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IGC5:
UHV System Controller

Precision Ion Gauge Controller with Bake-out and Interlock Hub

Version 2.47 and above.
Release data 19th Oct 2016
-See Update Summary for latest features-

Contents

UPDATE SUMMARY:

Version 2.21:
1/ Enhanced thermocouple and Pirani linearization accuracy.
2/ Improved calibration correction algorithms.
3/ Added Display Quiet Mode function.
4/ Added Display Screen Saver function.
5/ Added Display Gauge Swapping function.
6/ Power up screen reports type of Pirani unit is internally set-up for (521 or 841)
7/ Digital input inversion added
Version 2.22:
1/ Relative Gas Sensitivity added
Version 2.25:
1/ Replacement of Display Gauge Swapping with more versatile Gauge Positioning options. Modified Quiet Mode and Screen Saver to match
2/ New Bake-out and Pump-down Summaries
3/ Added restriction to starting bake-out if thermocouple disconnected
Version 2.28:
1/ Bake-out peak temperature parameter added
2/ Restructured communications processing for lower time-out and latency performance
Version 2.30:
1/ Add reference to type "W" module
Version 2.32:
1/ Introduced partial QuickBUS Protocol
2/ Added separate filament potential sensing - requires PCB 1P1 and above
Version 2.35:
1/ Replaced partial QuickBus Protocol with QueBUS offering full parameter access and multi-parameter read/write
2/ Provided option for comms indicator disable.
Serial Number 02400 and above:
1/ Added weak 12V supply at pin 11 of Digital I/O connector for self-powering of digital inputs.
Version 2.40
1/ Added Dual-zone bake-out control options.
2/ Added additional QueBUS parameters for dual-zone operation.
Version 2.41
1/ Added optional "W" module pull-up of input when output power from module is off
2/ Removed redundant "OK" response when successfully writing a parameter value in QueBUS
Version 2.47
1/ Added "Always On" option for supplying power from "W" module
2/ Replaced Pump-Down capability with Dual Gauge Mode gauge operation, incorporating Pump-Down options
3/ Updated Trip and analogue output functions to support Dual Gauge Mode

SAFETY NOTES

1. Voltages in excess of **400V** are present within the controller. During degas, voltages up to **400V** are present on the cable and in the ion gauge. Voltages up to **200V** are present on the cable during normal 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.
2. Before removing the top cover of the controller, allow at least 5 minutes for the high voltage capacitors do 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.
3. Always turn off power to the controller before connecting any cable or the ion gauge, or performing any maintenance to either.
4. It is the users' responsibility to ensure that the trips are employed safely. **In safety critical installations, an independent manual means of over-riding/inhibiting the trip signals is required**.
5. Operation with the mains line voltage selector wrongly set voids warranty.
6. 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 failsafe 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 >600V continuous.
Where shielding involves metal, 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 Controller integrates precision **UHV and secondary gauge pressure measurement** ($1x10^{-12}$ to >1000mBar) with **UHV system management** functions. These include combining ion gauge with another gauge for **Dual Gauge Mode operation** and a **multi-step bake-out controller**. A user configurable **Interlock Hub** comprising 7 digital output trips, 2 digital input and programmable analogue output provides complete system interlocking with minimal wiring.*

1.1 What's New?

The Controller described in this manual provides improved performance and capabilities over earlier models. The key enhancements are:

- **Ion gauge management**. The ion gauge filament is driven from an analogue (not switched mode), constant current dc source for electrically silent operation (as required for vibration-sensitive applications, such as STEM). A PID-based emission control extends the range of emission and provides unprecedented stability of control. In addition, new features, such as soft-start operation, new filament/gauge head conditioning, high voltage monitoring and current sensing provide protection for the gauge and controller against vacuum and electrical faults.
- **Pressure Measurement**. The Controller simultaneously measures the electrometer current and the actual emission current to provide an accurate real-time calculation of the pressure. This removes the need for separate picoAmmeter in special applications, such as Beam Flux Measurement.
- **Degas**. Switching to and from degas is executed without interruption of ion gauge operation. Pressure measurement during degas maintains full system and gauge head protection. Ramping to degas power is gradual (rather than stepped) and a user-defined pressure limiter allows the degas cycle to be suspended to allow pressure recovery.
- **Pirani Support as standard**. Support for Thyracont VSP84x and VSP52x Pirani gauge heads is built into the controller.
- **Bake-out Support as standard**. A type K thermocouple input is provided to facilitate multi-step bake-out control. Measurement accuracy has been improved by use of a compensated mini-K connector, improved CJC and higher measurement resolution.
- **Dual Gauge Mode**. Combines and automates operation of the ion gauge and a secondary gauge to operate as a single pressure measurement device.
- **Options Module**. The Controller has one module "slot" which supports a range of modules providing secondary measurement functions. For example, a second passive or active gauge head can be added (Pirani, mini-convectron, Stinger, Baratron...). The module slot capability has been extended for compatibility with a planned range of new interfaces to provide support for other devices (e.g. cold-cathode gauge, wide range gauge…).
- User-configurable **Analogue Output** is precision-reference based for high accuracy and stability.
- **Interlock Hub**. The response times of the 7 trips and 2 digital inputs have been improved to provide enhanced system protection.
- **Dual OLED display**. The Controller replaces the 20 character VFD display of the earlier models with two long life, high brightness/contrast, yellow-on-black displays providing clearer legibility at distance and detailed parameter description.
- **Gauge Naming and Swapping**. Each of the 3 possible gauges (ion, Pirani and Module-based) can now be assigned its own name to ease identification of the presented data. The display positions of gauges can be changed.

1.2 Controller Functions

The Controller integrates the following functions:

- Precision UHV ion gauge controller (section 5).
- Secondary gauging (section 6) comprising:
  - Built in support for Thryacont 84x and 52x Pirani gauge heads
  - Support for a wider range of other gauge heads via installation of an optional module: additional Thyracont 84x or 52x gauge, mini-Convectron, Stinger, VG Pirani, Baratron, most linearized output gauges..., even monitoring of output from another ion gauge controller. Note that these can be integrated into the Interlock Hub.
- Interlock Hub comprises 7 trips, 2 digital input and precision analogue output allows many aspects of system control and monitoring to be routed through and configured with the Controller with minimal wiring (section 7).
- Multi-step bake-out control with integrated support by the Interlock Hub, and primary and secondary gauge pressure interlocking (section 8).
- Beam Flux Measurement applications. As well pressure indication in units of mBar, Torr or Pascal, the ion gauge readings can display/transmit over comms the reading as a straight auto-ranging current measurement (pA-nA-µA-mA). In most applications, the values displayed or output (comms or analogue outputs) can be used directly without the need for an external PicoAmmeter (section 5.13)
- Computer control over its multi-drop RS232/RS485 interfaces with a choice of communications protocols. MODBUS-based EMComm AND ASCII-based QueBUS protocols. Both provides fast comprehensive, multi-parameter read/write software interfacing.

1.3 Controller and VacTools

The free **VacTools** software provides comprehensive control, monitoring and data logging of vacuum systems via multiple controllers - please refer to your vendor. Interface hardware kits are also available, for example, see section 3.9.4.

2 Specification

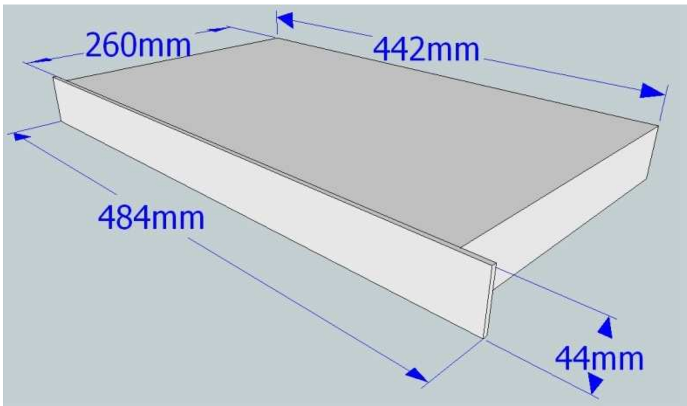
Parameter	DESCRIPTION
ION GAUGE:	
Ion Gauge:	1x UHV, dual Iridium-based filament. Yttria or Thoria-coated filaments.
Filament Drive:	Electrically silent, high stability constant current dc.
Filament Drive Rating:	0-4A (8V compliance)
Emission Control:	PID control with emission measurement for accurate 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 optimized for measured pressure
Emission features:	Soft-start and Ultra soft-start (new filament) options. User-definable min & max emission
Degas Type:	Thermal/Electron bombardment
Degas:	Ramped to user selectable low/mid/high power
Degas Features:	User-defined ramp/soak periods. User-defined pressure suspend to allow vacuum recovery.
Degas Pressure:	Displayed during degas
Degas on/off:	No interruption of ion gauge operation during degas start/stop transitions
Degas trip monitoring:	Continuous trip monitoring during degas with no interruption
Electrometer:	Range: <1e-12 to 1e-2. High stability
Gauge Sensitivity:	1.0 to 99.9 (resolution 0.1)
Gas Sensitivity:	0.01 to 99.99 (relative to Nitrogen = 1.00
Pump-down:	User-defined auto pump-down: backing gauge dependent ion gauge start-up pressure; trip allocation for external events (valves...), delay time, restart time etc...
SECONDARY GAUGES:	
Built in:	Support for VSP521/VSP841 as standard (user selectable)
Module supported:	1 module
Module options:	"V": VG Pirani. "E": VSP521. "F": VSP841 "U" and "W": Universal linearised output (e.g. other gauge controllers, mini-convectron, Stinger...) "K": Type K thermocouple input module for dual zone bake-out control
DUAL GAUGE MODE:	
Operation:	User-defined combination of ion gauge with another gauge head to simulate single gauge operation spanning combined pressure range.
BAKE-OUT CONTROL:	
Bake-out:	Single zone or Dual-zone. Can be run together or separately
Built in:	Type K thermocouple. Standard mini-thermocouple connector
Option:	Addition of "K" module for dual zone control
Module options:	(Not required)
Range:	Room temperature to 500°C. Precision CJC. Reproducibility <±0.5°C. Absolute <±2°C (can be user calibrated)
Bake-out Functions:	6x ramp/soak steps, each up to 99.9 hours duration (0.1 hour resolution). Individual trip allocation for power switching (e.g. 3 trips for 3Φ). User-defined pressure and digital input interlocking (ramp suspend/time suspend/abort). User-defined temperature hysteresis. Auto-degas at end of bake-out.
INTERLOCK HUB:	
Trips:	7 (4x SPCO relays 1A@24Vdc/ 0.5A@40Vac + 3x NPN open collector 250mA/12Vdc)
Trip assignments:	Individually assignable: external interlock to any ion, backing gauge or dual gauge pressure, ion gauge status (on, off, degas), bake-out power switching...
Digital Inputs:	2x opto-isolated inputs. 3-30Vdc; 2.4kΩ input resistance.
Digital Input assignment:	External interlock as trip for ion gauge; control over ion gauge on/off and degas either via input state or toggle state; bake-out trip; inhibit dual gauge operation; backing gauge...
Interlock Response times:	0.2 sec max. Typically <0.1sec

ANALOGUE OUTPUT:	
Output:	Full scale range: -0.2V to 10.2V (12 bit resolution). User-definable min and max.
Accuracy:	Precision reference-based: <±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...
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 (gauge off), Max: 60W (full degas)
Display Type:	Dual OLED display: Left: 100x16 pixel graphical display. Right: 2 line x 16 character display. High brightness. High contrast. Long life >100,000h to half-brightness
Display Modes: (v2.21 and above)	User-configurable Gauge positioning between Primary and secondary displays Display "screen saving" mode "Quiet" mode option removes unused/disconnected gauges/thermocouple
Display Resolution:	Ion gauge: 1 or 2 decimal place resolution. Secondary gauges: 1 decimal place resolution. Temperature: <0.1°C measurement resolution, 0.1°C display resolution.
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 connection:	2x RJ45 for simple daisy-chaining

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 internal 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

Left to right, the rear panel comprises:

- Two RJ45 serial communications connectors providing multi-drop RS232 and RS485 ports (section 3.9)

- Ion gauge collector (BNC connector) (section 3.5.2)
- Analogue output connector (2 pin, 3.5mm jack socket) (section 3.7)
- Access to optional slot module connector. All modules use a mini-DIN connector (section 6.2)
- Standard type K mini-thermocouple connector for bake-out (section 8)
- Connector for built-in Pirani gauge (3 pin mini-DIN) (section 6.1)
- DB25 male connector for Interlock Hub digital inputs and trip outputs (section 7)
- Fan vent - DO NOT OBSTRUCT. Note: fan does not operate continually; only as required.
- Filament fuse. F5A (fast fuse) (section 3.5.3)
- High voltage grid voltage fuse. F100mA (fast fuse) (section 3.5.3)
- Ion gauge head connector. 6-pin QM multipole (section 3.5.1)
- Earthing stud for connection to an earth point on the vacuum system (see SAFETY NOTES and section 3.5)
- Combined mains inlet, double fuse holder, mains on/off switch and 115/230V selector. (section 3.4)

3.3 Controller Front Panel

The controller uses 2 independent OLED displays, the operation of which is discussed in section 11:

- **Left Hand "Primary" Display**:
  - Top left: Current selected gauge name (Note: Refer to Setup menu to enable Gauge swapping)
  - Bottom left: 7 trip states and 2 digital input states
  - Centre: Either gauge data (large characters) or status information (inverted small characters)...
  - ...followed by units (if relevant)
  - Above units, up or down arrow indicating data change direction
  - Bottom right pixel: Flashes if communications message successfully received/responded to.
- **Right Hand "Secondary/Data Edit" Display**. This 2 line x 16 character display provides a range of information through its 4 data "pages", and access to editing the controller parameters via the menu.

The front panel has 5 domed buttons for accessing data manually:

DOWN BUTTON
Decrements
Data Value

UP BUTTON
Increments
Data Value

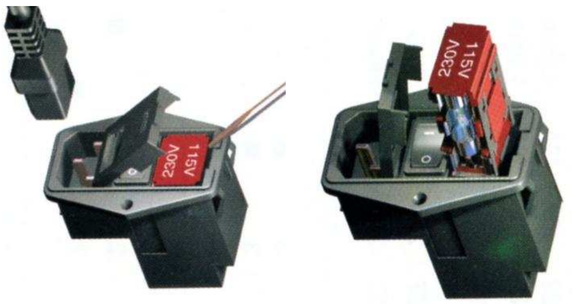
MENU BUTTON
Navigates Menus

CANCEL BUTTON
Cancel Data Entry.
Exits Menu

OK BUTTON
Enters new Data

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.

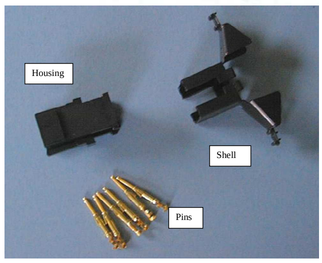
3.4 Line Voltage and Fusing



The controller houses 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, ***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 Ion Gauge Connections

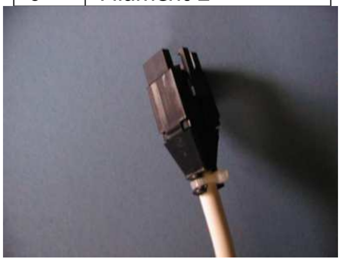


The ion gauge head is connected to the controller using 2 connectors: a 6 pin QM "power" connector, and a BNC connector for the collector current. **Potentially lethal voltages are**

present on the connectors; ALWAYS TURN THE CONTROLLER OFF BEFORE DISCONNECTING OR HANDLING 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, EMC-compliant cable assemblies are available from your controller supplier.

3.5.1 The 6 pin QM "power" connector

Pin	Function
1	Interlock[Note 1]
2	Grid
3	Interlock[Note 1]
4	Filament common
5	Filament 1[Note 2]
6	Filament 2[Note 2]



Only cables produced commercially or by qualified electrical engineers should be used. The Accessories pack includes parts needed to modify an existing cable for use with the controller.
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.
- 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 gauge lead MUST conform to the following:

- CABLING MUST BE RATED AT LEAST 20°C ABOVE THE **MAXIMUM** BAKEOUT TEMPERATURE.
- The filament wires MUST be rated at >5A AT THE MAXIMUM BAKEOUT TEMPERATURE.
- The Grid wire MUST be rated at >600Vdc and capable of carrying a current of >200mA.

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.

- 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.

3.5.2 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 screen. Instructions on assembling BNCs are provided with the connectors, or can be viewed on line.
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.

3.5.3 Ion Gauge Integrity, Safety and Fusing

- When the ion gauge is off, the high voltage grid and filament supplies are 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 ~4A. An in-line 5A fast fuse further protects 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.

3.6 Digital I/O Connector

3.6.1 Connector

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

Function	Pin	Pin	Function
		1	Relay 1 Normally Open
Relay 1 Common	14		
		2	Relay 1 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)
Outputs 5 to 7 0V (Earth)	20		
		8	Open Collector Trip 5
Open Collector Trip 6	21		
		9	Open Collector Trip 7
[Not connected]	22		
		10	Outputs 5 to 7 0V (Earth)
Outputs 5 to 7 0V (Earth)	23		
		11	Weak 12V supply (see 3.6.3)
Digital 1 input +ve	24		
		12	Digital input 1 –ve
Digital 2 input +ve	25		
		13	Digital input 2 –ve

3.6.2 Digital Trips

- Trips 1 to 4 are change-over relays: Do NOT exceed 1Adc or 0.5Aac at 40V
- 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) to the open-collector trip outputs 5 to 7.
- Do NOT exceed MAXIMUM current for trips outputs 5 to 7 of 250mA.

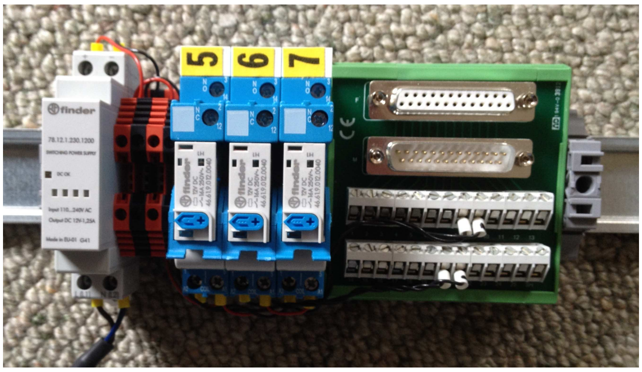
3.6.3 Digital Inputs

- The terminals of the digital inputs are each isolated using opto-couplers in series with 2k4Ω resistors.
- 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.

Note: Serial Numbers 02400 and above
Starting with serial numbers 02400, a weak 12V supply is provided at pin 11 of the connector allowing the digital inputs to be self-powered by the controller, 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.

However, please note that the weak 12V supply is referenced to earth at pin 10. Thus if, for example, switching via an external relay, connect the digital input -ve to pin 10 and route the weak 12V supply from pin 11 via the relay contact.

3.6.4 Digital I/O Options



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

PVCRL Power Relay Buster.
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.

3.7 Analogue Output Connector

The analogue output is a standard 3.5mm (⅛") jack socket. The central pin is the signal output and the outer is 0V (earth). Screened signal wire is recommended.

3.8 Module Installation/Removal in the "Options Slot"

The controller accepts one module to extend the secondary gauging capabilities; for module types, see section 6.2. Module are identified by the controller on power up, and any menu or system reconfiguration is automatically applied. A module can be supplied pre-installed, or can be ordered separately for user installation.

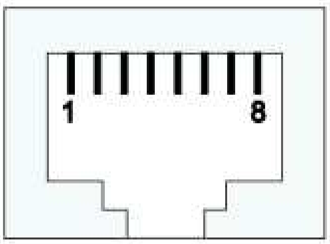
To install a module:

- Note: If available, please use an earthed wrist strap.
- Note: The controller and modules contain static sensitivity components. Avoid touching any component on the mother board or module. **Handle the modules by the edges only**.
- Note: Disconnect **ALL** leads to the controller during the installation procedure.
- Note: There are high, potentially lethal, voltages present in the controller. Before removing the cover, allow at least 5 minutes after disconnection of all leads to ensure that all power supplies have fully discharged.
- Place the controller so the front panel is facing you.
- Remove the 3 screws on each side of the controller. Raise the lid ***slowly*** to avoid snagging the earth wire attaching the cover to the base of the unit; the wire is sufficiently long that the lid can be laid by the left hand side of the base.
- The module slot is just left of the collector BNC connector. It comprises a 13 pin in-line socket, an M3 threaded pillar for securing the module, and a blanked hole through which the module connector is made.
- If there is no module in place, remove the blanking plate by pushing it from the inside of the controller.
- If a module is present, unscrew and remove the M3 bolt securing the module. Holding the module across its width, carefully pull the module upwards to remove.
- The module inserts into the 13 pin socket. Modules can be either "narrow" 8 pin or "wide" 13 pin.
  - 8 pin modules are inserted into the left-most holes of the 13 pin connector. If the module is inserted into the wrong holes, it should not be possible to insert the M3 securing bolt as the module will not align with the module connector hole on the rear panel. **Insertion in the wrong holes will damage the module.**
  - 13 pin modules should be inserted so all 13 pins engage in the socket.
- When the module is in place, secure with the M3 bolt and washer - do not over-tighten to avoid damaging the PCB. Gently manipulate the module so the connector aligns with the hole in the rear panel.
- If no module is to be inserted, insert a blanking plate by pushing in from the outside of the controller.
- Replace the lid and secure with the 6 screws.
- On powering up the controller, it should report the type of module installed during the power-up sequence.

