# Eaton HFX Product Family Installation and Operation Manual
## For C-API SDK
HFX Product Line


Powering Business Worldwide

# 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.

### ⚠ Warranty

In order to consistently bring you the highest quality, full featured products, we reserve the right to change our specifications and designs at any time.

A limited warranty is given with these Eaton products. Please see our website for details.
http://www.eaton.com/Eaton/ProductsServices/Hydraulics/WarrantyTermsConditions/PCT_612027

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# HFX Product Family

## 1.0 INTRODUCTION

The Eaton HFX product family is a series of advanced, CAN- based controllers for use with mobile and industrial equipment. Using C programming, 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 with C 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

| | |
|---|---|
| FW | Firmware |
| HW | Hardware |
| IDE | Integrated Development Environment |
| IP | Intellectual Property |
| MIL | Malfunction Indicator Lamp |
| POU | Program Organization Unit |
| PWM | Pulse Width Modulation |
| RTS | Run Time System |
| SW | Software |
| C-API | C Application Programming Interface |
| SDK | Software Development Kit |
| I/O | Input/Output |
| CRC | Cyclic Redundancy Check |

## 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 | TBD |
| Standby Current 12/24 VDC | <3.5mA@12V, <2.5mA@24V |
| Ignition Pin (K15) | 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 (4 Kbyte available to user.) |
| Flash (ROM program & data combined) | 3.75 Mbyte |
| SRAM | 256 Kbyte |
| EEPROM | 128 Kbyte |
| CAN Specification | 2.0A, 2.0B |
| Baud Rates | 50 kb/s,100 kb/s,125 kb/s,250 kb/s,500 kb/s,800 kb/s,1Mb/s |
| Protocol | Partial SAEJ1939 support |
| Default Node Address | 0 |
| Default Baud Rate | 250kb/s |
| USB Specification | N.A. |
| Baud Rates | N.A. |
| Default Node Address | N.A. |
| Default Baud Rate | N.A. |
| Number of Sensor Supplies | 1 for HFX 12/20; 2 for HFX32/48 |
| 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 (Ratiometric) |
| 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 Freq. mode Note: maximum aggregate is 200 kHz, Minimum detectable pulse duration is 20 µsec |
| Maximum Input Frequency Ch 3-8 (Dig) | |
| Switch-on Level | Standard switch on at 3.0 V |
| Switch-off Level | Standard switch off at 2.0 V |

# HFX Product Family

| | |
|---|---|
| Input Type | Variable reluctance (Software configurable) |
| Maximum Input Frequency Ch 1-2 (FREQ) (0-5 V square or sine wave) Note: phase and duty cycle are not supported by these inputs | 0Hz...25kHz* Note: maximum aggregate is 200 kHz, 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 |
| 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 |
| Type | PWMi, High side (Software configurable) |
| Max Amperage | 2A |
| Diagnostics | Open/Short Circuit Protection |
| PWM Frequency | 50 – 2 kHz |
| Dither Frequency | Configurable |
| Dither Amplitude | Configurable |
| Control Range | 0.05 - 2 A |
| Control Resolution | 1 mA |
| Fly Back Protection | Integrated |
| Duty Cycle Resolution | .01% @ 250 Hz |
| Type | PWMi, High Side (Software configurable) |
| Max Amperage | 4A |
| Diagnostics | Open/Short circuit protection |
| PWM Frequency | 50 – 500 Hz |
| Dither Frequency | Configurable |
| Dither Amplitude | Configurable |
| 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 |
| Connector Assembly Parts List | Mating connector DRC26-40SA & DRC26-40SB, size 20 solid contacts P/N 0460-202-20141 intended for 20AWG wire, 460-010-20141 intended for 16-18 AWG wire, size 20 stamped and formed contacts P/N 1060-20-0122(nickel plated), sealing plug P/N 0413-204-2005 |
| Tooling Manufacturer | Deutsch |
| Hand Tool Part Number | Solid contacts: Service crimper: HST-1561<br>Production crimper(ratcheting): HDT-48-00 Stamped contacts: DTT-20-00 |
| Die Part Number | N/A |
| Contact Removal Tool | P/N 0411-240-2005 |

# HFX Product Family

## 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 CAN via E-COM® or Kvaser®
- Three CAN ports
- Sleep input for improved power management
- Regulated supply for sensors
- Three programmable LED status indicators

## 4.0 SAFETY CONSIDERATIONS

Note: 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 hfx_capi_manual.pdf. 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.

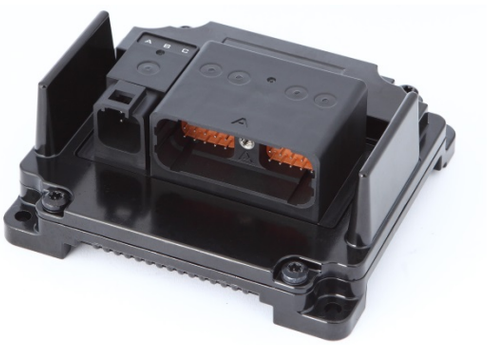
Note: That each controller within the HFX product family requires the installation of the HFX C-API SDK, service tool and CAN adapter drivers before initial use in the application environment. The HFX C-API SDK requires MS Windows® 7 or greater

.

## 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.

HFX controllers are programmed via CAN via an E-COM® adapter with either HFX service tool or FXST service tool. Both included in the installation package, see section 8 for service tool installation instructions. A Kvaser® CAN adapter is also compatible with the FXST service tool.

The two regulated outputs (sensor supplies) can be configured individually for either 5 or 10 V operation.

# HFX Product Family

**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 |

# HFX Product Family

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 handling variable reluctance sensors)
- 16 x Analog (0-5 V, 0-10 V, 0-32 V, 4-20 mA, and Thermistor)

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 also be configured as High Side or Low Side.

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 also be configured as High Side or Low Side.

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 also be configured as High Side or Low Side.

All 4 of the HFX controllers also integrate an internal temperature measurement that can be viewed with the HFX service tool.

## 7.0 SOFTWARE DESCRIPTION

Software for the HFX family of controllers is provided in the form of the HFX C-API SDK. This is distributed as a .exe installer file. After running the installer the following files will be added to the selected installation folder:

- \HFX_Firmware\: Firmware files (MOT files), A separate file is provided for each HFX controller model.
- \Service_Tools\Eaton_HFX_ST_Installer\: Setup.exe in the folder is the installation file for the HFX service tool.
- \Service_Tools\ECom_Drivers\: The Pro-FX Configure HFX Service Tool connects to the HFX over CAN using the ECOM device. This is the driver for that device.
- \Service_Tools\FXST\: NW.exe in the folder is executable for the FXST service tool.
- \Docs\: Contains all the C-API documentation; User guides, readme.txt and license.txt
- \capi: contains the SDK; build_tools, examples and includes.

When updating an existing HFX C-API, it is necessary to un-install the previous version and re-install the new installer executable. In some cases the service tool may also need to be re-installed. The release notes will mention this explicitly

## 8.0 SERVICE TOOL - INSTALLATION AND GETTING STARTED

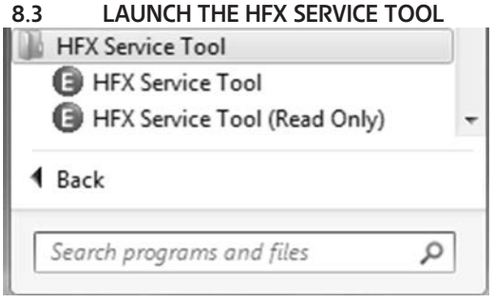
### 8.1 DRIVER INSTALLATION

Before using the HFX Service Tool, it is necessary to install the driver for the ECOM USB/CAN interface device. Prior to installing the driver, make sure that all ECOM devices are detached from your computer and that all programs are closed. Run the ECOM driver installation application Driver_Setup_C3.1.0.15.exe, located in \Service_Tools\ECom_Drivers\ folder of the C-API. Proceed with the installation by following the onscreen instructions. Once installation has completed, connect the ECOM device and Windows will complete the installation for the hardware and port.

