HFXd
Mobile electronic controller

Product numbers:
102EC20100A, 102EC20102A
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</tbody>
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Introduction

The HFXd is a compact, solenoid or remotely mountable controller designed for close integration with valve and pump products. This control unit features closed- and open-loop control capabilities, 2 inputs and 2 outputs (configurable), and CAN bus protocols in a rugged housing designed for on- and off-road mobile equipment.

There are two software options available for HFXd. The first option is to use the pre-programmed applications installed on HFXd to drive typical solenoid-operated hydraulic products. With these pre-programmed applications, no programming of the HFXd is required. Eaton’s Pro-FX™ Configure software is used to configure settings based on the product HFXd is controlling. The second software option is to program the HFXd using Matlab/Simulink. A Matlab Support Package is available to simplify developing code for deployment onto an HFXd.

Features and benefits

Small but powerful
In HFXd’s small package is a powerful 32 bit microprocessor with floating point support, 16 MB Flash, and CAN communication. Both HFXd variants can read 2 sensors and control 2 independent solenoids up to 2.5A each.

Streamline setup without programming
Software applications to control many electrohydraulic products are pre-programmed into HFXd. Just set up the pre-programmed application based on the product HFXd is controlling to get up and running quickly.

Flexibility through Matlab/Simulink
If a custom application is required, it can be built in Matlab/Simulink using the HFXd Matlab Support Package. The application is then flashed to HFXd using Pro-FX Configure.

Develop smart solutions
Convert Eaton electrohydraulic products into smart solutions that can communicate over CAN bus and provide diagnostic information about the product’s status. Using CAN simplifies wiring and can reduce material usage by up to 90%.

Ruggedized for mobile use
HFXd is rated to IP69k with an operating temperature of -40°C to 85°C (-40°F to 185°F) and a range of input voltages.

Repurpose outputs if not needed
HFXd has 2 dedicated inputs and 2 outputs that can individually be reconfigured to be additional inputs. This flexibility allows for monitoring 3 sensors if only one coil is being driven or 4 sensors if no outputs are needed.
## Specifications

### Technical data

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>L: 3.35 in (85 mm) x W: 1.89 in (48 mm) x H: 1.3 in (33 mm)</td>
</tr>
<tr>
<td>Weight</td>
<td>3.3 oz (94 grams)</td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>-40°C to +125°C</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>IP rating</td>
<td>IP69k</td>
</tr>
<tr>
<td>Operating altitude</td>
<td>0-4000 m</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>8-32 VDC, nominal operation @ 12/24 VDC</td>
</tr>
<tr>
<td>Peak supply voltage</td>
<td>36 VDC</td>
</tr>
<tr>
<td>Maximum load current</td>
<td>6A @ 85°C</td>
</tr>
<tr>
<td>Standby current 12/24 VDC</td>
<td>5mA @ 12/24 V</td>
</tr>
<tr>
<td>Processor</td>
<td>32 bit, 240 MHz, Expressif ESP32 module (dual core Xtensa 32-bit LX6 microprocessor)</td>
</tr>
<tr>
<td>ROM</td>
<td>448 Kbyte</td>
</tr>
<tr>
<td>SRAM</td>
<td>520 Kbyte</td>
</tr>
<tr>
<td>External flash &amp; SRAM</td>
<td>16 Mbyte</td>
</tr>
<tr>
<td>Electrical connectors</td>
<td>Main connector: Deutsch DTF13-12PB</td>
</tr>
<tr>
<td>Communications</td>
<td>CAN interface: 2.0A, 2.0B</td>
</tr>
<tr>
<td>Baud rates</td>
<td>125 kb/s, 250 kb/s, 500 kb/s, 1 Mb/s</td>
</tr>
<tr>
<td>Protocol</td>
<td>J1939</td>
</tr>
<tr>
<td>Default address</td>
<td>44</td>
</tr>
<tr>
<td>Default baud rate</td>
<td>250 kb/s</td>
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<tr>
<td>Software</td>
<td>Programming options: Pre-programmed applications, Matlab/ Simulink</td>
</tr>
<tr>
<td>Sensor supply</td>
<td>Number of sensor supplies: 1</td>
</tr>
<tr>
<td>Sensor supply output voltage</td>
<td>5 VDC</td>
</tr>
<tr>
<td>Sensor supply maximum current</td>
<td>50 mA @ 5 VDC</td>
</tr>
<tr>
<td>Standards</td>
<td>Temperature environment: SAE J1455</td>
</tr>
<tr>
<td></td>
<td>Environmental: SAE J1455</td>
</tr>
<tr>
<td></td>
<td>Salt spray: J1455 Section 4.3.4</td>
</tr>
<tr>
<td></td>
<td>Vibration: J1455 Section 4.10.4.2</td>
</tr>
<tr>
<td></td>
<td>Drop: J1455 Section 4.11.3.2</td>
</tr>
<tr>
<td></td>
<td>Shock: J1455 Section 4.10.5</td>
</tr>
<tr>
<td></td>
<td>Conducted immunity: SAE J1113, EN 61326-1, 2004/108/EC</td>
</tr>
<tr>
<td></td>
<td>Radiated immunity: SAE J1113, EN 61326-1, 2004/108/EC</td>
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<tr>
<td></td>
<td>Conducted emissions: CISPR 25, EN 60945, 2004/108/EC</td>
</tr>
<tr>
<td></td>
<td>Radiated emission: CISPR 25, CISPR 11, EN60946</td>
</tr>
<tr>
<td></td>
<td>Environmental directives: RoHS, REACH</td>
</tr>
<tr>
<td>Certifications</td>
<td>Markings: CE mark, UKCA mark, E mark, FCC mark</td>
</tr>
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### Inputs

