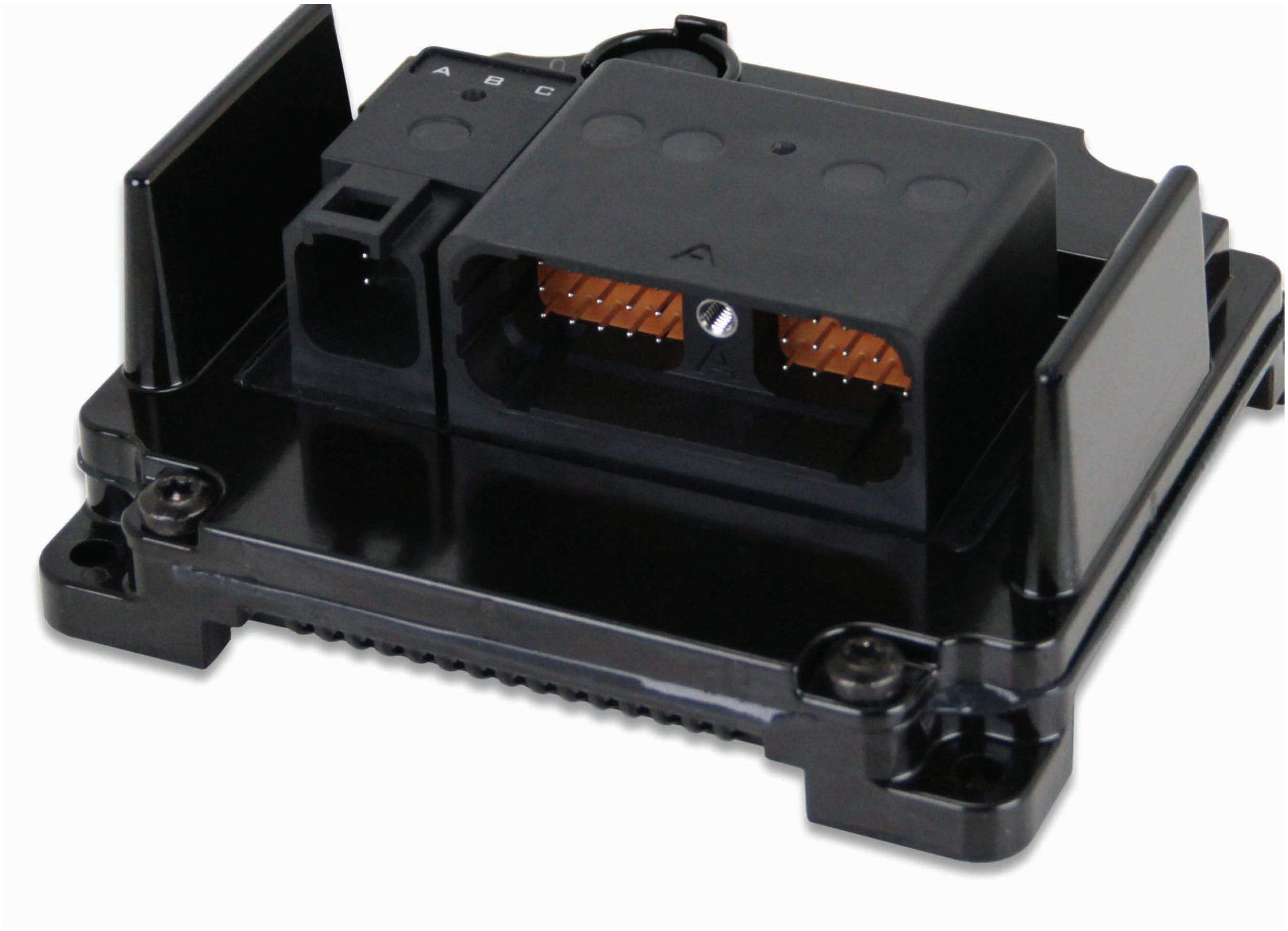
Eaton HFX Product Family Installation and Operation Manual

HFX Product Line



Powering Business Worldwide

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This symbol is the "Safety Alert Symbol". It occurs with either of two signal words: CAUTION or WARNING, as described below.

WARNING

Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

HFX Product Family

General Information

⚠ Warning

Before beginning installation of this product:
Read and follow all installation instructions.
Please contact Eaton immediately if you have any questions.

Note: This manual was written with great care and precision. However, since the potential for error exists, we can provide no assurance of the absolute accuracy of its contents.

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http://www.eaton.com/Eaton/ProductsServices/Hydraulics/WarrantyTermsConditions/PCT_612027

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1.0 INTRODUCTION

The Eaton HFX product family is a series of advanced, CAN-based controllers for use with mobile and industrial equipment. Using a standardized IEC 61131-3 programming environment, these controllers enable functional control over electrically operated components within a variety of applications (e.g. agricultural, construction, material handling). It is recommended that an individual have experience with control engineering and programming within the CODESYS 3.5 or MATLAB/Simulink & C software environment before using this hardware.

The HFX product family is optimized for reliable operation in severe environments, possessing IP and temperature ratings that exceed existing solutions from competitors. HFX controllers employ several advanced technologies (e.g. I/O with variable configuration architecture), enabling simple management and enhancing both ease of use and functionality. These controllers are intended as both a standalone solution, or as the centerpiece to a complete control system that can include other CAN-based devices such as displays and keypads.

Key Acronyms and Abbreviations

CODESYS	Controller Development System
FW	Firmware
HW	Hardware
IDE	Integrated Development Environment
IP	Ingress Protection
MIL	Malfunction Indicator Lamp
POU	Program Organization Unit
PWM	Pulse Width Modulation
RTS	Run Time System
SW	Software

2.0 TECHNICAL SPECIFICATIONS

Eaton HFX Controllers

Dimensions	212.61mm L x 134.17mm W x 58.55mm H
Weight	43.2 ounces (1225 grams)
Storage Temperature Range	-40 - +125 °C
Operating Temperature Range	-40 - +105°C (USB use is limited to 85°C)
IP Rating	IP67/IP69K
Operating Altitude	0-4000 m
Supply Voltage	6-32 VDC, Nominal operation @ 12 /24 VDC
Reverse Polarity Protection	Integrated
Peak Supply Voltage	36 VDC
Maximum Current	48 A @ 85°C (40 A @ 105°C)
Idle Current 12/24 VDC	120 mA
Standby Current 12/24 VDC	<3.5mA@12V, <2.5mA@24V
Ignition Pin (A16)	Enable/Disable standby mode
CPU Type	Renesas Super H 72546
Frequency	200 MHz
Bit Width	32 Bit
FPU	Integrated on chip
Data Memory (RAM retain) (additional to cpu)	32 Kbyte
Flash (ROM program & data combined)	3.75 Mbyte
SRAM	256 Kbyte
EEPROM	128 Kbyte
CAN Specification	2.0A, 2.0B
CAN Baud Rates	50 kb/s,100 kb/s,125 kb/s,250 kb/s,500 kb/s,800 kb/s,1Mb/s
CAN Protocol	CANOpen, SAE J1939
CAN CCP Default Node Address	0
CAN Default Baud Rate	250kb/s
USB Specification	USB 2.0 (Note: 3.0 devices are compatible)
USB Baud Rates	See below
USB Default Node Address	N.A.
USB Default Baud Rate	1.5 Mb/s
Number of Sensor Supplies	2
Sensor Supply Output Voltage	5 VDC or 10 VDC (configurable)
Sensor Supply Maximum Current	200 mA @ 5VDC, 100 mA @ 10V per supply
Analog Input Resolution	12 bits, *10 bits
Accuracy	+/- 1 % FS
Measuring Ranges	0...5 V, 0...10 V*, 0...32 V, 0...20 mA
Short Circuit Protection	Integrated
Open Circuit Detection	Dependent upon selectable termination
Input Sampling Frequency	1 kHz
Input Type	Digital Low/High Side (Software configurable)
Maximum Input Frequency	200 Hz
Switch-on Level	Software configurable
Switch-off Level	Software configurable
Input Type	Frequency, Digital Low/High side, (Software configurable)
Maximum Input Frequency Ch 3-8 (FREQ) (0-5 V square wave)	Ch 3-8 0 Hz...50 kHz* in Frequency mode. Note: maximum aggregate is 200 kHz, Minimum detectable pulse duration is 20 µsec
Maximum Input Frequency Ch 3-8 (Dig)	
Switch-on Level (design review required)	Standard switch on at 3.0 V (this can be changed in hardware)
Switch-off Level (design review required)	Standard switch off at 2.0 V (this can be changed in hardware)

Input Type	Frequency, Ch 3-8, Analog, Pull-up or Pull-down Resistor (Software Configurable)
Analog Input Resolution	9 bits
Accuracy	+/- 2% FS
Measuring Range	0…5V
Input Type	Variable reluctance (Software configurable)
Maximum Input Frequency Ch 1-2 (FREQ) (0-5 V square or sine wave)	0Hz...25kHz* Note: maximum aggregate is 200 kHz. Note: phase and duty cycle are not supported by these inputs minimum detectable pulse duration is 20 µsec
Switch-on Level	Selectable as 2.2 V or self-adaptive (input device changes voltage with frequency)
Switch-off Level	Selectable as 0.0 V or 1.0 V
Input Type	Variable Reluctance, Ch 1-2, Analog (Software Configurable)
Analog Input Resolution	9 bits
Accuracy	+/- 15% FS
Measuring Range	0…5V
Output Type	High Side (Software configurable)
Max Amperage	2A
Diagnostics	Open/Short circuit protection
Output Type	Low/High side, H-Bridge (Software configurable)
Max Amperage	4A
Diagnostics	Open/Short circuit protection
Output Type	PWMi, High side (Software configurable)
Max Amperage	2A
Diagnostics	Open/Short Circuit Protection
PWM Frequency	50 – 2 kHz
Dither Frequency	Configurable 1 - 500 Hz
Dither Amplitude	Configurable 1 - 100%
Control Range	0.05 - 2 A
Control Resolution	1 mA
Fly Back Protection	Integrated
Duty Cycle Resolution	.01% @ 250 Hz
Output Type	PWMi, High Side (Software configurable)
Max Amperage	4A
Diagnostics	Open/Short circuit protection
PWM Frequency	50 – 2 kHz
Dither Frequency	Configurable 1 - 500 Hz
Dither Amplitude	Configurable 1 - 100%
Control Range	0.05 - 4 A
Control Resolution	1.5 mA
Fly Back Protection	Integrated
Duty Cycle Resolution	.01% @ 250H
Connector Manufacturer	Deutsch Inc.
Model	DRC23-40PA & DRC23-40PB
Contact Surface	Nickel plated
A and B Connector Assembly Parts List	Mating connector: P/N: DRC26-40SA & DRC26-40SB, size 20 solid contacts P/N: 0462-201-20141 intended for 20AWG wire, P/N: 0462-005-20141 intended for 16-18 AWG wire, size 20 stamped and formed contacts P/N: 1062-20-0122 (nickel plated), and sealing plug P/N: 0413-204-2005
A and B Connector Tooling Manufacturer	Deutsch
A and B Connector Hand Tool Part Number	Solid contacts: Service crimper: HST-1561 Production crimper(ratcheting): HDT-48-00 Stamped contacts: DTT-20-00
A and B Connector Contact Removal Tool	P/N: 0411-240-2005
P Connector Assembly Parts List	Mating connector DT06-6S-EP06, size 16 solid contacts P/N 0462-201-16141 intended for 14-18AWG wire, size 16 stamped and formed contacts P/N 1062-16-0122(nickel plated), wedge W6S-P012, sealing plug P/N 0413-217-1605
P Connector Tooling Manufacturer	Deutsch
P Connector Hand Tool Part Number	Solid contacts: Service crimper: HST-1561 Production crimper(ratcheting): HDT-48-00 Stamped contacts: DTT-16-00

3.0 KEY FEATURES

- Robust, compact, fully sealed & potted cast aluminum construction
- Completely protected outputs (thermal and overcurrent)
- Reverse polarity protection
- Up to 24 multifunction inputs, depending on model
- Up to 24 multifunction outputs, depending on model
- Diagnostic feedback for short circuit & wire break on all outputs
- Use of proven Deutsch connectors for rigorous IP protection
- Programmable via USB for simple connection to PC
- Three CAN ports
- Sleep input for improved power management
- Regulated supply for sensors
- One customer programmable LED status indicator

4.0 SAFETY CONSIDERATIONS

This operating and installation manual is intended for use by a competent programmer, electrician, technician, or engineer. The instructions included in this manual should be read and kept as a reference document prior to initial controller installation and use. Incorrect operation of these controllers can present a significant threat to both individuals and equipment. In the event of an equipment break down, do not attempt to repair the controller as there are no user serviceable parts inside the enclosure. Any evidence of tampering will invalidate the warranty.

5.0 APPLICATION

This operating and installation manual should be used in conjunction with the online help provided with the Pro-FX Control development environment. Together, this information should form a basis for the simple configuration of the controller and the creation of programs specific to your application needs. Proper operation of the controller is dependent on the program that is created and ultimately downloaded to the hardware, therefore extensive testing is required. Customers programming the controller possess the responsibility of ensuring that both the hardware and software performs as intended with their applications.

Note: That each controller within the HFX product family requires the installation of hardware-specific firmware, description files and libraries before initial use in the application environment.

6.0 HARDWARE DESCRIPTION

The Eaton HFX product line consists of four controller models (HFX12m, HFX20m, HFX32m, and HFX48m), each possessing a unique number of I/O. The HFX12m/HFX20m (pictured below) and HFX32m/HFX48m (pictured below) both share common housings.

Each of these units is designed to function over an extended operating range of supply voltage, from 6 – 32 VDC.

HFX12m/HFX20m

HFX32m/HFX48m

The three integrated CAN ports on these units support CAN 2.0B, the first of which also possesses a software configurable termination. Both SAE J1939 and CANOpen stacks are available in the software development environment. Additionally, the CANLayer2 software library is available for use with CAN bus.

HFX controllers are programmed via a standard USB port. The gateway from a user’s computer automatically detects the hardware, eliminating the need to manually assign a COM port to the unit. The two regulated outputs (sensor supplies) can be configured individually for either 5 or 10 V operation.

The table below represents an I/O overview of the various HFX controller models.

Controller Model		HFX48m (24 I/O)	HFX32m (16 I/O)	HFX20m (10 I/O)	HFX12m (6 I/O)
Total Outputs		24	16	10	6
	Total 2 A channels	16	10	6	4
	Number of channels supporting function				
	PWM	16	10	6	4
	PWMi	16	10	6	4
	High Side output	16	10	6	4
	Total 4 A channels	8	6	4	2
	Number of channels supporting function				
	PWM	8	6	4	2
	PWMi	8	6	4	2
	High Side output	8	6	4	2
	Low Side output	8	6	4	2
	H-Bridge pair	4	3	2	1

Controller Model		HFX48m (24 I/O)	HFX32m (16 I/O)	HFX20m (10 I/O)	HFX12m (6 I/O)
Total Inputs		24	16	10	6
	Total frequency channels	8	6	4	2
	Number of channels supporting function				
	High frequency	8	6	4	2
	Variable reluctance	2	2	2	2
	High Side input	8	6	4	2
	Low Side input	8	6	4	2
	Total analog channels	16	10	6	4
	Number of channels supporting function				
	0 - 5 V input	16	10	6	4
	0 - 10 V input	16	10	6	4
	0 - 32 V input	16	10	6	4
	4 - 20 mA input	16	10	6	4
	High Side input	16	10	6	4
	Low Side input	16	10	6	4
	Thermistor	16	10	6	4

The HFX48m incorporates 24 total outputs, comprised of:

- 8 x 4 A channels
- 16 x 2 A channels

Each channel is capable of:

- High Side output
- Open loop PWM
- Closed loop PWM with current control

The 8 x 4 A channels are also capable of Low Side output and can be configured in pairs for H-Bridge operation.

The HFX48m also incorporates 24 total inputs, comprised of:

- 8 x Frequency (2 of which are capable of measuring variable reluctance sensors)
- 16 x Analog (0-5 V, 0-10 V, 0-32 V, 4-20 mA, and Thermistor)
- All 24 inputs can be configured to add either an internal pull-up or pull-down resistor.

The HFX32m incorporates 16 total outputs, comprised of:

- 6 x 4 A channels
- 10 x 2 A channels

Each channel is capable of:

- High Side output
- Open loop PWM
- Closed loop PWM with current control

The 6 x 4 A channels are also capable of Low Side output and can be configured in pairs for H-Bridge operation.

The HFX32m also incorporates 16 total inputs, comprised of:

- 6 x Frequency (2 of which are capable of handling variable reluctance sensors)
- 10 x Analog (0-5 V, 0-10 V, 0-32 V, 4-20 mA, and Thermistor)

All 16 inputs can be configured to add either an internal pull-up or pull-down resistor.

The HFX20m incorporates 10 total outputs, comprised of:

- 4 x 4 A channels
- 6 x 2 A channels

Each channel is capable of:

- High Side output
- Open loop PWM
- Closed loop PWM with current control

The 4 x 4 A channels are also capable of Low Side output and can be configured in pairs for H-Bridge operation.

The HFX20m also incorporates 10 total inputs, comprised of:

- 4 x Frequency (2 of which are capable of handling variable reluctance sensors)
- 6 x Analog (0-5 V, 0-10 V, 0-32 V, 4-20 mA,
- and Thermistor)

All 10 inputs can be configured to add either an internal pull-up or pull-down resistor.

The HFX12m incorporates 6 total outputs, comprised of:

- 2 x 4 A channels
- 4 x 2 A channels

Each channel is capable of:

- High Side output
- Open loop PWM
- Closed loop PWM with current control

The 2 x 4 A channels are also capable of Low Side output and can be configured as a pair for H-Bridge operation.

The HFX12m also incorporates 6 total inputs, comprised of:

- 2 x Frequency (2 of which are capable of handling variable reluctance sensors)
- 4 x Analog (0-5 V, 0-10 V, 0-32 V, 4-20 mA, and Thermistor)

All 6 inputs can be configured to add either an internal pull-up or pull-down resistor.

All 4 of the HFX controllers also integrate an internal temperature measurement that can be used with the IEC application environment.

7.0 SOFTWARE DESCRIPTION

Software for the HFX family of controllers is provided in the form of the HFX Platform Support Package. This is distributed as a .package file (C:\Users\Public\Pro-FX) and contains the following elements:

- Firmware files (MOT files): A separate file is provided for each HFX controller model.
- Device description package for Pro-FX Control: The HFX package file can be installed using the Pro-FX Control Package Manager. Once it is installed, any of the HFX devices can be used within Pro-FX Control.
- HFX Service Tool: Setup.exe in the Service Tool folder is the installation file.
- Gateway file: Gateway.cfg defines how Pro-FX Control connects to the HFX device.
- HFX USB Driver: Pro-FX Control connects to the HFX using USB. This is the driver to support that connection.
- ECOM USB Driver: The Pro-FX Configure HFX Service Tool connects to the HFX over CAN Port 1 at 250k, using the ECOM device. This is the driver for that device.

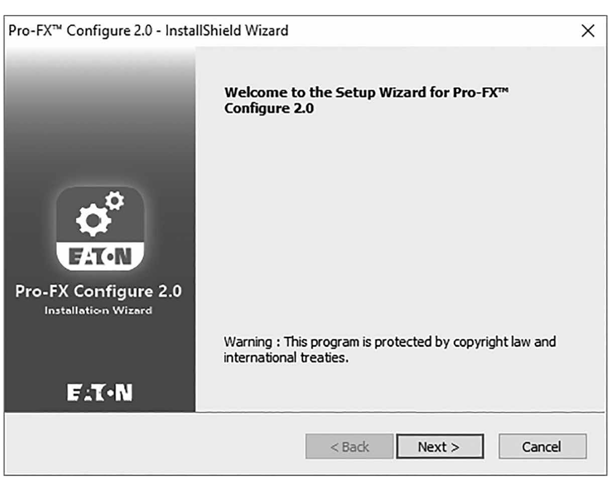
When updating an existing HFX Support Package, it is necessary to update each of the above elements except for the USB drivers, which do not need to be updated unless explicitly mentioned in a given release.

8.0 SERVICE TOOL - INSTALLATION AND GETTING STARTED

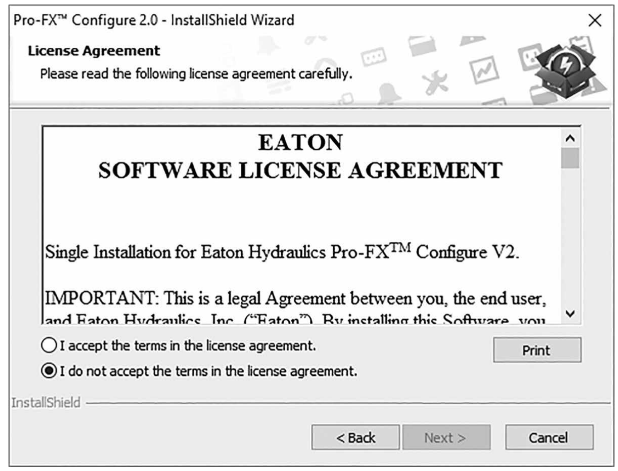
8.1 Installation Procedure

8.1.1 Launch the ProFXConfigure_v2.3.0.exe

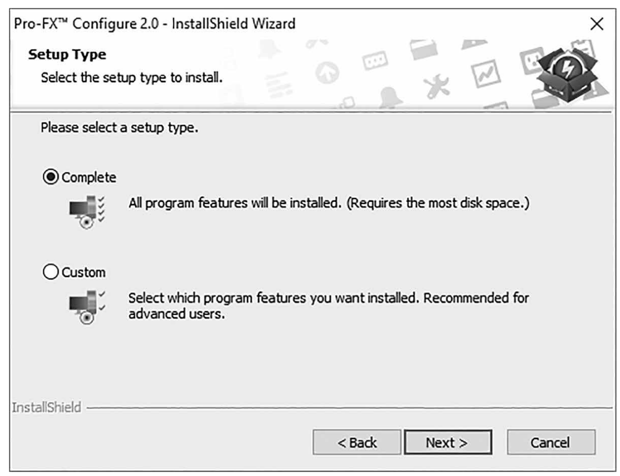
8.1.2 Click Next from the Welcome screen



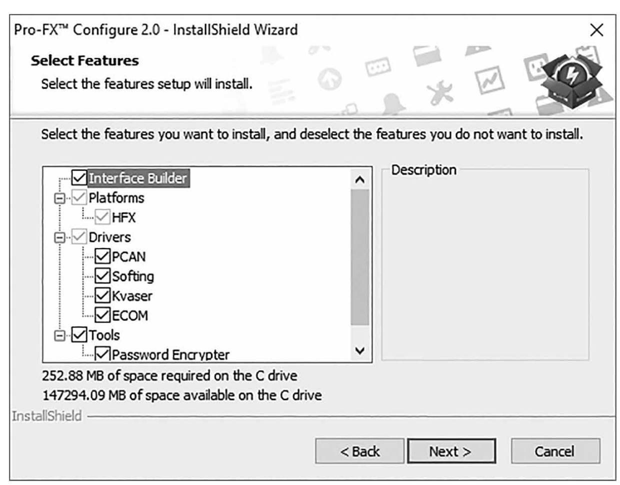
8.1.3 Agree to the software license and click Next



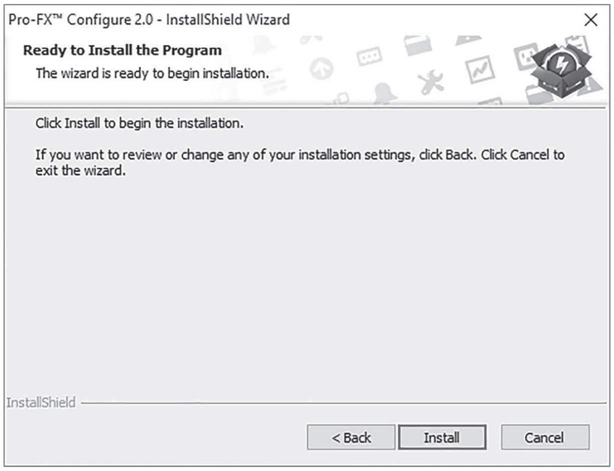
8.1.4 Choose Complete or Custom installation, then click Next



8.1.4.1 If Custom is shown, pick which options you'd like installed then click Next



8.1.5 Click Install from the Ready to Install dialog



8.1.6 Once the installation is complete, desktop shortcuts for the applications will be created as well as Start Menu shortcuts

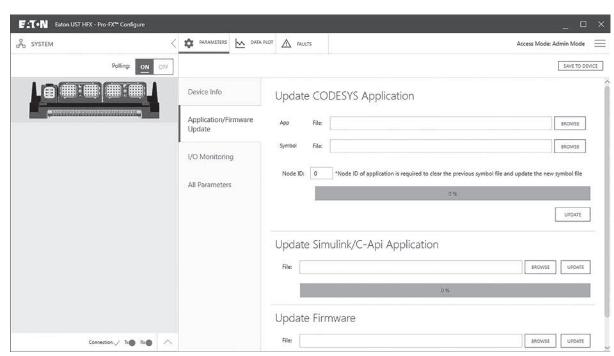
9.0 FIRMWARE

9.1 Install the Firmware

9.1.1 Launch Pro-FX Configure for HFX & SFX, select the appropriate adapter and click Next

9.1.2 Once the Pro-FX Configure UI is displayed, log into 'Admin mode'. This can be done by selecting Main Menu->Change Access Level, found in the top-right corner of the home screen. When prompted, enter the default Admin mode password: ADMINMODE. To log back into 'Normal mode' use the default NORMALMODE password. It is recommended that users change the default passwords after installation.

