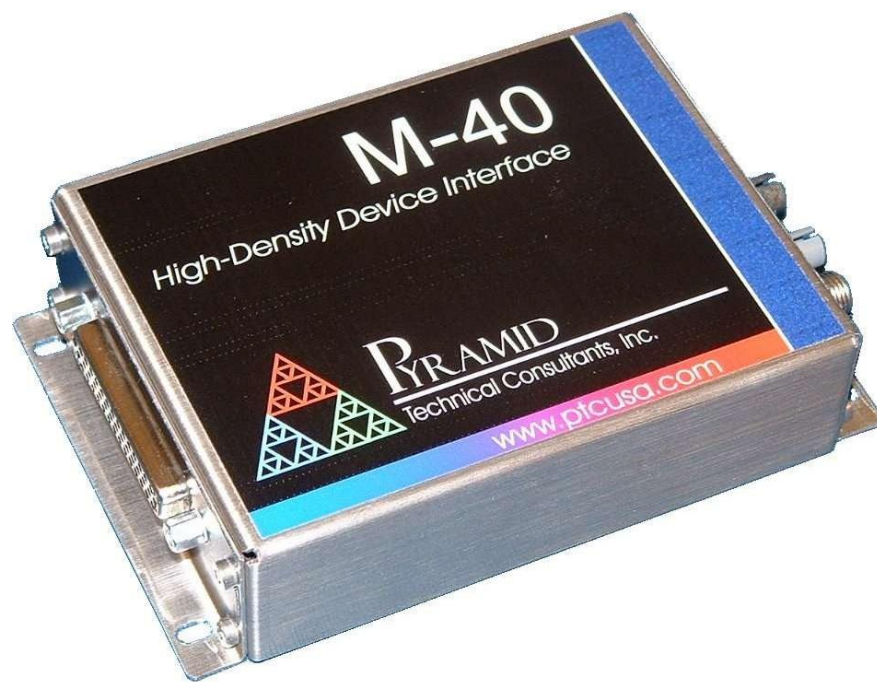


# M40

## High-Density Device Interface

### User Manual



**Pyramid Technical Consultants, Inc.**

**135 Beaver Street, Suite 102, Waltham, MA 02452 USA**

US: TEL: (781) 402 1700 ♦ FAX: (781) 402-1750 ♦ EMAIL: [SUPPORT@PTCUSA.COM](mailto:SUPPORT@PTCUSA.COM)

Europe: TEL: +44 1273 492001

# 1 Contents

<b>1</b>	<b>Contents</b>	<b>2</b>
<b>2</b>	<b>Figures</b>	<b>5</b>
<b>3</b>	<b>Safety Information</b>	<b>6</b>
<b>4</b>	<b>Models</b>	<b>8</b>
<b>5</b>	<b>Scope of Supply</b>	<b>9</b>
<b>6</b>	<b>Optional Items</b>	<b>10</b>
6.1	Power supplies	10
6.2	Signal cables	10
6.3	Data cables	10
6.4	Test connectors	10
6.5	Fiber-optic loop	10
6.6	DIN rail mount	10
<b>7</b>	<b>Intended Use and Key Features</b>	<b>11</b>
7.1	Intended Use	11
7.2	Key Features	11
<b>8</b>	<b>Specification</b>	<b>12</b>
<b>9</b>	<b>Installation</b>	<b>17</b>
9.1	Mounting	17
9.2	Grounding and power supply	17
9.3	Connection to equipment	18
9.3.1	Typical setup	18
9.3.2	Compatibility with loop controllers	19
9.3.3	Signal cables	19
9.3.4	Embedded installation	20
<b>10</b>	<b>Getting Started using the Pyramid Diagnostic Host Programs</b>	<b>21</b>
10.1	Preparing the M40 for operation	21
10.2	Installing and Using the PSI Diagnostic Program	22
10.2.1	Establishing communication with the M40	22
10.2.2	Data tab	24
10.2.3	Setup tab	28

10.2.4	Device tab .....	30
10.3	<i>Installing and Using the PTC Diagnostic G2 Program</i> .....	31
10.3.1	Establishing communication with the M40 .....	32
<b>11</b>	<b>Interfacing to EPICS via IG2 .....</b>	<b>35</b>
1.1	<i>What is EPICS?</i> .....	35
1.2	<i>Installing and Configuring IG2</i> .....	36
<b>12</b>	<b>Circuit overview</b> .....	<b>39</b>
<b>13</b>	<b>Calibration</b> .....	<b>43</b>
13.1	<i>M40 Calibration Factors</i> .....	43
13.2	<i>Application Calibration Factors</i> .....	43
<b>14</b>	<b>Wavetable Output and Logging</b> .....	<b>45</b>
<b>15</b>	<b>Connectors</b> .....	<b>46</b>
15.1	<i>Front panel connectors</i> .....	46
15.1.1	Analog and digital I/O .....	46
15.2	<i>Rear panel connectors</i> .....	47
15.2.1	Power input.....	47
15.2.2	Fiber-optic communications.....	47
<b>16</b>	<b>Controls and Indicators</b> .....	<b>48</b>
16.1	<i>Front panel controls</i> .....	48
16.2	<i>Rear panel controls</i> .....	48
16.2.1	Address switch .....	48
16.3	<i>Front panel indicators</i> .....	48
16.4	<i>Rear panel indicators</i> .....	48
16.4.1	Power.....	48
16.4.2	Activity.....	48
16.4.3	Network.....	48
16.4.4	Device.....	48
16.5	<i>Internal settings</i> .....	48
16.5.1	JPR1 settings.....	49
<b>17</b>	<b>Software updates</b> .....	<b>50</b>
17.1	<i>FPGA firmware updates</i> .....	50
17.2	<i>PIC firmware updates</i> .....	51
<b>18</b>	<b>Fault-finding</b> .....	<b>54</b>
<b>19</b>	<b>Maintenance</b> .....	<b>57</b>

<b>20</b>	<b>Returns procedure .....</b>	<b>58</b>
<b>21</b>	<b>Support .....</b>	<b>59</b>
<b>22</b>	<b>Disposal.....</b>	<b>60</b>
<b>23</b>	<b>Declaration of Conformity.....</b>	<b>61</b>
<b>24</b>	<b>Revision History.....</b>	<b>62</b>

## 2 Figures

Figure 1. M40 chassis end panels. Dimensions mm	15
Figure 2. M40 case plan and side views. Dimensions mm.	16
Figure 3. DIN rail mounting shown for the identically-shaped M10 device.	17
Figure 4. M40 power input options	18
Figure 5. Schematic M40 installation for remote control of a power supply group	19
Figure 6. Example of a connection to the M40 via an A500 and Ethernet	22
Figure 7. PSI Diagnostic Search Utility – adding a target IP address and port	23
Figure 8. PSI Diagnostic Search Utility – detection in progress	23
Figure 9. Result of device search	24
Figure 10. Data tab: M40 running with default settings, showing autoscaled background noise on the inputs.	25
Figure 11. Data tab: bargraph display	26
Figure 12. Setup tab.	29
Figure 13. Device tab, showing firmware update utility controls	30
Figure 14. PTC Diagnostic G2 discovery dialog	32
Figure 15. System pane showing M40 connected via A500	33
Figure 16. M40 data display in PTC Diagnostic G2	33
Figure 17. Example network for EPICS communications	35
Figure 18. Example user screen created using CS Studio BOY	36
Figure 19. Example xml system configuration file for IG2 / EPICS	38
Figure 20. M40 block schematic	39
Figure 21. M40 analog input configuration (referenced to AGnd)	40
Figure 22. M40 analog input filter response.	40
Figure 23. M40 analog output configuration	41
Figure 24. M40 analog output slew rate for full scale step (20 V in 32 $\mu$ sec)	41
Figure 25. M40 digital input configuration.	42
Figure 26. M40 digital output configuration	42
Figure 27. Using application scaling	44
Figure 28. Location of jumpers	49
Figure 29. Selecting the fhex file to load.	51
Figure 30. Restart prompt after FPGA update	51
Figure 31. Selecting the hex file to load	52
Figure 32. Firmware upload in progress	52

### 3 Safety Information

This unit is designed for compliance with harmonized electrical safety standard EN61010-1:2000. It must be used in accordance with its specifications and operating instructions. Operators of the unit are expected to be qualified personnel who are aware of electrical safety issues. The customer's Responsible Body, as defined in the standard, must ensure that operators are provided with the appropriate equipment and training.

The unit is designed to make measurements in **Measurement Category I** as defined in the standard.

Although the M40 does not generate dangerous voltages, nor is it designed to measure directly such voltages, in your application it may be controlling power supplies that do. Appropriate precautions must be taken.

The unit must not be operated unless correctly assembled in its case. Only Service Personnel, as defined in EN61010-1, should attempt to work on the disassembled unit, and then only under specific instruction from Pyramid Technical Consultants, Inc. or their authorized distributors. Pyramid may agree to the M40 being embedded within a customer device where this is necessary for an application, either cased or un-cased. The customer assumes responsibility for the safety, design and performance of the integrated system.

The unit is designed to operate from +24VDC power, with a maximum current requirement of 200mA. A suitably rated power supply module is available as an option.

The unit must be grounded by secure connection to a grounded conducting surface. If the unit is mounted on an insulating surface, then one of the four mounting screws must be re-assigned as a grounding connection.

Some of the following symbols may be displayed on the unit, and have the indicated meanings.



Direct current



Earth (ground) terminal



Protective conductor terminal



Frame or chassis terminal



Equipotentiality



Supply ON



Supply OFF



CAUTION – RISK OF ELECTRIC SHOCK



CAUTION – RISK OF DANGER – REFER TO MANUAL

## 4 Models

M40	Universal device interface with eight analog outputs, eight analog inputs, eight TTL outputs, eight TTL inputs.
-NOCASE	Option for supply as uncased circuit board for embedded applications



## 5 Scope of Supply

M40 model as specified in your order.

PSU24-40-1 power supply.

USB memory stick containing:

- Datasheet

- User manual

- PSI diagnostic software files

- PTC DiagnosticG2 software files

- IG2 interface layer files for EPICS connectivity

- Test data

Optional items as specified in your order.

OEM customers will not receive all items.

## 6 Optional Items

### 6.1 Power supplies

PSU24-40-1. +24 VDC 1.62 A PSU (100-250 VAC, 50-60 Hz, IEC C14 3-pin plug receptacle) with output lead terminated in 2.1mm threaded jack.

### 6.2 Signal cables

CAB-D44F-10-D44M Signal cable 44-way screened, D44 male to D44 female, 10'.

Other lengths available.

### 6.3 Data cables

CAB-ST-HCS-10-ST Fiber-optic cable, 200 um silica, ST terminated, 10'.

Other lengths available up to 1000'.

### 6.4 Test connectors

Loopback test connector for the M40.

### 6.5 Fiber-optic loop

A360 fiber-optic loop controller / Ethernet adaptor.

A500 intelligent real-time controller with Ethernet interface.

A560 intelligent real-time controller with Ethernet interface.

### 6.6 DIN rail mount

MTG-DIN35-11462. Mounting adaptor for 35mm standard DIN rail. M40 can be mounted along or across the rail.

## 7 Intended Use and Key Features

### 7.1 Intended Use

The M40 is intended for general control and monitoring applications using analog voltages in the +/-10 V range, and TTL level digital inputs and outputs. It has similar features to the M10 device, and the same case size, but it provides a higher number of inputs and outputs than the M10. A typical M40 application would be the remote control and monitoring of one or more power supplies. The analog outputs would set voltage and current commands or compliance limits, the analog inputs would monitor actual voltage and current. The digital outputs can be assigned to functions such as enable, reset and so on, and the digital inputs can monitor status bits.

The M40 has design features which make it tolerant of electrically noisy environments, but the place of use is otherwise assumed to be clean and sheltered, for example a laboratory or light industrial environment. The unit may be used stand-alone, or networked with other devices and integrated into a larger system. Users are assumed to be experienced in the general use of precision electronic circuits for sensitive measurements, and to be aware of the dangers that can arise in high-voltage circuits.

### 7.2 Key Features

Precision analog inputs and outputs +/- 10 V range with 16 bit digitization.

Fast digital inputs and outputs.

On-board digital averaging of analog inputs.

Very low transition transients on analog outputs between DAC levels, compatible with control of wideband devices.

Multiple waveform output capability with synchronized data collection.

Can be operated in a fiber-optic serial communication loop with up to fifteen other devices.

100BaseT Ethernet interfacing to a host computer available through the A360, A500 and A560 loop controllers.

## 8 Specification

<b>Analog outputs</b>	
Number	Eight identical, bipolar, +/-10 V
Configuration	Single-ended
Compliance	5 mA max per channel via internal 100R series resistance
Resolution	16 bit over full range.
Linearity	0.1 % maximum deviation of any point from linear fit to all points over full span.
Noise	< 0.5 mV RMS measured by loopback to analog inputs, with line frequency averaging. Typical RMS noise measured with external DVM < 50 $\mu$ V.
Crosstalk	< 1 mV for 10 V output on another channel
Thermal stability	< 200 $\mu$ V C-1
Slewing rate	0.6 V $\mu$ sec-1 typical
Maximum output refresh rate	100 kHz (internal wavetable driven) 10 kHz (host controlled via fiber optic interface, special host software)
Calibration	Independent gain and offset stored for each output in NVR

<b>Analog inputs</b>	
Number	Eight identical, bipolar, +/-10 V
Configuration	Single-ended
Input impedance	$\geq 1$ Mohm
Input protection	4.7 kohm series input.
Analog filter	2-pole LP filter, 10 kHz (-3dB)
Noise	< 0.50 mV RMS with line frequency averaging. Typical measured RMS noise with unconnected inputs: < 200 $\mu$ V at 1e-4 s averaging < 30 $\mu$ V at 1e-2 s averaging < 10 $\mu$ V at 2e-1 s averaging
Digitization	16 bit over full range
Crosstalk	< 1 mV with 10 VDC on another input < 30 mV with 10 VAC 1 MHz on another input

Conversion rate	250 kHz on each input, fully simultaneous
Digital filtering	Software configurable block averaging, 1 second maximum.
Linearity	0.1 % maximum deviation of any point from linear fit to all points over full span.
Calibration	Independent gain and offset stored for each input in NVR

<b>Waveform memory (future option)</b>	
Outputs	1024 output values x 8 analog channels plus one synch bit
Output rate	Period selectable 10 $\mu$ sec to 3600 seconds
Inputs	1024 input readings x 8 analog channels plus digital input byte

<b>Digital outputs</b>	
Number	Eight
Voltage levels	TTL
Maximum compliance	3 mA per channel source or sink
Output series resistance	100 ohm
Minimum output pulse length	15 nsec

<b>Digital inputs</b>	
Number	Eight
Voltage levels	TTL
Configuration	Active low with internal 47 kohm pull up to +5V
Input protection	470 ohm series

<b>Controls and displays</b>	
Controls	16 position rotary switch for loop address selection
Displays	Four LEDs (power, activity, network, device)

<b>Communications</b>	
Interface	Fiber optic 640 nm, ST connectors (10 Mbit/sec)
Data rate	Typical data rate to host > 1 kHz. Rate in optimised systems up to 10 kHz.

<b>Power</b>	
--------------	--

Power input	+24 VDC (+12 V, -4 V), 120 mA typical, 200 mA maximum, excluding any direct user load. 500 mA fused.
User power	Maximum user power from 24V supply 400 mA (500 mA fused).