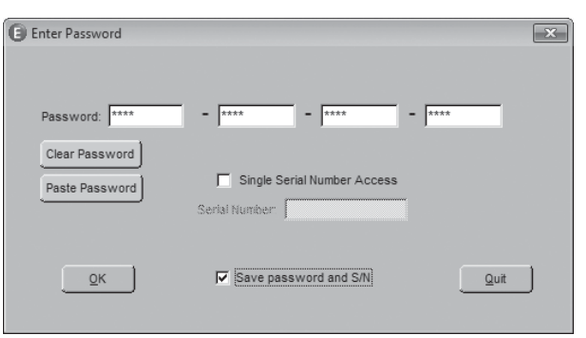
### 8.2 INSTALL THE HFX SERVICE TOOL SOFTWARE

Run the HFX Service Tool installation file setup.exe in \Service_Tools\Eaton_HFX_ST_Installer\.


### 8.3 LAUNCH THE HFX SERVICE TOOL




You may be prompted for a password. Use the C-API Read/Write password password can be found in the file 'Eaton Display Passwords.txt', located in the Service_Tools\Eaton_HFX_ST_Installer\ folder of the HFX C-API. You have the option to select 'Save password and S/N', which stores the password for the next time the software is used.



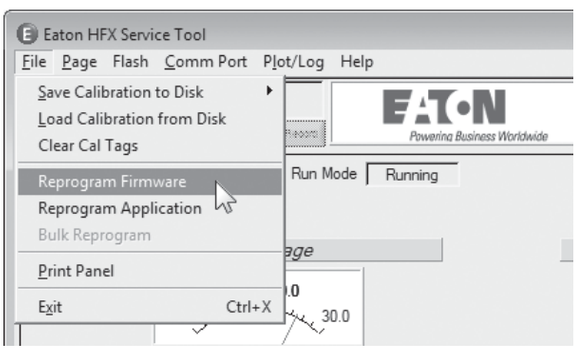
## 9.0 GETTING STARTED

## 9.1 FIRMWARE

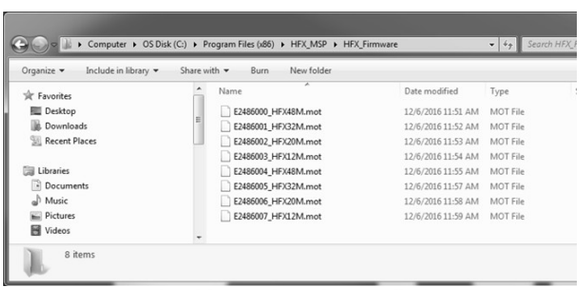
### Install the Firmware

HFX units are shipped blank, with no firmware loaded. Prior to first use, it is necessary to load firmware to the HFX.

Launch the HFX Service Tool if it is not already open. On the main page of the service tool select File->Reprogram Firmware.




Select the appropriate firmware to load based on the model of the controller intended for use.



The firmware should complete the installation process. If the wrong firmware has been selected, the software will provide a prompt which indicates that the firmware does not match the controller hardware. If this occurs, verify that the correct firmware was selected. There are two controller types, CODESYS and C-API. The CODESYS firmware versions are the files with names ending in 0_HFXMxx through 3_HFXMxx. The C-API versions go from 4_HFXMxx through 7_HFXMxx. The software should then load on the controller and complete installation. You should now be ready to proceed with the application software installation

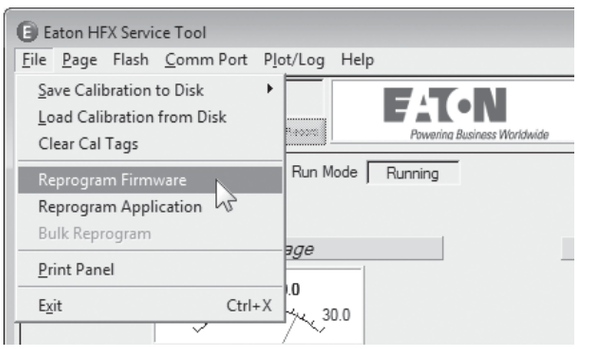
## 9.2 CREATING AN APPLICATION

Refer to the hfx_capi_manual.pdf and the example code to adapt the HFX C-API SDK to your projects particular needs.

## 9.3 INSTALL APPLICATION

**Option 1: Install application (HFX service tool)**

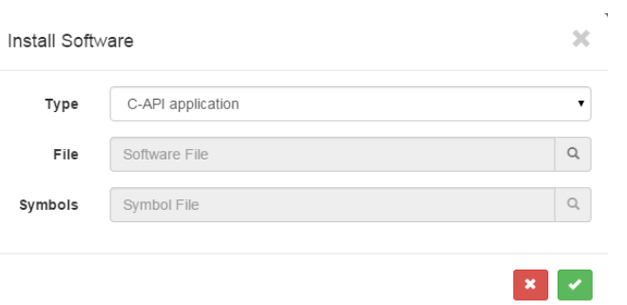
Launch the HFX Service Tool if it is not already open. On the main page of the service tool select File>Reprogram Application.




Select the *.HFX file from the project folder. The *.hfx file is located in the Build_<project_name>\output directory of the project folder.

**Option 2: Install application (FXST service tool)**

Launch the FXST service tool (NW.exe) and connect to the controller by pressing the button, then select the button and then select the C-API application option.




Then select the appropriate *.hfx file to download. The *.hfx file is located in the Build_<project_name>\output directory of the project folder.

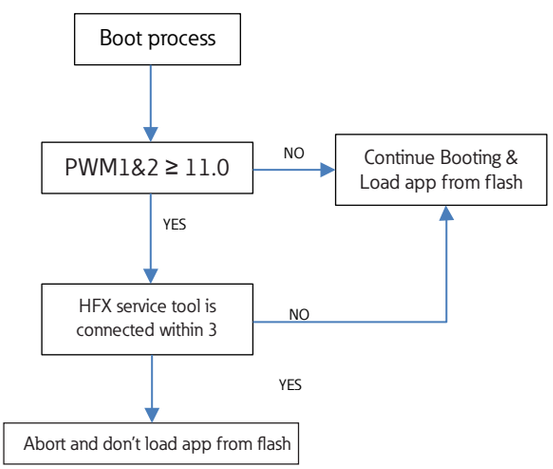
## 10.0 FUNCTIONALITY AND BASIC OPERATION

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 bootstrap mechanism is as follows:

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




## 10.1 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 | Ignition Pin < approximately 6.6 V) |
| Awaken | False | Ignition Pin > approximately 6.6 V) |

## 10.2 CONTROLLER STARTUP

The controller will transition to the shutdown state and then enter sleep mode after 5 seconds of the ignition pin being low.

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

## 10.3 TASK CONFIGURATION

The controller supports the following tasks:

- Cyclic: Task processed in a predefined time.

  There are 3 pre-defined task: 1 ms, 5 ms, 50 ms
- Freewheeling: Task processed as soon as the program is started. When complete, it will automatically restart in a continuous loop. "Background" is the only freewheeling task available.
- State Machine Tasks: Task processed in the 1 ms loop time, only one task is active at a time and depends on the state machine transitions.

Note: There are no external events available to trigger task execution. for more information on the tasks, open the help for the HFX Application block.

### 10.4 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 to the controller, tie PWM 1 & 2 to supply voltage, and then power up the unit. This will prevent the application code from loading

### 10.5 CONTROLLER MEMORY

The controller utilizes an advanced superscalar 32 Bit processor operating at 200 MHz. The memory is arranged into the following areas:
ROM Flash 3.75 Mbyte
EEPROM128 kbyte reserved for internal use i.e. firmware/bootloader
RAM 256 kbyte
MRAM 32 kbyte (4 kbyte user accessible calibration parameters)

### 10.6 CALIBRATION VARIABLES

See HFX CAPI Calibration Memory User Guide for more information

## 10.7 LED OPERATION

LED A (left-most) - Green power LED

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

LED B (middle) - Red MIL

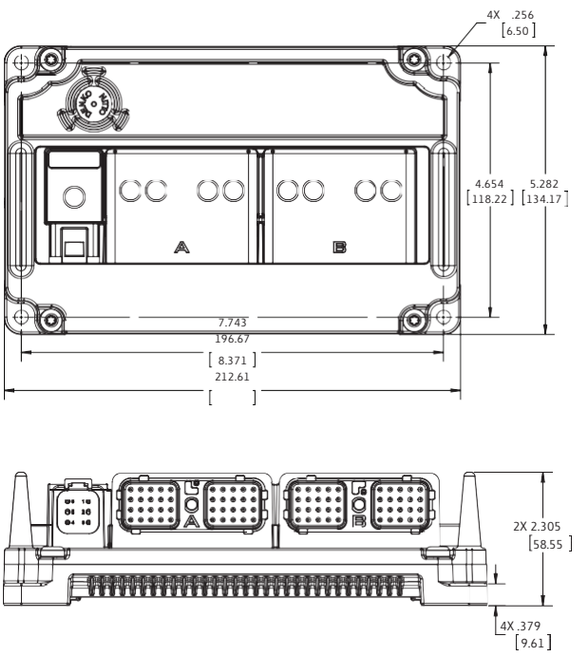
- Application running
  - Flashing (200ms on, 200ms off) ==> critical fault is active
  - Solid on ==> standard fault is active
  - Off ==> no fault
- Application not running
  - Fast Flashing (200ms on, 200ms off) ==> critical fault is active
  - Slow pulse (100ms on, 1500ms off) ==> historic fault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

LED C (right-most) - CAN TX is ok LED, blinks periodically if there are CAN messages being transmitted and there are no errors.