After logging into Admin mode, select the Application/Firmware Update tab. From this tab you can browse for a firmware file and click Update. During an update, the rest of Pro-FX Configure will not be usable.



10.0 PRO-FX CONTROL

10.1 Install Pro-FX Control

10.1.1 Install Pro-FX Control if it is not already installed.

10.2 Install the HFX Support Package

10.2.1 Launch Pro-FX Control and select Tools->Package Manager.

Note: That it is necessary to run Pro-FX Control with Administrator privileges to complete this step.

10.2.2 Click the "Install..." button.

10.2.3 Highlight the HFX Support package file and select open.

10.2.4 Follow the prompts to finish the installation. Close the Package Manager.

11.0 GETTING STARTED

11.1 Create your First Project

11.1.1 Click File->New Project.

11.1.2 Select "Standard Pro-FX Project". Click "OK".

11.1.3 Select the appropriate HFX device and I/O count for the controller you will be using for your project. Click OK.

11.2 Connect and Program your Controller

11.2.1 Connect the HFX controller to the USB port of your computer via the 6-pin Deutsch connector.

11.2.2 Ensure that the unit is powered-up properly by verifying that LED A is green.

11.2.3 In the Pro-FX Control "Devices" tree view, double click on the "Device".

11.2.4 Click on the "Communication Settings" tab.

11.2.5 Click on the "Gateway-1" and then click "Scan Network".

11.2.6 One HFX should appear. Click on it and select "Set active Path". If you have problems with this step, please see the troubleshooting steps in Appendix A.

11.2.7 Select "Online->Login" and then acknowledge any prompts that are displayed.

11.2.8 Click "Debug->Start".

11.2.9 You have now programmed an empty project to your HFX controller and are connected for the first time. LED A should be flashing on your controller which indicates that there is an application currently running on your controller.

12.0 FUNCTIONALITY AND BASIC OPERATION

12.1 Reset Procedure

A different service tool is required for the reset procedure. Run the HFX Service Tool installation file setup.exe in the Service Tool folder of the HFX Support Package. Follow the installation prompts to install the service tool.

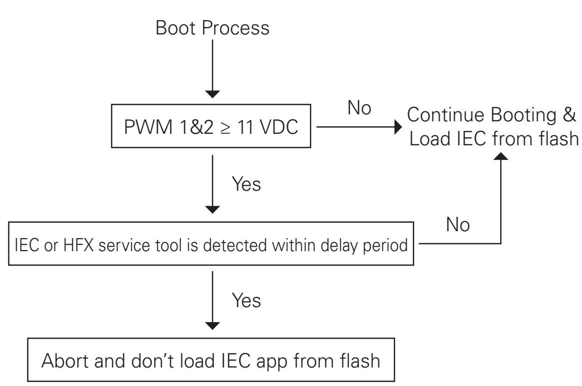
When launching the HFX Service Tool you may be prompted for a password. The latest passwords can be found in the file `Password.txt', located in the Service Tool folder of the HFX support package. You have the option to select `Save password and S/N', which stores the password for the next time the software is used. Note: The current read only password is: “YZJI-K2LH-0KCX-CYRC”

At initial startup, the controller enters the bootloader. A bootloader is simply a small program that loads the rest of the firmware when the controller is initially powered up. This firmware resides in the flash memory and provides the necessary memory mapping and instructions for the controller, allowing the application program to be processed. The bootstrap mechanism provides the means to enter the bootloader. The IEC bootstrap mechanism is as follows:

1. Check for PWM1&2 ≥ 11.0 V
2. Delay 3 seconds
3. If either the HFX service tool or IEC is connected, abort and don’t load IEC app from flash
4. Otherwise, load and run the IEC app in flash like normal.

This provides a mechanism to remove a frozen application.

1. Load a new application, or
2. Reset origin will clear entire application memory.



12.2 Sleep Mode (Time Delay Operation)

Sleep Mode provides a mechanism to have a controlled shutdown of the vehicle control system. This is a benefit because the unit can be put into an idle state where less current is required thus extending battery life. It is also useful with applications where, prior to shut down, the controller needs to return key functional outputs to a predefined or home position.

Operating Mode	Enter Sleep bit State	Sleep Allowed State
Sleep	True	True (Sleep Pin> approximately 6.6 V or Ignition Pin < approximately 6.6 V)
Awaken	False	False (Sleep Pin< approximately 6.6 V and Ignition Pin > approximately 6.6 V)

The controller will enter sleep by setting the “enterSleep” bit to TRUE anytime that the “sleepAllowed” status bit is TRUE ({Sleep is high} or {IGN is low or not connected}).

The controller will awaken from sleep if {Sleep is low or not connected} and {IGN is high}

Sleep current 2.4 mA, @ 10 V, 1.9 mA @ 15 V, 1.6 mA@ 20 V, 1.2 mA @ 25 V

12.3 Task Configuration

The maximum number of tasks is 5. The controller supports the following tasks:

- Cyclic: Task processed in a predefined time.
- Freewheeling: Task processed as soon as the program is started. When complete, it will automatically restart in a continuous loop.

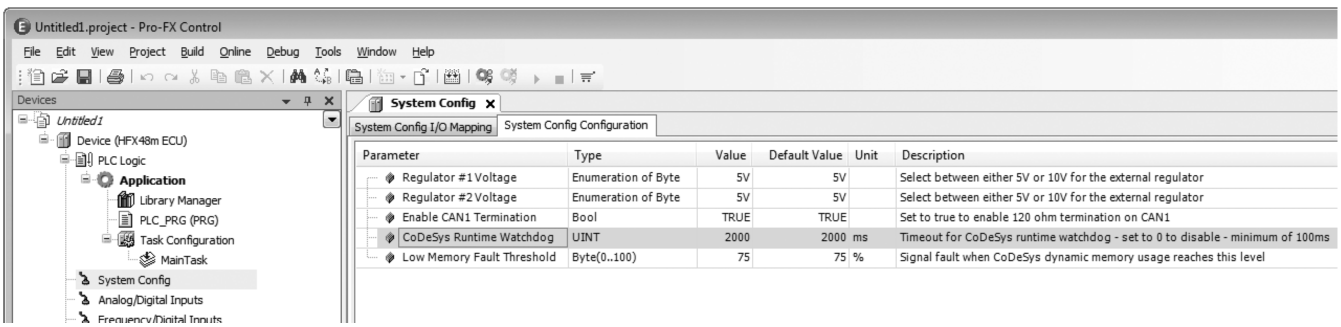
Note: There are no external events available to trigger task execution.

12.4 Watchdog Operation

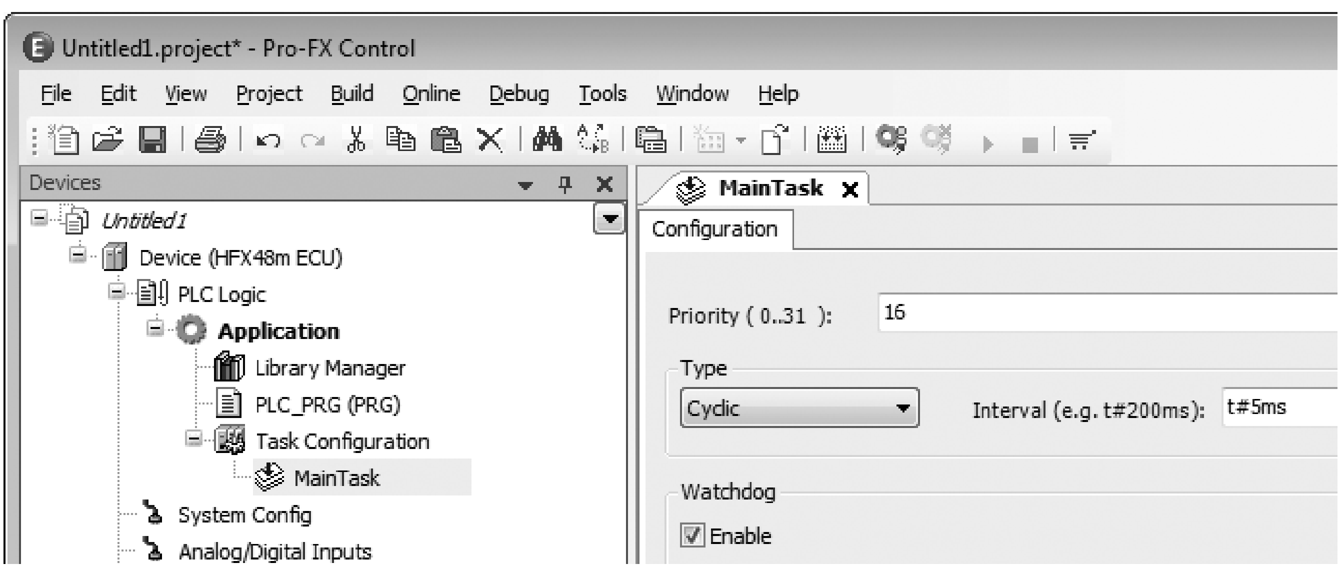
Watchdogs are present to provide an indication that something has gone wrong. Systems that are programmable can hang for a number of different reasons. One of the most common is the execution of an infinite loop due to a programming logic error. This type of failure prevents any of the other code from executing. Also, if an unusual number of interrupts arrives during a single cycle of the loop this can prevent the main loop from having sufficient time to execute. Another possibility is a failure in hardware that causes a constant reset.

Each controller has an internal hardware watchdog that is continuously running in the background to monitor for a system malfunction. This watchdog is not user serviceable and is not visible to the user. It will trigger in the event of a task timeout and can only be reset through a hard reset of the controller, which means that the user must connect the service tool or IEC programming tool to the controller, tie PWM 1 & 2 to supply voltage, and then power up the unit. This will prevent the IEC application code from loading.Each controller also features a second watchdog, which monitors the Pro-FX Control runtime system with a default value of 2 seconds and recommendation to be set above a minimum 100 ms. This is user configurable via the System Config Configuration tab (see below screen).

Note: That this watchdog is reset using the same protocol used to reset the internal hardware watchdog.



Pro-FX Control also has a watchdog that monitors specific tasks; the time is user configurable via the Task Configuration/MainTask tab (see below screen). For additional details see Pro-FX Control online help. It is typically reset by resetting an associated fault.



12.5 Controller Memory

The controller utilizes an advanced superscalar 32 Bit processor operating at 200 MHz. The memory is arranged into the following areas:

- Flash 3.75 Mbyte (1.75 Mbyte reserved for IEC application)
- EEPROM 128 kbyte reserved for internal use i.e. firmware/bootloader
- RAM 256 kbyte
- MRAM 32 kbyte (24 kbyte user accessible file-system + 4kbyte redundant retain)

12.6 Calibration parameter memory

The Pro-FX Control development Environment offers the ability to have local calibration parameters through the use of the parameter handler included in the Pro-FX Control standard project in the HFX templates. For further information on how to use the Parameter handler please review the information on the parameter handler in the Pro-FX Control help system.

12.7 LED Operation

LED A (left-most) - Green power LED

- Off ==> Not powered up
- Solid on ==> Powered up and Pro-FX Control application not running
- Fast flash (100ms on, 100ms off) ==> Pro-FX Control application running

LED B (middle) - Red MIL (Malfunction Indicator Lamp)

- Pro-FX Control application running
  - Flashing (200ms on, 200ms off) ==> critical fault is active
  - Solid on ==> standard fault is active
  - Off ==> no fault
- Pro-FX Control application not running
  - Fast Flashing (200ms on, 200ms off) ==> critical fault is active
  - Slow pulse (100ms on, 1500ms off) ==> historic fault is set - must be manually cleared
  - Solid on ==> standard fault is active
  - Off ==> no fault

LED C (right-most) - Green user programmable LED

- User programmable via System Config I/O variable: userLedState

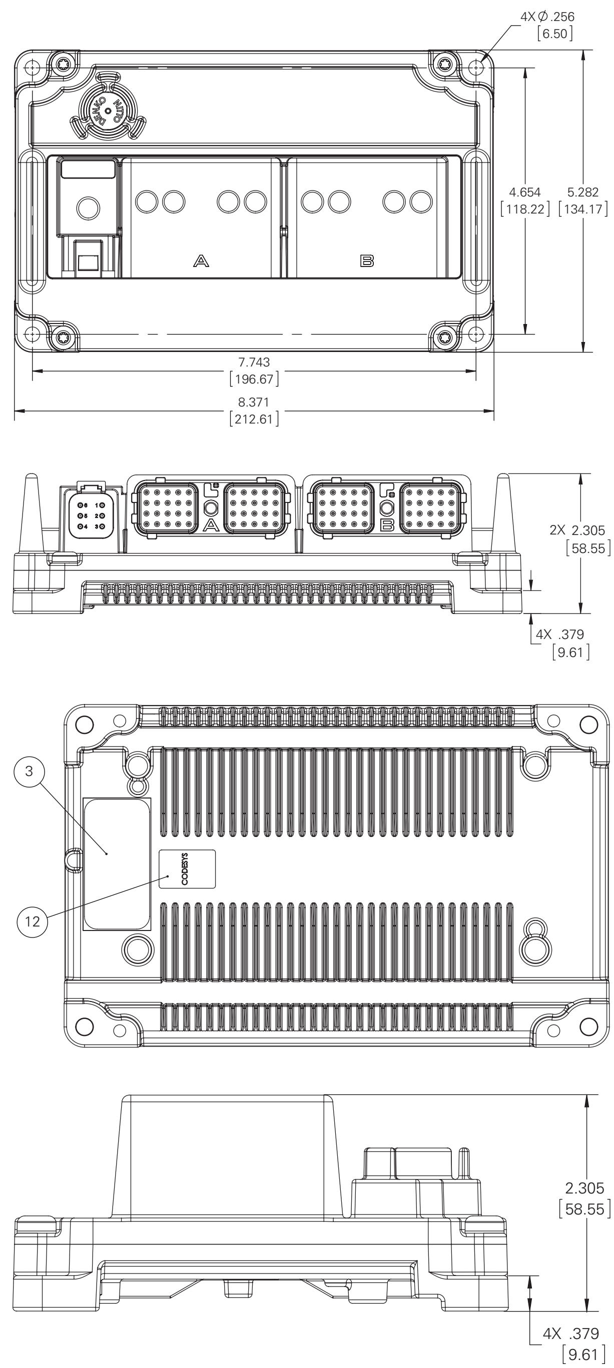
Miscellaneous states

- LED A Off and MIL light solid on ==> No firmware present
- MIL light will pulse briefly for a bulb check on every powerup
- MIL light will retain its state for 3 seconds after an active fault goes inactive

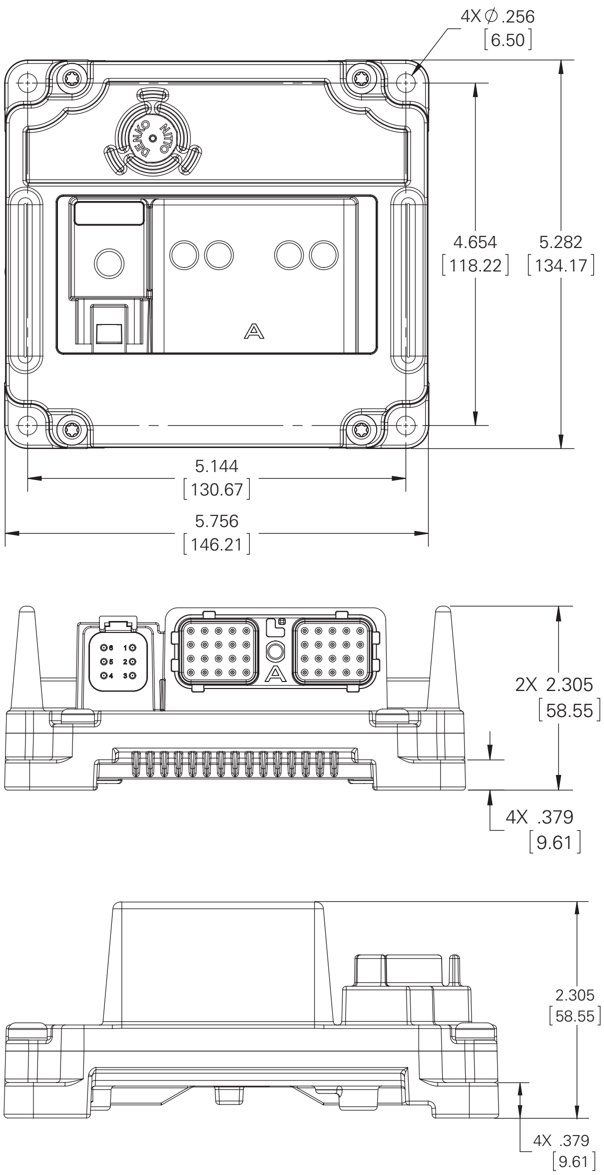
13.0 INSTALLING THE CONTROLLER

13.1 Product Dimensions

HFX32m & HFX48m Dimensional Data



HFX12m & HF20m Dimensional Data



13.2 Mounting Considerations

The following procedure is recommended when mounting the HFX series controllers.

- Ideally the controller should be mounted on a vertical flat surface with the open end of the connector facing down.
- Use four standard threaded fasteners to securely mount the controller to the surface (either 6mm or ¼″ diameter are acceptable).
- Note that the HFX series is designed for ambient operating temperatures up to 105°C maximum. The housing is constructed of cast aluminum and it allows for effective heat dissipation when mounted to metal surfaces and/or when adequate ventilation is available.
- When mounting multiple controllers inside a vented enclosure please allow for a minimum of 2″ between adjacent controller surfaces so that adequate air flow is present to aid in cooling.
- When mounting a controller(s) inside a sealed unvented enclosure, it is important to note that the temperature rise above ambient is determined by the size of the enclosure (surface area) and the expected power dissipation of the controller(s). A conservative guideline to use for the maximum power dissipation expected from one HFX controller is 50 watts.
- Please check with your enclosure manufacturer for appropriate guidelines concerning the necessary enclosure volume to adequately limit thermal rise below the maximum operating temperature of 105°C

13.3 Recommended Wiring Practices

This section contains information about the controller connectors and pin outs. Please use the following recommended wiring practices when installing and using the controller:

- Ensure correct and adequate single point ground to prevent ground loops.
- Use twisted or twisted shielded pair cable for CAN per the applicable standard.
- Confirm that the CAN network is properly terminated using 120Ω resistors.
- Ensure the appropriate sized conductor cross section is specified for the intended load current in the harness design.

  Note: Please review individual overcurrent shutdown values in the configuration and use the correct wire gauge conductor to accommodate maximum load current configured
- Make sure that voltage drops are kept within reasonable levels under maximum continuous load conditions e.g. 1 volt on 12-volt systems and 2 volts on 24-volt systems.
- Verify that the harness is constructed to meet the needs of the application environment (e.g. shock, vibration, moisture, temperature, chemicals, and impact).
- Make certain that the harness is designed and constructed to minimize induced interference resulting from EMI coupling between signal wires.
- Separate power circuits from low-level signals.
- All splices (soldered or crimped) should use adhesive lined heat shrink tubing.
- Make provisions for drip loops to attach devices in exposed locations and prevent moisture entry and formation.
- Provide sufficient clearance from moving parts.

- Wires routed through holes in the vehicle body/ chassis should use grommets.
- Avoid sharp metal edges, fasteners, and other abrasive surfaces or use protective shielding when routing harness assembly.
- Route wires to avoid exhaust system components or other high temperature areas, use appropriate heat shielding or other insulation where routing is a problem.
- Avoid routing near wheel wells or provide adequate mechanical protection to the assembly.
- Use a protective fuse sized appropriately for the controller supply current.

  Note: typical maximum load current is 60% - 80% of fuse rating. Verify that wiring can handle more current than the fuse rating. Note the following guideline for maximum fuse recommendations:

  - All Units: +VBat = 2 A
  - HFX48 :+Load total < 50 A depending upon anticipated load requirements.
  - HFX32: +Load total < 42 A depending upon anticipated load requirements.
  - HFX20: +Load total < 34 A depending upon anticipated load requirements.
  - HFX12: +Load total < 26 A depending upon anticipated load requirements.

⚠ WARNING

On a HFX12m or HFX20m all HFX Load PWR+ pins (9A, 10A, and 19A) must be connected to the same supply voltage source. On a HFX12m or HFX20m all SFX LOAD_PWR- pins (18A, 28A, and 29A) must be connected to the same supply voltage return point.

On a HFX32m or HFX48m all HFX Load PWR+ pins (9A, 10A, 19A, 1B, 2B, and 3B) must be connected to the same supply voltage source. On a HFX32m or HFX48m all HFX LOAD_PWR- pins (18A, 28A, 29A), 12B, 13B, and 22B) must be connected to the same supply voltage return point.

Failure to connect all the pins to their respective sources or returns or to use them to power or ground other devices may cause internal failures of the HFX controller, damage to the controller connector, or damage to the wiring harness, and is not covered by warranty.

⚠ WARNING

Prior to Welding

In order to avoid damaging the HFX controller ensure that all electrical connectors are fully disconnected from the HFX controller prior to welding on the machine.