<b><i>Mechanical</i></b>	
Case	Stainless steel.
Connector	Signal connector DSub 44 pin (high density) female. Power connector Switchcraft 2.1mm jack.
Case protection rating	The case is designed to rating IP43 (protected against solid objects greater than 1mm in size, protected against spraying water).
Weight	0.28 kg (0.62 lb).
Dimensions	(see figures 1 and 2).

<b><i>Environmental</i></b>	
Operating environment	10 to 35 C (15 to 25 C recommended to reduce drift and offset) < 80% humidity, non-condensing vibration < 0.2 g all axes (1 to 100 Hz)
Shipping and storage environment	0 to 50C < 80% humidity, non-condensing vibration < 2 g all axes, 1 to 100 Hz

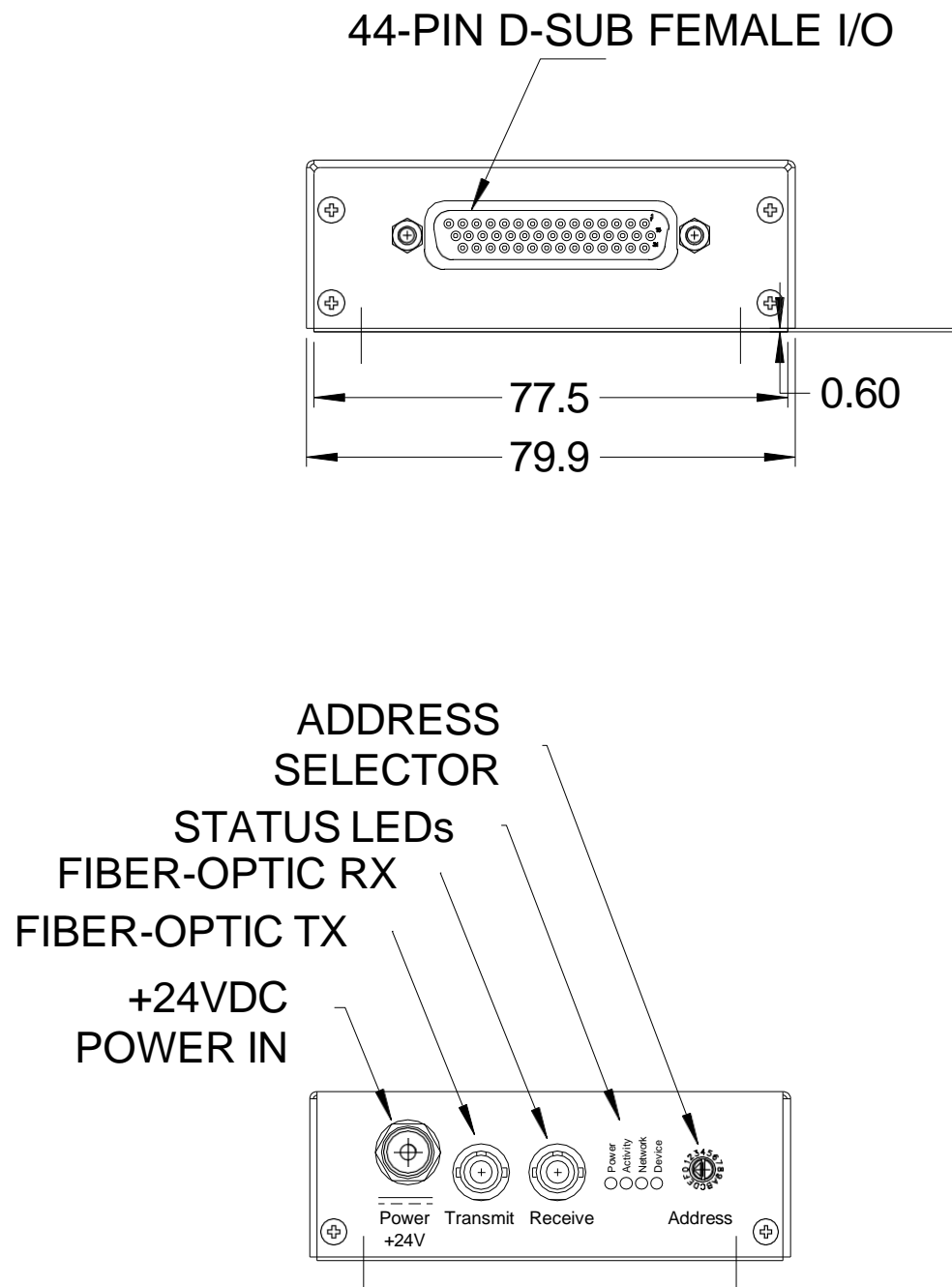


Figure 1. M40 chassis end panels. Dimensions mm.

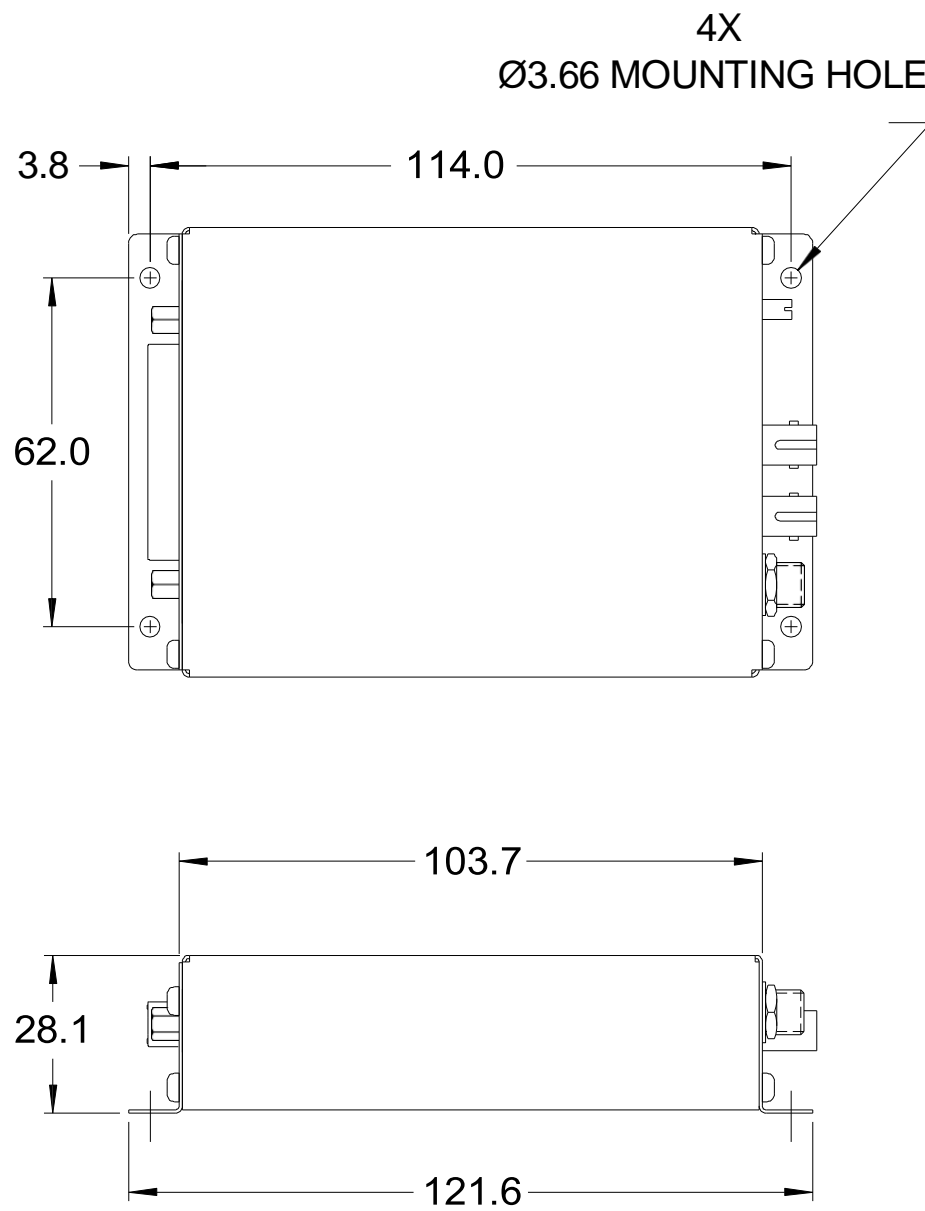


Figure 2. M40 case plan and side views. Dimensions mm.



## 9 Installation

### 9.1 Mounting

The M40 may be mounted in any orientation, or may be simply placed on a level surface. A fixed mounting to a secure frame is recommended in a permanent installation for best low current performance, as this can be degraded by movement and vibration. Four M3 clear holes are provided in the base flange on a 62 mm by 114 mm rectangular pattern (see figure 2). An adaptor for 35 mm EN 50022 DIN rail is available.



Figure 3. DIN rail mounting shown for the identically-shaped M10 device.

The mounting position should allow sufficient access to connectors and cable bend radii. Leave 60mm clearance at either end for mating connectors and cable radii.

Best performance will be achieved if the M40 is in a temperature-controlled environment. No forced-air cooling is required, but free convection should be allowed around the case.

### 9.2 Grounding and power supply

A secure connection should be made via the mounting flange to local ground potential. If the unit is mounted on an insulating surface, then one of the four mounting screws must be re-assigned as a grounding connection.

.+24 VDC power should be provided from a suitably-rated power supply with the following minimum performance:

Output voltage	+24 +/- 0.5 VDC
Output current	300 mA minimum, 2000 mA maximum
Ripple and noise	< 100 mV pk-pk, 1 Hz to 1 MHz
Line regulation	< 240 mV

The M40 is tolerant of line voltage in the range 18 VDC to 28 VDC, although we recommend using a 24 V supply with reasonable output regulation, as indicated.

You may deliver or extract 24 V power through the unit through one of two alternative connections, as illustrated in figure 4.

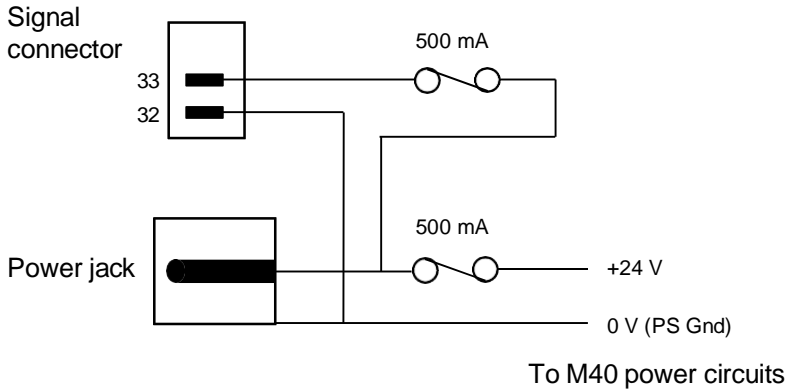


Figure 4. M40 power input options.

The primary input is the 2.1 mm power jack, and the alternative is pins 33 (+24V), 32 (0V) of the 44-way D connector. The second arrangement is provided for situations where the device being controlled is able to supply 24 VDC power. If power is provided through the jack input, then it is available as an output on pins 33, 32 of the D connector for user applications. In this case, you must ensure the following:

- a) Maximum current draw does not exceed the external power supply limit, or 500 mA.
- b) You do not inject noise into the M40 that will degrade its performance.

The M40 fuses are internal automatically re-setting PTC fuses rated at 500 mA. However the external power supply for power delivered via the 2.1 mm power jack should in no circumstances be rated higher than the connector limit of 5 A, and a maximum rating of 2.0 A is recommended.

## 9.3 Connection to equipment

### 9.3.1 Typical setup

Figure 5 shows a typical installation to control a group of power supplies, in schematic form. An M40 provides a current program and voltage compliance limit, and reads back actual current and voltage from each of four power supplies. Digital outputs are used to enable the supplies, and reset fault conditions. Digital inputs are used to monitor enabled and fault states. The M40 is on a fiber-optic communication loop, under control of one of the Pyramid Technical Consultants, Inc. loop controllers (A360, A500, A560). Software on the host computer exposes the I/O points provided by the M40, and thus allows remote control of the power supplies. Power for the M40 is obtained in this example from a separate power module.

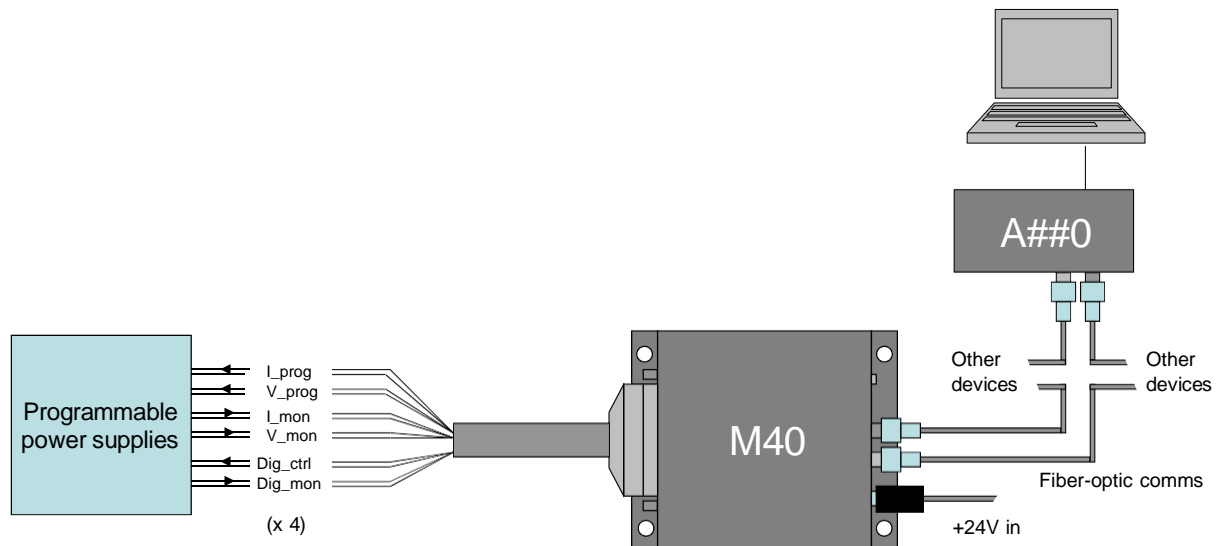


Figure 5. Schematic M40 installation for remote control of a power supply group

Typical M40 applications involve its use as part of a large control system integrated under one or more A500 or A560 controllers. The M40 may be the only device on the loop, or one of up to fifteen devices. As the number of devices is increased, the loop bandwidth has to be shared, so for fast control you would generally keep the number of devices on each loop to the minimum.

The M40 has very low glitch energy when its analog outputs change from one DAC setting to another, so it is well-suited to the control of fast power supplies such as those for electrostatic or magnetic beam scanners.

An arbitrary output waveform table can be loaded into the M40 and used to drive the outputs whilst the inputs are recorded. The M40 can thus function as a highly-flexible multi-channel signal generator and data recorder.

### 9.3.2 Compatibility with loop controllers

The M40 is compatible with any A500 controllers running DSP firmware version 5.40 or later and FPGA firmware 2.7.178 or later. The M40 is compatible with any A560 controllers running firmware package 0.6.138.15 or later.

### 9.3.3 Signal cables

Try to locate the M40 as close to the equipment being controlled as possible, with the case sharing the equipment ground. The longest transmission distance is thus handled by the fiber-optic lines, which are completely immune to electrical noise. If long signal cables from the M40 to the device being controlled are unavoidable, then you should observe the following precautions.

