C400

Four-channel Pulse Counting Detector Controller

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.

CAUTION. According to installed options the C400 can generate high voltages as follows, present on the central conductor of the SHV (Safe High Voltage) connectors.:

+ or – 2000 V DC at 0.5 mA maximum.
or
+ or – 1000 V DC at 1.0 mA maximum
or
+ or – 500 V DC at 2.0 mA maximum
or
+ or – 200 V DC at 5.0 mA maximum

The hazardous live voltages on the SHV central conductor are not accessible under the definitions of EN61010 but may nevertheless give a noticeable shock if misuse were to lead you to come into contact with them. The user must therefore exercise appropriate caution when using the device and when connecting cables. Power should be turned off before making any connections.

The unit must not be operated unless correctly assembled in its case. Protection from high voltages generated by the device will be impaired if the unit is operated without 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..

The unit is designed to operate from +24VDC power, with a typical maximum current requirement of 1000 mA. A suitably rated power supply module is available as an option. Users who make their own power provision should ensure that the supply cannot source more than 3000 mA.

A safety ground must be securely connected to the ground lug on the case.

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

C400	Four-channel pulse-counting detector controller
-nXP20/10/5/2	Add positive 0 to 2000V / 1000 V / 500 V / 200 V HV outputs to n channels
-nXN20/10/5/2	Add negative 0 to 2000V / 1000V / 500 V / 200 V HV outputs to n channels

Example:

C400-4XN20   C400 with four 2000V negative auxiliary high voltage outputs.

5 Scope of Supply

C400 model as specified in your order.

PSU24-40-1 24 VDC power supply.

USB memory stick containing:
 C400 User manual
 PTC DiagnosticG2 software installation files
 Terminal emulation program for testing ASCII communication
 Test data

Optional items as specified in your order.

6 Optional Items

6.1 Power supplies

PSU24-45-1 +24 VDC 45W PSU (universal voltage input, plug receptacle for standard IEC C14 three-pin socket) with output lead terminated in 2.1mm threaded jack.

PD-8 Eight output +24 VDC power supply unit, 19" rack mounting

6.2 Signal cables and cable accessories

CAB-LCO-xx-LCO Cable, coaxial signal, Lemo 00 plug to Lemo 00 plug, xx m long.

CAB-SHV-xx-SHV Cable, coaxial HV, SHV to SHV, xx m long.

6.3 Data cables

AB450K-R RS-232 6 pin DIN male to 9 pin D sub female adaptor.
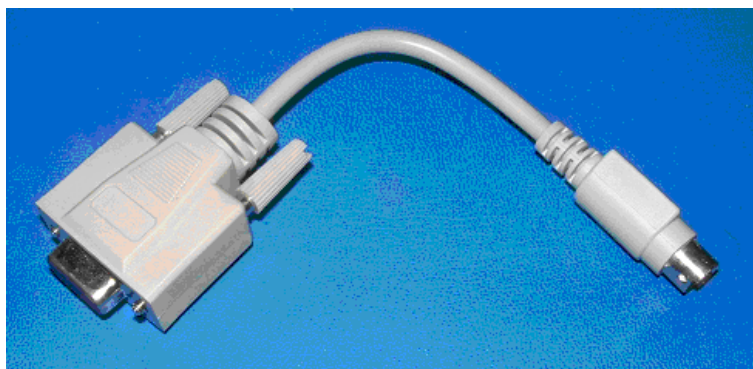
Figure 1. Serial adaptor cable

Fiber-optic cable pair 1 mm plastic fiber ST terminated with color-coded sleeves, 5 m. Other lengths available to order.

Fiber-optic cable pair 200 µm silica fiber ST terminated with color-coded sleeves, 5 m. Other lengths available to order.

6.4 Power and control cables

CAB-L4-10-D9 Cable, screened, four pin Lemo 0B plug to D9 male, 10 m, for pre-amp power.

6.5 Pre-ampliifiers

CP10-A Wide-band DC-coupled preamplifier suitable for NaI, $LaCl_3$, $LaBr_3$, and YAP scintillators coupled to photomultiplier tubes.

CP10-B Very wide-band DC-coupled preamplifier suitable for plastic scintillators, continuous dynode electron multipliers and other pulse counting detectors with very short output pulses.

Figure 2 CP10 pre-amplifier

6.6 Fiber-optic loop

A200 USB to fiber-optic adaptor.

A300 fiber-optic loop controller / Ethernet adaptor.

A500 intelligent real-time cell controller for five loops with Ethernet interface.

7 Intended Use and Key Features

7.1 Intended Use

The C400 is intended to count fast pulses generated by photomultipliers, avalanche photodiodes and similar devices on four parallel channels. It provides high voltage for the sensors and low voltage power for pre-amplifiers. Multiple C400 units can measure synchronously using a distributed trigger, and encoder pulses can be measured to coordinate pulse counting with the position of a motion system.

The C400 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

Four fully-parallel high speed window comparators and 100 MHz scalers.

Four independent high voltage outputs for detector biasing

Four power supply outlets for remote pre-amplifiers.

Four analog voltage outputs for remote HV control or other uses.

Four LED pulser outputs.

Input for quadrature position encoder.

Discriminated monitor pulse outputs.

Gate inputs and output for triggering on external events, and trigger distribution.

Ethernet interface with TCP/IP and UDP messaging. Static and DHCP IP address assignment.

Alternative RS-232, RS-485 and fast fiber-optic serial interfaces built-in. Selectable baud rates. (RS-485 operation will be enabled in a future firmware release).

Can be operated in a fiber-optic serial communication loop with up to fourteen other devices (Fiber optic host communication will be enabled in a future firmware release).

Slave devices can be connected to the C400 via the fiber optic interface.

7.3 **Specification**

Signal inputs		
	Number	Four, independent parallel
	Input impedance	50 ohm
	Pulse height range	0 to 5 volt, either polarity
	Minimum pulse width	Less than 10 nsec
	Pulse pair resolution	Better than 10 nsec
	Discriminator analog bandwidth	DC - 150 MHz
	Discriminator range	Window discriminator, upper and lower levels adjustable 0 to 5 V, either polarity 16 bit resolution over bipolar range
Scalers		
	Number	Four
	Depth	32 bit (transparent background readout)
	Integration period	Configurable, 100 µsec to 1 sec.
	Accumulation mode	Counts can be accumulated indefinitely (transparent background readout)
	Deadtime correction	Real-time non-paralyzable deadtime correction can be applied, calculated for each individual integration period.
	Internal buffering	On-board data buffer for up to 65536 integrations
Test pulsers		
	Number	Four
	Voltage	0 - 5 V (TTL levels)
	Current capability	30 mA
	Pulse duration	8 nsec to 1 µsec
	Frequency	1 Hz to 1 MHz
Preamp outputs		
	Number	Four
	Power output	+12 VDC 100 mA, -12 VDC 100 mA, fused
	Analog output	-5 to +5 VDC 16 bit resolution for remote high voltage control

		or other purpose
	Test pulser	TTL output with controllable frequency, pulse width and pulse count for test pulser LEDs
High voltage outputs		
	Number	Up to four, independently configurable for range and polarity at time of purchase.
	Output power	1 watt
	Voltage options	20 to 200 V. Line <0.01%, Load <0.05%, Ripple <0.01%
		50 to 500 V. Line <0.01%, Load <0.01%, Ripple <0.01%
		100 to 1250 V. Line <0.001%, Load <0.005%, Ripple <0.001%
		200 to 2000 V Line <0.01%, Load <0.01%, Ripple <0.001%
Monitor outputs		
	Number	Four
	Levels	TTL levels into minimum impedance of 50 ohm
	Pulse width	10 nsec minimum
	Latency	Less than 80 nsec after discriminator conditions are met
Triggers and gating		
	Trigger modes	Internal (autorun), plus custom control of start, pause and stop conditions.
	Gate input	TTL levels into 10 kohm
	Gate output (passthrough)	TTL levels into minimum impedance of 50 ohm
	Latency	Less than 50 nsec between gate input and gate output
Encoder input		
	Signals	Differential position pulses (A+/A-, B+/B-) and index (Z+/Z-)
	Levels	0.2 V to 20 V differential
	Isolation	8 kV
	Maximum count rate	1 MHz
	Counter depth	32 bit (transparent background readout)
Communication interfaces		
	Ethernet	Ethernet 10/100 Base T, TCP/IP and UDP. DHCP and static address support.
	RS-232	115.2 kbps, serial ASCII protocol

	RS-485	115.2 kbps, serial ASCII protocol
	Fiber optic	10 Mbps, binary serial protocol. For integrating into Pyramid systems architectures or attaching slave devices.
Controls and indicators		
	Controls	Rotary switches for communications mode and fiber optic loop address, rear panel Push button processor reset, rear panel
	Indicators	Four HV enabled yellow LEDs, front panel Eight status green LEDs, rear panel
Power input		
	Voltage	+24 VDC (+/-2 V)
	Current	Up to 1000 mA
Case		
	Format and materials	1U 19" 250 mm deep rack mounting steel chassis with Al alloy front panel and polycarbonate decals. Fan-cooled.
	Protection rating	The case is designed to rating IP43 (protected against solid objects greater than 1mm in size, protected against spraying water).
	Weight	2.9 kg (6.4 lb)
	Dimensions	(see figures 1 and 2).
Environment		
	Operating	0 to 35 C (15 to 25 C recommended) < 70% humidity, non-condensing vibration < 0.1g all axes (1 to 100Hz)
	Shipping and storage	-10 to 50C < 80% humidity, non-condensing vibration < 2 g all axes, 1 to 100 Hz

43.7
(1U)

4x PREAMP POWER OUT (DB9F)
4x SIGNAL IN (LEMO EPL.00.250.NTN))
4x HV OUT (SHV)
4x HV-ON LED

482.6
(19")

FRONT VIEW

RS-232/RS-485
FIBER-OPTIC RX (ST)
FIBER-OPTIC TX (ST)
COMMS SELECTOR
ADDRESS SELECTOR
ETHERNET

STATUS LEDs
GATE (SYNCH) OUT (BNC)
GATE IN (BNC)
ENCODER INPUT
(DB9F)

4x MONITOR OUTPUTS
RESET SWITCH
+24VDC
POWER IN
M4 GROUND LUG

REAR VIEW
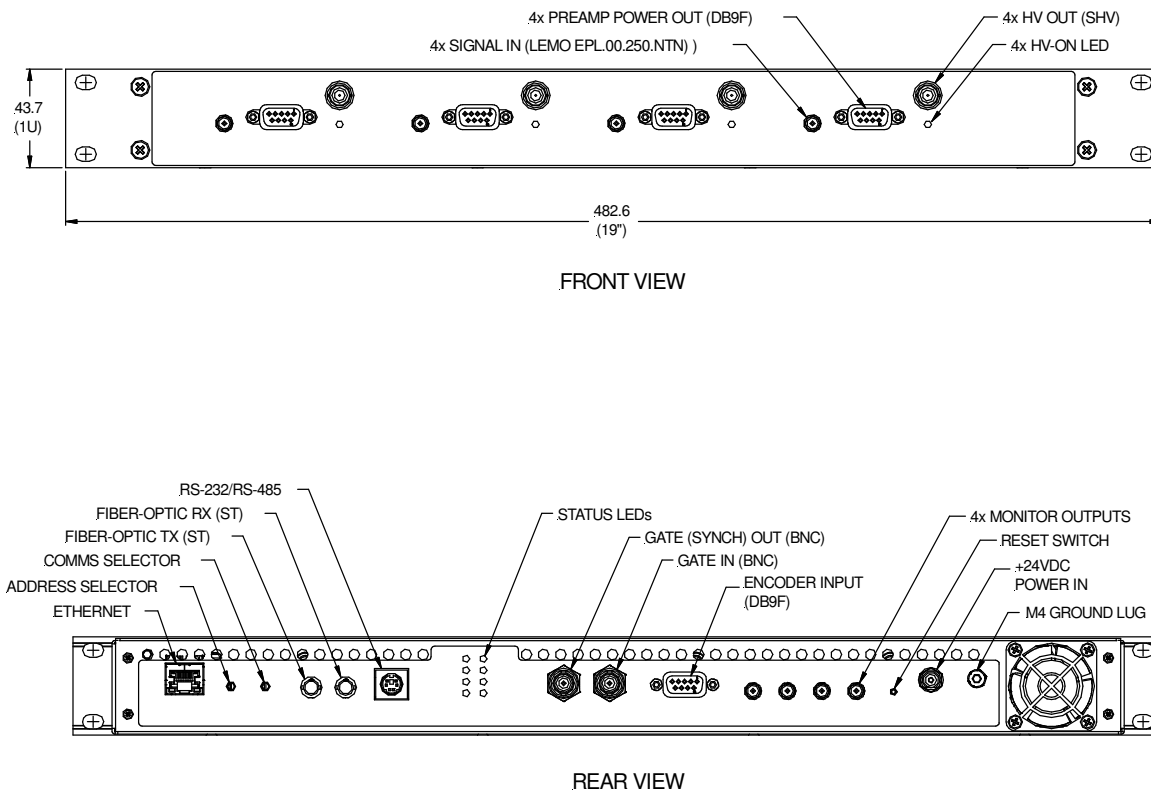
Figure 3.   C400 front and rear panels. Dimensions mm.

42.5

43.7
(1U)

.19.3

448.0

TOP VIEW

482.6
(19")

221.0

3.0

248.8
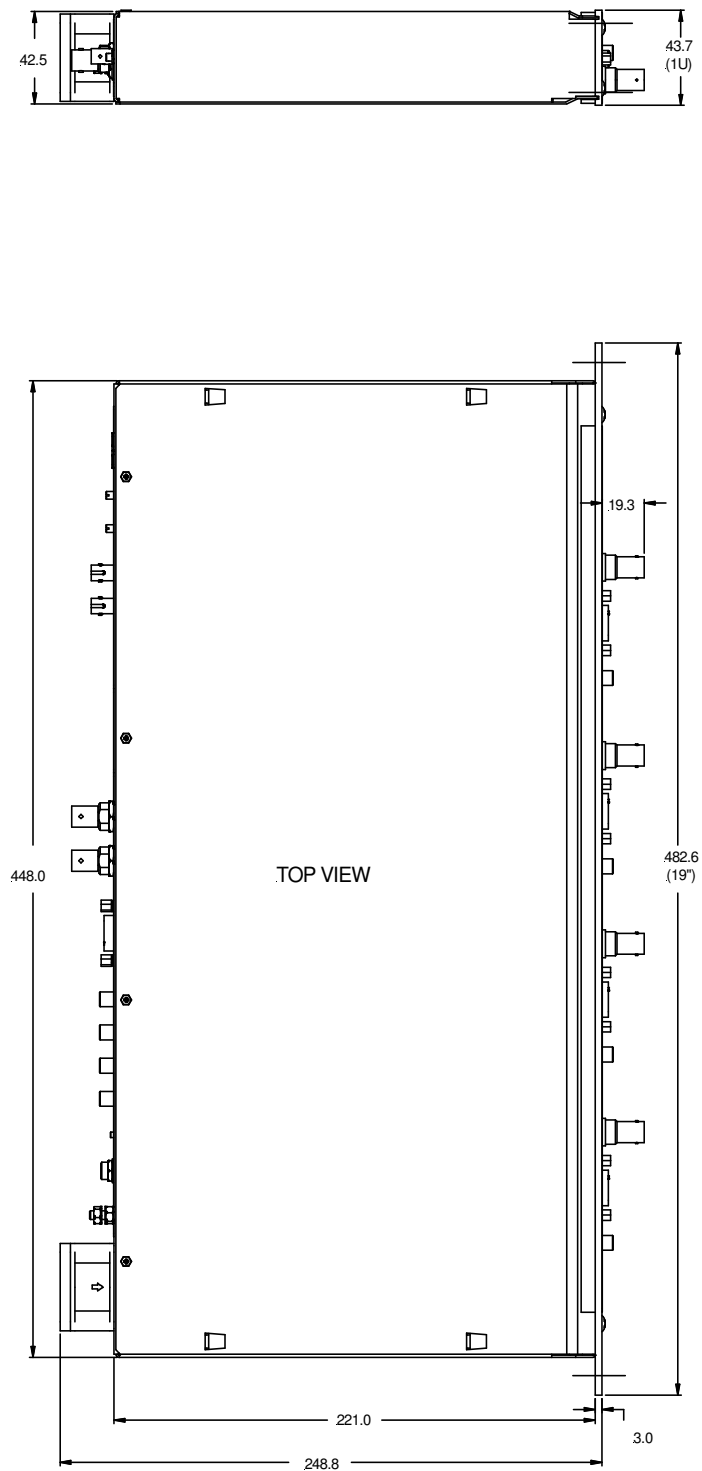
Figure 4. C400 case plan and side views. Dimensions mm.

8 Installation

8.1 Mounting

The C400 is intended for 19" rack mounting, but 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.

The mounting position should allow sufficient access to connectors and cable bend radii. 60 mm minimum clearance is recommended at front and back of the device.

Best performance will be achieved if the C400 is in a temperature-controlled environment. No forced-air cooling is required in addition to the unit's built-in fan, but free convection should be allowed around the back and sides of the case.

8.2 Grounding and power supply

A secure connection should be made using a ring lug, from the M4 ground lug to local chassis potential. This is the return path for any high voltage discharge passing via the C400.

+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	1000 mA minimum, 3000 mA maximum
Ripple and noise	< 100 mV pk-pk, 1 Hz to 1 MHz
Line regulation	< 240 mV

The C400 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 power connector limit of 5 A.

8.3   Connection to signal source

8.3.1   Typical setup

Figure 3 shows an example installation in schematic form. A scintillator / photomultiplier detector generates fast pulses when ionizing radiation interacts with the scintillator. The pulses are negative going and ground referenced, because we are measuring a current of electrons, and the photomultiplier is biased with negative high voltage at the photocathode. A pre-amplifier such as the Pyramid CP10 amplifies the pulses and sends them over a coaxial cable to the C400 input. Here the pulse height is compared to the lower and upper discriminator levels, and if it lies between them, a pulse is counted. High voltage for the photomultiplier is provided by the C400, as is DC power for the pre-amplifier. A test LED built into the scintillator assembly is driven by the pulser output of the C400 to provide a diagnostic test.

In the example shown, a goniometer is used to position a sample, for example in a diffraction experiment, and the C400 is able to read the position encoder so that signal counts can be correlated to sample position. A gate input signal is used to trigger measurements, and the C400 gate output signal is passed to another unit that needs to be triggered, for example another C400. The monitor output is used to feed pulses to an external counting device, such as a ratemeter.
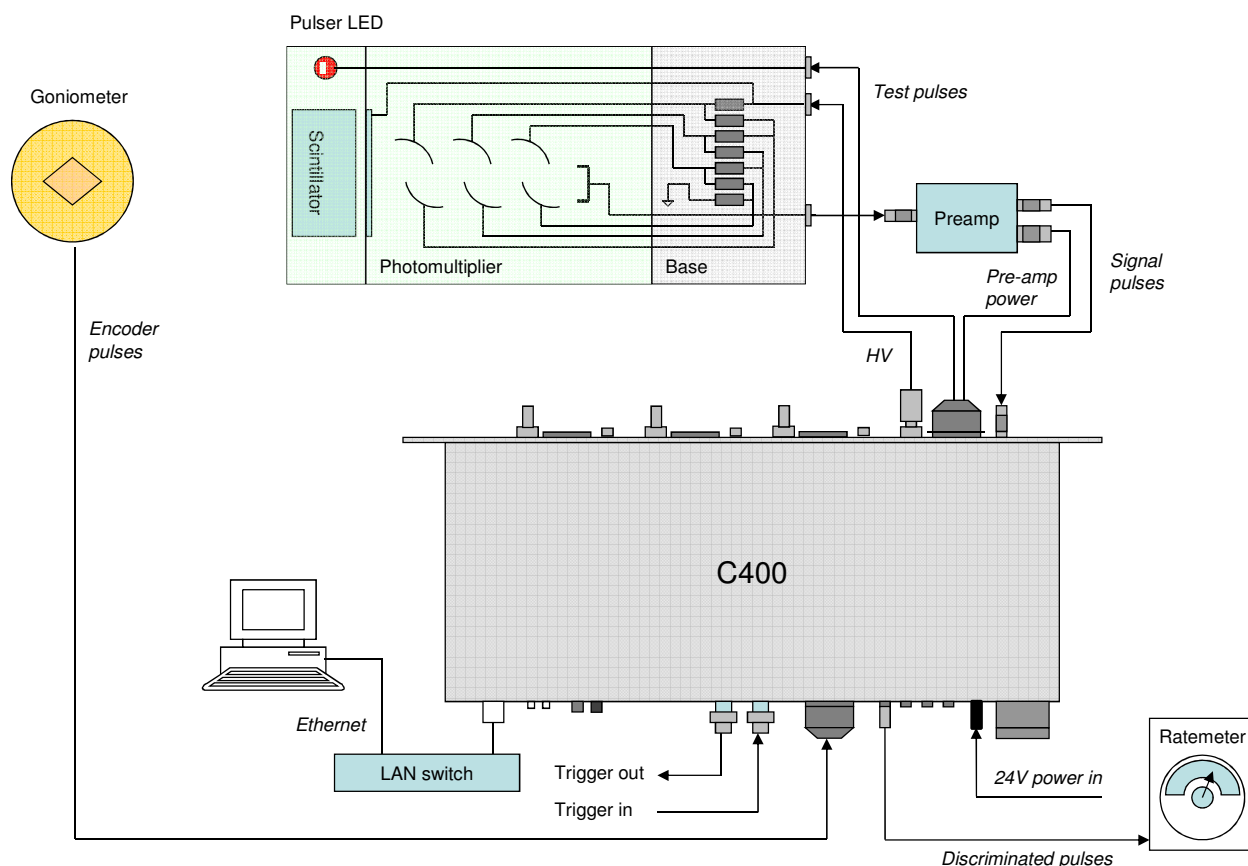
Figure 5. Schematic example C400 installation

Other signal sources can include channel electron multipliers, avalanche photodiodes, silicon photomultipliers and diamond detectors, or indeed any sensor that produces fast pulses in response to incoming radiation of particles or photons.