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>2, but outputs can be configured as inputs for up to 2 more</td>
</tr>
<tr>
<td>Type</td>
<td>Software configurable to analog, digital or frequency inputs</td>
</tr>
<tr>
<td>Digital input</td>
<td>Digital low</td>
</tr>
<tr>
<td>Input frequency</td>
<td>850Hz +/-20% @ -3db</td>
</tr>
<tr>
<td>Switch-on level</td>
<td>3.5V</td>
</tr>
<tr>
<td>Switch-off level</td>
<td>1.4V</td>
</tr>
<tr>
<td>Frequency input</td>
<td>Digital low</td>
</tr>
<tr>
<td>Input frequency</td>
<td>0 Hz - 50 kHz</td>
</tr>
<tr>
<td>Switch-on level</td>
<td>3.5V</td>
</tr>
<tr>
<td>Switch-off level</td>
<td>1.4V</td>
</tr>
<tr>
<td>Analog input</td>
<td>0 - 5 V (absolute &amp; ratiometric), 0 - 10 V, 0 - 32 V, 0 - 20 mA, thermistor (software configurable)</td>
</tr>
<tr>
<td>Resolution</td>
<td>12 bits</td>
</tr>
<tr>
<td>Accuracy</td>
<td>+/- 0.2 % FS (0-5 VDC mode), +/- 1 % FS (all other modes)</td>
</tr>
<tr>
<td>Short circuit protection</td>
<td>Integrated</td>
</tr>
<tr>
<td>Voltage input</td>
<td>0 - 5 V</td>
</tr>
<tr>
<td>Input frequency</td>
<td>850Hz +/-20% @ -3db</td>
</tr>
<tr>
<td>Voltage input</td>
<td>0 - 10 V</td>
</tr>
<tr>
<td>Input frequency</td>
<td>1.5kHz +/-20% @ -3db</td>
</tr>
</tbody>
</table>

### Thermistor input

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input resistance</td>
<td>10 kΩ pull up</td>
</tr>
<tr>
<td>Sample frequency</td>
<td>1 kHz</td>
</tr>
<tr>
<td>Accuracy</td>
<td>+/-1%</td>
</tr>
<tr>
<td>Current input</td>
<td>0 - 20 mA</td>
</tr>
<tr>
<td>Input resistance</td>
<td>200 Ohm</td>
</tr>
<tr>
<td>Input frequency</td>
<td>850Hz +/-20% @ -3db</td>
</tr>
</tbody>
</table>