Long signal cables increase the chances of picking up unwanted signals and noise on the analog voltage lines. A maximum length of 10 m is advised, and you should use good quality shielded

cable, with twisted pair cores for the analog inputs (analog in + and -) and outputs (analog out and AGND).

The strategy for connecting screens will vary according to the nature of the noise. At RF frequencies, it is generally best to connect the screen to the grounded chassis at both ends. At lower frequencies it is often best to connect at one end only to break up ground loops. Connect the cable screens to the M40 case, using the shell of the D connector, and leave them unconnected at the other end. In some cases, you may get better noise performance by reversing this screen connection arrangement.

If you are working with fast digital output pulses from the M40, you should also be careful with long cable runs. To avoid pulse distortion, use matched impedance (around 100 ohm) screened twisted pair cores (digital output and DGND) for each fast digital signal, and terminate the line with 100 ohms at the receiving end.

#### **9.3.4 Embedded installation**

The M40 is suitable for installation inside the equipment being controlled, and this is generally the arrangement that minimizes noise and minimizes risk of damage from electrical transients. In some cases space considerations may dictate that the M40 is installed without its steel case. Since this may expose the device to mechanical damage or electrical interference, such installations should only be performed in collaboration with Pyramid Technical Consultants, Inc.. This option is available as M40-NOCASE. The CE marking of the M40 is not applicable if it is operated without its case, and the user should make separate arrangements to ensure conformity of the overall assembly with applicable standards.

## 10 Getting Started using the Pyramid Diagnostic Host Programs

Usually you will use a custom application to communicate with the M40, either one you write yourself using the software interfaces available from Pyramid Technical Consultants, Inc., or one that is supplied by Pyramid. However you can get started immediately using one of the PSI Diagnostic host programs. These are available for free download from [www.ptcusa.com](http://www.ptcusa.com), and are provided with the M40 for end-user customers. There are two generations of the Diagnostic software, and the M40 is compatible with both.

**PSI Diagnostic.** This software supports all Pyramid products, apart from G2 devices. It allows you to connect the M40 via an A500 controller. Ethernet communications use UDP with an added reliability layer.

**PTC Diagnostic G2.** This software supports all G2 devices such as the A560, I128, F460 and C400, plus a growing selection of other Pyramid devices, including the M40. It allows you to connect the M40 via an A500 or A560 controller. Ethernet communications use TCP/IP and UDP.

Both Diagnostics are standalone Windows programs which allow you to set outputs and read, graph and log data from the M40. Their user interfaces are similar. For some applications one of the Diagnostic programs may be adequate for all of your data acquisition needs. In any event it is useful to understand what you can do with the Diagnostic programs, because they expose all of the functions of the devices they connect to. Application programmers will find this useful to help decide which functions to implement in their own host software.

### 10.1 Preparing the M40 for operation

Inspect the unit carefully to ensure there is no evidence of shipping damage. If there appears to be damage, or you are in doubt, contact your supplier before proceeding.

Connect 24 V DC power but no other connections. The LEDs will go through a startup sequence when the power is applied. All four LEDs light, then the power LED stays lit while the other three indicators light in sequence. When the M40 has started correctly and prior to connecting to a controller, only the power LED will remain lit.

It is simplest to start with to connect the M40 directly to a loop controller as the only device on the loop. The address switch can be set to anything between 1 and 15. Figure 5 shows a connection to an A500.

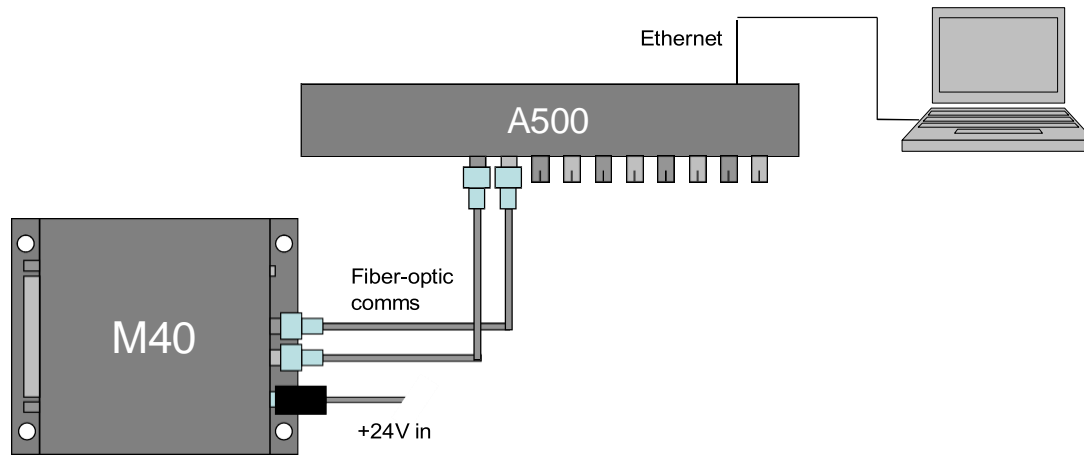


Figure 6. Example of a connection to the M40 via an A500 and Ethernet.

## 10.2 Installing and Using the PSI Diagnostic Program

Download the PSI Diagnostic installer (.msi file) or find the copy on the USB memory stick if you purchased the M40 as an end-user. We recommend that you copy the installer file into a directory on your host PC. Check the Pyramid Technical Consultants, Inc. web site at [www.ptcusa.com](http://www.ptcusa.com) for the latest version.

The program runs under the Microsoft Windows operating system with the 4.0 .NET framework. This has to be installed before the PSI Diagnostic. Most new PCs have .NET already installed, or it can be downloaded from the Microsoft web site at no charge. The Pyramid installer will prompt you if you need to update the version on your computer.

Launch the installer, and follow the screen prompts. Once the program has installed, you can run it at once. It will allow you to connect to the M40 via an A500 controller, and, depending upon your setup, to multiple additional devices at the same time. The Diagnostic uses the concepts of ports and loops to organize the connected devices. A port is a communications channel from your PC, such as a COM port, a USB port or Ethernet port. The A500 communicates via an Ethernet port. Each port can be a channel to one or more loops, and each loop may contain up to 15 devices.

### 10.2.1 Establishing communication with the M40

Start the PSI Diagnostic. It will search the available ports on your computer and present a search list in an autodetect utility window. If the first search does not reveal any ports, a second attempt will usually reveal them. The example in figure 6 shows two autodetected COM ports plus two previously entered IP addresses. We'll work through an example where the connection to the M40 is via an A500 at IP address 192.168.100.238.

We can add any specific IP address to the network search by typing the address followed by a colon and the standard port number 100, as shown in the figure below, and clicking "Add IP".

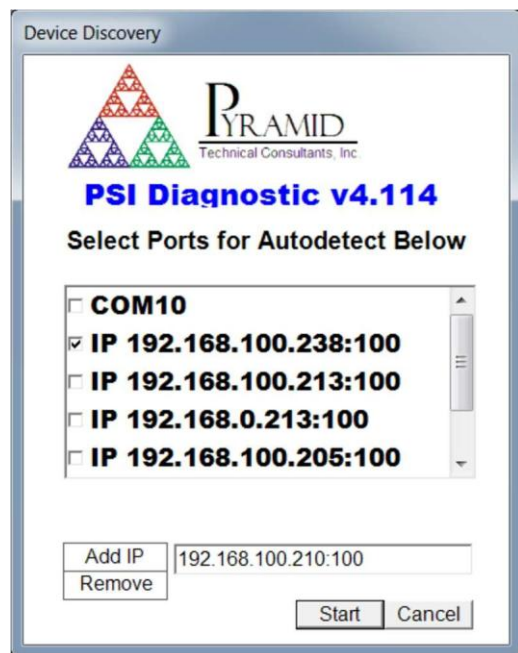


Figure 7. PSI Diagnostic Search Utility – adding a target IP address and port

Check that the target port is checked for inclusion in the search and click the “Start” button. The autodetection process will start.

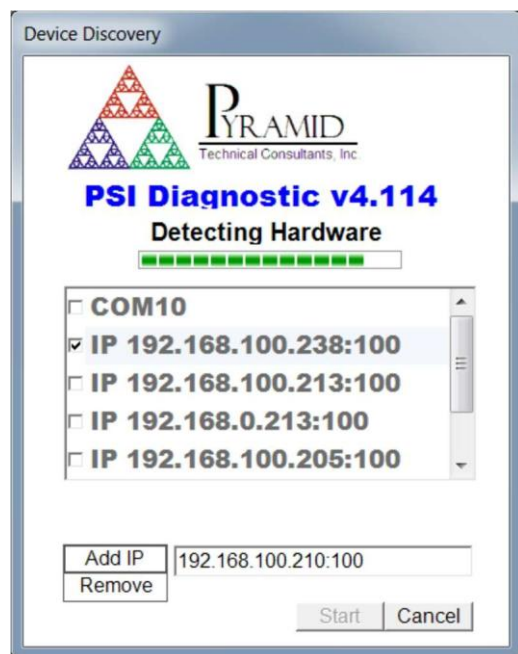


Figure 8. PSI Diagnostic Search Utility – detection in progress

After a few seconds the program should find the M40 (plus any other devices you have connected), and display the list of available devices in the System window. In the example

shown below, we have found one A500 controller, with an M40 on loop 6 plus other devices on loops 1 and 3.

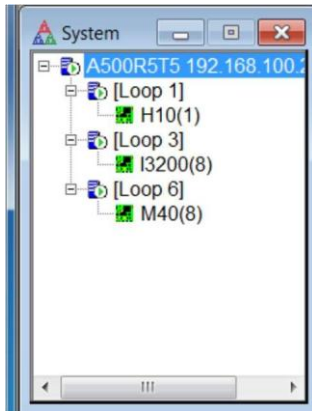


Figure 9. Result of device search

### 10.2.2 Data tab

Clicking on the M40 entry in the explorer list will open the M40 window with the data tab showing (figure 9). You can read the eight analog and eight digital inputs, and set the eight analog and eight digital outputs. At the top of the window a communications status bar progresses if the M40 is communicating successfully with the loop controller, and there are LEDs which indicate the connected state, the pending state (the M40 is occupied processing a command) and the error state.

You can resize, maximize and minimize this window in the usual manner. At startup the M40 will be acquiring data using default settings and you should see background noise values for all channels. If there is no connection to the M40 signal connector, then analog inputs will float towards a 10V limit, and the digital inputs will be pulled high by the internal pullups, so all the inputs will show “set” (green LEDs on the display). On the M40 itself, the network LED will blink indicating that the device is being polled by the loop controller over the fiber optic connection, and the Device LED will flash indicating that the M40 is initiated and acquiring data. If you abort the acquisition, the Device LED will turn off.





Figure 10. Data tab: M40 running with default settings, showing autoscaled background noise on the inputs.

Select one of the fixed Y scales if you want to inhibit autoscaling of the graph. You can display the analog signals either as a scrolling value against time graph (like a chart recorder) or as an analog bargraph. The scope display mode looks the same as the strip chart, but the data is displayed without scrolling for each 256 readings.

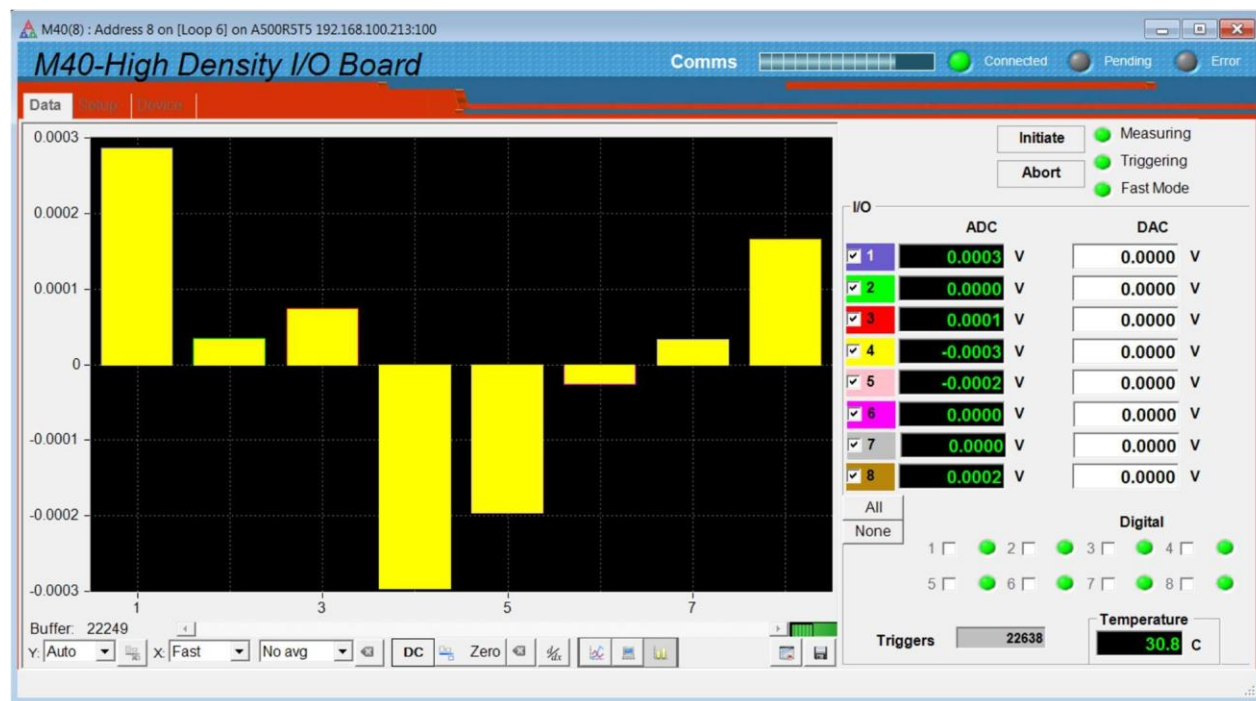




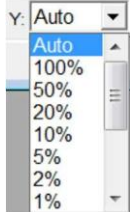

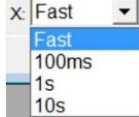
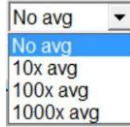


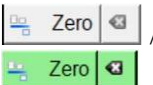





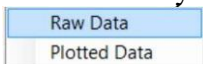


Figure 11. Data tab: bargraph display.

Try out the various screen controls and readouts to see their effect.

