socket connector Y11 to the UNIT. The switches are connected to the application board with 47 kOhm pull-up resistors. No pull-up/down resistors need to be activated in software. Reading a switch in the idle state (not pressed), a "1" is detected on the port, because of the 3.3V that is carried to the pin though the pull-up resistor.

LAN Port / Ethernet

The LAN port can be directly connected with an FTP cable to a switch or router. With the Ethernet interface of the C-Control PRO AVR32Bit a web server can easily be implemented (see Examples). Furthermore, via the Ethernet bootloader the UNIT can be programmed across the network. The LAN connector is permanently connected to the pins of UNIT (see pin assignment in the manual).

Relay

The pins on the socket connector Y13 are connected to the relay K1. The relay is switched by an FET driver, and the "REL" connector of Y13 can be connected directly to a port of the UNIT. The relay is used to switch smaller loads.

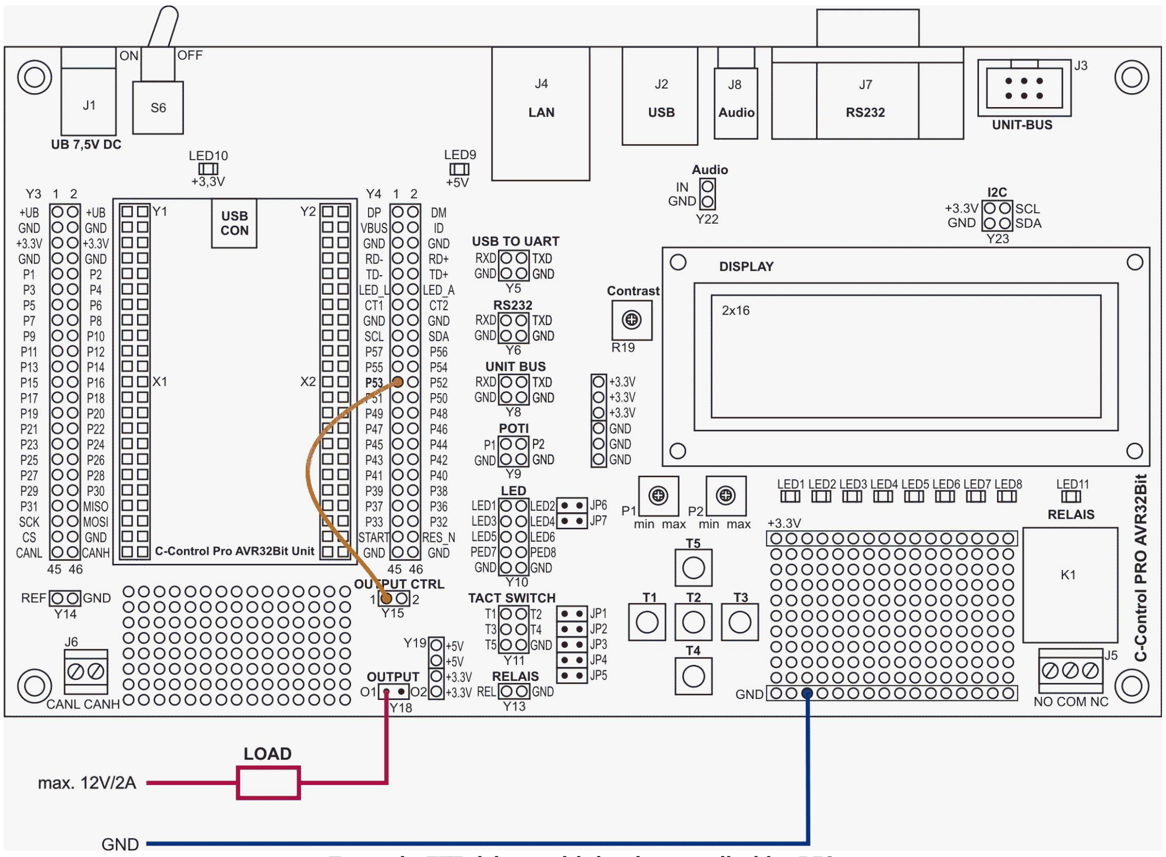


Example connect Relay to P54

FET driver

The pins of the socket strip Y15 are connected to the open-drain FET driver. Hereby ohmic consumers (max. 12VDC / 2A) can be controlled directly. The OUTPUT CTRL pins can be connected directly to a port on the UNIT. It can also be used to control PWM signals. At pin header Y18 open-drain outputs are ready for usage. These outputs are connected to the consumers - power supply (+).

When switching inductive loads, a free-wheeling diode must be attached to the open-drain outputs. The diode hast to be attached as close as possible to the the consumer.



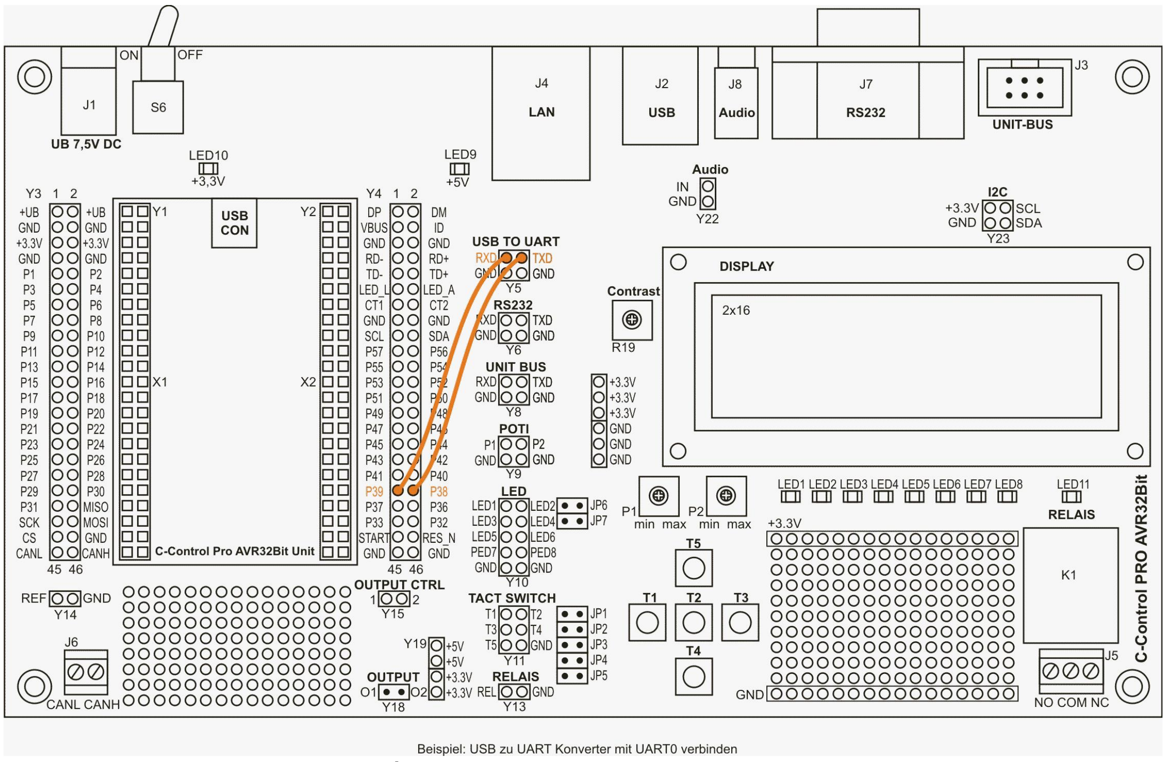
Example FET driver with load controlled by P53

USB to UART Converter

The pins on the socket connector Y5 (4 pin) are connected to the UART to USB converter (Silabs CP2104). At the USB connector (type B) the board is connected to the PC. The converter is used for serial data output from the Unit to the PC.

➜ **Install the driver first before making a connection.**

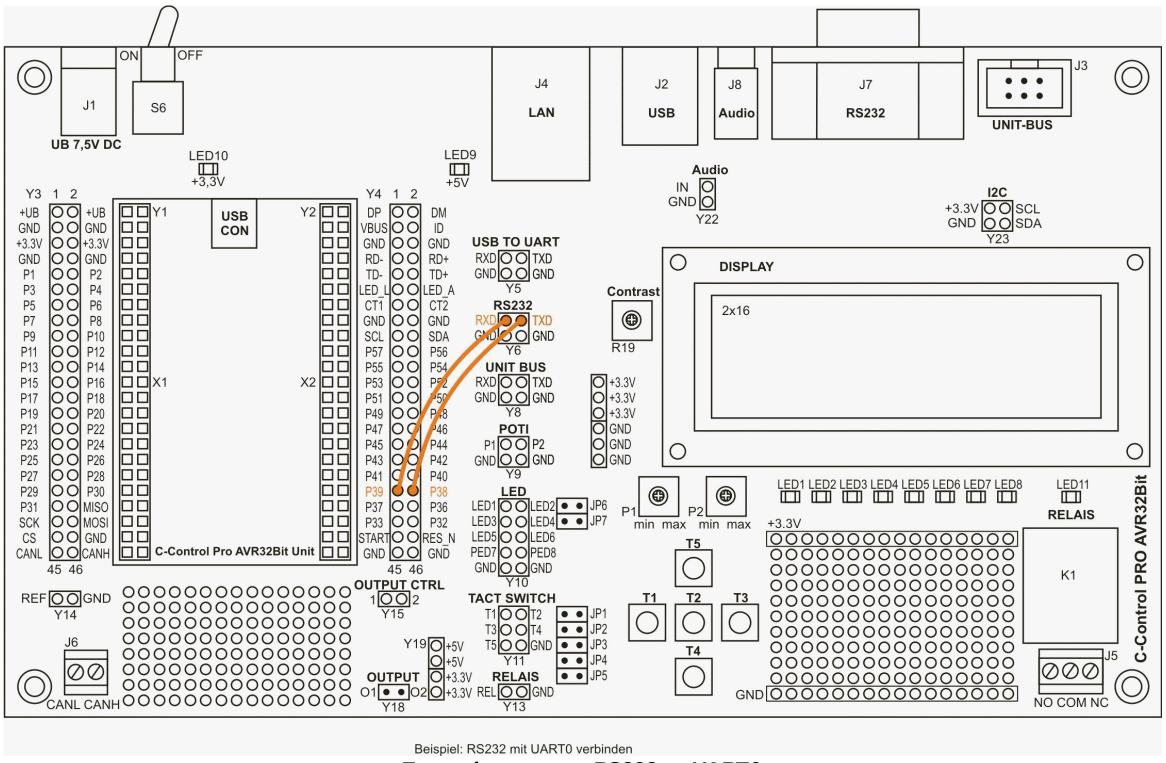
The drivers for the converter module can be found at:
http://www.silabs.com/PROducts/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx
http://www.silabs.com



Example connect USB-UART converter to UART0

RS232 to UART Converter

The pins on the socket connector Y6 (4 pin) are connected to the RS232 converter (MAX3232). At the 9-pin SUB-D connector the board is connected to the PC or a RS232 device. The converter is used to convert the 3.3V of the UNIT to the standard level of the RS232 serial interface (+/-12V). Through this interface data can be send data to a PC or a another RS232 device (e.g. meter).



Example connect RS232 to UART0

This product complies with the applicable national and European requirements. The "I2C bus" is a registered trademark of Philips Semiconductors. All other company and product names mentioned are trademarks of their respective owners. All rights reserved.

The cooling surface at the voltage regulators (between on/off switch and LAN connector) becomes hot during operation!

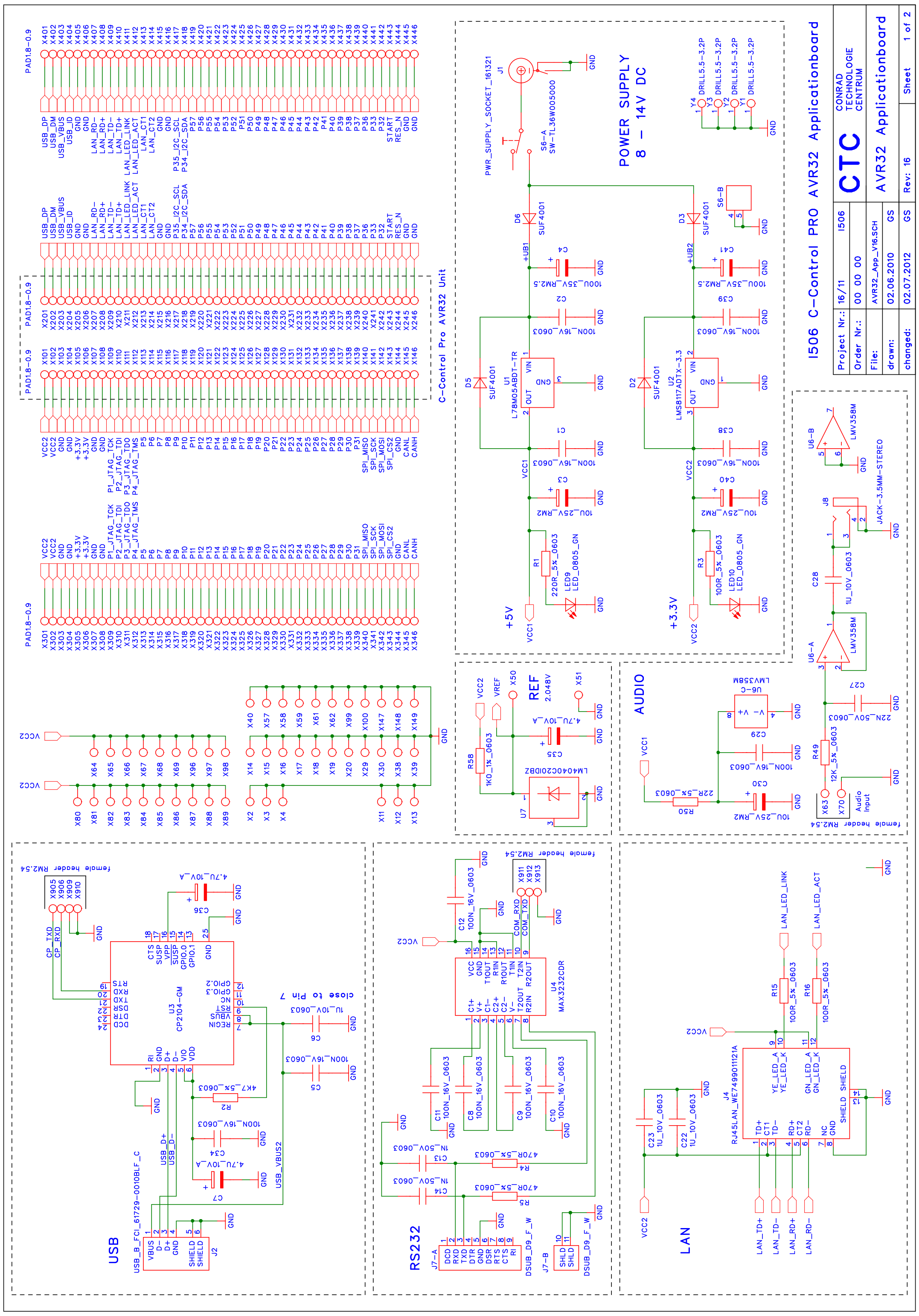
Technical Data

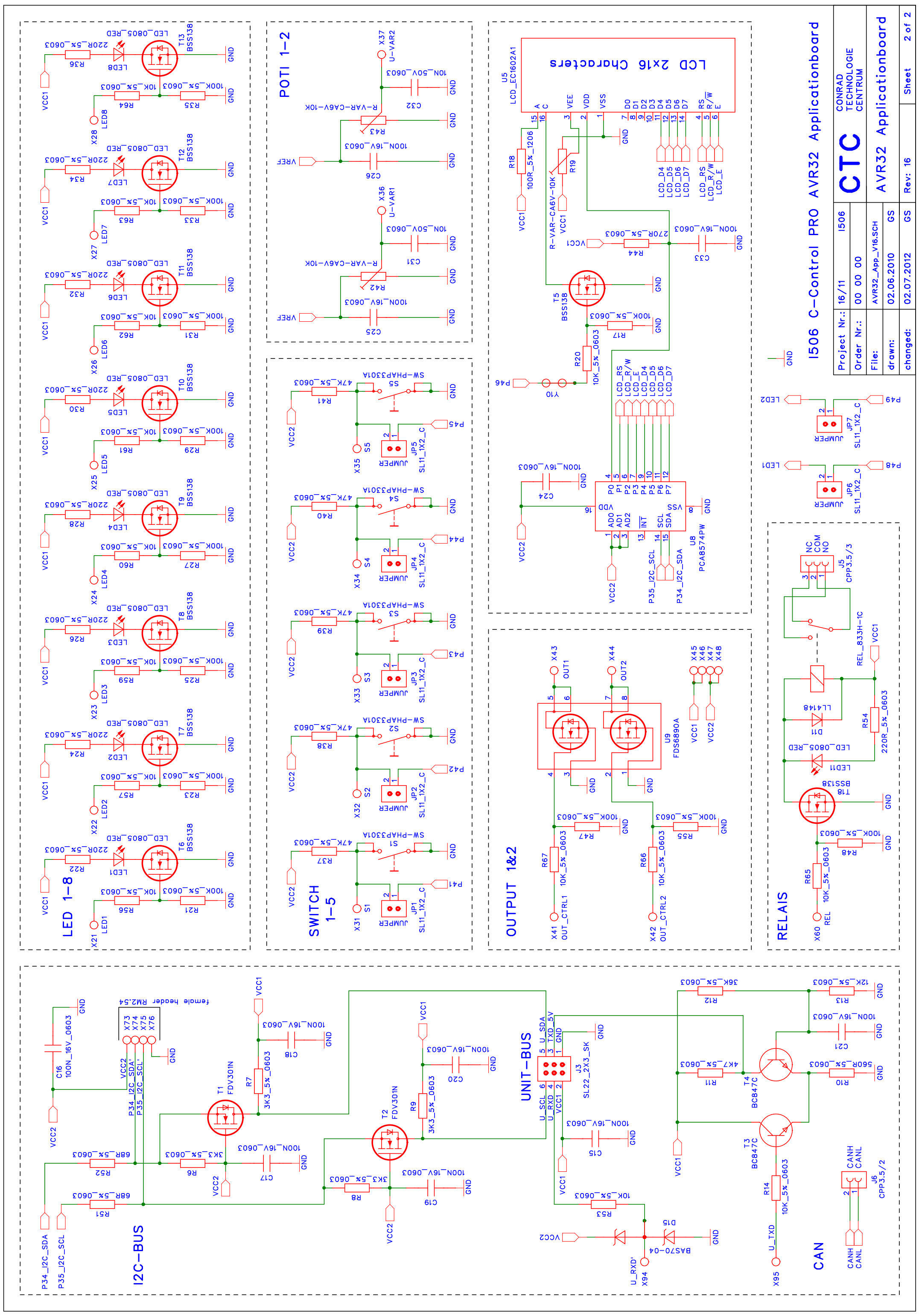
power supply external	7,5VDC / 500mA (stabilized)
power supply internal	3.3V and 5V
environmental temperature	0 to 60°C
dimensions	190x110mm
weight without UNIT	approx. 160g

Scope of delivery

- 1x C-Control PRO AVR32Bit Applicationboard
- 1x Mini-USB cable
- 7x jumper
- 1m wire wrap for jumpers
- Quick Guide

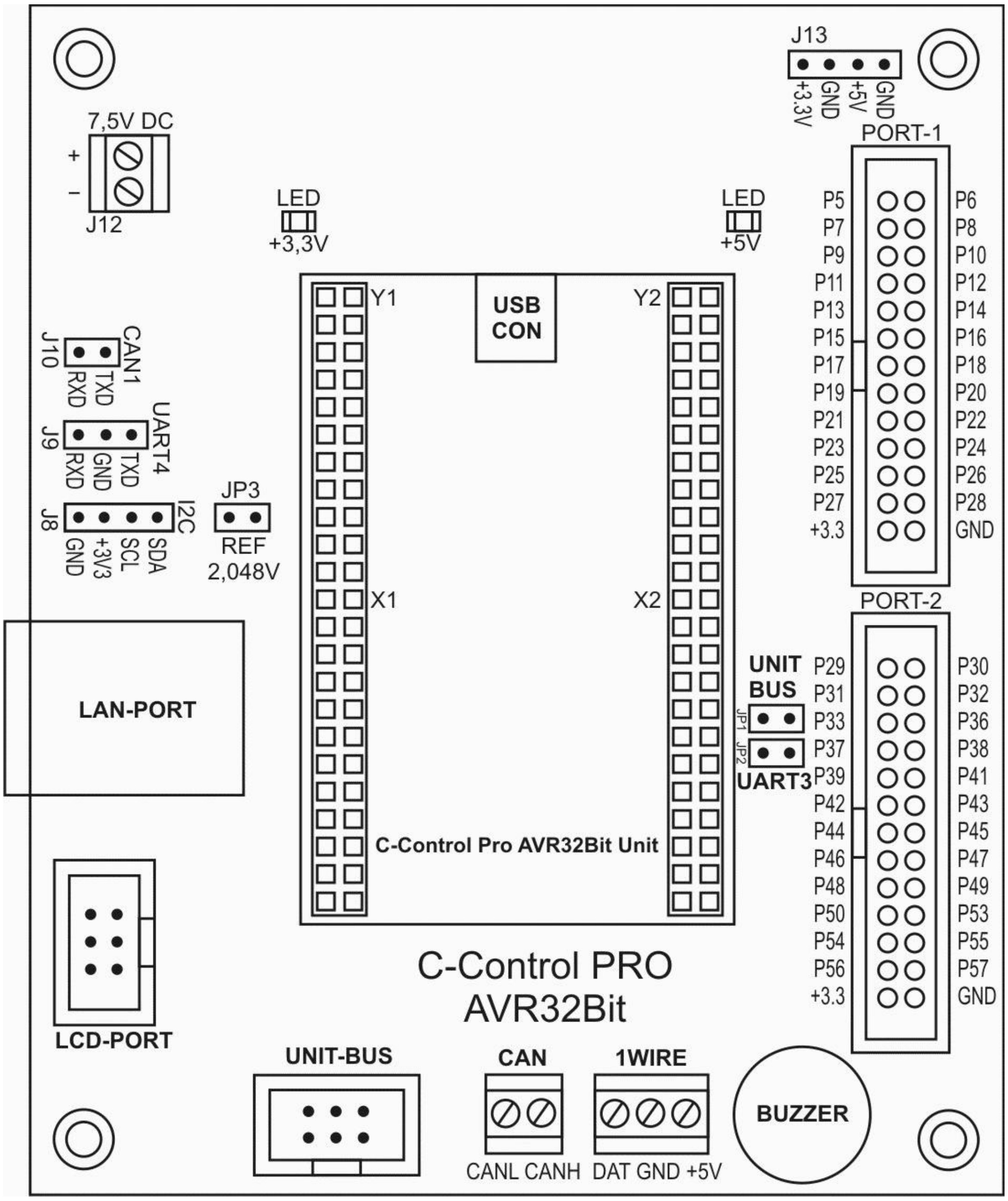
2.2.4.1 Connection Diagram




1506 C-Control PRO AVR32 Applicationboard
CTC
CONRAD TECHNOLOGIE CENTRUM
AVR32 Applicationboard
Project Nr.: 16/11 1506
Order Nr.: 00 00 00
File: AVR32_App_V16.SCH
drawn: 02.06.2010 GS
changed: 02.07.2012 GS
Rev: 16
Sheet 2 of 2
LED 1-8
POTI 1-2
LCD 2x16 Characters
SWITCH 1-5
OUTPUT 1&2
RELAIS
I2C-BUS
UNIT-BUS
CAN

2.2.5 Mainboard

The C-Control PRO AVR32Bit Mainboard (Conrad Order No.: 192702) is a compact experimental and development board for the C-Control PRO AVR32Bit UNIT. The C-Control PRO AVR32Bit Mainboard contains all the components required for the operation of the C-Control PRO AVR32Bit UNIT. In addition, the board has a good basic set of peripherals.



Mainboard Overview

The board offers the following features:

- 1x power supply (3.3V & 5V)
- 1x LAN connector (RJ45)
- 1x 2.048V external reference voltage
- 1x signal generator (Buzzer)
- 2x CAN connector
- 1x LCD-PORT for connection to the I2C LCD's (Conrad Order No.: 192602)
- 1x I2C-BUS connector
- 1x 1-Wire connector
- 2x I/O-PORT with 26 pins
- 1x UNIT-Bus (3.3V to 5V) for various sensors and actors

Installation / Commissioning

- The C-Control PRO AVR32Bit UNIT is attached so that the mini-USB socket corresponds to the marking (USB CON) on the Mainboard.
- In the baseline condition, the jumper (JP1, JP2 and JP3) are not plugged.
- The power supply of the Applicationboard occurs via a stabilized power supply or a laboratory power supply with an output voltage of 7.5V and a minimum current of 500mA.
- Install the C-Control PRO Development Environment "IDE" (Integrated Development Environment). See installation software.
- Install the USB driver.

Power Supply

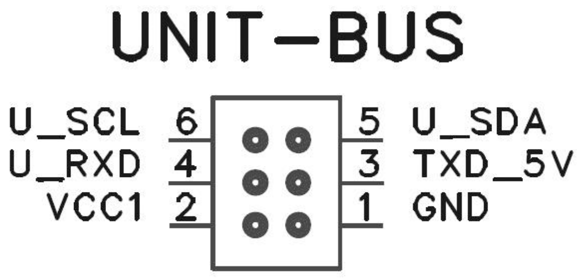
The Applicationboard is powered by a stabilized plug-in or laboratory power supply (7.5 V/500mA). Depending on the additional circuitry of the application motherboards it may be necessary later to use a mains adapter with a higher power. Two fixed voltage regulators on the application board generate the stabilized internal supply voltage of 3.3V and 5V. The two LED's +3.3V and +5V indicate the functionality of the power supply. All circuit components on the application board are supplied with these voltages (see diagram). On the board, some ports are available to allow you to tap out the different voltages. Make sure that the two voltage regulators are not getting too hot when using custom circuitry with higher loads. For larger loads, it is recommended to feed them externally!

➔ The mass between external circuitry (power supply) and the Applicationboard must be the same!

➔ The cooling surface of the voltage regulator is warm to hot during operation, depending on the connected consumer!

I2C, UART and UNIT-Bus

The pins on connector J8 are firmly connected to the pins P34 (I2C SDA) and P35 (I2C SCL). The UART4 interface is available at connector J9. The I2C bus is also connected directly to the UNIT-BUS. The UNIT-bus levels the 3.3V of the UNIT to 5V and 5V signals to 3.3V (bi-directional level shifter). C-Control I peripheral like I2C modules and other 5V circuitry can be connected to this bus. The UART3 interface can be placed on the UNIT-BUS via the jumpers JP1 and JP2.



UNIT-BUS Pin Configuration

Reference Voltage

The jumper JP3 connects the external 2.048V reference voltage to the ADCREF0 (P8) pin of the UNIT.

CAN Bus

At the clamp with the marking "CAN" the CAN bus (CAN0) is led out of the UNIT and can be used directly. It must be followed by no driver, since it is a driver already available on the UNIT. On the socket connector J10 the second CAN bus (CAN1) is led out. This does not have a CAN driver and can be used as a normal input/output.

LAN Port

The LAN port can be directly connected with a switch or router. The LAN connector is permanently connected to the pins of UNIT (see pin assignment in the manual). With the Ethernet interface of the C-Control PRO AVR32Bit a web server can easily be implemented (see demo programs). Furthermore, via the Ethernet bootloader (see manual chapter AVR32Bit Firmware bootloader) the UNIT can be programmed from afar.

LCD Port

At the 6-pin socket header with marking "LCD PORT" the C-Control PRO AVR32Bit LCD1602 board (Conrad Order No. 192602) can be attached. The Mainboard is connected with the LCD module via a 6-pin ribbon cable with a pin header connector (female). Because depending on the application, the cable lengths are varying, we offer these components for self-assembly using the following order numbers:

• Ribbon cable RM1.27 0.05mm²:	Order No. 607237
• Pin header connectors 2x3 RM:2.54mm:	Order No. 742063

- Matching connection cable pre-assembled (length 35cm) Order No. 198876

1-WIRE

At the screw clamp labeled "1WIRE" the pin P3 of the UNIT is led out. At this pin a 1-WIRE sensor such as a temperature sensor (Conrad Order No. 198284) can be connected. This pin can also be used as a normal digital input/output.

PORT-1, PORT-2

At the 26-pin pin header connectors labeled "PORT 1" and "PORT 2" the free pins are brought out of the AVR32Bit UNIT. Here, the experiment board (Conrad Order No. 192615) can be connected to the pin headers via two 26-pin ribbon cables.

• Ribbon cable 26-pin RM1.27 0.05mm²:	Order No. 607222
• Pin header connectors 2x13 RM:2.54mm:	Order No. 742185

Available pins at pin header connector PORT-1:
P5, P6, P7, P8, P9 , P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, +3.3V, GND

Available pins at pin header connector PORT-2:
P29, P30, P31, P32, P33, P36, P37, P38, P39, P41, P42, P43, P44, P45, P46, P47, P48, P49, P50, P53, P54, P55, P56, P57, +3.3V, GND

This product complies with the applicable national and European requirements. The "I2C bus" is a registered trademark of Philips Semiconductors. All other company and product names mentioned are trademarks of their respective owners. All rights reserved.

➔ **The cooling surface at the voltage regulators (near the mini-USB socket of the UNIT) becomes hot during operation!**

Technical Data

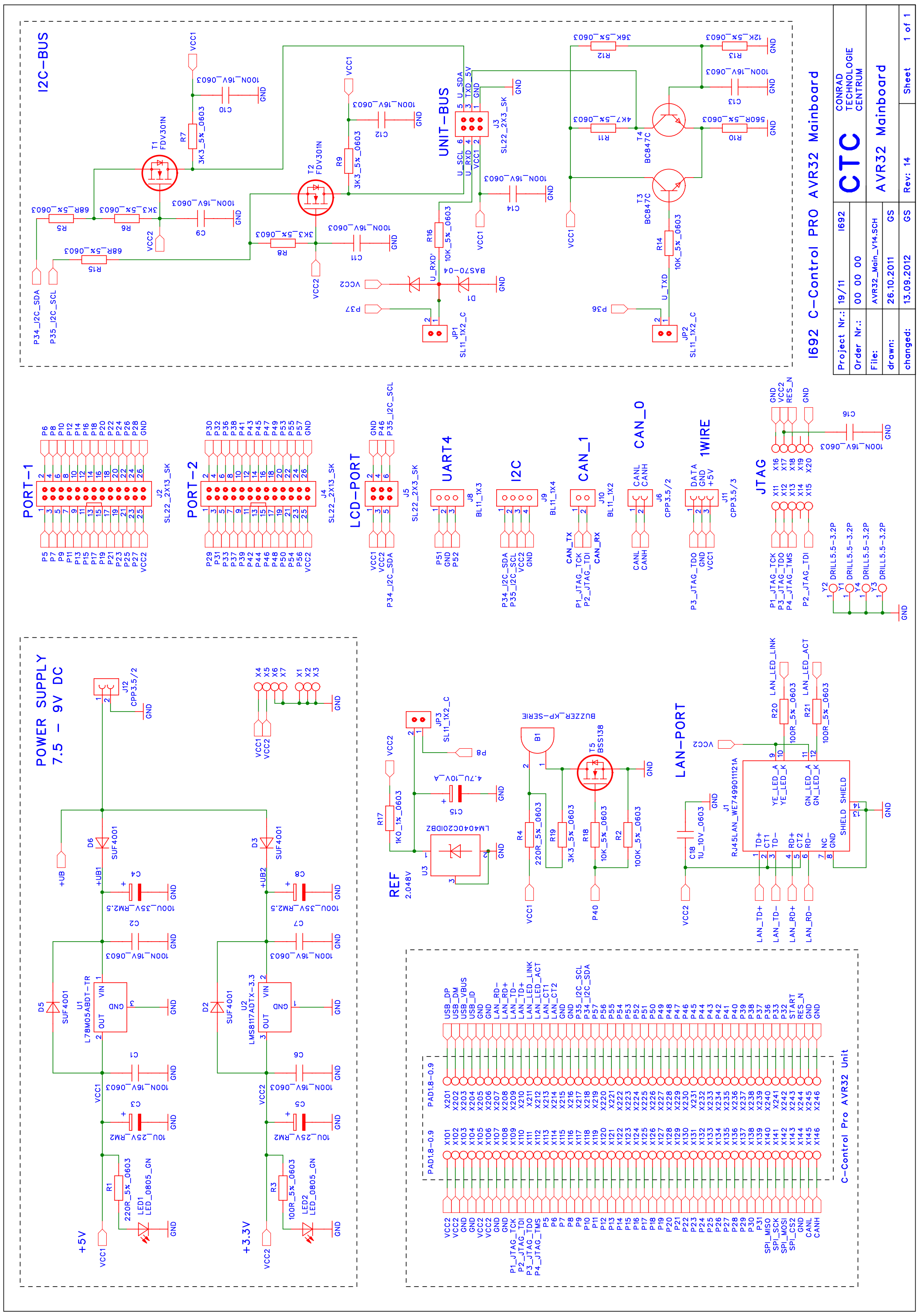
power supply external	7,5VDC / 500mA (stabilized)
power supply internal	3.3V and 5V
environmental temperature	0 to 60°C
dimensions	110x95mm
weight ohne UNIT	approx. 65g

Scope of Delivery

- 1x C-Control PRO AVR32Bit Mainboard
- 1x Mini-USB cable

- 3x Jumper
- Quick Guide

2.2.5.1 Connection Diagram



2.2.6 UNIT-BUS Exp. Board

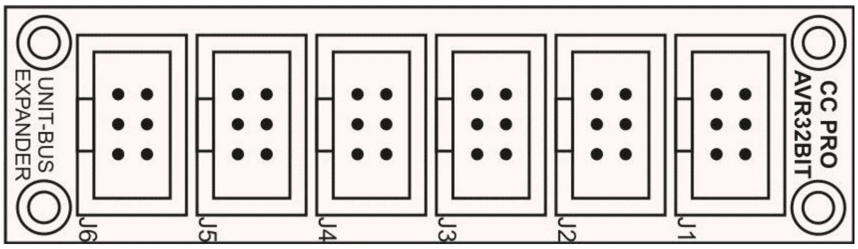
The C-Control PRO AVR32Bit UNIT BUS Exp. Board (Conrad Order No.: 192659) is designed to expand the functionality of the C-Control PRO AVR32Bit products. The product is designed as an open circuit board with six single 6-pin pin header sockets, and only determined for the UNIT-BUS of the C-Control PRO AVR32Bit and the C-Control I product family (extensions) and their sockets. The control of the individual modules is done via software. The software can be found in the folder of the example programs (see demo programs) and at www.c-control.de.

Connection and commissioning

Make sure that before you connect the modules to your C-Control PRO AVR32Bit base product (e.g. AVR32Bit Application Board - Order No. 192587 or Mainboard - Order No. 192702) all connections to connected devices are separated and voltage free. On the C-Control PRO AVR32Bit basic products there is also a 6-pin connector labeled UNIT-BUS. This pin header connector is suitable for connecting UNIT-BUS expansion modules. Each of these jacks includes the lines SDA, SCL, RxD, TxD, +5V and GND. The C-Control PRO AVR32Bit Unit works with 3.3V level, and the UNIT-BUS extensions, as well as the older C-Control I2C-bus modules, use 5V. Therefore a level converter is placed between the C-Control PRO AVR32Bit UNIT and the UNIT-BUS that converts the 3.3V signals of the UNIT to 5V signals of the UNIT-BUS. The UNIT-BUS Expander is used to distribute the I2C bus signals SDA and SCL and the UART signals RxD and TxD. In addition, the +5V supply and GND pins. The Expander can can be mounted in your application with its outer mounting holes (hole diameter: 2.5 mm).

When using C-Control I extension modules please study the documentation of the C-Control extension modules. You can find there more technical information on the individual products. Unless stated otherwise, all expansion modules are supplied with the required operating voltage via their respective connectors on the base unit. Because depending on the application, the cable length can vary, we offer you these components for self-assembly in the following order numbers:

• Ribbon cable RM1.27 0.05mm^2:	Order No. 607237
• Pin header connectors 2x3 RM:2.54mm:	Order No. 742063
• Matching connection cable pre-assembled (length 35cm)	Order No. 198876

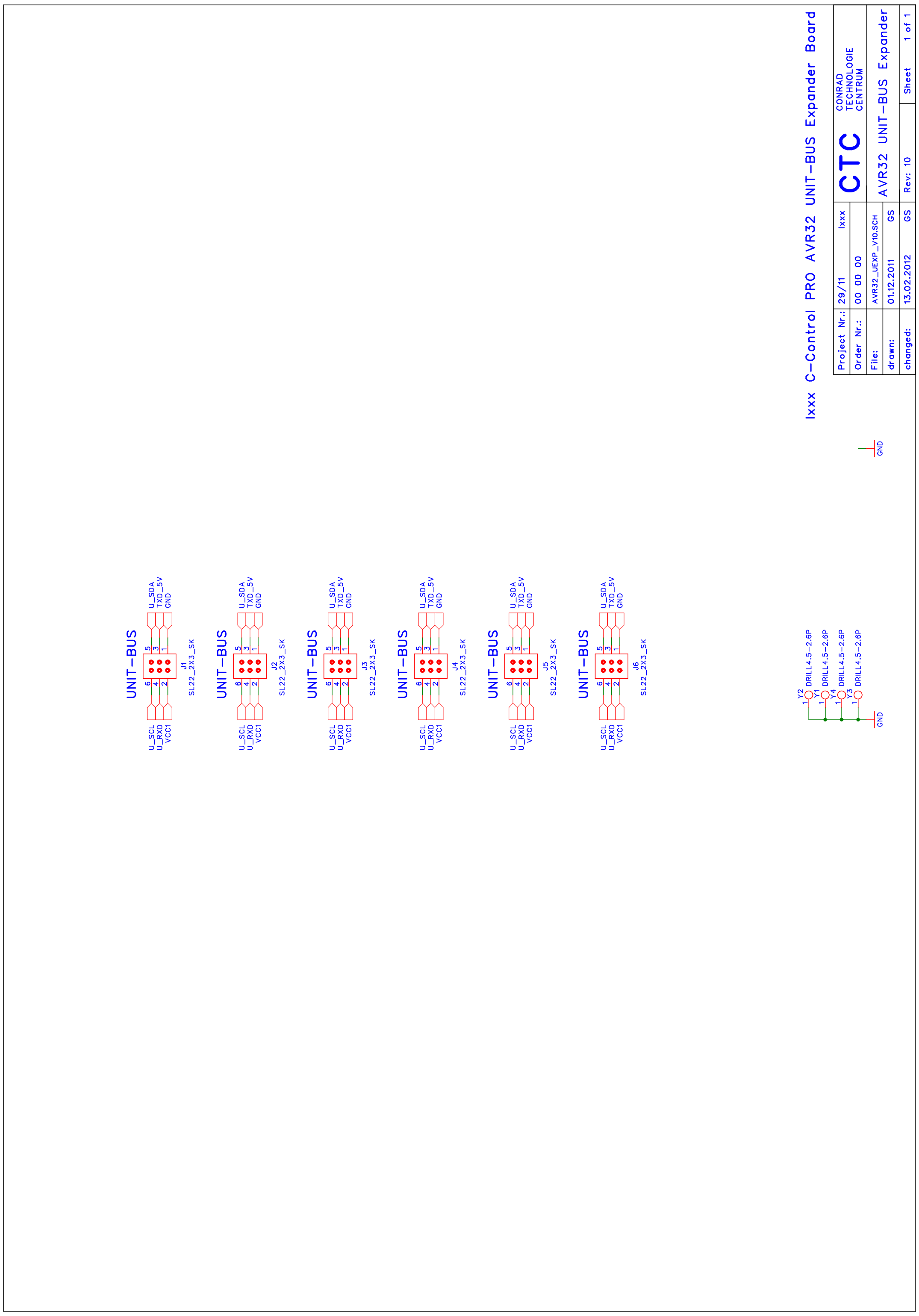


Expander Overview

Technical Data

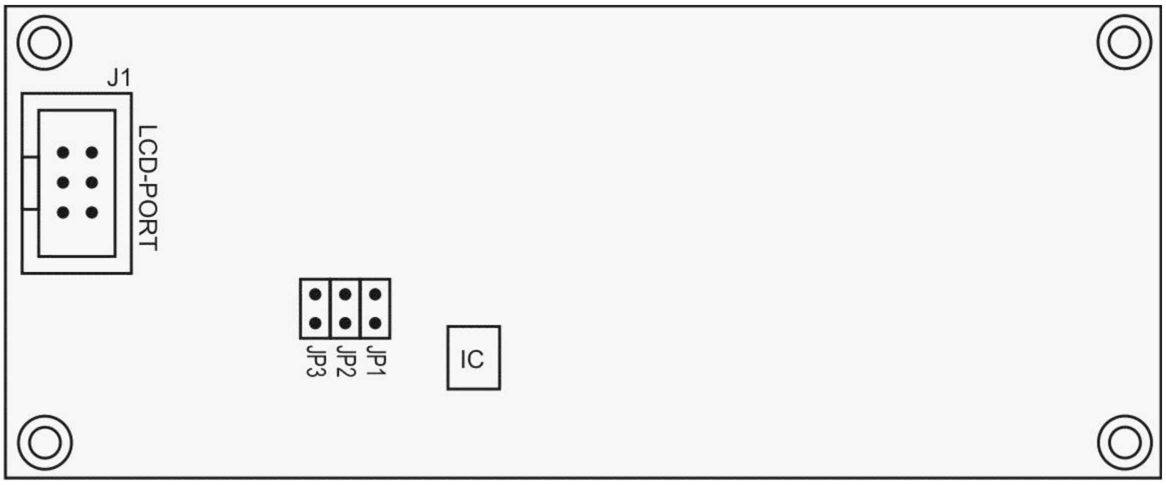
dimensions	72mm x 20mm x 12mm (LxWxH)
pin header pitch	2.54mm
weight	12g

2.2.6.1 Connection Diagram



2.2.7 LCD1602 Board

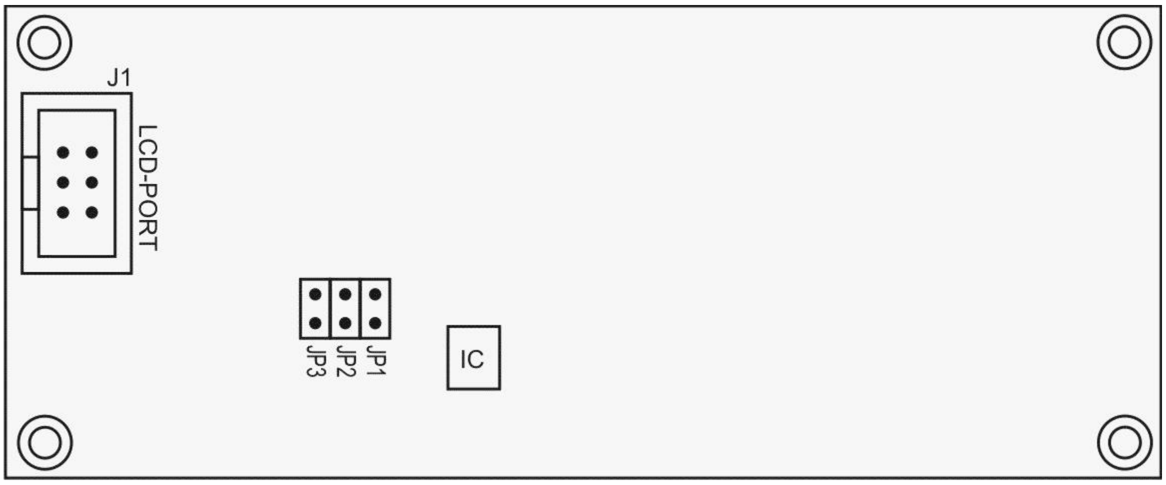
The C-Control PRO AVR32Bit LCD1602 board (Conrad Order No. 192602) is designed to expand the functionality of the C-Control PRO AVR32Bit products. The product is configured as open circuit board. The module is equipped with a two-line 16 character LCD display with backlight and a 6-pin header connector, and is only determined for the C-Control PRO AVR32Bit Mainboard (Conrad Order No. 192702) . The board is used to display data from the AVR32Bit UNIT (Conrad Order No. 192573) in conjunction with the AVR32Bit Mainboard. The control of the individual modules is done via software. The software can be found in the folder of the example programs (see demo programs) and at www.c-control.de.



PCB Front View

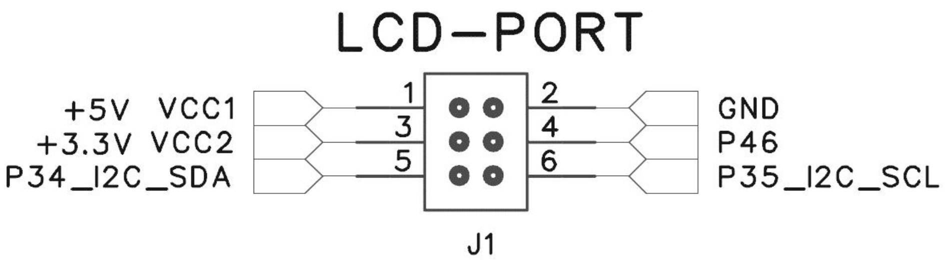
Connection and Commissioning

Make sure that before you connect the modules to your C-Control PRO AVR32Bit Mainboard all connections to connected devices are separated and voltage free. On the C-Control PRO AVR32Bit Mainboard a 6-pin header connector is labeled LCD PORT. This pin header connector is suitable for connecting the LCD1602 boards. The pins I2C, P46, 3.3V and +5 V are passed out. The LCD1602 board has an I2C bus port expander that is responsible for driving the LCD. As a result, fewer pins are assigned to the UNIT.



PCB Rear View

Is the base address of the LCD used (equal to the application board), the jumper must be removed on the LCD board. See also LCD_SetDispAddr.



LCD Port Connectors

The Mainboard is connected to the LCD1602 Board via a 6-pin ribbon cable with pin header connector (female). Since the cable may vary according to the application, we offer these components for self-assembly using the following order numbers:

• Ribbon cable RM1.27 0.05mm²:	Order No. 607237
• Pin header connectors 2x3 RM:2.54mm:	Order No. 742063
• Matching connection cable pre-assembled (length 35cm)	Order No. 198876

Tip: The pin header connectors can be easily pressed together with a small vise. Cut the cable to proper length and straight it in the plug (guide grooves in the plug), and then clamp between the two vise jaws, and turn it carefully until the connector clicks into place.

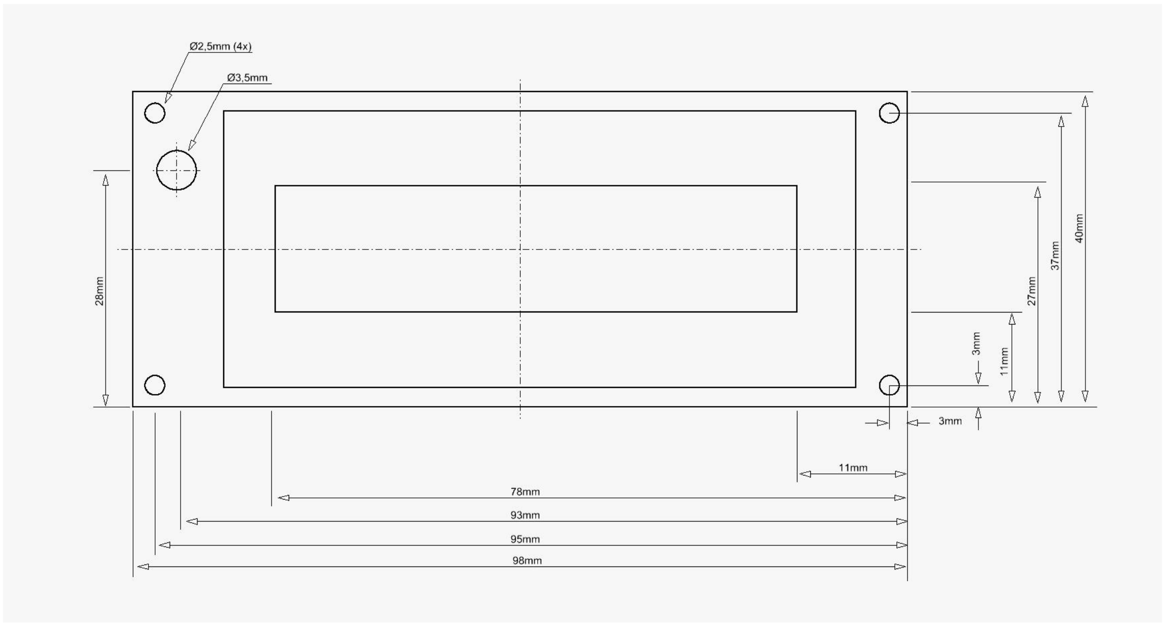
Addressing:

The I2C address jumpers JP1 and JP3 are located on the back of the LCD1602 module. With the use of multiple LCD modules (max. 8), the jumper must be set according to the desired address as follows (Jumper JP1 = points to IC):

JP3	JP2	JP1	address
-	-	-	Hex 27
-	-	x	Hex 26
-	x	-	Hex 25
-	x	x	Hex 24
x	-	-	Hex 23
x	-	x	Hex 22
x	x	-	Hex 21
x	x	x	Hex 20

x=Jumper set / - = **not** set

Attention: Other I2C bus modules use the same I2C expander chips (PCA8574). Therefore the maximum number of modules with this chip is limited to 8!



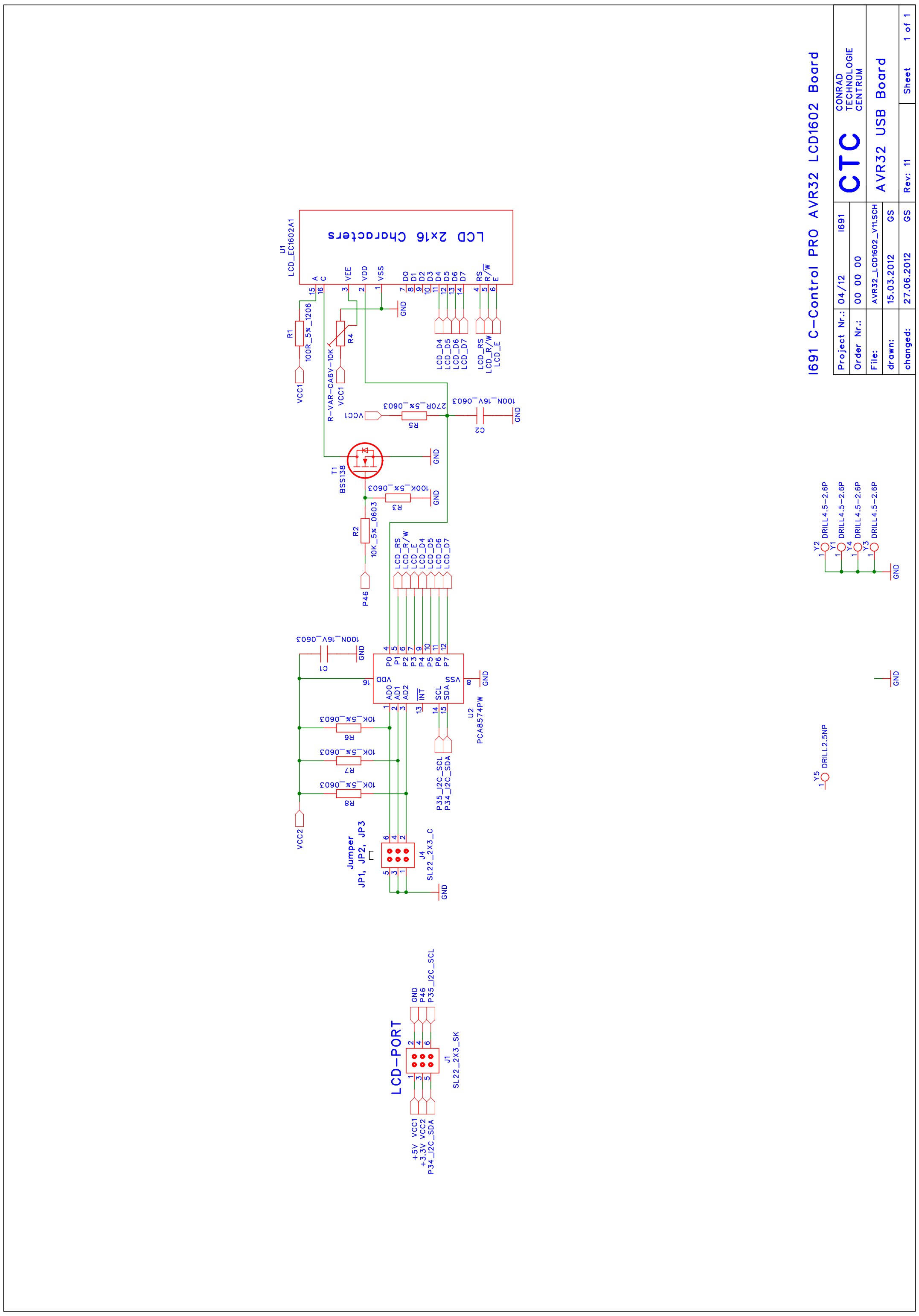
CAD

Technical Data

dimensions	98mm x 40mm x 26mm (LxWxH)
pin header pitch	2.54mm
operating voltage	3.3V (LCD) and 5V (backlight)
current consumption w/o backlight	3mA

current consumption with backlight	13mA
weight	55g

2.2.7.1 Connection Diagram



2.2.8 Port-Ext-Board

The Port-Ext-Board (Conrad Order No. 192615) is constructed to expand the functionality of the C-Control PRO AVR32Bit Mainboard (Conrad Order No. 192702). The product is designed as an open breadboard experimental circuit board with a pitch of 2.54mm. It is equipped with two single 26-pin header connectors and suitable only for the port outputs (PORT-1/PORT-2). The board serves to build your own circuits in conjunction with the C-Control PRO AVR32Bit Mainboard. For circuit design and the comfortable replica the circuit board is printed with a coordinate system. The board can directly be mounted under or next to the Mainboard. PCB spacers are needed for "sandwich" mounting with a minimum of 20mm length and a thread diameter of 3mm.

Connection and Commissioning

Make sure that before you connect the modules to your C-Control PRO AVR32Bit Mainboard all connections to connected devices are separated and voltage free. On the C-Control PRO AVR32Bit Mainboard there are two 26-pin header connectors, labeled PORT-1 and PORT-2. This pin header connectors are suitable for connecting the Port-Extension-Board. On this pins the free ports of C-Control PRO UNIT AVR32Bit are lead through (see Port-Extension-Board Overview):

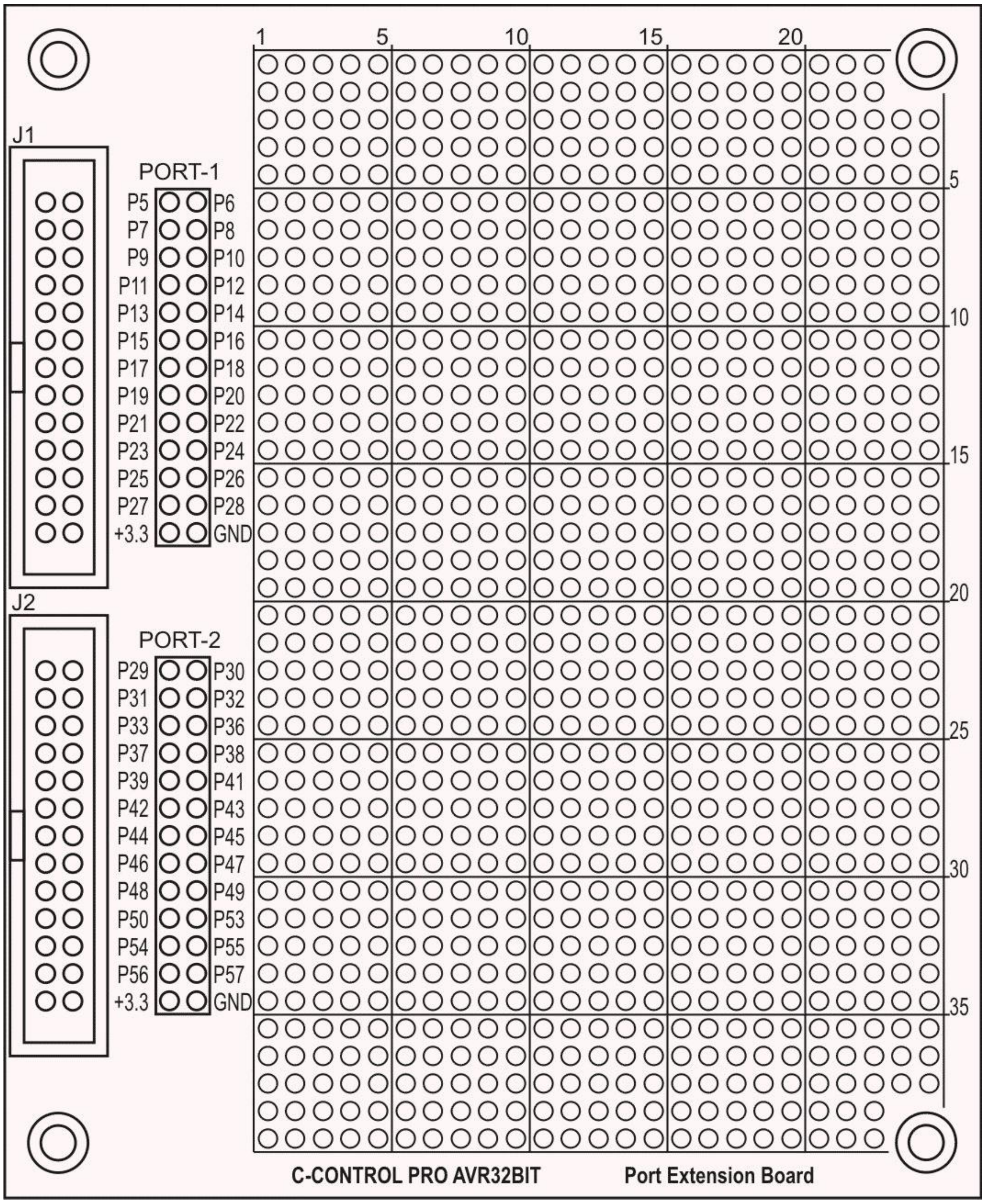
Available pins at pin header connector PORT-1:
P5, P6, P7, P8, P9 , P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, +3.3V, GND

Available pins at pin header connector PORT-2:
P29, P30, P31, P32, P33, P36, P37, P38, P39, P41, P42, P43, P44, P45, P46, P47, P48, P49, P50, P53, P54, P55, P56, P57, +3.3V, GND

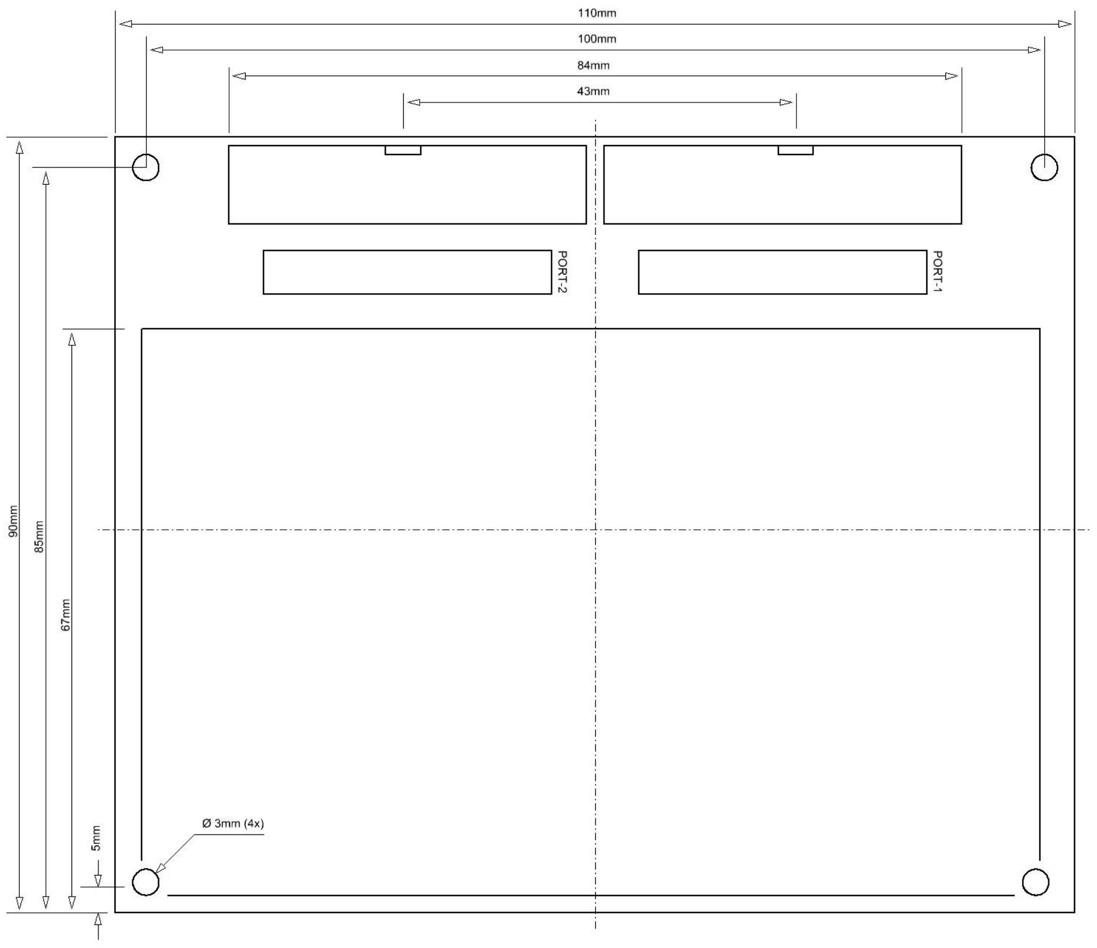
The Port-Extension-Board is connected to the Mainboard via two ribbon cable with pin header connectors (female). Since the cable length may vary according to the application, we offer these components for self-assembly using the following order numbers:

• Ribbon cable 26-pin RM1.27 0.05mm²:	Order No. 607222
• Pin header connectors 2x13 RM:2.54mm:	Order No. 742185

Tip: The pin header connectors can be easily pressed together with a small vise. Cut the cable to proper length and straight it in the plug (guide grooves in the plug), and then clamp between the two vise jaws, and turn it carefully until the connector clicks into place.



Port-Extension-Board Overview



CAD

Technical Data:

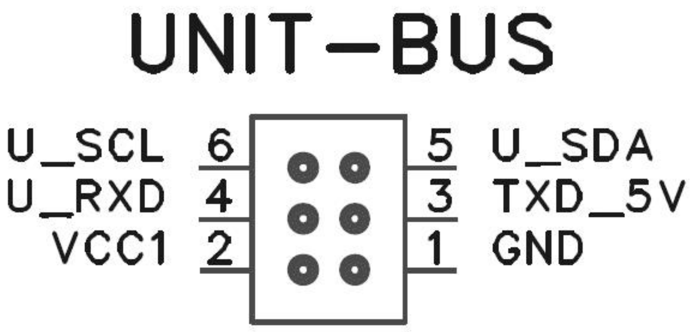
dimensions	110mm x 90mm x 13mm (LxWxH)
pin header pitch	2.54mm
breadboard pitch	2.54mm
breadboard size	25x40 pins
weight	35g

2.2.9 REL4-Board

The C-Control PRO AVR32Bit REL4 Board (Conrad Order No. 192631) is designed to expand the functionality of the C-Control PRO AVR32Bit products. The product is configured as open circuit board. The board is equipped with 4 relays for switching loads, and is intended only for C-Control PRO products.

Connection and Commissioning

Make sure that before you connect the modules to your C-Control PRO AVR32Bit Applicationboard or Mainboard, all connections to connected devices are separated and voltage free. On the C-Control PRO systems there is a 6-pin header connector labeled UNIT-BUS. This pin header connector is suitable for connecting the REL4 boards. At these pins, I2C, UART and +5 V are lead through. The REL4 board has an I2C-BUS port expander, which is responsible for controlling the relay. Through the I2C bus control no additional I/O pins of the UNIT are required.



