H10
MFP-25 / MFP-2.5
Magnetic Probe System

User Manual

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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 H10 does not generate dangerous voltages, nor is it designed to measure directly such voltages, in your application it may be measuring the field in electromagnets with high voltages present. 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.

The unit is designed to operate from +24VDC power, with a maximum current requirement of 250mA. 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

H10-SYS9-2T	H10 system comprising H10 control unit, MFP-25 magnetic field probe and 9' (2.7 m) cable.
H10-SYS22-2T	H10 system comprising H10 control unit, MFP-25 magnetic field probe and 22' (6.7 m) cable.
MFP-25	Precision magnetic field probe with +/- 2.5 T range.
H10-SYS9	H10 system comprising H10 control unit, MFP-2.5 magnetic field probe and 9' (2.7 m) cable.
H10-SYS22	H10 system comprising H10 control unit, MFP-2.5 magnetic field probe and 22' (6.7 m) cable.
MFP-2.5	Magnetic field probe with +/- 0.25 T range and dB/dt coil.

5 Scope of Supply

H10 system model as specified in your order.

USB memory stick containing:
>   User manual
>   PSI Diagnostic software guide
>   PSI diagnostic software files
>   Power supply

Optional items as specified in your order.

OEM customers may not receive all the items listed.

6 Optional Items

6.1 Power supplies

PSU24-40-1. +24 VDC 1.6 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 Data cables

CAB-ST-P-x-ST Fiber-optic cable, 1 mm plastic, ST terminated, x m long.

CAB-ST-HCS-x-ST Fiber-optic cable, 200 um silica, ST terminated, x m long.

6.3 Fiber-optic loop

A200 USB to fiber-optic adaptor.

A360 fiber-optic loop controller / Ethernet adaptor.

A500 intelligent real-time controller with Ethernet interface.

A560 intelligent real-time controller with Ethernet interface.

6.4 DIN rail mount

MTG-DIN35-11462.   Mounting adaptor for 35mm standard DIN rail. H10 control unit can be mounted along or across the rail.

7 Intended Use and Key Features

7.1 Intended Use

The H10 system is intended for magnetic field measurement, particularly in electromagnets. The field can be monitored at rates sufficient for real-time monitoring and for field control, and the probe design eliminates magnetic materials or conducting surfaces that would distort the measurement of AC fields. The MFP-2.5 probe is particularly suited to measure the magnetic fields typical of fast scanning electron beamlines such as medical therapy systems, industrial radiography, materials modification, and sterilization. The MFP-25 probe is particularly suited to measure the magnetic fields typical of ion beamlines which use conventional (non-superconducting) electromagnets, and has the range and precision to perform well in many general field measurement applications.

The H10 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 is typically integrated into a larger system, using fiber optic communication links. It can be operated independently, if combined with a suitable fiber optic loop controller and host computer. 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

Dual-range magnetic field measurement.

Probes designed to measure correctly in AC fields.

High performance HE244 Hall effect device (MFP-25).

Probe temperature sensor and compensation (MFP-25).

Automatic temperature and zero compensation (MFP-2.5).

Integrated pick up loop for direct dB/dt measurement (MFP-2.5).

Field inputs can be read at over 10 kHz, if communications rates to the host system allow.

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

USB interfacing to a host computer available via the A200 loop controller.

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

8 Specification

MFP-25 probe	
Analog signals	Magnetic flux density
	Probe temperature / Hall device current source voltage
Field ranges	+/- 2.5 Tesla (+/-25 kGauss)
	+/- 0.625 Tesla (+/-6.25 kGauss)
	Selected by software control.
Sensitive area	< 1 mm square (1 mm^2)
Field direction	Field entering the marked top surface of the probe gives a positive field reading (see figure 4).
Absolute accuracy	Better than 0.01% of full scale of selected range at 25 C.
Temperature coefficient of gain (negative)	< 200 ppm C-1 (temperature compensation disabled)
	< 50 ppm C-1 (temperature compensation enabled)
Temperature coefficient of offset	< 0.05 Gauss C-1 (temperature compensation disabled)
	< 0.01 Gauss C-1 (temperature compensation enabled)
Noise	< 0.005 % rms relative to full scale with lowest downsampling setting.
	< 0.0005% rms relative to full scale at 100 msec averaging.
Step response	Better than 100 usec to within 0.1% of full scale deviation from target setting for any instantaneous field step. Observed step depends on selected downsampling.
Resolution	Smallest increment of field 0.61 Gauss (2 Tesla range), 0.15 Gauss (0.5 Tesla range) before averaging.
Linearity	0.05 % maximum deviation relative to full scale of any point from linear fit to all points over full span.
Connector	Lemo 10-way EXG.1B.310
Probe body materials	Glass-reinforced polycarbonate, FR4 fiberglass epoxy.
Weight	60 g (2.1 oz)
Dimensions	(see figure 3)

MFP-2.5 probe	
Analog signals	Magnetic flux density

	Pickup loop signal (field rate of change)
Hall sensor	
Field ranges	+/- 0.25 Tesla (+/-2.5 kGauss) +/- 0.025 Tesla (+/-250 Gauss) Selected by software control.
Sensitive area	0.5 mm square (0.25 mm^2)
Field direction	Field entering the marked top surface of the probe gives a positive field reading (see figure 4).
Absolute accuracy	Better than 0.8% of full scale of selected range at 25 C.
Temperature coefficient of gain	< 100 ppm C-1
Temperature coefficient of offset	< 0.2 Gauss C-1
Step response	Better than 250 usec to within 0.1% of full scale deviation from target setting for any instantaneous field step. Observed step depends on selected downsampling.
Resolution	Smallest increment of field 0.08 Gauss (0.25 Tesla range), 0.008 Gauss (0.025 Tesla range) before averaging.
Linearity	0.05 % maximum deviation relative to full scale of any point from linear fit to all points over full span.
Pickup loop sensor	
Ranges	+/- 200 T s-1 +/- 20 T s-1 Selected by software control.
Sensitive area	150 mm^2, five turns
Absolute accuracy	< 0.2% of full scale
Linearity	0.5 % maximum deviation relative to full scale of any point from linear fit to all points over full span.
Temperature coefficient of gain	< 0.05% C-1
Bandwidth	10 Hz to 50 kHz (- 3dB)
Connector	Lemo 10-way EXG.1B.310
Probe body materials	Glass-reinforced polycarbonate, FR4 fiberglass epoxy.
Weight	60 g (2.1 oz)

Dimensions	(see figure 3)

H10 control unit	
Digitization	16 bit successive approximation over full range
Sample rate	50 kSa s-1
Downsampling	Averaging from 4 to 50,000 conversions per reading
Calibration	Gain and offset values for each analog signal and each range stored in EEPROM.
Communications to loop controller	Fiber optic (10 Mbit/sec)
Data rate through to host computer	1 kHz typical, up to 10 kHz in lightly-loaded networks and fast host systems
Probe connector	Lemo 10-way EXG.1B.310
Controls	16 position rotary switch for loop address selection
Displays	Four LEDs (power, activity, network, device).
Power input	+24 VDC (+12 V, -4 V), 100 mA typical, 200 mA maximum.

Case	Stainless steel.
Case protection rating	The case is designed to rating IP43 (protected against solid objects greater than 1mm in size, protected against spraying water).
Weight	0.24 kg (0.55 lb).
Operating environment	0 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 1000Hz)
Shipping and storage environment	-10 to 50C < 80% humidity, non-condensing vibration < 2 g all axes, 1 to 1000 Hz
Dimensions	(see figures 1 and 2).
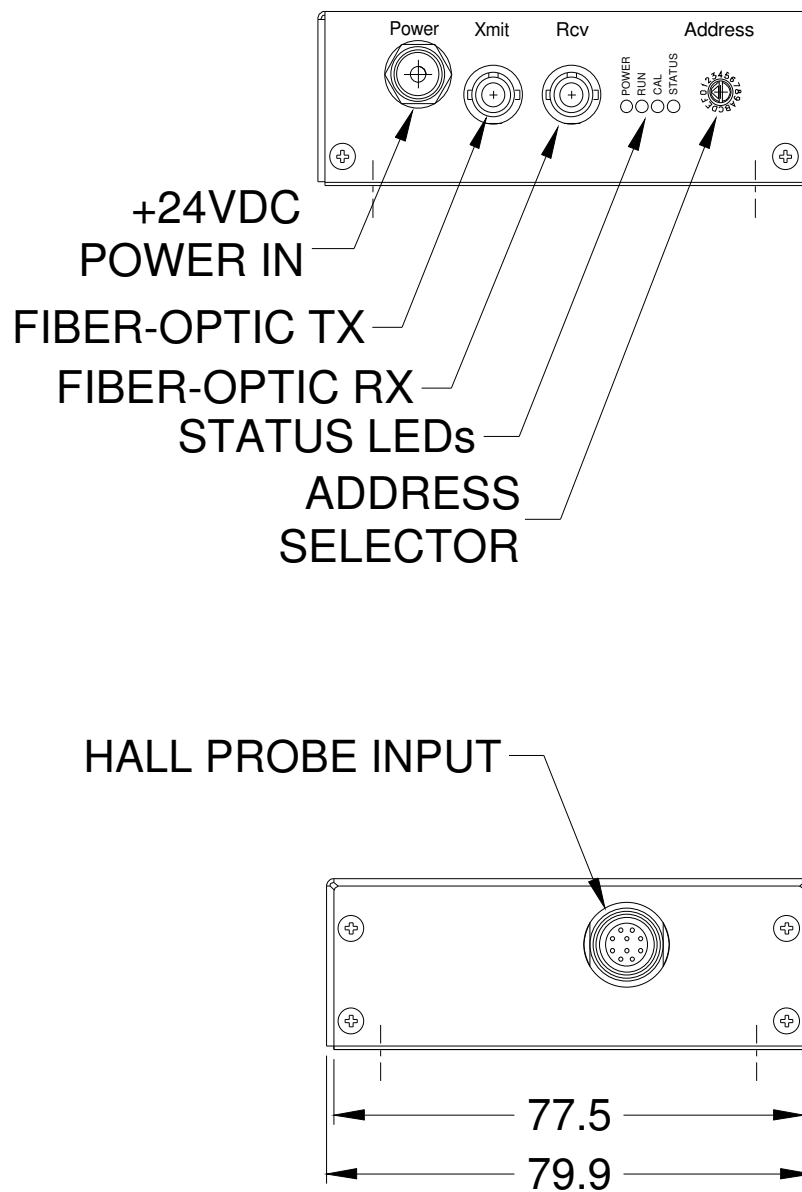
Figure 1.   H10 control unit end panels. Dimensions mm.