Initiate / Abort	These buttons start and stop data acquisition. LEDs indicate whether the M40 is measuring, triggered or streaming data to the controller in fast mode.
ADC	The eight analog inputs are continuously updated while the M40 is acquiring data. The displayed values are $\text{Input\_voltage} \times \text{Gain} - \text{Offset}$ . The offset and gain values are set on the Setup tab (see next section). The colour codes show which are the corresponding traces on the graphic display, and you can suppress plotting of any channel by unchecking it. This does not affect the data logging – all channels are always logged.
DAC	<p>You can set the eight analog outputs. The new value will be sent out as soon as you press the enter key, or click in another parameter field. The values that are sent out in volts are <math>(\text{Raw\_value} - \text{Offset}) \times \text{Gain}</math>, up to the <math>\pm 10\text{V}</math> limit. The offset and gain values are set on the Setup tab (see next section).</p> <p>If you have selected the check box to use the application calibration on the Setup tab, and supplied physical units, then these will be displayed on the Data tab alongside the relevant channel.</p>
Digitals	Eight check boxes allow you to set the corresponding digital outputs high. Eight LEDs show the states of the digital inputs. By default the

	LED is illuminated if the input is TTL high, but this logic can be inverted using controls on the Setup tab.
Triggers	This counter shows the number of readings made by the M40 since the last initiate. The number of readings you can log on the host computer may be less, depending on the number of readings you request, the averaging period and the available data rate up to the loop controller and the host computer.
Temperature	This is a readback of the internal temperature of the M40 in degrees centigrade.
Buffer Buffer: 22249	<p>The PSI Diagnostic collects data coming from the M40 into a buffer, with a rate that is the lesser of the actual acquisition rate or the X axis rate setting. The buffer contents can be cleared with the Clr button () , or can be written to a .csv file with the save button () . The buffer number shows how much data is currently in the buffer. The maximum allowed is 65535 bytes, after which the buffer wraps around to overwrite the earliest values.</p> <p>You can toggle data plotting and accumulation into the buffer with the Run Plot control ( /  ). When the accumulation is halted, then the slider is enabled, which allows you to scroll back through the data when in strip chart mode.</p>
Y: 	This drop-down controls the vertical scaling of the data plot. You can select automatic scaling or various fixed proportions of the nominal 10 V full scale.
Display only positive values 	This control is enabled for fixed vertical scaling. It toggles the graphic from a display that is symmetric around 0 to one that shows only 10% of the vertical scale in the negative direction.
X: 	This drop down controls how fast new points are added to the data plot and the data log. For example, if your acquisition settings generate a value every 100 msec but you have 1 second selected on this control, then every tenth reading will be stored.
Filtering 	<p>The PSI Diagnostic can apply a filter to the plotted data to allow you to pick small signals out of noise. This filter is independent of, and additional to, the block averaging filtering implemented by the M40 itself. The PSI Diagnostic filter is a simple IIR type, <math>Y_{plot\_N} = Y_{new}/A + (1-1/A)Y_{plot\_N-1}</math>, where <math>Y_{new}</math> is the latest reading, <math>Y_{plot\_N}</math> is the current value to be plotted, <math>Y_{plot\_N-1}</math> is the prior plotted value and A is the</p>

	<p>averaging value from the pull-down menu. You clear and restart the filter at any time by pressing the reset button .</p> <p>The filtering affects the graphed data and digital displays. If you choose to save the buffered data, you will have the opportunity to save the raw values or the filtered values.</p>
<p>DC/AC</p> 	<p>The DC/AC toggle removes the DC component from the strip chart or scope mode graphic data, but does not affect the digital display nor the logged data.</p>
<p>Zero correction</p> 	<p>When you press zero, the current values are captured and subtracted from all subsequent readings as displayed on all the graphic and digital displays, until you press the clear zeroes button . If you choose to save the buffered data, you will have the opportunity to save the raw values or the zero offset corrected values.</p>
<p>Differential display </p>	<p>When this control is pressed, the graphic changes to display the difference between successive readings. The buffered data is not affected.</p>
<p>Graphic mode</p> 	<p>You can plot the data as a rolling strip chart or a bar chart (histogram). The scope mode is a variant of the strip chart. Instead of a rolling chart, the graphic is refreshed as a whole for each 256 samples. In histogram mode you can place a cursor on a particular channel to read out its value.</p>
	<p>Clear buffered data. Values are cleared from the PSI Diagnostic data buffer, but any acquisition in progress continues and timestamps are not reset.</p>
	<p>Save data buffer contents to csv file. When you click this button you will see a drop down selection  which allows you to save either the raw data, or the values with the PSI Diagnostic zero offset and averaging</p>

### 10.2.3 Setup tab

Click on the “Setup” tab. On this screen you can alter digital input logic polarities, analog input filtering and analog calibration values.

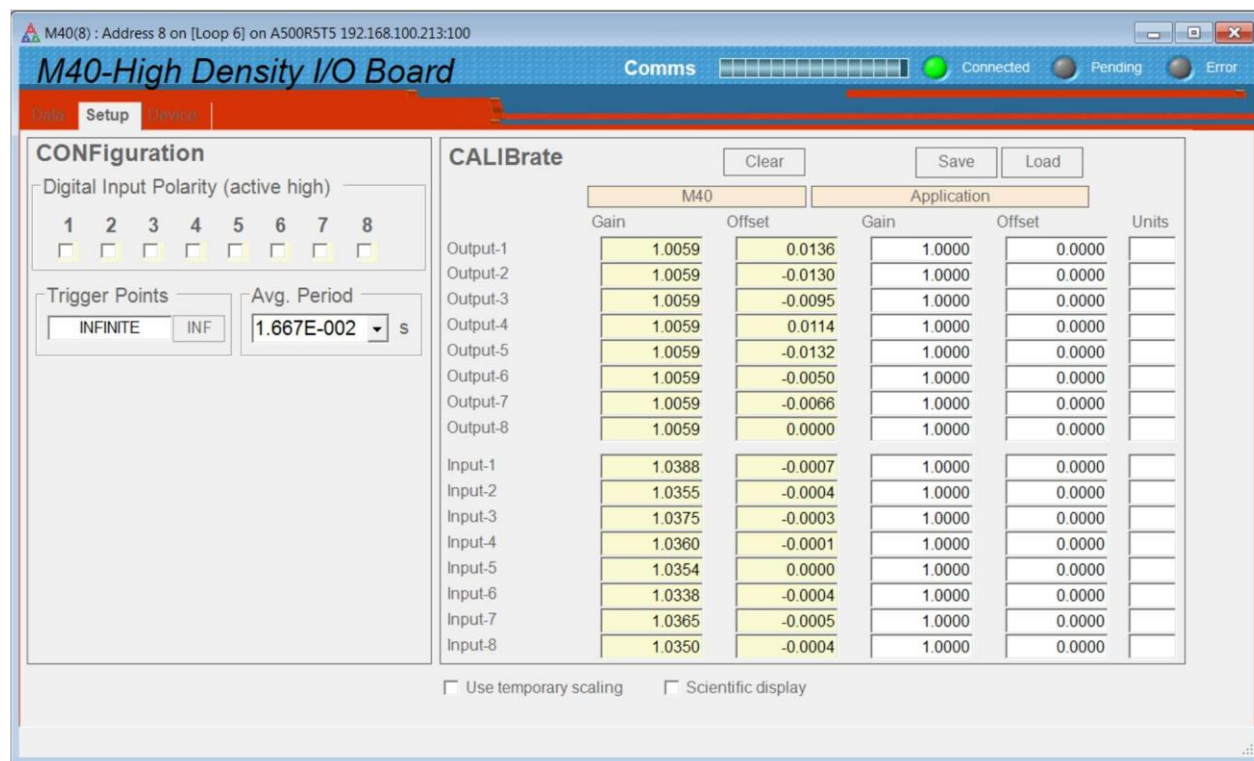


Figure 12. Setup tab.

Digital input polarity	By default, the digital inputs show true (green LEDs on the Data tab) when the electrical level is TTL high. You can change this individually for the eight inputs using the check boxes, so that true is TTL low.
Trigger points	The trigger points field determines how many readings will be taken following Initiate. The INF button sets a state where acquisition will continue indefinitely.
Averaging period	The analog inputs are converted in the M40 at 50 kSa/s. A digital filter then averages the samples over the selected period to give the final values make up each reading on each channel, and that are transmitted back to the host system for display and logging. A useful setting is the period of the local mains electricity (16.67 msec or 20 msec), as this will zero any mains pickup in the readings.
Calibrate	<p>The M40 uses two linear calibrations. The M40 calibration is established during manufacture or factory recalibration, and is intended to correct for small differences in the electronics, so that the outputs and inputs are accurate in volts. It is stored in the M40 itself in NVR.</p> <p>The application calibration is applied by the PSI Diagnostic in addition to the permanent calibration when the “Use temporary scaling” box is checked. Any physical units you have entered will be displayed alongside the relevant input/output values on the Data tab. The parameters are stored on your computer, referenced to the serial number</p>

of the M40. This calibration is primarily intended to allow you to program and readback a power supply or similar device in its native units. See section ## for more information on using the calibrations.

### 10.2.4 Device tab

Click on the “Device” tab. You can check the communication link status, read the M40 manufacturing serial number and verify the versions of the hardware and firmware. On the right is the firmware update utility. You can use this to download firmware updates (.hex and .fhex files) downloaded from the Pyramid Technical Consultants, Inc. web site.

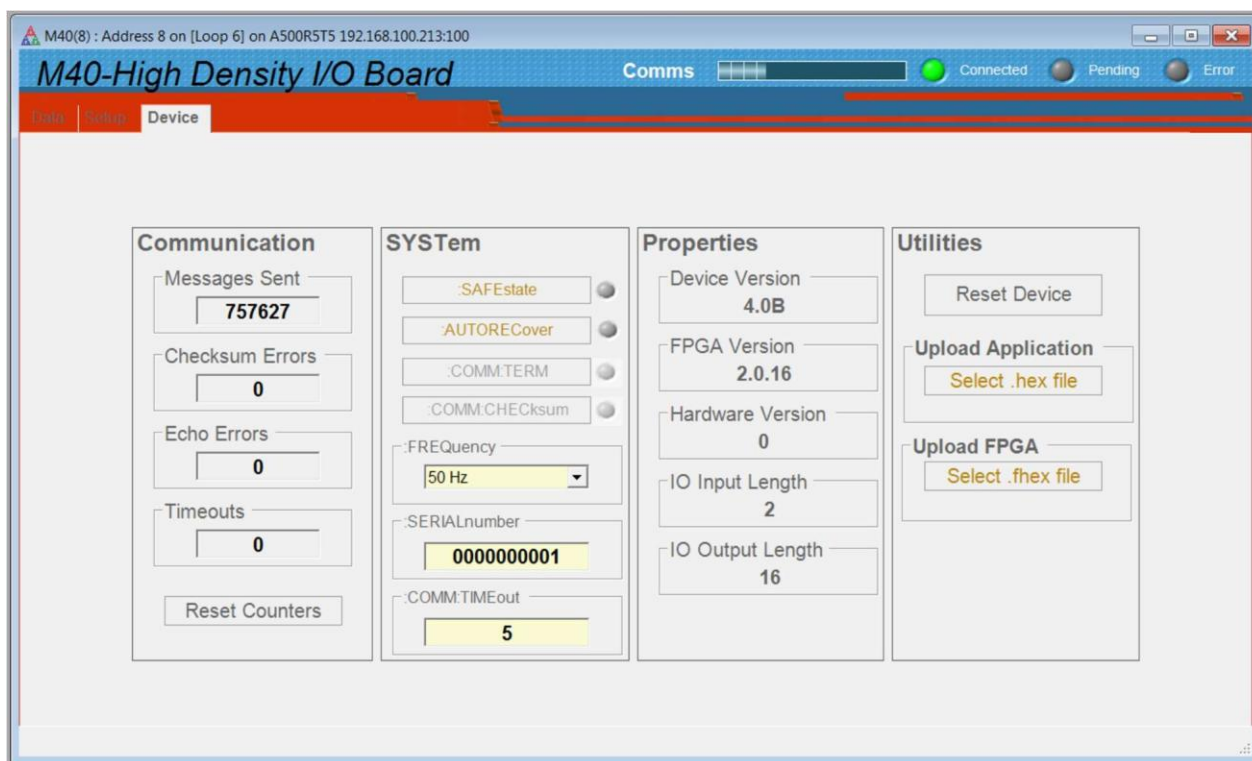


Figure 13. Device tab, showing firmware update utility controls.

Communication	The counters show details of the communications between the M40 and its host. You can click the Reset Counters button to reset the fields to zero.
System controls	Pressing :SAFEstate sets a mode in which the M40 goes to a defined safe state (all outputs zeroed) if it does not communicate with its host controller in the timeout period in seconds set by the :COMM:TIMEout parameter. If communications are restored, then the M40 will re-assert its prior output state. If you want to disable this feature, set the timeout to 0.



	<p>Pressing :AUTOrecover sets a state in which the M40 will attempt to restart automatically if it detects data corruption.</p> <p>The COMM:Term and COMM:Checksum controls are not used on the M40. You can ignore them when using the PSI Diagnostic</p> <p>The system controls are software password protected, so you will see a red warning message at the bottom of the window when you use them. The PSI Diagnostic automatically sends the password.</p>
Frequency	This parameter sets the averaging period that will be used by default on power up. You should set it to the dominant electronic noise frequency in your environment (normally the line frequency).
SerialNumber	This is the manufacturing serial number of your device, and should be left unchanged.
Comm:Timeout	The time period in seconds without communications before the M40 goes to the safe state. Set to zero if you don't want this feature.
Select .hex file	This button starts the M40 PIC firmware update process. It opens a file selection dialog. When you select a hex file it will start uploading to the M40 immediately. Upon completion the M40 will restart automatically, and you will see the new Device Version number displayed. See section 16 for more details.
Select .fhex file	This button starts the M40 FPGA firmware update process. It opens a file selection dialog. When you select a fhex file it will start uploading to the M40 immediately. Upon completion you will need to power cycle the M40, which will cause the new code to be loaded. You will see the new FPGA Version number displayed. See section 16 for more details.
Reset	This button causes a full warm reset of the M40. All outputs will go to zero during the reset, then will be set back to their prior settings by the PSI Diagnostic.

### 10.3 Installing and Using the PTC Diagnostic G2 Program

The PTC Diagnostic G2 host software provides the same user functions as the PSI Diagnostic, and has a similar look and feel, but it is built on a different software foundation. Unlike the PSI Diagnostic, the PTC Diagnostic G2 uses the same DLL function libraries that Pyramid uses to build user applications. These libraries can be provided to customers who want to build their own applications. The G2 Diagnostic can often provide faster average data rates to the host by its use of block data transfers. If you need a Diagnostic to operate the M40 in conjunction with G2 devices such as the A560, I128, and C400, then you must use the PTC Diagnostic G2.

PTC Diagnostic G2 can coexist with the PSI Diagnostic on the same computer. Both programs can in fact communicate with an A500 or A560 the M40 at the same time (the PSI Diagnostic must be launched first), although this is not generally recommended, as the results could be very confusing.

Since the two programs are similar, we shall concentrate on the differences.

Download the PTC Diagnostic G2 installer (.msi file) or find the copy on the USB memory stick if you purchased the M40 as an end-user. We recommend that you copy the installer file into a directory on your host PC. Check the Pyramid Technical Consultants, Inc. web site at [www.ptcusa.com](http://www.ptcusa.com) for the latest version.

The program runs under the Microsoft Windows operating system with the 4.0 .NET framework. This has to be installed before the PSI Diagnostic. Most new PCs have .NET already installed, or it can be downloaded from the Microsoft web site at no charge. The Pyramid installer will prompt you if you need to update the version on your computer.

### 10.3.1 Establishing communication with the M40

Start the PTC Diagnostic G2. The program expects all connections to devices like the M40 be via Ethernet ports, whether through dedicated loop controllers like the A500, A560 and A360, or via other Ethernet-enabled devices that support slave devices, such as the I128. Unlike the PSI Diagnostic, you do not need to specify the IP address. When you launch the program, it will open the Discover Devices dialog. Pressing the Discover Controllers button will give you a list of available controllers. The search will include all devices visible on your accessible subnet, including any on the far end of a VPN link. In the following example the search has found five A500 controllers. The A60 Recovery entry is a diagnostic utility used for some G2 devices, which you can ignore.