UNIT-BUS Pin Configuration

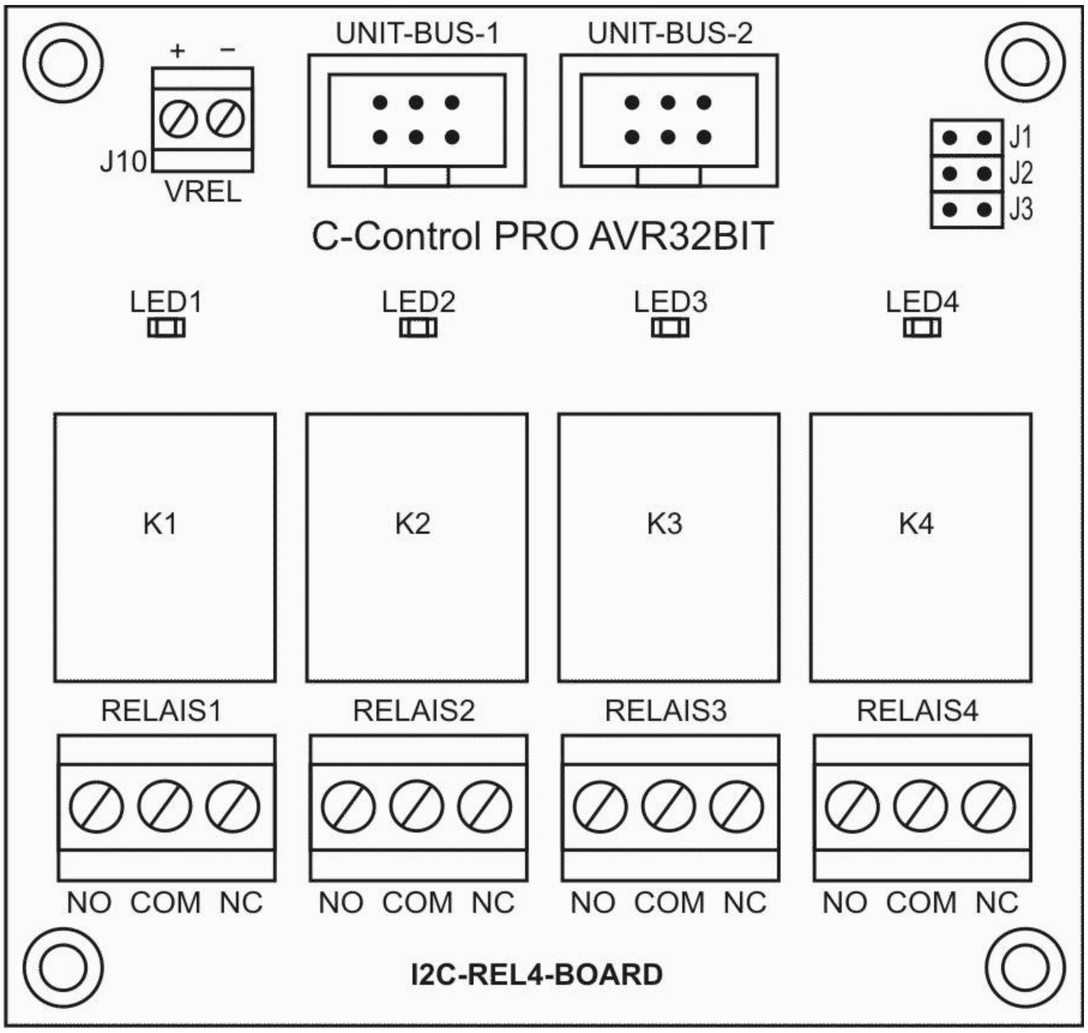
The REL4-Board is connected via a 6-pin ribbon cable to the pin header connector (UNIT-BUS) and a screw terminal labeled "VREL". Since the cable length to the UNIT BUS may vary according to the application, we offer these components for self-assembly using the following order numbers:

• Ribbon cable RM1.27 0.05mm²:	Order No. 607237
• Pin header connectors 2x3 RM:2.54mm:	Order No. 742063
• Matching connection cable pre-assembled (length 35cm)	Order No. 198876

➔ **Tip**: The pin header connectors can be easily pressed together with a small vise. Cut the cable to proper length and straight it in the plug (guide grooves in the plug), and then clamp between the two vise jaws, and turn it carefully until the connector clicks into place.

The REL4-Board-Board has two UNIT-BUS connections that are mutually connected 1:1. Thus, e.g., one of the connectors can be plugged to the Applicationboard or Mainboard, and the second port can be used as a junction that connects to another UNIT-BUS module. The cable length must not exceed 2m, since this will cause communication errors. However, when longer lines are needed, it is helpful to put an I2C power driver (Order No. 198280) in-between.

The RELBUS-Board is supplied by the screw clamp "VREL" with power. The UNIT-BUS is used in this module only as a communication interface, and for the supply of the digital electronic part of the circuit. The relays are powered externally via "VREL"!



REL4-Board overview

Addressing:

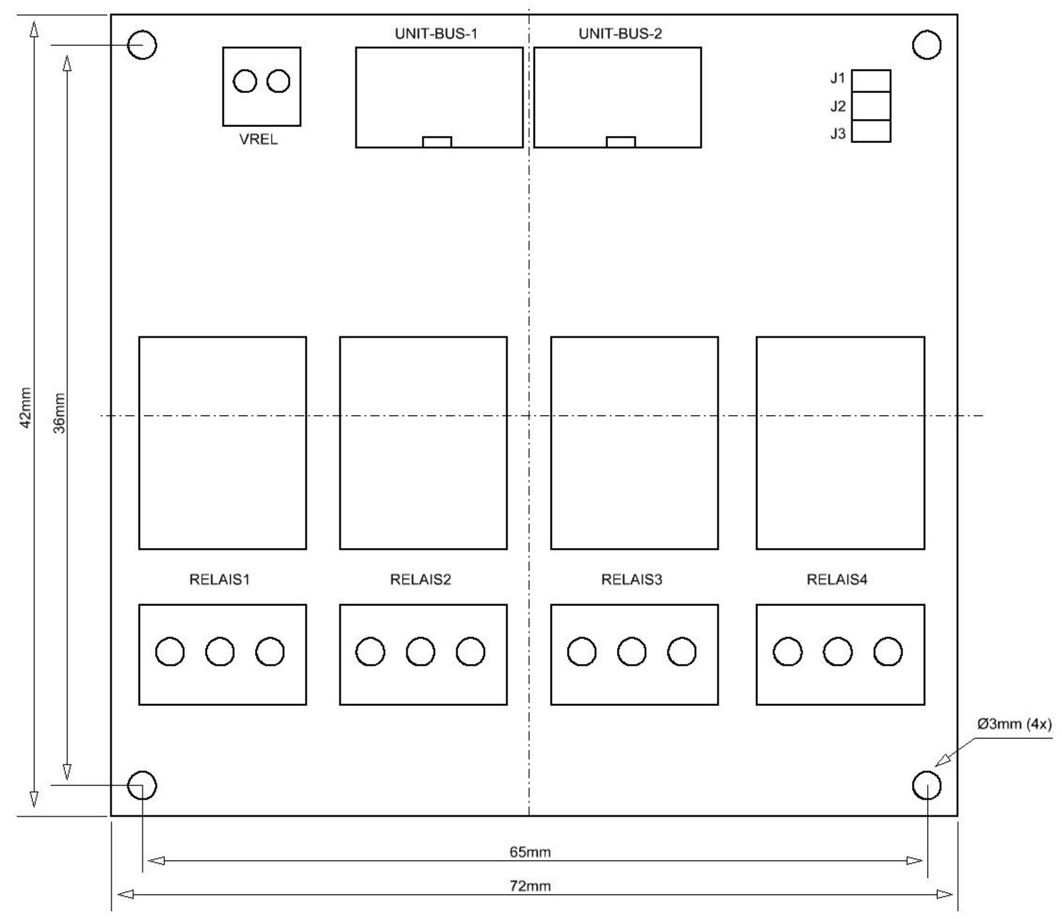
The I2C address jumpers J1 to J3 are located on the front of the REL4-Board. When using several modules and depending on the desired address the jumper must be set as follows:

J3	J2	J1	Address
-	-	-	Hex 27
-	-	x	Hex 26
-	x	-	Hex 25
-	x	x	Hex 24
x	-	-	Hex 23

x	-	x	Hex 22
x	x	-	Hex 21
x	x	x	Hex 20

x=Jumper set / - = **not** set

Attention: Other I2C bus modules use the same I2C expander chips (PCA8574). Therefore the maximum number of modules with this IC is limited to 8!



CAD

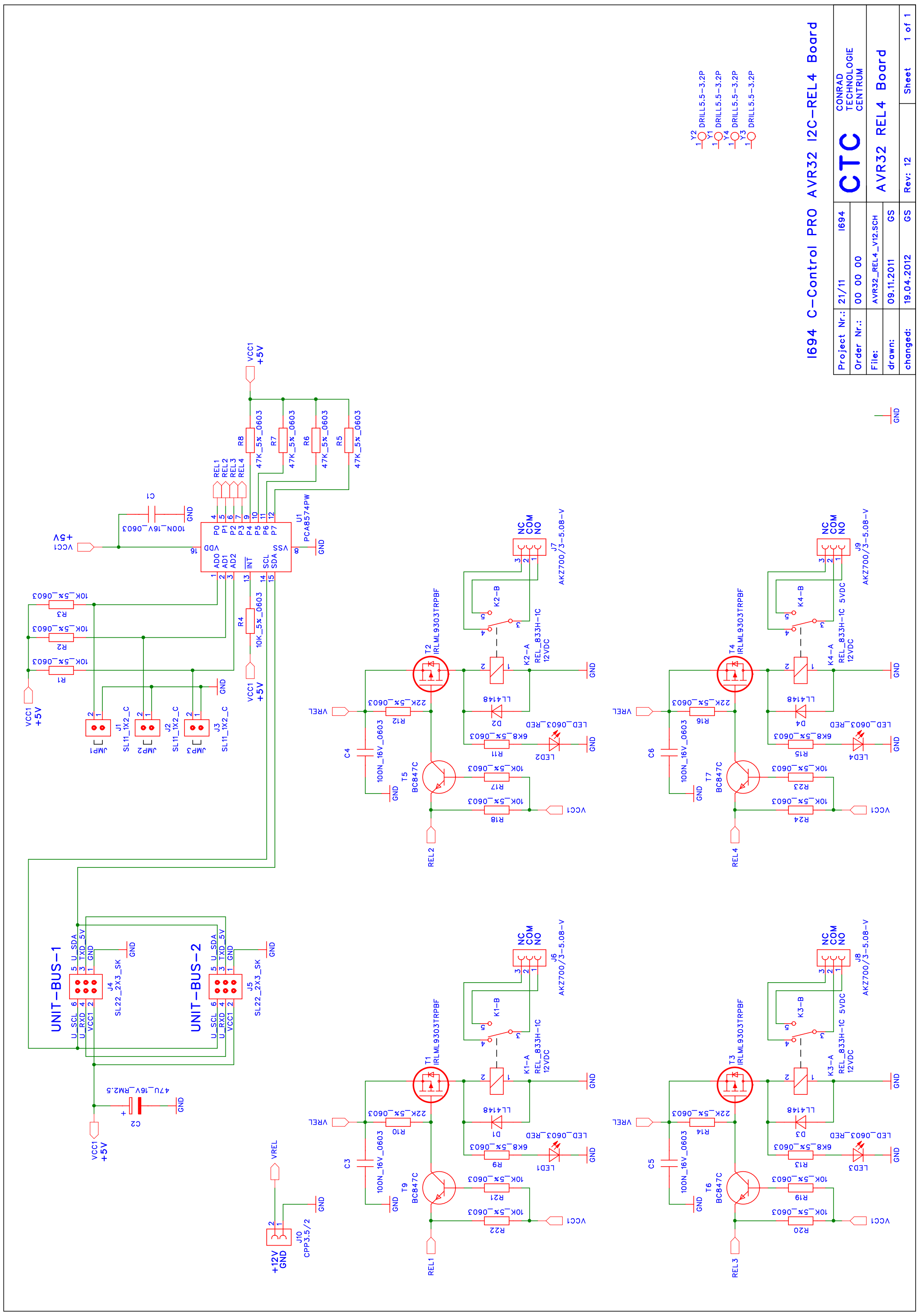
Info: The REL4-Board can be mounted on a DIN rail by Phoenix Contact DIN rail carrier of the series "UMK".

Technical Data

dimensions	76mm x 72mm x 18mm (LxWxH)
pin header pitch	2.54mm
relay	NC/NO, max. 24V/7A

operating voltage	12V
current consumption	120mA
weight	70g

2.2.9.1 Connection Diagram

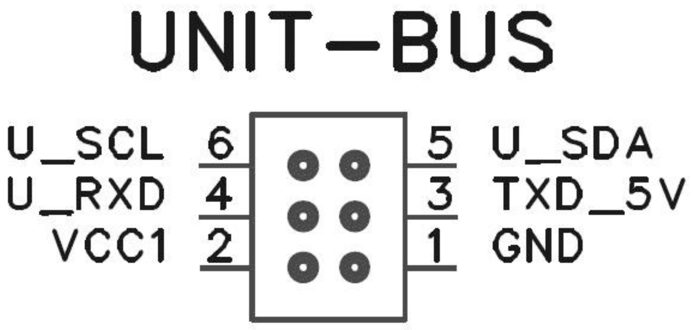


2.2.10 RELBUS-Board

The C-Control PRO AVR32Bit RELBUS-Board (Conrad Order No. 192645) is designed to expand the functionality of the C-Control PRO AVR32Bit products. The product is configured as open circuit board. It is equipped with 8 open source switching stages (high-side switch) to switch 8 consumers with small loads such as relay and intended only for the C-Control PRO UNIT-BUS.

Connection and Commissioning

Make sure that before you connect the modules to your C-Control PRO as AVR32Bit Application-board or Mainboard, all connections to connected devices are separated and voltage free. On C-Control PRO systems there is a 6-pin header connector labeled UNIT-BUS. This pin header connector is suitable for connecting the RELBUS-Boards. At these pins, I2C, UART and +5V are lead through. The RELBUS-Board has an I2C bus port expander for driving the load (e.g. relay) is responsible. Through the I2C bus control no additional I/O pins of the UNIT are required.

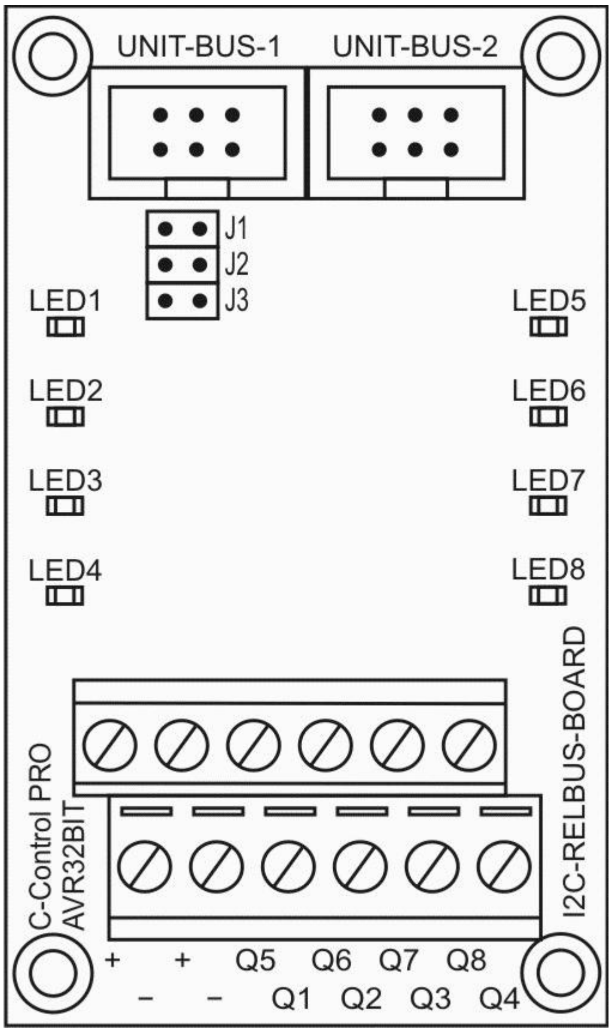


UNIT-BUS Pin Configuration

The RELBUS-Board is connected via a 6-pin ribbon cable to the pin header connector (UNIT-BUS). Since the cable length to the UNIT BUS may vary according to the application, we offer these components for self-assembly using the following order numbers:

• Ribbon cable RM1.27 0.05mm²:	Order No. 607237
• Pin header connectors 2x3 RM:2.54mm:	Order No. 742063
• Matching connection cable pre-assembled (length 35cm)	Order No. 198876

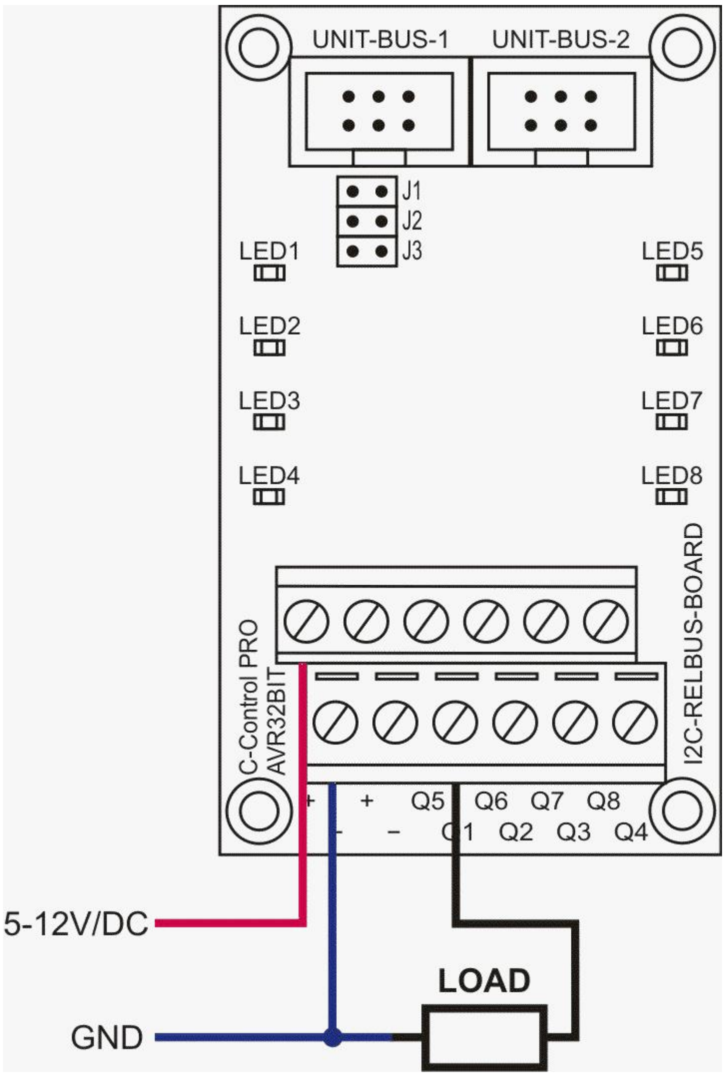
➡ **Tip**: The pin header connectors can be easily pressed together with a small vise. Cut the cable to proper length and straight it in the plug (guide grooves in the plug), and then clamp between the two vise jaws, and turn it carefully until the connector clicks into place.



RELBUS-Board overview

The RELBUS-Board has two UNIT-BUS connections that are mutually connected 1:1. Thus, e.g., one of the connectors can be plugged to the Applicationboard or Mainboard, and the second port can be used as a junction that connects to another UNIT-BUS module. The cable length must not exceed 2m, since this will cause communication errors. However, when longer lines are needed, it is helpful to put an I2C power driver (Order No. 198280) in-between.

The RELBUS-Board is powered by the UNIT-BUS with power. The consumer power supply is made at the screw clamps labeled "+" and "-" . The UNIT-BUS is used in this module only as a communication interface, and for the supply of the digital electronic part of the circuit. Consumers are powered externally via the ports "+" and "-"!



Beispiel Verbraucheranschluss an Ausgang Q1

Attention: Other I2C bus modules use the same I2C expander chips (PCA8574). Therefore the maximum number of modules with this IC is limited to 8!

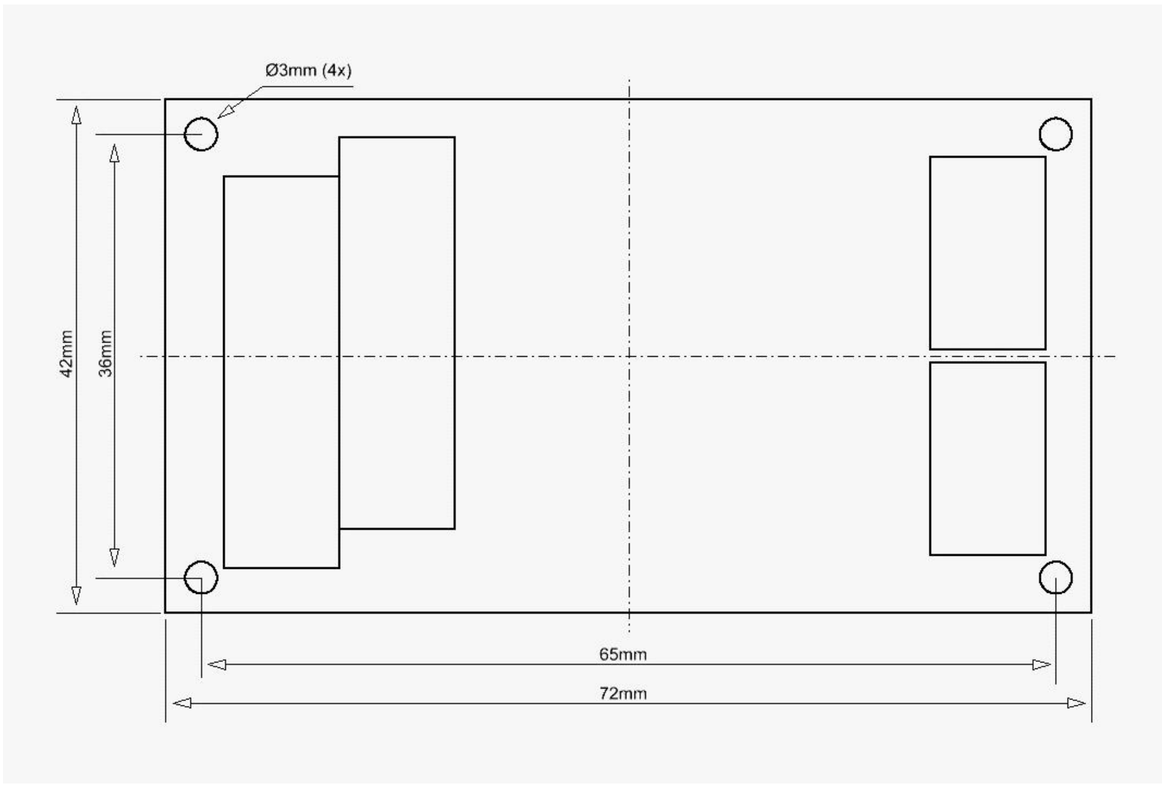
Addressing:

The I2C address jumpers J1 to J3 are located on the front of the RELBUS-Board. When using several modules and depending on the desired address the jumper must be set as follows:

J3	J2	J1	Address
-	-	-	Hex 27
-	-	x	Hex 26
-	x	-	Hex 25
-	x	x	Hex 24
x	-	-	Hex 23
x	-	x	Hex 22
x	x	-	Hex 21

x	x	x	Hex 20

x=Jumper set / - = **not** set



CAD

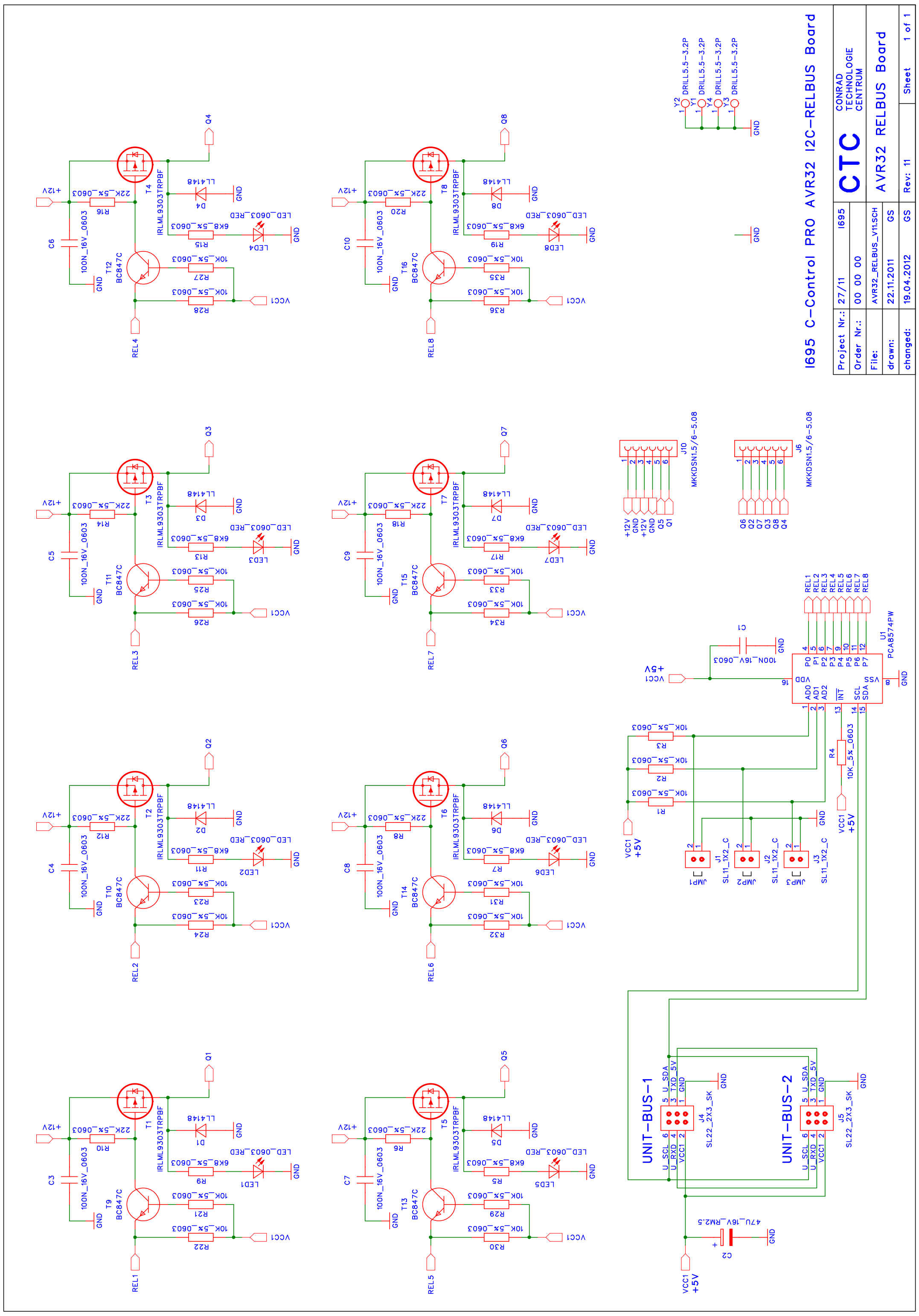
Info: The RELBUS-Board can be mounted on a DIN rail by Phoenix Contact DIN rail carrier of the series "UMK".

Attention: The outputs are not short-circuit proof and can be destroyed in a short to ground!

Technical Data

dimensions	42mm x 72mm x 22mm (LxWxH)
pin header pitch	2.54 mm
output implementation	open-source (high-side switch)
output load	max. per output 200mA (5V to 12V DC)
operating voltage	5V via UNIT-BUS
current consumption	20mA
weight	30g

2.2.10.1 Connection Diagram

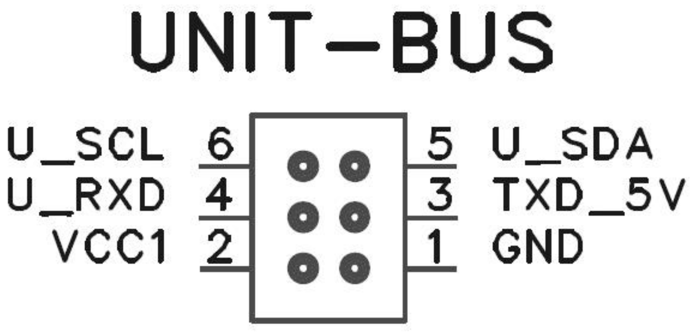


2.2.11 UNIT-BUS Ext-Board

The C-Control PRO AVR32Bit UNIT BUS Ext board (Conrad Order No. 192673) is designed to expand the functionality of the C-Control PRO AVR32Bit products. The product is designed as an open breadboard experimental circuit board with a pitch of 2.54mm. It is equipped with two 6-pin header connectors and is intended only for the C-Control UNIT-BUS. The board serves to build your own circuits. For circuit design and the comfortable replica the circuit board is printed with a coordinate system. The board can directly be mounted under or next to the Mainboard. PCB spacers are needed for "sandwich" mounting with a minimum of 20mm length and a thread diameter of 3mm.

Connection and Commissioning

Make sure that before you connect the modules to your C-Control Pro AVR32Bit Mainboard all connections to connected devices are separated and voltage free. On the C-Control PRO AVR32Bit Applicationboard and Mainboard, a 6-pin header connector is labeled UNIT-BUS. This header connector is suitable for connecting the UNIT-BUS Extension boards. On these pins, I2C, UART and 5V are passed out. The C-Control PRO AVR32Bit Unit works with 3.3V level, and extensions, as well as the older C-Control I2C-bus modules, use 5V. Therefore, between the C-Control PRO AVR32Bit UNIT and the UNIT-BUS are level converters that converts the 3.3V signals of the UNIT to 5V signals of the UNIT-BUS.



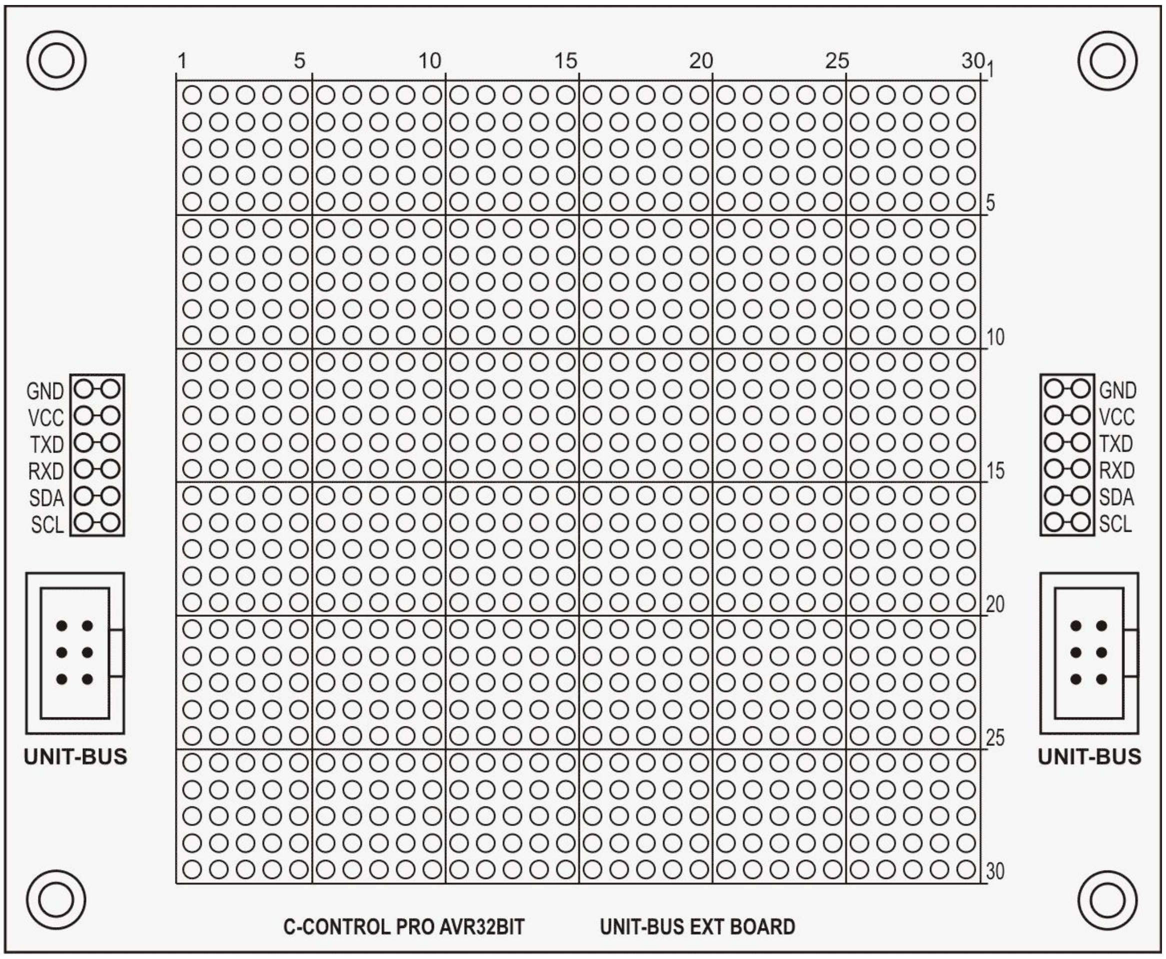
UNIT-BUS Pin Configuration

The UNIT-BUS Extension board gets connected via a 6-pin ribbon cable with pin header connector (female). Because depending on the application, the cable lengths are varying, we offer these components for self-assembly using the following order numbers:

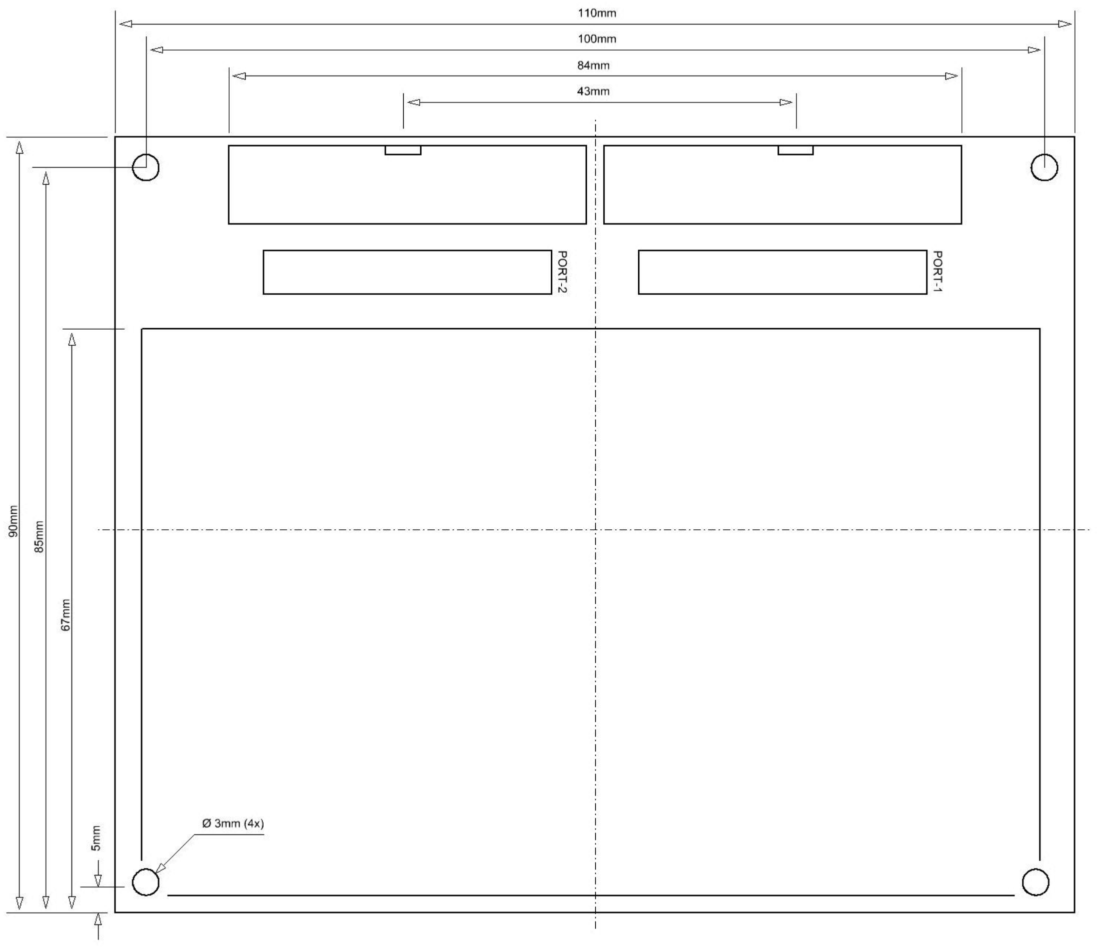
• Ribbon cable RM1.27 0.05mm²:	Order No. 607237
• Pin header connectors 2x3 RM:2.54mm:	Order No. 742063
• Matching connection cable pre-assembled (length 35cm)	Order No. 198876

- To get a clean signal for long cable lengths and high transmission capacity use the I2C line driver (Order No. 198280)

Tip: The pin header connectors can be easily pressed together with a small vise. Cut the cable to proper length and straight it in the plug (guide grooves in the plug), and then clamp between the two vise jaws, and turn it carefully until the connector clicks into place.



PCB Overview



CAD

Technical Data:

dimensions	110mm x 90mm x 13mm (LxWxH)
pin header pitch	2.54mm
hole grid pitch (PCB)	2.54mm
dimensions hole grid	30x30 pins
weight	30g

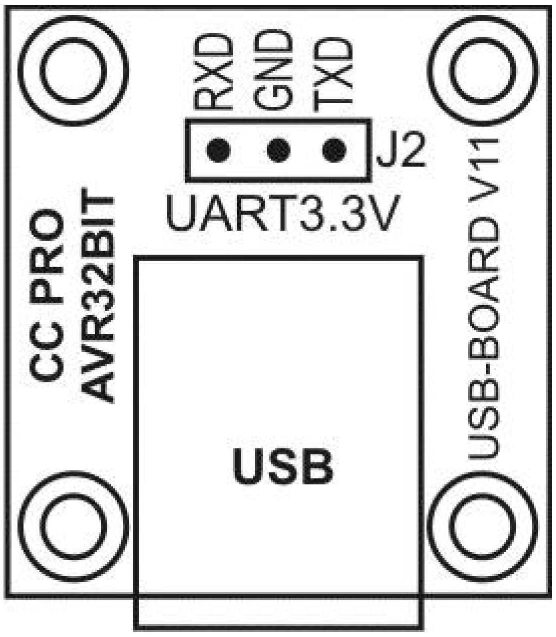
2.2.12 USB-Board

The C-Control PRO AVR32Bit USB-Board (Conrad Order No. 192688) is designed to expand the functionality of the C-Control PRO AVR32Bit products. The product is configured as open circuit board. It is equipped with a USB Type-B connector and a 3-pin header connector (pitch: 2.54mm) for connection to a 3.3V UART interface of the C-Control PRO AVR32Bit.

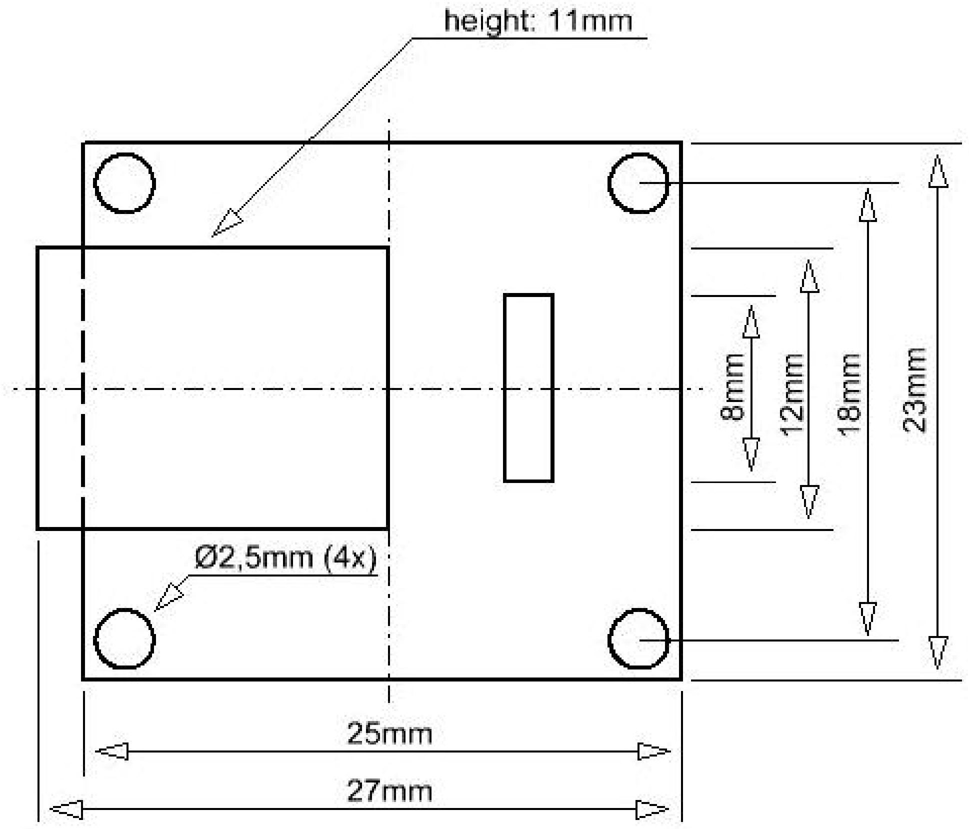
Connection and Commissioning

Make sure that before you connect the modules to your C-Control PRO system all connections to connected devices are separated and voltage free. The C-Control PRO AVR32Bit UNIT has several UART interfaces (see manual) that can be connected to the USB board. On the boards, e.g. Applicationboard or Mainboard, are the UART interfaces accessible through contacts at which the board can be connected. The USB board acts as an interface between the UNIT UART interface and a PC USB port to share data.

Under the following link you can download the driver for the product: http://www.sil-abs.com



PCB Overview

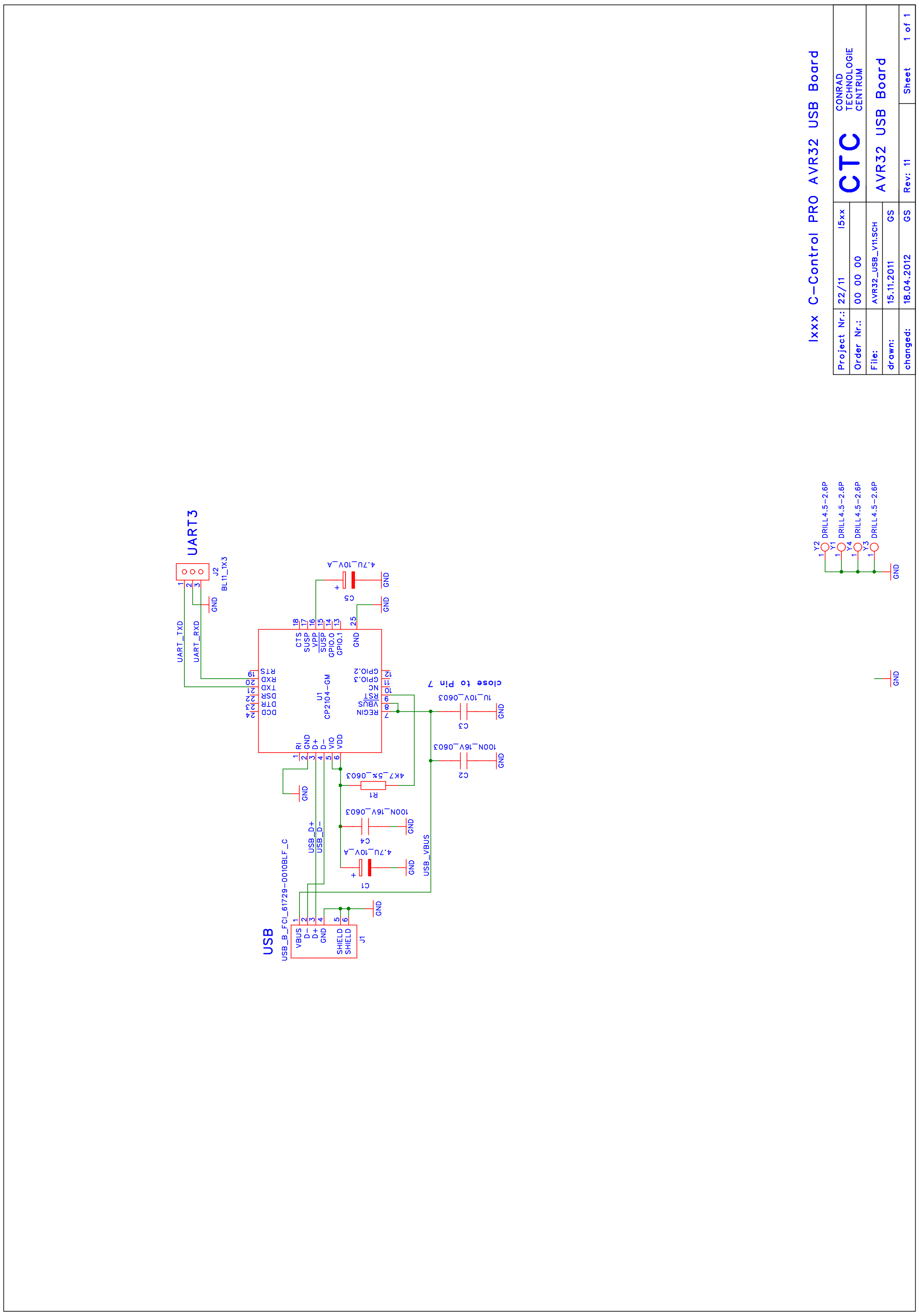


CAD

Technical Data:

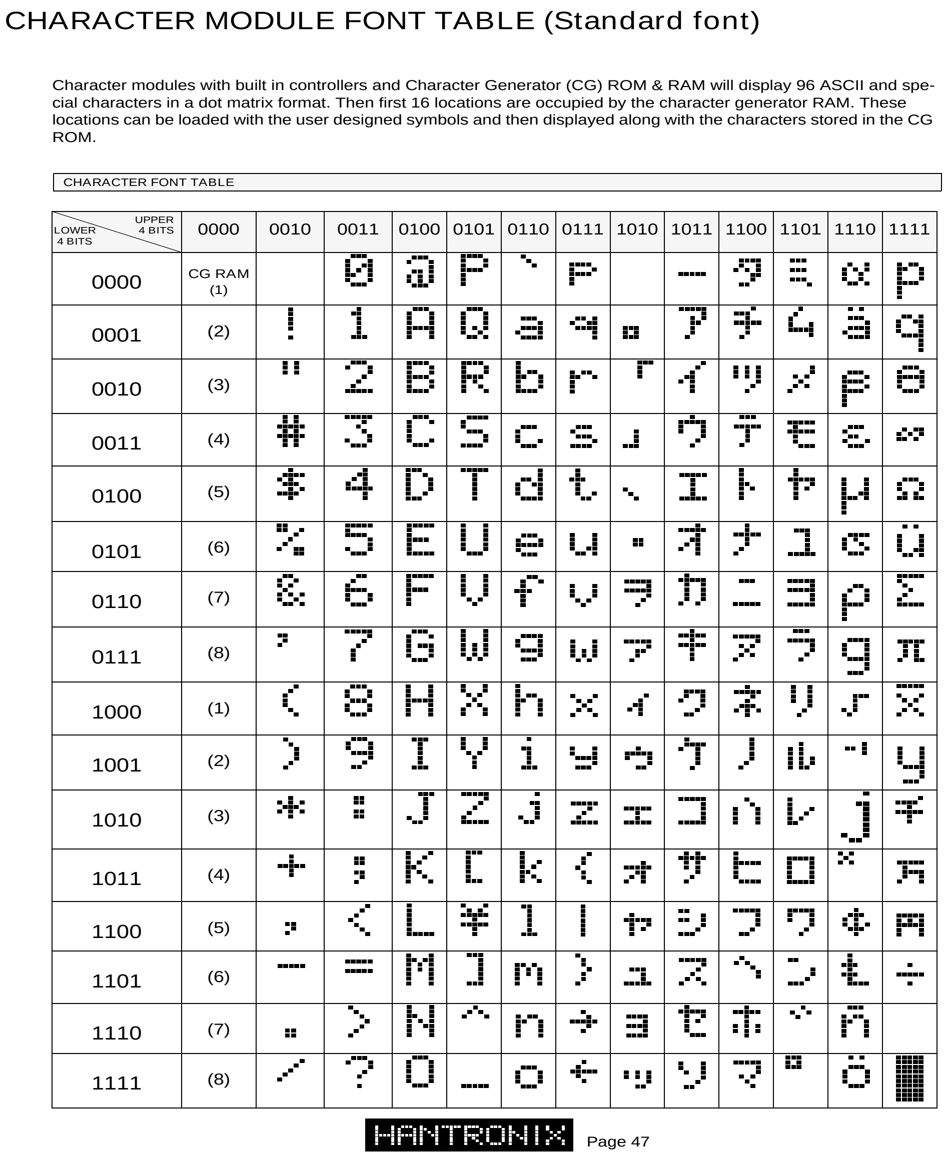
dimensions	23mm x 25mm x 12mm (LxWxH)
UART pin pitch	2.54mm
USB	Type-B
operating voltage	powered by USB port
UART level	3.3V RxD/TxD
weight	5g

2.2.12.1 Connection Diagram



2.3 LCD Matrix

The complete datasheets are on the CD-ROM in the directory "Datasheets".



CHARACTER MODULE FONT TABLE (Standard font)

Character modules with built in controllers and Character Generator (CG) ROM & RAM will display 96 ASCII and special characters in a dot matrix format. Then first 16 locations are occupied by the character generator RAM. These locations can be loaded with the user designed symbols and then displayed along with the characters stored in the CG ROM.

CHARACTER FONT TABLE

UPPER 4 BITS / LOWER 4 BITS	0000	0010	0011	0100	0101	0110	0111	1010	1011	1100	1101	1110	1111
0000	CG RAM (1)		0	@	P	`	p		ー	タ	ミ	α	p
0001	(2)	!	1	A	Q	a	q	。	ア	チ	ム	ä	q
0010	(3)	"	2	B	R	b	r	「	イ	ツ	メ	β	θ
0011	(4)	#	3	C	S	c	s	」	ウ	テ	モ	ε	∞
0100	(5)	$	4	D	T	d	t	、	エ	ト	ヤ	μ	Ω
0101	(6)	%	5	E	U	e	u	・	オ	ナ	ユ	σ	ü
0110	(7)	&	6	F	V	f	v	ヲ	カ	ニ	ヨ	ρ	Σ
0111	(8)	'	7	G	W	g	w	ァ	キ	ヌ	ラ	g	π
1000	(1)	(	8	H	X	h	x	ィ	ク	ネ	リ	√	x̄
1001	(2)	)	9	I	Y	i	y	ゥ	ケ	ノ	ル	$^{-1}$	y
1010	(3)	*	:	J	Z	j	z	ェ	コ	ハ	レ	j	千
1011	(4)	+	;	K	[	k	{	ォ	サ	ヒ	ロ	^{x}	万
1100	(5)	,	<	L	¥	l	|	ャ	シ	フ	ワ	¢	円
1101	(6)	-	=	M	]	m	}	ュ	ス	ヘ	ン	£	÷
1110	(7)	.	>	N	^	n	→	ョ	セ	ホ	゛	ñ	
1111	(8)	/	?	O	_	o	←	ッ	ソ	マ	゜	ö	█

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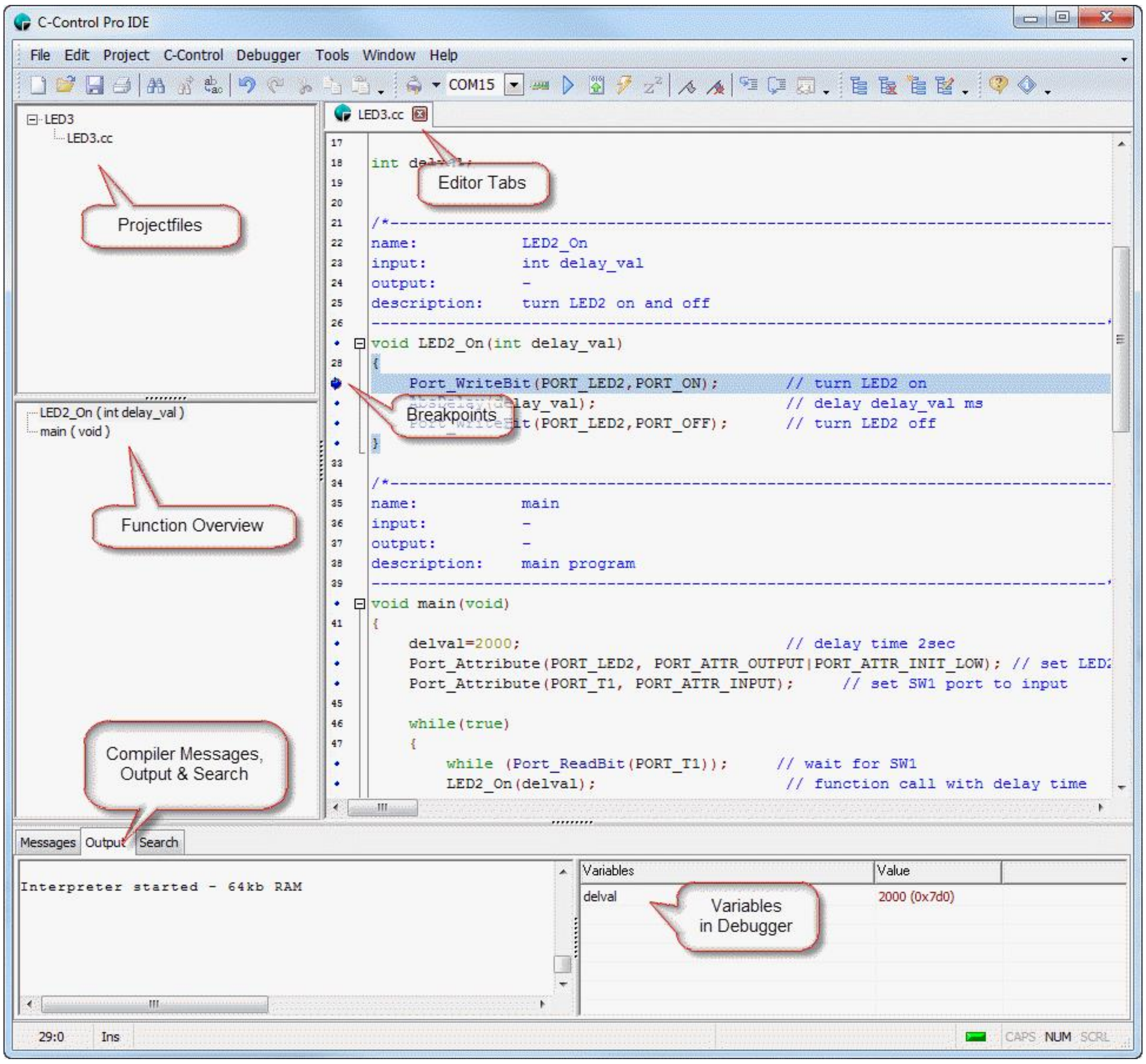
Part 3

3 IDE

The C-Control Pro User Interface (IDE) consists of the following main elements:

Sidebar for Project Files	Here several files can be filed to form a project
Editor Window	In order to edit files as many editor windows as necessary can be opened.
Compiler Messages	Here error messages and general compiler informations are displayed
C-Control Outputs	Distribution of the CompactC program's debug messages
Variables Window	Here monitored variables are displayed



```
int delval;

/*------------------------------------------------------------------------
name:           LED2_On
input:          int delay_val
output:         -
description:    turn LED2 on and off
------------------------------------------------------------------------*/
void LED2_On(int delay_val)
{
    Port_WriteBit(PORT_LED2,PORT_ON);           // turn LED2 on
    AbsDelay(delay_val);                        // delay delay_val ms
    Port_WriteBit(PORT_LED2,PORT_OFF);          // turn LED2 off
}

/*------------------------------------------------------------------------
name:           main
input:          -
output:         -
description:    main program
------------------------------------------------------------------------*/
void main(void)
{
    delval=2000;                                // delay time 2sec
    Port_Attribute(PORT_LED2, PORT_ATTR_OUTPUT|PORT_ATTR_INIT_LOW); // set LED2
    Port_Attribute(PORT_T1, PORT_ATTR_INPUT);       // set SW1 port to input

    while(true)
    {
        while (Port_ReadBit(PORT_T1));          // wait for SW1
        LED2_On(delval);                        // function call with delay time
```

```
Interpreter started - 64kb RAM
```

Variables	Value
delval	2000 (0x7d0)

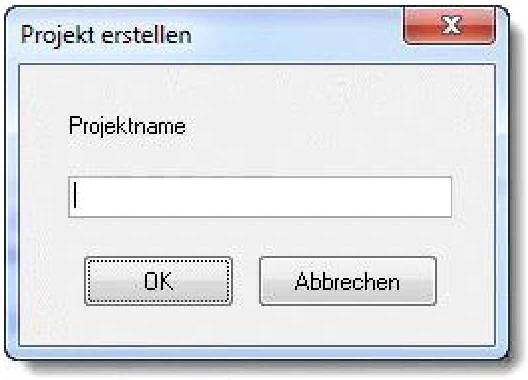
3.1 Projects

Every program for the C-Control Pro Module is configured through a project. The project states which source files and libraries are being utilized. Also the settings of the Compiler are noted. A project consists of the project file with the extension ".cprj" and the appropriate source files.

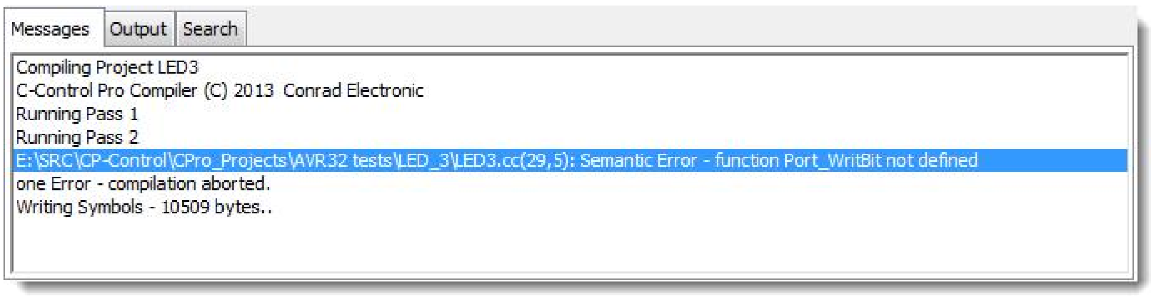
3.1.1 Create Projects

In the menu Project the dialog box Create Project can be opened by use of item New. Here a project name is issued for the project. Then the project is created in the sidebar.

➔ It is not necessary to decide in advance whether a CompactC or a BASIC project will be created. In a project CompactC or BASIC files can be arranged combined as project files in order to create a program. The source text files in a project will determine which programming language will be used. Files with the extension "*.cc" will run in a CompactC context while files with the extension "*.cbas" are translated into BASIC.



3.1.2 Compile Projects



```
Compiling Project LED3
C-Control Pro Compiler (C) 2013  Conrad Electronic
Running Pass 1
Running Pass 2
E:\SRC\CP-Control\CPro_Projects\AVR32 tests\LED_3\LED3.cc(29,5): Semantic Error - function Port_WritBit not defined
one Error - compilation aborted.
Writing Symbols - 10509 bytes..
```

In menu Project the current project can be translated by the Compiler by use of Compile (F9). The Compiler messages are displayed in a separate window section. If errors arise during compilation then one error will be described per line. The form is:

```
File Name(Line,Column): Error Description
```

The error positions can be found in the source text by use of commands Next Error (F11) or Previous Error (Shift-F11). Both commands are found in menu item Project. Alternative the cursor can in the Editor be placed onto the error position by use of a double mouse click on the Compiler's error message.

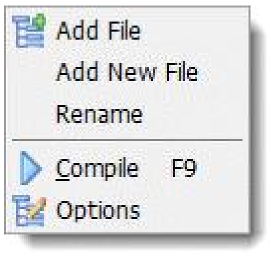
After successful compilation the Byte Code will be filed in the project list as file with the extension "*.bc".

By a right mouse click in the area of the compiler messages the following actions can be initiated:

- delete – will delete the list of compiler messages
- copy to clipboard – will copy all text messages onto the clipboard

3.1.3 Project Management

A right mouse click on the newly created project in the sidebar will open a pop-up menu with the following options:



- Newly Add – A new file will be set up and simultaneously an editor window will be opened.
- Add – An existing file will be attached to the project.
- Rename – The name of the project will be changed (This is not necessarily the name of the project file).
- Compile – The compiler for the project is started.
- Options – The project options can be changed.

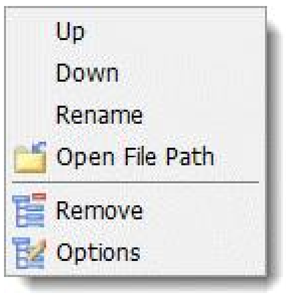
Adding of Project Files

When clicking Add project file the file Open Dialog will appear. Here the files to be added to the project can be selected. Any number of files can be selected.

Alternative by use of Drag&Drop files from the Windows Explorer can be transferred into the project management.

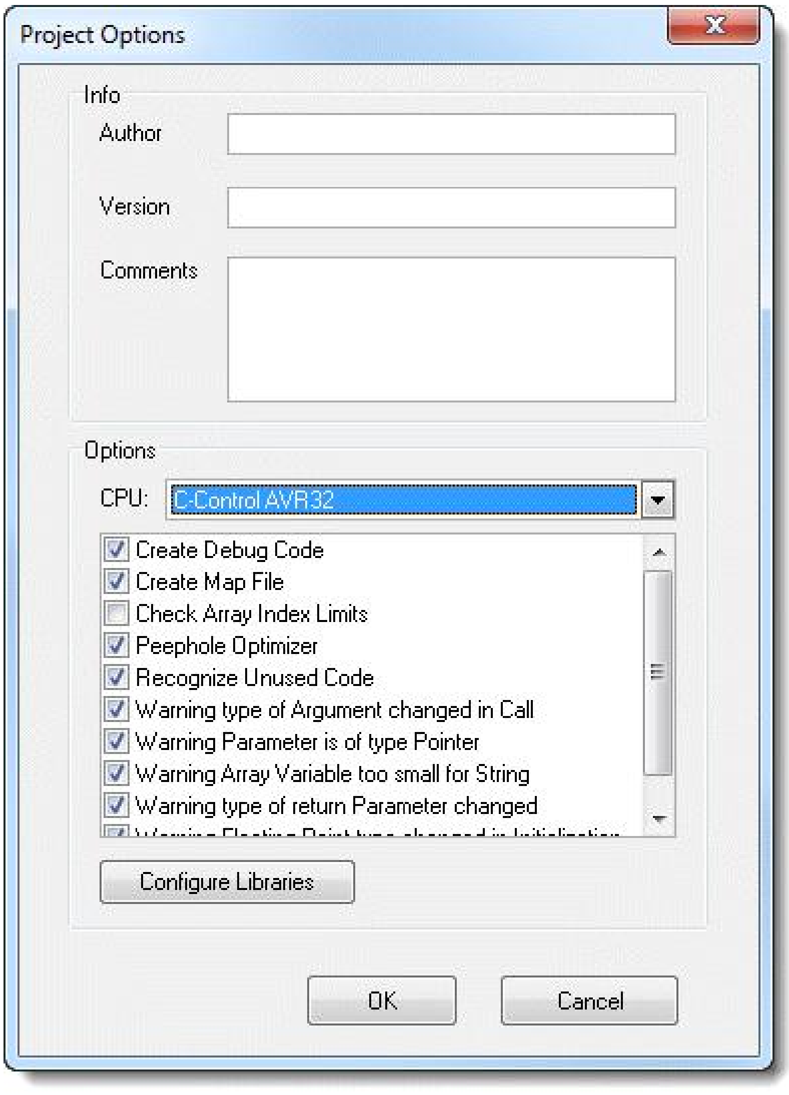
Project Files

When files have been added to the project these can be opened by a double mouse click onto the file name. By use of a right click further options will appear:



- Up – The project file will move up the list (also with Ctrl - Arrow up).
- Down – The project file will move down (also with Ctrl - Arrow down).
- Rename – The name of the project file will be changed.
- Delete – The file will be deleted from the project.
- Options – The project options can be changed.

3.1.4 Project Options


Project Options

Info

Author

Version

Comments

Options

CPU: C-Control AVR32

- ✓ Create Debug Code
- ✓ Create Map File
- Check Array Index Limits
- ✓ Peephole Optimizer
- ✓ Recognize Unused Code
- ✓ Warning type of Argument changed in Call
- ✓ Warning Parameter is of type Pointer
- ✓ Warning Array Variable too small for String
- ✓ Warning type of return Parameter changed

For each project the compiler settings can be changed separately.

The items *Author*, *Version*, *Commentary* can be freely inscribed. They serve as memory support in order to better remember the project details at a later date.

In "CPU" the target platform of the project is determined.

Configure Libraries calls the Library Management.

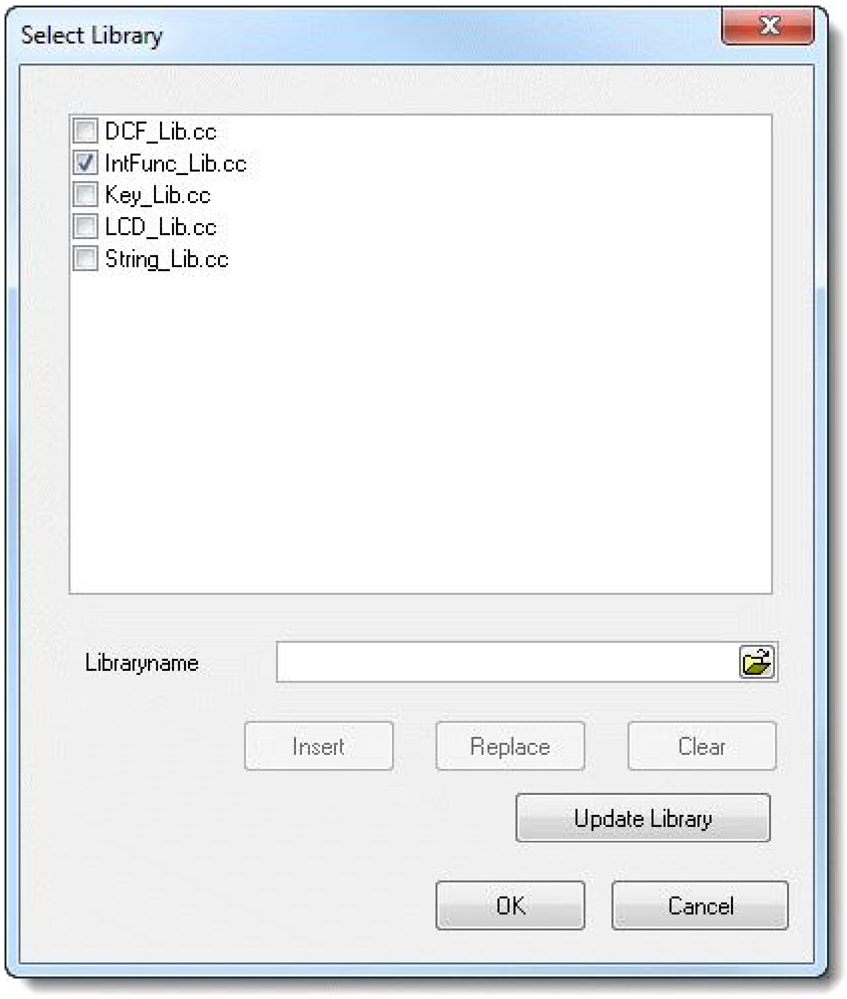
Options

Option	Meaning

Create Debug Code	Creates Debug Code. If Debug Code is compiled the Byte Code becomes insignificantly longer. For each line in the source text which contains executable commands the Byte Code will be one Byte longer.
Create Map File	Generates a map file that shows the address and length of variables.
Check Array Index Limits	Code will be inserted code that checks the index of array accesses. Use only for testing, since the runtime is increased.
Peephole Optimizer	Optimizes special code sequences. Turn always on.
Recognize Unused Code	Unused code will be optimized away. Turn always on.
Warning type of Argument changed in Call	The type of a variable was converted in a function call.
Warning Parameter is of type Pointer	The type of a pointer variable (array) is of a different type than expected by the called function.
Warning Array Variable too small for String	The string does not fit fully in the assigned array variable.
Warning type of return Parameter changed	The return value is of a different type than expected in the expression.
Warning Floating Point type changed in Initialization	The floating point value is converted during initialization to another type.