4X
Ø3.66 MOUNTING HOLE

3.8

114.0

62.0

103.7

28.1

0.60

121.6
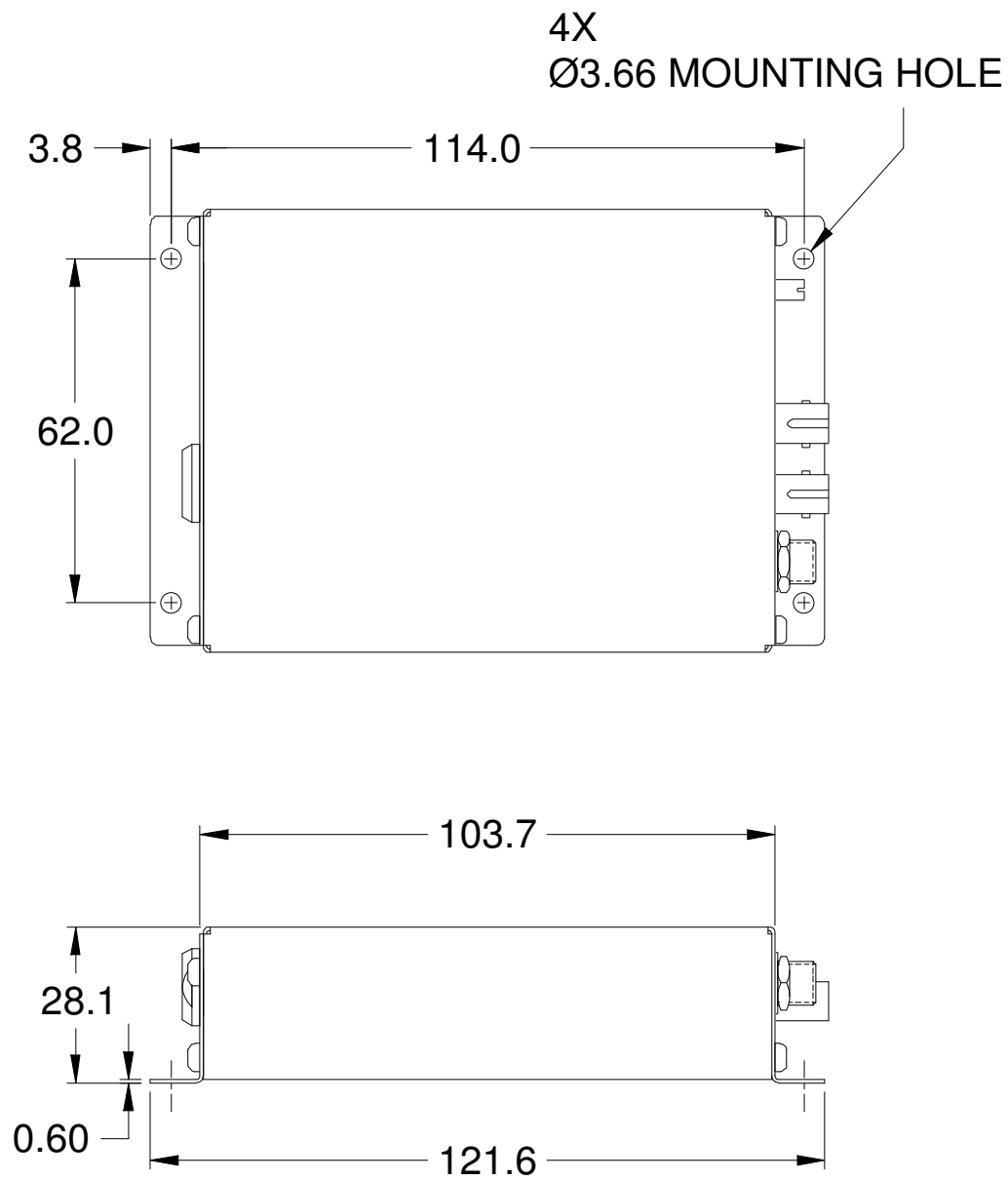
Figure 2. H10 control unit plan and side views. Dimensions mm.
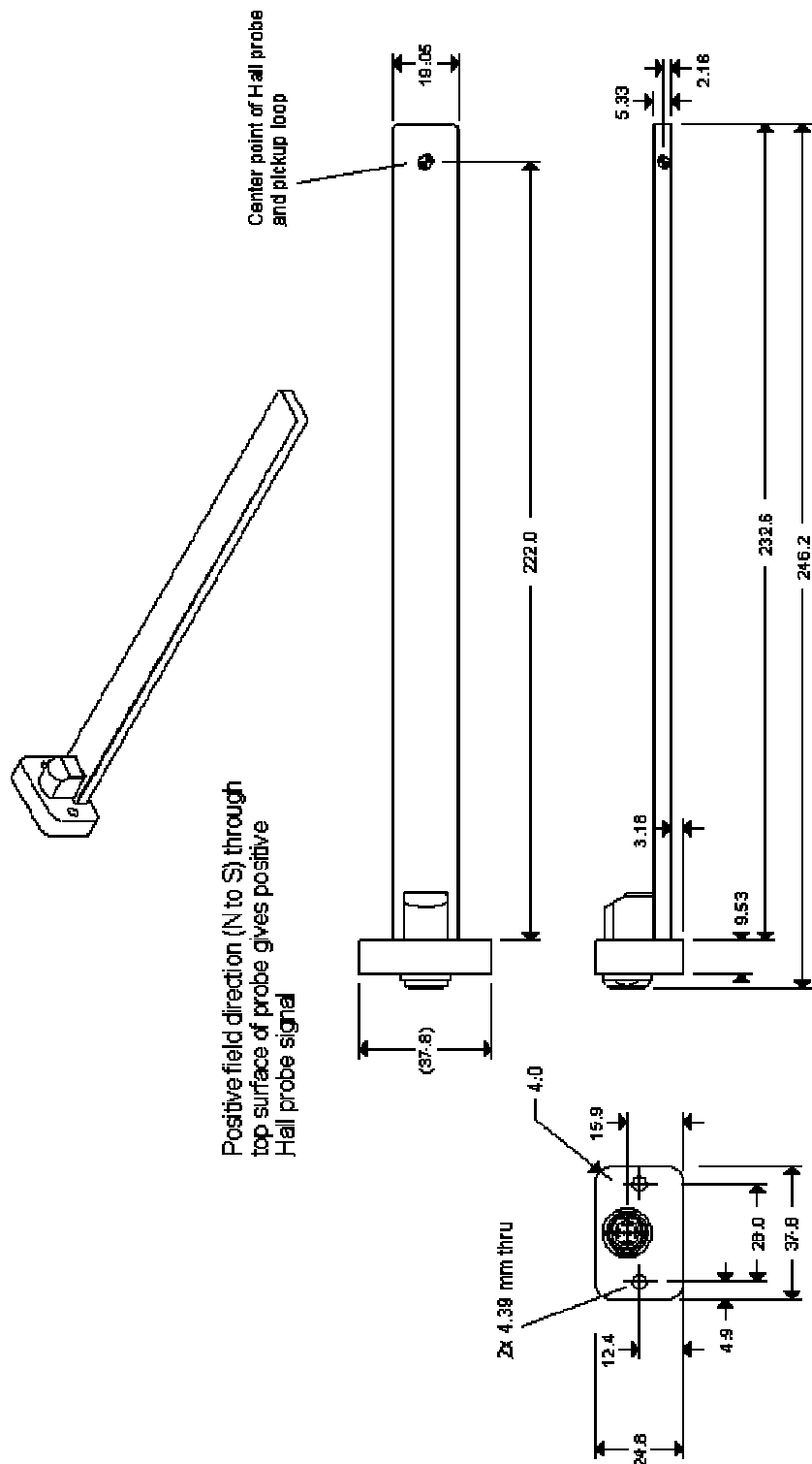
Figure 3. MFP25 and MFP-2.5 field probe geometry   Dimensions mm.

9 Installation

9.1 Mounting

The MFP probe should be mounted so that the sensitive spot is located in the field you want to measure. It will measure the field component normal to the flat surface of the probe. The polarity depends on the probe type. The MFP-25 probe will show a positive value for a field vector entering on the centre of the bullseye pattern.
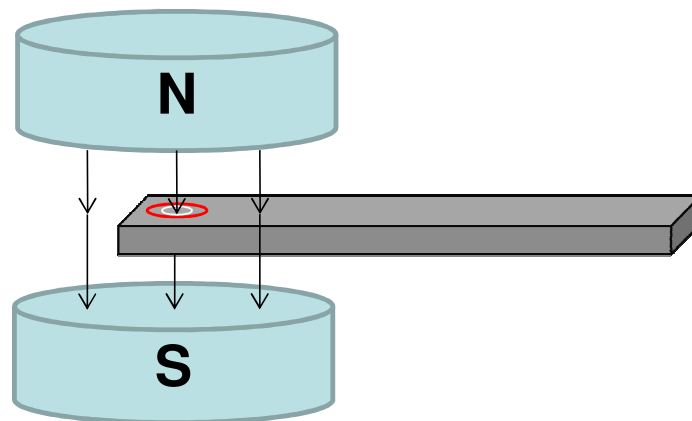
Figure 4. Probe orientation for a positive field reading (MFP-25 probe; +ve gain coefficient).

The MFP-2.5 probe will show a negative value for a field vector entering on the centre of the bullseye pattern.
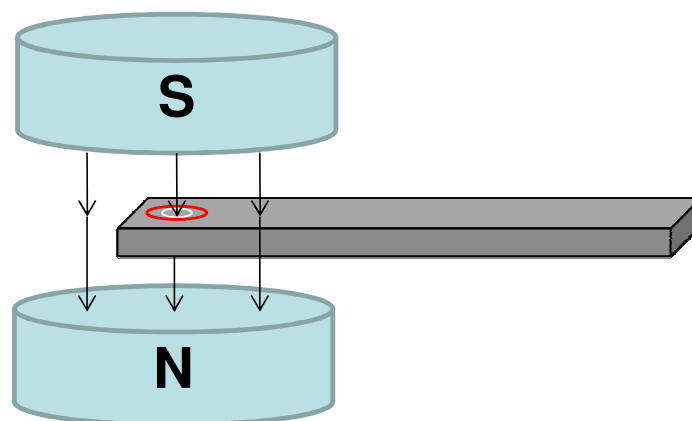
Figure 5. Probe orientation for a positive field reading (MFP-2.5 probe; +ve gain coefficient).

If you have both types of probe in your system, and want them to have the same response to field direction, then you can simply invert the calibration gain factor of one type to achieve this.

The mounting should prevent any tendency for movement or vibration, especially if the probe is measuring a fringe field where there is field curvature. If the field has significant AC components, the mounting should be non-conducting to avoid measurement errors due to eddy currents.

The H10 control unit must be mounted within cable reach of the MFP probe. Two standard cable lengths are available, 9 foot and 22 foot, with the shorter cable preferred for best noise performance. The control unit may be mounted in any orientation, or may be simply placed on a level surface. Four M3 clear holes are provided in the base flange on a 62 mm by 114 mm rectangular pattern (see figure 2). A DIN rail adaptor is available for the H10 control unit.

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.

H10 system includes temperature compensation, but you will get maximum precision if the control unit, and particularly the probe, are in a temperature-controlled environment. No forced-air cooling is required, but free convection should be allowed around the cases.

9.2   Grounding and power supply

A secure connection should be made via the H10 control unit 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. If you purchased your H10 as an end-user, a compatible power supply will have been provided.

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 H10 is tolerant of line voltage in the range 18 VDC to 36 VDC, although we recommend using a 24 V supply with reasonable output regulation, as indicated. The H10 includes an internal automatically re-setting PTC fuse rated at 1.1 A. However the external supply should in no circumstances be rated higher than the H10 connector limit of 5 A, and a maximum of 2.0 A is recommended.

9.3   Connection to equipment

9.3.1 Typical setup

Figure 6 shows a typical installation to monitor a magnetic field, in schematic form. An MFP probe is measuring a field component normal to the flat face of the probe. It is connected to the H10 control unit via the cable included with the H10 system. Note that this cable can be connected either way round. The H10 is on a fiber-optic communication loop, under control of one of the Pyramid Technical Consultants, Inc. loop controllers (A200, A360, A500, A560). Software on the host computer displays the field readings and controls provided by the H10.
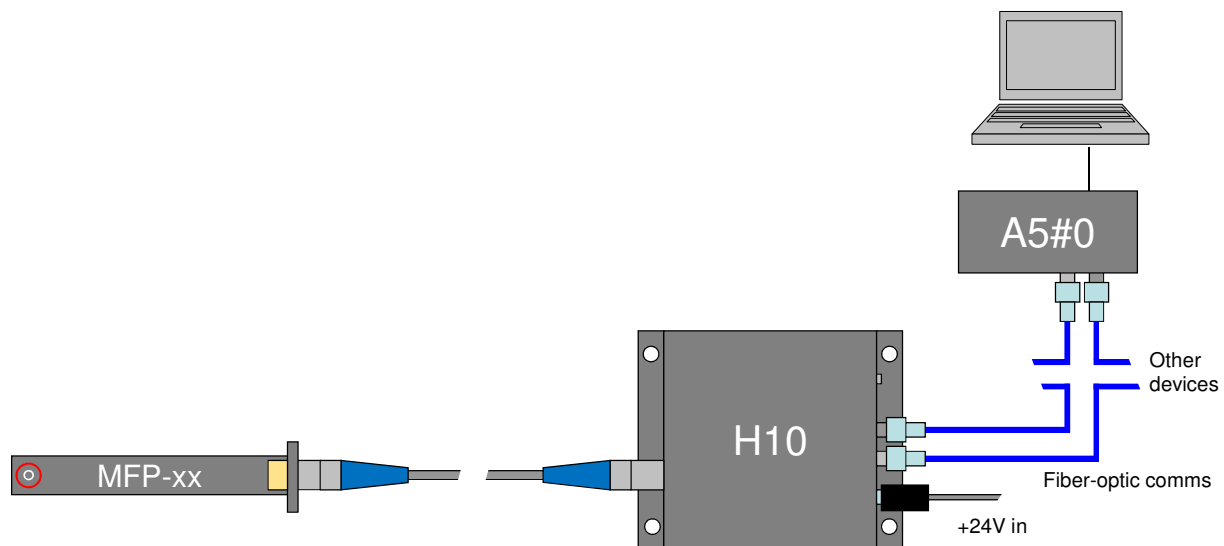
Figure 6. Schematic example H10 setup.

