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# IGC5: UHV System Controller

*Precision Ion Gauge Controller with Bake-out and Interlock Hub*

Version 2.20 and above.  
Release data 5<sup>th</sup> March 2015

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## Precision Ion Gauge Controller with Bake-out and Interlock Hub

SAFETY NOTES.....	5
1 Introduction.....	6
1.1 What's New?.....	6
1.2 IGC5 Functions.....	6
1.3 IGC5 and VacTools.....	7
2 IGC5 Specification.....	7
3. Installation and Setting Up.....	9
3.1 Physical.....	9
3.2 IGC5 Rear Panel.....	9
3.3 IGC5 Front Panel.....	10
3.4 Line Voltage and Fusing.....	10
3.5 Ion Gauge Connections.....	10
3.5.1 The 6 pin QM "power" connector.....	11
3.5.2 BNC Collector Connector.....	11
3.5.3 Ion Gauge Integrity, Safety and Fusing.....	12
3.6 Digital I/O Connector.....	12
3.7 Analogue Output Connector.....	12
3.8 Module Installation/Removal in the "Options Slot".....	13
3.9 Serial Communications.....	13
3.9.1 Overview.....	13
3.9.2 RJ45 Connectors.....	13
3.9.3 Interface Cabling from the Port to the first GC.....	13
3.9.3 Daisy-chaining cable between controllers.....	14
3.9.4 Communications Hardware Kits.....	14
3.10 Data Retention (Volatile/Stored Parameters).....	15
4 IGC5 Functions.....	15
4.1 Pressure Measurement.....	15
4.2 Interlock Hub.....	15
4.3 Bake-out Control.....	16
4.4 Vacuum System Auto Pump-down.....	16
5 Ion Gauge Operation.....	16
5.1 Ion Gauge Construction.....	16
5.2 Gauge Type and Filaments.....	17
5.3 Emission Currents: Setpoint and Measured values, and Pressure Calculation.....	17
5.4 Fixed Emission Currents and Emission Current Range.....	17
5.5 Emission Start-up and PID control.....	17
5.6 Auto-Emission.....	18
5.7 Changing Emission.....	18
5.8 Degas.....	18
5.9 Ion Gauge Status and Error Messages.....	18
5.10 Emission Leakage.....	19
5.11 Hints on using ion gauge measurements.....	19
5.11.1 Vacuum Pressure Measurements.....	19
5.11.2 New Filaments - Degassing.....	19
5.11.3 Degas.....	19
5.12 Beam Flux Measurements.....	20
5.12.1 Measurement Method.....	20
5.12.2 Measuring as Current.....	20
6 Secondary Gauging.....	20
6.1 Built-in Pirani Gauging.....	20
6.1.1 Pirani Gauge Types and Issues.....	20
6.1.2 Selecting the gauge type within the IGC5.....	20
6.1.3 Hardware settings for the Pirani gauge.....	21

6.1.4	Pirani Calibration.....	21
6.1.5	Pirani gauge Connector .....	21
6.2	Optional Gauge Modules .....	21
6.2.1	What are Modules? .....	21
6.2.2	The "E" Module: VSP52x.....	22
6.2.3	The "F" Module: VSP84x.....	22
6.2.4	The "V" Module: VG Pirani gauge heads.....	22
6.2.5	The "U" Universal Module: Linearized gauges .....	22
7	Interlock Hub: Digital I/O and Analogue Output .....	22
7.1	Trips (Digital Outputs) .....	23
7.1.1	Relay-based Trip Hardware.....	23
7.1.2	Open Collector-based Trip Hardware .....	23
7.1.3	Trip Assignments .....	24
7.2	Digital Inputs .....	24
7.2.1	Digital Input Hardware .....	24
7.2.2	Digital Input Assignments.....	24
7.3	Analogue Output .....	24
7.3.1	Overview .....	24
7.3.2	Parameters.....	24
8	Bake-out.....	25
8.1	Overview .....	25
8.2	Operating the Bake-out .....	25
9	Auto Pump-Down .....	26
9.1	Overview .....	26
10	Calibration .....	26
10.1	Ion Gauge Calibration.....	26
10.2	Pirani Gauge calibration .....	26
10.3	Thermocouple Input Calibration .....	27
10.4	"E", "F" and "V" Module Calibration .....	27
11	Operating the IGC5 .....	27
11.1	Manual Operation.....	27
11.2	"Primary" Display .....	27
11.3	"Data Edit" Display .....	28
11.4	The Secondary/Emission and Module/Emission Display Pages .....	28
11.5	The Pump-down Display Page .....	28
11.6	The Bake-out Display page .....	29
11.7	Screen-Saver and Quiet Modes.....	29
12	Parameters .....	29
12.1	Parameters and the Menu Structure .....	29
12.2	Navigating the Menus.....	29
12.3	Locked and Accessible Parameters .....	30
12.4	Changing a Parameter .....	30
12.5	Parameters .....	30
12.5.1	Emission.....	30
12.5.2	The Ion Gauge Menu .....	30
12.5.3	Trip $x$ (1 to 7) Menu.....	31
12.5.4	Digital Input $x$ (1 to 2) Menu .....	32
12.5.5	Analogue Out Menu .....	32
12.5.6	Bake Out Menu .....	33
12.5.7	Pump Down Menu.....	33
12.5.8	Calibration Menu .....	34
12.5.9	Setup Menu .....	35
13	Troubleshooting .....	35
13.1	Operation .....	35
13.2	Ion Gauge .....	36
13.3	Digital Output Trips .....	36
13.4	Digital Inputs .....	36
13.5	Pirani & Secondary Pressure Modules ("E", "F", "V" & "U").....	36

