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PVC*uni* and PVC*duo*

Process & Vacuum Controllers

- **UHV pressure measurement**. PVC*uni* 1 ion gauge. PVC*duo* 2 ion gauges.
- **2 secondary gauges**. Pirani, Convectron, Intelligent gauges...
- **Digital Interlock Hub**. User configurable seven trips and four digital inputs
- **Analogue Interfaces**. Two user-configurable analogue outputs
- **Multi-Step Bake-out controller**. Dual zone option
- **Timers**. Two user-configurable timers.
- **Full Computer Control**. MODBUS RTE and QueBUS (ASCII-based) protocols. VacTools compatible

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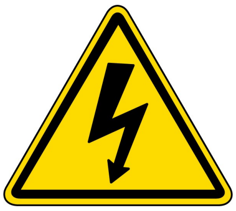
SAFETY NOTES



1. **This equipment MUST be earthed to a high integrity earth point**.
2. Voltages exceeding **400V** are present within the controller, and, during degas, on the cable and ion gauge head. Voltages up to **200V** are present on the cable and ion gauge head during normal (non-degas) operation. To prevent such voltages appearing between the chamber and controller, ensure that both are connected to a single, high-quality earthing (ground) point on the vacuum system using the screw terminal located on the rear panel.
3. **Before removing the top cover of the controller, allow at least 10 minutes for the high voltage capacitors to fully discharge**. **Unless technically qualified to do so, do NOT operate controller with the cover removed.** The top cover is connected to the base of the unit with a wire to ensure earth continuity. Do **not** remove this wire; ensure it is intact and tucked neatly between the transformer and side of the base before replacing the lid.
4. Always turn off power to the controller before connecting any cable or the ion gauge, or performing any maintenance to either.
5. It is the users' responsibility to ensure that the trips and digital inputs are employed safely. **In safety critical installations, an independent manual means of over-riding/inhibiting the trip signals is mandatory**.
6. Operation with the mains line voltage selector wrongly set voids warranty.
7. Careful design, commissioning and operation are essential to avoid damage to any part of the equipment configuration, or injury to personnel. In particular, consideration **must** be taken of the conditions and consequences of any part of the configuration failing, providing independent fail-safe mechanisms for protection, and ensuring that sensible safe limits are placed on controlled devices.

All conductors exposed to high voltage MUST be mechanically shielded to prevent contact with personnel.
Insulation MUST be rated at >500V continuous.
Where shielding involves metal, these parts MUST be connected to a high integrity earth.
In some situations, particularly at high pressures, dangerous high voltages can be coupled to any isolated metal parts of the vacuum system through the gas. This particularly relates to vacuum systems which use insulating components (e.g. glass, ceramic, plastic, rubber). All exposed and isolated metal parts should therefore be reliably grounded to a common system earth point via 4mm^2 or thicker copper wire/braid, the integrity of which should be checked regularly.

1 Introduction

*The PVCuni and PVCduo controllers integrates precision **UHV and secondary gauge pressure measurement** ($1x10^{-12}$ to >1000mBar) with **UHV system management** functions, such as multi-step bake-out, and comprehensive user-definable digital and analogue interlock hubs*

1.1 The PVCuni and PVCduo Controllers

The PVC*uni* supersedes the long-established PVCX controller, providing additional functionality. The PVC*duo* is a 2 ion gauge head version of the PVC*uni*.

The new **P**rocess & **V**accum **C**ontrollers integrate the following functions in a single 1U high 19" rack-mounting unit:

- **UHV pressure measurement** to pressures below $1x10^{-12}$ mBar (gauge head dependent). The PVC*uni* supports 1 ion gauge head and the PVC*duo* 2 ion gauge heads operating simultaneously. Optionally, ion gauge measurements as current for beam flux applications.
- **Support for 2 secondary gauges**. The addition of modules provides support for a wide range of secondary gauges, including Pirani's and intelligent output gauges/controllers.
- **Wide-range gauge operation**. Ion and secondary gauges can be coupled to provide operation as of a single gauge head to provide atmosphere to UHV monitoring. Can provide auto pump-down functionality.
- **Digital Interlock Hub** comprising 7 trips (4 relays and 3 open-collectors) and 4 opto-isolated digital inputs. Fully user configurable to provide protection for the vacuum system, gauges and controller.
- **Analogue interfacing**. Two independent analogue outputs: user-configurable voltage range and pressure relationship.
- **Bake-out controller**. Built in K thermocouple input. Up to 6 ramp/soak steps with configurable gauge, digital I/O and user interlocking. Option for dual zone bake-out control by addition of 'K' module to provide second thermocouple input.
- **Timers**. Two independent user-configurable timers provide single shot or repetitive operations, such as pump conditioning, automatic timed valve operation, TSP switching..., with user defined interlocking.
- **Comprehensive communications**. All aspects of the controller are can be controlled via the RS232 and RS485 ports. Both the binary MODBUS RTE and the ASCII-based QueBUS protocols provide read AND write of MULTIPLE parameters within each comms exchange for fast throughput. Complete vacuum system control and data logging via free VacTools software.

1.2 Communications

As indicated above, the controllers provide comprehensive serial communications capability, and free VacTools software for vacuum system monitoring. For further information, please refer to **PVCUDSerialComms** and **VacTools** documentation downloadable from www.epimax.com, or contact sales@epimax.com.

2 Specification

Parameter	**PVC*uni***	**PVC*duo***
ION GAUGES:		
Number:	**1** x UHV, dual Iridium-based filament. Yttria or Thoria-coated filaments.	**2** x UHV, dual Iridium-based filament. Yttria or Thoria-coated filaments.
Filament Drive:	Electrically silent, high stability constant current dc.	
Gauge potentials:	Normal operation: Filament 40V. Grid: 200V. Degas: Filament 40V. Grid 400V+.	
Filament Drive:	0-3.5A (8V compliance) *[PVCduo: per channel]*	
Emission Control:	PID control with emission measurement for accurate pressure correction	
Manual Emission:	OFF, 0.05, 0.1, 0.15, 0.25, 0.4, 0.6, 1, 1.5, 2.5, 4, 6, 10mA	
Auto-emission:	Emission automatically optimizes to the measured pressure	
Start-up features:	Slow, standard and fast start-up. "Learn" feature for start-up power.	
Degas Type:	Thermal/Electron bombardment	
Degas: *(Note 1)*	2 stage: Ramp/Soak. Ramp: 1 to 499mins, to selectable level: low(15mA)/mid(25mA)/high(50mA), Soak: 1 to 499mins.	
Degas interlocking:	Pressure and digital input interlocking	
Degas Pressure:	Displayed during degas	
Degas on/off:	No interruption of ion gauge operation during degas start/stop transitions	
Electrometer:	Range: <1pA to 1mA. High stability, temperature controlled enclosure. [Allow ~40mins from powering up to stabilize.]	
Gauge Sensitivity:	1.0 to 99.9 (resolution 0.1)	
Gas Sensitivity:	0.01 to 99.99 (relative to Nitrogen = 1.00)	
Interlocking:	Digital inputs: trip/control operation/degas of the gauge.	
SECONDARY GAUGES:		
Number:	2 slots allow user to add support for secondary gauges by plug in modules. Any combination of "E" (for VSP52x Pirani), "F" (for VSP84x Piranis), "V" (for VG Piranis), "K" module in slot 2 provides dual zone bake-out control, "W" and "U" universal (user-configurable support of a range of intelligent gauges, external controller outputs) – see section 6.	
Module operations:	Module channels can operate in the same way as ion gauge channels, having interlock trips, digital inputs and analogue outputs assigned. They can be coupled with ion gauge channels for "dual gauge mode" operation.	
DUAL GAUGE MODE:		
Operation:	An ion gauge can be assigned a secondary gauge such as the combination act as single wide range gauge, with auto switching of on gauge operation	
BAKE-OUT CONTROL:		
Thermocouple:	Type K thermocouple built-in. 1 to 999°C (0.1°C resolution). Controls zone 1 bake-out.	
Optional Thermocouple:	Optional addition of Type "K" module (1 to 500°C range) in slot 2 for dual zone bake-out control	
Bake-out Control:	User configurable: up to 6 ramp/soak steps, 0 to 99:59hm per step (1 minute resolution). Separate zone 1 and zone 2 temperature profiles	
Control Type:	On/off control. 1 second cycle time. User-defined temperature hysteresis.	
Power Control:	Any combination of the 7 trips can be assigned to switch heater power.	

Interlocking:	Each zone has independent ion gauge (separate ig 1 and ig2 for PVC*duo*), digital input and user interaction interlocks. Interlocks can independently *inhibit* heat output, *suspend* bake-out (inhibits output and stops bake-out clock, or *terminate* the bake-out.
Parameters:	As well as setpoint, measured value and interlock information, peak temperature data avaialble
Ion gauge options:	Optional auto-degas of ion gauge(s) at end of bake-out
DIGITAL INTERLOCK HUB:	
Number:	**7** output trips and **4** digital inputs. Fully user configurable
Trips:	Trips 1 to 4: Single pole, change over relays rated at 1A@24Vdc/ 0.5A@40Vac Trips 5 to 7: NPN open collector, earth-referenced outputs. Max drive: 200mA and 12Vdc
Trip assignment:	Each trip is individually assignable to various ion/secondary gauge functions, bake-out, timers, front panel or external (comms) control etc.
Trip Options:	Operate/inhibit/override. Power up operation. Direction (< or > assigned parameter value). Operating hysteresis.
Digital Inputs:	All opto-isolated. 3- 5Vdc input. 2.4kΩ input resistance in series with LED. Reverse diode protected. Digital inputs 1 and 2: electrically isolated from each other and ground Digital inputs 3 and 4: electrically isolated from ground. Share negative input terminal.
Digital Input assignment:	Each digital input can be used as required for ion/secondary gauge protection/control, and interlocking of bake-out, timer
Digital Input options:	Invert input. Operate/inhibit/override. Power up operation.
Connector:	Standard DB25 connector.
ANALOGUE OUTPUT INTERLOCK HUB:	
Number	2
Output:	Full scale range: 0V to ~10.5V (12 bit resolution). Use calibration of max output.
Linearity:	<±0.2%.
Assignment:	User configurable: Ion gauge (emission and sensitivity corrected), any secondary gauge, dual gauge, bake-out temperature…
Functionality:	User-defined voltage range, assigned pressure/temperature range, lin or log relationship...
TIMERS:	
Number:	2
Time Limits:	1 second to 999:59:59hms Cycle time defines off + on time
Operation:	Time can be set to start at start time, on time or user-defined time
Output Allocation:	Any combination of digital trips
Interlocking:	Digital input and ion gauge(s) inhibit of the output.
GENERAL:	
Dimensions:	19" rack mounting: WxHxD: 484x44x260mm (19”x1.73”x10.25”) Allow 50mm (2”) at rear for earth stud and connectors
Weight:	5.6kg
Electrical:	115/230Vac. 8W (gauges off), Max: 60W (full degas)
Protection:	Mains input: Both Neutral and Live fuse protected. 2A(T) for 230Vac; 3.15A(T) for 115Vac. Transformer: thermal trip protection
Display Type:	Graphic 200x16 pixel OLED display High brightness. High contrast. Long life >100,000h to half-brightness
Manual input:	Intuitive menu-driven via 5 front panel touch buttons

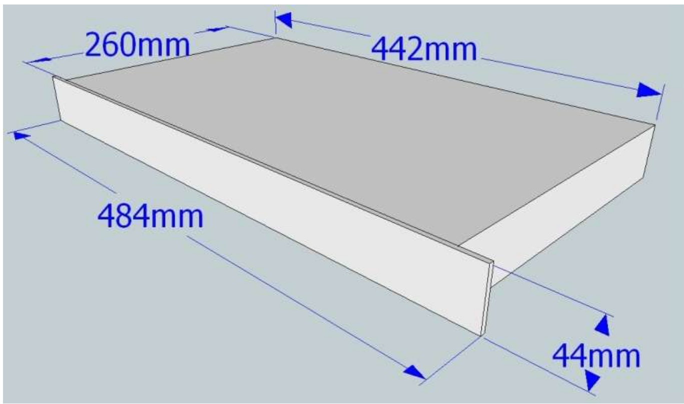
Communications:	Multi-drop RS232 (up to 8 units (port dependent)) and RS485-3 wire (up to 16 units). MODBUS protocol. Simultaneous multiple parameter read/write; floating point resolution. QueBUS protocol. ASCII-based protocol with multiple parameter read/write.
Communications connectors:	2x RJ45 for simple daisy-chaining

Note 1: PVCduo: Maximum total emission current (IG1 + IG2) is 56mA. An existing emission current takes precedence; the second gauge emission will be pinned to prevent a rise in total emission current above 56mA.

3 Installation and Setting Up

This section discusses controller installation, environmental issues, and the basics of instrument operation

3.1 Physical



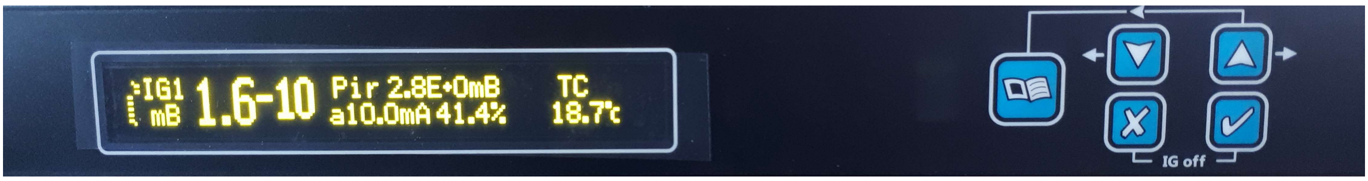
- The controller is enclosed in an earthed, metal, 1U high 19" rack-mounting enclosure.
- Please leave at least 50mm at the rear to accommodate the connectors and provide adequate ventilation for the fan
- The instrument should be mounted in a 19" rack, supported by runners/brackets beneath both sides; **do NOT support only via the front panel locating holes** as damage thus caused is NOT covered by warranty.
- Locate away from heat sources or cooling fans, at ambient temperature between 5 and 40°C.
- For ventilation, a 1U blanked gap is recommended between each group of 3 controllers.
- Avoid positioning near to equipment that generates high energy discharges. An ion gauge head located near a source of electrons or ions should be surrounded by an earthed fine-meshed screen to avoid disruption to operation.

Use of high frequency spark coils for leak testing should be avoided.

3.2 Controller Rear Panel

The upper controller is the PVC*duo*; the lower controller is the PVC*uni*.

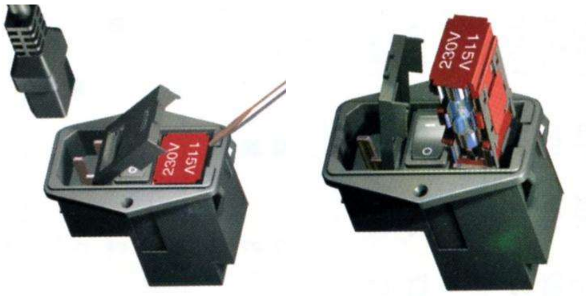
3.3 Controller Front Panel



The picture shows one of many ways in which the values of the gauges and thermocouple are displayed for both the PVC*uni* and PVC*duo*. For more information, please refer section 4.

The 5 tactile push buttons are used for manual operation of the controller (section 4.1).

3.4 Mains (Line) Voltage Selection and Fusing



Mains power is connected via a high quality power filter, integrated with mains selection switch and fusing. To select line voltage and/or replace fuses:

1. Disconnect the mains plug.
2. Using a small flat-bladed screw driver, raise the hinged panel cover.
3. Using a small flat-bladed screw driver **placed at the long side of the red fuse holder (NOT the short sides)**, ***gently*** ease the voltage selector/fuse holder and remove
4. Both Live and neutral are fused. The holder accommodates either 5x20mm or ¼x1¼″ fuses; the former fit into the rear section of the fuse slots. **For 230V use T2.0A; for 115V use T3.15A fuses**. **Slow Blow (type T) fuses**.
5. Replace the voltage selector/fuse holder **so that the required voltage shows through the window of the hinged panel cover**.