Many photomultipliers are biased with negative high voltage as shown in figure 5, with the result that the pulses emerging at the bottom of the dynode chain are ground-referenced, and can be connected directly to DC-coupled pre-amplifier, or even directly to the C400 inputs if they have sufficient amplitude. However, many photomultipliers are biased with positive high voltage at the anode and a grounded photocathode. The pulses are then referenced to the high voltage. In this case they must be AC-coupled using a suitably-rated capacitor before connecting to the preamplifier or the C400. Often such decoupling capacitors are integrated into the tube base bias network.

8.3.2 Cables

A pre-amplifier near the detector provides impedance matching so that the pulses can be transmitted along 50 ohm coaxial cable into a 50 ohm terminating impedance. A cable length of up to 10 metres (33 feet) should cause no problems. The cable will of course attenuate the pulse amplitude, with the higher frequency components of the pulse being attenuated more. Assuming

that the lowest and dominant frequency component of the pulse is around 20 MHz, corresponding to a typical 25 nsec pulse width, some typical cable attenuations are:

Coax type	*Attenuation per10 m*	*Distance to reduce amplitude to half*
RG-58 (Belden 9201)	0.55 dB	108 m
RG-174 (Belden 9239)	1.18 dB	51 m
RG-316 (M17/172)	1.16 dB	52 m

If you connect the photomultiplier output directly to the C400, then the cable length must be much less. The capacitive load of the cable will tend to integrate the signal, reducing its height and degrading the pulse pair resolution. We recommend maximum capacitive load of 50 pF, at which point the amplitude of the fastest detector pulses is reduced to about 67% when driving a 50 ohm load. This corresponds to a length of about 50 cm of miniature coaxial cable such as RG-174 or RG-316.

The high voltage cable should be coaxial with a DC rating sufficient for the maximum voltage you expect to use. RG-59 is a good choice, with a DC rating of 2.1 kV. However many photomultipliers do not require a voltage this high, and use a smaller coaxial cable such as RG-316 for convenience. SHV connectors that accept this smaller cable size are available from Pasternack (PE4498) and Tyco (5051426-8 and 51426-8).

The pre-amplifier power cables must be well-screened multi-way cable. It is important to avoid injecting noise into wideband pre-amplifiers. We recommend that the screen is connected at the C400 end and the pre-amplifier end, although you may find that it is beneficial to connect at one end only in some noise environments.

9 How the C400 Works - An Overview

The C400 is a very powerful instrument which provides many facilities for measuring fast pulses at high rates on four channels. In this section we shall take a general overview of these capabilities.

9.1 Pulse height discrimination and counting

Incoming fast pulses are terminated in 50 ohms and the resulting voltage is compared to user defined discriminator levels. If the pulse height lies between the low and high discriminator thresholds, then a counter is incremented, and a standard height fast pulse is transmitted from the monitor output. Note that pulses from photomultipliers and other electron multiplier types are negative going. The C400 can also handle positive going pulses if required, to suit inverting pre-amplifiers, or detectors that produce positive pulses.
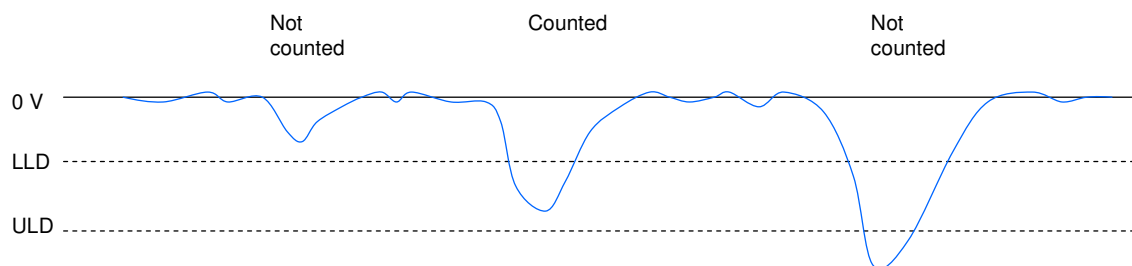
Figure 6. Comparator operation

The comparator circuit includes some hysteresis in the thresholds, to avoid spurious counts due to noise on the trailing side of a pulse.

The pulses are counted for a user-defined integration time, then the counter is reset and the process repeats. There is no deadtime between the integrations. You get better counting statistics for any given integration if the integration time is long, and a reduced data rate, but of course you trade off time resolution of the count rate.

9.2 Triggering

In many cases you will need to coordinate the C400 measurements with external events. A TTL signal or on the gate input can trigger a pre-defined acquisition sequence. The gate in signal is echoed quickly on the gate out connector, allowing you to connect multiple units in daisy chain. There are various external triggering modes, from a simple start trigger that starts a predefined sequence of integrations, to modes that allow you to use the gate line to start, stop or pause the counting.

If you don't need to synchronize to external events, you can use internal triggering, which is similar to the auto run facility on an oscilloscope. The C400 generates its own triggers, so counting starts as soon as you initiate an acquisition.

9.3   Acquisition modes

The C400 can generate data very quickly, at a rate higher than can generally be accepted in real time by either the communications link or the host computer. The C400 therefore provides buffering schemes that allow you to capture blocks of data at any rate.

Unbuffered mode does not store any results in the C400. The values are simply transmitted to the host computer as fast as the C400 can send them, and as fast as the host it can accept them. At the shortest integration times, some values may be lost because of limitations in the communications rate, but this is always obvious in any data you take because the readings are individually time-stamped.

Buffered mode uses the internal memory of the C400 to store up to 65535 sets of readings from the four channels. They are transmitted to the host while the data is accumulating in the buffer in segments of typically 400 readings, so that the data you see on the host computer is always relatively recent. There is no break in the readings, even at the shortest integration times.

Burst mode subdivides the buffer memory you allocate into smaller bursts of readings. Each burst is accumulated in response to an external trigger. This mode is useful if you have bursts of high speed data, interspersed with periods when there is no useful data.

Accumulation mode is a means of obtaining very long integration times by accumulating counts across multiple individual integrations. The latest status of the accumulation can be read out in the background, without disturbing the counting.

9.4   Detector services

Each of the four channels provides the services typically needed to operate a detector system. The C400 can be fitted with four individual programmable high-voltage modules to provide bias voltage to the detectors. Most applications will require all four to be specified with the same polarity and voltage range, although the C400 can accommodate them all being different if necessary. If you are instead using separate high voltage supplies, then you can use the analog output voltages from the C400 to program the voltage from those supplies. +/- 12 volt power rails are provided for pre-amplifiers.

9.5   Self-testing and calibration

Some scintillation detectors include test pulser LEDs. A short pulse of light from the LED causes the photocathode to emit, and you get a signal pulse from the anode of the photomultiplier, which can be discriminated and counted in the normal way. The C400 includes TTL test output pulses for each channel, which you can program with period and pulse width. With a suitable series resistor for the LED, you should count the same pulses coming in as you are putting out, and therefore validate the complete detector and counting system.

The C400 uses precision digital to analog converters (DACs) to control the high voltage supplies and to set the discriminators, and analog to digital converters (ADCs) to readback the high

voltages. Calibrations are provided for all these converters so that the high voltage and discriminators are as accurate as possible.

9.6   Monitor outputs

Each C400 channel has an associated monitor pulse output. Each valid input pulse that lies between the lower and upper discriminator thresholds is counted and also generates a fixed amplitude output pulse on the corresponding monitor. These pulses may be fed to independent counters, or be used to drive ratemeters or oscilloscope external triggers.

9.7   Communication to the host computer

The C400 provides three alternative communications interfaces to the host computer. You must work with a suitable host computer and software to set up acquisitions on the C400, and read back and display the results.

The most commonly-used is the standard 100/10BaseT Ethernet interface which supports TCP/IP and UDP protocols. The C400 can serve multiple host computers on the network.

Software is available from Pyramid Technical Consultants, Inc., which makes the C400 controls and readbacks available as Process Variables for the EPICS data distribution system (http://www.aps.anl.gov/epics/) . EPICS stands for Experimental Physics and Industrial Control System, and it is widely used in large-scale research systems. Once you have a computer running the necessary service program, then that computer and any other computer on your network can access the data using a wide range of client software including C, C++, C#, Python, Java, Labview™, Matlab™, and Control System Studio.

There is also a 10 Mbps serial fiber optic channel which provides compatibility with the Pyramid Technical Consultants, Inc. fiber optic real-time loop controllers, and thus the complete range of Pyramid products. The fiber optic interface can alternatively be used to connect slave devices to the C400, for example the Pyramid M10 device, to provide extended I/O capability.

Finally, a serial interface which can be operated with RS-232 or RS-485 levels provides a simple interface for applications where high data rates are not needed. An ASCII protocol is supported based on the SCPI standard. The C400 will support parallel communication on Ethernet and serial interfaces, although the results may be confusing if both are attempting to control and read back the C400 at once.

The initial C400 software release supports the Ethernet, ASCII serial interfaces and connection of slave devices via fiber optic. The other interfaces will be added in a future release.

9.8   Communication to slave devices

The fiber optic interface allows other devices such as the Pyramid M10 general I/O unit to connect to the C400, and thus be visible to the host software. With this capability you can build up a sophisticated measurement and control system around a C400.

9.9 Embedded software

The C400 runs an embedded version of the Linux operating system on NIOS processors implemented in the FPGAs. Four firmware files make up a full release, and you can update with a single file which integrates all the releases, and thus ensures that you have compatible versions.

10 Getting Started using the PTC DiagnosticG2 Host Program

The PTC DiagnosticG2 is a stand-alone program which allows you to read, graph and log data from the C400, and set all the important acquisition control parameters. It supports communication via any of the interfaces. For some applications it may be adequate for all of your data acquisition needs. The Diagnostic uses the same function library that is exposed for users who develop their own host applications, and therefore also serves as a debugging aid.

PTC DiagnosticG2 was introduced to support the G2 range of Pyramid Technical Consultants, Inc. products, which feature embedded Linux processors and built-in Ethernet interfaces. It is not compatible with the PSI Diagnostic program which supports previous Pyramid products. However the PTC DiagnosticG2 program will be extended in the future to add support for all the previous products.

Your C400 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 versions.

10.1 Installation

The program runs under the Microsoft Windows operating system with the 3.5 .NET framework, or later. This has to be installed before the PSI DiagnosticG2. New Windows PCs have .NET already installed. It can be downloaded from the Microsoft web site at no charge.

Copy the installer file PTCDiagnosticSetup-Vx_xx.msi to the hard drive of the host computer, where x_xx is the version of the Diagnostic. The program will run on Windows XP, Vista and Windows 7. The PC must have a standard Ethernet port.

Run the installer and follow the prompts. On Windows 7 systems you will be asked to allow the installer to make changes to the computer after the confirmation stage. You will require administrator access to permit this.
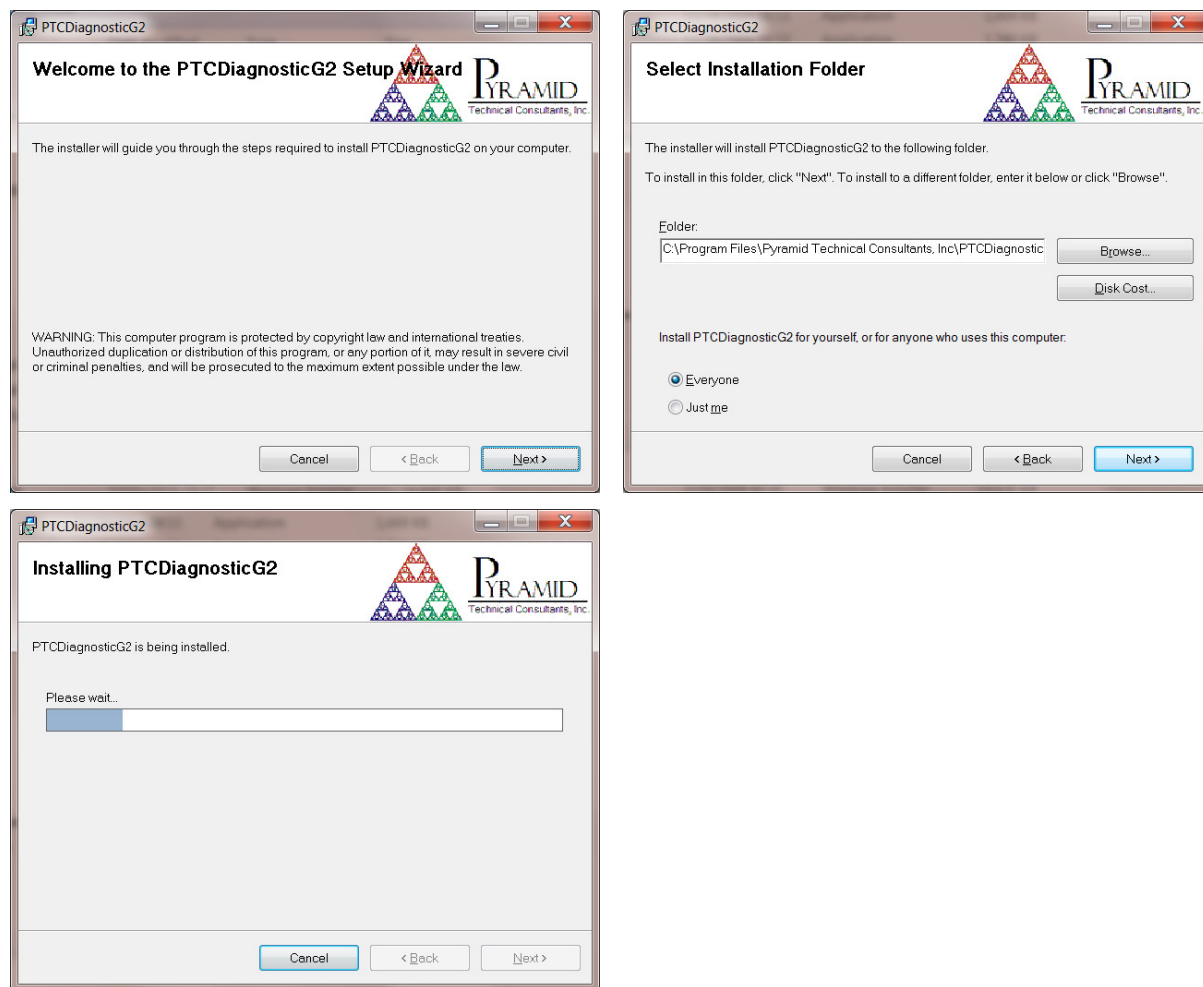
Figure 7. PTC DiagnosticG2 installation

The installer will create a subdirectory in the Program Files directory containing all the executables and configuration files, and create shortcuts on your desktop and in the Start menu.

10.2 Connecting to the C400

The following steps take you through the process of connecting to the device.

1) It is simplest to start with a direct connection from your host computer to the C400 using a CAT5 or CAT6 Ethernet cable as shown below. The C400 is shipped with a default static IP address and in this state it is able to communicate on this minimal network, which does not include DHCP address allocation. The network cable can be a patch or a crossover type – the C400 automatically adjusts itself to suit.
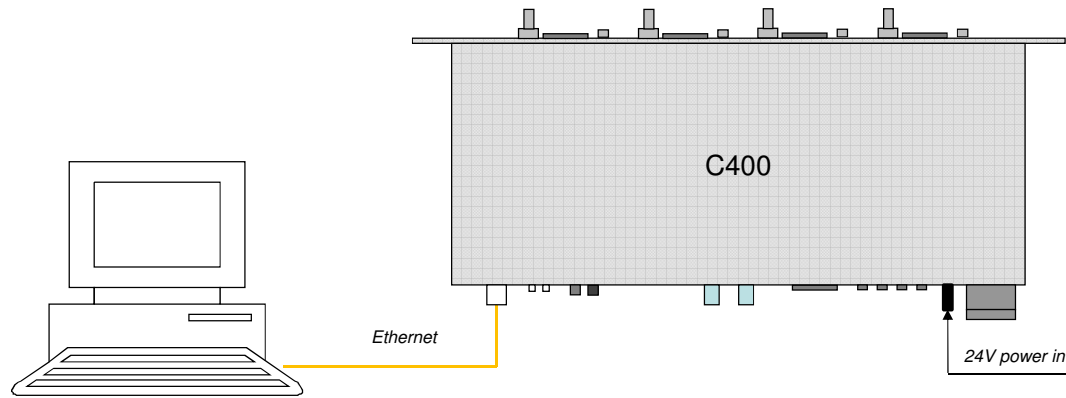
Figure 8. Direct Ethernet connection.

Once you have established reliable communication, and set a suitable unique IP address, then you can move the C400 onto a general local area network if required.

2) The device is set with IP address 192.168.100.20 at shipment unless you have requested otherwise. Once you have a connection you can change this setting to whatever you want, including DHCP address assignment. For this example, set up your host PC Ethernet port with a fixed, non-conflicting IP address in the same subnet range, for example 192.168.100.11.
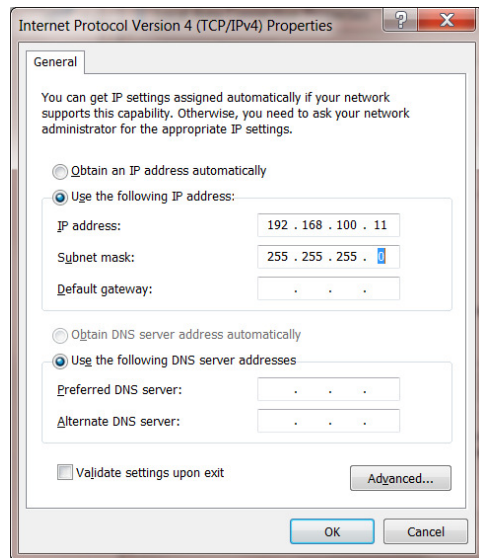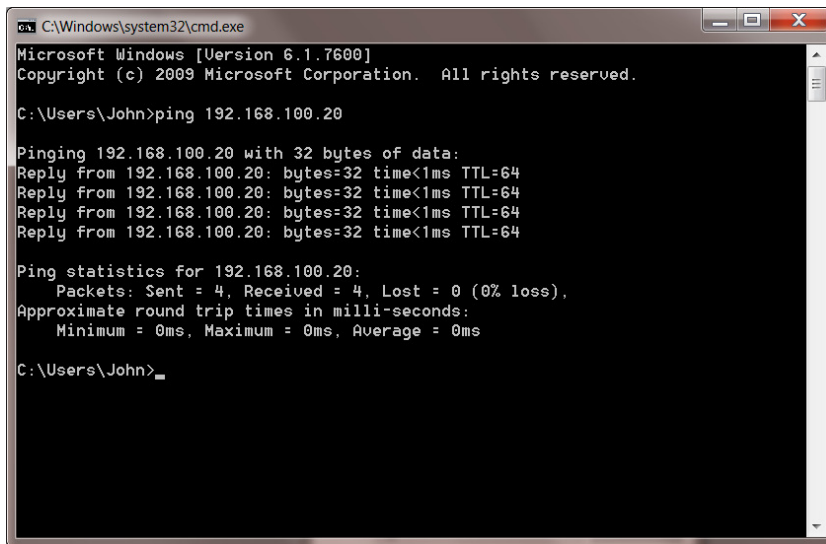
Figure 8. Configuring the IP address on the host computer.

3) Turn on 24 V DC power to the C400, but make no other connections. The two power LEDs on the rear panel should illuminate when the power is applied, and the cooling fan will start up. While the device is booting, the left hand bank of four LEDs on the rear panel cycle. When the device is ready, the "Active" and power LEDs only should be illuminated.

4) Make the Ethernet connection from the host PC to the C400. You should see activity on the LEDs that are mounted in the C400 RJ-45 connector. Check that you can ping the device from a command window prompt.

Figure 9. Ping test of the Ethernet connection.

The Windows firewall may block communication with the C400. It is simplest to start by turning off the firewall while you are testing. To maintain security, you can disable any wireless adaptor on the PC while you are doing this. Once you have established communication, then you can try restoring the firewall, and set up permissions for the PTC Diagnostic to communicate through the firewall. See section 22 for further details.

6) Start the PTCDiagnosticG2 software. It will start with the Discover Devices dialog open. Any history from previous discovery appears in the dialog, and also in the System explorer list on the left. If this is the very first use, the lists will be empty.
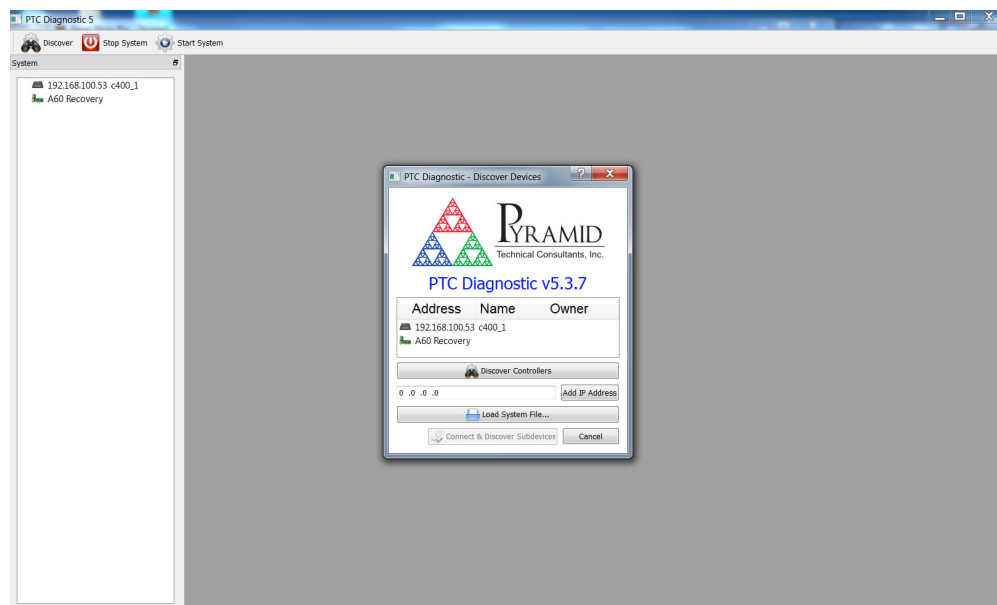
Figure 10. Discover devices

Click on Discover Controllers and the software will search all IP addresses within its available network looking for compatible Pyramid devices. Since you have the simplest possible network, it should find only the C400 you are working with. You will generally also see the A60 recovery utility. This is only used if your C400 firmware becomes corrupted, so you can ignore it for this test.

