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Q-DAQ-V
Pressure Scanner Acquisition System

INSTALLATION AND OPERATING MANUAL

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http://www.chell.co.uk

900273-1.0

Please read this manual carefully before using the instrument.

Use of this equipment in a manner not specified in this manual may impair the user's protection.

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Chell's policy of continuously updating and improving products means that this manual may contain minor differences in specification, components and software design from the actual instrument supplied.

CONTENTS

1 Description

1.1 General

The Q-DAQ-V is a self-contained pressure scanner that acquires and transmits pressure data to a host via Ethernet or a CAN bus. The Q-DAQ-V is mechanically based on the Chell SQDC range giving the user the ability to connect it to an existing SQDC loom or, with the appropriate mating half, connect the Q-DAQ-V to flexible or solid tubing.

The Q-DAQ-V has the ability to output absolute pressures or differential pressures. When differential pressures are required, one of the 16 transducers is selected as the reference and subtracted from the other 15 measurements.

The Q-DAQ-V also has a built-in heater which can be controlled via the web interface. The heater is capable of maintaining a temperature of around 30°C above ambient and it can be set to control any given temperature from 10°C to 70°C.

The Q-DAQ-V is configured by using its embedded web-server. The output can be configured in a number of ways including averaging, transmission speed, absolute or differential and also the ability to add a time stamp to the data (compliant with IEEE1588 PTP v2).

This manual revision covers firmware version 2.0.0.

2 Specifications

2.1 PoE Specification

IEEE 802.3at (Type 1 and 2) 25W auto sensing

2.2 Power Supply:

Line voltage:	8-30 VDC
Absolute Max. Line voltage	32 VDC
Consumption:	0.85A at 24VDC (0.05A without heaters)

2.3 CAN specifications:

CAN type	2.0B and FD
CAN baudrate	Configurable from 1M, 500K, 125K and 100K.
Programmable variables:	
Address 0x?nn	Most significant programmable device ID
Address 0xn?n	Next most significant programmable device ID
BRP	CAN bus timing
TSEG1	CAN bus timing
TSEG2	CAN bus timing
SJW	CAN bus timing

2.4 Ethernet Specifications:

TCP/IP	10Mb/s & 100Mb/s via Auto Negotiation TCP & UDP protocols supported

2.5 Environmental specification:

Operating temperature range:	-40°C to +90°C
Storage temperature range:	-40°C to +90°C
Maximum Relative humidity:	95% at 50°C (non-condensing)
Ambient altitude	5 mbar abs (100,000 ft) to 2.5 bar abs
Vibration (provisional)	Engine standard vibration test to DO160E category S, curve W with duration of 1 hr/axis. Fan blade (20 g 2 kHz)
Shock	Fan blade out to DO160F section 7 (40g 11m/s)
Radiated emissions	MIL standard 461-G: RE102 (Space)

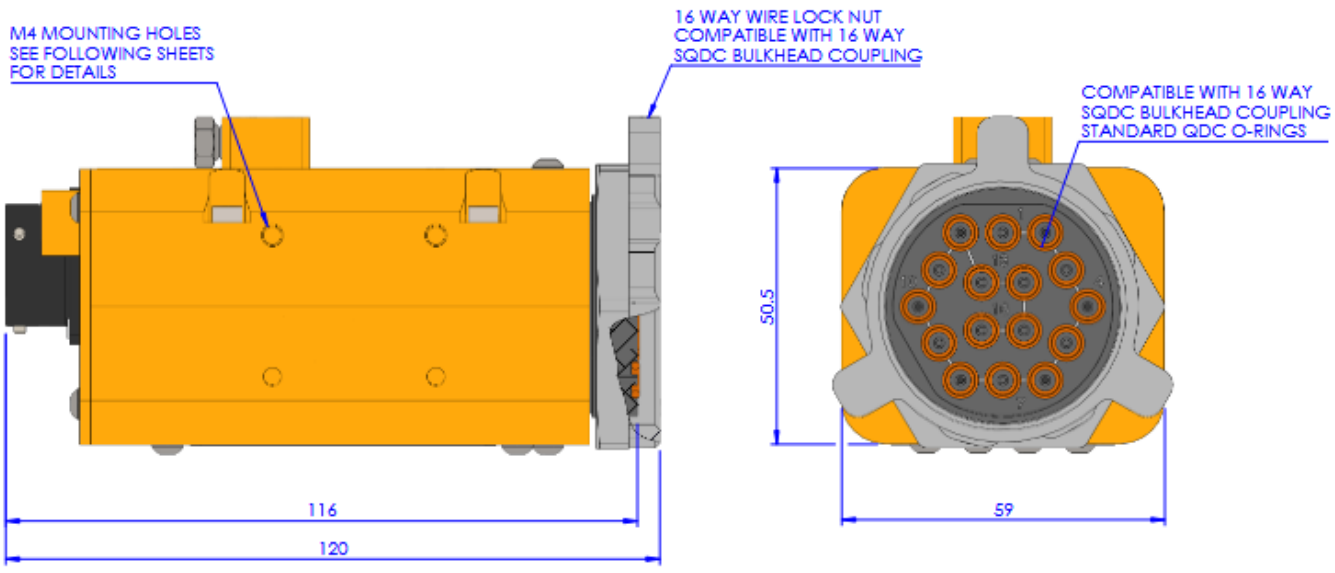
2.6 Mechanical specifications.

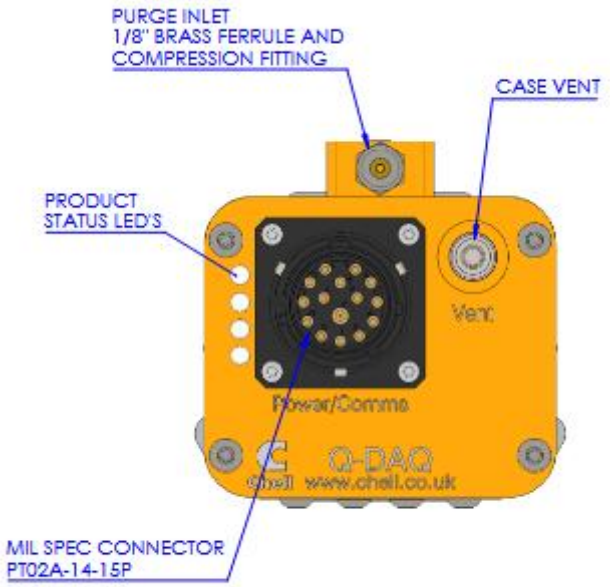
Pneumatic interface:	16 way SQDC male – will interface with: SQDC-R-16-01 to SQDC-R-16-07
Weight :	650g
Environmental sealing:	IP67

2.7 Heater Specifications

Controllable between 10°C and 70°C (via Webserver).