3.9 Serial Communications

3.9.1 Overview

The controller has both multi-drop RS232 and RS485 (3 wire) communications ports built-in 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 section 14 for communications protocols..



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.

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

3.9.3 Interface Cabling from the Port to the first GC

Cables are available from your vendor for connection to standard DB9 or DB25 PC ports for RS232 interfacing, as well as leads for RS485 interfacing (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 COMPLIANT, RJ45 PATCH LEADS** is recommended.

3.9.3.1 RS232

Note: Implementation of the RS232 port allows multiple controllers can be connected to a serial port.

The controller 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.

Standard RS232 serial ports use either 9pin or 25pin DB connectors and are wired as shown.

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	-	-	-

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

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.

3.9.3 Daisy-chaining cable between controllers

3.9.3.1 Standard RJ45 patch leads

The simplest method to daisy-chain controllers is to use standard RJ45 "patch" leads; shielded, Cat5 compliant cables are recommended. Note, if using such cables with a controller with software version 2.10 or lower, the **Low** comms mode (see section 14) should be used; **High** comms mode requires version 2.11 and above. For more information, see **VacTools** documentation.

3.9.3.2 RS232 specific patch leads

To use **High** comms mode with any controller (regardless of software version), RS232-specific patch leads are needed. In these, only pins 1, 2 and 3 are wired - all other pins are not connected.

3.9.4 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. Your vendor can supply a 5m long RS232 to RJ45 connector to the first controller (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.

3.9.5 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.

Your controller vendor can supply a range of these options, with appropriate cabling. The simplest (and most cost effective solution) is to use USB to RS232 converters. For example:

- The USBCom14 kit comprises a USB too serial converter and cabling for up to 4 controllers.
- The USBCom28 kit comprises a USB to dual serial converter and cabling for up to 4 controllers.

A range of options are also available, such as USB active extensions that allow the USB cable to be increased up to 12m in length, Ethernet options and greater number of serial ports.

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.

4 Controller Functions

The controller combines several functions which operate seamlessly together to integrate pressure measurement with interlocking, bake-out and system control.

4.1 Pressure Measurement

The controller pressure measurement supports:

- One Ir-based (Thoria, Yttria or uncoated), single or dual filament ion gauge head. Filaments are dc constant current driven at up to 4A (9V compliance).
- One Thyracont VSP84x or VSP52x Pirani gauge head. Note: although these gauge heads appear physically identical, they require different drive electronics and have different pin connections; gauges with appropriate interconnecting cables are available from your controller vendor. For selection between the gauge head types , see section 6.1.
- One optional gauge head via a "module". Depending on the gauge head and the module type selected, pressures over the range $1x10^{-13}$ to atmosphere can be measured and integrated with the Interlock hub.

4.2 Interlock Hub

The controller provides an interlock hub:

- **7 digital outputs (trips)**.
  - 4 single-pole change-over (SPCO) relays capable of switching 1A @ 24Vdc (0.5A @ up to 40Vac).
  - 3 earth-referenced, open-collector NPN Darlington transistors capable of sinking 250mA. The collectors are reverse-biased diode protected – DO NOT EXCEED 14Vdc AT THE COLLECTOR PINS.
- **2 opto-isolated digital inputs**. Activated by applying 3 to 30Vdc. The equivalent input resistance is >2.4kΩ; the opto-diode is reverse diode protected. If higher voltages are to be used, an external series resistor can be used - see section 7.2. The input action can be inverted (i.e. voltage present at input = OFF)
- 1 precision-referenced **analogue output**. The user can assign this to any of the gauges or the thermocouple input, as well as the pressure/temperature range, the output voltage range and lin/log relationship.

Notes:

- The trips are assignable to a wide range of controller functions, such as pressure trips, ion gauge status indication (gauge on/in degas), bake-out on/off power switching, interlock functions…
- Each trip is independent, thus several can be assigned to the same function – for example, 3 trips can be assigned to the bake-out to implement switching 3 phase power to a bake-out heater.
- Each digital input is independent. Several functions can be assigned to the same digital input, for example, trip off the ion gauge and abort bake-out in response to digital input 2 failure.

4.3 Bake-out Control

An industry standard type-K mini-thermocouple connector on the rear panel is provided for system temperature monitoring, and allocation of trips to switch heater power allows full multi-step bake-out control (section 8). Addition of a 'K' module allows a second thermocouple to be connected for dual bake-out zone operation:

- Measurement/control range to 500°C.
- The final temperature and duration of up to 6 ramp/soak steps can be defined up to 99.9 hours per step.
- The switching hysteresis can be user-defined to avoid switching "chatter".
- A pressure trip can be assigned such that if the pressure rises above the specified value, the bake-out power can be switched off, the bake-out timer suspended, or the bake-out can be aborted.
- Either or both digital inputs can be assigned such that in response to an external event, the bake-out power can be switched off, the bake-out timer suspended, or the bake-out can be aborted.
- The user can optionally set automatic degas of the ion gauge head when the bake-out has finished.
- In dual zone set-up, either one of the zones can be run, or they can be run simultaneously

4.4 Dual Gauge Mode Operation

A feature new to software version 2.47 is combining ion gauge operation and either the built-in Pirani or a gauge connected to a module as a single measurement device, with combined span. Pressure indication is derived from whichever gauge is "active", with interlocking depending on the indicated pressure. Please refer to section 9.

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 (see photograph):

- One or two (used separately) spiral or ribbon filaments. Current heats the filament inducing thermionic emission of electrons. Filaments are coated to reduce the work-function of the filament material and thus enhance emission at lower temperatures. Coated Iridium filaments typically operate at ~650°C compared with >2000°C for Tungsten, thus require much less power, reducing degassing of the gauge head and surrounds. The filament is biased at ~+45Vdc with respect to earth.
- A cylindrical "grid" made of an open mesh material. This is biased at ~+190Vdc (>+350Vdc during degas) to attract the emitted electrons. The grid has an open structure allowing electrons to make multiple passes before colliding with it. The controller adjusts the emission current to maintain a constant stream of electrons.
- A thin "collector" wire in the middle of the grid, connected to the earthed electrometer.

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

Emitted electrons colliding with gas molecules, knock an electron off the gas molecule, leaving a positive ion. This is attracted towards the collector (due to the relative bias on the grid and collector) from which it receives an electron. This induced ion current is proportional to the number of gaseous molecules and to the electron emission current allowing the pressure can be deduced.

To address the extremely wide range of ion current (10^{-12} to 10^{-2}A) that has to be measured by the electrometer and boost the number of ions at very low pressures, the emission current is varied from <0.1mA to 10mA during normal measurement.

The lowest pressure an ion gauge can measure is limited by the X-ray limit of the collector, as well as geometric parameters. X-ray limits for common gauges vary between 10^{-9} and $5x10^{-12}$mBar.

5.2 Ion Gauge and Relative Gas Sensitivity

The efficiency of generating ions depends on a number of additional factors apart from pressure and emission current. The "Ion Gauge Sensitivity" reflects the the geometry/design of the gauge head; values vary between 5 and 30 $mBar^{-1}$. Secondly, the ionization probability for different gases varies. This sensitivity to gas species is referenced to Nitrogen (as 1.00) and some typical values are shown left. The overall sensitivity = (gauge sensitivity) x (relative gas sensitivity). Note that the relative sensitivity values also varies with gauge head design, and values even between identical gauges can vary by 10% or more. Relative sensitivity values become even less reliable with increasing pressures above about 10^{-5}mBar. See the GaugeSensitivity and GasSensitivity parameters.

5.3 Gauge Type and Filaments

The controller was designed to operate one twin filament UHV gauge head with Thoria-, or Yttria-coated Iridium filaments. However, it will operate any nude gauge head (EpiMax, VG, SS Scientific, ITL, Instrutech...) that requires <4A of filament current at a maximum voltage across the filament plus cable of about 9V.

Either filament 1 or filament 2 can be selected; if "Auto" is set, the controller will first try to use filament 1 and if emission cannot be established, filament 2.

5.4 Emission Currents: Setpoint and Measured values, and Pressure Calculation

Emission (from the filament to the grid) is controlled by the dc current through the filament. This is established by comparing the required emission value with the measured emission value using a **PID** algorithm (see section 5.6).

As well as the collecto
r ion current, the indicated pressure depends on the emission current. The controller measures the emission current ion current simultaneously to ensure accurate calculation of the pressure value.

5.5 Fixed Emission Currents and Emission Current Range

The controller provides a range of "fixed" emission currents: 0.05, 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 5.7).

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.

5.6 Emission Start-up and PID control

The PID emission control algorithm uses the Proportional (P) and Damp (ID) parameters. These are set to 25, values appropriate for most gauge types and should not normally need adjusting.

The Minimum and Maximum power parameters (expressed as % of range) limit the current applied to the filament *under normal PID control*. The minimum current value should be set a little below that required for emission to start, and the maximum current protects the filament from being overdriven.

On starting up an ion gauge the required emission value is set to 0.05mA irrespective of the user selected emission current. The output current ramps from zero to the minimum power value over a period of several seconds (or at a slower rate if the New Filament Conditioning option is enabled – section 5.12.2). During this "soft-start", checks are performed to ensure presence of grid and filament potential, integrity of the filament and the onset of ion current. On reaching the minimum power value, PID control commences. If emission is established at or below 0.05mA and a sensible pressure measured, the controller ramps to the requested emission value; otherwise the gauge head is turned off (or the second filament is tried if auto-filament selection is set).

5.7 Auto-Emission

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

To avoid pressure bursts, auto-emission increases are performed in increments. However, the Auto-Emission algorithm responds immediately to sudden increases in pressure to protect the gauge head.

5.8 Changing Emission

Changes to emission settings are implemented by ramping the emission. The ramp is slower for increments in emission (to avoid pressure bursts) than for decrements in emission (to enhance gauge protection).

5.9 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 influence the ability of the collector to collect ions due to adsorption; 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) - see also section 5.12.3.

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 >350V 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 DegasRampTime and DegasHoldTime parameters can each be 2 to 999 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 smoothly ramped over the degas ramp time. Extended ramp periods (>10mins) ensures gradual gas desorption allowing pumps to handle degas gas loads.
- Pressures during degas exceeding the DegasSuspend parameter value temporarily suspend emission ramping.
- 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.

5.10 Ion Gauge Status and Error Messages

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

Display	Condition
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/D Error!	Fault detected with A/D converter. Ion gauge will be switched off.
HiVoltage Er	Fault detected with high voltage (grid) potential [Check rear panel high voltage grid fuse.]
FilHiV Er	Fault detected with filament potential [Often caused by grid touching chamber wall]
Over/UnderTemp	Internal heatsink over or under temperature condition. Ion gauge switched off.
NO Ion Gauge	Ion Gauge Interlock FAIL. [E.g. ion gauge lead is NOT connected.]
Filament Er	Ion gauge tripped: filament problem (e.g. open/short circuit filament)
Emission Er	Ion gauge tripped: emission failed or could not be established.
OverPres	System pressure too high for ion gauge operation. Ion gauge switched off.
PowerMax Er	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.
DIError	Digital input assigned to the ion gauge failed, causing the ion gauge to trip out
➔ OFF	The ion gauge is being powered down.

5.11 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.

5.12 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:

5.12.1 Vacuum Pressure Measurements

Wherever possible **use Auto-emission**. The controller will ensure protection and optimal emission current setting to provide good measurement accuracy commensurate with the pressure.

5.12.2 New Filaments – Conditioning and Degassing

New Iridium filaments require “conditioning” as the coating is not initially “activated” in reducing the work-function of the filament; whereas a conditioned filament may need ~30% filament power at 0.1mA emission, a new filament may initially need 40% or more. In addition, the first time a filament is run, heavy degassing may occur.

To address new filament (or gauge head) conditioning, the NewFilamentRamp Parameter provides an option for an extended power up taking upwards of 2 minutes (as opposed to the normal 10-20 seconds). The options are Off (normal ramp), Once, Twice and Always. For the Once and Twice setting, the count decrements each time the ion gauge is powered up, so that the filament is only powered up slowly the first times used.

The impact of gauge head conditioning can be further reduced:

- Use the Auto emission feature – the controller will increase the emission only as the pressure allows
- After several minutes operation, degas the filament at the Low level with a long (>30 minute) ramp time
- Note that both filaments need to be conditioned independently.

5.12.3 Degas

After air exposure, the gauge head requires degassing, e.g. >30minutes ramp and >10 minutes at DegasHi. This is best performed *after* bake-out of the UHV system, preferably whilst the system is cooling (but >100°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.

5.13 Ion Current and Beam Flux Measurements

5.13.1 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. The controller reads emission and ion current, 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.

5.13.2 Measuring as Current

For normal pressure measurement, the controller display in units of mBar, Torr or Pascal set by the PressureUnits parameter. The IonGaugeUnits parameter selects between Pressure and current indication. The value auto-ranges between units of pA, nA, µA or mA and data formats of x.xxx, xx.xx, xxx.x.

6 Secondary Gauging

The controller supports 2 levels of Secondary Gauging:
- Built-in support for one Thyracont VSP84x or VSP85x Pirani gauge head (10^{-4} to ~200mBar).
- Installation of one of a range of optional modules supporting a wider range of gauge types.

6.1 Built-in Pirani Gauging

6.1.1 Pirani Gauge Types and Issues

The Thyracont VSP84x and VSP52x are half-bridge Pirani gauge heads with built-in temperature compensation. Although a measurement range of 250 to 10^{-4}mBar range is possible, specified performance is over the range 100 to 10^{-3}mBar. The *x* in the part number refers to the type of flange (DN16 ISO KF or ⅛"NPT) and whether metal sealed.

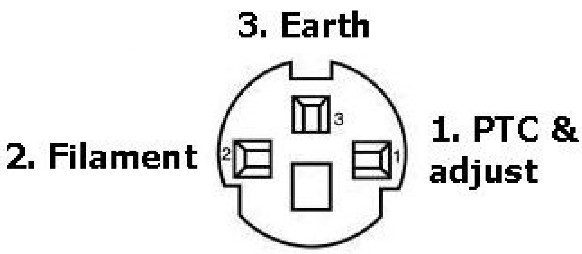
6.1.2 Selecting the gauge type within the controller.

Although the VSP84x and VSP52x gauge heads are physically identical, their pressure measurement and temperature compensation characteristics differ (requiring different electronics) as do their connector pin assignments (requiring different cables). To set the correct electronics for the Pirani gauge head, the controller has 5 internal "jumpers". *The positions for the jumpers are clearly labelled with legends for the two types of gauge*.

To set the jumpers:

- Note: If available, please use an earthed wrist strap.
- Note: The controller contains static sensitivity components. Avoid touching components on the motherboard.
- Note: Disconnect **ALL** leads to the controller during the installation procedure.
- Note: There are high, potentially lethal, voltages present in the controller. Before removing the cover, allow at least 5 minutes after disconnection of all leads to ensure that all power supplies have discharged fully.
- Place the controller so the front panel is facing you.
- Remove the 3 screws on each side of the controller. Raise the lid to avoid snagging the earth wire attaching the cover to the base of the unit; the wire is sufficiently long that the lid can be laid by the side of the base.
- (i) Locate the group of 4 jumpers near the Trips connector with markings showing "VSP52x" and "VSP84x" legends. Set these jumpers to match the gauge head.
  (ii) Locate the single jumper near the centre of the board with markings showing "VSP52x" and "VSP84x" legends. Set this jumper to match the gauge head.
- Replace the lid and secure with the 6 screws.
- Power up and go to the next section to ensure software settings.

The currently selected gauge head can be verified in Pirani Type parameter in the Calibration Menu.



6.1.4 Pirani Calibration

The resistance between Pirani filaments varies considerable between units leading to large differences in indicated pressure, particularly at the extremes of their pressure range. The controller provides a calibration procedure that matches the measurement to the specific Pirani head. This is accessed in the Calibration Menu - see section 10.

A factory service is available to calibrate Pirani heads when sold with a controller.

6.1.5 Pirani gauge Connector

The 3-pin mini-DIN connector pin assignments for both Pirani gauge types is as shown, viewed looking into the connector on the rear panel. However, the connection pins at the gauge head differ; appropriate cables are available for both Pirani types.

6.2 Optional Gauge Modules

6.2.1 What are Modules?

The controller has a "slot" to accommodate a plug-in PCB (module) to provide optional functionality. The type of module is automatically detected at power up and module-specific menus may become available. Please refer to section 3.8 for description of the slot and module installation/removal.

Modules are identified by a letter indicating their functionality. The most common are:

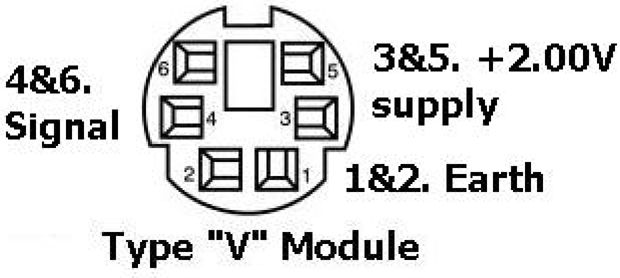
6.2.2 The "E" Module: VSP52x

The 8-pin "E" module supports an additional VSP52x Pirani gauge head; please refer to the connector and cabling information in section 6.1.5. The controller reports No Pirani if no gauge head is connected.

6.2.3 The "F" Module: VSP84x

The 8-pin "F" module supports an <u>additional</u> VSP84x Pirani gauge head; please refer to the connector and cabling information in section 6.1.5. The controller reports No Pirani if no gauge head is connected.

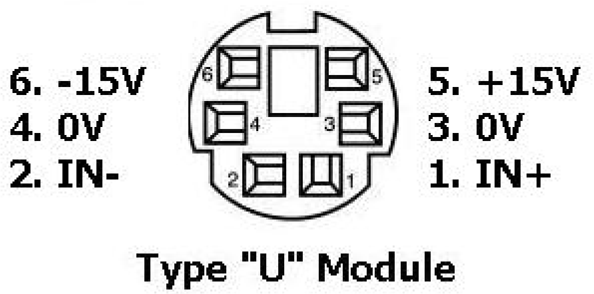
6.2.4 The "V" Module: VG Pirani gauge heads



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.

The controller reports Atm (atmosphere) if no Pirani head is attached.

6.2.5 The "U" Universal Module for Linearized 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:

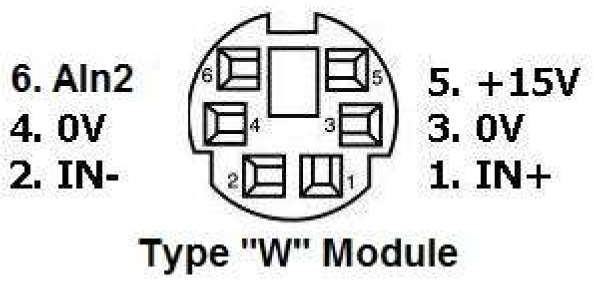
- A differential analogue input (pins 2 and 1) from the analogue output of the device. A jumper on the module allows the full scale input range to be selected between 0 to 10V, 0 to 3V and 0 to 1V, as labelled on the module.
- +14.5Vdc (pin 5), -14.5Vdc (pin 6) supplies (relative to 0V at pins 3 and 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.
- 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

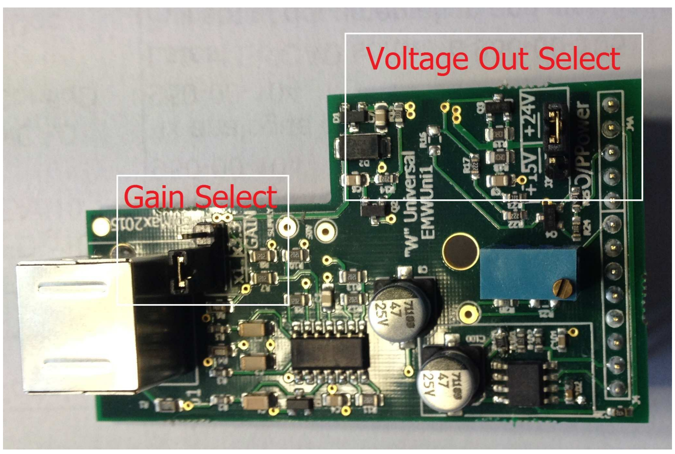
As an example, the table shows wiring to monitor the output *and* provide power to a Instrutech CVM-211 Stinger.

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

6.2.6 The "W" Universal Module for Linearized 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-linearized 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:



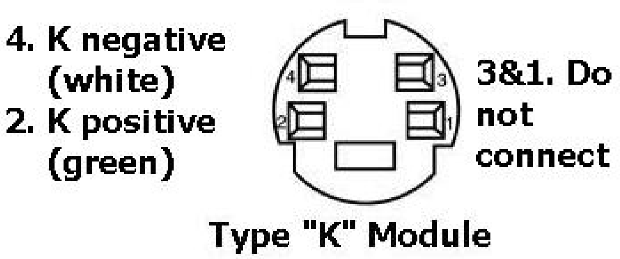
- A differential analogue input (pins 2 and 1) from the analogue output of the device. A jumper on the module allows the full scale input range to be selected between 0 to 10V and 0 to 3.3333V - see "Gain Select".
- A positive power supply (pin 5) capable of powering the device. This line is current 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 from the controller menu software (WModule: Power), allowing the device to be powered only when required. If the module is always to be powered up when the controller is on, set to "Always On".
- The WModule: Pull-up parameter provides a "software" pull-up of the input measurement to maximum value when the module power output is switched off 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 Calibration menu)

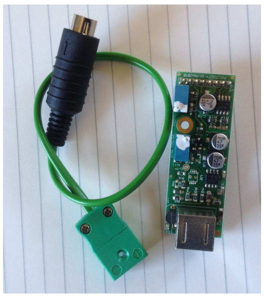
- The relationship between the input voltage and pressure can be set either to logarithmic or linear (see Calibration menu)
- Pin 6 offers an additional analogue/digital input. The function of this pin awaits implementation in the controller software. Use of screened cable is recommended, with the screen connected to pin 4 of the "W" module.