Prior to Electrostatic painting

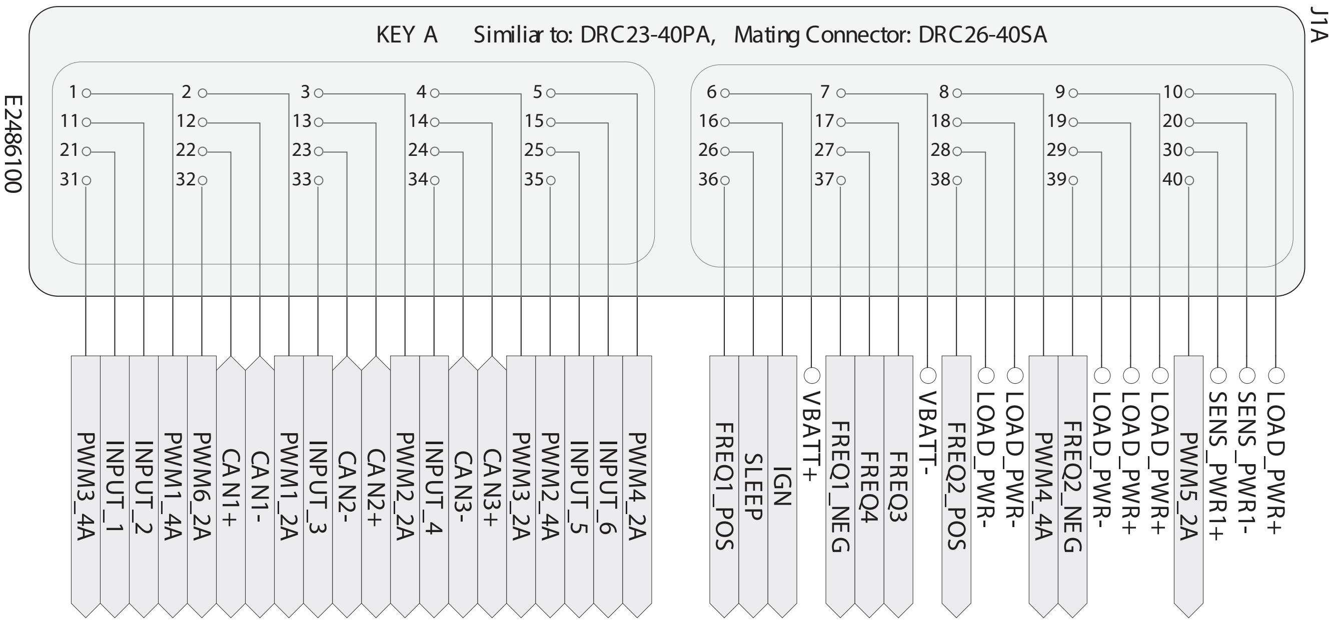
In order to avoid damaging the HFX controller ensure that all electrical connectors are fully disconnected from the HFX controller and that sealed mating connectors without wires are installed on the HFX connector ports prior to Electrostatic painting on the machine.

⚠ CAUTION

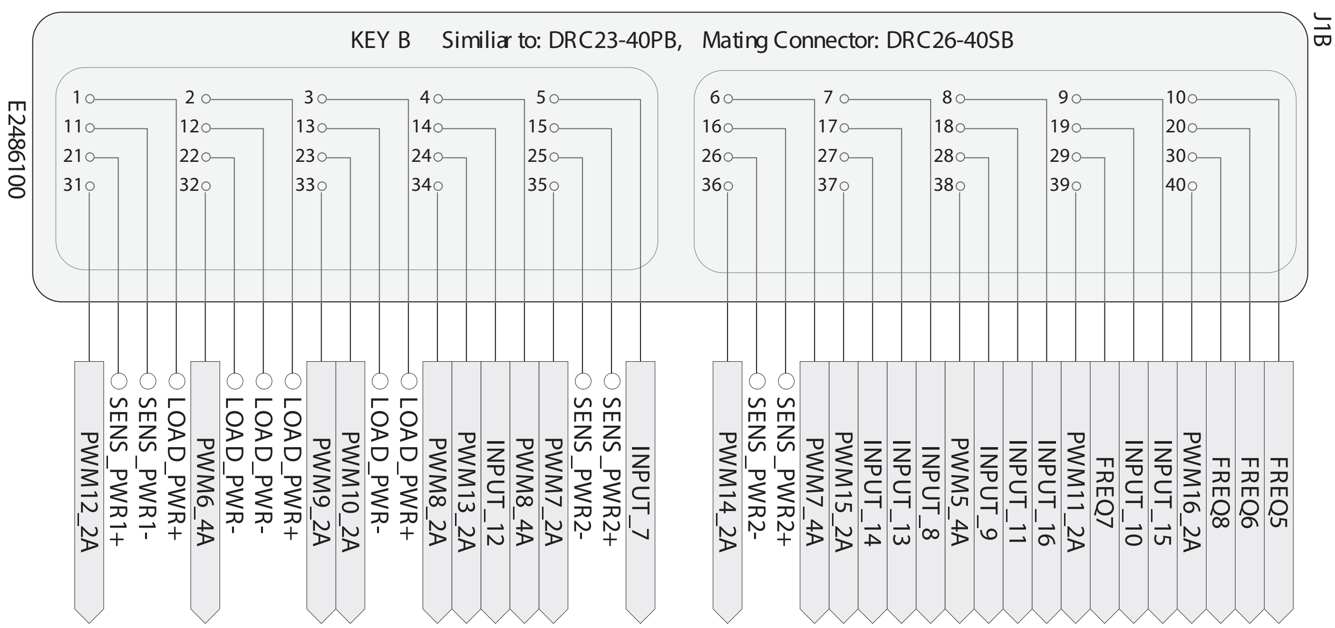
To maintain the environmental ratings of the HFX controller all connector locations must have a weather sealed connector as specified in the technical specifications installed. A dust plug may be shipped in the C connector of the controller, it is not an environmental seal. All connector cavities in each connector must have either an appropriate sized wire or the correct sealing plug installed. Torque the A and B connector, if applicable, to 25-28 in-lbs (2.82 – 3.16 Nm)

14.0 ELECTRICAL CONNECTION INFORMATION

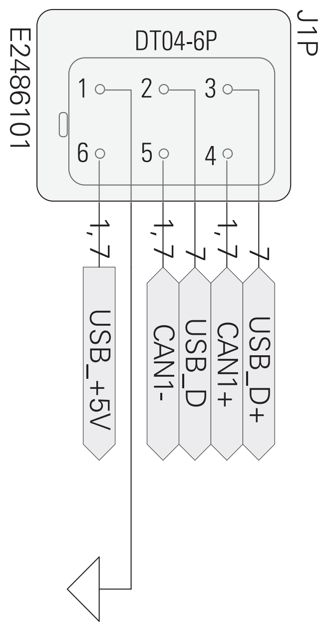
14.1 Wiring Pin Out



Note: All 4 of the HFX units share a common pin-out. The HFX12 does not utilize the following pins: 8, 15, 17, 25, 27, 31, 32, and 40.



Note: Although all 4 of the HFX units share a common pin-out, both the HFX12 and the HFX20 do not have connector B. The HFX32 does not utilize the following pins: 4, 6, 8, 14, 17, 18, 24, 27, 29, 30, 31, 36, 37, 39, and 40.

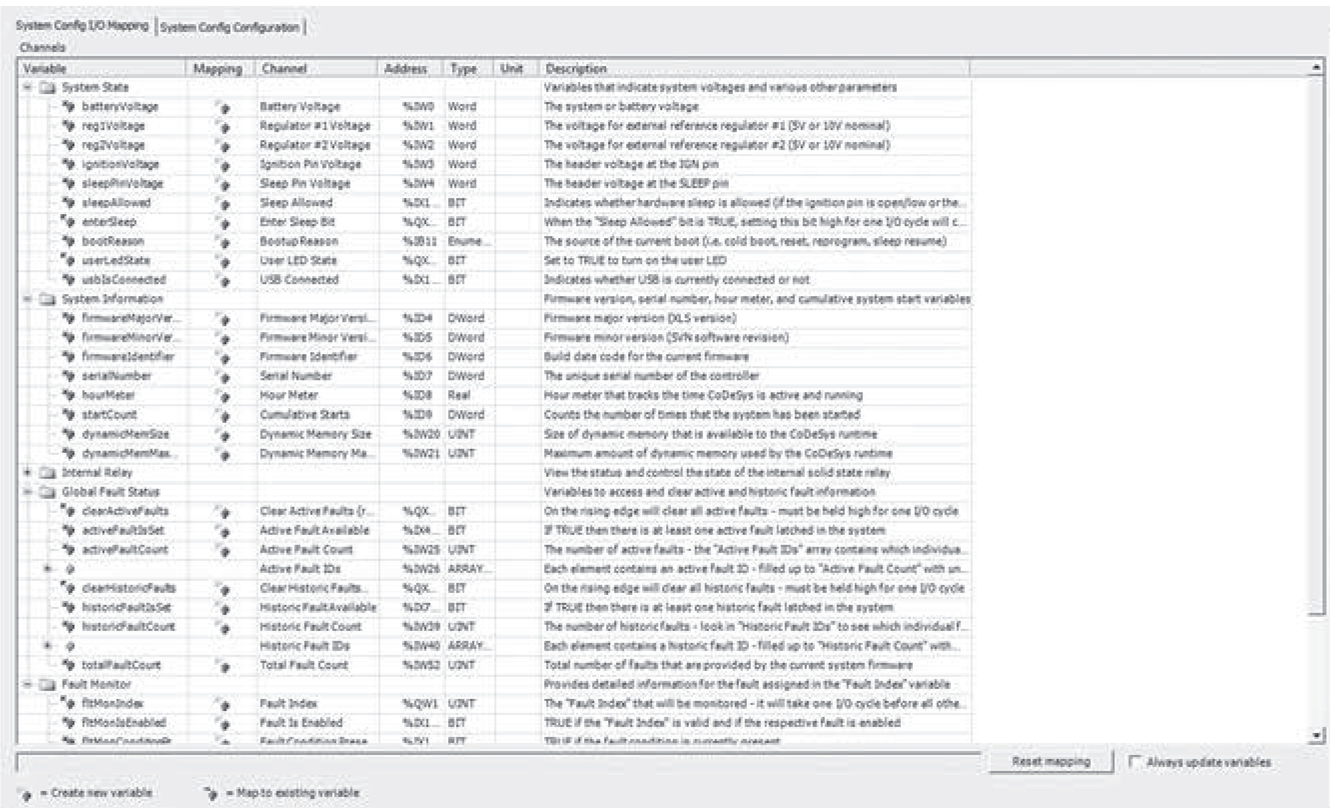


The above connector is used for programming and is common to all 4 models of the HFX controller.

15.0 CONFIGURATION

15.1 System Configuration

The controller features an advanced view into the hardware through the System Config I/O Mapping tab. There are numerous predefined variables associated with the controller that are accessible via the application program. This dramatically simplifies programming. All of these variables are pre-mapped with a relevant name linked with their respective channel. This name can be changed by the user if desirable. Each variable also has an associated address, type, and description all intended to help the programmer. The System Config I/O Mapping is organized into folders of related variables e.g. the System State folder contains information such as Supply Voltage, Regulator Voltage, Ignition Pin Voltage, Sleep Pin Voltage, User LED State, USB Connected, etc. The other folders consist of System Information e.g. Firmware Rev, Serial Number, Hour Meter, etc.; Internal Relay status; Global Fault Status for both active and historic faults; and a Fault Monitor for managing faults (see below image).


System Config I/O Mapping | System Config Configuration

Channels

Variable	Mapping	Channel	Address	Type	Unit	Description
System State						Variables that indicate system voltages and various other parameters
batteryVoltage		Battery Voltage	%IW0	Word		The system or battery voltage
reg1Voltage		Regulator #1 Voltage	%IW1	Word		The voltage for external reference regulator #1 (5V or 10V nominal)
reg2Voltage		Regulator #2 Voltage	%IW2	Word		The voltage for external reference regulator #2 (5V or 10V nominal)
ignitionVoltage		Ignition Pin Voltage	%IW3	Word		The header voltage at the IGN pin
sleepPinVoltage		Sleep Pin Voltage	%IW4	Word		The header voltage at the SLEEP pin
sleepAllowed		Sleep Allowed	%IX1...	BIT		Indicates whether hardware sleep is allowed (if the ignition pin is open/low or the...
enterSleep		Enter Sleep Bit	%QX...	BIT		When the "Sleep Allowed" bit is TRUE, setting this bit high for one I/O cycle will c...
bootReason		Bootup Reason	%IB11	Enume...		The source of the current boot (i.e. cold boot, reset, reprogram, sleep resume)
userLedState		User LED State	%QX...	BIT		Set to TRUE to turn on the user LED
usbIsConnected		USB Connected	%IX1...	BIT		Indicates whether USB is currently connected or not
System Information						Firmware version, serial number, hour meter, and cumulative system start variables
firmwareMajorVer...		Firmware Major Versi...	%ID4	DWord		Firmware major version (XLS version)
firmwareMinorVer...		Firmware Minor Versi...	%ID5	DWord		Firmware minor version (SVN software revision)
firmwareIdentifier		Firmware Identifier	%ID6	DWord		Build date code for the current firmware
serialNumber		Serial Number	%ID7	DWord		The unique serial number of the controller
hourMeter		Hour Meter	%ID8	Real		Hour meter that tracks the time CoDeSys is active and running
startCount		Cumulative Starts	%ID9	DWord		Counts the number of times that the system has been started
dynamicMemSize		Dynamic Memory Size	%IW20	UINT		Size of dynamic memory that is available to the CoDeSys runtime
dynamicMemMax...		Dynamic Memory Ma...	%IW21	UINT		Maximum amount of dynamic memory used by the CoDeSys runtime
Internal Relay						View the status and control the state of the internal solid state relay
Global Fault Status						Variables to access and clear active and historic fault information
clearActiveFaults		Clear Active Faults (r...	%QX...	BIT		On the rising edge will clear all active faults - must be held high for one I/O cycle
activeFaultIsSet		Active Fault Available	%IX4...	BIT		If TRUE then there is at least one active fault latched in the system
activeFaultCount		Active Fault Count	%IW25	UINT		The number of active faults - the "Active Fault IDs" array contains which individua...
		Active Fault IDs	%IW26	ARRAY...		Each element contains an active fault ID - filled up to "Active Fault Count" with un...
clearHistoricFaults		Clear Historic Faults...	%QX...	BIT		On the rising edge will clear all historic faults - must be held high for one I/O cycle
historicFaultIsSet		Historic Fault Available	%IX7...	BIT		If TRUE then there is at least one historic fault latched in the system
historicFaultCount		Historic Fault Count	%IW39	UINT		The number of historic faults - look in "Historic Fault IDs" to see which individual f...
		Historic Fault IDs	%IW40	ARRAY...		Each element contains a historic fault ID - filled up to "Historic Fault Count" with...
totalFaultCount		Total Fault Count	%IW52	UINT		Total number of faults that are provided by the current system firmware
Fault Monitor						Provides detailed information for the fault assigned in the "Fault Index" variable
fltMonIndex		Fault Index	%QW1	UINT		The "Fault Index" that will be monitored - it will take one I/O cycle before all othe...
fltMonIsEnabled		Fault Is Enabled	%IX1...	BIT		TRUE if the "Fault Index" is valid and if the respective fault is enabled

Reset mapping

Always update variables

= Create new variable

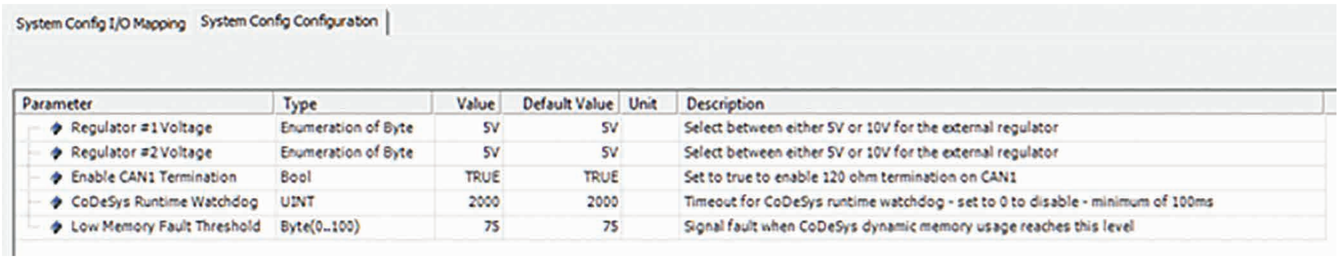
= Map to existing variable

The above variables can be monitored in the application program to alter controller response. For example, if the battery voltage falls below a predefined limit, or the temperature exceeds a limit, the programmer can choose to initiate a shutdown. Some variables can also be manipulated in the application control program. For instance, the user LED can be used to impart additional information to the user and the internal relay current can be monitored, and if it exceeds a predetermined limit, forced off.

Note: The variable radio button “Always update variables” (located in the lower right corner of the above picture) should be checked. If this is deselected, only variables used by the IEC application will be updated.

The system configuration has a second tab, the system config configuration that enables the user to configure settings for Regulator Voltage, CAN 1 Termination, Watchdog Time, and Low Memory Fault threshold.

Note: That depending on the parameter, double clicking the value in the appropriate value field will either open a drop down menu to select, allow direct editing or toggle the variable (see picture below).


System Config I/O Mapping | System Config Configuration

Parameter	Type	Value	Default Value	Unit	Description
Regulator #1 Voltage	Enumeration of Byte	5V	5V		Select between either 5V or 10V for the external regulator
Regulator #2 Voltage	Enumeration of Byte	5V	5V		Select between either 5V or 10V for the external regulator
Enable CAN1 Termination	Bool	TRUE	TRUE		Set to true to enable 120 ohm termination on CAN1
CoDeSys Runtime Watchdog	UINT	2000	2000		Timeout for CoDeSys runtime watchdog - set to 0 to disable - minimum of 100ms
Low Memory Fault Threshold	Byte(0..100)	75	75		Signal fault when CoDeSys dynamic memory usage reaches this level

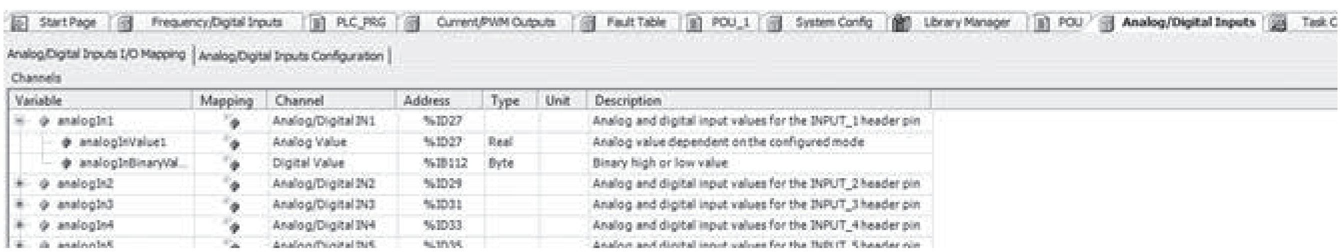
15.2 Input Modes

The controller has either 6, 10, 16 or 24 inputs available for use, depending on the selected model. The specific inputs are as follows:

- Configurable Analog/Digital Inputs
- Configurable Frequency/Digital Inputs
- Configurable Differential Frequency/Digital Inputs

These different configurations are possible through selection of the appropriate mode in the PLC configuration tab in the IDE (see screens below).

15.3 Analog Configuration


Start Page | Frequency/Digital Inputs | PLC_PRG | Current/PWM Outputs | Fault Table | POU_1 | System Config | Library Manager | POU | Analog/Digital Inputs | Task C

Analog/Digital Inputs I/O Mapping | Analog/Digital Inputs Configuration

Channels

Variable	Mapping	Channel	Address	Type	Unit	Description
analogIn1		Analog/Digital IN1	%ID27			Analog and digital input values for the INPUT_1 header pin
analogInValue1		Analog Value	%ID27	Real		Analog value dependent on the configured mode
analogInBinaryVal...		Digital Value	%IB112	Byte		Binary high or low value
analogIn2		Analog/Digital IN2	%ID29			Analog and digital input values for the INPUT_2 header pin
analogIn3		Analog/Digital IN3	%ID31			Analog and digital input values for the INPUT_3 header pin
analogIn4		Analog/Digital IN4	%ID33			Analog and digital input values for the INPUT_4 header pin
analogIn5		Analog/Digital IN5	%ID35			Analog and digital input values for the INPUT_5 header pin

Figure 1: Analog/Digital Inputs I/O Mapping tab.

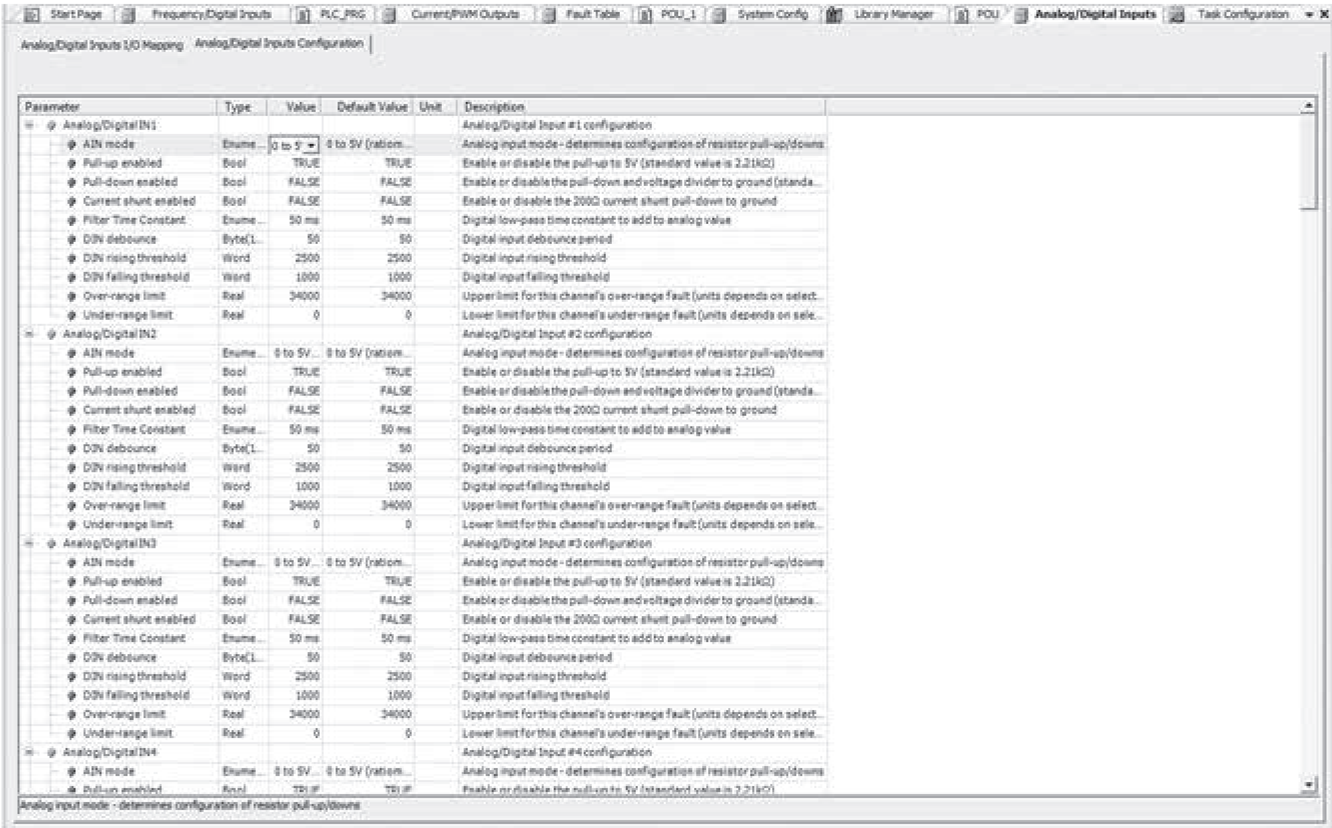
This is the area where analog or digit input values are mapped to addresses. These variables are all accessible in the application program.