3.5 Fuses

As well the mains fuses, the controller has other protection devices.

3.5.1 High Voltage Fuses

The high voltage (grid) pin for the ion gauge connector is protected with a 100mA(F) **fast** fuse. This protects both the gauge head and the controller from short-circuits of the high voltage line.

This fuse is accessible from the rear panel and is marked "100mA(F)"; the PVC*uni* has one fuse, the PVC*duo* has two (one per ion gauge).

The fuse is housed in a bayonet type holder. To release the fuse:

- Turn the controller off and disconnect the power lead.
- Using finger or thumb, push the assembly in against the spring action - it will move by about 2mm
- Whilst pushing, twist anti-clockwise by about 60°.
- The fuse assembly will then be free to remove.
- **DO NOT APPLY FORCE AS THIS WILL DAMAGE THE FUSE HOLDER.**

To check a fuse, use a meter - blown fuses may visually look intact!

To insert a fuse:

- Insert the fuse assembly in the holder - there is only one position in which the fuse can be inserted all the way.
- Using finger or thumb, push the assembly in against the spring action.
- Whilst pushing. twist clockwise by about 60° to lock the fuse in place.

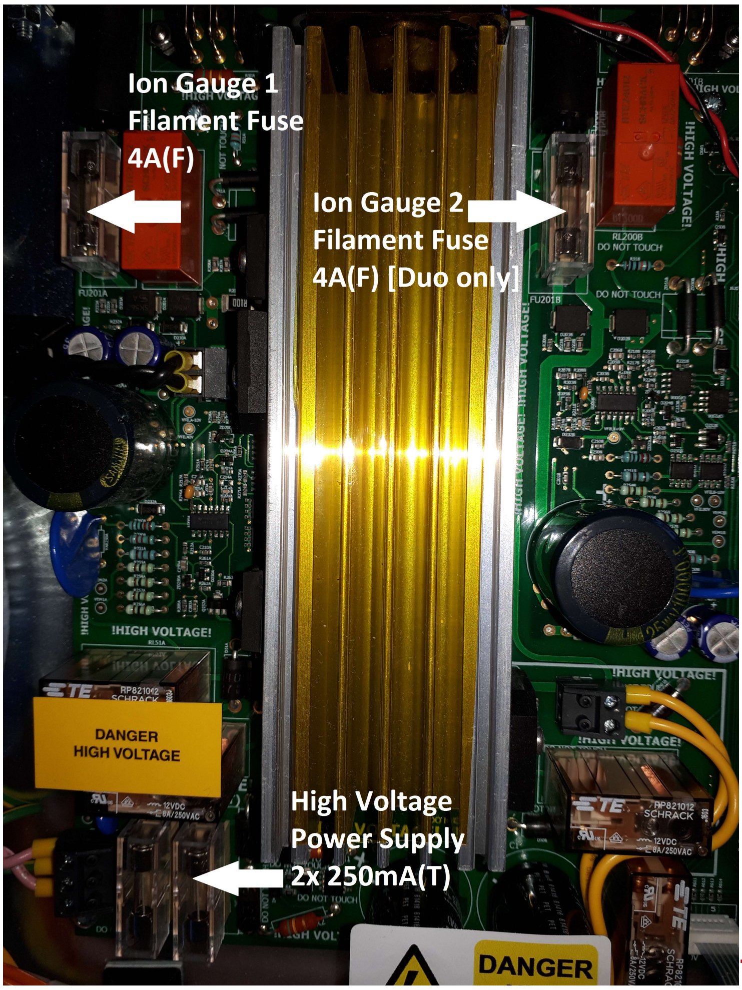
IF REPLACING THESE HIGH VOLTAGE FUSES, USE 100mA <u>FAST</u> FUSES. DO <u>NOT</u> USE TYPE 'T' FUSES AS THIS VOIDS THE PROTECTION OFFERED BY THE FUSE.

3.5.2 Internal fuses

As well as the high voltage fuses described in section 3.5.1, the controller has several internal fuses:

- The PVC*uni* has 3 internal fuses: 2x high voltage input fuses and 1x filament fuse
- The PVC*duo* has 4 internal fuses: 2x high voltage input fuses and 2x filament fuses (one per ion gauge).

It is unlikely that these fuses will need to be replaced as the current drawn through them is electronically limited. They are included in the event of a serious fault occurring, for safety and for fault diagnostics. If they need to be inspected or changed, please consult a qualified electrician or electronics engineer as high voltages may be present on these parts.



The photograph (right) shows the positions of the fuses in the PVC*duo;* the PVC*uni* is lacks the second ion gauge filament fuse. To gain access to the controller, remove the 6 off M3 screws securing the lid (3 on each side). Lift the lid carefully, mindful of the earthing wire connecting it to the base; the wire is long enough to lay fold the lid and lay it to the side of the controller on its top.

As indicated on the PCB legends:

- **The high voltage power supply input fuses are 250mA(T) (T = time-delay or slow-blow).**
- **The filament fuses are 4A(F) (F = fast).**

DO NOT REPLACE THESE FUSES WITH VALUES AND TYPES OTHER THAN THOSE SPECIFIED.

The fuses are protected by plastic covers ALWAYS replace the cover if removed. As the covers are see-through**,** the state of fuse may be apparent without the need for electrical checks.

BEFORE ATTEMPTING TO CHECK THE FUSES, REMOVE ALL CONNECTORS FROM THE CONTROLLER (ESPECIALLY THE MAINS) AND ALLOW 10-15 MINUTES FOR THE HIGH VOLTAGES TO DISCHARGE FROM THE STORAGE CAPACITORS.

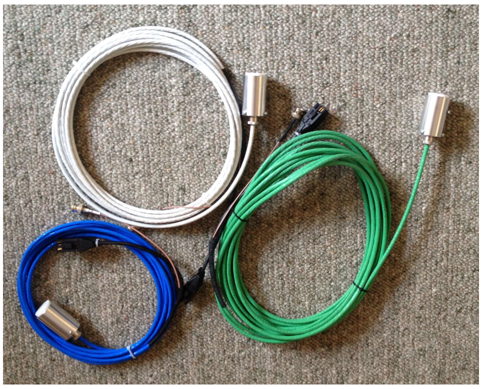
If any of these fuses is found to have failed, please consult the supplier of your controller for further information.

3.5.3 Transformer Thermal Trips

In addition to the fuses, the unit transformer contains thermal trips to protect against extended overload conditions. These are self-healing - they will reset when the transformer has cooled sufficiently.

3.6 Ion Gauge Cables

The ion gauge head is connected to the controller using 2 connectors: a 6 pin QM "power" connector, and a BNC connector for the collector current. **Potentially lethal voltages are present on the connectors; ALWAYS TURN THE CONTROLLER OFF BEFORE DISCONNECTING OR HANDLING**



Ion gauge cables bakeable to 200°C

THE CABLES.

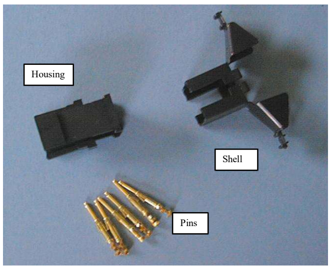
A high current capacity earth strap should be connected between the earth stud on the rear of the controller and the system's earth point.

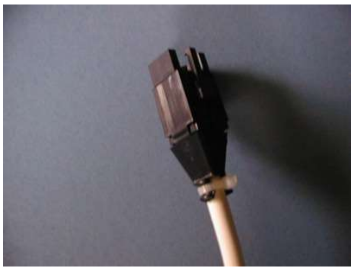
Ready-made cable assemblies are available from your controller supplier.

3.6.1 The 6 pin QM "power" connector

Due to the high voltages present, only cables produced commercially or certified by qualified electrical engineers should be used. Accessories packs are available, which include parts needed to modify an existing cable for use with the controller.

Pin 1	Interlock *(Note 1)*
Pin 2	Grid
Pin 3	Interlock *(Note 1)*
Pin 4	Filament Common
Pin 5	Filament 1 *(Note 2)*
Pin 6	Filament 2 *(Note 2)*





Ion gauge connections to the 6 pin QM connector are as shown:

- *Note 1*: Pins 1 and 3 MUST be linked either at the plug or the vacuum system as these indicate to the controller that a cable is connected. These act as a connection interlock
- *Note 2*: Filament 1 and 2 allocation may vary between cable manufacturers. For single filament gauges, use either pins 5 or 6, and set the filament parameter appropriately.

The ion gauges lead MUST conform to the following:

- CABLING **MUST** BE RATED AT THE **MAXIMUM** BAKEOUT TEMPERATURE
- Individual grid and filament wires **MUST** be rated at >5A AT THE MAXIMUM BAKEOUT TEMPERATURE
- The connection wires **MUST** be rated at >500Vdc

To modify an existing cable to connect to the controller:

Please check the function of each ion gauge cable wire before commencing as once the pins are inserted into the housing they are difficult to remove without special tooling.

- Remove the existing ion gauge connection connector
- Strip each of the wires ~12mm.
- Insert the bare wire into the pin; ensure the insulation is within the top crimp area of the pin.
- Crimp the bare wire section and top section to ensure an electrical connection that cannot be pulled out.
- Insert the pins into the housing from the rear. Ensure that each pin cannot be pulled out.
- If the existing ion gauge does not have interlock wires, connect a pin to each end of a 5cm long length of wire and insert to link positions 1 and 3.
- When all pins have been inserted, clip fit the shell onto the plug housing
- Secure the shell with the cable tie from the Accessories Pack as shown. This relieves strain on the individual conductors.

3.6.2 BNC Collector Connector

The small collector current is returned to the controller via a screened BNC connector, the central pin of which is connected to the collector, and the body to the earthed screen. Instructions on assembling BNCs are provided with the connectors, or can be viewed online.

To reduce the effects of noise picked-up on the collector lead, the controller provides analogue and digital input filtering. The default digital filter setting is 1 second. However, to ensure rapid response to pressure bursts (and thus good process reaction), the digital filter is disabled if a sudden large change in collector current is detected.

3.6.3 Ion Gauge Integrity, Safety and Fusing

- When the ion gauge is off, the high voltage grid and filament supplies are internally disconnected from the QM connector. However, before attempting any work on the ion gauge leads, disconnect the lead from both the controller and the ion gauge head.
- Pins 1 and 3 provide an interlock to detect the presence of the ion gauge. Ideally, these should be bridged *in vacuo*. However, if the gauge head does not have this facility, link the pins in the QM connector.
- When the ion gauge is on, the controller checks for gauge filament integrity and short-circuits between pins and to earth.

- The filament supply is based around a constant current source with a current limit of ~3.5A. The controller has a 4A fast fuse to protect the filament and controller from spurious fault conditions.
- High voltage to the grid and filament bias is protected via a 100mA(F) fast blow fuse. **DO NOT USE A "SLOW BLOW", "TIME DELAY" or "MAINS-STYLE" fuse in this position**.
- The controller has an internal PCB mounted high voltage 250mA (T) fuse.

3.7 Digital I/O Connector

3.7.1 Connector

A standard male DB25 connector provides access to the digital inputs and outputs.

3.7.2 Digital Trips

- **Trips 1 to 4** are change-over relays: Do NOT exceed 1Adc or 0.5Aac at 32V
- **Trips 5 to 7** are open-collector (Darlington pair) outputs with the emitter at 0V (earth potential) at pins 7 and 10. Do NOT apply more than 14V (absolute maximum) or exceed MAXIMUM current for trips outputs 5 to 7 of 200mA.

Function	Pin	Pin	Function
		1	Relay 1 Normally Open
Relay 1 Common	14		
		2	Relay 2 Normally Closed
Relay 2 Normally Open	15		
		3	Relay 2 Common
Relay 2 Normally Closed	16		
		4	Relay 3 Normally Open
Relay 3 Common	17		
		5	Relay 3 Normally Closed
Relay 4 Normally Open	18		
		6	Relay 4 Common
Relay 4 Normally Closed	19		
		7	Outputs 5 to 7 0V (Earth)
Digital Inputs 3 and 4 -ve	20		
		8	Open Collector Trip 5
Open Collector Trip 6	21		
		9	Open Collector Trip 7
Digital 3 input +ve	22		
		10	Digital 4 input +ve
Outputs 5 to 7 0V. At Earth	23		
		11	Weak +12V (see 3.7.4)
Digital 1 input +ve	24		
		12	Digital input 1 -ve
Digital 2 input +ve	25		
		13	Digital input 2 -ve

3.7.3 Digital Inputs

- The terminals of the digital inputs are each isolated using opto-couplers in series with 2k4Ω resistors.
- The digital inputs are internally protected against reverse bias
- Digital inputs 1 and 2 are electrically isolated positive and negative terminals
- Digital inputs 3 and 4 share a negative terminal (pin 20)
- Minimum guaranteed digital input operating voltage is 3.6V.
- Do NOT exceed 32Vdc input to the digital inputs. If higher voltage are to be applied, limit the input current to 10mA by using an external series resistor.
- The Digital inputs can be switched using an external relay contact, a logic gate or using an open collector output.

3.7.4 Weak +12V supply

A weak 12V supply is provided at pin 11 of the connector which is capable of powering the 4 digital inputs, thus obviating the need for an external power supply if switching via a relay or open collector device. The weak supply is fed via a protection diode and a 820Ω resistor, restricting the output current capable of switching the digital inputs to about 10mA.

This weak 12V supply is earth referenced, i.e. to pin 23. Thus if, for example, switching via an external relay, connect the digital input -ve to pin 23 and route the weak 12V supply from pin 11 via the relay contact.

3.7.5 Digital I/O Options

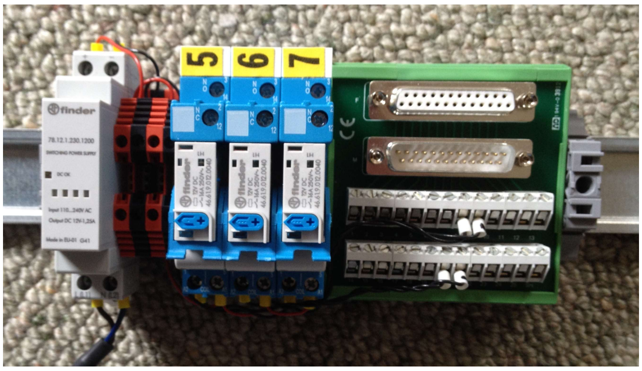
The following options are available for enhancing the capability of the Digital I/O port

PVCRL Power Relay Booster.

As some applications (such as switching bake-out heaters) require more switching power than can be afforded by the internal relays, a range of DIN-rail mounted power relay/contactor options are available. The photograph shows an assembly (PVC15RL3_5) with 3 15A relays wired to trigger using trips 5 , 6 and 7 with integrated 12V power supply, suitable for switching 3phase bake-out heaters. In addition, the assembly has screw terminal assembly providing soldering-free wiring of the remaining trips and digital inputs. A 3m cable to connect to the controller is included. Other combinations and powers of relays/ contactors are available.

PVCDB25.

The PVCDB25 is a screw-terminal connector housed providing soldering-free connection to the I/O connector.