6.2.7 The '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 the 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 is provided with a 150mm long mini-DIN to mini-thermocouple adaptor cable, as shown in the photograph.





7 Interlock Hub: Digital I/O and Analogue Output

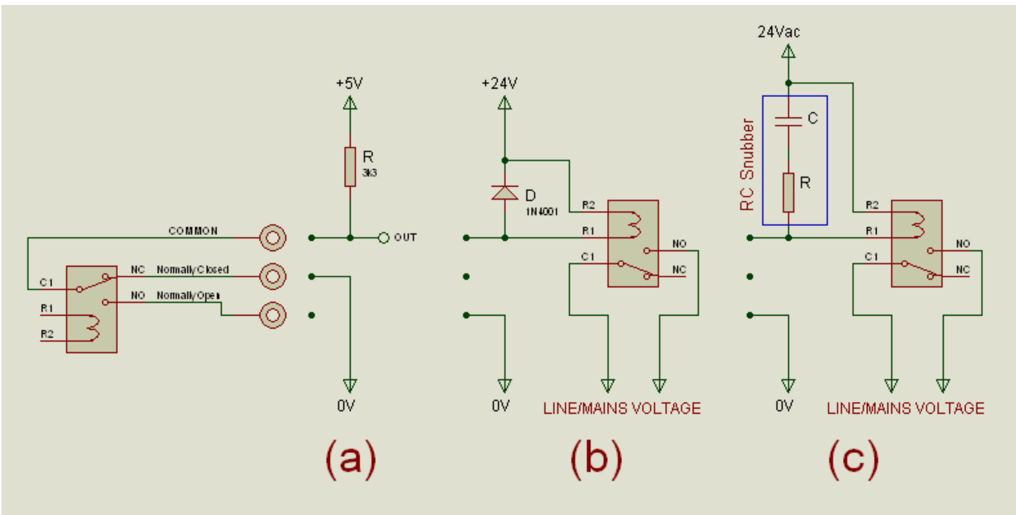
Being user-configurable, the Interlock Hub (which comprises the digital output trips, digital inputs and analogue output) relate the pressure/temperature measurements to various aspects of system operation (pumps, valves...). The hub can largely replace interlock wiring, and provides versatile implementation 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 need to be protected against. 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 to7 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.

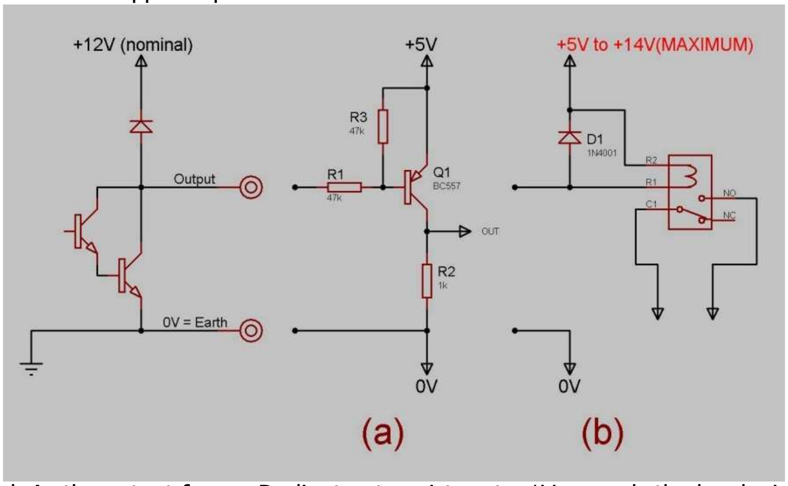
(b) Switches a contactor with dc coil, for example, to a heater. To comply with the 1A contact current limit, the resistance of the external relay coil must be >30Ω. The reverse biased diode MUST BE PRESENT to suppress the back emf generated by the inductive load presented by the relay coil; this diode 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

Open-collector Darlington transistor output, each capable of sinking 250mA 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**.

DO NOT USE A SUPPLY >+14V WITH TRIPS 5 to 7.

7.1.3 Trip Assignments

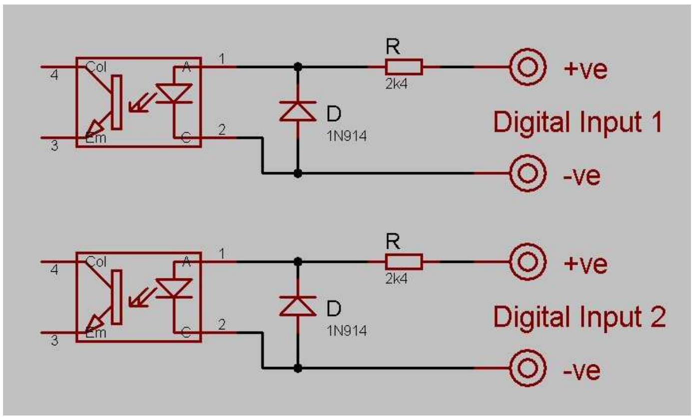
Each trip can be independently assigned to a wide range of functions including: ion or secondary gauge status, thermocouple temperature, bake-out control, gauge operation, communications event...

7.2 Digital Inputs

7.2.1 Digital Input Hardware

The equivalent circuit of the 2 digital inputs is shown:

- The inputs are independently opto-isolated.
- An input voltage range is 3 to 30Vdc.
- The digital inputs can be drive either from a logic output, or a voltage switched by a relay or open-collector device. The voltage can either be externally provided or (for serial numbers above 02400), using the weak supply at pins 10 and 11 of I/O connector.
- The equivalent resistance of the inputs is ~2k4Ω. For voltages higher than 24V, an external series resistor should be used to limit the input current to ~10mA. Resistor values can be calculated: R_{ext} = (V / 0.01) - 2400 (Ω). E.g. to use a 48V power supply, an external resistor of ~2400Ω is required (standard values of 2k2Ω or 2k7Ω); power dissipation would be (I^2R) 0.01 * 0.01 * 2400 = 0.24W (use a standard 0.6W resistor).
- Diodes (D) protect against reverse biasing.
- The input action can be inverted (Digital Input Invert Parameter), i.e. voltage present = OFF



7.2.2 Digital Input Assignments

Each digital input can be independently assigned to one or more functions simultaneously. These include gauge operation and bake-out...

7.3 Analogue Output

7.3.1 Overview

- A precision-reference based analogue output capable of sourcing/sinking 20mA.
- The nominally 0-10V output range has a resolution of 12 bits covering the range -0.03V (0 counts) to +10.2V (4095 counts), allowing for external offsets. The output range can be user-configured.
- Assignable to any analogue signal processed by the controller.

7.3.2 Parameters

There are 6 parameters associated with the analogue output:

- Assignment to ion gauge, dual gauge, Pirani, temperature. (see section 12.5.5)
- The minimum and maximum output voltage range is set by the AO OutPMin and AO OutPMax parameters, defined by 12bit numbers (0 to 4085). To allow these values to be set accurately by measurement, the analogue output tracks the value whilst either of these parameters is being adjusted.
- The minimum and maximum pressure (or temperature) value corresponding to the min and max voltage output values is set by the AO PrMin and AOI PrMax parameters. Note that AO PrMin CAN EXCEED AO PrMax to allow negative as well as positive slope relationships to be supported.
- The AD Function parameter sets the linear or logarithmic relationship between voltage and pressure.

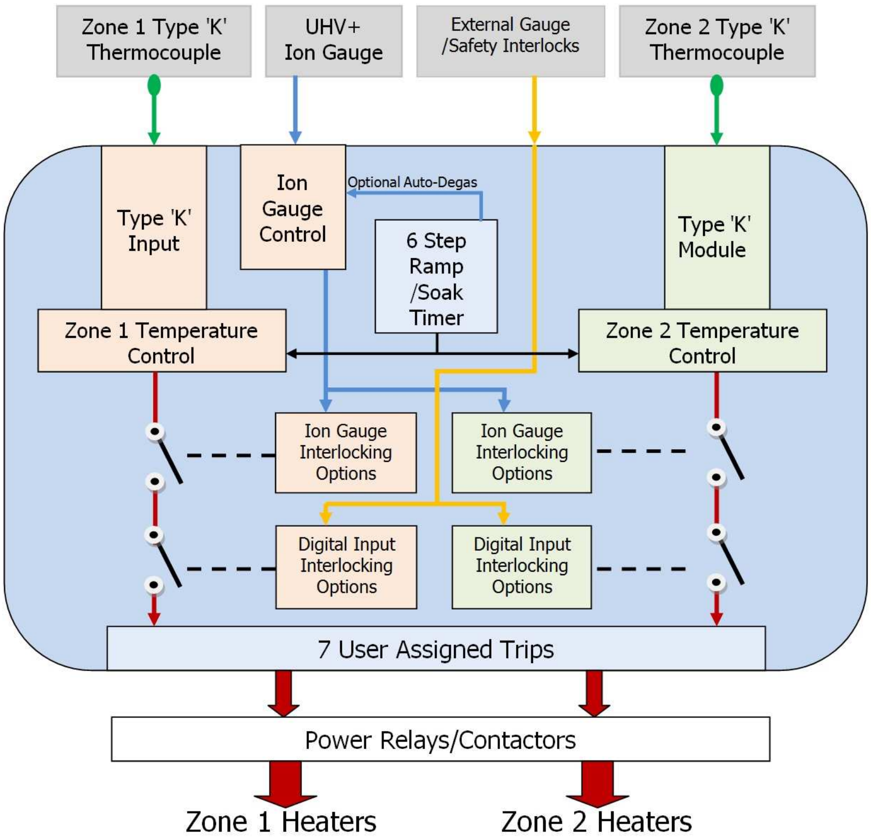
8 Single and Dual Zone Bake-out

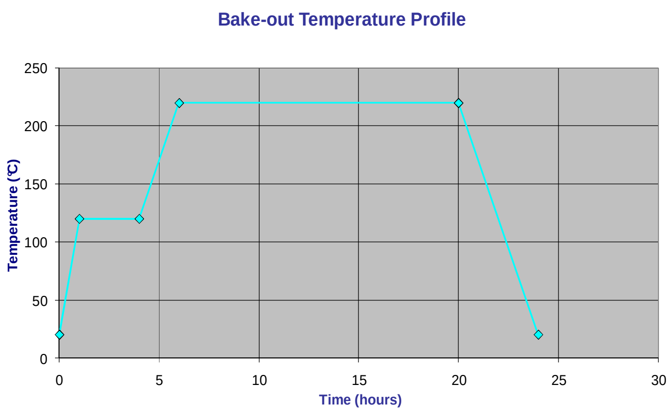
The controller has a multi-step ramp/soak bake out sequencer which integrates pressure and external interlocking, and provides auto-degassing of ion gauge. Version 2.40 added dual zone control.

8.1 Overview

The schematic (below) 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 (see section 6.2), the green blocks represent the second zone. Key features:

- A 6 step ramp/soak timer (each step up to 99.0 hours) drives the bake-out control, and provides for optional ion gauge degas at the end of bake-out
- For maximum flexibility, each zone has a separate 6 step temperature profile. Use of temperature ramps avoids pressure bursts and temperature overshoot.
- Any combination of the 7 trips can be assigned to either zone to switch the heaters
- Ion gauge interlocking options include tripping the heaters, suspending timer operation or aborting the bake-out in response to user-defined over pressure
- Externally-driven interlocking options include tripping the heaters, suspending timer operation or aborting the bake-out in response either or both digital inputs. This permits external gauge controllers or safety interlocks to affect bake-out
- For dual zone configurations, in addition to running both zones simultaneously (e.g. for system bake-out) zones can be run separately (e.g. to degas a load-lock heater, or entry chamber).





8.2 Single Zone Operation

In the absence of the 'K' module, the controller can only operate in single zone mode. In this mode, all menu options relating to dual zone operation (see section 12.5.6) are not accessible from the menu (although they can be accessed over comms).

The graph, left, provides an example of a single-zone 5 step bake-out sequence. The use of temperature ramps helps avoid pressure bursts during heating and temperature overshoot. Each step can be set for a duration of up to 99 hours.

Requirements:
- Type K thermocouple assembly connected to the thermocouple input.
- One or more power relays/contactor for heater switching (for example, see section 3.6.4).

To set up:
- Using the Bake-out menu (see section 12.5.6), set up to 6 time periods representing each step using the 6 Step*x* Time menu items. Set any unused steps to 0.0hours.
- For each step, set the temperature required at the end of that step using the Zone 1 Step*x* Temp menu items. Note that if a value is different from the previous step, the temperature is ramped linearly during that step.
- Set the ion gauge interlock requirements. The Zone 1 PresTrip menu item sets the pressure trip value. The Zone1 PresAction menu items set the action that will be taken on exceeding the trip value, e.g. no action at all, or turn heaters off until pressure recovers (with or without suspending the timer count-down), or terminating the bake-out.
- If required, set whether one or both digital inputs should influence bake-out using the Zone1 DITrip and what action to take (Zone1 DIAction) menu options
- If required, set the temperature on/off hysteresis (usually left as 0°C)
- Set whether the ion gauge will be degassed at the end of the bake-out.

8.3 Dual Zone Operation

For Dual Zone Operation, a 'K' module needs to be fitted in the options slot. This will automatically provide access to the additional parameters associated with dual zone operation from the front panel.

Requirements:
- Type 'K' module fitted in the options slot
- 2x Type K thermocouple assemblies
- Two or more power relays/contactors for heater switching (for example, see section 3.6.4).

To set up:
- Using the Bake-out menu (see section 12.5.6), set up to 6 time periods representing each step using the 6 Step*x* Time menu items. Set any unused steps to 0.0hours.
- Set zone 1 temperature profile. For each step, set the temperature required at the end of that step using the Zone 1 Step*x* Temp menu items. Note that if a value is different from the previous step, the temperature is ramped linearly during that step.
- Repeat for zone 2 temperature profile.
- Set the ion gauge interlock requirements for Zone 1. The Zone 1 PresTrip menu item sets the pressure trip value. The Zone1 PresAction menu items set the action that will be taken on exceeding the trip value, e.g. no action at all, or turn heaters off until pressure recovers (with or without suspending the timer count-down), or terminating the bake-out.
- Repeat for ion gauge interlock requirements for Zone 2.
- If required, set whether one or both digital inputs should influence bake-out using the Zone1 DITrip and what action to take (Zone1 DIAction) menu options
- Repeat for zone 2.
- If required, set the temperature on/off hysteresis (usually left as 0°C)
- Set whether the ion gauge will be degassed at the end of the bake-out. The options allow for the degas to depend on neither, either or both zones being run.

8.4 Operating the Bake-out

A zone bake-out sequence can only be started if thermocouple connected. Also, if a zone requires ion gauge interlocking, the ion gauge must be switched on. If no ion gauge interlocking is required, bake-out can be started even with the ion gauge switched off; this option allows for bake-out to be controlled solely on the basis of external interlocks (e.g. from external gauge controllers). Bake-out is started and stopped from the **Bake-out** Menu; for dual zone configurations, options are provided to run either or both zones. Once operating, error conditions, such as thermocouple open-circuit or ion gauge failure will inhibit or terminate bake-out.

Bake-out status is indicated via the setpoint and measured temperature, remaining time and/or bake-out error status (see section 11.6). In addition, the peak temperature achieved during the bake-out is inspected.

9 Dual (Combined) Gauge Mode

Dual Gauge Mode combines the ion gauge with either the built-in Pirani or a gauge connected to a module so they operate as a single pressure measurement device.

Note: DGM replaces and extends the Pump-down facility in controllers with software earlier than version 2.47.

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. When the SG pressure falls below the user-defined IG On (SG) value, the ion gauge automatically turns on and if the ion gauge pressure then rises above the user-defined IG Off (IG) value, the ion gauge is turned off and pressure indication reverts to the SG value. The transition from one gauge to the other is seamless, so pressure measurement is continuous.

Typical applications include:

- Extending the ion gauge pressure range to atmosphere (by combining with a high pressure gauge, e.g. Pirani, or Convectron).
- Restricting the range of operation of the ion gauge in preference to some other higher vacuum gauge head to avoid, for example, a pressure regime where process gases could damage an operating ion gauge filament.

When DGM is operating, the ion and secondary gauge head names, as displayed by the controller, have an an asterisk appended , e.g. "**IG ***" and "**SG ***".

9.2 DGM and Menu Parameters

DGM is controlled by the **Dual Gauge Menu** parameters. The "active gauge" (i.e. the one from which the pressure is displayed) is determined by the IG On (SG) and IG Off (IG) parameters. As long as SG's pressure exceeds IG On (SG), the SG is the active gauge and the IG remains off. When the pressure falls below this value, and after a brief delay set by the IG On Delay parameter, the controller attempts to start the ion gauge; if successful, IG becomes the active gauge and its pressure value is used. If the pressure, as measured by the ion gauge, then rises above the IG Off (IG) parameter value, the ion gauge turns off and pressure indication reverts to that of the SG.

The following additional parameters enhance flexibility and/or protection:

- If the IG SGProtected parameter is set to ON, when IG is the active gauge, the controller checks both the IG pressure AND the SG pressure; if **either** the IG pressure exceeds IG Off (IG) **or** the SG pressure exceeds IG On (SG), the ion gauge trips out and SG becomes the active gauge.
- The IG DIProtect parameter allows an external interlock to monitored by digital input(s) to inhibit ion gauge. Note: if the ion gauge is running, it will turned off if the allocated DI fails.
- The IG On Attempts parameter sets the maximum number of times the controller will try to start the ion gauge when permitted to do so by the SG pressure. If the controller fails after the specified number of attempts (e.g. due to an ion gauge fault), DGM is cancelled, and the appropriate error message is displayed. Note the attempt will be made on both filaments if the Filament # is set to Auto, otherwise the only the specified filament is used in the attempt.
- The DGM Operation parameter provides safety/operation options, particularly in the event of a power cut where the controller restarts. The default setting (PwrUp Reset) is that DGM is cancelled (i.e. no SG) on power up of the controller. Setting to NO PwrUp Reset means that if an SG is selected prior when switched off, the controller will commence DGM immediately on power up, i.e. the selected SG is the active gauge. A setting of Once: PumpDown will start DGM operation, but it is cancelled as soon as the ion gauge is successfully started; this option is useful for "one shot" operation as required, as required, for example, when pumping down a vacuum chamber from air.
- Note also the Dual Gauge option for allocating a trip using Trip *x* Allocation. The pressure value set in Trip at< then applies to whichever of the gauges is currently active.

9.3 Safe DGM Operation

- DGM **MUST** be used with a combination of 2 gauges on a single flange, or with 2 gauges mounted separately ***but within the same vacuum envelope***.
- 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 WModule: Power parameter is set to Always ON.
- To avoid damaging the ion gauge head or vacuum system, only use the NO PwrUp Reset if sure that it is safe for DGM operation to resume immediately on power up.
- To preclude "hunting" (i.e. where the ion gauge is turned on and then immediately turns off because IG Off (IG) pressure is immediately exceeded), gauges should be calibrated. In addition the controller adds hysteresis by not allowing IG On (SG) to exceed IG Off (IG).

9.4 Auto-cancellation of DGM Operation

For safety reasons, DGM operation is automatically cancelled (i.e. the DGM SecGauge will be set to Off) under the following conditions:

- If the ion gauge is turned off by the user either from the front panel or over comms
- If the ion gauge trips off, for example, due to over-pressure being detected
- If the ion gauge fails to start after the specified number of attempts

10 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.

10.1 Ion Gauge Calibration

Ion gauges do NOT measure absolute pressure. As discussed in section 5, variations in mechanical construction (Sensitivity), dominant gas species (Relative Gas Sensitivity), gauge/filament ageing and air exposure (requiring degas) all affect measurement accuracy. Other controller related factors, such as emission current accuracy, and electrometer precision and non-linearities, also play a part; these latter are calibrated against standards during manufacture of the controller to minimize these affects.

Well-documented techniques, such as ensuring gauge orientation to minimize the effects of filament droop, thorough degassing of the gauge, using the correct emission current for the pressure range (or using auto-emission) can ensure long-term reproducibility of measurement.

10.2 Pirani Gauge calibration

A Pirani gauge rely on measuring the effect on the resistance of a heated filament to thermal losses due to vacuum level in the "laminar flow" regime, over the range of ~100 to ~0.001mBar. As they are prone to variations in ambient temperature, they often incorporate thermal sensors to compensate. Unfortunately, manufacturing tolerances in filament resistance between identical Pirani heads of the same type can be very high (up to 15%).

The Calibration Menu provides a method for the user to "calibrate" the controller to match a specific Pirani gauge head. This applies to both built-in and module-based gauge heads:

1) Ensure that the controller is correctly set for the gauge type.
2) Mount the Pirani gauge and connect to the controller built-in Pirani or module input.
3) Expose to atmosphere.
4) Allow several minutes for the gauge to settle. The controller should display atmosphere, or a "high" pressure.
5) Select SetPir@Atmos parameter for the built in Pirani, or the SetMod@Atmos parameter for a module-based Pirani. Select "YES" and press the OK button to set the correction factor at atmosphere. The indicated pressure should then be atmosphere.
6) Evacuate the Pirani gauge vacuum line. This can be done to a known pressure (by comparison to a calibrated gauge - see 6a), or by evacuating to a pressure near or below 1e-4mBar (for example by exposure to the high vacuum system - see 6b). Select the SetPir@Vacuum parameter for the built in Pirani, or the SetMod@Vacuum parameter for a module-based Pirani; the actual pressure will be indicated.
   6a) For comparison with known pressure, use the UP and DOWN buttons to match the standard gauge reading; then press the OK button to retain the new calibration value.
   6b) For evacuation to low pressure, when the pressure is known to be ~1e-4mBar or below, use the UP and DOWN buttons to ensure that the pressure reading is ***just above*** 1e-4mBar.