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

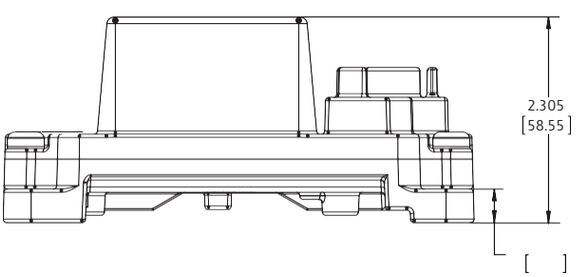
**HFX32m & HFX48m Dimensional Data**



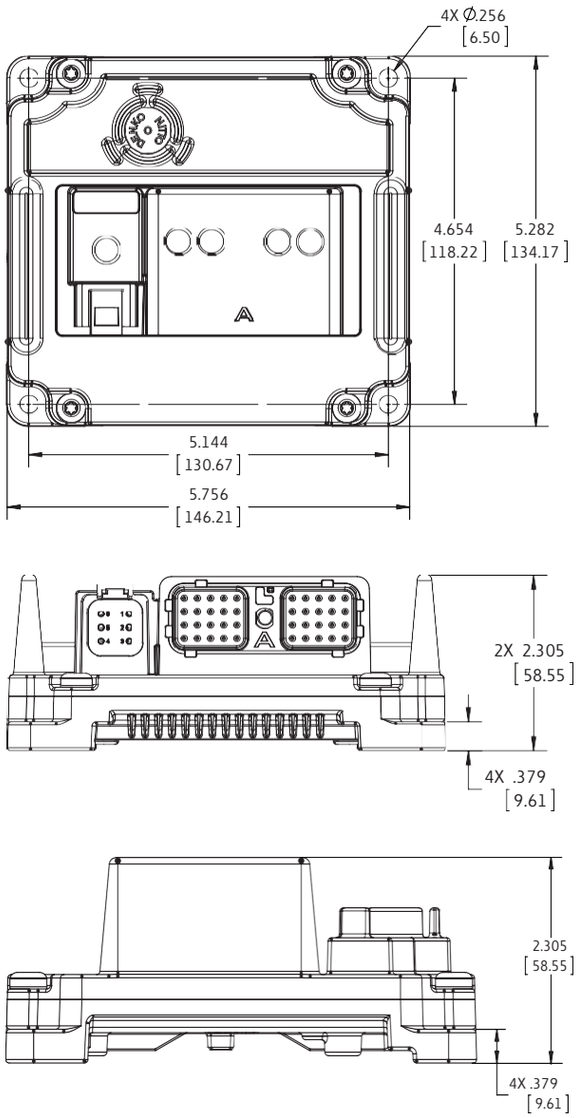

## 11.0 INSTALLING THE CONTROLLER

## 11.1 PRODUCT DIMENSIONS

Ideally the controller should be mounted on a vertical flat surface with connector facing down. Use four standard threaded fasteners to secure the controller to the surface (either 6 mm or ¼" diameter are acceptable).



**HFX12m & HF20m Dimensional Data**




## 11.2 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

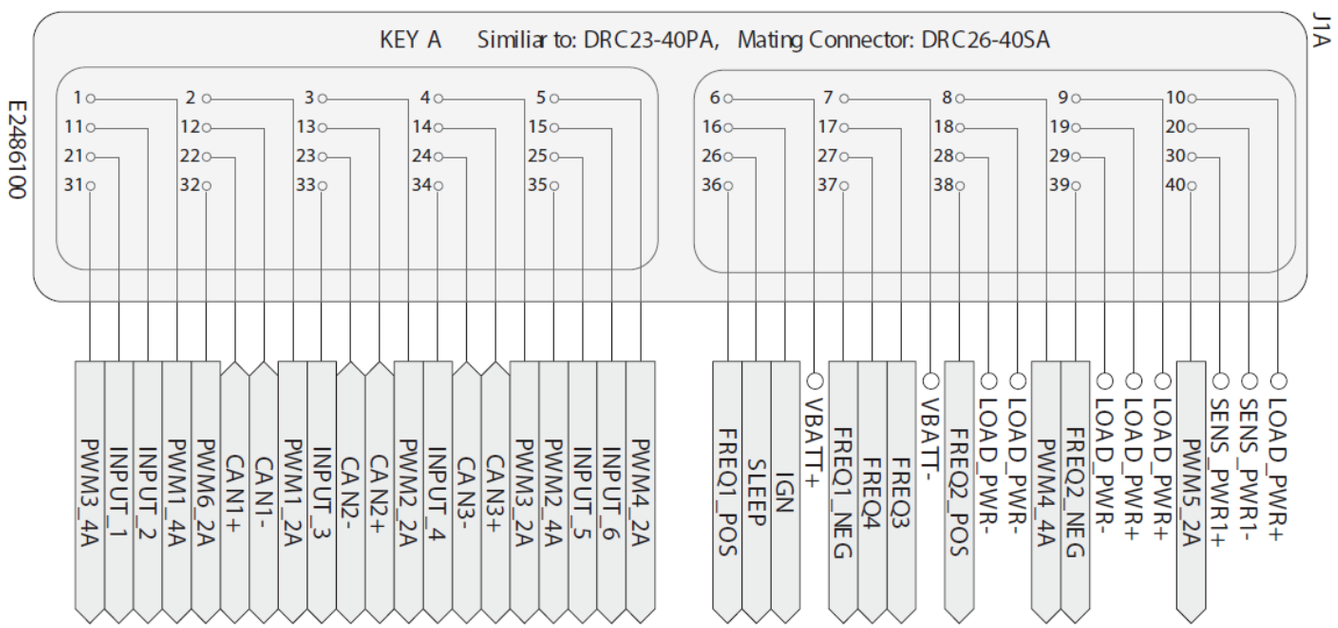
- Make sure that voltage drops are kept within reasonable levels under maximum continuous load conditions e.g. 1 volt on 12-volt systems and 2 volts on 24-volt systems.
- Verify that the harness is constructed to meet the needs of the application environment
  (e.g. shock, vibration, moisture, temperature, 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: Prior to Welding**