3.8 Analogue Output Connector

The analogue outputs share is a standard "stereo" 3 pin 3.5mm (⅛") jack socket. The central pin is the analogue 1 output, the next ring is analogue 2 and the outer is 0V (earth). Screened signal wire is recommended

3.9 Serial Communications

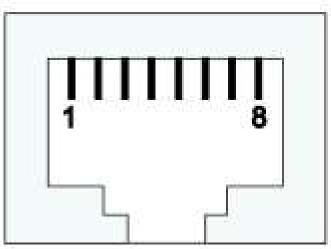
3.9.1 Overview

The controller provides multi-drop RS232 and RS485 (3 wire) communications ports as standard. Both are available at two parallel-wired RJ45 sockets (see right); this arrangement provides for convenient daisy chaining of controllers. Up to 16 controllers can be attached to an RS485 port. Due to a multi-drop implementation, up to 8 controllers can be connected to an RS232 port (this may vary between PC's). The controller is fully supported by VacTools software. See the Communications Handbook for further details.

Pin	Function	Colours
1	RS232 0V (Earth)	Orange/White
2	RS232 receive	Orange
3	RS232 transmit	Green/White
4	RS485 0V return	Blue
5	RS485 0V return	Blue/White
6	RS485 0V return	Green
7	RS485 transmit A	Brown/White
8	RS485 transmit B	Brown
Shield	Earth	Screen

3.9.2 RJ45 Connectors

The shielded RJ45 8/8 connector pin assignment and allocation is shown, along with the colours often used in commercially available cables. Note that the RS485 0V at pins 4, 5 and 6 is connected to internal 0V (earth) via a 100Ω resistor to reduce the likelihood of earth loops when using the RS485 interface.



3.9.3 Interface Cabling from the Port to the First Controller

Cables are available for connection to standard DB9 or DB25 PC ports for RS232 interfacing, as well as leads for RS485 (see below). However, if making up cables, it is often convenient to purchase ready-made RJ45 cables assemblies with pre-moulded connectors. Use of quality SHIELDED, Cat5e COMPLAINT, RJ45 PATCH LEADS is recommended.

3.9.3.1 RS232

Note: Implementation of the Note: Implementation of the RS232 port allows multiple controllers to be daisy-chained via the

RJ45 connectors.

The RS232 interface is a simple 3 wire interface, i.e. only receive, transmit and 0V lines are used. The remaining "hand-shaking" lines need to be correctly "terminated" at the PC. This can often be implemented by the driver software; however, using pin links (as shown below) guarantees hand-shaking termination.

The table shows wiring for both 9pin or 25pin RS232 ports.

If using RS232 interface, ensure that NONE of the RS485 pines are connected. If using an RJ45 patch lead, please ensure that ALL un-used wires are insulated from each other.

PC 25 pin Female DB25	PC 9 pin Female DB9 pin	Function	Cable	Function	Controlller
7	5	Ground	Orange/White	Ground	1
3	2	RxD	Green/White	TxD	3
2	3	TxD	Orange	RxD	2
Link 4 and 5	Link 7 and 8	Handshaking	-	-	-
Link 6, 8 and 20	Link 1, 4 and 6	Handshaking	-	-	-

3.9.3.2 RS485

RS485 provides a more electrically robust serial interface. Two wires (called B or Data+, and A or Data-) provide a differential signal resulting in better immunity to noise. There is no handshaking.

Unfortunately, there is no "standard" for pin-outs as different manufactures use different pin allocations (even between devices in the same range). For information about your RS485 serial port, please refer to the manufacturers' web-site. The following connections should be made:

- Connect the "0V" pin of the RS485 port to pin 6 (green)
- Connect the B (Data+) pin of the RS485 port to pin 7 (brown/white)
- Connect the A (Data-) pin of the RS485 port to pin 8 (brown)

If using RS485 interface, ensure that NONE of the RS232 pins are connected. If using an RJ45 patch lead, please ensure that ALL un-used wires are insulated from each other.

3.9.4 Daisy-chaining cable between controllers

The simplest method to daisy-chain controllers is to use standard RJ45 "patch" leads; shielded, Cat5 compliant cables are recommended.

3.9.5 Native PC RS232 Hardware Interface

One or more controllers can be connected to the native PC RS232 serial port, as wired in section 3.9.3.1. 5m long RS232 to RJ45 connector to the first controller are available (GC2DB9RJ45-05). To connect additional controllers, use 0.5m long daisy-chain cable (GC2RJ4545-0.5). The PCCom14 kit allows connection of up to 4 controllers. This kit can be used with VacTools.

3.9.6 USB and Ethernet Communications-based Hardware Kits

USB and Ethernet to serial port converters are readily available from many manufacturers. Often these contain multiple serial ports (2, 4, 8 or 16) and can be switched between serial port types (RS232, RS485, RS422). VacTools supports these setups.

3.10 Data Retention (Volatile/Stored Parameters)

The controller is operated by setting "parameters" either manually or over the communications interface. Some parameters are volatile, i.e. they are temporary and are not retained when the controller is powered off (for example, whether the ion gauge is on or off). Others are stored (in EEPROM). Note: it may take up to 2 minutes before a changed parameter is stored in EEPROM; please allow this time if the controller is to powered off.

The controller loads the EEPROM data on power up. If a memory error is detected, a message is displayed (**Mem Error**) at the end of the power up sequence, and all parameter settings are reset to their default conditions.

3.11 Factory Reset

The parameters for the controller can be returned to the their factory "default" values, i.e. the state in which the controller is shipped. To reset the controller:

- Turn the controller power OFF.
- Whilst simultaneously pushing and holding down the **CANCEL** and **ENTER** buttons, turn the controller power ON. [This is

intentionally not easy to do to avoid accidental resetting the controller!]
- If successful, the message "Load Failed" appears briefly and the controller performs the parameter reset function.
- The controller then restarts itself, loading the default parameter values.

Note: The controller cannot be factory reset using a communications command.

4 Manual Operation

This section describes operation of the controller from the front panel

4.1 The Manual User Interface

The controller presents information via a 200x16 pixel OLED graphical display module.

The controller is controlled manually using 5 tactile buttons on the front panel .

			**DOWN BUTTON** Decrements Menu Level and Data Values		**UP BUTTON** Increments Menu level and Data Values
	**MENU BUTTON** Navigates Menu				
			**CANCEL BUTTON** Cancel Data Entry Exits Menu		**ENTER BUTTON** Enters new Data

Depending on context, the length of time certain buttons are held can change their function. For example, when in STATUS mode, pressing the **MENU** button will cause the controller to enter Menu mode displaying the title of the first menu; continuing to hold the button will scroll through the menu list.

The buttons are "membrane" types, comprising a domed area with a tactile response when pressed. They are designed to be used with fingers. DAMAGE CAUSED BY USING SHARP OBJECTS ON THE BUTTONS IS NOT COVERED BY WARRANTY.

NOTE: Pressing the CANCEL and ENTER buttons together at any time will turn off emission to ion gauge(s) immediately.

4.2 Display Modes

There are 4 "modes" of controller operation:

MODE	Description	Buttons
STATUS: (section 4.3)	Provides information about controller operation via a number of "pages"	**DOWN**: Move to next status page **UP**: Move to previous status page **MENU**: Enter MENU mode **CANCEL**: Changes the screen to show alternative data; for example,, output power instead of emission current in pages showing ion gauges whilst held down
MENU: (section 4.4)	Display is divided into two: left shows ion gauge status, right is the menu selection areas.	**MENU**: Move to next menu **DOWN**: Move to next menu **UP**: Move to previous menu **MENU**+**UP**: Move to previous menu-drive **CANCEL**: Return to Status mode (at last page displayed) **ENTER**: Enter the Parameter editing mode at the first parameter in the menu
PARAMETER: (section 4.5)	Display is divided into two: left shows ion gauge status, right is parameter selection and editing area.	**MENU**: Move to next parameter **MENU**+**UP**: Return to previous parameter **UP**: Increment the selection or increases the number at the cursor position **DOWN**: Decrements the selection or decreases the number at the cursor position **CANCEL**: If the parameter value has been modified, initially returns the parameter value to its current value. If held, returns to the Menu mode at the menu position **ENTER**: Sets the display value into the parameter
DISPLAY SAVER: (section 4.8)	Display shows minimum data relating to operating gauges. Data scrolls slowly across the display.	Starts if no buttons are pressed for longer than the **Display Saver Time** parameter Pressing **ANY BUTTON** returns the display to the last status page being viewed

4.3 Status Mode and Status Mode Pages

The controller conveys information via the Status mode pages; each page relates to a specific feature of the controller. In the Status mode, you navigate the pages using the **UP** and **DOWN** buttons. Note that some of the pages for the PVC*duo* are missing for the PVC*uni*.

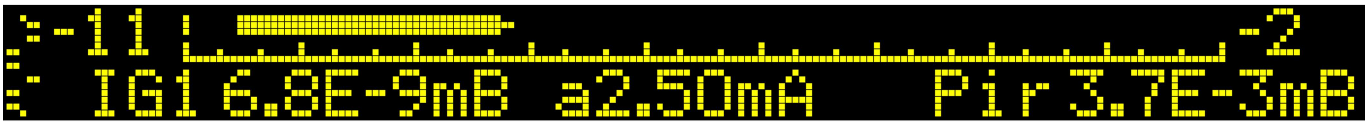
The following table summarises the pages, in order, and their function. Examples of page displays are provided in subsequent sections:

PAGE (Index)	Notes	Description	**G**raphic/**T**ext	***uni/duo***
General (0)	**1,2,3**	Data from ion gauge(s), thermocouple input and modules (if fitted) displayed as 2 lines of 34 text characters.	**T**	***ud***
IonGauge1 (1)	**1,3**	Displays ion gauge 1 data in large font. Secondary gauges (if installed) and thermocouple scrolled	**GT**	***ud***
IonGauge2 (2)	**1,3**	Displays ion gauge 2 data in large font. Secondary gauges (if installed) and thermocouple scrolled	**GT**	***Duo only***
Ion Gauge 1 and 2 (3)	**1,2,3**	Displays both ion gauges in large font. Secondary gauges (if installed) and thermocouple scrolled	**GT**	***Duo only***
BarGraph (4)	**1,2,3**	Upper screen: Ion gauge(s) (in dual gauge mode if enabled) displayed as bar graphs . Lower screen: All gauges data scrolled and displayed as text.	**GT**	***ud***

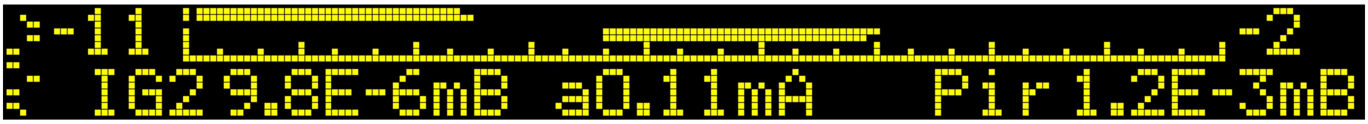
Modules (5)	**1,3**	Displays data from both modules as large font. Thermocouple and ion gauge(s) data (if operating) scrolled	**GT**	***ud***
Bake-out (6)	**4**	Provides summary of currently operating bake-out, or termination condition of last bake-out executed. If in dual zone mode, provides information for both zones. Press and hold **CANCEL** to show peak temperatures achieved in current (or previous) bake-out	**T**	***ud***
Interlock Hub (7)	**5**	Summarizes the current states of the 7 trips (top line) and 4 digital inputs (bottom line). Press and hold **CANCEL** to show scroll through the 7 trips showing their status and current allocation	**T**	***ud***
Timers (8)	**6**	Summarizes the status of the 2 timers	**T**	***ud***

Note 1: Ion gauge values: press and hold **CANCEL** to show output power instead of emission current
Note 2: Secondary gauge and thermocouple data scrolled
Note 3: Pressing **MENU** starts menu access at ion gauge 1 menu
Note 4: Pressing **MENU** starts menu access at bake-out menu. Pressing **CANCEL** provides peak temperatures attained
Note 5: Pressing **MENU** starts menu access at trips menu. Pressing **CANCEL** provides summary of DIO settings
Note 6: Pressing **MENU** starts menu access at timer 1 menu. Pressing **CANCEL** provides summary of timer settings

Examples:



PVCuni Bargraph Page



PVCduo Bargraph Page. The ion gauge(s) toggle between IG1 and IG2

Ion Gauge 1 Page. Pressure Display with secondary devices

Ion Gauge 1 Page. Pressure Display with emission details

4.4 Menu mode

From the Status Mode, pressing the **MENU** button to enter Menu mode. The order of menus is:

Ion Gauge 1 Menu
Ion Gauge 2 Menu[Note 1]
Module 1 Menu[Note 2]
Module 2 Menu[Note 3]
Trip 1, 2, 3, 4, 5, 6 and 7 Menus
Digital Input 1, 2, 3 and 4 Menus
Analogue Out 1 and 2 Menus
Bake-out Menu
Ion Gauge 1 Dual Gauge Menu
Ion Gauge 2 Dual Gauge Menu[Note 1]
Timer 1 and 2 Menus
Calibration Menu
Setup Menu
(returns to Ion Gauge 1 Menu)

Note 1: PVC*duo* only. **Note 2**: Only if 'U' or 'W' module installed in Slot 1. **Note 3**: Only if 'U' or 'W' module installed in Slot 2

Once in Menu mode:

- To move forward through the menu list, press either the **MENU** or **DOWN** buttons
- To move back through the menu list, press either the **UP** or the **MENU+UP** buttons together
- To leave menu and return to last status mode page, press **CANCEL**
- To enter the menu for parameter editing, press **ENTER**

Note that the first menu displayed on pressing **MENU** when in status mode depends on which page is being viewed:

- If viewing the Trips and Digital input summary page, menu mode is entered at Trip 1 menu
- If viewing the Bake-out page, menu mode is entered at Bake-out menu
- If viewing the Timer status page, menu mode is entered at Timer 1 menu
- For all other pages, menu mode is entered at Ion Gauge 1 Menu

4.5 Parameter Mode: Button Operation and Parameter Data Entry

4.5.1 Parameter Types

There are 3 parameter types:

- **SELECTION PARAMETERS**: These are parameters requiring selection from a limited range of options. Examples: ion gauge emission, allocation of trips, analogue outputs...
- **NUMERICAL DATA PARAMETERS**: These parameters require a numerical value. The controller takes care of formatting the parameter (integer, decimal, scientific, time) applying the relevant number of decimal places and restricting the input to the parameters range. Examples: Trip pressures, bake-out step times and temperatures...
- **TEXT PARAMETERS**: These parameter require entry of alphanumeric characters. Examples: unit and gauge names...

4.5.2 Parameter States

Parameters can be in 3 states:

- **LOCKED** parameters are indicated by a key symbol. The parameter cannot be edited. This may be because it is for information only (e.g. the heatsink temperature), the parameter would have no effect (e.g. the ion gauge emission if the gauge is disconnected at the rear panel), or the parameter is a "protected" type requiring parameter unlock being activated (e.g. calibration parameters).
  

  Note the "key symbol" which indicates that the parameter is locked and cannot be edited.

- **CURRENT VALUE**; the equals sign ('=') indicates that the display shows the current
  

value of the parameter and the parameter can be edited. In the example shown, this is because calibration had been unlocked (see section 11)

- **NEW VALUE**; the question mark ('?') indicates that the display is showing a new parameter value. Note that the new value is not used until **ENTER** button is pressed, at which point the '?' changes to '=' indicating that this is the operating parameter value.

4.5.3 Parameter Editing

Data presentation and the method for changing their values depends on the type of parameter:

SELECTION PARAMETERS:

The example below shows changing the emission current. On entering the parameter, the middle image indicates that the emission is off. Pressing the **DOWN** button changes the option to Auto emission, and pressing the **UP** button to the minimum emission value (0.1mA). Note the '?' indicating the change to the value.

To exit without changing, press **CANCEL**. To enter a new value, press **ENTER**.