Variables:

- AnalogInValue#: Analog value with units dependent upon configured mode.
- AnalogInBinaryValue#: Digital value after debounce and rising/falling voltage thresholds are applied.

Note: # above represents input numerical

16, 10, 6, or 4 of the inputs (depending on the model chosen) can be configured as either Analog or Digital. Both the Analog and Digital value have a name, value, address, type and description associated. The name can be altered by the programmer, if desired. Analog Inputs are displayed in actual engineering units depending on the mode configuration (either Voltage – mV, Current – µA, Resistance - Ω, or Temperature °C). Binary inputs are evaluated as true or false and our bits.



Parameter	Type	Value	Default Value	Unit	Description
Analog/Digital IN1					Analog/Digital Input #1 configuration
AIN mode	Enume...	0 to 5'	0 to 5V (ratiom...		Analog input mode - determines configuration of resistor pull-up/downs
Pull-up enabled	Bool	TRUE	TRUE		Enable or disable the pull-up to 5V (standard value is 2.21kΩ)
Pull-down enabled	Bool	FALSE	FALSE		Enable or disable the pull-down and voltage divider to ground (standa...
Current shunt enabled	Bool	FALSE	FALSE		Enable or disable the 200Ω current shunt pull-down to ground
Filter Time Constant	Enume...	50 ms	50 ms		Digital low-pass time constant to add to analog value
DIN debounce	Byte(1...	50	50		Digital input debounce period
DIN rising threshold	Word	2500	2500		Digital input rising threshold
DIN falling threshold	Word	1000	1000		Digital input falling threshold
Over-range limit	Real	34000	34000		Upper limit for this channel's over-range fault (units depends on select...
Under-range limit	Real	0	0		Lower limit for this channel's under-range fault (units depends on sele...
Analog/Digital IN2					Analog/Digital Input #2 configuration
AIN mode	Enume...	0 to 5V...	0 to 5V (ratiom...		Analog input mode - determines configuration of resistor pull-up/downs
Pull-up enabled	Bool	TRUE	TRUE		Enable or disable the pull-up to 5V (standard value is 2.21kΩ)
Pull-down enabled	Bool	FALSE	FALSE		Enable or disable the pull-down and voltage divider to ground (standa...
Current shunt enabled	Bool	FALSE	FALSE		Enable or disable the 200Ω current shunt pull-down to ground
Filter Time Constant	Enume...	50 ms	50 ms		Digital low-pass time constant to add to analog value
DIN debounce	Byte(1...	50	50		Digital input debounce period
DIN rising threshold	Word	2500	2500		Digital input rising threshold
DIN falling threshold	Word	1000	1000		Digital input falling threshold
Over-range limit	Real	34000	34000		Upper limit for this channel's over-range fault (units depends on select...
Under-range limit	Real	0	0		Lower limit for this channel's under-range fault (units depends on sele...
Analog/Digital IN3					Analog/Digital Input #3 configuration
AIN mode	Enume...	0 to 5V...	0 to 5V (ratiom...		Analog input mode - determines configuration of resistor pull-up/downs
Pull-up enabled	Bool	TRUE	TRUE		Enable or disable the pull-up to 5V (standard value is 2.21kΩ)
Pull-down enabled	Bool	FALSE	FALSE		Enable or disable the pull-down and voltage divider to ground (standa...
Current shunt enabled	Bool	FALSE	FALSE		Enable or disable the 200Ω current shunt pull-down to ground
Filter Time Constant	Enume...	50 ms	50 ms		Digital low-pass time constant to add to analog value
DIN debounce	Byte(1...	50	50		Digital input debounce period
DIN rising threshold	Word	2500	2500		Digital input rising threshold
DIN falling threshold	Word	1000	1000		Digital input falling threshold
Over-range limit	Real	34000	34000		Upper limit for this channel's over-range fault (units depends on select...
Under-range limit	Real	0	0		Lower limit for this channel's under-range fault (units depends on sele...
Analog/Digital IN4					Analog/Digital Input #4 configuration
AIN mode	Enume...	0 to 5V...	0 to 5V (ratiom...		Analog input mode - determines configuration of resistor pull-up/downs
Pull-up enabled	Bool	TRUE	TRUE		Enable or disable the pull-up to 5V (standard value is 2.21kΩ)

Figure 2: Analog/Digital Inputs Configuration tab.

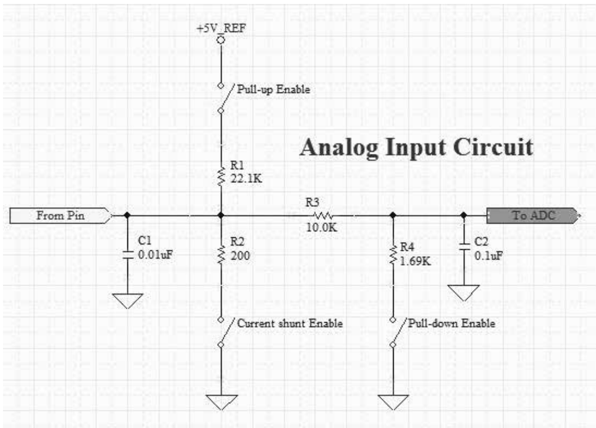
The programmer changes the configuration of an individual input using the AIN mode value drop down selection.

Note: That if any of the following auto configurations is selected offline, the state for the corresponding pull-up, pull-down, and current shunt will change once the program is downloaded into the application controller.

Variables:

- AIN mode: This represents the type of input connected.
- Pull-up enabled: This is used in manual mode to activate the Pull-up resistor.
- Pull-down enabled: This is used in manual mode to activate the Pull-down resistor.
- Current shunt enabled: This is used in manual mode to activate the Current shunt resistor.
- Filter time constant: This is a Digital low pass filter time constant that the input passes through, this is useful if you wish to filter out some random variation on the input or if you wish to reduce how quickly the input changes value.
- DIN debounce: This is a time value used to debounce mechanical switches that would otherwise trigger the input multiple times when closed.
- DIN rising threshold: This sets the lower limit voltage level necessary for the input to register as high.
- DIN falling threshold: This sets the upper limit voltage level necessary for the input to register as low. Used in conjunction with the above DIN rising threshold, an appropriate hysteresis level can be defined.
- Over-range limit: This sets the upper range limit for the associated over range fault.
- Under-range limit: This sets the lower range limit for the associated under range fault.

16.0 ANALOG INPUT CIRCUIT (PASSIVE REPRESENTATION)



The options are as follows:

Manual Config mode:

- Pull-up configurable
- Pull-down configurable
- Shunt configurable

Note: The manual mode is useful when connecting binary sensors. If you have a sensor that is switching ground to the input, you should enable the pull-up and set the rising threshold appropriately for the sensor (normally 2500 mV). If you have a sensor that is switching battery voltage, you should enable the pull-down and set the falling threshold appropriately for the sensor (normally less than half the battery voltage). Make sure to take into consideration the effect of hysteresis i.e. have some margin between rising and falling thresholds.

0-5 V mode (ratiometric):

- Pull-down forced off
- Pull-up configurable
- Shunt configurable

0-5 V mode (absolute):

- Pull-down forced off
- Pull-up configurable
- Shunt configurable

0-10 V and 0-34 V mode:

- Pull-down forced on
- Pull-up configurable
- Shunt configurable

0-22 mA mode:

- Pull-up forced off
- Pull-down forced off
- Shunt forced on

Thermistor raw mode
(output the 10 kΩ to 50 kΩ value):

- Pull-up forced on
- Pull-down forced off
- Shunt forced off

Thermistor #1 & #2 mode
(output the temperature value):

- Pull-up forced on
- Pull-down forced off
- Shunt forced off

The status of the Pull-up, Pull-down, and Shunt are displayed for convenience. In Manual Config, the programmer has complete control to alter these values.

Each of the analog modes offers a user adjustable filter. The purpose of this is to smooth an input signal and/or limit how quickly it is changing. The filter is a digital approximation of a first order series RC network (low pass filter). The adjustable time constant is equivalent to the product of R*C in a conventional RC filter. The input should follow the following curve approximately (+/- 10%): 63% of the new step-response value after 1 time constant - after 2 time constants you will get to 86% and after 3 you will get 98%.

The digital mode features adjustable rising and falling threshold levels. This is intended to offer additional flexibility in input device selection. There is also a debounce associated with each input. It is only intended for digital use (mainly to prevent inadvertent input triggering from multiple mechanical contact closures). The debounce has a user configurable time period. Each digital input can function with either Low Side or High Side input types.

Additionally, each of the modes offer a user configurable under-range and over-range limit coupled to respective fault bits.

Note 1: There is an overcurrent fault that triggers when the input exceeds approximately 23.5 mA for 25 ms in 0 – 22 mA mode.

Note 2: Ratiometric mode compensates for the measured regulated output voltage variance and normalizes the input value relative to 5 volt sensor supply.

Note: Thermistor #1 & #2 modes display value based on two user configurable lookup tables, see below:

Analog/Digital Inputs I/O Mapping | Analog/Digital Inputs Configuration

Parameter	Type	Value	Default Value	Unit	Description
Thermistor #1 Lookup Table					Lookup table for thermistor #1. Resistances must be in increasing order
Resistance Point #1	Real	101	101		Smallest resistance value
Temperature Point #1	Real	242.4	242.4		
Resistance Point #2	Real	121	121		
Temperature Point #2	Real	231.9	231.9		
Resistance Point #3	Real	175	175		
Temperature Point #3	Real	211.6	211.6		
Resistance Point #4	Real	209	209		
Temperature Point #4	Real	201.4	201.4		
Resistance Point #5	Real	302	302		
Temperature Point #5	Real	181.9	181.9		
Resistance Point #6	Real	434	434		
Temperature Point #6	Real	163.1	163.1		
Resistance Point #7	Real	625	625		
Temperature Point #7	Real	144.9	144.9		
Resistance Point #8	Real	901	901		
Temperature Point #8	Real	127.4	127.4		
Resistance Point #9	Real	1556	1556		
Temperature Point #9	Real	102.4	102.4		
Resistance Point #10	Real	2689	2689		
Temperature Point #10	Real	78.9	78.9		
Resistance Point #11	Real	5576	5576		
Temperature Point #11	Real	49.9	49.9		
Resistance Point #12	Real	11562	11562		
Temperature Point #12	Real	23.5	23.5		
Resistance Point #13	Real	28770	28770		
Temperature Point #13	Real	-5.7	-5.7		
Resistance Point #14	Real	49715	49715		
Temperature Point #14	Real	-21.2	-21.2		
Resistance Point #15	Real	71589	71589		
Temperature Point #15	Real	-30.8	-30.8		
Resistance Point #16	Real	99301	99301		Largest resistance value
Temperature Point #16	Real	-40.0	-40.0		
Thermistor #2 Lookup Table					Lookup table for thermistor #2. Resistances must be in increasing order
Resistance Point #1	Real	101	101		Smallest resistance value
Temperature Point #1	Real	242.4	242.4		
Resistance Point #2	Real	121	121		

16.1 Thermistor

We use 22 kΩ Pull-up resistors in this mode and therefore recommend that you use resistances in the range of 10 kΩ and 50 kΩ for optimal performance. The defaults shown above were derived from measuring an actual 100 kΩ thermistor.

Thermistor example of actual readings per channel.

Input Channel	0 ohm	100 ohm	1 kohm	10 kohm	20 kohm	50 kohm
1	10.8	113.8	1010.9	10088.8	20350.0	52347.0
2	10.2	108.5	1007.0	10089.2	20350.0	52438.0
3	6.8	108.5	1005.2	10089.2	20350.0	52418.0
4	8.8	108.5	1005.0	10074.8	20330.0	52346.0
5	5.4	108.3	1005.0	10066.0	20309.7	52283.0
6	10.8	108.5	1005.0	10066.0	20309.7	52346.0
7	X	103.0	999.1	10043.0	20269.8	52210.0
8	X	103.0	999.1	10031.3	20239.8	52094.0
9	0	99.5	993.2	10019.8	20228.7	52068.0
10	5.4	108.5	1005.0	10066.0	20309.7	52336.0
11	0	98.6	993.2	10006.0	20188.3	51969.0
12	0	102.5	999.1	10054.5	20289.4	52220.0
13	5.8	108.5	1005.0	10054.5	20289.4	52283.0
14	5.4	105.8	1005.0	10066.0	20309.7	52283.0
15	6.8	108.5	1005.0	10077.6	20330.0	52400.0
16	6.4	108.5	1005.0	10077.8	20331.0	52408.0

16.2 Frequency Configuration

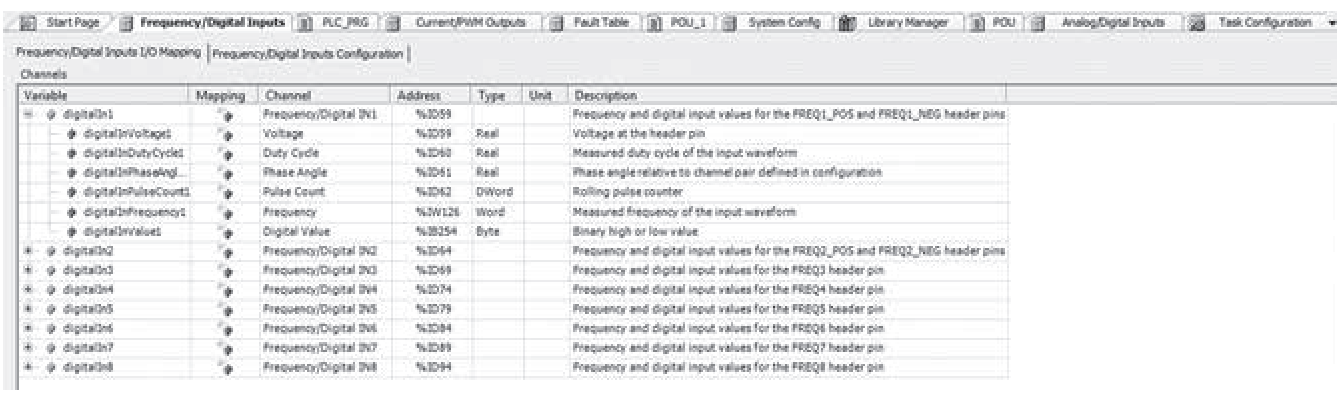
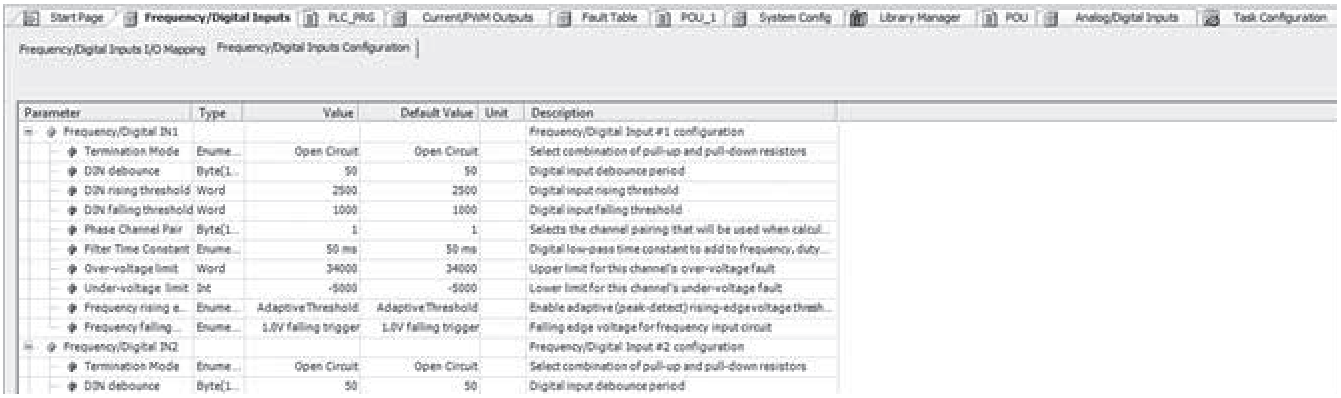


Figure 3: Frequency/Digital Input I/O Mapping Tab.

The tab displays the following: Selected Input, Variable, Address, Type, and Description. The tab also has predefined measurements of Voltage, Duty Cycle, Phase Angle, Pulse Count, Frequency, and Digital Value.

Variables:

- digitalInVoltage#: This is the voltage present at the input pin.
- digitalInDutyCycle#: This is the measured duty cycle at the input pin.
- digitalInPhaseAngle#: This is the phase angle relative to the channel pair defined in the configuration
- digitalInPulseCount#: This is a rolling pulse counter.
- digitalInFrequency#: This is the measured frequency of the input waveform.
- digitalInValue#: This is the digital value after debounce and rising/falling voltage thresholds are applied.



Parameter	Type	Value	Default Value	Unit	Description
Frequency/Digital IN1					Frequency/Digital Input #1 configuration
Termination Mode	Enume...	Open Circuit	Open Circuit		Select combination of pull-up and pull-down resistors
DIN debounce	Byte(1...	50	50		Digital input debounce period
DIN rising threshold	Word	2500	2500		Digital input rising threshold
DIN falling threshold	Word	1000	1000		Digital input falling threshold
Phase Channel Pair	Byte(1...	1	1		Selects the channel pairing that will be used when calcul...
Filter Time Constant	Enume...	50 ms	50 ms		Digital low-pass time constant to add to frequency, duty...
Over-voltage limit	Word	34000	34000		Upper limit for this channel's over-voltage fault
Under-voltage limit	Int	-5000	-5000		Lower limit for this channel's under-voltage fault
Frequency rising e...	Enume...	AdaptiveThreshold	AdaptiveThreshold		Enable adaptive (peak-detect) rising-edge voltage thresh...
Frequency falling...	Enume...	1.0V falling trigger	1.0V falling trigger		Falling edge voltage for frequency input circuit
Frequency/Digital IN2					Frequency/Digital Input #2 configuration
Termination Mode	Enume...	Open Circuit	Open Circuit		Select combination of pull-up and pull-down resistors
DIN debounce	Byte(1...	50	50		Digital input debounce period

Figure 4:Frequency/Digital Input Configuration tab

This tab allows the user to configure any of the frequency input tabs.

Variables:

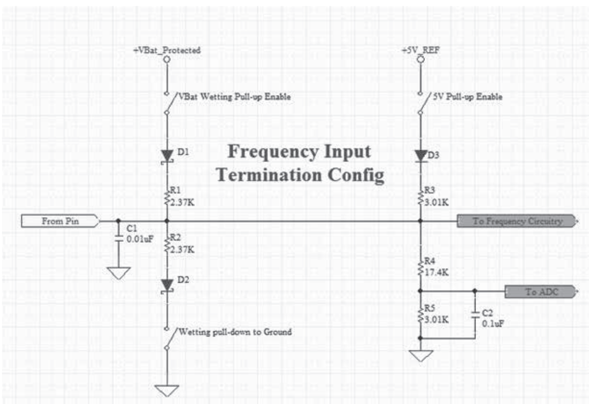
- Termination mode: This is where the combination of pull-up and pull-down resistors is configured.
- DIN debounce: This is the time value used to debounce mechanical switches that would otherwise trigger the input multiple times when closed.
- DIN rising threshold: This is the rising threshold voltage for digital inputs (effects the digital value only).
- DIN falling threshold: This is the falling threshold voltage for digital inputs (effects the digital value only).
- Phase channel pair: This selects channel pair used for phase comparison (1 is 1st pair, 2nd is 2nd pair, etc.). When configured in Encoder Mode.
- Filter time constant: This is a low pass filter time constant that is used on the following values: frequency, duty cycle, and voltage measurements.
- Over-voltage limit: This is the upper limit used for the over-voltage fault.
- Lower-voltage limit: This is the lower voltage limit used for the under-voltage fault.
- Frequency rising edge threshold: This enables either the adaptive (peak-detect) rising edge voltage threshold or the fixed 2.2 V threshold for the frequency circuit.
- Frequency falling edge threshold: This enables either 1.0 V or 0 V as the falling edge voltage threshold for the frequency circuit.

This tab enables the programmer to change the configuration of an individual input using the termination mode value drop down selection. The options are as follows:

17.0 FREQUENCY INPUT CIRCUIT (PASSIVE REPRESENTATION)

Open Circuit mode:

- Pull to VLoad
- Pull to 5 V
- Pull to Ground
- Pull to 5 V & Ground



The frequency inputs function similar to the digital inputs and add the ability to report the frequency of the input signal. It features the same set of parameters for configuring debounce, rising threshold level, and falling threshold. These inputs also support both Low-Side and High-Side input types. Although it is dependent on the specific sensor, normally in the case of a high side input (input is connected to ground) the Pull to VLoad should be selected. In this case it is important to make sure the sensor is rated for the full load voltage. Normally in the case of a low side input (input is connected to Battery +), the Pull to Ground option should be selected.

There are 8, 6, 4, or 2 inputs that can be configured as Frequency depending on the model selected. Inputs 1 and 2 have the additional capability to handle differential signals (i.e. VR inputs on all models). When measuring phase, do not mix Inputs 1 and 2 with any of the other frequency inputs. The differential inputs also work with single ended sensors. In order to use these, just ground the input on the differential pair.

Note that the VR input can be configured with preset rising (2.2 V) and falling (0 or 1 V) thresholds for the measurement of our proprietary adaptive algorithm which compensates for large increases in peak level that are common with these types of sensors. Due to the nature of the circuit design used in the differential frequency inputs, duty cycle calculation is not supported on these two channels. Additionally, note that the accuracy of phase measurement is more limited than with the other 6 channels. Also, when measuring frequency, phase, pulse width, or count, the measurement limit is the shortest detectable pulse i.e. 20 µS. When using inputs configured as Frequency, voltage indication is not supported. Also note that the debounce filters are not intended for frequency inputs in general. When using channels 3 – 8 as frequency input, these are single ended inputs and trigger on 3 volt rising and 2 volt falling.