More information about the Calibration parameters is provided in section 12.5.8.

10.3 Thermocouple Input Calibration

Temperature measurement using thermocouples (type K for the controller input) have three small sources of error: small variations thermocouple materials, cold junction sensor accuracy and component tolerances in the measurement electronics. The latter two can be corrected from the Calibration Menu:

1) Short-circuit the thermocouple input and allow a couple of minutes to ensure thermal stability. Select SetTC@0mV and press the OK button to set the room temperature condition.
2) Apply a 10mV dc voltage to the input from a precision voltage source - preferably use a type K connector and allow 5 minutes for thermal stability. Select SetTC@10mV and press the OK button to set the "high" temperature calibration point.
3) Note: this input is factory calibrated during manufacture.

10.4 "E", "F" and "V" Module Calibration

The "E", "F" and "V" modules support three different types of Pirani gauge head - see section 6.2. The calibration procedure is described in section 10.2.

10.5 'K' Module Calibration

The "K" module uses hardware calibration and is set-up at the factory. It should not need recalibration.

11 Controller Displays and Gauge Positions

This section describes the operating modes and the user-configurable aspects of displaying gauge information.

11.1 Displays

The controller has 2 displays, a 100x16 pixel graphical (left), and a 2 line, 16 character (right). There are 2 modes of operation of the controller which govern the way the displays are used: the **Status** mode provides information about the gauges and controller operation, and the **Edit** mode modifies parameters (see section 12). Note that if in Edit Mode, the controller automatically reverts to Status mode if no buttons are pressed for more than 5 minutes.

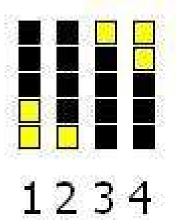
11.2 The Status Mode

The default Status mode is used to display the conditions of the gauges, gauge status, trips, digital inputs, bake-out and DGM status, and any fault conditions. The configuration of gauges in Status Mode can be changed using Gauge Positions parameter in the Setup Menu - see section 11.3.

11.2.1 Status Mode - Left Hand Display

The two examples show the information in the left hand display:

- The 4 character user-defined name of the selected "primary" gauge (see "Gauge Positions" section 11.3) is displayed top left (see also section 12.5.9: IonGauge Name, Pirani Name and Module Name parameters).



- Bottom left: the status of the seven trips (7 left-hand bars) and two digital inputs (2 right-hand bars). The picture right shows the indication of the pixels for the 4 trip and digital input states: 1: OFF, 2: Inhibit, 3: Override and 4: ON.
- The body of the display shows the primary gauge value (in large numbers) and units, or the gauge status (e.g. Ion Gauge Off), and a trend arrow.
- The top right-hand pixel of the display flashes briefly whenever valid data is received over the communications bus and the controller has responded.

11.2.2 Status Mode - Right Hand Display

In Status Mode, the right hand display can be scrolled through 4 "pages" using the UP and DOWN buttons:

- **Pages 1 and 2** show information as selected using Gauge Positions parameter in the Setup Menu - see section 11.3. For example, this view shows the Standard option with the Pirani pressure and thermocouple input on the top line, and the ion gauge emission status (emission setting/measured emission and power output) on the bottom line:

- **Page 3** indicates DGM status (see section 9). If digital input interlocking is enabled (as shown), the "Go" or "NoGo" message indicates interlock status. When the Secondary gauge reaches the ion gauge start pressure, the bottom line indicates the start-up attempt status.
- **Page 4** indicates bake-out status.

11.2.3 Bake-out and Dual Gauge Mode Summaries

During bake-out or Dual Gauge Mode (DGM - see section 9) operation, the bottom line of pages 1 and 2 toggle between the gauge position selected information and a summary of the Bake-out or DGM status.

11.3 User Configuration using the Gauge Positions Parameter

The Gauge Positions Parameter allows the user to select where the ion gauge, Pirani and Module readings, and the ion gauge status information are displayed in the left-hand display (the "Primary gauge") and in pages 1 and 2 of the right-hand display.

The following table shows the various parameter values for the Gauge Positions Parameter and the resulting display information. Note that, aside from the Standard setting, which also allows for the measured thermocouple temperature to be shown thus precluding space for the Pirani name, all gauges positions are accompanied by the gauge name:

<table>
<tr><th rowspan="2">Setting</th><th rowspan="2">Left Display (Primary gauge)</th><th colspan="2">Page 1</th><th rowspan="2">Page 2</th></tr>
<tr><th>Top Line</th><th>Bottom Line</th></tr>
<tr><td>Standard</td><td rowspan="5">Ion Gauge</td><td>Pirani gauge and thermocouple readings (no names)</td><td rowspan="2">Ion G emission status</td><td rowspan="2">Module</td></tr>
<tr><td>IG Pir/Status</td><td rowspan="2">Pirani Gauge</td></tr>
<tr><td>IG Pir/Mod</td><td>Module</td><td rowspan="2">Ion G emission status</td></tr>
<tr><td>IG Mod/Pir</td><td rowspan="2">Module</td><td>Pirani Gauge</td></tr>
<tr><td>IG Mod/Status</td><td rowspan="2">Ion G emission status</td><td>Pirani Gauge</td></tr>
<tr><td>Pir IG/Status</td><td rowspan="4">Pirani Gauge</td><td rowspan="2">Ion Gauge</td><td>Module</td></tr>
<tr><td>Pir IG/Mod</td><td>Module</td><td rowspan="2">Ion G emission status</td></tr>
<tr><td>Pir Mod/IG</td><td rowspan="2">Module</td><td>Ion gauge</td></tr>
<tr><td>Pir Mod/Status</td><td rowspan="2">Ion G emission status</td><td>Ion Gauge</td></tr>
<tr><td>Mod IG/Status</td><td rowspan="4">Module</td><td rowspan="2">Ion Gauge</td><td>Pirani Gauge</td></tr>
<tr><td>Mod IG/Pir</td><td>Pirani Gauge</td><td rowspan="2">Ion G emission status</td></tr>
<tr><td>Mod Pir/IG</td><td rowspan="2">Pirani Gauge</td><td>Ion Gauge</td></tr>
<tr><td>Mod Pir/Status</td><td>Ion G emission status</td><td>Ion Gauge</td></tr>
<tr><td>Dynamic</td><td colspan="4">See text</td></tr>
</table>

Unlike the other settings which "lock" the positions of the gauges to those set, Dynamic allows the user to make changes to the configuration on the fly from the Status Mode; this is useful where frequent changes in gauges positions are required. Each time the ENTER button is pressed whilst in Status Mode, the configuration advances to the next setting listed in the table, wrapping around from Mod Pir/Status to Standard.

Note that Gauge Positioning interacts with Screen-saver and quiet modes and may result in one or more of the displays and/or pages being blank.

11.4 Screen-Saver and Quiet Modes

Version 2.20 introduced the Screen saver and Quiet modes, selected from the Setup Menu:

- If Screen Saver Mode is enabled and no button action occurs for more than the Screen Saver Time value, the left-hand screen is blanked and the currently selected main gauge is displayed on the right hand screen. Pressing any of the buttons causes full display operation to resume.
- If Quiet Display Mode is enabled, 521 and 841 Pirani values are not displayed if no Pirani head is connected, temperature information is blanked if no thermocouple is connected, and the module secondary display is inaccessible in the absence of a module. Indication of communications is also suppressed.

12 Parameters

This section provides details of the controller parameters accessible manually and via the communications bus.

12.1 Parameters and the Menu Structure

The controller is operated by changing the values of "Parameters" in the **Edit** mode. Parameters can be volatile (i.e. their values are temporary, such as the value of the emission whilst the ion gauge is operating), or non-volatile (i.e. their value is saved even when power to the controller is off, for example, the allocation of a Trip).

Parameters are grouped by **Menu**; for example, all parameters associated with Trip 5 under the Trip 5 Menu.

All Parameter editing is performed on the 2 line Data Edit display; the top line indicates the Parameter name, and the bottom line the possible settings which are changed using the UP or DOWN buttons.

12.2 Navigating the Menus

Repeatedly pressing (or holding down) the MENU button scrolls the controller through the menu headings:

Data Edit Pages Set Emission Ion Gauge Menu Module Menu

Trip 1 Menu ... Trip 7 Menu

Digital Input 1 Menu Digital Input 2 Menu Analogue Out Menu Bake-out Menu

Dual Gauge Menu Calibration Menu Setup Menu (returns to Ion Gauge Menu)

To enter a Menu, so that, for example a parameter can be edited, press the OK button, revealing the first parameter. Then, pressing the MENU button repeatedly (or holding the button) will scroll through all the parameters in the menu.

To exit a Menu, press the CANCEL button.

12.3 Locked and Accessible Parameters

On first accessing a parameter, an equals symbol '=' indicates the value is current and can be edited, or a key symbol, indicating it is locked. Locked parameters are either for information only (such as software version), or are intentionally inaccessible, for example, when the ion gauge is operating, the user cannot change the filament number.

12.4 Changing a Parameter

If a parameter has an unlocked status (the parameter terminates with '='), the value can be changed pressing the UP or DOWN buttons. ***Note: holding the UP or DOWN buttons causes the parameters to change continually; the speed of parameter change will increase if the button is held.***

If the currently displayed value of the parameter is not the same as that currently being used, the '=' changes to '?'. To accept the new value, press OK. Pressing CANCEL exits the menu to return to the Menu Heading.

12.5 Parameters

This section lists the controller parameters by Menu. The "stored" column indicates whether the value is retained during power off (non-volatile) or whether the parameter is provided for information purposes only.

12.5.1 Emission

Parameter	Store	Description
Emission	N	**Emission Value** If the ion gauge is off, the options range from the MinEmission to the MaxEmission Parameter values, and Auto. If the ion gauge is already on and the pressure is less than that set in the DegasSuspend Parameter value, Degas Low, Mid and High are also available.

12.5.2 The Ion Gauge Menu

Parameter	Store	Description
DegasRampTime	Y	**Duration of Degas Ramp** 1 to 999 mins. Default = 10 mins
DegasHoldTime	Y	**Duration of Degas Hold** 1 to 999 mins. Default = 10 mins
AutoDegasLevel	Y	**Level for Auto-Degas Functions** This parameter controls automatic functions related with degas; for example, the degas level that is applied when auto-ion gauge degassing is requested at the end of bake-out. Low, Mid or High Degas. Default = Mid
DegasSuspend@	Y	**Pressure at which Degas timer is suspended** If exceeded, degas ramp is halted and timing is suspended. 1e-13 to 1e6
MinEmission	Y	**Minimum Emission Level** Minimum emission level that can be accessed by the user or Auto-emission. 0.05mA to MaxEmission Parameter value. Default = 0.05mA. This parameter is locked during ion gauge operation.
MaxEmission	Y	**Maximum Emission Level** Maximum emission level that can be accessed by the user or Auto-emission. MinEmission Parameter value to 10mA. Default = 10mA. This parameter is locked during ion gauge operation.
MinFilamentPower	Y	**Minimum Filament Power used by emission control PID loop and power up** Should be set to ~5% less than the value needed to achieve Minimum emission. 0 to MaxFilamentPower Parameter value. Default = 25%
MaxFilamentPower	Y	**Maximum Filament Power used by emission control PID loop** This parameter should be set to approx 10% higher than the current needed at the highest degas power used. MinFilamentPower Parameter value to 100%. Default = 75%
IonG PropBand	Y	**The Proportional Band value used by the Emission Control PID loop** 1 to 99. Default = 25 (this should operate with most ion gauge heads)
IonG Damp	Y	**Sets the Integral and Derivative terms for the Emission Control PID loop.**

		1 to 99. Default = 25 (this should operate with most ion gauge heads)
DIgIn1Mode	Y	**Action of Digital Input on ion gauge operation**
DigIn2Mode	Y	- None. No effect. - Interlock. Used to interlock ion gauge operation. If fails, turns ion gauge off - EmissionOn. When set, the ion gauge is powered up under Auto-emission setting. If the digital input fails, the ion gauge switches off. *Note: the ion gauge cannot be turned on manually if this option is set and the digital input is off.* - EmissionToggle. A brief (~ 1 second) on-off pulse at the digital input turns the ion gauge on (if off) or off (if on). Default = None.
Filament #	Y	**Filament Selection** Selects filament 1 or filament 2. If set to AUTO, the controller will attempt to establish emission using filament 1, and if this fails, attempt filament 2. 1, 2, AUTO. Default = AUTO This parameter is locked during ion gauge operation.
NewFilamentRamp	Y	**Ramping of new filament/gauge heads during gauge power up** – see 5.12.2 - Off. Normal ramp condition (Default). - Once. Slow ramp on next power-up of the ion gauge head. Clears once executed - Twice. Slow ramp for next 2 power-ups of the ion gauge head. Decrements on each execution. - Always. Always uses slow ramp.
GaugeSensitivity [mB^{-1}]	Y	**The sensitivity factor for the ion gauge** Note, regardless of the selected display units, this parameter is entered as mB^{-1} value. If given in $Torr^{-1}$ or $Pascal^{-1}$, convert using x1.32 or x0.001 respectively. 0.1 to 99.9. Default = 19.0
Gas Sensitivity [N2=1]	Y	**Relative Gas sensitivity** See section 5.2. 0.01 to 99.99. Default = 1.00 (nitrogen)
FilterTime	Y	**Filter time constant for collector measurement** Filters the measured ion current when calculating the pressure to remove noise. OFF, 0.1 to 9.9 seconds. Default = 1.0.
DecimalPlaces	Y	**Number of decimal places to display ion gauge pressure** 1 or 2. Default = 1
IonGRunTime	Y	**The cumulative time (hours) the ion gauge has been powered up** Time(h) or Reset. Selecting Reset sets the time to zero.

12.5.3 Trip *x* (1 to 7) Menu

There is one menu for each trip. *x* in each Parameter name is 1...7.

Parameter	Store	Description
Trip *x* State	Y	**Control of Trip** - Trip. Dictated by current trip allocation (Default) - Inhibit. Trip is permanently OFF - OvrRide. Over-ride; trip is permanently ON
Trip *x* Allocation	Y	**Trip Allocation** - None. Trip not used (Default) - IonGauge. Depends on ion gauge pressure. Polarity depends Trip *x* Direction and Trip *x* at parameters. - Pirani. Depends on Pirani gauge pressure. Polarity depends on Trip *x* Direction and Trip *x* at parameters. - BakeOut. During bake-out, state depends on bake-out temperature algorithm. - Module. Depends on module measured parameter. Polarity depends on Trip *x* Direction and Trip *x* at parameters. - DualGauge. Trips depending on which DGM gauge is displaying pressure. Polarity depends on Trip *x* Direction and Trip *x* at parameters. - IonGauge On. The trip is set when the ion gauge is on. - Degas On. The trip is set when the ion gauge is degassing
Trip *x* Direction	Y	**Selects whether trip operates above or below the Trip Level** If ion, Pirani or module gauge, state depends on whether less than or greater than the Trip *x* at value. < (less than) or > (greater than). Default: <.
Trip *x* at	Y	**Trip Level** The level at which the trip will operate; used in conjunction with Trip *x* Diection. 1e-13 to 1e+6. Default 1e+3.
Trip Hysteresis [x]	Y	**The Hysteresis Level for trips - this parameter applies to ALL Trips.** Defines trip band to avoid "cycling". For example, for a value of 2.0 at $1x10^{-6}$, the trip energizes at $1x10^{-6}$mBar but de-energizes at $2x10^{-6}$mBar. 1.0x (no hysteresis) to 99.9x. Default: x1.1

12.5.4 Digital Input *x* (1 to 2) Menu

There is one menu for each digital input. *x* in each Parameter name is 1 or 2.

Parameter	Store	Comments/Range
DigIn *x* State	Y	**Control of Digital Input State** - Trip. Dictated by external input (Default) - Inhibit. The digital input is permanently OFF regardless of input - OvrRide. Over-ride; the digital is permanently ON regardless of input
DigIn *x* Action	Y	**Action of the Digital Input** - Normal. Voltage present = ON (Default) - Invert. Voltage absent = ON

12.5.5 Analogue Out Menu

Parameter	Store	Comments/Range
AnalogOutAllocate	Y	**Allocation for the Analogue Output** - SetToMinimum. Outputs voltage corresponding to the AnalogOutDAMin value. - IonGauge. Output depends on Ion Gauge pressure. If the ion gauge is off, the voltage output corresponds to the AnalogOutDAMax parameter value. (Default) - Pirani. Output depends Pirani pressure value. - BakeTemp. Output depends on thermocouple input value. - DualGauge. Output depends on the DGM active gauge value. The AnalogOutPressMin and AnalogOutPressMax Parameters are treated as overall pressure range. - CommsExternal. Output is set over the communications bus. - Module. Output depends on measured value obtained from the module. - SetToMaximum. Outputs voltage corresponding to the AnalogueOutDAMax value.
AnalogOutPressMin	Y	**Pressure that minimum analogue output corresponds to** 1e-13 to AnalogOutPressMax parameter value. Default: 1e-13
AnalogOutPresMax	Y	**Pressure that maximum analogue output corresponds to** AnalogOutPressMin parameter value to 1e+6. Default: 1e+3
AnalogOutDAMin	Y	**Minimum D/A converter output** Bit count output corresponding to the AnalogOutPressMin parameter value. 0 to 4095 (12 bit range). Note: AnalogOutPressMin can exceed AnalogOutPressMax. **NOTE: Whilst being displayed, the output voltage corresponds to the** AnalogOutDAMin **value to allow the user to measure and set the value.**
AnalogOutDAMax	Y	**Maximum D/A converter output** Bit count corresponding to the AnalogOutPressMax parameter value. 0 to 4095 (12 bit range). Note: AnalogOutPressMin can exceed AnalogOutPressMax. **NOTE: Whilst being displayed, the output voltage corresponds to the** AnalogOutDAMin **value to allow the user to measure and set the value.**
AnalogOutFunction	Y	**Relationship between pressure and output voltage** logarithmic (Default) or linear.

12.5.6 Bake Out Menu

Parameter	Store	Comments/Range
BakeOut (single and dual*** zone options)	N	**Start/Stop Bake-out** If bake-out is prohibited, "---" is displayed. **Stop Bake-out** If bake-out is running, "Stop" is available **Single zone operation**: If conditions permit bake-out and bake-out is not running, "Start Zone 1" is available **Dual zone operation**:*** If conditions permit bake-out and bake-out is not running, available options are: "Start Zone 1", "Start Zone 2" and "Start Zone 1&2"
Step1 Time... ...Step6 Time	Y	**Duration of the bake-out step** 0.0 (Default) to 99.9hours
Zone1 Step1 Temp... ...Zone1 Step6 Temp	Y	**Final temperature for zone 1 step** 0 (Default) to 500°C
Zone2 Step1 Temp... ...Zone2 Step6 Temp***	Y	**Final temperature for zone 2 step** 0 (Default) to 500°C
Zone1 PresTrip	Y	**Ion Gauge pressure trip point for zone 1** Pressure limit for the bake-out. 1e-13 to 1e+6. (Default: 1e+3)
Zone1 PresAction	Y	**Action when ion gauge pressure exceeds zone 1 pressure trip point** - Trip Only. Trips are set to off. Temperature ramp and time countdown continues (Default). - Trip & Suspend. Trips are set to off. Temperature ramp and time countdown suspended.

		- Abort. Bake-out is aborted. Auto-degassing is ignored. - None. No Action
Zone1 DITrip	Y	**Selects Digital Input Interlocking for zone 1** - None. No DI interlock protection (Default) - DigIn 1. Digital input 1 interlock protection - DinIn 2. Digital input 2 interlock protection - DigIn 1&2. Both Digital Inputs provide interlock protection (OR function)
Zone1 DIAction	Y	**Action on zone 1 when digital input interlocking fails** See Zone1 PresAction for options
Zone2 PresTrip***	Y	**Ion Gauge pressure trip point for zone 2 -** see Zone1 PresTrip
Zone2 PresAction***	Y	**Action when ion gauge pressure exceeds zone 2 pressure trip point -** see Zone1 PresAction
Zone2 DITrip***	Y	**Selects Digital Input Interlocking for zone 2 -** see Zone2 DITrip
Zone2 DIAction***	Y	**Action on zone 2 when digital input interlocking fails -** see Zone1 DIAction
BakeTHysteresis	Y	**Temperature Control hysteresis for bake-out** Avoids on/off cycling ("hunting") when the measured and setpoint values are close. For example, at *X*°C and a hysteresis of *H*°C, trips turn on at *X*°C, and off at *(X-H)*°C. 0 to 99°C. Default: 0°C
BakeAutoDegas	Y	**Auto Degas ion gauge at end of bake-out sequence** The ion gauge degases at the AutoDegasLevel for the duration of the DegasRampTime and DegasHoldTimeT parameters Off (Default), On.
(Zone2 PeakTemp) ***	Y	**The peak measured temperature achieved during zone 2 bake-out** This read-only is reset at the start of a bake-out sequence. At the end of the bake-out, this value is stored to EPROM for subsequent viewing
(Zone1 PeakTemp)	Y	**The peak measured temperature achieved during zone 1 bake-out** This read-only is reset at the start of a bake-out sequence. At the end of the bake-out, this value is stored to EPROM for subsequent viewing

*** ONLY ACCESSIBLE FROM MENU IF 'K' MODULE INSTALLED IN SLOT ALLOWING DUAL ZONE BAKE-OUT OPERATION

12.5.7 Dual Gauge Menu

Note: Dual Gauge Menu replaces and extends the Pump-down Menu in controllers with software earlier than version 2.47.