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13.6	Thermocouple/Bake-out.....	37
13.7	Analogue output.....	37
14	Serial Communications.....	37
14.1	Introduction.....	37
14.1.1	Hardware .....	37
14.1.2	Timing Restriction .....	37
14.2	Communication Protocols.....	38
14.3	The EMComm protocol .....	38
14.3.1	Introduction.....	38
14.3.2	Messages .....	38
14.3.3	EMComm message structure - the Frame .....	38
14.3.4	The Structure of the CRC.....	38
14.3.5	Message Structure from the Client (the Command) .....	40
14.3.6	The "Invalid" Parameter Value - FFFFFFFFh .....	40
14.3.7	Message Structure From the Server (the Response) .....	41
14.3.8	Error Response .....	41
14.3.9	Parameter Types.....	41
14.3.10	Parameter Listing .....	42
14.4	QUICKComm Protocol.....	50
14.4.1	Introduction.....	50
14.4.2	Messages .....	50
14.4.3	QuickComm Message Structure.....	50
14.4.4	QUICKComm Mnemonics – Write Commands.....	50
14.4.5	QUICKComm Mnemonics – Read Commands .....	51

## UPDATE SUMMARY:

To 2.20:

- 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/ Power up screen reports type of Pirani unit is internally set-up for (521 or 841)

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## SAFETY NOTES

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1. Voltages in excess of **400V** are present within the IGC5 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 IGC5, ensure that both are connected to a single high-quality earthing (ground) point on the vacuum system.
2. Before removing the top cover of the instrument, allow at least 5 minutes for the high voltage capacitors to discharge fully. **Unless technically qualified to do so, do NOT operate IGC5 with the cover removed.**
3. Always turn off power to the controller before connecting any cable to it or the ion gauge, or performing any maintenance to either.
4. It is the user's responsibility to ensure that the signals used with the trip outputs are employed safely. In safety critical installations, an independent means of over-riding/inhibiting the trip signals should be provided to facilitate manual control.
5. Operation with an erroneous setting of the mains line voltage selector will damage the IGC5 and may cause injury to personnel.
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 >1000V 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 glass, ceramic, plastic or rubber components. All exposed and isolated metal parts should therefore be reliably grounded to a common system earth point via 4mm<sup>2</sup> or thicker copper wire/braid, the integrity of which should be checked regularly.**

# 1 Introduction

*The IGC5 integrates precision **pressure measurement** ( $<1 \times 10^{-11}$  to  $>1000$  mBar) with **UHV system management** functions, such as a **multi-step bake-out controller** and **pump-down** and a comprehensive, user-definable **Interlock Hub**. The interlock hub comprises 7 digital output trips, 2 digital input and precision analogue output, which can provide complete system interlocking with minimal wiring.*

## 1.1 What's New?

The IGC5 is the latest version to the well-established VG IGC range of ion gauge controllers. Key new/enhanced features of the IGC5 include:

- **Ion gauge management.** The IGC5 drives the filament from an analogue (not switched mode), constant current dc source, resulting in electrically silent operation (as required for vibration sensitive applications, such as STEM). The PID-based emission control extends the range of emission and provides unprecedented stability of control. In addition, new features, such as soft, low emission 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 IGC5 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 now executed without interrupting ion gauge operation, and the new degas method allows for continuous pressure measurement during degas to provide full system and gauge head protection throughout. Ramping to degas power is now gradual (rather than stepped) and a user-defined pressure limiter has been added that allows the degas cycle to be suspended to allow pressure recovery before further emission increases.
- **Pirani Support as standard.** Support for Thyracont VSP84x and VSP52x Pirani gauge heads is built into the controller as standard.
- **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.
- **Pump-down Support.** By combining the Pirani gauge measurement and the interlock hub, the IGC5 can be set up to automatically evacuate a vacuum system and start the ion gauge.

**Options Module.** The IGC5 has one module "slot" which supports all the modules available to earlier models. This permits a second passive or active gauge head to be added, such as an additional Thyracont or VG Pirani gauge head, or a 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...).

- **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 IGC5\_II replaces the 20 character VFD display of the earlier models with two long life, high brightness, high contrast, yellow-on-black displays providing clearer legibility at distance and more detailed parameter description.
- **Gauge Naming.** To improve the display experience, 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.

## 1.2 IGC5 Functions

The IGC5 integrates the following functions:

- Precision UHV ion gauge controller (section 5).
- Secondary gauging (section 6) comprising:
  - Built in support for Thyracont 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, comprising 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 IGC5 with minimal wiring (section 7).
- Bake-out support fully supported by the Interlock Hub, and primary and secondary gauge pressure interlocking (section 8).
- Vacuum system pump-down support and automatic starting of ion gauge.
- 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- $\mu$ A-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 5.12)
- Computer control over its multi-drop RS232/RS485 interfaces with a choice of communications protocols. EMComm provides fast comprehensive, multi-parameter read/write and floating point resolution data transfer, whilst QUICKComm is a conventional ASCII-based protocol.

### 1.3 IGC5 and VacTools

The IGC5 is fully compliant with **VacTools** software which provides comprehensive control, monitoring and data logging of vacuum systems - for further information, please contact your vendor. Interface hardware kits are also available, for example, see section 3.9.4.