3.1.5 Library Management

In the Library Management the source text libraries can be chosen that will be compiled in addition to the project files.



- [ ] DCF_Lib.cc
- [x] IntFunc_Lib.cc
- [ ] Key_Lib.cc
- [ ] LCD_Lib.cc
- [ ] String_Lib.cc

Only those files will be used for compilation whose CheckBox has been selected.

The list can be altered by use of the path text input field "Library Name" and the buttons in the dia-log:

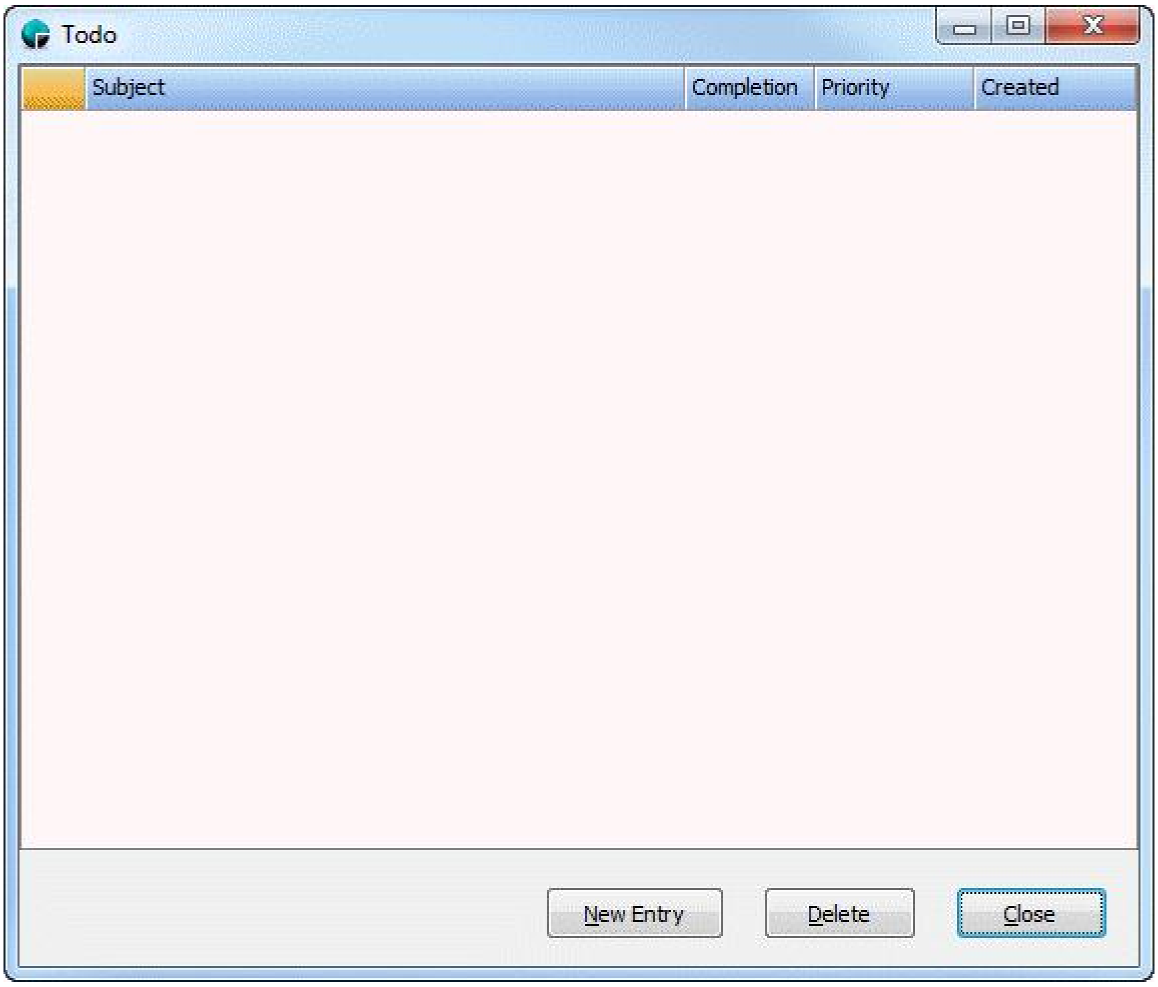
- Add – The path will be added to the list.
- Replace – The selected entry in the list is replaced by the path name.
- Delete – The selected list entry is deleted.
- Update Library – Files present in the Compiler Presetting but not in this list will be added.

3.1.6 Thread Options

Since version 2.12 of the IDE the thread configuration is no longer made in the project options. Please see the new syntax in Threads.

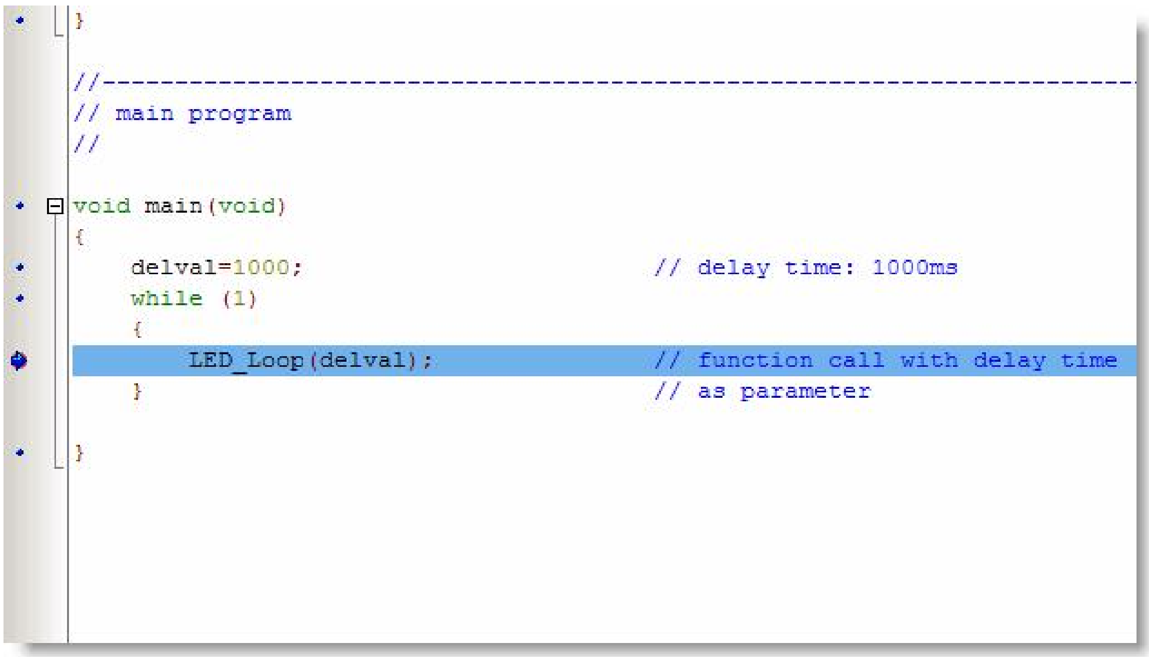
3.1.7 Todo Liste

On the Project menu a simple todo list can be called. The content is stored together with the project.



3.2 Editor

Several windows can be opened in the C-Control Pro Interface. Each window can be altered in size and displayed text detail. A double mouse click on the title line will maximize the window.

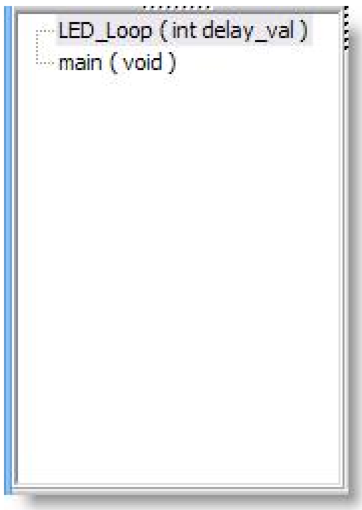


```
}

//-----------------------------------------------------------------------
// main program
//

void main(void)
{
    delval=1000;                        // delay time: 1000ms
    while (1)
    {
        LED_Loop(delval);               // function call with delay time
    }                                   // as parameter

}
```

A mouse click in the area to the left of the text will there set a Breakpoint. Prior to this the source text must be compiled error free with "*Debug Info*" and in the corresponding line really executable program text must be placed (i. e. no commentary line o. e.).

Functions Overview

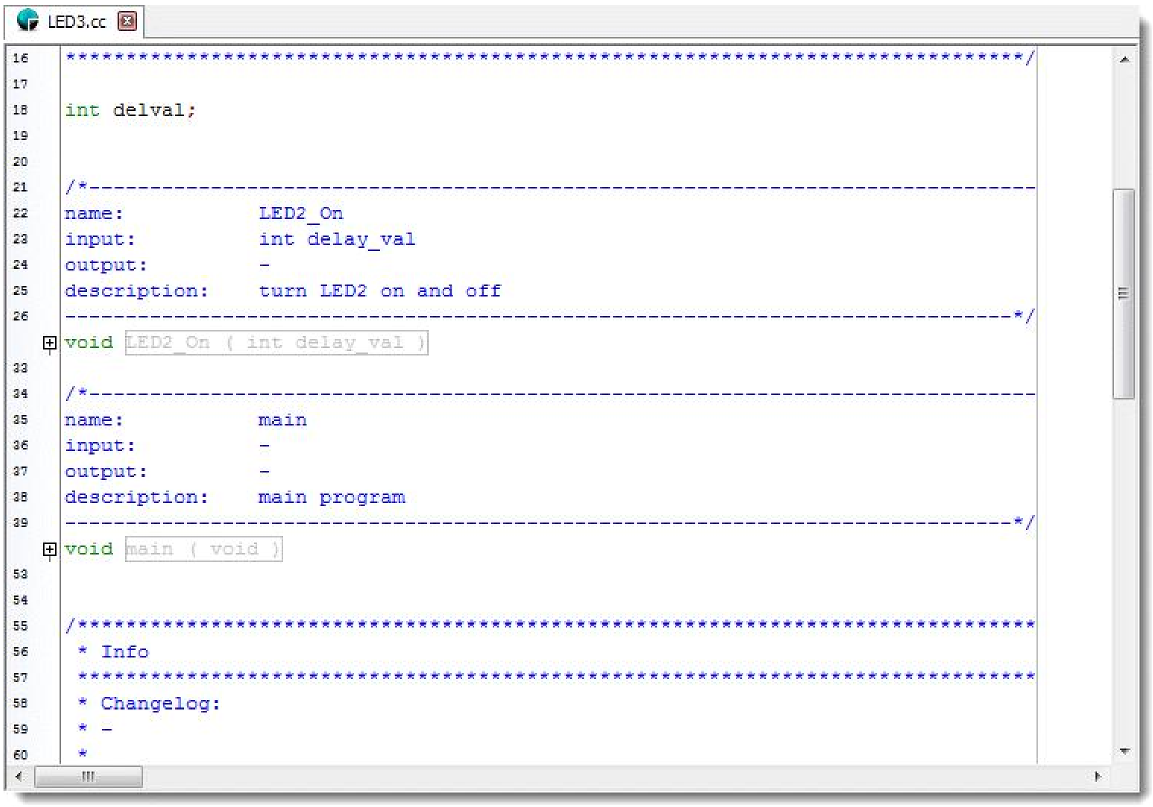
On the left side is an overview of all syntactically correct defined functions. The function names with parameters are expressed in this view. The function where the cursor in this moment resides is drawn with a grey bar in the background. After a double click on the function name the cursor jumps to the beginning of that function in the editor.



```
LED_Loop ( int delay_val )
main ( void )
```

Code Folding

To maintain a good overview over the source code, the code can be folded. After the syntactical analyzer, that is built into the editor, recognizes a defined function, beams are drawn on the left side along the range of the function. A click on the minus sign in the small box folds the text, so that only the first line of the function can be seen. Another click on the small plus sign, and the code unfolds again.



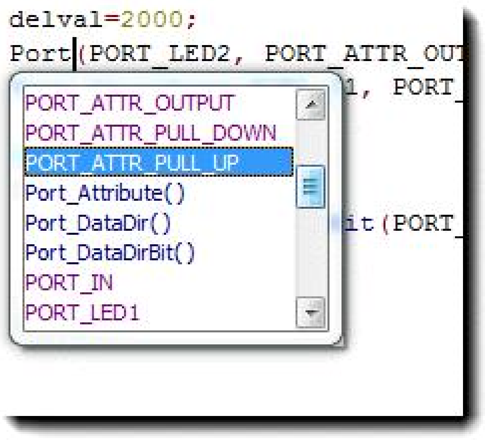
LED3.cc

```
*******************************************************************************/

int delval;


/*-----------------------------------------------------------------------------
name:           LED2_On
input:          int delay_val
output:         -
description:    turn LED2 on and off
-----------------------------------------------------------------------------*/
void LED2_On ( int delay_val )

/*-----------------------------------------------------------------------------
name:           main
input:          -
output:         -
description:    main program
-----------------------------------------------------------------------------*/
void main ( void )


/*******************************************************************************
 * Info
 *******************************************************************************
 * Changelog:
 * -
 *
```

To fold or unfold all functions in an editor file, the options Full Collapse and Full Expand are selectable in the right click editor pull-up menu.

Syntactical Input Help

The editor now has a syntactical input help. When the beginning of a reserved word or a function name from the standard library is typed into the editor, the input help can be activated with Ctrl-Space. In dependency from the already entered characters, a popup select box opens, that shows the words that can be inserted into the source code.

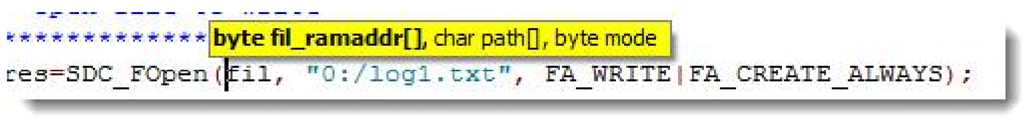


```
delval=2000;
Port(PORT_LED2, PORT_ATTR_OU
```

Parameter Input Help

Nach einer erfolgreichen Kompilierung werden auch die Parameter einer Function analysiert. Tippt man einen bekannten Funktionsnamen und Klammer auf "(", so wird in gelb die erwarteten Typen der Funktionsparameter angezeigt.

After a successful compilation, the parameters of all function are analyzed. If you tap a known function name and a parenthesis "(", the expected types of the function parameters displayed in yellow.



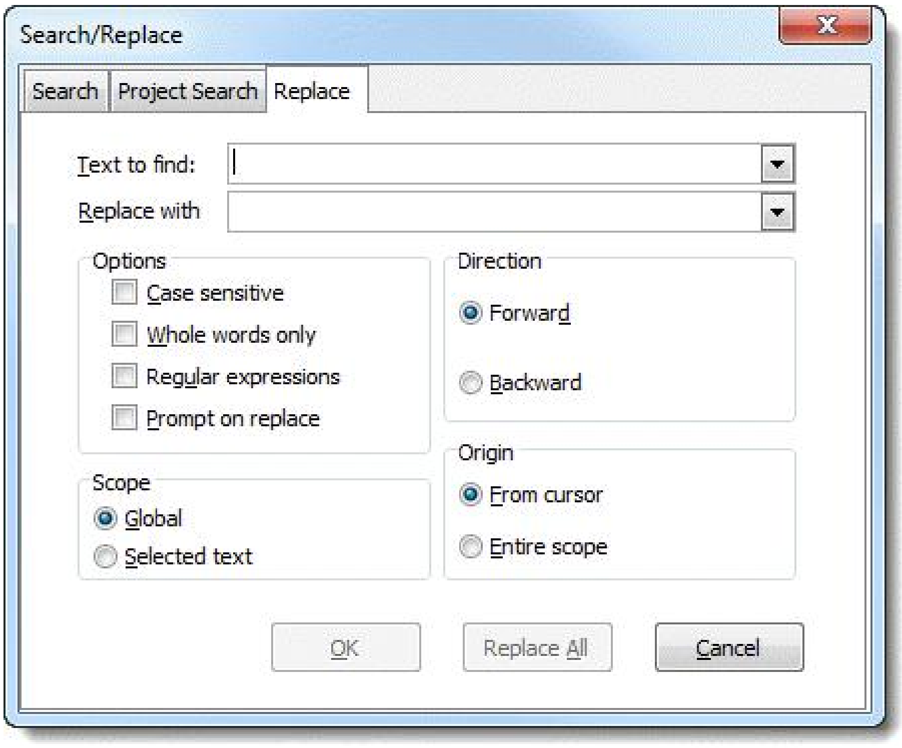
```
res=SDC_FOpen(fil, "0:/log1.txt", FA_WRITE|FA_CREATE_ALWAYS);
```

3.2.1 Editor Functions

Under menu item Edit the most important editor functions can be found:

- Undo (Ctrl-Z) – will execute an Undo operation. The possible number of Undo steps depends on the settings in Undo Groups.
- Restore (Ctrl-Y) – will restore the editor condition that has been changed by previous use of the Undo command.
- Cut (Ctrl-X) – will cut out selected text and will copy it to the clipboard.
- Copy (Ctrl-C) – will copy selected text to the clipboard.
- Insert (Ctrl-V) – will copy the contents of the clipboard to the cursor position.
- Select All (Ctrl-A) – will select the entire text.
- Search (Ctrl-F) – will open the Search dialog.
- Continue Search (F3) – will continue the search using the set search criteria.
- Replace (Ctrl-R) – will open the Replace dialog.
- Go To (Alt-G) – will allow to jump to a definite line.

Search/Restore Dialog



Text to find:
Replace with

Options
- [ ] Case sensitive
- [ ] Whole words only
- [ ] Regular expressions
- [ ] Prompt on replace

Direction
- [✓ Forward]
- Backward

Scope
- [✓ Global]
- Selected text

Origin
- [✓ From cursor]
- Entire scope

- Text to find – Input field for the text to be searched for.
- Replace with – Text that will replace the text found.
- Case Sensitive – makes the distinction between upper and lower case writing.
- Whole words only – will find only whole words rather than part character chains.
- Regular expressions – activates the input of Regular Expressions in the search mask.
- Prompt on replace – prior to replacing the user will be asked for approval.

Next, the search direction (Forward, Backward) can be predetermined, if the entire text (Global) or only a selected area (Selected text) is searched. Also sets whether the search starts at the cursor (From cursor) or the beginning of the text (Entire scope).

Project Search

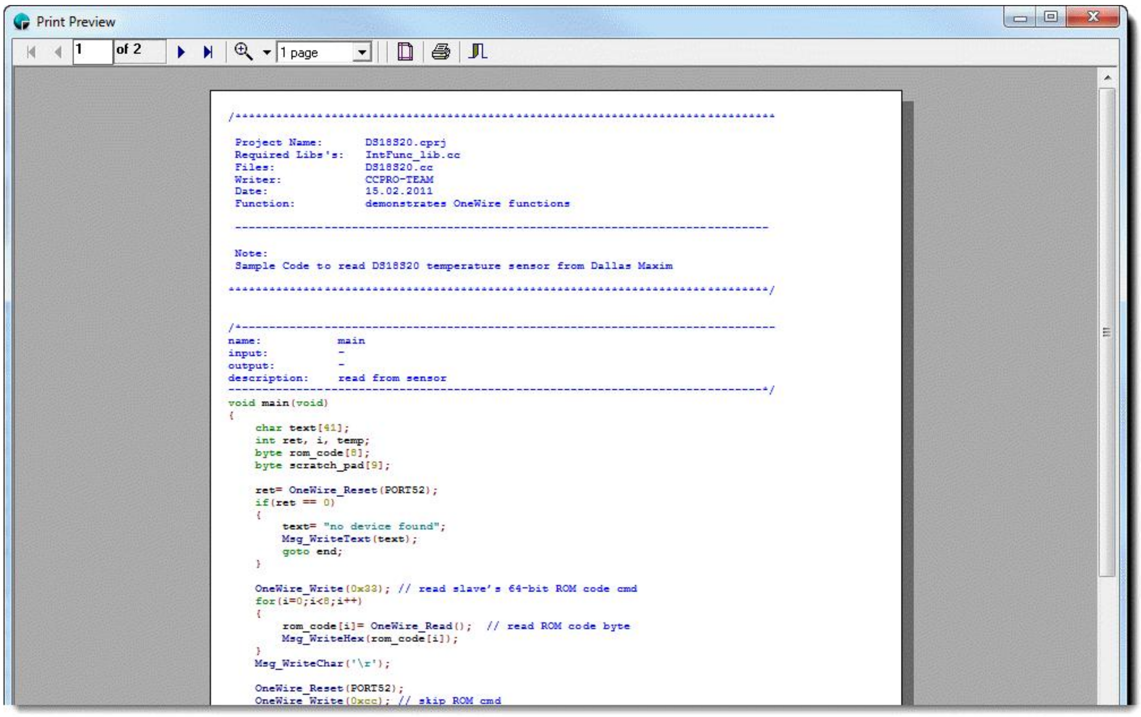
In project search, a text is searched in more than one file.

All project files - Searches the text in all stored project files, even if they are not open in the editor.
All open files - Scans all files open in the editor. It will, however, not consider unsaved changes.

3.2.2 Print Preview

To deliver the source code as Hard Copy or for archiving purposes, the C-Control Pro IDE has built in printer functions. The following options can be selected from the File Pull-Down Menu:

Print:	Prints the indicated pages
Print Preview:	Shows a print preview
Printer Setup:	Choose the printer, paper size and orientation
Page Setup:	Header and Footer lines, line numbers and other parameters can be selected



```
/************************************************************************

 Project Name:      DS18S20.cprj
 Required Libs's:   IntFunc_lib.cc
 Files:             DS18S20.cc
 Writer:            CCPRO-TEAM
 Date:              15.02.2011
 Function:          demonstrates OneWire functions

 ------------------------------------------------------------------------

 Note:
 Sample Code to read DS18S20 temperature sensor from Dallas Maxim

************************************************************************/


/*-----------------------------------------------------------------------
name:               main
input:              -
output:             -
description:        read from sensor
-----------------------------------------------------------------------*/
void main(void)
{
    char text[41];
    int ret, i, temp;
    byte rom_code[8];
    byte scratch_pad[9];

    ret= OneWire_Reset(PORT52);
    if(ret == 0)
    {
        text= "no device found";
        Msg_WriteText(text);
        goto end;
    }

    OneWire_Write(0x33); // read slave's 64-bit ROM code cmd
    for(i=0;i<8;i++)
    {
        rom_code[i]= OneWire_Read();  // read ROM code byte
        Msg_WriteHex(rom_code[i]);
    }
    Msg_WriteChar('\r');

    OneWire_Reset(PORT52);
    OneWire_Write(0xcc); // skip ROM cmd
```

3.2.3 Keyboard Shortcuts

Taste	Function
Left	Move cursor left one char
Right	Move cursor right one char
Up	Move cursor up one line
Down	Move cursor down one line
Ctrl + Left	Move cursor left one word
Ctrl + Right	Move cursor right one word
PgUp	Move cursor up one page
PgDn	Move cursor down one page
Ctrl + PgUp	Move cursor to top of page
Ctrl + PgDn	Move cursor to bottom of page
Ctrl + Home	Move cursor to absolute beginning
Ctrl + End	Move cursor to absolute end
Home	Move cursor to first char of line
End	Move cursor to last char of line
Shift + Left	Move cursor and select left one char

Shift + Right	Move cursor and select right one char
Shift + Up	Move cursor and select up one line
Shift + Down	Move cursor and select down one line
Shift + Ctrl + Left	Move cursor and select left one word
Shift + Ctrl + Right	Move cursor and select right one word
Shift + PgUp	Move cursor and select up one page
Shift + PgDn	Move cursor and select down one page
Shift + Ctrl + PgUp	Move cursor and select to top of page
Shift + Ctrl + PgDn	Move cursor and select to bottom of page
Shift + Ctrl + Home	Move cursor and select to absolute beginning
Shift + Ctrl + End	Move cursor and select to absolute end
Shift + Home	Move cursor and select to first char of line
Shift + End	Move cursor and select left and up at line start
Alt + Shift + Left	Move cursor and column select left one char
Alt + Shift + Right	Move cursor and column select right one char
Alt + Shift + Up	Move cursor and column select up one line
Alt + Shift + Down	Move cursor and column select down one line
Alt + Shift + Ctrl + Left	Move cursor and column select left one word
Alt + Shift + Ctrl + Right	Move cursor and column select right one word
Alt + Shift + PgUp	Move cursor and column select up one page
Alt + Shift + PgDn	Move cursor and column select down one page
Alt + Shift + Ctrl + PgUp	Move cursor and column select to top of page
Alt + Shift + Ctrl + Alt + PgDn	Move cursor and column select to bottom of page
Alt + Shift + Ctrl + Home	Move cursor and column select to absolute beginning
Alt + Shift + Ctrl + End	Move cursor and column select to absolute end
Alt + Shift + Home	Move cursor and column select to first char of line
Alt + Shift + End	Move cursor and column select to last char of line
Ctrl + C; Ctrl + Ins	Copy selection to clipboard
Ctrl + X	Cut selection to clipboard
Ctrl + V; Shift + Ins	Paste clipboard to current position
Ctrl + Z; Alt + Backspace	Perform undo if available
Shift +Ctrl + Z	Perform redo if available
Ctrl + A	Select entire contents of editor
Ctrl + Del	Clear current selection
Ctrl + Up	Scroll up one line leaving cursor position unchanged
Ctrl + Down	Scroll down one line leaving cursor position unchanged
Backspace	Delete last char
Del	Delete char at cursor
Ctrl + T	Delete from cursor to next word
Ctrl + Backspace	Delete from cursor to start of word
Ctrl + B	Delete from cursor to beginning of line
Ctrl + E	Delete from cursor to end of line
Ctrl + Y	Delete current line
Enter	Break line at current position, move caret to new line
Ctrl + N	Break line at current position, leave caret
Tab	Tab key
Tab (block selected)	Indent selection
Shift + Tab	Unindent selection
Ctrl + K + N	Upper case to current selection or current char
Ctrl + K + O	Lower case to current selection or current char
Ins	Toggle insert/overwrite mode
Ctrl + O + K	Normal selection mode
Ctrl + O + C	Column selection mode

Ctrl + K + B	Marks the beginning of a block
Ctrl + K + K	Marks the end of a block
Esc	Reset selection
Ctrl + digit (0-9)	Go to Bookmark digit (0-9)
Shift + Ctrl + (0-9)	Set Bookmark digit (0-9)
Ctrl + Space	Auto completion popup

3.2.4 Regular Expressions

The search function in the editor supports Regular Expressions. With this function character chains can highly flexible be searched for and replaced.

^	A Circumflex at the beginning of the word finds the word at the beginning of a line
$	A Dollar Sign represents the end of a line
.	A Dot symbolizes an arbitrary character
*	A Star stands for the repeated appearance of a pattern. The number of repetitions may also be Zero
+	A Plus stands for the multiple or at least solitary appearance of a pattern
[ ]	Characters in square brackets represent the appearance of one of the characters
[^]	A Circumflex in square brackets negates the selection
[-]	A Minus in square brackets symbolizes a character range
{ }	Tailed braces will group separate expressions. Up to ten levels may be nested
\	A Back Slash will take the special meaning from the following character

Examples

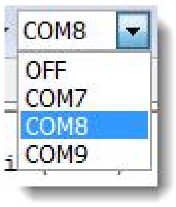
Example	will find
^void	the word "void" only at the beginning of a line
;$	the Semicolon only at the end of a line
^void$	Only "void" may stand in this line
vo.*d	e. g. "vod","void","vqqd"
vo.+d	e. g. "void","vqqd" but not "vod"
[qs]	the letters 'q' or 's'
[qs]port	"qport" or "sport"
[^qs]	all letters other than 'q' or 's'
[a-g]	all letters from 'a' through 'g' (including)
{tg}+	e. g. "tg", "tgtg", "tgtgtg" asf.
\$	'$'

3.3 C-Control Hardware

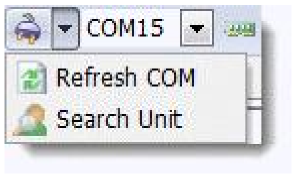
Under menu item C-Control all hardware relevant functions can be executed. These include transfer and start of the program on the hardware as well as password functions.

3.3.1 Interface Selection

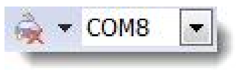
In the toolbar the COM interface that addresses the C-Control Pro module can be directly selected in a drop-down menu.



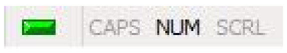
In this list all interfaces are labeled **COM**, regardless of whether it really is a serial port or a USB-connected virtual comport.



The menu entry Search Unit searches for connected C-Control Pro modules. The function Refresh COM looks for changes of the connected COM interfaces. If for example a USB cable is connected, and a new COM port is available.



A click on the plug icon turns the COM port off (red cross), another click on again.



The green "LED" display indicates that the COM Port is open. If the indicator is red, the COM Port is closed.

➔ An open COM Port (green) does not necessarily mean that a C-Control is connected, it could be another device e.g. a USB-serial converter. Only a Search Unit checks whether there is a connected C-Control module,

3.3.2 Start Program

Program Transfer

After a project has been translated free of errors the Bytecode must first be transferred onto the C-Control Pro module before it can be executed. This is done by use of the command Transfer (Shift-F9) in menu C-Control.

➡ After an update of the IDE, if necessary, not just the bytecode is transferred to the module, but also the latest version of the interpreter is sent to the C-Control module.

Program Transfer without source

If you want to transfer a program from which you have only the bytecode (.bc) and no source code, then you can load the bytecode to the C-Control Pro Module by pressing Transfer File.

Start

By Start (F10) the execution of the Bytecode is started. On the Mega Applicationboard this is signaled by turning on the red LED.

Stop

During normal operation a program will be stopped by pressing RESET1 (Mega) or the start/stop button (AVR32Bit). For performance reasons the program execution on the Module is during normal operation not being stopped by use of software. This can however be performed with the IDE function Stop Program when the program runs in Debug Mode.

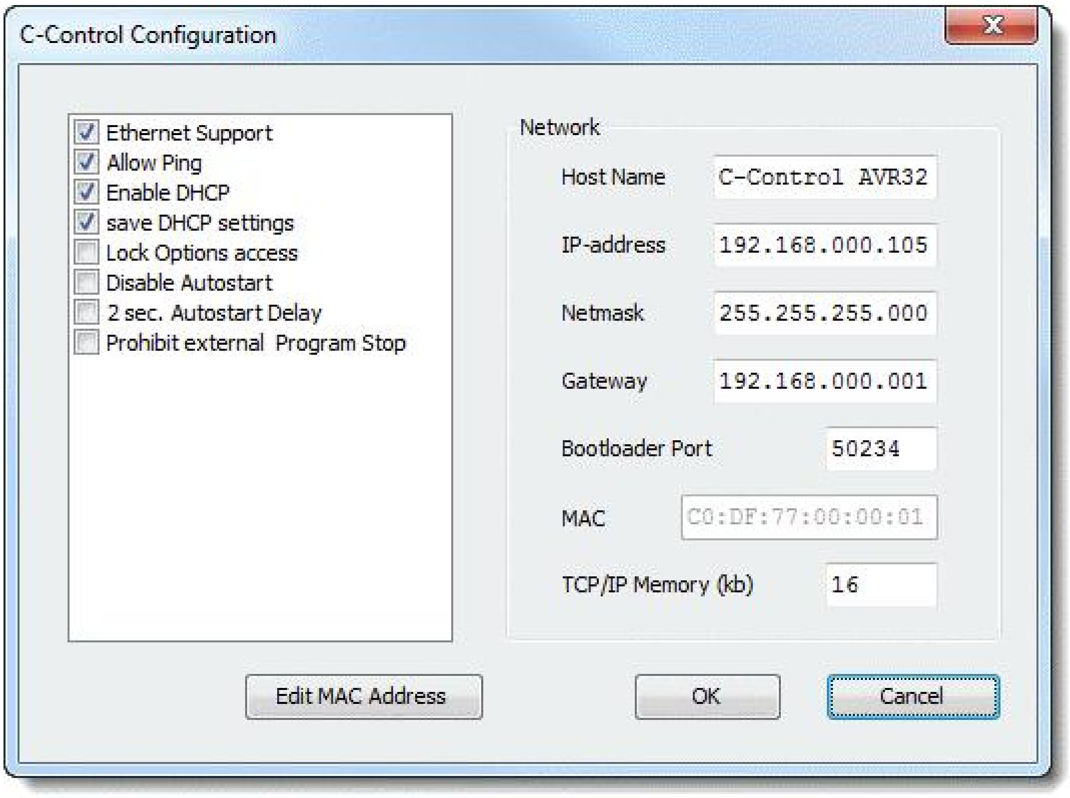
➡ In rare cases the system can get jammed during USB operation (only C-Control Pro Mega Applicationboard) when the RESET1 button is pressed. To overcome this please also press RESET2 in order to issue a Reset pulse to the Mega8, too. The Mega8 is on the Application Board responsible for the USB interface.

Auto Start

If the module is installed in a hardware application, it is often wanted that the user program is started automatically. See Autostart (Mega) and Autostart (AVR32Bit).

3.3.3 C-Control Configuration

The function C-Control Configuration allows to change the hardware settings of the C-Control Pro AVR32Bit. Here you cannot control settings of the C-Control Pro Mega modules.


C-Control Configuration

- [✓] Ethernet Support
- [✓] Allow Ping
- [✓] Enable DHCP
- [✓] save DHCP settings
- [ ] Lock Options access
- [ ] Disable Autostart
- [ ] 2 sec. Autostart Delay
- [ ] Prohibit external Program Stop

Network

Host Name	C-Control AVR32
IP-address	192.168.000.105
Netmask	255.255.255.000
Gateway	192.168.000.001
Bootloader Port	50234
MAC	C0:DF:77:00:00:01
TCP/IP Memory (kb)	16

You can enter the current network settings, the UDP port of the bootloader and the MAC address.

To avoid connection problems, the MAC address should be set to a new value before switching on the Ethernet support. To this end, its own MAC address is generated and supplied on a label for each C-Control Pro AVR32Bit. See Software Installation.

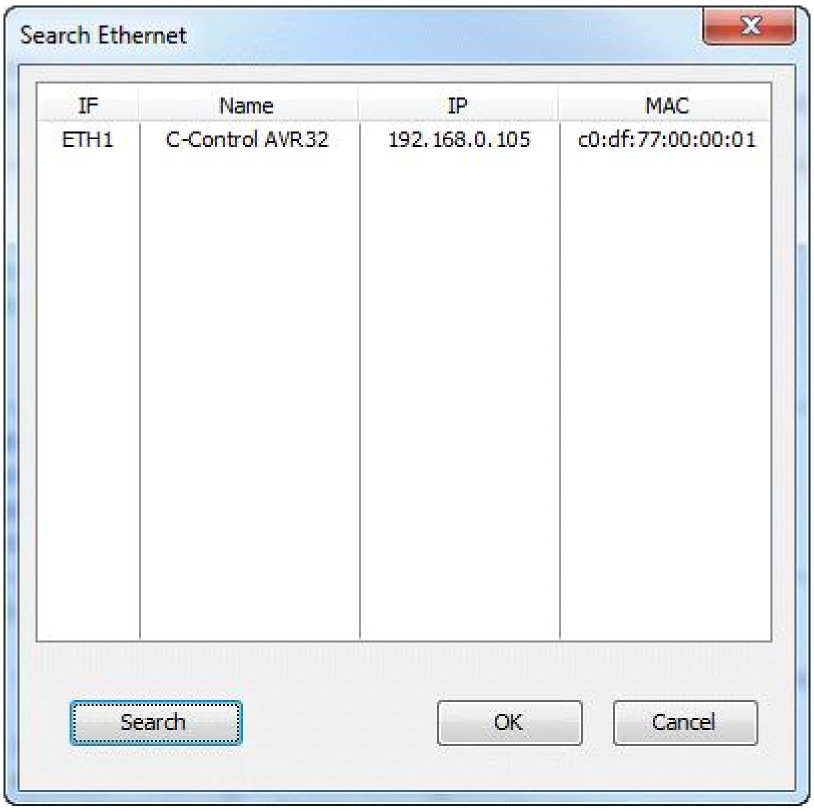
Options

Ethernet Support - Switches on Ethernet support.
Allow Ping - ICMP echo requests are answered.
Lock Options Access - The C-Control configuration cannot be changed. Only Reset Module only allows this again.
Disable Autostart - Autostart is not performed (see Autostart).
Enable DHCP - Gets network information from a DHCP server.
save DHCP settings ?Changed DHCP data is stored.
Prohibit external Program Stop - A program cannot stopped by software.
2 sec. Autostart Delay - Autostart is delayed by 2 seconds so that USB is powered up.

3.3.4 Search Ethernet

If Ethernet Support is enabled, the C-Control Pro AVR32Bit module is visible on the local Ethernet LAN. As the search is performed via UDP broadcast, it is limited to the local subnet, since routers generally do not forward broadcasts. The default UDP port for the Ethernet access is 50234. This port should not be restricted by a local firewall on the PC.

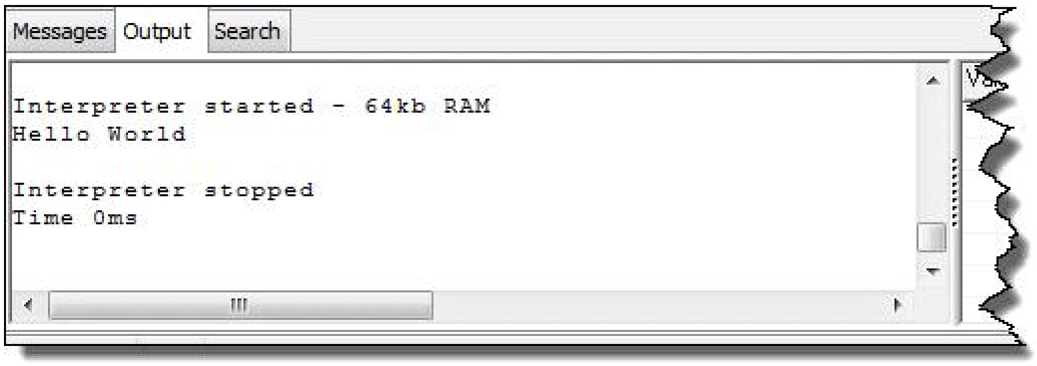
➡ Currently, the Ethernet support is limited to program update.



IF	Name	IP	MAC
ETH1	C-Control AVR32	192.168.0.105	c0:df:77:00:00:01

3.3.5 Outputs

For display of Debug messages there is an "Outputs" window section.



```
Interpreter started - 64kb RAM
Hello World

Interpreter stopped
Time 0ms
```

Here is shown when the Bytecode Interpreter has been started and terminated and for how long (in milliseconds) the Interpreter was in operation. The operation time however is not very useful if the Interpreter has been stopped during Debug Mode.

The Outputs window can also be used to display the user's own Debug messages. For this there are several Debug Functions.

With a right mouse click in the Debug Outputs section the following commands can be selected:

- Delete – will delete the list of Debug outputs
- Copy to Clipboard – will copy all text messages onto the clipboard

3.3.6 PIN Functions

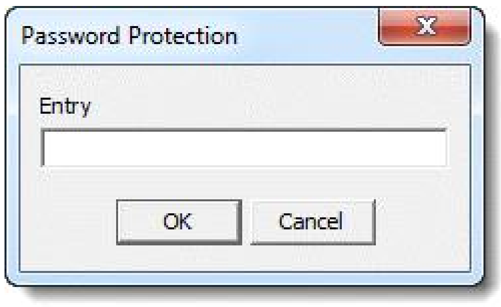
Some solitary functions of the Interpreter can be protected by use of an alpha-numeric PIN. If an Interpreter is protected by a PIN normal operations are prohibited. By means of a new transfer the Interpreter can be overwritten, the PIN will however stay preserved. Also a normal start other than the Autostart behaviour is no longer allowed. Furthermore the scans of hardware and firmware version numbers are locked.

If access to a forbidden function is tried a dialod with the following text will be displayed: "C-Control is Password protected. Operation not allowed!".

Through inscription of the PIN with Enter PIN in the C-Control Menu all operations can again be released.

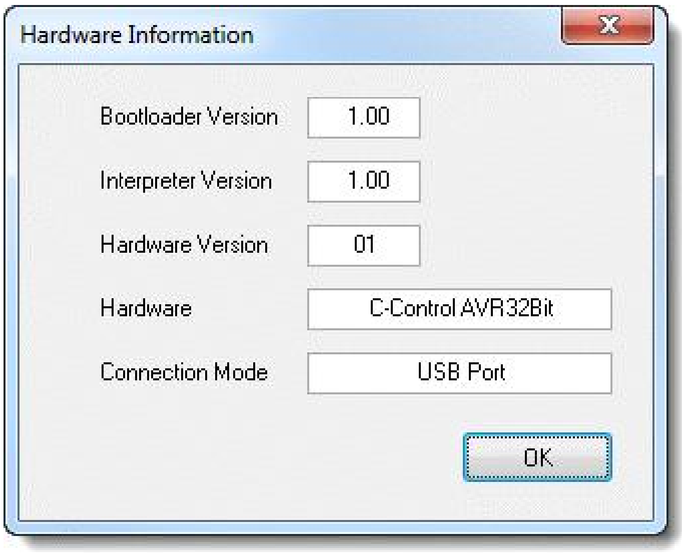
In order to enter a new PIN or to delete a set PIN there are the commands Set PIN and Delete PIN in the C-Control Menu. If there is an old PIN in exitence then the Module must of course first be unlocked by entering the old PIN. The PIN can have a length of up to 6 alpha-numeric characters.

➔ In case the password has been lost there is an emergency function which can be used to reset the Module to its initial state. In C-Control there is the option Reset Module which can be used to delete PIN, Interpreter and Program.



3.3.7 Version Check

Since the C-Control Pro Mega Series supports various hardware platforms it is important to closely monitor the current version numbers of Bootloader, Interpreter and Hardware. This is possible by use of item Hardware Version in the C-Control menu.


Hardware Information

Bootloader Version	1.00
Interpreter Version	1.00
Hardware Version	01
Hardware	C-Control AVR32Bit
Connection Mode	USB Port

3.4 Debugger

In order to activate the Debugger the project must first be compiled in Debug Code free of errors and then transferred to the Module. The file holding the Debug Code (*.dbg) must be present in the project list.

In the Debugger menu all Debugger commands can be found. The Debugger ist started with Debug Mode (Shift-F10). If at this point of time no Breakpoint is set then the Debugger will stop at the first executable instruction.

If in Debug Mode, the next Breakpoint will be reached by use of Start (F10). If no Breakpoint is set then the program will be executed in its normal way. There is the exception however that the program flow can be stopped by use of Stop Program. This only works providing that the program has been started from the Debug Mode.

If the Debugger has stopped in the program (a blue bar is displayed) then the program can be executed in single steps. The instructions Single Step (Shift-F8) and Procedure Step (F8) respectively will execute the program code up to the next code line and will then stop again. Opposing to Single Step the function Procedure Step will not jump into the function calls but will overpass them. If the program has stopped all breakpoints can be changed.

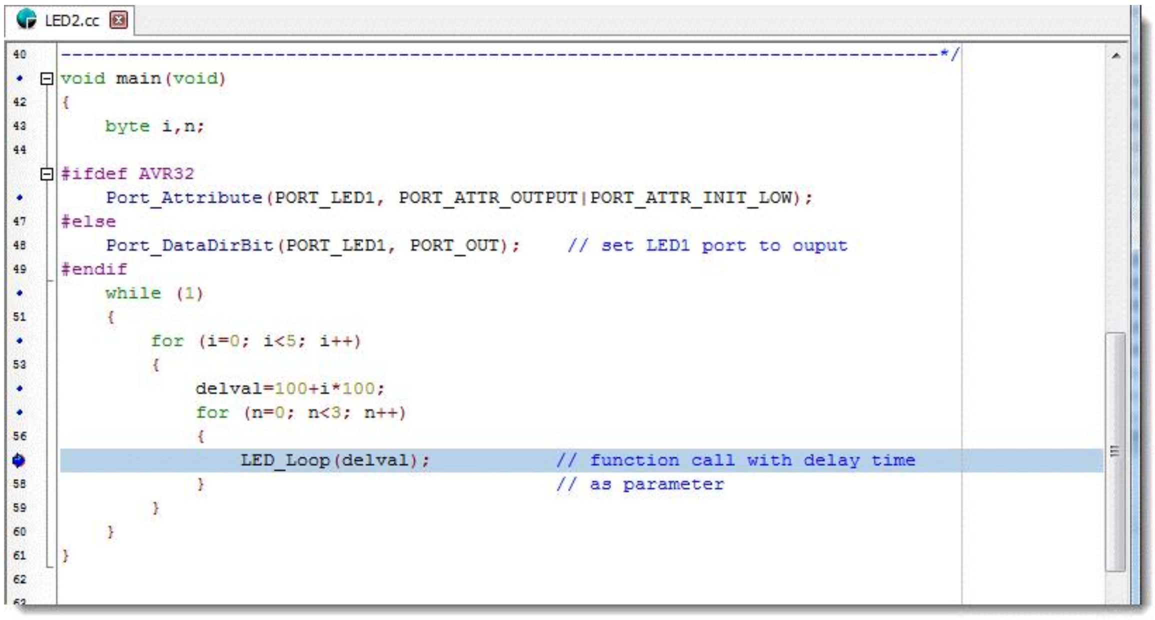
➔ If a loop contains only one code line then one single step will execute the entire loop since only after this branching out to a new code line will take place.

With the instruction Leave Debug Mode the Debug Mode will be terminated.

➔ During active Debug Mode the program text can not be altered. This is because line numbers holding set Breakpoints must not be moved out of place. Otherwise the Debugger would not be able to synchronize with the Bytecode onto the C-Control Module.

3.4.1 Breakpoints

The editor allows to set up to 16 Breakpoints. A Breakpoint is entered by a mouse click to the left of the beginning of a line (see IDE or Editor Window).



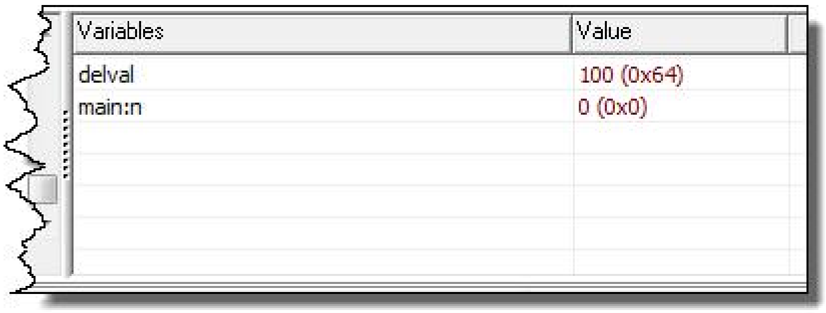
```
/*---------------------------------------------------------------------------*/
void main(void)
{
    byte i,n;

#ifdef AVR32
    Port_Attribute(PORT_LED1, PORT_ATTR_OUTPUT|PORT_ATTR_INIT_LOW);
#else
    Port_DataDirBit(PORT_LED1, PORT_OUT);    // set LED1 port to ouput
#endif
    while (1)
    {
        for (i=0; i<5; i++)
        {
            delval=100+i*100;
            for (n=0; n<3; n++)
            {
                LED_Loop(delval);           // function call with delay time
            }                               // as parameter
        }
    }
}
```

➡ The number of Breakpoints is limited to 16 because this information is carried along in RAM during operation of the Bytecode Interpreter. Other Debuggers on the Market will set Breakpoints directly into the program code. In our case this is not desirable since it would drastically reduce the life time of the flash memory (appr. 10,000 writing accesses).

3.4.2 Variable Watch Window

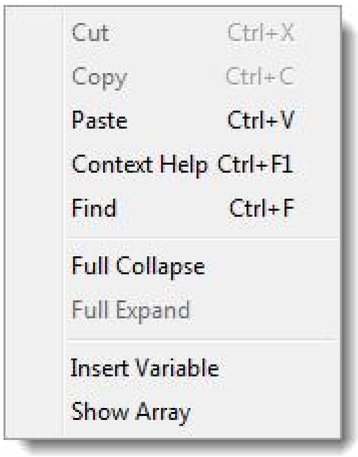
The contents of variables can be displayed within the Debugger. To do this the mouse pointer is placed over the variable. Within approximately 2 seconds the content of the variable is displayed in form of a Tooltip. The variable is first displayed in accordance to its data type and then, separated by a comma, as Hex number with a preceeding "0x".

If several variables need to be monitored then the variables can be comprised in a list.



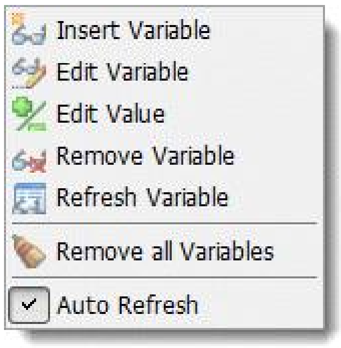
Variables	Value
delval	100 (0x64)
main:n	0 (0x0)

In order to enter a variable into the list of monitored variables there are two possibilities. For one the cursor can be placed in the text editor at the beginning of a variable and then Insert Variable can be selected by a right mouse click.



The other possibility is by use of the context menu in the variables list which can also be activated by a right mouse click.

When Insert Variable is selected then the variable to be monitored can as text be entered into the list. In case of a local variable the function name with a preceeding colon (**Function Name** : **Variable Name**) is entered. With Change Variable the text entry in the list can be altered and with Delete Variable the variable can be entirely erased from the list. Prior to this the line holding the variable to be deleted must be selected. The command Remove All Variables will delete all entries from the list.



Under certain circumstances an error message is shown instead of a value in the list:

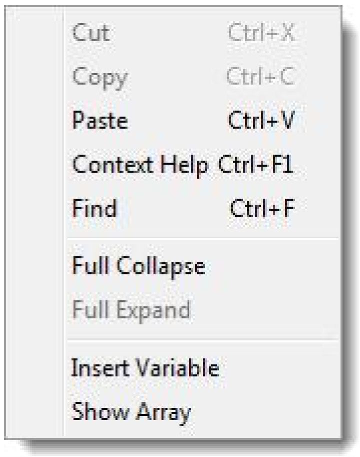
no Debug Code	No Debug Code has been generated
wrong Syntax	During text entry invalid characters have been entered for a variable
Function unknown	The Function Name is not known
Variable unknown	The Variable Name is not known
not in Debug Mode	The Debug Mode has not been activated
no Context	Local variables can only be displayed while within this function
not actual	The content of the variable has not been updated

If a high number of variables is entered in the monitor list it may during single step operation take quite some time until all variable contents from the module have been scanned. For this reason the Option Auto Actualize can be switched off for individual variables. The contents of these variables will then only be displayed after the command Actualize Variable is executed. This way the Debugger can quickly be operated in single steps and the contents are only actualized on demand.

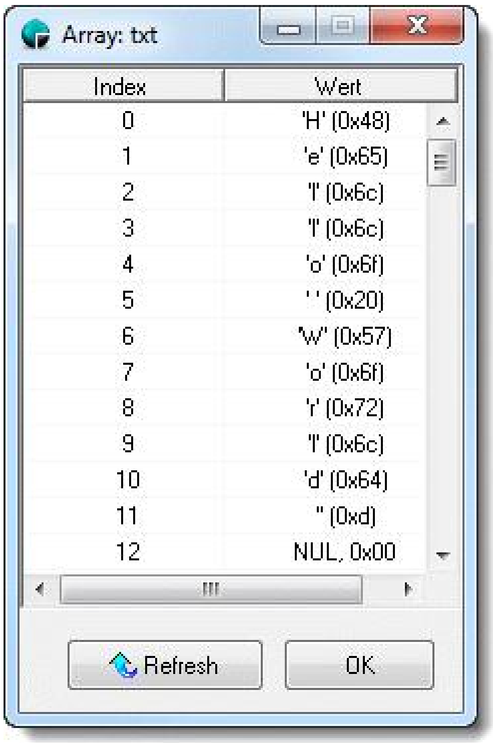
Variables of the Character type are displayed as single ASCII characters.

3.4.3 Array Window

In order to monitor the contents of Array Variables it is possible to call up a window with the array contents. To do this the pointer is placed over the variable and Show Array is selected by a right mouse click.

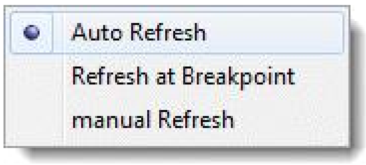


On the left side the Array indices are shown while the contents are displayed on the right side. It should be noted that with multi-dimensional arrays the indices on the right will gain at the faster pace.



Index	Wert
0	'H' (0x48)
1	'e' (0x65)
2	'l' (0x6c)
3	'l' (0x6c)
4	'o' (0x6f)
5	' ' (0x20)
6	'W' (0x57)
7	'o' (0x6f)
8	'r' (0x72)
9	'l' (0x6c)
10	'd' (0x64)
11	'' (0xd)
12	NUL, 0x00

The contents of an array window may at every stop of the Debugger or at every single step no longer be actual. If with each single step in the Debugger several array windows are newly brought up-to-date then delays may occur since the data must always be loaded from the Module. For this reason there are three operating modes:

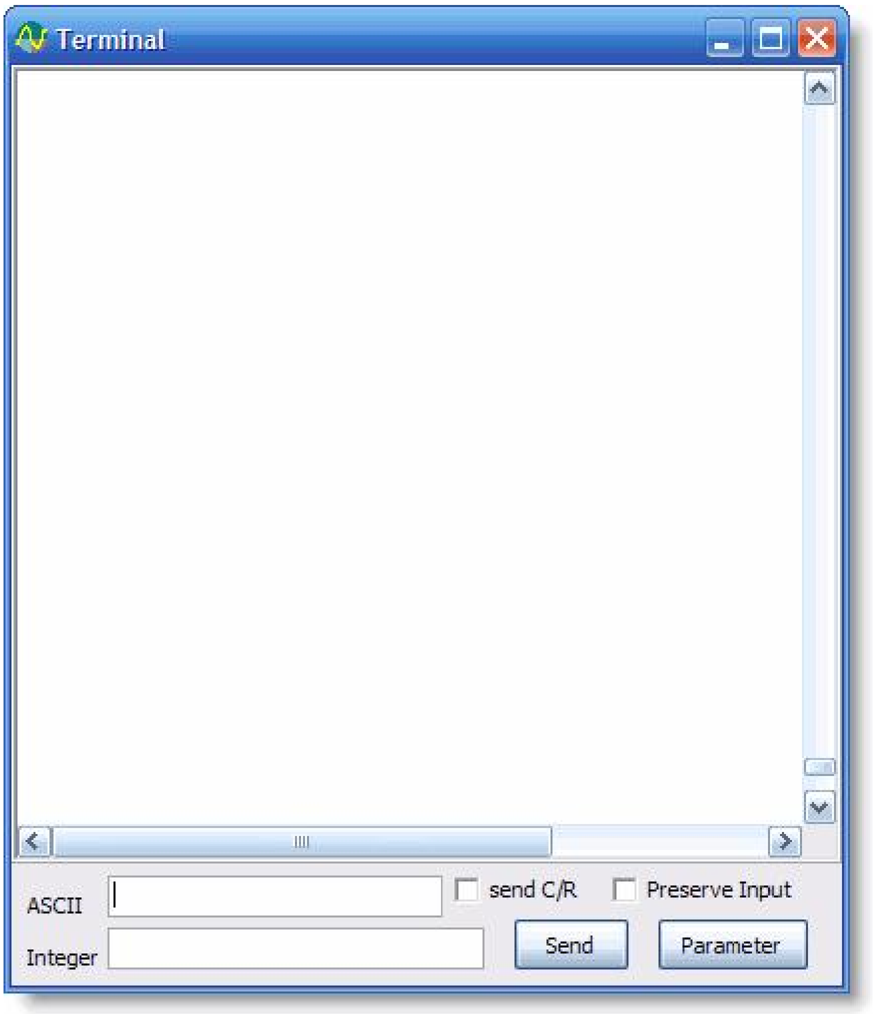


Auto Actualize	Actualize at Single Step and Breakpoint
Actualize at Breakpoint	Actualize only at Breakpoint
Manually Actualize	Only by clicking switch "Actualize"

3.5 Tools

In the Tools menu you can start the simple built-in terminal program, add your own programs and change the IDE options.

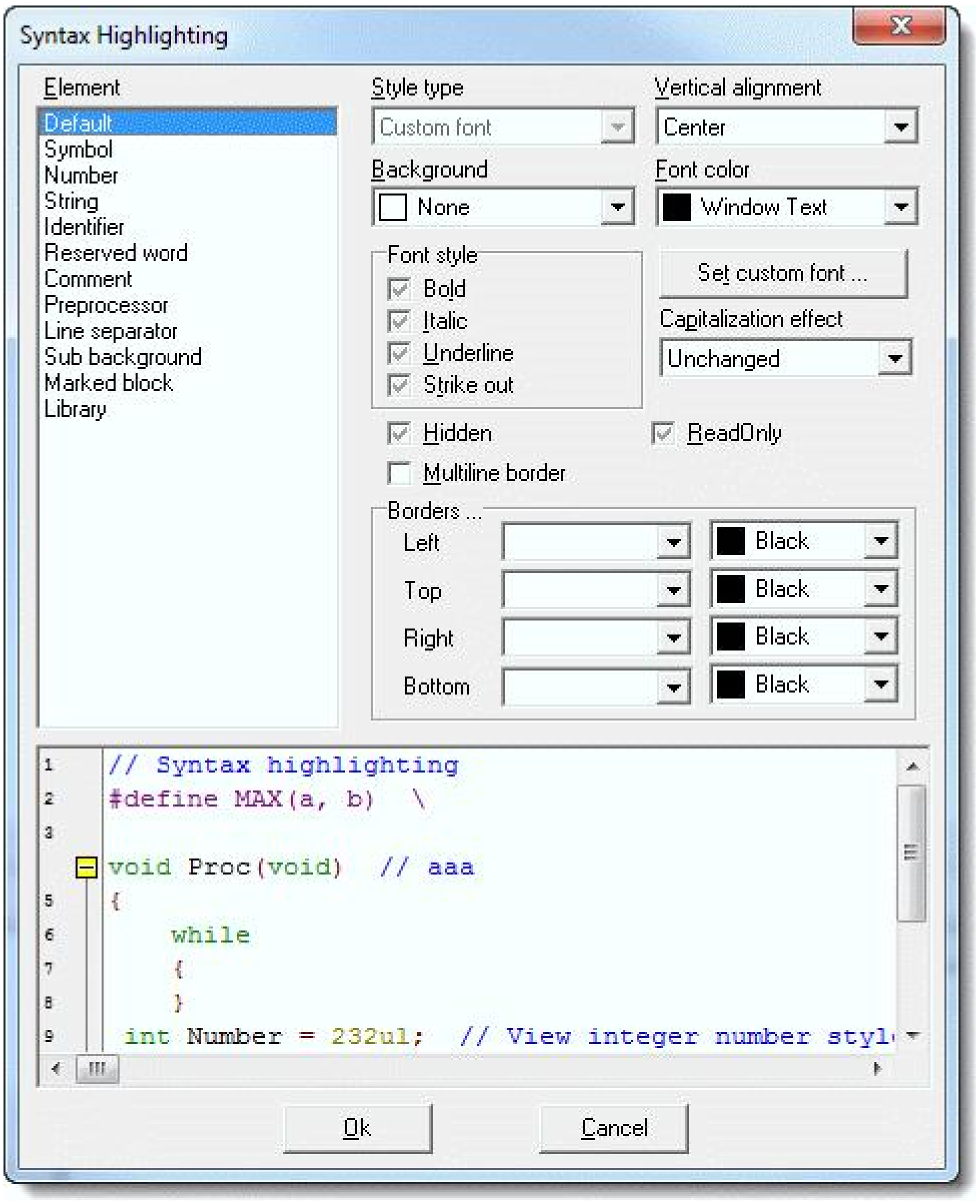
Terminal Window



Received characters are directly shown in the terminal window. Characters can be send in two different ways. On the one hand the user can click into the terminal window and directly type the characters from the keyboard, on the other hand the text can be entered in to the ASCII input line and send with the Send button. Instead of ASCII the characters can be defined as integer values in the Integer input line. Is send C/R selected, a Carriage Return (13) is sent at the end of the line. Enable Preserve Input to prevent that the input lines are cleared after pressing the Send button. The Parameter button opens the Terminal settings dialog from the IDE settings.

3.5.1 Syntax Highlighting

In this Dialog the user can change the specific Syntax Highlighting for CompactC and BASIC. The chosen language for the setting is CompactC or BASIC in dependency on what language is used in the actual selected editor window.



```
// Syntax highlighting
#define MAX(a, b)   \

void Proc(void)   // aaa
{
    while
    {
    }
 int Number = 232ul;  // View integer number styl
```

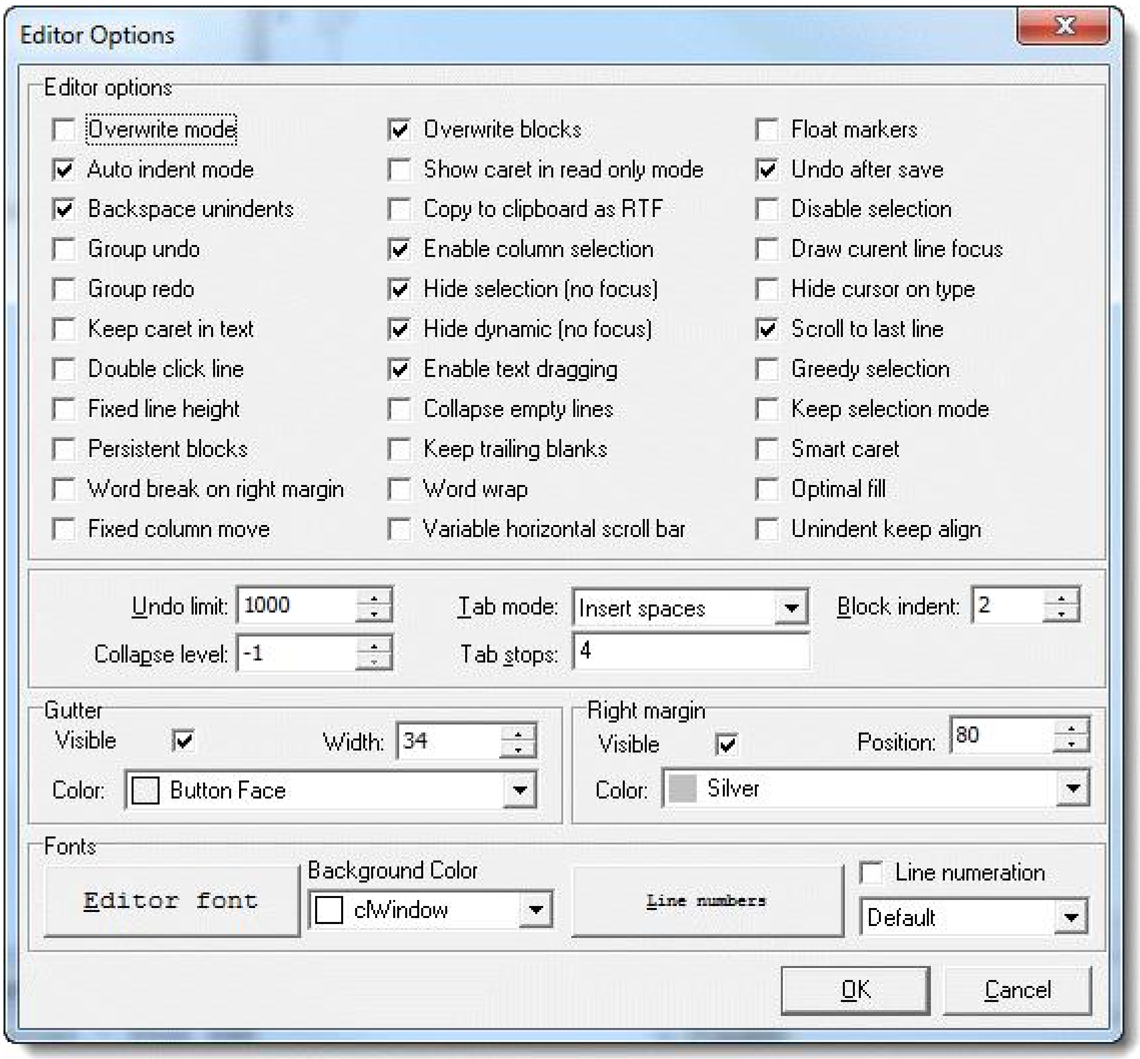
You can change the attributes of the font, and the foreground- and background color. With Multiline border a colored border can be drawn around the highlighted strings. Also case changes can be made with the option Capitalization Effect. The selectable Elements have the following meaning:

Symbol:	all non alpha-numeric characters
Number:	all numeric characters
String:	all characters that are recognized as strings
Identifier:	all names that are not reserved words or part of the library
Reserved Word:	all reserved words of the destination language
Comment:	comments
Preprocessor:	preprocessor statements
Marked Block:	marked editor blocks
Library:	function names of the standard library

Default, Line separator and Sub background are not used.