Parameter	Store	Comments/Range
DGM SecGauge	N	**Selects Secondary Gauge for DGM Operation** - Off: No DGM Operation - IonG + Pirani: Ion gauge coupled with built-in Pirani - IonG +Module: Ion gauge coupled with gauge connected to module
DGM Operation	Y	**Dual Gauge Power Up and Operation** - PwrUp Reset: DGM operation is cancelled on power up of controller - NO PwrUp Reset: DGM operation starts as soon as controller is powered up. - Once: PumpDown: DGM operation when ion gauge starts.
IG DIProtect	Y	**Selects Digital Input Interlocking.** - None. No DI interlock protection (Default) - DigIn 1. Digital input 1 inhibits ion gauge operation - DigIn 2. Digital input 2 inhibits ion gauge operation - DigIn 1&2. Eith Digital Input failing inhibits ion gauge operation
IG SGProtected	Y	**Ion gauge Off Protect condition** - Off: Ion gauge turns off when ion gauge pressure exceeds IG Off (IG) pressure value - On: Ion gauge turns off when either ion gauge pressure exceeds IG Off (IG) pressure value OR secondary gauge exceeds the IG On (SG) pressure value
IG On (SG)	Y	**Secondary Gauge Pressure below which to attempt to start the ion gauge** 1e-13 to 1e+6 (Default: 1e-2)
IG Off (IG)	Y	**Ion Gauge Pressure above which ion gauge turns off** 1e-13 to pressure IG On (SG) value
IG On Delay	Y	**Delay Time before starts ion gauge** The time in seconds before the first attempt and between attempts to start the ion gauge when the Secondary has reached IG On (SG) 1 to 999 seconds. (Default: 10 secs)
IG On Attempts	Y	**Number of attempts to make to start the ion gauge** 1 to 9 (Default: 1)

12.5.8 Calibration Menu

On entering the calibration menu, all calibration parameters (except Unlock Calib) are locked. This allows parameters to be inspected but prevents accidental "recalibration". To execute a calibration, Unlock Calib must be set to “YES”. On leaving the calibration menu, all parameters will become locked again.

Parameter	Store	Comments/Range
Unlock Calib	N	**Allow Calibration menu to operate** To enable calibration, must be set to "YES" on each entry into this menu. NO (Default), YES.
PiraniType	Y	**Indicates Pirani Type** For information only; the controller reports the setting of internal jumpers to VSP84x or VSP52x gauge type.
SetPir@Atmos	Y	**Sets the calibration correction offset for the Pirani head at atmosphere** - see section 10. NO (Default), YES.
SetPir@Vacuum	Y	**Sets the calibration correction at the user-adjusted pressure**. Displays the current Pirani Pressure; Adjust to match the actual value using the UP and DOWN buttons. Press OK to set - see section 10 for further details.
SetTC@0mV	Y	**Set the calibration correction offset when thermocouple input is 0mV** See section 10. NO (Default), YES.
SetTC@10mV	Y	**Sets the calibration correction with thermocouple input at 10mV** See section 10. NO (Default), YES.

The remainder of the menu depends on the type of module installed:
"E", "F", "V" modules:

SetMod@Atmos	Y	**Sets the calibration correction offset for the gauge attached to the module at atmosphere** - see section 10. NO (Default), YES.
SetMod@Vacuum	Y	**Sets the calibration correction at the user adjusted pressure**. Displays current Module value. Adjust to match the actual value using the UP and DOWN buttons. Press OK to set - see section 10.

"U" and "W" modules:

Function	Y	**Input/pressure Relationship** Logarithmic (Default) or Linear
PressureMin	Y	**Pressure at minimum input** 1e-13 to 1e+6 (Default: 1e+3)
PressureMax	Y	**Pressure at maximum input** 1e-13 to 1e+6 (Default: 1e+3)
InputMin	Y	**Minimum voltage input** 0.000 to 9.999V. Note that if the module jumpers are set to 3V or 1V full-scale, the parameter values entered must be 3.333x or 10x required. (Default: 0.000V)
InputMax	Y	**Maximum voltage input** 0.000 to 9.999V. Note that if the module jumpers are set to 3V or 1V full-scale, the parameter values entered must be 3.333x or 10x required. (Default: 9.999V)

12.5.9 Setup Menu

Parameter	Store	Comments/Range
IonGauge Name	Y	**4 character Name (shown on primary display when ion gauge data shown)** Enters the name one character at a time, pressing the OK button to move to the next parameter. Forth OK confirms the full name.
Pirani Name	Y	**4 character Name (shown on primary display when Pirani data shown)** See IonGauge Name Parameter
Module Name	Y	**4 character Name (shown on primary display when module data shown)** See IonGauge Name Parameter
IonGaugeUnits	Y	**Measurement units for the ion gauge** Pressure (as defined in PressureUnits parameter) or collector current (auto-ranging units (pA, nA, µA or mA) and format (x.xxx, xx.xx or xxx.x))
PressureUnits	Y	**Units for display of pressure information** mBar, Torr, Pascal. (Default: mBar) *Changing the pressure units will immediately affect the displayed values. However, pressure setting values (e.g. Trip levels, Bake-out pressure limit...) remain fixed at their numerical values (e.g. a value of 1e-3 would change from 1e-3 mBar to 1e-3 Pascal). Pressure setting values will therefore have to be changed to retain their absolute values.*
Gauge Positions	Y	**User-defined positions of Gauges** See section 11.3
Display Mode	Y	**Parameter display option** If set to Quiet, data for absent devices is not shown if device not connected/absent, and no communications indication. Full, Quiet (Default: Full)

ScreenSaver Mode	Y	**Turns screen saver on or off**
ScreenSaver Time	Y	**Time after a button press before screen saver initializes** 1-999 minutes
Extend Ion Gauge	Y	**Extends pressure range when ion gauge is off** - IonGauge Only. Always shows ion gauge status with ion gauge name top left. - IonG & Pirani. When the ion gauge is off, shows the Pirani gauge pressure with the Pirani gauge name top left. - IonG & Module. When the ion gauge is off, shows slot module measured value with Module Name top left.
Comms Address	Y	**Communications Bus Address** 1 (default) to 99. Address of controller on an RS232 or RS485 bus
Comms Protocol	Y	**Communications Protocols** (see section 14) MODBUS:LITend (default), MODBUS:BIGend, QUICKComm, QueBUS-NoCheck, QueBUS+CS, QueBUS+CRC
Comms BaudRate	Y	**Communications Baud Rate** 9600, 4800, 19200 (Default), 38400, 57600, 115200 All controllers on an RS232 or RS485 bus MUST have same Baud Rate setting
Comms Parity	Y	**Communications Parity** None (Default), Even, Odd. All controllers on an RS232 or RS485 bus MUST use same Parity setting
Comms Indicator From version 2.34	Y	**Comms Display Indicator**. If on, flashes top right-most pixel of main display on receipt of comms message. Off (Default), On.
(Version)	Info	**Software Version** In form: *xx.yy* where *xx* is major release version and *yy* minor release version
(HeatsinkTemp)	Info	**Internal Heatsink Temperature** INFORMATION ONLY: Indicates the current temperature of the heat-sink.

12.5.10 Module Menu

The Module Menu (between the Ion Gauge and Trip 1 Menu) only appears for some modules:

Parameter	Store	Comments/Range
WModule: Power	N	**Module "W" output power** Turns power out of module to device on or off. As well as manually set "OFF" and "ON", the "Always ON" setting powers up the module when the controlled is powered up.
WModule: Pullup	Y	**Module "W" Pull-up on/off when output power is off** Selects if the software pull-up (to max value) applies when "W" output power is off

13 Troubleshooting

This section lists problem symptoms along with suggested solutions. If the problem persists, contact your supplier.

13.1 Operation

Symptom	Cause
Instrument will not start: no display	1. Check Mains voltage selector is set correctly. 2. Check mains fuses (both neutral and live are fused)
Does not restart after brief power down	Under some circumstances, instrument may not restart (e.g. no display or operation) after brief power down or brown-out. **Solution**: Turn off for 10 seconds then back on.

13.2 Ion Gauge

Symptom	Cause
NO Ion Gauge message on front panel	1. Ion gauge power cable not connected 2. Interlock connection (pins 1 & 3) not made (section 3.5)
No HiVoltage message on front panel	Fault on either the grid of filament bias power supply: 1. Ion gauge head for short-circuit between grid/filament/ground. 2. High voltage grid fuse (100mA - MUST be type "F" (fast)) 3. Ion gauge lead damaged.
OverTemp or UnderTemp message	Over or Under temperature. Check heatsink temperature in the Setup menu. If under temperature, usually caused by A/D fault. If over temperature, ensure fan operates.
Ion gauge emission cannot be established or has failed: EmFail message	1. Filament blown. Check filament integrity. Try second filament 2. 5A(F) filament fuse(s). MUST be type F (fast)

Ion gauge will not start	3. Filament type not Ir-based. 4. Inhibited by digital inputs if assigned to interlock the gauge
OverPress message	1. Vacuum system above 10^{-2}mBar 2. Sensitivity parameter set to correct value?
MaxPower Er message (added v2.08)	1. Max power setting too low to allow requested emission. 2. Problem with filament. Coating absent or aged
Unstable pressure measurement (e.g. drifts around)	Ensure electrical integrity of the gauge collector lead and connector
Ion gauge repeatedly trips during degas	1. Dirty gauge head. Try long degas ramp time at Low Degas level for initial cleaning 2. Check for good electrical isolation from the grid to the filaments and to ground at the gauge connector. Clean gauge thoroughly. 3. Inhibited by digital inputs if assigned to interlock the gauge

13.3 Digital Output Trips

Symptom	Cause
Does not operate as expected	1. Check trip menu parameter allocations and values 2. Check direction, trip level and hysteresis parameters
Trip on and off pressures different. Trip cycles on/off ("chattering")	1. Set Hysteresis parameter appropriate to the process

13.4 Digital Inputs

Symptom	Cause
Do not have desired effect on gauge or other processes	1. Check digital inputs are being sensed (as indicated on Main Display) 2. Check the digital input menu parameter allocations and values 3. Check the gauge or other process dependences (within their own menus) for correct parameter assignments

13.5 Pirani & Secondary Pressure Modules ("E", "F", "V", "U" & "W")

Symptom	Cause
Incompatible connector type VG Pirani	An adaptor cable is available to connector old-style VG Pirani heads
Device powered by type "U" or "W" module does not operate correctly.	If powered from "U" or "W" module, check the supplied voltage in case current limit (~120mA) exceeded
Erroneous pressure indication	1. Check connecting cable 2. Recalibrate the gauge head using the Calibration Menu 3. "U" or "W" module. Check range and pressure settings

13.6 Thermocouple/Bake-out

Symptom	Cause
Persistent sensor break indication	1. Check the thermocouple integrity and lead 2. Check controller reads room temperature with shorting link input
Wrong temperature indication	Ensure that type K thermocouple is used
Cannot start bake-out No heating	1. Ensure ion gauge is on 2. Check digital input interlocks are made
Bake-out timing is too short or too long	1. Check time and temperature parameters in the Bake-out menu 2. Set/reset the pressure and digital input action parameters
On/off control cycles or chatters Large temperature oscillation occurs	Set bake-out hysteresis parameter appropriately for the process (usually 1-2°C is sufficient)
Ion gauge auto-degas at end of bake-out trips the ion gauge	Add a bake-out step to allow system cool down and pressure to recover

13.7 Analogue output

Symptom	Cause
Output voltage for the pressure value	1. Ensure log/lin function is set appropriately. 2. Adjust analogue output/voltage values
The output voltage range is too large/small for the voltage monitor	Adjust the minimum and maximum analogue output values to correspond to the minimum and maximum required output

14 Serial Communications

Computer control over the RS232/RS485 bus of all aspects of controller operation is available via 2 different protocols:
***EMCOMM** is MODBUS-based and provides fast full control over all aspects of the device.*
***QueBUS** is a simple ASCII-based protocol (which has superseded QUICKComm)*
Both Protocols support transfer of multiple parameters within a single communications exchange

14.1 Introduction

The instrument provides several different methods of accessing all the parameters over a serial comms link:

- **EMComm** (see section 14.3) is a robust binary-level MODBUS-based protocol. Key features: complete control over controller operation, reading ***and*** writing multiple parameters within a comms exchange, high efficiency and speed, high integrity. Direct floating point data transfer. Big and Little Endian data transfer formats supported. For more information and sample code, please refer to the **EMComm Handbook**.
- **QueBUS** (see section 14.4) provides the same level of control as EMComm, including multiple parameter reads and writes within a single comms exchange, but is ASCII character-based. *Note: QueBUS has superseded the limited access QUICKComm protocol. Although not included in this manual, for those users already using QUICKComm, controllers will continue to respond to QUICKComm messages (if selected in the protocol parameter). However, porting to QueBUS is recommended due to its many advantages.*
- **VacTools** is a free Windows application that monitors and controls vacuum systems via PVC controllers, providing graphical data presentation and full data logging. In addition, it can provide access to third-party software to all parameters with connected PVC's via a dll.

14.2 Common Requirements

14.2.1 Hardware

- RS232 and RS485 (3 wire) interfaces as standard. Both are "multi-drop" allowing several controllers to share the same port. See section 3.9.
- Two RJ56 sockets allow ease of daisy-chaining.
- Baud rate for RS232 & RS485: 2400, 4800, 9600, 19200, 38400, 57600 and 115200 baud (Note: high quality cable required for 115200 baud).
- Parity options: None, Even, Odd
- 8 bits, 1 start bit, 1 stop bit
- Address range 01 to 99.
- Communication latency (i.e. the response time of the controller to a command): typically 20-60ms (100ms max). If nothing returns within ~150msecs, it is safe to assume that the comms exchange has failed.

14.2.2 Timing Restriction - EMComm only

If using multiple daisy-chained controllers on a bus, please note:

- If one or more of the controllers run software **versions 2.10 or below**, a slight delay occurs in clearing the bus after each send/receive cycle. A 150ms break is recommended between receipt of a response and issue of the next command. **Alternatively, use RS232-specific daisy-chain leads, as described in section 3.9.3. See also VacTools manual**
- This restriction does NOT apply to controllers running **version 2.11 or above** (including use of QueBUS protocol).

14.2.3 Pressure values, Units and Pressure Settings Values

- All pressure values are returned over comms in display units. Please check the units-associated parameter before reading over comms
- If the ion gauge collector is set to display as current (rather than in pressure units), the value for the measure parameter is returned over comms in units of Amps (e.g. 2.500e-8 for a displayed value of 25nA).
- Changing the pressure units will immediately affect the displayed values. However, pressure setting values (e.g. Trip levels, Bake-out pressure limit...) remain fixed at their numerical values (e.g. a value of 1e-3 would change from 1e-3 mBar to 1e-3 Pascal). Pressure setting values will therefore have to be changed to retain their absolute values.

14.3 The EMComm protocol

14.3.1 Introduction

EMComm is based on the industry-standard MODBUS protocol; for more information, please refer to the "MODBUS Application Protocol Specification" available on-line from MODBUS.ORG.

To reflect the parameter structure of the controller, implementation differs from the standard:

- Only Function Code hexadecimal 17h (decimal 23) is used; this allows writing and reading of data within a single message transaction. All other function codes ("coils" etc) are NOT implemented.
- To facilitate floating point access, **all** controller parameters (including integer and flag parameters) are 32 bit, i.e. take up 2 MODBUS registers (2x 16bit MODBUS register WORDs, or 4x 8 bit BYTES). **Thus, all controller register parameter addresses are even (i.e. address 0, 2, 4, 6...)**
- Programmer selection between **LITTLE ENDIAN** (least significant byte first) or **BIG ENDIAN** (most significant byte first) data transfer. In the examples given, LITTLE ENDIAN representation is used.
- Up to 16 parameters that can be read and/or written within a single message.
- The "INVALID" data value allows parameters in the middle of a multiple write command to be ignored.

14.3.2 Messages

Communication from the PC/PLC (the client) to the controller (the server) is ALWAYS initiated by the client sending a message. The controller CANNOT initialize a communication.

14.3.3 EMComm message structure - the Frame

An EMComm message (referred to as a "Frame") from either the client or the server comprises:

Frame start	Device Address	Function Code	Data Package	CRC	End Indicator
(3.5 bytes)	1 byte	1 byte	n bytes	2 bytes	(3.5 bytes)
	01h-63h (1-99)	17h (decimal 23)			

- Frame start is assumed when there is no bus activity for more than 3.5 times the time required to transmit an 8-bit BYTE. Once started, messages MUST be sent contiguously, i.e. without interruption of the data flow.
- The first byte is the address 1-99 (01h-63h) of the controller.
- The second byte is the function code, and is ALWAYS 17h.
- The Data Package containing the parameter addresses to be written/read, the data and the amount of data.
- The 2 BYTE Cyclical Redundancy Check (CRC) is a highly efficient method of error detection.

14.3.4 The Structure of the CRC

The CRC detects transmission errors, offering 100% detection for single-, double- and odd-numbered bit errors, 100% on burst errors of 16 bits or less and >>99.9969% detection on burst errors in excess of 16 bits. ***If the controller device fails to verify the CRC, no reply is sent***.

The CRC is performed on all bytes within the frame. The algorithm used to generate the CRC is:

1. Create a 16 bit (WORD) CRC register and load with FFFFh.
2. Exclusive OR the first byte with the CRC register.
3. Shift the CRC register one bit to the right.
4. If the over-flow bit is set, exclusive OR the CRC register with A001h. If not, no operation.
5. Repeat 3 and 4 until 8 shifts have been performed.
6. Repeat steps 2 to 6 until all bytes have been exclusive OR'ed and shifted 8 times.
7. Append the lower BYTE of the CRC register to the message
8. Append the upper BYTE of the CRC register to the message.

The following 'C' code function shows that generating the CRC is an efficient and simple process:

```
// Generates crc check bytes and places these in lpCRC
// The initial message is pointed to by lpMess and the total message //  length (including address and function code bytes) are indicated //  in nMessLen
int zet_calc_modbuscrc
(unsigned char* lpMess, int nMessLen, unsigned char* lpCRC)
{
 int                    j;
 unsigned short int     wCarry, wNext, wCRC;
 // Initialise the CRC register…
 wCRC = 0xFFFF;
 while (nMessLen--)
 {
  // Cast the byte to a 16 bit value…
  wNext = (unsigned short)lpMess;
  // Exclusive OR it with the CRC register…
  wCRC ^= wNext;
  // Shift loop 8 times…
  for (j=0; j<8; j++)
  {
   // Save bottom bit…
   wCarry = wCRC & 0x0001;
   // Shift CRC register to the right by 1 bit…
   wCRC >>= 1;
   // If the saved bottom bit was set, EXOR with A001h…
```

```
  if (wCarry)
   wCRC ^= 0xA001;
 }
 // Next byte…
 lpMess++;
}
// Set upper byte of CRC register to second CRC byte…
lpCRC[1] = (unsigned char)(wCRC >> 8);
// Set the low byte of the CRC register to the first CRC byte…
lpCRC[0] = (unsigned char)(wCRC);
// Return the number of extra bytes…
return 2;
}
```

As an example of using such a function, to append the CRC to a message:

```
unsigned char    sMess[128];      // buffer for the message
int              nMessLen;        // Stores the message length so far
…
… Code to generate the message
…
nMessLen += zet_calc_modbuscrc(sMess, nMessLen, &sMess[nMessLen]);
// The nMessLen parameter will have been extended by 2 to indicate
//  addition of 2 bytes
…
… Send the message
…
```

To use the function to verify a CRC message…

```
unsigned char    sMess[128];      // buffer for the message
unsigned char    sCRC[2];  // buffer for the CRC
int              nMessLen;        // Stores the message length received (including the returned CRC)
…
… Read the message into sMess
… Store the number of character read in nMessLen
… Perform any checks (such as returned unit address and function code, is length valid for the number of parameters sent? etc.)
…
zet_calc_modbuscrc(sMess, nMessLen-2, sCRC);
// Note use of nMessLen-2 since we do not want to include
//  received back CRC in the CRC generation process
if ((sMess[nMessLen-2] == sCRC[0]) && (sMess[nMessLen-1] == sCRC[1]))
{
 // SUCCESS!!!!
}
else
{
 // ERROR PROCESSING!!!!
}
```

14.3.5 Data Package: Message Structure from the Client (the Command)

A communication is initiated by the PC/PLC sending data to and/or requesting data from the controller. Note: when constructing the data package, **BYTE order must correspond to the selected ENDIAN representation**.

14.3.5.1 READING DATA:

Following the address and function code, 4 BYTES indicate what data is to be **read**:

Address of first Parameter to be read		Number of Registers to be read	
Always 00h	Xxh	Always 00h	yyh

Note:

- Since parameters use 2 registers, the number of registers to be read is twice the number of parameters and is therefore also ALWAYS even.
- If no Parameters are to be read, all four BYTES MUST be set to zero.