## 2 IGC5 Specification

Parameter	DESCRIPTION
<b>ION GAUGE:</b>	
Ion Gauge:	1x UHV, dual Iridium-based filament.
Filament Drive technology:	Electrically silent, high stability constant current dc.
Filament drive rating:	0-4A (8V compliance)
Emission Control:	Precision PID control with emission measurement
Manual Emission:	0.05, 0.1, 0.15, 0.25, 0.4, 0.6, 1, 1.5, 2.5, 4, 6, 10mA
Auto-emission:	Continually ramped optimized
Emission features:	Ultra soft-start. 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:	High-resolution during degas
Degas on/off:	No interruption of ion gauge operation during degas start/stop transitions
Degas trip monitoring:	Continuous trip monitoring during degas
Electrometer:	Range: <1e-12 to 1e-2 Enhanced stability
Gauge Sensitivity:	1.0 to 99.9 (resolution 0.1)
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...
<b>SECONDARY GAUGES:</b>	
Built in:	Support for VSP521/VSP841 as standard (user selectable)
Module supported:	1 module
Module options:	"V": VG Pirani "E": VSP521 "F": VSP841 "U": Universal linearised output (e.g. other gauge controllers, mini-convectron, Stinger...) (Thermocouple support built-in).
<b>BAKE-OUT</b>	

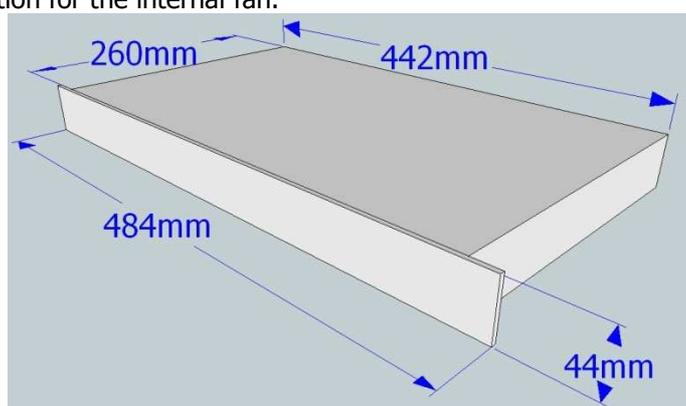
<b>CONTROL:</b>	
Built in:	Type K thermocouple. Standard mini-thermocouple connector
Module options:	(Not required)
Range:	Room temperature to 500°C. Precision CJC. Reproducibility <±0.5°C. Absolute <±2°C (can be user calibrated)
Bake-out Functions:	6x ramp/soak steps, each up to 99.9 hours duration (0.2 hour resolution). Individual trip allocation for power switching (e.g. 3 trips for 3Φ). User-defined pressure interlocking (ramp suspend/time suspend/abort). User-defined temperature hysteresis. Auto-degas at end of bake-out.
<b>INTERLOCK HUB:</b>	
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 or backing gauge, ion gauge status (on, off, degas), bake-out power switching, pump down external drive...
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; pump-down trip; backing gauge/pump operation...
Interlock Response times:	0.2 sec max. Typically <0.1sec
<b>ANALOGUE OUTPUT:</b>	
Output:	Full scale range: -0.2V to 10.2V (12 bit resolution). User-definable min and max.
Accuracy and reproducibility:	Precision reference-based: <±0.2%.
Assignment:	Ion gauge (emission and sensitivity corrected), any secondary gauge, gauge combinations, bake-out temperature...
Functionality:	User-defined voltage range, assigned pressure/temperature range, lin or log relationship...
<b>GENERAL:</b>	
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: one 100x16 pixel graphical and one 2linex16character High brightness. High contrast. Long life >100,000h to half-brightness
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. QUICKComm protocol. ASCII-based communications protocol
Communications connection:	2x RJ45 for simple daisy-chaining

### 3. Installation and Setting Up

*This section discusses installation of the IGC5, wiring and environmental issues, and the basics of instrument operation*

#### 3.1 Physical

The IGC5 is enclosed in an earthed, metal, 1U high 19" rack-mounting enclosure. Although the depth of the instrument is only 260mm, it is recommended that at least 50mm be left at the rear to accommodate the connectors and provide adequate ventilation for the internal fan.



**Figure 1: IGC5 dimensions. Allow 50mm (2") at rear for earth stud and connectors**

Locate the instrument(s) within the 19" rack, preferably away from heat sources or powerful cooling fans. The temperature in the rack should be between 5 and 40°C. A 1U gap should be allowed between each group of 3 IGC5's (blanked with a suitable panel) to allow ventilation.

The instrument should be supported by runners/support brackets within the rack; **do NOT support it by simply bolting it to the front of the rack via the front panel locating holes** - the resulting physical damage is NOT covered by the warranty.

Avoid locating the instrument near to equipment that can generate high energy discharges within the rack. If the ion gauge head is near an *in vacuo* source of electrons or ions, it is recommended that it is screened by an earthed fine-meshed screen to avoid disruption to its operation.

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

#### 3.2 IGC5 Rear Panel



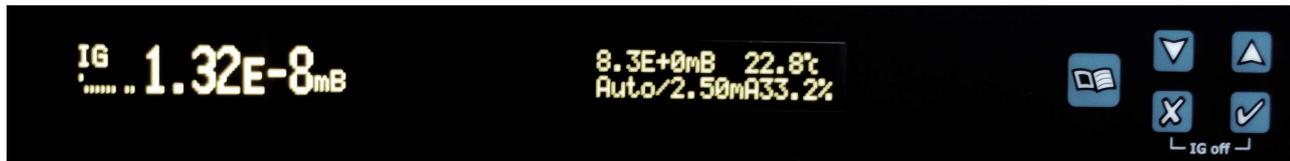
Left to right, the rear panel comprises:

- Serial communications connectors: both RJ45 sockets provide identical multi-drop RS232 and RS485 protocols, simplifying daisy-chaining
- Ion gauge collector (BNC connector)
- Analogue output connector (2 pin, 3.5mm jack socket)
- Access to optional slot module connector. All modules use a mini-DIN connector, but the number of pins can vary from 3 to 9
- Standard type K mini-thermocouple connector (mini-standard thermocouple)
- Connector for built-in Pirani gauge (3 pin mini-DIN)
- DB25 male connector for Interlock Hub digital inputs and trip outputs
- Fan vent - DO NOT OBSTRUCT
- Filament fuse. F5A (fast fuse)
- pHigh voltage grid voltage fuse. F100mA (fast fuse)

- Ion gauge head connector. 6-pin QM multipole
- Earthing stud. This should be connected to the earth point on the vacuum system
- Combined mains inlet, double fuse holder, mains on/off switch and 115/230V selector.