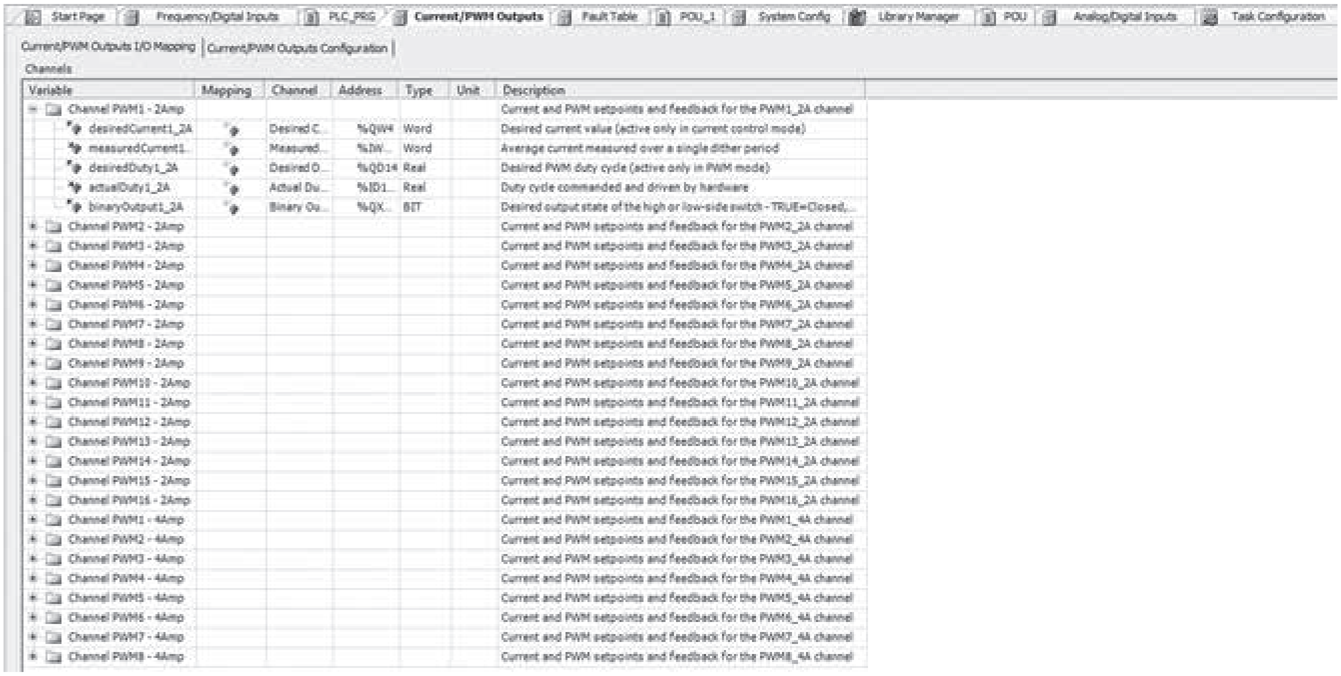
Note: That there is a fault (Max Total input frequency limit exceeded) that trips, if the combined input frequency of all channels exceeds 200 kHz. This does not stop operation but is intended as a warning that you are exceeding the limits of what the hardware can measure.

Note: When any of the above channels are configured as digital (HS or LS) the sampling frequency is 200 Hz. The debounce filters are intended for this mode.

17.1 Output Modes

The controller has either 6, 10, 16, or 24 outputs available for use. The outputs are all configurable as High Side Digital (ON/OFF), PWM open loop voltage, PWM(i) closed loop current control. In addition to these options a group of outputs support Low Side Digital Output (ON/OFF), PWM

1. High Side Switch (HS): This mode of operation is the standard output to turn a load on or off. The individual outputs can switch up to either 2 or 4 A loads depending on the output selected. This mode also supports PWM to drive a load proportionally.
2. Binary: This mode is intended for strictly on/off switching of a load.
3. Dither Current: The amount of peak-to-peak variation(in milliamps) to use for dithering.
4. Load resistance: The estimated load resistance in ohms of the driven load.



Variable	Mapping	Channel	Address	Type	Unit	Description
Channel PWM1 - 2Amp						Current and PWM setpoints and feedback for the PWM1_2A channel
desiredCurrent1_2A		Desired C...	%QW4	Word		Desired current value (active only in current control mode)
measuredCurrent1...		Measured...	%IW...	Word		Average current measured over a single dither period
desiredDuty1_2A		Desired D...	%QD14	Real		Desired PWM duty cycle (active only in PWM mode)
actualDuty1_2A		Actual Du...	%ID1...	Real		Duty cycle commanded and driven by hardware
binaryOutput1_2A		Binary Ou...	%QX...	BIT		Desired output state of the high or low-side switch - TRUE=Closed,...
Channel PWM2 - 2Amp						Current and PWM setpoints and feedback for the PWM2_2A channel
Channel PWM3 - 2Amp						Current and PWM setpoints and feedback for the PWM3_2A channel
Channel PWM4 - 2Amp						Current and PWM setpoints and feedback for the PWM4_2A channel
Channel PWM5 - 2Amp						Current and PWM setpoints and feedback for the PWM5_2A channel
Channel PWM6 - 2Amp						Current and PWM setpoints and feedback for the PWM6_2A channel
Channel PWM7 - 2Amp						Current and PWM setpoints and feedback for the PWM7_2A channel
Channel PWM8 - 2Amp						Current and PWM setpoints and feedback for the PWM8_2A channel
Channel PWM9 - 2Amp						Current and PWM setpoints and feedback for the PWM9_2A channel
Channel PWM10 - 2Amp						Current and PWM setpoints and feedback for the PWM10_2A channel
Channel PWM11 - 2Amp						Current and PWM setpoints and feedback for the PWM11_2A channel
Channel PWM12 - 2Amp						Current and PWM setpoints and feedback for the PWM12_2A channel
Channel PWM13 - 2Amp						Current and PWM setpoints and feedback for the PWM13_2A channel
Channel PWM14 - 2Amp						Current and PWM setpoints and feedback for the PWM14_2A channel
Channel PWM15 - 2Amp						Current and PWM setpoints and feedback for the PWM15_2A channel
Channel PWM16 - 2Amp						Current and PWM setpoints and feedback for the PWM16_2A channel
Channel PWM1 - 4Amp						Current and PWM setpoints and feedback for the PWM1_4A channel
Channel PWM2 - 4Amp						Current and PWM setpoints and feedback for the PWM2_4A channel
Channel PWM3 - 4Amp						Current and PWM setpoints and feedback for the PWM3_4A channel
Channel PWM4 - 4Amp						Current and PWM setpoints and feedback for the PWM4_4A channel
Channel PWM5 - 4Amp						Current and PWM setpoints and feedback for the PWM5_4A channel
Channel PWM6 - 4Amp						Current and PWM setpoints and feedback for the PWM6_4A channel
Channel PWM7 - 4Amp						Current and PWM setpoints and feedback for the PWM7_4A channel
Channel PWM8 - 4Amp						Current and PWM setpoints and feedback for the PWM8_4A channel

Figure 5: Current/PWM Outputs I/O Mapping tab.

This tab displays the desired current, actual current, desired PWM duty cycle, actual PWM duty cycle, and the binary output status.

Variables:

- desiredCurrent#_#A: This is the desired output current for the channel.

Note: That this is only active in Current Control mode.

- measuredCurrent#_#A: This is the average current measured over a single dither period.

- desiredDuty#_#A: This is the desired PWM duty cycle.

Note: That this is only active in PWM mode.

- actualDuty#_#A: This is the PWM duty cycle commanded by the hardware.
- binaryOutput#_#A: This is the commanded output state of the high or low side output (false: open or True: closed).

Note: That this is only active in Binary mode.

Start Page | Frequency/Digital Inputs | PLC_PRG | **Current/PWM Outputs** | Fault Table | POU_1 | System Config | Library Manager | POU | Analog/Digital Inputs | Task Configuration

Current/PWM Outputs I/O Mapping | Current/PWM Outputs Configuration

Parameter	Type	Value	Default Value	Unit	Description
Short to battery					((High-side duty < DUTY_HS) or (Low-side duty > DUTY_LS)) and (Voltage/Vbat > VBAT_RATIO)
DUTY_HS	Byte(0...	25	25		
DUTY_LS	Byte(0...	50	50		
VBAT_RATIO	Byte(0...	90	90		
Open circuit or low-side driver ground short					(Duty > OPEN_DUTY and Current < OPEN_CURRENT) or (Low-side duty ≤ GND_SHRT_DUTY and Voltage/Vbat < GND_SHRT_VR...
OPEN_DUTY	Byte(0...	10	10		
OPEN_CURRENT	INT	50	50		
GND_SHRT_DUTY	Byte(0...	10	10		
GND_SHRT_VRATIO	Byte(0...	10	10		
Over Current					(High-side current > hardware limit) or (High-side current > MAX_CURRENT)
MAX_CURRENT	INT	4000	4000		
Loss of Control					(Duty = 0% and Current > OFF_CURRENT) or (Reverse current is > 75mA)
OFF_CURRENT	INT	75	75		
PWM1 - 2A channel					Output current control, PWM, and dither configuration parameters for the PWM1 header pin
PWM Frequency	Word(...	500	500		The fundamental frequency used to drive the output driver (must be >= to dither frequency)
Dither Frequency	Word(...	100	100		Sub-frequency that is superimposed into the waveform by varying the duty cycle (must be <= to PWM frequency)
Dither Amplitude	Byte(0...	10	10		The amount of peak-to-peak variation (in duty cycle percent) to use for dithering
Drive mode	Enume...	Disabled	Disabled		Select either closed-loop current control mode or open-loop PWM duty-cycle mode
Enable Channel Faults	Bool	TRUE	TRUE		Set TRUE to enable automatic system fault processing for this PWM channel
K_p	Real	0.25	0.25		Proportional gain (K_p) for current control loop
K_i	Real	8	8		Integral gain (K_i) for current control loop
PWM2 - 2A channel					Output current control, PWM, and dither configuration parameters for the PWM2 header pin
PWM Frequency	Word(...	500	500		The fundamental frequency used to drive the output driver (must be >= to dither frequency)
Dither Frequency	Word(...	100	100		Sub-frequency that is superimposed into the waveform by varying the duty cycle (must be <= to PWM frequency)
Dither Amplitude	Byte(0...	10	10		The amount of peak-to-peak variation (in duty cycle percent) to use for dithering
Drive mode	Enume...	Disabled	Disabled		Select either closed-loop current control mode or open-loop PWM duty-cycle mode
Enable Channel Faults	Bool	TRUE	TRUE		Set TRUE to enable automatic system fault processing for this PWM channel
K_p	Real	0.25	0.25		Proportional gain (K_p) for current control loop
K_i	Real	8	8		Integral gain (K_i) for current control loop
PWM3 - 2A channel					Output current control, PWM, and dither configuration parameters for the PWM3 header pin
PWM Frequency	Word(...	500	500		The fundamental frequency used to drive the output driver (must be >= to dither frequency)
Dither Frequency	Word(...	100	100		Sub-frequency that is superimposed into the waveform by varying the duty cycle (must be <= to PWM frequency)
Dither Amplitude	Byte(0...	10	10		The amount of peak-to-peak variation (in duty cycle percent) to use for dithering
Drive mode	Enume...	Disabled	Disabled		Select either closed-loop current control mode or open-loop PWM duty-cycle mode
Enable Channel Faults	Bool	TRUE	TRUE		Set TRUE to enable automatic system fault processing for this PWM channel
K_p	Real	0.25	0.25		Proportional gain (K_p) for current control loop
K_i	Real	8	8		Integral gain (K_i) for current control loop
PWM4 - 2A channel					Output current control, PWM, and dither configuration parameters for the PWM4 header pin
PWM Frequency	Word(...	500	500		The fundamental frequency used to drive the output driver (must be >= to dither frequency)
Dither Frequency	Word(...	100	100		Sub-frequency that is superimposed into the waveform by varying the duty cycle (must be <= to PWM frequency)
Dither Amplitude	Byte(0	10	10		The amount of peak-to-peak variation (in duty cycle percent) to use for dithering

Above is the Current/PWM Outputs Configuration tab.

This tab displays indications that reflect faults associated with the outputs (i.e. short to Vbat, short to ground, open circuit, over current, and loss of control). Additionally, the individual channels PWM Frequency, Dither Frequency, Dither Amplitude, Drive Mode, Fault processing, Proportional, and Integral gain can all be configured here.

Variables:

- PWM Frequency: This is the fundamental frequency used to drive the output driver (note) that this must be ≥ Dither Frequency. The 2 A outputs support a maximum of 2 kHz & the 4 A outputs support a maximum of 500 Hz.
- Dither Frequency: This is the frequency that modulates the PWM duty cycle signal (note) that this must be ≤ PWM Frequency.
- Dither Amplitude: This is the amount of peak to peak variation in % of PWM duty cycle used for dithering.
- Drive Mode: This selects between closed loop current control mode or open loop PWM duty cycle mode.
- High or Low Side: Selects between a high or low side driver for the channel (note that this only applies to 4 A channels).
- Enable Channel Faults: Select to enable automatic system fault processing for this output channel.
- K_p: Proportional gain for current control loop.
- K_i: Integral gain for current control loop.

Shared Variables:

- DUTY_HS: High Side PWM duty cycle commanded Less Than High Side PWM measured indicates a short to battery fault.
- DUTY_LS: Low Side PWM duty cycle commanded Greater Than Low Side PWM measured indicates a potential short to battery fault.
- VLOAD_RATIO: Measured output voltage > commanded output voltage indicates a potential short to battery fault.
- OPEN_DUTY: Commanded duty cycle > measured duty cycle indicates a potential open load condition.

- OPEN_CURRENT: Commanded current > measured current indicates a potential open load condition.
- GND_SHRT_DUTY: Measured low side duty cycle < commanded indicates a potential short to ground condition.
- GND_SHRT_VRATIO: Measured voltage < commanded voltage indicates a potential short to ground condition.
- MAX_CURRENT: The value selected here sets a software limit for monitoring individual High Side output current. If the measured current exceeds either the hardware limit or the value defined here, it will cause the Over Current fault.
- OFF_CURRENT: If Duty Cycle = 0% and measured current > OFF_CURRENT value defined here or the measured reverse current > 75 mA the Loss of Control fault will be triggered.

17.2 H-Bridge

The HFX 4A PWM output channels have hardware support for both High-Side and Low-Side drivers. Starting with HFX Support Package 1.1.0, an H-Bridge mode is also supported. This corresponds to Firmware Minor version of 21622 on the HFX, as reported by the HFX Service Tool. H-Bridge mode supports PWM mode, but not closed loop current control. 4A PWM outputs can be paired in any combination in H-Bridge mode. For an application to pair outputs, it is critical they be configured with the same frequency. All remaining synchronization is handled automatically in the firmware, including a 50µs dead time.

Each leg of an H-Bridge is individually given a command between -100% and 100%. A positive command closes the Low-Side driver and switches the High-Side PWM corresponding to the command value. The inverse occurs for a negative command. A command of 0% switches off both sides.
There are a number of strategies to work with H-Bridge. For thermal efficiency, the recommended approach is Low-Side switching.

The following function block provides an example of how to work the H-Bridge with Low-Side switching:

```
FUNCTION_BLOCK HBridge
VAR_INPUT
        Command :             REAL;
        HighSideCurrent   :  REAL;
        LowSideCurrent    :  REAL;
END_VAR
VAR_OUTPUT
        HighSidePct       :  REAL;
        LowSidePct        :  REAL;
        MeasuredCurrent :  REAL;
END_VAR
IF Command >= 0 THEN
        HighSidePct       : = 100.0;
        LowSidePct        : = -Command;
        MeasuredCurrent : = HighSideCurrent - LowSideCurrent;
ELSE
        HighSidePct       : = Command;
        LowSidePct        : = 100.0;
        MeasuredCurrent : = -(LowSideCurrent - HighSideCurrent);
END_IF
```

The block would be used in an application like this:

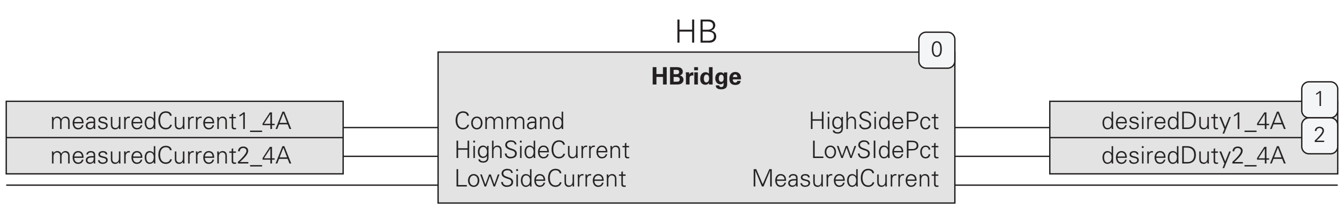


Figure 6: H Bridge Example

Note: That because current is measured only in the positive direction, the accuracy of the reported current is limited when rapidly switching command polarity on highly inductive loads.

18.0 OUTPUT CIRCUIT (PASSIVE REPRESENTATION)

18.1 Overcurrent Shutdown

The individual outputs of the unit are fully protected and will switch off if overloaded. When diagnostics are enabled and an overcurrent event occurs, the output will switch and remain off until another off/on command is received. The overcurrent shutdown is dependent upon the specific output. 2 A rated outputs have a slow blow level of approximately 2.1 A and a fast blow level of approximately 2.4 A. 4 A rated outputs have a slow blow level of approximately 4.1 A and a fast blow level of approximately 4.4 A. All outputs are additionally protected via an internal solid state relay. The relay can be active monitored for current and controlled in the user program.

19.0 Pulse Width Modulation (PWM)

19.1 What is PWM?

PWM stands for Pulse Width Modulation. It is a method that can be used to efficiently drive solenoid valves. Typically the output device is switched at a fast rate (60 Hz – 2 kHz).

In the past solenoid valves were driven using a transistor or op amp in linear mode. This worked well to control the valve as a directly proportional voltage signal could be easily controlled using feedback. The negative of this technique is that it generates a great deal of heat, is inefficient, and requires a larger enclosure since the output device is operated in between cutoff and saturation and is behaving like a variable resistor constantly having to dissipate the power not used by the load as heat.

PWM uses the output device digitally and therefore the device is either on or off. Using this technique, the output device supplies a series of pulses of the same voltage level to the load. Since transistors are very efficient when either on or off, much less heat is dissipated. Varying the duty cycle (on time/switching period) the output power is modulated effectively emulating an analog signal, especially at the higher switching frequencies through a solenoid valve coils inductance.

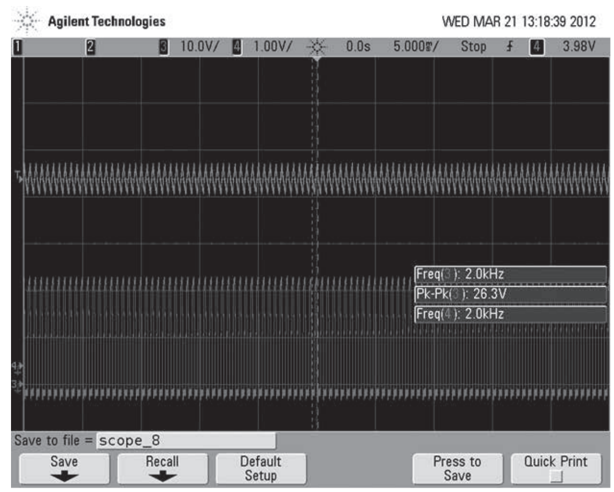
Current feedback can be used to more effectively control the valve. With a known current flowing through the valve coil, the valve spool position can be precisely determined. The added advantage of this method is that it is independent of temperature.

19.1.1 Dither

Dither is a small modulation of the PWM signal. This is intended to compensate for stiction and hysteresis by continually changing the PWM signal slightly and thus keeping the valve spool in constant motion. This can dramatically improve the valve performance by improving response to small signal changes.

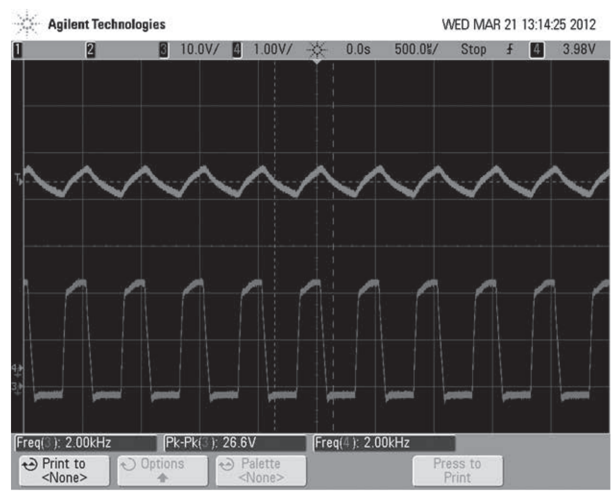
The following oscilloscope images illustrate both the PWM voltage and current waveforms. Also illustrated are the effects of varying PWM duty cycle and of adding dither.

19.1.2.1 PWM



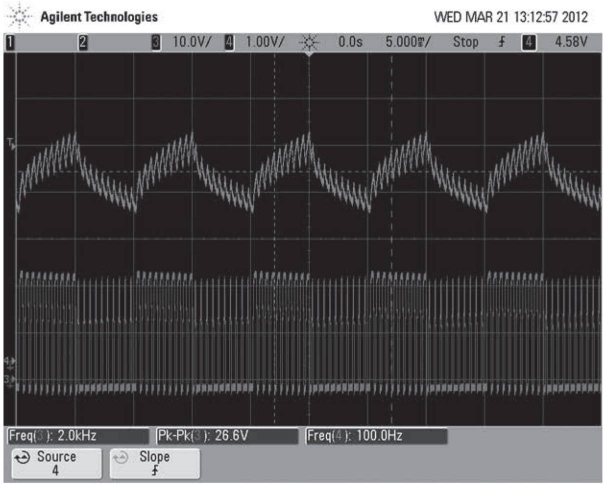
Depiction of 2 kHz PWM. Lower waveform is voltage, upper is current through a typical inductance.

19.1.2.2 PWM



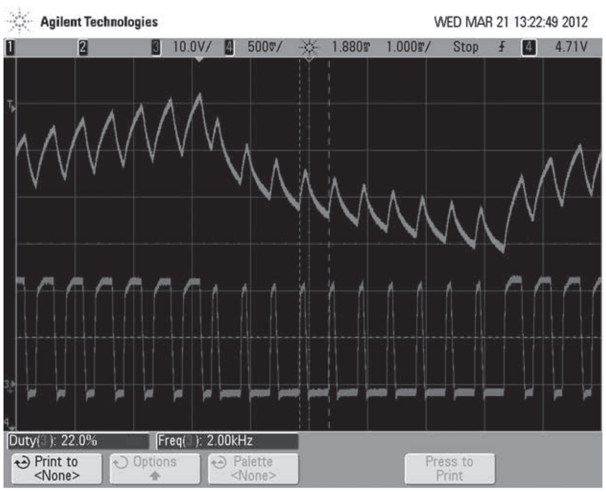
Depiction of 2 kHz PWM waveforms (note faster time scale factor of 10). Lower waveform is voltage, upper waveform is current through a typical inductance.

19.1.3.1 PWM with Dither



Depiction of 2 kHz PWM with 100 Hz 40% dither. Lower waveform is voltage, upper waveform is current through a typical inductance.

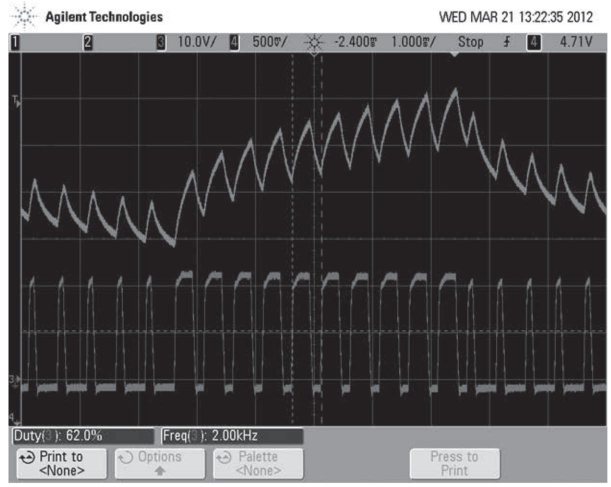
19.1.3.2 PWM with Dither



Single cycle of 2 kHz PWM with 100 Hz 40% dither.