2.6 Dimensions



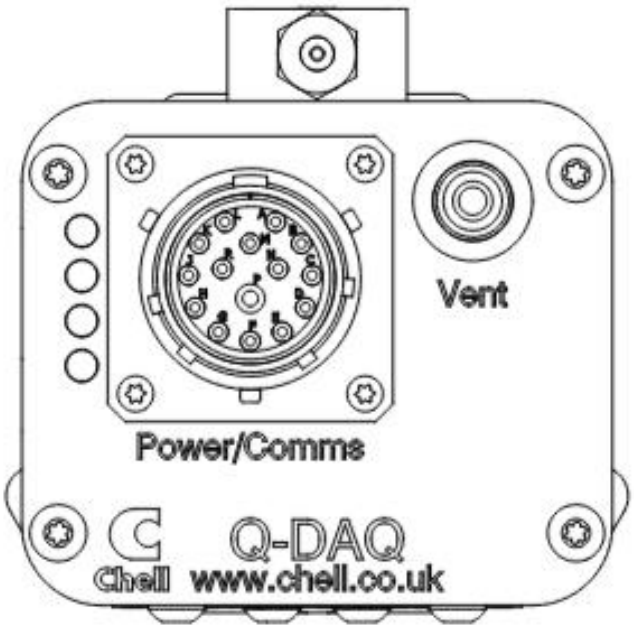


3 Installation and Interconnections

3.1 Electrical connections

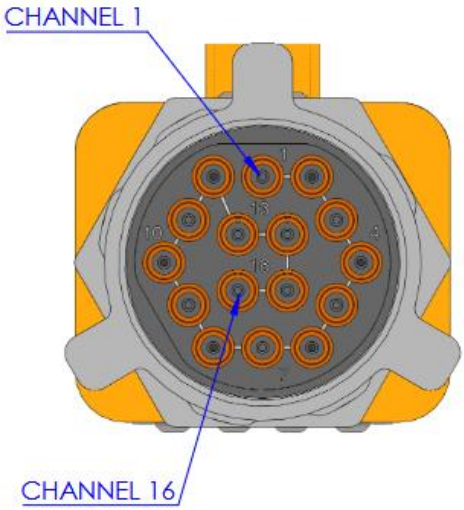
3.1.1 Q-DAQ-V PoE Electrical connections (Mating connector: KPSE6E14-15S-DZ-A232)

Pin Number	Designation
A	Ethernet BI_DB+ / RXP
B	Ethernet BI_DA+ / TXP
C	Ethernet BI_DA- / TXM
D	TRIG IN (TTL)
E	TRIG RTN
F	Ethernet BI_DC+ (POE)
G	CHASSIS GND (SHIELD)
H	CAN Hi (RS232:TXD)
J	CAN Lo (RS232:RXD)
K	Ethernet BI_DC- (POE)
L	Ethernet BI_DD+ (POE)
M	Ethernet BI_DD- (POE)
N	Ethernet BI_DB- / RXM
P	PWR RTN (RS232:COM)
R	+24V DC PWR



⚠	**Hot plugging the power to the Q-DAQ-V at the connector can cause permanent damage to the unit. Always switch the power at the power supply source.**

3.2 Q-DAQ-V Pneumatic Connections



For Details on the SQDC interface, please refer to the SQDC data (SL00914.pdf) sheet and manual (90014723.pdf)

4 Operation of the instrument

4.1 Connecting up the Q-DAQ-V.

The Q-DAQ-V has one connector and cable which supplies the unit with power and also provides CAN and Ethernet comms. Ensure all the connections are made before powering up the Q-DAQ-V. **The Q-DAQ-V should not be hot plugged with the power connector. Doing so can cause permanent damage to the unit. Always switch the power at the power supply source.**

Upon power up, the blue LED will light constantly while the Q-DAQ-V boots up. This will typically take around 2 seconds. When the Q-DAQ-V has finished booting, the blue LED will flash at a constant rate to show that the system is running (unless auto hardware trigger enable has been set – see later).

To connect to the Q-DAQ-V, establish an Ethernet connection to the Q-DAQ-V using the appropriate cables and check that the necessary link lights are lit. The host PC must have an i/p address in the same range as the Q-DAQ-V. For example, if the Q-DAQ-V had an i/p address of 192.168.1.190 then (depending on the subnet mask used) the first three octets of the subnet mask should be the same – i.e. 192.168.1.XXX. Once the connection has been established, the i/p address can be changed and the Q-DAQ-V connected to the user network.

NOTE: If the i/p address is changed, it is very important that a record is made of the new i/p address as it cannot be ascertained without returning the unit to Chell Instruments.

4.2 Configuring the Q-DAQ-V

The Q-DAQ-V is designed to be configured by using the embedded web server. Here all the product variables may be changed including i/p address, CAN i/d, averaging, transmission speed etc. Once these setting are configured, they can be permanently saved by clicking on 'BURN TO EEPROM'. Once the unit is reset, the Q-DAQ-V will run using these setting.

The Q-DAQ-V can be configured to output data over CAN or Ethernet (TCP/IP or UDP) and, if configured to do so, it will output this data immediately upon power up. The Q-DAQ-V can also accept commands over the Ethernet or CAN networks to configure the majority of the internal setting (with the exception of CAN i/d, i/p address and some lower level functions). Please refer to document 900204 – Chell DAQ Systems user programming guide for available CAN and Ethernet commands and the format of the data output stream.

4.3 Re-zeroing the Q-DAQ-V.

It is possible to re-zero the output of the Q-DAQ-V for either absolute or differential measurements.

The Q-DAQ-V is re-zeroed by sending the appropriate command over the CAN or Ethernet link via the Chell software or via the embedded webserver. The system will then average a number of zero readings and perform a re-zero. Naturally, there should be no pressure applied to the ports of the scanner when a re-zero is being performed.

When a re-zero is being performed, the red LED will light momentarily. The re-zero value is not stored in volatile memory and will be lost upon reset. See section 5.5.5 for permanently saving the zero values if necessary.

4.4 Hardware Trigger

The Q-DAQ-V features a hardware trigger to enable the user to synchronise multiple Q-DAQ-V's and to calculate the timing of the measurements made. The hardware trigger takes the form of a pulse train. Each time the Q-DAQ-V receives a positive edge, it will generate a set of measurements for all the channels configured in the system.

4.4.1 Hardware Trigger Input

The hardware trigger input is a 5V TTL square wave pulse train. Minimum frequency 0.5Hz and maximum frequency 400Hz.

4.4.2 Timing Information

The hardware trigger allows the user to calculate the time of each measurement. For example, if the hardware trigger were running at 100Hz then the user would receive 100 measurements per channel per second. The first pulse would generate the first set of measurements and 10ms later the second pulse would generate the second set and so on. When the hardware trigger is activated, the Q-DAQ-V will wait for the first pulse. The time that this first pulse is generated can be measured by the user and therefore the time of the first set of data and all subsequent sets can be determined

4.4.3 Software Control

The hardware trigger mode is activated by the T command over the CAN or Ethernet interfaces. The T command can be used to enable the hardware trigger that will cause the Q-DAQ-V to stop free-running and wait for the first pulse. The disable command will return the Q-DAQ-V to free-running. The command structure is as follows:

Command	Interface	On / Off
T01	Ethernet	Off
T11	Ethernet	On
T02	CAN	Off
T12	CAN	On

The hardware trigger can also be set to auto enable on power up which means that the Q-DAQ-V will not go into free-running mode after initialisation and will instead wait for the first hardware trigger pulse. In this instance the blue LED will not flash at a constant rate after initialisation and will actually turn off. This feature can be enabled/disabled from the embedded webserver configuration.

5 Q-DAQ-V Configuration Webserver

5.1 Introduction.

The Q-DAQ-V web Configuration provides the means of setting up and demonstrating the Q-DAQ-V unit from a standard PC with an Ethernet port and browser.

The webserver is divided by tabs into five areas of functionality, namely 'Setup', 'Live Data', 'Advanced', 'Timestamp' and 'Factory Tools'.