More detailed information on many of the above can be found in this manual.

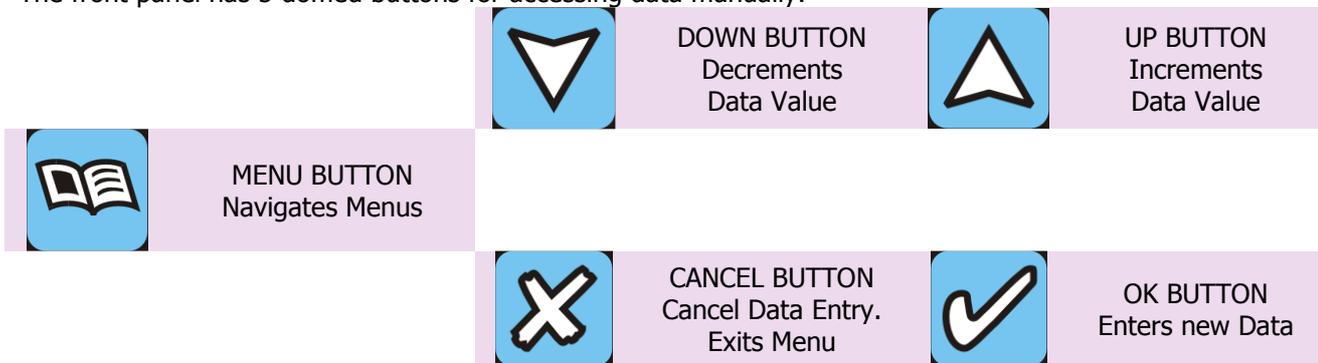
### 3.3 IGC5 Front Panel



The IGC5 uses 2 independent OLED displays, the operation of which is discussed in section 11:

- **Left Hand "Primary" Display.** This 100x16 pixel graphical display shows the currently displayed gauge name (top left), status of the 7 trips and 2 digital inputs (bottom left) and ion gauge status/pressure. The top right pixel flashes in response to valid data over comms.
- **Right Hand "Data Edit" Display.** This 2 line x 16 character display provides a range of information through its 4 data "pages", and access to editing controller parameters via the menu.

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



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

As indicated above, the IGC5 houses a high quality power filter, which also integrates mains selections switch and input 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. There are 2 fuses – both the Live and Neutral lines are fused – one on each side of the holder. The fuses can be either 5x20mm or ¼ x 1 ¼" types; the former fit into the rear section of the fuse slots, the latter the whole fuse slot. IGC5 has 5x20mm fuses. **T2.0A fuses are required for 230V operation and T3.15A fuses are required for 115V operation. Please ensure correct fuse rating and integrity of BOTH 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 IGC5 via 2 connectors: the 6 pin QM "power" connector, and a BNC connector that carries the collector current. **Potentially lethal voltages are present on the connectors; ALWAYS TURN OFF THE CONTROLLER BEFORE DISCONNECTING OR HANDLING THE CABLES.** In addition,

a high current capacity earth strap should be connected between the earth stud on the rear of the IGC5 and the system's earth point. **Ready-made, EMC-compliant cable assemblies are available from your IGC5 supplier.**

### 3.5.1 The 6 pin QM "power" connector

Your supplier can supply suitable, bake-able cables for most gauge heads, and, for safety, cables produced commercially or by qualified electrical engineers should be used. However, the Accessories pack contains all the parts need to modify an existing cable for use with the IGC5.

The ion gauge head is connected to the 6 pin QM connector. The pin configuration is indicated in the table:

Pin	Function
1	Interlock <sup>Note 1</sup>
2	Grid
3	Interlock <sup>Note 1</sup>
4	Filament common
5	Filament 1 <sup>Note 2</sup>
6	Filament 2 <sup>Note 2</sup>

- Note 1: Pins 1 and 3 provide an interlock for the IGC5 to detect whether an ion gauge is connected. These pins MUST be connected together (either at the plug, or preferably within the vacuum system at the ion gauge head flange) before the IGC5 will power up an ion gauge.

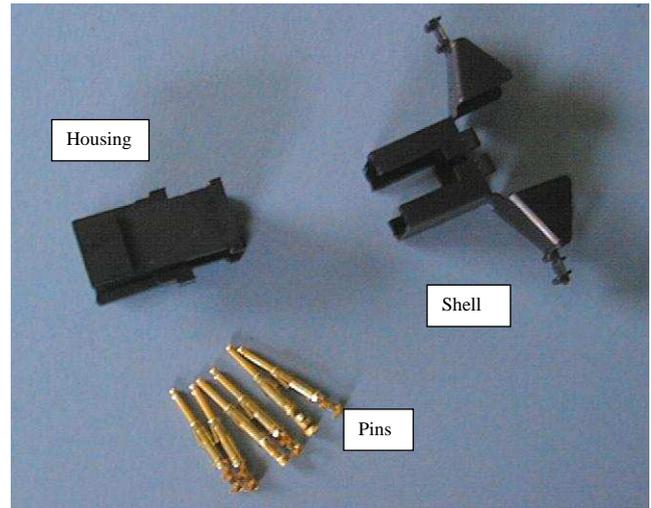
- Note 2: Whereas pin 4 is the filament common pin to the ion gauge head, the relative allocation of filament 1 and 2 may vary between gauge heads. For single ion filament gauge heads, use either pins 5 or 6, and set the filament select parameter appropriately.

The ion gauge lead MUST conform to the following:

- ALL CABLING MUST BE CAPABLE OF OPERATING AT TEMPERATURES AT LEAST 20°C ABOVE THE **MAXIMUM** TEMPERATURE OF OPERATION OF THE CABLE.
- The filament wires MUST be rated at >5A AT THE MAXIMUM TEMPERATURE OF OPERATION OF THE CABLE.
- The Grid wire MUST be rated at >1000Vdc and capable of carrying a current of >200mA.