➜ Due to technical limitations, this dialog is always displayed in English!

3.5.2 Editor Settings



Editor Options

Editor options

- [ ] Overwrite mode
- [✓] Auto indent mode
- [✓] Backspace unindents
- [ ] Group undo
- [ ] Group redo
- [ ] Keep caret in text
- [ ] Double click line
- [ ] Fixed line height
- [ ] Persistent blocks
- [ ] Word break on right margin
- [ ] Fixed column move
- [✓] Overwrite blocks
- [ ] Show caret in read only mode
- [ ] Copy to clipboard as RTF
- [✓] Enable column selection
- [✓] Hide selection (no focus)
- [✓] Hide dynamic (no focus)
- [✓] Enable text dragging
- [ ] Collapse empty lines
- [ ] Keep trailing blanks
- [ ] Word wrap
- [ ] Variable horizontal scroll bar
- [ ] Float markers
- [✓] Undo after save
- [ ] Disable selection
- [ ] Draw curent line focus
- [ ] Hide cursor on type
- [✓] Scroll to last line
- [ ] Greedy selection
- [ ] Keep selection mode
- [ ] Smart caret
- [ ] Optimal fill
- [ ] Unindent keep align

Undo limit: 1000 Tab mode: Insert spaces Block indent: 2
Collapse level: -1 Tab stops: 4

Gutter
Visible [✓] Width: 34
Color: Button Face

Right margin
Visible [✓] Position: 80
Color: Silver

Fonts
Editor font Background Color: clWindow Line numbers [ ] Line numeration Default

- Overwrite mode – Inserts text at the cursor overwriting existing text.
- Auto indent mode - Positions the cursor under the first non blank character of the preceding non blank line when you press Enter.
- Backspace unindents - Aligns the insertion point to the previous indentation level (outdents it) when you press Backspace, if the cursor is on the first non blank character of a line.
- Group undo - Undo operation will not be performed in small steps but in blocks.
- Group redo - If it is set Redo will involve group of changes.
- Keep caret in text - Allows move caret only into text like in Memo.
- Double click line - Highlights the line when you double-click any character in the line. If disabled,

only the selected word is highlighted.
- Fixed line height - Prevents line height calculation. Line height will be calculated by means of Default Style.
- Persistent blocks - Keeps marked blocks selected even when the cursor is moved using the arrow keys, until a new block is selected.
- Overwrite blocks - Replaces a marked block of text with whatever is typed next. If Persistent Blocks is also selected, text you enter is appended following the currently selected block.
- Show caret in read only mode - Shows caret in read only mode.
- Copy to clipboard as RTF - Copies selected text also in RTF format.
- Enable column selection - Enabled column selection mode.
- Hide selection - Hides selection when editor loses focus.
- Hide dynamic - Hides dynamic highlighting when editor loses focus.
- Enable text dragging - Enables drag & drop operation for text movement.
- Collapse empty lines - Collapse empty lines after text range when this rang have been collapsed.
- Keep trailing blanks - Keeps any blanks you might have at the end of a line.
- Float markers - If it is set markers are linked to text, so they will move with text during editing. Otherwise they are linked to caret position, and stay unchanged during editing. Also markers save scroll position.
- Undo after save - Stay undo buffer unchanged after save with SaveToFile method.
- Disable selection - Disables any selection.
- Draw current line focus - Draws focus rectangle around current line when editor have focus.
- Hide cursor on type - Hides mouse cursor when user type text and mouse cursor within client area.
- Scroll to last line - When it is true you may scroll to last line of text, otherwise you can scroll to last page. When this option is off and total text height less then client height vertical scroll bar will be hidden.
- Greedy selection - If this option is set selection will contain extra column/line during column/line selection modes.
- Keep selection mode - Selection enabled for caret movement commands (like in BRIEF).
- Smart caret - Acts on the caret movement (up, down, line start, line end). Caret is moved to the nearest position on the screen.
- Word wrap - Determines whether the editor wraps text at the right side of text area.
- Word break on right margin - Determines whether text wraps (word-wrap mode) on the right margin instead of right side of client area.
- Optimal fill - Begins every auto indented line with the minimum number of characters possible, using tabs and spaces as necessary.
- Fixed column move - Keeps X position of caret before editing text, this position is used when moving up/down caret.
- Variable horizontal scroll bar - Sets range of horizontal scroll bar to the maximal width of only visible lines. Hides horizontal scroll bar if visible lines fit client width.
- Unindent keep align - Restricts unindent operation when at least one of lines can not be unindented.

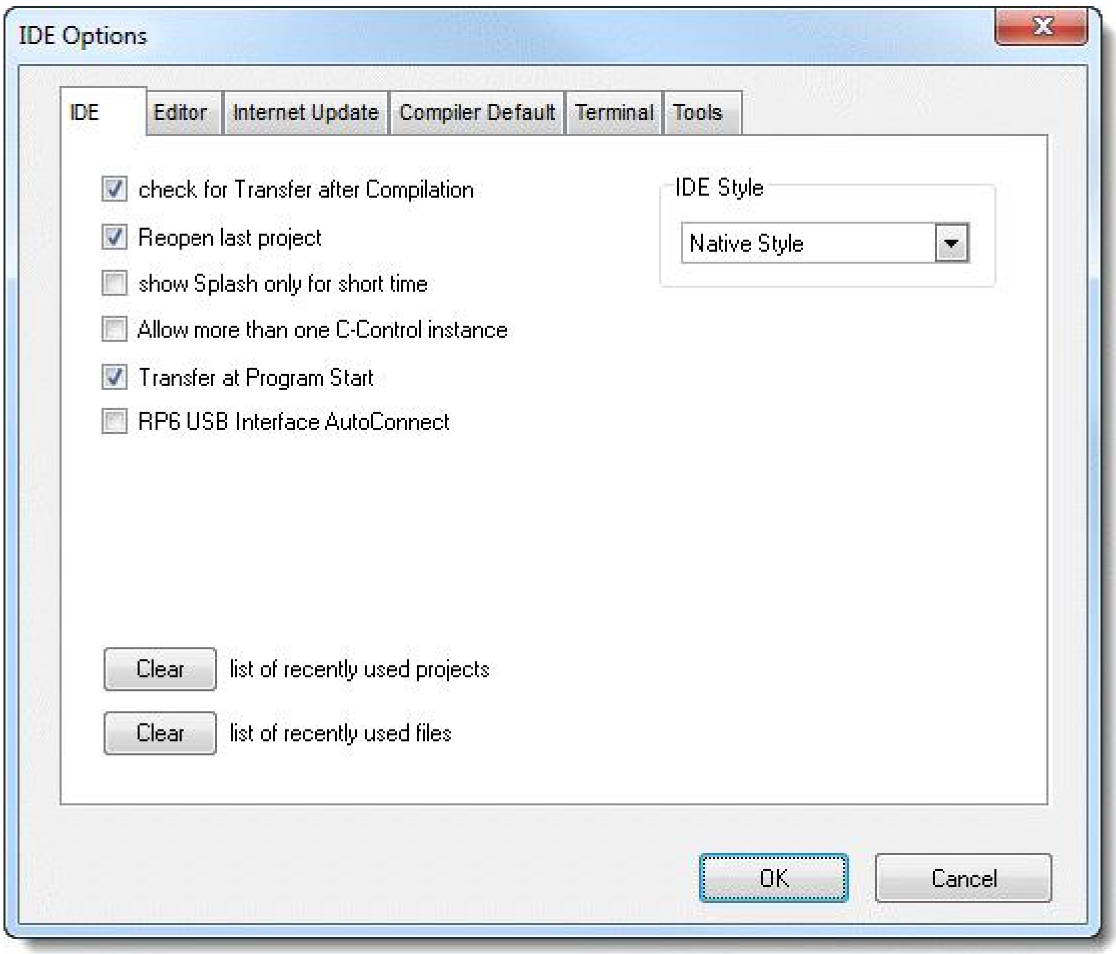
At Block indent the number of blanks is inscribed by which a selected block can be indented or backed by use of the Tabulator key.

The input field Tab stops determines the width of the tabulator by numbers of characters.

➔ Due to technical limitations, this dialog is always displayed in English!

3.5.3 IDE Settings

Separate aspects of the IDE can be configured.



[✓] check for Transfer after Compilation
[✓] Reopen last project
[ ] show Splash only for short time
[ ] Allow more than one C-Control instance
[✓] Transfer at Program Start
[ ] RP6 USB Interface AutoConnect

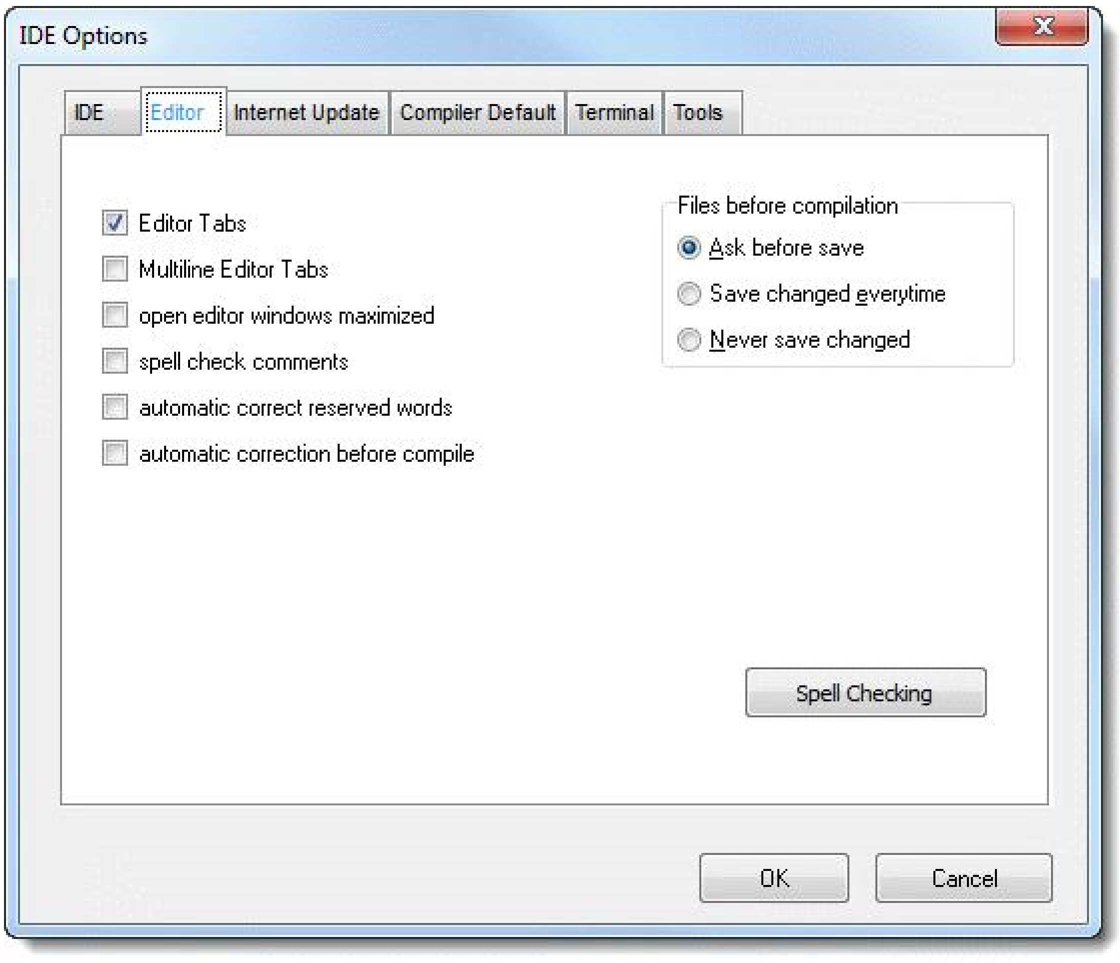
IDE Style: Native Style

Clear list of recently used projects
Clear list of recently used files

- check for Transfer after Compilation – After a program has been compiled but not transferred to the C-Control Module then the user will be questioned whether or not the program should be started.
- Reopen last Project – The last open project will be re-opened when the C-Control Pro IDE is started.
- show Splash only for short time - The Splashscreen is only displayed until the main window opens.
- Allow more than one C-Control instance – When the C-Control Pro interface is started several times it may create conflicts with regard to the USB interface.
- Transfer at Program Start - The program is transferred automatically when the program is started from the IDE.
- RP6 USB Interface AutoConnect - Supports the hardware interface of the RP6 robot.

Also here the lists of the "last opened projects" as well as the "last opened files" can be deleted.

3.5.3.1 Editor


IDE Options

IDE | Editor | Internet Update | Compiler Default | Terminal | Tools

- [✓] Editor Tabs
- [ ] Multiline Editor Tabs
- [ ] open editor windows maximized
- [ ] spell check comments
- [ ] automatic correct reserved words
- [ ] automatic correction before compile

Files before compilation
- (●) Ask before save
- ( ) Save changed everytime
- ( ) Never save changed

- Editor Tabs - Different files are displayed in Editor Tabs.
- Multiline Editor Tabs - The Tabs are displayed as multiple-rows.
- open editor windows maximized – When a file is opened the editor window will automatically be switched to maximum size.
- spell check comments - The comments within the editor are checked for spelling errors.
- automatic correct reserved words - While writing all reserved words and known library functions the case is corrected.
- automatic correction before compile - When the compiler is started the case of all reserved words and known library functions is corrected.
- Files before compilation - Determines the action for changed files when compiling.

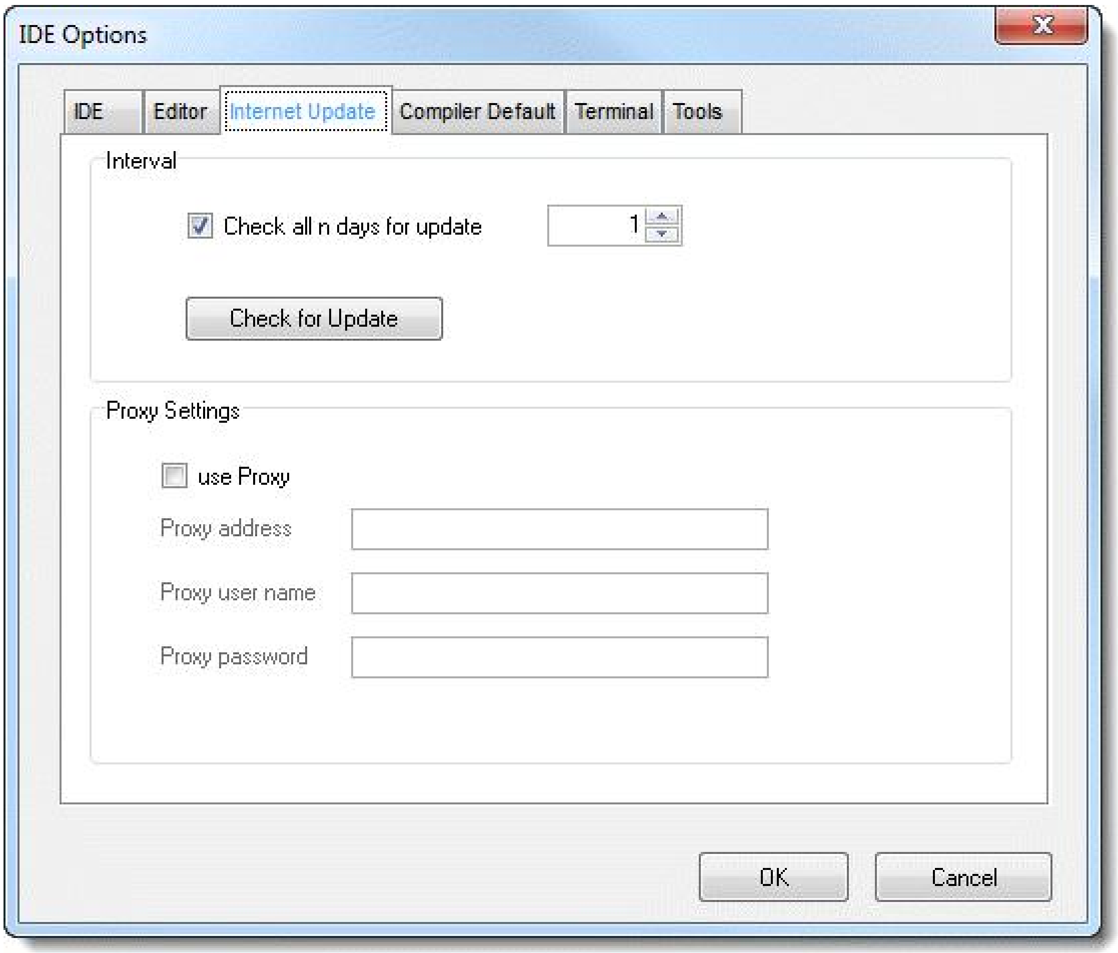
The button Spell Checking displays the spell checking configuration dialog.

3.5.3.2 Internet Update

In order to check if any improvements or error corrections have been issued by Conrad Electronic the Internet Update can be activated. When the selection box "Update Check Every n Days" is selected then an update will be searched for in the Internet at an interval of n days at every start of the IDE. The parameter n can be set in the input field on the right.

The button "Update Check Now" will immediately activate an update search.

➡ In order to have the Internet update function correctly the MS Internet Explorer must not be in "Offline" Mode.



[✓] Check all n days for update: 1

[ ] use Proxy

Proxy address:

Proxy user name:

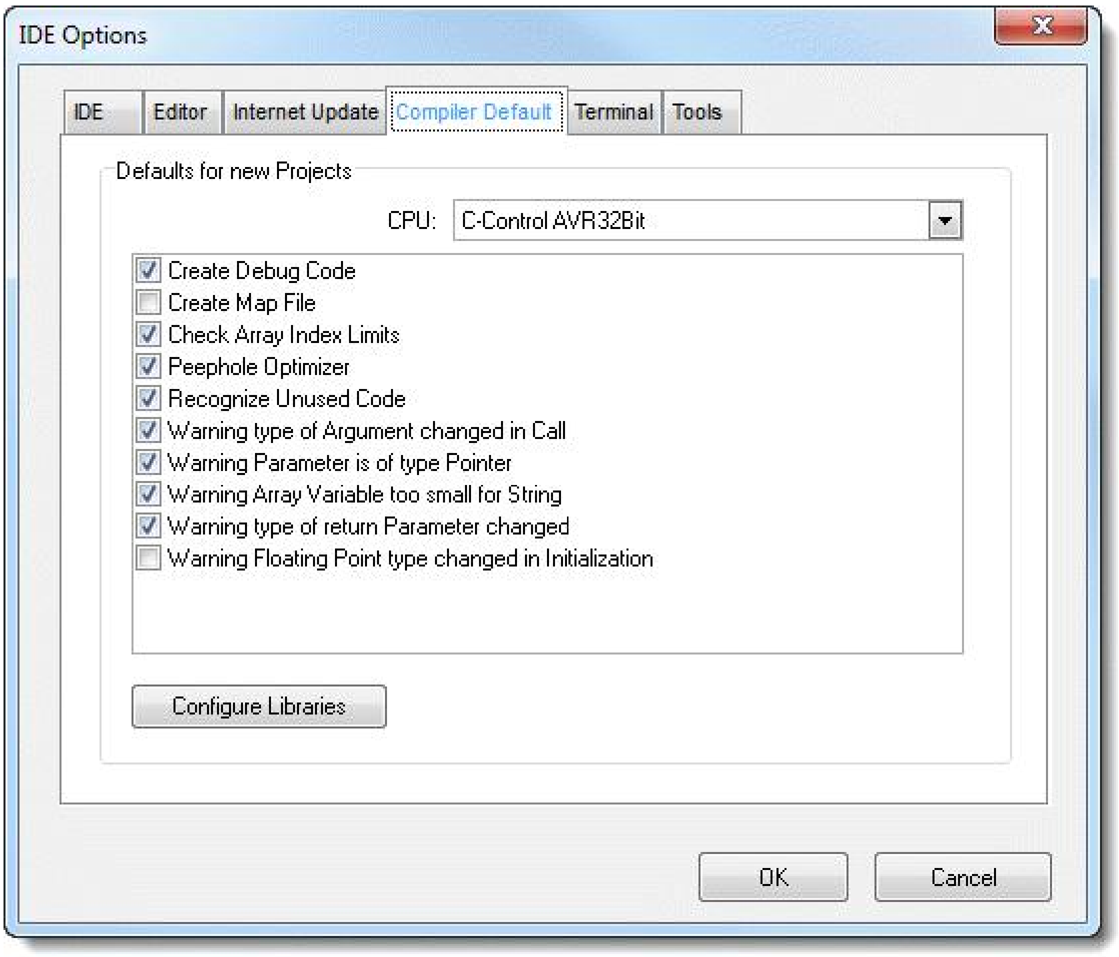
Proxy password:

If e. g. the Internet access is restricted by a Proxy due to a firewall then the Proxy settings such as address, user name and password can be entered in this dialog.

➡ If there are Proxy data set in the MS Internet Explorer then they will be of higher priority and will thus overwrite the settings in this dialog.

3.5.3.3 Compiler Presetting

In the Compiler Presetting the standard values can be configured which will be stored during creation of a new project. Presetting can be reached under Compiler in the Options menu.



Defaults for new Projects

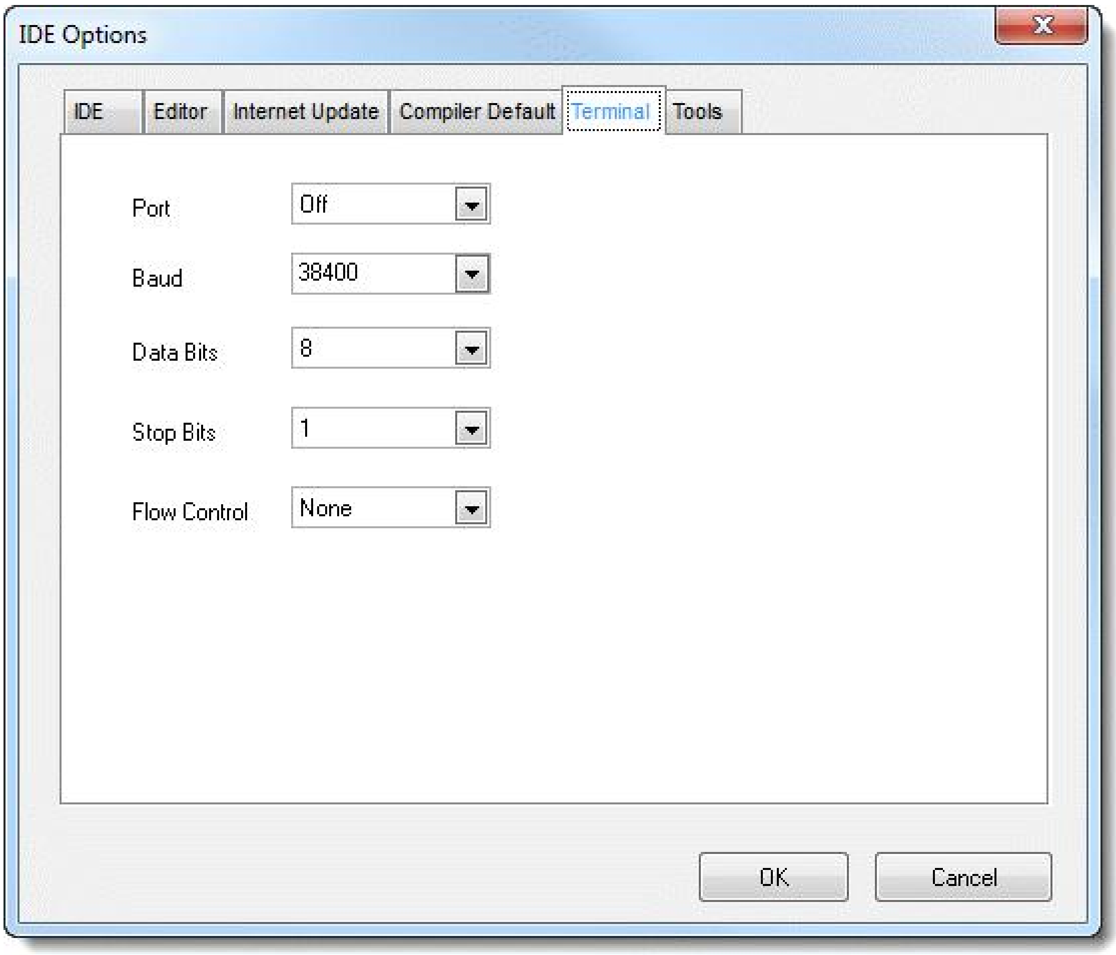
CPU: C-Control AVR32Bit

- [✓] Create Debug Code
- [ ] Create Map File
- [✓] Check Array Index Limits
- [✓] Peephole Optimizer
- [✓] Recognize Unused Code
- [✓] Warning type of Argument changed in Call
- [✓] Warning Parameter is of type Pointer
- [✓] Warning Array Variable too small for String
- [✓] Warning type of return Parameter changed
- [ ] Warning Floating Point type changed in Initialization

A description of the options can be found under Project Options. The selection box "Configure Library" is identical to the description in chapter Projects.

3.5.3.4 Terminal

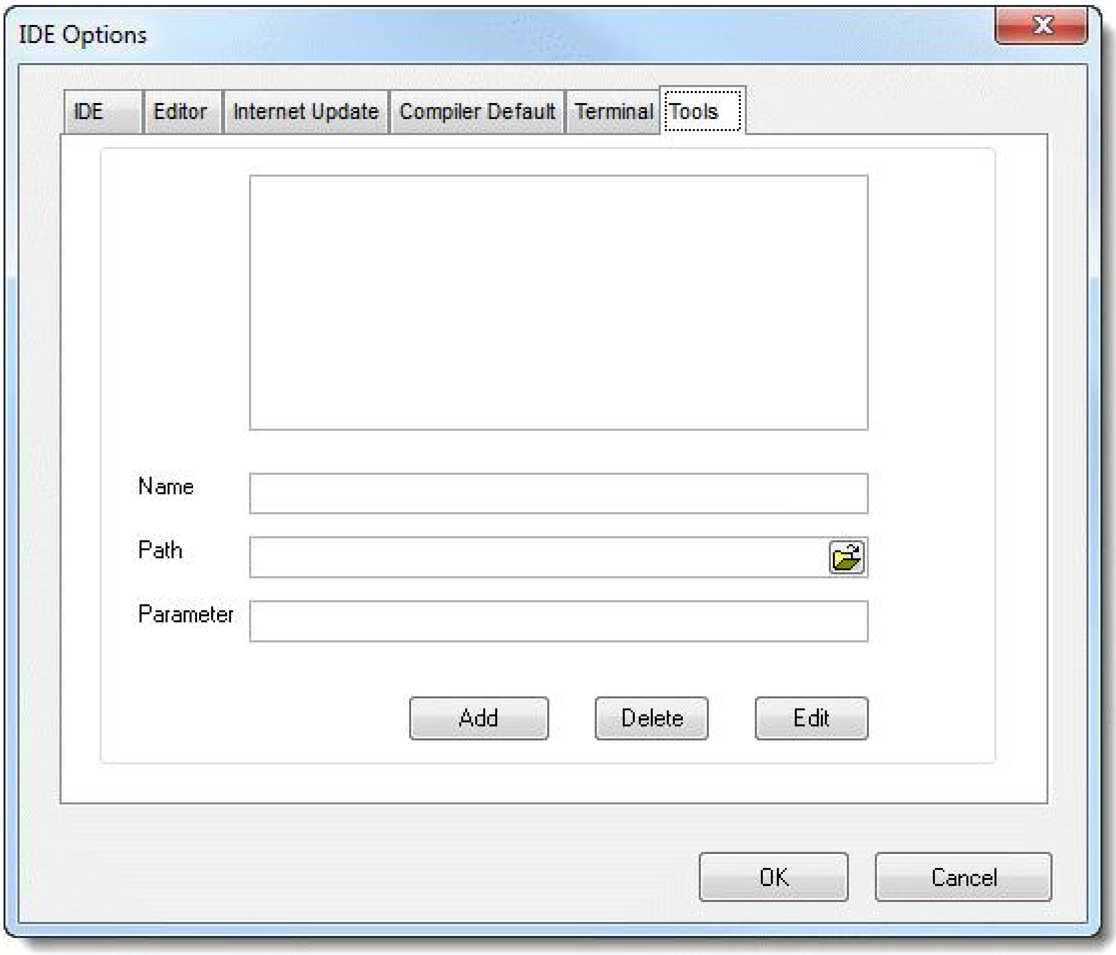
Here you can set the serial parameter for the built in terminal program. For the Port entry an available serial COM Port can be chosen from. Further the standard baudrates, the number of Data Bits and Stop Bits, and the Flow Control is selectable.



Port: Off
Baud: 38400
Data Bits: 8
Stop Bits: 1
Flow Control: None

3.5.3.5 Tools

In the Tool settings the user can insert, delete and edit entries that defines external programs that can be executed fast and simple from the IDE. The names of the programs can be found in the Tools pulldown menu and can be started with a single click
.



For each program that is inserted, the user can choose the name, the execution path and the parameters that are submitted.

3.6 Windows

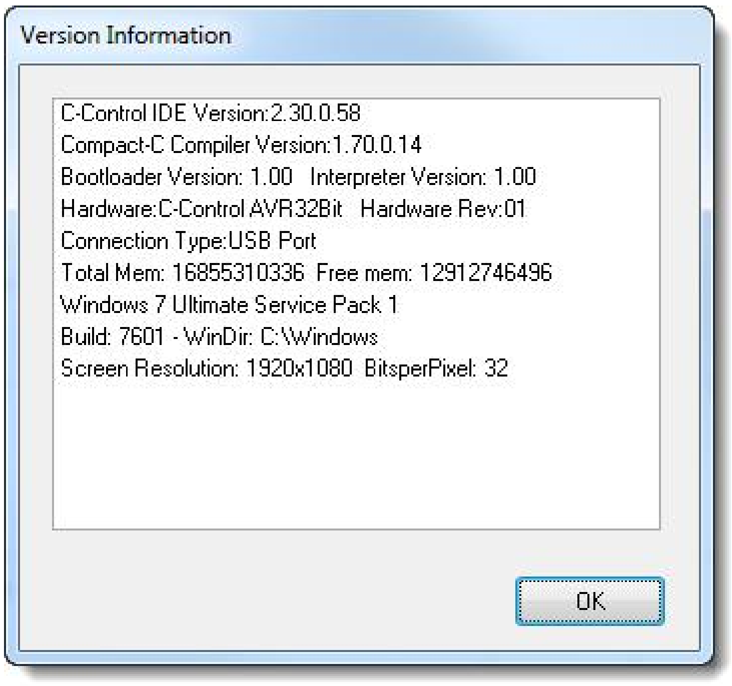
When there are several windows opened within the editor area they can automatically be arranged by use of commands in the Window Menu.

- Overlap – The windows will be arranged on top of each other with each successive window placed fractionally lower and more to the right than the preceding one.
- Beneath – The windows are placed vertically beneath each other.
- Side By Side – Will arrange the windows next to each other from left to right.
- Minimize All – Will minimize all windows to symbol size.
- Close – Will close all active windows.

3.7 Help

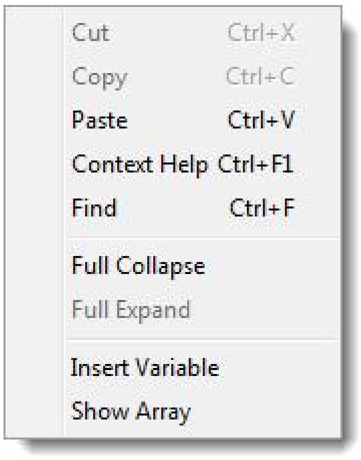
Under menu item Help the Help file can be opened by use of Contents (Key F1).

Menu item Program Version will open the window "Version Information" and will at the same time copy the contents onto the clipboard.
These informations are important if a Support E-Mail needs to be sent to Conrad Electronic. Since these informations are automatically placed onto the clipboard when Program Version is called up the data can easily be added to the end of an E-Mail.



```
C-Control IDE Version:2.30.0.58
Compact-C Compiler Version:1.70.0.14
Bootloader Version: 1.00   Interpreter Version: 1.00
Hardware:C-Control AVR32Bit   Hardware Rev:01
Connection Type:USB Port
Total Mem: 16855310336  Free mem: 12912746496
Windows 7 Ultimate Service Pack 1
Build: 7601 - WinDir: C:\Windows
Screen Resolution: 1920x1080  BitsperPixel: 32
```

If the user needs to find a certain search term in the Help file the Context Help may be of advantage. If e. g. in the Editor the cursor stands over the word "AbsDelay" and the correct parameters are searched for then Context Help should be selected. This function will automatically use the word under the cursor for a search term and will consequently show the results in the Help File.



The command Context Help is also available in the editor window after a right mouse click.

Part 4

4 Compiler

4.1 General Features

This domain provides information on the Compiler's properties and features which are independent of the programming language used.

4.1.1 Preprocessor

The Gnu Generic Preprocessor used here provides some additional functions which are documented under http://nothingisreal.com/gpp/gpp.html. Only the functions described here however have also together with the C-Control Pro Compiler been thoroughly tested. Using the here undocumented functions will thus be at your own risk!

The C-Control development system contains a complete C-Preprozessor. The Preprocessor processes the source text prior to Compiler start. The following commands are supported:

Definitions

By the command "#define" text constants are defined.

```
#define symbol text constant
```

Since the Preprocessor runs ahead of the Compiler at each appearance of symbol in the source text the symbol will be replaced by text constant.

Example

```
#define PI 3.141
```

If a project consists of several sources then #define is a constant for all source files existing following the file, in which the constant has been defined. It is thus possible to change the order of source files in a project.

Conditional Compiling

```
#ifdef symbol
...
#else  // optional
...
#endif
```

It is possible to monitor which parts of the source texts are really being compiled. After a #ifdef symbol instruction the following text is only compiled when symbol has also been defined by #define symbol.

If there is an optional #else instruction then the source text will be processed after #else if the symbol has not been defined.

Insertion of Text

```
#include path\file name
```

By this instruction a text file can be inserted into the source code.

➔ Because of some restrictions in the Preprocessor a path within a #include instruction must not contain any blank characters!

4.1.1.1 Predefined Symbols

In order to ease the work with different versions of the C-Control Pro series there are a number of definitions which are set depending on target system and Compiler project options. These constants can be called up by #ifdef, #ifndef or #if.

Symbol	Meaning
MEGA32	Configuration for Mega 32
MEGA128	Configuration for Mega 128
MEGA128CAN	Configuration for Mega 128 CAN Bus
AVR32	Configuration for AVR 32
MEGA128_ARCH	Mega 128 or Mega 128 CAN
CANBUS_SUPP	CAN Bus is supported
DEBUG	Debug Data will be created
MAPFILE	A Memory Layout will be computed

The following constants contain a string. It is sensible to use them in conjunction with text outputs.

Symbol	Meaning
__DATE__	Current Date
__TIME__	Time of Compiling
__LINE__	Current Line in Sourcecode
__FILE__	Name of Current Source File
__FUNCTION__	Current Function Name

Example

Line number, file name and function name will be issued. Since file names may become quite long it is recommended to dimension character arrays somewhat generous.

```
char txt[60];
```

```
txt=__LINE__;
Msg_WriteText(txt);  // Issue Line Number
Msg_WriteChar(13);   // LF
txt=__FILE__;
Msg_WriteText(txt);  // Issue File Number
Msg_WriteChar(13);   // LF
txt=__FUNCTION__;
Msg_WriteText(txt);  // Issue Function Name
Msg_WriteChar(13);   // LF
```

4.1.2 Pragma Instructions

By use of the #pragma instruction output and flow of the Compiler can be controlled. The following commands are authorized:

#pragma Error "xyz..."	An error is created and text "xyz..." is issued
#pragma Warning "xyz..."	A warning is created and text "xyz..." is issued
#pragma Message "xyz..."	The text "xyz..." is issued by the Compiler

Example

These #pragma instructions are often used in conjunction with Preprocessor commands and Pre-defined Constants. A classical example is the creation of an error message in case specific hard-ware criteria are not met.

```
#ifdef MEGA128
#pragma Error "Counter Functions not with Timer0 and Mega128"
#endif
```

4.1.3 Map File

If during compilation a Map File has been generated then the memory size of the used variable can there be ascertained.

Example

The project CNT0.cprj generates the following Map File during compilation:

```
Global Variable               Length    Position (RAM Start)
---------------------------------------------------------------
Total Length: 0 bytes

Local Variable                Length    Position (Stack relative)
-----------------------------------------------------------------
Function Pulse()
count                           2         4
i                               2         0
```

```
Total Length: 4 bytes

Function main()
count                           2         2
n                               2         0
Total Length: 4 bytes
```

From this list can be seen that no global variables are being used. There are further the two functions "Pulse()" and "main()". Each one of these functions consumes a memory space of 4 Bytes on local variables.

4.2 CompactC

One possibility to program the C-Control Pro Mega 32 or Mega 128 is offered by the programming language CompactC. The Compiler translates the language CompactC into a Bytecode which is then processed by the Interpreter of the C-Control Pro. The language volume of CompactC does essentially correspond with ANSI-C. It is however reduced to some extent since the firmware had to be implemented in a resource saving way. The following language constructs are missing:

- **structs** / **unions**
- **typedef**
- **enum**
- constants (**const** instruction)
- pointer Arithmetic

Detailed program examples can be found in directory C-Control Pro Demos which was installed along with the design interface. There example solutions can be found for almost every field of purpose.

The following chapter contains a systematic introduction into syntax and semantics of CompactC.

4.2.1 Program

A program consists of a number of instructions (such as "a=5;") which are distributed among various Functions. The starting function, which must be present in every program, is the function "main()". The following is a minimalistic program able to print a number into the output window:

```
void main(void)
{
      Msg_WriteInt(42);  // the answer to anything
}
```

Projects

A program can be separated into several files which are combined in a project (see Project Management). In addition to these project files Libraries can be added to the project which are able to offer functions used by the program.

4.2.2 Instructions

Instruction

An instruction consists of several reserved command words, identifiers and operators and is at the end terminated by a semicolon ('**;**'). In order to separate various elements of an instruction there are spaces in between the instruction elements which are called "*Whitespaces*". By “spaces“ space characters, tabulators and line feeds ("C/R and LF") are meant. It is of no consequence whether a space is built by one or several "*Whitespaces*".

Simple Instruction:

```
a=  5;
```

➔ An instruction does not necessarily have to completely stand in one line. Since line feeds do also belong to the space category it is legitimate to separate an instruction across several lines.

```
if(a==5)   // instruction across 2 lines
a=a+10;
```

Instruction Block

Several instructions can be grouped into a block. Here the block is opened by a left tailed bracket ("{"), followed by the instructions and closed at the end by a right tailed bracket ("}"). A block does not necessarily have to be terminated by a semicolon. I. e., if a block builds the end of an instruction then the last character in the instruction will be the right tailed bracket.

```
if(a>5)
{
    a=a+1;     //  instruction block
    b=a+2;
}
```

Comments

There are two types of commentaries, which are the single line and the multi line commentaries. The text within commentaries is ignored by the Compiler.

- Single line commentaries start with "//" and end up at the line’s end.
- Multi line commentaries start with "/*" and end up with "*/".

```
/* a
multi line
commentary */

// a single line commentary
```

Identifier

Identifier are the names of Functions or Variables.

- Valid characters are letters (A-Z,a-z), numbers (0-9) and the low dash ('_')
- An identifier always starts with a letter
- Upper and lower case writings are differentiated
- Reserved Words are not allowed as identifier
- The length of identifiers is unlimited

Arithmetic Expressions

An arithmetic expression is a quantity of values connected by Operators. In this case quantities can either be Figures, Variables and Functions.

A simple example:

```
2 + 3
```

Here the numerical values 2 and 3 are connected by the Operator "+". An arithmetic value again represents a value. In this case the value is 5.

Further examples:

```
a - 3
```

```
b + f(5)
```

```
2 + 3 * 6
```

Following the rule "Dot before Line" here 3 times 6 is calculated first and then 2 is added. This priority is in case of operators called precedence. A list of priorities can be found in the Precedence Table.

➡ Comparisons too are arithmetic expressions. The comparison operators return a truth value of "1" or "0", depening on whether the comparison was true or not. The expression "3 < 5" yields the value "1" (true).

Constant Expressions

An expression or portions of an expression can be constant. Portions of an expression can already be calculated during Compiler runtime.

So e. g. the expression

```
12 + 123 - 15
```

is combined by the Compiler to

```
120.
```

In some cases expressions must be constant in order to be valid. E. g. also see Declaration of Array Variables.

4.2.3 Data Types

Values always are of a certain data type. Integer values (integral values; whole numbered values) in CompactC are of the 8, 16 or 32 Bit wide data type, floating point values are always 4 byte long.

Data Type	Sign	Range	Bit
char	Yes	-128 ... +127	8
unsigned char	No	0 ... 255 8	8
byte	No	0 ... 255 8	8
int	Yes	-32768 ... +32767	16
unsigned int	No	0 ... 65535	16
word	No	0 ... 65535	16
long **(no Mega32)**	Yes	-2147483648 ... 2147483647	32
unsigned long **(no Mega32)**	No	0 ... 4294967295	32
dword **(no Mega32)**	No	0 ... 4294967295	32
float	Yes	±1.175e-38 to ±3.402e38	32

As one can see the data types "**unsigned char**" and **byte,** "**unsigned int**" and **word** as well as "**unsigned long**" and **dword** are identical.

➔ Due to size restrictions of the interpreter, 32-Bit Integer are not available on the Mega32.

Strings

There is no explicit "String" data type. A string is based on a character array. The size of the array must be chosen in such a way that all characters of the string fit into the character array. Additionally some space is needed for a terminating character (decimal Zero) in order to indicate the end of the character string.

Type Conversion

In arithmetic expressions it is very often the case that individual values are not of the same type. So the data types of the following expression are combined (a is of type integer variable).

```
a + 5.5
```

In this case a is first converted into the data type **float** and then 5.5 is added. The data type of the result is also **float**. For data type conversion there are the following rules:

- If in a linkage of 8 Bit or 16 Bit integer values one of the two data types is sign afflicted ("**signed**") then the result of the expression is also sign afflicted. I. e. the operation is executed "**signed**".

- If one of the operands is of the **float** type then the result is also of the **float** type. If one of the two operands happens to be of the 8 Bit or 16 Bit data type then it will be converted into a **float** data type prior to the operation.

4.2.4 Variables

Variables can take on various values depending on the Data Type by which they have been defined. A variable definition appears as follows:

```
Type Variable Name;
```

When several variables of the same type need to be defined then these variables can be stated separated by commas:

```
Typ Name1, Name2, Name3, ...;
```

As types are allowed: **char**, **unsigned char**, **byte**, **int**, **unsigned int**, **word**, **long**, **dword**, **float**

Examples:

```
int a;

int i,j;

float xyz;
```

Integer variables may have decimal figure values or Hex values assigned to. With Hex values the characters "**0x**" will be placed ahead of the figure. Binary numbers can be created with the prefix "**0b**". With variables of the sign afflicted data type negative decimal figures can be assigned to by putting a minus sign ahead of the figure.

Numbers without period or exponent are normally of type signed integer. To explicitly define an unsigned integer write an "u" direct after the number. To declare a number to be 32-Bit, either the value is greater 65535 or put an "l" after the number. Can be combined with "u" from unsigned.

Examples:

```
char c;
word a;
int i,j;

c=5;
c='a';        // single quotes defines the ASCII value
a=0x3ff;      // hex digits are always unsigned
x=0b1001;     // binary number
a=50000u;     // unsigned
a=100ul;      // unsigned 32 Bit (dword)
i=15;         // default is signed
j=-22;        // signed
```

Floating Point Figures (data type **float**) may contain a decimal point and an exponent.

```
float x,y;

x=5.70;
y=2.3e+2;
x=-5.33e-1;
```

sizeof Operator

By the operator **sizeof**() the number of Bytes a variable takes up in memory can be determined.

Examples:

```
int s;
float f:

s=sizeof(f);  // the value of s is 4
```

➔ With arrays only the Byte length of the basic data type is returned. On order to calculate the memory consumption of the array the value must be multiplied by the number of elements.

Array Variables

If behind the name, which in case of a variable definition is set in brackets, a figure value is written then an array has been defined. An array will arrange the space for a defined variable manifold in memory. With the following example definition

```
int x[10];
```

a tenfold memory space has been arranged for variable x. The first memory space can be addressed by `X[0]`, the second by `x[1]`, the third by `x[2]`, ... up to `x[9]`. When defining of course other index dimensions can also be chosen. The memory space of C-Control Pro is the only limit.

Multi dimensional arrays can also be declared by attaching further brackets during variable definition:

```
int x[3][4];      // array with 3*4 entries
int y[2][2][2];  // array with 2*2*2 entries
```

➔ Arrays may in CompactC have up to 16 indices (dimensions). The maximum value for an index is 65535. The indices of arrays are in any case zero based, i .e. each index will start with a 0.

➔ Only if the compiler option "Check Array Index Limits" is set, there will be a verification whether or not the defined index limits of an array have been exceeded. Otherwise, if an index becomes too large during program execution the access to alien variables will be tried which in turn may create a good chance for a program breakdown.

Table support by predefined Arrays

Since version 2.0 of the IDE arrays can be predefined with values:

```
byte glob[10] = {1,2,3,4,5,6,7,8,9,10};
flash byte fglob[2][2]={10,11,12,13};

void main(void)
{
    byte loc[5]= {2,3,4,5,6};
    byte xloc[2][2];

    xloc= fglob;
}
```

Because there is more flash memory than RAM available, it is possible with the **flash** keyword to define data that are written in the flash memory only. These data can be copied to a RAM array with same dimensions with an assignment operation. In this example this is done through "xloc= fglob". This kind of assignment is not available in normal "C".

Direct Access to flash Array entries

With version 2.12 it is possible to access single entries in flash arrays:

```
flash byte glob[10] = {1,2,3,4,5,6,7,8,9,10};

void main(void)
{
    int a;

    a= glob[2];
}
```

➔ There is still one limitation: Only references to arrays that lie in RAM can be passed as function parameters. This is not possible with references to flash arrays.

Strings

There is no explicit "String" data type. A string is based on a character array. The size of the array must be chosen in such a way that all characters of the string fit into the character array. Additionally some space is needed for a terminating character (decimal Zero) inorder to indicate the end of the character string.

Example for a character string with a 20 character maximum:

```
char str1[21];
```

As an exception **char** arrays may have character strings assigned to. Here the character string is placed between quotation marks.

```
str1="hallo world!";
```

You may embed special characters in strings that are started with a "\" (backslash). The following sequences are defined:

Sequence	Char/Value
\\	\
\'	'
\a	7
\b	8
\t	9
\n	10
\v	11
\f	12
\r	13

Strings cannot be assigned to multi dimensional **Char** arrays. There are however tricks for advanced users:

```
char str_array[3][40];
char single_str[40];

single_str="A String";

// will copy single_str in the second string of str_array
Str_StrCopy(str_array,single_str,40);
```

This will work because with a gap of 40 characters after the first string there will in str_array be room for the second string.

Visibility of Variables

When variables are declared outside of functions then they will have global visibility. I. e. they can be addressed from every function. Variable declarations within functions produce local variables. Local variables can only be reached within the function. An example:

```
int a,b;

void func1(void)
{
    int a,x,y;
    // global b is accessable
    // global a is not accessable since concealed by local a
    // local x,y are accessable
    // u is not accessable since local to function main
}

void main(void)
{
    int u;
    // globale a,b are accessable
    // local u is accessable
    // x,y not accessable since local to function func1
}
```

Global variables have a defined memory space which is available throughout the entire program run.

➔ At program start the global variables will be initialized by zero. Local Variables get not initialized at the begin of a function!

Local variables will during calculation of a function be arranged on the stack. I. e. local variables exist in memory only during the time period in which the function is executed.

If with local variables the same name is selected as with a global variable then the local variable will conceal the global variable. While the program is working in the function where the identically named variable has been defined the global variable cannot be addressed.

Static Variables

With local variables the property **static** can be placed for the data type.

```
void func1(void)
{
    static int a;
}
```

In opposition to normal local variables will static variables still keep their value even if the function is left. At a further call-up of the function the static variable will have the same contents as when leaving the function. In order to have the contents of a **static** variable defined at first access the static variables will equally to global variables at program start also be initialized by zero.

4.2.5 Operators

Priorities of Operators

Operators separate arithmetic expressions into partial expressions. The operators are then evaluated in the succession of their priorities (precedence). Expressions with operators of identical precedence will be calculated from left to right.
Example:

```
i= 2+3*4-5;  // result 9 => first 3*4, then +2, finally -5
```

The succession of the execution can be influenced by setting of parenthesis. Parenthesis have the highest priority.
If the last example should strictly be calculated from left to right, then:

```
i= (2+3)*4-5;  // result 15 => first 2+3, then *4, finally -5
```

A list of priorities can be found in Precedence Table.

4.2.5.1 Arithmetic Operators

All arithmetic operators with the exception of Modulo are defined for Integer and Floating Point data types. Modulo is restricted to data type Integer only.
➡ It must be observed that in an expression the figure 7 will have an Integer data type assigned to it. If a figure of data type **float** should be explicitly created then a decimal point has to be added: 7.0

Operator	Description	Example	Result
+	**Addition**	2+1 3.2 + 4	3 7.2
-	**Subtraction**	2 - 3 22 - 1.1e1	-1 11
*	**Multiplication**	5 * 4	20
/	**Division**	7 / 2 7.0 / 2	3 3.5
%	**Modulo**	15 % 4 17 % 2	3 1
-	**Negative Sign**	-(2+2)	-4

4.2.5.2 Bit Operators

Bit operators are only allowed for Integer data types

Operator	Description	Example	Result
&	**And**	0x0f & 3 0xf0 & 0x0f	3 0
|	**Or**	1 | 3 0xf0 | 0x0f	3 0xff
^	**exclusive Or**	0xff ^ 0x0f 0xf0 ^ 0x0f	0xf0 0xff
~	**Bit inversion**	~0xff ~0xf0	0 0x0f

4.2.5.3 Bit-Shift Operators

Bit-Shift operators are only allowed for Integer data types. With a Bit-Shift operation a 0 will always be moved into one end.

Operator	Description	Example	Result
<<	**shift to left**	1 << 2 3 << 3	4 24
>>	**shift to right**	0xff >> 6	3

		16 >> 2	4

4.2.5.4 In- /Decrement Operators

Incremental and decremental operators are only allowed for variables with Integer data types.

Operator	Description	Example	Result
variable++	first variable value, after access variable gets incremented by one (postincrement)	a++	a
variable--	first variable value, after access variable gets decremented by one (postdecrement)	a--	a
++variable	value of the variable gets incremented by one before access (preincrement)	++a	a+1
--variable	value of the variable gets decremented by one before access (predecrement)	--a	a-1

4.2.5.5 Comparison Operators

Comparison operators are allowed for **float** and Integer data types.

Operator	Description	Example	Result
<	**smaller**	1 < 2 2 < 1 2 < 2	1 0 0
>	**greater**	-3 > 2 3 > 2	0 1
<=	**smaller or equal**	2 <= 2 3 <= 2	1 0
>=	**greater or equal**	2 >= 3 3 >= 2	0 1
==	**equal**	5 == 5 1 == 2	1 0
!=	**not equal**	2 != 2 2 != 5	0 1

4.2.5.6 Logical Operators

Logical operators are only allowed for Integer data types. Any value unequal **null** is meant to be a logical 1. Only **null** is valid as logical 0.

Operator	Description	Example	Result

&&	**logical And**	1 && 1 5 && 0	1 0
||	**logical Or**	0 || 0 1 || 0	0 1
!	**logical Not**	!2 !0	0 1

4.2.6 Control Structures

Control structures allow to change the program completion depending on expressions, variables or external influences.

4.2.6.1 Conditional Valuation

With a conditional valuation expressions can be generated which will be conditionally calculated. The form is:

```
( Expression1 )  ? Expression2 : Expression3
```

The result of this expression is expression2, if expression1 had been calculated as unequal 0, otherwise the result is expression 3.

Examples:

```
a = (i>5) ? i : 0;

a= (i>b*2) ? i-5 : b+1;

while(i> ((x>y) ? x : y) ) i++;
```

4.2.6.2 do .. while

With a **do** .. **while** construct the instructions can depending on a condition be repeated in a loop:

```
do Instruction while( Expression );
```

The instruction or the Instruction Block is being executed. At the end the *Expression* is evaluated. If the result is unequal 0 then the execution of the expression will be repeated. The entire procedure will constantly be repeated until the *Expression* takes on the value 0.

Example:

```
do
a=a+2;
while(a<10);

do
```

```
{
    a=a*2;
    x=a;
} while(a);
```

➔ The essential difference between the **do** .. **while** loop and the normal **while** loop is the fact that in a **do** .. **while** loop the instruction is executed at least once.

break Instruction

A **break** instruction will leave the loop and the program execution will start with the next instruction after the **do** .. **while** loop.

continue Instruction

When executing **continue** within a loop there will immediately be a new calculation of the *Expression*. Depending on the result the loop will be repeated at unequal 0. At a result of 0 the loop will be terminated.

Example:

```
do
{
    a++;
    if(a>10) break; // will terminate loop
} while(1);  // endless loop
```

4.2.6.3 for

A **for** loop is normally used to program a definite number of loop runs.

```
for(Instruction1; Expression; Instruction2) Instruction3;
```

At first Instruction1 will be executed which normally contains an initialization. Following the evaluation of the *Expression* takes place. If the *Expression* is unequal 0 Instruction2 and Instruction3 will be executed and the loop will repeat itself. When *Expression* reaches the value 0 the loop will be terminated. As with other loop types at Instruction3 an Instruction Block can be used instead of a single instruction.

```
for(i=0;i<10;i++)
{
    if(i>a) a=i;
    a--;
}
```

➔ It must be observed that variable i will within the loop run through values 0 through 9 rather than 1 through 10!

If a loop needs to be programmed with a different step width Instruction2 needs to be modified accordingly:

```
for(i=0;i<100;i=i+3)  // variable i does now increment in steps to 3
{
    a=5*i;
}
```

break Instruction

A **break** instruction will leave the loop and the program execution starts with the next instruction after the **for** loop.

continue Instruction

continue will immediately initialize a new calculation of the *Expression*. Depending on the result Instruction2 will be executed at unequal 0 and the loop will repeat itself. A result of 0 will terminate the loop.

Example:

```
for(i=0;i<10;i++)
{
    if(i==5) continue;
}
```

4.2.6.4 goto

Even though it should be avoided within structured programming languages, it is possible with **goto** to jump to a label within a procedure:

```
// for loop with realized with goto
void main(void)
{
    int a;

    a=0;
label0:
    a++;
    if(a<10) goto label0;
}
```

4.2.6.5 if .. else

An **if** instruction does have the following syntax:

```
if( Expression ) Instruction1;
else Instruction2;
```

After the **if** instruction an Arithmetic Expression will follow in parenthesis. If this *Expression* is evaluated as unequal 0 then Instruction1 will be executed. By use of the command word **else** an alternative Instruction2 can be defined which will be executed when the *Expression* has been calculated as 0. The addition of an **else** instruction is optional and is not necessary.

Examples:

```
if(a==2) b++;

if(x==y) a=a+2;
else a=a-2;
```

An Instruction Block can be defined instead of a single instruction.

Examples:

```
if(x<y)
{
    c++;
    if(c==10) c=0;
}
else d--;

if(x>y)
{
    a=b*5;
    b--;
}
else
{
    a=b*4;
    y++;
}
```

4.2.6.6 switch

If depending on the value of an expression various commands should be executed a **switch** instruction is an elegant solution:

```
switch( Expression )
{
    case constant_1:
        Instruction_1;
    break;
    case constant_2:
        Instruction_2;
    break;
    .
    .
    case constant_n:
        Instruction_n;
    break;
    default:   // default is optional
        Instruction_0;
};
```

The value of the *Expression* is calculated. Then the program execution will jump to the constant corresponding to the value of the *Expression* and will continue the program from there. If no constant corresponds to the value of the expression the **switch** construct will be left.

If a **default** is defined within a **switch** instruction then the instructions after **default** will be executed if no constant corresponding to the value of the instruction has been found.

Example:

```
switch(a+2)
{
    case 1:
        b=b*2;
    break;

    case 5*5:
        b=b+2;
    break;

    case 100&0xf:
        b=b/c;
    break;

    default:
        b=b+2;
}
```

➔ The execution of a **switch** statement is highly optimized. All values are stored inside a jumptable. Therefore exists a constraint that the calculated Expression is of type signed 16 Bit Integer (-32768 .. 32767). For this reason a e.g. "**case** > 32767" is rather senseless.

break Instruction

A **break** will leave the **switch** instruction. If **break** is left out ahead of **case** then the instruction will be executed even when a jump to the preceeding **case** does take place:

```
switch(a)
{
    case 1:
        a++;
    case 2:
        a++;  // is also executed at a value of a==1

    case 3:
        a++; // is also executed at a value of a==1 or a==2
}
```

In this example all three "a++" instructions are executed if a equals 1.

4.2.6.7 while

With a **while** instruction the instructions can depending on a condition be repeated in a loop.

```
while( Expression ) Instruction;
```

At first the *Expression* is evaluated. If the result is unequal 0 then the *Expression* is executed. After that the *Expression* is again calculated and the entire procedure will constantly be repeated until the *Expression* takes on the value 0. An Instruction Block can be defined instead of a single instruction.

Example:

```
while(a<10) a=a+2;

while(a)
{
    a=a*2;
    x=a;
}
```

break Instruction

If a **break** is executed within the loop then the loop will be left and the program execution starts with the next instruction after the **while** loop.

continue Instruction

An execution of **continue** within a loop will immediately initialize a new calculation of the *Expression*. Depending on the result the loop will be repeated at unequal 0. A result of 0 will terminate the loop.

Example:

```
while(1)  // endless loop
{
    a++;
    if(a>10) break; // will terminate the loop
}
```

4.2.7 Functions

In order to structure a larger program it is separated into several sub-functions. This not only improves the readability but allows to combine all program instructions repeatedly appearing in functions. A program does in any case contain the function "main", which is started in first place. After that other functions can be called up.
A simple example:

```
void func1(void)
{
    // instructions in function func1
    .
    .
}

void main(void)
{
    // function func1 will be called up twice
    func1();
    func1();
}
```

Parameter Passing

In order to enable functions to be flexibly used they can be set up parametric. To do this the parameters for the function are separated by commas and passed in parenthesis after the function name. Similar to the variables declaration first the data type and then the parameter name are stated. If no parameter is passed then **void** has to be set into the parenthesis.
An example:

```
void func1(word param1, float param2)
{
    Msg_WriteHex(param1);  // first parameter output
    Msg_WriteFloat(param2);  // second parameter output
}
```

➜ Similar to local variables passed parameters are only visible within the function itself.

In order to call up function func1 by use of the parameters the parameters for call up should be written in the same succession as they have been defined in func1. If the function does not get parameters the parenthesis will stay empty.

```
void main(void)
{
    word a;
    float f;

    func1(128,12.0);  // you can passs numerical constants
    a=100;
    f=12.0;
    func1(a+28,f); // or yet variables too and even numerical expressions
}
```

When calling up a function all parameters must always be stated. The following call up is inadmissible:

```
func1();          // func1 gets 2 parameters!
func1(128);       // func1 gets 2 parameters!
```

Return Parameters

It is not only possible to pass parameters. A function can also offer a return value. The data type of this value is during function definition entered ahead of the function name. If no value needs to be returned the data type used will be **void**.

```
int func1(int a)
{
    return a-10;
}
```

The return value is within the function stated as instruction "**return** *Expression*". If there is a function of the **void** type then the **return** instruction can be used without parameters in order to leave the function.

References

Since it is not possible to pass on arrays as parameters the access to parameters is possible through references. For this a pair of brackets is written after the parameter names in the parameter declaration of a function.

```
int StringLength(char str[])
{
    int i;

    i=0;
    while(str[i]) i++;  // repeat character as long as unequal zero
    return(i);
}

void main(void)
{
    int len;
    char text[15];

    text="hello world";
    len=StringLength(text);
}
```

In **main** the reference of text is presented as parameters to the function StringLength. If in a function a normal parameter is changed then the change is not visible outside this function. With references this is different. Through parameter *str* in StringLength the contents of *text* can be changed since *str* is only the reference (pointer) to the array variable *text*.

Presently arrays can only be passed "by Reference"!

Pointer Arithmetic

In the current C-Control Pro software also arithmetic on a reference (pointer) is permitted, as the following example shows. The arithmetic is limited to addition, subtraction, multiplication and division.

```
void main(void)
{
    int len;
    char text[15];

    text="hello world";
    len=StringLength(text+2*3);
}
```

Pointer arithmetic is currently experimental and may possibly still contain errors.

Strings as Parameter

Since Version 2.0 of the IDE it is possible to call functions with a string as parameter. The called function gets the string as reference. Since references are RAM based and predefined strings are stored in the flash memory, the compiler creates internally an anonymous variable, and copies the data from flash into memory.

```
int StringLength(char str[])
{
...
}

void main(void)
{
    int len;

    len=StringLength("hallo welt");
}
```

4.2.8 Tabellen

4.2.8.1 Operator Precedence

Rang	Operator
13	( )
12	++ -- ! ~ - (negatives Vorzeichen)
11	* / %

10	+ -
9	<< >>
8	< <= > >=
7	== !=
6	&
5	^
4	|
3	&&
2	||
1	? :

4.2.8.2 Operators

	Arithmetische Operatoren
+	Addition
-	Subtraktion
*	Multiplikation
/	Division
%	Modulo
-	negatives Vorzeichen

	Vergleichsoperatoren
<	kleiner
>	größer
<=	kleiner gleich
>=	größer gleich
==	gleich
!=	ungleich

	Bitschiebeoperatoren
<<	um ein Bit nach links schieben
>>	um ein Bit nach rechts schieben

	Inkrement/Dekrement Operatoren
++	Post/Pre Inkrement
--	Post/Pre Dekrement

	Logische Operatoren
&&	logisches Und
||	logisches Oder

!	logisches Nicht

	Bitoperatoren
&	Und
|	Oder
^	exclusives Oder
~	Bitinvertierung

4.2.8.3 Reserved Words

The following words are **reserved** and cannot be used as identifier:

break	byte	case	char	continue
default	do	else	false	float
for	goto	if	int	return
signed	static	switch	true	unsigned
void	while	word	dword	long

4.3 BASIC

The second programming language for the C-Control Pro Mega Module is BASIC. The Compiler translates the BASIC commands into a Bytecode which is then processed by the C-Control Pro Interpreter. The language volume of the BASIC dialect used here corresponds to a large extent to the industry standard of the large software suppliers.

The following language constructs are missing:

- Object oriented programming
- Structures
- Constants

Detailed program examples can be found in directory C-Control Pro Demos which was installed along with the design interface. There example solutions can be found for almost every field of purpose of the C-Control Pro Module.

The following chapters offer a systematical introduction to syntax and semantics of C-Control Pro BASIC.

4.3.1 Program

A program consists of a number of instructions (such as e. g. "a=5;") which are distributed among various Functions. The starting function, which must be present in every program, is the function "main()". The following is a simplistic program able to print a number into the output window:

```
Sub main()
      Msg_WriteInt(42)  // the answer to anything
End Sub
```

Projects

A program can be separated into several files which are combined in a project (see Project Management). In addition to these project files Libraries can be added to the project which are able to offer functions used by the program.

4.3.2 Instructions

Instruction

An instruction consists of several reserved command words, identifiers and operators and is at the end terminated by the end of the line. In order to separate various elements of an instruction there are spaces in between the instruction elements which are called "*Whitespaces*". By “spaces“ space characters, tabulators and line feeds ("C/R and LF") are meant. It is of no consequence whether a space is built by one or several "*Whitespaces*".

Simple Instruction:

```
a=  5
```

➜ An instruction does not necessarily have to completely stand in one line. By use of the "_" character (low dash) it is possible to extend the instruction into the next line.

```
If a=5 _ ' instruction across two lines
a=a+10
```

➜ It is also possible to place more than one instruction into the same line. The ":" character (colon) will then separate the individual instructions. For reason of better readability however this option should rather seldom be used.

```
a=1 : b=2 : c=3
```

Comments

There are two types of commentaries, which are the single line and the multi line commentaries. The text within commentaries is ignored by the Compiler.

- Single line commentaries start with a single quotation mark and end up at the line’s end.
- Multi line commentaries start with "/*" and end up with "*/".

```
/* a
multi line
commentary */

' a single line commentary
```

Identifier

Identifiers are the names of Functions or Variables.

- Valid characters are letters (A-Z,a-z), numbers (0-9) and the low dash ('_')
- An identifier always starts with a letter
- Upper and lower case writings are differentiated
- Reserved Words are not allowed as identifiers
- The length of an identifier is unlimited

Arithmetic Expressions

An arithmetic expression is a quantity of values connected by Operators. In this case quantities can either be Figures, Variables or Functions.