'Setup Parameters' provides the means to set Q-DAQ-V's main operating parameters such as data streaming rates and Device addresses.

The unit's function may be checked and demonstrated using **'Live Data'** to show the Q-DAQ-V's calibrated output.

'Advanced' provides setup for all the other more advance parameters that may require setting on a per application basis.

'Timestamp' provides some options for configuring the timestamping feature of the Q-DAQ-V.

'**Factory Tools'** provides some functionality to change the MAC address of the Ethernet hardware. This tab is password protected and therefore not readily available to everyone and further detail is beyond the scope of this document.

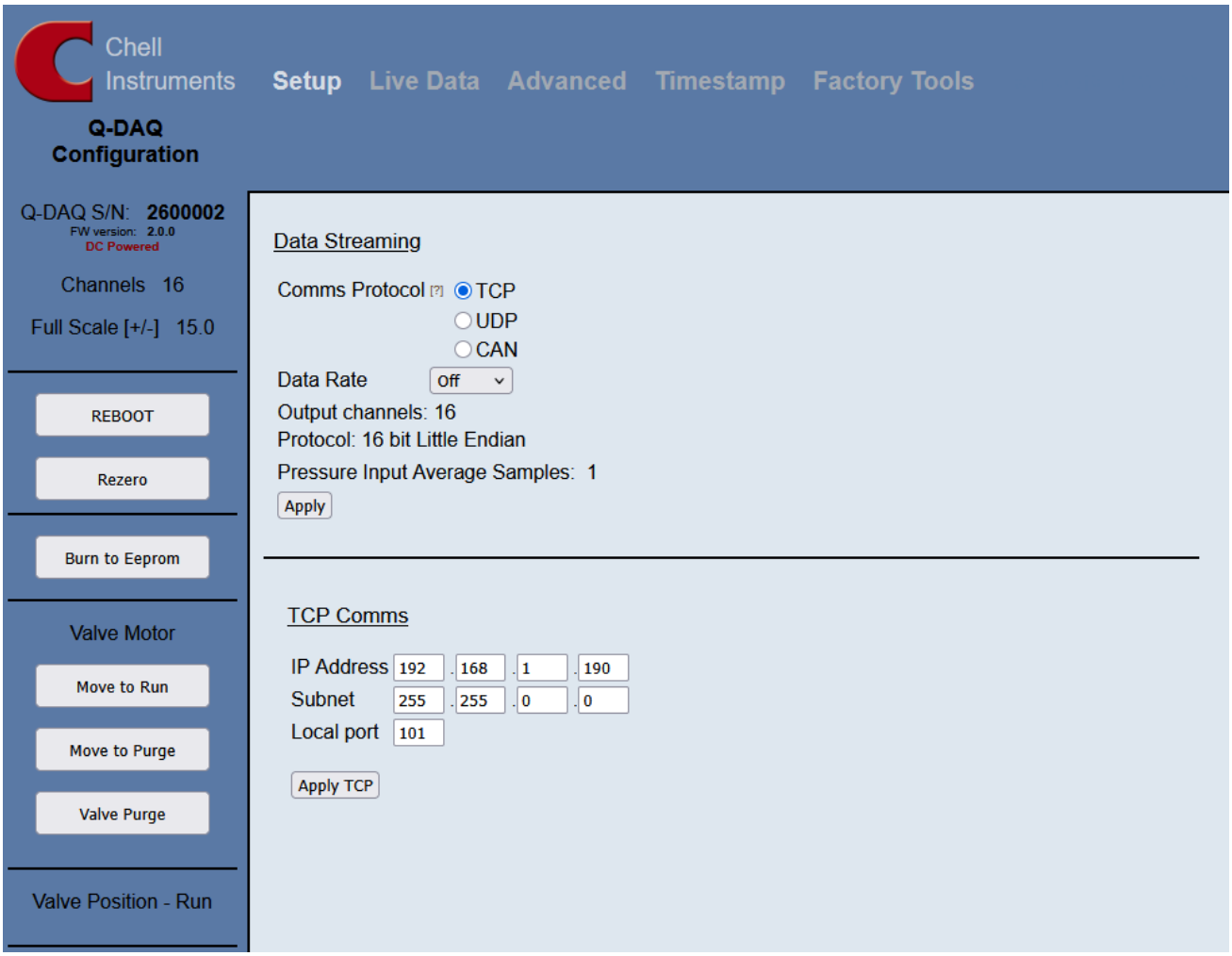


Figure 5.1, Main Setup page

5.2 Common Controls Sidebar

Figure 5.1 above shows the first page viewed when navigating to the webserver. It includes the common controls sidebar and the main group of setup parameters. The sidebar provides information on the Q-DAQ-V unit including serial numbers and current firmware revision along with the configured scanner full scales and total channels, the current position of the valve is also shown here. The function of the common controls is detailed in the subsequent table (Table 5.1)

Control	Function
'RESET' button	Resets the Q-DAQ-V , similar to power cycling the device. Use to activate new settings and/or rebuild calibration tables.
'Rezero' button	Starts a Q-DAQ-V rezero operation.
'Burn to eeprom" button	Burns all changes made to the local settings into the eeprom so they can be retrieved on restart.
'Move to Run'	Moves the valve to the run position
'Move to Purge'	Moves the valve to the purge position
'Valve purge'	Performs the Valve purge function, moves the valve to the purge position and remains there for an amount of time specified by the 'Function time' in the valve miscellaneous section then returns to the previous position.
'Valve Position'	Shows the current position of the valve.

Table 5.1, Common sidebar control functions.

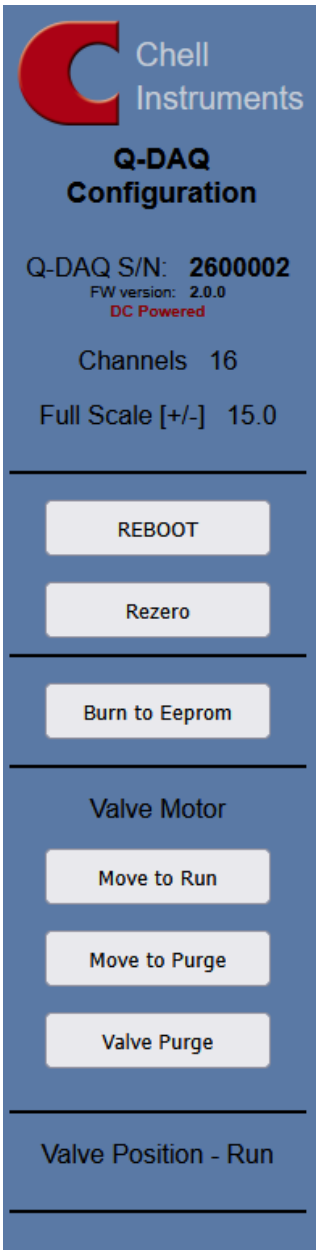


Figure 5.2, Sidebar

5.3 The 'Setup Parameters' Page

5.3.1 Introduction

The 'Setup Parameters' page shows all of the Q-DAQ-V's main operating parameters. Setup Parameters is divided into different categories by function, and each category is detailed separately in the following.

5.3.2 Data Streaming

The ‘Data Streaming’ section allows the user to change settings that affect all three communication protocols, and allows the user to choose the protocol that is to be used, along with the data transfer rate.