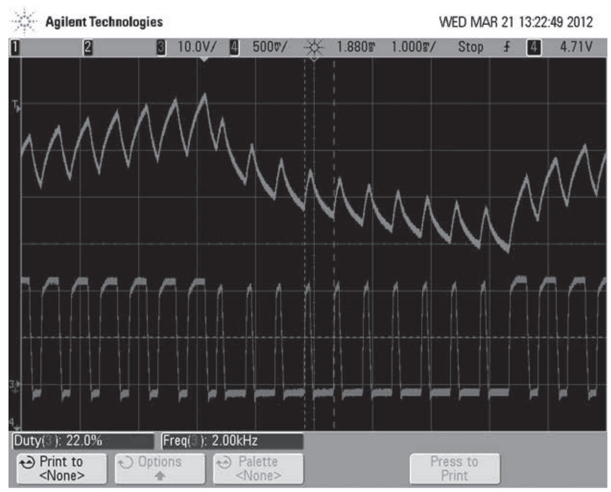
Note: PWM voltage duty cycle is changing value +/- 20% from commanded value at a rate of 100 Hz.

19.1.3.3 PWM with Dither



PWM with dither illustrating duty cycle 62% (42% + 20%)

19.1.3.4 PWM with Dither



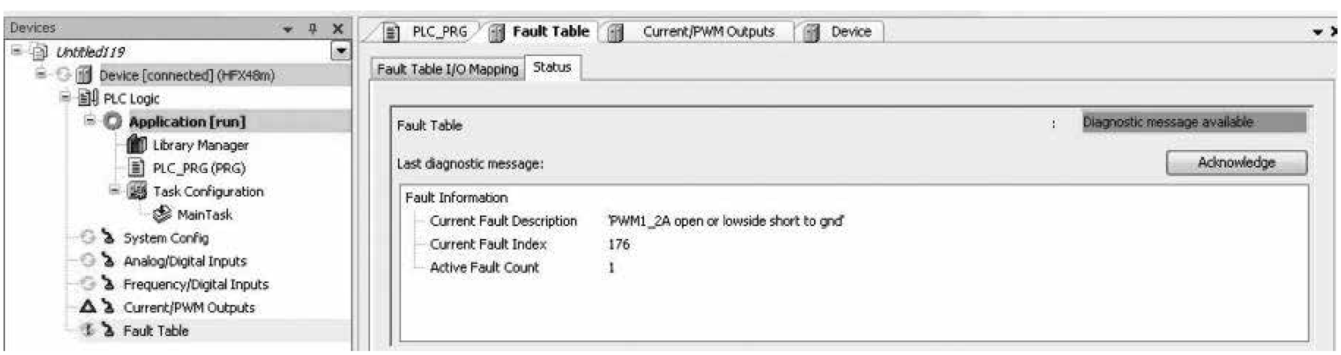
PWM with dither illustrating duty cycle 22% (42% - 20%)

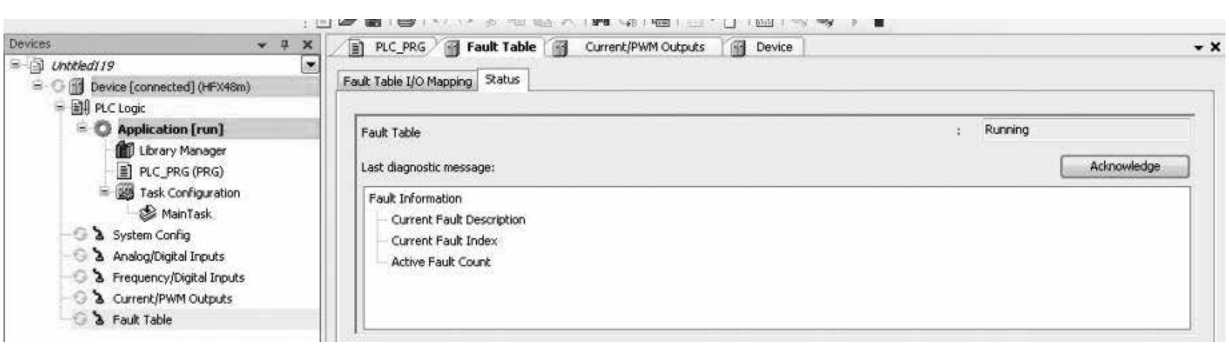
20.0 CAN & SAE J1939

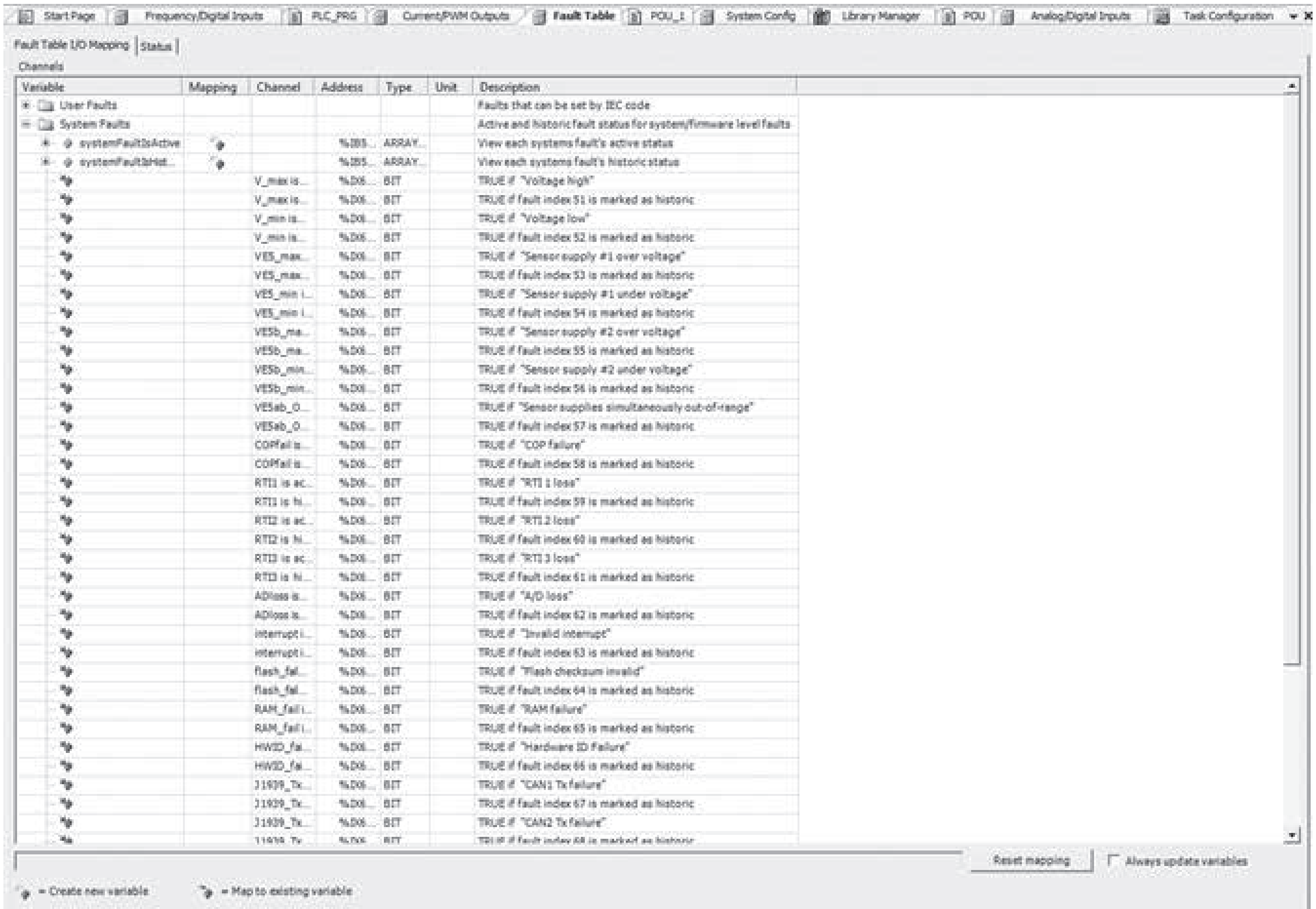
- Each device added to the J1939 manager represents a physical device on the bus.
    - So a "local device" represents the local mobile controller. This is the message the controller will be *transmitting*. See the "local device" checkbox in the general tab.
    - A non-"local device" represents a physical device on the bus. Thus its "Tx Signals" are what the device is sending and the mobile controller is receiving.
    - Thus you should generally add one "device" to the tree to represent each device that is on the physical bus, including the "local" device.
    - Also make sure you have the "local device" checked for the node that you want to use to transmit or receive P2P signals. While this is not intuitive at first, it makes complete sense once you are aware of it.
- There are no function blocks and everything happens automatically in the background. You just get scaled variables you can read or write from code.
- All transmission happens automatically per the configuration for each PGN. The "TransmissionMode" tab specifies the interval. Relevant options are "Change of State" and "Cyclic", but the default is change of state, so the packet will not be sent unless one of the variables changes (i.e. from your code). Cyclic is the more traditional J1939 method and better for testing. The "I/O" mapping tab represents all the variables available in the device. These can be used in code for either inputs or outputs depending on whether it is a transmitted or received packet.
- You can automatically convert and scale variables by clicking on the SPN in the "Tx Signals" page, and then enabling the "Conversion" option. This lets you deal in engineering units (i.e. %, rpm, mph, etc.) as opposed to the raw data bytes.
- Variables in the I/O mapping tab will not be updated unless physically used in code. This is an optimization done by the 3S compiler to reduce computation for unused variables. For debugging, you can check the "Always update variables" box and it will instruct the compiler/debugger to always display and update the values.
- The CAN "Network" option is an indexed value that starts counting at Zero. Thus Network 0 represents the first CAN bus, Network 1 represents the second CAN bus, and Network 2 represents the third.

21.0 INPUT STATUS, FEEDBACK, AND DIAGNOSTICS

A fault table is integrated in the IDE. Please see the below samples. When a fault occurs, an exclamation will come on the "Fault Table" icon indicating "Diagnostic message available". If there is an active fault that relates to a PWM, analog, or frequency channel, then the respective icon will also display the red triangle as well. One message is displayed at a time in the "Fault Table Status" tab. When Acknowledge is selected the current fault is cleared and the next fault is displayed. If the fault cannot be cleared, it will remain until the condition is fixed.





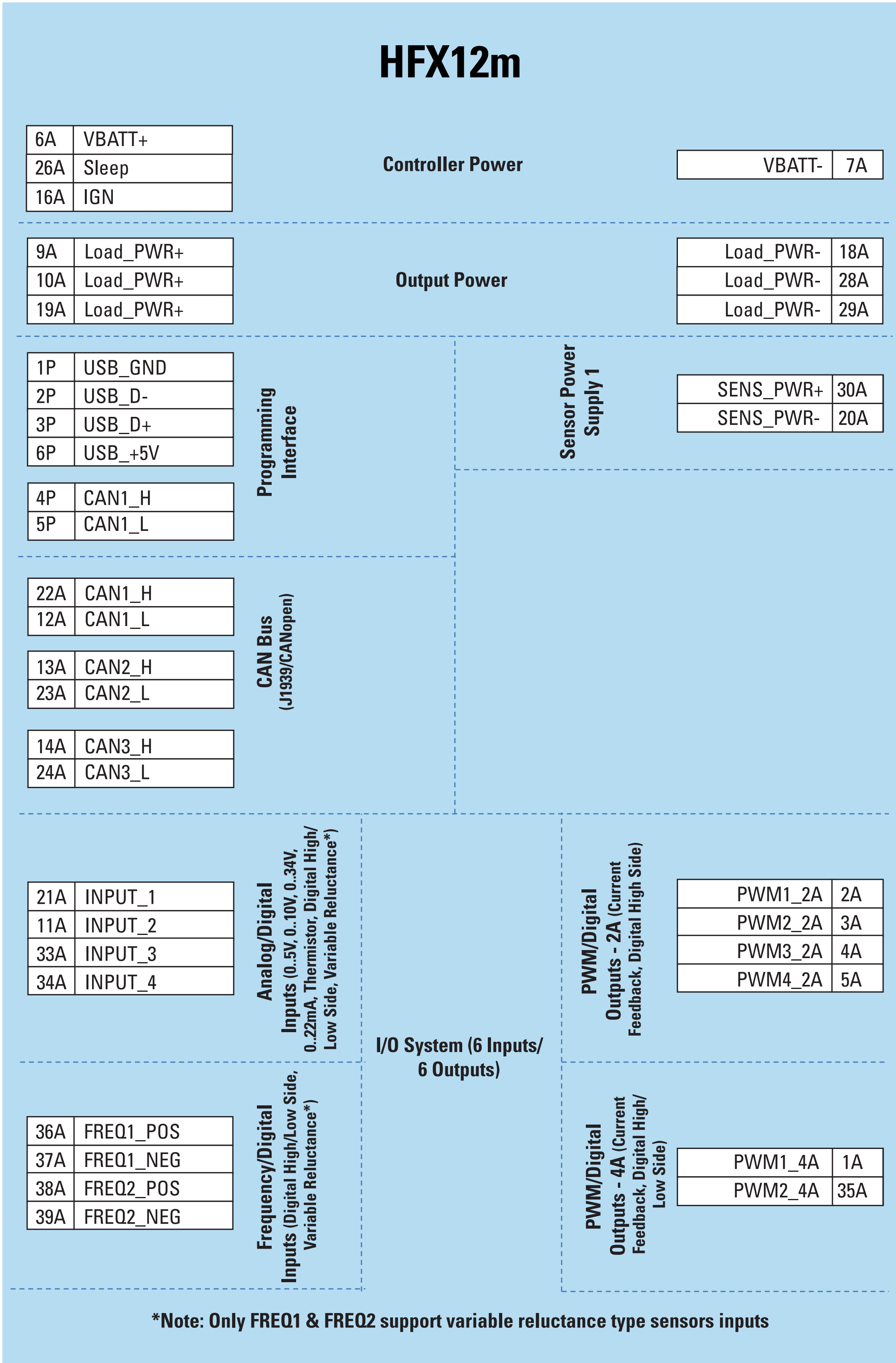


Variable	Mapping	Channel	Address	Type	Unit	Description
User Faults						Faults that can be set by IEC code
System Faults						Active and historic fault status for system/firmware level faults
systemFaultIsActive			%IB5...	ARRAY...		View each systems fault's active status
systemFaultIsHist...			%IB5...	ARRAY...		View each systems fault's historic status
		V_max is...	%IX6...	BIT		TRUE if "Voltage high"
		V_max is...	%IX6...	BIT		TRUE if fault index 51 is marked as historic
		V_min is...	%IX6...	BIT		TRUE if "Voltage low"
		V_min is...	%IX6...	BIT		TRUE if fault index 52 is marked as historic
		VE5_max...	%IX6...	BIT		TRUE if "Sensor supply #1 over voltage"
		VE5_max...	%IX6...	BIT		TRUE if fault index 53 is marked as historic
		VE5_min i...	%IX6...	BIT		TRUE if "Sensor supply #1 under voltage"
		VE5_min i...	%IX6...	BIT		TRUE if fault index 54 is marked as historic
		VE5b_ma...	%IX6...	BIT		TRUE if "Sensor supply #2 over voltage"
		VE5b_ma...	%IX6...	BIT		TRUE if fault index 55 is marked as historic
		VE5b_min...	%IX6...	BIT		TRUE if "Sensor supply #2 under voltage"
		VE5b_min...	%IX6...	BIT		TRUE if fault index 56 is marked as historic
		VE5ab_O...	%IX6...	BIT		TRUE if "Sensor supplies simultaneously out-of-range"
		VE5ab_O...	%IX6...	BIT		TRUE if fault index 57 is marked as historic
		COPfail is...	%IX6...	BIT		TRUE if "COP failure"
		COPfail is...	%IX6...	BIT		TRUE if fault index 58 is marked as historic
		RTI1 is ac...	%IX6...	BIT		TRUE if "RTI 1 loss"
		RTI1 is hi...	%IX6...	BIT		TRUE if fault index 59 is marked as historic
		RTI2 is ac...	%IX6...	BIT		TRUE if "RTI 2 loss"
		RTI2 is hi...	%IX6...	BIT		TRUE if fault index 60 is marked as historic
		RTI3 is ac...	%IX6...	BIT		TRUE if "RTI 3 loss"
		RTI3 is hi...	%IX6...	BIT		TRUE if fault index 61 is marked as historic
		ADloss is...	%IX6...	BIT		TRUE if "A/D loss"
		ADloss is...	%IX6...	BIT		TRUE if fault index 62 is marked as historic
		interrupt i...	%IX6...	BIT		TRUE if "Invalid interrupt"
		interrupt i...	%IX6...	BIT		TRUE if fault index 63 is marked as historic
		flash_fal...	%IX6...	BIT		TRUE if "Flash checksum invalid"
		flash_fal...	%IX6...	BIT		TRUE if fault index 64 is marked as historic
		RAM_fail i...	%IX6...	BIT		TRUE if "RAM failure"
		RAM_fail i...	%IX6...	BIT		TRUE if fault index 65 is marked as historic
		HWID_fa...	%IX6...	BIT		TRUE if "Hardware ID Failure"
		HWID_fa...	%IX6...	BIT		TRUE if fault index 66 is marked as historic
		J1939_Tx...	%IX6...	BIT		TRUE if "CAN1 Tx failure"
		J1939_Tx...	%IX6...	BIT		TRUE if fault index 67 is marked as historic
		J1939_Tx...	%IX6...	BIT		TRUE if "CAN2 Tx failure"
		J1939_Tx...	%IX6...	BIT		TRUE if fault index 68 is marked as historic

Figure 7: Fault Table I/O Mapping

This is convenient location where all active and historic faults can be viewed. Additionally, user defined faults from the IEC application can be set here for monitoring. There are numerous faults and further details in the appendix.

21.1 Block Diagram



HFX20m

Controller Power

6A	VBATT+
26A	Sleep
16A	IGN

VBATT-	7A

Output Power

9A	Load_PWR+
10A	Load_PWR+
19A	Load_PWR+

Load_PWR-	18A
Load_PWR-	28A
Load_PWR-	29A

Programming Interface

1P	USB_GND
2P	USB_D-
3P	USB_D+
6P	USB_+5V

4P	CAN1_H
5P	CAN1_L

Sensor Power Supply 1

SENS_PWR+	30A
SENS_PWR-	20A

CAN Bus (J1939/CANopen)

22A	CAN1_H
12A	CAN1_L

13A	CAN2_H
23A	CAN2_L

14A	CAN3_H
24A	CAN3_L

I/O System (10 Inputs/ 10 Outputs)

Analog/Digital Inputs (0..5V, 0..10V, 0..34V, 0..22mA, Thermistor, Digital High/Low Side, Variable Reluctance*)

21A	INPUT_1
11A	INPUT_2
33A	INPUT_3
34A	INPUT_4
25A	INPUT_5
15A	INPUT_6

Frequency/Digital Inputs (Digital High/Low Side, Variable Reluctance*)

36A	FREQ1_POS
37A	FREQ1_NEG
38A	FREQ2_POS
39A	FREQ2_NEG
17A	FREQ3
27A	FREQ4

PWM/Digital Outputs - 2A (Current Feedback, Digital High Side)

PWM1_2A	2A
PWM2_2A	3A
PWM3_2A	4A
PWM4_2A	5A
PWM5_2A	40A
PWM6_2A	32A

PWM/Digital Outputs - 4A (Current Feedback, Digital High/Low Side)

PWM1_4A	1A
PWM2_4A	35A
PWM3_4A	31A
PWM4_4A	8A

***Note: Only FREQ1 & FREQ2 support variable reluctance type sensors inputs**

HFX32m

Controller Power

6A	VBATT+
26A	Sleep
16A	IGN
7A	VBATT-

Output Power

9A	Load_PWR+
10A	Load_PWR+
19A	Load_PWR+
1B	Load_PWR+
2B	Load_PWR+
3B	Load_PWR+
18A	Load_PWR-
28A	Load_PWR-
29A	Load_PWR-
12B	Load_PWR-
13B	Load_PWR-
22B	Load_PWR-

Programming Interface

1P	USB_GND
2P	USB_D-
3P	USB_D+
6P	USB_+5V
4P	CAN1_H
5P	CAN1_L

Sensor Power Supply 1

30A	SENS_PWR1+
21B	SENS_PWR1+
20A	SENS_PWR1-
11B	SENS_PWR1-

CAN Bus (J1939/CANopen)

22A	CAN1_H
12A	CAN1_L
13A	CAN2_H
23A	CAN2_L
14A	CAN3_H
24A	CAN3_L

Sensor Power Supply 2

15B	SENS_PWR2+
16B	SENS_PWR2+
25B	SENS_PWR2-
26B	SENS_PWR2-

I/O System (16 Inputs/ 16 Outputs)

Analog/Digital Inputs (0..5V, 0..10V, 0..34V, 0..22mA, Thermistor, Digital High/ Low Side, Variable Reluctance*)

21A	INPUT_1
11A	INPUT_2
33A	INPUT_3
34A	INPUT_4
25A	INPUT_5
15A	INPUT_6
5B	INPUT_7
7B	INPUT_8
28B	INPUT_9
19B	INPUT_10

Frequency/Digital Inputs (Digital High/Low Side, Variable Reluctance*)

36A	FREQ1_POS
37A	FREQ1_NEG
38A	FREQ2_POS
39A	FREQ2_NEG
17A	FREQ3
27A	FREQ4
10B	FREQ5
20B	FREQ6

PWM/Digital Outputs - 2A (Current Feedback, Digital High Side)

2A	PWM1_2A
3A	PWM2_2A
4A	PWM3_2A
5A	PWM4_2A
40A	PWM5_2A
32A	PWM6_2A
35B	PWM7_2A
34B	PWM8_2A
33B	PWM9_2A
23B	PWM10_2A

PWM/Digital Outputs - 4A (Current Feedback, Digital High/ Low Side)

1A	PWM1_4A
35A	PWM2_4A
31A	PWM3_4A
8A	PWM4_4A
38B	PWM5_4A
32B	PWM6_4A

***Note: Only FREQ1 & FREQ2 support variable reluctance type sensors inputs**

HFX48m

Controller Power

6A	VBATT+
26A	Sleep
16A	IGN

VBATT-	7A

Output Power

9A	Load_PWR+
10A	Load_PWR+
19A	Load_PWR+
1B	Load_PWR+
2B	Load_PWR+
3B	Load_PWR+

Load_PWR-	18A
Load_PWR-	28A
Load_PWR-	29A
Load_PWR-	12B
Load_PWR-	13B
Load_PWR-	22B

Programming Interface

1P	USB_GND
2P	USB_D-
3P	USB_D+
6P	USB_+5V

4P	CAN1_H
5P	CAN1_L

Sensor Power Supply 1

SENS_PWR1+	30A
SENS_PWR1+	21B
SENS_PWR1-	20A
SENS_PWR1-	11B

CAN Bus (J1939/CANopen)

22A	CAN1_H
12A	CAN1_L

13A	CAN2_H
23A	CAN2_L

14A	CAN3_H
24A	CAN3_L

Sensor Power Supply 2

SENS_PWR2+	15B
SENS_PWR2+	16B
SENS_PWR2-	25B
SENS_PWR2-	26B

I/O System (24 Inputs/ 24 Outputs)

Analog/Digital Inputs (0..5V, 0..10V, 0..34V, 0..22mA, Thermistor, Digital High/Low Side, Variable Reluctance*)

21A	INPUT_1
11A	INPUT_2
33A	INPUT_3
34A	INPUT_4
25A	INPUT_5
15A	INPUT_6
5B	INPUT_7
7B	INPUT_8
28B	INPUT_9
19B	INPUT_10
18B	INPUT_11
14B	INPUT_12
17B	INPUT_13
27B	INPUT_14
9B	INPUT_15
8B	INPUT_16

PWM/Digital Outputs - 2A (Current Feedback, Digital High Side)