### Outputs

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>2, or can be configured as inputs</td>
</tr>
<tr>
<td>Digital output</td>
<td>High side</td>
</tr>
<tr>
<td>Max load current</td>
<td>2.5A</td>
</tr>
<tr>
<td>PWM output current feedback</td>
<td>High side</td>
</tr>
<tr>
<td>Diagnostics</td>
<td>Open/short circuit protection</td>
</tr>
<tr>
<td>PWM frequency</td>
<td>0.05 Hz - 2 kHz</td>
</tr>
<tr>
<td>Dither frequency</td>
<td>Software configurable</td>
</tr>
<tr>
<td>Dither amplitude</td>
<td>Software configurable</td>
</tr>
<tr>
<td>Control range</td>
<td>0.05 - 2A</td>
</tr>
<tr>
<td>Control resolution</td>
<td>20 mA</td>
</tr>
<tr>
<td>Fly back protection</td>
<td>Integrated</td>
</tr>
<tr>
<td>Duty cycle resolution</td>
<td>0.01% @ 250 Hz</td>
</tr>
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</table>
Software options

Pre-programmed applications for driving hydraulic products

To enable quick setup with electrohydraulic products, HFXd can come with a set of pre-programmed applications. Each application has configurable settings to allow for tuning of the controls to a specific machine. These settings are configured using Pro-FX Configure for HFXd.

All pre-programmed applications include:
- Command via direct inputs or CAN message
- Configurable ramp and filter
- Closed-loop current control with dither
- Configurable fault detection and response
- Overrides for commissioning and troubleshooting

Additional features available for pumps include:
- Open- or closed-loop displacement control
- Electronic torque limit, fixed setting
- Electronic power limit, speed-dependent setting
- CAN broadcast of pump flow
- Electronic automotive drive with direction control
- C-Steer or S-Steer for dual path applications

The table below summarizes the available pre-programmed applications. For more details, refer to HFXd’s pre-programmed applications documentation.

<table>
<thead>
<tr>
<th>Available Pre-programmed Applications</th>
<th>Example Eaton Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solenoid Valve(s)</td>
<td></td>
</tr>
<tr>
<td>Single Coil Valve</td>
<td>ESV1-10-C</td>
</tr>
<tr>
<td>Two Single Coil Valves</td>
<td>2x ESV1-10-C</td>
</tr>
<tr>
<td>Dual Coil Valve</td>
<td>ESLV9</td>
</tr>
<tr>
<td>Open Circuit Pump</td>
<td></td>
</tr>
<tr>
<td>Electronic Displacement Control*</td>
<td>x20 EDC</td>
</tr>
<tr>
<td>Outlet Pressure Control*</td>
<td>x20 IPPC</td>
</tr>
<tr>
<td>Closed Circuit Pump or Motor</td>
<td></td>
</tr>
<tr>
<td>Electronic Displacement Rate Control*†</td>
<td>X3, Series 2 EP</td>
</tr>
<tr>
<td>Electronic Servo Pressure Control*†</td>
<td>Series 2 Solenoid Control</td>
</tr>
</tbody>
</table>

*Available options include open-loop or closed-loop control, torque or power limiting
†Electronic automotive drive or dual path propel also available

Matlab/Simulink for custom applications

Custom applications can be developed for HFXd using the HFXd Matlab Support Package (MSP). Simulink blocks are provided for interfacing with HFXd’s I/O, including blocks for tasks, CAN, reading sensors, current outputs, and storing calibratable parameters in memory.

Settings created in a custom application can then be configured using Pro-FX Configure. Custom user interfaces for Pro-FX Configure can be developed with Pro-FX Configure Builder. Refer to Pro-FX Configure documentation for more details.

HFXd’s MSP requires Matlab version 2020a and the Matlab Embedded Coder toolbox.