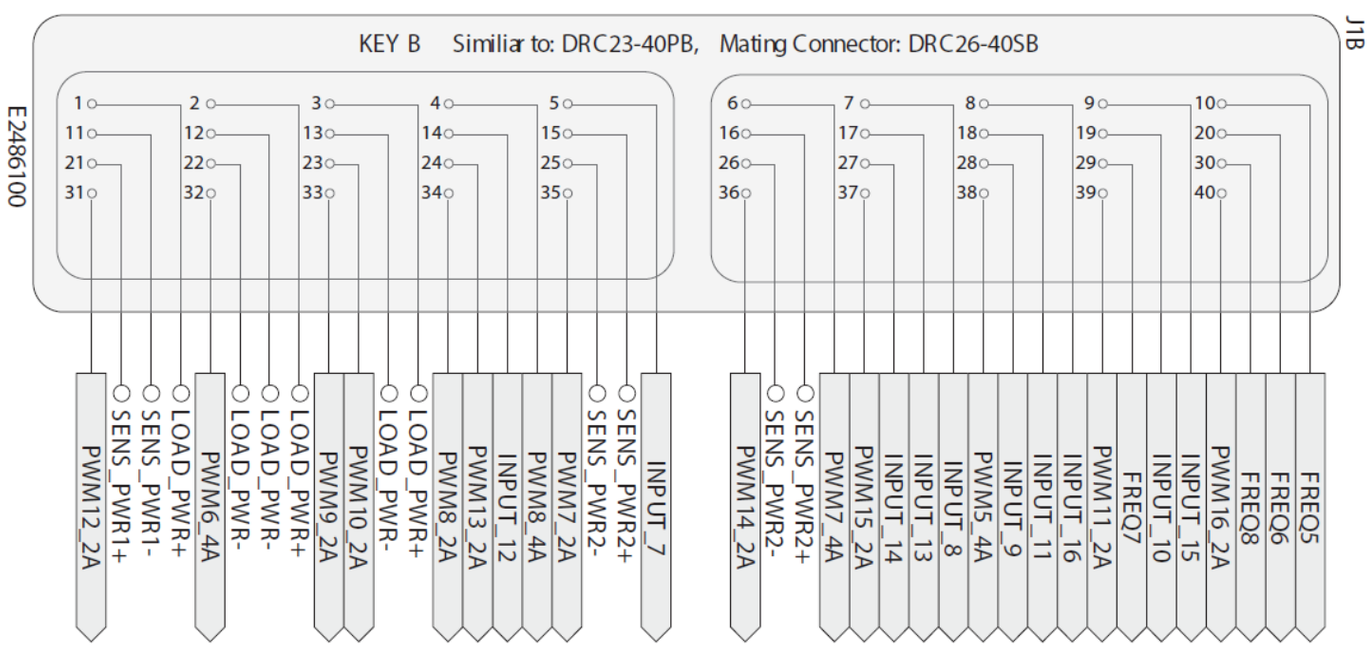
In order to avoid damaging the HFX controller ensure that all electrical connectors are fully disconnected from the HFX controller prior to welding on the machine.

## 12.0 ELECTRICAL CONNECTION INFORMATION

### Wiring Pin Out

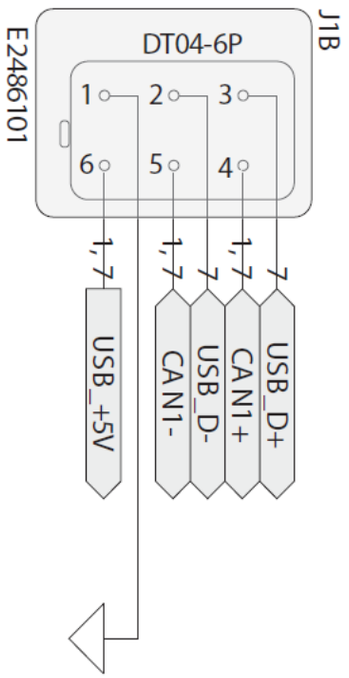



Note: All 4 of the HFX units share a common pin-out. The HFX12 does not utilize the following pins: 8, 15, 17, 25, 27, 31, 32, and 40.



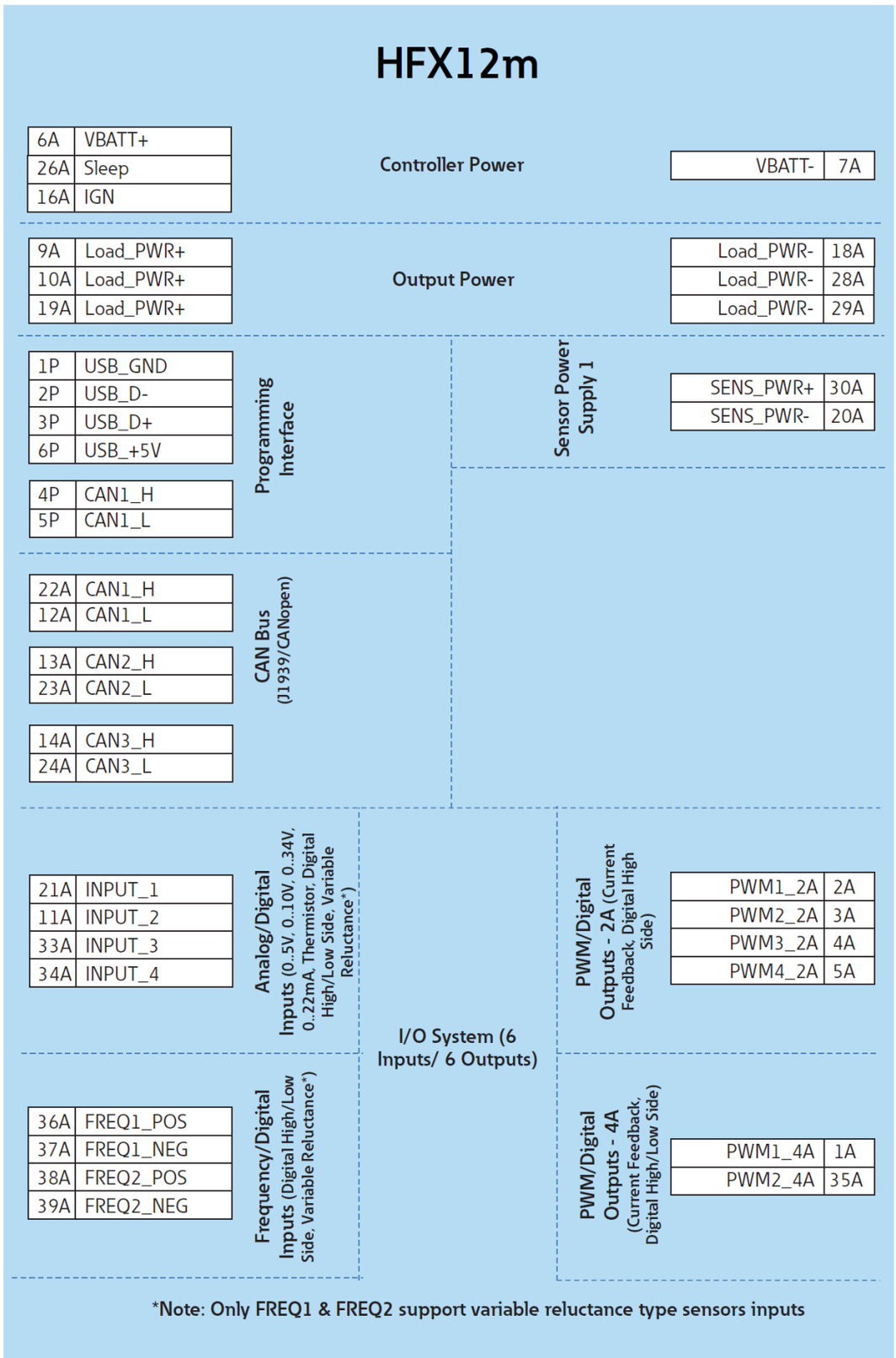

Note: Although all 4 of the HFX units share a common pin-out, both the HFX12 and the HFX20 do not have connector B. The HFX32 does not utilize the following pins: 4, 6, 8, 14, 17, 18, 24, 27, 29, 30, 31, 36, 37, 39, and 40.