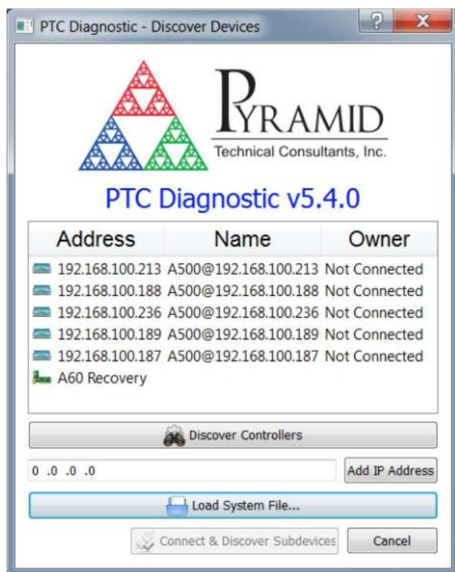


Figure 14. PTC Diagnostic G2 discovery dialog.

Highlight the target device to enable the Connect & Discover Subdevices button. Clicking this should result in the controller appearing in the System area on the left, with its connected subdevices shown. In this case we only have an M40 on loop 6.



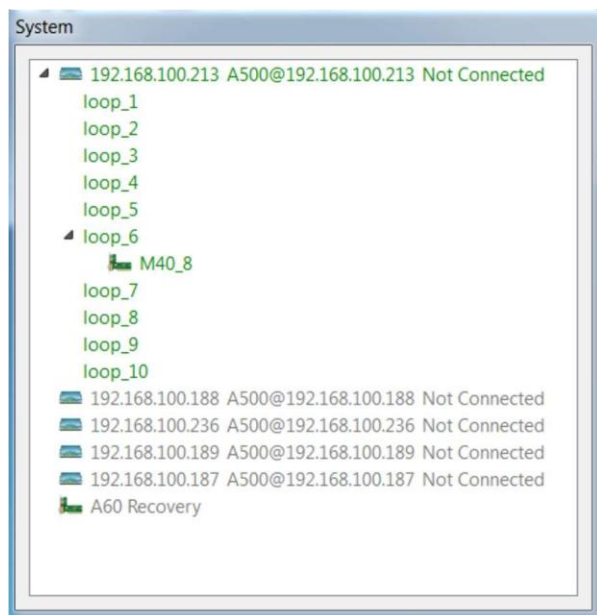


Figure 15. System pane showing M40 connected via A500

Clicking on the M40 entry opens a window for it, with the same basic strip chart and histogram graphing options, and digital displays.

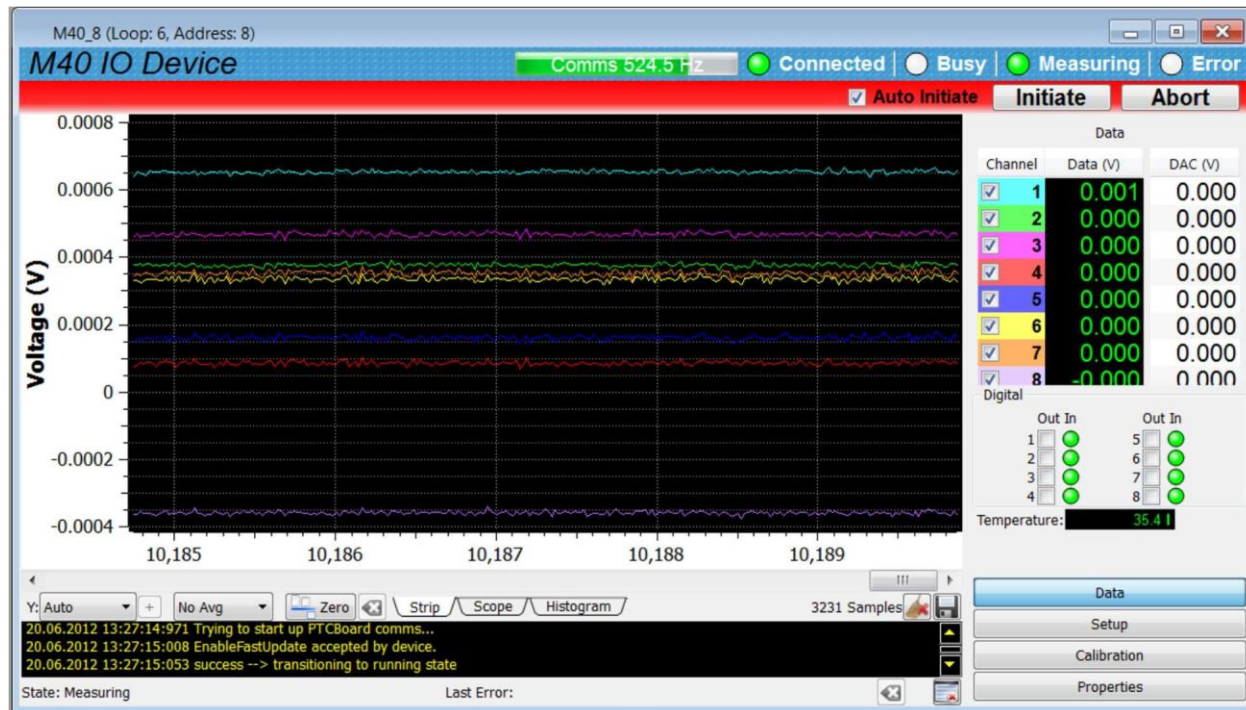


Figure 16. M40 data display in PTC Diagnostic G2

Checking the Auto Initiate button causes the program to automatically start data taking after you make any change to the M40 parameters.

The Setup and Calibration buttons access areas that provide the same functions as the PSI Diagnostic Setup tab. PTC Diagnostic G2 does not support application calibration in its current version. Buffered data acquisition uses M40 on-board memory to permit bursts of contiguous data to be captured at high rate. This will be supported in a future M40 firmware release.

The firmware update utility is accessed on the Properties area.

## 11 Interfacing to EPICS via IG2

### 1.1 What is EPICS?

The Experimental Physics and Industrial Control System (EPICS, <http://www.aps.anl.gov/epics/>) is:

“A set of Open Source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control systems for scientific instruments such as particle accelerators, telescopes and other large scientific experiments. EPICS uses Client/Server and Publish/Subscribe techniques to communicate between the various computers. Most servers (called Input/Output Controllers or IOCs) perform real-world I/O and local control tasks, and publish this information to clients using the Channel Access (CA) network protocol. CA is specially designed for the kind of high bandwidth, soft real-time networking applications that EPICS is used for, and is one reason why it can be used to build a control system comprising hundreds of computers.”

Pyramid supplies an executable called IG2 which embeds an open source Channel Access Server from the EPICS community. This allows connection via the Ethernet interface. IG2 is configured for the devices you wish to connect using editable xml files. Once IG2 is running on a computer in your network, then any other computer can run a client program which can display and control the process variables for the devices. In the simple network in figure 17, the process variables of an M40 attached to an A360 via fiber optics, are exposed to the network by the IG2 service running on a server computer. One or more client GUI computers can then access the values.

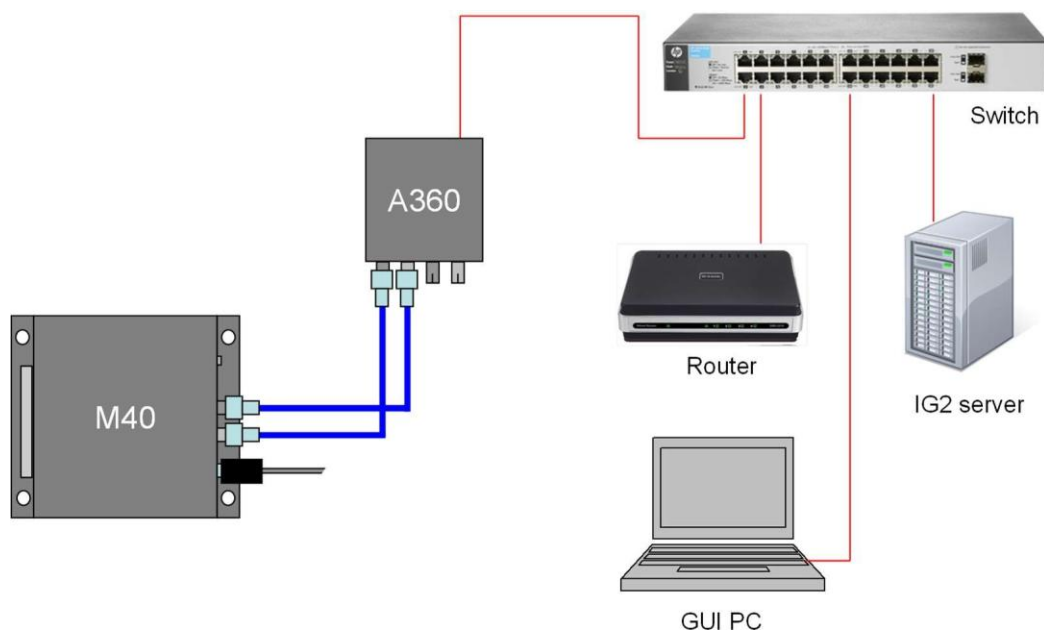


Figure 17. Example network for EPICS communications.

There is a wide range of client interfaces from the EPICS community, including interfaces for C++, C#, Java, Python, and Matlab™. The Control System Studio, or CS Studio, (<http://controlsystmstudio.github.io/>) is a set of ready-made tools built on Java and Eclipse (<http://www.eclipse.org/>) that allows users to get started with little or no programming required. There are various logging, plotting, post-processing and alarm point tools. A fully-featured “drag and drop” user interface editor (BOY) allows quite complex customized user interfaces to be created with minimum development time. As an example, the following screenshot shows a simple user interface created in the CS Studio BOY OPI editor. The M40 was assumed to be controlling a high voltage power supply.

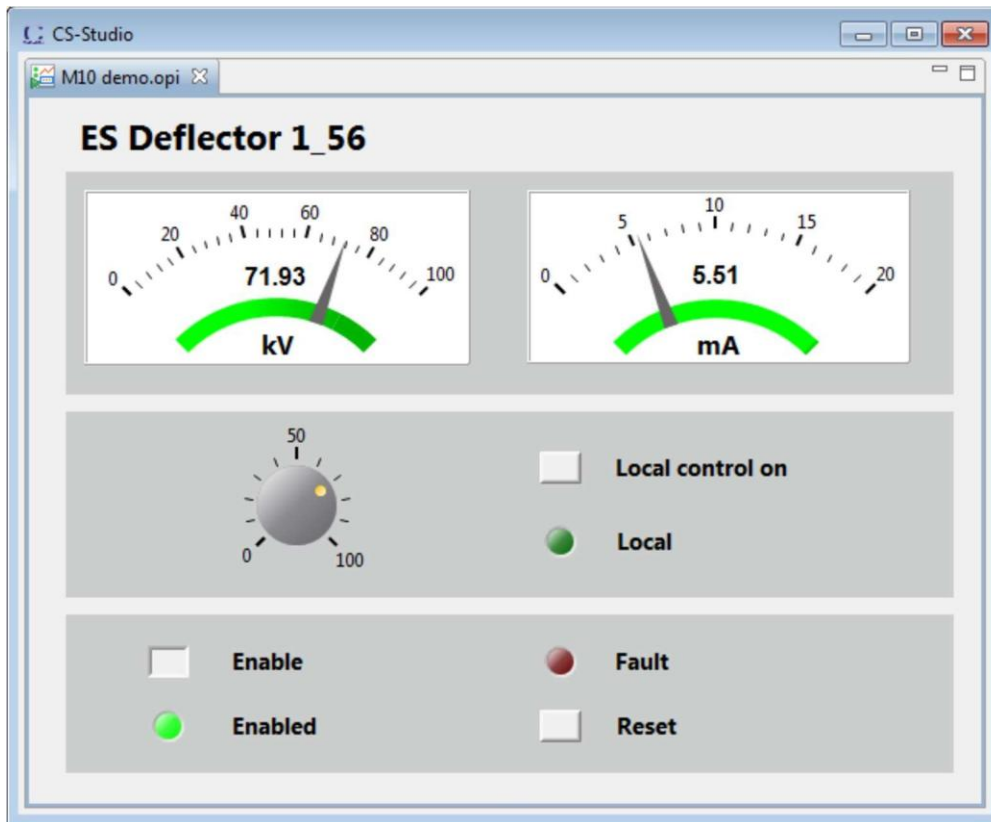


Figure 18. Example user screen created using CS Studio BOY.

## 1.2 Installing and Configuring IG2

The IG2 package is available to users of Pyramid products. It is supplied as a zip file which should be de-compressed and the entire folder moved to the computer that will act as the server. The server and the user interface computer can be the same machine. The loop controller, the server and the user interface computer should be able to communicate with each other over your network.

In the folders you have saved, there is an xml files in the \service subdirectory that need to be edited to customize your particular setup. IG2 looks for the file “system.xml” in the \service subdirectory to establish the configuration of the system. You can locate system.xml elsewhere

than the default location, or give it a different name, in which case you need to specify the path and file name by means of an argument in the command line that launches IG2.

The system file comprises a header section on the xml schema, which does not need to change. Then comes a description of the user interface host computer, descriptions of the fiber optic loop controller devices in your system and descriptions of the devices attached to loops. You don't have to describe every device and every input/output point that is present in your system, but only the ones that you expose in the system file will be visible to EPICS.

The simplified example in figure 19 illustrates the xml schema. The analog inputs and outputs are scaled to suit the application, and only those necessary are exposed. The A360 is supporting the M40 as the only looped device.

The convention of “wires” for Pyramid device process variables, and the fixed names of those wires for each supported product, are described in the document “ig2\_scripting\_v#.#.pdf”, where #.# is the document revision number, included with each release. The document also describes how you can scale the values, for example to convert voltages from general purpose I/O devices to physical units relevant to the item they are controlling, and how you can set up monitoring against tolerance bands.

The choice of a corresponding working name for each wire is up to the user; it is sensible to choose something descriptive that is relevant to what you are measuring or controlling. We nevertheless recommend a naming convention that makes it clear whether a value is a readback or control (the prefixes c\_ and r\_ are used in the example), which particular device the value is associated with, and a number or letter to indicate the channel for multichannel devices.

```

<?xml version="1.0" encoding="iso-8859-1"?>
<system
  xmlns="http://www.ptcusa.com"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.ptcusa.com A510.xsd" type="pyramid" >
  <hosts>
    <host ip="192.168.1.65" name="PTCE_Laptop1" localhost="true" />
  </hosts>

  <loopcontrollers>
    <loopcontroller type="A360" name="A360_1" ip="192.168.1.68" timeout="50" timeslice="1000" >
      <loops>
        <loop number="1" name="A360_1_loop_1">
          <boards>
            <board type="M40" name="m40_1" address="1">
              <channels>
                <channel name="r_m40_1_ain1" wire="analog_in_1" scaleB="10"/>
                <channel name="r_m40_1_ain2" wire="analog_in_2" scaleB="2" scaleC="5.5"/>
                <channel name="c_m40_1_aout1" wire="analog_out_1" scaleB="10" limitLow="0" limitHigh="100"/>
                <channel name="c_m40_1_aout2" wire="analog_out_2" />
                <channel name="r_m40_1_din1" wire="digital_in_1" />
                <channel name="r_m40_1_din2" wire="digital_in_2" />
                <channel name="r_m40_1_din3" wire="digital_in_3" />
                <channel name="c_m40_1_dout1" wire="digital_out_1" />
                <channel name="c_m40_1_dout2" wire="digital_out_2" />
                <channel name="c_m40_1_dout3" wire="digital_out_3" />
              </channels>
            </board>
          </boards>
        </loop>
      </loops>
    </loopcontroller>
  </loopcontrollers>

  <interpreter>
    <devices>
      <epicscas type="epicscas" name="epics_server" />
    </devices>
  </interpreter>
</system>

```

Figure 19. Example xml system configuration file for IG2 / EPICS.