DATA PARAMETERS:

Data parameters require numerical data entry. In these cases, an underline cursor indicates the currently "active" digit:

- Briefly pressing and releasing (0.2 – 0.8 second) **DOWN** moves the cursor one character to the left
- Briefly pressing and releasing (0.2 – 0.8 second) **UP** moves the cursor one character to the right-hand
- Pressing and holding (>1 second) **DOWN** decreases the parameter value at the cursor position. Continuing to hold scrolls the value
- Pressing and holding (>1 second) **UP** increases the parameter value at the cursor position. Continuing to hold scrolls the value

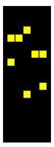
Note: the new value is automatically checked against the range of the parameter, pinning the value to within the parameter range.

In the case of exponential data formats, the cursor appears below the entire exponent section. The **UP** and **DOWN** buttons increments/decrements the value over the entire exponent range.

TEXT PARAMETERS:

The unit, ion gauge and secondary gauge names are text parameters. These behave like data parameters, except the character range is not limited to numbers. Valid characters are: ' ' (space), '0' to '9', 'A' to 'Z' and 'a' to 'z'.

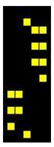
4.6 Trips and Digital Input Status Indication



The status of the 7 trips and 4 digital inputs are indicated at the far left of the display, regardless of display mode. The display toggles between displaying trip state and digital input state every 2 seconds.

DIGITAL INPUT INDICATION

The states of the 4 digital inputs are indicated by 4 bars, the topmost being digital input 1, the bottom one being digital input 4. The figure shows the 4 possible states: DI1 = OFF, DI2 = ON, DI3 = Inhibit, DI4 = Override.



TRIP INDICATION

The states of the 7 trips are indicated by 7 bars, the top most being trip 1, the bottom one being trip 7. For example, the figure indicates that trips 1, 2 and 3 are on, trip 4 is overriden, trips 5 and 6 are off and trip7 is inhibited.

4.7 Communications Indication

If the communications indicator is switched on (see section 12.4), the top left pixel of the screen will flash during communications. Note that as the display rate and communication arrival rates are not synchronized, the rate of flashing does not correspond directly to communications messaging rate; rather, it is purely an indicator of communications.

4.8 Display Saver Mode

At times when the controller is not going to be observed (e.g. over-night), the user can set the display to enter Display Saver Mode. If no buttons are then pressed for longer than the **Display Saver Time** parameter (see section 12.3), the display will only show information for operating devices on the controller. This information slowly scrolls across the screen:

The displayed information comprises 2 fields:

- Ion Gauge(s): If an ion gauge is operating, the gauge name and pressure are indicated. For the PVC*duo*, if both gauges are operating, the information shown toggles between the two ion gauge values. If no ion gauge is operating, this field is blank
- Secondary Gauges/thermocouple: This field toggles through the 3 potentially operating secondary devices: Slot 1 module, Slot 2 module and thermocouple. If a slot is empty, it is ignored. The device name and its value are displayed, and, if a bake-out is occurring, that is followed by the remaining time.

The controller reverts to the last observed Status Mode page as soon as any button is pressed.

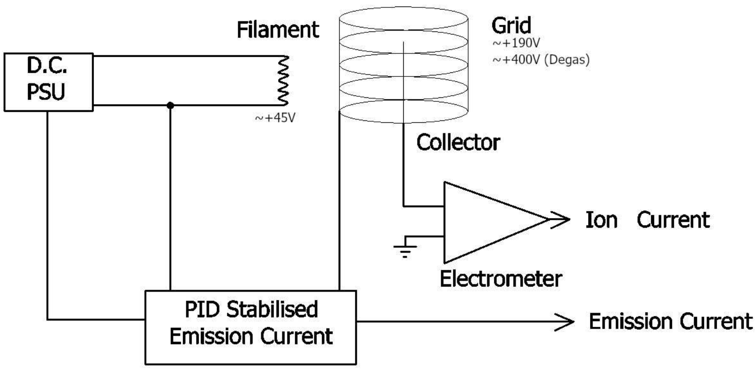
5 Ion Gauge Operation

The controller provides stable and electrically silent (dc) control of a UHV ion gauge head. This section discusses ion gauge operation and some of the features offered by the controller such as Auto Emission, Degas pressure measurement, new filament conditioning and uninterrupted normal/degas transitions.

5.1 Ion Gauge Construction

An ion gauge head comprises:

- A filament assembly, usually comprising 2 independent filaments biased at ~+45V wrt earth. The filaments are Iridium, coated with either Thoria or Yttria to reduce the work-function for emission of electrons.
- A cylindrical grid biased at ~+190V during normal operation and ~+400V during degas that attracts the electrons. It's open structure ensures that electrons make multiple passes through it before being collected. Electrons that strike a gas molecule ionize it, and the resulting positive ion is attracted to...
- A thin "collector" wire in the middle of the grid. The tiny ion current is measured in the controller by a very sensitive electrometer.



The measurement process is shown in the schematic. In the PVCs, the filament is heated by a high stability, low noise, constant current source. The emission current from the filament to the grid is PID stabilized at the desired value. The controller simultaneously measures the ion current **AND** the emission current to determine the pressure.

Because of the very large dynamic range of the ion current (10^{-12} to 10^{-2} Amps), emission currents are adjusted to match the pressure range of interest; for example, the Auto-emission setting automatically selects the optimum emission for the measured pressure.

The need to measure very low currents means that the electrometer amplifier is sensitive to thermal variation; a notable feature of the PVC design is the siting of the electrometer in a "thermal" oven that keeps it at a near constant temperature.

5.2 Ion Gauge and Relative Gas Sensitivity

The efficiency of ion generation depends n the design/geometry of the gauge head. The "Ion Gauge Sensitivity" parameter allows the accepted value for the ion gauge head to be input into the controller; values typically vary between 5 and 30 $mBar^{-1}$.

Ionization probability also differs with gas type. This sensitivity to gas species is referenced to Nitrogen (as 1.00); values for some gases are shown below, and these, too, can be entered as an ion gauge parameter.

The overall "gauge" sensitivity = (gauge sensitivity) x (relative gas sensitivity). Note that the relative sensitivity values also vary with gauge head design, and values even between "identical" gauges can vary by 10% or more. Relative sensitivity values become less reliable with increasing pressures above about 10^{-5}mBar.

H_2 0.46	Air/N_2 1.00	NO 1.15	CH_4 1.40
D_2 0.35	O_2 1.01	NH_3 1.22	C_2H_6 2.60
He 0.18	CO 1.05	Ar 1.29	C_3H_8 4.21
Ne 0.30	H_2O 1.12	CO_2 1.42	Kr 1.94
			Xe 2.86

5.3 Fixed Emission Currents and Auto-Emission

The controller provides a range of "fixed" emission currents: 0.06, 0.1, 0.15, 0.25, 0.4, 0.6, 1, 1.5, 2.5, 4, 6 and 10mA; note that each value is approximately 1.5x the previous value to provide an "exponential" sequence. Optimum choice of which emission to use depends on the operating pressure range of the vacuum system; higher emission currents are required at lower pressure to boost ion current. The controller also provides an "Auto-emission" setting that automatically adjusts the emission current to match the gauge head operating conditions (section 5.5).

The user can define a minimum and maximum emission setting to reflect optimum conditions for a specific design of ion gauge head, for example, to limit the maximum current (manual or auto-emission) to 4mA.

5.4 Emission Start-up, Filament Ramping and PID control

Ion gauge has 2 modes of operation: Start-up and Emission control.

5.4.1 Emission Start-up

The ion gauge emission is ramped up in 2 stages. Initially the power is ramped from zero power to the value specified by the **Start Power** parameter value. The rate at which the power is ramped can be selected using the **Filament Ramp Rate** parameter as slow (0.2% per second), standard (1% per second) or fast (10% per second). If, during this period, emission is established, emission control takes over.

If emission is not established by the time the **Start Power** parameter is reached, the second stage commences, ramping the power at a rate of 0.5% per second until emission is established. If emission fails to occur by the time power has reached 75% of the **Max Power** parameter value, emission for the filament is deemed to have failed.

5.4.2 PID Emission Control

Once emission is established, the µprocessor employs a PID control loop to maintain emission stability at the required value. The **PropBand** and **Damp** parameters are set to 25 arbitrary units which is suitable for most ion gauge designs. During normal PID operation, the power level is maintained between the **Minimum Power** and the **Maximum Power** parameter values.

5.4.3 Start Power Learn Mode

For optimum start-up of an ion gauge (for example, when using fast ramp rate, or in DGM mode when switching from secondary to ion gauge), having a **Start Power** appropriate to the gauge is important. The **Filament Ramp Rate** parameter provides the **Learn Start Power** option. On ion gauge start-up, this forces the controller to perform a slow (0.2%/sec) ramp until emission is established - the power value at which emission starts is automatically stored in the **Start Power** parameter for future use.

Note: The Learn Start Power option should NOT be used with a new filament or one that has not been adequately conditioned by use; conditioned filaments require less power than new ones - see section 5.10.2.

5.5 Auto-Emission

In "Auto-emission" the controller selects the most appropriate emission current (within the **Minimum** and M**aximum** emission range) for the measured pressure; the lower the pressure, the higher the selected emission.

To avoid pressure bursts, auto-emission ramps the emission; it ramps the emission more slowly when increasing than when decreasing. However, to protect the ion gauge, the Auto-Emission algorithm responds immediately to sudden increases in pressure.

5.6 Degas

After air exposure, or extended filament non-use *in vacuo*, starting an ion gauge can degrade the vacuum due to out-gassing, and can adsorption can influence operation of the collector; effectively these change the sensitivity of the gauge. A gauge can be "cleaned" by raising the emission current and grid potential above normal operating values, so-called "degassing". The frequency and extent of degassing depends on the process, but a long (>30 min) is generally recommended after air exposure (usually following bake-out).

The controller provides 3 levels of degas, Low, Mid and High, which set the emission current to 15, 25 and 50mA respectively; the grid potential is also raised to ~400V to enhance grid heating. The high emission currents also drive the filament at a higher power (thus temperature).

Degas is a 2 step process. Emission is ramped from the current emission to the selected degas level and then held. The duration of the **Degas Ramp** and **Degas Hold** parameters can each be 1 to 499 minutes.

The controller provides several levels of protection to militate against large gauge-head induced pressure bursts that can

occur during degas and to protect the vacuum system:
- The emission current is ramped linearly over the degas ramp time. Extended ramp periods (>10mins) ensures gradual gas desorption allowing pumps to handle gas loads.
- Pressures during degas exceeding the **Degas Trip Pressure** parameter value temporarily suspend emission ramping, until the pressure recovers.
- Pressure measurement continues during degas thereby maintaining gauge head trip protection.
- Switching between normal measurement and degas occurs ***without*** interrupting operation of the gauge.
- A degas sequence cannot be started if the ion gauge is not already operating.
- Degas can be interrupted at any time by selecting a fixed emission current or Auto-emission.

5.7 Ion Gauge Status and Error Messages

Checks are performed on gauge integrity. Status and error conditions include (see also Troubleshooting):

Display	Condition
blank	Ion gauge not connected (interlock not made)
OFF	The ion gauge is off and no error conditions apply
<MinLimit	During ion gauge operation, a collector ion current cannot be measured. [Faulty/disconnected collector lead; collector swamped by electron/ion source]
A/DEr	Fault detected with A/D converter. Ion gauge will be switched off.
HiVEr	Fault detected with high voltage (grid) potential [Check rear panel high voltage grid fuse.]
FHiVEr	Fault detected with filament potential [Often caused by filament touching chamber wall]
OvrTemp/ UndTemp	Internal heatsink over or under temperature condition. Ion gauge switched off.
Fil Er	Ion gauge tripped: filament problem (e.g. open/short circuit filament)
Emiss Er	Ion gauge tripped: emission failed or could not be established.
OvrPres	System pressure too high for ion gauge operation. Ion gauge switched off.
PowerEr	Ion gauge tripped: power output exceeded max power during normal operation setting for > ~30secs. This error condition is not checked during degas as, for very long ion gauge cables, the power needed may exceed maximum voltage available.
DI Er	Digital input assigned to the ion gauge failed, causing the ion gauge to trip out
To OFF	The ion gauge is being powered down.
->*emission*	During power up, the initial emission current setpoint value

5.8 PVCduo and Ion Gauge Emission Settings

The high voltage output to the ion gauge grid is protected by a 100mA ***fast-blow*** fuse to provide instant safety, ion gauge head and controller protection (see section 3.5.1). In addition, the controller software places a limit of ~56mA on the current that the ion gauge(s) can draw from the high voltage power supply. In the case of the PVC*uni*, this has no effect on ion gauge degas under all conditions. However, for the PVC*duo*, if one or both gauges are set to Degas High (i.e. 50mA emission), the controller will control the emission ramp(s) of the gauge(s) such that the total current drawn does not exceed ~56mA. Aside from this restriction, the ion gauges will continue to operate normally and the degas finish according to its timed schedule.

5.9 Emission Leakage

Ion gauge operation requires good electrical isolation between grid, filament and earth. Gauge feedthroughs can become internally coated causing electrical "leakage" between the pins. Symptoms of leakage include:
- The ion gauge apparently powers up very quickly, or at low filament currents.
- Pressure readings are erratic and very low at low emission currents, or <MinLimit is indicated.

Resistance measurements using a meter may not provide adequate indication of leakage since breakdown/leakage often requires presence of a high voltage. The controller *may* continue to operate a leaky gauge head, but remedial action or replacement of the gauge head is recommended.

5.10 Hints on using ion gauge measurements

The controller has been designed to make use of the ion gauge as simple as possible and provide maximum protection of the ion gauge head and vacuum system. This section provides some hints regarding operation:

5.10.1 Auto-Emission vs Fixed Emission

Wherever possible **use Auto-emission**. The controller will ensure protection and optimal emission current setting to provide good measurement accuracy commensurate with the pressure. The dynamic ion gauge filter algorithm ensures that the controller responds to sudden changes in pressure, for example, due to a pressure burst and will reduce the emission or turn the gauge off to provide protection.

On the other hand, for beam flux measurements require static operating conditions for the ion gauge head; fixed emission may be preferable.

5.10.2 New Filaments – Conditioning and Degassing

New Iridium filaments require "conditioning" as the coating is not initially "activated" until it has been heated for several hours at typical operation temperatures. As a result, the power required to operate a new filament is <u>much</u> higher than after conditioning. In addition, the first time a filament is run, heavy degassing may occur.

5.10.3 Degas

After air exposure, the gauge head requires degassing, e.g. >30minutes emission ramp and >10minutes at DegasHi. This is best performed *after* bake-out of the UHV system, preferably whilst the system is cooling (but>100^{O}C); see section 8 for bake-out auto-degas. Subsequent occasional short degas sequences (5+5 minutes at lower degas power) can keep the gauge operating optimally.

Degassing only affects the currently selected filament. If, a UHV system is to be under vacuum for an extended period, conditioning and degassing *both* filaments after air exposure will minimize subsequent disruption to the vacuum integrity should the second filament be required.

5.10.4 The Ion Gauge Measurement Filtering

Being very small, the collector ion current is prone to disruption from electrical noise. The controller applies to filter to reduce the effects on noise on the pressure reading:

- An input filter applied to the digital measurement of both the collector current and emission current readings. The **Input Filter** parameter is set to a nominal value of 4 and should not need adjusting
- A low pass "smoothing" filter applied to the pressure value. The **LP Filter** parameter can be adjusted between 0.1 and 9.0 secs; the default is 1.0 sec.

Note that both filters operate "dynamically" and their algorithms interact so that sudden pressure bursts and not ignored and the indicated pressure is accurate at the time of display.

5.11 Ion Current and Beam Flux Measurements

5.11.1 Measurement Method

The controller provides the option to display the ion current value directly. This removes the need to use a separate picoAmmeter, for example, for Beam Flux Measurements (BFM). The controller reads both the emission and ion currents, ensuring that the measurement is compensated for changes in emission (which is not possible if using a separate Ammeter). The measured value can be output from the analogue output and read over comms, for external processing.