14.3.5.2 WRITING DATA:

The above is followed by the data to be written to the controller. The first 5 BYTES of this section are the Address of the first Parameter to be written to, the number of registers (twice the number parameters) to be read, and the number of data BYTES to follow; the data BYTES are then appended.

Address of first Parameter to be written to	Number of Registers to write	Number of data Bytes (n)	Data

Always 00h	xxh	Always 00h	yyh	1 BYTE	*n* BYTES

Note:
- Since parameters use 2 registers, the number of registers to be written is twice the number of parameters and is therefore also ALWAYS even.
- If no Parameters are to be written, all five BYTES MUST be set to zero and no data appended.
- The number of data bytes value will ALWAYS be four times number of parameters (or 2 times the number registers) that are to be written.

14.3.6 The "Invalid" Parameter Value - FFFFFFFFh

When sending multiple parameters, any parameters that are not to be changed can be set with the "Invalid" parameter value of FFFFFFFFh. This implies that, by design, no parameter has this as a "valid" value.

14.3.7 Data Package: Message Structure From the Server (the Response)

On receiving a transmission:
- The controller checks the first byte for compliance of the address with its own settings. If this agrees...
- Checks the next BYTE is Function Code 23 (17h). If not, sends error message (section 14.3.8). If it agrees...
- Checks the integrity of the message by verifying the received CRC value. If this agrees...
- Looks to see if any parameters are to be written. If so, ignores any parameter values set to FFFFFFFFh (see 14.3.6). If an invalid value for a parameter is received, an error message is generated - see section 14.3.8.
- If all parameters correctly written, looks to see if any parameters are to be read - these can be the same or different parameters to those written. If so, these are prepared.
- Calculates a CRC.

A message is then returned that comprises:

Device Address	Function Code	Num of Data BYTES being returned	Data	CRC
1 BYTE	1 BYTE	1 BYTE	*n* BYTES	2 BYTES
01h-63h (1-99)	17h (decimal 23)	(0,4,8,12...)		

Note:
- The Client programme should check the address corresponds to that sent and that the second BYTE is 17h.
- Since each Parameter comprises of 2x 16 bit registers of 2x 8 bit BYTES, the number of data BYTES value is 0 or a multiple of 4. This value should be four times the number of parameters requested.
- Each parameter comprises of 4 BYTES in the Data section.
- The returned BYTE order depends on the selected ENDIAN representation.

14.3.8 Error Response

An error response message comprises 5 BYTES:

Device Address	Function Code + 80h	Error Code	CRC	
1 BYTE	97h	01h or 02h	MSB	LSB

The first BYTE is the address, followed by the (Function Code + 80h) i.e. a decimal value of 151. A single error code value follows and the message terminates in the CRC. The error codes are:

Code	Description
01h	Invalid Function Code, i.e. function code BYTE was NOT 17h
02h	Invalid Parameter Address or Value

14.3.9 Parameter Types

All parameters within the controller are 32 bit. The controller deals with 3 parameter types:
- **Integer Parameters**. These store 32 bit integer vales. They can either be real integers (-2147483648 to +2147483647) or unsigned integer types (0 to 4294967295) - determined by context
- **Flag Parameters** are unsigned integer types that store flags or combinations of flags. Note that since some of the parameters are composite (i.e. hold settings for several items), each settings has a "VALID" flag that MUST be set if that setting is to be changed when writing - see the parameter listing; if the xxxxxx_VALID flag is not present, the setting will be ignored within the parameter.
- **Floating Point Parameters**. Hold 32 bit floating point values. The floating point values are obtained by transferring the bit representation to type (**float**) - for examples, please see the EMComm handbook. This allows the client direct access to high resolution (floating point) values. The floating point data format used is the standard floating point IEEE format, as employed in most high level languages such as 'C', BASIC, Pascal, SCADA etc. with the following bit allocations:

SIGN	EXPONENT	FRACTION
Bit 31	Bit 30 to Bit 23	Bit 22 to Bit 0
±	2^7 to 2^0	2^{-1} to 2^{-23}

For more information and full worked code, please refer to the EMComm Handbook available from your controller distributor.

14.3.10 Parameter Listing

The controller has space for 128 parameters:

- The first 72 parameters are 32-bit integers, storing integer value and flags. The remainder are 32-bit floating point values
- All parameter addresses are even
- Not all parameters are used

The following table lists and describes the parameters in detail:

Parameter Address gives the decimal and hexadecimal value of the parameter address.
Parameter Name relates the parameter to its function.
Type indicates whether the parameter is an integer or a floating point value.
R/W indicates the Read and Write status. Parameters marked "R" can be read only. Parameters marked as "R/W" can be read from AND written to. Composite parameter may have several independently R/W values.
Description provides a detailed breakdown of the parameter function.

Para-meter Address	*Parameter Name*	Type	R/W	Description
0 – 00h	*Global ID*	Int	R	Returns a value of 58435650h [ASCII representation of "Controller"].
2 – 02h	*Firmware Version*	Int	R	Returns a value of 4558*xxyy*h, where *xx* is major version, and *yy* is sub-version; e.g. 45580101h indicates version 1.01. The value 58h [ASCII 'X'] identifies the unit
8 – 08h	*Communications*	Int	R	For internal use only. Holds information about comms address, settings, protocol.
14 – 0Eh	*Safety Status*	Int	R	Internally used.
16 – 10h	*Ion Gauge Name*	Int	R/W	4 ASCII character name displayed when the ion gauge status/pressure is displayed on the Primary Display. Valid characters are in the range 20h (space), '0' to '9', 'A' to 'Z', and 'a' to 'z'. Any spaces at the start of the name are removed so that the name starts with a valid character in the range 21h to 7Ah.
18 – 12h	*User ID*	Int	R/W	USER DEFINED IDENTIFIER. Can be used, for example, to automatically configure or identify specific units with a software object.
20 – 14h	*Module Name*	Int	R/W	A 4 ASCII character name displayed when the slot module status/pressure is displayed on the Primary Display. See "Ion Gauge Name" parameter for details
22 – 16h	*Pirani Name*	Int	R/W	A 4 ASCII character name displayed when the Pirani status/pressure is displayed on the Primary Display. See "Ion Gauge Name" parameter for details
24 – 18h	*Degas Ramp Time*	Int	R/W	**0 to 999 minutes**. DURATION OF DEGAS POWER RISE
26 – 1Ah	*Degas Time*	Int	R/W	**0 to 999 minutes**. DURATION OF DEGAS.
28 – 1Ch	*Degas Power*	Int	R/W	ULTIMATE DEGAS POWER REACHED AT END OF DEGAS RAMP TIME; power applied during the degas time or if Quick degas is initialized. Values are IGS_EM_DEGASLO (0Dh), IGS_EM_DEGASMID (0Eh) or IGS_EM_DEHASHI (0Fh).
36 – 24h	*Display Settings: Gauge Positions, Screen saver and Display Mode*	Int	R/W R/W R/W	Bits 000000FFh - Gauge Positions DS_GAUGE_VALID (0x00000080h) must be set to write value. DS_GAUGE_STANDARD (00000000h). DS_GAUGE_ION_PIR_EM (00000001h), DS_GAUGE_ION_PIR_MOD (00000002h), DS_GAUGE_ION_MOD_PIR (00000003h), DS_GAUGE_ION_MOD_EM (00000004h), DS_GAUGE_PIR_ION_EM (00000005h), DS_GAUGE_PIR_ION_MOD (00000006h), DS_GAUGE_PIR_MOD_ION (00000007h), DS_GAUGE_ PIR_MOD_EM (00000008h), DS_GAUGE_MOD_ION_EM (00000009h), DS_GAUGE_MOD_ION_PIR (0000000Ah), DS_GAUGE_MOD_PIR_ION (0000000Bh), DS_GAUGE_MOD_PIR_EM (0000000Ch), DS_GAUGE_DYNAMIC (0000000Dh), Bits 00000F00h – Display Quiet Mode on/off. DS_MODE_VALID (00000800h). Must be set to write value. Bits 00000100h turns on/off: DS_MODE_OFF (00000000h), DS_MODE_ON (00000100h) Bits 0000F000h – Display Screen Saver on/off. DS_SAVER_VALID (00008000h). Must be set to write value. Bits 00001000h turns on/off: DS_SAVER_OFF (00000000h), DS_SAVER_ON (00000001h)
38 – 26h	*Display Saver Time*	Int	R/W	**1 to 999 minutes**. Time between last key press and start of Display Screen Saver mode. Default: 5mins.
40 – 28h	*Remaining Degas Time*	Int	R	REMAINING DEGAS TIME: (Seconds). 0 if not in degas [v2.06 and above]
42 – 2Ah	*Ion Gauge running time*	Int	R/W	CUMULATIVE RUNNING TIME FOR ION GAUGE: (Minutes)
44 – 2Ch	*Unit Running Time*	int	R	CUMULATIVE POWERED UP TIME: (Minutes)
48 – 30h	*Pirani Vacuum Level Calibration*	int	R	PIRANI GAUGE CALIBRATION PARAMETER when calibrating for VACUUM. Range 200 to 800, default 500. [Can only be set from Calibration Menu]
50 – 32h	*Pirani Atmospheric Level Calibration*	int	R	PIRANI GAUGE CALIBRATION PARAMETER when calibrating for ATMOSPHERE. Range 200 to 800, default 500. [Can only be set from Calibration Menu]
52 – 34h	*Thermocouple Low Calibration*	int	R	THERMOCOUPLE CALIBRATION PARAMETER when calibrating at 0mV input. Range 200 to 800, default 500. [Can only be set from Calibration Menu]
54 – 36h	*Thermocouple High Calibration*	int	R	THERMOCOUPLE CALIBRATION PARAMETER SET when calibrating for 10.00mV input. Range 200 to 800, default 500. [Can only be set from Calibration Menu]

Para-meter Address	Parameter Name	Type	R/W	Description
56 – 38h	*Slot Low Level Calibration*	int	R	For "V", "E" & "F" modules, the PIRANI GAUGE PARAMETER when calibrating for VACUUM. Range 200 to 800, default 500. [Can only be set from Calibration Menu]
58 – 3Ah	*Slot High Level Calibration*	int	R	For "V", "E" & "F" modules, the PIRANI GAUGE PARAMETER when calibrating for ATMOSPHERE. Range 200 to 800, default 500. [Can only be set from Calibration Menu]
64 – 40h	*Global Settings*	int	 R/W R/W R/W R/W	GLOBAL FLAGS Bits F0000000h – Display setting. Selects what the display shows on front panel. GS_DISPLAY_VALID (80000000h). Must be set to write value. Bits 30000000h indicate the display type: GS_DISPLAY_SUMMARY (00000000h) default ion gauge display, GS_DISPLAY _SLOTS (10000000h) summary value for the 2 slots, GS_DISPLAY _BAKEOUT (20000000h) bake-out status, GS_DISPLAY _TIMER (30000000h) timer status Bits 00000F00h - Ion gauge display Units. Selects between ion gauge measurement being displayed in pressure units or as collector current. GS_IGUNITS_VALID (00000800h) Must be set to write the value Bit 00000100h selects units: GS_IGUNITS_PRESSURE (00000000h) unit as defined in GS_UNITS, GS_IGUNITS_AMPS displays collector current Bits 000000F0h – Pressure Units GS_UNITS_VALID (00000080h) Must be set to write value. Bits 00000030h select units: GS_UNITS _MBAR (00000000h) default mBar, GS_UNITS _TORR (00000010h) Torr, GS_UNITS _PASCAL (00000020h) Pascal, GS_UNITS_AMPS (00000030h) Bits 0000000Fh – Ion gauge pressure display resolution GS_IGDPS_VALID (00000008h) Must be set to write value Bit 00000001h selects number of decimal places: (00000000h) default 1 decimal place, (00000001h) 2 decimal places. Note if pressure units of AMPS is selected, value is ignored.
66 – 42h	*Slot A ID*	int	 R R R/W R/W R/W	TYPE OF MODULE IN SLOT A Bits 000000FFh – Module type TYPE_VALID (00000080h) TYPE_EMPTY (00000000h) default – no module fitted (TYPE_IG (00000001h) internally set for ion gauge structure) TYPE_VGPIRANI (00000002h) "V" module for VG Pirani gauge head TYPE_TC (00000003h) "K" module for Type K thermocouple module TYPE_PIR521 (00000004h) "E" module for Thyracont 521 Pirani gauge head TYPE_UNIVERSAL (00000005h) "U" module for universal input range TYPE_PIR841 (00000006h) "F" module for Thyracont 841 Pirani gauge head TYPE_WUNIVERSAL (00000007h) "W" module for universal input range Bits 00000F00h – Internal Pirani type set TYPE_PIR_VALID (00000800h) TYPE_PIR_VSP841 (00000000h) TYPE_PIR_VSP521 (00000100h) Bits 0000F000h – Power on/off ("W" module only, otherwise ignored) TYPE_WUNIVERSAL_VALID (00008000h) TYPE_WUNIVERSAL _OFF (00000000h) TYPE_ WUNIVERSAL _ON (00000100h) Bits 000F0000h – Universal flags ("U" or "W" module only, otherwise ignored) TYPE_UNIVERSAL_VALID (00080000h) TYPE_UNIVERSAL_LOG (00000000h) logarithmic input to pressure relationship (default). TYPE_UNIVERSAL_LIN (00010000h) linear input to pressure relationship Bits 00F00000h – Pull-up on/off ("W" module only, otherwise ignored) TYPE_WPULLUP_VALID (00800000h) TYPE_WPULLUP _OFF (00000000h) TYPE_ PULLUP _ON (00100000h)
70 – 46h	*Dual Gauge Mode Flags*	int	 R/W R/W R/W R/W R	DGM SETTINGS Bits 0F000000h – Secondary gauge protection DGMF_PP_VALID (08000000h) Must be set to write value. DGMF_PP_ON (01000000h) Secondary gauge protection ON Bits 00F00000h – Secondary Gauge DGMF_SS_VALID (00800000h) Must be set to write value. DGMF_SS_NONE (00000000h) DGM Off DGMF_SS_PIRANI (00100000h) Combines ion gauge with Pirani DGMF_SS_MODULE (00200000h) Combines ion gauge with Module Bits 000F0000h – Operating Mode DGMF_OP_VALID (00080000h) Must be set to write value. DGMF_OP_PURESET (00000000h) DGM reset on power up DGMF_OP_NOPURESET (000100000h) DGM starts on power up DGMF_OP_ONCE (00020000h) Only operate in DGM once until IG On Bits 0000F000h – Digital Inputs assignment DGMF_DI_VALID (00008000h) Must be set to write value. Bits 00003000h set which digital inputs ion gauge operation: DGMF_DI_1 (00001000h) digital input 1, DGMF_DI_2 (00002000h) digital input 2 (Note: both can be set) Bits 00000FF0h – Internally used for status indication

Para-meter Address	*Parameter Name*	Type	R/W	Description
			R	PDF_VALID (00000800h) always set Status bits: DGMF_OPERATING (00000010h), DGMF_INDELAY (00000020h) in delay time, DGMF_IGSTART (00000040h) attempting to start the ion gauge, DGMF_DIINHIBITED (00000100h) ion gauge operation inhibited by one or both digital inputs Bits 0000000Fh – Attempt count The number of attempts made to start the ion gauge (value between 0 and 9) *[see also WR IG Start Pressure, WR IG Delay, WR IG Attempts]*
72 – 48h	*Bake Out Flags - Zone 1*	int	R R/W R/W R/W R/W R/W R	BAKE-OUT FLAGS FOR ZONE 1 Bits F0000000h (Version 2.07 and above) - Current Bake-out Step BOF_STEP_VALID (80000000h) Always set Remaining bits (70000000h) have value of 0 (bake-out off), or value between 1 and 6 indicating current Bake-out step Bits 0F000000h – Auto-degas at end of bake-out BOF_DG_VALID (08000000h) Must be set to write value BOF_DG_ON (01000000h) auto-degas ion gauge 1 at end of bake-out Bits 00F00000h – Action of assigned digital inputs on Bake-out BOF_DIS_VALID (00800000h) Must be set to write value Bits 00300000h select action: BOF_DIS_TRIP (00000000h) default: output is off if assigned digital inputs fail, BOF_DIS_SUSPEND (00100000h) as normal but bake-out timer also stops, BOF_DIS_TERMINATE (00200000h) bake-out terminates if assigned digital inputs fail, BOF_DIS_IGNORE (00300000h) has no effect on bakeout Bits 000F0000h – Action of ion gauge pressure on Bake-out BOF_IGS_VALID (00080000h) Must be set to write value Bits 00030000h select action: BOF_IGS_TRIP (00000000h) default: output is off if ion gauge pressures rises above Pressure Limit parameter value, BOF_IGS_SUSPEND (00010000h) as normal but bake-out timer also stops, BOF_IGS_TERMINATE (00020000h) bake-out terminates if pressure rises above Pressure Limit parameter value, BOF_IGS_IGNORE (00300000h) has no effect on bakeout Bits 0000F000h – Digital Input assignment BOF_DI_VALID (00008000h) Must be set to write value BOF_DI_1 (00001000h) assigns digital input 1, BOF_DI_2 (00002000h) assigns digital input 2. [Both can be assigned]. Bits 00000F00 – Start/Stop Bake-Out BOF_SS_VALID (00000800h) Must be set to write value BOF_SS_STARTZONE1 (00000100h) starts zone 1 bake-out, BOF_SS_STOP (00000200h) stops bake-out. For dual zone bake-out configurations only: BOF_SS_STARTZONE2 (00000300h) starts zone 2 bake-out only, BOF_SS_STARTZONE1AND2 (00000400h) starts zone 1 and 2 bake-out Bits 000000FFh – Status Information BOF_VALID (00000080h) Always set Remaining bits are set in combinations to reflect status: BOF_BAKE_OUT (00000001h) bake-out started, BOF_DIINHIBITED (00000002h) bake-out is inhibited by assigned digital inputs, BOF_IGINHIBITED (00000004h) bake-out is inhibited by ion gauge pressure, BOF_SUSPENDED (00000008h) bake-out is suspended, BOF_TRIPSON (00000010h) bake-out output is on, BOF_DITERMINATED (00000020h) last bake-out terminated by DI trip, BOF_IGTERMINATED (00000040h) last bake-out terminated by ion gauge trip. *[See also BO Step temperatures 1-6, BO Step times 1-6, BO IG Pressure Limit, BO Hysteresis]*
74 - 50h	*Bake Out Flags - Zone 2*	Int	R/W R/W R	BAKE-OUT FLAGS FOR ZONE 2; This is a sub-set of the BO Flags Zone 1, please see the references for parameter 72 (48h) Bits 00F00000h - Action of assigned digital inputs Bits 000F0000h – Action of ion gauge pressure Bits 000000FFh – Status Information
76 – 4Ch	*Digital Input 1 Flags*	int	R/W R/W	DIGITAL INPUT 1 FLAGS Bits 0000000Fh DI_STATUS_VALID (00000008h) Must be set to write value DI_STATUS_ON (00000001h) Digital input 1 is on (read only bit), DI_STATUS_INHIBIT (00000002h) Inhibit digital input 1, DI_STATUS_OVERRIDE (00000004h) Override Digital input 1 *[See also Digital Input 1-2 Status Summary]* Bits 000000F0h DI_INVERT_VALID (00000080h) Must be set to write value DI_INVERT_OFF (00000000h) Input voltage present = ON. DI_INVERT_ON (0x00000010h) Input voltage absent = ON.
78 – 4Eh	*Digital Input 2 Flags*	int	R/W	DIGITAL INPUT 2 FLAGS See *Digital Input 1 flags for bit assignments*