The figures above show the parts needed and a

completed connector.



**Please ensure that you know the function of each wire of your ion gauge cable before commencing since once the pins are inserted into the housing they are difficult to remove without special tooling.**

- Strip each of the wires to the ion gauge by ~15mm.
- Insert the bare wire into the pin, so that the insulation meets the crimp end of the pin; if it does not meet, remove and trim.
- Carefully crimp the pin and ensure that the wire cannot be pulled out.
- Insert the pins into the housing from the rear, taking great care to ensure correct position, as indicated on the plug housing. Ensure that each pin cannot be pulled out.
- If your existing ion gauge does not provide for the interlock wires (i.e. to ensure that the cable is also attached at the ion gauge), connect a pin to each end of a 5cm long length of wire and insert into 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 below. This acts to relieve strain on the individual conductors.



### 3.5.2 BNC Collector Connector

To avoid disruption of the tiny ion current collected by the gauge head collector, it is returned to the electrometer in the controller via a screened cable terminated in a BNC connector. The central pin is connected to the collector, and the body to the screen. Instructions for wiring BNCs are provided with the connectors supplied in the accessories pack, or can be viewed on the internet.

Note, it is not necessary for the screen to be connected at the gauge head connector (and in any case, this is not possible with some connector types). However, the rear stud of the controller MUST be connected to the system earthing point via separate wire with cross-section of at least 4mm<sup>2</sup>.

To reduce the effects of noise picked-up on the collector lead, and thus on the measured pressure, the IGC5 provides both analogue input filtering and a digital filter. The default 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 measured.

### 3.5.3 Ion Gauge Integrity, Safety and Fusing

The IGC5 provides a range of facilities to protect the ion gauge head, controller and personnel:

- When the ion gauge is turned off, the high voltage grid and filament supplies are isolated from the QM connector. However, before attempting any work on the ion gauge leads, they should ALWAYS be disconnected from both the controller and the ion gauge head.
- Pins 1 and 3 provide an interlock which detects presence of the connector. Ideally, these 2 wires should be taken all the way to the gauge head and bridged *in vacuo* to confirm connection to the controller and ion gauge. However, if this facility is not present in the ion gauge head, these pins should be bridged in the QM connector.
- When the ion gauge is on, the IGC5 continually checks for short-circuits of the grid and filaments to each other and/or to ground. This protects the gauge head and controller.
- The filament supply is based around a constant current source with a hard-wired current limit of ~4A to protect the filament and power supplies. An in-series 5A(F) fuse further protects the filament and controller from spurious fault conditions.



- High voltage to the grid and filament bias is provided via a 100mA(F) fuse. Note that unlike the other IGCs, this is a FAST fuse; i.e. will fail immediately if 100mA is exceeded. **DO NOT USE A "SLOW BLOW", "TIME DELAY" or "MAINS-STYLE" fuse in this position.**

### 3.6 Digital I/O Connector

The digital inputs and outputs are accessed via a standard male DB25 connector (see below).

Note:

- Do NOT exceed 1Adc or 0.5Aac at 40V to Trip relays 1 to 4
- Do NOT apply more than 14V (absolute maximum) to the open-collector Trip outputs 5 to 7, or attempt to

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	[Not connected]
Digital 1 input +ve	24		
		12	Digital input 1 -ve
Digital 2 input +ve	25		
		13	Digital input 2 -ve

### 3.7 Analogue Output Connector

The analogue output is accessed via a standard 3.5mm (1/8") jack socket. The internal connector pin is the signal output and the outer is 0V (earth).

sink more than 250mA.  
*[Note: these values differ from the 24V and 100mA values in the other IGC controllers.]*

- Do NOT exceed 32Vdc input to the digital inputs (unless using an external series resistor to limit the input current to 10mA).

A solder-free option is available from your supplier:

- A DIN-rail unit that provides 3x high current (15A) relays driven by the open-collector trips (5 to 7), and screw terminals to trips 1 to 4 and both digital inputs. The rail includes a 12Vdc power supply to power the high current relays and to provide a power source for interlocks.
- A special soldering-free screw terminal assembly (shown left).

## 3.8 Module Installation/Removal in the "Options Slot"

The IGC5 accepts one module to extend the secondary gauging capabilities; the options available to the IGC5 are described in section 5.2. Module types are identified by the IGC5 on power up, and any menu or system reconfiguration is automatically applied. A module can be ordered pre-installed, or can be ordered separately and installed by the user.

To install, remove or change a module:

- If you have an earthed wrist strap, we recommend its use during this procedure.
- Disconnect **ALL** leads to the IGC5. Whilst performing the following steps, do NOT connect any lead to the instrument.
- 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.
- Remove the 3 screws on each side of the controller. Carefully raise the lid, but note that a wire attaches the cover to the base of the unit.
- There are static sensitive components within the controller. Please avoid touching any component on the mother board. Handle the modules by the edges - do not touch any components on the module.
- Place the controller so the front panel is facing you.
- The module slot is just left of the collector BNC connector. It comprises a 12 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 there is a module in place, unscrew and remove the M3 bolt securing the module in place. Holding the module across its width, simply pull the module upwards to remove.
- The IGC5 has an enhanced module slot, which has a 13 rather than 8 pin connector (as in the IGCi or IGCiDuo); this is to provide support for future "enhanced" modules, currently in development. Existing modules, however, have 8 pins - these should be inserted into the left-most 8 holes of the 13 pin connector. Note: if the module is inserted into the wrong holes, it will not be possible to insert the M3 securing bolt and module connector will not align with the module connector hole on the rear panel.
- When the module is in place, insert the M3 securing bolt with its anti-slip washer - do not over-tighten to avoid damaging the PCB. If necessary gently manipulate the module to ensure the connector correctly 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 IGC5.
- Replace the lid and secure with the 6 screws.
- On powering up the IGC5, it should report the type of module installed during the power-up sequence.