When you click to highlight the discovered C400, the Connect and Discover Subdevices button is enabled. Click on this to establish the connection to the C400.
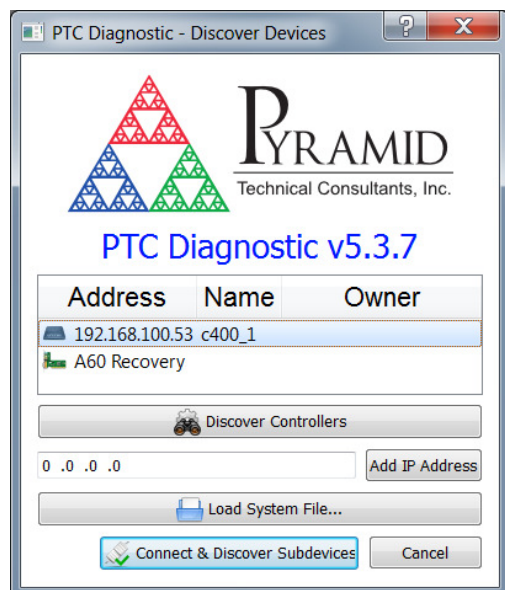
Figure 11. Ready to connect to the C400

A window for the C400 will open to the right of the System window, and you will see messages in the message area as the C400 adds your PC as a host. You may also see the error message "Fiber message timeout". This indicates that the C400 has not found any devices on its fiber optic communications channel. You can clear this error if you wish with the "Clear last error" button at the bottom of the screen (⌫).
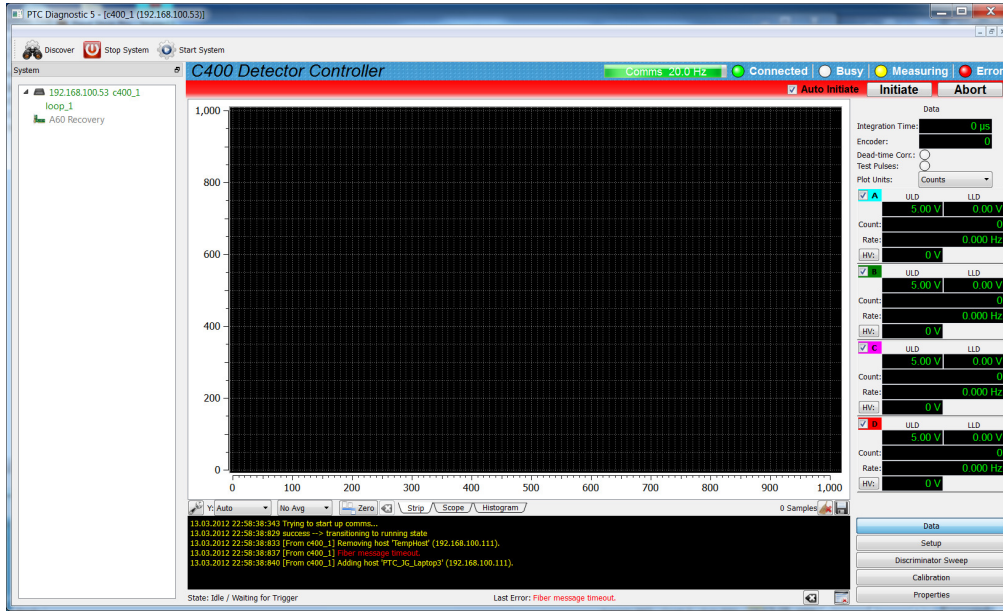
Figure 12. Opening the C400 window

10.3 G2 Diagnostic Screen layout

The top ribbon of the G2 Diagnostic window contains buttons that act on all connected devices.
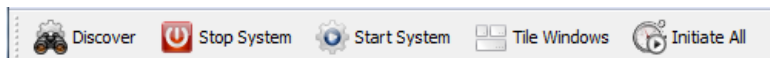
Figure 13. G2 Diagnostic common controls

Discover	Launches the Discover Devices utility
Stop System	Halts messaging to all connected devices
Start System	Restarts messaging to all connected devices
Tile Windows	Arrange all open device windows into a tile pattern
Initiate All	Send the Initiate command simultaneously to all connected devices.

The C400-specific user interface screen is divided into four sections. These are:

- Top banner

- Graphic data display

- Data display and controls, with multiple tabs and sub tabs

- Message area

10.3.1 Top banner

The top banner contains the following indicators:

Comms bar	When moving, this indicates that messages from the C400 are being received by the PTCDiagnosticG2. The message frequency is displayed.
Connected LED	When lit, this indicates that communications are valid and the system is not in error.
Busy LED	When lit, this indicates the C400 is busy and cannot respond to inputs, for example while performing a calibration.
Measuring LED	When lit, this indicates that data acquisition has been initiated.
Error LED	When lit, the C400 is in an error state.

On the left below the banner there is a graphic display of the data with controls for how the data is plotted below it.

Below the graphic is a message window which reports all the commands issued to the C400 by the PTC Diagnostic program, and the corresponding acknowledgements. Generally you can ignore this display, but it will be valuable for diagnosis if you have any operating problems.

On the right there is a screen area which changes according to which display option you select.

Data	A numeric display of the data on each channel, and check boxes to allow you to suppress the graphic display of any subset of the channels. The color codes correspond to the colors of the traces of the strip chart and scope mode graphics. Any channel which is highlighted in red is overrange.
Setup	Controls to set the acquisition mode, deadtime correction, signal polarity, discriminator levels, high voltage settings, triggering, data buffering, test pulse outputs and the position encoder input.
Discriminator Sweep	Controls for the automatic discriminator sweep facility which will create a pulse height spectrum for you, and thus allow you to adjust discriminator levels and high voltage settings to optimum values.
Calibration	Controls for the calibration of all built-in digital to analog and analog to digital converters.
Properties	Firmware version display and update controls, and IP address setting.

10.3.2 Graphic display area

There are three ways of displaying incoming data in a graphical way, as a rolling strip chart, as a scope display and as a histogram.

Strip	Data from the four channels, with the selected averaging, is plotted onto a rolling strip chart as it is acquired. The horizontal axis is the time of acquisition and the vertical (y) axis is the current. You can select automatic or fixed vertical scaling.
Scope	A 256 sample data block that has been buffered in the C400 is displayed as a whole. The next available data block replaces the previous one as a whole in the display. This mode is similar to the operation of a digital storage oscilloscope, and is most appropriate for displaying buffered signals acquired in response to an external trigger. The screen looks the same as strip mode.
Histogram	The count or rate in each channel is displayed as a vertical bar. This mode emulates a ratemeter, and can be useful for instrument tuning.

Clicking in the graphic area adds a color-coded cursor which gives the count at that time (strip display) or continuously in that channel (histogram).
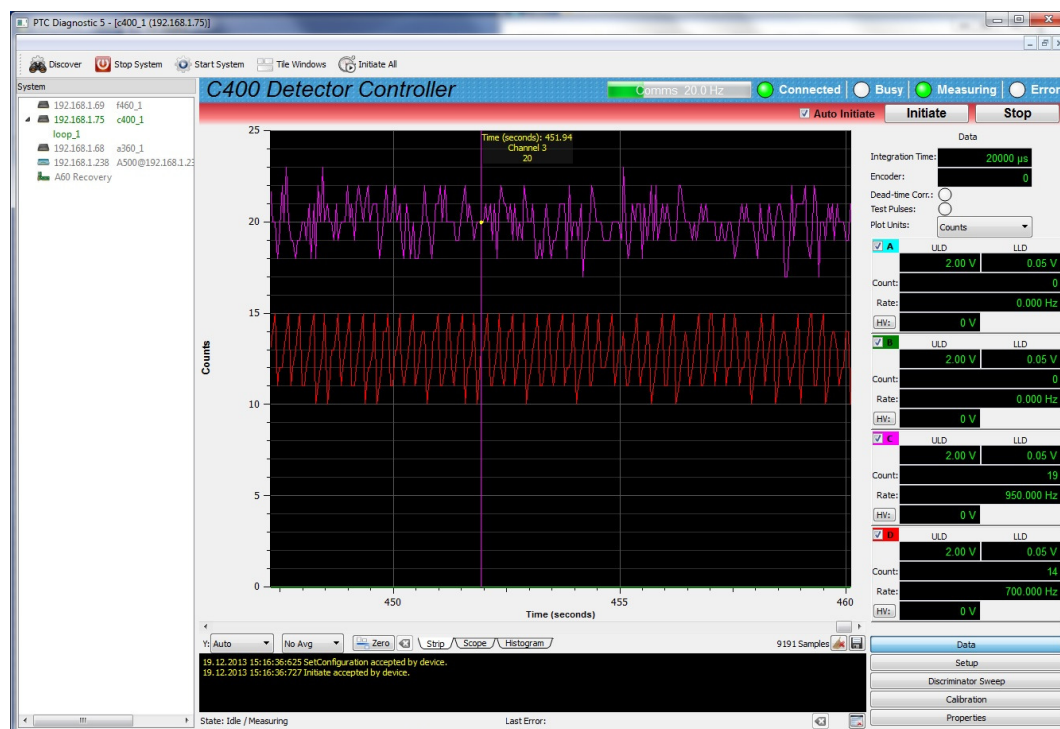
Figure 14. Strip chart data display showing cursor. The scope display looks similar.
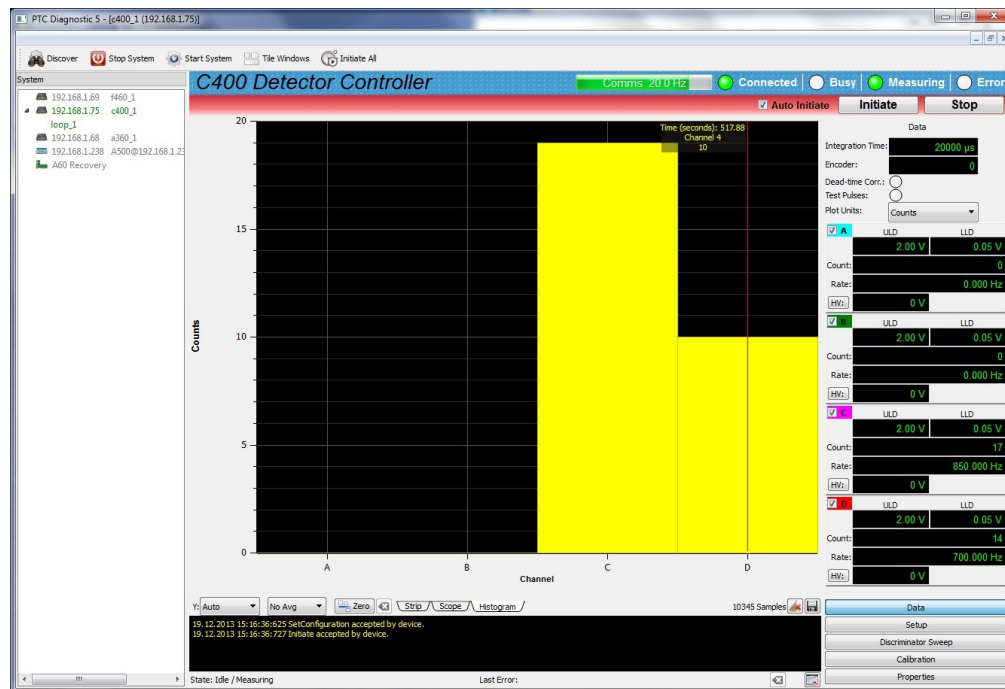
Figure 15. Histogram data display showing cursor.

You can choose whether to display the data as raw counts per integration period, or as the equivalent count rate in Hz or kHz. The displayed data can be filtered by a low pass filter to allow you to pick trends from noisy data.
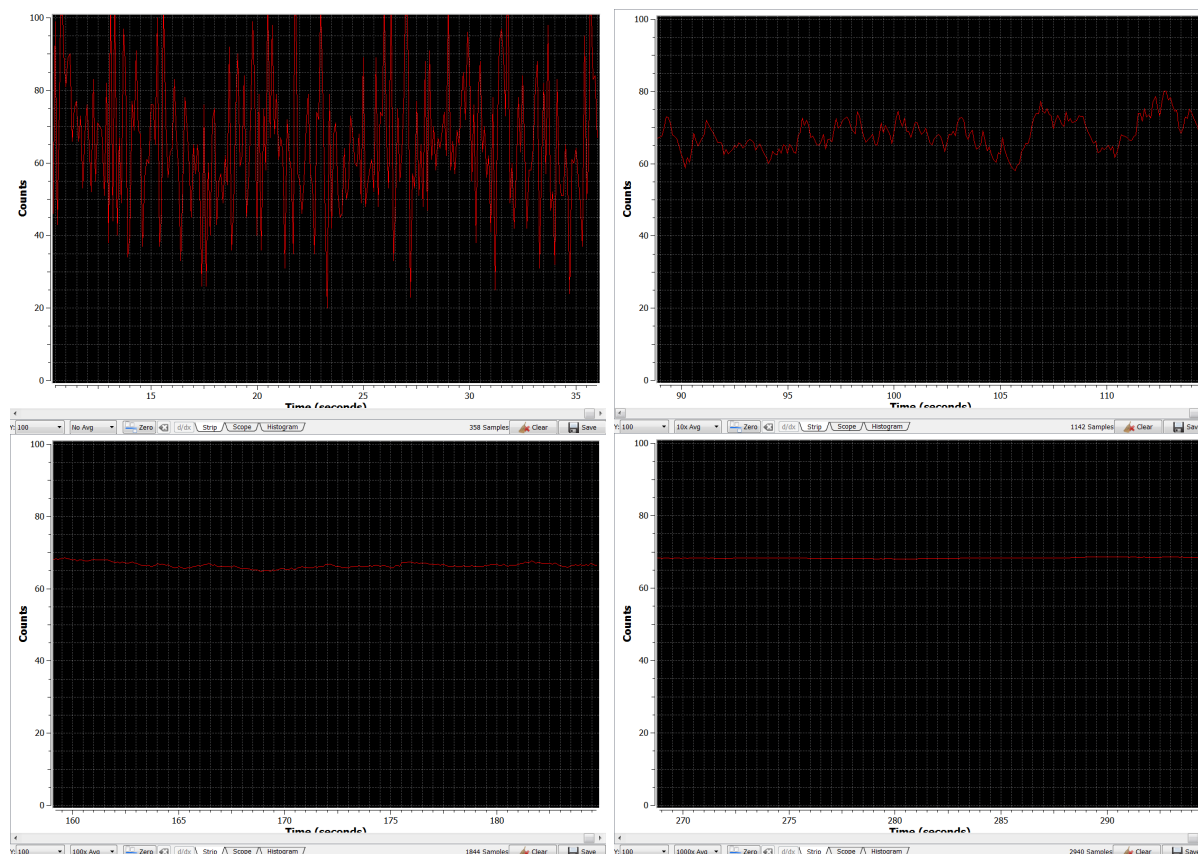
Figure 16. Increasing the low pass filtering of the displayed data.

You can remove any zero offset count rate and thus display changes relative to that offset. This means you may see negative frequencies.

Figure 17. Zero offset subtraction control inactive and active.

All of these display options can be selected independently of the acquisition mode, and do not affect the raw data or the logged data, only how it is displayed on the graphic.

Any subset of the four channels can be selected for display on the graphic by checking and unchecking the channels in the Data area. The vertical scale can be set to autoscale, or to be set to various fixed values using the drop down control.

10.3.2.1   Data logging

The PTCDiagnosticG2 software has a data buffer which can accumulate up to 65535 samples, at which point it wraps around and starts overwriting the oldest data. Accumulation starts automatically when you click Initiate. You can capture the contents to a .csv format file at any time using the Save button. Pressing the Clear button clears the buffer and restarts the logging.

Note that the logged data is the raw data: any low-pass filtering or zero offset removal does not affect the values you save. However if you have a deadtime correction active, this <u>will</u> be reflected in the data because it is applied in real time to the incoming data. If you need to record data with and without the deadtime correction, and the data can be reproduced, simply toggle the correction off and take a second data set.

10.3.3 Data display

The data display area is the first tab of the data and parameters screen area. It shows you the numeric values corresponding to the graphic, plus information such as the integration period, the high voltage readings, the discriminator settings in use and whether deadtime correction or the test pulser is active. The high voltage outputs can be enabled and disabled from this display, but if you want to change the values, you must switch to the Setup display.

Figure 18. Data display.

Counts	You can set whether the display of the data is the counts per integration period, or the corresponding count rate in Hz or kHz.

10.3.4 Setup display: detector, discriminator and counter-scaler control

The Setup screen area is the second tab in the right hand screen area. It is divided in its turn into three sub-tabs, covering channel setup (discriminator and HV settings), trigger setup and other setups. The integration time and accumulation setting is common to all the sub-tabs.
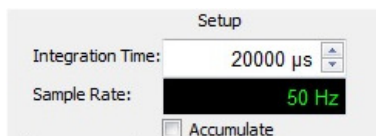
Figure 19. Integration time control.

Integration time	This sets the time intervals over which the scalers accumulate counts, and thus the rate that new readings are taken. You can set from 10 µsec to 1000000 µsec (one second). You would generally use longer times for low count rates, but note that you can always sum any number of consecutive readings in host-computer data processing to achieve the effect of very long integrations.
Accumulate	Checking this box stops the counters from being reset to zero after each integration period. In this way you can achieve effective integration times arbitrary length. Accumulate mode is primarily intended for use with the serial ASCII interface, where the host system is not necessarily in continual communication with the C400.

In order for any change you make in a parameter box to be sent to the C400, you must either press the Enter key on your computer, or click into another parameter field. Any change to the acquisition mode, or to any acquisition parameters, will abort the acquisition in progress. If you have the Auto Initiate box checked, a new acquisition with the new parameters will start immediately.

Also common to all the setup sub-tabs is the Save Configuration button.
Pressing this copies all your settings to non-volatile memory in the C400. The C400 will restore these settings when it boots up next time. Note that the saved configuration does not include the enable state of the high voltage; all high voltage outputs are disabled at startup. The settings of the analog output voltages that are provided on the pre-amp connectors is restored however, so exercise caution if you are using these voltages to control external high voltage supplies.
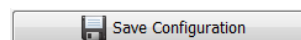
10.3.4.1   Channel setup

This sub-tab allows you to control all the basic pulse counting parameters: the discriminator levels, the high voltage outputs and deadtime correction.

Figure 20. Channel setup parameters.

Deadtime correction	The C400 can apply a non-paralyzable deadtime correction in real time to the incoming counts in all channels. You can set the deadtime duration in nsec and independently toggle the correction on or off. See section 16 for further details.
Signal polarity	The C400 can handle negative-going or positive-going pulses, and you can set this polarity independently for each channel.
ULD and LLD	The upper and lower levels for the window discriminator can be set independently for each channel. The polarity of the levels is set automatically according to the signal polarity selection. The value of the ULD must be higher than the LLD.
HV	If you have the high voltage options installed, you can set the output voltages individually for each channel. The "Max:" value in the display shows the highest voltage and polarity available with the installed option, which could be different for each channel. You must enter a value in range, and with the explicit polarity For example, if you have negative modules installed, you must enter "-525" to get a negative 525 volt output. The high voltage is only enabled when you press the HV: button; you should then see the voltage ramp to the set point.
Analog out	The C400 has a precision +/- 5V analog output for each channel. You can set the value directly in this edit box. This may be used for example to program a remote high voltage supply.
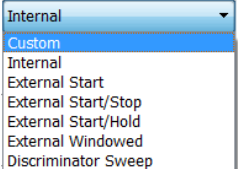
10.3.4.2   Trigger setup

The second setup sub-tab gives you access to the trigger controls. You can select from various pre-defined trigger modes using the drop-down control.

Figure 21. Trigger setup parameters.

If you choose Custom mode, you get complete control of the conditions that start, pause and stop data acquisition using the selection and parameter boxes. The External modes are various specific start, pause and stop conditions that you could also enter via Custom mode. If you simply want to acquire counts right away without worrying about the complexities of triggering, select Internal trigger mode. See section 13 for full details about triggering.

Trigger mode	Several trigger modes are available with this drop-down control. *Custom:* The user has full control over the start, pause and stop conditions. *Internal*: The C400 generates its own triggers, so acquisition starts as soon as the unit is initiated *External Start*: After initiation, the C400 waits for a rising (falling) edge on the gate input to start integrating counts *External Start/Stop*: After initiation, the C400 waits for a rising (falling) edge on the gate input to start integrating counts. A falling (rising) edge stops the acquisition. *External Start/Hold*: After initiation, the C400 waits for a rising (falling) edge on the gate input to start integrating counts. A falling (rising) edge suspends the acquisition until the next rising edge. *External Windowed*: The way that acquisitions are triggered, and the numbers of readings that are taken in response to triggers is controlled by the trigger mode, the buffer size and the burst count. This is explained in more detail in section 13. *Discriminator sweep:* A special triggering mode reserved for the discriminator sweep function.
Buffer size	If you require contiguous readings at high rates, then you must buffer the data in the C400 because the communication link and the host computer cannot be guaranteed to keep up with the data rate. You can define a buffer of up to 65536

	readings. Data is uploaded to the host in blocks of 100 while the acquisition is in progress. If you set a buffer of 0, then buffering is disabled and the data is sent to the host computer as fast as it can be accepted.
Burst count	The burst count is the number of readings that are taken after each trigger. The buffer may be considered as a reserve from which fixed portion of size burst count is drawn whenever there is a trigger.