To ensure optimal stability of operation of the ion gauge head and controller:

- Set the emission current to a fixed value (usually 10mA) and allow to it stabilize thermally
- Leave the controller on even when the ion gauge is off to maintain thermal stability of the electronics
- Turn the ion gauge on at least 10 minutes before measurements to allow the gauge head to degas

5.11.2 Measuring as Current

For normal pressure measurement (when the ion gauges **IG*x* Display Units** parameter is set to Pressure) the ion gauge value is displayed in units of mBar, Torr or Pascal, as set by the **Pressure Units** parameter.

The **IG*x* Display Units** parameter allows the measurement to be presented in Amps in 2 different ways:

- **Direct Current**: This displays the actual ion current being measured (as would a separate picoameter).
- **10mA Normalized Current**: The measured current is corrected for emission current and the value normalized to a 10mA equivalent value.

When displaying current, the value auto-ranges between units of pA, nA, μA or mA and data formats of x.xxx, xx.xx, xxx.x.

5.12 Ion Gauge Parameters

The ion gauge has a menu with the following user-definable parameters:

IG*x* Emission		Fixed or Auto-Emission Current: Off turn the ion gauge off. Fixed emission currents for measurement are 0.06mA, 0.1mA, 0.15mA, 0.25mA, 0.4mA, 0.6mA, 1.0mA, 1.5mA, 2.5mA, 4.0mA, 6.0mA, 10mA. The available fixed emission currents depend on the **Minimum** and **Maximum Emission** currents parameter values. Auto-emission current. The control automatically selects the optimum emission current for the pressure range being measured. If the ion gauge is running AND the pressure is below the **IG1 Degas Trip** parameter value, options to degas the ion gauge at Low Degas, Medium Degas or High Degas powers are also available.
IG*x* Degas Ramp Time **IG*x* Degas Hold Time**		Degas is a 2 stage process. The emission current is first ramped linearly from its current value to that corresponding to degas power level selected over Degas Ramp Time; during the ramp, the grid voltage is raised to ~+400Vdc. The power is then held for the Degas Hold Time. *Each* step can be set to have a duration of between 1 and 499 minutes.
IG*x* Auto-Degas		The degas level used for automatic degas, for example, optionally at the end of bake-out. Low Degas, Medium Degas, or High Degas
IG*x* Degas Trip Level		This has 2 functions: - If the pressure is above this level, a degas cannot be started; the 3 Degas Level options will not appear in the **IG*x* Emission** parameter menu - If the pressure rises above this level *during* the degas ramp time, the emission setpoint stops incrementing until the pressure recovers to below this level. However, please not that the degas timer continues to ensure that the degas completes
IG*x* Min Emission **IG*x* Max Emission**	*Note 3*	Set the minimum and maximum selectable fixed emission current, and emission current range used during Auto-Emission.
IG*x* Min Power **IG*x* Max Power**		Set the filament power range used by the PID emission stabilization algorithm. *[Defaults of 20 and 60% are suitable for most gauges, but may be varied for small or large gauge heads*
IG*x* Start Power	*Note 1*	When powering up the gauge, the controller ramps the power to the filament from 0 to this value. The speed of ramp depends on the **Filament Ramp Rate** parameter value, which can also be set to "learn" this value automatically. The **Start Power** cannot be less than the **Minimum Power** value
IG*x* Filament Ramp Rate	*Note 1* *Note 3*	Standard Ramp: Low Ramp: Fast Ramp: Learn Start Power: The controller performs a slow filament power up, establishes where emission just starts and set this power value to the **IG*x* Start Power** parameter. *MUST be used with caution on new, unconditioned filaments!*
IG*x* Prop Band **IG*x* Damp**	*Note 1*	Set the gain, integral and differential terms for the PID control of the emission current. *[Default values of 25 arbitrary units are suitable for most gauges]*
IG*x* Dig In 1 **...** **IG*x* Dig In 4**	*Note 2*	Digital input control over the ion gauge-head None: Interlock: If the digital input fails, the ion gauge turns off Emission On: The ion gauge turns on when the digital input is on, and off when the digital input fails Emission Toggle: A brief (~1second) pulse of the digital input turns the gauge on or off.

IG*x* Filament Number	*Note 3*	Selects which filament to use. Auto: Tries filament 1 first and this fails automatically tries filament 2 1: Uses filament 1 2: Uses filament 2
IG*x* Sensitivity		The gauge sensitivity value. Range 0.1 to 99.9 (AU)
IG*x* Gas Sensitivity		The sensitivity of the gauge to ambient gas type normalized to Nitrogen having a value of 1. Range 0.01 to 99.99
IG*x* Filter		Pressure measurement filter. 0.1 to 9.0secs
IG*x* Input Filter		Reduces low level noise to the collector and emission measurement signals. Range 0 (off) to 9 arbitrary units)
IG*x* Resolution		Number of decimal places that the ion gauge pressure will be displayed to: 1dps or 2dps.
IG*x* Units	*Note 4*	The ion gauge collector can be displayed a current or as a pressure: Pressure: The ion gauge measurement is displayed as a pressure, normalized to the "global" pressure units selected in the Setup Menu (i.e. mBar, Torr or Pascal). The pressure value is ALWAYS corrected for emission current Direct Current: The ion current (Amps) without correction for emission current Norm Current: The ion current (Amps) after normalizing the emission current to 10mA equivalent
IG*x* Run Time		Xxx.x hours: The accumulated number of hours of operation of the ion gauge. Reset: Reset the time to zero. For example, after replacing the filament assembly.

Note 1: See section 5.4
Note 2: Emission On and Emission Toggle are mutually exclusive; Emission On will always dominate
Note 3: Cannot be changed when ion gauge is operating
Note 4: Direct Current and Normalized Current options are suitable for beam flux monitoring applications (BFM)

6 Secondary Gauging

In addition to one (PVCuni) or two (PVCduo) ion gauges, the controller has 2 slots into which modules can be added by the user to support 2 further "secondary" gauge modules. A range of different gauges and types are supported. Secondary gauges can be coupled to the ion gauges, for example, to provide continuous wide-range (UHV to atmosphere) operation (see DGM).

6.1 Secondary Gauge Modules

6.1.1 Module Slots

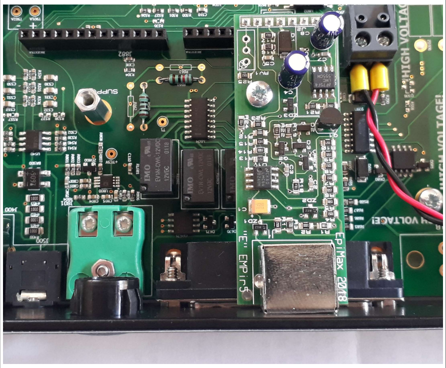
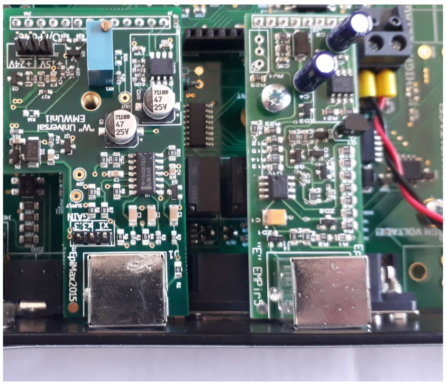
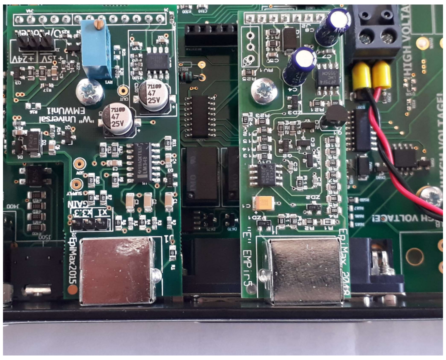
The controller supports 2 slots into which the user can install "modules" to provide secondary gauging:

- Each module slots comprises a 13 pin in line socket for insertion of the module connector, a support pillar for fixing the module using an M3 bolt and a hole in the rear panel for accessing the module external connector.
- Modules are either 8 pin or 13 pin. They are inserted into the slot connector such that the support pillar aligns with the hole in the module, and the external connector aligns with the rear panel hole - see section 6.1.2
- Any combination of modules can be inserted into the slots, with the exception that slot 1 does not accept the "K" module (zone 2 thermocouple 'K' module must be inserted in slot 2)
- After a new module is inserted, the controller will auto-detect the module type and re-configure itself to use the module.

6.1.2 Module Installation

Your controller may have been delivered with specified modules installed. However, modules can be added/removed by the user. The controller will auto-configure itself as required.

Before commencing module installation, turn the controller off and allow 10 minutes for all the high voltage capacitors to discharge FULLY. Place the controller on a bench with the rear panel facing towards you, leaving space on right to lay the lid on the desk as this is attached to the base with an earth wire.
DO NOT CONNECT POWER OR ANY OTHER LEADS TO THE CONTROLLER WHEN OPEN.
DO NOT OPERATE THE CONTROLLER WITH THE LID REMOVED.
AVOID TOUCHING ANY COMPONENT ON THE PCB OR ON THE MODULE - IF AVAILABLE, USE AN EARTHED WRIST STRAP.

 Module 1 installed	 Module 2 positioned	 Module 2 installed and secured

INSTALLING A MODULE:

- Remove the 6 off M3 screws securing the lid (3 on each side). Lift the lid carefully, mindful of the earthing wire connecting it to the base; the wire is long enough to lay fold the lid and lay it to the right side of the controller on its top.
- The first picture (above) shows a controller with module in slot 1 already installed, and slot 2 free.

- Note that the rear panel hole for slot 2 is blanked off with a plastic insert. Carefully remove the insert - keep it for future use if a module is to be removed.
- Insert the module into the free socket, second picture above. For 13 pin modules, all 13 pins should engage in the 13 pins of the socket. For 8 pin modules, these should engage with the 8 right hand pins of the socket.
- Ensure that the securing screw hole aligns with the top the support pillar (see second picture above).
- Secure the module in place with the M3 bolt supplied with the module (see third picture above).
- Replace the lid, tucking the earth cable between the transformer and the side of base, and secure with the 6x M3 screws.

REMOVING A MODULE

- Remove the 6 off M3 screws securing the lid (3 on each side). Lift the lid carefully, mindful of the earthing wire connecting it to the base; the wire is long enough to lay fold the lid and lay it to the right side of the controller on its top.
- Unscrew the M3 bold securing the module to the support pillar (see third picture above).
- Pull the module upwards to disengage its pins from the socket.
- Blank the rear panel hole with a blanking plate.
- Replace the lid, tucking the earth cable between the transformer and the side of base, and secure with the 6x M3 screws.

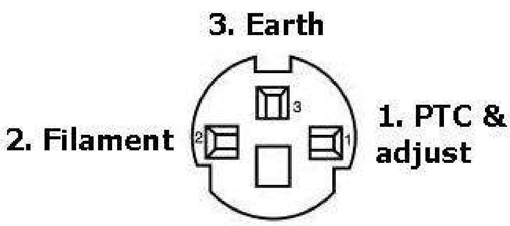
6.2 Module Types

6.2.1 "E" Module: VSP52x Pirani Gauges

The "E" module supports a VSP52x gauge head; the *x* in the part number refers to the type of flange (DN16 ISO KF or ⅛"NPT) and whether metal sealed. These are half-bridge gauges with built-in temperature compensation. It has a 3 pin mini-DIN connector; note the connector is the same as the "F" module - please ensure you connect the correct gauge type.

EMP521 Pirani gauges are supplied with a 3m connection cable, and optional extensions (in 2m lengths) are available to make up longer leads.

Note that Pirani gauge heads have a large tolerance between units, so calibration of the module to match your Pirani head is recommended - see section 11.



"E" and "F" Module Connector

6.2.2 "F" Module: VSP84x Pirani Gauges

The "F" module supports a VSP84x gauge head; the *x* in the part number refers to the type of flange (DN16 ISO KF or ⅛"NPT) and whether metal sealed. These are half-bridge gauges with built-in temperature compensation. It has a 3 pin mini-DIN connector; note the connector is the same as the "E" module - please ensure you connect the correct gauge type.

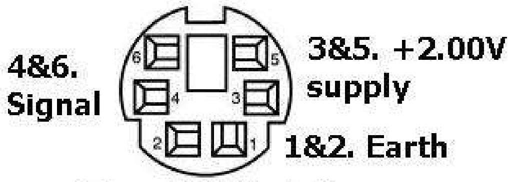
EMP841 Pirani gauges are supplied with a 3m connection cable, and optional extensions (in 2m lengths) are available to make up longer leads.

Note that Pirani gauge heads have a large tolerance between units, so calibration of the module to match your Pirani head is recommended - see section 11

6.2.3 "V" Module: VG Pirani Gauges

The "V" module supports the (now obsolete) VG range of Pirani gauge heads. The module provides a 6 pin mini-DIN connector. As the cable from the Pirani terminates in a 5 pin DIN socket, a converter cable is available.

Note that Pirani gauge heads have a large tolerance between units, so calibration of the module to match your Pirani head is recommended - see section 11



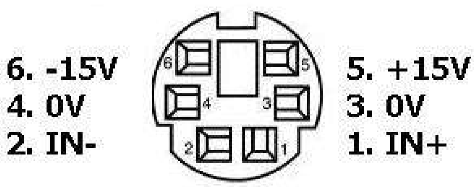
Type "V" Module

6.2.4 "U" Universal Module for Linearised gauges

Note: This module has been superseded by the "W" module

The "U" module supports a range of active gauge heads, i.e. where electronics is included in the gauge head or as part of the cable assembly. The "U" module and the controller software provide the following:

- A differential analogue input (pins 2 and 1) from the analogue output of the device. A jumper on the module allows the full scale input range to be selected between 0 to 10V, 0 to 3V and 0 to 1V, as labelled on



Type "U" Module

the module.

- +14.5Vdc (pin 5), -14.5Vdc (pin 6) supplies (relative to 0V at pins 3 and 4) for optionally powering the device. These lines are current limited at ~120mA. This is sufficient for many devices, such as the mini-Convectron, Instrutech Stinger, Thyracont VSP62x...
- The input voltage and pressure ranges can be set in software to match the output range of the device, or the pressure range of interest - see section 6.3.1
- The relationship between the input voltage and pressure can be set either to logarithmic or linear.

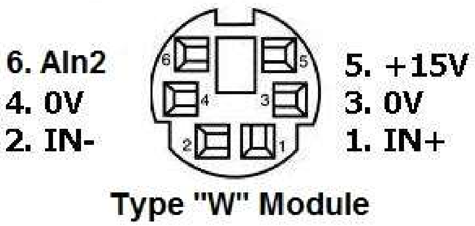
Stinger DB9 connector	Function	"U" or "W" module pin
3	Power (+ve)	5
4	Power 0V	3
5	Signal +	1
8	Signal 0V	2

As an example, the table shows wiring to monitor the output *and* provide power to a Instrutech CVM-211 Stinger.

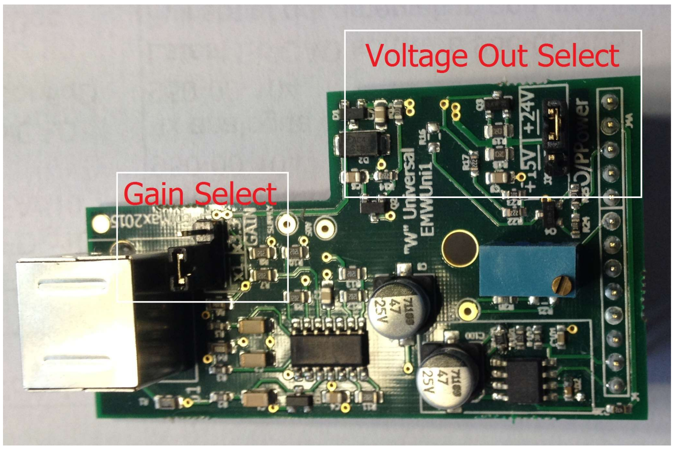
Use of screened cable is recommended, with the screen connected to pin 4 of the "U" module.