Once the H10 is included in such a system, it becomes practicable to implement closed-loop field control, as illustrated in figure 7. The example shows both H10 and M10 on the same fiber optic loop, but this is not essential. The M10 would typically be mounted on or in the power supply, whereas the H10 must be close to the magnet; magnet and power supply may be some distance apart. Software in the fiber optic loop controller, or in the host computer system, can control an electromagnet power supply to reach a target as measured by the H10, using an M10 general purpose I/O device to interface the power supply.
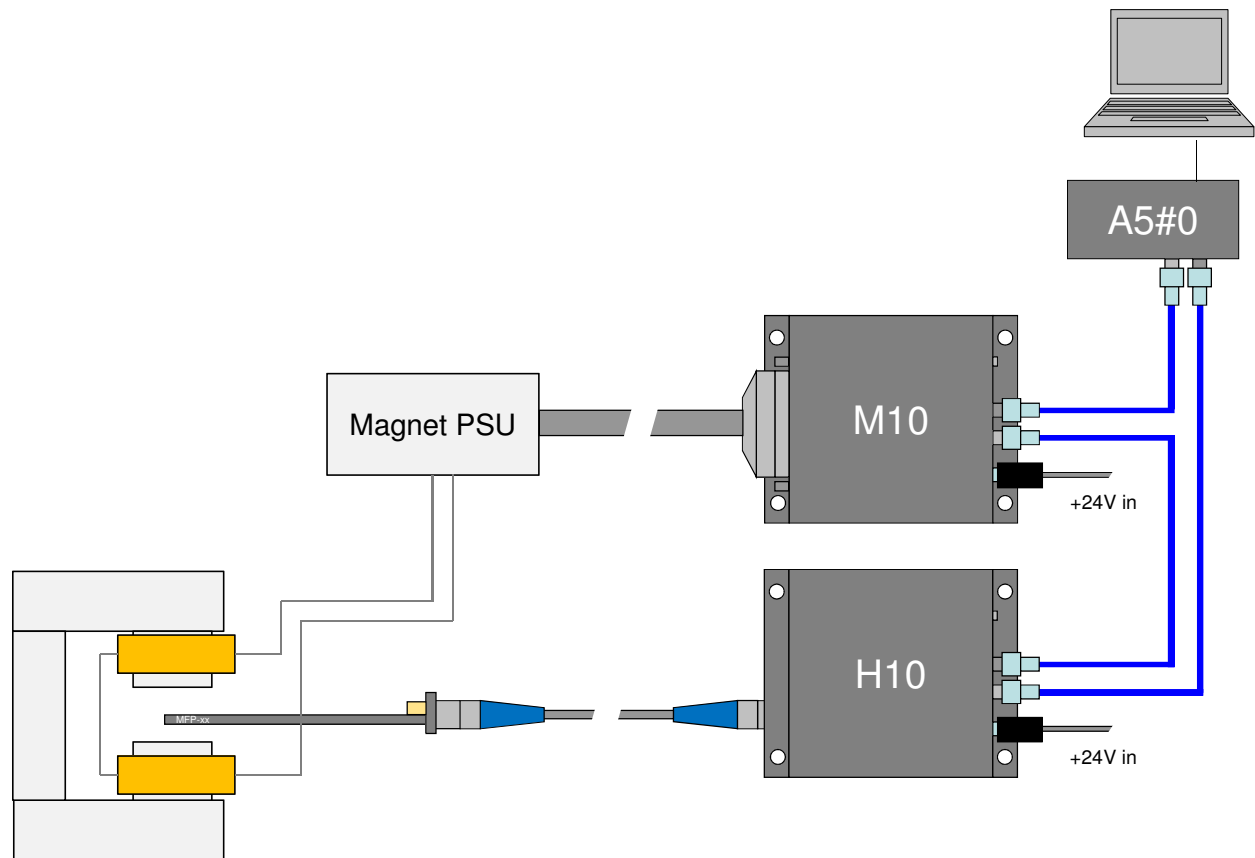
Figure 7. Schematic example setup for electromagnet field control.

10 Getting Started using the Pyramid Diagnostic Host Programs

Usually you will use a custom application to communicate with the H10, 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, and are provided with the H10 for end-user customers. There are two generations of the Diagnostic software, and the H10 is compatible with both.

PSI Diagnostic. This software supports all Pyramid products, apart from G2 devices. It allows you to connect the H10 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 and C400, plus a growing selection of other Pyramid devices, including the H10. It allows you to connect the H10 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 H10. 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.

It is useful to understand what you can do with the Diagnostic programs, because they expose all of the functions of the H10. Application programmers will find it useful to help decide which functions to implement in their host software.

10.1 Preparing the H10 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 the probe to the H10 control unit using the cable supplied. Connect 24 V DC power. 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 H10 has started correctly, and prior to connecting to a controller, the power LED will remain lit and the device LED will flash, showing that the device has automatically started measuring data.

It is simplest to start with to connect the H10 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 7 shows a connection to an A500. The A500 controller has a static IP address defined by a software setting of the first three bytes, and rear panel switches for the last byte. It is simplest if you set your PC to an IP4 static address in the same subnet range. For example if the A500 has address 192.168.100.213, then the PC could be 192.168.100.113, with subnet mask 255.255.255.0.
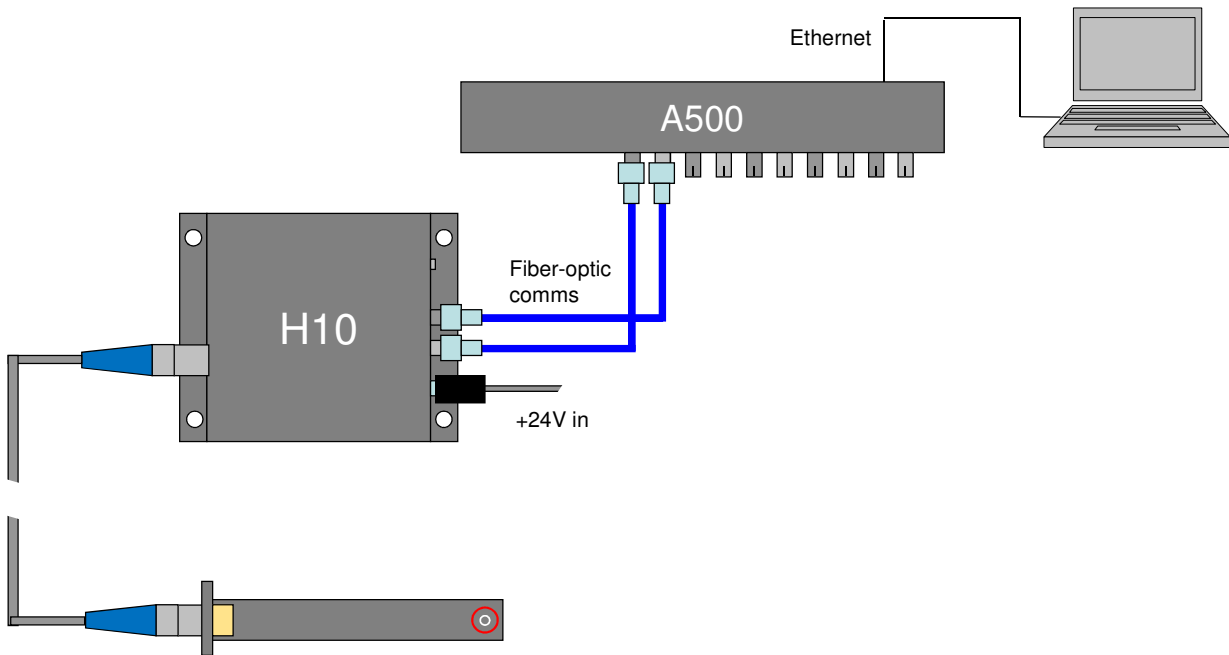
Figure 8. Example of a connection to the H10 via an A500 and Ethernet.

10.2 Installing and using the PSI Diagnostic Program

If you are an end-user, your H10 was shipped with a USB memory stick with the installation files you need. We recommend that you copy the files into a directory on your host PC. Check the Pyramid Technical Consultants, Inc. web site at 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. 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.

Install the PSI Diagnostic by running the PTCDiagnosticSetup.msi installer, and following the screen prompts. Once the program has installed, you can run it at once. It will allow you to connect to the H10, and, depending upon your setup, 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. 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 H10

Start the PSI Diagnostic. It will search the available ports on your computer and present a search list in an autodetect utility window. Figure 7 shows a case where the program found two serial ports and a network adaptor. One IP address was defined in a previous session with the program. We'll work through an example where the connection to the H10 is via an A500 at IP address

192.168.100.213. We can add this specific address to the network search to avoid the need to broadcast to the whole LAN by typing the address followed by a colon and the standard port number 100, as shown in the figure, and clicking "Add IP".
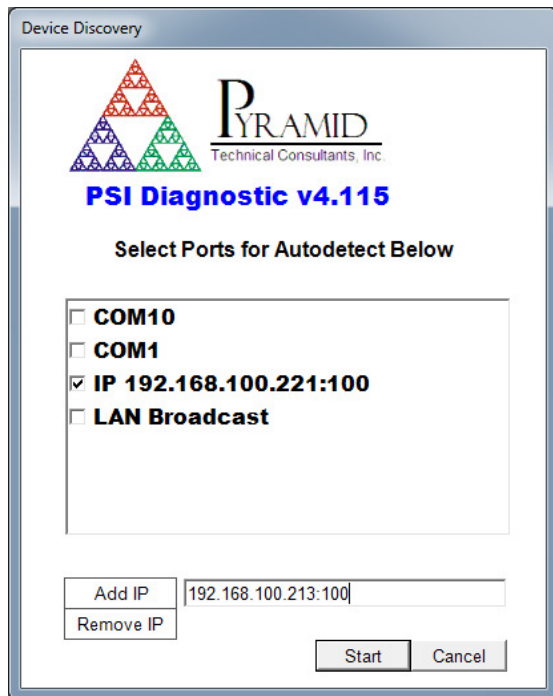
Figure 9. PSI Diagnostic Search Utility – adding a target IP address and port

Check that the target port is checked for inclusion in the search and click the "Start" button. The autodetection process will start (figure 10).
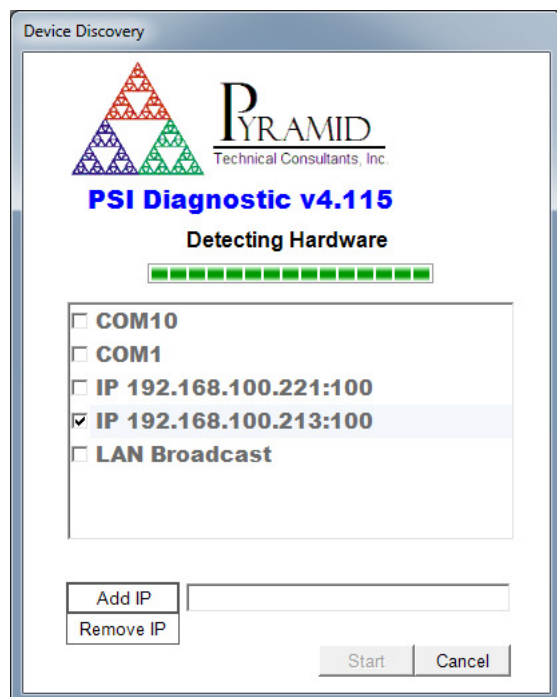
Figure 10. PSI Diagnostic Search Utility – detection in progress

After a few seconds the program should find the H10 (plus any other devices you may have connected). The System pane will show a tree of all the discovered devices. On the H10 control unit itself you should see the network LED illuminate regularly to show that loop messages are being processed.