10.3.4.3   Other setup

Figure 22. Other setup parameters.

Pulse setup	You can enable the diagnostic pulse output individually for the four channels by checking any combination of the boxes A to D. This facility is typically used in scintillation detectors that include a test LED in the housing, to confirm the complete detector and counting system is working. The pulse width is adjustable down to 1 nsec and the period down to 1 µsec (corresponding to 1 MHz).
Encoder	You can limit the encoder count to a specific maximum, beyond which it starts again from zero. This is typical for shaft encoders. Setting zero means there is no limit to the count. If there is an index signal available, you can cause this to zero the counter, and you can choose the polarity of the index. The counting sense relative to the physical motion sense can be swapped by checking the Invert Encoder box.

10.3.5 Discriminator sweep

In order to set the detector high voltage and the discriminator levels, you need information about the distribution of pulse heights. The C400 provides an automatic discriminator sweep facility that displays a spectrum of pulse heights, allowing you to make informed decisions about the settings. The discriminator and high voltage settings are reproduced in this display area so that you can enter the values you choose conveniently. See section 15 for further details.

Figure 23. Discriminator sweep controls.

Enable discriminator sweep	Discriminator sweep is a special acquisition mode that you must enable by checking the box. The usual upper and lower levels are overridden by the dynamic values used in the sweep.
Start, End	These controls set the starting and ending lower discriminator levels for the sweep.
Increment	The window that is swept through the pulse height range, and thus the resolution of the measurement, is set by the increment control. The steps are the same size, so that the resulting spectrum is contiguous.
Dwell time	This sets how long data is accumulated at each step.

10.3.6 Calibration

The C400 stores calibrations for all its DACs and ADCs to improve their absolute accuracy. Any of the values can be edited on this display, and are stored in non-volatile memory when the values are entered. You should clearly be careful not to enter incorrect values as you will get confusing results. The discriminator upper and lower level voltages and the high voltage readback can be calibrated automatically, either selectively by channel, or altogether.

Figure 24. Calibration control and display.

Discriminator limit DACs	The gain values are in DAC bits per volt, and the offsets are in volts. The Calibrate button at the top of the display adjusts the offsets automatically. The offset can be adjusted to include the offset voltage of any pre-amplifier that is attached to the channel.
Analog out DAC	The gain values are in DAC bits per volt, and the offsets are in volts. These values can be altered manually based upon measurement of the analog output voltage with an independent meter.
HV DAC	The gain values are in DAC bits per volt, and the offsets are in volts. These values can be altered manually based upon measurement of the high voltage output with an independent meter.
HV readback ADC	The gain values are in volts per ADC bit, and the offsets are in volts. These values are adjusted automatically by the C400 when you press the Calibrate button at the bottom of the display area. The HV setpoint DACs must be calibrated using external equipment before using this function. You should ensure that there is nothing connected to the high voltage connectors before

	pressing Calibrate. The process takes a few minute to complete; you will see the Busy indicator lit. After calibration you should see good agreement between the commanded HV values and the readback.
Clear All Calibrations	Clicking the Clear button deletes all the stored calibration values, setting all the offsets to zero and all the gains to default values.

10.3.7 Properties

The properties tab provides details of the C400 hardware and software versions, serial number and network configuration. You can perform firmware updates, and change the IP configuration for Ethernet communications.

Properties
Firmware

Update All Firmware...

Firmware Version: 0.7.5.92
OS Firmware: 0.3.0.16
                     Wed Mar 7
                     23:31:18 2012
Realtime Application: 0.2.5.3
                     Wed Mar 7
                     23:32:11 2012
FPGA: 0.1.0.56
Secondary FPGA: 0.1.0.17
Hardware Revision: 0

Communications

Configure...

IP Addess: 192.168.100.20
Mode: Static IPv4
MAC: 00:50:c2:97:5a:55

Serial Number: 0000002645
Baseboard: 0000000000

Figure 25. Properties tab.

10.3.7.1   Firmware

Version details of the four embedded codes are listed. Pressing the Update All Firmware button starts the sequence of a full update of all these codes. If you press this button you can still cancel the process at the firmware file selection stage. See section 27 for full details about firmware updating.

10.3.7.2   Changing the IP address

You can alter the C400 IP address to any valid setting, or enable DHCP in which case the C400 will be assigned an address by a router.
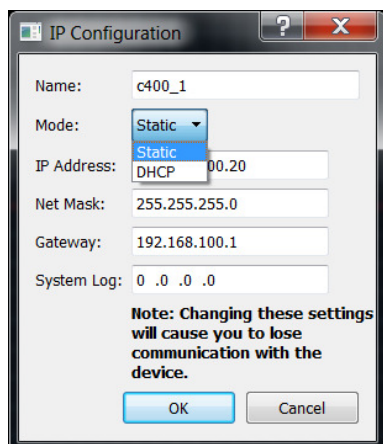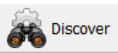
Figure 26. IP address configuration dialog.

Name	Enter a unique name for the C400 that will allow it to be identified on networks.
Mode	Select static or dynamic (DHCP) IP address allocation. If you select DHCP, the address and mask fields are greyed out.
IP address	Enter the required address if you have selected a static IP.
Net mask	Enter the subnet mask.
Gateway	Enter the address of the gateway that messages will be directed to if the host cannot be found in the subnet.
System Log	This is the address of a diagnostic logging server. This should be left set to 0.0.0.0 unless you are doing investigative fault-finding under the direction of Pyramid.

Note that the address change takes effect immediately, so you will lose communication in the session you were running. Simply click [Discover] on the Diagnostic to rediscover the device. If you have set the IP address outside the subdomain that is accessible to your host computer, you will need to change the IP address of the computer so that it is in the same subdomain as the C400.

10.3.8 Message Area

The message log area shows the response of the C400 to your commands, and activities on the Ethernet communications such as hosts being connected. You can scroll back through earlier messages with the sliders.

Errors and warnings are highlighted in red text. These can include warnings such as that an attempt to change a parameter has failed, or the internal data buffer has overflowed, or communications are being blocked.

```
14.03.2012 15:53:23:483 Trying to start up comms...
14.03.2012 15:53:23:985 success --> transitioning to running state
14.03.2012 15:53:24:065 [From c400_2640] Removing host 'PTC_JG_Laptop3' (192.168.100.111).
14.03.2012 15:53:24:066 [From c400_2640] Fiber message timeout.
14.03.2012 15:53:24:068 [From c400_2640] Adding host 'PTC_JG_Laptop3' (192.168.100.111).
14.03.2012 16:36:21:311 SetConfiguration accepted by device.
14.03.2012 16:36:21:536 Initiate accepted by device.
```

State: Idle / Measuring   Last Error: Fiber message timeout.

Figure 27. Message area.

You can clear the messages at any time by pressing the clear button (⬚). The last error message is captured at the bottom of the message are; you can clear this with the clear last error button (⬚). The internal state of the C400 is shown at the left underneath the message area.

11 C400 Circuit Overview

11.1 Discriminator inputs

The C400 uses fast level discriminators to compare the size of the signal at its input with thresholds set by digital to analog converters. The signal is terminated in 50 ohms and fed in parallel to the lower and upper level discriminators. The logic outputs are delivered to a high-performance FPGA (Field Programmable Gate Array).
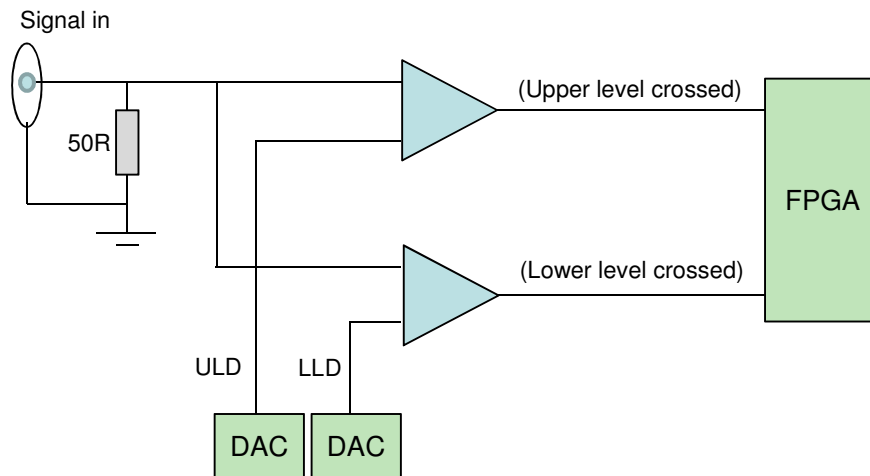
Figure 28. The basic discriminator circuit.

The discriminators have hysteresis of about 30 mV to prevent multiple triggering on noise. The C400 sets the levels as necessary to handle negative or positive going pulses, as selected by the user.

The FPGA sets a bit when the low level discriminator produces an output. If the upper level also produces an output, then the bit is reset, and nothing is counted. If the bit is not reset, it is counted into the scalers. The scalers have a depth of 32 bits, or 4.3 billion counts. They are read out transparently, with no interruption to the counting. An overflow bit which can be read by software is set if a scaler overflows.

11.2 Overall circuit

The C400 is based around high-performance two field programmable gate arrays (FPGAs) which handle all data collection, processing and communications. One is on the standard Pyramid A60 processor module, which includes the NIOS II embedded processor core which runs the C400 real time application. The A60 manages all the communications with the host computer. It reads the communication mode switches, jumpers on the main board that inform it about system configuration, and drives the system status LEDs.
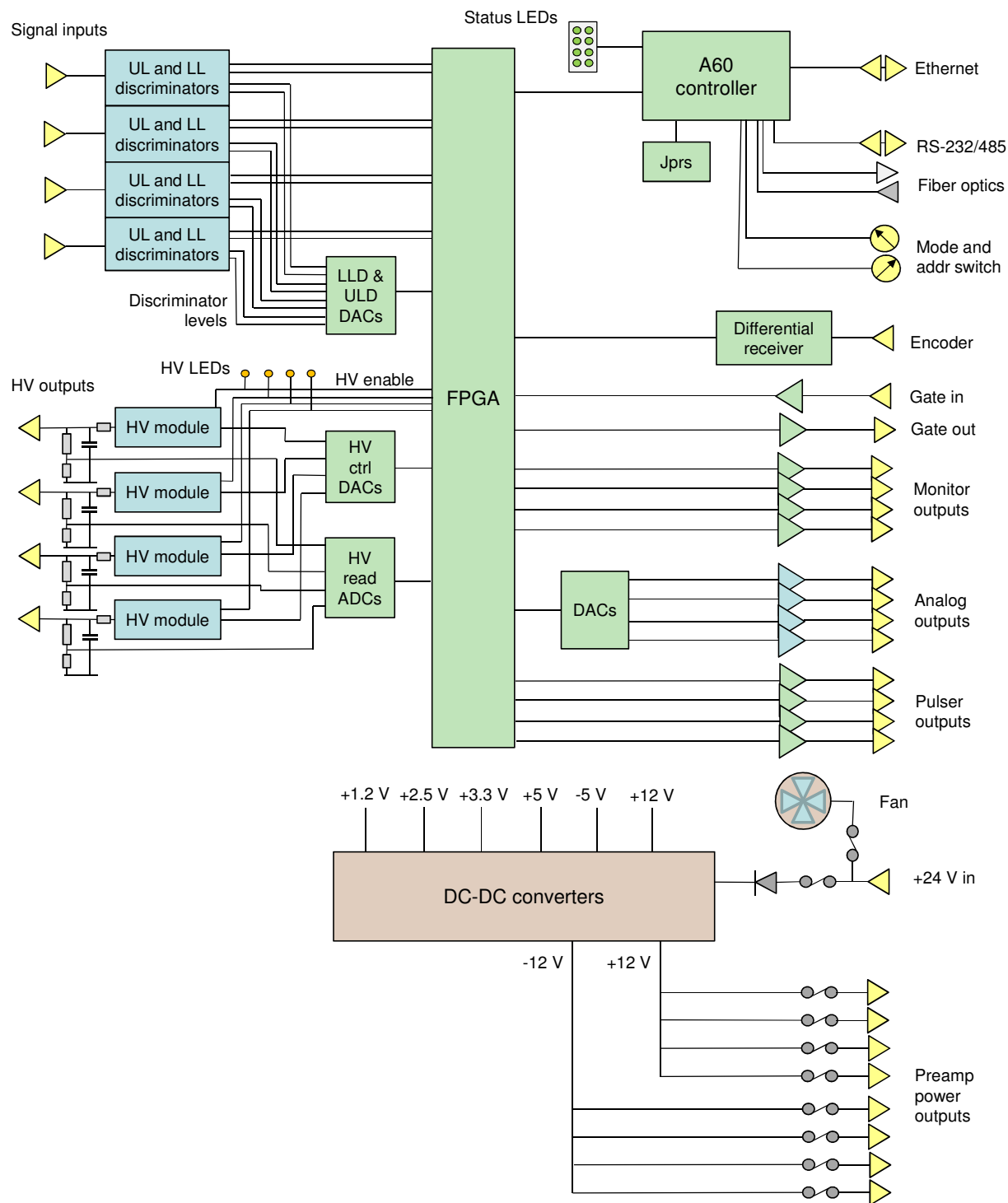
Figure 29. C400 block schematic.

The second FPGA is on the main board, and handles all the specific tasks such as discriminator logic, scalers, encoder pulse counting, and all DAC and ADC management.

The high voltage outputs include 100 µsec RC filters to reduce ripple. The high voltage readback is taken from resistive dividers directly on the outputs.

24 VDC input power enters via a 1.1 A resettable fuse, and is used directly to power the cooling fan. The 24 V input is protected against polarity reversal by a series diode, and from transients by series inductors and transorbs to chassis which limit excursions to 6 V (not shown on the block schematic). DC-DC converters generate the +/-12 VDC supplies for the pre-amplifier outputs, +12 VDC for the high voltage modules, +/-5 VDC for the discriminators, and +3.3 VDC, +2.5 VDC and +1.2 VDC for the digital circuits. The pre-amplifier power outputs are individually protected by 200 mA resettable fuses.

12 High Voltage Supplies

12.1 Setting the High Voltage Supplies

The C400 is available with a one-watt high voltage supply suitable for biasing photomultipliers, continuous dynode multiplier and diodes. The voltage range can be specified at time of purchase from 200, 500, 1000 and 2000V with either polarity. This can be done individually by channel, although this is not recommended due to the risk of connecting a detector to the wrong high voltage output. The A60 processor reads internal jumpers to detect the supply rating. Note that the supplies are not intended to deliver output voltage less than about 10% of their maximum rating.

The front panel HV on LED illuminates when the adjacent output is enabled. The set value can be adjusted at any time. If you are using the PTC Diagnostic software and have checked Auto Initiate, any measurement in progress will restart so you can see the effect of the change at once.

The outputs of the high voltage modules are filtered by an RC filter to reduce ripple and noise. For large current drains there will be a voltage drop across the series resistor, but you can see the actual output voltage because readback is taken from a voltage divider after the filter, directly on the HV output. The voltage divider places a fixed 60 Mohm load on the supply.

The following table gives the smallest value of external load resistance that the various supply options can drive at full voltage, the filter time constant and also the volts dropped across the series resistor at maximum current.

HV module	Current rating	Smallest load resistance	Filter time constant	Filter series resistor	Voltage drop across filter no load	Voltage drop across filter full load
+2000, -2000	0.5 mA	4.3 Mohm	110 µsec	33.2 kohm	1 V	17 V
+1000, -1000	1.0 mA	1.0 Mohm	33 µsec	10 kohm	0.2 V	10 V
+500, -500	2.0 mA	250 kohm	16 µsec	4.7 kohm	< 0.1 V	10 V
+200, -200	5.0 mA	40 kohm	0	0	0	0

If the readback value differs from the setpoint by more than the expected drop across the filter resistor, you know that the output is either being overloaded by a low resistance to ground, or that it is being driven by another source of higher compliance. Be aware of how the high voltage readback calibration might affect this. We recommend that the calibration is done with no connection to the HV outputs. Thus only the no-load voltage drop across the filter is hidden by the calibration, and when you connect a load you should expect to see small reductions in the measured voltage, up to the maxima given in the table. The measured voltage is the actual voltage at the output connector.

The C400 is available with higher power high voltage modules to special order. Please contact Pyramid Technical Consultants or your supplier for more details.

CAUTION

Do not connect external power supplies to the C400 external high voltage outputs that will drive the built-in supplies away from the voltages they are trying to regulate, or you may cause damage to the C400.

12.2 Changing the High Voltage Supply Range and Polarity

The range and polarity of the high voltage supplies is fixed and must be specified at time of purchase. Units may be returned to the factory to change the high voltage modules if necessary. It not recommended that users change the high voltage supply modules. The jumper settings are given here for reference only. There is a jumper bank for each channel.

+ HV0 HV1 HV2	-2000 V	
+ HV0 HV1 HV2	-1000 V	
+ HV0 HV1 HV2	-500 V	
+ HV0 HV1 HV2	-200 V	
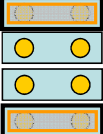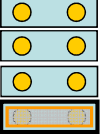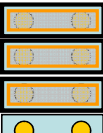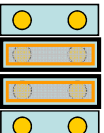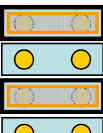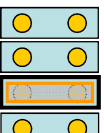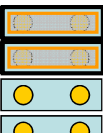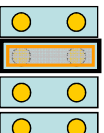
+ HV0 HV1 HV2	+2000 V	
+ HV0 HV1 HV2	+1000 V	
+ HV0 HV1 HV2	+500 V	
+ HV0 HV1 HV2	+200 V	

Figure 30. High voltage jumper settings

All other settings are interpreted as no HV option fitted.

13 Triggers and Data Buffering

13.1 C400 acquisition states

The best way to understand the ways that the C400 trigger modes and buffering options is to consider the internal states of the device concerning data acquisition, and the way you can control the transitions between these states by selecting the trigger modes, the buffer size and the burst count.
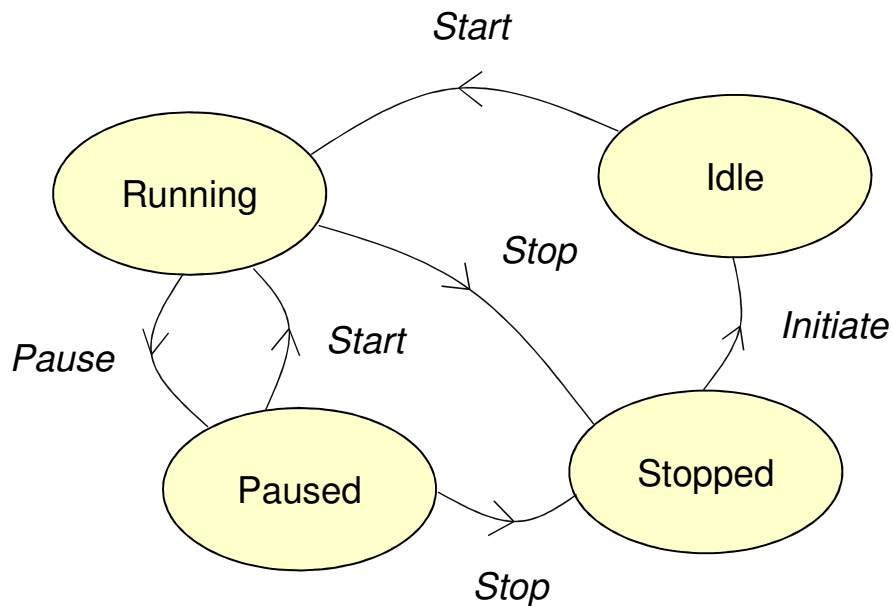
Figure 31. C400 acquisition state diagram.

The C400 is Stopped when there is no data acquisition in progress or pending. When you send the Initiate command it moves to the Idle state. It will then transition to the Running (acquiring data) state when the correct conditions are met. From Running the C400 may then transition to a Paused state while it waits for a condition to be met before resuming, or to the Stopped state to complete the acquisition.

There are three sources regulating the transitions, namely the Start source, the Burst (or Pause) source, and the Stop source. Each can be set to Internal (a C400 internal condition is met) or BNC (an external trigger signal is detected at the gate in connector).

The C400 will transition from Idle to Running if:

- The start source is set to BNC, and the appropriate edge is seen on the BNC gate

- If start source is set to internal, it will automatically go to Running when initiated

The C400 will transition from Running to Paused if:

-   Burst Count is greater than zero and that number of samples is acquired

-   The Burst Source is set to BNC, and the appropriate edge is seen on the BNC gate

The C400 will transition from Running or Paused to Stopped if:

-   Buffer Size is not Unbuffered (tie, it is greater than 0) and that number of samples is acquired

-   An abort command is received

-   The stop source is set to BNC, and the appropriate edge is seen on the BNC gate

13.2 Trigger modes

In the Custom trigger mode, you have full control over whether state transitions are driven by internal or external sources, for starting, pausing and stopping the acquisition. In the other trigger modes, some of the sources for various transitions are preset, as described in the following table. In the table, NBuf is the buffer size and NBst is the burst size. For every trigger mode you can force the C400 to the stopped state at any time by sending the Abort command.