6.2.5 "W" Universal Module for Linearised gauges

The "W" module has replaced the "U" module, offering additional features and improved specification. It supports a range of active gauge heads, with integrated electronics/cable providing a pressure-linearised output. Pins 1 to 5 offer the same functionality as the "U" module; pin 6 provides a secondary analogue/digital input, see below. The "W" module provides the following:



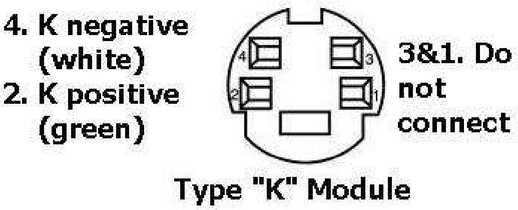
- A differential analogue input (pins 2 and 1) from the analogue output of the device. A jumper on the module allows the full scale input range to be selected between 0 to 10V (x1) and 0 to 3.3333V (x3).
- A positive power supply (pin 5) capable of powering the external device. This line is current limited at ~120mA. The output voltage can be selected between +14.5V (nominal) and +24V (nominal) using the "Voltage Out Select" jumper. The higher voltage extends the range of supported devices.
- The output voltage can be switched on and off using the **'W' Power** parameter, allowing the device to be powered only when required. If the external device is always to be powered up when the controller is on, set to **Always On**.
- The **'W' Pull-up** parameter provides a "software" pull-up of the input measurement to maximum value when the module power output is switched off or if the gauge becomes disconnected providing for safe operation of trips associated with the module
- The input voltage and pressure ranges can be set in software to match the output range of the device, or the pressure range of interest (see section 6.3.1)
- The relationship between the input voltage and pressure can be set either to logarithmic or linear (see section 6.3.1)
- Pin 6 offers an additional analogue/digital input. The function of this pin awaits implementation in the controller software.

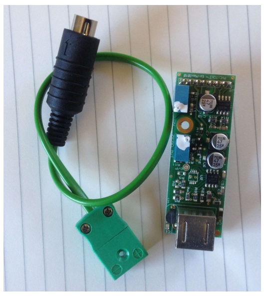


Use of screened cable is recommended, with the screen connected to pin 4 of the "W" module.

6.2.6 "K" Module: Type K thermocouple input

Although the controller has a type K thermocouple built in for single zone bake-out control, the 'K' module permits addition of a second 'K' thermocouple for **dual zone bake-out** applications (see section 8). The temperature range is 0-500°C and a temperature sensor at the connector provides cold-junction compensation.





The 'K' module has a 4 pin mini-DIN connector - see below. To assist with installation, it can be provided with a 150mm long mini-DIN to mini-thermocouple adaptor cable, as shown in the photograph.

6.3 Module Parameters

6.3.1 "U" and "W" Module Parameters

The "U" and "W" modules have a menu with the following user-definable parameters:

Power	Turns the power supply to the external gauge (if used) on and off: Off: Power is off. On: Power is on. If the controller is switched off, it will restart with **Power** Parameter value set to Off. Always On: On controller power up, the power supply is automatically switched on. If this is not set, the power will be off on controller power up
Pull-Up *("W" module only)*	If the **Power** Parameter is set to Off: Off: The module will continue to report the input voltage On: The module will report a "High" reading regardless of the input voltage This eliminates the possibility of a low pressure reading from a gauge if it is intended to be powered by the controller and is inadvertently turned off
Calib Unlock	Unlocks the calibration lock for subsequent parameters. Locked: The parameters are locked, can be inspected but NOT edited Unlocked: The parameters can be edited Note: The calibration lock is reset on returning to the controller Status Mode
Minimum Input Voltage	Voltage corresponding to the **Minimum Pressure** parameter. Range 0.000V to **Maximum Input Voltage** parameter value.
Maximum Input Voltage	Voltage corresponding to the **Maximum Pressure** parameter. Range **Minimum Input Voltage** parameter value to 9.999V
Minimum Pressure	Pressure value corresponding to the **Minimum Input Voltage** parameter. Range 1.000e-15 to **Maximum Pressure** parameter value.
Maximum Pressure	Pressure value corresponding to the **Maximum Input Voltage** parameter. Range **Minimum Pressure** parameter value to 1.000e+06
Conversion Function	Relationship between input voltage and Pressures Logarithmic: *Pressure* proportional to log10(*input voltage*) Linear: *Pressure* proportional to *input voltage*.

6.3.2 Module Calibration Parameters

Modules interface to external devices, such as gauge heads, outputs from intelligent gauges or controllers. In some cases, particularly Pirani gauge heads, there can be significant differences between performance of individual devices (due to manufacturing tolerance), and performance can change over time.

To address this, all modules can be "calibrated" against known measurement values to match the performance of individual device, using the dual (low and high point) calibration procedures discussed in section 11.3. Clearly, if a module is replaced and another device attached, calibration values may not apply and recalibration may be necessary.

7 Interlock Hub: Digital I/O and Analogue Outputs

Being user-configurable, the Interlock Hub (which comprises 7 digital output trips, 4 digital inputs and 2 analogue outputs) relate the pressure/temperature measurements to various aspects of system operation (pumps, valves...). The hub can largely replace interlock wiring, and provides versatile implementation of interlocking and bake-out heater control.

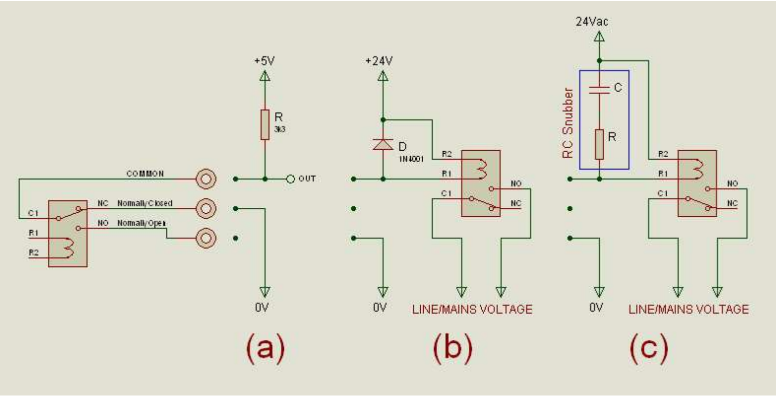
Note: The controller Interlock Hub is NOT a substitute for hard-wire interlocking where safety, high level security, or potentially hazardous situations can arise. No liability is accepted for problems caused by inappropriate use of the controller.

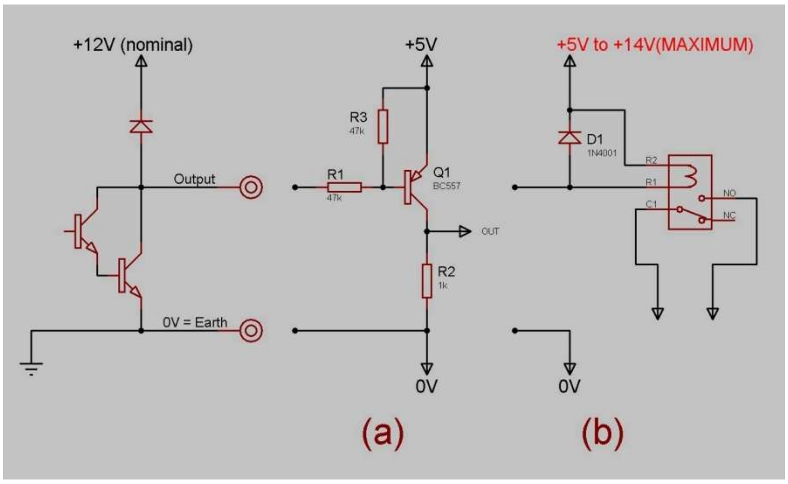
7.1 Trips (Digital Outputs)

There are 7 trips: trips 1 to 4 are relay-based and trips 5 to 7 open-collector NPN Darlington outputs.

7.1.1 Relay-based Trips 1 to 4

SPCO (single-pole, change-over) relays, rated at 1A@24Vdc, and 0.5A@40Vac. The minimum switching current is 1mA@5Vdc. When using the relay outputs with inductive (e.g. relays or valve solenoids) or capacitive loads, suppression of back emf or current surges **MUST** be employed:
(a) Drive of a resistive load: e.g. TTL input. Note that the value of R must be sufficiently low to ensure that at least 1mA flows through the relay contacts. Using the normally open contact inverts the signal.
(b) Switches a contactor with dc coil, for example, to a heater. To comply with the 1A contact current limit, the resistance of the external relay coil must be >30Ω. The reverse biased diode MUST BE PRESENT to suppress the back emf generated by the inductive load presented by the relay coil; this diode requires a reverse voltage rating >>+24V supply, and a current rating at least twice that consumed by the relay coil. The 1N4001 is suitable for supplies up to about 40V.
(c) Switches a contactor with ac coil. An RC snubber network MUST BE used for back-emf suppression. Typical R and C values are 100Ω and 0.1μF; composite snubbers components are available.





7.1.2 Open Collector-based Trips 5 to 7

DO NOT USE APPLY >+14V TO TRIPS 5 to 7.

Open-collector Darlington transistor output, each capable of sinking 200mA at 12Vdc. **Only dc devices can be driven with these outputs. The outputs are 0V (earth) referenced.**

The output configuration is shown on the left of the diagram. A built-in protection diode connected to the internal +12V supply limits the voltage to the driven devices (the potential at the outputs) to just over 12Vdc.
(a) Shows a scheme for driving a 5V TTL, or similar, load. As the output from a Darlington transistor at ~1V exceeds the low logic threshold of some logic families, a transistor buffer is used. This also inverts the signal so that the output is high when the

trip is on.
(b) Shows the output driving a relay, e.g. for mains switching. Note that despite the presence of an internal diode, an external diode is required across the relay coil for emf suppression **to the relay supply rail**.

7.1.3 Trip Parameters

Each Trip has a menu with the following user-definable parameters:

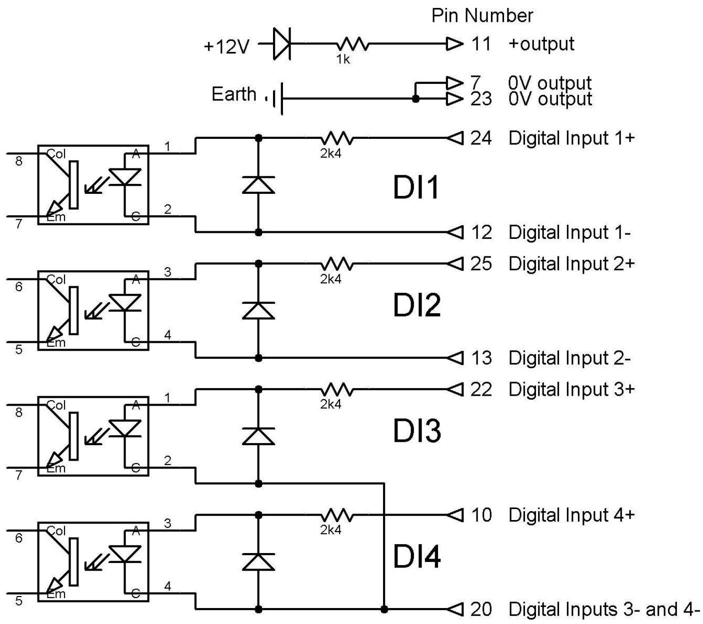
State	Trip: the trip state is determined by its allocation Inhibit: the trip is off Override: the trip is on
Power-up State	Last Setting: On power up, the trip resumes the state it had powered down. Reset On Power Up: On power up, an inhibit or override state current when powered down is removed Inhibit: The trip will power up in the inhibit state Override: The trip will power up in the override state
Allocation	None: The trip is not used IG1 Pressure: The trip is triggered by ion gauge 1 at its trip point Module 1: The trip is triggered by the device connected to module 1 at its trip point BakeOut Zone1: The trip is triggered by bake-out temperature control for zone 1 Module 2: The trip is triggered by the device connected to module 2 at its trip point IG1 DGM Pressure: The trip is triggered by the ion gauge 1 operating in dual gauge mode at its trip point IG1 On: The trip is when when ion gauge 1 is operating IG1 Degas: The trip is when when ion gauge 1 is degassing BakeOut Zone2: The trip is triggered by bake-out temperature control for zone 2 Timer 1: The trip is on during the on period of timer 1 Timer 2: The trip is on during the on period of timer 2 Live Heartbeat: The output changes state every second as indicator that controller operating (*open collector trips 5, 6 and 7 only*) IG2 Pressure: The trip is triggered by ion gauge 2 at its trip point (*duo only*) IG2 DGM Pressure: The trip is triggered by the ion gauge 2 operating in dual gauge mode at its trip point (*duo only*) IG1 On: The trip is when when ion gauge 1 is operating (*duo only*) IG2 Degas: The trip is when when ion gauge 2 is degassing (*duo only*)
Direction	≤ The trip is on when the allocation is below the "Trip at" parameter value ≥ The trip is on when the allocation us above the "Trip at" parameter value
Trip at	For gauge type allocations, the pressure at which the trip operates, moderated by the hystersis parameter
Trip Hysteresis	To avoid trip on/off "chatter" when the pressure value is near the trip value, the off trip value is higher than the on trip value by a factor defined in this parameter. For example, setting the value to 1.5x sets the off trip value to 1.5x the trip at value. Note that this parameter is common to all the trips.

7.2 Digital Inputs

7.2.1 Digital Input Hardware

The diagram shows the equivalent circuit for the 4 digital inputs, as well as the drive circuitry that can be optionally used to drive the inputs:

- All digital inputs are opto-isolated from the controller electronics.
- Diodes protect against reverse connection.
- Digital inputs 1 and 2 are isolated, whereas digital inputs 3 and 4 share a negative terminal
- The input voltage range is ~**3** to **30V**dc (limited by power rating of the input resistor). If higher voltages are to be used, add a series resistor to limit the input current to 10mA.
- The inputs can be driven directly from most 5 – 15V logic families (TTL, CMOS…), or from an external power supply switched through a relay or contactor.
- Alternatively, pins 11 and 7/23 provide an internal current limited supply that can be used to drive the digital inputs, for example, switched through a relay. Please note that care is needed to ensure that this internal supply is not inadvertently connected to an external supply.



7.2.2 Digital Input Parameters

Each Digital Input has a menu with the following user-definable parameters:

State	Trip: the input voltage determines if the digital input is off or on. Inhibit: the digital input is off, regardless of the input voltage Override: the digital input is on, regardless of the input voltage
Power Up State	Last Setting: On power up, the digital input will have inhibit or override state it had when powered down. Reset On Power Up: On power up, the digital input is reset to trip state Inhibit: The digital input will power up in the inhibit state Override: The digital input will power up in the override state
Invert	Normal: A voltage applied to the digital input turns it on; the default state is off Invert: A voltage applied to the digital input turns it off; the default state is on

7.2.3 Digital Input Applications

Digital inputs can be used to interlock the following:

- **Ion gauge**(s) interlocking, switching on and off and degas on and off
- **Bake-out**. Individual digital inputs can be used independently to inhibit the heater output, suspend the bake-out (i.e. inhibit the heater output and pause the bake-out timer) or terminate the bake-out.
- **Timers**. Individual digital inputs can be used independently to inhibit the ON time output

Please refer to the parameters for each of these for further information.

7.3 Interlock Hub Status Page

The Interlock Hub Status Page provides a summary of the trip and digital input states:

If the **CANCEL** button is pressed and held, the display scrolls through the 7 trips and 4 digital inputs providing information about trip allocation and digital input usage:

The example above indicates that:
- Trip 4 is currently off and is allocated to IG1 pressure.
- Digital Input 2 is used to interlock both IG1 and Bake-out.