10.2.2 Data tab

Clicking on the H10 entry in the explorer list will open the H10 window (figures 9 and 10) after a few seconds. The screen layout details depend which probe type you are using. The device will be acquiring data using default settings and you should see background noise values for the field reading. The Device LED on the H10 will flash to show acquisition is in progress (it will turn off if you abort the acquisition). You can display the signals either as a scrolling value against time graph (like a chart recorder) or as an analog bargraph. Toggle to one of the fixed Y scales if you want to inhibit autoscaling of the graph.
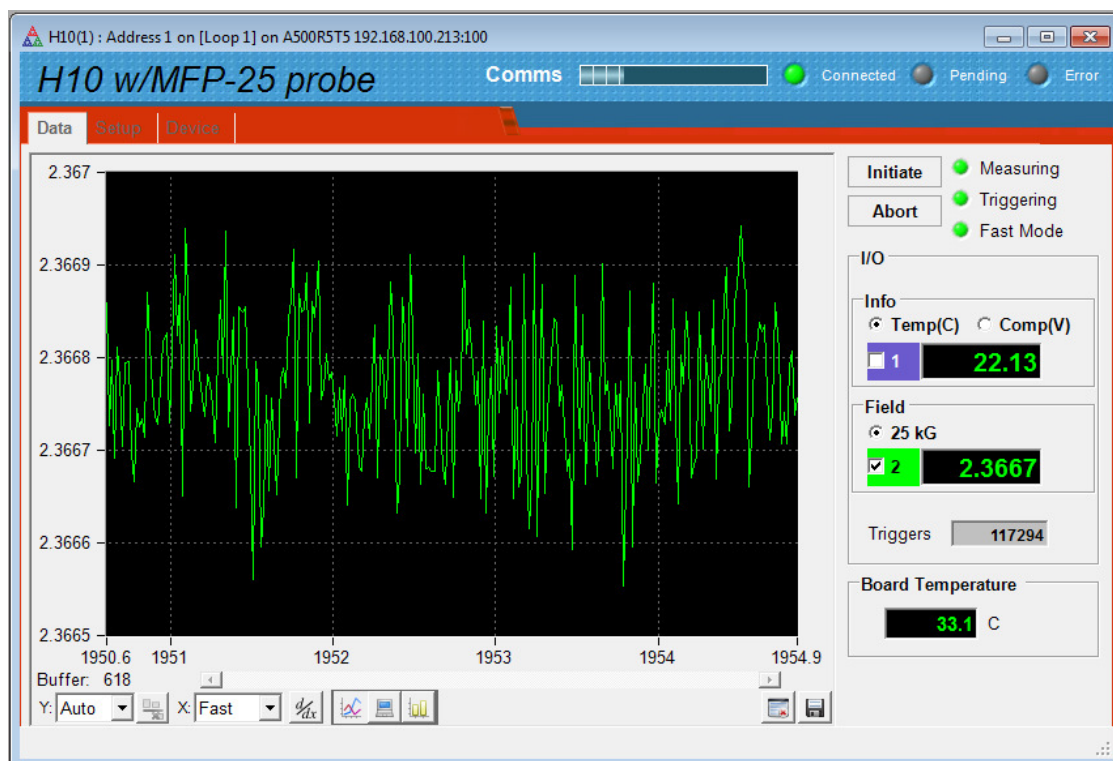
Figure 11. Data tab: MFP-25 probe.
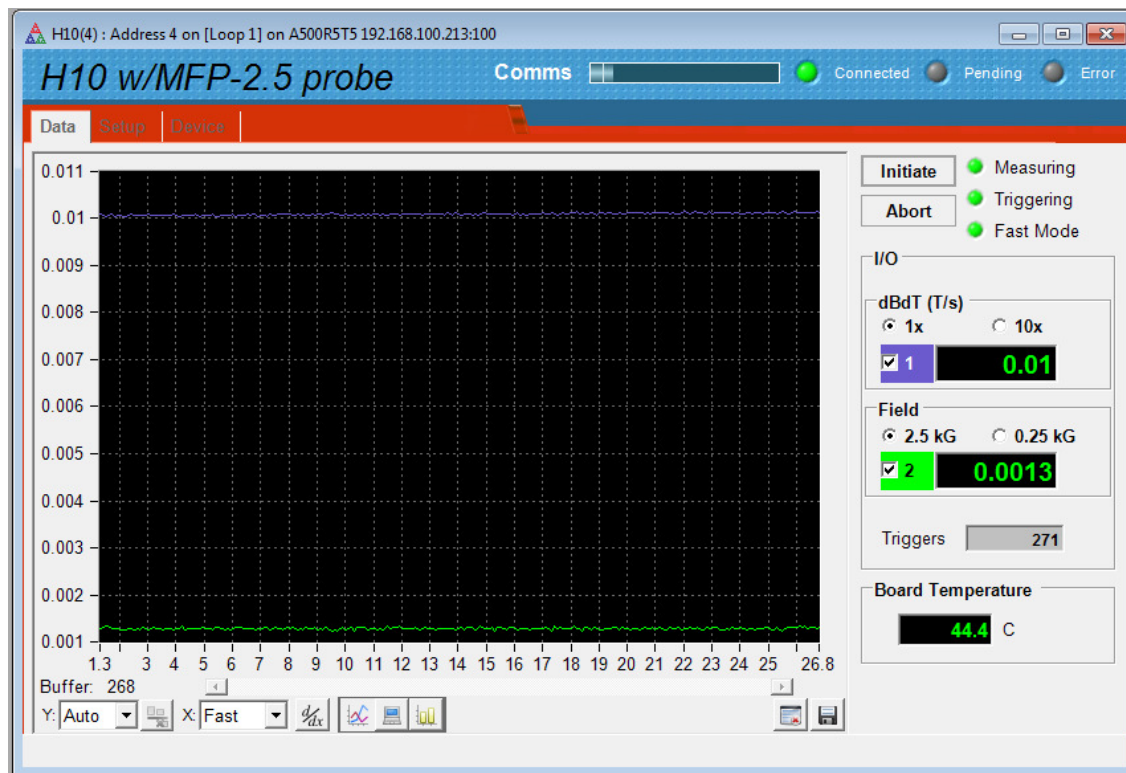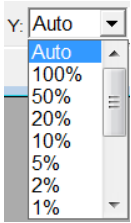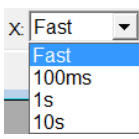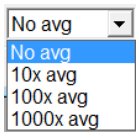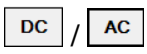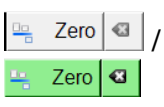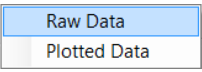
Figure 12. Data tab: MFP-2.5 probe.

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.

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

|	
Initiate / Abort	These buttons start and stop data acquisition. Screen LEDs indicate whether the H10 is measuring, triggered or streaming data to the controller in fast mode. On the H10 control unit, you will see the Device LED flashing when readings are being taken, and off when data taking is aborted.
I/O	The analog readings displayed depend on the probe type.
	For the MFP-25, analog channel one is used for the probe temperature sensor and the Hall sensor compliance voltage (the voltage required to establish the constant current). One or the other can be displayed. Analog channel two is used for the field reading +/-25 kGauss (+/-2.5 T).
	For the MFP-2.5, analog channel one is used for the dB/dt pickup loop signal, and you can select a low gain (x1, +/-20 T s-1) or high gain (x10, +/-200 T s-1) setting. Analog channel two is used for the field reading and you can select from a +/-2.5 kGauss
	The checked channels are displayed on the strip chart and scope mode displays. For example you may wish to uncheck channel 1 so that you can concentrate on the plotting of field. Note that this does not stop the data being collected – both channels are always logged.
Triggers	This counter shows the number of readings made by the H10 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.
Board temperature	This is a readback of the internal temperature of the H10 control unit in degrees centigrade.
Buffer Buffer: 22249	The PSI Diagnostic collects data coming from the H10 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. 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.

Y: Y: Auto ▾ Auto 100% 50% 20% 10% 5% 2% 1%	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. Note that if you have both analog channels checked, you will be plotting two different physical units at the same time, which can lead to lack of vertical resolution. Uncheck the reading you are less interested in and set a vertical scale for the remaining reading.
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: X: Fast ▾ Fast 100ms 1s 10s	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 No avg ▾ No avg 10x avg 100x avg 1000x avg	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 H10 itself. The PSI Diagnostic filter is a simple IIR type, $Y_{plot\_N} = Y_{new}/A + (1-1/A)Y_{plot\_N-1}$, where Y_{new} is the latest reading, Y_{plot_N} is the current value to be plotted, Y_{plot_N-1} is the prior plotted value and A is the averaging value from the pull-down menu. You clear and restart the filter at any time by pressing the reset button. 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.
DC/AC DC / AC	The DC/AC toggle removes the DC component from the strip chart or scope mode graphic data, but does not affect the digital display or the logged data.
Zero correction Zero / Zero	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.
Differential display	When this control is pressed, the graphic changes to display the difference between successive readings. The buffered data is not affected.
Graphic mode	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.

🖼	Clear buffered data. Values are cleared from the PSI Diagnostic data buffer, but any acquisition in progress continues and timestamps are not reset.
💾	Save data buffer contents to csv file. When you click this button you will see a drop down selection [Raw Data / Plotted Data] which allows you to save either the raw data, or the values with the PSI Diagnostic zero offset and averaging

10.2.3 Setup tab

Click on the "Setup" tab. Here you can alter scaling, polarities, averaging and calibration values. The details of the screen depend on the probe type.
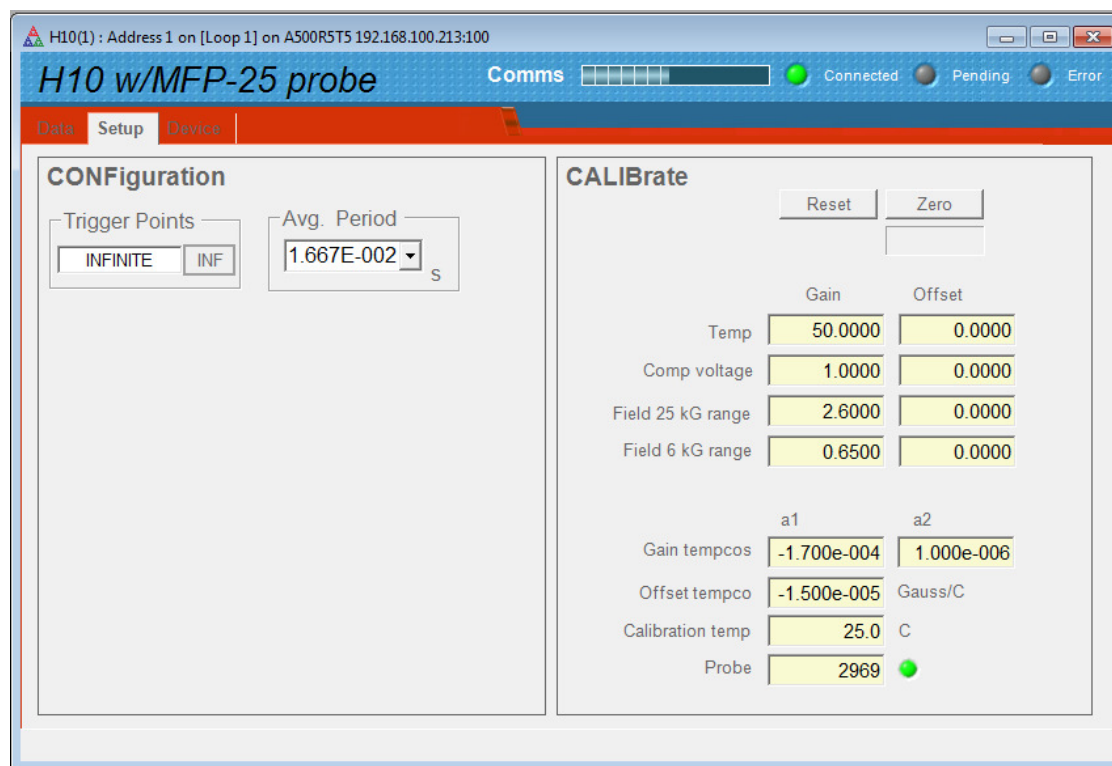
Figure 13. Setup tab – MFP-25 probe
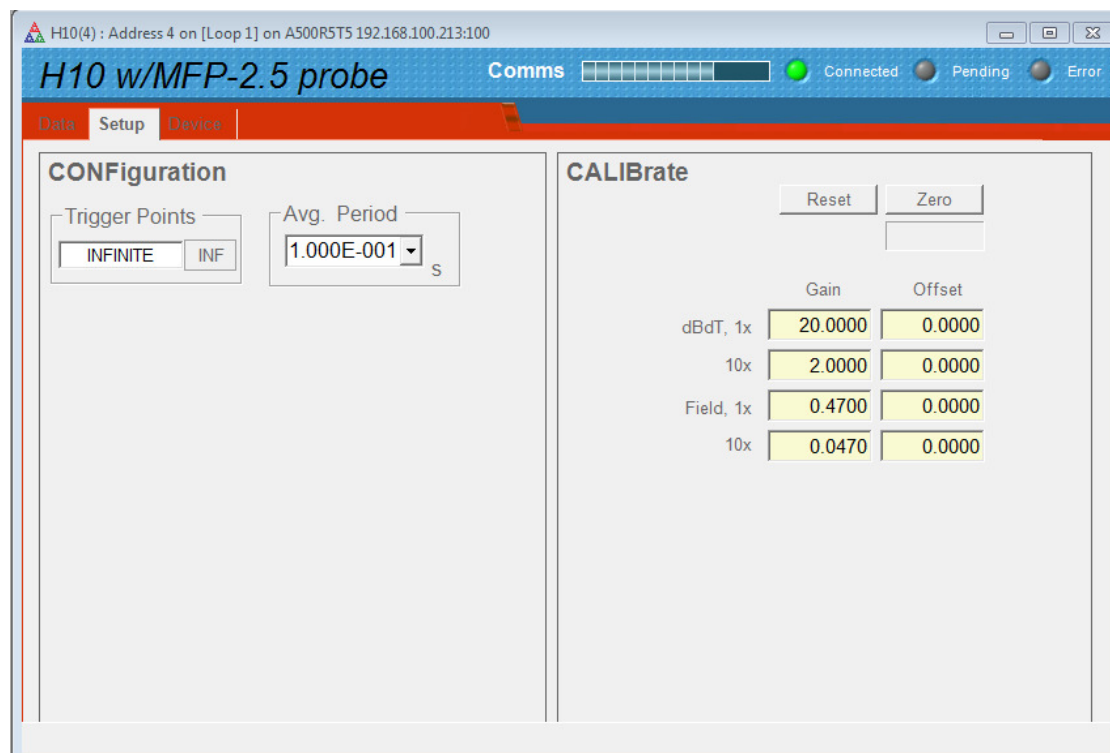
Figure 14. Setup tab – MFP-2.5 probe