Mode	*Start*	*Pause*	*Stop*	*Notes*
Custom				Custom mode gives you direct control over the start, pause and stop conditions. All other modes are particular configurations that can be achieved by suitable selections in Custom mode.
Internal	Internal	n/a	n/a	Acquisition will start immediately you send Initiate, and continue indefinitely if unbuffered, or to the lesser of NBuf size and NBst if buffered.
External Start	BNC	n/a	n/a	Acquisition will start when a valid trigger edge is seen after you send Initiate, and continue indefinitely if unbuffered. If buffered, it will do NBst readings on each valid trigger edge until it has acquired NBuf readings.
External StartStop	BNC	n/a	BNC	Acquisition will start when a valid trigger edge is seen after you send Initiate. If unbuffered, readings will continue until the opposite polarity trigger edge is seen. If buffered, it will stop on the lesser of NBst or Nbuf readings, or on the opposite polarity trigger edge, whichever comes first.
External StartHold	BNC	n/a	n/a	NBst is forced to a value of 1 in this mode. A single reading is taken for each valid trigger edge. This will continue indefinitely if unbuffered. If buffered, it will continue until NBuf is reached.
External Windowed	BNC	BNC	n/a	Acquisition will start when a valid trigger edge is seen after you send Initiate. They continue until either NBst is reached, or the opposite polarity edge is seen, at which point

				the acquisitions pause. They resume when the next trigger edge is seen. In unbuffered mode, this continues indefinitely. In buffered mode, it continues until NBuf is reached.
Discriminator Sweep	Internal	n/a	n/a	Special internal mode used for discriminator sweeps only.

13.3 Buffer memory

If you are taking measurements at a relatively low data rate, or if you don't care about having time contiguous data, then you can use the unbuffered mode and use the memory of your PC to accumulate the results. You can tell the maximum data rate before you will start to loose samples to a reasonable approximation if you are using the PTC Diagnostic host software by observing the Comms rate indication. For example, if the rate is shown as 20 Hz, then you can take readings with integration time down to 50,000 µsec before you will start missing data points in the logged data. The fact that data is missing is evident from the gaps in the trigger counts, as shown in the following examples which used internal trigger mode.

timestamp	triggercou	channel_1	channel_1	channel_2	channel_2	channel_3	channel_3	channel_4	channel_4	encodercount
25.6	0	0	-0.05	0	-0.05	0	-0.05	4357	-0.05	20
25.7	1	0	-0.05	0	-0.05	0	-0.05	4147	-0.05	20
25.8	2	0	-0.05	0	-0.05	0	-0.05	4431	-0.05	20
25.9	3	0	-0.05	0	-0.05	0	-0.05	4124	-0.05	20
26	4	0	-0.05	0	-0.05	0	-0.05	4661	-0.05	20
26.1	5	0	-0.05	0	-0.05	0	-0.05	4559	-0.05	20
26.2	6	0	-0.05	0	-0.05	0	-0.05	5180	-0.05	20
26.3	7	0	-0.05	0	-0.05	0	-0.05	4200	-0.05	20
26.4	8	0	-0.05	0	-0.05	0	-0.05	4405	-0.05	20
26.5	9	0	-0.05	0	-0.05	0	-0.05	5103	-0.05	20
26.6	10	0	-0.05	0	-0.05	0	-0.05	5080	-0.05	20
26.7	11	0	-0.05	0	-0.05	0	-0.05	4433	-0.05	20
26.8	12	0	-0.05	0	-0.05	0	-0.05	4120	-0.05	20

Figure 32. Unbuffered logged data with a 10 Hz comms rate, 100000 µsec integration time.

timestamp	triggercou	channel_1	channel_1	channel_2	channel_2	channel_3	channel_3	channel_4	channel_4	encodercount
0.01	1	0	-0.05	0	-0.05	0	-0.05	405	-0.05	20
0.11	11	0	-0.05	0	-0.05	0	-0.05	321	-0.05	20
0.21	21	0	-0.05	0	-0.05	0	-0.05	351	-0.05	20
0.31	31	0	-0.05	0	-0.05	0	-0.05	360	-0.05	20
0.41	41	0	-0.05	0	-0.05	0	-0.05	425	-0.05	20
0.51	51	0	-0.05	0	-0.05	0	-0.05	495	-0.05	20
0.61	61	0	-0.05	0	-0.05	0	-0.05	541	-0.05	20
0.71	71	0	-0.05	0	-0.05	0	-0.05	327	-0.05	20
0.81	81	0	-0.05	0	-0.05	0	-0.05	382	-0.05	20
0.91	91	0	-0.05	0	-0.05	0	-0.05	589	-0.05	20
1.01	101	0	-0.05	0	-0.05	0	-0.05	477	-0.05	20

Figure 33. Unbuffered logged data with a 10 Hz comms rate, 10000 µsec integration time.

By contrast, the C400 internal data memory can accept data from the counters at the maximum rate, so you should use buffering in cases where it is critical to take time contiguous data.

timestamp	triggercou	channel_1	channel_1	channel_2	channel_2	channel_3	channel_3	channel_4	channel_4	encodercount
0	0	0	-0.05	0	-0.05	0	-0.05	1	-0.05	20
1.00E-05	1	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
2.00E-05	2	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
3.00E-05	3	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
4.00E-05	4	0	-0.05	0	-0.05	0	-0.05	1	-0.05	20
5.00E-05	5	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
6.00E-05	6	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
7.00E-05	7	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
8.00E-05	8	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
9.00E-05	9	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
0.0001	10	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20
0.00011	11	0	-0.05	0	-0.05	0	-0.05	0	-0.05	20

Figure 34. Buffered logged data with a 10 Hz comms rate, 10 μsec integration time.

Note that if you select a buffered mode and relatively long integration time, there can be an appreciable delay before the first data appears on the DiagnosticG2 display.

14 Monitor Outputs

The monitor outputs provide a standard 10 nsec TTL logic pulse into a 50 ohm load whenever an incoming pulse into the corresponding channel falls into the discriminator window. The lag between the arrival of the pulse and the output of the monitor is around 80 nsec after the discriminator conditions are met. In the following figure, the input pulse and the discriminator levels are shown in yellow, and the resulting monitor output pulse in blue.
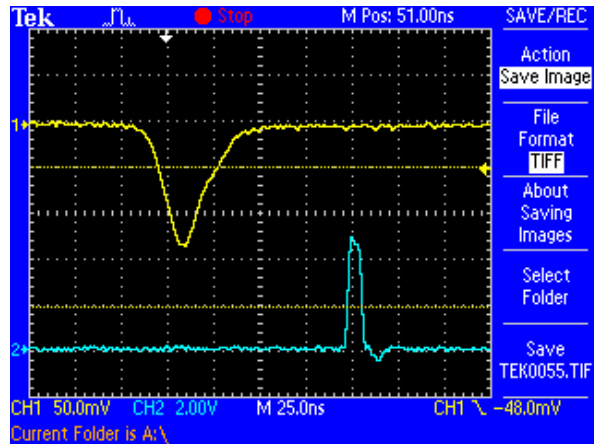
Figure 35. Example of monitor output pulse.

You can use the monitor outputs to drive external scalers, or diagnostic devices such as ratemeters.

If you are viewing the input pulses on a digital oscilloscope, and also feeding them to the C400, then the monitor can make a very useful trigger for the oscilloscope that selects only the pulses in your range of interest for display. This is not possible on an analog oscilloscope because the monitor occurs after the incoming pulse.

15 Discriminator Sweep

In order to make informed decisions about setting detector high voltage and the discriminator levels, you need to know about the range of pulse heights coming from the detector. The C400 provides an automated discriminator sweep function. A small discriminator window is stepped from a starting voltage to an ending voltage that you nominate, and the counts measured at each step are plotted as a function of the lower limit of the window. The sweep repeats so that the counting statistics improve. Making the increment small increases the resolution of the pulse height analysis, but slows down the acquisition. If your count rate is relatively low, it is beneficial to use buffered mode to maximize the number of pulses that you count in a given time– simply set the buffer to the maximum size of 65536.

Although the C400 is not primarily designed to be a pulse height analyzer, you can obtain recognizable energy spectra if the incoming pulses are sufficiently well-defined. This means that you should use a pre-amplifier with sufficient integration to give smooth pulses. See section 17 for more details. The following example shows a spectrum from a Na-22 source, as measured with a LaBr$_3$ scintillation detector, a CP10-A preamplifier and the C400. The 511 keV positron annihilation peak and the 1.275 MeV peak from the decay to Ne-22 are visible.
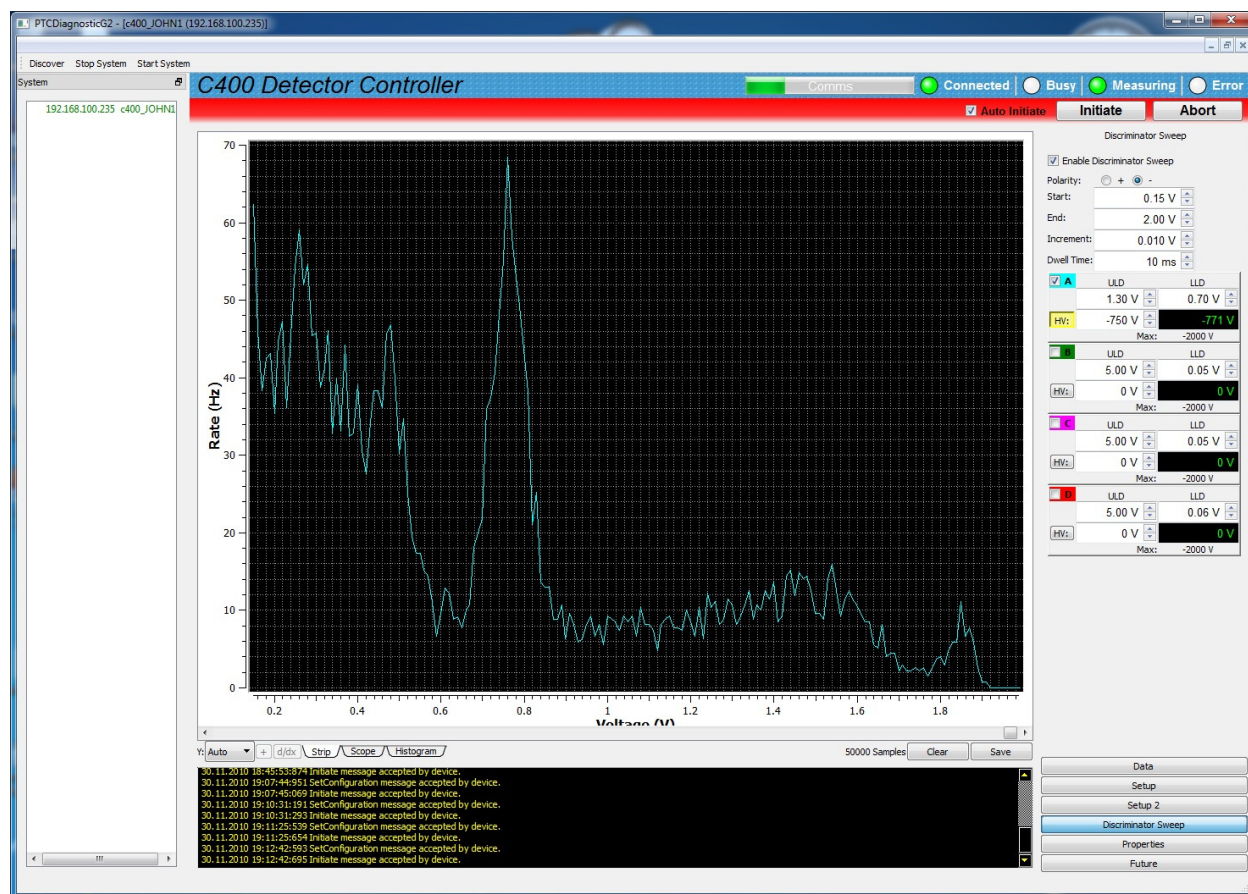
Figure 36. Na-22 spectrum acquire using discriminator sweep.

There are two unwanted features in pulse height spectra that you should avoid. If you start the sweep at very low voltage, below about 0.05 V, you will start to see electronic noise from the pre-amplifier. It is easy to identify because it will be present even when there is no high voltage bias on the detector. Remove the noise from the spectrum by starting the sweep just above the noise level.

Secondly, be aware of the maximum height that pulses can reach. If you are using a CP10 pre-amplifier for example, the maximum voltage output is about 2 V. Any larger pulses will saturate at this level, resulting in a spurious peak at the high voltage end of the spectrum. Even if your detector gain is set so that the pulses of interest to you are well clear of saturation, there will still be a natural background of high energy radiation. Avoid creating a spurious peak by ensuring the maximum of the sweep is below the maximum output voltage of the pre-amplifier when driving into the 50 ohm load of the C400 input.

16 Deadtime Correction

16.1 Models of deadtime

All pulse counting detector systems have an unavoidable deadtime. There are two models of deadtime, called non-paralyzable and paralyzable deadtime. In the non-paralyzable case we assume there is a deadtime when a pulse is being handled. Another pulse arriving during this time is not counted, but has no other impact. In the paralyzable case, we assume that another pulse arriving in the deadtime is not counted, but that it can nevertheless extend the deadtime. The non-paralyzable case is more mathematically tractable, so the extent that we can perform a reliable calculation to estimate the counts that were lost, assuming only that the counting statistics are Poissonian, which is the case for most radiation sources.
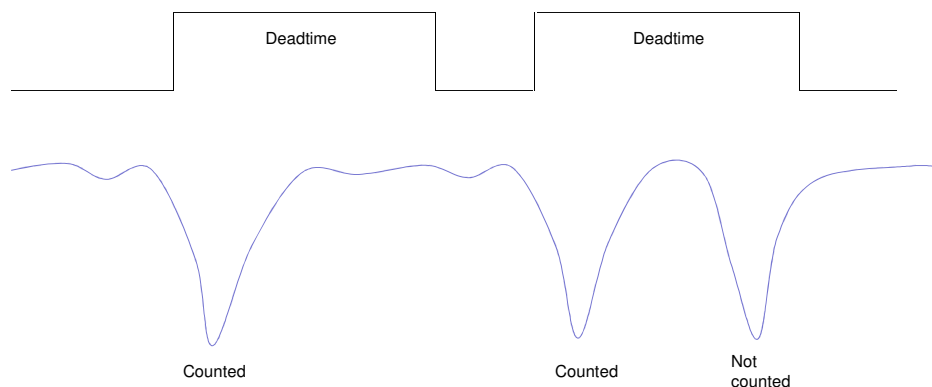
Figure 37. Non-paralysable deadtime model.

The deadtime is composed of individual effects such as the processing time of the electronics and the physical duration of the detector pulse and the lengthening of the detector pulse due to integration on parasitic or deliberately introduced capacitances in the signal processing chain. Generally one component will dominate, and the shorter components have no influence. The deadtime due to the C400 itself is better than 10 nsec, so in most cases the detector/pre-amplifier will be limiting.

The C400 calculates the actual counts for each individual integration period in real time, using the equation

$$N_{actual} = N_{meas} / (1 - (\tau/T)*N_{meas})$$

where N_{meas} is the actual measured counts in integration length T seconds and τ is the fixed deadtime in seconds. The correction can be turned on or off using the check box on the setup page of the PTC Diagnostic program. The correction is generally dependable up to 20 to 30%, but if you are making larger corrections, then it is likely that the non-paralyzable model is becoming invalid as effects like detector gain suppression start to dominate. You should exercise

care in using data which has been extrapolated too far. As an illustration, if we have a system deadtime of 50 nsec, then an incoming rate of 3.3 MHz will be corrected up to 4 MHz, a 20% correction. If the deadtime is 10 nsec, then the same relative correction occurs at an incoming count rate of 16.7 MHz.

16.2 Determining the deadtime

You can often make a reasonable estimate of the deadtime by observing the pulses being delivered to the C400 inputs on a fast oscilloscope, and making an estimate of the typical pulse width. However the most reliable way of measuring the deadtime is to measure the detector response to a radiation source whose intensity you can control at will. Examples include emission stabilized X-ray tubes, or various numbers of small, equal radioactive sources. Alternatively you may be able to control the geometry of the measurement setup to adjust the flux reaching the detector, for example using collimators of known apertures, or by altering the separation between the source and the detector.

The following example uses data from a LaBr$_3$ scintillation detector measuring the flux from a small stabilized X-ray tube. The geometry and the high voltage on the tube were kept constant, and the tube emission current was adjusted.
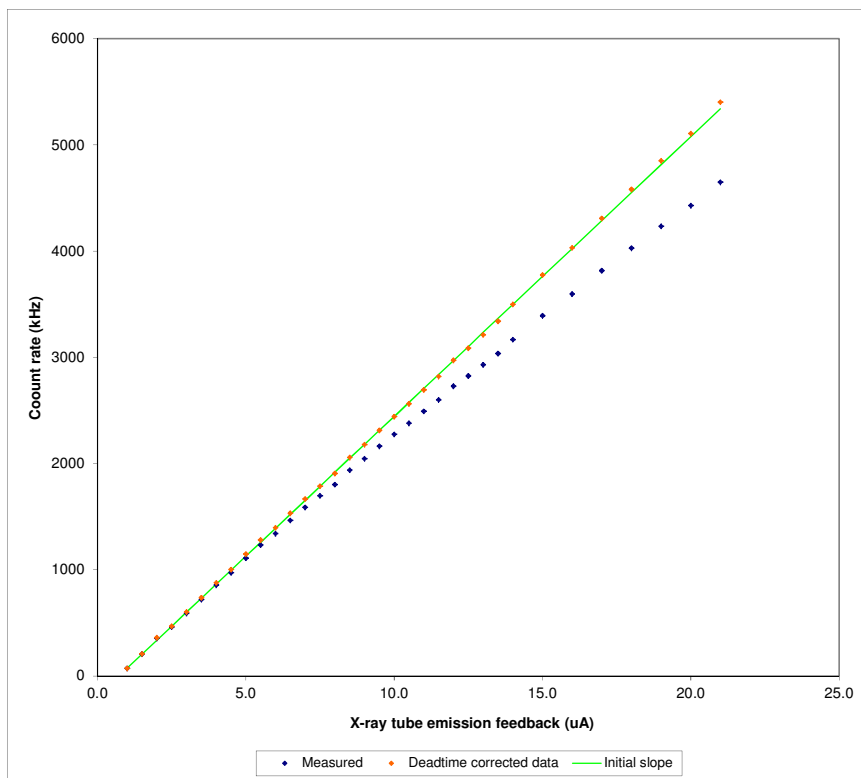
Figure 38. Deadtime measurement using a controllable intensity source.

The blue points are the measured counts recorded by the C400 with no deadtime correction applied, as a function of the X-ray tube emission current. The green line is a linear fit to the first

few data points, where we can assume the effect of deadtime is negligible, and thus represents the ideal detector response. You can see how the recorded counts fall increasingly below the ideal line at increasing intensity, as the losses due to deadtime become significant. The red points are the recorded values with an off-line correction using a deadtime of 30 nsec. This was in accordance with the pulse widths as observed on an oscilloscope. The validity of the proposed value was checked by entering the value as the deadtime in the C400, and repeating the measurements with correction enabled.

17 Pre-amplifier selection

The C400 is compatible with many pre-amplifiers, and can provide power to any that require +/-12 VDC at no more than 100 mA. The Pyramid CP10-A and CP10-B types are designed for use with the C400.

It is important to choose an appropriate pre-amplifier type for your application. The C400 is a fast pulse counting device, so an integrating pre-amplifier is generally not suitable, because pulses are converted into steps. A wide-band amplifier will preserve the fast pulse from your detector. This means a low input impedance is required, usually 50 ohms, to minimize unwanted integration of the pulses on the capacitance of the detector plus the cable connecting it to the pre-amplifier. DC-coupled pre-amplifiers are preferred because they will suffer less from baseline shift at high count rates than AC-coupled ones.

At first you might feel inclined to always use the highest bandwidth pre-amplifier available, but this is not the best strategy in all cases. The high-speed usually comes with a price in noise levels and DC offset. Most important, however, is that excess bandwidth may simply expose characteristics of the detector output pulses that are detrimental to best pulse counting performance. The following single pulses captured on a digital oscilloscope show the pulses from a $LaCl_3$ scintillation detector amplified by the CP10-A and the faster CP10-B pre-amplifier. The bandwidth of the CP10-A is suited to this type of detector in the pulse counting application, but the CP10-B reveals individual electron avalanches in the photomultiplier during the light decay which could confuse the discriminator logic and lead to incorrect counting.
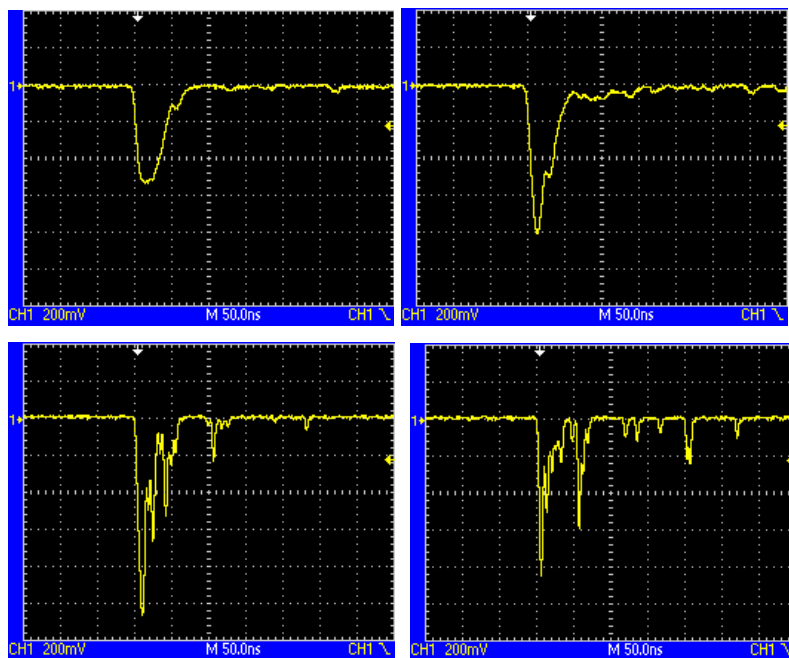
Figure 39. Pulse shapes from a $LaCl_3$ scintillation detector as seen by the C400 with CP10-A pre-amplifier (upper traces) and CP10-B pre-amplifier (lower traces).

18 Pulser Outputs

The C400 pulser output allows you to perform a full validation of your counting system in suitably configured detector systems. An LED is fitted inside the housing of a scintillation detector so that it can deliver light pulses to the scintillator. If the LED is driven by short pulses, then the resulting detector response can be a good simulation of ionizing radiation events, except with exactly known frequency.