7.4 Analogue Outputs

The two analogue outputs share a stereo (3 pin) jack-plug output. If a mono (2 pin) jack-plug is used, ensure that analogue output 2 Allocation is set to “OFF” to avoid accidentally electrically "shorting" the output.

7.4.1 Overview

The controller has 2 independent analogue outputs (AOs). Each AO is designed to provide up to ~10.2V and is factory calibrated (using the Calibrate menu - see section 11.4) to provide a range of 0 to 10.00V; this can subsequently be adjusted by the user.

The maximum current available from the output is ~20mA. However, to avoid excessive power dissipation of the output amplifiers, please heed of the warning at the start of this section.

The AOs are user configurable by setting the minimum and maximum voltage to scale with the minimum and maximum pressure to be monitored. The relationship between pressure and voltage can be set to either Logarithmic or Linear. In addition, the AOs can be inhibited by the digital inputs (see section 7.4.3).

7.4.2 Analogue Output and Ion gauge Allocation

An AO allocated to an ion gauge follows the measured pressure when the ion gauge is on. However, when the ion gauge is not operating, the AO outputs either the **Maximum** or **Minimum Output Voltage** parameter value, depending on the setting of the **Fail to** parameter setting. For most applications where failure of vacuum is the fault condition, this should be set to Fail To Maximum Output Voltage.

7.4.3 Digital Input Interlocking of Analogue Outputs

The **DI*x* Interlock** parameters allow one or more of the digital inputs to inhibit the AO. When inhibited, the AO outputs either the **Maximum** or **Minimum Output Voltage** parameter value, depending on the setting of the **Fail to** parameter setting.

7.4.4 Analogue Output Parameters

Each Analogue Output has a menu with the following user-defined parameters:

Allocation	Set to Min Out: Output set to minimum output parameter value Set to Max Out: Output set to maximum output parameter value IG1 Pressure*: Output voltage reflects the ion gauge 1 value DualIG1 Pressure*: Output voltage reflects the ion gauge 1 dual gauge value Module 1: Output voltage reflects the device attached to module 1 value (*if module 1 fitted*) Module 2: Output voltage reflects the device attached to module 2 value (*if module 2 fitted*) Thermocouple: Output depends on the measured thermocouple value. Depends on the minimum output, maximum output, minimum and maximum pressure (interpreted as temperature) and log/lin parameter values Comms External: The output value is set directly to match the value set over comms Off: Analogue output not used. Output value set to 0.0V IG2 Pressure: Output voltage reflects the ion gauge 2 value (*duo only*) DualIG2 Pressure: Output voltage reflects the ion gauge 2 dual gauge value (*duo only*)
Pressure Minimum	The pressure value that the minimum voltage parameter corresponds to. Range 1.000e-16 to Maximum Pressure

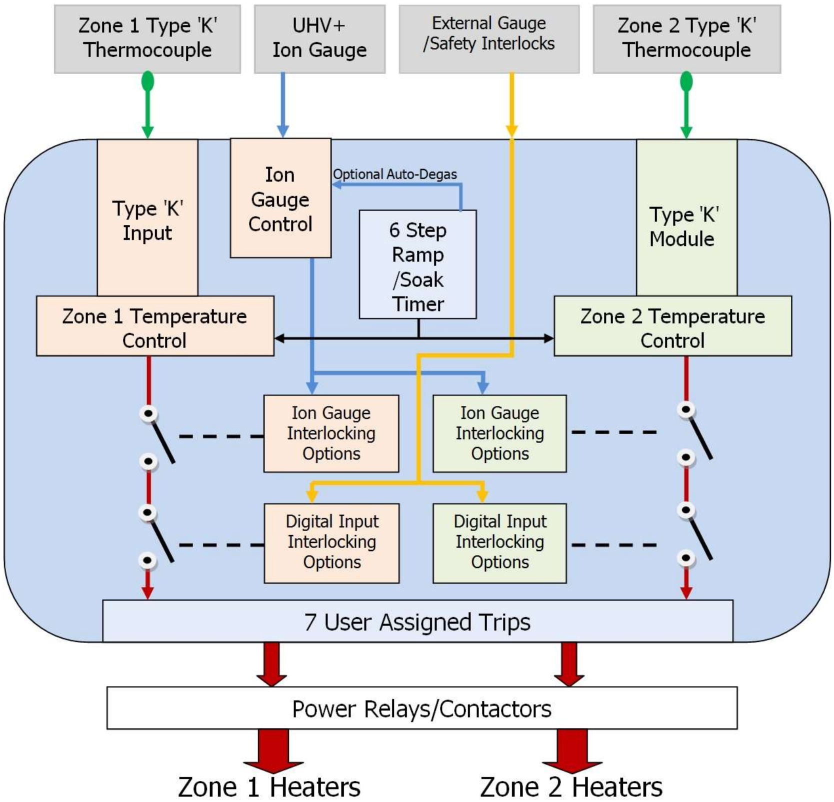
Pressure Maximum	The pressure value that the maximum voltage parameter corresponds to. Range Minimum Pressure to 1.000e+6
Minimum Output Voltage	The output voltage (in *milliVolts*) that the minimum pressure parameter corresponds to. Range 0 to Maximum Output Voltage
Maximum Output Voltage	The output voltage (in *milliVolts*) that the maximum pressure parameter corresponds to. Range Minimum Output Voltage to 9999mV
Function	Defines the relationship between the pressure and voltage output. Either Logarithmic or Linear
Fail to:	Max Output: The failed state of the analogue output is the **Maximum Output Voltage** parameter value. Min Output: The failed state of the analogue output is the **Minimum Output Voltage** parameter value. For discussion of the "failed" state, please refer to sections 7.4.2 and 7.4.3.
DI1 Interlock	OFF: No effect. The AO follows the allocated device Inhibit: The AO outputs the **Maximum Output Voltage** parameter value
DI2 Interlock	
DI3 Interlock	
DI4 Interlock	

8 Single and Dual Zone Bake-out Control

The controller has a multi-step ramp/soak bake out sequencer which integrates pressure and external interlocking, and provides auto-degassing of ion gauge. Version 2.40 added dual zone control.

8.1 Overview

The schematic represents the single- and dual-zone bake-out operation. The pink blocks represent the components for the first zone bake-out available as standard on the controller. By addition of a 'K' module in slot 2 (see section xxx), a second bakle-out zone (represented by the green blocks) becomes available.



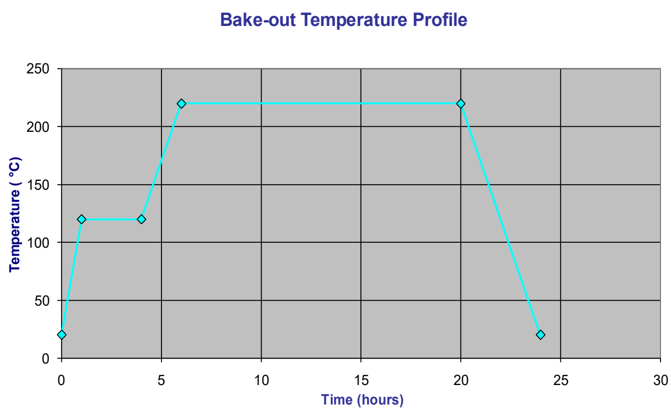
Key features:

- Up to 6 ramp/soak periods, each step up to 99:59 hours:mins.
- Each zone has its own definable 6 step temperature profile.
- Any combination of the 7 trips can be assigned to either zone to switch the heaters
- Digital inputs, ion gauge(s) can be individually set to inhibit (trips off), suspend (trips off and suspend bake-out timer) or terminate the bake-out
- Zones can be run individually or simultaneously.
- Optional auto-degassing of ion gauge(s) at the end of bake-out
- As well as setpoint, measured value, remaining time and step number for each zone, the peak temperatures reached during the bake-out are recorded and accessible from the display and over communications.

8.2 Temperature Profile

The graph, right, is an example of a 5 step bake-out temperature profile (step 6 is ignored by setting its time to 00:00). The graph shows that during the first step, the temperature setpoint rises linearly from the current measured value to the step 1 value (120°C) in 1 hour. As the step 2 temperature is the same as step 1, the setpoint is then held for 3 hours. In step 3, the temperature ramps to 220°C over a period of 2 hours, is held there for 14 hours in step 4 and finally ramped back down to room temperature in step 5.

In the case of dual zone control, each zone can have its own temperature profile defined, although the 2 zones share the same step times.



The use of temperature ramps helps avoid pressure bursts during heating and temperature overshoot.

8.3 Bake-out Interlocking

Bake-out operation can be influenced by the digital inputs and ion gauges, or by user intervention – see the bake-out parameters There are 3 levels of interlocking:

- **Inhibit**. Allocated trip operation is set to off. However, the bake-out imer continues.
- **Suspend**. As well as setting the allocated trips to off, the bake-out timer clock is suspended until the interlocks are cleared
- **Suspend**. As well as inhibiting the allocated trips, the bake-out time is suspended whilst the interlock is failed
- **Terminate**. The bake-out is terminated. If ion gauge auto-degas is set, it is NOT executed

8.4 Display of Bake-out Operation

Bake-out has a dedicated Status screen, for example:

- The top line indicates the currently executing step number and the **remaining** time for the bake-out
- The bottom line indicates the currently displayed zone; if 2 zones are executing, the display toggles between the 2 zones. This is followed by the Setpoint/Measured value and the trip states. The first image shows that allocated trips are ON, whereas the second image shows that bake-out is suspended due to a digital input failure.

Pressing the **CANCEL** button displays the peak temperatures for both zones during the present or previous bake-out:

In addition, bake-out is indicated in other Status screens. If a zone 1 bake-out is in progress, the thermocouple name is inverted, and if zone 2 bake-out is in progress, the module 2 name is displayed.

8.5 Bake-out Parameters

The bake-out menu provides the following user-definable parameters:

BO Start/Stop		---: No action Start Zone 1: Start bake-out zone 1 profile only Start Zone 2: Start bake-out zone 2 profile only. {Only available if module 2 is fitted with “K” module} Start Zones 1&2: Start bake-out, both zones. {Only available if module 2 is fitted with “K” module} STOP: Stops the bake-out ***Note: Zone 1 cannot be started if thermocouple is its disconnected. Zone 2 cannot be started if no 'K' module in slot 2, or its thermocouple is disconnected.***
BO User Interlock		Allows the user to temporarily inhibit or suspend the bake-out OFF: No user action Inhibit: Trips turned off Suspend: Trips turned off and bake-out timer is suspended
BO Step1 Time **.....** **BO Step6 Time**		Step duration. Value: 00:00 to 99:59 hm.

BO Z1 Step1 Temp **.....** **BO Z1 Step6 Temp**		Zone 1 temperature attained at the end of the step. Value: 1 to 500°C. If different from previous step, the temperature is linearly ramped from the previous value.
BO Hysteresis		To avoid on/off switching (contact chatter), the trip turn-on temperature = zone setpoint and the trips turn-on tmperature = (zone setpoint + hysteresis value). Value: 0.1 to 9.0°C.
BO Z2 Step1 Temp **.....** **BO Z2 Step6 Temp**	*Note 2*	Zone 2 temperature attained at the end of the step. Value: 1 to 500°C. If different from previous step, the temperature is linearly ramped from the previous value.
BO DI1 Interlock **.....** **BO DI4 Interlock**		OFF: No operation Inhibit: Trips turned off Suspend: Trips turned off and bake-out timer stopped Terminate: Terminates the bake-out, turning all allocated trips to off, and resetting zone setpoints Note: Different digital inputs can be set to perform different functions
BO IG1 Interlock		OFF: No operation Inhibit: Trips turned off Suspend: Trips turned off and bake-out timer stopped Terminate: Terminates the bake-out, turning all allocated trips to off, and resetting zone setpoints
BO IG1 Pressure Trip		Ion gauge 1 interlock pressure value. If exceeded, the ion gauge interlock operates
BO IG1 AutoDegas		Auto-start degas of ion gauge 1 at its Auto-degas parameter setting at the end of bake-out
BO IG2 Interlock	*Note 1*	OFF: No operation Inhibit: Trips turned off Suspend: Trips turned off and bake-out timer stopped Terminate: Terminates the bake-out, turning all allocated trips to off, and resetting zone setpoints
BO IG2 Pressure Trip	*Note 1*	Ion gauge 1 interlock pressure value. If exceeded, the ion gauge interlock operates
BO IG2 AutoDegas	*Note 1*	Auto-start degas of ion gauge 1 at its Auto-degas parameter setting at the end of bake-out

Note 1: Only available for PVC*duo*
Note 2: Only available if K module installed in Slot 2

9 Dual (wide-range) Gauge Mode

Dual Gauge Mode combines the ion gauge with a module-based gauge so they operate as a single pressure measurement device.

9.1 Overview

Dual Gauge (DGM) is a special controller mode in which ion gauge operation is combined with a secondary gauge (**SG**) so they operate as though they were a single gauge head from the point of view of pressure display (and optionally) trip setting. The ion gauge automatically starts and stops depending on user-defined parameters. This allows continuous monitoring of the pressure over a wider range than available to just the ion gauge, for example, all the way from atmosphere to UHV.

The PVC*uni* ion gauge can be combined with a module in either slot. Similarly, either PVC*duo* ion gauge can be combined with either module, but both ion gauges cannot be combined with the same module. Once a module is assigned to an ion gauge (**DGM Assign**), DGM operation can be enabled and disabled as required (**DGM Operation**).

The way DGM operates is as follows:

- Assuming the ion gauge is off, the pressure read by the SG will be reported for the ion gauge.
- If the SG pressure falls below the **DGM Gauge On** parameter value, the controller waits for a period defined by the **DGM Delay** parameter and then attempts to start the ion gauge at the **DGM Emission** parameter value (usually set to Auto-emission).
- If successful, the ion gauge reports its own reading.
- If not successful (e.g. because the pressure is not low enough for ion gauge operation), the controller will repeat the attempt the number of times set by the **DGM Attempts** parameter.
- If, during ion gauge operation, the ion gauge pressure rises above the **DGM Gauge Off** parameter value, the ion gauge turns off and the SG pressure is reported for the ion gauge.
- In the addition, the **DGM SG Protect** parameter optionally defines whether the SG pressure value is monitored for exceeding the off pressure, as well as the ion gauge pressure.

The **DGM Options** parameter defines how and when DGM will operate:

- **Enabled at Power Up**: If a DGM SG is assigned and enabled for operation, this option will start DGM processing as soon as the controller is switched on.
- **Disabled at Power Up**: If a DGM SG is assigned and enabled for operation, the controller will set the **DGM Operation** parameter to disabled on power up.
- **Once: Pump Down**: Once the ion gauge has been started successfully through DGM processing, the **DGM Operation** parameter is disabled to inhibit any further DGM action

When DGM is operating, the third character in the ion gauge's name is changed to '*'. For example, for "IG1", the name appears in all screens as "IG*".