Trigger Points	The number of readings that the H10 will take after being initiated. If you click the INF button, it will take readings indefinitely.
Averaging period	The two analog inputs are converted in the H10 control unit at 50 kSa/s. A digital filter then averages the samples over the selected period to give the final values that are transmitted back to the host system. The H10 starts up with the integration period set to the inverse of the mains frequency, as set on the Device tab.
Calibrate	These factors and offsets are determined during factory calibration of the probe and H10 unit, and should not need further alteration. The green LED by the MFP-25 probe serial number indicates that the original factory calibration is valid, provided you have that probe connected. See section 13 for more details.

Pressing the Reset button returns all gains to defaults and offsets to zero.

Pressing the Zero button starts an automated zero offset compensation in which the current zero values are measured for all relevant signals and ranges, and the results are used as the offset values. The probe should be shielded from magnetic fields before using this function. |

10.2.4 Device tab

Click on the "Device" tab. You can check the communication link status, read the H10 manufacturing serial number and verify the versions of the hardware and firmware. The page is the same for both probe types. On the right is the firmware update utility. You can use this to download firmware updates (.hex files) downloaded from the Pyramid Technical Consultants, Inc. web site.
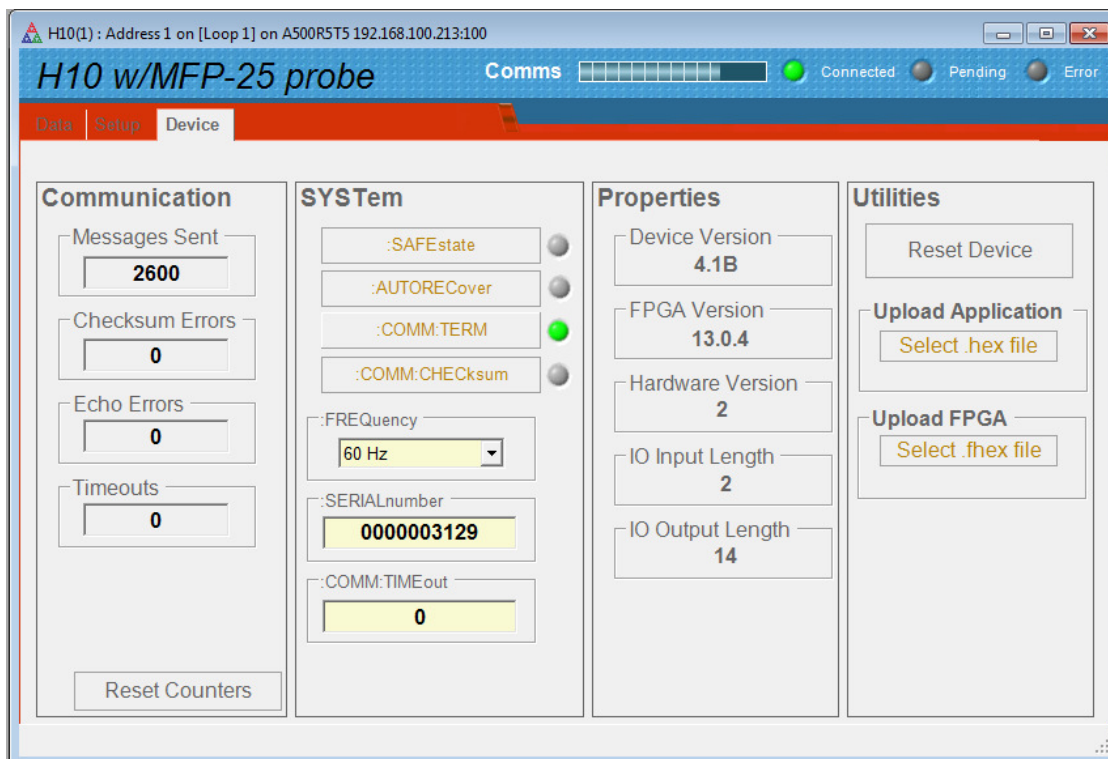
Figure 15. Device tab, showing firmware update utility controls.

Communication	The counters show details of the communications between the H10 and its host loop controller. You can click the Reset Counters button to reset the fields to zero.
System controls	Pressing :SAFEstate sets a mode in which the H10 goes to a defined safe state if it does not communicate with its host controller in the timeout period in seconds set by the :COMM:TIMEout parameter. Since the H10 is an input device only, this feature has little effect and can be ignored. If you want to disable this feature, set the timeout to 0. Pressing :AUTOrecover sets a state in which the H10 will attempt to restart automatically if it detects data corruption. The COMM:Term and COMM:Checksum controls are not used on the H10. You can ignore them when using the PSI Diagnostic 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.
Frequency	This parameter sets the averaging period that will be used by default on power up. You should set it to the local line frequency.
SerialNumber	This is the manufacturing serial number of the H10 control unit, and should be left unchanged.
Comm:Timeout	The time period in seconds without communications before the H10 goes to the safe state. Set to zero if you don't want this feature.
Select .hex file	This button starts the H10 PIC firmware update process. It opens a file selection dialog. When you select a hex file it will start uploading to the H10 immediately. Upon completion the H10 will restart automatically, and you will see the new Device Version number displayed. See section ## for more details.
Select .fhex file	This button starts the H10 FPGA firmware update process. It opens a file selection dialog. When you select a fhex file it will start uploading to the H10 immediately. Upon completion you will need to power cycle the H10, which will cause the new code to be loaded. You will see the new FPGA Version number displayed. See section ## for more details.
Reset	This button causes a full warm reset of the H10.

10.3 Installing and using the PTC G2 Diagnostic 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 H10 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 H10 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 H10 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 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 H10

Start the PTC Diagnostic G2. The program expects all connections to devices like the H10 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 various controllers. If your target controller is not discovered, then you can force it to be probed by adding its IP address specifically. Unlike the PSI Diagnostic, you do not need to include a port number. The A60 Recovery entry is a diagnostic utility used for some G2 devices, which you can ignore.

Note that the "Not Connected" message returned by A500 controllers can be ignored. This field will be used in a future firmware release to show the IP address of the host device (your computer).
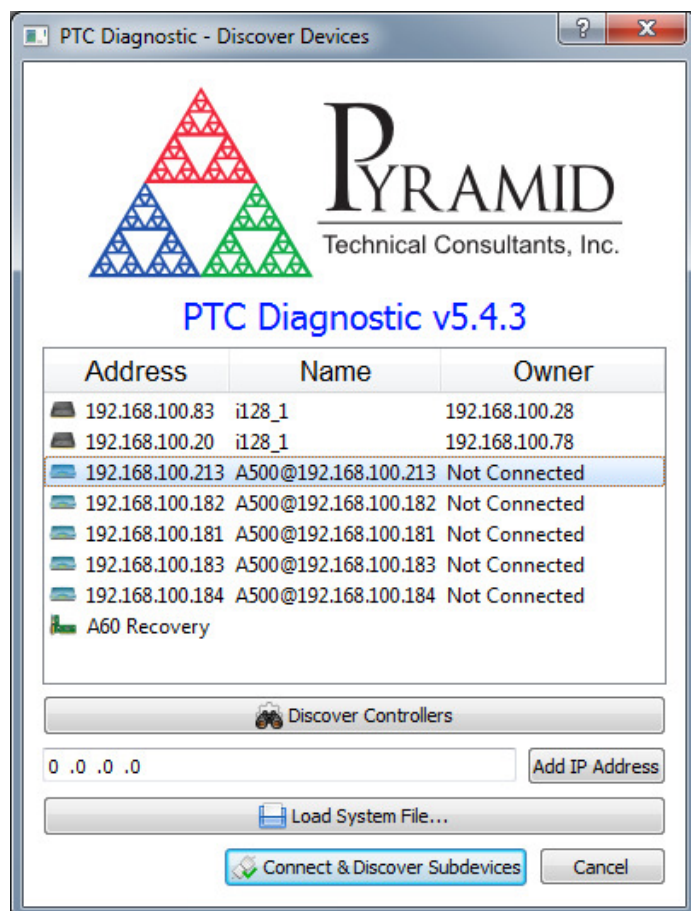
Figure 16. PTC Diagnostic G2 discovery dialog after Discover Controllers.

Highlight the target device, which is an A500 at 192.168.100.213 in this example, 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 sub-devices shown.
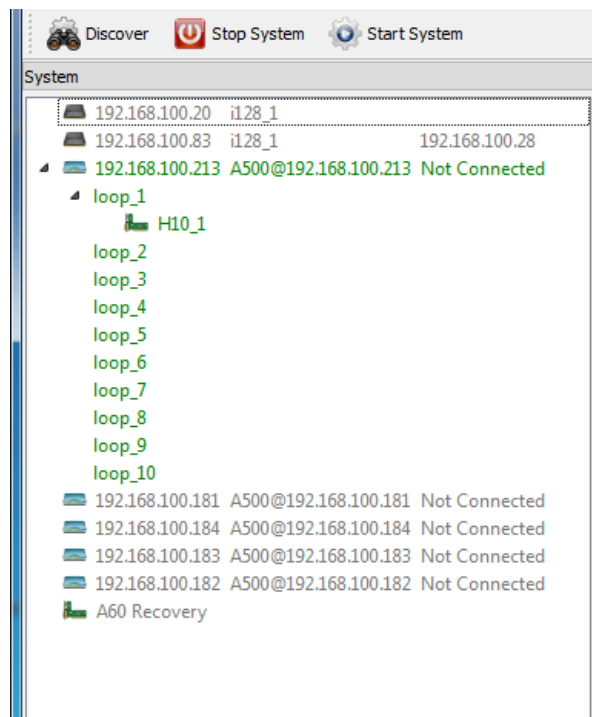
Figure 17. System pane showing an H10 connected via an A500 controller

Clicking on the H10 entry opens a window for it, with the same basic strip chart and histogram graphing options, and digital displays as used in the PSI Diagnostic.

(H10 support will be added to a future G2 Diagnostic release)

Figure 18. H10 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 H10 parameters.