A simple example:

```
2 + 3
```

Here the numerical values 2 and 3 are connected by the Operator "+". An arithmetic value again represents a value. In this case the value is 5.

Further examples:

```
a - 3
```

```
b + f(5)
```

```
2 + 3 * 6
```

Following the rule "Dot before Line" here 3 times 6 is calculated first and then 2 is added. This priority is in case of operators called precedence. A list of priorities can be found in the Precedence Table.

➨ Comparisons too are arithmetic expressions. The comparison operators return a truth value of "1" or "0", depending on whether the comparison was true or not. The expression "3 < 5" yields the value "1" (true).

Constant Expressions

An expression or portions of an expression can be constant. Portions of an expression can already be calculated during Compiler runtime.

So e. g. the expression

```
12 + 123 - 15
```

is combined by the Compiler to

```
120.
```

In some cases expressions must be constant in order to be valid. E. g. also see Declaration of Array Variables.

4.3.3 Data Types

Values always are of a certain data type. Integer values (integral values; whole numbered values) in BASIC are of the 8, 16 or 32 Bit wide data type, floating point values are always 4 byte long.

Data Type	Sign	Range	Bit
Char	Yes	-128 ... +127	8
Byte	No	0 ... 255	8
Integer	Yes	-32768 ... +32767	16
UInteger	No	0 ... 65535	16
Word	No	0 ... 65535	16
Long (no Mega32)	Yes	-2147483648 ... 2147483647	32
ULong (no Mega32)	No	0 ... 4294967295	32
Single	Yes	±1.175e-38 to ±3.402e38	32

Due to size restrictions of the interpreter, 32-Bit Integer are not available on the Mega32.

Strings

There is no explicit "String" data type. A string is based on a character array. The size of the array must be chosen in such a way that all characters of the string fit into the character array. Additionally some space is needed for a terminating character (decimal Zero) in order to indicate the end of the character string.

Type Conversion

In arithmetic expressions it is very often the case that individual values are not of the same type. So the data types

```
a + 5.5
```

In this case a is first converted into the **Single** data type and then 5.5 is added. The data type of the result is also **Single**. For data type conversion there are the following rules:

- If in a linkage of 8 Bit or 16 Bit integer values one of the two data types is sign afflicted then the result of the expression is also sign afflicted.
- If one of the operands is of the **Single** type then the result is also of the **Single** type. If one of the two operands happens to be of the 8 Bit or 16 Bit data type then it will be converted into a **Single** data type prior to the operation.

4.3.4 Variables

Variables can take on various values depending on the Data Type by which they have been defined. A variable definition appears as follows:

```
Dim Variable Name As Type
```

When several variables of the same type need to be defined then these variables can be stated separated by commas:

```
Dim Name1, Name2, Name3 As Integer
```

As types are allowed: **Char**, **Byte**, **Integer**, **Word**, **Single**

Examples:

```
Dim a As Integer

Dim i,j As Integer

Dim xyz As Single
```

Integer variables may have decimal figure values or Hex values assigned to. With Hex values the characters "**&H**" will be placed ahead of the figure. Just as with CompactC it is also allowed to place the prefix "**0x**" ahead of the Hex values. Binary numbers can be created with the prefix "**0B**". With variables of the sign afflicted data type negative decimal figures can be assigned to by putting a minus sign ahead of the figure.

Numbers without period or exponent are normally of type signed integer. To explicitly define an unsigned integer write an "u" direct after the number. To declare a number to be 32-Bit, either the value is greater 65535 or put an "l" after the number. Can be combined with "u" from unsigned.

Examples:

```
Dim c As Char
Dim a As Word
Dim i,j As Integer

c=5;
c=&"a";     ' syntax for ASCII value
a=&H3ff     ' hex numbers are always unsigned
a=50000u    ' unsigned
x=0b1001    ' binary number
a=100ul     ' unsigned 32 Bit (ULong)
i=15        ' default is signed
j=-22       ' signed
a=0x3ff     ' hex numbers are always unsigned
```

Floating Point Figures (data type **Single**) may contain a decimal point and an exponent.

```
Dim x,y As Single

x=5.70
y=2.3e+2
x=-5.33e-1
```

SizeOf Operator

By the operator **SizeOf**() the number of Bytes a variable takes up in memory can be determined.

Examples:

```
Dim s As Integer
Dim f As Single

s=SizeOf(f)  ' the value of s is 4
```

➡ With arrays only the Byte length of the basic data type is returned. On order to calculate the memory consumption of the array the value must be multiplied by the number of elements.

Array Variables

If behind the name, which in case of a variable definition is set in parenthesis, a figure value is written then an array has been defined. An array will arrange the space for a defined variable manifold in memory. With the following example definition

```
Dim x(10) As Integer
```

a tenfold memory space has been arranged for variable x. The first memory space can be addressed by `X[0]`, the second by `x[1]`, the third by `x[2]`, ... up to `x[9]`. When defining of course other index dimensions can also be chosen. The memory space of C-Control Pro is the only limit.

Multi dimensional arrays can also be declared by attaching further indices during variable definition, which have to be separated by commas:

```
Dim x(3,4) As Integer  ' array with 3*4 entries
Dim y(2,2,2) As Integer ' array with 2*2*2 entries
```

➡ Arrays may in BASIC have up to 16 indices (dimensions). The maximum value for an index is 65535. The indices of arrays are in any case zero based, i .e. each index will start with a 0.

➡ Only if the compiler option "Check Array Index Limits" is set, there will be a verification whether or not the defined index limits of an array have been exceeded. Otherwise, if an index becomes too large during program execution the access to alien variables will be tried which in turn may create a good chance for a program breakdown.

Table support by predefined Arrays

Since version 2.0 of the IDE arrays can be predefined with values:

```
Dim glob(10) = {1,2,3,4,5,6,7,8,9,10} As Byte
Flash fglob(2,2)={10,11,12,13} As Byte

Sub main()
    Dim loc(5)= {2,3,4,5,6} As Byte
    Dim xloc(2,2) As Byte

    xloc= fglob
End Sub
```

Because there is more flash memory than RAM available, it is possible with the **flash** keyword to define data that are written in the flash memory only. These data can be copied to a RAM array with same dimensions with an assignment operation. In this example this is done through "xloc= fglob".

Direct Access to flash Array entries

With version 2.12 it is possible to access single entries in flash arrays:

```
Flash glob(10) = {1,2,3,4,5,6,7,8,9,10} As Byte

Sub main()
    Dim a As Byte

    a= glob(2)
End Sub
```

➡ There is still one limitation: Only references to arrays that lie in RAM can be passed as function parameters. This is not possible with references to flash arrays.

Strings

There is no explicit "String" data type. A string is based on an array of data type **Char**. The size of the array must be chosen in such a way that all characters of the string fit into the character array. Additionally some space is needed for a terminating character (decimal Zero) inorder to indicate the end of the character string.

Example for a character string with a 20 character maximum:

```
Dim str1(21) As Char
```

As an exception **Char** arrays may have character strings assigned to. Here the character string is placed between quotation marks.

```
str1="hallo world!"
```

You may embed special characters in strings that are started with a "\" (backslash). The following sequences are defined:

Sequence	Char/Value
\\	\
\'	'
\a	7
\b	8
\t	9
\n	10
\v	11
\f	12
\r	13

➡ Strings cannot be assigned to multi dimensional **Char** arrays. There are however tricks for advanced users:

```
Dim str_array(3,40) As Char
Dim Single_str(40) As Char

Single_str="A String"

' will copy Single_str in the second string of str_array
Str_StrCopy(str_array,Single_str,40)
```

This will work because with a gap of 40 characters after the first string there will in str_array be room for the second string.

Visibility of Variables

When variables are declared outside of functions then they will have global visibility. I. e. they can be addressed from every function. Variable declarations within functions produce local variables. Local variables can only be reached within the function. An example:

```
Dim a,b As Integer

Sub func1()
Dim a,x,y As Integer
    ' global b is accessible
    ' global a is not accessible since concealed by local a
    ' local x,y is accessible
    ' u is not accessible since local to function main
End Sub

Sub main()
    Dim u As Integer
    ' global a,b is accessible
    ' local u is accessible
    ' x,y u is not accessible since local to function main
End Sub
```

Global variables have a defined memory space which is available throughout the entire program run.

➡ At program start the global variables will be initialized by zero. Local Variables get not initialized at the begin of a function!

Local variables will during calculation of a function be arranged on the stack. I. e. local variables exist in memory only during the time period in which the function is executed.

If with local variables the same name is selected as with a global variable then the local variable will conceal the global variable. While the program is working in the function where the identically named variable has been defined the global variable cannot be addressed.

Static Variables

With local variables the property **Static** can be placed for the data type.

```
Sub func1()
    Static a As Integer
End Sub
```

In opposition to normal local variables will static variables still keep their value even if the function is left. At a further call-up of the function the static variable will have the same contents as when leaving the function. In order to have the contents of a **Static** variable defined at first access the static variables will equally to global variables at program start also be initialized by zero.

4.3.5 Operators

Priorities of Operators

Operators separate arithmetic expressions into partial expressions. The operators are then evaluated in the succession of their priorities (precedence). Expressions with operators of identical precedence will be calculated from left to right.
Example:

```
i= 2+3*4-5  ' result 9 => first 3*4, then +2, finally -5
```

The succession of the execution can be influenced by setting of parenthesis. Parenthesis have the highest priority.
If the last example should strictly be calculated from left to right, then:

```
i= (2+3)*4-5  ' result 15 => first 2+3, then *4, finally -5
```

A list of priorities can be found in Precedence Table.

4.3.5.1 Arithmetic Operators

All arithmetic operators with the exception of Modulo are defined for Integer and Floating Point data types. Modulo is restricted to data type Integer only.
➔ It must be observed that in an expression the figure 7 will have an Integer data type assigned to it. If a figure of data type **Single** should be explicitly created then a decimal point has to be added: 7.0

Operator	Description	Example	Result
+	**Addition**	2+1 3.2 + 4	3 7.2
-	**Subtraction**	2 - 3 22 - 1.1e1	-1 11
*	**Multiplication**	5 * 4	20
/	**Division**	7 / 2 7.0 / 2	3 3.5
Mod	**Modulo**	15 Mod 4 17 Mod 2	3 1

-	**Negative Sign**	-(2+2)	-4

4.3.5.2 Bitoperators

Bit operators are only allowed for Integer data types

Operator	Description	Example	Result
And	**And**	&H0f And 3 &Hf0 And &H0f	3 0
Or	**Or**	1 Or 3 &Hf0 Or &H0f	3 &Hff
Xor	**exclusive Or**	&Hff Xor &H0f &Hf0 Xor &H0f	&Hf0 &Hff
Not	**Bit inversion**	Not &Hff Not &Hf0	0 &H0f

➡ All these Operators work arithmetically: E.g. **Not** &H01 = &Hfe. Both values are evaluated to true in an **If** expression. This is different to a logical **Not** operator, where **Not** &H01 = &H00.

4.3.5.3 Bit-Shift Operators

Bit-Shift operators are only allowed for Integer data types. With a Bit-Shift operation a 0 will always be moved into one end.

Operator	Description	Example	Result
<<	**shift to left**	1 << 2 3 << 3	4 24
>>	**shift to right**	&Hff >> 6 16 >> 2	3 4

4.3.5.4 In- /Decrement Operators

Incremental and decremental operators are only allowed for variables with Integer data types.

Operator	Description	Example	Result
variable++	first variable value, after access variable gets incremented by one (postincrement)	a++	a
variable--	first variable value, after access variable gets decremented by one (postdecrement)	a--	a
++variable	value of the variable gets incremented by one before access (preincrement)	++a	a+1
--variable	value of the variable gets decremented by one before access (predecrement)	--a	a-1

➡ These operators are normally not a part of a Basic dialect and have their origin in the world of C inspired languages.

4.3.5.5 Comparison Operators

Comparison operators are allowed for **Single** and Integer data types.

Operator	Description	Example	Result
<	**smaller**	1 < 2 2 < 1 2 < 2	1 0 0
>	**greater**	-3 > 2 3 > 2	0 1
<=	**smaller or equal**	2 <= 2 3 <= 2	1 0
>=	**greater or equal**	2 >= 3 3 >= 2	0 1
=	**equal**	5 = 5 1 = 2	1 0
<>	**not equal**	2 <> 2 2 <> 5	0 1

4.3.6 Control Structures

Control structures allow to change the program completion depending on expressions, variables or external influences.

4.3.6.1 Do Loop While

With a **Do ... Loop While** construct the instructions can depending on a condition be repeated in a loop:

```
Do
    Instructions
Loop While Expression
```

The instructions are being executed. At the end the *Expression* is evaluated. If the result is unequal 0 then the execution of the expression will be repeated. The entire procedure will constantly be repeated until the *Expression* takes on the value 0.

Examples:

```
Do
    a=a+2
Loop While a<10

Do
    a=a*2
    x=a
Loop While a
```

➔ The essential difference between the **Do Loop While** loop and the normal **Do While** loop is the fact that in a **Do Loop While** loop the instruction is executed at least once.

Exit Instruction

An **Exit** instruction will leave the loop and the program execution starts with the next instruction after the **Do Loop While** loop.

Example:

```
Do
    a=a+1
    If a>10 Then
        Exit ' Will terminate loop
    End If
Loop While 1  ' Endless loop
```

4.3.6.2 Do While

With a **while** instruction the instructions can depending on a condition be repeated in a loop:

```
Do While Expression
    Instructions
End While
```

At first the *Expression* is evaluated. If the result is unequal 0 then the expression is executed. After that the *Expression* is again calculated and the entire procedure will constantly be repeated until the *Expression* takes on the value 0.

Examples:

```
Do While a<10
    a=a+2
End While

Do While a
    a=a*2
    x=a
End While
```

Exit Instruction

If an **Exit** instruction is executed within a loop than the loop will be left and the program execution starts with the next instruction after the **While** loop.

Example:

```
Do While 1   ' Endless loop
    a=a+1
    If a>10 Then
        Exit ' Will terminate loop
    End If
End While
```

4.3.6.3 For Next

A **For Next** loop is normally used to program a definite number of loop runs.

```
For Counter Variable=Startvalue To Endvalue Step Stepwidth
    Instructions
Next
```

The Counter Variable is set to a Start Value. Then the instructions are repeated until the End Value is reached. With each loop run the value of the Counter Variable is increased by one step width which may also be negative. The stating of the step width after the End Value is optional. If no Step Width is stated it has the value 1.

Since the **For Next** loop will be used to especially optimized the counter variable must be of the Integer type.

Example:

```
For i=1 To 10
    If i>a Then
        a=i
    End If
    a=a-1
Next
```

```
For i=1 To 10 Step 3  'Increment i in steps of 3
    If i>3 Then
        a=i
    End If
    a=a-1
Next
```

➔ In this location please note again that arrays are in any case zero based. A For Next loop should thus rather run from 0 through 9.

Exit Instruction

An **Exit** instruction will leave the loop and the program execution starts with the next instruction after the **For** loop.

Example:

```
For i=1 To 10
    If i=6 Then
        Exit
    End If
Next
```

4.3.6.4 Goto

Even though it should be avoided within structured programming languages, it is still possible with **goto** to jump to a label within a procedure. In order to mark a label the command word **Lab** is set in front of the label name.

```
' For loop with goto will realize

Sub main()
    Dim a As Integer

    a=0
Lab label1
    a=a+1
    If a<10 Then
        Goto label1
    End If
End Sub
```

4.3.6.5 If .. Else

An **If** instruction does have the following syntax:

```
If Expression1 Then
    Instructions1
ElseIf Expression2 Then
```

```
    Instructions2
Else
    Instructions3
End If
```

After the **if** instruction an Arithmetic Expression will follow. If this *Expression* is evaluated as unequal 0 then Instruction1 will be executed. By use of the command word **else** an alternative Instruction2 can be defined which will be executed when the *Expression* has been calculated as 0. The addition of an **else** instruction is optional and not really necessary.

If directly in an **Else** branch an **If** instruction needs again to be placed then it is possible to initialize an **If** again direcly by use of an **ElseIf**. Thus the new **If** does not need to be interlocked into an **Else** block and the source text remains more clearly.

Examples:

```
If a=2 Then
    b=b+1
End If


If x=y Then
    a=a+2
Else
    a=a-2
End If


If a<5 Then
    a=a-2
ElseIf a<10 Then
    a=a-1
Else
    a=a+1
End If
```

4.3.6.6 Select Case

If depending on the value of an expression various commands should be executed then a **Select Case** instruction seems to be an elegant solution:

```
Select Case Expression
    Case constant_comparison1
        Instructions_1
    Case constant_comparison2
        Instructions_2
    .
    .
    Case constant_comparison_x
        Instructions_x
    Else   ' Else is optional
        Instructions
```

```
End Case
```

The value of the *Expression* is calculated. Then the program execution will jump to the first constant comparison that can be evaluated as true and will continue the program from there. If no constant comparison can be fulfilled the **Select Case** construct will be left.

For constant comparisons special comparisons and ranges can be defined . Here examples for all possibilities:

Comparison	Execute on
Constant, = Constant	Expression **equal** Constant
< Constant	Expression **smaller** Constant
<= Constant	Expression **smaller equal** Constant
> Constant	Expression **greater** Constant
>= Constant	Expression **greater equal** Constant
<> Constant	Expression **unequal** Constant
Constant1 To Constant2	Constant1 <= Expression <= Constant2

The new features that allow to use comparisons are introduced for Select Case statements with IDE version 1.71. This extension is not available for CompactC switch statements.

The execution of a **Select Case** statement is highly optimized. All values are stored inside a jumptable. Therefore exists a constraint that the calculated Expression is of type signed 16 Bit Integer (-32768 .. 32767). For this reason a e.g. "**Case** > 32767" is rather senseless.

Exit Instruction

An **Exit** will leave the **Select Case** instruction.

If an **Else** is defined within a **Select Case** instruction then the instructions after **Else** will be executed if no constant comparison could be fulfilled.

Example:

```
Select Case a+2
    Case 1
        b=b*2
    Case = 5*5
        b=b+2
    Case 100 And &Hf
        b=b/c
    Case < 10
        b=10
    Case <= 10
        b=11
    Case 20 To 30
        b=12
    Case > 100
        b=13
    Case >= 100
        b=14
    Case <> 25
        b=15
    Else
        b=b+2
End Case
```

➨ In CompactC the instructions will be continued after a **Case** instruction until a **break** comes up or the **switch** instruction is left. With BASIC this is different: Here the execution of the commands will break off after a **Case**, if the next **Case** instruction is reached.

4.3.7 Functions

In order to structure a larger program it is separated into several sub-functions. This not only improves the readability but allows to combine all program instructions repeatedly appearing in functions. A program does in any case contain the function "main", which is started in first place. After that other functions can be called up from main. A simple example:

```
Sub func1()
    ' Instructions in function func1
    .
    .
End Sub

Sub main()
    ' Function func1 will be called up twice
    func1()
    func1()
End Sub
```

Parameter Passing

In order to enable functions to be flexibly used they can be set up parametric. To do this the parameters for the function are separated by commas and passed in parenthesis after the function name. Similar to the variables declaration first the parameter name and then the data type is stated. If no parameter is passed then the parenthesis will stay empty.
An example:

```
Sub func1(param1 As Word, param2 As Single)
    Msg_WriteHex(param1)  ' first parameter output
    Msg_WriteFloat(param2)  ' second parameter output
End Sub
```

➨ Similar to local variables passed parameters are only visible within the function itself.

In order to call up function func1 by use of the parameters the parameters for call up should be written in the same succession as they have been defined in func1. If the function does not get parameters the parenthesis will stay empty.

```
Sub main()
    Dim a As Word
    Dim f As Single

    func1(128,12.0)  ' you can pass Numerical constants
    a=100
    f=12.0
    func1(a+28,f) ' or yet variables too and even numerical expressions
End Sub
```

➔ When calling up a function all parameters must always be stated. The following call up is inadmissible:

```
func1()         ' func1 gets 2 parameters!
func1(128)      ' func1 gets 2 parameters!
```

Return Parameters

It is not only possible to pass parameters. A function can also offer a return value. The data type of this value is during function definition entered after the parameter list of the function.

```
Sub func1(a As Integer) As Integer
    Return a-10
End Sub
```

The return value is within the function stated as instruction "**return** *Expression*". If there is a function without return value then the **return** instruction can be used without parameters in order to leave the function.

References

Since it is not possible to pass on arrays as parameters the access to parameters is possible through references. For this the attribute "**ByRef**" is written ahead of the parameter name in the parameter declaration of a function.

```
Sub StringLength(ByRef str As Char) As Integer
    Dim i As Integer

    i=0
    Do While str(i)
        i=i+1  ' Repeat character as long as unequal zero

    End While
    Return i
End Sub

Sub main()
    Dim Len As Integer
    Dim Text(15) As Char
    Text="hello world"
    Len=StringLength(Text)
End Sub
```

In **main** the reference of text is presented as parameters to the function StringLength. If in a function a normal parameter is changed then the change is not visible outside this function. With references this is different. Through parameter *str* can in StringLength the contents of *text* be changed since *str* is only the reference (pointer) to the array variable *text*.

➔ Presently arrays can only be presented "by Reference"!

Pointer Arithmetic

In the current C-Control Pro software also arithmetic on a reference (pointer) is permitted, as the following example shows. The arithmetic is limited to addition, subtraction, multiplication and division.

```
Sub main()
    Dim Len As Integer
    Dim Text(15) As Char

    Text="hello world"
    Len=StringLength(Text+2*3)
End Sub
```

➔ Pointer arithmetic is currently experimental and may possibly still contain errors.

Strings as Parameter

Since Version 2.0 of the IDE it is possible to call functions with a string as parameter. The called function gets the string as reference. Since references are RAM based and predefined strings are stored in the flash memory, the compiler creates internally an anonymous variable, and copies the data from flash into memory.

```
Sub StringLength(ByRef str As Char) As Integer
....
End Sub

Sub main()
    Dim Len As Integer

    Len=StringLength("hallo welt")
End Sub
```

4.3.8 Tables

4.3.8.1 Operator Precedence

Rank	Operator
10	( )
9	- (negative sign)
8	* /
7	Mod
6	+ -
5	<< >>
4	= <> < <= > >=
3	Not
2	And
1	Or Xor

4.3.8.2 Operators

	Arithmetic Operators
+	Addition
-	Subtraction
*	Multiplication
/	Division
Mod	Modulo
-	negative sign

	Comparison Operators
<	smaller
>	greater
<=	smaller or equal
>=	greater or equal
=	equal
<>	not equal

	Bitshift Operators
<<	shift to left
>>	shift to right

	Bitoperators
And	And
Or	Or

Xor	exclusive Or
Not	Bit inversion

4.3.8.3 Reserved Words

The following words are **reserved** and cannot be used as identifiers:

And	As	ByRef	Byte	Case
Char	Dim	Do	Else	ElseIf
End	Exit	False	For	Goto
If	Integer	Lab	Loop	Mod
Next	Not	Opc	Or	Return
Select	Single	SizeOf	Static	Step
Sub	Then	To	True	While
Word	Xor	ULong	Long	UInteger

4.4 Assembler

With IDE Version 2.0 it is possible to integrate Assembler routines into a project. The used Assembler is the GNU Open Source Assembler AVRA. The sources of the AVRA Assembler can be found in the installation directory "GNU". Assembler routines that are called from CompactC and Basic run in full CPU speed, in contrary to the Bytecode Interpreter. It is possible to pass parameters to Assembler procedures and get their return values. Also global CompactC and Basic variables can be accessed. The compiler recognizes assembler files with their ".asm" ending. Assembler sources are added to a project like CompactC or Basic files.

➔ The programming in assembly language is only recommended for the advanced user of the system. The programming is very complex and error prone, and should only be used by these people that have a very good knowledge of the system.

➔ There is no free assembler available for AVR32 Unit. Since the C-Control Pro AVR32Bit is also much faster than the C-Control Pro Mega series, no assembly support is planned for the AVR32.

Literature

You can find manifold literature about assembly language programming on the internet and in the book trade. Important are the "AVR Instruction Reference Manual" that can be found on the Atmel website and in the "Manual" directory of the C-Control Pro installation, and the "AVR Assembler User Guide" from the Atmel website.

4.4.1 An Example

The structure of assembly routines is explained in the following example (also included in the demo programs). In the project the CompactC source code file must have the ending ".cc", the assembler source files have to end with ".asm".

```
// CompactC Source
void proc1 $asm("tag1")(void);
int proc2 $asm("tag2")(int a, float b, byte c);

int glob1;
void main(void)
{
    int a;

    proc1();
    a= proc2(11, 2.71, 33);
}
```

The procedures *proc1* and *proc2* must first be declared, before they can be called. This happens with the keyword **$asm**. The declaration in Basic looks similar:

```
' Basic delaration of assembler routines
$Asm("tag1") proc1()
$Asm("tag2") proc2(a As Integer, b As Single, c As Byte) As Integer
```

The strings "tag1" and "tag" are visible in the declaration. These strings are defined in a ".def" file, if the Assembler routines are really called from the CompactC and Basic source. In this case the ".def" file looks like:´

```
; .def file
.equ glob1 = 2
.define tag1 1
.define tag2 1
```

When all the routines in the Assembler sources are placed in ".ifdef ..." directions, only the routines are assembled that are really called. This saves space at the code generation. Additionally the position of the global variables are stored in the definition file. The ".def" file is automatically included in the translation of the assembler files, it needed not to be manually included.

Here follows the assembler source of procedure *proc1*. In this source the global variable *glob1* is set to the value 42.

```
; Assembler Source
.ifdef tag1
proc1:
    ; global variable access example
    ; write 42 to global variable glob1

    MOVW R26,R8           ; get RamTop from register 8,9
    SUBI R26,LOW(glob1)   ; subtract index from glob1 to get address
    SBCI R27,HIGH(glob1)

    LDI  R30,LOW(42)
    ST   X+,R30
    CLR  R30             ; the high byte is zero
    ST   X,R30

  ret
.endif
```

In the second part of the assembler sources the passed parameters "a" and "c" are added as integers, and then the sum is returned.

```
.ifdef tag2
proc2:
    ; example for accessing and returning parameter
    ; we have int proc2(int a, float b, byte c);
    ; return a + c

    MOVW R30, R10   ; move parameter stack pointer into Z
    LDD R24, Z+5  ; load parameter "a" into R24,25
    LDD R25, Z+6

    LDD R26, Z+0  ; load byte parameter "c" into X (R26)
    CLR R27       ; hi byte zero because parameter is byte

    ADD R24, R26  ; add X to R24,25
    ADC R25, R27

    MOVW R30, R6      ; copy stack pointer from R6
    ADIW R30, 4       ; add 4 to sp  - ADIW only works for R24 and greater
    MOVW R6, R30      ; copy back to stack pointer location

    ST   Z+, R24      ; store R24,25 on stack
    ST   Z, R25

    ret
.endif
```

4.4.2 Data Access

Global Variables

In the Bytecode Interpreter in the register R8 and R9 lies the 16-Bit pointer to the end of the global variable memory. If a global variable that is defined in the ".def" file should be accessed, the address of the variable can be calculated when the variable position is subtracted from the R8, R9 16-Bit pointer. This looks like:

```
    ; global variable access example
    ; write 0042 to global variable glob1
    MOVW R26,R8          ; get Ram Top from register 8,9
    SUBI R26,LOW(glob1)  ; subtract index from glob1 to get address
    SBCI R27,HIGH(glob1)
```

When the address of the global variable is in the X register pair (R26,R27), the desired value (in our example 42) can be written there:

```
    LDI  R30,LOW(42)
    ST   X+,R30
    CLR  R30             ; the high byte of 42 is zero
    ST   X,R30
```

Parameter Passing

Parameters are passed on the stack of the Bytecode Interpreter. The stackpointer (SP) lies in the register pair R10,R11. Are parameters passed, they are written one after another onto the stack. Since the stack grows to the bottom, in our example (integer a, floating point b, byte c) the memory layout looks like this:

```
SP+5: a  (type integer, length 2)
SP+1: b  (type float, length 4)
SP+0: c  (type byte, length 1)
```

If the variables a and c should be accessed, a will be found at SP+5 and c at SP. In the following Assembler code the stack pointer SP (R10,R11) will be copied in the register pair Z (R30,R31), and the parameters a and c are loaded indirect via Z.

```
    ; example for accessing and returning parameter
    ; we have int proc2(int a, float b, byte c);
    MOVW R30, R10   ; move parameter stack pointer into Z
    LDD R24, Z+5  ; load parameter "a" into R24,25
    LDD R25, Z+6

    LDD R26, Z+0  ; load byte parameter "c" into X (R26)
    CLR R27       ; hi byte zero because parameter is byte
```

The parameter a and c are now in the register pairs X and R24, R25. Now they can be added:

```
    ADD R24, R26  ; add X to R24, R25
    ADC R25, R27
```

Return Parameters

In the routine *proc2* the sum is returned. Return parameters are written on the Parameter Stack (PSP) of the Bytecode Interpreter. The pointer to the PSP lies in the register pair R6,R7. To return a parameter the PSP pointer must be increased by 4 before the parameter can be written. In opposite to the normal parameter passing the type of the return parameter is not important. All parameter on the Parameter Stack have the same length of 4 bytes.

➔ Even with a declared 8-bit return value, the interpreter expects always a 16-bit value. This is done to save bytecodes in the interpreter. Is the assembly routine declared as **byte**, a **word** must be a written as the return value, if the assembly routine is of type **char**, an **int** is required. In all other cases no change is needed.

```
; return a + c
MOVW R30, R6      ; copy stack pointer from R6
ADIW R30, 4       ; add 4 to sp  - ADIW only works for R24 and greater
MOVW R6, R30      ; copy back to stack pointer location

ST   Z+, R24      ; store R24, R25 on stack
ST   Z, R25
```

4.4.3 Guideline

The most important topics on how to program in Assembler for C-Control Pro are explained here:

- Assembler calls are atomic. An Assembler call cannot be interrupted by Multithreading or an Bytecode Interruptroutine. This is similar to Library calls. An interrupt is recorded immediately by the internal interrupt structure, but the corresponding Bytecode interrupt routine is called after the assembler procedure has been ended.

- Do not change the Y Register (R28 and R29), it is used from the interpreter as a data stack pointer. Assembler interrupt routines use the Y-Register to save register contents and might else be crash.

- The register R0, R1, R22, R23, R24, R25, R26, R27, R30, R31 can be used in Assembler routines without backup. If other register are used, the contents must be saved first. Normally these values are stored on the stack. E.g.

```
at begin: PUSH R5
          PUSH R6
...
at end:   POP R6
          POP R5
```

- An Assembler routine is left with a "RET" instruction. At this point the CPU stack must be in the same state as before the call. The contents of the register that need to be backuped must be re-stored.

- Debugging only works in the Bytecode Interpreter, it is not possible to debug in Assembler.

- The Bytecode Interpreter has a fixed memory layout. In **no** case use Assembler directives like .**byte**, .**db**, .**dw**, .**dseg** or similar. In an access to the data segment this would cause the Assembler to overwrite memory that is used by the Bytecode Interpreter. If global variables are needed, they should be declared in CompactC and Basic, and then can be accessed like described in the chapter Data Access.

- **Do not** set the address of an Assembler routine with .org. The IDE generates itself a .org directive when starting the AVRA Assembler.

4.5 ASCII Table

ASCII Table				
CHAR	**DEC**	**HEX**	**BIN**	**Description**
NUL	000	000	00000000	Null Character
SOH	001	001	00000001	Start of Header
STX	002	002	00000010	Start of Text
ETX	003	003	00000011	End of Text
EOT	004	004	00000100	End of Transmission
ENQ	005	005	00000101	Enquiry
ACK	006	006	00000110	Acknowledgment
BEL	007	007	00000111	Bell
BS	008	008	00001000	Backspace
HAT	009	009	00001001	Horizontal TAB
LF	010	00A	00001010	Line Feed
VT	011	00B	00001011	Vertical TAB
FF	012	00C	00001100	Form Feed
CR	013	00D	00001101	Carriage Return
SO	014	00E	00001110	Shift Out
SI	015	00F	00001111	Shift In
DLE	016	010	00010000	Data Link Escape
DC1	017	011	00010001	Device Control 1
DC2	018	012	00010010	Device Control 2
DC3	019	013	00010011	Device Control 3
DC4	020	014	00010100	Device Control 4
NAK	021	015	00010101	Negative Acknowledgment
SYN	022	016	00010110	Synchronous Idle
ETB	023	017	00010111	End of Transmission Block
CAN	024	018	00011000	Cancel
EM	025	019	00011001	End of Medium

SUB	026	01A	00011010	Substitute
ESC	027	01B	00011011	Escape
FS	028	01C	00011100	File Separator
GS	029	01D	00011101	Group Separator
RS	030	01E	00011110	Request to Send, Record Separator
US	031	01F	00011111	Unit Separator
SP	032	020	00100000	Space
!	033	021	00100001	Exclamation Mark
“	034	022	00100010	Double Quote
#	035	023	00100011	Number Sign
$	036	024	00100100	Dollar Sign
%	037	025	00100101	Percent
&	038	026	00100110	Ampersand
‘	039	027	00100111	Single Quote
(	040	028	00101000	Left Opening Parenthesis
)	041	029	00101001	Right Closing Parenthesis
*****	042	02A	00101010	Asterisk
+	043	02B	00101011	Plus
,	044	02C	00101100	Comma
-	045	02D	00101101	Minus or Dash
.	046	02E	00101110	Dot

CHAR	DEC	HEX	BIN	Description
/	047	02F	00101111	Forward Slash
0	048	030	00110000	
1	049	031	00110001	
2	050	032	00110010	
3	051	033	00110011	
4	052	034	00110100	
5	053	035	00110101	

6	054	036	00110110	
7	055	037	00110111	
8	056	038	00111000	
9	057	039	00111001	
:	058	03A	00111010	Colon
;	059	03B	00111011	Semi-Colon
<	060	03C	00111100	Less Than
=	061	03D	00111101	Equal
>	062	03E	00111110	Greater Than
?	063	03F	00111111	Question Mark
@	064	040	01000000	AT Symbol
A	065	041	01000001	
B	066	042	01000010	
C	067	043	01000011	
D	068	044	01000100	
E	069	045	01000101	
F	070	046	01000110	
G	071	047	01000111	
H	072	048	01001000	
I	073	049	01001001	
J	074	04A	01001010	
K	075	04B	01001011	
L	076	04C	01001100	
M	077	04D	01001101	
N	078	04E	01001110	
O	079	04F	01001111	
P	080	050	01010000	
Q	081	051	01010001	
R	082	052	01010010	
S	083	053	01010011	
T	084	054	01010100	

U	085	055	01010101	
V	086	056	01010110	
W	087	057	01010111	
X	088	058	01011000	
Y	089	059	01011001	
Z	090	05A	01011010	
[	091	05B	01011011	Left Opening Bracket
\	092	05C	01011100	Back Slash
]	093	05D	01011101	Right Closing Bracket
^	094	05E	01011110	Caret

CHAR	**DEC**	**HEX**	**BIN**	**Description**
_	095	05F	01011111	Underscore
`	096	060	01100000	
a	097	061	01100001	
b	098	062	01100010	
c	099	063	01100011	
d	100	064	01100100	
e	101	065	01100101	
f	102	066	01100110	
g	103	067	01100111	
h	104	068	01101000	
i	105	069	01101001	
j	106	06A	01101010	
k	107	06B	01101011	
l	108	06C	01101100	
m	109	06D	01101101	
n	110	06E	01101110	
o	111	06F	01101111	
p	112	070	01110000	

q	113	071	01110001	
r	114	072	01110010	
s	115	073	01110011	
t	116	074	01110100	
u	117	075	01110101	
v	118	076	01110110	
w	119	077	01110111	
x	120	078	01111000	
y	121	079	01111001	
z	122	07A	01111010	
{	123	07B	01111011	Left Opening Brace
|	124	07C	01111100	Vertical Bar
}	125	07D	01111101	Right Closing Brace
~	126	07E	01111110	Tilde
DEL	127	07F	01111111	Delete

Part 5

5 Libraries

In this part of the documentation all attached Help functions are described which allow the user to comfortably gain access to the hardware. At the beginning of each function the syntax for CompactC and BASIC is shown. After that the description of functions and involved parameters will follow.

5.1 Internal Functions

To allow the Compiler to recognize the internal functions present in the Interpreter these functions must be defined in library "IntFunc_Lib.cc". If this library is not tied in no outputs can be performed by the program. The following would e. g. be a typical entry in "IntFunc_Lib.cc":

```
void Msg_WriteHex$Opc(0x23)(Word val);
```

This definition states that the function ("Msg_WriteHex") in the Interpreter is called up by a jump vector of 0x23 and a word has to be transferred to the stack as a parameter.

➨ Changes in the library "IntFunc_Lib.cc" may cause that the functions declared there can no longer be executed correctly.

5.2 General

In this chapter all single functions are collected that cannot be categorized to other chapters in the library.

5.2.1 AbsDelay

General Functions

Syntax

```
void AbsDelay(word ms);

Sub AbsDelay(ms As Word);
```

Description

The function Absdelay() waits for a specified number of milliseconds.

➨ This function works in a very accurate manner, but suspends the bytecode interpreter. A thread change will not happen during this time. Interrupts are recognized, but will not be processed since the interpreter is necessary for this operations.

➨ Please use Thread_Delay instead of AbsDelay if you work with threads. If you call an AbsDelay(1000) in an endless loop nevertheless, the following will happen: Since the thread is changing after 5000 cycles (default value) to the next thread, the next thread will begin after after about 5000 * 1000ms. This happens because an AbsDelay() call will be treated like on cycle.

Parameter

`ms   wait duration in milliseconds`

5.2.2 ForceBootloader (AVR32Bit)

General Functions

Syntax

```
void ForceBootloader(void);

Sub ForceBootloader();
```

Description

Jumps into the bootloader. After that, the unit is again available for commands, eg to update the software.

Parameter

None

5.2.3 Sleep (Mega)

General Functions

Syntax

```
void Sleep(byte ctrl);

Sub Sleep(ctrl As Byte)
```

Description

Using this function the Atmel CPU is set in one of the 6 different sleep modes. The exact functionality is provided in the Atmel Mega Reference Manual in the chapter "Power Management and Sleep Modes". The value of ctrl is written into the bits *SM0* and *SM2*. The sleep enable bit (SE in **MCUCR**) is set and an assembler *sleep* instruction is executed.

Parameter

ctrl   Initialization (*SM0* to *SM2*)

Sleep Modes

SM2	SM1	SM0	Sleep Mode
0	0	0	Idle

0	0	1	ADC Noise Reduction
0	1	0	Power-down
0	1	1	Power-save
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Standby
1	1	1	Extended Standby

5.3 Analog-Comparator

5.3.1 Mega

The Analog Comparator allows to compare two analog signals. The result of this comparison is returned as either "0" or "1". Voltages of between 0 and 5V can be compared at the positive and negative inputs.

5.3.1.1 AComp

AComp Functions Example

Syntax

```
void AComp(byte mode);

Sub AComp(mode As Byte);
```

Description

The Analog Comparator allows to compare two analog signals. The result of this comparison is returned as either "0" or "1". (Comparator Output). The negative input is **Mega32**: AIN1 (PortB.3), **Mega128**: AIN1 (PortE.3). The positive input can either be **Mega32**: AIN0 (PortB.2), **Mega128**: AIN0 (PortE.2) , or an internal reference voltage of 1,22V.

Parameter

mode working mode

Mode Values:

00 (Hex)	external inputs (+)AIN0 and (-)AIN1 are used
40 (Hex)	external Input (-)AIN1and internal reference voltage are used
80 (Hex)	Analog-Comparator gets disabled

5.3.1.2 AComp Example

Example: Usage of Analog-Comparators

```
// AComp: Analog Comparator
// Mega32:  Input (+) PB2 (PortB.2) bzw. band gap reference 1,22V
//          Input (-) PB3 (PortB.3)
// Mega128: Input (+) PE2 (PortE.2) bzw. band gap reference 1,22V
//          Input (-) PE3 (PortE.3)
// used Library: IntFunc_Lib.cc

// The function AComp returns the value of the comparator.
// If the voltage on input PB2/PE2 is greater than the input PB3/PE3 the
// function AComp returns the value 1.
// Mode:
// 0x00  external inputs (+)AIN0 and (-)AIN1 are used
// 0x40  external input (-)AIN1 and the internal reference voltage are used
// 0x80  the Analog-Comparator is disabled
// In this example you can call AComp with parameter 0 (both inputs are used)
// or with 0x40 (int. reference voltage on (+) input, external Input PB3/PE3)


//--------------------------------------------------------------------------------
// main program
//
void main(void)
{
    while (true)
    {
        if (AComp(0x40)==1)         // Input (+) band gap reference 1,22V
        {
            Msg_WriteChar('1');     // Output: 1
        }
        else
        {
            Msg_WriteChar('0');     // Output: 0
        }
        // the comparator value is read all 500ms
        AbsDelay(500);
    }
}
```

5.3.2 AVR32Bit

The Analog Comparator allows to compare two analog signals. The result of this comparison is returned as either "0" or "1". Voltages of between 0 and 3.3V can be compared at the positive and negative inputs.

5.3.2.1 AC_Disable

Analog Compare Functions Example

Syntax

```
void AC_Disable(byte ctrl);

Sub AC_Disable(ctrl As Byte);
```

Description

Turns the specified Analog Comparator off.

Parameter

ctrl	Analog Comparator (0 - 1)

5.3.2.2 AC_Enable

Analog Compare Functions Example

Syntax

```
void AC_Enable(byte ctrl, byte in_pos, byte in_neg);

Sub AC_Enable(ctrl As Byte, in_pos As Byte, in_neg As Byte);
```

Description

Turns the Analog Comparator on. The Atmel AVR32 has 2 Analog Comparators. The table shows which port inputs can be used for which comparator (Ctrl 0, Ctrl 1), and for what input parameter (in_pos or in_neg). Only inputs on the same comparator can be compared, but both comparators can work on the same time. A hysteresis of 0 is used.

➔ Due to the used TQFP100 version of the processor, Analog Comparator 0 has fewer choices for the selection of the input pins than Comparator 1.

Parameter

ctrl	Analog Comparator (0 - 1)
in_pos	Input V_ip
in_neg	Input V_in

Table Analog Comparator Pin Selection

#define	Port	Value	Ctrl 0	Ctrl 1
AC_AC0AP0	P18	0	in_pos	-

AC_AC0AN0	P20	1	in_neg	-
AC_AC0BP0	P21	2	in_neg	-
AC_AC1AP0	P25	0	-	in_pos
AC_AC1AP1	P11	1	-	in_pos
AC_AC1AN0	P24	2	-	in_neg
AC_AC1AN1	P12	3	-	in_neg
AC_AC1BP0	P26	4	-	in_neg
AC_AC1BP1	P13	5	-	in_neg

5.3.2.3 AC_InpHigher

Analog Compare Functions Example

Syntax

```
byte AC_InpHigher(byte ctrl);

Sub AC_Disable(ctrl As Byte) As Byte;
```

Description

Returns whether the voltage of in_pos is greater than the voltage of in_neg.

Parameter

ctrl Analog Comparator (0 - 1)

Return Parameter

Not zero, if in_pos is greater than in_neg.

5.3.2.4 AC Example

```
// AVR32Bit Analog Comparator Example
void main(void)
{
    AC_Enable(0, AC_AC0AP0, AC_AC0AN0);

    while(1)
    {
        if(AC_InpHigher(0)) Msg_WriteText("AC_AC0AP0 > AC_AC0AN0\r");
        else Msg_WriteText("AC_AC0AP0 < AC_AC0AN0\r");

        AbsDelay(500); // 500ms delay
    }
}
```

5.4 Analog-Digital-Converter

5.4.1 Mega

The Micro Controller has an Analog Digital Converter with a resolution of 10 Bit. I. e. measured voltages can be displayed as integral numbers from 0 through 1023. Reference voltage for the lower limit is GND level (0V). The reference voltage for the upper limit can be selected at will.

- External Reference Voltage
- AVCC with capacitor on AREF
- Internal Reference Voltage 2.56V with capacitor on AREF

Analog Inputs ADC0 ... ADC7, ADC_BG, ADC_GND

For the ADC the Inputs ADC0 ... ADC7 (Port A.0 to A.7 with **Mega32**, Port F.0 to F.7 with **Mega128)**, an internal Band Gap (1.22V) or GND (0V) are available. ADC_BG and ADC_GND can be used for review of the ADC.

If x is a digital measuring value then the corresponding voltage value u is calculated as follows:

*u = x * Reference Voltage / 1024*

If the external reference voltage e. g. produced by a reference voltage IC is 4.096V, then the difference of one bit of the digitized measuring value corresponds to a voltage difference of 4mV, or:

*u = x * 0,004V*

➡ The result of an A/D conversion can be influenced, if any Port Bit (configured for output) on the same Port as the A/D channel, is changed during the measurement.

Differential Inputs

ADC22x10	Differential Inputs ADC2, ADC2, Gain 10	; Offset Measurement
ADC23x10	Differential Inputs ADC2, ADC3, Gain 10	
ADC22x200	Differential Inputs ADC2, ADC2, Gain 200	; Offset Measurement
ADC23x200	Differential Inputs ADC2, ADC3, Gain 200	
ADC20x1	Differential Inputs ADC2, ADC0, Gain 1	
ADC21x1	Differential Inputs ADC2, ADC1, Gain 1	
ADC22x1	Differential Inputs ADC2, ADC2, Gain 1	; Offset Measurement
ADC23x1	Differential Inputs ADC2, ADC3, Gain 1	
ADC24x1	Differential Inputs ADC2, ADC4, Gain 1	
ADC25x1	Differential Inputs ADC2, ADC5, Gain 1	

ADC2 is the negative input.

The ADC can also perform differential measurements. The result can either be positive or negative. The resolution during differential operation amounts to +/- 9 bit and is displayed in Two's Complement format. For differential operation an amplifier with gains of V: x1, x10, x200 is available. If x is a digital measuring value then the corresponding voltage value u is calculated as follows:

*u = x * Reference Voltage / 512 / V*

5.4.1.1 ADC_Disable

ADC Functions

Syntax

```
void ADC_Disable(void);

Sub ADC_Disable()
```

Description

This function disables to the A/D-Converter to reduce power consumption.

Parameter

None

5.4.1.2 ADC_Read

ADC Functions

Syntax

```
word ADC_Read(void);

Sub ADC_Read() As Word
```

Description

The function ADC_Read delivers the digitized measured value from one of the 8 ADC ports. The port number (0..7) has been given as a parameter in the call of ADC_Set(). The result is in the range from 0 to 1023 according to the 10bit resolution of the A/D-Converter. The analog inputs ADC0 to ADC7 can be measured against ground, or differentiation measurement with gain factor of 1/10/100 can be made.

Return Parameter

measured value at the ADC-Port

5.4.1.3 ADC_ReadInt

ADC Functions

Syntax

```
word ADC_ReadInt(void);
```

```
Sub ADC_ReadInt() As Word
```

Description

This function is used to read the measurement value after a successful ADC-Interrupt. The ADC-Interrupt gets triggered after the AD conversion is completed and a new measurement value is available. See ADC_SetInt and ADC_StartInt. The function ADC_Read delivers the digitized measured value from one of the 8 ADC ports. The port number (0..7) has been given as a parameter in the call of ADC_Set(). The result is in the range from 0 to 1023 according to the 10bit resolution of the A/D-Converter. The analog inputs ADC0 to ADC7 can be measured against ground, or differentiation measurement with gain factor of 1/10/100 can be made.

Return Parameter

measured value of ADC-Port

5.4.1.4 ADC_Set

ADC Functions

Syntax

```
word ADC_Set(byte v_ref, byte channel);

Sub ADC_Set(v_ref As Byte, channel As Byte) As Word
```

Description

The function ADC_Set initializes the Analog-Digital converter. The reference voltage and the measurement channel number is selected and the A/D converter is prepared for usage. After the measurement the value is read with ADC_Read().

➡ The result of an A/D conversion can be influenced, if any Port Bit (configured for output) on the same Port as the A/D channel, is changed during the measurement.

Parameter

channel	port number (0..7)of ADC (Port A.0 to A.7 at Mega32, Port F.0 to F.7 at Mega128)
v_ref	reference voltage (see table)

Name	Value (Hex)	Description
ADC_VREF_BG	C0	2,56V internal reference voltage
ADC_VREF_VCC	40	supply voltage (5V)
ADC_VREF_EXT	00	external reference voltage on PAD3

For the location of PAD3 see Jumper Application Board M32 or M128.

5.4.1.5 ADC_SetInt

ADC Functions

Syntax

```
word ADC_SetInt(byte v_ref, byte channel);

Sub ADC_SetInt(v_ref As Byte, channel As Byte) As Word
```

Description

The function ADC_SetInt initializes the Analog-Digital converter for interrupt usage. The reference voltage and the measurement channel number is selected and the A/D converter is prepared for the measurement. An interrupt service routine must be defined. After successful interrupt the value can be read with ADC_ReadInt().

➔ The result of an A/D conversion can be influenced, if any Port Bit (configured for output) on the same Port as the A/D channel, is changed during the measurement.

Parameter

channel	port number (0..7)of ADC (Port A.0 to A.7 at Mega32, Port F.0 to F.7 at Mega128)
v_ref	reference voltage (see table)

Name	Value (Hex)	Description
ADC_VREF_BG	C0	2,56V internal reference voltage
ADC_VREF_VCC	40	supply voltage (5V)
ADC_VREF_EXT	00	external reference voltage on PAD3

For the location of PAD3 see Jumper Application Board M32 or M128.

5.4.1.6 ADC_StartInt

ADC Functions

Syntax

```
void ADC_StartInt(void);

Sub ADC_StartInt()
```

Description

The measurement is started if the A/D converter has previously been initialized to interrupt service with a call to ADC_SetInt(). After the measurement is ready, the interrupt gets triggered.

Parameter

None

5.4.2 AVR32Bit

The microcontroller has an Analog-to-Digital converter with a selectable resolution of 8/10/12 bits. This means that measured voltages can be represented as whole numbers from -2048 to 2048, since the AD-converter always works differential. In addition, an ADC preamplifier gain of 1, 2, 4, 8, 16, 32, 64 can be set by software.

The following reference voltage sources are available:

- 0,6 * VDDANA internal (0,6 * 3.3V = 1,98V)
- internal reference voltage of 1V
- two external reference voltage inputs, e.g. 2.048V generated by reference-voltage-IC

If "x" is a digital measurement value, calculate the corresponding voltage value "u" as follows:
The resolution depends on the configuration of the ADC.

Resolution	Maximal Value
8 Bit	-128 to +127
10 Bit	-512 to +511
12 Bit	-2048 to +2047

Formula for calculating the present ADC voltage:
u = x * reference voltage / resolution

5.4.2.1 ADC_Disable

ADC Functions

Syntax

```
void ADC_Disable(void);

Sub ADC_Disable()
```

Description

The function ADC_Disable turns off the A/D-Converter to reduce power consumption.

Parameter

None

5.4.2.2 ADC_Enable

ADC Functions

Syntax

```
void ADC_Enable(byte mode, dword speed, byte ref, byte input_cnt, char
offset);

Sub ADC_Enable(mode As Byte, speed As ULong, ref As Byte, input_cnt As
Byte, offset As Char)
```

Description

The ADC sequencer in the AVR32 can carry up to 8 A/D-conversions at the same time. An A/D-conversion can be a differential measurement between an ADC pin and GND, or a differential measurement between two pins. See ADC_SetInput.

For the mode parameter various properties can be ORed (this of course only makes sense with one ADC resolution). Oversampling and Sample & Hold can be turned off. If enabled, an interrupt is triggered when an ADC measurement is finished (see interrupt Table).

ADC_Start has to be called for each new measurement. The end of the measurement can be displayed via interrupt, or use ADC_GetValues with the parameter **ADC_GET_WAIT**. Is the Free Running mode selected, ADC_Start is called only once, after that the inputs are continuously measured, and ADC_GetValues always returns the value of the last measurement.

Please look into the datasheet AT32UC3C for the exact meaning of oversampling and sample & hold, and the impact on the measurements.

If ADC is set to very high speeds and the interrupt is enabled, this can overwhelm the interpreter.

Parameter

mode	work modes (see Table)
speed	ADC Clock (32khz - 1.5Mhz)
ref	reference Voltage (see Table)
input_cnt	number of ADC Pins (1-8)
offset	correction factor (-128 to 127)

Mode Table

Definition	Function
ADC_MODE_12BIT	ADC 12-Bit resolution
ADC_MODE_8BIT	ADC 8-Bit resolution
ADC_MODE_10BIT	ADC 10-Bit resolution
ADC_MODE_NO_OVERSAMP	turns Oversampling off
ADC_MODE_ENAB_IRQ	activates ADC IRQ
ADC_MODE_NO_SAMPHOLD	no Sample & Hold
ADC_MODE_FREE_RUN	activates Free Running

Reference Voltage Table

Definition	Function
ADC_REF1V	internal 1V Reference

ADC_REF06VDD	internal 0.6 x VDDANA Reference
ADC_ADCREF0	external ADCREF0 Reference
ADC_ADCREF1	external ADCREF1 Reference

5.4.2.3 ADC_GetValue

ADC Functions

Syntax

```
int ADC_GetValue(byte indx);

Sub ADC_GetValue(indx As Byte) As Integer
```

Description

The function reads a measured value from the A/D-converter. The indx parameter corresponds to the entry in the inputs array in ADC_Enable(). If the value **ADC_GET_WAIT** (80 Hex) is ORed to indx, then the function waits for the completion of all ADC measurements before the value is returned.

The **ADC_GET_WAIT** functionality should not be used in "free running" mode, or when the ADC is switched off.

Parameter

indx	index of measured A/D value

Return Parameter

measured A/D value

5.4.2.4 ADC_GetValues

ADC Functions

Syntax

```
void ADC_GetValues(int values[], byte cnt);

Sub ADC_GetValues(Byref values As Integer, cnt As Byte)
```

Description

The function read the measured values from the A/D-converter and copies them into a 16-bit array. If the value **ADC_GET_WAIT** (80 Hex) is ORed to cnt, then the function waits for the completion of all ADC measurements before the values are copied.

The **ADC_GET_WAIT** functionality should not be used in "free running" mode, or when the ADC is switched off.

Parameter

values	pointer to the 16-Bit array (0-7)
cnt	number of values that are copied into the array

5.4.2.5 ADC_SetInput

ADC Functions

Syntax

```
void ADC_SetInput(byte indx, byte inp1, byte inp2, byte gain);

Sub ADC_Enable(indx As Byte, inp1 As Byte, inp2 As Byte, gain As Byte)
```

Description

The ADC sequencer in the AVR32 can carry up to 8 AD conversion at a time. The function ADC_SetInput defines the ADC inputs between a differential measurement is carried out. If you want to measure only one input, one define ADC_GND as the second input. In addition, a GAIN factor can be defined.

Even if a measurement between an input and ADC_GND delivers only positive values? one bit of the ADC resolution still remains reserved for the sign.

Parameter

indx	index for conversion (0-7)
inp1	first AD input (0-15)
inp2	second AD input (0-15)
gain	GAIN factor

GAIN Table

Definition	Meaning
ADC_SHG_1	gain factor 1
ADC_SHG_2	gain factor 2
ADC_SHG_4	gain factor 4
ADC_SHG_8	gain factor 8
ADC_SHG_16	gain factor 16
ADC_SHG_32	gain factor 32
ADC_SHG_64	gain factor 64

5.4.2.6 ADC_Start

ADC Functions

Syntax

```
void ADC_Start(void);
```

```
Sub ADC_Start()
```

Description

The built-in A / D converter starts to convert analog data.

Parameter

None

5.4.2.7 ADC Example

```
// program to read the measured data from two ADC pins
void main(void)
{
    int result[2];
    char str[40];

    ADC_Disable();

    ADC_SetInput(0, 2, ADC_GND, ADC_SHG_1);  // activate ADC2 - Gain 1
    ADC_SetInput(1, 5, ADC_GND, ADC_SHG_4);  // activate ADC5 - Gain 4

    //12Bit ADC,free running,1MHz sampling rate,reference 1V,offset 0
    ADC_Enable(ADC_MODE_12BIT | ADC_MODE_FREE_RUN, 1000000, ADC_REF1V,
       2, 0);
    ADC_Start();

    while(1)
    {
        ADC_GetValues(result, 2); // read values

        Str_Printf(str, "adc2: %d\r", result[0]);
        Msg_WriteText(str);
        Str_Printf(str, "adc5: %d\r", result[1]);
        Msg_WriteText(str);
        AbsDelay(300);
    }
}
```

5.5 CAN Bus

The CAN bus (Controller Area Network Data Sheet) is an asynchronous serial bus system and belongs to the field buses. It is internationally standardized in ISO 11898 and defines the Layer 1 (physical layer) and 2 (data security layer).

The CAN-bus was developed in 1983 from Bosch. Originally, the CAN-Bus was developed for the automotive sector, because with increasing vehicle electronics the wiring harnesses got larger, and a solution for weight and cost reduction had to be found. This successful and very safe approach is not only used today in the automotive industry, but also in the areas of automation, aviation, aerospace and medical technology.

➡ The C-Control Manual cannot provide an introduction to the CAN standard, due to the complexity of the topic. Prior knowledge about the CAN standard and Full CAN message objects are assumed at this point. It is therefore recommended that beginner to embedded controllers will not work directly with the CAN bus. A good summary of CAN and Message Objects provides the "Atmel AT90CAN" Reference Manual Chapter 19, "Controller Area Network - CAN".

MEGA128CAN

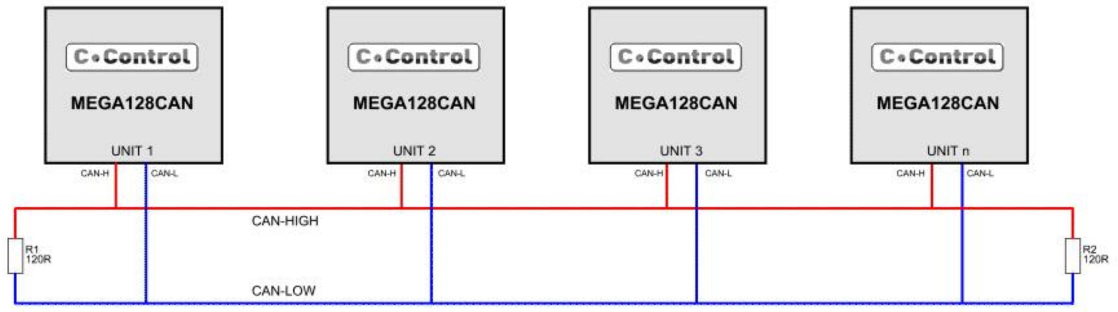
The CAN signals of the C-Control Pro MEGA128CAN are available on pins X4_13 (CANL) and X4_14 (CANH) .

AVR32Bit

In the C-Control Pro AVR32Bit there is a CAN controller that operates two channels. But only the first channel is connected to a transceiver, which is led out on the application board. On the Mainboard CAN1 is led out through a socket connector (without transceiver). The lines CANH and CANL are passed out on the module connector X1. To use the second channel, the user must connect a transceiver himself. As an example, the data sheet of the AVR32 module can be used. The second Controller is on Port 1 (CAN_TX, PA00) and Port 2 (CAN_RX, PA01).

Network

Multiple CAN-bus network participants can be connected over the two pins (CAN-H and CAN-L). The first and last stations have to be completed with a 120 Ohm resistor. As a data cable, a twisted pair cable should be used. For shorter distances of a few centimeters up to 2 meters, even a simple parallel cable (twin lead) can be used.



The UNIT supports the low- and high-speed bus (MEGA128CAN 10 kbit/s to 1 Mbit/s, AVR32Bit 50 kbit/s to 1 Mbit/s). For theoretical line lengths, depending on the bus speed, see the chart below.

Speed	Cable Length
1 Mbit/s	40m
Up to 500 kbit/s	100m
Up to 125 kbit/s	500m

Less than 125 kbit/s	Up to 1000m

The line lengths are highly dependent on the used cables and the number of participants. It is possible to use a "twist-pair cables with a characteristic impedance 108-132 Ohm. A maximum of 32 MEGA128CAN units can operate on a bus. It is best to start at the theoretical maximum speed for the used cable length, and to lower the transfer rate when there is no packet transfer at all or there occur too many packet errors.

The MEGA128CAN supports the "Base frame format" CAN 2.0A (11 bit identifier) and the extended frame format "CAN 2.0B (29 bit identifier).

To use the CAN bus in your own projects together with the C-Control Pro Mega128 CAN, it is essential to understand the CAN data format and the technical details of the CAN bus. Background information can be found in books and in Wikipedia: http://en.wikipedia.org/wiki/Controller_Area_Network

Message Objects

The active CAN bus controller works with 15 (MEGA128CAN) or 16 (AVR32Bit) independent message objects (MOb) with which one can send and receive messages with certain identifiers. For this purpose the message objects are parametrized with CAN_SetMOb() for the related task.

➡ Message Objects with a low MOb number have always precedence before a MOb with a higher number. When two MOb's are capable to receive a certain message, the message will be received from the MOb with the lower number.

CAN Protocol

The CAN bus controller can simultaneously process normal packets (CAN 2.0A) and extended packets (CAN 2.0B). CAN bus identifier are passed as 32-bit dword (ULong). Depending on the type of packets an identifier is 11-bit (V2.0 part A) or 29-bit long (V2.0 part B). The unused bits are ignored. The maskID determines which packages are received for a specific identifier (ID). Only the bits in the maskID that are "1" are to be reviewed at a bit comparison between the set identifier and the ID of the incoming packet.

automatic reply

If a Message Object is set to automatic reply, the MOb inherits the Data Length Code (DLC) of the incoming remote trigger package. I.e. the sender of the trigger packet determines with the DLC the number of data bytes that are sent in the reply packet.

Message FIFO

During the initialization of the CAN library the user provides RAM for the message FIFO, in which all incoming CAN packets are stored. The received messages can then be read asynchronously from the FIFO.

5.5.1 CAN Examples

In this chapter some initialization examples are given to clarify the operation of the CAN Library.

Initialization

In any event, the CAN library must be initialized before use. This example is for the CAN bus at a speed of 1 mega bps, and for a FIFO RAM with 10 entries.

```
byte fifo_buf[140];

CAN_Init(CAN_1MBPS, 10, fifo_buf);
```

Reception

1. On MOb 2 messages of type CAN 2.0A are received, that have exactly an identifier of 0x123.

```
CAN_SetMOb(2, 0x123, 0x7ff, CAN_RECV);
```

2. On MOb 3 messages of type CAN 2.0B are received, that have exactly an identifier of 0x12345.

```
CAN_SetMOb(3, 0x12345, 0x1fffffff, CAN_RECV|CAN_EXTID);
```

3. On MOb 3 messages of type CAN2.0A and CAN 2.0B are received, because the CAN_IGN_EXTID flag is set. Because the maskID is null messages with all identifiers are received. Since CAN_IGN_RTR is set, normal and trigger packets are accepted.

```
CAN_SetMOb(3, 0x12345, 0, CAN_RECV|CAN_IGN_EXTID|CAN_IGN_RTR);
```

4. On MOb 2 messages of type CAN 2.0A are received, that have an identifier of 0x120, 0x121, 0x122 or 0x123.

```
CAN_SetMOb(2, 0x120, 0x7fc, CAN_RECV);
```

Send

1. On MOb 0 is sent a CAN 2.0A message with ID 0x432 and 6 data byte.

```
byte data[8], i;

for(i=0;i<8;i++) data[i]=i;
CAN_SetMOb(0, 0x432, 0, CAN_SEND);
CAN_MObSend(0, 6, data);
```

2. On MOb 1 a CAN 2.0B message will be sent with ID 0x12345678 and 8 data.

```
byte data[8], i;

for(i=0;i<8;i++) data[i]=i;
CAN_SetMOb(1, 0x12345678, 0, CAN_SEND|CAN_EXTID);
CAN_MObSend(1, 8, data);
```

Automatic Reply

MOb 4 is set to automatic reply. The data bytes provided with CAN_SetMOb () are sent when a CAN 2.0B trigger message is received with ID of 0x999. The number of transmitted data bytes depends on the DLC incoming trigger message.

```
byte data[5], i;

for(i=0;i<5;i++) data[i]=i;
CAN_SetMOb(4, 0x999, 0x1fffffff, CAN_REPL|CAN_EXTID);
CAN_MObSend(4, 5, data);
```

5.5.2 CAN_Exit

CAN Bus Functions

Syntax

```
void CAN_Exit(void);

Sub CAN_Exit()
```

Description

The CAN chip functions are turned off.

Parameter

None

5.5.3 CAN_GetInfo

CAN Bus Functions

Syntax

```
byte CAN_GetInfo(byte infotype);

Sub CAN_GetInfo(infotype As Byte) As Byte
```

Description

Returns information about the number of received CAN messages and CAN transmission errors.

Parameter

infotype	selected CAN Bus information

Return Parameter

CAN Library information

infotype parameter:

Value	Definition	Meaning
1	CAN_MSGS	Number of already received CAN messages in the FIFO
2	CAN_ERR_RECV	Number of CAN receive errors (max. 255)
3	CAN_ERR_TRAN	Number of CAN send errors (max. 255)

5.5.4 CAN_Init

CAN Bus Functions

Syntax

```
void CAN_Init(byte speed, byte fifo_len, byte fifo_addr[]);

Sub CAN_Init(speed As Byte, fifo_len As Byte, ByRef fifo_addr As Byte);
```

Description

Initializes the CAN functions. During initialization the user provides a RAM buffer for the reception of CAN messages. Inside this buffer a total of fifo_len messages can be stored. The RAM area must have the size fifo_len * 14 bytes. If the FIFO is full, incoming CAN messages are not stored.

The user-provided RAM buffer must remain reserved during the use of the CAN interface. Since local variables will be released after leaving the function, it usually makes sense to declare the buffer as a global variable.