# HFX Product Family

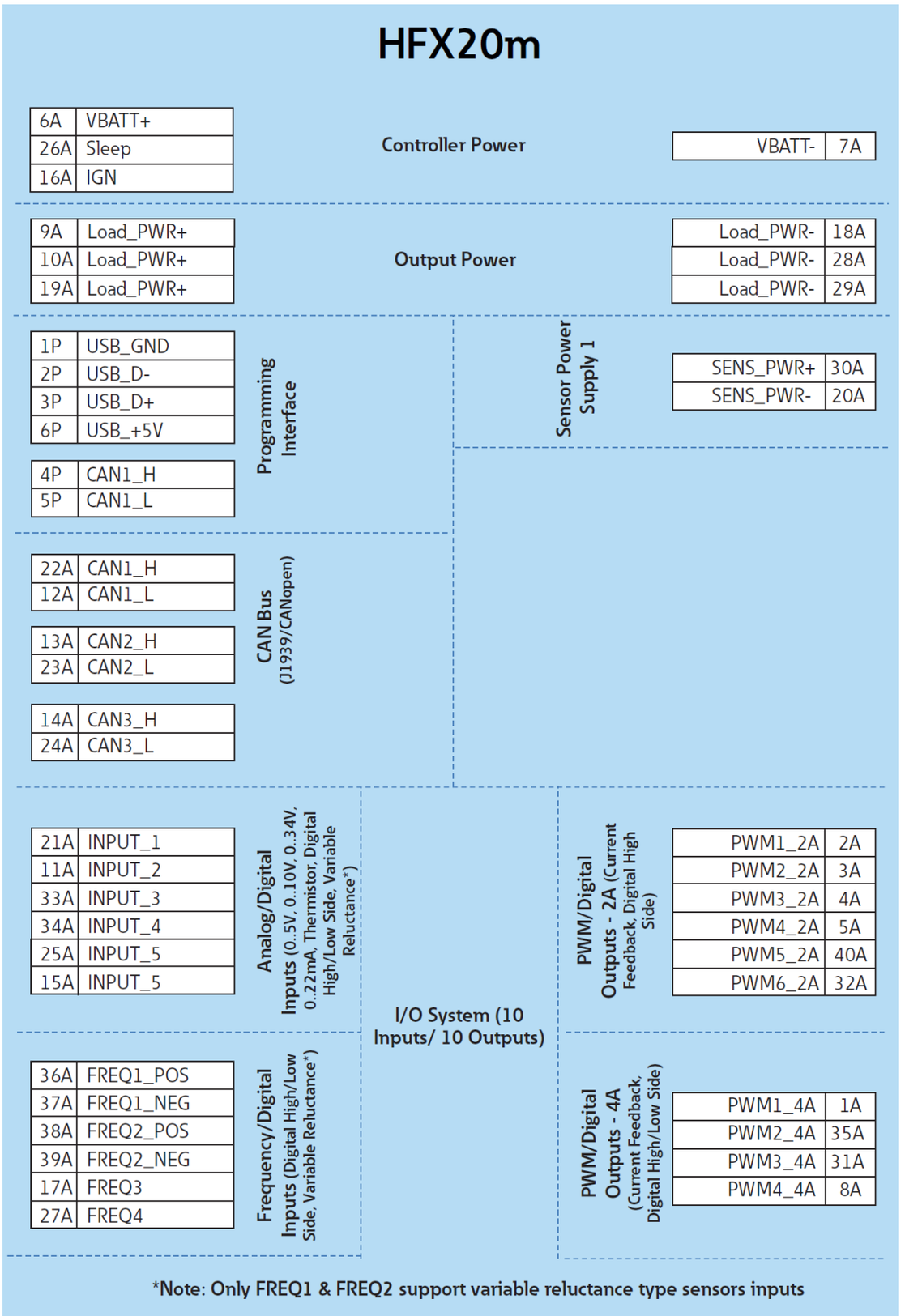


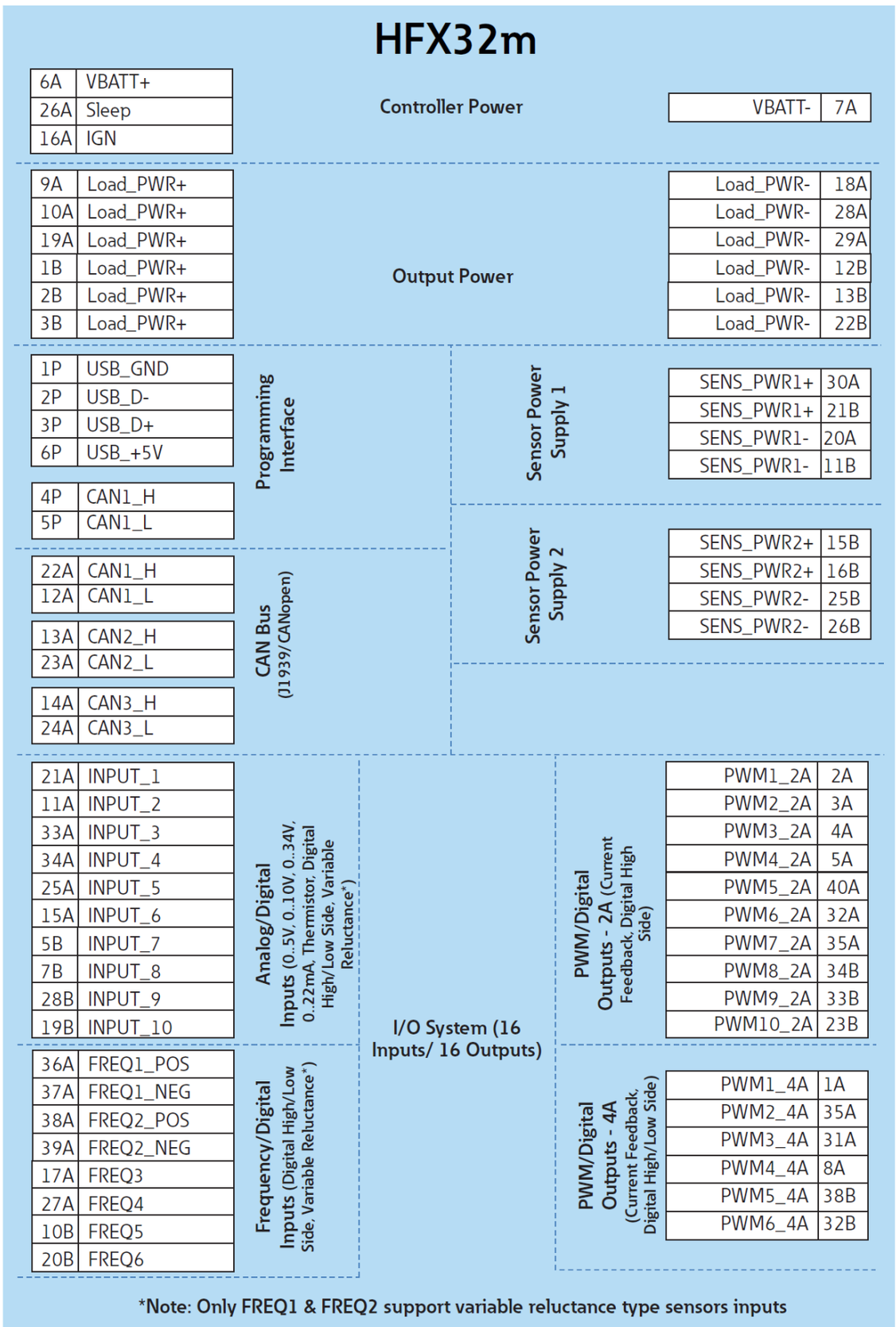

The above connector is used for programming and is common to all 4 models of the HFX controller.