The C400 can generate 5V pulses as short as 1 nsec with a frequency of up to 1 MHz, and current up to 30 mA. The size of the detector response will depend on the pulse duration and the LED current. You can set the current by choosing a series resistor for the LED. For a typical LED forward voltage of 2V, the LED current will be 3000/R mA. Thus a series resistor R of 150 ohms will give current of 20 mA, and this is also a good termination for a twisted pair line. However you can try any value within the current compliance of the C400 and the rating of the LED in the detector.
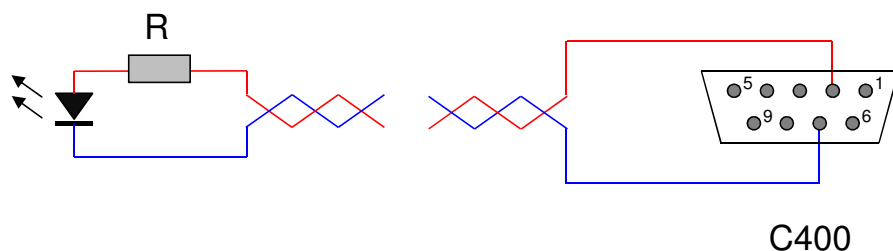
Figure 40. Test pulser LED connection.

Having chosen a suitable LED current, you should then observe the detector pulses on an oscilloscope and adjust the pulse duration to give the best match to real radiation events.

19 Encoder Input

Many situations require that the measurements from one or more detectors are correlated with the physical position of a sample, or of the detector itself. The encoder input on the C400 allows a standard position encoder to be read out in synchronization with the pulse counting measurements.

The encoder input handles standard differential quadrature signals.
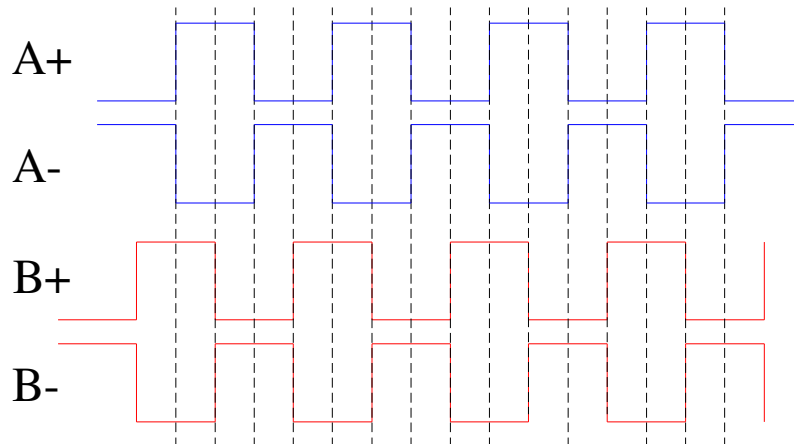
Figure 41. Differential quadrature signals from a shaft encoder, clockwise movement.

The input voltages can be up to +/-25 V, with a differential of greater than 0.2 V necessary to define an input state. Input levels of 0 V and 5 V are typical. A +5 VDC output is provided which can be used to power suitably-rated encoders. A differential index signal is also supported.

Differential signals are recommended for their good noise immunity. However many encoders only provide A and B inputs. In this case you should bias the unused A- and B- inputs (and Z- if you are using the index) to a voltage halfway between the high and low states of the pulses.
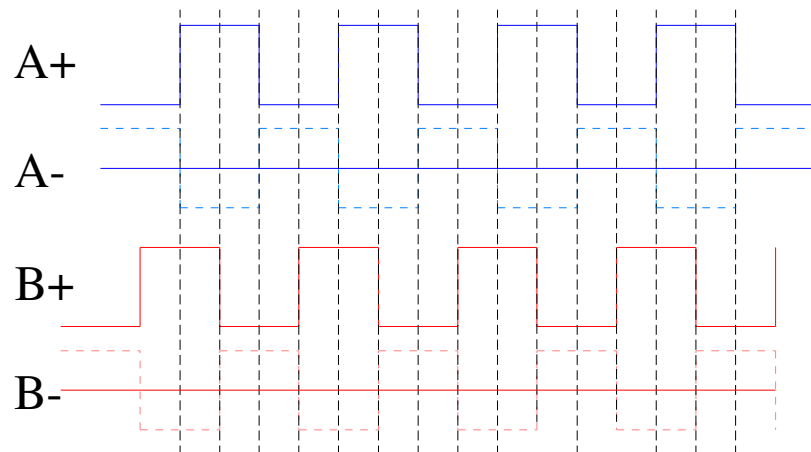
Figure 42. Encoder signals when no differential signals are available.
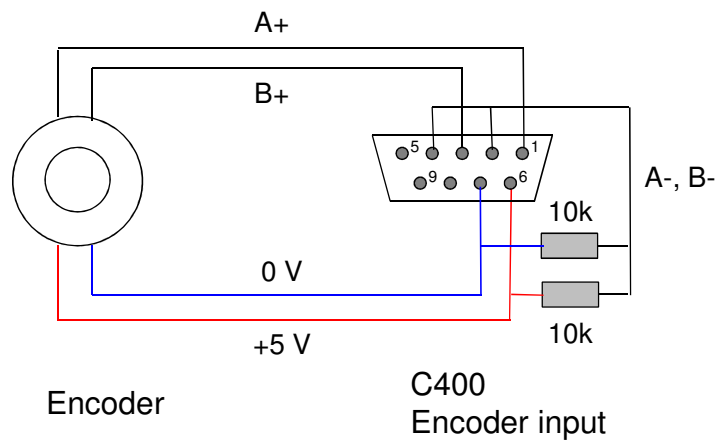
Figure 43.   Example bias circuit for encoder inputs when no differential signals are available.

20 Connectors

20.1 Front panel connectors

Four identical sets of connectors for the four channels.

20.1.1 Signal input

Four Lemo 00 50 ohm coaxial.

Core: signal

Screen: AGnd
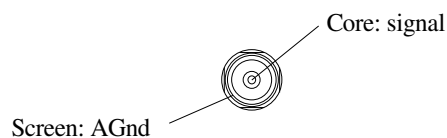
20.1.2 Pre-amplifier power and other services

Four Dsub 9 pin female.

Pin 5   Pin 1
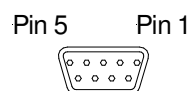
Pin 9   Pin 6   (External view on connector / solder side of mating plug)

1	DGnd	6	DGnd
2	Pulser out	7	DGnd
3	AGnd	8	+12 VDC
4	-12 VDC	9	AGnd
5	Analog output		

20.1.3 High voltage outputs

Four SHV male. To mate with standard SHV connector.

Core: high voltage
(2 kV max)

Outer screen: shield
(at chassis GND)
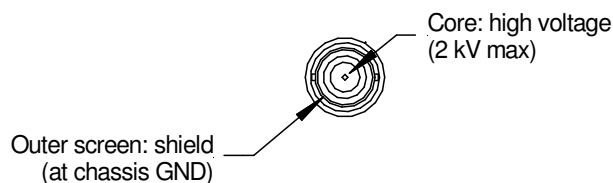
20.2 Rear panel connectors

20.2.1   Ethernet communications

RJ-45 jack. To mate with standard RJ-45 plug.

Auto MDIX facilty - cable can be direct or crossover type.

20.2.2 Fiber-optic communications:

HFBR ST bayonets suitable for 1 mm plastic or 200 um silica fiber. 664 nm (visible red) light.
Dark casing = receiver, light casing = transmitter.

20.2.3 RS-232 / RS-485 communications

Six pin mini-DIN socket (PS/2 mouse/keyboard type).

Pin 6 — Pin 5
Pin 4 — Pin 3
Pin 2 — Pin 1
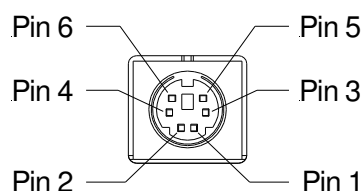
(External view on connector / solder side of mating plug)

1	RS-232 Tx / RS-485 Tx-	4	n/c
2	RS-232 Rx / RS-485 Rx+	5	RS-485 Tx+
3	Gnd	6	RS-485 Rx-

The socket incorporates a sensor switch that allows the C400 to detect that a plug has been connected. When a connection is made, the RS-232 / RS-485 transceiver is active, and the communication mode is set by the mode switch.

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

20.2.4 Gate output

BNC socket (female). To mate with standard signal BNC. Able to drive a 50 ohm load.

Core: signal, TTL levels

Outer screen: shield / 0 V reference
(at DGnd)
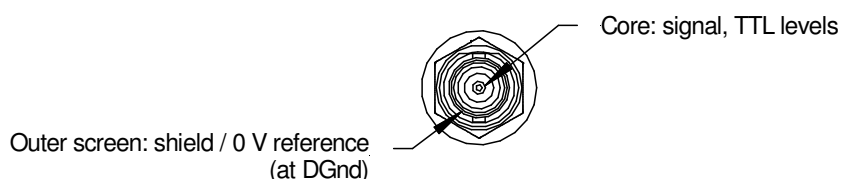
20.2.5 Gate input

BNC socket (female). To mate with standard signal BNC.

Core: signal, TTL levels

Outer screen: shield / 0 V reference
(at DGnd)
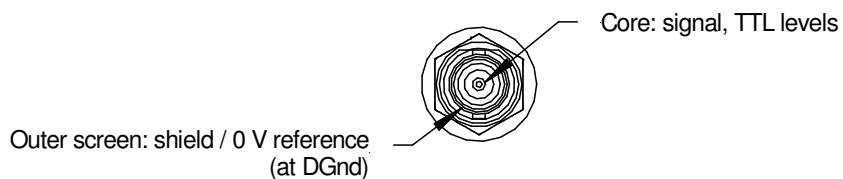
20.2.6 Encoder input

Dsub 9 pin female.

Pin 5   Pin 1

Pin 9   Pin 6   (External view on connector / solder side of mating plug)

1	Enc A+	6	+5 VDC out
2	Enc A-	7	DGnd
3	Enc B+	8	DGnd
4	Enc B-	9	Enc Z+
5	Enc Z-		

20.2.7 Monitor outputs

Four Lemo 00 coaxial.

D   C   B   A
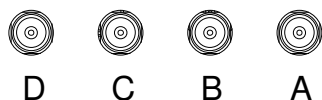
20.2.8 Power input

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

Center pin: +24VDC

Outer: 0V
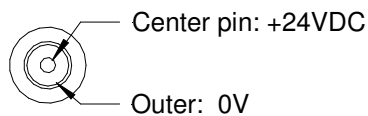
20.2.9 Ground lug

M4 threaded stud. To mate with M4 ring lug.

21 Controls and Indicators

21.1 Front panel controls

None.

21.2 Rear panel controls

21.2.1 Reset button

Momentary push-button that forces a warm reset of the on-board processor. If you keep the button pressed during boot up, the IP address is forced to the default of 192.168.100.20.

21.2.2 Address switch

16 position rotary switch setting device address for use when you have the C400 as a client device on a fiber optic loop. 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)
1-15	Available address settings.

If you are using the C400 as a loop controller, the address switch has no function.

21.2.3 Mode switch

10 position rotary switch setting communications mode. This switch is read if a connection is made to the serial connector. The ASCII protocol is provided for ease of connection to existing systems and simple terminal programs. Note that binary communications over RS-232 or RS-485 is not currently supported by the C400, only so settings 0 and 3 are equivalent, so are 1 and 4, and so on.

Setting	Protocol	Baud rate	Signal levels
0	8 bit binary	115.2 kbps	RS-232
1	8 bit binary	57.6 kbps	RS-232
2	8 bit binary	19.2 kbps	RS-232
3	ASCII	115.2 kbps	RS-232
4	ASCII	57.6 kbps	RS-232
5	ASCII	19.2 kbps	RS-232
6	8 bit binary	115.2 kbps	RS-485
7	8 bit binary	57.6 kbps	RS-485
8	ASCII	115.2 kbps	RS-485
9	ASCII	57.6 kbps	RS-485

21.3 Front panel indicators

21.3.1 HV on
Four yellow LEDs. Illuminated if the HV supply is enabled on the channel.

21.4 Rear panel indicators
Eight green LEDs.

24V	●	●	Com
2.5V	●	●	Ethernet
Initiated	●	●	Optical
Active	●	●	Serial

Figure 44. LED functions.

21.4.1 24V
Green LED. 24 VDC power is present.

21.4.2 2.5V
Green LED. 5V DC-DC converter is running, 2.5 V regulator running and generating 2.5 VDC power.

21.4.3 Initiated
Green LED. Unit has been initiated and triggered to acquire data.

21.4.4 Active
Green LED. C400 processor has booted and is running normally.

21.4.5 Com
Green LED. A host communication channel is active.

21.4.6 Ethernet
Green LED. Ethernet commands are being received. The on state is stretched so that it can be seen. This LED does not illuminate for pings or if the C400 is streaming data to the host.

21.4.7 Optical

Green LED. Fiber optic is the active communication interface.

21.4.8 Serial

Green LED. Serial (RS-232 or RS-485) is the active communication interface.

21.4.9 Power up sequence

On power-up, all LEDs light initially. The Initiated and Active LEDs then extinguish, and the Com, Ethernet, Fiber and Serial LEDs light in sequence while the C400 is booting.

21.4.10 RJ-45 indicators

Green LEDs incorporated in the Ethernet connector show that a connection has been established (left hand LED) and that messages are passing (right hand LED).

21.5 Internal jumpers

Two jumper banks (JPR5, JPR6) are provided inside the C400 for general functions, plus four individual banks (JPR1-4) for HV configuration. 2mm jumpers are used. The HV configuration jumpers are described in section 12. Other functions are as follows:
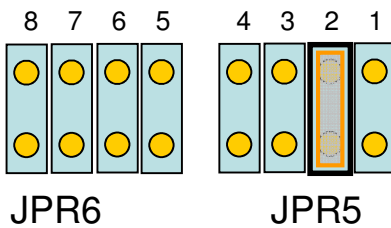
Figure 45.   Internal jumpers.

Position	Function if fitted
JPR5 - 1	Enable bootloader mode
JPR5 - 2	Disable watchdog
JPR5 – 3	Ultravolt HV module used instead of EMCO HV module
JPR5 – 4	Reserved
JPR6-1..4	Reserved

In normal operation there should be a jumper on JPR5-2 only.

22 Communications Interfaces

The C400 is a member of the PSI G2 range of devices. The unit is provided with four hardware interfaces, RS-232, RS-485, fiber-optic and Ethernet. The RS-232 and RS-485 interfaces are intended for simple direct connection to PCs, with no other equipment necessary. The fiber-optic interface provides greater speed, excellent noise immunity, and allows multiple devices to be connected in a looped topology. The Ethernet interface is provided to allow direct connection to systems which are integrated using standard local area network hardware and protocols.

The C400 can support multiple clients, and in particular you can be connected via Ethernet and the serial port at the same time.

The baud rate, type of protocol and choice of RS-232 or RS-485 levels for serial communication is made using the mode switch. Only ASCII communication with RS-232 levels is supported on the serial interface with current firmware. Therefore the binary and ASCII settings of the mode switch are equivalent; for example both setting 0 and setting 3 give the same 115kbps ASCII communication.

If the Ethernet connection is made then the Ethernet port becomes active. The connection speed is negotiated when the connection is made, in the normal way. Allocation of transmit and receive lines at the C400 is also automatic, so you don't need to worry about whether you are using a patch cable or a crossover cable. The mode switch and address switch have no function for Ethernet communications. LEDs incorporated in the RJ-45 jack indicate activity on the port.

To have the C400 connected on a fiber optic network, you require a fiber-optic adaptor or loop controller device to connect to the host computer. The fiber-optic interface is well-suited to large systems and experiments. Support for C400 connection to fiber optic loops will be added in a future firmware release. The C400 will act as a fiber optic loop controller with current firmware. See section 24 for more details.

22.1.1 Device name

You can assign a unique name to the C400 which allows it to be identified more easily in a networked system. The name is assigned using the PTC DiagnosticG2 program as part of the IP configuration dialog. It is stored in non-volatile memory.
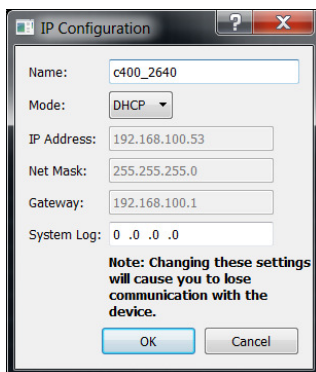
Figure 46. Device name assignment.

This name is displayed when you discover devices with the PTC DiagnosticG2 program, in the DiagnosticG2 properties tab, on the C400 webpage, and it is returned over the serial interface in the response to *IDN? ASCII command.

22.2 Ethernet connection

22.2.1 Static IP Address

Most instrumentation networks require devices to work with static IP addresses. These addresses will be assigned by the network administrator to ensure that the C400 address does not conflict with any other device. You will also be assigned a subnet mask that limits the range of addresses used by your local network. Typically this will be 255.255.255.0, meaning that the local network only allows device addresses to differ in the last byte. If you are using a wider range, for example 255.255.0.0, then all devices must be set this way.

22.2.2 DHCP

The C400 supports dynamic IP address assignment (DHCP). For this to work, you need to have the C400 connected in a network containing a router that provides this service. The C400 will negotiate with the router when it boots up or is otherwise connected to the network.

22.2.3 Default gateway

Any C400 messages that cannot be routed within the local subnet will be sent to the default gateway you define.

22.2.4 System Log

The C400 can send log messages to an IP address you define. There must be a suitable service running at this address. If it is not running, you may see unpredictable behavior. Therefore we recommend that you disable this function unless specifically instructed by Pyramid or your supplier, by setting it to 0.0.0.0.

22.2.5 Firewalls

An instrumentation network will typically be isolated from the wider internet, so that the computers servicing the network can operate without firewalls. This provides the most reliable communications, as firewalls can interfere with connections in unpredictable ways. However if you do need to have firewalls in place, and need the C400 communications to pass through the firewall, then the following rules should be set up on the host computer:

C400 RPC messages: allow TCP traffic on local port 111 to any remote port

PTC DiagnosticG2: allow all traffic, all ports

22.2.6 Restoring the default IP address

You can force the C400 to restore its default IP address of 192.168.100.20 by power cycling and keeping the rear panel reset button pressed while it boots up.

If the C400 is set to DHCP but does not get an address assigned, it will default to 192.168.100.20 after about 30 seconds. If it was assigned an address by a previous DHCP service, it will initially use this.

22.2.7 Webserver

The C400 provides a simple HTML webserver, so you can connect to it using a browser. The C400 will display device name and firmware details, and allow you to search for devices connected to the C400 on a fiber optic loop. You can then interrogate these devices for their details.
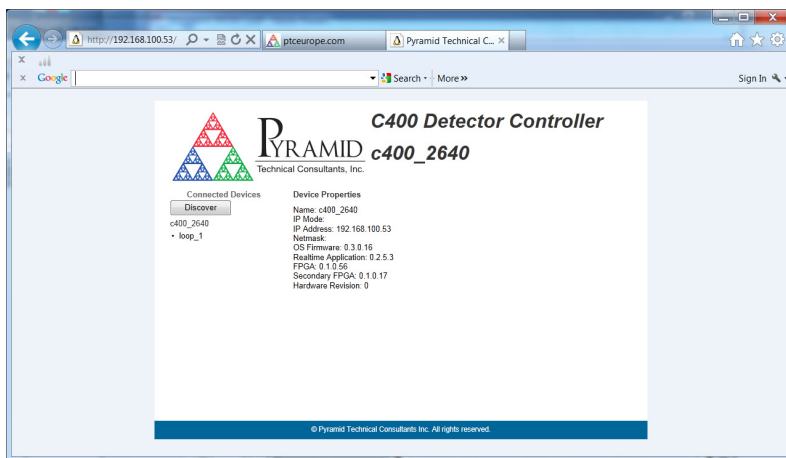
Figure 47. C400 webpage.

22.3 RS-232 connection

A basic three-wire RS-232 connection is all that is required to communicate with the C400. The C400 uses a 6-pin mini-DIN connector. An adaptor to a 9-pin female DSub is available from Pyramid; a standard pin to pin male to female 9-pin DSub cable can them be used to connect to the PC. The cable length should not exceed about 5m, especially at the maximum baud rate. For longer serial cable runs you should use RS-485.
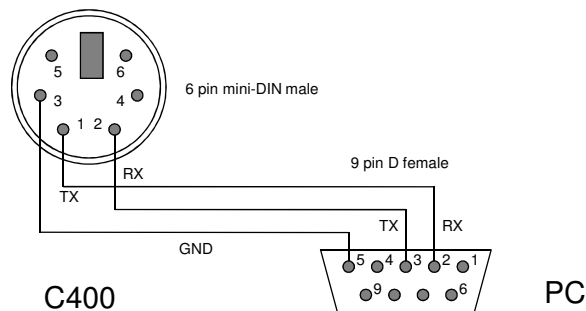
Figure 48. RS-232 cable C400 to PC.

22.4 RS-485 connection example

RS-485 is used to extend a serial connection over a long distance. If you have a RS-232 serial port on the host PC, then an RS-232 to RS-485 converter is used at the host PC end. The built-in RS-485 of the C400 allows a direct connection at its end.