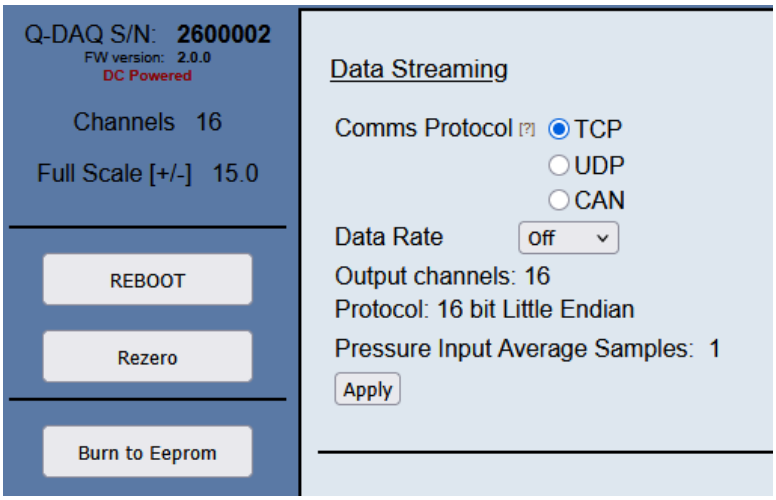


Figure 5.3, Data Streaming group

Control	Function
‘Comms Protocol’ radio button	Chooses the communication protocol that is to be used. This button changes what options are available below it.
‘Data Rate’ option list	Selects the rate at which the Q-DAQ-V will automatically transmit data after reset. The maximum data rate available will be changed by which Oversampling rate is selected.
‘Protocol’ option list	Selects the format that the data will be transmitted as, options are 16 bit LE, 16 bit BE for all protocols and eng. units as an extra option for TCP and UDP Comms.
‘Apply’ button	Applies the changes made to the local settings memory.
Pressure Input Average Samples	Displays the number of samples used for deriving the average pressure.

Table 5.2, Data Streaming settings.

Note that selecting Engineering Units for a protocol will cause the scanner addressing rate to be reduced; it is better to scale calibrated 16 bit data to engineering units within the client software.

It should also be noted that changing the data rate also changes the Pressure input averaging samples to the maximum value that will not have any detrimental effect on the dynamic response of the Q-DAQ-V.

The max measurement per channel per second value is gained from the Sensor Response setting.

Averaging required = max measurement per channel / requested data rate

The average required is then dropped to the next value down in the averaging index. An averaging of 1 is equal to off.

So, if the Oversampling is on High resolution and the data rate selected is 5Hz then the Pressure and Temperature input average samples will be 4.

5.3.3 TCP Parameters

The TCP communication protocol parameters are shown in Figure 5.4. This only shows if the TCP radio button is selected in the datastreaming section. The options in this section control the Q-DAQ-V's IP address, subnet mask and Local port.

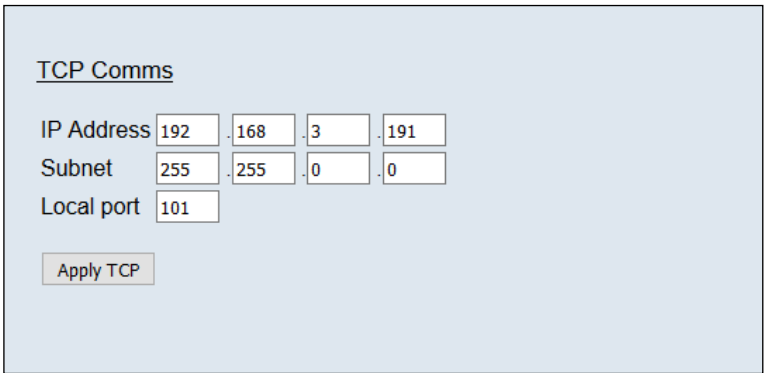


Figure 5.4, TCP Comms group

'IP Address'	IP address allocated to Q-DAQ-V on the user's network.
'Subnet'	Subnet mask as set on the user's network.
'Local port'	Local port of the device.
'Apply TCP'	Applies the settings to the local memory

Table 5.3, TCP Comms group settings

5.3.4 UDP Parameters

The UDP section (figure 5.5) holds all the settings specific to UDP. In UDP mode each acquisition cycle (of 'x' number of channels) is packed as a separate UDP packet with a four-byte representation of the Q-DAQ-V serial number at the start of the packet. These are attempted to be sent out at the required rate but with no checking for reception or validity of data.
It is also possible to change the output data packet format to IENA specification format by using the check box.
Note that the Q-DAQ-V's local IP address is the same setting as from the TCP Comms group.

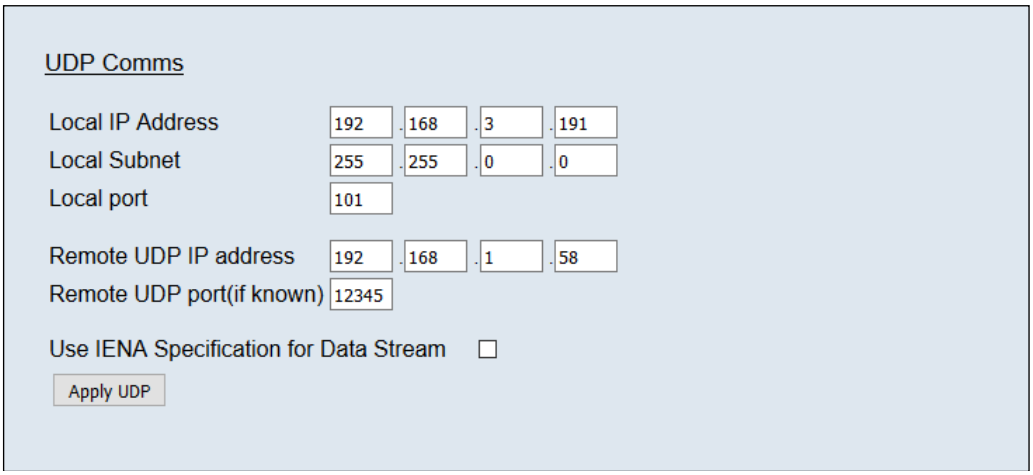


Figure 5.5, UDP Comms group

'Local IP address and subnet'	This displays the IP address of the Q-DAQ-V, this is the same as in the TCP comms section.
'Local port'	Local port of the device.
'Remote UDP IP address'.	Address of remote connection to Q-DAQ-V. If set then the Q-DAQ-V can be set to auto stream data to that remote host on boot up (after initialisation)
'Remote UDP port.'	Port of remote connection to Q-DAQ-V. If set then the Q-DAQ-V can be set to auto stream data to that remote host on boot up (after initialisation)
'Use IENA Specification for data stream'	Changes the format of data output packets to IENA specification.
'Apply'	Applies the settings to the local settings memory

Table 5.4, UDP Comms group settings

5.3.5 CAN Parameters

The CAN communication settings are shown in Figure 5.6. Options are available to set the operation mode, the base message ID number may be selected, and the offset from this base number for the reception of user commands over CAN, and whether an acknowledgement of these user commands is sent on the next higher message number. Data may be transmitted on either multiple messages, or alternatively on a single message ID, with a selectable delay between messages.