## 13.0 BLOCK DIAGRAM

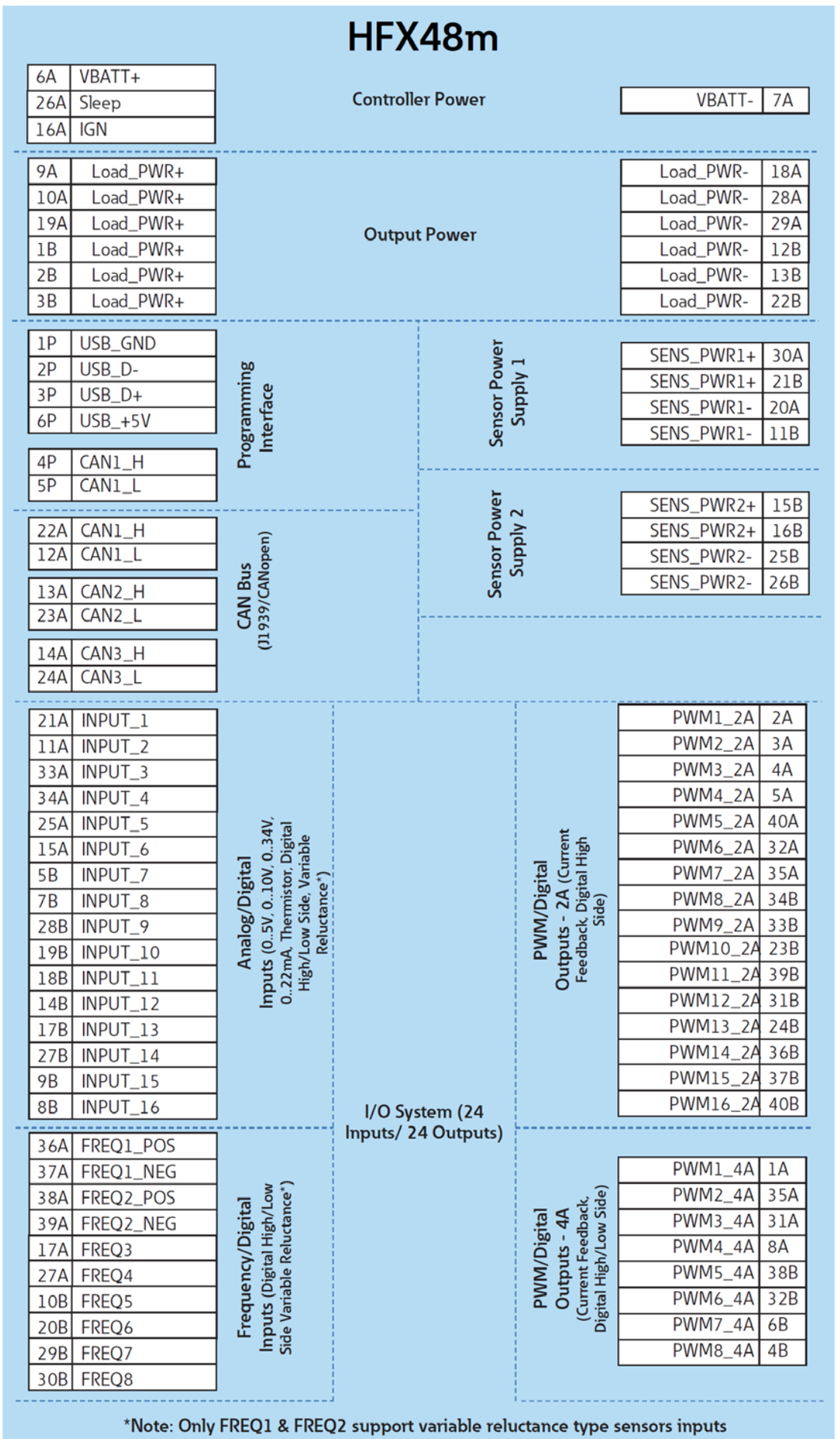


# HFX Product Family




HFX32m
6A VBATT+
26A Sleep
16A IGN
Controller Power
VBATT- 7A
9A Load_PWR+
10A Load_PWR+
19A Load_PWR+
1B Load_PWR+
2B Load_PWR+
3B Load_PWR+
Output Power
Load_PWR- 18A
Load_PWR- 28A
Load_PWR- 29A
Load_PWR- 12B
Load_PWR- 13B
Load_PWR- 22B
1P USB_GND
2P USB_D-
3P USB_D+
6P USB_+5V
Programming Interface
4P CAN1_H
5P CAN1_L
Sensor Power Supply 1
SENS_PWR1+ 30A
SENS_PWR1+ 21B
SENS_PWR1- 20A
SENS_PWR1- 11B
Sensor Power Supply 2
SENS_PWR2+ 15B
SENS_PWR2+ 16B
SENS_PWR2- 25B
SENS_PWR2- 26B
22A CAN1_H
12A CAN1_L
13A CAN2_H
23A CAN2_L
14A CAN3_H
24A CAN3_L
CAN Bus (J1939/CANopen)
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
Analog/Digital Inputs (0..5V, 0..10V, 0..34V, 0..22mA, Thermistor, Digital High/Low Side, Variable Reluctance*)
I/O System (16 Inputs/ 16 Outputs)
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 35A
PWM8_2A 34B
PWM9_2A 33B
PWM10_2A 23B
36A FREQ1_POS
37A FREQ1_NEG
38A FREQ2_POS
39A FREQ2_NEG
17A FREQ3
27A FREQ4
10B FREQ5
20B FREQ6
Frequency/Digital Inputs (Digital High/Low Side, Variable Reluctance*)
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
*Note: Only FREQ1 & FREQ2 support variable reluctance type sensors inputs

# HFX Product Family



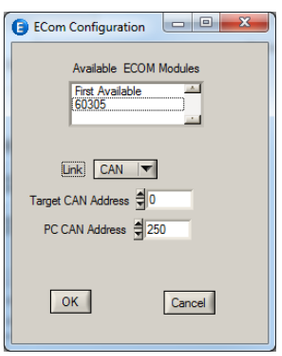
## 14.0 TESTING AND VALIDATION

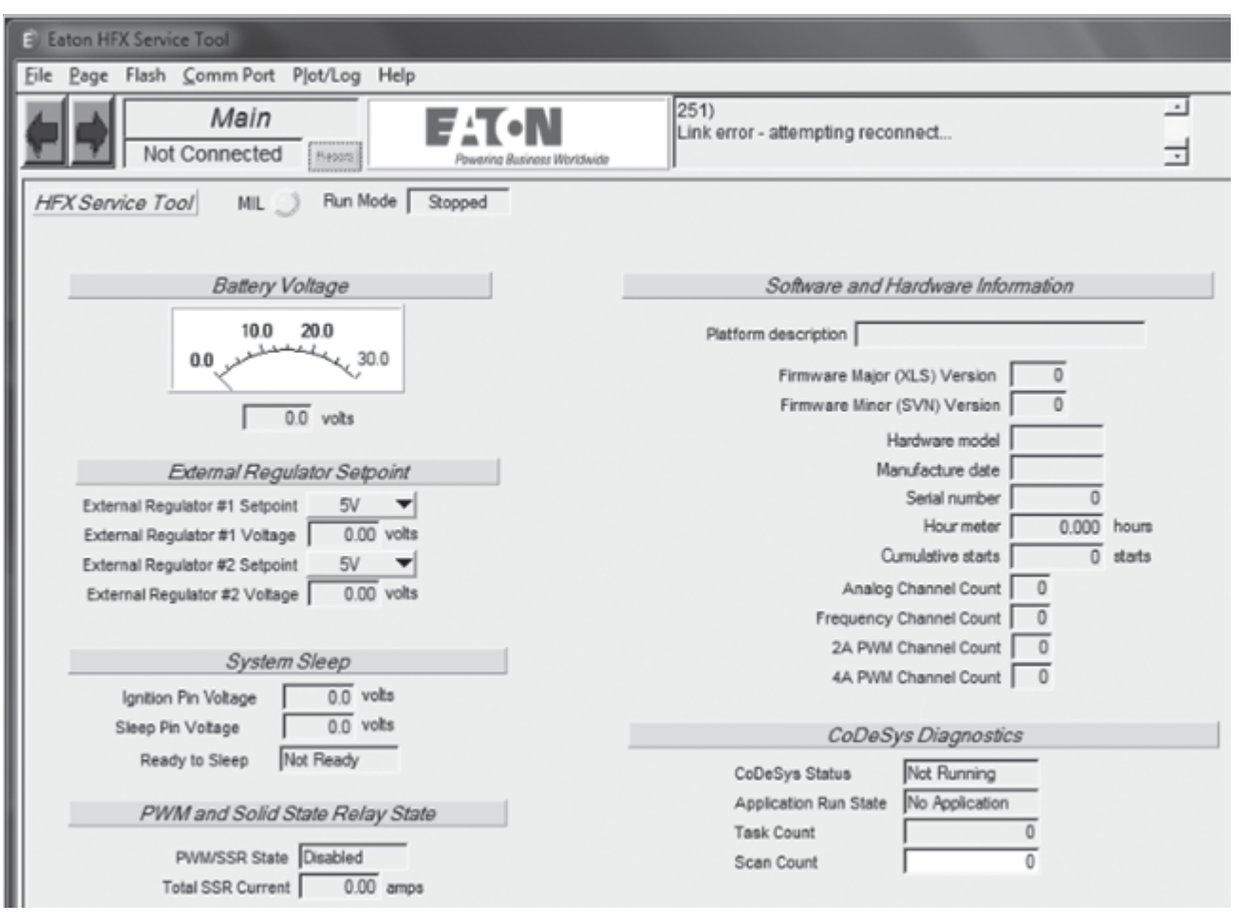
| Requirement | Specifications |
|---|---|
| **Electrical/EMI/EMC** | |
| EU (2004/104/) | EU automotive EMC directive |
| CISPR 25 | Conducted emissions (EU broadband & narowband limits) |
| CISPR 25 | Radiated emissions (EU broadband & narowband limits) |
| ISO 11452-4 | Immunity to narrowband conducted electormagnetic energy via bulk current injection |
| ISO 11452-2 | Immunity to narrowband radiated electormagnetic 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 testlevel 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 | Immuniy to A.C. power line electric fields reference +/- 15 kV |
| SAE J1113-26 | Immuniy 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 Potection | IP67/IP69K |
| Tansit 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 Circit | 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 | 1, 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) |