Para-meter Address	*Parameter Name*	Type	R/W	Description
80 – 50h	*Trip1 Flags*	int	R/W R/W R/W	TRIP 1 FLAGS Bits 0000F000h – Trip 1 assignment DO_ASSIGN_VALID (00008000h) Must be set to write value The remaining 3 bits indicate what trip 1 is assigned to: DO_ASSIGN_NONE (00000000h) no assignment, DO_ASSIGN_IG (00001000h) ion gauge, DO_ASSIGN_PIRANI (00002000h) Pirani pressure value, DO_ASSIGN_BAKEOUT (00003000h) bake-out controlled, DO_ASSIGN_MODULE (00004000h) depends on module in slot value, DO_ASSIGN_DUALGAUGE (00005000h) trip 1 is set whilst DGM trip is valid, DO_ASSIGN_IGON (00006000h) trip 1 set whilst ion gauge is on, DO_ASSIGN_DEGAS (00007000h) trip 1 is set to "on" during degas. Bits 00000F00h – Trip 1 direction DO_ACTION_VALID (00000800h) Must be set to write value. DO_ACTION_GREATERTHAN (00000100h) Trip 1 is on when the controlling value exceeds the Trip 1 Level parameter value. If this bit is not set, Trip 1 is on when the controlling value is less than the Trip 1 Level parameter value. Bits 0000000Fh – Trip 1 state DO_STATUS_VALID (00000008h) Must be set to write value DO_STATUS_ON (00000001h) Trip 1 is on (read only bit), DO_STATUS_INHIBIT (00000002h) Inhibit trip 1, DO_STATUS_OVERRIDE (00000004h) Override Trip 1 *[See also Global Settings (for ion gauge degas protect), Trip 1 Level, Trip Hysteresis, Trip 1-7 Status Summary]*
82 – 52h	*Trip 2 Flags*	int	R/W	TRIP 2 FLAGS See *Trip 1 Flags for all bit assignments*
84 – 54h	*Trip 3 Flags*	int	R/W	TRIP 3 FLAGS See *Trip 1 Flags for all bit assignments*
86 – 56h	*Trip 4 Flags*	int	R/W	TRIP 4 FLAGS See *Trip 1 Flags for all bit assignments*
88 – 58h	*Trip 5 Flags*	int	R/W	TRIP 5 FLAGS See *Trip 1 Flags for all bit assignments*
90 – 5Ah	*Trip 6 Flags*	int	R/W	TRIP 6 FLAGS See *Trip 1 Flags for all bit assignments*
92 – 5Ch	*Trip 7 Flags*	int	R/W	TRIP 7 FLAGS See *Trip 1 Flags for all bit assignments*
94 – 5Eh	*D/A Flags Analogue Output*	int	R/W R/W	DIGITAL/ANALOGUE CONVERTER SETTINGS Bits 00000F00h – Linear/logarithmic response DA_FUNC_VALID (00000800h) Must be set to write DA_FUNC_LIN (00000100h) sets output to linear relationship. Default is logarithmic (as generally used with pressure assignment) Bits 0000000Fh – D/A Assignment DA_SET_VALID (00000008h) Must be set to write Remaining 3 bits select one of the following assignments: DA_SET_MIN (00000000h) output is permanently at D/A Min value parameter, DA_SET_IG (00000001h) assigned to ion gauge, DA_SET_PIRANI (00000002h) assigned to Pirani Pressure, AD_SET_TC (00000003h) assigned to thermocouple temperature, AD_SET_DUALGAUGE (00000004h) assignment moves from ion gauge when ion gauge is on to Pirani when ion gauge is off thus potentially providing coverage from atmosphere to UHV, DA_SET_EXTERNAL (00000005) output corresponds to value set over comms to parameter D/A output, DA_SET_MODULE (00000006) assigned to the measured parameter of the module in the slot, DA_SET_MAX (00000007) output fixed at D/A max value
96 – 60h	*Minimum Ion Gauge Emission*	int	R/W	MINIMUM ION GAUGE EMISSION. Range IGS_EM_50uA to maximum ion gauge emission value. Bits 000000FFh IGS_EM_VALID (00000080h) Must be set to write Possible values are: IGS_EM_50uA (00000001h), IGS_EM_100uA (00000002h), IGS_EM_150uA (00000003h), IGS_EM_250uA (00000004h), IGS_EM_400uA (00000005h), IGS_EM_600uA (00000006h), IGS_EM_1mA (00000007h), IGS_EM_1mA5 (00000008h), IGS_EM_2mA5 (00000009h), IGS_EM_4mA (0000000Ah), IGS_EM_6mA (0000000Bh), IGS_EM_10mA (0000000Ch).
98 – 62h	*Maximum Ion Gauge Emission*	int	R/W	MAXIMUM ION GAUGE EMISSION. Range minimum ion gauge emission value to IGS_EM_10mA. Bits 000000FFh See Minimum ion gauge emission for possible values.
100–64h	*Minimum % Filament Current*	int	R/W	MINIMUM % FILAMENT CURRENT DURING PID CONTROL OVER EMISSION Range: 0% to Maximum filament current setting, default 20%
102–66h	*Maximum % Filament Current*	int	R/W	MAXIMUM % FILAMENT CURRENT DURING PID CONTROL OVER EMISSION Range Minimum filament current setting to 100%, default 100%
104–68h	*Emission Control Prop Band*	int	R/W	PROPORTIONAL BAND SETTING FOR PID CONTROL OVER EMISSION Range 1 to 99, default 25.
106–6Ah	*Emission Control Damp*	int	R/W	DAMP PARAMETER; SETS THE INTEGRAL AND DIFFERENTIAL TERMS FOR PID CONTROL OVER EMISSION Range 1 to 99, default 25.
128–80h	*Trip 1-7 Status Summary*	int	R	SUMMARY OF STATUS OF ALL 7 TRIPS Each group of 4 bits summarises the status of one of the trips. 0000000Fh for trip

Para-meter Address	*Parameter Name*	Type	R/W	Description
				1, 000000F0h for trip 2 etc… In each case: DOx_VALID (8h) always set, DOx_ON (1h) set when the trip is on, DOx_INHIBIT (2h) set in inhibit, DOx_OVERRIDE (4h) set in override. (Note: DOx_ON always set if DOx_OVERRIDE is set.) *[See also Global Settings (for ion gauge degas protect), Trip 1 Level, Trip Hysteresis, Trip 1 Flags – Trip 7 Flags]*
130–82h	*Digital Input 1-2 Status Summary* *Secondary Functions Status*	int	R	SUMMARY OF STATUS OF BOTH DIGITAL INPUTS Bottom 2 groups of 4 bits indicate the status of the digital inputs. 0000000Fh for DI 1 and 000000F0h for DI 2 In each case: DIx_VALID (8h) always set, DIx_ON (1h) set when input is on, DIx_INHIBIT (2h) set to inhibit, DIx_OVERRIDE (4h) set in override. (Note: DIx_ON always set if DIx_OVERRIDE is set.) *[See also Digital Input 1 and Digital Input 2 Flags]* SUMMARY OF SECONDARY FUNCTIONS STATUS Bits 000F0000h - Status of secondary functions DISEC_SEC_VALID (00080000h) DISEC_PIR_NOPIRANI (00010000h): no Pirani gauge head connected DISEC_TC_NOTC (00020000h): no thermocouple connected DISEC_SLOT_NOGAUGE (00040000h): Type 'E' & 'F' modules, no Pirani connected
136–88h	*Ion Gauge Status*	int	R R R R R	STATUS OF ION GAUGE – This parameter reports status of ion gauge (1). *Note that parameters that can be changed are written to through the Ion Gauge Settings parameter (8Eh).* Bits FF000000h – Ion Gauge Operating Status/Failure Mode IGS_OP_VALID (80000000h) Remaining bits indicate the failure mode: IGS_OP_FANFAIL (40000000h) ion gauge tripped due to fan fail condition, IGS_OP_DIFAIL (20000000h) digital input fail, IGS_OP_OVERP (10000000h) overpressure fail, IGS_OP_POWERMAXTRIP (08000000h) tripped due to max power > 30 secs**, IGS_OP _INTERLOCKTRIP (04000000h) ion gauge lead interlock not made, IGS_OP _EMTRIP (02000000h) emission tripped, IGS_OP _FILTRIP (01000000h), filament over-current trip Bits 000F0000h – Filament Number IGS_FILNUM_VALID (00080000h). Must be set to write the value. [Cannot be set if ion gauge is on]. IGS_FILNUM _2 (00010000h) Filament 2, else filament 1 Bits 0000F000h – Measurement error IGS_IND_VALID (00008000) IGS_IND_MINLIMIT (00004000h) if electrometer input below measurement limit (e.g. collector lead disconnected) Bits 00000F00h – Ion gauge pressure trend IGS_TREND_VALID (00000800) IGS_TREND_UP (00000100) pressure is rising. IGS_TREND_DOWN (00000200) pressure is falling Bits 000000FFh – Current ion gauge emission/degas setting IGS_EM_VALID (00000080h). Always set The emission/degas status of the ion gauge is set via one of the following: IGS_EM_OFF (00000000h), IGS_EM_50uA (00000001h), IGS_EM_100uA (00000002h), IGS_EM_150uA (00000003h), IGS_EM_250uA (00000004h), IGS_EM_400uA (00000005h) , IGS_EM_600uA (00000006h), IGS_EM_1mA (00000007h), IGS_EM_1mA5 (00000008h), IGS_EM_2mA5 (00000009h), IGS_EM_4mA (0000000Ah), IGS_EM_6mA (0000000Bh) , IGS_EM_10mA (0000000Ch), IGS_EM_DEGASLO (0000000Dh), IGS_EM_DEGASMID (0000000Eh), IGS_EM_DEGASHI (0000000Eh). The above values are OR'ed with: IGS_EM_AUTO (00000010h) if the ion gauge is being run in auto-emission mode. *[See also Ion Gauge Settings: 8Eh]*
138–8Ah	*Fan Status*	int	R	FAN STATUS Bits 0000000Fh – Fan Status FAN_VALID (00000008h) always set FAN_ERROR (00000001h) Fan error has occurred FAN_ON (00000002h) Fan is running
140–8Ch	*Ion Gauge Settings Extended*	int	R/W R/W	EXTENDED ION GAUGE SETTINGS Bits 0000000Fh – Digital Input 1 action on ion gauge operation IGSX_DI1_VALID (00000008h) Must be set to write value The remaining 3 bits set the action: IGSX_DI1_NONE (00000000h) no assignment, IGSX_DI1_INTERLOCK (00000001h) gauge trips if DI1 fails, IGSX_DI1_EMON (00000002h) ion gauge is on whilst DI1 is on, IGSX_DI1_EMTOGGLE (00000003h) ion gauge turns on/off in response to a short pulse applied to DI1. Bits 000000F0h – Digital Input 2 action on ion gauge operation These bits mirror the above operation but for digital input 2. Flags are IGSX_DI2_xxxxx and bits are shifted up 4
142–8Eh	*Ion Gauge Settings*	int		ION GAUGE SETTINGS – This parameter sets changes to the ion gauge. *To obtain latest status information about the ion gauge, use the Ion Gauge Status Parameter*

Para-meter Address	Parameter Name	Type	R/W	Description
			R/W R/W R/W	*(88h)* Bits 00F00000h – New Filament Setting. IGS_NEWFIL_VALID (00800000h). Must be set to write the value. IGS_NEWFIL_OFF (00000000h), IGS_NEWFIL_ONCE (00100000h), IGS_NEWFIL_TWICE (00200000h) or IGS_NEWFIL_ALWAYS (00300000h). Bits 000F0000h – Filament Number IGS_FILNUM_VALID (00080000h). Must be set to write the value. [Cannot be set if ion gauge is on]. IGS_FILNUM _2 (00010000h) Filament 2. If this bit is not set, filament 1. This parameter cannot be changed when the ion gauge is on. Bits 000000FFh – Ion gauge emission/degas setting IGS_EM_VALID (00000080h). Must be set to write the value. Please see the relevant corresponding section in the Ion Gauge Status parameter for bit/value settings. To change emission, select the desired value, OR'ing with IGS_EM_AUTO if auto emission is required. To start degas, set to any of the degas values, OR'ed with IGS_EM_QUICKDEGAS if quick degas is required. Whether the degas starts also depends on the setting for the Degas protection parameter or pressure. *[See also Ion Gauge Status – 88h]*
144–90h	*Pirani Pressure*	float	R	INDICATED PIRANI GAUGE PRESSURE
146–92h	*Thermocouple Temperature*	float	R	THERMOCOUPLE TEMPERATURE (with cold junction compensation applied)
148–94h	*Module Value*	float	R	SLOT MEASURED VALUE 1.
150–96h	*Emission Setpoint Value*	float	R	CURRENT EMISSION CURRENT SETPOINT value used by emission PID control in mA.
152–98h	*Measured Emission Value*	float	R	CURRENT MEASURED EMISSION CURRENT VALUE (process value) in mA.
154–9Ah	*Ion Gauge Pressure*	float	R	ION GAUGE PRESSURE Range $1x10^{-14}$ to $1x10^{+3}$. $1x10^{+3}$ returned when ion gauge is off. The values are corrected for the sensitivity factor and are returned in the selected display units
156–9Ch	*Ion Gauge Sensitivity Factor*	float	R/W	ION GAUGE SENSITIVITY FACTOR Range: 1.0 to 99.9. Default = 19
158–9Eh	*Ion gauge Low Pass Filter*	float	R/W	ION GAUGE LOW PASS FILTER Range: 0.0 (OFF) to 9.9 seconds. Default = 1.5
160–A0h	*Trip 1 Level*	float	R/W	TRIP 1 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
162–A2h	*Trip 2 Level*	float	R/W	TRIP 2 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
164–A4h	*Trip 3 Level*	float	R/W	TRIP 3 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
166–A6h	*Trip 4 Level*	float	R/W	TRIP 4 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
168–A8h	*Trip 5 Level*	float	R/W	TRIP 5 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
170–AAh	*Trip 6 Level*	float	R/W	TRIP 6 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
172–ACh	*Trip 7 Level*	float	R/W	TRIP 7 LEVEL. Range: $1x10^{-13}$ to $1x10^{+6}$ current units.
174–AEh	*Trip Hysteresis Level*	float	R/W	TRIP HYSTERESIS. Range: 1.0 to 99.0. Default = 1.1x
176–B0h	*D/A Output Min value*	float	R/W	MINIMUM D/A SETTING Range 0 to 4095. Usually set to correspond to 0V output (=~ 20). Can be made larger than D/A Output Max value if reverse D/A output action required.
178–B2h	*D/A Output Max value*	float	R/W	MAXIMUM D/A SETTING Range 0 to 4095. Usually set to correspond to 10V output (=~ 4026). Can be made smaller than D/A Output Min value if reverse D/A output action required.
180–B4h	*D/A Min Pressure value*	float	R/W	D/A MINIMUM Parameter value (pressure or temperature) Range: $1x10^{-13}$ to $1x10^{+6}$. Units set to the device that D/A is allocated to.
182–B6h	*D/A Max Pressure value*	float	R/W	D/A MAXIMUM Parameter value (pressure or temperature) Range: $1x10^{-13}$ to $1x10^{+6}$. Units set to the device that D/A is allocated to.
184–B8h	*D/A Output*	float	R/W	D/A OUTPUT VALUE Range 0 to 4095. Although this parameter can be written to, it should only be written to if the D/A Flags Parameter(5Eh) is set to DA_SET_EXTERNAL.
186–BAh	*Heatsink Temperature*	float	R	HEATSINK TEMPERATURE in °C
192–C0h	*Dual Gauge Mode IG ON Pressure*	float	R/W	ION GAUGE ON PRESSURE Range: $1x10^{-13}$ to $1x10^{+6}$. Units to suit device in slot A.
194–C2h	*Dual Gauge Mode IG Delay*	float	R/W	ION GAUGE DELAY TIME Range: 0 to 999 seconds
196–C4h	*Dual Gauge Mode IG Start Attempts*	float	R/W	NUMBER OF ATTEMPTS TO STARTION GAUGE Range: 1 to 9
198-C6	*Dual Gauge Mode IG OFF Pressure*	float	R/W	ION GAUGE OFF PRESSURE Range: IG ON Pressure to $1x10^{+6}$. Units to suit device in slot A.
200-C8h	*Bake Zone 2 Peak Temp*	float	R	PEAK MEASURED TEMPERATURE DURING BAKE-OUT FOR ZONE 2

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Para-meter Address	*Parameter Name*	Type	R/W	Description
202-CAh	*Bake Zone 1 Peak Temp*	float	R	PEAK MEASURED TEMPERATURE DURING BAKE-OUT FOR ZONE 1
204–CCh	*Degas Pressure Suspend Limit*	float	R/W	DEGAS SUSPEND VALUE Range: $1x10^{-13}$ to $1x10^{+6}$.
206–CEh	*Ion Gauge Power*	float	R	OUTPUT POWER TO ION GAUGE FILAMENT Range: 0.1 to 99.9%
208–D0h	*Z1 Bake-out Temp 1*	float	R/W	ZONE 1 BAKE-OUT TEMPERATURE FOR STEP 1. Range: 0 to 500°C
210–D2h	*Z1 Bake-out Temp 2*	float	R/W	ZONE 1 BAKE-OUT TEMPERATURE FOR STEP 2. Range: 0 to 500°C
212–D4h	*Z1 Bake-out Temp 3*	float	R/W	ZONE 1 BAKE-OUT TEMPERATURE FOR STEP 3. Range: 0 to 500°C
214–D6h	*Z1 Bake-out Temp 4*	float	R/W	ZONE 1 BAKE-OUT TEMPERATURE FOR STEP 4. Range: 0 to 500°C
216–D8h	*Z1 Bake-out Temp 5*	float	R/W	ZONE 1 BAKE-OUT TEMPERATURE FOR STEP 5. Range: 0 to 500°C
218-DAh	*Z1 Bake-out Temp 6*	float	R/W	ZONE 1 BAKE-OUT TEMPERATURE FOR STEP 6. Range: 0 to 500°C
220–DCh	*Bake-out Temp Hysteresis*	float	R/W	HYSTERESIS APPLIED TO BAKE-OUT TEMPERATURE SETPOINTS. Range: 0 to 99°C
222–DEh	*Ion Gauge Bake-out Pressure Trip*	float	R/W	ION GAUGE BAKE-OUT PRESSURE LIMIT Range: $1x10^{-13}$ to $1x10^{+6}$ in currently selected pressure units
224–E0h	*Bake-out Time 1*	float	R/W	BAKE-OUT TIME FOR STEP 1. Range: 0 to 99.9 hours
226–E2h	*Bake-out Time 2*	float	R/W	BAKE-OUT TIME FOR STEP 2. Range: 0 to 99.9 hours
228–E4h	*Bake-out Time 3*	float	R/W	BAKE-OUT TIME FOR STEP 3. Range: 0 to 99.9 hours
230–E6h	*Bake-out Time 4*	float	R/W	BAKE-OUT TIME FOR STEP 4. Range: 0 to 99.9 hours
232–E8h	*Bake-out Time 5*	float	R/W	BAKE-OUT TIME FOR STEP 5. Range: 0 to 99.9 hours
234-EAh	*Bake-out Time 6*	float	R/W	BAKE-OUT TIME FOR STEP 6. Range: 0 to 99.9 hours
236–ECh	*Z1 Bake-out Setpoint*	float	R	CURRENT ZONE 1 BAKE-OUT TEMPERATURE SET-POINT. Range: 0 to 600°C. Note this is the required temperature. The actual measured temperature is available from Parameter Thermocouple Temperature Measured.
238–EEh	*Remaining bake-out time*	float	R	TOTAL REMAINING BAKE-OUT TIME Range: 0 to 599.4 hours
240–F0h	*"U" or "W" Module Min Pressure*	float	R/W	UNIVERSAL MODULE MINIMUM PRESSURE SETTING (corresponding to minimum output) Range: 10^{-13} to module maximum pressure setting
242–F2h	*"U" or "W" Module Max Pressure*	float	R/W	UNIVERSAL MODULE MAXIMUM PRESSURE SETTING (corresponding to maximum output) Range: Module minimum pressure setting to 10^{6}.
244–F4h	*"U" or "W" Module Min Input*	float	R/W	UNIVERSAL MODULE MINIMUM INPUT SETTING Range: 0.000V to 9.999V
246–F6h	*"U" or "W" Module Max Input*	float	R/W	UNIVERSAL MODULE MAXIMUM INPUT SETTING Range: 0.000V to 9.999V
256–100h	*Z2 Bake-out Temp 1*	float	R/W	ZONE 2 BAKE-OUT TEMPERATURE FOR STEP 1. Range: 0 to 500°C
258–102h	*Z2 Bake-out Temp 2*	float	R/W	ZONE 2 BAKE-OUT TEMPERATURE FOR STEP 2. Range: 0 to 500°C
260–104h	*Z2 Bake-out Temp 3*	float	R/W	ZONE 2 BAKE-OUT TEMPERATURE FOR STEP 3. Range: 0 to 500°C
262–106h	*Z2 Bake-out Temp 4*	float	R/W	ZONE 2 BAKE-OUT TEMPERATURE FOR STEP 4. Range: 0 to 500°C
264–108h	*Z2 Bake-out Temp 5*	float	R/W	ZONE 2 BAKE-OUT TEMPERATURE FOR STEP 5. Range: 0 to 500°C
266-10Ah	*Z2 Bake-out Temp 6*	float	R/W	ZONE 2 BAKE-OUT TEMPERATURE FOR STEP 6. Range: 0 to 500°C
268–10Ch	*Z2 Bake-out Setpoint*	float	R	CURRENT ZONE 2 BAKE-OUT TEMPERATURE SET-POINT. Range: 0 to 600°C. Note this is the required temperature. The actual measured temperature is available from Parameter Thermocouple Temperature Measured.
270–10Eh	*Ion Gauge Z2 Bake-out Pressure Trip*	float	R/W	ION GAUGE FOR ZONE 2 BAKE-OUT PRESSURE LIMIT Range: $1x10^{-13}$ to $1x10^{+6}$ in currently selected pressure units

14.4 QueBUS Protocol (QueBUS, QueBUS+CS & QueBUS+CRC)

14.4.1 Features

QueBUS was introduced with software version 2.35.

- Simple to use ASCII character based protocol.
- Up to 10 parameters can be read and/or written to during each communications exchange.
- 3 optional levels of error checking (none, check-sum or cyclic redundancy check) - see section 14.4.3.

14.4.2 Messages

Communication from the PC/PLC (the client) to the controller (the server) is ALWAYS initiated by the client sending a message. The controller CANNOT initialize a communication.

14.4.3 Error Checking Check-sum and CRC

Many comms protocols allow of one or two BYTEs to be appended to a comms message that can be used by the receiver to verify that the message was correctly received. The Setup Protocol Parameter provides three options for use of QueBUS:

- QueBUS-NoCheck: The message transfer occurs without any error checking. This can be useful, for example, during development.
- QueBUS+CS: A 2 BYTE check-sum is appended to the end of the message. This simple algorithm for generating the check-sum is described in section 14.4.4.
- QueBUS+CRC: This 2 BYTE addition to the message provides very effective error detection. The algorithm used is the same as MODBUS communications and is described in section 14.3.4. This provides the best level of integrity.

Note that if using the check sum or CRC, the 2 BYTEs generated can have any of the 256 possible BYTE values, including special characters that have specific meaning to QueBUS (see 14.4.5). However, because of the structure of QueBUS, the occurrence of '!' 2 characters before the last message character provides for end of message detection, as this will be first occurrence of this character.