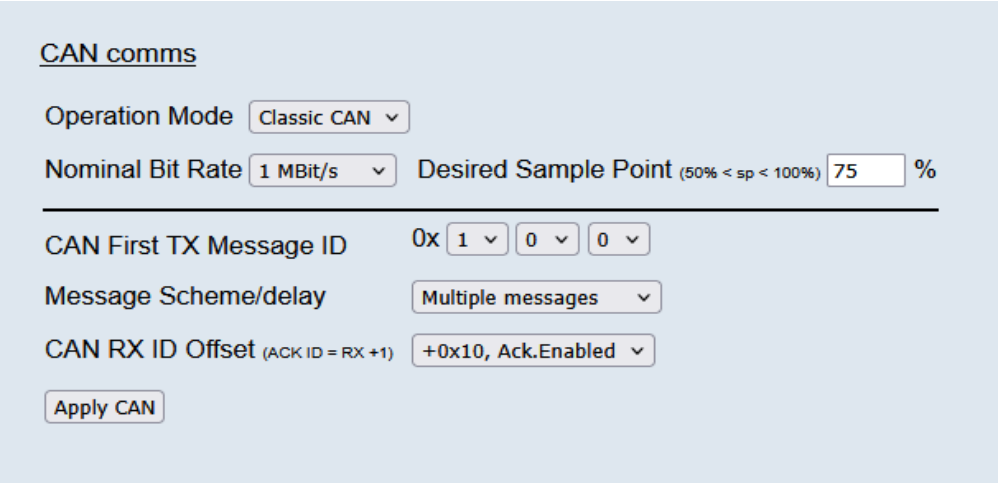


Figure 5.6, CAN Comms group Classic CAN selected

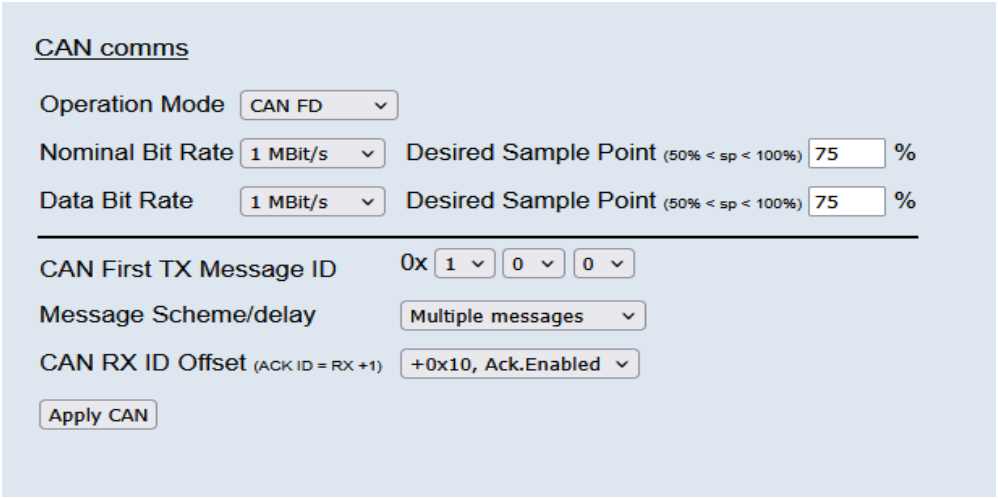


Figure 5.6, CAN Comms group CAN FD selected

'Operation Mode'	Change the CAN operation mode – Classic CAN or CAN FD.
'Nominal Bit Rate'	Change the Nominal Bit Rate value.
'Desired Sample Point (Nominal Bit Rate)'	Change the desired sample point value for the Nominal Bit Rate.
'Data Bit Rate'	Change the Data Bit Rate value.
'Desired Sample Point (Data Bit Rate)'	Change the desired sample point value for the Data Bit Rate.
'CAN First TX Message ID'	Q-DAQ-V uses standard CAN message arbitration id's, and the unit is assigned the most significant 2 digits of the Hex base address. For the digits 0x1A for example, data for the first 4 channels will be sent on 0x1A0, the next 4 on 0x1A1, etc.
Message scheme/delay	Select 'Multiple Messages' for the 4 channels per message, multiple message scheme. Alternatively, data may be packed 3 channels per message + identifier byte, with a selectable delay between messages.
'CAN RX ID Offset'	Selects the hex offset from the base message ID where Q-DAQ-V will receive incoming user commands (see user command document). If 'Ack. Enabled' is selected, the unit will acknowledge the reception of a correctly formatted command on the message ID calculated as Base ID + RX Offset + 1
'Apply'	Applies the settings to the local settings memory

Table 5.5, CAN Comms group settings.

5.4. ‘Live Data’ Page

Figure 5.7 shows the 'Live Data' page of the webserver, for a 16-channel pressure scanner.

Figure 5.7, Live Data Page

The live data page is a means to demonstrating the correct operation of Q-DAQ-V and testing the unit's calibration. A measurement for pressure and temperature is shown for each channel.

There is also a reference pressure and temperature value at the bottom of the page. This value is a duplicate of the channel selected to be the reference (see section 5.5.2).

The pressure data can be in either BAR, PSI or Pa(Pascals), this is decided on the advanced page, but is displayed on the top right of the live data page for convenience.
The type of value shown in the labels may be selected by means of the option buttons in the righthand frame. These are as follows:

- Differential Pressure (Eng) — Calibrated engineering units pressure value scaled to known full scale and relative to the reference port (selectable between ports 1 and 16).
- Absolute Pressure (Eng) — As above, but represented as an absolute.

Values are updated automatically, once every 500ms, with the default view being Differential Pressure (Eng).

NOTE : The selection of differential or absolute pressures (Radio buttons on the right) on this page is for diagnostics only. This setting does not affect the main output stream configuration (see section 5.5.2).

5.5 ‘Advanced’ Page

The advanced tab contains extra options that users may find useful for more detailed configuration.

5.5.1 Advanced Data Stream Settings

This section contains additional output streaming options.