PWM1_2A	2A
PWM2_2A	3A
PWM3_2A	4A
PWM4_2A	5A
PWM5_2A	40A
PWM6_2A	32A
PWM7_2A	35B
PWM8_2A	34B
PWM9_2A	33B
PWM10_2A	23B
PWM11_2A	39B
PWM12_2A	31B
PWM13_2A	24B
PWM14_2A	36B
PWM15_2A	37B
PWM16_2A	40B

Frequency/Digital Inputs (Digital High/Low Side Variable Reluctance*)

36A	FREQ1_POS
37A	FREQ1_NEG
38A	FREQ2_POS
39A	FREQ2_NEG
17A	FREQ3
27A	FREQ4
10B	FREQ5
20B	FREQ6
29B	FREQ7
30B	FREQ8

PWM/Digital Outputs - 4A (Current Feedback, Digital High/Low Side)

PWM1_4A	1A
PWM2_4A	35A
PWM3_4A	31A
PWM4_4A	8A
PWM5_4A	38B
PWM6_4A	32B
PWM7_4A	6B
PWM8_4A	4B

***Note: Only FREQ1 & FREQ2 support variable reluctance type sensors inputs**

22.0 TESTING AND VALIDATION

Requirement	Specifications
Electrical/EMI/EMC	
2004/104/EC	European Union automotive EMC directive
CISPR 25	Conducted emissions (EU broadband & narrowband limits)
CISPR 25	Radiated emissions (EU broadband & narrowband limits)
ISO 11452-4	Immunity to narrowband conducted electromagnetic energy via bulk current injection
ISO 11452-2	Immunity to narrowband radiated electromagnetic energy via absorption lined chamber
SAE J1113-2:2004	Audio frequency noise immunity
ISO7637-2:2004	Automotive test pulse 1 reference level IV
ISO7637-2:2004	Automotive test pulse 2a, 2b reference level IV
ISO7637-2:2004	Automotive test pulse 3a, 3b reference level IV
ISO7637-2:2004	Automotive test pulse 4 reference level IV
ISO7637-2:2004	Automotive test pulse 5 reference level IV
SAE J1113-12	Chattering relay test
SAE J1113-12	Mutual coupling
ISO 10605:2001 Sect 5.2.2	ESD powered up test - direct contact discharge test level IV ISO
10605:2001 Sect 5.2.3	ESD powered up test - air discharge test level IV
ISO 10605:2001 Sect 7	ESD unpowered handling - direct contact discharge test level IV
ISO 10605:2001 Sect 7	ESD unpowered handling - air discharge test level IV
EN61000-4-2:1995 Sect 8.3.2.1&2	ESD indirect discharge with horizontal and vertical coupling plane method test level IV SAE
J1113-26	Immunity to A.C. power line electric fields reference +/- 15 kV
SAE J1113-26	Immunity to A.C. power line magnetic fields reference 40 uT
Mechanical/Environmental	
Storage Temperature Range	-40°C - 125°C
Operating Temperature Range	-40°C - 105°C (USB use is limited to 85°C)
Initial Conditioning	-40°C for 24 hours, 105°C for 24 hours
High Temperature endurance	125°C for 200 hours unpowered. After test unit must be functional Voltage
Range	6 V - 32 V
Ignition Cycling	10,000 cycles of I minute max supply voltage alternating with 1 minute no voltage at power supply connection.
Thermal Shock	J1455 Section 4.1.3.2; 2 hour -40°C two hour soak, 5 four hour cycles, two hours @ -40°C & two hours @ 105°C
Humidity/Temp Cycling	J1455 Section 4.2.3 Six 48 hour cycle at 20°C to 60°C, 90 - 98% RH
Rain Cycle	100 cycles 1 hour tap water spray, 1 hour 71°C
Thermal Cycling	1000 cycles from -40°C to 105°C powered, test full load every 200 cycles
Brine Ingestion	8 cycles of 1 hour at 105°C followed by 1 hour in brine solution @ 13°C
Hot Plugging	5 cycles connect/disconnect while active
Ingress Protection	IP67/IP69K
Transit Shock	J1455 Section 4.11.3.2
Vibration	J1455 Section 4.10.4.1/5.82Grms, 8 hours per axis
Shock	J1455 Section 4.10.4/6+/-pulses, 50 G's, 6 ms
Fluid Compatibility	J1455 Section 4.4.3
Dust	J1455 Section 4.7.3/IEC529
Thermal Shock	J1455 Section 4.1.3.2
Handling Drop Test	J1455 Section 4.11.3.1/ 1 meter drop on concrete on each of 6 box faces
Salt Spray	J1455 Section 4.3.3
Wash Down	J1455 Section 4.5.3/4.83MPa, 11.4 l/min, 10.2 cm away, 2 minutes duration
Ice	3 cycles (stabilize -20°C then submerge in 0°C water, then -20°C)
Maximum Voltage	168 hours at 105°C with 16 VDC
Salt Fog	ASTM-B117/96 hours at 35°C 5% NaCl
Short Circuit	Short each pin to supply and ground in powered state
Steam Clean	5.7 l/min 2.41 Mpa 20 -30 cm distance for 375 cycles
Tri-Temperature Functional	One 24 hour cycle form -40°C to +105°C
Chemical Compatibility	See list below
Temperature Destruct Test	Increase temperature until unit is destroyed (dwell at max for 10 minutes, bring down to room temp and repeat cyclically)

23.0 SERVICE TOOL

Please see page 13 for details covering firmware installation. One of the primary purposes of the Service tool is to provide an aid for troubleshooting. There are five pages that display and or allow configuration of various I/O types.

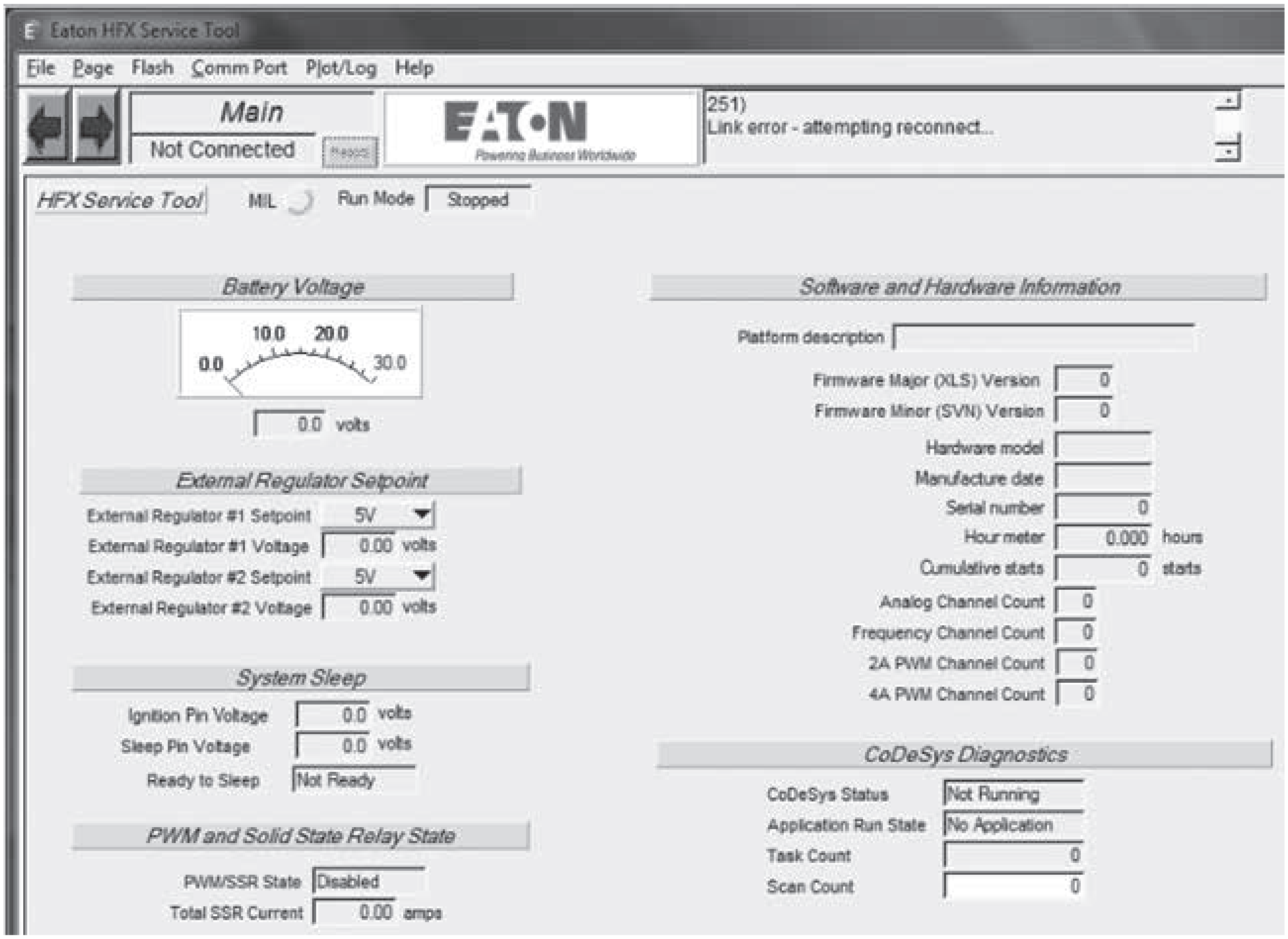


Figure 8: Service Tool Main Page

This page allows the user to check the status of the MIL, supply voltage, ignition pin voltage, solid state relay, hours of use, and application. It also provides the total output current and several additional details about the software and hardware setup. Additionally, the output voltage on the regulated sensor supply can be adjusted.

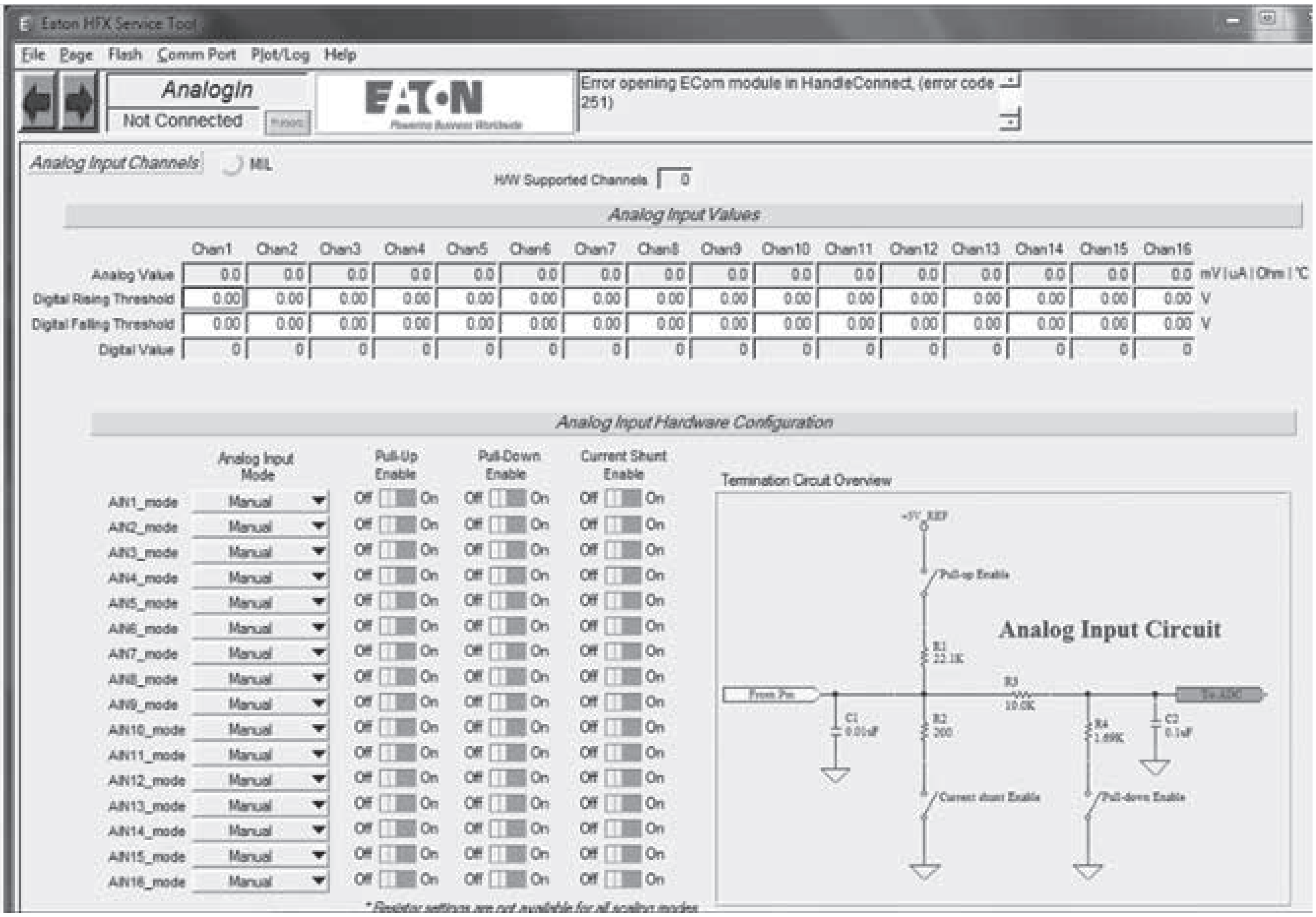


Figure 9: Service Tool Analog Input Page

This page enables the user to view input values associated with the analog channels and configure each channel for a specific type of input. It also offers the ability to individually select filters for each channel.

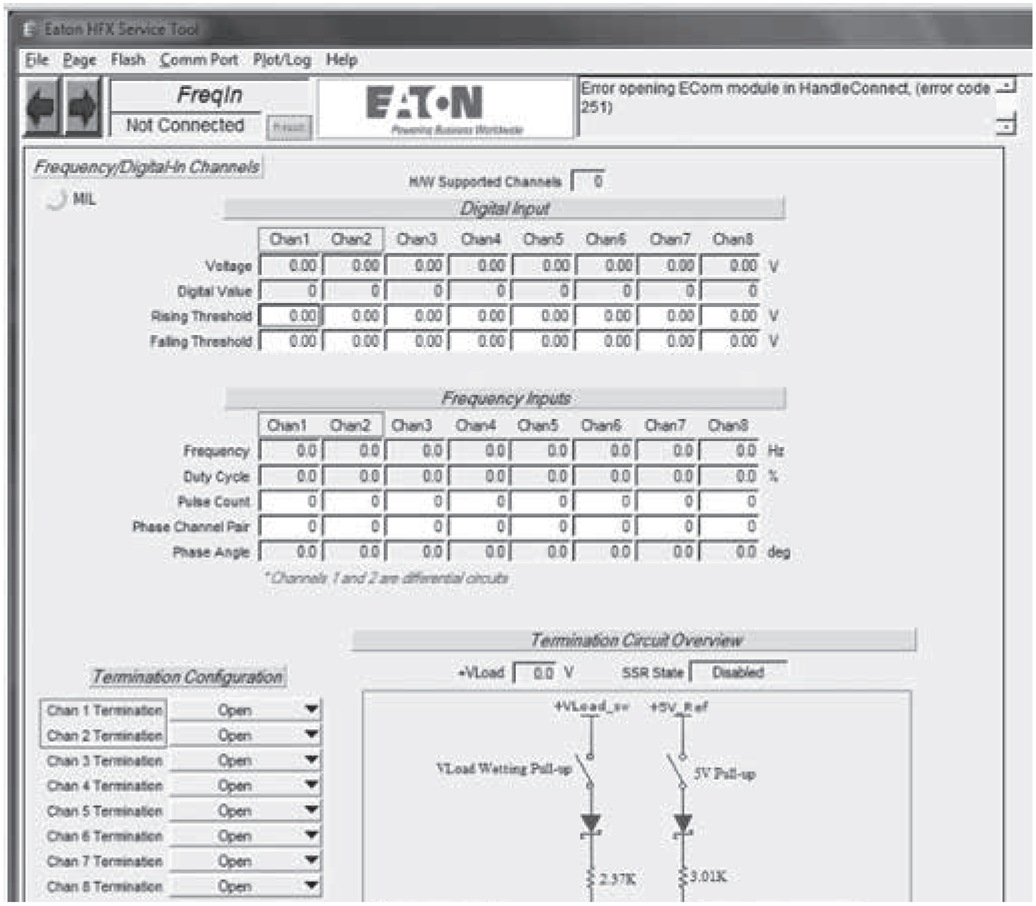


Figure 10: Service Tool Frequency Input Page

This page enables the user to view input values associated with the frequency channels and configure each channel for a specific type of input.

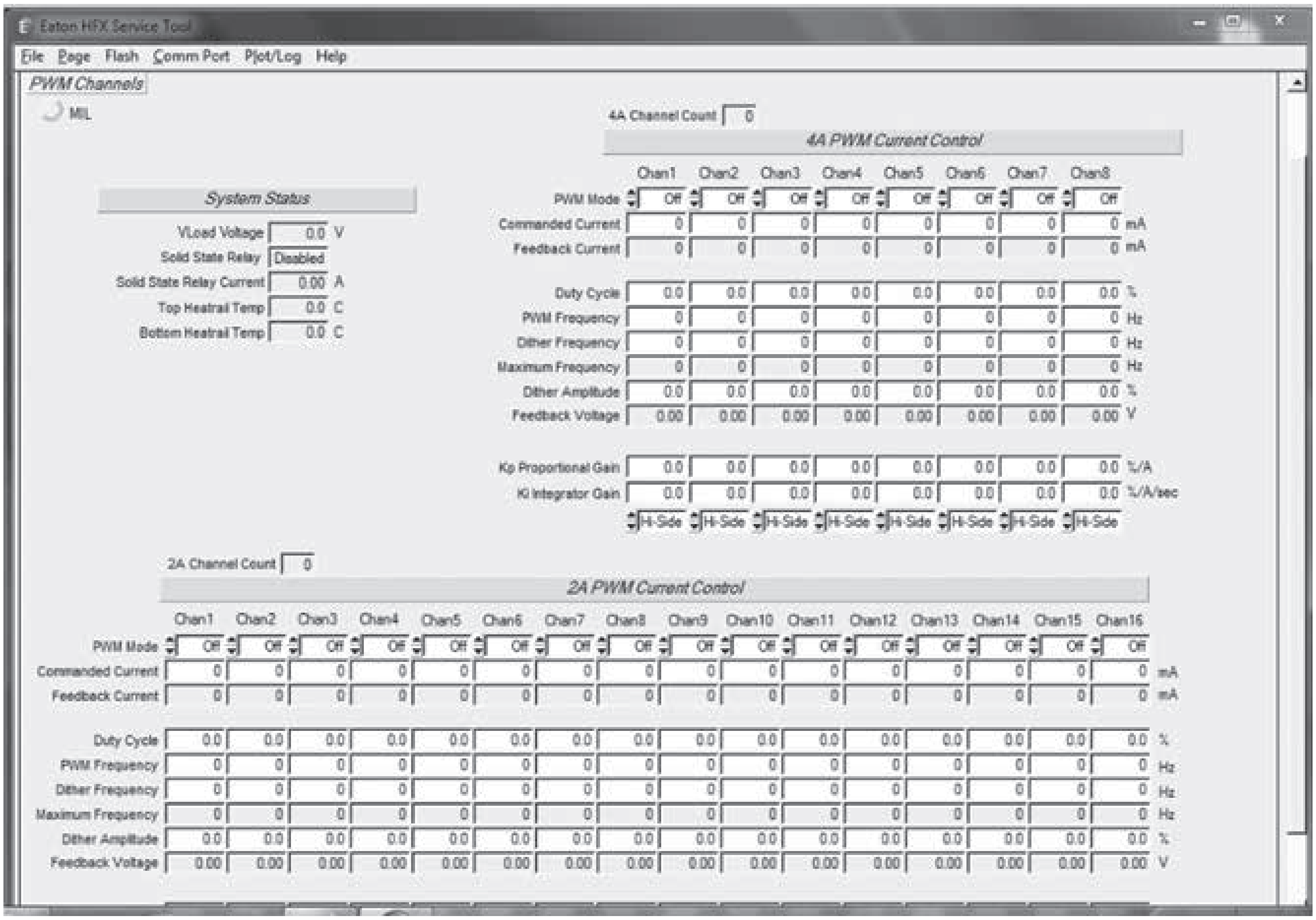


Figure 11: Service Tool Output Page

This page enables the user to view controller temperature, individual channel feedback current/voltage, dither, duty cycle, frequency and current control gain specific to each output channel. Each channel can also be configured as current control, or PWM. Additionally, the 4 A channels can be configured as Low-Side outputs.

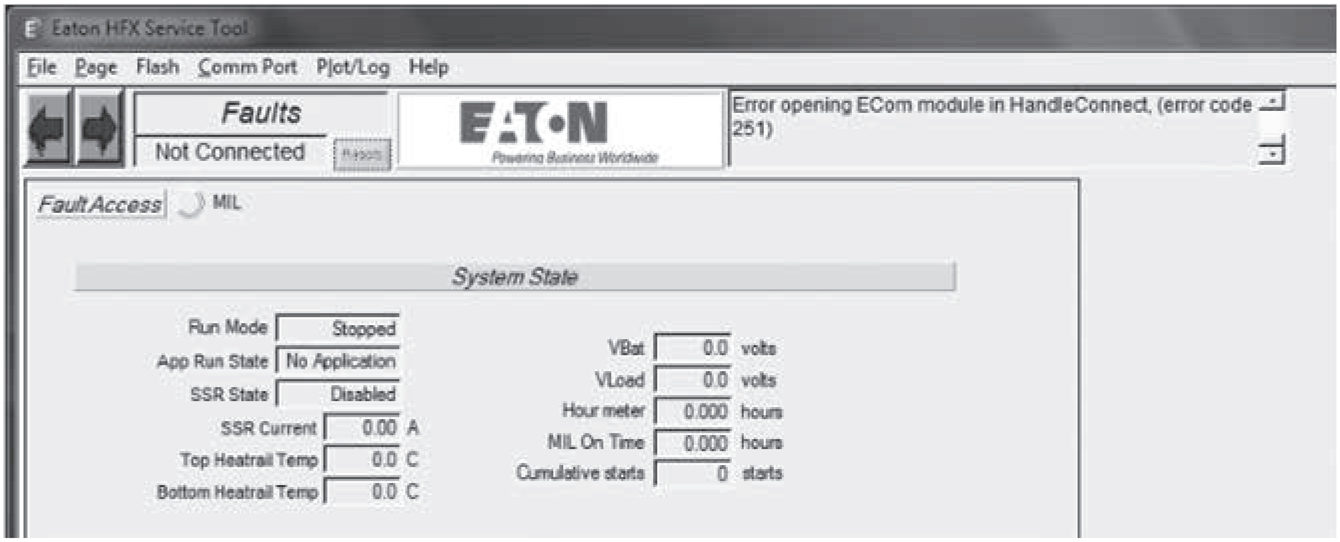


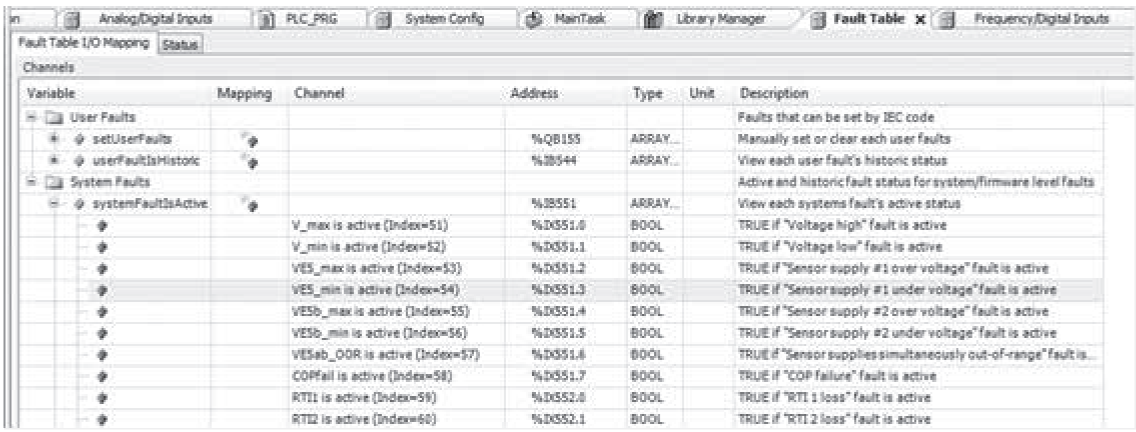
Figure 12: The Service Tool Fault Page

The faults page displays warnings, system status, and any faults that are active.