## 3.9 Serial Communications

### 3.9.1 Overview

All aspects of the IGC5 can be controlled over serial communications. Both RS232 and RS485 (3 wire) ports are supported via two parallel-wired RJ45 sockets; the provision of 2 sockets allows simple daisy chaining. Up to 16 IGC5's can be attached to an RS485 port; due to a multi-drop implementation, up to 8 IGC5's can be connected to an RS232 port (though this may vary between PC's). Details of serial comms protocols are described in section 14. IGC5 is fully supported by **VacTools** software.

### 3.9.2 RJ45 Connectors

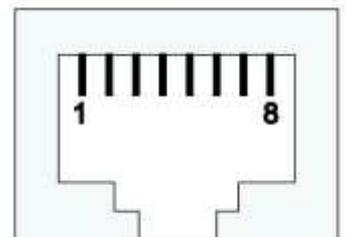
The shielded RJ45 8/8 connector pin assignment and allocation is shown right, along with the colours often used in commercially available cables (see below). Note that the RS485 0V at pins 4, 5 and 6 is connected to internal 0V (earth) via a 100Ω resistor to reduce the likelihood of earth loops when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

### 3.9.3 Interface Cabling from the Port to the first GC

A range of cables are available from your vendor for connection to standard DB9 or DB25 PC ports for RS232 interfacing, as well as leads suitable 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

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



Detailed information about the RS232 interface and how it works is available on the web. Please note that the IGC implementation differs from a standard RS232 port, as multiple devices (rather than 1 as is standard for RS232) can be connected to the port.

IGC5 implementation of the RS232 interface uses only the receive, transmit and return wires, i.e. a simple 3 wire interface. The remaining "hand-shaking" lines need to be correctly "terminated". Although this can be done in many cases in the driver software, we recommend using the pin links (as shown below) as this guarantees correct hand-shaking termination.

Ports on the most RS232 serial ports use either 9pin or 25 pin DB connectors following standard pin configurations. Wiring (along with colours if using patch leads) is as follows:

PC 25 pin Female DB25	PC 9 pin Female DB9 pin	Function	Cable	Function	GC
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	Disable handshaking	-	-	-
Link 6, 8 and 20	Link 1, 4 and 6	Disable 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

Detailed information about the 2-wire RS485 interface is available on the web. It provides a more electrically robust connection with much better immunity to noise, as the 2 wires are used provide a differential signal. Unfortunately, there is no "standard" for pin-outs as different manufactures use different pin allocations (even between devices in the same range). Thus this manual does not provide specific wiring details. However, however 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 of daisy-chaining controllers is to use standard RJ45 patch leads; shielded, Cat5 compliant cables are recommended. However, please note that when using such cables with IGC5's 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** information.

### 3.9.3.2 RS232 specific patch leads

To use **High** comms mode with any IGC5 (regardless of software version, RS232-specific patch leads are needed. In these, only pins 1, 2 and 3 are wired - all other pins are left not connected.

## 3.9.4 Communications Hardware Kits

Although suitable readily hardware from a range of sources, standard hardware kits are available from your controller vendor. These are fully compatible with VacTools. In addition, special multi-port (1, 2, 4, 8... port), multi-cable assemblies can be provided to specification.

Note that the multiple kits can be used on the same PC, provided that each USB-based kit is connected to a USB port on the PC (not via a multiport extension). Note that the more IGC5 are connected to a port, the slower the data throughput per controller; a maximum of 4 devices is recommended.

### 3.9.4.1 PCCom14

For connection of up to 4 IGC5's from the standard PC DB9 serial port. This comprises:

- 1x 5m long RS232 to RJ45 cable to connect to the first GC. (GC2DB9RJ45-05)
- 3x 0.5m long daisy-chain cables. (GC2RJ4545-0.5)

### 3.9.4.2 USBCom14

For connection of up to 4 IGC5's to a PC via USB. This comprises:

- 1x USB-RS232 converter (USB powered) with lead. The converter is USB powered. (GCUSB01)
- 1x 5m long RS232 to RJ45 cable to connect to the first GC. (GC2DB9RJ45-05)
- 3x 0.5m long daisy-chain cables. (GC2RJ4545-0.5)

### 3.9.4.3 Accessories

The kits can be expanded by provision of:

- Additional RS232 to RJ45 cables (5m standard or ordered to length).
- Additional daisy-chain cables.
- USB active extensions (GCUSBEXT4). These 4.8m long cable assemblies allow the USB connection to be extended up to 15m between the PC and the serial converter.

## 3.10 Data Retention (Volatile/Stored Parameters)

The IGC5 is controlled by manipulating "parameters", either manually through the front panel, or over the communications interface. Some parameters are volatile, i.e. they are temporary and are not retained when the IGC5 is powered off (for example, whether the ion gauge is on or off). Others need to be stored (in EEPROM) when the unit is powered off – this may take up to 3 minutes.

During power up, IGC5 loads the EEPROM data. 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; these are then saved to EEPROM before normal operation commences.

## 4 IGC5 Functions

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*The IGC5 combines several functions in a single 19" rack unit. These functions, described in more detail in this section, operate seamlessly together to integrate pressure measurement with interlocking and system control.*

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### 4.1 Pressure Measurement

The IGC5 pressure measurement supports:

- One Ir-based (Thoria, Yttria or uncoated), single or dual filament ion gauge head. Filaments are dc constant current driven, up to a maximum of 4A (9V compliance).
- One Thyracont VSP84x or VSP52x Pirani gauge head. Note: though these gauge heads appear physically identical, they require different drive electronics and have different pin connections; appropriate interconnecting cables are available. Selection between the gauge head type is via internal jumpers within the IGC5 – see section 6.1.
- One optional gauge head via an options "module". Depending on the gauge head and the module type selected, pressures over the range  $1 \times 10^{-13}$  to atmosphere can be monitored and integrated into the pressure measurement arrangement. For information about modules, see section 6.2.