9.2 DGM and Menu Parameters

The DGM menu(s) provide the following user-definable parameters. Note that the parameter name is preceded by the name of ion gauge (e.g. "LL DGM Operation"):

DGM Operation	Disabled: DGM not operating Enabled: DGM operating if a **DGM Assign** parameter is set.
DGM Assign	OFF: Not assigned. DGM not operational *ppp + ss1*: Gauge in slot 1 is assigned to the ion gauge (only appears if a suitable module is present) *ppp + ss2*: Gauge in slot 1 is assigned to the ion gauge (only appears if a suitable module is present)
DGM Options	Disabled at Power Up: Enabled at Power Up: Once: Pump Down: Please refer to section 9.1 for details

DGM SG Protect	Off: During ion gauge operation, only the ion gauge pressure is tested against the **DGM Gauge Off** parameter value for turning the ion gauge off. On: During ion gauge operation, both the ion gauge and SG pressures are tested against the **DGM Gauge Off** parameter value for turning the ion gauge off.
DGM Gauge On	The SG pressure value at which the ion gauge can be turned on. Note: the controller does not allow this value to be greater than the **DGM Gauge Off** value.
DGM Gauge Off	The ion gauge (and optionally SG) pressure value at which the ion gauge is turned off. Note: the controller does not allow this value to be less than the **DGM Gauge On** value
DGM Emission	The emission at which the ion gauge will operate during DGM processing (usually Auto-emission)
DGM Delay	Once the **DGM Gauge On** pressure has been reached, the controller will wait for the specified period before attempting to start the ion gauge. If, during this period, the pressure goes above the gauge on value, the process for testing restarts. Range: 0.0 to 499.0 seconds.
DGM Attempts	The number of attempts DGM processing will make to start the ion gauge. Once the ion gauge is started, the attempt count is reset to zero for the next cycle. If the ion gauge cannot be started after the specified number of attempts, DGM operation is disabled

9.3 Safe DGM Operation

- **DGM MUST be used with a combination of ion gauge and secondary gauge mounted *within the same vacuum envelope*.** The presence of an isolating valve between the two would clearly preclude sampling the vacuum. The only exception is if used with the "Once Pump Down" option where isolation between, say a vacuum chamber and its evacuation/ backing line is required at the end of the pump-down cycle and DGM processing then ceases.
- If using a secondary gauge is a powered device, ensure that the gauge is suitably powered **at all times**. For example, if using a gauge connected to and powered by a "W" module, ensure that the "W" module **'W' Power** parameter is set to "Always On". It is advisable to also set the **'W' Pull-up** parameter to ON so that high pressure is indicated if the gauge is disconnected.
- To preclude "hunting", ensure sufficient hysteresis between the **DGM Gauge On** and **DGM Gauge Off** parameter values. The controller will in any case not allow the pressure off value to exceed the pressure on value.

9.4 Auto-cancellation of DGM Operation

For safety reasons, DGM operation is automatically disabled under the following conditions:

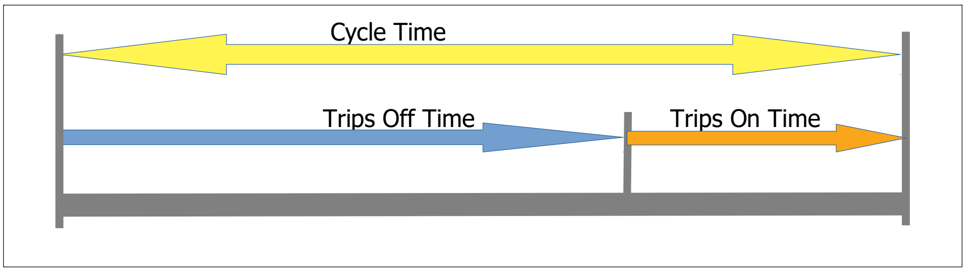
- If no ion gauge is connected
- If the ion gauge is turned off by the user either from the front panel or over comms
- If the ion gauge fails to start after the specified number of attempts

10 Timers 1 and 2

A new feature to the PVC range is inclusion of 2 timers, which can be used to drive external events as one-shot or cyclical operations: firing TSP pumps, auto-opening valves during work periods, triggering pump/degas cycles, to automatically closing a valve after a period of time has elapsed...

10.1 Overview

The controller has two independent timers that can be used to trigger external events, via allocated trips, either just once or on a repeating cyclical basis. The user can intervene at will to modify timer operation, and optional digital input and ion gauge interlocks can automatically provide protection.



Timers can be "one-shot" (they run once and terminate) or cyclical (they repeat until terminated by the user or an interlock).

When running, a timer can be restarted at the start of the off, or the start of the on time, or at any other point in its cycle time.

10.2 Timer Interlocking

Timer operation can be influenced by the digital inputs and ion gauges, or by user intervention – see the timer parameters, section xxx. There are 3 levels of interlocking:

- **Inhibit**. Allocated trip operation is set to off. However, the timer clock continues.
- **Suspend**. As well as setting the allocated trips to off, the timer clock is suspended until the interlocks are cleared
- **Terminate**. The timer operation is terminated

10.3 Timer Status Display

Bake-out has a dedicated Status screen, for example:

This shows the status of both timers. In the example above:

- Timer 1 is not operating
- Timer 2 is at 15:10 in its cycle. The ON message indicates that it is within the trips on time and the allocated trips are ON.

- This image shows that Timer 2 is at 6:30 in its cycle. The (on) message indicates that it is within the trips on time; however, the trips are off due to a digital input interlock failure indicated by **DI**.

Pressing the **CANCEL** button provides the main settings for the timers, namely the type of timer and the cycle time:

10.4 Timer Parameters

Each Timer has a menu with the following user-defined parameters

Tmr*x* Type		One-Shot: The timer runs once and automatically terminates Cyclical: Once reaching the end time, the timer repeats indefinitely The type can be changed during timer operation
Tmr*x* Operation		---: No action Set@ OFFTime: (Re-)Start the timer at the start of the off time Set@ ONTime: (Re-)Start the timer at the end time parameter value (i.e. the start of the on time) Set@ RESTARTTime: (Re-)Start the timer at the point in the cycle defined by the timer Restart parameter STOP Timer: Cancels timer operation
Tmr*x* User Inhibit		Allows the user to temporarily inhibit the timer trip outputs OFF: No action Inhibit: Trips turned off Suspend: Trips turned off and the timer is suspended
Tmr*x* Cycle Time		The total (off + on) time. 000:00:01 to 999:59:59 hms
Tmr*x* Off Time		The time the trips allocated to the timer remain off, i.e. the start of the on time 000:00:01 to the Cycle Timer parameter value
Tmr*x* Restart Time		The restart time used for the Set@ RESTARTTime setting the restart time to an arbitrary value using the Tmr Operation | Set@ RESATRTTime parameter value
Tmr*x* DI1 Interlock **.....** **Tmr*x* DI4 Interlock**		Sets the digital input action on the timer trip outputs OFF: No action Inhibit: Trips turned off by the DI Suspend: Trips turned off and the timer is suspended Terminate: Terminates the timer turning all allocated trips to off Note: Different digital inputs can be set to perform different functions
Tmr*x* IG1 Interlock		Sets whether ion gauge 1 inhibits the timer trip outputs if above the pressure set in the Tmr IG1 Pressure parameter OFF: No action Inhibit: Trips turned off by the ion gauge Suspend: Trips turned off and the timer is suspended Terminate: Terminates the timer turning all allocated trips to off
Tmr*x* IG1 Pressure		The pressure value at which the ion gauge 1 inhibits the timer trip outputs
Tmr*x* IG2 Interlock	*Note 1*	Sets whether ion gauge 2 inhibits the timer trip outputs if above the pressure set in the Tmr IG2 Pressure parameter OFF: No action Inhibit: Trips turned off by the ion gauge Suspend: Trips turned off and the timer is suspended Terminate: Terminates the timer turning all allocated trips to off
Tmr*x* IG2 Pressure	*Note 1*	The pressure value at which the ion gauge 2 inhibits the timer trip outputs

Note 1: PVC*duo* only

11 Calibration

The controller is calibrated against "standards" during manufacture. However, gauge heads vary significantly due to their structure. The methods available to the controller to match specific gauge heads is discussed.

11.1 Calibration

The controllers are calibrated during final testing before dispatching to remove the effects of component and design tolerance. However, there are 2 circumstances where re-calibration may be necessary:

- All electronics can "drift" with time, or when used at extremes of temperature. Although this is usually a small effect and should not be a requirement within the lifetime of the controller.
- The electronics may need calibration to "match" the behaviour of a specific device. For example, due to manufacturing tolerance, Pirani gauges of the same type can differ by up to 5% between units.

The PVC controllers provide the facility for the user to execute calibration.

There are 2 types of calibration:

- Single High point or "gain" calibration used for calibrating the two analogue outputs
- Low and High dual point calibration used to calibrate thermocouples, and gauge modules such as the 'E', 'F', 'U', 'W' and 'K'.

11.2 High Point (Gain) Calibration of Analogue Outputs

This entails measuring the analogue output voltages on a calibrated voltmeter whilst adjusting the calibration parameter:

- From the relevant Analogue Output Menu, set the **Maximum Output** parameter to a high value (we recommend using the maximum 9999mV)
- Also set the **Allocation Parameter** to "SetToMaxOut"
- Enter the Calibration Menu and unlock it (see section xxxx)
- Scroll to the relevant parameter (either **AO1** or **AO2 Calibrate High**) and adjust the value so you meter reads as close to 9.999V as possible. Note that the designed full range for the analogue outputs is 0 to ~10.2V, so typical calibration values are in the range -200 to -240 (nominal mV).
- Restore the **Maximum Output** and **Allocation Parameters** for the analogue output

11.3 Low and High Dual Point Calibration

The Low/High calibration is a two step process where separate low and high value adjustments are made. They require some independent measurement or knowledge of the devices being calibrated with. This applies to thermocouple inputs (the built-in thermocouple and that provided by the 'K' module) and all secondary gauges attached to 'E', 'F', 'U' and 'W' modules.

All Low and High Calibration have a "neutral" (i.e. no correction) value of **5000**; calibration involved adjusting the values over the range 1 to 12000 to match the "correct" value.

With Low/High calibration, as well as the value of the calibration parameter, the actual current measurement is also displayed, for example, for a Pirani calibration:

As the adjustment procedure is the same for all devices is the same, we will take the example of calibrating a 521 Pirani gauge head attached to an 'E' module. Note that calibration of Pirani's is particularly sensitive due to their poor resolution in output at the extremes of the measurement range.

<u>Calibration at Atmosphere</u>

For Pirani gauges, it is suggested that calibration at atmosphere be performed first. Vent the Pirani gauge chamber and allow a few minutes to settle.

- Enter the Calibration Menu, and unlock calibration (see section 11.4)
- Select the relevant **HIGH Calib** Parameter:

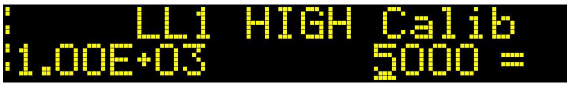
Note that in this case, the indicated pressure appears to be below 1.00E3 mBar (atmosphere).
- Adjust the Calibration Parameter value so that the indicated pressure just moves just above and below atmosphere.

Calibration at Vacuum
- Evacuate the Pirani chamber, allowing it to settle at a known pressure, or below the measurement range of the Pirani.
- Select the **LOW Calib** Parameter for the device
- If calibration is against a known reference, for example, another gauge or the minimum pressure for a rotary backing pump, adjust the calibration parameter to indicate that value
- If calibration is at a pressure below the minimum for the Pirani (1e-4mBar), adjust the calibration parameter to indicate as close to 1e-4mBar as possible.

11.4 Calibration Menu Parameters

To avoid "accidental" changes to calibration parameter values, on entering the calibration menu all parameters (except the first) are locked, as indicated by the key symbol adjacent to the parameter value. This indicates that the parameter value cannot be changed:

To access editing of the parameter values in the calibration menu, the **Calib Unlock** parameter (the first parameter) needs to be changed from "locked" to "unlocked" as indicated by the change from a key to an editing symbol:



Calib Unlock		Unlocks the calibration lock for subsequent parameters. Locked: The parameters are locked, can be inspected but NOT edited Unlocked: The parameters can be edited Note: The calibration lock is reset on returning to the controller Status Mode
T/C HIGH **T/C LOW**		Dual low and high point calibration parameters for the built-in thermocouple The current measured value is shown on the left of the menu area. The calibration parameter value (in the range 1 to 12000) is shown on the right
<Slot1 name> **HIGH** *<Slot1 name>* **LOW**	*Note 1*	Dual low and high point calibration parameters for the module in Slot 1. The current measured value is shown on the left of the menu area. The calibration parameter value (in the range 1 to 12000) is shown on the right
<Slot2 name> **HIGH** *<Slot2 name>* **LOW**	*Note 2*	Dual low and high point calibration parameters for the module in Slot 2 The current measured value is shown on the left of the menu area. The calibration parameter value (in the range 1 to 12000) is shown on the right
AO1 Calibrate High		Analogue 1 Output high point calibration. This should be adjusted whilst measuring the voltage on analogue 1. Range ±500.
AO2 Calibrate High		Analogue 2 Output high point calibration. This should be adjusted whilst measuring the voltage on analogue 2. Range ±500.

Note 1: Only if module installed in Slot 1

12 Setup Menu and Miscellaneous Parameters

The Setup menu provides control over a range of miscellaneous controller-wide parameters, such as component naming, communications, display pressure units, menu and display operation, as well as several operational parameters.

12.1 Component Naming

For identification purposes, the ion gauge(s) and secondary gauges can be given 3 character names which are displayed with the corresponding pressure. In addition, each controller can be given a unique 3 character name, for example, to aid identification over comms.

The names can be made up of any combination of the following characters: <space>, '0' to '9', 'A' to 'Z' and 'a' to 'z'. As for numerical data input, each character can be changed using the **UP** and **DOWN** buttons to scroll and change the characters.

Unit Name		3 character name for the controller. *[The factory default is PVC]*
IG1 Name		3 character name for ion gauge 1
IG2 Name	*Note 1*	3 character name for ion gauge 2
Module 1 Name		3 character name for module 1
Module 2 Name		3 character name for module 2

Note 1: PVC*duo* only

12.2 Pressure Units

Pressures are displayed in units of mBar, Torr or Pascal.

Notes:

- Trip settings are interpreted numerically in the currently selected units
- Ion gauges can individually be selected to display as ion current (Amps) rather than in pressure units – see section xxx

Pressure Units	mBar Torr Pascal

12.3 Menu and Display Related Parameters

Menu Escape Time	If in Menu or Parameter Edit modes, and no button press is executed, the controller will automatically revert to the last viewed Status page after waiting for the **Menu Escape Time**. Range: 20 to 999 seconds
Display Saver	Turns display saver functionality on and off
Display Saver Time	If turned on, the time between the last button press and the start of screen display. Range: 1 to 999 minutes
Bar Graph Minimum	For the BarGraph page, the minimum exponent value. For example, a value of -12 equates to 1^{-12}.
Bar Graph Maximum	For the BarGraph page, the maximum exponent value. For example, a value of -3 equates to 1^{-3}.

12.4 Communications Parameters

The PVC provide extensive support for control and monitoring over serial RS232 and RS485:

Comms Address	Each controller on a serial bus must have a unique address set in this parameter. Range: 01 to 99
Comms Protocol	Communications can be executed using either a binary MODBUS-based RTE protocol, or via an ASCII-based protocol: MODBUS LITend: MODBUS RTE using little endian data transfer MODBUS BIGend: MODBUS RTE using big endian data transfer QueBUS-No Check: QueBus ASCII protocol without error checking QueBUS+CS: QueBus ASCII protocol with simple check sum error checking QueBUS+CRC: QueBus ASCII protocol with full Cyclical Redundancy Check
Comms Baud Rate	4800, 9600, 19200, 38400 or 57600 baud
Comms Parity	None, Even or Odd
Comms Indicator	Turns the comms indicator on and off.

12.5 Information Parameters

All information parameters are non-editable and are "locked".

Software Version	As well as the UNIT id comms parameter, to help distinguish the PVC*uni* and PVC*duo*, version numbers start at 3.00. Note that the PVC*uni* and PVC*duo* controllers use the same software – functionality is auto-detected on power up.
Heatsink Temperature	The temperature of the heatsink is monitored and controls the fan
Internal Temperature	(Diagnostics)
Int Ctrl Power	(Diagnostics)
Unit Run Time	The total operating time of the controller since last factory reset