Once you have created and saved your system file, you can run the IG2 service executable. If the server has a display, you will see a console window that shows the connection process and then records subsequent control value changes sent to the M40. The names you declared will now be recognized as process variables by any EPICS-compatible client program.



### CAUTION

Don't try to control the M40 simultaneously from an EPICS client and from a Diagnostic. The results will be confusing. In particular, if you attempt to run the IG2 service and PTC DiagnosticG2 on the same computer, the communications will conflict.

## 12 Circuit overview

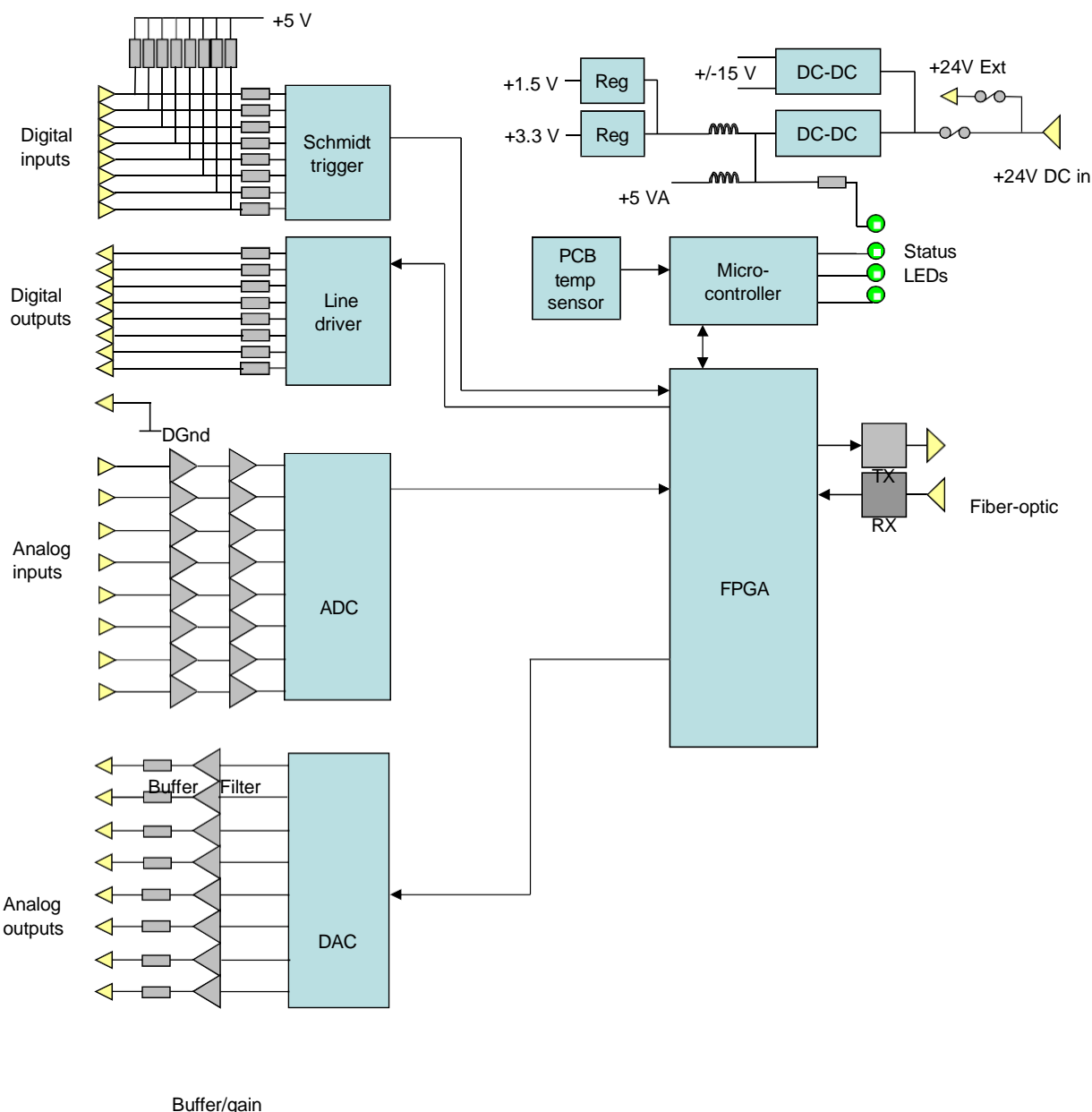


Figure 20. M40 block schematic.

All input and output functions are handled through an FPGA. A PIC microcontroller handles calibration, communications message handling and some ancillary I/O. Incoming 24 VDC power is fused, clamped against overvoltage and heavily filtered. Isolation DC-DC converters generate independent voltage rails for the internal analog and digital circuitry.

The eight identical analog inputs, with allowable range -10 to +10V, are inrush limited by 4.7k resistors and buffered through a unity gain buffer.





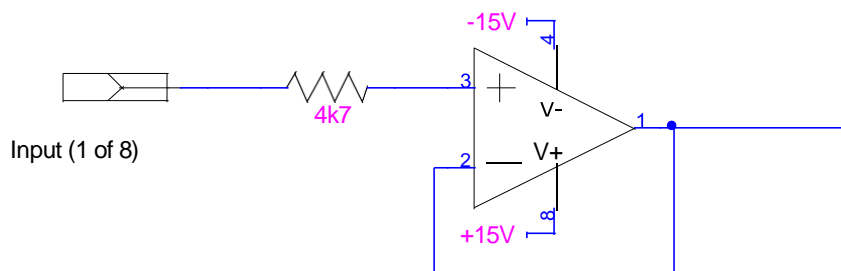


Figure 21. M40 analog input configuration (referenced to AGnd).

The signals then pass through a two-pole low-pass analog filter with a -3dB point at 10 kHz and a gain of 0.50, before being delivered to the ADC.

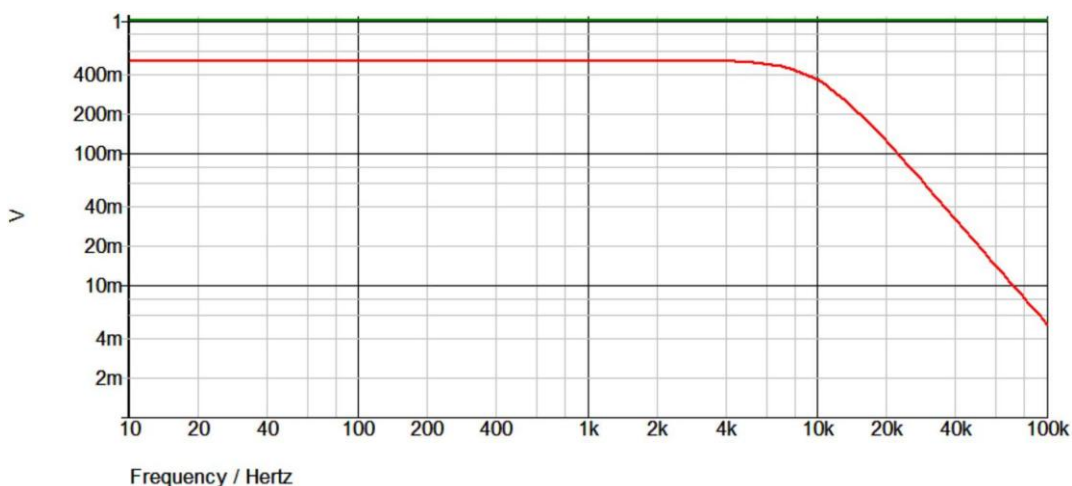


Figure 22. M40 analog input filter response.

The multichannel ADC is fully bipolar,  $\pm 5$  V range with 16 bit resolution. All eight inputs are sampled simultaneously at 250 kHz and accumulated in the averaging buffer of the FPGA. The use of averaging (downsampling) increases the effective resolution of the M40 greatly. The amount of averaging is under software control. The PIC microcontroller applies the calibration to convert to floating point values in volts.

The eight identical analog outputs are generated by a 16-bit DAC, offset to give an analog value centred on 0.0 V, and passed through an output stage with gain 2.01 to give a certain -10 to +10 V range. A 100 ohm series resistor in the feedback loop protects against external short circuits.

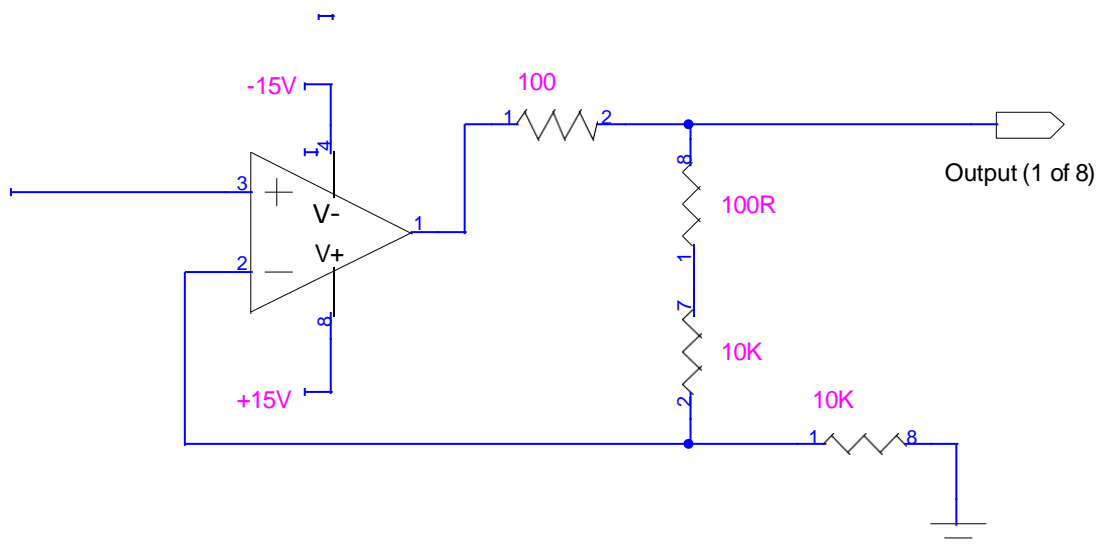


Figure 23. M40 analog output configuration.

The analog voltage outputs slew at around 0.6 V per microsecond when changing from one setting to another. This rate of change may be too high for some devices controlled by the M40, in which case the change should be delivered as a sequence of smaller steps.

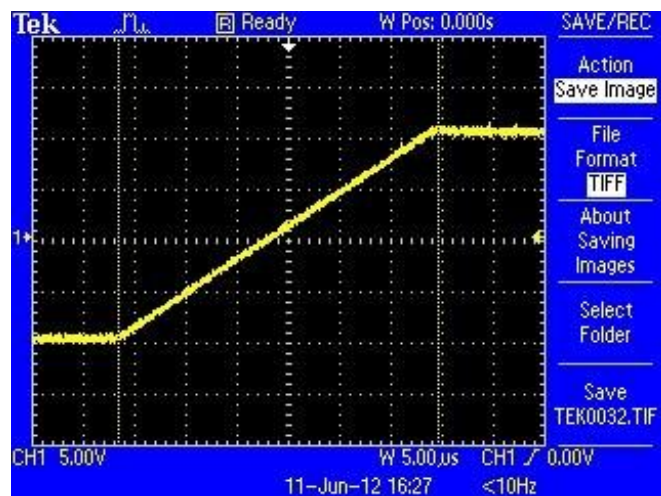


Figure 24. M40 analog output slew rate for full scale step (20 V in 32  $\mu$ sec).

The eight digital inputs are pulled up to +5 V via 47 kohm, and protected by 470 ohm series. Schmitt triggers buffer and clean the inputs before they pass to the M40 digital processing.

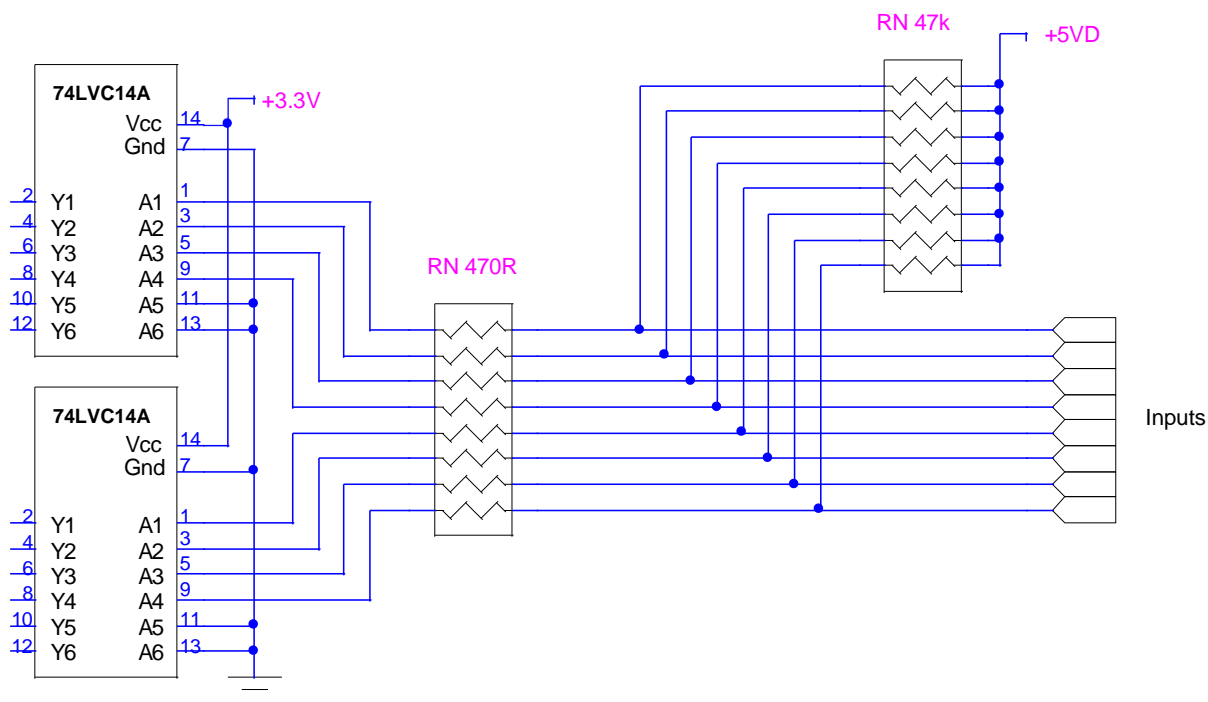


Figure 25. M40 digital input configuration.

The eight digital outputs are buffered and level shifted to TTL levels by a line driver, and the signal passes out via a 100 ohm current limiting resistor.