Notes:

- A combined Pirani/ion gauge pressure reading or Module/ion gauge pressure reading can be optionally set such that the secondary gauge reading is displayed on the main display when the ion gauge is off – see section 12.5.9.
- All three gauges can have trips and/or the analogue output independently assigned to them, and can, where appropriate, be influenced by digital inputs.

### 4.2 Interlock Hub

The IGC5 provides an interlock hub:

- 7 digital outputs (trips). 4 of these are single-pole change-over (SPCO) relays, i.e. the common, normally-open and normally-closed contacts are accessible at the connector. The contacts are capable of switching 1A @ 24Vdc (0.5A @ up to 40Vac). The remaining 3 trips are earth-referenced, open-collector NPN Darlington transistors capable of sinking 250mA. Note that the collectors have a reverse-biased protection diode to the internal power supply – **THEREFORE DO NOT APPLY MORE THAN 14Vdc AT THE COLLECTOR PINS.**

- 2 opto-isolated digital inputs. These can be activated by applying a dc voltage of between 3 and 30V. The equivalent input resistance is  $>2.4\text{k}\Omega$ ; 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.
- 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 IGC5 functions, such as pressure trips, ion gauge status indication (gauge on/in degas), bake-out on/off power switching, pump-down 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.
- The trips and digital inputs are available via a male DB25 connector. A solder-free connector is available.
- The analogue output is available via a standard 3.5mm ( $\frac{1}{4}$ " ) jack socket.

### 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 one or more trips to switch heater power allows full multi-step bake-out control:

- Measurement/control range is room temperature to 500°C. The accuracy of measurement (including cold junction compensation) is factory calibrated to better than  $\pm 1^\circ\text{C}$ . Measurement and display resolution is  $<0.1^\circ$  and  $1^\circ\text{C}$  respectively.
- The final temperature and duration of up to 6 ramp/soak steps can be defined (up to 99.9 hours per step in 0.1 hour increments).
- 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 instruct the IGC5 to automatically degas the ion gauge head when the bake-out has finished.

### 4.4 Vacuum System Auto Pump-down

By allocating trips to the Pump-down, Pirani/ion gauges to valve/pump control, and digital input interlocking, the IGC5 allows complete automation of a vacuum system evacuation and ion gauge start-up as dictated by user preference. For further information, please section 9.

## 5 Ion Gauge Operation

*The IGC5 provides stable and electrically silent control of a UHV ion gauge head. This section describes ion gauge operation, and discusses some of the unique features offered by IGC5, such as Auto Emission, Degas pressure measurement and uninterrupted gauge operation during normal/degas transitions. Some applications and hints for ion gauge operation are also discussed.*



### 5.1 Ion Gauge Construction

The internal construction of an ion gauge head, as shown, comprises:

- A wire, spiral or ribbon filament (left), made of a low vapour pressure metal. The assembly shown has 2 filaments that are used independently to provide redundancy. Passing current to heat the filament induces thermionic emission of electrons; filaments are often coated to reduce the work-function of the filament material and thus enhance emission at lower temperatures. Coated Iridium filaments typically operate at  $\sim 650^\circ\text{C}$ , compared with  $>2000^\circ\text{C}$  for Tungsten, thus require much less power which reduces degassing of the gauge head and any surrounding items. The filament is at  $\sim +45\text{Vdc}$  with respect to earth.

- A cylindrical "grid" made of an open mesh material. This is biased at +190Vdc (>+380Vdc during degas) to attract the emitted electrons. The grid has an open structure allowing emitted electrons to make multiple passes before colliding with it. The IGC5 electronics controls the emission current from filament to grid to maintain a constant stream of electrons.

- A thin "collector" wire in the middle of the grid. This is connected to the earthed IGC5 electrometer.

When emitted electrons collide with gas molecules, an electron may be knocked off the gas molecule, leaving a positive ion. Due to the relative mass of the ion, this is attracted towards the collector (due to the relative bias on the grid and collector) from which it receives an electron, thereby inducing an "ion current" in the collector. The pressure can be deduced from the ion current, since this is proportional to the number of gaseous molecules and to the electron emission current.

The efficiency of generating ions depends on a number of additional factors apart from pressure and emission current. The "Sensitivity" factor reflects the effect of the geometry and size of the gauge head and is different for each gauge type. Secondly, the ionization probability for different gases varies; these are generally referenced to Nitrogen (as 1) and are well documented in the literature. The IGC5 does not provide a separate parameter to enter this correction. However, if necessary, this can be taken in consideration by entering a composite Sensitivity factor; dividing the gauge head Sensitivity value by the relative ionization probability for the gas of interest.

To reduce the extremely wide range of ion current ( $10^{-12}$  to  $10^{-2}$ A) required to be measured by the electrometer and boost the number of ions at very low pressures, the emission current is varied over a range of <0.1mA to 10mA. Degassing of the gauge head is executed by raising the grid potential and allowing emission currents of up to 50mA. For safety, the high voltage power supply is isolated from the gauge head connector when the gauge is switched off.

## 5.2 Gauge Type and Filaments

The IGC5 was designed to operate one twin filament UHV gauge head with Thoria-, or Ytria-coated Iridium filaments; however, it will operate any nude gauge head (i.e. without integrated electronics) that requires <4A of filament current at a maximum voltage across the filament of about 8V; this includes some Tungsten filament gauge heads, but not all. Supported gauge heads include those manufactured by VG Scienta, SS-Scientific, ITL, Instrutech, Leybold, Balzers, Leskers... as well as our own IGC5IrT and IGC5IrY heads (respectively with dual Thoria- and Ytria-coated filaments and pressure range of  $3 \times 10^{-11}$  to  $1 \times 10^{-2}$ mBar).

Either filament 1 or filament 2 can be selected; if "Auto" is set, the IGC5 will first try to use filament 1 and if emission cannot be established, filament 2.