The Setup and Calibration buttons access areas that provide the same functions as the PSI Diagnostic Setup tab.

The firmware update utility is accessed on the Properties area.

11 Magnetic Measurements

11.1 Measures of Magnetic Field Strength

Hall probes measure the magnetic flux density (also called magnetic induction), but it is useful to see how this related to other measures of the magnetic field.

There is a field around a current carrying conductor or a permanent magnet that exerts a force on other current carrying conductors, moving charged particles, and compass needles. The force is proportional to a measure of the field called the magnetic flux density. This is measured in teslas (T), or kg m s-2 A-1 m-1 = kg s-2 A-1 in SI base units. One tesla is a high field by everyday standards, and is typical of the field in the air gap of a particle beamline bending dipole electromagnet. The old cgs unit is the Gauss, and this is still widely used.

1 T = 10e4 Gauss

1 T = 10 kGauss

The Earth's magnetic field is around 0.5 Gauss at the surface of the Earth, varying with location from about 0.25 to 0.65 Gauss.

It is common to describe the resistance of an energetic charged particle to being deflected by a magnetic field by its magnetic rigidity, measured in Telsa meters (Tm). A one Tm beam in a one T dipole field will bend with a radius of one m. An example of a one Tm beam would be 46.75 MeV protons.

The magnetic flux Φ which gives rise to the magnetic flux density is measured in Webers.

1 T = 1 Wb m-2

The old cgs unit of magnetic flux is the maxwell, but this is rarely used (1 Wb = 10e8 Mx).

You can consider that the magnetic field arises from a magnetizing field, H, which is due to the motion of charged particles, usually electrons. In the SI system H is measured in amp per meter. A magnetizing field H produces a magnetic flux density

$B = \mu H$

where μ is the permeability of the local medium. In vacuum the permeability $\mu_0 = 4\pi \times 10^{-7}$ henry m-1. The permeabilities of other materials are expressed relative to this. In ferromagnetic materials the relative permeability may be hundreds or thousands. Air has a relative permeability of very nearly one, however, thus when you measure the B field with the H10 system, you also get the H field in A m-1 after division by μ_0.

The old cgs unit for magnetizing field is the Oersted.

1 Oe = 1000/4π A m-1

and in vacuum 1 Oe creates 1 Gauss.

11.2 Field vectors

The B field is a vector field, which you can decompose at any point into three orthogonal components. Magnetic field lines are assumed by convention to point from the north pole to the south pole of a magnet, A compass will point to the south pole of a magnet (thus there is a south magnetic pole at the Earth's magnetic north pole).
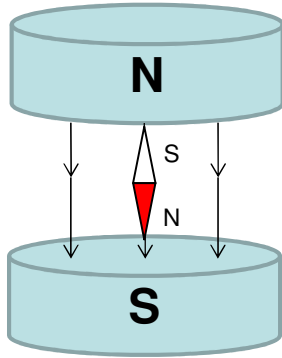
Figure 19. Direction convention for magnetic field lines

The MFP probe measures the field component that is perpendicular to the flat face of the probe, at the position of the bulls eye mark. If you orient the MFP-25 probe so that the field vectors point into the bulls eye, you will get a positive field reading, as shown in figure 20, where you can also see the deflection direction of a positive ion beam for the illustrated field direction, and the current direction in the coils of an electromagnet producing the field.
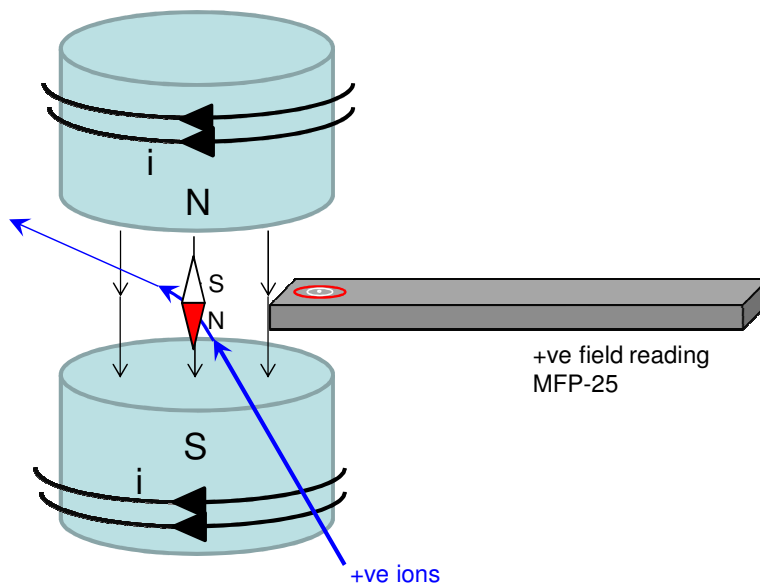
Figure 20. Direction convention for magnetic field lines

The sign of the field reading assumes you have a positive calibration gain value. Should you wish to reverse the directionality, then you must make the gain factor negative.

11.3 Rate of Change of Magnetic Flux Density

Any conductor loop which encloses an area through which the magnetic flux is changing with time will have a current induced in it. If the loop is not shorted, there will be a voltage induced across the terminals that is the negative of the rate of change of B integrated over the surface area of the loop.

$$V = -\frac{d}{dt}\int_{S} B.ds$$

We can assume that the loop area is small enough that B is constant over its area, so we have

$$V = -\frac{dB}{dt}A$$

where is the area of the loop. Thus we get a direct reading of the rate of change of the field. In the MFP-2.5 the effective area of the loop is increased by having five superimposed loops in series, for a total area of 150 mm^2.

12 Circuit overview

12.1 MFP-25 Probe
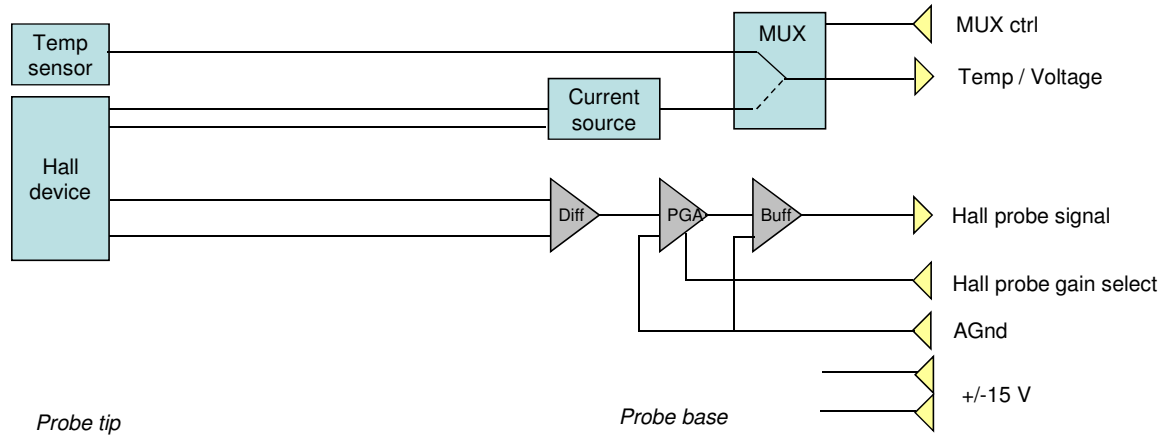
Figure 21. MFP-25 probe block schematic.

The MFP-25 probe uses the very high performance HE244 Hall device, which provides extremely low noise and drift. A 1 mA constant current is provided from a current source. Current stability is ensured by a precision voltage reference and high precision resistor. The Hall effect voltage is amplified x10 by a differential instrumentation amplifier. A following programmable gain amplifier is ground referenced and can selected for x2 gain for the 25 kGauss range, or x8 gain for the 6 kGauss range. The 6 kGauss range is not used by the PSI Diagnostic software. A unity gain buffer delivers the signal to the output connector.

A temperature sensor is located at the probe tip close to the Hall device. A MUX switch selects either the temperature signal or the compliance voltage that the current source is generating. It is possible to use this voltage as a measure of temperature also.

Connections to the devices at the probe tip are made using screened twisted pair traces.

12.2 MFP-2.5 probe
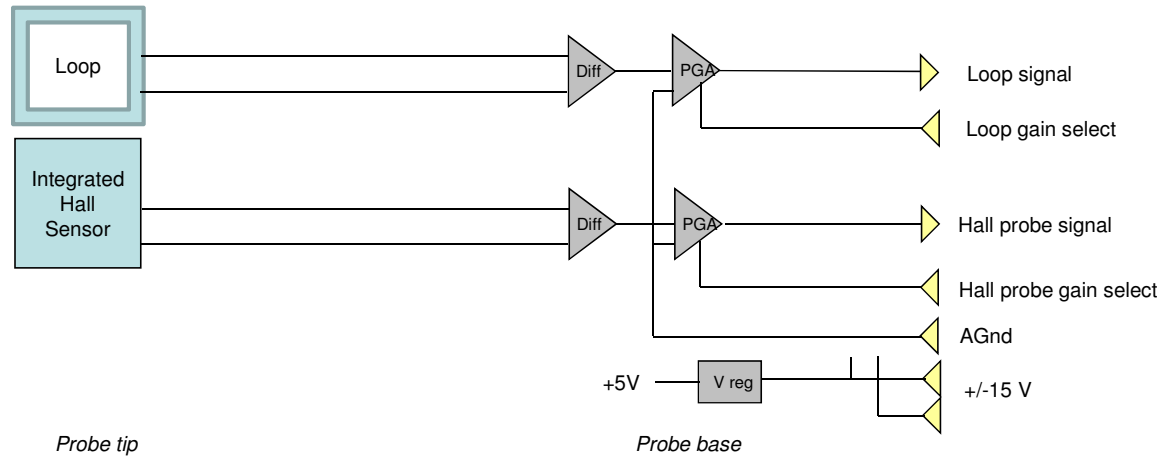
Figure 22. MFP-2.5 block schematic.

The MFP-2.5 uses an integrated Hall sensor which has the current source and temperature compensation included. The field signal is amplified x5 by a differential amplifier, then by either x1 or x10 by a programmable gain amplifier.

The loop signal is amplified x64 by a differential amplifier, than by another x1 or x10 by a programmable gain amplifier.

A regulator creates a local +5V rail from the incoming +15V.

12.3 H10 Control Unit
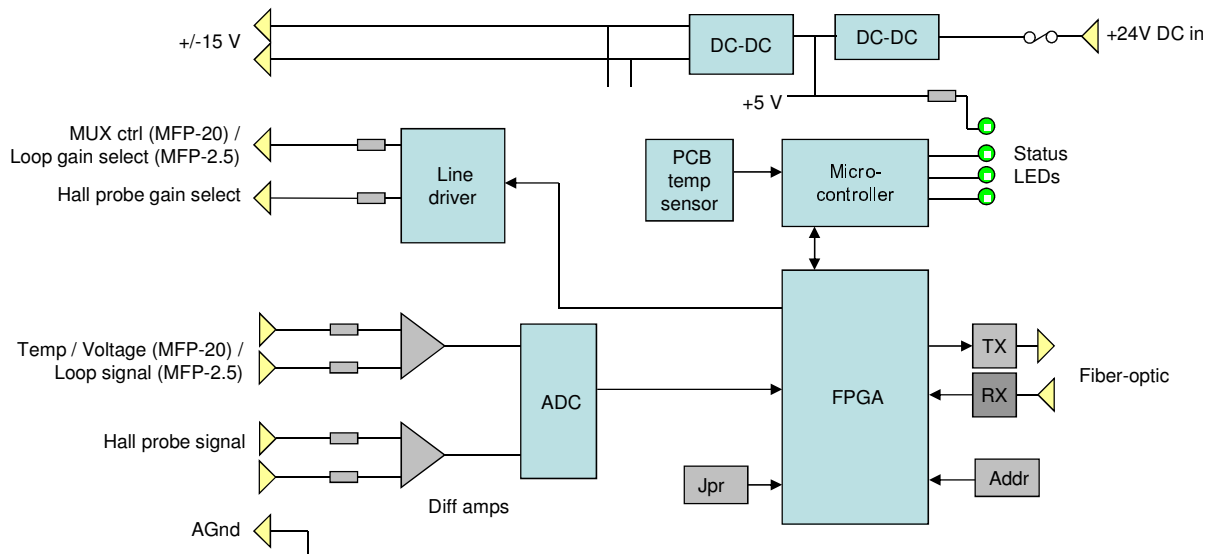
Figure 23. H10 control unit block schematic.

The H10 control unit is derived from the widely-used M10 general purpose I/O device. A field programmable gate array (FPGA) handles all input output, and communicates with the PIC microcontroller via an internal bus. The microcontroller stores calibration values in its internal EEPROM.