Refer to the HFXd MSP documentation for more details.
Examples

Closed loop displacement control with X3 EDCF for propel application

Flow control with SLV20 for work circuit application
Mounting diagram – remote mounted

Available Products

<table>
<thead>
<tr>
<th>Software</th>
<th>Product Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-programmed applications</td>
<td>102EC20100A</td>
</tr>
<tr>
<td>Matlab Support Package</td>
<td>102EC20102A</td>
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</table>

Main Connector

<table>
<thead>
<tr>
<th>Type</th>
<th>Deutsch DTF13-12PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
<td>Function</td>
</tr>
<tr>
<td>1</td>
<td>System Power Positive</td>
</tr>
<tr>
<td>2</td>
<td>System Power Negative</td>
</tr>
<tr>
<td>3</td>
<td>Output PWM1 2.5A +</td>
</tr>
<tr>
<td>4</td>
<td>Ignition Input</td>
</tr>
<tr>
<td>5</td>
<td>CANH</td>
</tr>
<tr>
<td>6</td>
<td>CANL</td>
</tr>
<tr>
<td>7</td>
<td>Channel 1 Input</td>
</tr>
<tr>
<td>8</td>
<td>Channel 2 Input</td>
</tr>
<tr>
<td>9</td>
<td>PWM Negative</td>
</tr>
<tr>
<td>10</td>
<td>Output PWM2 2.5A +</td>
</tr>
<tr>
<td>11</td>
<td>Gnd</td>
</tr>
<tr>
<td>12</td>
<td>5V out</td>
</tr>
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</table>

Refer to the HFXd Installation and Service Manual for mounting recommendations.
Mounting diagram – solenoid mounting with bracket

<table>
<thead>
<tr>
<th>Available Brackets</th>
<th>Coil Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bracket Part Number</td>
<td>Coil Part Number</td>
</tr>
<tr>
<td>6048402-001</td>
<td>A-4059-006</td>
</tr>
<tr>
<td>6048402-002</td>
<td>A-4059-001</td>
</tr>
<tr>
<td>6048402-003</td>
<td>A-2508-XXX</td>
</tr>
<tr>
<td>6048402-004</td>
<td>A-2507-XXX</td>
</tr>
</tbody>
</table>

Example of HFXd mounted with required bracket onto a solenoid coil. Refer to HFXd’s Installation and Service Manual for mounting instructions.
Wiring recommendations

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 ISO11989-2.
- Confirm that the CAN network is properly terminated using 120Ω resistors.
- Ensure the appropriately sized conductor cross section is specified for the intended load current in the harness design.
- 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 be covered with 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.

Refer to the HFXd Installation and Service Manual for more details.

Notes:

1. Signal and battery ground are recommended to be connected in star fashion, with least resistance connection to source.
2. The diagram represents high level connections for analog/digital input for ANALOG_INPUT_1. The same can be repeated for ANALOG_INPUT_2.
3. Battery line and IGN line fuses are recommended as 10000mA and 100mA slow blow fuse respectively.
4. IGN_INP must be connected to VIN either thru a fuse and switch or with a fuse to turn on the HFXd.
5. +5V_SENSOR_SUPPLY should be referenced to either Pin 9 or 11. Sensor supply must be used on ratiometric output sensors. It is optional on other sensor types.
6. PWM2_OUT may be configured as an input for the sensor output types shown. The same can be repeated for PWM1_OUT.
Pro-FX™ Configure

Pro-FX™ Configure is the PC tool used to configure the various software features of the HFXd. It can also be used to check alerts, take and load backups of the controller, plot data from the controller, and send commands to the controller.

Pro-FX Configure can be downloaded from PowerSource.

**Supported CAN cards**
Pro-FX Configure 2.0:
- Softing USB
- Softing CANPro USB
- All Kvaser CAN cards
- Peak PCAN-USB
- ECOM

**PC requirements**
- Operating system: Windows 7, 8 or 8.1, 10
- Processor: 1 GHz
- RAM: 512 MB
- Disk space (minimum): 4.6 GB
- Minimum screen resolution: 1366x768