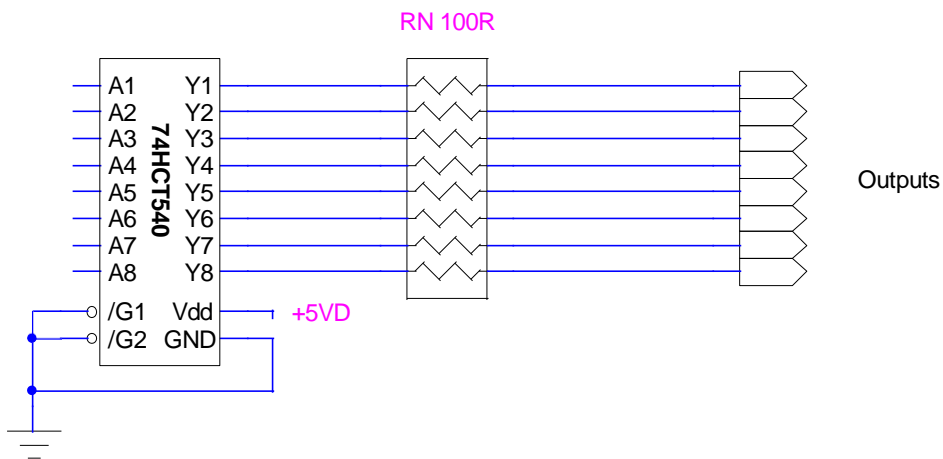


Figure 26. M40 digital output configuration.

## 13 Calibration

### 13.1 M40 Calibration Factors

Ideally the M40 would output and input perfectly accurate analog voltages. In practice small circuit offsets and gain errors result in small inaccuracies. The M40 stores calibration factors (“Permanent calibration”) that allow these to be compensated, increasing the absolute accuracy of the device by an order of magnitude.

There is a gain and offset factor for each analog output, and a gain and offset factor for each analog input. The values can be viewed on the setup tab in either version of Diagnostic host. The factors are determined using high-precision test equipment and stored in the M40 internal memory as part of the manufacturing process, or if the unit is returned for recalibration. The parameters are reloaded whenever the M40 is powered up.

The permanent calibration factors are applied as follows:

Output:  $V_{\text{out}} = \text{Gain} * (V_{\text{raw}} - \text{Offset})$

where  $V_{\text{out}}$  is the voltage sent out by the M40, and  $V_{\text{raw}}$  is the voltage that would be sent out if there was no calibration.

Input:  $V_{\text{read}} = \text{Gain} * V_{\text{in}} - \text{Offset}$

where  $V_{\text{in}}$  is the actual input voltage and  $V_{\text{read}}$  is the displayed value.

Note that the input gains should all be around 3-4% greater than 1.000. This is by design, to ensure that the full scale voltage of 10.00 V can be read without risk of ADC overrange.

### 13.2 Application Calibration Factors

Application calibration factors are provided to allow you to map the +/-10 V native range of the M40 onto the output and readback of a power supply or similar device that it is controlling. The temporary calibration is applied on top of the permanent calibration, when the “Use temporary scaling” option is checked.

The simplest way to appreciate this function is to consider an example. Say we have a high voltage power supply, designed by a rather confused engineer, that outputs -50 kV to +50 kV linearly in response to a control input of 0 to +5 V. It has a linear readback of -10 V to +10 V corresponding to -50 kV to +100 kV. We want to enter and read back values in kV on the M40 diagnostic, and we know that the permanent calibration is good so that the M40 outputs and inputs are accurate in voltage. When we have selected the analog input and output pair we shall use, we can enter “kV” in the units field so that the Data tab readings are labeled appropriately.

For the output,

$$V_{\text{out}} = \text{Gain} * (V_{\text{set}} + \text{Offset}),$$

so for the example, we put Gain = 0.05 and Offset = 50.

For the input,

$$V_{\text{read}} = \text{Gain} * V_{\text{in}} - \text{Offset},$$

so for the example, Gain = 6.25 and Offset = -12.5.

In practice you may be able measure the response of the power supply by independent means as a function of the M40 output and input values with the temporary calibration disabled, to obtain the necessary parameters.

Notice that this procedure is most intuitive when you can associate one M40 analog input and output pair to setting and reading back one parameter, so that the physical units are common. For example, analog output 3 could be calibrated as described to provide a command in kV, and analog input 3 would be used to read back the corresponding monitor value also scaled in kV. Then we might use analog input 4 to readback and scale a monitored current in mA, for example, and analog input 5 to readback and scale a temperature in centigrade. The following figure shows how this might look.

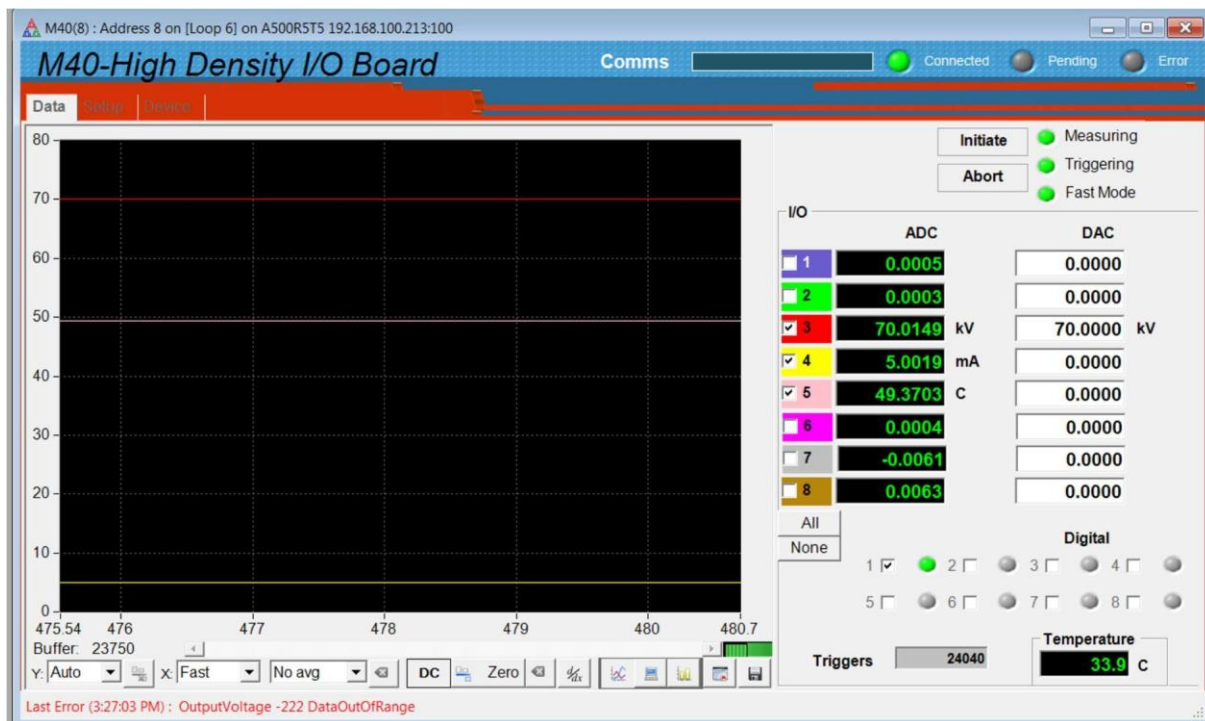


Figure 27. Using application scaling.

## 14 Wavetable Output and Logging

The M40 is able to output tables of values on up to eight analog outputs simultaneously. While these values are being put out, the device can log the eight inputs. Thus it can act as a multichannel arbitrary waveform generator and data logger. If the output and sampling rate is high, the output values and logged data reside in the M40 on-board memory to ensure contiguous data, but this limits the size of the tables. At lower rates the tables can be managed by the host system thus much larger files can be handled.

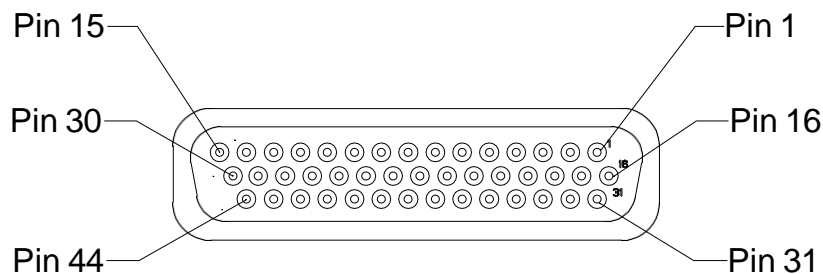
The wavetable facility will be added in a future firmware release.

## 15 Connectors

### 15.1 Front panel connectors

#### 15.1.1 Analog and digital I/O

Forty-four pin high-density Dsub female.



(External view on connector / solder side of mating plug)

1	Analog In 7	16	Analog In 8	31	Shield
2	Analog In 5	17	Analog In 6	32	Power Supply Gnd
3	Analog In 3	18	Analog In 4	33	+24 VDC in/out fused
4	Analog In 1	19	Analog In 2	34	Digital In 1
5	Gnd	20	Digital In 2	35	Digital In 3
6	Gnd	21	Digital In 4	36	Digital In 5
7	Gnd	22	Digital In 6	37	Digital In 7
8	Gnd	23	Digital In 8	38	Digital Out 1
9	Gnd	24	Digital Out 2	39	Digital Out 3
10	Gnd	25	Digital Out 4	40	Digital Out 5
11	Gnd	26	Digital Out 6	41	Digital Out 7
12	Analog Out 7	27	Analog Out 8	42	Digital Out 8
13	Analog Out 5	28	Analog Out 6	43	Gnd
14	Analog Out 3	29	Analog Out 4	44	+5 VDC out
15	Analog Out 1	30	Analog Out 2		

#### CAUTION



Do not connect +24 V to any of the inputs or outputs.

#### CAUTION



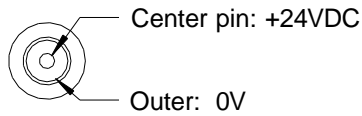
Digital inputs should not lie outside the range 0 to +5.5 V or damage may result.

Analog inputs should not lie outside the range +/- 15V or damage may result.

## 15.2 Rear panel connectors

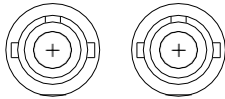
### 15.2.1 Power input

2.1 mm threaded jack. To mate with Switchcraft S761K or equivalent



### 15.2.2 Fiber-optic communications

ST bayonet. To mate with ST male terminated fiber optic cable. Recommended cable types 1 mm plastic (such as Avago HFBR-EUS-500) or 200 um silica (such as OCS BC03597-10 BL). Signal: 650 nm light (red).



Transmit      Receive  
(light grey)   (dark grey)

Note: Most fiber optic ST connectors include a key tab which must align with the keyway in the M40 connectors. Rotate the cable and centre of the mating connector until the key engages before pushing the connector home and engaging the bayonet.



## 16 Controls and Indicators

### 16.1 Front panel controls

None.

### 16.2 Rear panel controls

#### 16.2.1 Address switch

16 position rotary switch setting device address. Choice of address is arbitrary, but each device in a fiber-optic loop system must have a unique address.

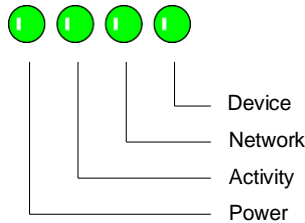
Setting	Function
0	(Reserved to loop controller)
1-F (decimal 1 to 15)	Available address settings.

### 16.3 Front panel indicators

None.

### 16.4 Rear panel indicators

Quad green LED.



#### 16.4.1 Power

Green LED. On = input power is present; internal DC-DC converters are running.

#### 16.4.2 Activity

Green LED. Green LED. Flashes when M40 has received new analog or digital output setting.

#### 16.4.3 Network

Green LED. Flashes when M40 is processing messages on the fiber-optic channel.

#### 16.4.4 Device

Green LED. Green LED. Flashing 5 Hz = M40 is initiated and acquiring data.

### 16.5 Internal settings

We do not recommend that you open the M40 case unless specifically instructed to do so by your supplier or Pyramid Technical Consultants, Inc. There are no user-serviceable parts inside. The following information is provided for reference only.

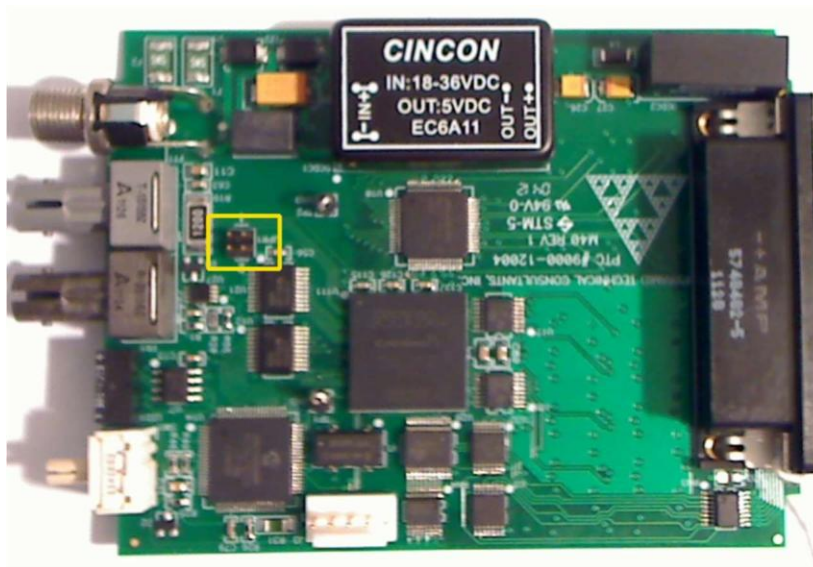


Figure 28. Location of jumpers

### 16.5.1 JPR1 settings

Links	Function
None	Normal operation mode.
1	(Reserved)
2	(Reserved)
1 & 2	(Reserved)

## 17 Software updates

The M40 has three embedded firmware releases.

Firmware	Function
FPGA (.pof file / .fhex file)	General logic, loop message passthrough, ADC reading and averaging
PIC Boot (.hex file)	Boot up, code upload
PIC Application (.hex file)	Main application; calibration, conversion to floating point values, communication messaging.

The PIC microcontroller boot code should not require updating. It would require access to the circuit board and dedicated programming tools to load new code. If the boot code ever does need to be updated, your supplier will contact you and make arrangements either to return the unit for upgrade, or to have an engineer perform the upgrade for you.

The FPGA and PIC microcontroller application code may be updated periodically to add new operating features. New code releases will be provided by your supplier, or can be downloaded from the Pyramid Technical Consultants, Inc. website. The fhex (for FPGA) and hex (for PIC microcontroller) files can be loaded using the PSI Diagnostic host without any need to access the unit. The uploads can be performed directly from the PC host.

### 17.1 FPGA firmware updates

To update the FPGA, click the “Select .fhex file” button under Upload FPGA on the Device tab, and navigate to the relevant file. The code will then load. The process takes about 20 seconds.