## 15.0 SERVICE TOOL

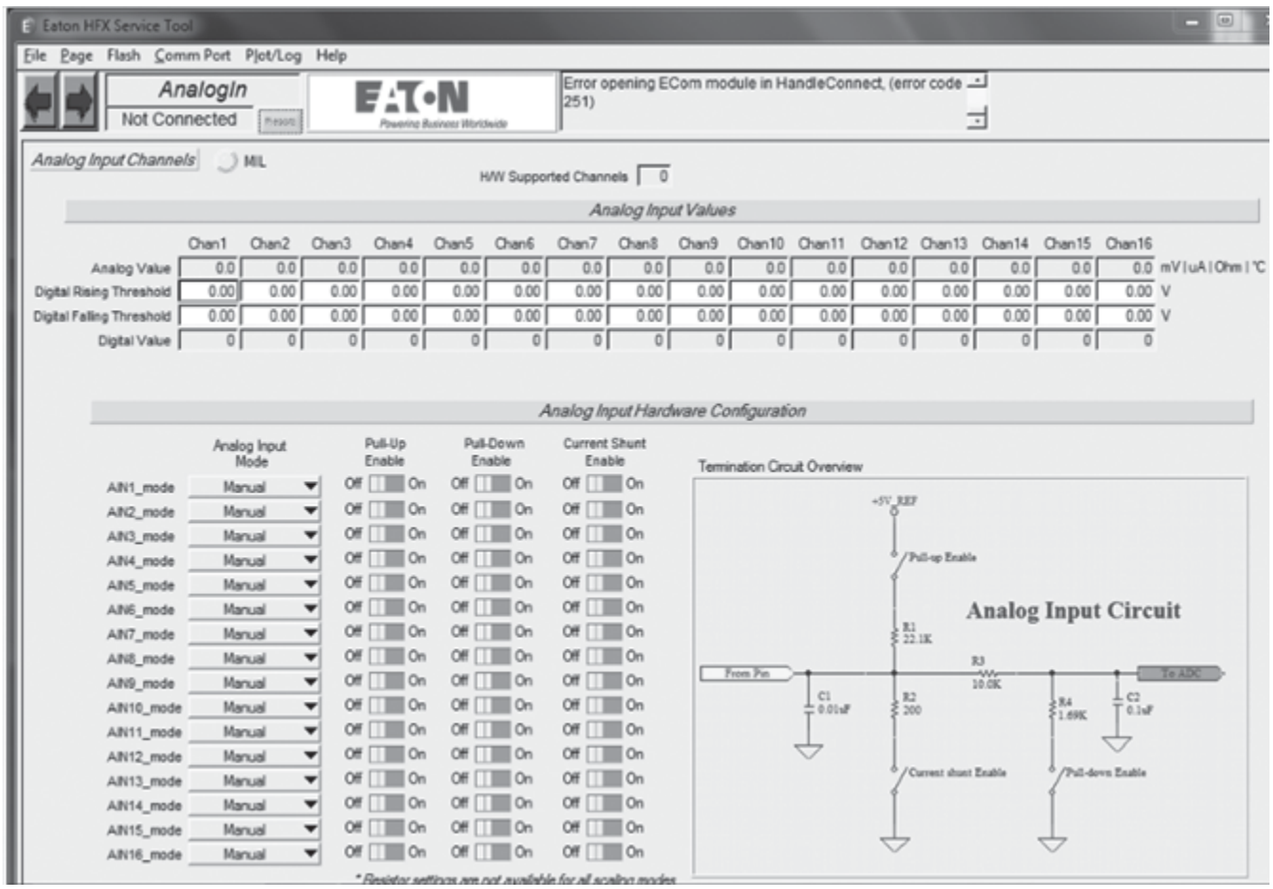
### 15.1 HFX SERVICE TOOL

The HFX service tool allows the user to download firmware or application programs and provides an aid for troubleshooting. There are five pages that display and/or allow configuration of various I/O types. Please see section 9 for details covering firmware and application installation. The tool has to be configured to the target node address to be able to connect. The configuration option is in the "Com Port" menu under "ECOM Configuration"



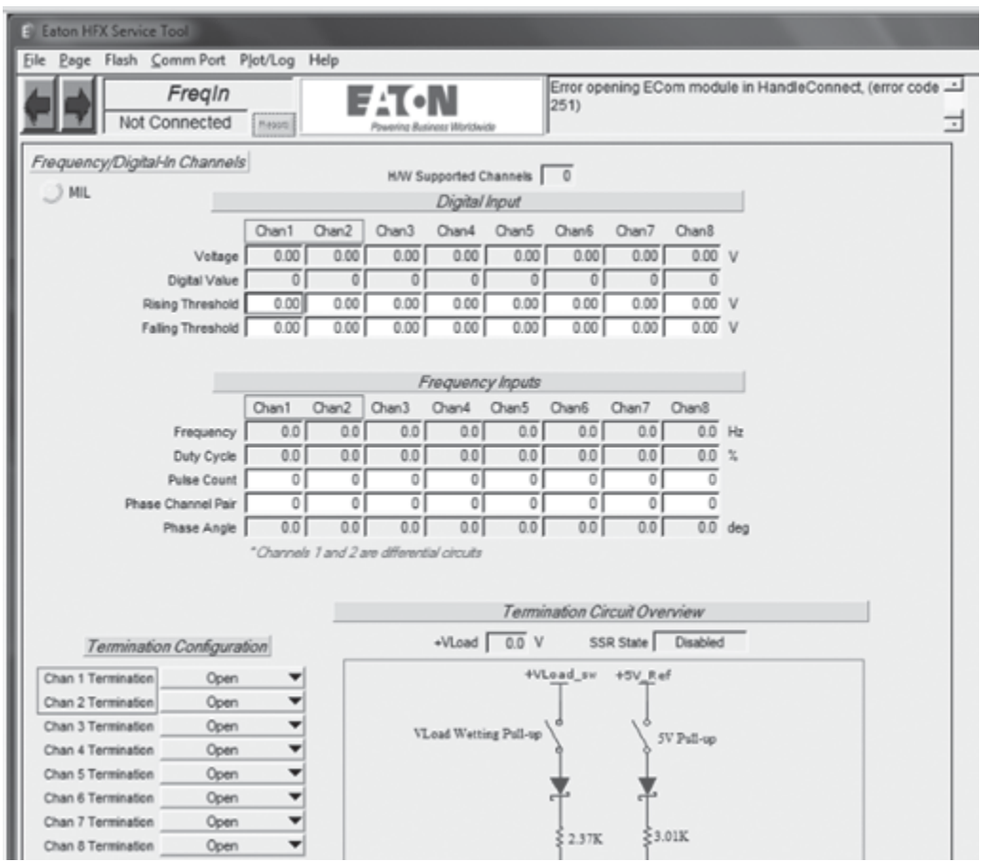




The above page is the Main page. This page allow the user to check the status of the MIL, supply voltage, ignition pin voltage, solid state relay, hours of use, and application. It also provides the total output current and several additional details about the software and hardware setup. Additionally,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