24.0 FAULT CONDITIONS

Note: That while every effort has been taken to assist in identifying faults and providing a system to manage these faults, there is still the possibility of faults occurring that are not detected. The system designer must take this into account. This system is intended to assist with faults but is not intended to take the place of a safety system.

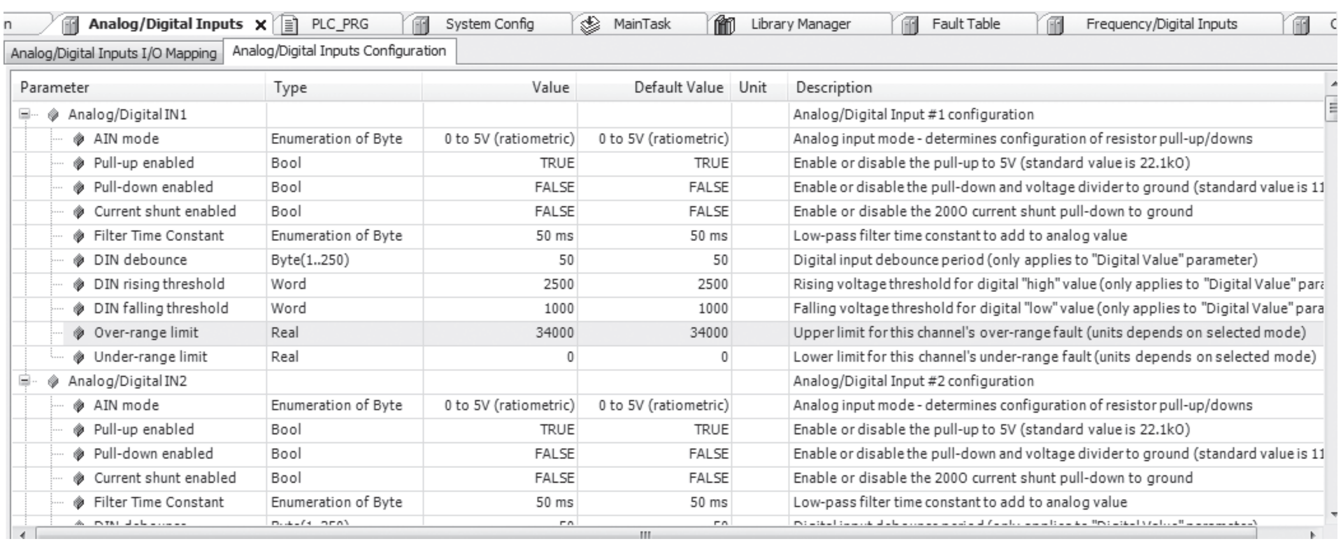
The controller features a highly refined fault management system. The system consists of a fault table of predefined system faults. All of the faults are mapped to addresses that are directly accessible in the application control program. There is also a reserved area for user defined IEC faults in this section. This is very flexible as all faults can be easily scanned through in one area of the environment. Both the predefined System Faults and the User Faults feature active and historic fault indication. Please see below:



Variable	Mapping	Channel	Address	Type	Unit	Description
User Faults						Faults that can be set by IEC code
setUserFaults			%QB155	ARRAY...		Manually set or clear each user faults
userFaultIsHistoric			%IB544	ARRAY...		View each user fault's historic status
System Faults						Active and historic fault status for system/firmware level faults
systemFaultIsActive			%IB551	ARRAY...		View each systems fault's active status
		V_max is active (Index=51)	%IX551.0	BOOL		TRUE if "Voltage high" fault is active
		V_min is active (Index=52)	%IX551.1	BOOL		TRUE if "Voltage low" fault is active
		VE5_max is active (Index=53)	%IX551.2	BOOL		TRUE if "Sensor supply #1 over voltage" fault is active
		VE5_min is active (Index=54)	%IX551.3	BOOL		TRUE if "Sensor supply #1 under voltage" fault is active
		VE5b_max is active (Index=55)	%IX551.4	BOOL		TRUE if "Sensor supply #2 over voltage" fault is active
		VE5b_min is active (Index=56)	%IX551.5	BOOL		TRUE if "Sensor supply #2 under voltage" fault is active
		VE5ab_OOR is active (Index=57)	%IX551.6	BOOL		TRUE if "Sensor supplies simultaneously out-of-range" fault is...
		COPfail is active (Index=58)	%IX551.7	BOOL		TRUE if "COP failure" fault is active
		RTI1 is active (Index=59)	%IX552.0	BOOL		TRUE if "RTI 1 loss" fault is active
		RTI2 is active (Index=60)	%IX552.1	BOOL		TRUE if "RTI 2 loss" fault is active

Fault table indicating User and System faults

The range limits for many of the faults have default values that can be overwritten in the appropriate I/O configuration tab. Please see below:



Parameter	Type	Value	Default Value	Unit	Description
Analog/Digital IN1					Analog/Digital Input #1 configuration
AIN mode	Enumeration of Byte	0 to 5V (ratiometric)	0 to 5V (ratiometric)		Analog input mode - determines configuration of resistor pull-up/downs
Pull-up enabled	Bool	TRUE	TRUE		Enable or disable the pull-up to 5V (standard value is 22.1kO)
Pull-down enabled	Bool	FALSE	FALSE		Enable or disable the pull-down and voltage divider to ground (standard value is 11
Current shunt enabled	Bool	FALSE	FALSE		Enable or disable the 200O current shunt pull-down to ground
Filter Time Constant	Enumeration of Byte	50 ms	50 ms		Low-pass filter time constant to add to analog value
DIN debounce	Byte(1..250)	50	50		Digital input debounce period (only applies to "Digital Value" parameter)
DIN rising threshold	Word	2500	2500		Rising voltage threshold for digital "high" value (only applies to "Digital Value" para
DIN falling threshold	Word	1000	1000		Falling voltage threshold for digital "low" value (only applies to "Digital Value" para
Over-range limit	Real	34000	34000		Upper limit for this channel's over-range fault (units depends on selected mode)
Under-range limit	Real	0	0		Lower limit for this channel's under-range fault (units depends on selected mode)
Analog/Digital IN2					Analog/Digital Input #2 configuration
AIN mode	Enumeration of Byte	0 to 5V (ratiometric)	0 to 5V (ratiometric)		Analog input mode - determines configuration of resistor pull-up/downs
Pull-up enabled	Bool	TRUE	TRUE		Enable or disable the pull-up to 5V (standard value is 22.1kO)
Pull-down enabled	Bool	FALSE	FALSE		Enable or disable the pull-down and voltage divider to ground (standard value is 11
Current shunt enabled	Bool	FALSE	FALSE		Enable or disable the 200O current shunt pull-down to ground
Filter Time Constant	Enumeration of Byte	50 ms	50 ms		Low-pass filter time constant to add to analog value

Note in this example the range limit for an analog input is highlighted (34,000 mV), this is used for defining the appropriate range limit and if exceeded the corresponding fault will trigger if active.

Fault table indicating PWM faults:

The range limits for many of the faults have default values that can be overwritten in the appropriate I/O configuration tab. Please see below:

Parameter	Type	Value	Default Value	Unit	Description
Shared PWM Fault Configuration					Shared configuration parameters for detection of each PWM fault condition
Short to battery					((High-side duty < DUTY_HS) or (Low-side duty > DUTY_LS)) and (Voltage/VLoad > VLOAD_RATIO)
DUTY_HS	Byte(0..100)	25	25	%	
DUTY_LS	Byte(0..100)	50	50	%	
VLOAD_RATIO	Byte(0..100)	90	90	% VLoad	
Open circuit or low-side driver ground short					(Duty > OPEN_DUTY and Current < OPEN_CURRENT) or (Low-side duty ≤ GND_SHRT_DUTY and Voltage/VLoad < GND_SHRT_VR...
OPEN_DUTY	Byte(0..100)	10	10	%	
OPEN_CURRENT	INT	50	50	mA	
GND_SHRT_DUTY	Byte(0..100)	10	10	%	
GND_SHRT_VRATIO	Byte(0..100)	10	10	% VLoad	
Over Current					(High-side current > hardware limit) or (High-side current > MAX_CURRENT)
MAX_CURRENT	INT	4000	4000	mA	
Loss of Control					(Duty = 0% and Current > OFF_CURRENT) or (Reverse current is > 75mA)
OFF_CURRENT	INT	75	75	mA	

DUTY_HS and VLOAD_RATIO – In High Side output configuration, if duty cycle is commanded below DUTY_HS (25%) and (Voltage on output/Input Load Power) >VLOAD_RATIO (90%), then trigger the “Short to Power” fault.

DUTY_LS and VLOAD_RATIO – In Low Side output configuration, if duty cycle is commanded above DUTY_LS (50%) and (Voltage on output/Input Load Power) >VLOAD_RATIO (90%), then trigger the “Short to Power” fault.

OPEN_DUTY and OPEN_CURRENT – If the duty cycle is commanded above OPEN_DUTY (10%) and the measured current is less than OPEN_CURRENT (50mA), trigger the PWM output “Open is Active” fault.

GND_SHRT_DUTY and GND_SHRT_VRATIO – In Low Side output configuration, if duty cycle is commanded below GND_SHRT_DUTY (10%) and (Voltage on output/Input Load Power) <GND_SHRT_VRATIO (10%), trigger the “Open is Active” fault

MAX_CURRENT – If measured current is greater than MAX_CURRENT, then trigger the “Over Current” Fault.

OFF_CURRENT – If the output duty cycle is 0% and the measured current is greater than OFF_CURRENT (75mA), then trigger the “Loss of Control” fault.

The System Configuration I/O mapping contains the following:

A set of Global fault status variables to aid in managing faults. This consists of active and historic faults, a fault count, as well as a means to clear the faults. There is also a Fault Monitor where specific faults can be monitored. See below:

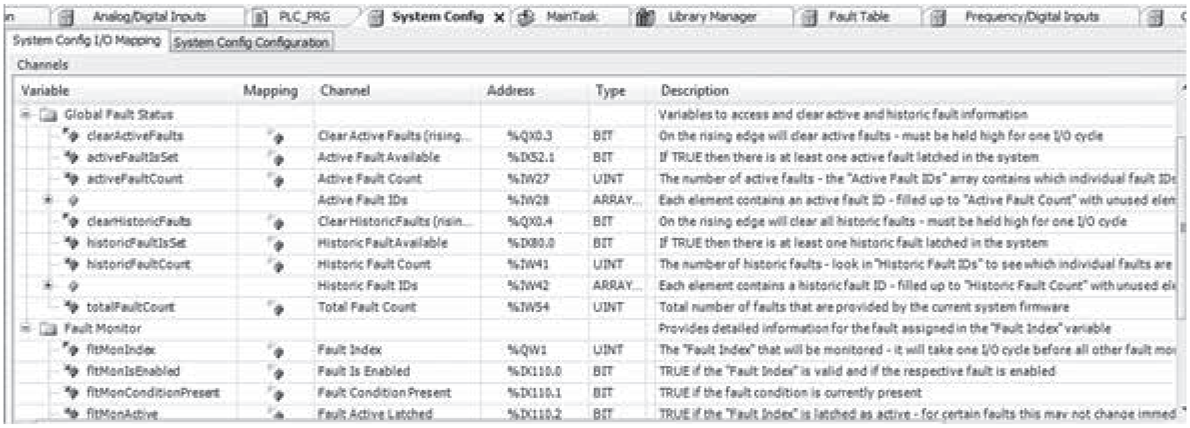


Figure 13:

Note: the location of Global Fault Status and Fault Monitor shown above.

The following are the predefined faults:

List of Codesys Faults

VE5_max and VE5b_max – indicates the sensor_ supply_1/2 are shorted to something above 5V (i.e. 12V power).

VE5_min and VE5b_min – indicates the sensor_ supply_1/2 is shorted to ground.

VE5ab_OOR – Both sensor supplies are "out-of-range". So if you short both high or short both low it will occur. It is functionally (VE5_max OR VE5_min) AND (VE5b_max OR VE5b_min).

COPfail is active – This is the system/firmware COP (computer operating properly) fault, AKA watchdog. This will only occur if there is a bug that causes the firmware to lock up or not trigger the COP approximately every 100ms.

RTI is active – This indicates that one of the internal firmware loops is not executing (1ms/5ms/50ms). Basically, this is similar to a COP for each of our internal loops.

RTI2 is active – This indicates that one of the internal firmware loops is not executing (1ms/5ms/50ms). Basically, this is similar to a COP for each of our internal loops.

RTI3 is active – This indicates that one of the internal firmware loops is not executing (1ms/5ms/50ms). Basically, this is similar to a COP for each of our internal loops.

Adloss is active – This occurs if the ADC routine is not running for some reason (similar to a COP overseeing the ADC operation).

Interrupt is active – This is caused if an invalid/ unhandled interrupt is ever executed.

flash_fail is active – CPU hardware error.

RAM_fail is active – CPU hardware error.

HWID_fail is active – 2 specific resistors are present on the PCB. Their value is used to identify the PCB hardware version. If these are at an unknown value, this fault will trigger.

J1939_Tx(x)Fail is active – Currently unsupported in CODESYS.

J1939_Rx(x)Fail is active – Currently unsupported in CODESYS.

DevDesc_error is active – This indicates there is a mismatch between the firmware and CODESYS device description.xml.

Illegal_flash write is active – This is an indication that CODESYS is attempting to write to a restricted address in flash.

Cpu_addr_err is active – This fault occurs if the CPU attempts to read or write an illegal or mis- aligned address. CODESYS will trigger this fault if you don't do a clean all.

Illegal_instr is active – This is similar to cpu_addr_err; however, it is for illegal instructions encountered by the CPU

FPU_exception is active – This fault is not supported by our hardware

MRAM_fail is active – This indicates a detected CRC error or other problem with the MRAM used to store RETAIN variables. If this error occurs it is a major hardware failure.

PWMx_loss control is active – This is an indication that an output channel has failed. It should occur if the PWM driver fails in a shorted condition.
It indicates that the program is instructing the output off, but the output is still flowing current. When this occurs it will then trip the secondary protection which is the internal solid state relay. This fault may also occur if a higher than supply voltage is placed on the output pin as this will cause reverse current to flow (through the body diode of the high side FET), which should be detected and thus trip the solid state relay.

CODESYS exception is active – CODESYS has its own exception implementation. Take for example the watchdog you can enable for each task. If you set enable the task watchdog and violate it then CODESYS throws an exception and displays an error message in the IDE and this fault will mirror that activity.

CODESYS low mem is active – running low on CODESYS memory. There is 16KB of internal "dynamic" memory that is allocated to CODESYS – This is used for all of their code. There is information about this on the EDIS "Debug Sys" page.

CODESYS out of dn mem is active – similar to low memory fault above, but this is when the operating system is out of dynamic memory.

CODESYS bad pointer is active – CODESYS internal code calls a function that checks if memory is good

CODESYS target mismatch – The CODESYS target description does not match the firmware

CODESYS exception is active – CODESYS has its own exception implementation. Take for example the watchdog you can enable for each task. If you set enable the task watchdog and violate it then CODESYS throws an exception and displays an error message in the IDE and this fault will mirror that activity.

CODESYS watchdog is active – This is monitoring the internal CODESYS task in firmware that executes all things CODESYS. Subtly but significantly different from the watchdog you enable in CODESYS via the IDE. This will happen if CODESYS locks up for any reason. Take for example you write a while(TRUE) {} loop in IEC code. Since everything runs from a single context, CODESYS will never see that the while(TRUE) loop has locked up, but the operating system will and in turn trigger this error. The watchdog time for this is configured in"CODESYS Runtime Watchdog" under System Config Configuration tab. The default for the "CODESYS watchdog" is 2 seconds so your individual task watchdog should be less.

CODESYS low mem is active – running low on CODESYS memory. There is 16KB of internal "dynamic" memory that is allocated to CODESYS – This is used for all of their code. There is information about this on the EDIS "Debug Sys" page.

CODESYS out of dn mem is active – similar to low memory fault above, but this is when the operating system is out of dynamic memory.

CODESYS bad pointer is active – CODESYS internal code calls a function that checks if memory is good

CODESYS target mismatch – The CODESYS target description does not match the firmware

List of Battery Faults

Batt_Low – This occurs whenever the supply voltage drops below 6 V for more than 5 seconds.

Batt_High – This occurs whenever the supply voltage exceeds 32 V for more than 3 seconds.

List of PWM Faults for PWM1_2A to PWM16_2A

PWM#_2A Loss of Control – This fault indicates that current or reverse current exceeding a default 75 mA is flowing without any commanded output current on the channel.

PWM#_2A Over Current – High-Side current measured on output 1(2A) is greater than the hardware limit or greater than a default Max current of 2000 mA. The default current values can be overwritten in the configuration of the unit.

PWM#_2A Short to battery – This fault indicates when output channel 1(2A) has a short to the battery.

Note: That the controller is comparing commanded current value to the measured value to evaluate for the fault. The default current value is 25 mA but can be overwritten in the configuration of the unit.

PWM#_2A Open circuit or Low-Side drive grounded – This fault indicates when there is an open circuit on output channel 1(2A). The controller is comparing the commanded current value to the measured value or checking for a ground short on the output. The default values can be overwritten in the configuration of the unit.

List of PWM Faults for PWM1_4A to PWM8_4A – Fault Description

PWM#_4A Loss of Control – This fault indicates that current or reverse current exceeding a default 75 mA is flowing without any commanded output current on the channel.

PWM#_4A Over Current – High-Side current measured on the output (4A) is greater than the hardware limit or greater than a default Max current of 4000 mA. The default current values can be overwritten in the configuration of the unit.

PWM#_4A Short to battery – This fault indicates when output channel (4A) has a short to the battery.

Note: That the controller is comparing commanded current value to the measured value to evaluate for the fault. The default current value is 25 mA but can be overwritten in the configuration of the unit.

PWM#_4A Open circuit or Low-Side drive grounded – This fault indicates when there is an open circuit on the output channel (4A). The controller is comparing the commanded current value to the measured value or checking for a ground short on the output. The default values can be overwritten in the configuration of the unit.

List of CAN Bus Faults: – Fault Description

CANx Tx Failure – Can transmit error counter exceeds 100

CANx Rx Failure – Can receive error counter exceeds 100.

List of Analog Faults for AIN1 to AIN16 – Fault Description

AINX max current exceeded – The max current for input X in analog mode has been exceeded

AINX value over-range – The value of the signal on the analog input X is too high.

AINX value under-range – The value of the signal on the analog input X is too low.

Frequency Fault List: For FREQ1 to FREQ8 – Fault Description

FREQX Input over voltage – The max voltage for input X in frequency mode has been exceeded (>34 Volts).

FREQX max frequency limit exceeded – The max frequency for input X in frequency mode has been exceeded (>50 kHz).

Max Total input frequency limit exceeded – The maximum aggregate frequency for all frequency inputs in total has been exceeded (>200kHz).

FREQX Input under voltage – The voltage for input X in frequency mode is too low. (< -5 Volts).

25.0 APPENDIX

25.1 Supported & Unsupported CODESYS Features

Since CODESYS is a generic broad based software environment that supports a multitude of different products, not all features are relevant with a given product. This is the list of supported and unsupported features in HFX controllers:

25.2 Supported

1. Debug variable viewing
2. Login
3. Logout
4. Download (single Application)
5. Run
6. Stop
7. Reset (warm, cold, origin)
8. Logger
9. Files and directories (24KB max storage and 16 character names or directories)
10. Write values
11. Create boot application (downloaded with service tool)
12. Debug visualization (debugging in IDE)
13. Task monitor (no jitter measurements though)
14. Retain (cycle-by-cycle, 4K)
15. Task timing – cyclic, freewheeling, event
16. Dynamic IO configuration.
17. Fault monitoring and acknowledgement.
18. Debug > Display mode
19. Simulation
20. IEC Task watchdog
21. IEC 61131-3 Programming languages
22. Microsecond time resolution
23. Force/unforce (available next release)
24. Breakpoints
25. Single-cycle
26. Step through (step over, step into, 9 step out – depends on #1)
27. Trace

25.3 Not Supported

1. Show call stack
2. Display flow stack
3. PLC shell
4. Users and groups
5. Access rights
6. Online change
7. Source download
8. Persistent
9. Data server
10. Alarm manager
11. Text editor
12. Path3D
13. Cam displayer
14. Task timing – status, external event

26.0 DEVICE COMMUNICATION TROUBLESHOOTING

The following is a list of things to check, in order of priority, if you are having problems connecting to your controller from Pro-FX Control.

1. Make sure the device is powered up. You should see a green light on LED A of the device. It is okay if this is flashing (this just means the controller is currently in run mode).
2. Make sure the USB port is connected and Windows has properly loaded the drivers. In the device manager you should see under "Ports" an entry that say’s "Mobile Controller: Enhanced COM Port".
3. Make sure that the gateway.cfg file has been properly installed per the instructions in this document. Installation of an alternate CODESYS device gateway may have overwritten this file.
4. In the Pro-FX Control "Communication Settings", select "None" for the "Filter". Then rescan for the device. If something new shows up, then it could be that the device variant being used by your project is different than the connected device. Pro-FX Control will only let you connect to a device variant that matches the configuration of your project. To switch to the appropriate device, right click on it in the "Devices" project tree and select "Update Device".
5. Stop and start the gateway. Plug and unplug the USB port.
6. Restart Pro-FX Control.
7. Restart your PC
8. In some cases, Windows will automatically assign a high COM port number to the USB device. If the device manager shows something higher than "COM20" then you should reassign it to something lower. Then restart the gateway and unplug and plug the USB port.
9. Each time a unique mobile controller is connected to your PC, Windows will provide 2 new COM port numbers. In some cases, Pro-FX Control appears to have problems automatically discovering the device's COM port when the value gets too high. In this case there are 2 options:

- From the device manager, click the COM port's properties, select "Port Settings" tab, click "Advanced", and select a "Com Port Number" that is below COM20. Then restart the gateway and replug the USB device to ensure changes are applied properly.
- You can alternately edit the gateway.cfg to manually assign your device's COM port number. Open the gateway.cfg file located in the directory {ProgramFiles (x86)}\3S CODESYS\GatewayPLC and change the line that begins with "Com.0.Port". After making this change, restart the gateway.

  Note: After making this change, your installation will no longer automatically detect other controllers, so this must be repeated for all unique controllers that are connected to your PC.

27.0 DEVICE RECOVERY

On HFX, short PWM1_2A *AND* PWM2_2A to VBAT (must be > 11 V). Then power the system with either the service tool running or attempt to connect via CODESYS within 3 seconds after powerup. This will prevent the CODESYS application from running and then you can recover it.

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