14.4.4 The QueBUS-CS Check-sum

The QueBUS-CS check-sum is based on the Fletcher algorithm (e.g. https://en.wikipedia.org/wiki/Fletcher's_checksum) and comprises of 2 BYTES derived from ALL the message characters (including the start character and the terminating '!'). The code sample below clarifies the procedure:

1. Set two 16bit (or larger) variables to 0.
2. For each message character:
   - Add the character to the first check-sum variable, then apply modulo FFh (255) (remainder after dividing by 255) to first check-sum BYTE.
   - Add first check-sum variable to the second variable and take modulo FFh (255) to the second variable
3. Finally cast the variables to the 2 check-sum BYTEs

C SAMPLE CODE:

```
int zpvc_QBChecksum(unsigned char* lpMess, int nMessLen, unsigned char* lpCS)
{
 int            i, CS0, CS1;
 // Initialize to 0...
 CS0 = CS1 = 0;
 // Loop through the message characters...
 for (i=0; i<nMessLen; i++)
 {
  // Add character to CS0, them modulo to keep in range...
  CS0 = (CS0 + lpMess[i]) % 0xFF;
  // Add first checks sum to second and modulo to keep in range
  CS1 = (CS1 + CS0) % 0xFF;
 }
 // Cast the integers to the check sum characters...
 lpCS[0] = (unsigned char)CS0;
 lpCS[1] = (unsigned char)CS1;
 return 2;  // return length of checksum.
}
```

14.4.5 Valid QueBUS characters

The QueBUS protocol reserves several characters for specific functions; they can only appear for these purposes:

- '**>**' (ASCII character 62/3Eh): the start of a new message ***from the computer to the controller***. If is followed by 2 BYTEs representing the address of the controller to be addressed (e.g. "03" for address 3)
- '**<**' (ASCII character 60/3Ch): the start of the response ***from the controller to the computer***. If is followed by 2 BYTEs indicating the address of the responding controller (e.g. "15" for address 15)
- '**!**' (ASCII character 33/21h): the end of a message. If the no check-sum or CRC is selected, it is the last character in the message. If check-sum or CRC options are selected, it is followed by the 2 check-sum or CRC BYTEs.
- '**?**' (ASCII character 63/3Fh): the start of a parameter package requesting data. It is followed by a 2 BYTE mnemonic.
- '**#**' (ASCII character 35/23h): the start of a parameter package writing data. It is followed by a 2 character mnemonic and the data string.
- '*****' (ASCII character 42/2Ah): a parameter package error has occurred. Followed by the error code (see 14.4.7)

In the rest of a QueBUS message, only the following characters are allowed: 'A' to 'Z', 'a' to 'z', '0' to '9', '.' and ' ' (space).

14.4.6 QueBUS Message Structure

Sending messages to the controller

- **1 Start BYTE**: Message to the controller ALWAYS starts with '**>**' (ASCII character 62/3Eh).
- **2 Address BYTEs**: In the range "01" to "99".
- **Up to 10 multi-BYTE Send Parameter Packages** - see section 14.4.7
- **1 Termination BYTE**: Always '!' (ASCII character 33/21h)
- **2 *OPTIONAL* Checksum or CRC BYTEs** - see section 14.4.3 or 14.4.4

Response from controller

- **1 Start BYTE**: Message to the controller ALWAYS starts with '**<**' (ASCII character 60/3Ch).
- **2 Address BYTEs**: In the range "01" to "99".

- **Up to 10 multi-BYTE Response Parameter Packages** - see section 14.4.7
- **1 Termination BYTE**: Always '!' (ASCII character 33/21h)
- **2 *OPTIONAL* Checksum or CRC BYTEs** - see section 14.4.3 or 14.4.4

14.4.7 Parameter Packages

Parameter Package from computer to controller

- **1 Command BYTE**: To read a parameter value: '?' (3Fh). To write a parameter value: '#' (23h)
- **2 BYTE Parameter Mnemonic** as listed in section 14.4.9. First character is ALWAYS upper case. Second character is usually lower case, except where multiple parameter settings are involved.
- **Multi-BYTE Data**. (Note: this is only required when writing data to the controller)

Example 1: **?Ee** requests the emission setting.
Example 2: **#BA234** sets the first bake-out temperature to 234°C.
Example 3: **#Hb2.0e-9** sets the trip level for Relay 2 to 2.0e-9.

Response Parameter Package

- **Echo of the 1 Command BYTE**
- **Echo 2 BYTE Parameter Mnemonic**
- **Multi-BYTE Response Data**.

Multi-BYTE Response to a '?' Read Command

- If the parameter mnemonic was recognised, the required data string
- If an error occurred, a 2 BYTE error code - see below

Multi-BYTE Response to a '#' Write Command

- If the parameter mnemonic was recognized and the value valid and in range, no data bytes[1]
- If an error occurred, a 2 BYTE error code - see below

ERROR CODES:

- ***R**: The mnemonic was not recognized, or attempt to write to a read-only parameter, or data corrupted
- ***O**: The data value was out of parameter range.
- ***D**: Attempt to write a parameter but no data sent.

Example 1: **?Ee16** Emission set to Auto-emission
Example 2: **#BA** first bake-out temperature successfully set to 234°C
Example 3: **#Ea*R** would be returned as **Ea** is not a recognized parameter mnemonic

Notes:

- Maximum parameter package length: 15 characters. If a longer package is sent, extra characters are ignored.
- Only the following characters are allowed in Parameter Packages: '0' to '9', 'A' to 'Z', 'a' to 'z', '-', '+', '.' and ' ' (space). Inclusion of other characters will result in an error code.
- Numerical data can be sent any format, e.g. as integers (12), floating point (11.35) or exponential format (2.35e-08). Only 'E' or 'e' (for exponential format) and '0' to '9', '-', '+', '.' and ' ' (space) characters are permitted. Space characters are ignored. Presence of any other character will result in an error.
- Numerical data is returned in a format suitable to the parameter and generally complying to that shown on the instruments display. However, some values are returned at higher resolution; for example, pressure values are returned to 3 decimal place accuracy (e.g. 2.345e-09).
- If requesting data, any BYTEs additional to the 3 command and mnemonic BYTEs are ignored.

14.4.8 Putting it all together

As an example of using the protocol, consider wanting to read the measured ion gauge and Pirani pressures, the measured emission current, setting trip 3 to override and reading the trip states from instrument at address 1. This can all be done in one communication transfer:

>01?Iv?Pv?Ev#HS 5 ?HS!

If the check-sum is in use, add the 2 BYTEs <90h><F5h> as generated using 14.4.4.
If the CRC was in use, add the 2 BYTEs <EFh><34h> as generated using 14.3.4.

The response from the controller could be:

<01?Iv2.350e-9?Pv7.300e-1?Ev02.50#TD?TD105000005!

If the check-sum is in use, this would be followed with 2 BYTEs <86h><A9h> (see 14.4.4)
If the CRC was in use, this would be followed by the 2 BYTEs <67h><0Bh> (see 14.3.4)

Analysis of response:

- Start of a message is determined by receipt of '<'. If any other character, discard and wait for next.

---

[1] The response of no data BYTEs to a valid parameter write was introduced at version 2.41. For the few controllers operating earlier versions, 2 data BYTES ("OK") were sent

- A complete message can readily be determined by occurrence of '!' as last character (if no check option is being used) or for last but 2 character being '!' (for check-sum or CRC options).
- If being used, before processing the message, check the check-sum and CRC for valid data receipt.
- The start of each Parameter Package can be detected by scanning for '?' or '#'. The start of the returned data or error response is 3 characters further along and the end of the data is when '?', '#' or '!' is encountered.
- Parameter Packages are processed by the controller in the order they appear in the message. Thus it is possible to set a parameter and then read it in the next package. In most cases, the result should confirm the newly written value. However, in some circumstances (particularly where the required action requires another internal process), the old value may be returned even if the command was accepted without error. In these circumstances, it is better to check for compliance in the next comms exchange.

14.4.9 Parameter Mnemonics

The following table lists all the parameter Mnemonics. Pressure values have a range of 1e-13 to 1e+6. For further explanation regarding parameter function and ranges, please refer to the indicated sections.

ANALOGUE OUTPUT- see section 12.5.5

	Parameter	**RW**	**Comments**
Aa	*Allocation*	R/W	'0': Set to minimum value. '1': IonGauge. '2': Pirani. '3': BakeTemp. '4': IonG&Pirani. '5': CommsExternal. '6': Module. '7': Set to maximum value.
Af	*Function*	R/W	'0': Log. '1': Linear
An	*Minimum Value*	R/W	0 to Maximum Value
Ap	*Minimum Pressure*	R/W	1e-13 to 1e+6
Aq	*Maximum Pressure*	R/W	1e-13 to 1e+6
Av	*Output Value*	R	In range Minimum to Maximum Value
Ax	*Maximum value*	R/W	Minimum Value to 4095

BAKE-OUT - see section 12.5.6
Mnemonics starting with 'B' relate to standard single zone bake-out parameters. Mnemonics starting with 'C' related to second zone bake-out parameters and require presence of 'K' thermocouple module in slot. As indicated, some parameter commands can be accessed via either 'B' or 'C' mnemonics.
Note: Some Bake-out commands may take up to 1 second to be implemented as other processing required.

Z1	**Z2**	***Parameter***	**RW**	**Comments**
BA - BF	**-**	*Bake-out Temperatures*	R/W	0 to 500.0°C
-	**CA - CF**			
BU - BZ	**CU - CZ**	*Both Zones Bake-out Times*	R/W	00.0 to 99.9 hours
Ba	**-**	*Ion gauge Action*	R/W	'0': Trips to off. '1': Trips to off and Suspend time count. '2': Abort Bake-out. '3': Ignore (no action)
-	**Ca**			
Bd	**-**	*Digital Input Action*	R/W	
-	**Cd**			
Bg	**Cg**	*Auto Degas*	R/W	'0': Off. '1': Run if only Zone 1 is baked. '2': Run only if zone 2 is baked. '3': Run only if both zones are baked.
Bh	**Ch**	*Hysteresis*	R/W	00 to 99°C
Bi	**-**	*Digital Input*	R/W	'0': None. '1': DI1. '2': DI2. '3': Both
-	**Ci**			
Bk	**-**	*Peak Temperature*	R	0.0 to 500.0°C
-	**Ck**			
Bl	**-**	*Pressure Limit*	R/W	1e-13 to 1e+6
-	**Cl**			
Bo	**Co**	*Start/Stop*	R/W	**Single Zone** (no type 'K' module in slot): '0': Stops Bake-out. '1': No effect. '2': Starts Bake-out. **Dual Zone** (with type 'K' module in slot and 2 thermocouples connected): '0': Stops Bake-out. '1': No effect. '2': Starts single Zone 1 Bake-out. '3': Starts single Zone 2 Bake-out. '4': Start Dual zone (both zones) bake-out. (Note: If writing, can take up to 1 second to initialize and report. Bake-out operation subject to thermocouple open-circuit, ion gauge and digital interlock settings).
Bp	**Cp**	*Current Bake Step*	R	'0': Bake-out off. Else '1' to '6'.
Bs	**-**	*Bake-out Working Setpoint*	R	The returned value is only valid if bake-out is running. Check the first BYTE of the Bake-out Status (**SB)** message is '1' before using the value.
-	**Cs**			

Z1	Z2	Parameter	RW	Comments
Bt	**Ct**	*Remaining time*	R	
Bv	**-**	*Measured temp*	R	0.0 to 500.0°C
-	**Cv**			

DISPLAY - see section 12.5.9

	Parameter	RW	Comments
Dm	*Mode*	R/W	'0': Normal. '1': Quiet
Dp	*Gauge Positions*	R/W	'00': Standard to '13': Dynamic. Please refer to section 11.3 for settings
Ds	*Screen Saver*	R/W	'0': Off. '1': On
Dt	*Screen Saver Time*	R/W	1 to 999 minutes

EMISSION - see section 12.5.2

	Parameter	RW	Comments
Ee	*Emission Setting*	R/W	2 BYTEs: "00" = Off, "01" = 0.05mA .... "11" = 6mA, "12" = 10mA. "13" = Degas Low ... "15" = Degas High. "16" Auto-emission Note: If a degas value set but teh emission off, controller may still return OK though degas will fail.
En	*Min Emission Setting*	R/W	In range "01" to max emission (**Ex**). This parameter is locked when emission is on
Ep	*Min Power*	R/W	0% to max power (**Eq**).
Eq	*Max Power*	R/W	Min power (**Ep**) to 100%
Ev	*Measured Emission*	R	Measured emission. Format xxx.xxx (mA)
Ew	*Measured Power*	R	Filament power. Format xxx.x (%)
Ex	*Max Emission Setting*	R/W	In range min emission (**En**) to "12". This parameter is locked when emission is on
Ey	*Prop Band*	R/W	Range 1 to 99
Ez	*Damp*	R/W	

INTERLOCK HUB (TRIPS AND DIGITAL INPUTS) - see sections 12.5.3 and 12.5.4

	Parameter	RW	Comments
Ha - Hg	*Trip 1 to 7 Levels*	R/W	Range 1e-13 to 1e+6
HD	*Trip Direction*	R/W	7 BYTEs for the 7 Trips. '0': Less than. '1': Greater than. If **writing**: see **HS** for no change character Note: No effect for trips allocated to Bake-out or unallocated.
Hh	*Trip Hysteresis*	R/W	Range 1.0 to 99.0
HI	*Digital Input Invert*	R/W	2 BYTEs for the 2 DI's. '0': Normal. '1': Invert. If **writing**: see **HS** for no change character
HS	*Trip and Digital Input States*	R/W	9 BYTEs: 7 for the trips followed by 2 for the digital inputs **READ**: Each BYTE - '0': off, '1': on, '2': Inhibit, '5': Override **WRITE**: Each BYTE - '0' or '1' to set to Trip mode. '2' to Inhibit. '5' to Override. For no change to a Trip or DI, use ' ' (space 20h). e.g. "#HS 5 20" trip 4 override, DI1 inhibit, set DI2 trip mode; no affect on rest
HT	*Trip assignments*	R/W	7 BYTEs for the trips. '0': None. '1': IonGauge. '2': Pirani. '3': BakeOut. '4': Module. '5' DualRange. '6': IonGauge On. '7': Degas On. If **writing**: see **HS** for no change character

ION GAUGE - see section 12.5.2

	Parameter	RW	Comments
Ia	*Degas Ramp Time*	R/W	Range 2 to 999 (mins)
Ib	*Degas Hold Time*	R/W	
Ic	*Auto-Degas Level*	R/W	See **Ee**. Range is "13" (Degas Low) to "15" (Degas High)
Id	*Degas Trip Pressure*	R/W	Range 1e-13 to 1e+6
If	*Filament Number*	R/W	'0': Auto. '1': Fil 1. '2': Fil 2. Parameter is locked when ion gauge is on
Ig	*Gas Sensitivity*	R/W	Range 0.01 to 99.99
Ii	*Digital Input 1 Action*	R/W	'0': None. '1': Interlock. '2': EmissionOn. '3': EmissionToggle
Ij	*Digital Input 2 Action*	R/W	
Il	*Low Pass Filter*	R/W	Range 0.0 (off) to 9.9 (secs)
In	*New Filament*	R/W	'0': Off. '1': Once. '2': Twice. '3': Always
Ir	*Display Resolution*	R/W	'0': 1 decimal place. '1': 2 decimal places
Is	*Gauge Sensitivity*	R/W	Range 1.0 to 99.9
It	*Gauge Operating Time*	R/W	**READ**: Time that ion gauge has been switched on (Hours) **WRITE**: '0': No change. '1': Resets the time to 0
Iu	*Ion Gauge Units*	R/W	'0': Pressure Units. '1': Current

	Parameter	RW	Comments
Iv	*Measured Pressure*	R	Format x.xxxe-xx.
Ix	*Extended Range Setting*	R/W	'0': IonGauge Only. '1': IonG & Pirani. '2': IonG & Module.

MODULE

	Parameter	RW	Comments
Mt	*Module Type*	R	'0': Empty. '1': Invalid value. '2': V VG Pirani. '3': K Thermocouple. '4': VSP521. '5' U Universal Module. '6' VSP841. '7' W Univeral Module
Mv	*Measured Value*	R	Format x.xxxe-xx.

GAUGE NAMES - see section 12.5.9

	Parameter	RW	Comments
Ni	*Ion Gauge Name*	R/W	4 characters. Invalid characters replaced by ' '.
Nm	*Module Name*	R/W	
Np	*Pirani Name*	R/W	

INTERNAL PIRANI

	Parameter	RW	Comments
Pt	*Internal Pirani Type*	R	'0': VSP841. '1': VSP521
Pv	*Pirani Measured Value*	R	Format x.xxxe±xx.

DUAL GAUGE MODE OPERATION[2] - see section 12.5.7.

	Parameter	RW	Comments
Ra	*IG start Attempts*	R/W	Range: 1 to 9
Rd	*IG Start Delay*	R/W	Range 0 to 999 (secs)
Rf	*IG OFF (IG pressure at which IG to OFF)*	R/W	Range: DGM IG ON value to 1e+1. Format xe±xx
Ri	*Digital input(s) protection*	R/W	'0': None. '1': DI1. '2': DI2. '3': Both
Rn	*IG ON Pressure (set by secondary gauge). Also pressure IG trips if optional SG protect is on*	R/W	Range 1e-13 to 1e+6. Format xe±xx
Ro	*DGM Operation*	R/W	'0': DGM Power Up Reset. '1': NO Power Up Reset. '2': DGM cancels as soon as ion gauge operating, e.g. for Pump Down.
Rp	*Secondary gauge protect*	R/W	'0': Off. '1': On
Rs	*DGM Secondary Gauge*	R/W	'0': Off. '1': Ion Gauge & Pirani. '2': Ion Gauge & Module.

SYSTEM AND STATUS INFORMATION - see section 12.5.9

	Parameter	RW	Comments
SB	*Bake-out**	R	BYTE 1: '0': Off. '1': Bake-out operating BYTE 2: '0': OK. '1': DI Inhibited BYTE 3: '0': OK. '1': Ion gauge Inhibited BYTE 4: '0': OK. '1': Suspended BYTE 5: Allocated Trips off ('0') or on ('1') BYTES 6 to 10 reserved (returned as <space> 20h
Sd	*ID*		Returns "PVCX"
SG	*Secondary Gauges**	R	BYTE 1: '0': OK. '1': Pirani disconnected BYTE 2: '0': OK. '1': TC disconnected BYTE 3: '0': OK. '1': Module gauge disconnected BYTE 4: '0': OK. '1': Pirani at atmosphere BYTE 5: '0': OK. '1': Module at atmosphere BYTES 6 to 10 reserved (returned as <space> 20h
Sh	*Heatsink Temperature*	R	°C
SI	*Ion Gauge**	R	BYTE 1: '0': Off. '1': Ion gauge On BYTE 2: '0': Degas Off. '1': Degas Potential applied to gauge head BYTE 3: '0': OK. '1': Tripped due to digital input fail BYTE 4: '0': OK. '1' Tripped to over-pressure BYTE 5: '0': OK. '1': Tripped due to power max limit reached BYTE 6: '0': Interlock OK. '1': Ion gauge Interlock

[2] Added version 2.47

	Parameter	RW	Comments
			BYTE 7: '0': OK. '1': Emission failed BYTE 8: '0': OK. '1': Filament Error BYTES 9 to 10 reserved (returned as <space> 20h
SP	*Dual Gauge Mode **	R	BYTE 1: Setting: '0': Off. '1': IG + Pirani. '2': IG + Module BYTE 2: '0': Off. '1': Operating BYTE 3: '0' or '1': 1 = In delay BYTE 4: '0' or '1': 1 = Ion gauge starting BYTE 5: '0' or '1': 1 = Inhibited by digital input BYTE 6: Number of attempts made to start ion gauge last time (0 to 9) BYTES 7 to 10 reserved (returned as <space> 20h
SS	*System**	R	BYTE 1: '0': OK. '1': AD Failed BYTE 2: '0': OK. '1': Under temp error. '2' Over temp error BYTE 3: '0': OK. '1': Emission Over-current BYTE 4: '0': OK. '1': High voltage grid potential failed. '2': Filament potential failed. '3': Both failed BYTE 5: '0': OK. '1': Fan error BYTES 6 to 10 reserved (returned as <space> 20h
St	*Operating time*	R	Total powered on time of controller (hours)
Su	*Pressure Units*	R/W	'0': mBar. '1' = Torr. '2' = Pascal.
Sv	*Software Version*	R	e.g. "v 2.40"
Sz	*Comms Display Indicator*	R/W	'0': off. '1' on

* Multiple flag parameters. All values are "soft" (volatile) flags set as required. These are internally automatically reset.

"U" AND "W" MODULE CONTROL

	Parameter	RW	Comments
Wl	*Function*	R/W	'0': Log. '1': Linear
Wn	*Minimum Input*	R/W	Format: x.xxx (V) Range: 0.000 to Maximum Input
Wo	*Power Output on/off*	R/W	"W" module only. '0': Power Off. '1': Power On (manual - reset on power up). '2': Always On (set to on at power up)
Wp	*Pressure Minimum*	R/W	Range 1e-13 to 1e+6. Note: If the pressure are changed (Su mnemonic), these values will also need to be changed.
Wq	*Pressure Maximum*	R/W	
Wu	*Pull-up when Power off*[3]	R/W	"W" module only: '0': No pull up when power off. '1' Pull up when power on
Wv	*Measured Value*	R	Returns same as **Mv** (measured module value)
Wx	*Maximum Input*	R/W	Format: x.xxx (V) Range: Minimum Intput to 9.999

[3] Introduced at version 2.41