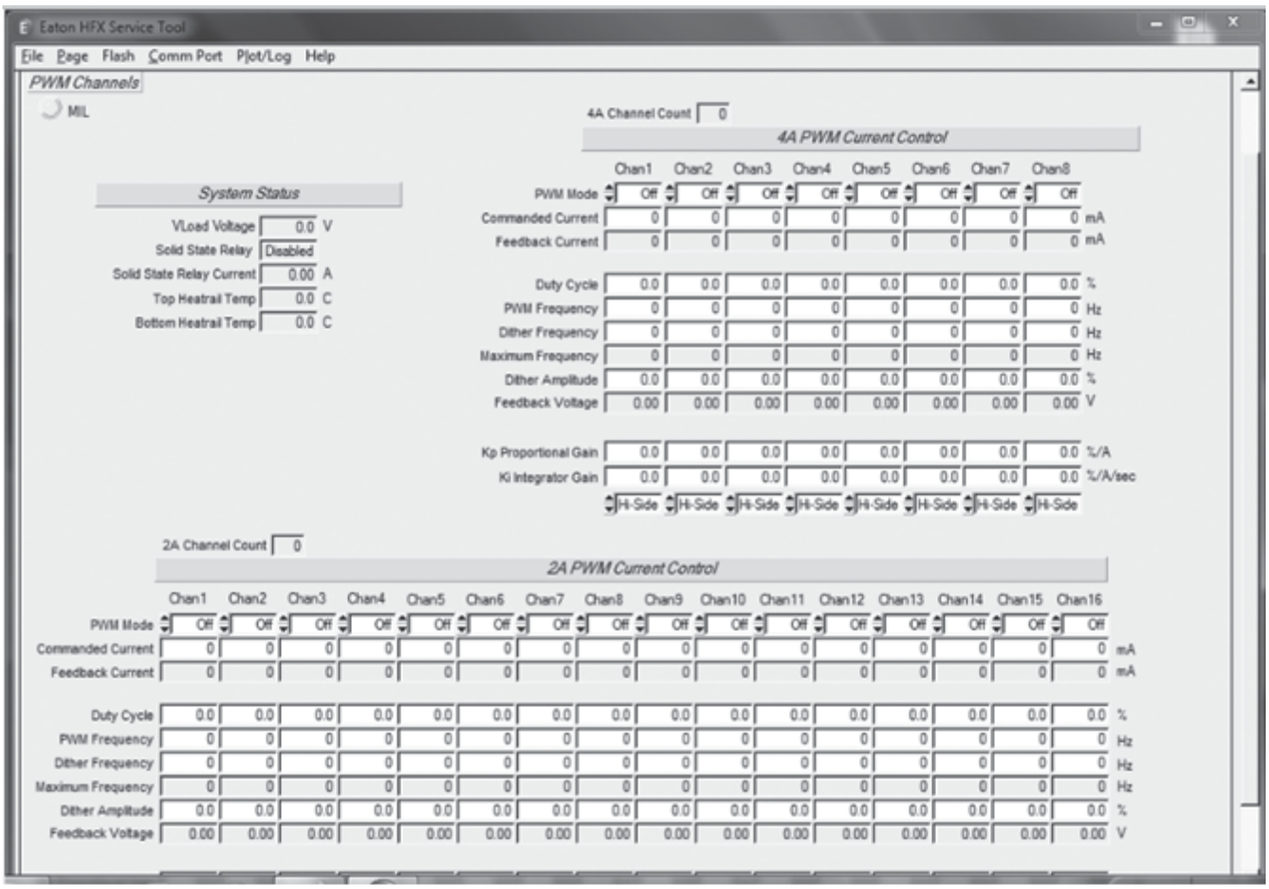



The above page is the Analog In page. This page enables the user to view input values associated with the analog channels and configure each channel for a specific type of input. It also offers the ability to individually select filters for each channel.

# HFX Product Family

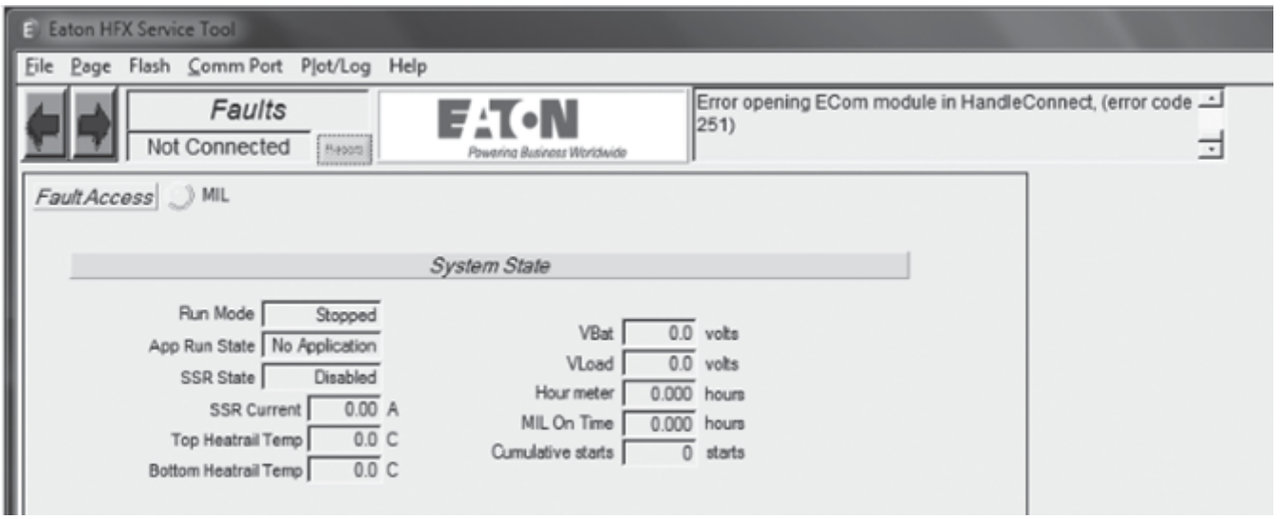



The above page is the Freq In page. This page enables the user to view input values associated with the frequency channels and configure each channel for a specific type of input to temporarily deviate from the application defined configuration..




The above page is the 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 to temporarily deviate from the application configuration. Additionally, the 4 A channels can be configured temporarily as Low-Side outputs.

# HFX Product Family




The above page is the fault page and it displays warnings, system status, and any faults that are active. To see the full list of faults consult the capi_hfx_manual.pdf.

## 15.2 FXST SERVICE TOOL

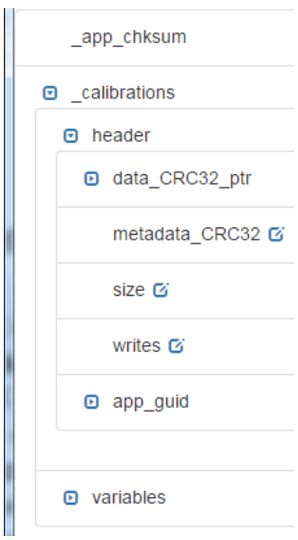
The purpose of this tool is to allow access to the application level build information calibrations, probes and overrides and allow reprograming of the target application and view faults and certain configurations. For uploading a new application see section 9.

Any Value shown in the tool with a  icon, indicates that this is a read/write value and can be changed . Changes to Overrides are only temporary and return to the original after a power-cycle. Changes to calibration parameter are persistent and will be maintained thru power-cycles, the exceptions are the calibration header information. Any changes to this region will cause the ROM defaults to be loaded on the next power-cycle. For more information on Overrides and Calibrations consult the help documentation of the respective blocks in Simulink®.

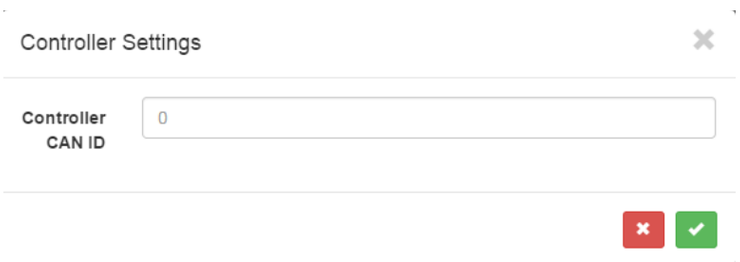
All projects will include the following information plus any Probes and Overrides added to the application:

_app_checksum: Application CRC32 value. The 32 bit Cyclic Redundancy Check is an error detection code that validates the integrity of the application.

_calibrations: contains a calibration header with a CRC32 value for the calibrations, a parameter storing the size of the calibration section, a counter indication how many times the values in the calibration has been changed and the GUID of the application for compatibility check. After the header group all the user calibration parameter will be included in the variable group.




For both tools the default node address of an HFX unit is 0, this can be configured in the application and it has to match the configured value in the service tool. To configure the FXST service too select the  icon.




To support more than 1 HFX unit in the CAN 1 channel the units must be programmed to have different node addresses so that the tool can differentiate between the units.

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