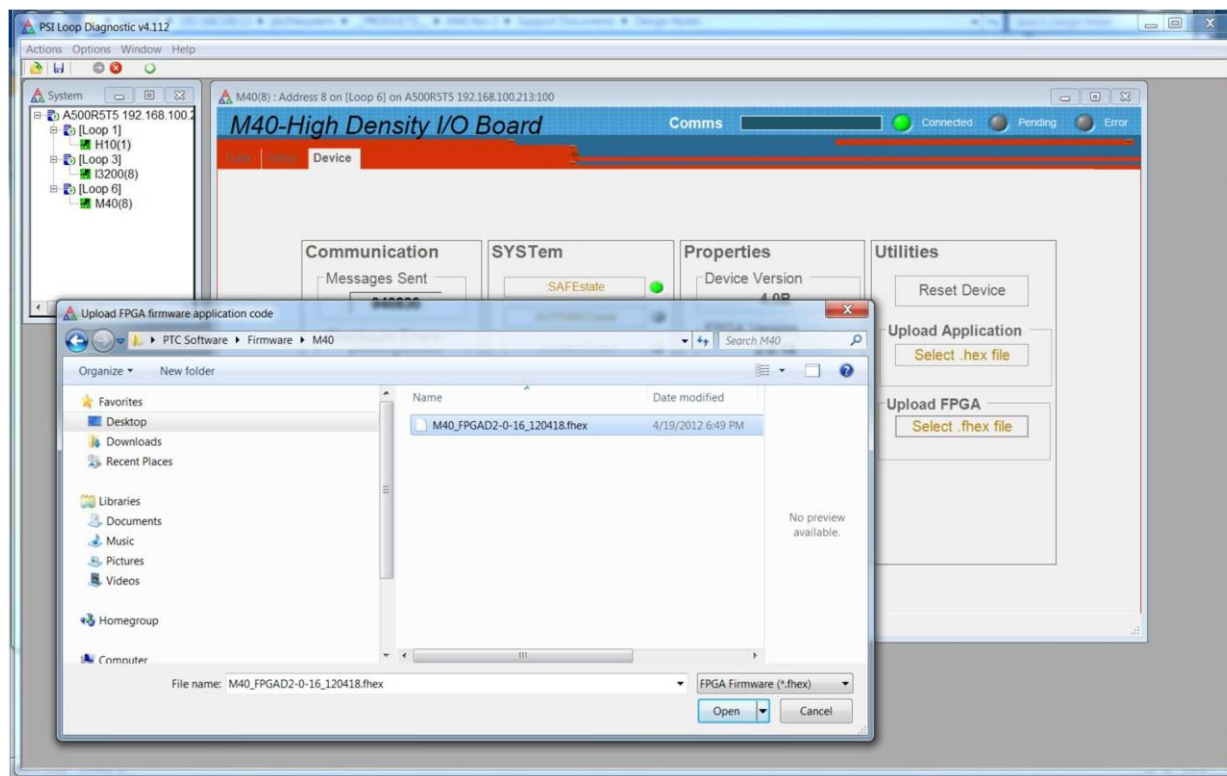


Figure 29. Selecting the fhex file to load.

When the upload is complete, you will get a prompt to power cycle the M40 in order to load the new code.

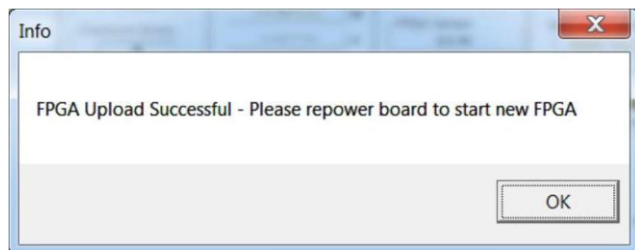


Figure 30. Restart prompt after FPGA update.

If the FPGA upload fails for any reason such as loss of power during the upload, or data corruption, then the M40 may not be able to communicate. In the unlikely circumstance that this happens, it can be recovered using an FPGA programming tool and the .pof version of the FPGA code. Contact your supplier or Pyramid Technical Consultants who will arrange for the unit to be repaired.

## 17.2 PIC firmware updates

To update the PIC microcontroller, click the “Select .hex file” button on the Device tab and navigate to the relevant file. The code will then load. The process takes about 30 seconds.

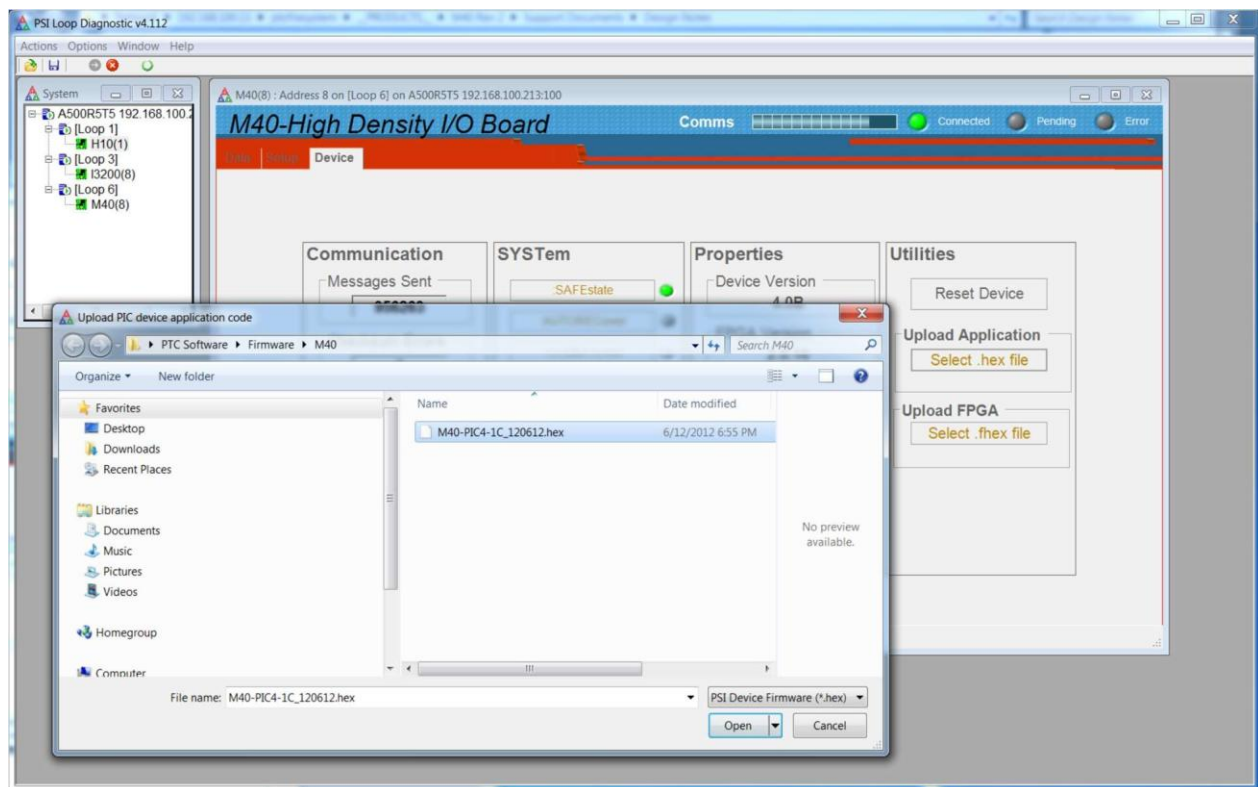


Figure 31. Selecting the hex file to load.

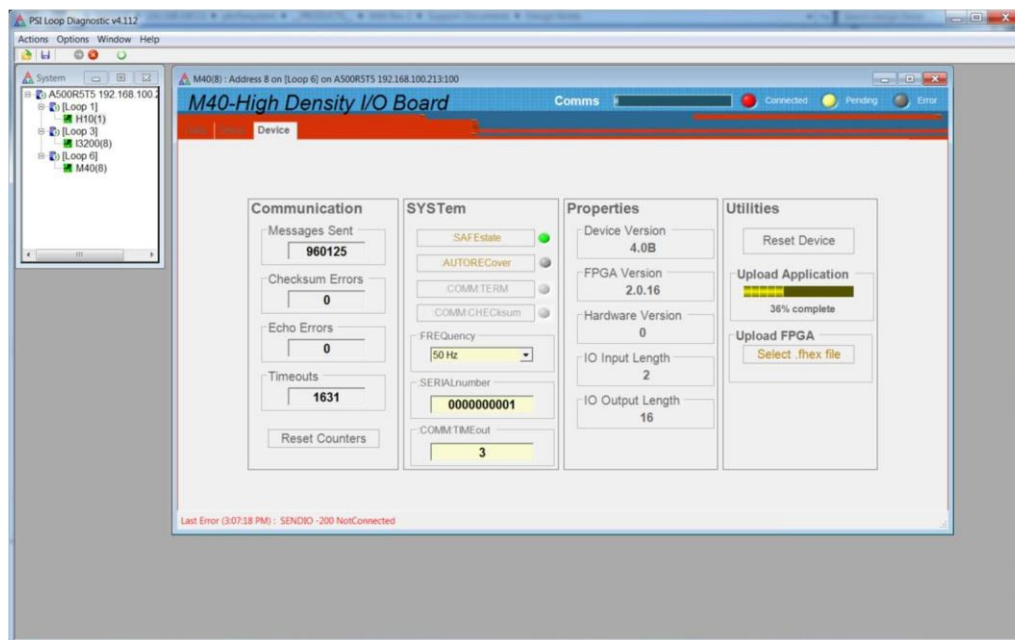


Figure 32. Firmware upload in progress

When the upload is complete, the M40 will reset itself and start running the new firmware. You should see the new device version number displayed on the screen.

## 18 Fault-finding

Symptom	Possible Cause	Confirmation	Solution
Incorrect analog input readings	Cabling error	Check signals are connected to the correct pins.	Use appropriate connection.
	Calibration incorrect or corrupted	Check calibration values.	Re-enter correct values, or contact supplier or Pyramid Technical Consultants, Inc. if no problem found.
	Unintentional or incorrect use of the application calibration.	Check application calibration values and whether “Use temporary scaling” is checked.	
Incorrect analog output values	Terminating impedance is too low.	Disconnect load and re-measure.	Ensure load is within the current compliance of the analog outputs.
Outputs drop to zero	SAFEstate is enabled and communication has been lost.	Check setting and state of communications.	Check connections to controller, status of controller. Use appropriate SAFEstate setting for the application.
High noise levels	Integration time too short for signal being measured	Noise level reduces with integration period.	Use an appropriate integration time for the signal level.
	Line voltage pickup	Noise level drops sharply if integration period is 16.7 msec (60 Hz) or 20 msec (50 Hz)	Keep M40 and signal cables clear of unscreened high current mains voltage. Use integration periods (N/line frequency) if possible.
	Averaging period does not match the line frequency.	Check averaging period setting.	Use integration periods (N/line frequency) if possible.

Analog in signals respond very slowly	M40 averaging period has been set very long.	Check setting.	Set averaging appropriate to the required time resolution and noise levels.
	PSI Diagnostic filter has been set.	Check setting.	Set filtering appropriate to the required time resolution and noise levels.
Digital input not registering signal as expected	Incorrect electrical connection to target device, typically lack of appropriate ground path.	Check that unloaded output changes as expected with a loop back connector (all outputs connected directly to corresponding inputs).	Make correct electrical arrangement.
Digital inputs operate with incorrect polarity.	Input polarity setting is incorrect for the application.	Check requirement and set input polarities accordingly.	Use the correct digital input settings.
Unable to set digital outputs as expected	Incorrect electrical connection to target device, typically lack of appropriate ground path.	Check that unloaded output changes as expected with a loop back connector or by direct measurement.	Make correct electrical configuration.
Data taking stops.	Selected number of triggers has been reached.	Check trigger points setting.	Use the correct setting, or click INF for continuous acquisition.
Unable to communicate with M40	Duplicate address setting	Check address against expected address in host software.	Use correct switch setting. Switches can be changed while the unit is operating.
	Communication link timeout		Investigate and fix communications issue. Use a longer timeout setting if necessary.
	RX and TX cables cross connected somewhere in loop.	Network LED not lit.	Correct cabling as necessary.



	Fiber optics are damaged	Inspect fibers, especially the connectors. Check light can be seen through fiber. Exchange fibers and retry.	Fit new fibers or re-terminate as necessary.
Unexpected changes in parameters	Another host software program is accessing the device.	Check host programs running on connected computers.	Run a single host program only.
Communications interruptions	Other processes on PC host interfering with comms ports.		Use a dedicated PC with simple configuration and minimum number of processes running.

## 19 Maintenance

The M40 does not require routine maintenance or calibration. There is risk of contamination which may degrade performance if the case is opened. There are no user-serviceable parts inside.

The M40 is fitted with a 0.5 A automatically resetting positive temperature coefficient (PTC) fuse in the 24 VDC input. No user intervention is required if the fuse operates due to overcurrent. The fuse will reset when the overcurrent condition ends.

## 20 Returns procedure

Damaged or faulty units cannot be returned unless a Returns Material Authorization (RMA) number has been issued by Pyramid Technical Consultants, Inc. If you need to return a unit, contact Pyramid Technical Consultants at [support@ptcusa.com](mailto:support@ptcusa.com), stating

- model
- serial number
- nature of fault

An RMA will be issued, including details of which service center to return the unit to.

## 21 Support

Manual and software driver updates are available for download from the Pyramid Technical Consultants website at [www.ptcusa.com](http://www.ptcusa.com). Technical support is available by email from [support@ptcusa.com](mailto:support@ptcusa.com). Please provide the model number and serial number of your unit, plus relevant details of your application.

## 22 Disposal

We hope that the M40 gives you long and reliable service. The M40 is manufactured to be compliance with the European Union RoHS Directive 2002/95/EC, and as such should not present any health hazard. Nevertheless, when your device has reached the end of its working life, you must dispose of it in accordance with local regulations in force. If you are disposing of the product in the European Union, this includes compliance with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC. Please contact Pyramid Technical Consultants, Inc. for instructions when you wish to dispose of the device.

## 23 Declaration of Conformity

### Declaration of Conformity

Issued by: Pyramid Technical Consultants, Inc.  
1050 Waltham Street, Lexington MA 02421, USA

The undersigned hereby declares, on behalf of Pyramid Technical Consultants, Inc. that the referenced product conforms to the provisions as listed. Refer to the document: *Extension of testing and analysis to the PTC product line, December 10, 2007*, and its continuations, and the *I400 Technical Construction File* for detailed testing information.

Product: M40 High-Density Device Interface

Year of initial manufacture: 2012

Applicable Directives: 73/23/EEC Low Voltage Directive:  
Laws for electrical equipment within certain voltage limits


89/336/EEC – EMC Directive:  
Laws relating to electromagnetic compatibility

Applicable Standards: IEC 610101:2002 (2<sup>nd</sup> Edition)  
UL 61010-1:2004  
EN 61326: 1997+A1:1998+A2:2001  
EN 55011:1998, A2:2002  
EN 61000-6-2:2001 – Electromagnetic Compatibility  
Generic Standard, Immunity for Industrial Applications

Issuing Agencies: Safety: TUV Rheinland North America.  
12 Commerce Rd, Newtown, CT 06470 USA

EMC: TUV Rheinland North America.  
12 Commerce Rd, Newtown, CT 06470 USA

Applicable Markings: TUV, FCC, CE

Authorized by:   
President, Pyramid Technical Consultants, Inc.

Date: 25 June 2012

The Technical Construction File required by these Directives are maintained at the offices of Pyramid Technical Consultants, Inc, 1050 Waltham Street, Lexington MA 02421, USA  
A copy of this file is available within the EU at the offices of Pyramid Technical Consultants Europe, Ltd, Suite 3 Unit 6-7 Henfield Business Park, Henfield BN5 9SL, United Kingdom.

## 24 Revision History

The release date of a Pyramid Technical Consultants, Inc. user manual can be determined from the document file name, where it is encoded yymmdd. For example, M10\_UM\_080105 would be a M10 manual released on 5 January 2008.

<i><b>Version</b></i>	<i><b>Changes</b></i>
M40_UM_120621	First general release
M40_UM_120703	Added information about data buffer save options introduced in PSI Diagnostic version 4.114.
M40_UM_120907	Correction to analog output circuitry.
M40_UM_141212	Update specification table. Add section on EPICS interfacing via IG2.
M40_UM_150226	Update specification table.
M40_UM_171214 V2.0	Moved to document control repository.
M40_UM_250722	Updated address and removed outdated references