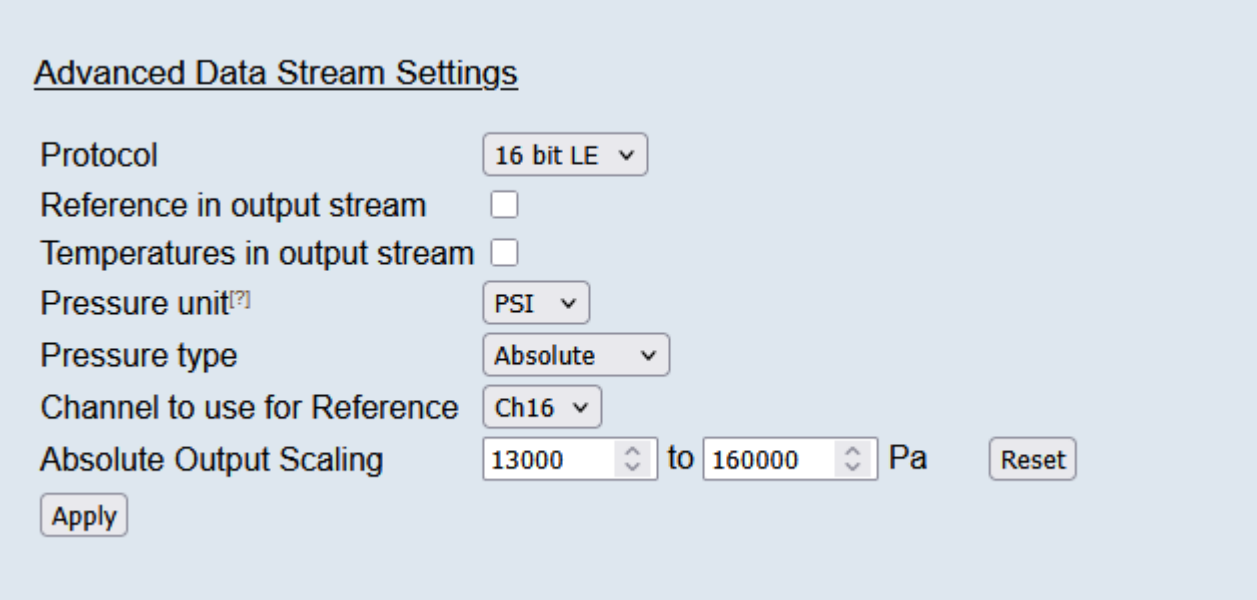


Figure 5.8 Advanced Data Stream Settings

‘Protocol’	Saves the Rezero values to the eeprom
‘Reference in output stream’	Clears the span calibration on all channels
‘Temperatures in output stream’	Selects
‘Pressure unit’	Selects whether the data is in Pa(Pascals), PSI or BAR
‘Pressure type’	This selects whether the Q-DAQ-V transmits differential or absolute values.
‘Channel to use for Reference’	This selects which channel is the reference channel when differential pressure is required. Any channel between 1 and 16 can be used as the reference channel.
‘Absolute Output Scaling’	
‘Apply’	Applies the settings to the local settings memory

Table 5.8, Zero Coefficients controls

5.5.2 Advanced communication settings

The Q-DAQ-V has extra communication variables that may help get a more precise connection between the Q-DAQ-V and the PC.

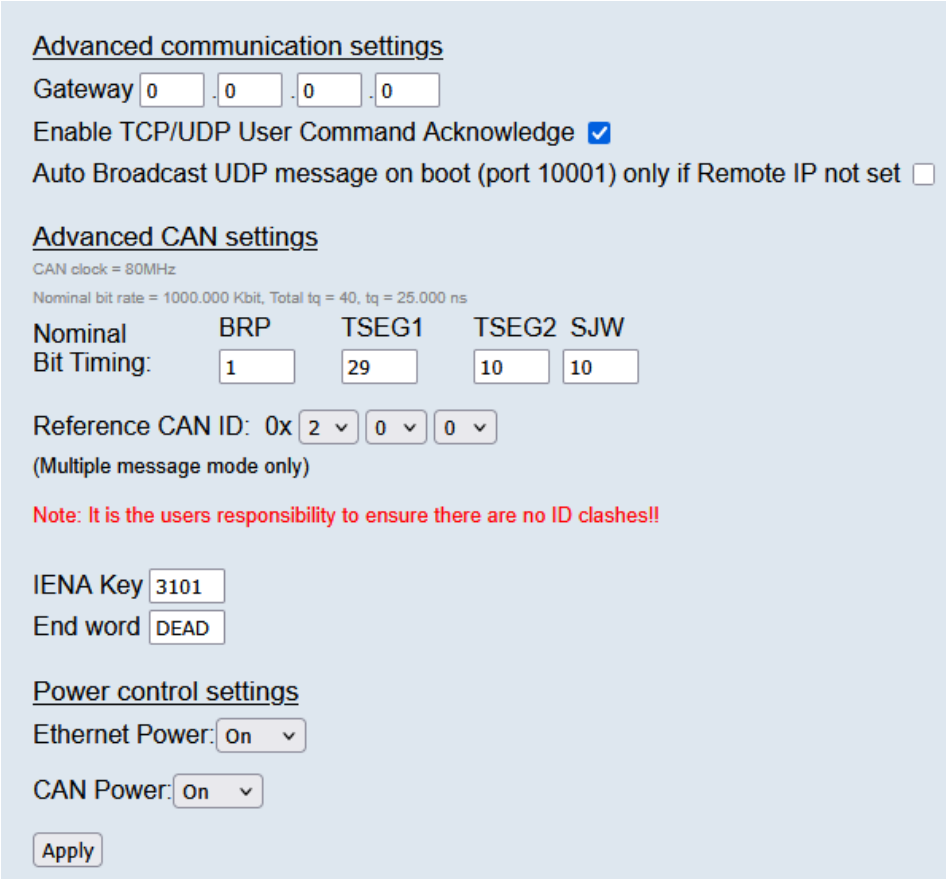


Figure 5.8 Advanced comms group

Control	Function
Gateway	Allows the Q-DAQ-V gateway address to be changed.
Enable TCP/UDP User Command Acknowledge	Turns on or off acknowledge bytes from commands sent via TCP or UDP.
Ethernet Initialisation Check Timeouts	At bootup the Ethernet module performs two checks for auto negotiation and link check status. This timeout can be controlled via this text box. If Ethernet comms are not going to be used then this value can be set at 0 to speed up startup time.
Auto Broadcast UDP message on boot	If checked, auto broadcasts a UDP message on port 10001 on startup which details the Q-DAQ-Vs serial number, IP address, etc. in an ASCII, comma separated list. (should not be used if remote UDP address/port has been configured and auto streaming has been set – via TCP rate on Standard tab)
BRP, TSEG1, TSEG2, SJW	Register values for the CAN module within the Q-DAQ-Vs microcontroller.
Reference CAN ID	Set the reference CAN ID.
IENA key	This changes the key word at the start of an IENA data packet.
End Word	This changes the IENA END word at the end of an IENA packet.
Ethernet power	Turns the Ethernet power Phy to ‘Off’, ‘On’ or ‘Auto’. This can be used to save power and reduce device temperature.
CAN power	Turns the CAN transceiver to ‘Off’, ‘On’ or ‘Auto’. This can be used to save power and to reduce device temperature.

Table 5.6 Advanced comms settings

5.5.2 Miscellaneous

The remaining parameters are edited via the Miscellaneous group shown in Figure 5.09.

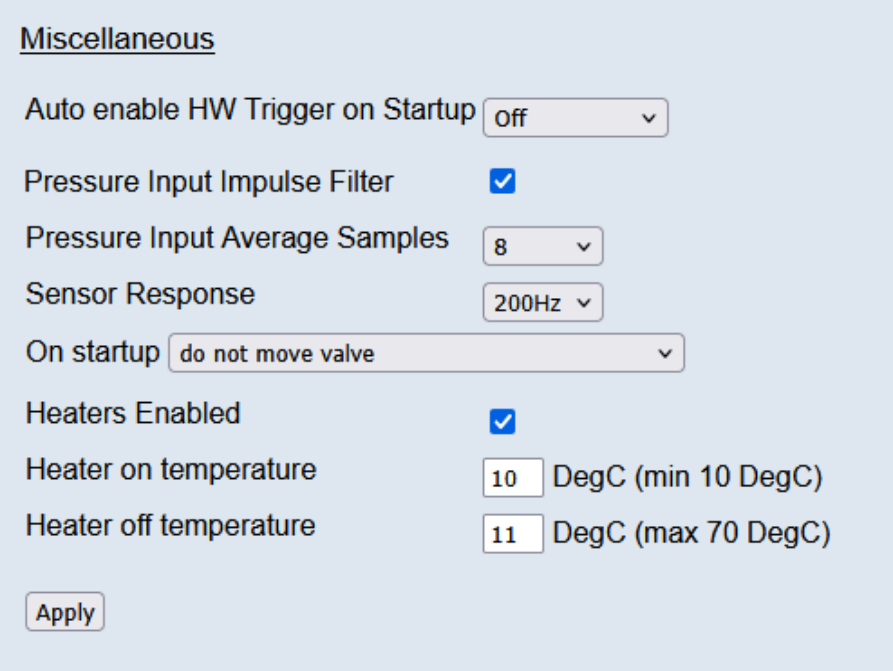


Figure 5.9, Miscellaneous group.