A commonly-used converter is the MOXA TC100. The Moxa TCC-80 is a low-cost alternative for less critical applications. The converter should be configured for four wire (full duplex) RS-485 operation. The C400 provides parallel termination for transmit and receive. It is therefore optional whether you also terminate at the TC100 end, but there is no harm if you do. The recommended Dip switch setting for the TC100 is:

Sw1	Sw2	Sw3
OFF	ON	ON

The recommended Dip switch setting for the TCC-80 is:

Sw1	Sw2	Sw3
ON	OFF	ON

1 :Tx-
2: Rx+
3: Gnd
4: n/c
5: Tx+
6: Rx-

F3200E

Tx+ (B)
Tx- (A)
Rx+ (B)
Rx- (A)

SGnd
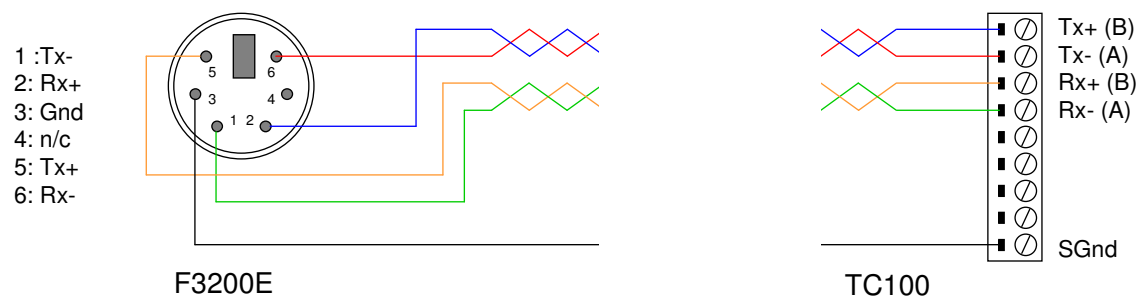
TC100

Figure 49. RS-485 cable C400 to TC100.

In order to enable the RS-485 interface on the C400, you must have a physical connection to the serial port, and you must select one of the relevant modes (modes 6 through 9). If you have trouble getting the RS-485 connection to work, check carefully to ensure that you have all the transmit and receive lines connected as shown.

23 ASCII Communication

The C400 is a high performance device that will give you best performance with a dedicated host software application and high bandwidth communications interface. Nevertheless, there are numerous applications that do not require especially high performance, and connections to the C400 may be most convenient with a simple serial interface. The C400 supports a basic ASCII interface over RS-232 or RS-485. It supports some of the commands prescribed by Standard Commands for Programmable Instruments (SCPI) and IEEE 488.2, plus specific commands as required by the operation of the device.

All commands to the C400 should be terminated with LF only (ASCII char 10 / ctrl-J), although a carriage feed (ASCII char 13 / ctrl-M) or combination of both will be handled. All C400 responses are terminated with CR LF. The backspace is CTRL-H (ASCII char 8).

The commands are grouped with a hierarchical structure, with the levels separated by the colon character. For example:

CONFigure:PERiod 1e-2   // This command configures the integration period to have a length of 10 milliseconds.

SCPI provides for a long and short form for each command. The short forms are indicated by the capitalized part of the command.

Commands which have a query equivalent for readback are marked with "(?)" in the following tables. Parameters are generally passed to the C400 with the set version of the command, but no parameters are passed for the query version. For example:

CONFigure:PERiod 1e-2   // set the integration period to 10 msec
CONFigure:PERiod?   // query the integration period

In the following tables,

{} denotes a required argument.

[] denotes an optional argument.

23.1 IEEE 488.2 Mandatory commands

*CLS		Not supported
*ESE	(?)	Not supported
*ESR		Not supported
*IDN?		Identification Query. C400 returns manufacturer, model number, serial number, master firmware version, individual firmware versions
*OPC	(?)	Not supported
*RST		Reset Command. Restart the device software and return to the *RST default conditions. This command is not yet supported.
*SRE	(?)	Not supported.
*STB?		Not supported
*TST?		Not supported
*WAI		Not supported

23.2 IEEE 488.2 Optional commands

*RCL		Recall device configuration from flash
*SAV		Save device configuration to flash

The settings covered by *RCL and *SAV are:

CONFigure:ACCUMulate
CONFigure:DAC
CONFigure:DLO
CONFigure:DHI

CONFigure:POLarity
CONFigure:PERiod
CONFigure:PULSer
CONFigure:DEADtime
CONFigure:HIVOltage:VOLts   (Note that the CONFigure:HIVOltage:ENable settings are not included).
TRIGger:BUFfer
TRIGger:BURst
TRIGger:MODe
TRIGger:SOURce
TRIGger:POLarity

Settings saved using *SAV are automatically recalled when the device is turned on.

23.3 C400 specific commands

ABORt					Abort measurement
CONFigure	:ACCUulate {0|1}			(?)	Set (query) the accumulate mode. 0 = the counters are reset to zero for the start of each integration, 1 = the counters are not reset for the start of each integration.
	:DAC {Ch} {Val}			(?)	Set analog outputs DAC Ch to Val volts. (Query all 4 DAC settings.).
	:DEADtime			(?)	Set (query) the deadtime correction in ns to be applied to the incoming counts for all channels.
	:DHI {Hi1 Hi2 Hi3 Hi4}			(?)	Set (query) the discriminator high level Hi1..Hi4 in volts for each channel. The sign is ignored (see CONFigure:POLarity).
	:DLO {Lo1 Lo2 Lo3 Lo4}			(?)	Set (query) the discriminator low level Lo1..Lo4 in volts for each channel. The sign is ignored (see CONFigure:POLarity).
	:ENCOder {Enc}				(Command not yet supported)
	:HIVOltage	:MAXvalue {HVm1 HVm2 HVm3		(?)	Set (query) maximum allowable external high voltage setting HVm1…HVm4 in volts for each channel. This is a software

		HVm4}			enforced limit.
		:SUPply?			Query maximum allowable external high voltage setting in volts for each channel, as determined by the installed HV module.
		:VOLts {HV1 HV2 HV3 HV4}		(?)	Set (query) the auxiliary (external) high voltage setting HV1..HV4 in volts for each channel. See FETch:HIVOltage? for readback values.
		:ENable {0|1} {0|1} {0|1} {0|1}		(?)	Enable/disable (query) the auxiliary (external) high voltage power supply for each channel.
	:PERiod {Per}			(?)	Set (query) integration period Per in seconds.
	:POLarity {N|P} {N|P} {N|P} {N|P}			(?)	Set (query) the discriminator polarity for each channel.
	:PULSer {Period Width}			(?)	Set (query) the LED pulser output. Period and width are in nsec.
COUNTs	:OVERflow	:CLEar {ch}			Clears the overflow bit for channel ch.
FETch	:COUNts? [numSamples]				Returns counts for the numSamples most recent triggers for the four channels. Returns: numSamples * {integration_time,count1,count2,count3,count4,timestamp,trigger count,Lo1,Lo2,Lo3,Lo4, overflow mask CR LF}. It is only possible to request multiple samples if TRIGger:BUFfer > 0. Otherwise, numSamples should be omitted.
					Maximum samples returned per call is about 12, limited to keep the return strings to a reasonable size. To recover a full buffer of size N, call FET:COUN? [N] repeatedly until all samples are recovered.
					If accumulate mode is enabled, the integration time is the summed integration time over the number of integrations up that point.
					In buffered mode, the values update after every 400 integrations, and after the last integration. If the integration time is large, this means that readouts during the acquisition will only change infrequently (every 400 x integration time seconds).
	:RATE?				Returns rates for the numSamples most recent triggers for the four channels. Returns: numSamples *{integration

	[numSamples]				time,rate1,rate2,rate3,rate4,timestamp,trigger count,Lo1,Lo2,Lo3,Lo4, overflow mask CR LF}. It is only possible to request multiple samples if TRIGger:BUFfer > 0. Otherwise, numSamples should be omitted. Maximum samples returned per call is about 12, limited to keep the return strings to a reasonable size. To recover a full buffer of size N, call FET:RATE? [N] repeatedly until all samples are recovered. This command is not appropriate for accumulate mode.
	:DIGital?				Read digital status bits. See following section for the meaning of the bits.
	:ENCOder?				Return the current encoder count.
	:HIVOltage?				Read HV readback ADCs. Returns {HV1,HV2,HV3,HV4}.
INITiate					Initiate data acquisition on valid trigger.
PULSe {channels}					Send out LED pulses on channels (0-15 binary pattern).
SCAN {start_V} {stop_V} {window_V} {period}					Configure and initiate a discriminator sweep starting at start_V (signed) and ending at stop_V (signed) in increments of window_V and a dwell time of period seconds.
SYSTem	:COMMunication	:TIMEout		(?)	Set (query) timeout in seconds. 0 = timeout disabled. C400 will turn HV off if no valid message is received in the timeout period. This command is not yet supported.
		:IPMODE {DHCP|Static}		(?)	Set (query) the IP address setting mode. NOTE: Changing this setting may cause loss of communication with the device for several seconds.
		:IPaddress {x.x.x.x}		(?)	Set (query) the IP address.
		:NETmask {x.x.x.x}		(?)	Set (query) the subnet mask.
		:GATEway {x.x.x.x}		(?)	Set (query) the LAN gateway IP adddress.
		:LOGipaddress {x.x.x.x}		(?)	Set (query) the system log IP address.

	:ERRor	:COUNt?			Query the error counter.
	:SERIALnumber?				Query the serial number of the C400.
	:VERSion?				Query the SCPI standard version.
TRIGger	:BUFfer {size}			(?)	Set (query) the C400 on-board data buffer size.
	:BURst {count}			(?)	Set (query) the number of samples acquired in a burst (i.e. before a pause). This is 1 in EXTERNAL_START_HOLD mode.
	:MODE {mode}			(?)	Set (query) the trigger mode to mode . The options are: CUSTom, INTernal, EXTERNAL_START, EXTERNAL_START_STOP, EXTERNAL_START_HOLD, EXTERNAL_WINDOWED, DISCRIMINATOR_SWEEP
	:POLarity {0|1}			(?)	Set (query) external gate polarity (external trigger only). 0 = rising edge, 1 = falling edge (invert BNC trigger)
	:SOURce	:STARt {INTernal|BNC}		(?)	Set (query) the start trigger source. Used in CUSTom, EXTERNAL_START, EXTERNAL_STARTSTOP, EXTERNAL_START_HOLD, and EXTERNAL_WINDOWED modes.
		:STOP {INTernal|BNC}		(?)	Set (query) the stop trigger source. Used in CUSTom and EXTERNAL_STARTSTOP modes.
		:PAUse {INTernal|BNC}		(?)	Set (query) the pause/burst trigger source. Used in CUSTom and EXTERNAL_WINDOWED modes.

23.4 Digital status bits

0	Connected
1	Pending/Busy
2	Error
3	Reserved
4	Output changed (NOT SUPPORTED)

5	Reserved
6	Urgent device error (NOT SUPPORTED)
7	Reserved
8	Updating firmware
9	Starting up
10-15	Reserved
16	Measuring

23.5 Overflow mask

0	Channel A overflow
1	Channel B overflow
2	Channel C overflow
3	Channel D overflow

23.6 Using PuTTY to test the serial ASCII connection

Microsoft Windows no longer includes a terminal emulator that you can use to test the ASCII communications. Various public domain programs are available to perform this task. Pyramid has tested PuTTY and Realterm with the C400. The following screenshots show the configuration of PuTTY with 115kbps baud rate.

Figure 50. Setup of PuTTY for ASCII serial communication with the C400.

Figure 51. Example terminal session.

23.7 Using accumulation mode with a serial ASCII connection

The SCPI standard expects that devices will only respond when interrogated: there is no continuous dataflow between the device and the host computer. To avoid the risk of losing data because integrations are being completed faster than the host computer can recover the count data, the C400 supports an accumulation mode where the counters are not reset after each integration. The result is that you can integrate counts for arbitrary time. There are two useful modes of operation:

23.7.1 Indefinite duration accumulation

If you set a buffer size of zero (no buffering), then you can initiate an acquisition that will run indefinitely, until an abort command is issued. You can interrogate the counters at any time, as many times as you want, and get the accumulated counts and accumulated integration time up to that point.

The terminal session below illustrates setting up an indefinite sequence of 0.2 second integrations with accumulation. Four readout calls are made before the acquisition is aborted, and a final readout is made. The first parameter is the total integration time over which the counts in each channel (second to fifth parameters) have been accumulated. If any channel overflows the 2^{32} count maximum, the overflow mask (last parameter) would reflect this.

```
COM1 - PuTTY                                                                  ☐ ☐ ✕

conf:per 0.2
OK

conf:accum 1
OK

trig:buf 0
OK

init
OK

fet:coun?
5.2000e+00 S,22098002,5200004,7810,18113,5.0000e+00 S,25,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

fet:coun?
1.1400e+01 S,48444817,11400009,17113,39751,1.1200e+01 S,56,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

fet:coun?
1.6800e+01 S,59725926,16800013,25091,58584,1.6600e+01 S,83,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

fet:coun?
3.3200e+01 S,59725926,33200025,49660,115828,3.3000e+01 S,165,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

abort
OK

fet:coun?
3.9600e+01 S,59725926,39600030,59264,138168,3.9400e+01 S,197,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0
```
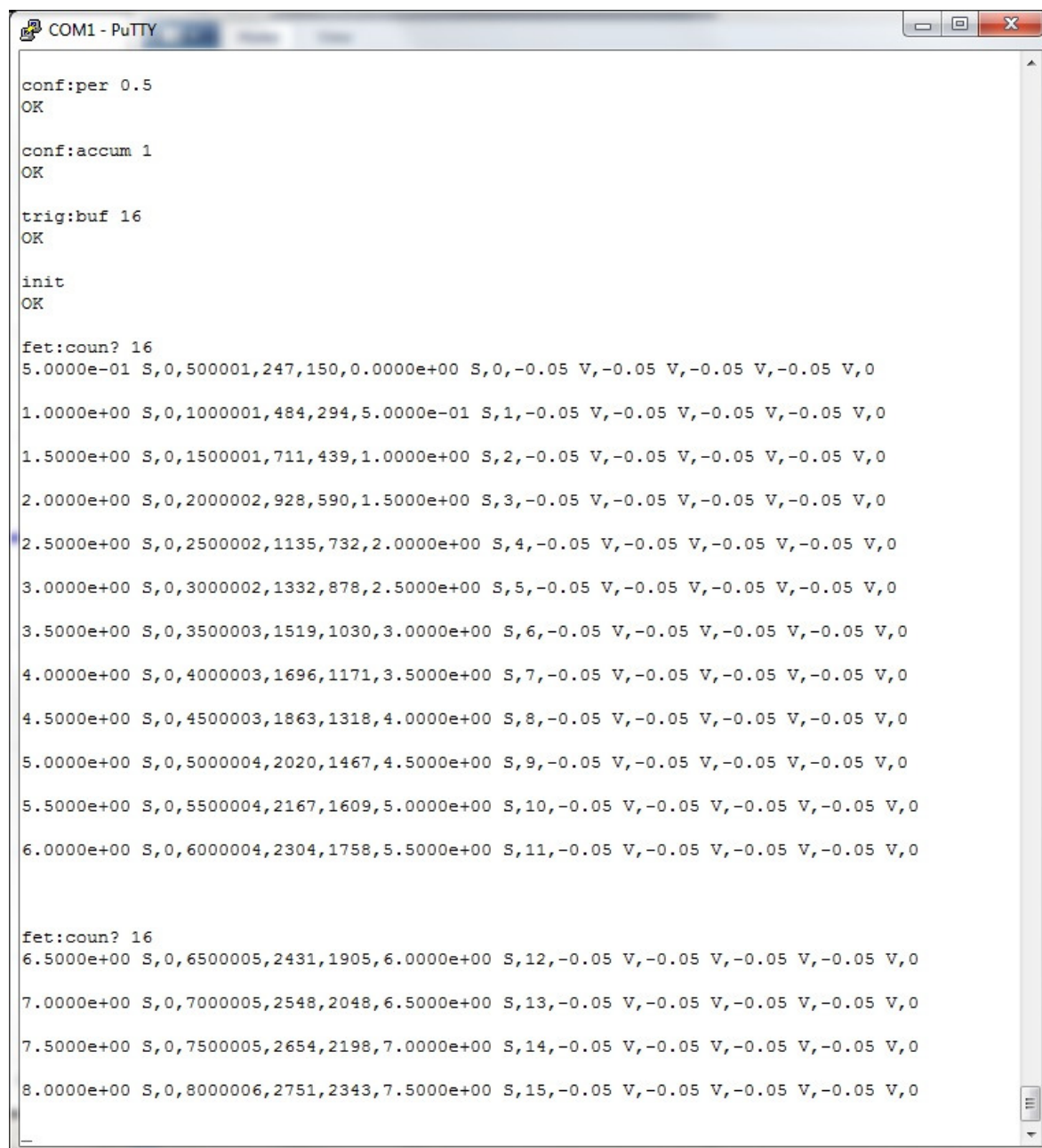
Figure 52. Terminal session illustrating indefinite duration acquisition

23.7.2 Pre-defined long duration accumulation

If you set a non-zero buffer size in accumulation mode, then you can pre-define a long acquisition. When it has completed, you can either recover just the final counts, or the complete buffer showing all the individual integrations. The maximum long integration period is (65535 x 1 second), or about 18 hours.

The terminal session below illustrates setting up an integration of 16 x 0.5 = 8 seconds. After it has completed, the buffer contents are recovered with two calls.

```
COM1 - PuTTY                                                        □ ▣ ✕

conf:per 0.5
OK

conf:accum 1
OK

trig:buf 16
OK

init
OK

fet:coun? 16
5.0000e-01 S,0,500001,247,150,0.0000e+00 S,0,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

1.0000e+00 S,0,1000001,484,294,5.0000e-01 S,1,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

1.5000e+00 S,0,1500001,711,439,1.0000e+00 S,2,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

2.0000e+00 S,0,2000002,928,590,1.5000e+00 S,3,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

2.5000e+00 S,0,2500002,1135,732,2.0000e+00 S,4,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

3.0000e+00 S,0,3000002,1332,878,2.5000e+00 S,5,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

3.5000e+00 S,0,3500003,1519,1030,3.0000e+00 S,6,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

4.0000e+00 S,0,4000003,1696,1171,3.5000e+00 S,7,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

4.5000e+00 S,0,4500003,1863,1318,4.0000e+00 S,8,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

5.0000e+00 S,0,5000004,2020,1467,4.5000e+00 S,9,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

5.5000e+00 S,0,5500004,2167,1609,5.0000e+00 S,10,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

6.0000e+00 S,0,6000004,2304,1758,5.5000e+00 S,11,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0


fet:coun? 16
6.5000e+00 S,0,6500005,2431,1905,6.0000e+00 S,12,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

7.0000e+00 S,0,7000005,2548,2048,6.5000e+00 S,13,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

7.5000e+00 S,0,7500005,2654,2198,7.0000e+00 S,14,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0

8.0000e+00 S,0,8000006,2751,2343,7.5000e+00 S,15,-0.05 V,-0.05 V,-0.05 V,-0.05 V,0
```

Figure 53. Terminal session illustrating pre-defined long duration acquisition

24 Connecting a Device to the C400 via Fiber Optics

The C400 can provide loop controller services for selected Pyramid devices. A useful example is the M10 general purpose I/O device which provides analog and digital inputs and outputs. When you connect to the C400, any valid devices on its fiber optic loop will be discovered and you can open windows in the G2 Diagnostic program to view data and set parameters on those devices.

In the following illustration, the C400 is managing a loop of three M10 devices. Each M10 is set with an individual loop address (01 to 0F). All four devices (C400 and three M10s) are accessed via the Ethernet interface. This facility allows you to build up a system without needing a dedicated fiber optic loop controller.
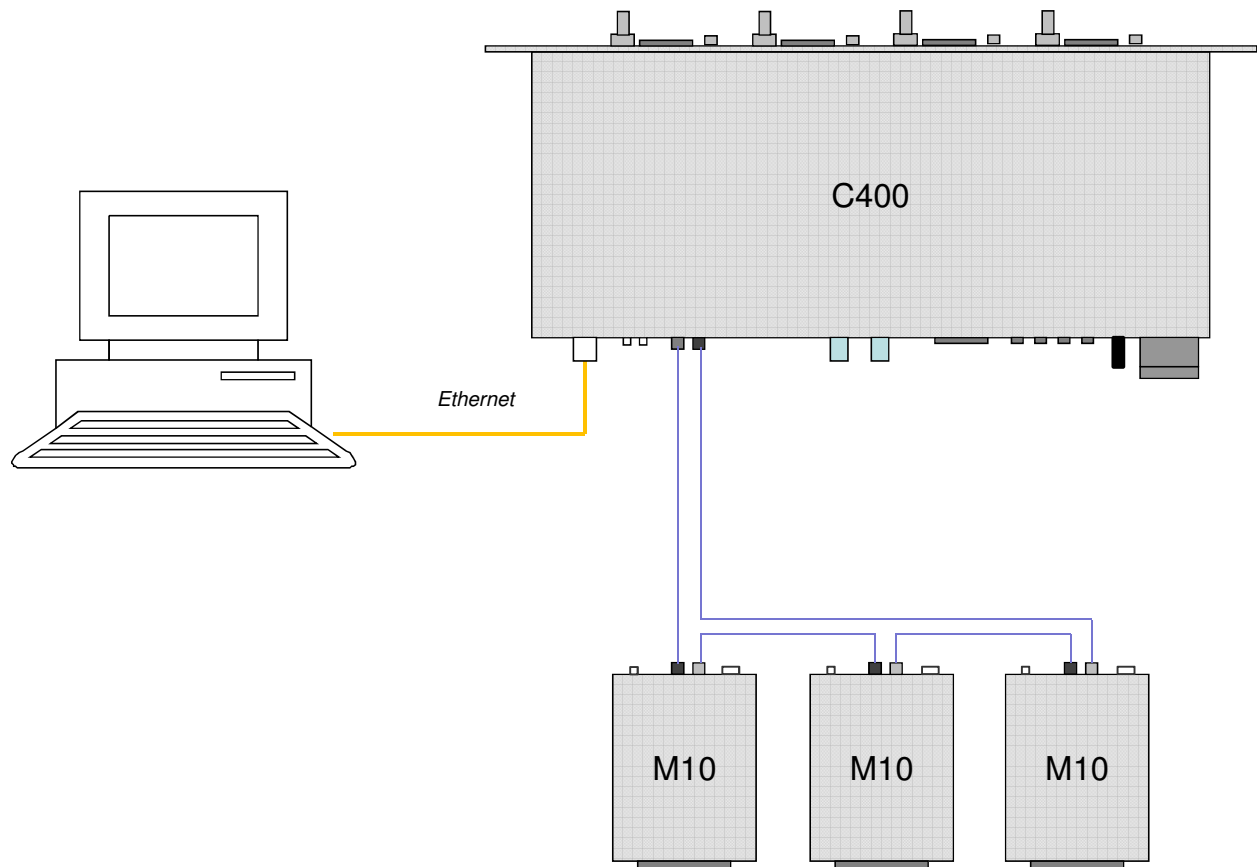
Figure 54. Using the C400 as a loop controller.