The analog inputs are connected to differential amplifiers. The negative inputs are referenced to analog ground in the probes. A 100 kSa/sec ADC multiplexes the two inputs, so that each is sampled at 50 kSa/sec. Any ADC over-ranges are flagged and communicated to the host computer along with the digital input bit pattern.

An on-board thermistor is used to measure the H10 board temperature. It is read by a 10-bit ADC integrated in the PIC microcontroller. A two position jumper informs the microcontroller what probe is connected, and a 16-position switch sets the fiber optic loop address. An internal 10-position switch is no longer used.

Incoming 24V power is fused, polarity protected and filtered. It is used to supply isolation DC-DC converters which create the internal voltage rails, and provide +/-15 VDC for the probe.

13 Calibration

13.1 Calibration Parameters

The H10 uses a number of calibration parameters to convert the raw values delivered by the ADC (analog to digital converter) into accurate, physically meaningful readings.

Reading = $\text{Gain} * V_{meas} - \text{Offset}$

where V_{meas} is the measured signal at the ADC, and we have normalized out the nominal conversion gain of the ADC $(=2^{16}/20$ bits per volt).

These parameters incorporate the conversion gains of sensors such as Hall devices, pickup loops and temperature sensors, and the amplifier gains and offsets of the circuits in the probes and the H10 control unit. In manufacture the probe and H10 control unit are calibrated against a reference field probe over a wide range of fields to determine the exact calibration parameters. The probe and H10 thus form a matched pair.

13.2 Temperature Coefficients

Hall probes work due to migration of electrons in a bulk semiconductor, and thus the signal for a given field depends on the mobility of these electrons which in turn upon temperature. The MFP-2.5 probe integrates temperature measurement and compensation, and the output signal is temperature corrected. The MFP-25 probe includes a separate temperature sensor, and the compensation is carried out in real time using coefficients stored by the H10 control unit by the A500 loop controller that receives its data.

There are two components to the temperature compensation, a zero field offset coefficient and a gain correction. The gain correction allows a first and second order term. A reference temperature is recorded as part of the factory calibration. The factory calibration is linked to the serial number of the probe. You should be sure that the probe you have connected matches the serial number shown on the Setup tab. The green LED on the Setup table illuminates when neither the probe serial number nor calibration coefficients have not been altered since factory calibration.

Measurements then use the difference ΔT between the measured temperature and the reference to correct the measured field

$B_{corr} = B_{meas} * (1 - (a_{gain1} * \Delta T + a_{gain2} * \Delta T^2)) - a_{off} * \Delta T$

where B_{meas} is the field reading before compensation, a_{gain1} and a_{gain2} are the first and second order gain coefficients and a_{off} is the offset coefficient. Figure 24 illustrates how the correction functions for the measurement of a fixed field over a typical operating temperature range.
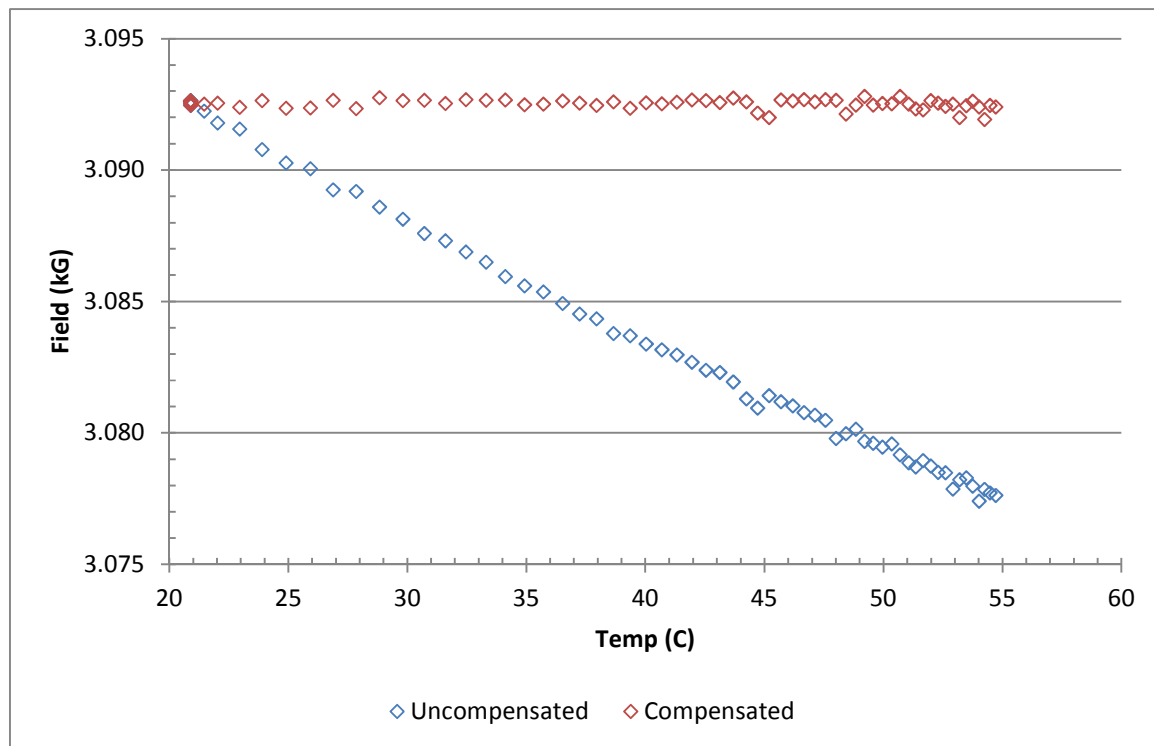
Figure 24. Example of MFP-20 temperature compensation.

14 Connectors

14.1 H10 control unit front panel connectors

14.1.1 Probe connection

Ten pin Lemo EXG.1B.310 female. The connector on the MFP probes is identical.
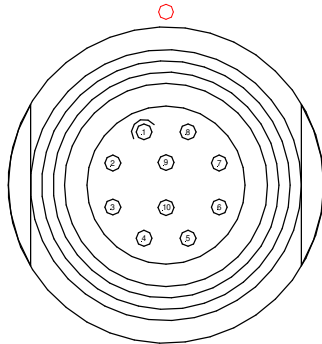
External view on connector / solder side of mating plug. Pins numbered anticlockwise from top left, with 9 and ten in the centre.

MFP-25 probe

1	Cable shield	6	Temperature / voltage signal
2	Analog ground	7	Analog ground
3	Hall sensor signal	8	Analog ground
4	Hall gain select	9	+15 VDC
5	MUX control	10	-15 VDC

MFP-2.5 probe

1	Cable shield	6	Pickup loop signal
2	Analog ground	7	Analog ground
3	Hall sensor signal	8	Analog ground
4	Hall gain select	9	+15 VDC
5	Pickup loop gain select	10	-15 VDC

14.2 Rear panel connectors

14.2.1 Power input

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

Center pin: +24VDC

Outer: 0V
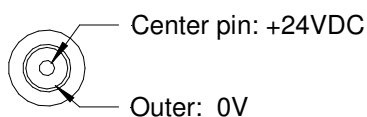
14.2.2 Fiber-optic communications

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).
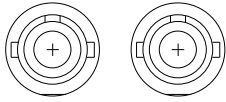
Transmit
(light grey)

Receive
(dark grey)

15 Controls and Indicators

15.1 Front panel controls

None.

15.2 Rear panel controls

15.2.1 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.

15.3 Front panel indicators

None.

15.4 Rear panel indicators

Quad green LED.

- Device
- Network
- Activity
- Power
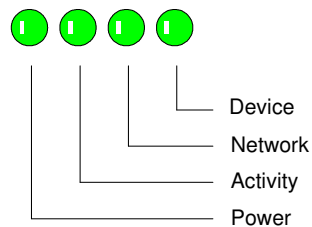
15.4.1 Power

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

15.4.2 Activity

Green LED.   Flashes for 100 msec when H10 has received digital output setting such as gain change.

15.4.3 Network

Green LED. Flashes when H10 is processing messages on the fiber-optic channel.

15.4.4 Device

Green LED. Flashes on for 100 msec with period (250 msec + averaging time) when H10 is initiated and acquiring data.

15.5 Internal settings

We do not recommend that you open the H10 case unless specifically instructed to do so by your supplier or Pyramid Technical Consultants, Inc. Otherwise, there are no user-serviceable parts inside.
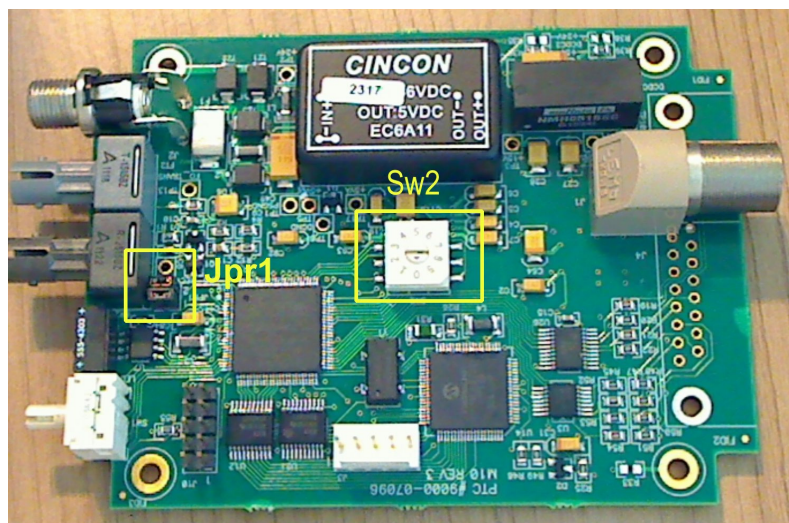
Figure 25. Location of internal switches and jumpers.

15.5.1 SW2 settings

Communications mode switch. Not used on the H10, reserved for future use.

15.5.2 JPR1 settings

Probe identification.

Links	Function
None	MFP-2.5 probe.
1	(Reserved)
2	(Reserved)
1 & 2	MFP-25 probe

16 Software updates

The H10 has three embedded firmware releases.

Firmware	Function
FPGA (.pof 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, range control, host communications, SCPI instrument model.

The boot code is unlikely to require updating. It requires use of a programming adaptor. A factory recall will be issued if an update is ever necessary. The two other codes can be updated by upload from the host computer via the normal communications link.

16.1 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.
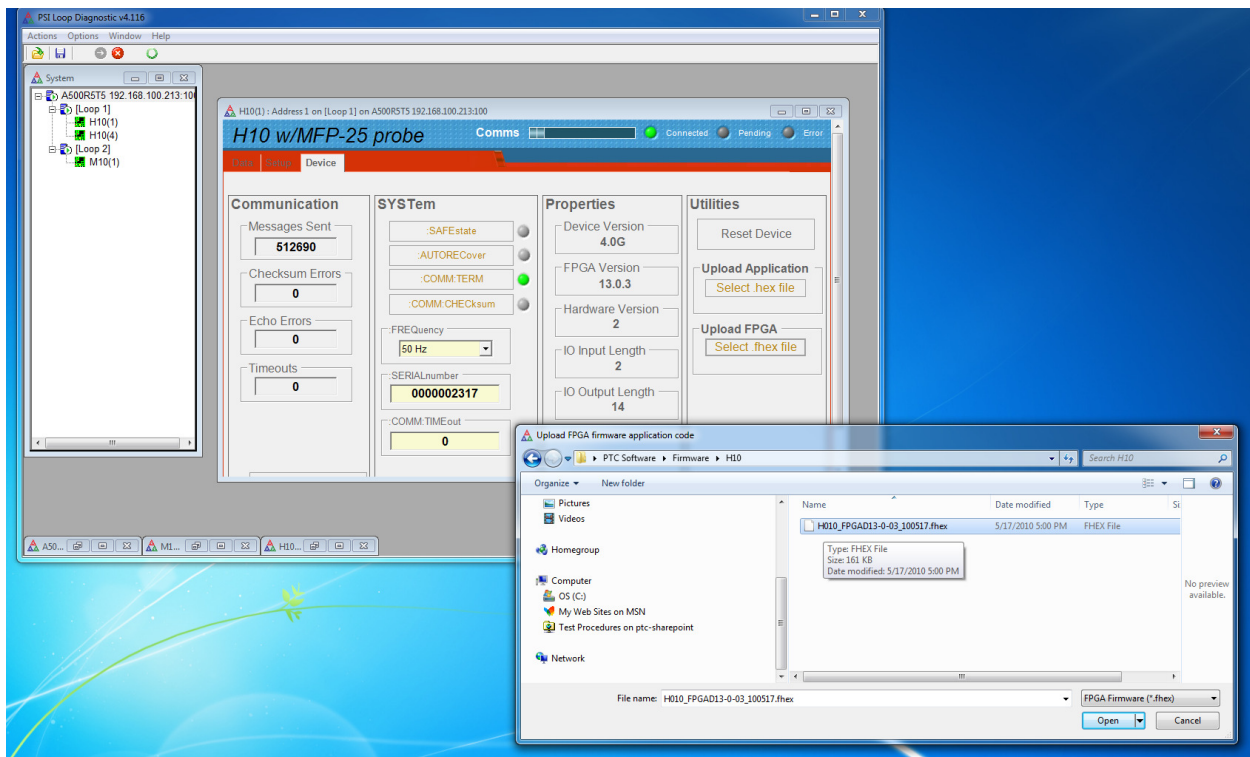
Figure 26. Selecting the fhex file to load.