Parameter

speed	CAN Bus transmission speed
fifo_len	Number of entries in the receive FIFO
fifo_addr	RAM address of the reception buffer

speed parameter:

Value	Definition	CAN Baudrate

0	CAN_10KBPS	10.000bps
1	CAN_20KBPS	20.000bps
2	CAN_40KBPS	40.000bps
3	CAN_100KBPS	100.000bps
4	CAN_125KBPS	125.000bps
5	CAN_200KBPS	200.000bps
6	CAN_250KBPS	250.000bps
7	CAN_500KBPS	500.000bps
8	CAN_800KBPS	800.000bps
9	CAN_1MBPS	1.000.000bps

5.5.5 CAN_Receive

CAN Bus Functions

Syntax

```
byte CAN_Receive(byte data[]);

Sub CAN_Receive(ByRef data As Byte) As Byte
```

Description

If messages are in the receive FIFO, the 14-byte data is copied in the user array, which must have a length of 14 bytes. Is bit 31 of the IDT is set in the received message, then RTR was set in the CAN packet.

Parameter

data Array in which the CAN message is copied

Return Parameter

Length of CAN packet (0-8 Byte) or ff (Hex) if no packet was in buffer

Structure of the data set

Byte 0:	MOb Number (0-14)
Byte 1-4:	29-Bit IDT (at V2.0 part A Msgs the upper bits are null)
Byte 5:	Length of CAN Data (0-8)
Byte 6-13:	Packetdata

5.5.6 CAN_MObSend

CAN Bus Functions

Syntax

```
void CAN_MObSend(byte mob, byte len, byte data[]);

Sub CAN_MObSend(mob As Byte, len As Byte, ByRef data As Byte);
```

Description

A CAN message is sent over the bus. If, however, the CAN_REPL flag was set at CAN_SetMOb (), the data for the automatic reply will be saved and not sent immediately.

Parameter

mob	MOb Number (0-14)
len	Length of the data to send
data	Array in der

5.5.7 CAN_SetChan (AVR32Bit)

CAN Bus Functions

Syntax

```
void CAN_SetChan(byte chan);

Sub CAN_SetChan(chan As Byte)
```

Description

Selects a CAN channel (CAN0 or CAN1) for further access.

➜ The C-Control Pro Mega128 CAN only has one CAN channel.

Parameter

chan	CAN Bus channel (0 - 1)

5.5.8 CAN_SetMOb

CAN Bus Functions

Syntax

```
void CAN_SetMOb(byte mob, dword ID, dword maskID, byte flag);

Sub CAN_SetMOb(mob As Byte, ID As ULong, maskID As ULong, flag As Byte);
```

Description

With this function, the parameters for a Message Object (MOB) are set. The identifier and the identifier mask is passed as a dword (ULong). WHen used with a 11-bit identifier, the upper bits are ignored. The maskID is used only during reception. Only when a bit is set in the maskID, the received messages are checked at the same bit position in the identifier whether the received identifier matches.

Parameter

mob	MOb Number(0-14)
ID	Identifier
maskID	Identifier Mask
flag	Operation parameter for the Message Object (MOb)

flag Parameter:

Value (Hex)	Definition	Description
01	CAN_RECV	Messages are received on this MOb
02	CAN_RTR	The Remote Trigger Bit is set
04	CAN_EXTID	The CAN Message has a 29-Bit ID (V2.0 part B)
08	CAN_REPL	Automatic Reply is initialized
10	CAN_IGN_RTR	RTR is **not** set in ID Mask
20	CAN_IGN_EXTID	IDEMSK is **not** set in ID Mask
40	CAN_SEND	Messages are sent on this MOb

5.6 Clock

Mega

The internal software clock is clocked by the 10ms interrupt of Timer2. Time and date can be set and then continue to run independently. Leap years are taken into account. Depending on the Quartz inaccuracy the error is between 4-6 seconds per day. A correction factor in 10ms ticks can be applied, that is added every hour to the internal counter.

Example: If you have a deviation of 9.5 sec for 2 days, then you have to correct a deviation of 9.5 / (2 * 24) = 0.197 sec. This corresponds to a correction factor of 20, if the software clock goes in advance, or -20 else.

When Timer 2 off, or used for other purposes, the internal software clock is not functional.

AVR32Bit

Inside the AVR32Bit Unit the builtin AVR32 Real Time Clock module is used for the clock functions. In addition, the external 32khz crystal offers here a far more accuracy than the clock oscillator of the C-Control Pro Mega Units. Therefore, the correction factor remains unused in the C-Control Pro AVR32Bit.

5.6.1 Clock_GetVal

Clock Functions

Syntax

```
byte Clock_GetVal(byte indx);

Sub Clock_GetVal(indx As Byte) As Byte
```

Description

All Date and Time values of the internal software clock can be read.

➔ The values of day and month are zero based, a one should be added when printing.

Parameter

indx	index of date or time parameter

#define	Index	Meaning
CLOCK_SEC	0	Second
CLOCK_MIN	1	Minute
CLOCK_HOUR	2	Hour
CLOCK_DAY	3	Day
CLOCK_MON	4	Month
CLOCK_YEAR	5	Year

Return Parameter

requested time parameter

5.6.2 Clock_SetDate

Clock Functions

Syntax

```
void Clock_SetDate(byte day, byte mon, byte year);

Sub Clock_SetDate(day As Byte, mon As Byte, year As Byte)
```

Description

Sets the date of the internal software clock.

➔ The values of day and month are zero based.

Parameter

day	Day
mon	Month
year	Year

5.6.3 Clock_SetTime

Clock Functions

Syntax

```
void Clock_SetTime(byte hour, byte min, byte sec, char corr);

Sub Clock_SetTime(hour As Byte, min As Byte, sec As Byte, corr As Char)
```

Description

Sets the time of the internal software clock. For a description of the correction factor refer to chapter Clock.

➔ The correction factor is unused in the AVR32Bit, you can specify any value there.

Parameter

hour	Hour
min	Minute
sec	Second
corr	Correction Factor

5.7 DCF 77

All DCF routines are realized in library "LCD_Lib.cc". For use of this function the library "DCF_Lib.cc" has to be tied into the project.

RTC with DCF 77 Time Synchronization

The DCF 77 Time Signal

The logical informations (time informations) are transmitted in addition to the normal frequency (carrier frequency of the transmitter, i. e. 77.5 kHz). This is performed by negative modulation of the signal (decrease of carrier amplitude to 25%). The start of the decrease lies at the respective beginning of the seconds 0 … 58 within a minute. In second 59 there is no decrease, so the following second mark can indicate the beginning of a minute and the receiver can be synchronized. The sign duration yields the logical value of the signs: 100 ms are "0", 200 ms are "1". Because of this there are 59 bits for informations available within one minute. From these the second marks 1 through 14 are used for operation informations which are not meant for DCF77 users. The second marks 15 through 19 indicate the transmitter antenna, the time zone and will give notice of coming time changes.

From second 20 through 58 the time information for the respective following minute will be transmitted serially in from of BCD numbers, whereby in any case the least significant bit will be the start bit.

Bits	Meaning
20	Start bit (in any case "1")
21 - 27	Minute

28	Parity Minute
29 - 34	Hour
35	Parity Hour
36 - 41	Day of the Month
42 - 44	Weekday
45 - 49	Month
50 - 57	Year
58	Parity Date

This signifies that reception must be in progress for at least one full minute before time information can be provided. The information decoded during this minute is only secured by three parity bits. So two incorrectly received bits will already lead to a transmission error that can not be recognized in this way. For higher demands additional checking mechanisms can be used, such as plausibility check (is the received time within the admissible limits) or multiple reading of the DCF77 time information with data comparison. Another possibility would be to compare the DCF time with the current RTC time and only allow a specific deviation. This method does not work right after program start since the RTC has to be set first.

Description of the example program "DCF_RTC.cc"

The program DCF_RTC.cc represents a clock which is synchronized by use of DCF 77. Time and date are displayed on an LCD. Synchronization takes place after program start and then daily at a time determined in the program (Update_Hour, Update_Minute). There are two libraries used: DCF_Lib.cc and LCD_Lib.cc.
For the radio reception of the time signal a DCF77 receiver is necessary. The output of the DCF receiver is connected to the input port (**Mega32**: PortD.7 - **M128**: PortF.0 **AVR32Bit**: P27(PA15)). At first the beginning of a time information has to be found. It will be synchronized onto the pulse gap (bit 59). Following the bit will be received in seconds time. There will be a parity check after the minute and hour information and also at the end of the transmission. The result of the parity check will be stored in DCF_ARRAY[6]. For transfer of the time information DCF_ARRAY[0..6] will be used. After reception of a valid time information the RTC will be set with this new time and will then run independently. RTC as well as DCF77 decoding is controlled by a 10ms interrupt. This time base is derived from the quartz frequency of the Controller. DCF_Mode will control the completion of the DCF77 time reception.

Changing the input pin

The used input port is defined as DCF_IN in the library "DCF_Lib.cc".

Table DCF Modes

DCF_Mode	Description
0	No DCF 77 operation
1	Find pulse
2	Synchronization on frame start
3	Decode and store data. Parity check

RTC (Real Time Clock)

The RTC is controlled by a 10ms interrupt and runs in the background independent of the user program. The display on the LCD is updated every second. The display format is in the first line: Hour : Minute : Second, in the second line: Date of Day : Month : Year.

LED1 flashes once per second.
After program start the RTC begins with the set time. The date is set to zero and thus indicates that no DCF time adjustment has yet taken place. After reception of the DCF time the RTC is updated with the current data. The RTC is not backed up by a battery, i. e. the clock time will not be updated if there is no power applied to the Controller.

5.7.1 DCF_FRAME

DCF Functions

Syntax

```
void DCF_FRAME(void);

Sub DCF_FRAME()
```

Description

Set DCF_Mode to 3 ("data decode and save, parity check").

Parameter

None

5.7.2 DCF_INIT

DCF Functions

Syntax

```
void DCF_INIT(void);

Sub DCF_INIT()
```

Description

DCF_INIT initializes DCF usage. The input of the DCF signal is adjusted. DCF_Mode is set to 0.

Parameter

None

5.7.3 DCF_PULS

DCF Functions

Syntax

```
void DCF_PULS(void);

Sub DCF_PULS()
```

Description

Set DCF_Mode to 1 ("look for pulse").

Parameter

None

5.7.4 DCF_START

DCF Functions

Syntax

```
void DCF_START(void);

Sub DCF_START()
```

Description

DCF_START initializes all variables and sets DCF_Mode to 1. From now on DCF time recording is working automatically.

Parameter

None

5.7.5 DCF_SYNC

DCF Functions

Syntax

```
void DCF_SYNC(void);

Sub DCF_SYNC()
```

Description

Set DCF_Mode to 2 ("synchronize for frame beginning").

Parameter

None

5.8 Debug

The Debug Message Functions allow to send formatted text to the output window of the IDE. These functions are interrupt driven with a buffer of up to 128 Byte. I. e. 128 Byte can be transferred through the debug interface without the Mega 32 or Mega 128 Module having to wait for completion of the output. The transmission of the individual characters takes place in the background. If it is tried to send more than 128 Byte then the Mega RISC CPU will have to wait until all characters not fitting into the buffer anymore have been transferred.

5.8.1 Msg_WriteChar

Debug Message Functions

Syntax

```
void Msg_WriteChar(char c);

Sub Msg_WriteChar(c As Char);
```

Description

One character is written to the output window. A C/R (Carriage Return - Value:13) generates a jump to the next line (linefeed).

Parameter

c output character

5.8.2 Msg_WriteFloat

Debug Message Functions

Syntax

```
void Msg_WriteFloat(float val);
```

```
Sub Msg_WriteFloat(val As Single)
```

Description

The passed floating point number is displayed with a preceding decimal sign.

Parameter

val	float value

5.8.3 Msg_WriteHex

Debug Message Functions

Syntax

```
void Msg_WriteHex(word val);

Sub Msg_WriteHex(val As Word)
```

Description

The 16bit value is displayed in the output window. The Output is formatted as a hexadecimal value with 4 digits. Leading zeros are displayed.

Parameter

val	16bit integer value

5.8.4 Msg_WriteInt

Debug Message Functions

Syntax

```
void Msg_WriteInt(int val);

Sub Msg_WriteInt(val As Integer)
```

Description

The passed 16bit value is display in the output window. Negative values are displayed with a preceding minus sign.

Parameter

val 16bit integer value

5.8.5 Msg_WriteText

Debug Message Functions

Syntax

```
void Msg_WriteText(char text[]);

Sub Msg_WriteText(ByRef text As Char)
```

Description

All characters of a character array up to the terminating null are sent to the output window.

Parameter

text pointer to char array

5.8.6 Msg_WriteWord

Debug Message Functions

Syntax

```
void Msg_WriteWord(word val);

Sub Msg_WriteWord(val As Word)
```

Description

The parameter val is written to the output windows as an unsigned decimal number.

Parameter

val 16bit unsigned integer value

5.9 Direct Access (Mega)

The Direct Access functions allow direct access to all registers of the Atmel processor. The Register numbers of the Atmel MEGA32 and Mega128 processors can be found in the Reference manual in the chapter "**Register Summary**".

➡ **Caution!** A careless reading or writing access to a register can strongly affect the functionality of all library functions. Only someone who knows what he does, should use the Direct Access functions!

5.9.1 DirAcc_Read

Direct Access Functions

Syntax

```
byte DirAcc_Read(byte register);

Sub DirAcc_Read(register As Byte) As Byte
```

Description

A Byte is read from a Register of the Atmel CPU.

Parameter

register	Register number (refer to chapter "**Register Summary**" in the Atmel Reference Manual)

Return Parameter

Value of Register

5.9.2 DirAcc_Write

Direct Access Functions

Syntax

```
void DirAcc_Write(byte register, byte val);

Sub DirAcc_Write(register As Byte, val As Byte)
```

Description

A Byte value is written into a Register of the Atmel CPU.

Parameter

register	Register number (refer to chapter "**Register Summary**" in the Atmel Reference Manual)
val	Byte value

5.10 EEPROM

The C-Control Pro Modules integrate **AVR32Bit**:64kB **M32**:1kB resp. **M128**:4kB EEPROM. These library functions allow access to the EEPROM of the Interpreter.

5.10.1 EEPROM_Read

EEPROM Functions

Syntax

```
byte EEPROM_Read(word pos);
```

```
Sub EEPROM_Read(pos As Word) As Byte
```

Description

Reads one byte out of the EEPROM at position pos.

➡ On the C-Control Pro Mega Units the first 32 byte are reserved for the system of the C-Control Pro. Therefore a pos value of 0 and higher accesses the EEPROM memory at position 32 and upwards.

Parameter

pos	byte position in EEPROM

Return Parameter

EEPROM value

5.10.2 EEPROM_ReadWord

EEPROM Functions

Syntax

```
word EEPROM_ReadWord(word pos);
```

```
Sub EEPROM_ReadWord(pos As Word) As Word
```

Description

Reads one word out of the EEPROM at position pos. The value of pos describes a byte position in the EEPROM. This should be taken care of when using word or floating point accesses.

➡ On the C-Control Pro Mega Units the first 32 byte are reserved for the system of the C-Control Pro. Therefore a pos value of 0 and higher accesses the EEPROM memory at position 32 and upwards.
Parameter

pos	byte position in EEPROM

Return Parameter

EEPROM value

5.10.3 EEPROM_ReadFloat

EEPROM Functions

Syntax

```
float EEPROM_ReadFloat(word pos);

Sub EEPROM_ReadFloat(pos As Word) As Single
```

Description

Reads a floating point value out of the EEPROM at position pos. The value of pos describes a byte position in the EEPROM. This should be taken care of when using word or floating point accesses.

On the C-Control Pro Mega Units the first 32 byte are reserved for the system of the C-Control Pro. Therefore a pos value of 0 and higher accesses the EEPROM memory at position 32 and upwards.

Parameter

pos	byte position in EEPROM

Return Parameter

EEPROM value

5.10.4 EEPROM_Write

EEPROM Functions

Syntax

```
void EEPROM_Write(word pos, byte val);

Sub EEPROM_Write(pos As Word, val As Byte)
```

Description

Writes one byte into the EEPROM at position pos.

On the C-Control Pro Mega Units the first 32 byte are reserved for the system of the C-Control Pro. Therefore a pos value of 0 and higher accesses the EEPROM memory at position 32 and upwards.

Parameter

pos	byte position in EEPROM
val	new EEPROM value

5.10.5 EEPROM_WriteWord

EEPROM Functions

Syntax

```
void EEPROM_WriteWord(word pos, word val);

Sub EEPROM_WriteWord(pos As Word, val As Word)
```

Description

Writes one word into the EEPROM at position pos. The value of pos describes a byte position in the EEPROM. This should be taken care of when using word or floating point accesses.

➡ On the C-Control Pro Mega Units the first 32 byte are reserved for the system of the C-Control Pro. Therefore a pos value of 0 and higher accesses the EEPROM memory at position 32 and upwards.

Parameter

pos	byte position in EEPROM
val	new EEPROM value

5.10.6 EEPROM_WriteFloat

EEPROM Functions

Syntax

```
void EEPROM_WriteFloat(word pos, float val);

Sub EEPROM_WriteFloat(pos As Word, val As Single)
```

Description

Writes a floating point value into the EEPROM at position pos. The value of pos describes a byte position in the EEPROM. This should be taken care of when using word or floating point accesses.

➡ On the C-Control Pro Mega Units the first 32 byte are reserved for the system of the C-Control Pro. Therefore a pos value of 0 and higher accesses the EEPROM memory at position 32 and upwards.

Parameter

pos	byte position in EEPROM
val	new EEPROM value

5.11 Ethernet (AVR32Bit)

The C-Control Pro Unit AVR32Bit supports Ethernet hardware and protocols that follow the IEEE 802.3 standard. The associated PHY works with auto-negotiation and connects to a speed of 100Mbit or a 10Mbit, whatever speed the opposite side (eg a switch) offers. Power-over-Ethernet is not supported. The following protocols are currently implemented:

- ARP
- ICMP Echo (ping)
- DHCP
- TCP/IP
- UDP
- C-Control Pro (UDP Port 50234)
- HTTP (TCP/IP)

Foreknowledge

Prerequisite to understand this chapter and the successful use of the library is a basic knowledge of the following areas of IPv4:

- IP-numbers
- Port addresses and significance
- UDP packets
- TCP/IP data stream

➔ It is recommended to have knowledge about TCP/IP in a programming environment like the BSD socket interface.

5.11.1 Ethernet Activation

➔ To avoid connection problems, the MAC address should be set to a new value ("Edit MAC Address") before switching on the Ethernet support (see C-Control configuration). To this end, for each sold C-Control Pro AVR32Bit Unit a unique MAC address is generated and supplied on a label. See Software Installation.

- In the C-Control configuration, the Ethernet Support has to be enabled. When plugging in the Ethernet connector, the yellow LED should stay on and the green LED will flash sporadically .
- If DHCP is not enabled, the network parameters from the C-Control configuration will be used. The entries of IP address, subnet mask, and gateway must be entered manually.
- If DHCP is in use, the network parameters are retrieved from the DHCP server (eg DSL router or similar). The DHCP protocol is not supported in the bootloader, but only by the interpreter. Therefore, after the DHCP is enabled in the configuration, press the reset button once to start the interpreter.
- A change of the DHCP network data is stored directly in the configuration if the option save DHCP settings is turned on.
- To test whether the network is configured correctly, send a ping from the PC to the AVR32Bit Unit. The parameter Allow Ping must be enabled for it.

➔ When stopping the program with the Start/Stop button, the lwIP TCP/IP stack can get in a state, where not all dynamic memory for the current connection is released. This memory may be missing when you restart the program. If in doubt when encountering problems, press the reset button to initiate a complete system reboot.

5.11.2 TCP/IP Programming

Open a TCP/IP connection:

- Create a receive buffer with ETH_SetConnBuf.
- The call of ETH_ConnectTCP establishes a connection and sets the internal state to ES_CONNECTING.
- With periodical calling of ETH_GetStateTCP the connection state is monitored. After ES_CONNECTING the state can change to ES_CONNECTED or ES_DISCONNECTED. At ES_CONNECTED, the connection is open, else there might be a timout or the opposite side has declined.
- After the connection is open, it is possible to send data with ETH_SendTCP.
- Simultaneously check periodically with ETH_CheckReceiveBuf if data has been received, and monitor with ETH_GetStateTCP if the connection goes to the state ES_DISCONNECTED sometime.
- A call to ETH_DisconnectTCP terminates the connection.

Wait on a TCP/IP port for an incoming connection:

- Create a receive buffer with ETH_SetConnBuf.
- ETH_ListenTCP monitors a specified port.
- Check periodically ETH_CheckReceiveBuf to see if data has been received and therefore a new connection has been opened from the outside. The state of ETH_GetStateTCP now has the value ES_LCONNECTED.
- After the connection is open, it is possible to send data with ETH_SendTCP.
- Monitor periodically ETH_GetStateTCP to check if the connection gets terminated (state ES_DISCONNECTED).
- A call to ETH_DisconnectTCP terminates the connection.

➔ It is recommended to look at the demo programs for UDP and TCP/IP.

➔ The TCP/IP configuration allows up to 10 simultaneously TCP/IP connections to be opened, and be listened to up to 3 ports for incoming connections.

➔ For default 4kb are reserved for the TCP/IP stack. Depending on the use the stack needs more RAM or less. The memory needed is difficult to calculate, and should be determined by tests.

Examples

The program will connect to the HTTP port, sends a "GET" command and receives the response:

```
byte tcp_buf[ETH_BUF(4000,6)], rbuf[1461];

void main(void)
{
    word info[4], plen;
    char cmdtxt[50];
    dword ip;
    byte id, state;

    ETH_SetConnBuf(tcp_buf, 4000, 6);
    id= ETH_ConnectTCP(IP_ADDR(192,168,0,1), 80);

    state= ES_CONNECTING;
    while(state == ES_CONNECTING)
    {
        state= ETH_GetStateTCP(id);
    }

    if(state == ES_CONNECTED)
    {
        cmdtxt= "GET / HTTP/1.1\n\n";
        ETH_SendTCP(id, cmdtxt, Str_Len(cmdtxt));

        while(1)
        {
            ip= ETH_CheckReceiveBuf(info);
            if(ip)
            {
                plen= info[3];
                if(plen > 1460) plen= 1460;  // limi to 1460 bytes
                ETH_ReceiveData(rbuf, plen);
            }
        }
    }
}
```

The following Example waits for incoming connections on port 23 (Telnet). The data is collected in rbuf, but not further prepared:

```
byte tcp_buf[ETH_BUF(4000,6)], rbuf[200];  // 4000 byte receive buffer

void main(void)
{
    word info[4], plen;
    dword ip;
```

```
        char text[10];

        ETH_SetConnBuf(tcp_buf, 4000, 6);  // 4000 byte buffer and allow 6 connections
        ETH_ListenTCP(23);  // Listen Telnet port

        while(1)
        {
            ip= ETH_CheckReceiveBuf(info);
            if(ip)
            {
                plen= info[3];  //
                if(plen > 200) plen= 200;  // limit to 200 bytes
                ETH_ReceiveData(rbuf, plen);
                txt= "Cmd:\n";
                ETH_SendTCP(info[0], txt, 5); // send Cmd String
            }
        }

    }
```

5.11.3 UDP Programming

- UDP packets can directly be sent with ETH_SendUDP. The maximum size is 1460 bytes. This corresponds to an MTU of 1500 and a 40-byte UDP/IP header.
- In order to receive UDP packets, a receive buffer (ring buffer) is reserved with ETH_SetConnBuf and ETH_ListenUDP will start listening to aport. Now all incoming packets arrive in the receive buffer. When the buffer is full, further received data is lost. Therefore buffer should be checked regularly with the Function ETH_CheckReceiveBuf. A call to ETH_ReceiveData copies the data into a byte array buffer. If there are less bytes specified than there are bytes in the packet, the remaining bytes of the packet are discarded from the ring buffer.

➔ It is recommended to look at the demo programs for UDP and TCP/IP.

➔ For default 4kb are reserved for the TCP/IP stack. Depending on the use the stack needs more RAM or less. The memory needed is difficult to calculate, and should be determined by tests.

Examples

1. Program sends every second a string to Syslog Port 514:

```
void SendSyslogMsg(dword ip, byte level, char text[])
{
    byte buf[100];

    Str_Printf(buf, "<%d>%s", 16*8+level, text);
    ETH_SendUDP(ip, 514, buf, Str_Len(buf));
}

void main(void)
{
    while(1)
    {
        SendSyslogMsg(IP_ADDR(192,168,0,1), 3, "test message");
        AbsDelay(1000);
    }
}
```

2. Program receives data on UDP Port 50000 and echoes data back to sender:

```
byte buf[ETH_BUF(500,0)], rbuf[200];  // 500 byte receive buffer

void main(void)
{
    word info[4], plen;
    dword ip;

    ETH_SetConnBuf(buf, 500, 0);
    ETH_ListenUDP(50000);  // listen to Port 50000

    while(1)
    {
        ip= ETH_CheckReceiveBuf(info);
        if(ip)
        {
            plen= info[3];  // length
            if(plen > 200) plen= 200;  // limit to 200 bytes
            ETH_ReceiveData(rbuf, plen);
            ETH_SendUDP(ip, 50000, rbuf, plen);
        }
    }
}
```

5.11.4 ETH_ConnectTCP

Ethernet Functions

Syntax

```
byte ETH_ConnectTCP(dword ip, word port);

Sub ETH_ConnectTCP(ip As ULong, port As Word) As Byte
```

Description

Opens a TCP / IP connection to a port. The 32-bit value of the IP address can be calculated with the macro IP_ADDR () from the accustomed notation: For example, IP_ADDR (192,168,1,1).

➡ When returning from ETH_ConnectTCP the connection is not established directly. You have to monitor the status of the connection with ETH_GetStateTCP.

Parameter

ip	IP-Address
port	UDP Port

Return Parameter

sock_id (Socket Index), ff (Hex) in case of error

5.11.5 ETH_CheckReceiveBuf

Ethernet Functions

Syntax

```
dword ETH_CheckReceiveBuf(word info[]);

Sub ETH_CheckReceiveBuf(ByRef info As Word) As ULong
```

Description

Checks whether packets are available in the receive buffer. If the return parameter is zero, no Ethernet packets have been received. Is a package there, additional parameters are stored into the info array. The info array (16-bit) should have a size of 4 words. If a UDP packet is received, the socket index (info [0]) is equal to ff (Hex).

➡ One should be careful not to confuse the socket index (sock_idx) with the socket handle. The lists commands (ListenTCP, CloseListenTCP etc.) work with the socket handle, the other with the socket index.

Parameter

info

Return Parameter

IP address of the sender
0, when there are no packets in the buffer

Info Array

info[0]	socket index
info[1]	IP port of sender
info[2]	socket handle
info[3]	packet length

5.11.6 ETH_CloseListenTCP

Ethernet Functions

Syntax

```
void ETH_CloseListenTCP(word handle);
```

```
Sub ETH_CloseListenTCP(handle As Word)
```

Description

Closes a TCP listening socket that was created with ETH_ListenTCP.

Parameter

handle	ETH_ListenTCP handle

5.11.7 ETH_CloseListenUDP

Ethernet Functions

Syntax

```
void ETH_CloseListenUDP(word handle);
```

```
Sub ETH_CloseListenUDP(handle As Word)
```

Description

Closes a UDP listening socket that was created with ETH_ListenUDP.

Parameter

handle	ETH_ListenUDP handle

5.11.8 ETH_DisconnectTCP

Ethernet Functions

Syntax

```
void ETH_DisconnectTCP(byte sock_id);
```

```
Sub ETH_DisconnectTCP(sock_id As Byte)
```

Description

Terminates an open connection.

Parameter

sock_id	Socket Index

5.11.9 ETH_GetIPInfo

Ethernet Functions

Syntax

```
void ETH_GetIPInfo(byte info, byte data[]);

Sub ETH_GetIPInfo(info As Byte, ByRef data As Byte)
```

Description

Returns Ethernet information in a byte array. The length of the array must be sized to fit the values?If DHCP is enabled and the IP address is currently 0.0.0.0, no valid IP address has been assigned by DHCP yet.

Parameter

info	info type
data	return array

Info Type	Meaning	Length
EI_IP_ADDR	IP-address	4
EI_NETMASK	netmask	4
EI_GATEWAY	gateway address	4
EI_MACADDR	MAC address	6

5.11.10 ETH_GetStateTCP

Ethernet Functions

Syntax

```
byte ETH_GetStateTCP(byte sock_id);

Sub ETH_GetStateTCP(sock_id As Byte) As Byte
```

Description

Informs about the status of the connection. Since the other party can cancel a TCP / IP connection at any time, the status of the program should be monitored periodically in the main loop.

The sock_id parameter is returned either by ETH_ConnectTCP, or you get it as info [0] value of ETH_CheckReceiveBuf.

Parameter

`sock_id   Socket Index`

Return Parameter

Connection state

State Table

#define	Value	Meaning
ES_DISCONNECTED	0	no TCP/IP connection
ES_CONNECTING	1	connection request initiated (ETH_ConnectTCP)
ES_CONNECTED	2	connection is open (ETH_ConnectTCP)
ES_LCONNECTED	3	connection is open (ETH_ListenTCP)

5.11.11 ETH_ListenTCP

Ethernet Functions

Syntax

```
word ETH_ListenTCP(word port);

Sub ETH_ListenTCP(port As Word) As Word
```

Description

Opens a listening socket on a TCP port. Received packets are stored in the buffer that was initialized with ETH_SetConnBuf.

Parameter

port   TCP Port

Return Parameter

handle to TCP listening Socket, 0 in case of error

5.11.12 ETH_ListenUDP

Ethernet Functions

Syntax

```
word ETH_ListenUDP(word port);

Sub ETH_ListenUDP(port As Word) As Word
```

Description

Opens a listening socket on a TCP port. Received packets are stored in the buffer that was initialized with ETH_SetConnBuf.

Parameter

port	UDP Port

Return Parameter

handle to UDP listening Socket, 0 in case of error

5.11.13 ETH_ReceiveData

Ethernet Functions

Syntax

```
void ETH_ReceiveData(byte buf[], word len);

Sub ETH_ReceiveData(ByRef buf As Byte, len As Word)
```

Description

Saves a packet from the Ethernet receive buffer to address buf. The len parameter can be smaller than the length of the packet data, the remaining bytes of the packet are discarded. If you want to discard the whole packet data, set len to zero.

Parameter

buf	Arrayvariable in that the buffer data is stored
len	number of bytes that are copied

5.11.14 ETH_SendTCP

Ethernet Functions

Syntax

```
byte ETH_SendTCP(byte sock_id, byte buf[], word len);
```

Sub ETH_SendTCP(sock_id **As Byte**, **ByRef** buf **As Byte**, len **As Word**) **As Byte**

Description

Sends TCP data to an open TCP/IP connection.

➔ The sock_id parameter is returned either by ETH_ConnectTCP, or you get it as info [0] value of ETH_CheckReceiveBuf.

Parameter

sock_id	socket index
buf	address of TCP data buffer
len	length of TCP data

Return Parameter

0 if no error

5.11.15 ETH_SendUDP

Ethernet Functions

Syntax

void ETH_SendUDP(d**word** ip, **word** port, **byte** buf[], **word** len);

Sub ETH_SendUDP(ip **As ULong**, port **As Word**, **ByRef** buf **As Byte**, len **As Word**)

Description

Sends a UDP packet to an IP address and port.

Parameter

ip	IP-address
port	UDP port
buf	address of packet buffer
len	length of UDP packet

5.11.16 ETH_SetConnBuf

Ethernet Functions

Syntax

void ETH_SetConnBuf(**byte** buf[], **word** size, **byte** TCP_conn);

```
Sub ETH_SetConnBuf(ByRef buf As Byte, size As Word, TCP_conn As Byte)
```

Description

Creates an Ethernet receive buffer where received TCP/IP and UDP packets are stored.

Parameter

buf	address of receive buffer
size	size of buffer

5.12 I2C

The Controller provides an I2C Logic which allows effective communication. The Controller operates as an I2C Master (single master system). A slave operating mode is possible but not yet implemented in the current version.

5.12.1 Mega

5.12.1.1 I2C_Init

I2C Functions Example

Syntax

```
void I2C_Init(byte I2C_BR);

Sub I2C_Init(I2C_BR As Byte)
```

Description

This function initializes the I2C interface.

Parameter

I2C_BR describes the baud rate. The following values are predefined:

I2C_100kHz
I2C_400kHz

Definition	14,7456 Mhz	16 Mhz
I2C_100kHz	66	72
I2C_400kHz	10	12

➔ The Bitrate can be calculated as follows: Bitrate = ((CPU_CLOCK / TARGET_I2C_SPEED) - 16) / 2

5.12.1.2 I2C_Read_ACK

I2C Functions

Syntax

```
byte I2C_Read_ACK(void);

Sub I2C_Read_ACK() As Byte
```

Description

This function receives a byte and acknowledges with ACK. Afterwards the status of the interface can be re-turned with I2C_Status().

Return Parameter

value read from the I2C bus

5.12.1.3 I2C_Read_NACK

I2C Functions **Example**

Syntax

```
byte I2C_Read_NACK(void);

Sub I2C_Read_NACK() As Byte
```

Description

This function receives a byte and acknowledges with NACK. Afterwards the status of the interface can be returned with I2C_Status().

Return Parameter

value read from the I2C bus

5.12.1.4 I2C_Start

I2C Functions **Example**

Syntax

```
void I2C_Start(void);

Sub I2C_Start()
```

Description

This function introduces communication with a starting sequence. Afterwards the status of the interface can be returned with I2C_Status().

Parameter

None

5.12.1.5 I2C_Status

I2C Functions

Syntax

```
byte I2C_Status(void);

Sub I2C_Status()
```

Description

With I2C_Status the status of the I2C interface can be accessed. For the meaning of the return value please look inside the I2C status code table.

Return Parameter

current I2C Status

5.12.1.6 I2C_Stop

I2C Functions **Example**

Syntax

```
void I2C_Stop(void);

Sub I2C_Stop()
```

Description

This function ceases the I2C communication with a stop sequence. Afterwards the status of the interface can be returned with I2C_Status().

Parameter

None

5.12.1.7 I2C_Write

I2C Functions Example

Syntax

```
void I2C_Write(byte data);

Sub I2C_Write(data As Byte)
```

Description

I2C_Write() sends a byte to the I2C bus. Afterwards the status of the interface can be returned with I2C_Status().

Parameter

data data byte

5.12.1.8 I2C Status Table

Table: **Status Codes Master Transmitter Mode**

Status Code (Hex)	Description
08	a START sequence has been sent
10	a "repeated" START sequence has been sent
18	SLA+W has been sent, ACK has been received
20	SLA+W has been sent, NACK has been received
28	Data byte has been sent, ACK has been received
30	Data byte has been sent, NACK has been received
38	conflict with SLA+W or data bytes

Table: **Status Codes Master Receiver Mode**

Status Code (Hex)	Description
08	a START sequence has been sent
10	a "repeated" START sequence has been sent
38	conflict with SLA+R or data bytes

40	SLA+R has been sent, ACK has been received
48	SLA+R has been sent, NACK has been received
50	Data byte has been sent, ACK has been received
58	Data byte has been sent, NACK has been received

5.12.1.9 I2C Example

Example: read EEPROM 24C64 and write without I2C_Status check

```
// I2C Initialization, Bit Rate 100kHz

main(void)
{
    word address;
    byte data,EEPROM_data;

    address=0x20;
    data=0x42;

    I2C_Init(I2C_100kHz );
    // write data to 24C64 (8k x 8) EEPROM
    I2C_Start();
    I2C_Write(0xA0);          // DEVICE ADDRESS : A0
    I2C_Write(address>>8);    // HIGH WORD ADDRESS
    I2C_Write(address);       // LOW WORD ADDRESS
    I2C_Write(data);          // write Data
    I2C_Stop();
    AbsDelay(5);              // delay for EEPROM Write Cycle

    // read data from 24C64 (8k x 8) EEPROM
    I2C_Start();
    I2C_Write(0xA0);          // DEVICE ADDRESS : A0
    I2C_Write(address>>8);    // HIGH WORD ADDRESS
    I2C_Write(address);       // LOW WORD ADDRESS
    I2C_Start();              // RESTART
    I2C_Write(0xA1);          // DEVICE ADDRESS : A1
    EEPROM_data=I2C_Read_NACK();
    I2C_Stop();
    Msg_WriteHex(EEPROM_data);
}
```

5.12.2 AVR32Bit

5.12.2.1 I2C_Probe

I2C Functions

Syntax

```
byte I2C_Probe(byte addr);

Sub I2C_Probe(addr As Byte) As Byte
```

Description

I2C_Probe tries to address an I2C device and gives as result whether the attempt was successful.

Parameter

addr	address of I2C device

Return Parameter

1 = device has answered
0 else

5.12.2.2 I2C_Read

I2C Functions

Syntax

```
byte I2C_Read(byte addr, dword hdr, byte hdr_len, byte mem_addr[],
              word length);

Sub I2C_Read(addr As Byte, hdr As ULong, hdr_len As Byte,
             ByRef mem_addr As Byte, length As Word) As Byte
```

Description

First, up to 4 bytes of header data are written to the I2C device with address addr (I2C 7-bit address). The data is passed in hdr (dword), the number of bytes in hdr_len. The hdr_len may be zero, means that is there is no header data transferred. There are always the first high-order bytes of the header transmitted (big endian). After transferring the header, length bytes are written from the I2C device into the array mem_addr.

➔ The term header stands not for a specific I2C term, but for up to 4 bytes, that are transmitted to the I2C device. Many I2C devices use such a header, e.g. as to index a register.

Parameter

addr	address of I2C device
hdr	up to 4 byte header data
hdr_len	length of header
mem_addr	array in that the I2C device data is copied into

length number of bytes that are transferred (exclusive header)

Return Parameter

-1 = transmission error
0 = successful

5.12.2.3 I2C_SetSpeed

I2C Functions Example

Syntax

```
void I2C_SetSpeed(dword I2C_BR);

Sub I2C_SetSpeed(I2C_BR As ULong)
```

Description

This function sets the speed of the I2C interface.

Parameter

I2C_BR Indicates the bit rate as a 32-bit value. The following values are already predefined:

I2C_100kHz
I2C_400kHz

Definition	Value
I2C_100kHz	100000
I2C_400kHz	400000

Return Parameter

-8 = transmission error
0 = successful

5.12.2.4 I2C_Write

I2C Functions

Syntax

```
byte I2C_Write(byte addr, dword hdr, byte hdr_len, byte mem_addr[],
               word length);
```

```
Sub I2C_Write(addr As Byte, hdr As ULong, hdr_len As Byte,
              ByRef mem_addr As Byte, length As Word) As Byte
```

Description

First, up to 4 bytes of header data are written to the I2C device with address addr (I2C 7-bit address). The header data is passed in hdr (dword), the number of bytes in hdr_len. The hdr_len may be zero, means that is there is no header data transferred. There are always the first high-order bytes of the header transmitted (big endian). After transferring the header, length bytes are written from the array mem_addr to the I2C device.

➔ The term header stands not for a specific I2C term, but for up to 4 bytes, that are transmitted to the I2C device. Many I2C devices use such a header, e.g. as to index a register.

Parameter

addr	address of I2C device
hdr	up to 4 byte header data
hdr_len	length of header
mem_addr	array that is written to I2C device
length	number of bytes that are transferred (exclusive header)

Return Parameter

-1	= transmission error
0	= successful

5.12.2.5 I2C Example

Example: EEPROM 24C64 read and write

```
// I2C device address = 0x50, Bit Rate 100kHz
// EEPROM has 16bit memory address
byte data[10];

void main(void)
{
    // read 10 bytes from memory address 0x20 into array data[]
    I2C_Read(0x50, 0x20, 2, data, 10);

    // write 10 bytes from array data[] to EEPROM memory address 0x20
    I2C_Write(0x50, 0x20, 2, data, 10);
}
```

5.13 Interrupt

The Controller provides a multitude of interrupts. Some of them are used for system functions and are thus not available to the user. The following interrupts can be utilized by the user.

Table: Interrupts

Interrupt Name	**Mega32**	**Mega128 (CAN)**
INT_0	external Interrupt0	external Interrupt0
INT_1	external Interrupt1	external Interrupt1
INT_2	external Interrupt2	external Interrupt2
INT_3	---	external Interrupt3
INT_4	---	external Interrupt4
INT_5	---	external Interrupt5
INT_6	---	external Interrupt6
INT_7	---	external Interrupt7
INT_TIM1CAPT	Timer1 Capture	Timer1 Capture
INT_TIM1CMPA	Timer1 CompareA	Timer1 CompareA
INT_TIM1CMPB	Timer1 CompareB	Timer1 CompareB
INT_TIM1OVF	Timer1 Overflow	Timer1 Overflow
INT_TIM0COMP	Timer0 Compare	Timer0 Compare
INT_TIM0OVF	Timer0 Overflow	Timer0 Overflow
INT_ANA_COMP	Analog Comparator	Analog Comparator
INT_ADC	ADC	ADC
INT_TIM2COMP	Timer2 Compare	Timer2 Compare
INT_TIM2OVF	Timer2 Overflow	Timer2 Overflow
INT_TIM3CAPT	---	Timer3 Capture
INT_TIM3CMPA	---	Timer3 CompareA
INT_TIM3CMPB	---	Timer3 CompareB
INT_TIM3CMPC	---	Timer3 CompareC
INT_TIM3OVF	---	Timer3 Overflow

➜ A signal on INT_0 (**Mega32**) or INT_4 (**Mega128 (CAN)**) can interfere with the Autostart Behaviour when the C-Control Pro Module is switched on. According to the pin assignment of M32 and M128 these pins share the same pin with SW1. If SW1 is pressed during power up of the Module then the Bootloader Mode will be activated and the program will not be automatically started.

Interrupt Name	**AVR32Bit**
INT_ANA_COMP	Analog Comparator
INT_1	external Interrupt 1
INT_2	external Interrupt 2
INT_3	external Interrupt 3

INT_4	external Interrupt 4
INT_5	external Interrupt 5
INT_6	external Interrupt 6
INT_7	external Interrupt 7
INT_ADC	ADC
INT_100Hz	100 Hz Interrupt
INT_TIMER0	Timer 0
INT_TIMER1	Timer 1
INT_TIMER2	Timer 2
INT_TIMER3	Timer 3
INT_TIMER4	Timer 4
INT_TIMER5	Timer 5
INT_CAN	CAN

The corresponding interrupt has to receive the corresponding instructions in an Interrupt Service Routine (ISR) and also the interrupt has to be enabled. See **Example**. During execution of the interrupt routine the Multi Threading is suspended.

5.13.1 Ext_IntEnable

Interrupt Functions

Syntax

```
void Ext_IntEnable(byte IRQ, byte Mode);

Sub Ext_IntEnable(IRQ As Byte, Mode As Byte)
```

Description

This function enables the external Interrupt IRQ. The Mode parameter defines when to trigger the interrupt.

➔ The parameter IRQ has a numeric value. Not to be confused with the #defines of parameter irqno in function Irq_SetVect().

Parameter

IRQ	number of the interrupt to be enabled **Mega32** (0-2) , **Mega128** (0-7) , **AVR32** (1-7)
Mode	parameter:

0:	a low level triggers the interrupt
1:	every changing edge triggers the interrupt
2:	a falling edge triggers the interrupt
3:	a rising edge triggers the interrupt

➔ A signal on **Mega32**:IRQ 0 or **Mega128**:IRQ 4 at power up time can lead to Autostart problems.

Mode parameter only for **Mega32** and IRQ2:

0: a falling edge triggers the interrupt
1: a rising edge triggers the interrupt

Mode parameter for **AVR32**

0: a low level triggers the interrupt
1: a high level edge triggers the interrupt
2: a falling edge triggers the interrupt
3: a rising edge triggers the interrupt

When 40 (Hex) is ORed to the parameter Mode (only AVR32) an internal pull-down is set, if 80 (Hex) is ORed an internal pull-up gets enabled.

5.13.2 Ext_IntDisable

Interrupt Functions

Syntax

```
void Ext_IntDisable(byte IRQ);

Sub Ext_IntDisable(IRQ As Byte)
```

Description

The external Interrupt IRQ gets disabled.

Parameter

IRQ number of the interrupt to disable **Mega32** (0-2) , **Mega128** (0-7) , **AVR32** (1-7)

5.13.3 Irq_GetCount

Interrupt Functions Example

Syntax

```
byte Irq_GetCount(byte irqnr);

Sub Irq_GetCount(irqnr As Byte) As Byte
```

Description

Acknowledges the interrupt. If the function is not called at the end of a interrupt service routine, the interrupt service routine gets called continuously.

Parameter

`irqnr` specifies the interrupt type (see table)

Return Parameter

The return value expresses how often a interrupt got triggered until the function Irq_GetCount() has been called. A value greater 1 shows that the interrupts
are triggered more rapidly than the interrupt service routine is processed.

5.13.4 Irq_SetVect

Interrupt Functions Example

Syntax

```
void Irq_SetVect(byte irqnr, dword vect);

Sub Irq_SetVect(irqnr As Byte, vect As ULong)
```

Description

Defines an interrupt service routine for a specified interrupt. At the end of the interrupt service routine the function Irq_GetCount() has to be called, otherwise the interrupt service routine gets called continuously. A vect of value Null sets the interrupt inactive again.

Parameter

irqnr	specifies the interrupt type (see table)
vect	is the name of the interrupt function to be called

5.13.5 IRQ Example

Example: Usage of Interrupt Routines

```
// INT_100HZ (AVR32Bit) or Timer 2 (MEGA) are normally called all 10ms.
// In this example the variable cnt gets increased every 10ms by one.
```

```
int cnt;

void ISR(void)
{
    cnt=cnt+1;
#if AVR32
    Irq_GetCount(INT_100HZ);
#else
    Irq_GetCount(INT_TIM2COMP);
#endif
}

void main(void)
{
    cnt=0;

#if AVR32
    Irq_SetVect(INT_100HZ, ISR);
#else
    Irq_SetVect(INT_TIM2COMP, ISR);
#endif
    while(true);  // endless loop
}
```

5.14 Keyboard (Mega)

One part of these keyboard routines is implemented in the Interpreter, another can be called up after appending library "LCD_Lib.cc". Since the functions in "LCD_Lib.cc" are realized through Bytecode they are slower when executed. Library functions however have the advantage that they can be taken from the project by omitting the library in case they are not needed. Direct Interpreter functions are always present, will however take up flash memory.

➔ There is no keyboard included with the AVR32 Application Board, so there are no keyboard routines in the library.

5.14.1 Key_Init

Keyboard Functions (Library "*Key_Lib.cc*")

Syntax

```
void Key_Init(void);

Sub Key_Init()
```

Description

The global keymap array gets initialized with the ASCII values of the keyboard.

Parameter

None

5.14.2 Key_Scan

Keyboard Functions

Syntax

```
word Key_Scan(void);

Sub Key_Scan() As Word
```

Description

Key_Scan scans sequentially the input pins of the connected keyboard and returns the result as a bit field with 16 bits. Bits that are set represent keys that have been pressed during the scan.

Return Parameter

16 bits that represent the input lines of the keyboard

5.14.3 Key_TranslateKey

Keyboard Functions (Library "*Key_Lib.cc*")

Syntax

```
char Key_TranslateKey(word keys);

Sub Key_TranslateKey(keys As Word) As Char
```

Description

This help function looks for the first "1" in the bit field, and returns the ASCII value of the corresponding key.

Parameter

keys bit field value that has been retuned from Key_Scan()

Return Parameter

ASCII value of recognized keys
-1 if no key is pressed

5.15 LCD

A part of these routines is implemented in the Interpreter, another part can be called up by appending library "LCD_Lib.cc". Since the functions in "LCD_Lib.cc" are realized through Bytecode they are slower when executed. Library functions however have the advantage that they can be taken from the project by omitting the library in case they are not needed. Direct Interpreter functions are always present, will however take up flash memory.

5.15.1 Internal Functions

The Functions listed here are used internally and should normally not used by the user.

5.15.1.1 LCD_SubInit

LCD Functions

Syntax

```
void LCD_SubInit(void);

Sub LCD_SubInit()
```

Description

Initializes the display ports on assembler level. Must be called before all other LCD output functions. This function will be used as first command from LCD_Init().

Parameter

None

5.15.1.2 LCD_TestBusy

LCD Functions

Syntax

```
void LCD_TestBusy(void);

Sub LCD_TestBusy()
```

Description

This function waits for a non-busy of the display controller. If the controller is accessed in his busy period the output data will be corrupted.

Parameter

None

5.15.1.3 LCD_WriteDataRegister

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_WriteDataRegister(char x);

Sub LCD_WriteDataRegister(x As Char)
```

Description

Sends a data byte to the display controller.

Parameter

x data byte

5.15.1.4 LCD_WriteCTRRegister

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_WriteCTRRegister(byte cmd);

Sub LCD_WriteCTRRegister(cmd As Byte)
```

Description

Sends a command to the display controller.

Parameter

cmd byte command

5.15.2 LCD_ClearLCD

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_ClearLCD(void);

Sub LCD_ClearLCD()
```

Description

Clears the display and enables the Cursor.

Parameter

None

5.15.3 LCD_CursorOff

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_CursorOff(void);
```

```
Sub LCD_CursorOff()
```

Description

Turns the cursor off on the display.

Parameter

None

5.15.4 LCD_CursorOn

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_CursorOn(void);
```

```
Sub LCD_CursorOn()
```

Description

Turns the cursor in the display on.

Parameter

None

5.15.5 LCD_CursorPos

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_CursorPos(byte pos);

Sub LCD_CursorPos(pos As Byte)
```

Description

Moves the cursor to position pos.

Parameter

pos cursorposition

Value of pos (Hex)	**Position on Display**
00-07	0-7 on 1st line
40-47	0-7 on 2nd line

The following table is valid for displays with more than 2 lines and up to 32 chars per line:

Value of pos (Hex)	**Position on Display**
00-1f	0-31 on line 1
40-5f	0-31 on line 2
20-3f	0-31 on line 3
60-6f	0-31 on line 4

5.15.6 LCD_Init

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_Init(void);

Sub LCD_Init()
```

Description

High level intialization of the LCD display. Calls LCD_InitDisplay() as first.

Parameter

None

5.15.7 LCD_Locate

LCD Functions

Syntax

```
void LCD_Locate(int row, int column);

Sub LCD_Locate(row As Integer, column As Integer)
```

Description

Sets the cursor of the LCD display to given row and column.

Parameter

row
column

5.15.8 LCD_SetDispAddr (AVR32Bit)

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_SetDispAddr(byte addr);

Sub LCD_SetDispAddr(addr As Byte)
```

Description

Sets a new destination address for the LCD output. In this way, several LCD1602 boards can be addressed simultaneously. See addressing in the chapter "C-Control PRO AVR32 LCD1602 board". The default value for the display address is 27 (Hex).

Parameter

addr	new address

5.15.9 LCD_WriteChar

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_WriteChar(char c);

Sub LCD_WriteChar(c As Char)
```

Description

Displays one character at the cursor position on the LCD display.

Parameter

c	ASCII value of output character

5.15.10 LCD_WriteFloat

LCD Functions

Syntax

```
void LCD_WriteFloat(float value, byte length);

Sub LCD_WriteFloat(value As Single, length As Byte)
```

Description

Writes a floating point value with given length to LCD display.

Parameter

value	floating point value
length	output length

5.15.11 LCD_WriteRegister

LCD Functions

Syntax

```
void LCD_WriteRegister(byte y,byte x);

Sub LCD_WriteRegister(y As Byte,x As Byte)
```

Description

`LCD_WriteRegister divides the data byte y in 2 nibbles (4bit values) and sends the nibbles to the display controller.`

y data byte
x command nibble

5.15.12 LCD_WriteText

LCD Functions (Library "*LCD_Lib.cc*")

Syntax

```
void LCD_WriteText(char text[]);

Sub LCD_WriteText(ByRef Text As Char)
```

Description

All characters of the char array up to the terminating zero are displayed.

Parameter

text char array

5.15.13 LCD_WriteWord

LCD Functions

Syntax

```
void LCD_WriteWord(word value, byte length);

Sub LCD_WriteWord(value As Word, length As Byte)
```

Description

Writes an unsigned integer (word) with given length to the LCD display. If the resulting LCD output is smaller than the given length, the output filled with zeros "0" at the beginning.

Parameter

value word value
length output length

5.16 Math

Mathematical Functions.

5.16.1 Floating Point

In the following the mathematical functions are listed which the C-Control Pro is able to master with single floating point accuracy (32 bit). These functions are not contained in the C-Control Pro 32 since it would then not offer enough memory for user programs.

5.16.1.1 FPU (AVR32Bit)

The AVR32Bit UNIT has an integrated floating point unit (FPU), that greatly accelerates floating point operations. An exception is the floating-point division performed in software. By dividing by a constant, one should therefore consider to multiply by the reciprocal.

5.16.1.2 acos

Floating Point Functions

Syntax

```
float acos(float val);

Sub acos(val As Single) As Single
```

Description

The mathematical arc cosine (inverse cosine) is calculated.

Parameter

val input value between -1 and 1

Return Parameter

arc cosine of the input value in the range [0..Pi], expressed in radians

5.16.1.3 asin

Floating Point Functions

Syntax

```
float asin(float val);

Sub asin(val As Single) As Single
```

Description

The mathematical arc sine (inverse sine) is calculated.

Parameter

val input value between -1 and 1

Return Parameter

arc sine of the input value in the range [-Pi/2..Pi/2], expressed in radians

5.16.1.4 atan

Floating Point Functions

Syntax

```
float atan(float val);

Sub atan(val As Single) As Single
```

Description

The mathematical arc tangent (inverse tangent) is calculated.

Parameter

val input value

Return Parameter

arc tangent of the input value in the range [-Pi/2..Pi/2], expressed in radians

5.16.1.5 ceil

Floating Point Functions

Syntax

```
float ceil(float val);

Sub ceil(val As Single) As Single
```

Description

The largest integer value of the floating point number x is calculated.

Parameter

val input value

Return Parameter

result

5.16.1.6 cos

Floating Point Functions

Syntax

float cos(**float** val);

Sub cos(val **As Single**) **As Single**

Description

The mathematical cosine is calculated.

Parameter

val input angle expressed in radians

Return Parameter

cosine of the input value between -1 and 1

5.16.1.7 exp

Floating Point Functions

Syntax

float exp(**float** val);

Sub exp(val **As Single**) **As Single**

Description

The exponential function e ^ val is calculated.

Parameter

val exponent

Return Parameter

result

5.16.1.8 fabs

Floating Point Functions

Syntax

```
float fabs(float val);

Sub fabs(val As Single) As Single
```

Description

The absolute value of the floating point number val is calculated.

Parameter

val input value

Return Parameter

result

5.16.1.9 floor

Floating Point Functions

Syntax

```
float floor(float val);

Sub floor(val As Single) As Single
```

Description

The smallest integer value of the floating point number x is calculated.

Parameter

val input value

Return Parameter

result

5.16.1.10 ldexp

Floating Point Functions

Syntax

```
float ldexp(float val,int expn);
```

```
Sub ldexp(val As Single,expn As Integer) As Single
```

Description

The function val * 2 ^ expn is calculated (also used as internal help function for other mathematical functions).

Parameter

val	multiplier
expn	exponent

Return Parameter

result

5.16.1.11 ln

Floating Point Functions

Syntax

```
float ln(float val);
```

```
Sub ln(val As Single) As Single
```

Description

The natural logarithm is calculated.

Parameter

val input value

Return Parameter

result

5.16.1.12 log

Floating Point Functions

Syntax

```
float log(float val);
```

```
Sub log(val As Single) As Single
```

Description

The logarithm base 10 is calculated.

Parameter

val input value

Return Parameter

result

5.16.1.13 pow

Floating Point Functions

Syntax

```
float pow(float x, float y);

Sub pow(x As Single, y As Single) As Single
```

Description

The power function x^y is calculated.

Parameter

x base
y exponent

Return Parameter

result

5.16.1.14 round

Floating Point Functions

Syntax

```
float round(float val);

Sub round(val As Single) As Single
```

Description

Rounding function. The floating point value is rounded up or down to a number without decimal places.

Parameter

val input value

Return Parameter

result of the function

5.16.1.15 sin

Floating Point Functions

Syntax

```
float sin(float val);

Sub sin(val As Single) As Single
```

Description

The mathematical sine is calculated.

Parameter

val input angle expressed in radians

Return Parameter

sine of the input value between -1 and 1

5.16.1.16 sqrt

Floating Point Functions

Syntax

```
float sqrt(float val);

Sub sqrt(val As Single) As Single
```

Description

The square root of a positive floating point number is calculated.

Parameter

val input value

Return Parameter

result

5.16.1.17 tan

Floating Point Functions

Syntax

```
float tan(float val);

Sub tan(val As Single) As Single
```

Description

The mathematical tangent is calculated.

Parameter

val	input angle expressed in radians

Return Parameter

tangent of the input value

5.16.2 Integer

Mathematical Integer Functions.

5.16.2.1 rand

Integer Functions

Syntax

```
int rand(void);

Sub rand() As Integer
```

Description

This function returns a pseudo random number between 0 and 32768. Use srand() with different seeds for varying sequences of numbers.

Return Parameter

Pseudo Random Number

5.16.2.2 srand

Integer Functions

Syntax

```
void srand(int seed);

Sub srand(seed As Integer)
```

Description

Sets the seed for the pseudo random number generator. With the same seed the pseudo random number sequences can be reproduced.

Parameter

seed	pseudo random number generator starting value.

5.17 OneWire

1-Wire or One-Wire is a serial interface that needs only one wire for signaling and power. The data is transferred asynchronously (without clock signal) in groups of 64 bit. Data can either be sent or received, but not at the same time (half-duplex).

The special about 1-Wire devices is the parasitically power supply, that is made over the signal wire: When there is no communication, the signal wire has a +5V level and charges a capacitor. During low-pulse communication the slave device is powered from his capacitor. Dependent on the charge of the capacitor, low-time gaps up to 960 µs can be bridged.

5.17.1 Onewire_Read

1-Wire Functions

Syntax

```
byte Onewire_Read(void);

Sub Onewire_Read() As Byte
```

Description

A Byte is read from the One-Wire Bus.

Return Parameter

value read from One-Wire Bus

5.17.2 Onewire_Reset

1-Wire Functions

Syntax

```
void Onewire_Reset(byte portbit);

Sub Onewire_Reset(portbit As Byte)
```

Description

A reset is made on the One-Wire Bus. The port bit number for the One-Wire Bus communication is specified.

Parameter

portbit	port bit number (see Port Table)

5.17.3 Onewire_Write

1-Wire Functions

Syntax

```
void Onewire_Write(byte data);

Sub Onewire_Write(data As Byte)
```

Description

A byte is written to the One-Wire Bus.

Parameter

data	data byte

5.17.4 Onewire Example

CompactC

```
// Sample Code to read DS18S20 temp. sensor from Dallas Maxim
void main(void)
{
    char text[40];
    int ret, i, temp;
    byte rom_code[8];
    byte scratch_pad[9];
    ret= OneWire_Reset(7); // PortA.7
    if(ret == 0)
    {
        text= "no device found";
        Msg_WriteText(text);
        goto end;
    }

    OneWire_Write(0xcc); // skip ROM cmd
    OneWire_Write(0x44); // start temperature measure cmd

    AbsDelay(3000);

    OneWire_Reset(7);    // PortA.7
    OneWire_Write(0xcc); // skip ROM cmd
    OneWire_Write(0xbe); // read scratch_pad cmd
    for(i=0;i<9;i++)     // read whole scratchpad
    {
        scratch_pad[i]= OneWire_Read();
        Msg_WriteHex(scratch_pad[i]);
    }
    Msg_WriteChar('\r');

    text= "Temperature: ";
    Msg_WriteText(text);

    temp= scratch_pad[1]*256 + scratch_pad[0];
    Msg_WriteFloat(temp* 0.5);
    Msg_WriteChar('C');
    Msg_WriteChar('\r');

    end:
}
```

BASIC

```
' Sample Code to read DS18S20 temp. sensor from Dallas Maxim
Dim Text(40) As Char
Dim ret,i As Integer
Dim temp As Integer
Dim rom_code(8) As Byte
Dim scratch_pad(9) As Byte

Sub main()

    ret = OneWire_Reset(7) ' PortA.7

    If ret = 0 Then
       Text= "no device found"
       Msg_WriteText(Text)
       Goto Ende
    End If

    OneWire_Write(0xcc)    ' skip ROM cmd
    OneWire_Write(0x44)    ' start temperature measure cmd

    AbsDelay(3000)

    OneWire_Reset(7)       ' PortA.7
    OneWire_Write(0xcc)    ' skip ROM cmd
    OneWire_Write(0xbe)    ' read scratch_pad cmd

    For i = 0 To 9         ' read whole scratchpad
        scratch_pad(i)= OneWire_Read()
        Msg_WriteHex(scratch_pad(i))
    Next
    Msg_WriteChar(13)

    Text = "Temperature: "
    Msg_WriteText(Text)

    temp = scratch_pad(1) * 256 + scratch_pad(0)
    Msg_WriteFloat(temp * 0.5)
    Msg_WriteChar(99)
    Msg_WriteChar(13)

    Lab Ende
End Sub
```

5.18 Port

Atmel Mega

The Atmel Mega 32 provides 4 input/output ports at 8 bits each. The Atmel Mega 128 provides 6 input/output ports at 8 bits each and one input/output port at 5 bits. Each bit of the individual ports can be configured as input or output. Since however the number of pins in the Mega 32 Risc CPU is limited, additional functions are assigned to individual ports. A pin assignment table for M32 and M128 can be found in the documentation.

➔ It is important to study the pin assignment prior to programming since important functions of the program design (e. g. the USB Interface of the Application Board) are assigned to specific ports. If these ports are programmed differently or the corresponding jumpers on the Application Board are no longer set it may happen that the design interface is no longer able to transfer programs to the C-Control Pro.

➔ The direction of data flow (input/output) can be determined with function Port_DataDir or Port_DataDirBit. If a pin is configured as input then this pin can either be operated high resistive ("floating") or with an internal pull-up resistor. If with Port_Write or Port_WriteBit a "1" is written to an input then the pull-up resistor (Reference Level VCC) is activated and the input is defined.

Atmel AVR32Bit

The Atmel AVR32Bit provides the ports A to D, which are each 32 bits in width. Each bit of every port can be configured as input or output. In addition, it is possible to enable a pullup, pulldown, and adjust the drive strength. The functions Port_DataDir, Port_Toggle and Port_Write known by the Atmel Mega were omitted at the AVR32Bit, since in practice working with the complete 32-bit port is very unwieldy.

It is important to study the pin assignment before programming, as important peripheral functions lie on certain ports. When these ports are reprogrammed, it may happen that the development environment can no longer transmit programs to the C-Control Pro.

Use the Port_Attribute function at the AVR32Bit instead of Port_DataDirBit to switch between input and output.

If a function such as a PWM is used only temporarily on a port pin, it is usually recommended to set the pin later to a defined level with Port_Attribute, after the function is no longer used.

5.18.1 Port_Attribute

Port Functions

Syntax

```
void Port_Attribute(byte portbit, word attribute);

Sub Port_Attribute(portbit As Byte, attribute As Word)
```

Description

The function Port_Attribute configures the properties of a port. Multiple attribute values can be or'ed. See Example.

Parameter

portbit	port bit number (see Port Table)
attribute	Portbit Attribute

Attribut Table

Function	Definition	Value (Hex)
Port set to Input	PORT_ATTR_INPUT	00
Port set to Output	PORT_ATTR_OUTPUT	01
set output low	PORT_ATTR_INIT_LOW	00
set output high	PORT_ATTR_INIT_HIGH	02
set PullUp	PORT_ATTR_PULL_UP	04

set PullDown	PORT_ATTR_PULL_DOWN	08
minimum Drive Strength	PORT_ATTR_DRIVE_MIN	00
normal Drive Strength	PORT_ATTR_DRIVE_LOW	10
high Drive Strength	PORT_ATTR_DRIVE_HIGH	20
maximum Drive Strength	PORT_ATTR_DRIVE_MAX	30

To obtain more accurate values of the drive strength of a port please refer to the chapter "Electrical Characteristics" in the Atmel AT32UC3C datasheet.

5.18.2 Port_DataDir (Mega)

Port Functions Example

Syntax

```
void Port_DataDir(byte port, byte val);

Sub Port_DataDir(port As Byte, val As Byte)
```

Description

The function Port_DataDir configures the port for input or output direction. Is a bit set, then the Pin corresponding to the bit position is switched to output. Example: Is port = PortB and val = 02, then PortB.1 is configured for output, all other ports on PortB are set to input (see Pin Assignment of M32 and M128).

Parameter

port	port number (see Port Table)
val	output byte

5.18.3 Port_DataDirBit (Mega)

Port Functions

Syntax

```
void Port_DataDirBit(byte portbit, byte val);

Sub Port_DataDirBit(portbit As Byte, val As Byte)
```

Description

The function Port_DataDirBit configures one bit (Pin) of a port for input or output direction. Is a bit set, then the Pin corresponding to the bit position is switched to output. Example: Is portbit = 10 and val = 0, then PortB.2 is configured for input. All other ports on PortB stay the same (see Pin Assignment of M32 and M128.).

Please use the function Port_Attribute instead of Port_DataDirBit for the AVR32Bit. The AVR32 MCU provides advanced options such as pull-down or adjust the drive strength.

➡ Port Bit access is always significant slower than the normal Port access that transfers 8 Bit. If the desired values of all Port Bits are known, 8-Bit Port access is always preferable.

Parameter

portbit	port bit number (see Port Table)
val	0=Input, 1= Output

5.18.4 Port_Read (Mega)

Port Functions

Syntax

```
byte Port_Read(byte port);

Sub Port_Read(port As Byte) As Byte
```

Description

Reads a byte from the specified port. Only the Pins of port that are configured for input return a valid value on their bit position (see Pin Assignment of M32 and M128).

Parameter

port	port number (see Port Table)

Return Parameter

port byte value

5.18.5 Port_ReadBit

Port Functions

Syntax

```
byte Port_ReadBit(byte port);

Sub Port_ReadBit(port As Byte) As Byte
```

Description

The function Port_ReadBit reads the value of a Pin that is configured for input. (See Pin Assignment of AVR32, M32 and M128.).

➡ Port Bit access is always significant slower than the normal Port access that transfers 8 Bit. If the desired values of all Port Bits are known, 8-Bit Port access is always preferable.

Parameter

portbit bit number of port (see Port Table)

Return Parameter

bit value (0 or 1)

5.18.6 Port_ToggleBit

Port Functions

Syntax

```
void Port_ToggleBit(byte portbit);

Sub Port_ToggleBit(portbit As Byte)
```

Description

The function Port_WriteBit inverts the value of a Pin that is configured for output. See Pin Assignment of AVR32, M32 and M128.

➔ Mega: Is a Pin configured as input, this will set an internal pull-up resistor on (bit = 1) or off (bit = 0).

➔ Mega: Port Bit access is always significant slower than the normal Port access that transfers 8 Bit. If the desired values of all Port Bits are known, 8-Bit Port access is always preferable.

Parameter

portbit bit number of port (see Port Table)

5.18.7 Port_Toggle (Mega)

Port Functions

Syntax

```
void Port_Toggle(byte port);

Sub Port_Toggle(port As Byte)
```

Description

Inverts all Bits on the specified port. Only the Pins of port that are configured for output will show their value as port output on their bit position (see Pin Assignment of M32 and M128). Is a Pin configured as input, this will set an internal pull-up resistor on (bit = 1) or off (bit = 0). See Pin Assignment of M32 and M128.

Parameter

port	port number (see Port Table)

5.18.8 Port_Write (Mega)

Port Functions Example

Syntax

```
void Port_Write(byte port, byte val);

Sub Port_Write(port As Byte, val As Byte)
```

Description

Writes a byte to the specified port. Only the Pins of port that are configured for output will show their value as port output on their bit position (see Pin Assignment of M32 and M128). Is a Pin configured as input, this will set an internal pull-up resistor on (bit = 1) or off (bit = 0). See Pin Assignment of M32 and M128.

➡ In older IDE versions PORT_ON and PORT_OFF were incorrectly defined, which is now corrected.

Parameter

port	port number (see Port Table)
val	output byte

5.18.9 Port_WriteBit

Port Functions

Syntax

```
void Port_WriteBit(byte portbit, byte val);

Sub Port_WriteBit(portbit As Byte, val As Byte)
```

Description

The function Port_WriteBit sets the value of a Pin that is configured for output. Is a Pin configured as input, a Port_WriteBit() will set an internal pull-up resistor on (bit = 1) or off (bit = 0). See Pin Assignment of AVR32, M32 and M128.

➡ Port Bit access is always significant slower than the normal Port access that transfers 8 Bit. If the desired values of all Port Bits are known, 8-Bit Port access is always preferable.

➡ At the C-Control Pro AVR32Bit the internal pullup is switched with the command Port_Attribute.

➡ In older IDE versions PORT_ON and PORT_OFF were incorrectly defined, which is now corrected.

Parameter

portbit	bit number of port (see Port Table)
val	bit value (0 or 1)

5.18.10 Port Table

Port Number Table Mega32 and Mega128 (CAN)

Definition	Value
PortA	0
PortB	1
PortC	2
PortD	3
PortE (Mega128)	4
PortF (Mega128)	5
PortG (Mega128)	6

Portbits Table Mega32 and Mega128 (CAN)

Definition	Portbit	Portbit Name
PortA.0	0	PA0
...	...	...
PortA.7	7	PA7
PortB.0	8	PB0
...	...	...
PortB.7	15	PB7
PortC.0	16	PC0
...	...	...
PortC.7	23	PC7
PortD.0	24	PD0
...	...	...
PortD.7	31	PD7
from here only Mega128		
PortE.0	32	PE0
...	...	...
PortE.7	39	PE7
PortF.0	40	PF0
...	...	...
PortF.7	47	PF7
PortG.0	48	PG0
...	...	...
PortG.4	52	PG4

Portbits Table AVR32

Definition	Portbit	Portbit Name
PortA.0	0	PA00
...	...	...
PortA.31	31	PA31
PortB.0	32	PB00
...	...	...
PortB.31	63	PB31
PortC.0	64	PC00
...	...	...
PortC.31	95	PC31
PortD.0	96	PD00
...	...	...
PortD.31	127	PD31

AVR32 Application Board Port Table

Board Port	Portbit	Portbit Name
Port1	0	PA00
Port2	1	PA01
Port3	2	PA02
Port4	3	PA03
Port5	36	PB04
Port6	37	PB05
Port7	38	PB06
Port8	16	PA16
Port9	4	PA04
Port10	5	PA05
Port11	6	PA06
Port12	7	PA07
Port13	8	PA08
Port14	9	PA09
Port15	10	PA10
Port16	11	PA11
Port17	19	PA19
Port18	20	PA20
Port19	21	PA21
Port20	22	PA22
Port21	23	PA23
Port22	24	PA24
Port23	25	PA25
Port24	13	PA13
Port25	12	PA12
Port26	14	PA14
Port27	15	PA15

Port28	52	PB20
Port29	53	PB21
Port30	54	PB22
Port31	55	PB23
Port32	65	PC01
Port33	70	PC06
Port34	68	PC04
Port35	69	PC05
Port36	81	PC17
Port37	82	PC18
Port38	79	PC15
Port39	80	PC16
Port40	83	PC19
Port41	84	PC20
Port42	76	PC12
Port43	75	PC11
Port44	77	PC13
Port45	78	PC14
Port46	85	PC21
Port47	86	PC22
Port48	87	PC23
Port49	88	PC24
Port50	95	PC31
Port51	103	PD07
Port52	104	PD08
Port53	117	PD21
Port54	118	PD22
Port55	119	PD23
Port56	51	PB19
Port57	34	PB02

5.18.11 Port Example (Mega)

```
// Program toggles the LED's on the applicationboard
// alternately every second
void main(void)
{
    Port_DataDirBit(PORT_LED1,PORT_OUT);
    Port_DataDirBit(PORT_LED2,PORT_OUT);

    while(true)  // endless loop
    {
        Port_WriteBit(PORT_LED1,PORT_ON);
        Port_WriteBit(PORT_LED2,PORT_OFF);
        AbsDelay(1000);
        Port_WriteBit(PORT_LED1,PORT_OFF);
        Port_WriteBit(PORT_LED2,PORT_ON);
        AbsDelay(1000);
    }
}
```

5.18.12 Port Example (AVR32Bit)

All three program examples will light LED1 as long as button T1 is pressed. The examples differ in addressing the port name. If the button is not pressed, a "1" will be read from the port because each switch on the Applicationboard is connected to a pull-up resistor.