'Auto enable HW trigger on startup' dropdown	If set to anything other than Off, the Q-DAQ-V will immediately switch to hardware trigger mode, waiting for the first trigger pulse, after initialisation. The dropdown indicates the comms protocol used to send acquired data during triggering. NOTE : Once this option is enabled, the Q-DAQ-V will power up and wait for a hardware trigger before outputting any data.The Blue run LED will not flash.
'Pressure input impulse filter'	Applies median filter the data – it will remove single impulse noise events in the pressure data.
'Pressure input average samples'	Selects the number of samples for a moving average of pre-calibration data.
'Sensor Response'	Select the internal filtering and oversampling of the transducer. This will have an effect on the maximum data rate available. These are:
'On startup'	Select what the valve action on startup should be
'Heaters Enabled'	Select whether the Q-DAQ-V's heaters are enabled – if ticked this means the heaters will control based on the specified on/off values, if this is un-ticked the heaters will never activate.
'Heater control on value'	This setting and the one below controls the in-built heater within the Q-DAQ-V. If the 'control on' setting is set to say 20°C then the heater will come on when the reference temperature is below this temperature. The 'control off' value works in a similar way meaning a 'control on' value of 20°C and a 'control off' value of 25°C, the Q-DAQ-V will maintain a temperature between 20 and 25°C
'Heater control off value'	
'Apply'	Applies the settings to the local settings memory

Table 5.7, Miscellaneous group settings

5.5.4 Valve Miscellaneous

The Valve miscellaneous parameters are edited via the Valve Miscellaneous group shown in Figure 5.10.

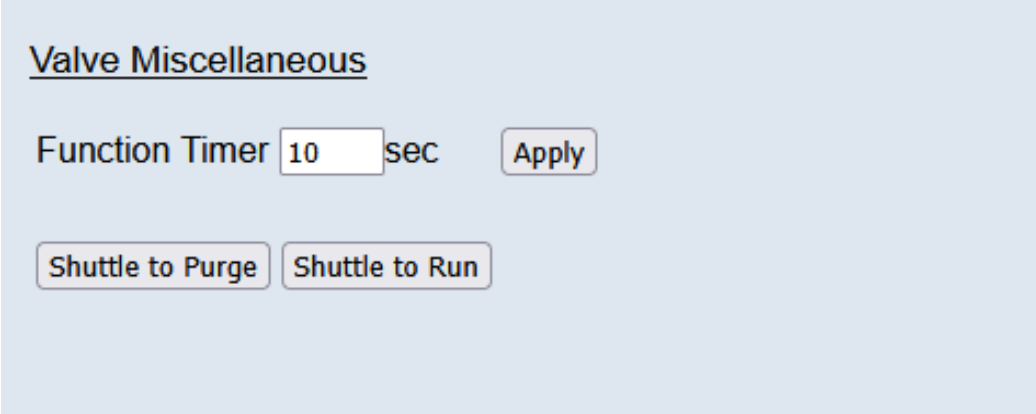


Figure 5.10, Valve Miscellaneous group.

'Function Timer'	Change the length of time in seconds for the purge function
'Shuttle to Purge'	Shuttles the valve to the purge position
'Shuttle to Run'	Shuttles the valve to the run position

Table 5.8, Valve Miscellaneous group settings

5.5.5 Zero Coefficients

The Zero coefficients for the linear cal. are displayed as a separate group at the bottom of this page. These values are the current zero offsets gained when the device is rezeroed.

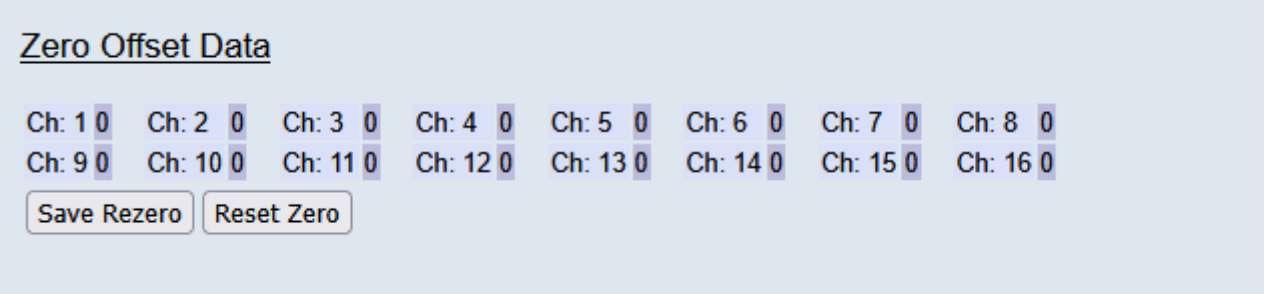


Figure 5.11 Span and Zero Coefficients group

'Save Rezero'	Saves the Rezero values to the eeprom
'Reset Zero'	Clears the span calibration on all channels

Table 5.9, Zero Coefficients controls

5.5.6 XidML configuration file

This section allows you to import or export an XidML file.

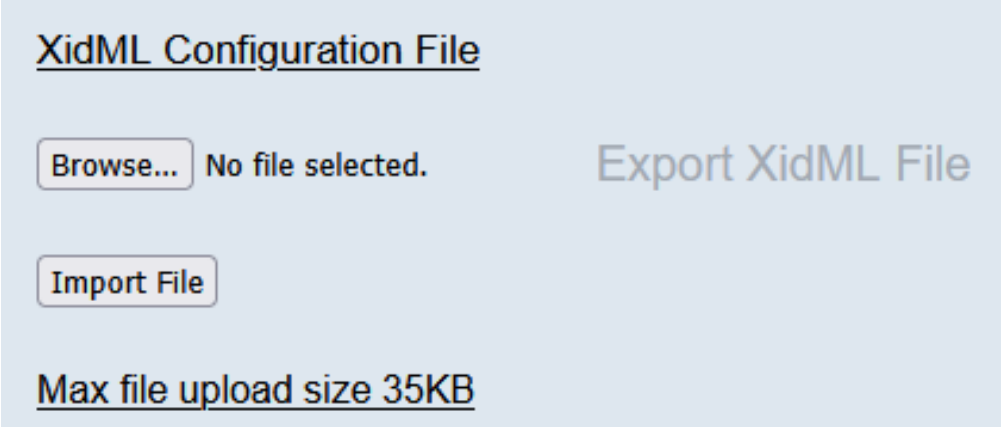


Figure 5.12 XidML configuration file group

'Browse'	Browse for an XidML file on the current computer for import
'Export XidML File'	Download a copy of the devices current XidML File
'Import File'	Import the selected XidML file.

Table 5.10, XidML configuration file controls

5.5.6 XidML analogue parameter names

This section allows you edit the XidML analogue parameter names.