When the upload is complete, you will get a prompt to power cycle the H10 in order to load the new code.
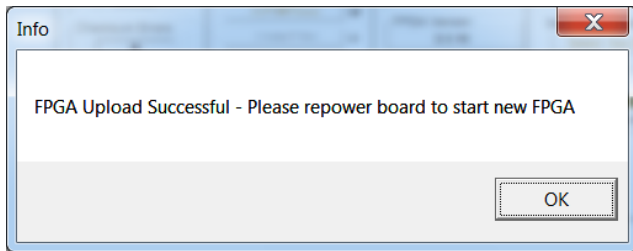
Figure 27. Restart prompt after FPGA update.

If the FPGA upload fails for any reason such as loss of power during the upload, or data corruption, then the H10 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.

16.2 PIC microcontroller firmware updates

The 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 hex file can be loaded using the PSI Diagnostic host without any need to access the unit. The upload can be performed directly from the PC host. On the Device tab, click the "Select .hex file" button and navigate to the relevant file. The code will then load. The process takes about 20 seconds, and the H10 will start running the new code immediately.
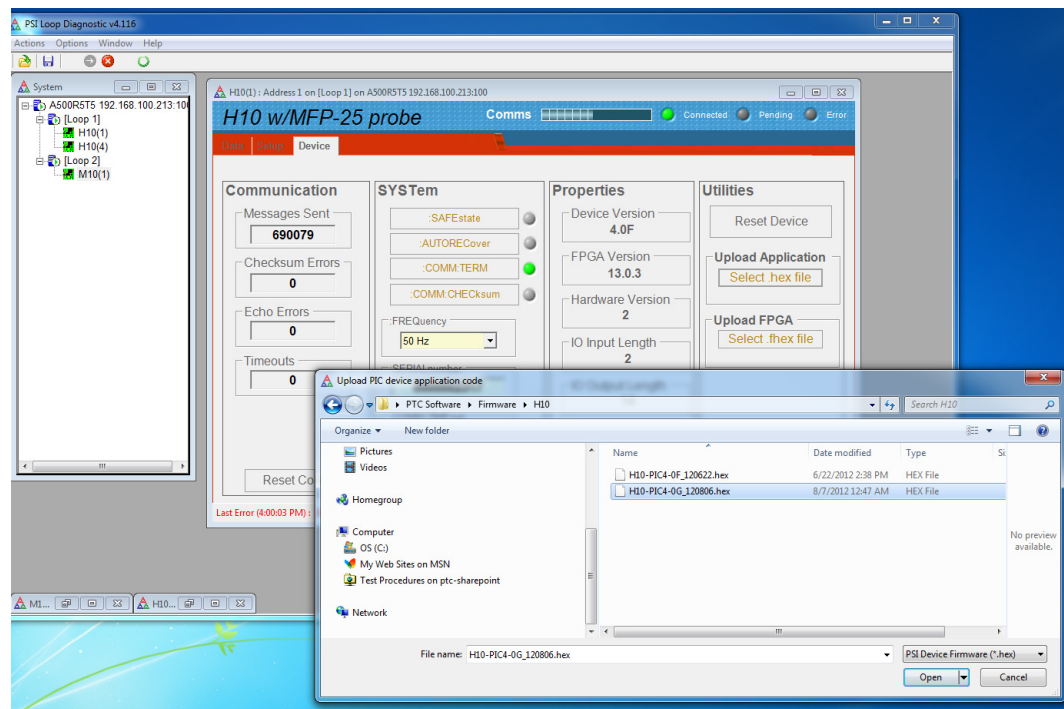
Figure 28. Selecting the hex file to load.
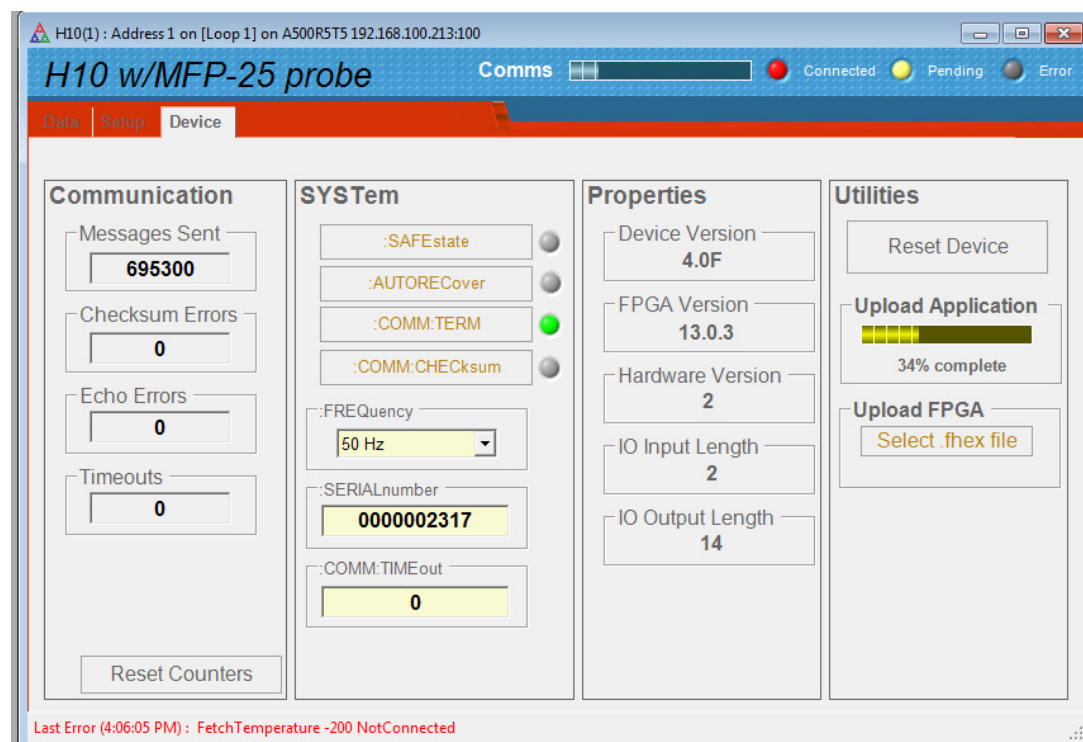
Figure 29. Firmware upload in progress

17 Versions and Compatibility

There are some compatibility constraints for the various versions of the H10. We recommend
the configurations shown below. However if you have H10s embedded in a complex system
running application-specific host software, you should not change your firmware or software
versions without consulting your supplier or Pyramid Technical Consultants, Inc.

H10 with MFP-2.5 probe

	H10 PIC	4.0F or later
	H10 FPGA	13.0.03 or later
	A500 DSP	5.43 or later
	A500 FPGA	2.7.42 or later
	A500 Ethernet	8.5
or	A560	(future option)
	PSI Diagnostic	4.114 or later
or	PTC G2 Diagnostic	(future option)

H10 with MFP-25 probe

	H10 PIC	4.1B or later
	H10 FPGA	13.0.04 or later
	A500 DSP	5.43 or later
	A500 FPGA	2.7.42 or later
	A500 Ethernet	8.5
or	A560	(future option)
	PSI Diagnostic	4.123 or later
or	PTC G2 Diagnostic	(future option)

18 Fault-finding

Symptom	Possible Cause	Confirmation	Solution
Incorrect field readings	Probe orientation not as expected	Check orientation of the probe relative to the expected field direction.	Orient and secure the probe.
	Probe out of position	Check probe position	Locate and secure the probe.
	Calibration incorrect or corrupted	Check calibration values for erratic values.	Contact supplier or Pyramid Technical Consultants, Inc.
	Temperature compensation not in use.	Check compensation parameters.	Use factory compensation values.
	Mechanical stress on probe.	Check mounting arrangement.	Mount the probe securely by without applying bending force.
	Probe and H10 control unit are not a matched pair.	Check serial numbers against shipping documentation.	Use matched pairs. Return to Pyramid Technical Consultants, Inc. for recalibration if necessary.
Unstable field reading	Field is actually changing	Check field by independent means.	
	Probe position is unstable in a spatially varying field.	Check field by independent means, or by placing the MFP in a known stable field.	Provide a mechanically stable probe mounting.
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.
	H10 case not grounded.	Check continuity to local	Make dedicated ground

		ground.	connection if mounting does not provide this.
	Field has unsuspected AC components.	Check field by independent means, or by placing the MFP in a known stable field.	
	Line voltage pickup	Noise level drops sharply if integration period is 16.7 msec (60 Hz) or 20 msec (50 Hz)	Keep H10 and signal cable clear of unscreened high current mains voltage. Use integration periods (N/line frequency).
Analog signals respond very slowly	Averaging period has been set very high.	Reduce period	Set averaging appropriate to the required time resolution and noise levels
	Filtering is enabled in the Diagnostic host program.	Check averaging setting on the Data tab.	Use the correct filtering setting.
Unable to communicate with H10	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.
	Fiber optics are damaged	Inspect fibers, especially the connectors. Check light can be seen through fiber.	Fit new fibers or re-terminate as necessary.

		Exchange fibers and retry	
Unable to connect to H10C	Using PTC G2 Diagnostic which does not support the H10.	Check Diagnostic type and version.	Use the PSI Diagnostic to connect to the H10 until H10 support is added to the PTC G2 Diagnostic.
Communications interruptions	Other processes on PC host interfering with comms ports.		Use a dedicated PC with simple configuration and minimum number of processes running.
PSI Diagnostic will not connect to devices	Two copies of program running		Run a single instance only
Random changes to parameters	Another host program is interacting with the same H10.	Check software running on hosts that could access the H10.	Run a single host program only.

19 Maintenance

The H10 does not require routine maintenance or calibration. There are no user-serviceable parts inside the case of the control unit.

The H10 is fitted with a 1.1 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, 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**.   Technical support is available by email from support@ptcusa.com.   Please provide the model number and serial number of your unit, plus relevant details of your application.

22 Disposal
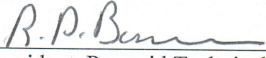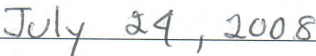
We hope that the H10 gives you long and reliable service. The H10 is manufactured to be compliance with the European Union RoHS Directive 2002/95/EC, and as such should not present any health hazard. Nevertheless, when your device has reached the end of its working life, you must dispose of it in accordance 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 products conform to the provisions as listed. Refer to the document: *Extension of testing and analysis to the PTC product line, December 10, 2007* and the *I400 Technical Construction File* for detailed testing information.

Product: M10 / M10C Multifunction I/O, H10 Field Probe
                                  Controller, B10A / B10B / B10C Digital I/O

Year of initial manufacture: 2007

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 (2nd 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: *R.P. Benn*
                                  President, Pyramid Technical Consultants, Inc.

Date: July 24, 2008

The Technical Construction File required by theses 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, 2 Chanctonbury View, Henfield BN5 9TW, 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.

Version	Changes
H10_UM_121105	First general release