The following screenshot shows a single M10 at loop address 06 connected to a C400.
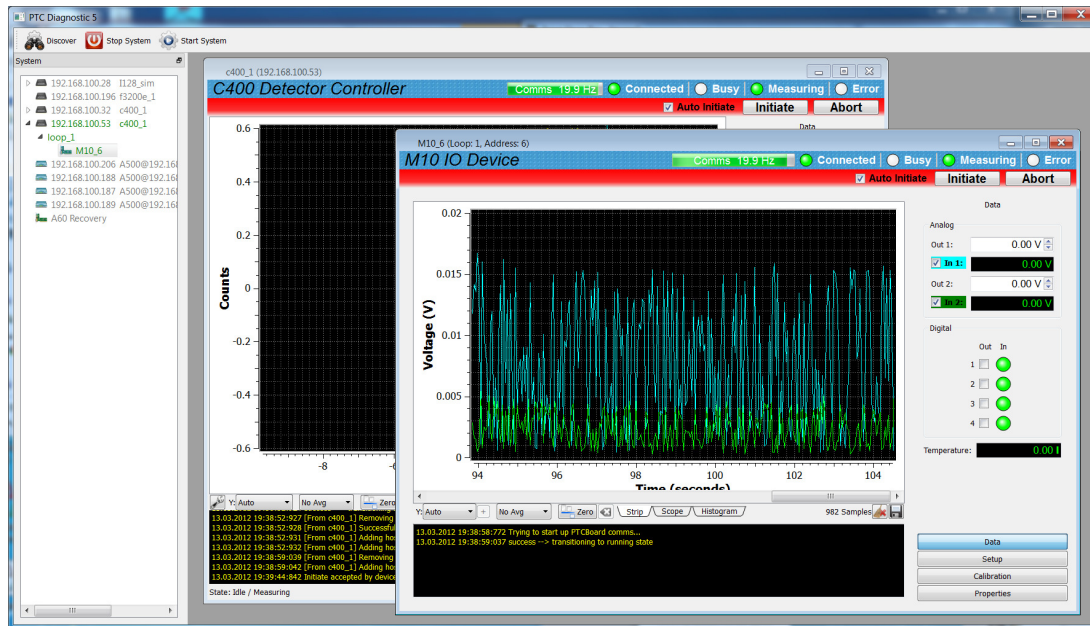
Figure 55. Connecting an M10 device through the C400.

25 Creating a Host Software Application

Pyramid Technical Consultants, Inc. provides a full application programming interface for the C400, based upon a C++ library. Full details are available upon request.

The Pyramid IG2 package uses an EPICS channel access server to make the C400 process variables available to the EPICS data distribution service. The data and controls can then be accessed by a wide range of client applications. See section 26 for further details.

Alternatively, for less demanding applications you can use the ASCII serial protocol, which can be accessed using generic serial device services in environments such as Labview and EPICS. Contact your supplier for more details about the options.

26 Interfacing to EPICS

26.1 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."

There are EPICS services for serial ASCII devices that can be used as the basis for custom EPICS interfaces for the C400. Alternatively, 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 56, the process variables of and C400 and an M10 attached to the C400 via fiber optics, are exposed to the network by the IG2 service running on a server computer. One or more client computers can then access the values.
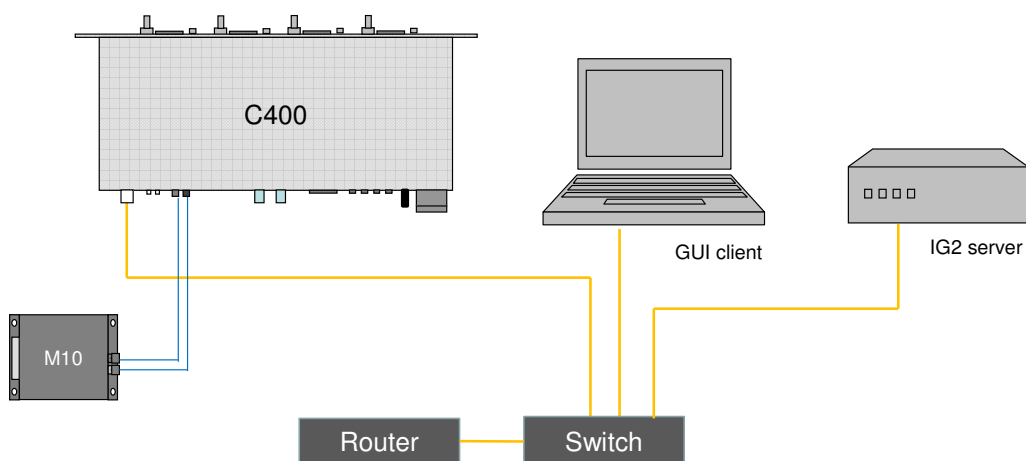

Figure 56. Simple example network for EPICS communications.

There is a wide range of client interfaces from the EPICS community, including interfaces for C++, C#, Java, Python, Labview ™, and Matlab ™. The Control System Studio, or CS Studio, (http://controlsystemstudio.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.

26.2 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 C400, 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 file that needs 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 name and path by means of an argument in the command line that launches IG2. The system.xml file includes all the information about your setup, including all the process variables that you want to expose, and what you want to call them. Since the names must be unique, it is a good idea to include the device name and the process variable description in the name.

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. The C400 is a loop controller, because it has the capability to support multiple slave devices through its fiber optic port. 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 convention of "wires" for Pyramid device process variables, and the fixed names of those wires for each supported product, are described in Pyramid document "ig2_scripting_v#.#.pdf", where #.# is the document revision number. 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; you may wish 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.

27 Updating Firmware

The C400 has four embedded firmware installations, which need to be compatible with each other. The installations are the Linux operating system, the NIOS processor real time application and the FPGA programs for primary and secondary FPGAs. In order to simplify the task of updating the firmware and ensuring the versions are all compatible, Pyramid Technical Consultants, Inc. releases C400 firmware as a single integrated zip file which is unpacked and uploaded to the correct memory areas by the software.

You should ensure that the C400 and the host computer will not be disturbed for the four minutes approximately that the update requires. To perform the update, click the Update All Firmware button on the Properties screen area. The software will now warn about the update process, and ask if you want to proceed.
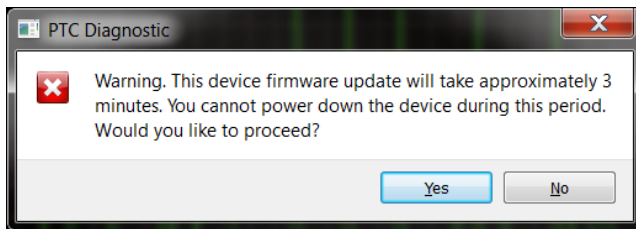
Figure 57. Firmware update warning.

Navigate to the update file, which is typically about 5 Mb in size and has filename C400_Firmware_x.x.x.x.zip where x.x.x.x is the version number.
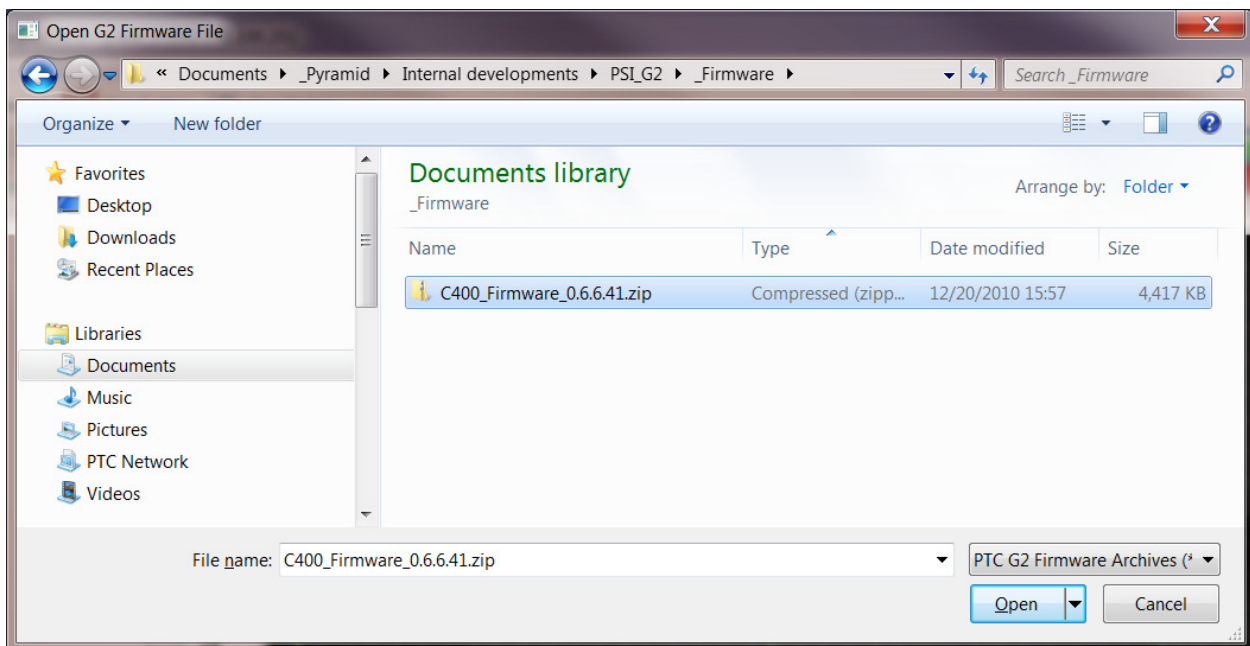
Figure 58. Selecting the firmware file.

While the update is taking place, you will see a countdown of the time remaining, and you can see detailed activities reported in the message window.
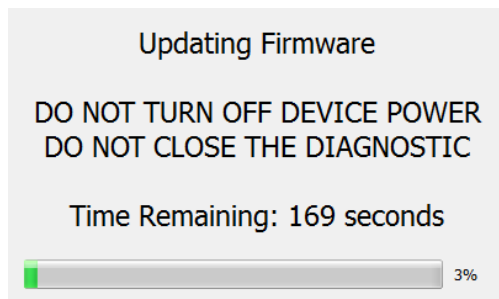
Figure 59. Firmware update status window.

If the process does get interrupted, it is possible that the C400 will not be able to do another update because core programs have become corrupted. In this case you should contact Pyramid or your supplier who can organize a recovery. When the update is complete, you should reboot the device by power cycling it, and check the Properties screen area to ensure that the new versions are correctly reported.

28 A60 Recovery

If your C400 ever suffers corruption of its stored programs, it may no longer be able to communication with it via normal means. This could happen if you were to suffer a power failure or communications interruption during a firmware update. We hope this never happens to you, but in case it ever does, the A60 recovery utility can recover the situation. We recommend that you only use this utility under direction of Pyramid.

CAUTION

Do not use the A60 Recovery utility except under the direction of Pyramid. Misuse could render your C400 inoperable, and you would then need to return it to the factory for repair.

28.1 Starting the A60 Recovery Utility

You need to start the C400 in bootloader mode. To invoke this, you must fit a 2mm jumper to position four of jumper JPR5.

Disconnect power from the C400. The jumper can be accessed by removing the four small screws at the rear of the top cover of the unit, sliding the cover back and removing it. JPR5 is located near the rear panel, between the gate BNC connectors and the LED indicators. Make sure you are well grounded to the C400 chassis before touching the jumper or any other internal component, to prevent damaging the electronics by static discharge. Fit the jumper and ensure all other positions on JPR5 are open.
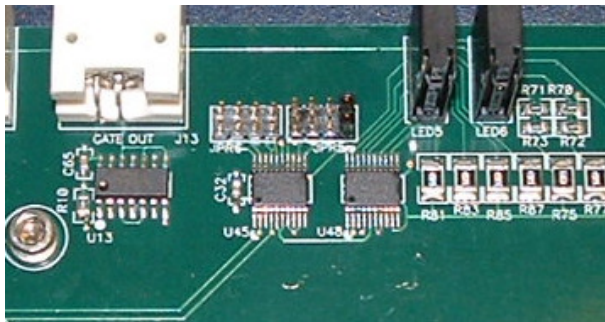
Figure 60. JPR 5 location; bootloader mode jumper installed.

28.2 Using the A60 Recovery Utility

Reconnect the power and let the C400 boot up. Start the G2 Diagnostic software and discover devices. The A60 Recovery will appear. Connect to this and the recover screen will open. You can confirm you are connected to the correct device in case of doubt by looking at the serial number.
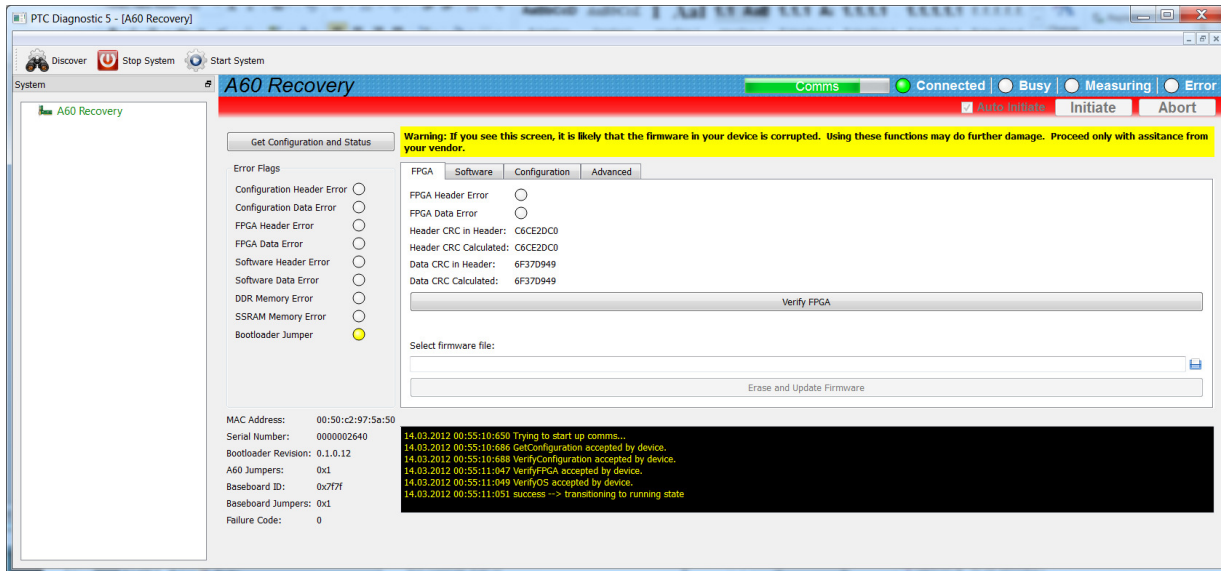
Figure 61. A60 recovery screen.

Using the information on the screen, Pyramid will be able to tell you if any of the firmware is corrupted. It is possible to load individual firmware files without going through the full update process using the Erase and Update firmware button, and this may restore the function of your C400.

After using the A60 Recovery utility, power down the C400, restore the original jumper setting and refit the top cover.

29 Fault-finding

Symptom	Possible Cause	Confirmation	Solution
High background count rates	Discriminator lower level too low	Increase discriminator – counts drop suddenly	Set low discriminator limit to exclude electronic noise.
	Noisy pre-amplifier	Change pre-amplifier	Set low discriminator limit to exclude electronic noise for pre-amp in use.
	Large DC offset on pre-amplifier	Change pre-amplifier	Set low discriminator limit to exclude electronic noise for pre-amp in use.
No pulses	Pulse polarity set incorrectly	Look at pulses on oscilloscope (50 ohm terminated)	Use correct polarity setting.
	Pulses are outside discriminator window	Open window settings and recheck. Look at pulses on oscilloscope (50 ohm terminated)	Use appropriate discriminator settings. Discriminator sweep function can assist you to select the values.
Counts higher than expected	Deadtime correction is enabled; deadtime setting so too high.	Disable deadtime correction.	Ensure use of deatime correction is appropriate and the correct value is entered.
	Pulser output is connected and enabled.	Turn off pulser.	Disable pulser when taking data.
Counts lower than expected.	Detector gain has dropped.	Look at pulses on oscilloscope (50 ohm terminated). Increase	Use correct high voltage setting. Replace detector if

		high voltage and/or reduce discriminator lower level.	needed.
	Counter has overflowed (most likely in accumulation mode).	Check overflow flag	Reduce integration period so that total count for a channel is unlikely to exceed 4e9.
No signal on monitor outputs.	Unit is not measuring.	Signal appears when unit initiated and triggered.	Ensure C400 is measuring when you want to see the monitor output.
Unit not collecting data	Inappropriate trigger mode	Select internal trigger mode.	Use appropriate trigger mode.
Encoder not reading, or erratic.	Encoder is not producing differential pulses, and A-, B- lines are floating.	Check pulses with oscilloscope.	Use a differential encoder, or tie the unused lines to a voltage halfway between the two input states.
Encoder counting backwards	Direction of motion can be defined arbitrarily for incremental encoders.		Check invert encoder option (if using PTC Diagnostic).
Encoder counts not updating	C400 not initiated	Initiate C400 and check encoder counts.	
	Communication link timeout		Investigate and fix communications issue. Use a longer timeout setting.
No or incorrect response to external gate	Incorrect gate polarity selected.		Use correct polarity.
No or low high voltage	Shorted to ground in external circuit	Monitor HV reading zero or very low relative to setpoint.	Eliminate shorts to ground.

		Monitor value recovers if C400 disconnected from the external circuit.	
	External load resistance too low.	Voltage recovers if setting is reduced.	Do not attempt to draw more than 1 watt from each high voltage supply. Higher power modules are available to special order.
High voltage not at setpoint	A high compliance source such as a charged particle beam is driving the HV electrode.	Monitor value recovers if C400 disconnected from the external circuit.	Change geometry to reduce beam strike.
Cannot set high voltage	Trying to set above the maximum allowed value soft limit.	Sets OK if a lower value is chosen.	If allowed, increase the maximum allowed value.
High voltage turns off	Power has been interrupted, causing C400 to reboot.	Monitor 24 V power.	Provide UPS if needed.
Unable to communicate via Ethernet	Incorrect IP address for C400 or host (not in the same subdomain).	Check settings of C400 host PC.	Use consistent IP addresses.
	Messages being blocked by anti virus software.	Disable anti-virus software	Set up allowed channels for C400 messages.
You've forgotten the IP mode, address or subnet mask of the C400			Interrogate via the serial ASCII interface.
			Force unit back to default static address 192.168.100.20

			(see section 22)
Unexpected changes to C400 state	Another host is communicating with the C400.	Change IP address. Use a direct cable connection instead of a network.	Set up IP addresses and subnet masks to prevent conflicts.
Communications interruptions	Other processes on PC host interfering with comms ports.		Use a dedicated PC with simple configuration and minimum number of processes running.
Unable to connect on serial port	Another program is using the COM port.	Try to access the required port with a terminal program.	Choose another port or close down the other program.
	Incorrect port settings.		Correct the settings.
	Incorrect cable.		Make up a suitable cable.
Responses to ASCII serial commands are slow	Old firmware version is installed.	Check version – should be 0.7.23.82 or later.	Update firmware.
	Command requires flash write.	Watch messages in G2 Diagnostic after sending the ASCII command.	Host application must allow time for commands that require flash memory writes by the C400.
Unexpected behavior	Unit is overheating due to failed fan	Unit feels warm. Fan stopped.	Return unit for fan replacement.
	Unit is overheating due to airflow blockage	Unit feels warm. Performance improves when operated on the bench.	Clear space around the unit and improve airflow.

30 Maintenance

The C400 does not require routine maintenance, except to clear any dust accumulation in the fan filter.

There are no user-serviceable parts inside.

CAUTION. High voltages may be present inside the case. Do not open the case when power is applied.

If there is buildup of dust in the filter, you should clear this by vacuum cleaning in situ, or by removing the filter element and cleaning it separately with an air jet. Note that detaching the filter element also detaches the fan from the case.

The C400 is fitted with a 1.1 amp automatically resetting positive temperature coefficient (PTC) fuse in the 24 VDC input. There are individual 200 mA PTC fuses on the pre-amplifier power outputs and the fan power feed. No user intervention is required if the fuse operates due to overcurrent. The fuse will reset when the overcurrent condition ends.

31 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.

32 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.

33 Disposal

We hope that the C400 gives you long and reliable service. The C400 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 C400 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.

34 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: C400 Pulse counting detector controller

Year of initial manufacture: 2010

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: _____
                                  President, Pyramid Technical Consultants, Inc.

Date: 19 March 2012

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, Suite 3 Unit 6-7 Henfield Business Park, Henfield BN5 9SL, United Kingdom.

35 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, B10_UM_080105 would be a B10 manual released on 5 January 2008.

Version	*Changes*
C400_UM_110329	First general release
C400_UM_110404	Correct analog voltage output range to -5 to +5 VDC (was 0 to +10 VDC). Minor corrections to text.
C400_UM_120313	General changes to conform to firmware release 0.7.5.92 Add internal jumper details. Add details of DHCP option. Update ASCII command table. Add section on connecting fiber optic loop devices. Add section on A60 recovery. Add Certificate of Conformance
C400_UM_130730	Added description of G2 Diagnostic common controls Corrections to ASCII command table. Add fault-finding entries.
C400_UM_131230	Added information about new accumulation mode Updated ASCII commands table