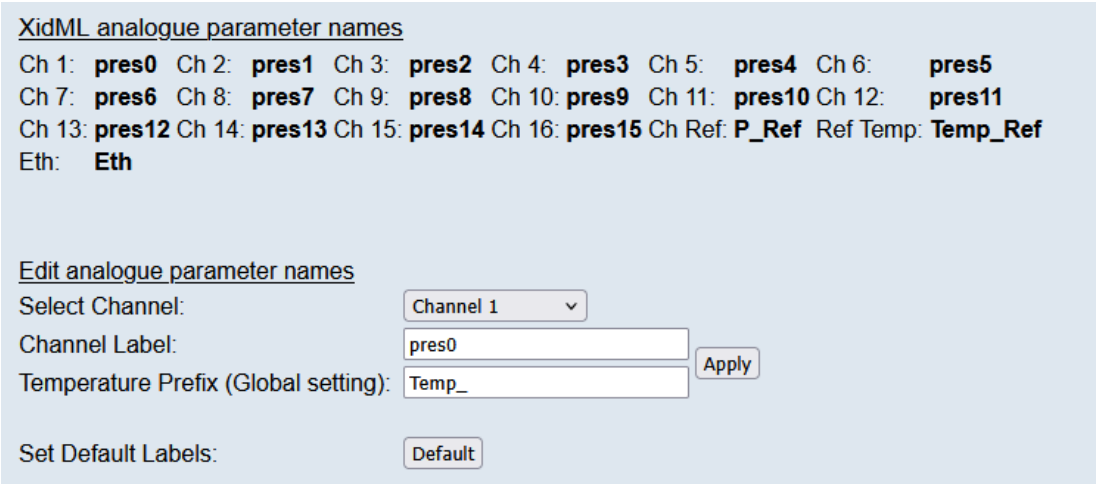


Figure 5.13 Span and Zero Coefficients group

'Select Channel'	Dropdown allows the selection for which channel label to be edited.
'Channel Label'	The label for the selected channel
'Temperature Prefix (Global setting)'	The global label for the prefix of the temperature channels.
'Set Default Labels'	Sets all labels to their default values.

Table 5.11, Zero Coefficients controls

5.5.7 Flash Over Ethernet

This section allows you to enable flash over ethernet mode to allow Firmware updating.

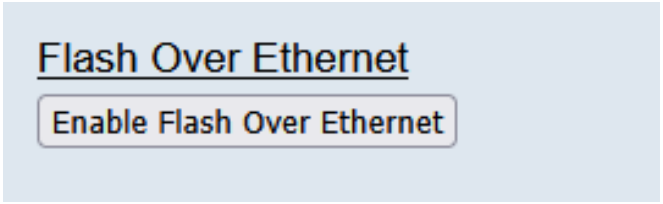


Figure 5.14 Flash over ethernet

5.6 Timestamp page

This page allows the user to edit the timestamp settings of the Q-DAQ-V. This timestamp will allow the user to get millisecond level accuracy timestamps on the data packets. If the timestamp is enabled, it will have an effect on the maximum transmission rate.

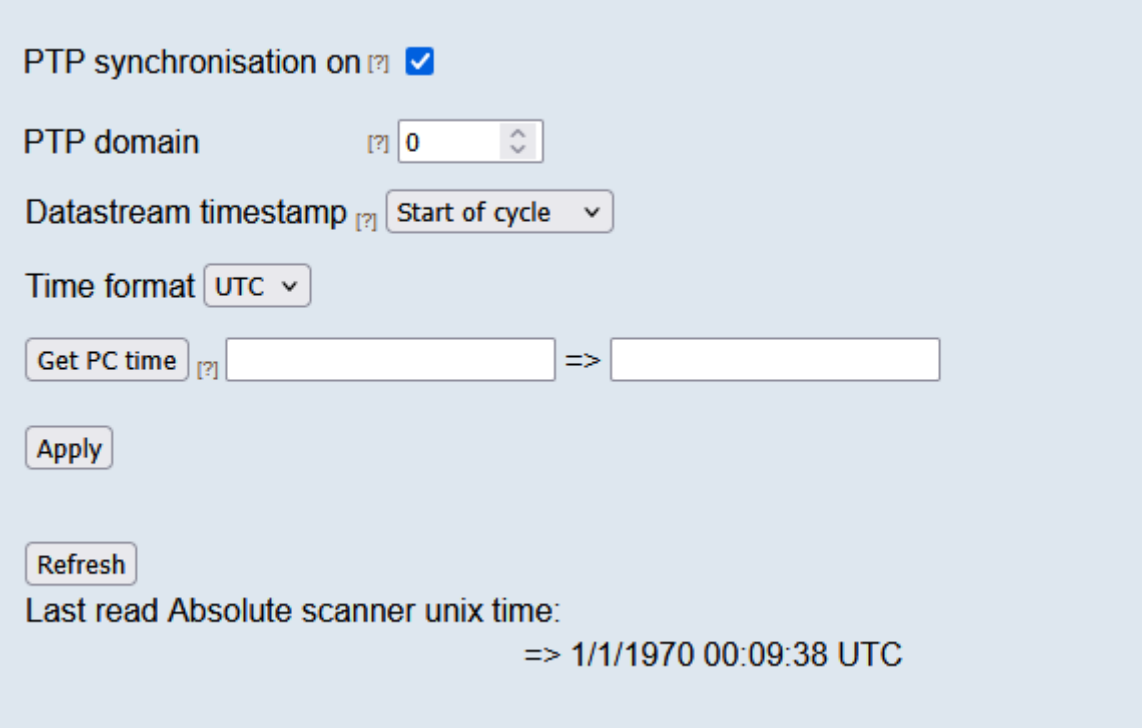


Figure 5.15, Timestamp

'PTP synchronisation on' checkbox	This allows the user to select whether any timestamps that may be added to the datastream are PTP synchronised or not. Please note this will only work if there is a PTP grandmaster clock on the same network as the Q-DAQ-V.
'PTP domain'	Set the PTP domain value
'Datastream timestamp' dropbox	The user can use this to select where the timestamp is positioned in the datastream, either none which will turn the timestamp off, start of cycle which will place a timestamp at the beginning of all the channels and every channel which will read the timestamp for every channel. It should be noted that the latter 2 options will reduce the maximum transmission speed due to the increased bandwidth required .
'Time format'	Select between TAI and UTC time format.
'get PC time'	This button allows the user to get the timestamp from the PC time of the PC they are using. This can be used as a base time for the timestamps if the user is not using PTP. In the first box it will show the timestamp and in the second box it displays the timestamp converted date/time to make it easier to understand. NOTE the user has to click apply to send the timestamp to the Q-DAQ-V
'Apply'	This button will apply the settings chosen on this page.
'Refresh'	This allows the user to refresh the displayed value of the last read timestamp from the Q-DAQ-V.
'last read absolute scanner unix time'	The top line shows the current time in the Q-DAQ-V

Table 5.12, Timestamp

6. Service and Calibration

6.1 Service

There are no user serviceable parts inside the instruments. Should any difficulties be encountered in the use of the Q-DAQ-V, it is recommended that you contact Chell Instruments Ltd for advice and instructions.

6.2 Calibration

Calibration is recommended on an annual basis and Chell Instruments Ltd. provides a fully traceable facility for this purpose.

6.3 Adjustment

There are no user adjustments in the instrument. The user is strictly forbidden from removing the covers without invalidating Chell's obligations under warranty.

6.4 Cleaning

A dirty instrument may be wiped clean with a soft cloth that has been sprayed with a proprietary 'foaming cleaner', then wiped dry immediately.

Under no circumstances should the instrument be wetted directly or left damp.