```
// Example with Function Name defines
void main(void)
{
    Port_Attribute(PORT_LED1, PORT_ATTR_OUTPUT | PORT_ATTR_INIT_LOW);
    Port_Attribute(PORT_T1, PORT_ATTR_INPUT);

    while(true)  // endless loop
    {
        if(Port_ReadBit(PORT_T1))
        {
            Port_WriteBit(PORT_LED1, PORT_OFF);
        }
        else
        {
            Port_WriteBit(PORT_LED1, PORT_ON);
        }
    }
}

// LED1 will be lit as long as button T1 is pressed
// Example with Unit Name defines
void main(void)
{
    Port_Attribute(P48, PORT_ATTR_OUTPUT | PORT_ATTR_INIT_LOW);
    Port_Attribute(P41, PORT_ATTR_INPUT);

    while(true)  // Endlosschleife
    {
        if(Port_ReadBit(P41))
        {
            Port_WriteBit(P48, PORT_OFF);
        }
        else
        {
            Port_WriteBit(P48, PORT_ON);
        }
    }
}

// LED1 will be lit as long as button T1 is pressed
// Example with AVR32 Port Name defines
```

```
void main(void)
{
    Port_Attribute(PC23, PORT_ATTR_OUTPUT | PORT_ATTR_INIT_LOW);
    Port_Attribute(PC20, PORT_ATTR_INPUT);

    while(true)  // Endlosschleife
    {
        if(Port_ReadBit(PC20))
        {
            Port_WriteBit(PC23, PORT_OFF);
        }
        else
        {
            Port_WriteBit(PC23, PORT_ON);
        }
    }
}
```

5.19 RC5

A common used standard protocol for infrared data communication is the RC5 code, originally developed by Phillips. This code has an instruction set of 2048 different instructions and is divided into 32 address of each 64 instructions. Every kind of equipment use his own address, so this makes it possible to change the volume of the TV without change the volume of the hifi. The transmitted code is a dataword which consists of 14 bits.

Original protocol:

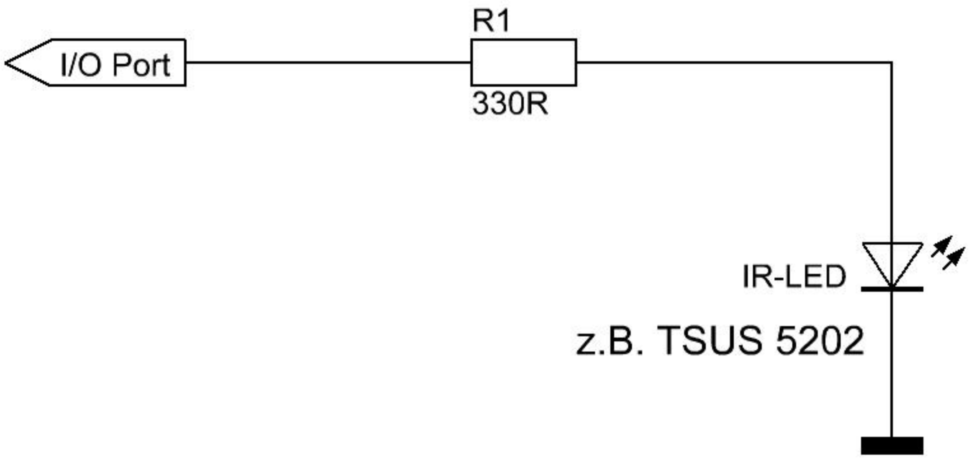
- 2 start bits for the automatic gain control in the infrared receiver
- 1 toggle bit (changes every time a new button is pressed on the IR transmitter)
- 5 address bits for the system address
- 6 instruction bits for the pressed key

The start bits help the IR receiver to synchronize and to adjust the automatic gain control of the signal. The toggle bit changes its value with every keypress. Therefore it is possible to distinguish the long press of a key with repeated presses of the same key. After a while there was a need to extend the number of possible instructions from 64 to 128. To maintain compatibility the second start bit was used for this purpose. If the second start bit is "1", the first 64 instructions can be addressed, if the 2nd start bit is "0" the next 64 instructions can be selected.

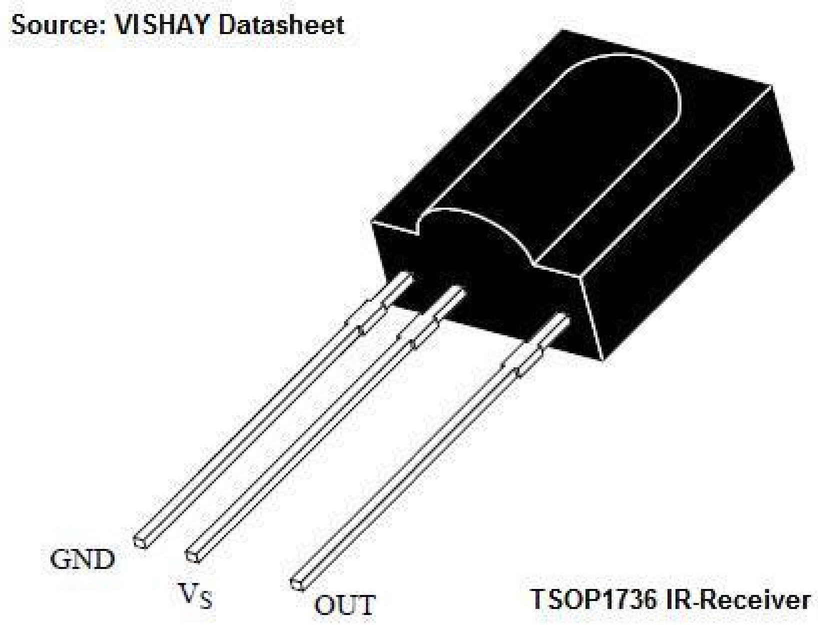
How are the individual bits transferred?

The C-Control Pro generates a carrier frequency of approx. 36Khz on the configured pin, that is connected to the IR-Diode. All transmission pulses are 6,9444 long. There is a delay of 20,8332 µs between two pulses. For a "1" value, the frequency generation of the transmission is turned of for 889µs, and then turned on for 889µs (this equals to 32 IR impulses). A value of "0" is created with a pause of 889µs, followed from a frequency generation of 889µs. The time to transfer a whole bit is 1,778ms (2 * 889µs) and to transfer a complete 14 bit dataword is 24,889ms. If a key on remote control is pressed for a longer duration, the corresponding dataword is repeated every 113m778ms.

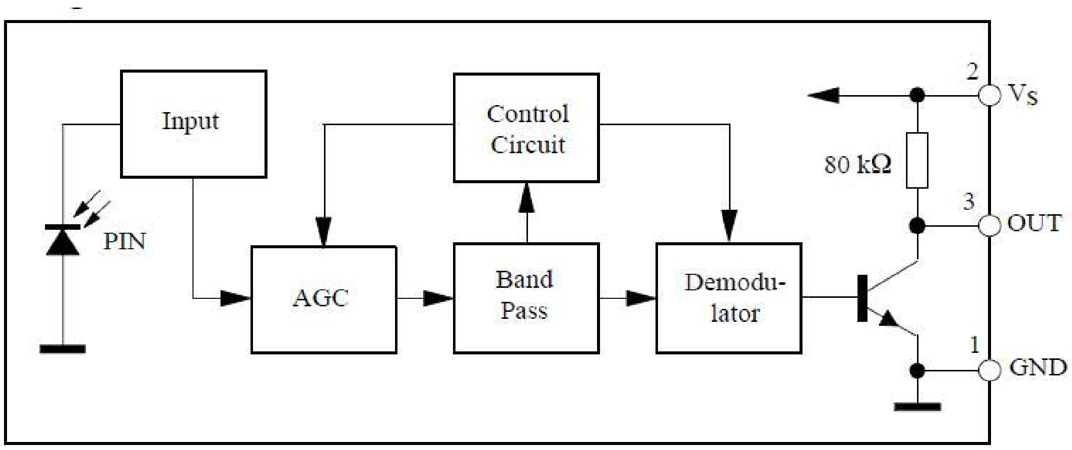
Connection to C-Control Pro (Sender diode)



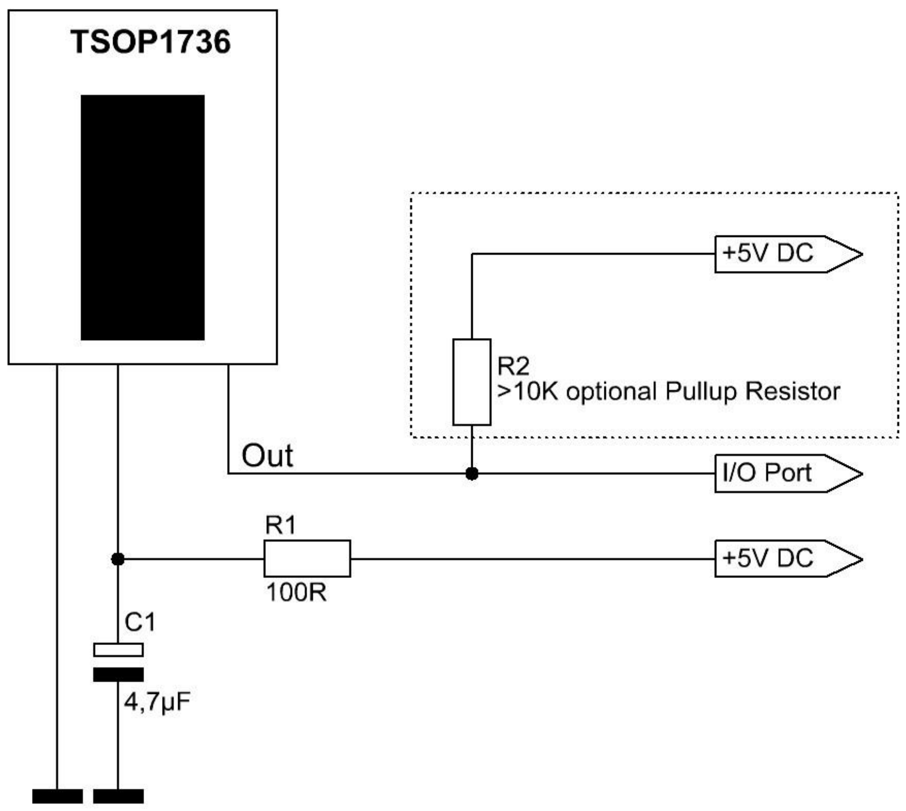
Connection to C-Control Pro (Receiver)



Pin assignment of TSOP1736 IR-Receiver



Internal struture of receiver



External circuit of receiver for connection to C-Control Pro

5.19.1 RC5_Init

RC5 Functions

Syntax

```
void RC5_Init(byte pin);

Sub RC5_Init(pin As Byte)
```

Description

The port pin is defined, that is connected to RC5 sender or receiver.

Parameter

pin	bit number of port (see Port Table)

5.19.2 RC5_Read

RC5 Functions

Syntax

```
word RC5_Read(void);

Sub RC5_Read() As Word
```

Description

Recognized RC5 datawords are received from the defined port pin. If there is no signal, the receive routine waits up to 130ms. This is because there is a 113ms gap between two repeated RC5 datawords. A return value of 0 means that no RC5 signal could be detected.

This function will not recognize if a different format than RC-5 is used. In case of doubt it will return wrong values.

Return Parameter

14 Bit of the received RC-5 commands

5.19.3 RC5_Write

RC5 Functions

Syntax

```
void RC5_Write(word data);

Sub RC5_Write(data As Word)
```

Description

The 14 bit of a RC5 dataword are send to the defined port pin.

To drive the infrared LED the output port is set to maximum drive strength. But not all port pin have this output rating. See AVR32Bit Module.

Parameter

data	recognized RC5 dataword

5.20 RS232

➜ There is a chance to miss received characters when using the polled serial routines, especially at high baud rates. If this is an issue, please use the interrupt driven serial routines with Serial_Init_IRQ() instead of Serial_Init().

Mega

The serial interface can be operated at speeds of up to 230.4 kilo baud. With the functions for the serial interface the first parameter will indicate the port number (0 or 1). The Mega32 does only provide one serial interface (0), while the Mega128 does provide two interfaces (0, 1).

AVR32Bit

The C-Control Pro AVR32Bit supports up to 3 serial interfaces with maximum rates to 460.8 kilo baud. The serial interfaces are enumerated from 0 to 2. The number differs from the naming on the Atmel AVR32 Microcontroller:

C-Control AVR32Bit	Atmel AVR32
0	USART0
1	USART3
2	USART4

5.20.1 Divider (Mega)

The functions Serial_Init() and Serial_Init_IRQ get a divider value as baudrate parameter. The baudrate is derived from the processor clock (14,7456 MHz for Mega32, Mega128 and 16 MHz for Mega128 CAN).

According to the Atmel processor handbook the following formula is used to calculate the divider for a specified baudrate:

divider = (processor clock / baudrate / 16) -1

Example: 15 = (14745600 / 57600 / 16) -1

➡ It is difficult to obtain the standard baudrates from the 16 MHz processor clock of the Mega128 CAN. Therefore are differences at higher baudrates between both divider tables.

DoubleClock Mode

If the High-Bit of the divider is set, the DoubleClock Mode is enabled. In this mode the divider value must be doubled. E.g. for 57600 baud a divider value of 0f Hex (decimal 15) or 801e Hex (= 0x8000 + 2 * 15) can be used. For the MIDI baudrate (31250 baud) a divider of (14745600 / 31250 / 16) -1 = 28.49 has to be used. Since you can only pass integer values?you get a better value in double clock mode: 8039 Hex (= 8000 Hex + 2 * 28.5).

Table divider definition 14,7456 MHz (Mega32, Mega128):

divider	definition	baudrate
3071	SR_BD300	300bps
1535	SR_BD600	600bps
767	SR_BD1200	1200bps
383	SR_BD2400	2400bps
191	SR_BD4800	4800bps
95	SR_BD9600	9600bps
63	SR_BD14400	14400bps
47	SR_BD19200	19200bps
31	SR_BD28800	28800bps
8039 (Hex)	SR_BDMIDI	31250bps
23	SR_BD38400	38400bps
15	SR_BD57600	57600bps
11	SR_BD76800	76800bps
7	SR_BD115200	115200bps
3	SR_BD230400	230400bps

Table divider definition 16 MHz (Mega128 CAN):

divider	definition	baudrate
3332	SR_BD300	300bps
1666	SR_BD600	600bps
832	SR_BD1200	1200bps
416	SR_BD2400	2400bps
207	SR_BD4800	4800bps
103	SR_BD9600	9600bps
68	SR_BD14400	14400bps
51	SR_BD19200	19200bps
34	SR_BD28800	28800bps

31	SR_BDMIDI	31250bps
25	SR_BD38400	38400bps
8022 (Hex)	SR_BD57600	57600bps
12	SR_BD76800	76800bps
6	SR_BD125000	125000bps
3	SR_BD250000	250000bps

5.20.2 Serial_Disable

Serial Functions

Syntax

```
void Serial_Disable(byte serport);

Sub Serial_Disable(serport As Byte)
```

Description

The serial interface gets switched off and the corresponding ports can be used otherwise.

Parameter

serport interface number (0 = 1st serial port, 1 = 2nd serial port, ...)

5.20.3 Serial_Init (Mega)

Serial Functions Example

Syntax

```
void Serial_Init(byte serport, byte par, word divider);

Sub Serial_Init(serport As Byte, par As Byte, divider As Word)
```

Description

The serial interface gets initialized. The parameter par is defined through successive or-ing of predefined bit values. The values of *character length*, *stop bits* and *parity* are or'd together. E.g. "SR_7BIT | SR_2STOP | SR_EVEN_PAR" means 7 bit character length, 2 stop bits and even parity (see Example). An example in BASIC Syntax: "SR_7BIT Or SR_2STOP Or SR_EVEN_PAR". The baud rate is defined as a divider value (see divider table).

There is a chance to miss received characters when using the polled serial routines, especially at high baud rates. If this is an issue, please use the interrupt driven serial routines with Serial_Init_IRQ() instead of Serial_Init().

It is possible to activate the DoubleClock Mode of the Atmel AVR. This happens if the Hi-bit of the divider is set. In DoubleClock mode the normal value from the divider table must be doubled to get the same baudrate. This has the advantage that baudrates, that have no exact divider value can be represented. E.g. MIDI: The new value SB_MIDI (=803a Hex) lies much nearer at the correct value of 31250baud. An example for 19200 baud: The normal divider value for 19200 baud is 002f (Hex). If DoubleClock Mode is used, the divider must be doubled (=005e Hex). Then set the Hi-bit, and the alternative divider value for 19200 baud is 805e (Hex).

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port, ...)
par	interface parameter (see par table)
divider	baud rate initialization (see table)

table par definitions:

Definition	Function
SR_5BIT	5 Bit char length
SR_6BIT	6 Bit char length
SR_7BIT	7 Bit char length
SR_8BIT	8 Bit char length
SR_1STOP	1 stop bit
SR_2STOP	2 stop bit
SR_NO_PAR	no parity
SR_EVEN_PAR	even parity
SR_ODD_PAR	odd parity

5.20.4 Serial_Init (AVR32)

Serial Functions Example

Syntax

```
void Serial_Init(byte serport, byte par, dword baud);

Sub Serial_Init(serport As Byte,par As Byte, baud As ULong)
```

Description

The serial interface gets initialized. The parameter par is defined through successive or-ing of predefined bit values. The values of *character length*, *stop bits* and *parity* are or'd together. E.g. "SR_7BIT | SR_2STOP | SR_EVEN_PAR" means 7 bit character length, 2 stop bits and even parity (see Example). An example in BASIC Syntax: "SR_7BIT Or SR_2STOP Or SR_EVEN_PAR".

➡ There is a chance to miss received characters when using the polled serial routines, especially at high baud rates. If this is an issue, please use the interrupt driven serial routines with Serial_Init_IRQ() instead of Serial_Init().

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port, ...)
par	interface parameter (see par table)
baud	baud rate

table par definitions:

Definition	Function
SR_5BIT	5 Bit char length
SR_6BIT	6 Bit char length
SR_7BIT	7 Bit char length
SR_8BIT	8 Bit char length
SR_1STOP	1 stop bit
SR_2STOP	2 stop bit
SR_NO_PAR	no parity
SR_EVEN_PAR	even parity
SR_ODD_PAR	odd parity

5.20.5 Serial_Init_IRQ (Mega)

Serial Functions Example

Syntax

```
void Serial_Init_IRQ(byte serport, byte ramaddr[], byte recvlen,
                     byte sendlen, byte par, word divider);

Sub Serial_Init_IRQ(serport As Byte,ByRef ramaddr As Byte,recvlen As Byte,
                    sendlen As Byte, par As Byte, divider As Word)
```

Description

The serial interface gets initialized for usage in interrupt mode. The user has to provide a global variable as a serial buffer. This buffer services as a storage for the data that is sent to the serial interface and is received from it. The size of the buffer must be **length of the send buffer plus the length of the receive buffer plus SR_BUF** (see Example).

The maximum value for the size of the send and the receive buffer is 255 bytes each. The parameter par is defined through successive or-ing of predefined bit values. The values of *character length*, *stop bits* and *parity* are or'd together. E.g. "SR_7BIT | SR_2STOP | SR_EVEN_PAR" means 7 bit character length, 2 stop bits and even parity (see Example). An example in BASIC Syntax: "SR_7BIT Or SR_2STOP Or SR_EVEN_PAR". The baud rate is defined as a divider value (see divider table).

➔ The user supplied buffer must be available the whole time the serial interface is working. Since after leaving a function the local variables are no longer available, it is most times a good idea to provide the user supplied buffer as a global variable.

➔ It is possible to activate the DoubleClock Mode of the Atmel AVR. See Divider.

Please use Serial_ReadExt() if you work in serial IRQ mode. Serial_Read() only supports polled mode.

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port, ...)
ramaddr	address of the buffer
recvlen	size of receive buffer
sendlen	size of send buffer
par	interface parameter (see par table)
divider	baud rate initialization (see table)

table par definitions:

Definition	Function
SR_5BIT	5 Bit char length
SR_6BIT	6 Bit char length
SR_7BIT	7 Bit char length
SR_8BIT	8 Bit char length
SR_1STOP	1 stop bit
SR_2STOP	2 stop bit
SR_NO_PAR	no parity
SR_EVEN_PAR	even parity
SR_ODD_PAR	odd parity

5.20.6 Serial_Init_IRQ (AVR32)

Serial Functions Example

Syntax

```
void Serial_Init_IRQ(byte serport, byte ramaddr[], word recvlen,
                     word sendlen, byte par, dword baud);

Sub Serial_Init_IRQ(serport As Byte,ByRef ramaddr As Byte,recvlen As Word,
                    sendlen As Word, par As Byte, baud As ULong)
```

Description

The serial interface gets initialized for usage in interrupt mode. The user has to provide a global variable as a serial buffer. This buffer services as a storage for the data that is sent to the serial interface and is received from it. The size of the buffer must be **length of the send buffer plus the length of the receive buffer plus SR_BUF** (see Example).

The maximum value for the size of the send and the receive buffer is 65535 bytes each, but this is of course limited to the RAM size. The parameter par is defined through successive or-ing of predefined bit values. The values of *character length*, *stop bits* and *parity* are or'd together. E.g. "SR_7BIT | SR_2STOP |

SR_EVEN_PAR" means 7 bit character length, 2 stop bits and even parity (see Example). An example in BASIC Syntax: "SR_7BIT Or SR_2STOP Or SR_EVEN_PAR".

The user supplied buffer must be available the whole time the serial interface is working. Since after leaving a function the local variables are no longer available, it is most times a good idea to provide the user supplied buffer as a global variable.

Please use Serial_ReadExt() if you work in serial IRQ mode. Serial_Read() only supports polled mode.

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port, ...)
ramaddr	address of the buffer
recvlen	size of receive buffer
sendlen	size of send buffer
par	interface parameter (see par table)
baud	baud rate

table par definitions:

Definition	Function
SR_5BIT	5 Bit char length
SR_6BIT	6 Bit char length
SR_7BIT	7 Bit char length
SR_8BIT	8 Bit char length
SR_1STOP	1 stop bit
SR_2STOP	2 stop bit
SR_NO_PAR	no parity
SR_EVEN_PAR	even parity
SR_ODD_PAR	odd parity

5.20.7 Serial_IRQ_Info

Serial Functions

Syntax

```
byte Serial_IRQ_Info(byte serport, byte info);

Sub Serial_IRQ_Info(serport As Byte, info As Byte) As Byte
```

Description

In dependency of the info parameter the function returns how many bytes have been received or a written to the send buffer.

Parameter

serport interface number (0 = 1st serial port, 1 = 2nd serial port)

info values:

RS232_FIFO_RECV (0)	number of bytes received
RS232_FIFO_SEND(1)	number of bytes written to he send buffer

Return Parameter

result in bytes

5.20.8 Serial_Read (Mega)

Serial Functions

Syntax

```
byte Serial_Read(byte serport);

Sub Serial_Read(serport As Byte) As Byte
```

Description

Reads one byte from the serial interface. If is there is no byte available in the serial interface, the function waits until a byte has been received.

➔ Please use Serial_ReadExt() if you work in serial IRQ mode. Serial_Read() only supports polled mode.

➔ The function is not supported in the AVR32Bit, since the function is waiting forever, when no data is received. E.g. no incoming Ethernet packets would be processed.

Parameter

serport interface number (0 = 1st serial port, 1 = 2nd serial port)

Return Parameter

received byte from the serial interface

5.20.9 Serial_ReadExt

Serial Functions

Syntax

```
word Serial_ReadExt(byte serport);

Sub Serial_ReadExt(serport As Byte) As Word
```

Description

Reads one byte from the serial interface. In opposite to Serial_Read() Serial_ReadExt() returns immediately even if there is no byte available in the serial port. In this case 256 (100 Hex) is returned.

➔ Please use Serial_ReadExt() if you work in serial IRQ mode. Serial_Read() only supports polled mode.

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port)

Return Parameter

received byte from the serial interface
256 (100 Hex) if there was no byte available

5.20.10 Serial_Write

Serial Functions Example

Syntax

```
void Serial_Write(byte serport, byte val);

Sub Serial_Write(serport As Byte, val As Byte)
```

Description

One byte is send to the serial interface.

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port)
val	output byte value

5.20.11 Serial_WriteText

Serial Functions

Syntax

```
void Serial_WriteText(byte serport, char text[]);

Sub Serial_WriteText(serport As Byte, ByRef Text As Char)
```

Description

All characters of the char array up to the terminating zero are send to the serial interface.

Parameter

serport	interface number (0 = 1st serial port, 1 = 2nd serial port)
text	char array

5.20.12 Serial Example

```
// string output on the serial interface
void main(void)
{
    int i;
    char str[10];

    str="test";
    i=0;
    // initialize serial port with 19200baud, 8 bit, 1 stop bit, no parity
    Serial_Init(0,SR_8BIT|SR_1STOP|SR_NO_PAR,SR_BD19200);

    while(str[i]) Serial_Write(0,str[i++]);  // output string to serial port
}
```

5.20.13 Serial Example (IRQ)

```
// 35 byte send + receive buffer + SR_BUF byte internal FIFO organization
byte buffer[35+SR_BUF];                              // array declaration

// string output to serial interface
void main(void)
{
    int i;
    char str[10];

    str="test";
    i=0;
    // initialize serial port with 19200baud, 8 bit, 1 stop bit, no parity
    // 20 byte receive buffer - 15 byte send buffer
    Serial_Init_IRQ(0,buffer,20,15,SR_8BIT|SR_1STOP|SR_NO_PAR,SR_BD19200);

    while(str[i]) Serial_Write(0,str[i++]);  // display string
    while(1);  // endless loop
}
```

5.21 SDCard

SD-Card Support for C-Control Pro AVR32Bit

The card holder for the Micro SD cards is directly under the C-Control Pro AVR32Bit Unit. See description of the AVR32Bit Unit. Please consult the Pin Assignment for the description of the used signals. Unlike the mega-SD card interface, there is no Enable line over which a reset can be triggered. In the demo programs this part is commented out for the AVR32Bit Unit.

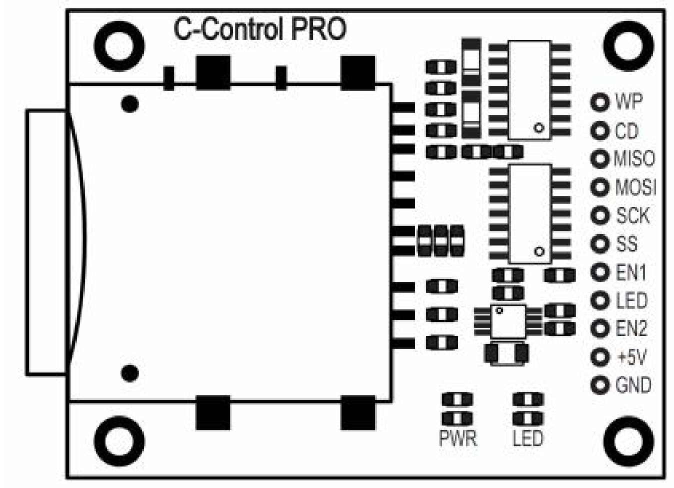
SD-Card Support for C-Control Pro Mega 128 and Mega 128 CAN

The C-Control Pro SD Card interface (Conrad Order No. 197220) is used for connecting a microcontroller, such as C-Control Unit 128 Mega (Conrad Order No. 198219) to a 3.3 SD card. The SD-card expansion features a level converter, which bidirectional converts the signals, allowing a direct connection of the SD card to a 5V microcontroller. All memory cards, on the market this time, such as SD, SDHC, MMC and other cards can be used with a corresponding SD card adapter.

The SD card is not supported on the C-Control Pro Mega32 because there is no room in the flash memory (32kb) to contain the FAT file system routines.

When the SD card is used in conjunction with USB and the application board, there is a collision on the SPI bus. Unfortunately, the USB interface on the application board allows no sharing of the SPI interface. The Projectboards are not affected, because they communicate via the serial interface. If you want to use the SD Card interface, you have to remove the jumper on the application board (**Mega128** PB.0 to PB.4 and PE.5).

The signals PB.5 to PB.7 are not absolutely necessary, in the demo programs they will be used for the enable signals and LED control. You can save these pins, if you decide to hardwire these signals.



Card holder	PIN Mega128
WP	PE.5
CD	PB.4
MISO	PB.3
MOSI	PB.2
SCK	PB.1
SS	PB.0
EN1	PB.5

LED	PB.7
EN2	PB.6

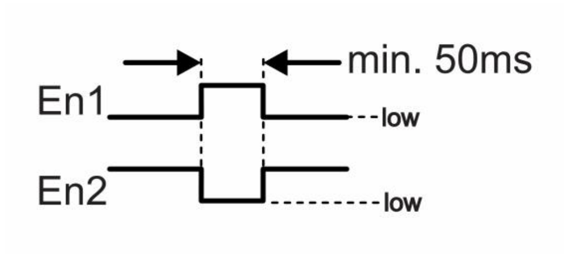
WP (Write Protect):
high = write protected SD card
low = access allowed

CD (Card Detect):
high = SD-Card not recognized
low = SD-Card detected

SPI- Interface:
MISO
MOSI
SCK
SS

Other:
LED -> User Led (5V level)

Reset Circuit:
En1 = Reset the SD-Card (low = running mode / high = reset)
En2 = Supply SD-Card holder (low = off / high = on)
The bottom diagram shows the performance of the hardware reset.



Insert SD-Card:
The SD card must always be inserted that the contacts show towards the circuit board of the SD-Card interface. An incorrect insertion of the SD-Card may damage the card holder.

Technical data:
Supply voltage: +5V/DC
Current consumption: max. 150mA
SPI inputs and outputs: 5V level (TTL)
Permissible ambient temperature: 0° C to +70 °C
Permissible ambient relative humidity: 20 - 80% RH, noncondensing
Dimensions: approx 53.5 x 42 x 4.5 mm
Weight: 10g

5.21.1 FAT Support

FAT Specification

- FAT support: FAT12, FAT16 and FAT32.
- Open files: Unlimited, depending on available memory.
- File size: Dependent from FAT Type (up to 4G bytes).
- Volume size: Dependent from FAT Type (up to 2T bytes at 512 bytes/sector)
- Cluster size: Dependent from FAT Type (up to 64K bytes at 512 bytes/sector)
- Sector size: Dependent from FAT Type (up to 4K bytes)

The SD card functions support no long file names (LFN) under FAT. Firstly, the long file names have expanded RAM and flash memory requirements, since they are based on Unicode, secondly, the company Microsoft (TM) holds a patent on the use of LFN. The file or directory name must therefore have the 8.3 format.

5.21.2 SDC Return Values

All SDC Functions return a status Byte that describes the success of the SDC operation.

Error	Value	Description
FR_OK	0	operation successful
FR_DISK_ERR	1	physical access failed
FR_INT_ERR	2	wrong FAT structure or internal error
FR_NOT_READY	3	no disk available
FR_NO_FILE	4	file not found
FR_NO_PATH	5	path not correct
FR_INVALID_NAME	6	invalid file name
FR_DENIED	7	file access denied
FR_EXIST	8	file already exists
FR_INVALID_OBJECT	9	file not opened with SDC_FOpen
FR_WRITE_PROTECTED	10	disk write protected
FR_INVALID_DRIVE	11	drive number invalid
FR_NOT_ENABLED	12	logical drive not mounted
FR_NO_FILESYSTEM	13	no FAT table found on disk
FR_MKFS_ABORTED	14	not possible, since mkfs not available
FR_TIMEOUT	15	device is not answering

5.21.3 SDC_FClose

SDCard Functions

Syntax

```
byte SDC_FClose(byte fil_ramaddr[]);

Sub SDC_FClose(ByRef fil_ramaddr As Byte) As Byte
```

Description

Closes a previously opened file.

Parameter

fil_ramaddr	address of the FILE buffer

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.4 SDC_FOpen

SDCard Functions

Syntax

```
byte SDC_FOpen(byte fil_ramaddr[], char path[], byte mode);

Sub SDC_FOpen(ByRef fil_ramaddr As Byte, ByRef path As Char,
              mode As Byte) As Byte;
```

Description

Opens a file. For each open file a FILE buffer has to be created. For this we define a byte array of size 32.

➔ The user-provided RAM buffer must be reserved during the access to the SD card. Since local variables will be released after leaving the function, it usually makes sense to declare the buffer as a global variable.

Parameter

fil_ramaddr	address of the FILE buffer
path	file path
mode	file mode

Return Parameter

Success of the called SDC function. See SDC Return Values.

mode parameter:

The individual parameters are ORed like e.g.:

```
  FA_CREATE_NEW | FA_WRITE  // CompactC
  FA_CREATE_NEW Or FA_WRITE  ' BASIC
```

Mode	Value (Hex)	Description
FA_OPEN_EXISTING	00	Opens file. If file does not exist, then error
FA_READ	01	File reading allowed
FA_WRITE	02	File writing allowed
FA_CREATE_NEW	04	Creates file, if file already exists, then error
FA_CREATE_ALWAYS	08	Creates file, if file already exists, then file is truncated
FA_OPEN_ALWAYS	10	Opens file. If file does not exist, then file is created

5.21.5 SDC_FRead

SDCard Functions

Syntax

```
byte SDC_FRead(byte fil_ramaddr[], byte buf[], word btr, word br[]);

Sub SDC_FRead(ByRef fil_ramaddr As Byte, ByRef buf As Byte, btr As Word,
              ByRef br As Word) As Byte
```

Description

Reads data from an open file. The data is written at the reading position from the file into the buffer buf. The number of bytes to read is btr, the number of bytes that were actually read is copied in the first element of br. The reading position can be determined with SDC_FSeek.

Parameter

fil_ramaddr	address of the FILE buffer
buf	RAM address to where the bytes a read from the SD card
btr	number of bytes to read
br	actual number of bytes read

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.6 SDC_FSeek

SDCard Functions

Syntax

```
byte SDC_FSeek(byte fil_ramaddr[], dword pos);

Sub SDC_FSeek(ByRef fil_ramaddr As Byte, pos As ULong) As Byte
```

Description

Sets the read / write position of the opened file. The position pos is always counted from the beginning of the file.

Parameter

fil_ramaddr	address of the FILE buffer
pos	read / write position

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.7 SDC_FSetDateTime

SDCard Functions

Syntax

```
byte SDC_FSetDateTime(char path[], byte day, byte mon, word year, byte min,
                      byte hours, byte sec);

Sub SDC_FSetDateTime(ByRef path As Char,day As Byte,mon As Byte,year As Word,
                     min As Byte, hours As Byte, sec As Byte) As Byte
```

Description

Set the date and time attributes of a file.

Parameter

path	file path
day	Day (1-31)
mon	Month (1-12)
year	Year (1980-2107)
min	Minute (0-59)
hours	Gour (0-23)
sec	Second (0-59) (is always set to an even value)

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.8 SDC_FStat

SDCard Functions

Syntax

```
byte SDC_FStat(char path[], dword filinfo[]);

Sub SDC_FStat(ByRef path As Char, ByRef filinfo As ULong) As Byte
```

Description

Read attributes of a file to a dword (ULong) array with 4 elements.

Parameter

path	file path
filinfo	return array

Return Parameter

Success of the called SDC function. See SDC Return Values.

Rückgabe Array:

fileinfo[0]	file length
fileinfo[1]	date
fileinfo[2]	time
fileinfo[3]	file attribute

Coding date:
Bits 0:4 - day: 1...31
Bits 5:8 - month: 1...12
Bits 9:15 - year begin with 1980: 0...127

Coding time:
Bits 0:4 - seconds/2: 0...29
Bits 5:10 - minute: 0...59
Bits 11:15 - hour: 0...23

Coding file attribute:
Bit 1: Read Only
Bit 2: Hidden
Bit 3: Volume label
Bit 4: Directory
Bit 5: Archive

5.21.9 SDC_FSync

SDCard Functions

Syntax

```
byte SDC_FSync(byte fil_ramaddr[]);

Sub SDC_FSync(ByRef fil_ramaddr As Byte) As Byte
```

Description

Waits for all data to be written from the buffer into the file on the SD card.

Parameter

fil_ramaddr	address of the FILE buffer

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.10 SDC_FTruncate

SDCard Functions

Syntax

```
byte SDC_FTruncate(byte fil_ramaddr[]);

Sub SDC_FTruncate(ByRef fil_ramaddr As Byte) As Byte
```

Description

Delete the rest of the file from the current cursor position.

Parameter

fil_ramaddr	address of the FILE buffer

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.11 SDC_FWrite

SDCard Functions

Syntax

```
byte SDC_FWrite(byte fil_ramaddr[], byte buf[], word btr, word br[]);

Sub SDC_FWrite(ByRef fil_ramaddr As Byte, ByRef buf As Byte, btr As Word,
               ByRef br As Word) As Byte
```

Description

Writes data to an open file. The data from the buffer buf is written to the file at current file position. The parameter btr determines number of bytes to write. The number of bytes actual written is copied into the first element of br. The write position can be determined with SDC_FSeek.

Parameter

fil_ramaddr	address of the FILE buffer
buf	RAM address from where the bytes a written to the SD card
btr	number of bytes to write
br	actual number of bytes written

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.12 SDC_GetFree

SDCard Functions

Syntax

```
byte SDC_GetFree(char path[], dword kbfree[]);

Sub SDC_GetFree(ByRef path As Char, ByRef kbfree As ULong) As Byte
```

Description

Returns the number of free clusters on the SD Card. The number of free clusters is copied to the first element of the array kbfree.

Parameter

path	path to the root of the disk.
kbfree	return array

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.13 SDC_Init

SDCard Functions

Syntax

```
void SDC_Init(byte fat_ramaddr[]);

Sub SDC_Init(ByRef fat_ramaddr As Byte)
```

Description

Initializes the SD card library. For this operation a FAT buffer must be created. Therefore an array of size 562 is declared.

➔ The user-provided RAM buffer must be reserved during the access to the SD Card. Since local variables will be released after leaving the function, it usually makes sense to declare the buffer as a global variable.

Parameter

fat_ramaddr	address of the FAT buffer

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.14 SDC_MkDir

SDCard Functions

Syntax

```
byte SDC_MkDir(char path[]);

Sub SDC_MkDir(ByRef path As Char) As Byte
```

Description

Creates a directory on the SD card.

Parameter

path	path to the directory

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.15 SDC_Rename

SDCard Functions

Syntax

```
byte SDC_Rename(char oldpath[], char newpath[]);

Sub SDC_Rename(ByRef oldpath As Char, ByRef newpath As Char) As Byte
```

Description

Renames a file from oldpath to newpath.

Parameter

oldpath	file path
newpath	path to file with new name

➡ If newpath points to a directory other than oldpath, the file is not renamed only, but also moved into the new directory. In newpath may not be logical disk number, only in oldpath.

Return Parameter

Success of the called SDC function. See SDC Return Values.

5.21.16 SDC_Unlink

SDCard Functions

Syntax

```
byte SDC_Unlink(char path[]);

Sub SDC_Unlink(ByRef path As Char) As Byte
```

Description

Deletes a file.

Parameter

path	file path

Return Parameter

Success of the called SDC function. See SDC Return Values.

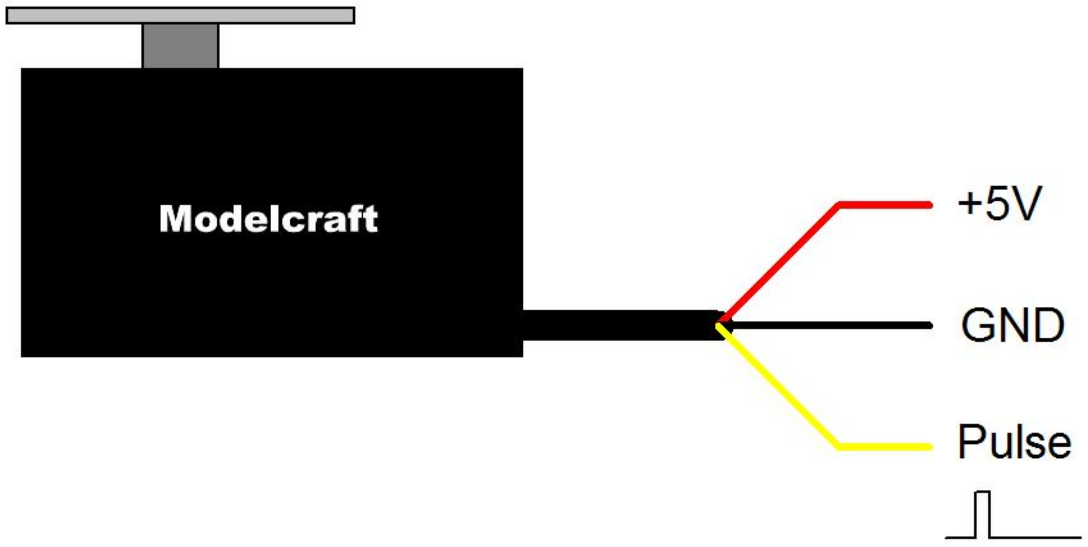
5.21.17 SD card Example

```
// Global variables
byte fat[562];
byte fil[32];

void main(void)
{
    // Local variables
    byte res;
    char buf[100];
    word bytes_written[1];

    // SD-Card reset
    Port_DataDirBit(13,1);           // PB.5 = output (EN1)
    Port_DataDirBit(14,1);           // PB.6 = Ausgang (EN2)

    Port_WriteBit(13,1);             // set EN1 for 50ms at +5V (PB.5)
    Port_WriteBit(14,0);             // set EN2 for 50ms to GND (PB.6)

    AbsDelay(50);                    // 50ms break

    Port_WriteBit(13,0);             // EN1 GND
    Port_WriteBit(14,1);             // EN2 +5V
    // Power on -> SD-Card
    Port_WriteBit(14,1);             // EN2 (PB.6) +5V

    AbsDelay(50);                    // 50ms Pause

    // SD-Card Fat init
    SDC_Init        (fat);

    // Create a new file folders
    SDC_MkDir("0:/CC-PRO");

    // Does the file already exists?
    // If the file is not created
    res=SDC_FOpen(fil, "0:/CC-PRO/test.txt", FA_READ|FA_WRITE|FA_OPEN_EXISTING);
    if(res!=0)SDC_FOpen(fil, "0:/CC-PRO/test.txt", FA_WRITE|FA_CREATE_ALWAYS);

    // Writes to a text file
    buf= "Hallo... 123!\r\n";
    SDC_FWrite(fil, buf, Str_Len(buf), bytes_written);
    SDC_FSync(fil);

    // File is closed
    SDC_FClose(fil);
}
```

5.22 Servo

RC servos are composed of a DC motor mechanically linked to a potentiometer. Pulse-width modulation (PWM) signals sent to the servo are translated into position commands by electronics inside the servo. When the servo is commanded to rotate, the DC motor is powered until the potentiometer reaches the value corresponding to the commanded position. The servo is controlled by three wires: ground (usually black/orange), power (red) and control (brown/other colour). The servo will move based on the pulses sent over the control wire, which set the angle of the actuator arm. The servo expects a pulse every 20 ms in order to gain correct information about the angle. The width of the servo pulse dictates the range of the servo's angular motion. A servo pulse of 1.5 ms width will set the servo to its "neutral" position, or 90°. For example a servo pulse of 1.25 ms could set the servo to 0° and a pulse of 1.75 ms could set the servo to 180°. The physical limits and timings of the servo hardware varies between brands and models, but a general servo's angular motion will travel somewhere in the range of 180° - 210° and the neutral position is almost always at 1.5 ms.

Connection to C-Control Pro



+5Volt ist the supply voltage of the servo, it must provide enough current to drive the servo. The ground of the servo and the ground of the C-Control Pro unit must be the same. The pulse for the servo is generated by the PWM signal of the C-Control unit.

5.22.1 Servo_Init

Servo Functions Example

Syntax

```
void Servo_Init(byte servo_cnt, byte servo_interval, byte ramaddr[],
                byte timer);

Sub Servo_Init(servo_cnt As Byte, servo_interval As Byte,
               ByRef ramaddr As Byte, timer As Byte)
```

Description

Intializes the internal servo routines. The servo_cnt parameter controls how many servos can be driven at the same time. The servo_interval parameter describes the period length (10 or 20ms), with timer the used 16-Bit timer can be chosen. Timer 3 is only available on the Mega128. The user must supply ram space to operate the servos. The required size is servo_cnt * 3. E.g., if the user wants to operate 10 servos, at **byte** array of 30 bytes is needed.

➔ The user supplied ram space must be available the whole time the servos are working. Since after leaving a function the local variables are no longer available, it is most times a good idea to provide the user supplied ram as a global variable.

➡ A 16-bit Timer is needed for the servo steering routines. Is the timer turned off, or is used for other purposes the servo routines will not work.

Parameter

servo_cnt	number of possible servos (maximum 20)
servo_interval	periodic length (0=10ms, 1=20ms)
ramaddr	address of memory block
timer	16-Bit Timer used for servo steering Mega32: 0 = Timer 1 Mega128 & Mega128 CAN: 0=Timer 1, 1=Timer 3 AVR32: all Timer (0 - 5)

5.22.2 Servo_Set

Servo Functions Example

Syntax

```
void Servo_Set(byte portbit, word pos);

Sub Serial_Init(portbit As Byte, pos As Word)
```

Description

Sets the pulse length to steer the actuator arm. The output port is set with the portbit parameter (See Pin Assignment of M32 and M128).

➡ The sum of all user set pulse lengths should not exceed the period length (see servo_interval parameter), otherwise an erratic behaviour could happen. E.g. with 20ms period length, a total of 8 servos can each be set to a pulse length of 2500µs. To have some safety margin, the sum of the pulse lengths should be **less** than the period length for a small amount.

Parameter

portbit	bit number of port (see Port Table)
pos	pulse length for servo in µsec (500 - 2500)

5.22.3 Servo Example

```
byte servo_var[30]; // Servo internal variables

// Activation of 3 Servos and stop after 10 seconds
void main(void)
{
    // Max. 10 Servos, 20ms interval, Timer 3
    Servo_Init(10, 1, servo_var, 1);

    Servo_Set(7, 2000);  // Servo Portbit 7   2000µs
    Servo_Set(6, 1800);  // Servo Portbit 6   1800µs
    Servo_Set(5, 1600);  // Servo Portbit 5   1600µs
```

```
        AbsDelay(5000);

        Servo_Set(7, 1000);  // Servo Portbit 7   1000µs

        AbsDelay(5000);

        Servo_Set(7, 0);     // all Servos off
        Servo_Set(6, 0);
        Servo_Set(5, 0);
    }
```

5.23 SPI

The Serial Peripheral Interface Bus or SPI bus is a synchronous serial data link standard named by Motorola that operates in full duplex mode. Devices communicate in master/slave mode where the master device initiates the data frame. Multiple slave devices are allowed with individual slave select (chip select) lines.

5.23.1 Mega

5.23.1.1 SPI_Disable

SPI Functions

Syntax

```
void SPI_Disable(void);

Sub SPI_Disable()
```

Description

The SPI will be disabled and the corresponding ports can be used otherwise.

➔ Disabling the SPI interface will prevent usage of the USB interface on the application board. On the other hand, if you don't use the USB interface, SPI_Disable() will allow to use these ports for other purposes.

Parameter

None

5.23.1.2 SPI_Enable

SPI Functions

Syntax

```
void SPI_Enable(byte ctrl);

Sub SPI_Enable(ctrl As Byte)
```

Description

The SPI interface is initialized with the value of ctrl (see **SPCR** register in Atmel Mega Reference Manual).

Parameter

ctrl initialization parameter (Mega SPCR Register)

Bit 7 - SPI Interrupt Enable (do not enable, cannot be used from C-Control Pro now)
Bit 6 - SPI Enable (must be set)
Bit 5 - Data Order (1 = LSB first, 0 = MSB first)
Bit 4 - Master/Slave Select (1 = Master, 0 = Slave)
Bit 3 - Clock polarity (1 = leading edge falling, 0 = leading edge rising)
Bit 2 - Clock Phase (1 = sample on trailing edge, 0 = sample on leading edge)

Bit 1	Bit 0	SCK Frequency
0	0	f_{Osc} / 4
0	1	f_{Osc} / 16
1	0	f_{Osc} / 64
1	1	f_{Osc} / 128

➔ Please consider, that f_{Osc} = 14,7456 Mhz for C-Control Pro Mega 32 and Mega128, while the C-Control Pro Mega128 CAN works at 16 Mhz.

5.23.1.3 SPI_Read

SPI Functions

Syntax

```
byte SPI_Read();

Sub SPI_Read() As Byte
```

Description

A byte is read from the SPI interface.

Return Parameter

received byte from the SPI interface

5.23.1.4 SPI_ReadBuf

SPI Functions

Syntax

```
void SPI_ReadBuf(byte buf[], word length);

Sub SPI_ReadBuf(ByRef buf As Byte, length As Word)
```

Description

A number of bytes are read from the SPI interface into an array.

Parameter

buf	pointer to byte array
length	number of bytes to read

5.23.1.5 SPI_Write

SPI Functions

Syntax

```
void SPI_Write(byte data);

Sub SPI_Write(data As Byte)
```

Description

One byte is send to the serial interface.

Parameter

data	output byte value

5.23.1.6 SPI_WriteBuf

SPI Functions

Syntax

```
void SPI_WriteBuf(byte buf[], word length);
```

```
Sub SPI_WriteBuf(ByRef buf As Byte, length As Word)
```

Description

A number of bytes are sent to the SPI interface.

Parameter

buf	pointer to byte array
length	number of bytes to be transferred

5.23.2 AVR32Bit

5.23.2.1 SPI_Disable

SPI Functions

Syntax

```
void SPI_Disable(byte chan);
```

```
Sub SPI_Disable(chan As Byte)
```

Description

The SPI interface is switched off and the associated ports can be used differently.

Parameter

chan	SPI channel (0 - 1)

5.23.2.2 SPI_Enable

SPI Functions

Syntax

```
void SPI_Enable(byte chan, dword speed, byte bits, byte mode);
```

```
Sub SPI_Enable(chan As Byte, speed As ULong, bits As Byte, mode As Byte)
```

Description

The SPI interface is initialized at a clock rate, number of data bits and SPI mode. A divider is then calculated internally from the speed parameter, to set the chip to the desired baud rate. Since the divider can only take a value between 1 and 255, the specified speed parameter is roughly maintained. The divider is selected that meets the desired clock rate closest: divider = 66Mhz / speed. The actual speed is then 66Mhz / divider. As a result, baud rates less than 259000 may not be used.

Parameter

chan	SPI channel (0 - 1)
speed	SPI baud rate (259000 - 66000000)
bits	number of data bits
mode	SPI mode

SPI Mode	CPOL	NCPHA
0	0	1
1	0	0
2	1	1
3	1	0

5.23.2.3 SPI_Read

SPI Functions

Syntax

```
word SPI_Read();

Sub SPI_Read() As Word
```

Description

Data is read from the SPI interface.

Return Parameter

received data (4-16 Bit) from the SPI interface

5.23.2.4 SPI_ReadBuf

SPI Functions

Syntax

```
void SPI_ReadBuf(byte buf[], word length);

Sub SPI_ReadBuf(ByRef buf As Byte, length As Word)
```

Description

A number of bytes is read from the SPI interface into an array. The functions works with up to 8 bits, regardless of whether the SPI interface is initialized with more bits.

Parameter

buf	pointer to byte array
length	number of bytes to read

5.23.2.5 SPI_SetChan

SPI Functions

Syntax

```
void SPI_SetChan(byte chan);

Sub SPI_SetChan(chan As Byte)
```

Description

Selects an SPI interface (SPI0 or SPI1) for further access.

Parameter

chan	SPI channel (0 - 1)

5.23.2.6 SPI_Write

SPI Functions

Syntax

```
void SPI_Write(word data);

Sub SPI_Write(data As Word)
```

Description

Data is written to the SPI interface.

Parameter

data	output data (4-16 Bit)

5.23.2.7 SPI_WriteBuf

SPI Functions

Syntax

```
void SPI_WriteBuf(byte buf[], word length);
```

```
Sub SPI_WriteBuf(ByRef buf As Byte, length As Word)
```

Description

A number of bytes are sent to the SPI interface. The function works with 8 bits, regardless of whether the SPI interface is initialized with more bits.

Parameter

buf	pointer to byte array
length	number of bytes to be transferred

5.24 Strings

One part of these string routines is implemented in the Interpreter, another can be called up after appending library "String_Lib.cc". Since the functions in "String_Lib.cc" are realized through Bytecode they are slower when executed. Library functions however have the advantage that they can be taken from the project by omitting the library in case they are not needed. Direct Interpreter functions are always present, will however take up flash memory.
There is no explicit "String" data type. A string is based on a character array. The size of the array must be chosen in such a way that all characters of the string fit into the character array. Additionally some space is needed for a terminating character (decimal Zero) in order to indicate the end of the character string.

5.24.1 Str_Comp

String Functions

Syntax

```
char Str_Comp(char str1[], char str2[]);

Sub Str_Comp(ByRef str1 As Char, ByRef str2 As Char) As Char
```

Description

Two strings are compared.

Parameter

str1	pointer to char array 1
str2	pointer to char array 2

Return Parameter

0	both strings are equal
<0	if the first string is smaller than the second
>0	if the first string is greater than the second

Remark

The attribute smaller or greater is specified for the character difference at the first point of difference between both strings.

5.24.2 Str_Copy

String Functions

Syntax

```
void Str_Copy(char destination[], char source[], word offset);

Sub Str_Copy(ByRef destination As Char, ByRef source As Char, offset As
Word)
```

Description

The source string (source) is copied to the destination string (destination). During copying also the string termination character of the source character string is copied.

Parameter

`destination`	pointer to destination string
`source`	pointer to source string
offset	Number of characters by which the source string is offset when copied to the destination string..

If offset has the value **STR_APPEND** (ffff Hex) then the length of the destination string is assumed as offset. In this case the source string is copied behind the destination string.

5.24.3 Str_Fill

String Functions (Library "*String_Lib.cc*")

Syntax

```
void Str_Fill(char dest[], char c, word len);

Sub Str_Fill(ByRef dest As Char, c As Char, len As Word)
```

Description

The string dest is filled with character c.

Parameter

dest	pointer to destination string
c	character that is written into the string
len	count, how often c is written into the string

5.24.4 Str_Isalnum

String Functions (Library "*String_Lib.cc*")

Syntax

```
byte Str_Isalnum(char c);

Sub Str_Isalnum(c As Char) As Byte
```

Description

A character is tested if it is alphabetically or a digit.

Parameter

c	tested character

Return Parameter

1	if the character is alphabetically or a digit (upper- or lowercase)
0	else

5.24.5 Str_Isalpha

String Functions (Library "*String_Lib.cc*")

Syntax

```
byte Str_Isalpha(char c);

Sub Str_Isalpha(c As Char) As Byte
```

Description

A character is tested if it is alphabetically.

Parameter

c	tested character

Return Parameter

1	if the character is alphabetically (upper- or lowercase)
0	else

5.24.6 Str_Len

String Functions

Syntax

```
word Str_Len(char str[]);

Sub Str_Len(ByRef str As Char) As Word
```

Description

The length of the string (character array) is returned.

Parameter

str pointer to string

Return Parameter

length of the string (without terminating zero)

5.24.7 Str_Printf

String Functions Example

Syntax

```
void Str_Printf(char str[], char format[], ...);

Sub Str_Printf(ByRef str As Char, ByRef format As Char, ...)
```

Description

This function creates a formatted string into str. The format string is similar to the formatting of printf() in C. The format always begins with "**%**", then follow optional **flags** (**0**,**l**), and it ends with a **type** (**d**,**x**,**s**,**f**). In the following table all type parameters are explained. Between **%** and **type** an optional **width** and **precision** can be used.

%[flags][*width]*[.*prec*]**Typ** (the brackets describes the optional part)

The **width** is the minimal space for the output of the number. If the number is smaller than **width**, the number is padded to the left with spaces. If the **width** begins with "0" the left is padded width "0" instead of spaces. A period "." describes an optional **precision** parameter, that defines the number of decimal places, when floating point numbers (**%f**) are used, or the base of the number when using unsigned integer (**%u**). See Str_Printf Example.

➔ If there is no "l" flag when a 32-Bit number is printed, only the lower 16 bits are displayed.

Flags	Description

0	padd with "0"
l	32-Bit Integer

Format	**Description**
%[*width*]**d**	integer
%[*width*][.*prec*]**u**	unsigned integer
%[*width*]**x**	hexadecimal
%[*width*][.*prec*]**f**	floating point
%[*width*]**s**	string
%[*width*]**c**	char

Parameter

str	pointer to string
format	pointer to format string

5.24.8 Str_ReadFloat

String Functions

Syntax

```
float Str_ReadFloat(char str[]);
```

```
Sub Str_ReadFloat(ByRef str As Char) As Single
```

Description

The value of a string representing a floating point number is returned. The number is recognized, even if there or other characters after the number.

Parameter

str pointer to string

Return Parameter

floating point value of string

5.24.9 Str_ReadInt

String Functions

Syntax

```
int Str_ReadInt(char str[]);
```

```
Sub Str_ReadInt(ByRef str As Char) As Integer
```

Description

The value of a string representing an integer number is returned. The number is recognized, even if there or other characters after the number.

Parameter

str pointer to string

Return Parameter

integer value of string

5.24.10 Str_ReadNum

String Functions

Syntax

```
word Str_ReadNum(char str[], byte base);

Sub Str_ReadNum(ByRef str As Char, base As Byte) As Word
```

Description

The value of a string representing an unsigned number is returned. The number is recognized, even if there or other characters after the number. The base parameter is the base of the numeric value. E.g. to read a hexadecimal number, a base of 16 is to apply.

Parameter

str	pointer to string
base	base of converted number

Return Parameter

numeric value of string

5.24.11 Str_Substr

String Functions (Library "*String_Lib.cc*")

Syntax

```
int Str_SubStr(char source[], char search[]);

Sub Str_SubStr(ByRef source As Char, ByRef search As Char) As Integer
```

Description

A substring search is searched inside string source. If the substring is found, the position of the substring is returned.

Parameter

source	string that is searched
search	substring that is looked for

Return Parameter

position of the found substring
-1 else

5.24.12 Str_WriteFloat

String Functions

Syntax

```
void Str_WriteFloat(float n, byte decimal, char text[], word offset);

Sub Str_WriteFloat(n As Single, decimal As Byte, ByRef text As Char,
offset As Word)
```

Description

The floating point number n is converted to an ASCII string with decimal number of decimal digits after the period. The result is stored in the string text with an offset of offset. The offset parameter is used to change a string after a specified number (offset) of characters and leave the beginning of the string intact.

Parameter

n	float number
decimal	number of decimal digit after the period
text	pointer to destination string
offset	offset that is applied to the position where the string is copied

If offset has the value **STR_APPEND** (ffff Hex) then the length of the destination string is assumed as offset. In this case the source string is copied behind the destination string.

5.24.13 Str_WriteInt

String Functions

Syntax

```
void Str_WriteInt(int n, char text[], word offset);

Sub Str_WriteInt(n As Integer, ByRef text As Char, offset As Word)
```

Description

The integer number n is converted to a signed ASCII string. The result is stored in the string text with an offset of offset. The offset parameter is used to change a string after a specified number (offset) of characters and leave the beginning of the string intact.

Parameter

n	integer number
text	pointer to destination string
offset	offset that is applied to the position where the string is copied

If offset has the value **STR_APPEND** (ffff Hex) then the length of the destination string is assumed as offset. In this case the source string is copied behind the destination string.

5.24.14 Str_WriteWord

String Functions

Syntax

```
void Str_WriteWord(word n, byte base, char text[], word offset, byte
minwidth);
```

```
Sub Str_WriteWord(n As Word, base As Byte, ByRef text As Char ,offset As
 Word, minwidth As Byte)
```

Description

The word n is converted to an ASCII string. The result is stored in the string text with an offset of offset. The offset parameter is used to change a string after a specified number (offset) of characters and leave the beginning of the string intact. If the resulting string is smaller than minwidth the beginning of the string gets filled with zeros "0".

The base of the numbering system can be given in the base parameter. If you set base to 2, you will get a string with binary digits. A base of 8 produces an octal string, and a base of 16 a hexadecimal string. If the base is set to a number greater than 16, more characters of the alphabet are used. E.g. a base of 18 produces a string with the digits '0'-'9' and 'A'-'H'.

Parameter

n	16 bit word
base	base of the number system
text	pointer to destination string
offset	offset that is applied to the position where the string is copied
minwidth	minimal width of the string

If offset has the value **STR_APPEND** (ffff Hex) then the length of the destination string is assumed as offset. In this case the source string is copied behind the destination string.

5.24.15 Str_Printf Example

```
// CompactC
void main(void)
{
    char str[80];

    // Integer
    Str_Printf(str, "arg1: %d\r", 1234);
    Msg_WriteText(str);

    // Ouput of integer, floating point, string und hex number
    Str_Printf(str, "arg1: %8d arg2:%10.3f arg3:%20s arg4: %x\r",
        1234, 2.34567, "hello world", 256);
    Msg_WriteText(str);
    Str_Printf(str, "arg1: %u arg2: %.2u\r", 65000, 0xff);
    Msg_WriteText(str);}
}
```

```
' Basic
Sub main()
    Dim str(80) As Char

    Str_Printf(str, "arg1: %08d arg2:%10.3f arg3:%20s arg4: %x\r",
      1234, 2.34567, "hello world", 256)
    Msg_WriteText(str)
    Str_Printf(str, "arg1: %u arg2: %.2u\r", 65000, &Hff)
    Msg_WriteText(str)
End Sub
```

5.25 Threads

Multi Threading

Multi Threading is a so to speak parallel execution of several tasks in a program. One of these tasks is called “Thread”. When Multi Threading it will rather rapidly be toggled between the various threads so the impression of simultaneousness is created.

The C-Control Pro firmware supports besides the main program (Thread "0") up to 13 additional threads. With Version 2.12 of the IDE the multithreading changed. Before 2.12 the user could set in the project options the number of Bytecodes that were executed before there was a thread change. This behavior was unfair, because some Bytecodes (especially floating point) needed much more CPU time than other Bytecodes. Now the multithreading scheduler works with time cycles. A user can assign the number of 10ms cycles a thread has before the next threads get executed.

In multithreading, after a certain number of time cycles the current thread will be set "*inactive*" and the next executable thread is searched for. After that the execution of the new thread will be started. The new thread may again be the same as before depending on how many threads had been activated or are ready for processing. The main program counts as first thread. Therefore thread "0" is active at all times even if no threads have explicitly been started.

➡ If the main program (thread "0") terminates, all other threads stop, too.

The priority of threads can be influenced by changing the number of time cycles which one thread is allowed to execute until the next thread change takes place. The smaller the number of cycles until the change takes place, the lower the priority of the thread.

Thread Configuration

Before IDE version 2.12 the threads were configured in the project options. That has changed. The configuration is now placed inside the source code with the new "**#thread**" keyword. The syntax is:

```
#thread thread_number, ram_used, number_of_time_cylces
```

A thread will receive as much space for its local variables as has been assigned to it. The exception is thread "0" (the main program). This thread will receive the entire memory space that has been left over by the other threads. The RAM assignment by the "**#thread 0"** statement for the main thread is ignored. Therefore it should be planned in advance how much memory space may be needed by each additional thread.

➡ The **"#thread"** statements need not be near the thread functions, but may be anywhere in the program. If no threads are used, a **"#thread 0"** command is unnecessary. If you forget to define a thread, the thread_start is ignored.

Example CompactC:

```
#thread 0, 0, 20  // main thread with task change every 20 * 10ms =200ms
#thread 1, 128, 10 //thread 1 with 128 Byte & task change 10*10ms =100ms
#thread 2, 256, 10 //thread 2 with 256 Byte & task change 10*10ms =100ms
```

Example BASIC (syntax identical to CompactC):

```
#thread 0, 0, 20   ' main thread with task change every 20 * 10ms =200ms
#thread 1, 128, 10 ' thread 1 with 128 Byte & task change 10*10ms =100ms
#thread 2, 256, 10 ' thread 2 with 256 Byte & task change 10*10ms =100ms
```

➡ Since e. g. Serial_Read will wait until a character arrives from the serial interface, a thread can in some cases be active longer than the assigned number of time cycles.

➡ When working with threads Thread_Delay rather than AbsDelay should always be used. If nevertheless e. g. an AbsDelay(1000) is used, the thread will wait for 1000ms even if a smaller number of time cycles is assigned.

Thread Synchronization

Sometimes it is necessary for a thread to wait for another thread. This may e. g. be a common hardware resource which can only execute one thread. Sometimes also critical program areas may be defined which may only be entered by one thread. This functions are being realized through instructions Thread_Wait and Thread_Signal.

A thread bound to wait will execute instruction Thread_Wait with a signal number. The condition of the thread is set on *waiting*. This means that the thread may be ignored at a possible thread change. If the other thread has completed its critical work it will send the command Thread_Signal with the same signal number the first thread had used for its Thread_Wait. The thread condition of the waiting thread will change from *waiting* to *inactive* and will then be considered again at a possible thread change.

Deadlocks

When all active threads set out for a waiting condition with Thread_Wait then there will be no more threads which can release the other threads from their waiting conditon. Therefore these constellations should be avoided when programming.

Table Thread Conditions

Condition	**Meaning**
active	The thread is presently executed
inactive	Can be activated again after a thread change
sleeping	Will after a number of ticks be set to "inactive" again
waiting	The thread awaits a signal

5.25.1 Thread_Cycles

Thread Functions

Syntax

```
void Thread_Cycles(byte thread, word cycles);

Sub Thread_Cycles(thread As Byte, cycles As Word)
```

Description

Sets the number of executed bytecode instructions before thread change to the parameter cycles.

If a thread is freshly started, it will get the cycle count that was defined in the project options. It only makes sense to call Thread_Cylces() **after** a thread has been started.

Parameter

thread	(0-13) number of the thread
cycles	cycle count until thread change

5.25.2 Thread_Delay

Thread Functions Example

Syntax

```
void Thread_Delay(word delay);

Sub Thread_Delay(delay As Word)
```

Description

With this function a thread will set to "sleep" for a specified time. After this time the thread is again ready for execution. The waiting period is given in ticks that are created by Timer 2. If Timer 2 is set off or used for other purposes, the mode of operation of Thread_Delay() is not defined.

Even if Thread_Delay() looks like any other wait function, you have to keep in mind that the thread is not automatically executed after the waiting period. The thread is then ready for execution, but it will not started until the next thread change.

Parameter

delay	number of 10ms ticks that should be waited

5.25.3 Thread_Info

Thread Functions

Syntax

```
word Thread_Info(byte info);

Sub Thread_Info(info As Byte) As Word
```

Description

The function returns information about the calling thread. The info parameter defines what kind of information is returned.

Parameter

info values:

TI_THREADNUM	number of the calling thread
TI_STACKSIZE	defined stack size
TI_CYCLES	number of cycles before thread change

Return Parameter

info result

5.25.4 Thread_Kill

Thread Functions

Syntax

```
void Thread_Kill(byte thread);

Sub Thread_Kill(thread As Byte)
```

Description

Terminates a thread. If 0 is given as thread number, the whole program will be terminated.

Parameter

thread	(0-13) thread number

5.25.5 Thread_Lock

Thread Functions

Syntax

```
void Thread_Lock(byte lock);

Sub Thread_Lock(lock As Byte)
```

Description

With this function you can inhibit thread changes. This is reasonable if you have a series of port operations or other hardware actions that should not timely be separated in a thread change.

➡ If you forget to remove the thread lock, the multithreading is not working.

Parameter

lock	if set to 1 thread changes are inhibited, 0 means thread changes are allowed

5.25.6 Thread_MemFree

Thread Functions

Syntax

```
word Thread_MemFree(void);

Sub Thread_MemFree() As Word
```

Description

Returns the free memory that is available for the calling thread.

Parameter

None

Return Parameter

free memory in bytes

5.25.7 Thread_Resume

Thread Functions

Syntax

```
void Thread_Resume(byte thread);

Sub Thread_Resume(thread As Byte)
```

Description

If a thread has the state "waiting" it can be set to "inactive" with this function call. "Inactive" means that a thread is ready for activation at a thread change.

Parameter

thread (0-13) thread number

5.25.8 Thread_Signal

Thread Functions

Syntax

```
void Thread_Signal(byte signal);

Sub Thread_Signal(signal As Byte)
```

Description

Has a thread been set to state "waiting" with a call to Thread_Wait() it can be set to "inactive" with a call to Thread_Signal(). The signal parameter must have the same value as the value that has been used in the call to Thread_Wait().

Parameter

signal	signal value

5.25.9 Thread_Start

Thread Functions Example

Syntax

```
void Thread_Start(byte thread, dword func);

Sub Thread_Start(Byte thread As Byte, func As ULong)
```

Description

A new thread gets started. Every function in the program can be used as starting function for the thread.

➔ If the thread is started inside a function that has parameters defined in the function header, the value of these parameters is undefined!

Parameter

thread	(0-13) thread number
func	function name of the function where the thread will be started

5.25.10 Thread_Wait

Thread Functions

Syntax

```
void Thread_Wait(byte thread, byte signal);

Sub Thread_Wait(thread As Byte, signal As Byte)
```

Description

The thread gets the state "waiting". The state can be changed back to "inactive" with calls to Thread_Resume() or Thread_Signal().

Parameter

thread	(0-13) thread number
signal	signal value

5.25.11 Thread Example

```
// demo program of multithreading
// this program makes no debouncing, therefore a short trigger of the switch
// can lead to more than one string outputs

#thread 0, 0, 10   //main thread with task change every 10 * 10ms =100ms
#thread 1, 128, 10 //thread 1 with 128 Byte & task change 10*10ms =100ms

void thread1(void)
{
    while(true)  // endless loop
    {
        if(!Port_ReadBit(PORT_SW2)) Msg_WriteText("Switch 2"); // SW2 is pressed
    }
}

void main(void)
{
#ifdef AVR32
    // set noth Pin to input & pull-up
    Port_Attribute(PORT_T1, PORT_ATTR_INPUT | PORT_ATTR_PULL_UP);
    Port_Attribute(PORT_T2, PORT_ATTR_INPUT | PORT_ATTR_PULL_UP);
#else
    Port_DataDirBit(PORT_SW1, PORT_IN);  // set Pin to input
    Port_DataDirBit(PORT_SW2, PORT_IN);  // set Pin to input
    Port_WriteBit(PORT_SW1, 1);  // set pull-up
    Port_WriteBit(PORT_SW1, 1);  // set pull-up
#endif

    Thread_Start(1,thread1); // start new Thread

    while(true)     // endless loop
    {
        if(!Port_ReadBit(PORT_SW1)) Msg_WriteText("Switch 1");// SW1 is pressed
    }
}
```

5.25.12 Thread Example 2

```
// multithread2: multithreading with Thread_Delay()
// necessary library: IntFunc_Lib.cc

#thread 0, 0, 10   //main thread with task change every 10 * 10ms =100ms
#thread 1, 128, 10 //thread 1 with 128 Byte & task change 10*10ms =100ms

void thread1(void)
{
    while(true)
    {
        Msg_WriteText("Thread2"); Thread_Delay(200);
    }                            // "Thread2" is displayed
}                                       // after that the thread
                                        // sleeps for 200ms

//------------------------------------------------------------------
// main program
//
void main(void)
{
    Thread_Start(1,thread1);            // start new thread

    while(true)                         // endless loop
    {
        Thread_Delay(100); Msg_WriteText("Thread1");
    }                                   // the thread sleeps for 100ms
}                                       // after that "Thread1" is displayed
```

5.26 Timer

5.26.1 Mega

In C-Control Pro Mega 32 there are two, in Mega128 are three independent timers available. These are *Timer_0* with 8 bit and *Timer_1* with 16 bit (*Timer_3* with 16 bit for Mega128 only). *Timer_2* is used by the firmware as an internal time base and is set firm to a 10ms interrupt. These internal timers can be utilized for a multitude of tasks:

- Event Counter
- Frequency Generation
- Pulse Width Modulation
- Timer Functions
- Pulse & Period Measurement
- Frequency Measurement

5.26.1.1 Event Counter

Here are two examples for how a Timer can be used for an Event Counter:

Timer0 (8 Bit)

```
//  Example: Pulse Counting with CNT0
Timer_T0CNT();
pulse(n);             //  generate n Pulses
count=Timer_T0GetCNT();
```

With **Mega128** for reasons of the hardware the use of *Timer_0* as counter is not possible!

Timer1 (16 Bit)

```
//  Example: Pulse Counting with CNT1
Timer_T1CNT();
pulse(n);            //  generate n Pulses
count=Timer_T1GetCNT();
```

5.26.1.2 Frequency Generation

To generate frequencies *Timer_0*, *Timer_1* and *Timer_3* can be utilized as follows:

Timer0 (8 Bit)

1. Example:

```
// Square Wave Signal with 10*1,085 µs = 10,85 µs Period Duration
Timer_T0FRQ(10, PS0_8)
```

2. Example: Pulsed Frequency Blocks (Project FRQ0)

```
void main(void)
{
    int delval;           // Variable for the On/Off Time
    delval=200;           // Value Assignment for Variable delval

 // Frequency: Period=138,9 µs*100=13,9 ms,Frequency=72Hz
    Timer_T0FRQ(100,PS0_1024); // Timer is set to Frequency

    while (1)
    {
        AbsDelay(delval);         // Time Delay by 200ms
        Timer_T0Stop();           // Timer is stopped
        AbsDelay(delval);         // Time Delay by 200ms
        Timer_T0Start(PS0_1024); // Timer will be switched on with
                                  // Timer Prescaler PS0_1024.
    }
}
```

➡ The program will on **Mega128** not work in USB mode since output PB4 is in conjunction with the USB interface used on the Application Board.

Timer1 (16 Bit)

Example: Frequency Generation with 125 * 4,34 µs = 1085µs Period

```
Timer_T1FRQ(125,PS_64);
```

Timer3 (16 Bit) **(only Mega128)**

Example: Frequency Generation with 10*1,085 µs =10,85 µs Period and 2*1,085µs =2,17 µs Phase Shift

```
Timer_T3FRQX(10,2,PS_8);
```

5.26.1.3 Frequency Measurement

Timer_1 (16Bit) and *Timer_3* (16Bit) (only Mega128) can be used for direct measurement of a frequency. The pulses per second are being counted, the result is then delivered in Hertz units. The maximum frequency is 64kHz and is yielded by the 16 bit counter. An example for this kind of frequency measurement can be found under "Demo Programs/FreqMeasurement". By shortening the measuring time also higher frequencies can be measured. The result has then to be re-calculated accordingly.

5.26.1.4 Pulse Width Modulation

There are two independent timers available for pulse width modulation. These are *Timer_0* with 8 bit and *Timer_1* with 16 bit. By use of a pulse width modulation Digital-Analog-Converters can be realized very easily. On the Mega128 *Timer_3* can be used additionally.

Timer0 (8 Bit)

Example: Pulse Width Modulation with 138,9 µs Period and 5,42 µs Pulse Width, changed to 10,84 µs Pulse Width

```
//  Pulse: 10*542,5 ns = 5,42 µs, Period: 256*542,5 ns = 138,9 µs
Timer_T0PWM(10,PS0_8);

Timer_T0PW(20);          //  Pulse: 20*542,5 ns = 10,84 µs
```

Timer1 (16 Bit)

Example: Pulse Width Modulation with 6,4 ms Period and 1,28 ms Pulse Width Channel A and 640 µs Pulse Width Channel B

```
Timer_T1PWMX(100,20,10,PS_1024); //  Period: 100*69,44 µs = 6,94 ms
                                 //  PulseA: 20*69,44 µs = 1,389 ms
                                 //  PulseB: 10*69,44 µs = 694,4 µs
```

When using the PWM timer functions a value of zero for the duty parameter is not allowed, and will not turn the PIN off. To produce a low signal, the timer must be turned off (Timer_Disable) and the PIN should be switched to output. If a PWM function is used, that generates multiple PWM signals, then a PWM function should be called (e.g. Timer_T1PWM), that will not include the PIN, that should be switched to low.

An example:

```
        while(1)
        {
```

```
        Timer_T1PWMX(255,128,128,PS_8);
        Timer_T1PWA(128);
        Timer_T1PWB(128);

        AbsDelay(1000);

        // set OC1B off
        Timer_Disable(1);
        Timer_T1PWM(255,128,PS_8);
        Port_DataDirBit(14,1);
        Port_WriteBit(14,0);
    }
```

5.26.1.5 Pulse & Period Measurement

By use of *Timer_1* or *Timer_3* (only Mega128) pulse widths and signal periods can be measured. Here by use of the Input Capture Function (specific register of the Controller) the time between two signal slopes is measured. This function utilizes the Capture-Interrupt (INT_TIM1CAPT). A pulse is measured between a rising and the next falling signal edge. A period is measured between two rising signal edges. Because of the Input Capture Function program delay times will not as an inaccuracy be entered into the measuring result. With a programmable prescaler the resolution of *Timer_1* can be set. Prescaler see **Table**.

Example: Activate Pulse Width Measurement (Project PMeasurement) 434 µs (100 x 4,34 µs, see Table)

```
word PM_Value;

void Timer1_ISR(void)
{
    int irqcnt;

    PM_Value=Timer_T1GetPM();
    irqcnt=Irq_GetCount(INT_TIM1CAPT);
}

void main(void)
{
    byte n;

    // Define Interrupt Service Routine
    Irq_SetVect(INT_TIM1CAPT,Timer1_ISR);

    Timer_T0PWM(100,PS0_64);    // Start Pulse Generator Timer 0

 // Measurement starts here
 // Output Timer0 OC0(PortB.3) connect to ICP(input capture pin, PortD.6)

    PM_Value=0;
 // Set mode to Pulse Width Measurement and determine prescaler
    Timer_T1PM(0,PS_64);
    while(PM_Value==0);     // Measure Pulse Width or Period

    Msg_WriteHex(PM_Value); // Output Measuring Value
}
```

➡ For reason of better survey only a simplified version is shown here. Because of a collision on Pin B.4 *Timer_0* is used for pulse generation with Mega128. The entire program can be found in directory PW_Measurement.

5.26.1.6 Timer Functions

In C-Control Pro Mega 32 there are two, in Mega128 three independent Timer available. These are *Timer_0* with 8 bit and *Timer_1* with 16 bit (*Timer_3* with 16 bit for Mega128 only). The timer have a programmable prescaler (see **Table**). After the defined period the timer will trigger an interrupt. An interrupt routine can then be used to execute specific actions.

Timer_T0Time (8 Bit)

Example: Timer0: Switch output on with a delay of 6,94 ms (100x 69,44 µs, see Table)

```
void Timer0_ISR(void)
{
    int  irqcnt;

    Port_WriteBit(0,1);
    Timer_T0Stop() ;                       // stop Timer0
    irqcnt=Irq_GetCount(INT_TIM0COMP);
}

void main(void)
{
    Port_DataDirBit(0,0);                // PortA.0 Output
    Port_WriteBit(0,0);                  // PortA.0 Output=0
    Irq_SetVect(INT_TIM0COMP,Timer0_ISR);// define Interrupt Service Routine
    Timer_T0Time(100,PS0_1024);          // set time and start Timer0
    //  other program code....
}
```

5.26.1.7 Timer_Disable

Timer Functions

Syntax

```
void Timer_Disable(byte timer);

Sub Timer_Disable(timer As Byte)
```

Description

This function disables the specified timer. Timer functions occupy I/O ports. If a timer is not needed and the corresponding I/O ports are used otherwise, the timer must be disabled.

Parameter

0 = *Timer_0*
1 = *Timer_1*
3 = *Timer_3* (only Mega128)

5.26.1.8 Timer_T0CNT

Timer Functions

Syntax

```
void Timer_T0CNT(void);

Sub Timer_T0CNT()
```

Description

These function initializes Counter0. Counter0 gets incremented at every positive signal edge at Input **Mega32**:T0 (PIN1).

➔ Due to hardware reasons it is not possible to use *Timer_0* as a counter in the **Mega128!**

Parameter

None

5.26.1.9 Timer_T0FRQ

Timer Functions

Syntax

```
void Timer_T0FRQ(byte period, byte PS);

Sub Timer_T0FRQ(period As Byte, PS As Byte)
```

Description

This function initializes Timer0 for frequency generation. Parameters are period duration and prescaler, see table. The output signal is generated at **Mega32**: PortB.3 (PIN4), **Mega128**: PortB.4 (X1_4). The frequency generation is started automatically. There is a extended prescaler definition for the Mega128, see table.

Parameter

period	period duration
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32
PS0_1 (1)	135,6 ns
PS0_8 (2)	1,085 µs
PS0_64 (3)	8,681 µs
PS0_256 (4)	34,72 µs
PS0_1024 (5)	138,9 µs

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN
PS0_1 (1)	135,6 ns	125 ns
PS0_8 (2)	1,085 µs	1 µs
PS0_32 (3)	4,340 µs	4 µs
PS0_64 (4)	8,681 µs	8µs
PS0_128 (5)	17,36 µs	16 µs
PS0_256 (6)	34,72 µs	32 µs
PS0_1024 (7)	138,9 µs	128 µs

5.26.1.10 Timer_T0GetCNT

Timer Functions

Syntax

```
byte Timer_T0GetCNT(void);

Sub Timer_T0GetCNT() As Byte
```

Description

The value of Counter0 is read. If there was an overflow a value of ff (Hex) is returned.

Due to hardware reasons it is not possible to use *Timer_0* as a counter in the **Mega128**!

Return Parameter

counter value

5.26.1.11 Timer_T0PW

Timer Functions

Syntax

```
void Timer_T0PW(byte PW);

Sub Timer_T0PW(PW As Byte)
```

Description

This function sets a new pulse width for Timer0 without changing the prescaler.

➔ For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

PW	pulse width

5.26.1.12 Timer_T0PWM

Timer Functions

Syntax

```
void Timer_T0PWM(byte PW, byte PS);

Sub Timer_T0PWM(PW As Byte, PS As Byte)
```

Description

This function initializes Timer0 with given prescaler and pulse width, see table. The output signal is generated at **Mega32**: PortB.3 (PIN4), **Mega128**: PortB.4 (X1_4). There is an extended prescaler definition for the Mega128, see table.

Parameter

➔ For the pulse width parameters do not use the value zero. See Pulse Width Modulation

PW	pulse width
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32
PS0_1 (1)	67,8 ns
PS0_8 (2)	542,5 ns
PS0_64 (3)	4,34 µs
PS0_256 (4)	17,36 µs
PS0_1024 (5)	69,44 µs

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN

PS0 1 (1)	67,8 ns	62,5 ns
PS0 8 (2)	542,5 ns	500 ns
PS0 32 (3)	2,17 µs	2 µs
PS0 64 (4)	4,34 µs	4 µs
PS0 128 (5)	8,68 µs	8 µs
PS0 256 (6)	17,36 µs	16 µs
PS0 1024 (7)	69,44 µs	64 µs

5.26.1.13 Timer_T0Start

Timer Functions

Syntax

```
void Timer_T0Start(byte prescaler);

Sub Timer_T0Start(prescaler As Byte)
```

Description

The timer continues with the already set parameters. The prescaler must be given again.

Parameter

prescaler	prescaler (see table)

5.26.1.14 Timer_T0Stop

Timer Functions

Syntax

```
void Timer_T0Stop(void);

Sub Timer_T0Stop()
```

Description

The frequency generation gets stopped. The output signal can be 0 or 1, dependent on the last state. Only the clock generation is stopped, all other settings stay the same.

Parameter

None

5.26.1.15 Timer_T0Time

Timer Functions

Syntax

```
void Timer_T0Time(byte Time, byte PS);

Sub Timer_T0Time(Time As Byte, PS As Byte)
```

Description

This function initializes Timer_0 with a prescaler and a timer interval value, see table. After the timing interval is expired The Timer_0 Interrupt (INT_TIM0COMP) is triggered. There is an extended prescaler definition for the Mega128, see table.

Parameter

Time	time period after that the interrupt is triggered
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32
PS0_1 (1)	67,8 ns
PS0_8 (2)	542,5 ns
PS0_64 (3)	4,34 µs
PS0_256 (4)	17,36 µs
PS0_1024 (5)	69,44 µs

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN
PS0_1 (1)	67,8 ns	62,5 ns
PS0_8 (2)	542,5 ns	500 ns
PS0_32 (3)	2,17 µs	2 µs
PS0_64 (4)	4,34 µs	4 µs
PS0_128 (5)	8,68 µs	8 µs
PS0_256 (6)	17,36 µs	16 µs
PS0_1024 (7)	69,44 µs	64 µs

5.26.1.16 Timer_T1CNT

Timer Functions

Syntax

```
void Timer_T1CNT(void);

Sub Timer_T1CNT()
```

Description

These function initializes Counter1. Counter1 gets incremented at every positive signal edge at input **Mega32**: PortB.1 (PIN2) **Mega128**: PortD.6 (X2_15).

Parameter

None

5.26.1.17 Timer_T1CNT_Int

Timer Functions

Syntax

```
void Timer_T1CNT_Int(word limit);

Sub Timer_T1CNT_Int(limit As Word)
```

Description

These function initializes Counter1. Counter1 gets incremented at every positive signal edge at input **Mega32**: PortB.1 (PIN2) **Mega128**: PortD.6 (X2_15). After the limit is reached an interrupt ("Timer1 CompareA" - define: INT_TIM1CMPA) is triggered. An appropriate Interrupt Service Routine must be specified.

Parameter

limit

5.26.1.18 Timer_T1FRQ

Timer Functions

Syntax

```
void Timer_T1FRQ(word period, byte PS);

Sub Timer_T1FRQ(period As Word, PS As Byte)
```

Description

This function initializes Timer1 for frequency generation. Parameters are period duration and prescaler, see table. The output signal is generated at **Mega32**: PortD.5 (PIN19). **Mega128**: PortB.5 (X1_3). The frequency generation is started automatically. There is an extended prescaler definition for the Mega128, see table.

Parameter

period	period duration
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32 + Mega128	Tickduration Mega128 CAN
PS_1 (1)	135,6 ns	125 ns
PS_8 (2)	1,085 µs	1 µs
PS_64 (3)	8,681 µs	8 µs
PS_256 (4)	34,72 µs	32 µs
PS_1024 (5)	138,9 µs	128 µs

5.26.1.19 Timer_T1FRQX

Timer Functions

Syntax

```
void Timer_T1FRQX(word period, word skew, byte PS);

Sub Timer_T1FRQX(period As Word, skew As Word, PS As Byte)
```

Description

This function initializes Timer1 for frequency generation. Parameters are period duration, prescaler and phase shift,see table. The output signal is generated at **Mega32**: PortD.5 (PIN19). **Mega128**: PortB.5 (X1_3). The frequency generation is started automatically. There is an extended prescaler definition for the Mega128, see table. The phase shift must be smaller than half the period.

Parameter

period	period duration
skew	phase shift
PS	prescaler (table prescaler)

5.26.1.20 Timer_T1GetCNT

Timer Functions

Syntax

```
word Timer_T1GetCNT(void);

Sub Timer_T1GetCNT() As Word
```

Description

The value of Counter1 is read. If there was an overflow a value of ffff (Hex) is returned.

Return Parameter

counter value

5.26.1.21 Timer_T1GetPM

Timer Functions

Syntax

```
word Timer_T1GetPM(void);

Sub Timer_T1GetPM() As Word
```

Description

Returns the result of the measurement.

Parameter

None

Return Parameter

result of measurement

➜ To calculate the correct value, the 16bit result is multiplied with the entry of the prescaler Table that was passed in the call to `Timer_T1PM`.

5.26.1.22 Timer_T1PWA

Timer Functions

Syntax

```
void Timer_T1PWA(word PW0);

Sub Timer_T1PWA(PW0 As Word)
```

Description

This function sets a new pulse width (Channel A) for Timer1 without changing the prescaler.

➜ For the pulse-width parameters do not use the value zero. See Pulse Width Modulation

Parameter

PW0	pulse width

5.26.1.23 Timer_T1PM

Timer Functions

Syntax

```
void Timer_T1PM(byte Mode, byte PS);

void Timer_T1PM(Mode As Byte, PS As Byte)
```

Description

This function defines if pulse width measurement or period measurement should be done. Then it initializes *Timer_1* and sets the prescaler.

Parameter

Mode	0 = pulse width measurement, 1 = period measurement
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32 + Mega128	Tickduration Mega128 CAN
PS_1 (1)	67,8 ns	62,5 ns
PS_8 (2)	542,5 ns	500 ns
PS_64 (3)	4,34 µs	4 µs
PS_256 (4)	17,36 µs	16 µs
PS_1024 (5)	69,44 µs	64 µs

5.26.1.24 Timer_T1PWB

Timer Functions

Syntax

```
void Timer_T1PWB(word PW1);

Sub Timer_T1PWB(PW1 As Word)
```

Description

This function sets a new pulse width (Channel B) for Timer1 without changing the prescaler.

➔ For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

PW1	pulse width

5.26.1.25 Timer_T1PWM

Timer Functions

Syntax

```
void Timer_T1PWM(word period, word PW0, byte PS);

Sub Timer_T1PWM(period As Word, PW0 As Word, PS As Byte)
```

Description

This function initializes *Timer_1* with given period duration, pulse width and prescaler, see table. The output signal is generated at **Mega32**: PortD.5 (PIN19), **Mega128**: PortB.5 (X1_3). There is an extended prescaler definition for the Mega128, see table.

For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

period	period duration
PW0	pulse width
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32 + Mega128	Tickduration Mega128 CAN
PS_1 (1)	67,8 ns	62,5 ns
PS_8 (2)	542,5 ns	500 ns
PS_64 (3)	4,34 µs	4 µs
PS_256 (4)	17,36 µs	16 µs
PS_1024 (5)	69,44 µs	64 µs

5.26.1.26 Timer_T1PWMX

Timer Functions

Syntax

```
void Timer_T1PWMX(word period, word PW0, word PW1, byte PS);

Sub Timer_T1PWMX(period As Word, PW0 As Word, PW1 As Word, PS As Byte)
```

Description

This function initializes *Timer_1* with given period duration, prescaler, pulse width for channel A and B. The output signal is generated at
Mega32: PortD.4 (PIN18) and PortD.5 (PIN19). **Mega128**: PortB.5 (X1_3) and PortB.6 (X1_2).

For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

period	period duration
PW0	pulse width channel A
PW1	pulse width channel B
PS	prescaler (see table prescaler)

5.26.1.27 Timer_T1PWMY

Timer Functions

Syntax

```
void Timer_T1PWMY(word period, word PW0, word PW1, word PW2, byte PS);

Sub Timer_T1PWMY(period As Word, PW0 As Word, PW1 As Word, PW2 As Word,
PS As Byte)
```

Description

This function initializes *Timer_1* with given period duration, prescaler, pulse width for channel A, B and C. The output signal is generated at
PortB.5 (X1_3) , PortB.6 (X1_2) and PortB.7 (X1_1).

➔ For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

period	period duration
PW0	pulse width channel A
PW1	pulse width channel B
PW2	pulse width channel C
PS	prescaler (see table prescaler)

5.26.1.28 Timer_T1Start

Timer Functions

Syntax

```
void Timer_T1Start(byte prescaler);

Sub Timer_T1Start(prescaler As Byte)
```

Description

The timer continues with the already set parameters. The prescaler must be given again.

Parameter

prescaler	prescaler (see table)

5.26.1.29 Timer_T1Stop

Timer Functions

Syntax

```
void Timer_T1Stop(void);

Sub Timer_T1Stop()
```

Description

The frequency generation gets stopped. The output signal can be 0 or 1, dependent on the last state. Only the clock generation is stopped, all other settings stay the same.

Parameter

None

5.26.1.30 Timer_T1Time

Timer Functions

Syntax

```
void Timer_T1Time(word Time, byte PS);

Sub Timer_T1Time(Time As Word, PS As Byte)
```

Description

This function initializes *Timer_1* with a prescaler and a timer interval value (16bit), see table. After the timing interval is expired *Timer_1* Interrupt (INT_TIM1CMPA) is triggered. There is an extended prescaler definition for the Mega128, see table.

Parameter

Time	time period after that the interrupt is triggered
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega32 + Mega128	Tickduration Mega128 CAN

PS_1 (1)	67,8 ns	62,5 ns
PS_8 (2)	542,5 ns	500 ns
PS_64 (3)	4,34 µs	4 µs
PS_256 (4)	17,36 µs	16 µs
PS_1024 (5)	69,44 µs	64 µs

5.26.1.31 Timer_T3CNT

Timer Functions

Syntax

```
void Timer_T3CNT(void);

Sub Timer_T3CNT()
```

Description

These function initializes Counter3. Counter3 gets incremented at every positive signal edge at input PortE.6 (X1_10)

Parameter

None

5.26.1.32 Timer_T3CNT_Int

Timer Functions

Syntax

```
void Timer_T3CNT_Int(word limit);

Sub Timer_T3CNT_Int(limit As Word)
```

Description

These function initializes *Counter_3*. *Counter_3* gets incremented at every positive signal edge at input PortE.6 (X1_10). After the limit is reached an interrupt ("Timer3 CompareA" - define: INT_TIM3CMPA) is triggered. An appropriate Interrupt Service Routine must be specified.

Parameter

limit

5.26.1.33 Timer_T3FRQ

Timer Functions

Syntax

```
void Timer_T3FRQ(word period, byte PS);

Sub Timer_T3FRQ(period As Word, PS As Byte)
```

Description

This function initializes Timer3 for frequency generation. Parameters are period duration and prescaler, see table. The output signal is generated at PortE.3 (X1_13). The frequency generation is started automatically..

Parameter

period	period duration
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN
PS_1 (1)	135,6 ns	125 ns
PS_8 (2)	1,085 µs	1 µs
PS_64 (3)	8,681 µs	8 µs
PS_256 (4)	34,72 µs	32 µs
PS_1024 (5)	138,9 µs	128 µs

5.26.1.34 Timer_T3FRQX

Timer Functions

Syntax

```
void Timer_T3FRQX(word period, word skew, byte PS);

Sub Timer_T3FRQX(period As Word, skew As Word, PS As Byte)
```

Description

This function initializes Timer3 for frequency generation. Parameters are period duration, prescaler and phase shift,see table. The output signal is generated at PortE.3 (X1_13) und PortE.4 (X1_12). The frequency generation is started automatically. There is an extended prescaler definition for the Mega128, see table. The phase shift must be smaller than half the period.

Parameter

period	period duration
skew	phase shift
PS	prescaler (table prescaler)

5.26.1.35 Timer_T3GetCNT

Timer Functions

Syntax

```
word Timer_T3GetCNT(void);

Sub Timer_T3GetCNT() As Word
```

Description

The value of Counter1 is read. If there was an overflow a value of ffff (Hex) is returned.

Return Parameter

counter value

5.26.1.36 Timer_T3GetPM

Timer Functions

Syntax

```
word Timer_T3GetPM(void);

Sub Timer_T3GetPM() As Word
```

Description

Returns the result of the measurement.

Parameter

None

Return Parameter

result of measurement

➡ To calculate the correct value, the 16bit result is multiplied with the entry of the prescaler Table that was passed in the call to `Timer_T3PM`.

5.26.1.37 Timer_T3PWA

Timer Functions

Syntax

```
void Timer_T3PWA(word PW0);

Sub Timer_T3PWA(PW0 As Word)
```

Description

This function sets a new pulse width (Channel A) for Timer3 without changing the prescaler.

For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

PW0	pulse width

5.26.1.38 Timer_T3PM

Timer Functions

Syntax

```
void Timer_T3PM(byte Mode, byte PS);

void Timer_T3PM(Mode As Byte, PS As Byte)
```

Description

This function defines if pulse width measurement or period measurement should be done. Then it initializes *Timer_3* and sets the prescaler.

Parameter

Mode	0 = pulse width measurement, 1 = period measurement
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN
PS_1 (1)	67,8 ns	62,5 ns
PS_8 (2)	542,5 ns	500 ns
PS_64 (3)	4,34 µs	4 µs
PS_256 (4)	17,36 µs	16 µs

PS_1024 (5)	69,44 µs	64 µs

5.26.1.39 Timer_T3PWB

Timer Functions

Syntax

```
void Timer_T3PWB(word PW1);

Sub Timer_T3PWB(PW1 As Word)
```

Description

This function sets a new pulse width (Channel B) for Timer3 without changing the prescaler.

➔ For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

PW1	pulse width

5.26.1.40 Timer_T3PWM

Timer Functions

Syntax

```
void Timer_T3PWM(word period, word PW0, byte PS);

Sub Timer_T3PWM(period As Word, PW0 As Word, PS As Byte)
```

Description

This function initializes *Timer_3* with given period duration, pulse width and prescaler, see table. The output signal is generated at PortE.3 (X1_13).

➔ For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

period	period duration
PW0	pulse width
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN

PS_1 (1)	67,8 ns	62,5 ns
PS_8 (2)	542,5 ns	500 ns
PS_64 (3)	4,34 µs	4 µs
PS_256 (4)	17,36 µs	16 µs
PS_1024 (5)	69,44 µs	64 µs

5.26.1.41 Timer_T3PWMX

Timer Functions

Syntax

```
void Timer_T3PWMX(word period, word PW0, word PW1, byte PS);

Sub Timer_T3PWMX(period As Word, PW0 As Word, PW1 As Word, PS As Byte)
```

Description

This function initializes *Timer_3* with given period duration, prescaler, pulse width for channel A and B. The output signal is generated at
PortE.3 (X1_13) and PortE.4 (X1_12).

For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

period	period duration
PW0	pulse width channel A
PW1	pulse width channel B
PS	prescaler (see table prescaler)

5.26.1.42 Timer_T3PWMY

Timer Functions

Syntax

```
void Timer_T3PWMY(word period, word PW0, word PW1, word PW2, byte PS);

Sub Timer_T3PWMY(period As Word, PW0 As Word, PW1 As Word, PW2 As Word,
PS As Byte)
```

Description

This function initializes *Timer_3* with given period duration, prescaler, pulse width for channel A, B and C. The output signal is generated at
PortE.3 (X1_13), PortE.4 (X1_12) and PortE.5 (X1_11).

For the pulse width parameters do not use the value zero. See Pulse Width Modulation

Parameter

period	period duration
PW0	pulse width channel A
PW1	pulse width channel B
PW2	pulse width channel C
PS	prescaler (see table prescaler)

5.26.1.43 Timer_T3Start

Timer Functions

Syntax

```
void Timer_T3Start(byte prescaler);

Sub Timer_T3Start(prescaler As Byte)
```

Description

The timer continues with the already set parameters. The prescaler must be given again.

Parameter

prescaler	prescaler (see table)

5.26.1.44 Timer_T3Stop

Timer Functions

Syntax

```
void Timer_T3Stop(void);

Sub Timer_T3Stop()
```

Description

The frequency generation gets stopped. The output signal can be 0 or 1, dependent on the last state. Only the clock generation is stopped, all other settings stay the same.

Parameter

None

5.26.1.45 Timer_T3Time

Timer Functions

Syntax

```
void Timer_T3Time(word Time, byte PS);

Sub Timer_T3Time(Time As Word, PS As Byte)
```

Description

This function initializes *Timer_3* with a prescaler and a timer interval value (16bit), see table. After the timing interval is expired *Timer_3* Interrupt (INT_TIM3CMPA) is triggered.

Parameter

Time	time period after that the interrupt is triggered
PS	prescaler

Table prescaler:

Prescaler	Tickduration Mega128	Tickduration Mega128 CAN
PS_1 (1)	67,8 ns	62,5 ns
PS_8 (2)	542,5 ns	500 ns
PS_64 (3)	4,34 µs	4 µs
PS_256 (4)	17,36 µs	16 µs
PS_1024 (5)	69,44 µs	64 µs

5.26.1.46 Timer_TickCount

Timer Functions

Syntax

```
word Timer_TickCount(void);

Sub Timer_TickCount() As Word
```

Description

Measures the number of 10ms ticks between two calls of Timer_TickCount(). Ignore the return value of the first call to Timer_TickCount(). If the delay between the two calls is greater than 655.36 seconds, the result is undefined.

Parameter

None

Return Parameter

time interval expressed in 10ms ticks

Example

```
void main(void)
{
    word time;
    Timer_TickCount();
    AbsDelay(500);  // wait 500 ms
    time=Timer_TickCount();  // the value should be 50
}
```

5.26.2 AVR32Bit

There are 2 timer with 3 channels available in the C-Control Pro AVR32Bit. These will show up in the library as 6 timer. You can use the internal timer for various tasks:

- Event Counter
- Frequency Generation

In addition, there are three dedicated functional units for Pulse Width Modulation.

5.26.2.1 Event Counter

On each of the 6 timer channels events (up to 16-bit) can be counted. In this Example, the rising edges on input COUNTA_1 are counted in timer 2 (see Pin Assignment). After every 300 events an interrupt will be triggered, while the counter is reset. The sample program outputs after 10 seconds the current state of the counter.

Example

```
word cnt;

void count_irq(void)
{
    cnt++;
    Irq_GetCount(INT_TIMER0);
}

void main(void)
{
    cnt= 0;
    Irq_SetVect(INT_TIMER2, count_irq);
    Timer_ConfigCounter(2, COUNTA_1, CNT_RISING, 300);

    AbsDelay(10000);
    Msg_WriteWord(Timer_GetCounterVal(2));
    Msg_WriteChar('\r');

    while(1);
}
```

5.26.2.2 Frequency Generation

On each of the 6 timer channels a rectangular signal can be generated. In the following Example, a 50Hz signal is generated which (see Pin Assignment) is output on pin TIMER0-A and TIMER0-B. In addition, an interrupt is triggered. The prescaler TIM_128 determines a tick duration of 1,939µs (= 128 / 66.000.000 Mhz). By multiplying 5157 * 1.939µs = 10ms results in 100 edge changes per second = 50Hz.

Example

```
word cnt;

void irq(void)
{
    cnt++;
    Irq_GetCount(INT_TIMER0);
}

void main(void)
{
    cnt= 0;
    Irq_SetVect(INT_TIMER0, irq);
    Timer_Set(0, TIM_128, 5157, TIMFLG_IRQ|TIMFLG_PINA|TIMFLG_PINB);
    while(1);
}
```

5.26.2.3 Pulse Width Modulation

The C-Control AVR32Bit can output a pulse width modulated signal on up to 4 channels. The following Example 1 will produce a signal of 1.65 MHz period, and 50% duty on PWM channel 1.
After 10 seconds, the PWM channel is switched off. The signal is output to pin PWMH_1 and PWML_1 (see Pin Assignment).

Example

```
void main(void)
{
    PWM_Init(1, PWM_1, PWM_ENAB_HIGH|PWM_ENAB_LOW);
    PWM_Update(1, 40L, 20L, 0, 0);

    AbsDelay(10000);
    PWM_Disable(1);
}
```

5.26.2.4 PWM_Disable

Timer Functions

Syntax

```
void PWM_Disable(byte chan);

Sub PWM_Disable(chan As Byte)
```

Description

The function switches off the selected PWM channel.

Parameter

chan	number of the PWM channel (0 - 3)

5.26.2.5 PWM_Init

Timer Functions

Syntax

```
void PWM_Init(byte chan, byte PS, byte mode);

Sub PWM_Init(chan As Byte, PS As Byte, mode As Byte)
```

Description

Initializes a PWM channel. With the mode parameter can be selected individually, whether the signal is output on **PWMH_x** and / or **PWML_x**. A **deadtime** can be enabled or the polarity negated.

To create the mode parameter, the bit values from the table are ORed (see PWM_Example).

➔ For a more detailed description of PWMH_x, PWML_x and deadtime, please consult the AT32UC3C data sheet.

Parameter

chan	number of PWM channel (0 - 3)
PS	prescaler
mode	work mode of PWM channel

Table PS:

Prescaler	Tickduration
PWM_1(0)	15,15 ns
PWM_2(1)	30,30 ns
PWM_4(2)	60,60 ns
PWM_8(3)	121,21 ns
PWM_16(4)	242,42 ns
PWM_32(5)	484,84 ns
PWM_64(6)	969,69 ns
PWM_128(7)	1,939 µs
PWM_256(8)	3,878 µs
PWM_512(9)	7,757 µs
PWM_1024(10)	15,51 µs

Table mode:

mode	Description
PWM_ENAB_HIGH (1)	signal on Pin PWMH_x
PWM_ENAB_LOW (2)	signal on Pin PWML_x
PWM_ENAB_DEAD (4)	activate deadtime
PWM_CPOL (8)	negate polarity

5.26.2.6 PWM_Update

Timer Functions

Syntax

```
void PWM_Update(byte chan, dword period, dword duty, word dtl, word dth);

Sub PWM_Update(chan As Byte, period As ULong, duty As ULong, dtl As Word,
               dth As Word)
```

Description

During operation the period (frequency), duty (latitude) and **deadtime** of the PWM signal can be specified.

➡ For the frequency, the following formula applies: Frq = 66,000,000 / prescaler / period. Permitted values for duty are 0 to period. A duty of 0 means that the signal is permanently off, wherein a duty of value period means the signal is permanently on. Therefore a duty of 50% is period / 2. Thus the width (duty) of the PWM signal can be set as finely as possible, a prescaler must be selected so that the period parameter for the desired frequency is as large as possible (maximum 20 bits).

Parameter

chan	number of PWM channel (0 - 3)
period	frequency of the PWM signal (20 Bit)
duty	duty of the PWM signal (20 Bit)
dtl	deadtime of **PWML_x** signal
dth	deadtime of **PWMH_x** signal

5.26.2.7 Timer_ConfigCounter

Timer Functions

Syntax

```
void Timer_ConfigCounter(byte timer, byte portbit, byte edge, word irq_-
threshold);

Sub Timer_ConfigCounter(timer As Byte, portbit As Byte, edge As Byte,
irq_threshold As Word)
```

Description

The function initializes a timer as a counter. The inputs COUNTA-0, COUNTA-1, COUNTA-2 and COUNTB-2 are available (see Pin Assignment). For the x-COUNTA inputs only the timer 0,2,4 can be used, for COUNTB-2 the timer 1,3,5 are available. If the parameter irq_threshold is non-zero, then an interrupt is generated when the counter is equal to the value of irq_threshold. After an interrupt, the counter is reset to zero.

➡ After initialization, the counter retains its old value. The first edge then sets the counter to zero. When reading the counter, it therefore looks as if one edge less has been counted. This behavior is due to the structure of the internal counter of the AVR32 controller.

Parameter

timer	number of timer (0 - 5)
portbit	(**GPIO** in Pin Assignment)
edge	edge type: CNT_FALLING (falling) or CNT_RISING (rising)
irq_threshold	counter when an IRQ will be triggered

5.26.2.8 Timer_CPUCycles

Timer Functions

Syntax

```
dword Timer_CPUCycles(void);

Sub Timer_CPUCycles() As ULong
```

Description

Measures the CPU cycles between two calls of Timer_CPUCycles() and returns the value at the second call of Timer_CPUCycles(). The return value of the first call can be ignored.

➜ Since the processor is clocked at 66Mhz, only periods of up to 65 seconds can be measured.

Parameter

None

Return Parameter

CPU cycles between two calls

5.26.2.9 Timer_Disable

Timer Functions

Syntax

```
void Timer_Disable(byte timer);

Sub Timer_Disable(timer As Byte)
```

Description

The function turns off the selected Timer or Counter.

Parameter

timer	number of timer (0 - 5)

5.26.2.10 Timer_GetCounterVal

Timer Functions

Syntax

```
word Timer_GetCounterVal(byte timer);
```

```
Sub Timer_GetCounterVal(timer As Byte) As Word
```

Description

Returns the 16-bit counter of a timer.

Parameter

timer	number of timer (0 - 5)

Return Parameter

counter value

5.26.2.11 Timer_Set

Timer Functions

Syntax

```
void Timer_Set(byte timer, byte PS, word period, word flags);

Sub Timer_Set(timer As Byte, PS As Byte, period As Word, flags As Word)
```

Description

This function initializes the timer with the specified prescaler and period, see Table. Through the use of flags (you can have multiple values ØRing), an interrupt is triggered and/or a signal on pins TIMERx-A resp. TIMERx-B is generated (see Pin Assignment).

Due to the configuration of the connected peripheral not all pin TIMERx-A and TIMERx-B are available.

Parameter

timer	number of timer (0 - 5)
PS	prescaler
period	signal period
flags	timer options

Table prescaler:

Vorteiler (prescaler)	Tickduration
TIM 32KHZ (0)	31,25 µs
TIM 2 (1)	30,30 ns
TIM 8 (2)	121,21 ns
TIM 32 (3)	484,84 ns

TIM_128 (4)	1,939 µs

Table flags:

Definition	Meaning
TIMFLG_IRQ	Interrupts are generated
TIMFLG_PINA	signal is output on pin TIMERx-A
TIMFLG_PINB	signal is output on pin TIMERx-B

5.26.2.12 Timer_TickCount

Timer Functions

Syntax

```
dword Timer_TickCount(void);

Sub Timer_TickCount() As ULong
```

Description

Measures the time in 10ms ticks between two calls of Timer_TickCount() and returns the value at the second call of Timer_TickCount(). The return value of the first call can be ignored.

Parameter

None

Return Parameter

time interval expressed in 10ms ticks

Example

```
void main(void)
{
    word time;
    Timer_TickCount();
    AbsDelay(500);  // wait 500 ms
    time=Timer_TickCount();  // the value should be 50
}
```

5.27 Webserver (AVR32Bit)

The web server of the C-Control Pro AVR32Bit is started with WEB_StartServer. Any TCP/IP port may be selected for this. When the web server starts the number of dynamic variables is defined with whom you want to work. The dynamic variables take the values of the URL variables in the URL, and you can use dynamic variables to output values within web pages.

All web pages that are returned by the server must be located in the root directory on the SD card that is inserted into the C-Control Pro Unit. Since the SDCard library does not support long file names, file names of all websites must be available in DOS format (8.3). Therefore the main page has the file name "index.htm". Note the shortened ending.

HTTP Header

For files with a known extension (see Table), an HTTP header is automatically generated, which is placed in front of the file's contents. The header

```
HTTP/1.1 200 OK\r\n
Connection: close\r\n
Content-Type: Type\r\n
\r\n
```

is always prepended. There "\r\n" means carriage return line feed, and **Type** the corresponding content type from the table. E.g. for the extension ".htm" a "Content-Type: text/html" is generated in the header.

File Extension	Type
.htm	text/html
.js	application/x-javascript
.txt	text/plain
.css	text/css
.gif	image/gif
.ico	image/x-icon
.jpg	image/jpeg
.bmp	image/bmp
.png	image/png

➡ If the file extension is not present in the table, the header must be set manually at the beginning of the file on the SD card.

Dynamic Variables

With the function WEB_SetDynVar() the web server is given the address and type of a normal program variable. If for example an integer variable "int a;" is defined, a call to "WEB_SetDynVar (0, a, DYN_INT, 0);" would define the variable **a** as a dynamic variable with index 0. If some text inside a web page is **$var0$**, then **$var0$** is replaced by the numeric value of **a**. The number after **$var** is the index of the dynamic variable.

URL (CGI) Variables

When there are no URL variables specified for a web request, the whole process runs in the background, and there must be no program interaction. If a URL variable is present (e.g. "?var0=5") web server checks if there is variable name that corresponds to the scheme "var" + number. The number must not exceed the maximum index of defined dynamic variables. If the scheme is met, the value "5" is assigned to the dynamic variable. Then the integer variable **a** gets the value 5.

There is a special URL ("setvars.js") which takes only the URL variables, but does not return any website content. With that mechanism variable content can be transferred to Javascript without generating much TCP/IP traffic.

➡ A variable can be modified only via URL, when WEB_SetDynVar () is called with the DYN_CGIVAR flag set. This allows normal variables to be protected from a change from the outside.

JSON

If you want to work with JavaScript, dynamic variables can be output as a JSON list. For this purpose, in the definition of WEB_SetDynVar () the flag DYN_JSONVAR has to be set. Access to "getvars.js" then provides the JSON data. E.g: "{" 1 ":" 123 "," 3 ":" 0 "}". This is a list of two dynamic variables with the indices 1 and 3. The first variable has the content "123", the second variable contains "0".

Interaction

In normal operation, the main loop of the program is queried continuously with WEB_GetRequest(), if there is a request with an URL variable present. There is a request, when the return parameter is unequal to zero. You can then check the hash of the file name with WEB_GetFileHash() and evaluate the passed URL variables. Thereafter, the output variables (dynamic variables of the site) should be set to new values according the program logic. At the end of request the web server is signaled with WEB_ReleaseRequest() that the Website should be shipped to the browser.

5.27.1 Webserver Hints

Web Server Checklist

- The invoked Web pages must have been copied to the micro SD card, and the card must be inserted in the SD card slot of the AVR32Bit Unit.
- For the SD card, only the FAT file system is supported (see FAT support).
- The web server is started after ETH_StartWebserver() is called from the user program. The TCP/IP port in the web browser (default: 80) must match the port in the call to ETH_StartWebserver.
- The number of dynamic variables used in WEB_SetDynVar must correspond with the definition in the WEB_BUF macro and dynvar_cnt in WEB_StartServer.

➡ When stopping the program with the Start/Stop button, the lwIP TCP/IP stack can get in a state, where not all dynamic memory for the current connection is released. This memory may be missing when you restart the program. If in doubt when encountering problems, press the reset button to initiate a complete system reboot.

Web Server Optimization

The lwIP TCP / IP stack is optimized to work best with embedded devices that store websites in flash memory. The SD card allows to store much more websites than the flash memory of an embedded controller, but has the disadvantage that the web pages must be between loaded to RAM before they are sent over the Ethernet. To limit the "RAM hunger" of the lwIP stack, several things should be noted:

- In normal web server operation the "TCP/IP Memory" in the C-Control configuration should be set to ca.16kb.
- All GET requests of the web server, that do not pass CGI variables in the URL, are serialized in a queue. This is done so only few RAM is needed to send a web page at a time.
- Because the SD card in the C-Control Pro is connected via SPI, and not in 4-bit parallel mode like a PC, only slower transmission rates are realized. In tests with wget.exe an average transfer rate between 140-150 kbytes/sec is reached. Therefore, e.g. Images and other resources should not exceed 100kb significantly, otherwise the website is built slowly.
- The web server supports the "If-Modified-Since" caching protocol of the current web browser. Therefore, the caching should be enabled in the web browser, and date and time of the files on the SD card should not lie in the future.
- If you want just to pass CGI variables in the URL of a Javascript GET request, without the requirement of a response from the server, the URL "setvars.js" should be used. This request takes only the variable values and generates no response.
- If a request from Javascript only accesses variable values in JSON format, the URL "getvars.js" generates only the JSON output, without accessing the SD card, what is a lot faster.
- It is recommended to look at the demo programs for web server usage.
- Only specify the flags and WEB_CACHE_HTML and WEB_CACHE_TEXT in WEB_StartServer, if you are sure that HTML or text web pages really should be cached!

5.27.2 WEB_GetRequest

Ethernet Functions

Syntax

```
byte WEB_GetRequest(void);

Sub WEB_GetRequest() As Byte
```

Description

Queries the web server if an HTTP request is made for the delivery of a website. A value of zero indicates that there is no request. After a valid request, you should evaluate the dynamic variables and set any new values?

Return Parameter

request parameter (0 = nothing received)

5.27.3 WEB_GetFileHash

Ethernet Functions

Syntax

```
word WEB_GetFileHash(byte request);

Sub WEB_GetFileHash(request As Byte) As Word
```

Description

Returns the 16-bit CRC hash of the file name. The request parameter must be identical to the value that has been obtained from WEB_GetRequest().

Parameter

request	request parameter

Return Parameter

16 Bit CRC hash of the file name (8.3)

5.27.4 WEB_ReleaseRequest

Ethernet Functions

Syntax

```
void WEB_ReleaseRequest(byte request);

Sub WEB_ReleaseRequest(request As Byte)
```

Description

Signals the web server that the passed URL variables were evaluated, and now the web server delivers the requested web page via TCP/IP. The request parameter must be identical to the value that has been obtained from WEB_GetRequest().

Parameter

request	request parameter

5.27.5 WEB_SetDynVar

Ethernet Functions

Syntax

```
void WEB_SetDynVar(word indx, ptr var_addr[], byte type, byte flags,
byte len);

Sub WEB_SetDynVar(indx As Word, var_addr As Pointer, type As Byte, flags
 As Byte, len As Byte)
```

Description

Defines a dynamic variable on its index, address and variable type. The len parameter is important for string variables, other types ignore this parameter. You can specify multiple flags simultaneously by ORing values.

The number of dynamic variables used must correspond with the definition in the WEB_BUF macro and dynvar_cnt in WEB_StartServer.

Parameter

indx	index of variable
var_addr	address of variable
type	variable type
flags	property of variable
len	length (0 to 255) only for strings

Type Definitions

Definition	Meaning
DYN_BYTE	8-Bit without sign
DYN_CHAR	8-Bit with sign
DYN_INT	16-Bit with sign
DYN_INTEGER	16-Bit with sign
DYN_WORD	16-Bit without sign
DYN_UINTEGER	16-Bit without sign
DYN_LONG	32-Bit with sign
DYN_DWORD	32-Bit without sign
DYN_ULONG	32-Bit without sign
DYN_STR	character array
DYN_FLOAT	floating point
DYN_SINGLE	floating point

Flag Definitions

Definition	Meaning
DYN_CGIVAR	can be changed in URL
DYN_JSONVAR	variable in JSON list

5.27.6 WEB_StartServer

Ethernet Functions

Syntax

```
void WEB_StartServer(word port, byte ramaddr[], word dynvar_cnt, word
flags);
```

```
Sub WEB_StartServer(port As Word, ByRef ramaddr As Byte, dynvar_cnt As
Word, flags As Word)
```

Description

Starts the web server on TCP/IP port port. The parameter dynvar_cnt defines how many dynamic variables can be used. The user should provide a **global** variable as a buffer. In this buffer, the working state of the web server is stored and there is memory for copy operations. For the size of the buffer, there exists a #define **WEB_BUF**. If you want to define a byte array with space for dynamic variables X, one writes "byte buf [WEB_BUF (X)];". You can specify multiple flags simultaneously by ORing the values.

The user-supplied RAM buffer must be reserved during the entire use of the web server. Since local variables are released after leaving the function, it is strongly recommended to declare the buffer as a global variable.

Parameter

port	TCP/IP Port the web server listens
ramaddr	buffer address
dynvar_cnt	number of dynamic variables
flags	webserver options

Flagsdefinitionen

Definition	Meaning
WEB_CACHE_NORM	HTML and Text pages are not cached
WEB_CACHE_HTML	HTML pages are cached
WEB_CACHE_TEXT	Text pages are cached

5.27.7 WEB_StopServer

Ethernet Functions

Syntax

```
void WEB_StopServer(void);
```

```
Sub WEB_StopServer()
```

Description

Stops the webserver.

Parameter

None

Part 6

6 FAQ

6.1 General

1. The spelling check does not function.

- Is the spelling check switched on in Options->Editor?
- The spelling check does only display spelling errors in the commentaries. The check of any other area would not make sense.

2. Where can be determined whether the new project is a BASIC or C project?

- There is no difference in project type. The source text files in a project determine which programming language is being used. Files with the extension *.cc will run in a CompactC context, Files with the extension *.cbas will be translated into BASIC. Also C and BASIC can be combined in a project.

3. I am using an LCD other than the one shipped with the product, but am using the same Controller. The cursor positions do not work correctly.

- The Controller can display 4 lines at 32 characters each. The beginnings of the lines are stored transposed in memory following the scheme below:

Value of pos (Hex)	**Position in the display**
00-1f	0-31in the line 1
40-5f	0-31in the line 2
20-3f	0-31in the line 3
60-6f	0-31in the line 4

4. Where are the demo programs located?

- The demo programs are installed to "C:\Documents and Settings\All Users\Documents\C-Control Pro Demos" (XP and earlier) or to "C:\Users\Public\Public Documents\C-Control Pro Demos" directory (Vista and later). See Chapter Demo Programs.

5. Can I program the C-Control Pro Module in Linux?

- There is no native IDE for Linux, but customer had successfully started the IDE under Wine und programmed the module in serial mode.

6. Is it possible to develop for C-Control Pro with other Compilers?

- There are many developing systems for the Atmel Mega CPU. Some of these Compilers are commercial, others a free. A good example of a free development system is the GNU C-Compiler. You can transfer programs, that you wrote with the GNU C-Compiler, to the Atmel Mega CPU with a AVR ISP programmer. But once you overwrote the installed bootloader, there is no way back, you cannot longer use the C-Control Pro software.

6.2 Mega

1. How can I switch on the Pull-Up resistor of a port?

- First switch the port to input with PortDataDir() (or PortDataDirBit()), then use PortWrite() (or PortWriteBit()) to write a "1" into the port.

2. No USB connection existing to the Application Board.

- Has the FTDI USB driver been loaded onto the PC? Or does “Unknown Device” appear in the Hardware Manager, when the USB connector is plugged in?
- Has the correct communication port been set in Options->IDE->Interfaces?
- Are the ports **M32**:B.4-B.7,A.6-A.7 resp. **M128**:B.0-B.4,E.5 erroneously being used in the software (see pin assignment of M32 and M128)? Are the jumpers on the Application Board set to these ports?
- A signal on **M32**:PortD.2 resp. **M128**:PortE.4 (SW1) during startup will activate the serial Bootloader.
- (Mega128 only) Is Port.G4 (LED2) on Low during Reset? See SPI Switch Off in chapter "Firmware".
- When the SD card is used in conjunction with USB and the application board, there is a collision on the SPI bus. If you want to use the SD Card interface, you have to remove the jumper on the application board (**Mega128** PB.0 to PB.4 and PE.5) and to use the serial mode.

3. The serial interface does not issue any characters or does not receive any characters.

- Are the Ports D.0-D.1 erroneously used in the software (see pin assignment of M32 and M128)? Are the jumpers on the Application Board set to these ports?

4. The Application Board does not react to any commands when serially connected.

- In order to get the Bootloader into the serial mode the button SW1 must be pressed during startup of the Application Board (observe jumper for SW1). For the serial mode **M32**:PortD.2 resp. **M128**:PortE.4 (SW1) can also be fixed to GND level.

5. The Hardware Application does not start by itself (Autostart Behaviour).

- A signal on the SPI interface during startup may activate USB communication.
- A signal on **M32**:PortD.2 resp. **M128**:PortE.4 (SW1) during startup may activate the serial Bootloader.

6. How much RAM do I have for my programs?

- There are 930 bytes left for own programs on the Mega32, on the Mega128 remain 2494 bytes. Interpreter and Debugger are using buffer for interrupt driven I/O, and 256 bytes for the data stack. Beside this resources, there are some internal tables, that are needed for interrupt handling and multitasking. Additionally some RAM Variables are used from library functions.

7. Where is the second serial interface on the Mega128 Application Board?

- See J4 chapter Jumper Application Board M128.

8. I need no USB connection to the application board, how can I reclaim the reserved ports for USB?

- The USB interface is wired to the C-Control module over the SPI interface. The SPI interface can be disabled with SPI_Disable(). Do not forget to remove the jumper that connects the SPI with the Mega8 (USB interface) on the application board.

9. Where do I have the supply voltage on the breadboard of the Application Board?

- If you turn the application board to a position where the interface connectors (USB and serial) show to the upper side, the leftmost column on the breadboard is GND and the rightmost column is VCC. You can see it clearly, when you take a look of the backside of the board.

10. I need more ports for my hardware application. Many ports are used by other functions.

- Take a look at the Pin Assignment of M32 and M128. You can use all ports that have no special functionalities (SPI, RS232, LCD, Keyboard etc.) that are needed for your application. Do not forget to remove the jumper that connects the port pins to the application board. Otherwise the behaviour can be undetermined.

6.3 AVR32Bit

1. There is no USB connection to the Application Board.

- Is the USB (usbser.sys) driver loaded on the PC? Or maybe an "unknown device" appears in the hardware manager when inserting the USB plug?
- Is the correct communication port set?
- Please read the USB Troubleshooting guide!
- On delivery, the Autostart jumper is set. Please remove, otherwise no program transfer is possible.

2. How do I turn on the pull-up resistor of an input port?

- See Port_Attribute ().

3. I need more ports for my hardware application. Many ports are used by other functions.

- Take a look at the Pin Assignment of the AVR32Bit. You can use all ports that have no special AVR32Bit Module functionality (not connected to I2C, SPI, MACB etc). Do not forget to remove the jumper that connects the port pins to the application board (e.g. for LED's or Button's). Otherwise the behavior can be undetermined.

4. I cannot reset the module or a transfer of the interpreter after a software update no longer works.

- A power cycle brings the module securely back to the boot loader to allow a Reset Module. See Firmware.

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