## 5.3 Emission Currents: Setpoint and Measured values, and Pressure Calculation

Emission (from the filament to the grid) is established by controlling the dc current through the filament. The filament current is established by comparing the requested (Setpoint) emission value with the actual (Measured) emission value using a **PID** loop (see section 5.5).

As well as the collector ion current, the indicated pressure depends on the emission current. In the IGC5, the actual emission current is measured simultaneously with the collector (ion) current to ensure an accurate pressure value.

## 5.4 Fixed Emission Currents and Emission Current Range

The IGC5 supports a range of user-selectable "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 a natural "anti-logarithmic" sequence. Optimum choice of which emission to use depends on the operating pressure range of the vacuum system; higher currents are required at lower pressure to ensure sufficient ion current. Alternatively, you can set the IGC5 to automatically adjust the emission current to match the gauge head operating conditions by setting to "Auto-emission" (see section 5.6).

The user can define a minimum and maximum emission setting to reflect optimum conditions for a specific design of ion gauge head. For example, setting the maximum emission value to 4mA will inhibit higher values being made available to the user and to the Auto-emission algorithm.

## 5.5 Emission Start-up and PID control

The Proportional and Damp parameters should not normally need adjusting since the controller is shipped with values appropriate to the majority of ion gauge heads encountered. The P-term of the PID is set by the Proportional parameter value; the Damp parameter sets both the I & D values. These parameters are dimensionless in the IGC5 and set normalized for a value of 25 equaling optimum for most gauge types.

In addition, there are 2 "power" related parameters, measured as % of maximum current output. The minimum and maximum current values limit the range that the filament will be driven at during normal PID control. The minimum current value is usually selected to be 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 (either to a user defined emission value or to Auto-emission) the IGC5 first sets the Setpoint emission value to 0.05mA (irrespective of the user-defined minimum emission current), and ramps the output current from zero to the minimum power value over a period of 5-10 seconds. 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 current, PID control commences. If emission is established at or below 0.05mA and a sensible pressure measured, the IGC5 establishes the requested emission value; otherwise the gauge head is turned off (or the second filament is tried if auto-filament selection is set).

## 5.6 Auto-Emission

Setting emission to "Auto" allows the IGC5 to automatically select the most appropriate emission current based on the measured pressure. Auto-emission initially powers up at 0.05mA (regardless of the user-defined minimum setting), and then gradually changes the emission between the minimum and maximum emission limits, depending on pressure.

To avoid pressure bursts, emission increases are performed in increments. However, the Auto-Emission algorithm responds immediately to sudden increases in pressure to protect the gauge head. Auto-emission computes a suitable level of hysteresis to ensure that emission "hunting" does not occur.

## 5.7 Changing Emission

When a new emission value is required, the IGC5 ramps the emission setpoint from the currently measured value to the new value, to avoid sudden changes in the filament current. The ramp is slower for increasing emission (to avoid pressure bursts) than for decreasing emission currents (where decrease may be requested for gauge protection).

## 5.8 Degas

Ion gauge assemblies adsorb gas molecules after being exposed to air or to relatively high pressures of introduced gas. This can cause the gauge head to contribute to the gas load during operation due to desorption, and also influences the ability of the collector to collect ions and the grid to collect electrons; these factors effectively change the sensitivity factor for the gauge. To ensure optimum performance, ion gauges are "degassed". 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 5.11.

The IGC5 provides 3 levels of degas, Low, Mid and High power, which sets the maximum emission used (15, 25 and 50mA respectively); at the same time, the grid potential is raised to ~400V to provide more energy to the impinging electrons to enhance heating. Further heating is provided by the increased filament power required to achieve the raised emission currents; this varies depending on the gauge type.

The IGC5's degas cycle comprises 2 steps: a timed ramp from the currently measured emission value to the selected power (**DegasRampTime** parameter) and a "soak" period (**DegasHoldTime** parameter). The duration of each step is user-defined to between 1 and 999 minutes.

The IGC5 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 (rather than stepped abruptly). Using extended ramp periods (>10mins), heating of the gauge head, and thus desorption of gases, is gradual, allowing pumps to cope with and/or recover from large degas gas loads.
- If the pressure during degas exceeds a user-defined limit (**DegasSuspend** parameter), degas ramping is suspended to allow the pressure to recover before any further increases in emission.
- The collector current (measured pressure) continues to be measured during degas; thus software and trip interlocks continue to be protected during degas.
- The IGC5 switches from normal measurement to degas modes (and back) **without** interrupting operation of the gauge; there is only a very brief (~0.5 sec) transition period during which measurement is suspended to allow the gauge head to adjust to the new operating conditions.
- 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.

## 5.9 Ion Gauge Status and Error Messages

The IGC5 performs a range of checks on the ion gauge integrity during operation; these are displayed on the Primary Display. If an ion gauge trips out, for example, due to loss of grid voltage or emission, the fault condition is reported and remains until ion gauge is next powered up. See also Troubleshooting.

The common messages are:

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) or filament bias power supply. Ion gauge will be switched off. [Check rear panel high voltage grid fuse.]
OverTemp UnderTemp	Internal over or under temperature condition. Ion gauge will be 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.
PowerMax Er	(Added v2.08). Ion gauge tripped: power output exceeded max power setting for > ~30secs. Note: (added v2.18) this does NOT apply during degas as, for some types of 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.

## 5.10 Emission Leakage

Since accurate and stable pressure measurements requires knowledge of the emission current, good electrical isolation is required between grid, filament and earth. However, ion gauges can become coated leading to an electrical "leakage" path between the pins. Typical symptoms of leakage are:

- 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 indicated.

Simple resistance measurements using a meter may not provide adequate indication of leakage since breakdown/leakage often requires presence of a high voltage.

The IGC5 will continue to operate leaky gauge heads, but remedial action or replacement of the gauge head may become necessary if operation only occurs at high emission currents.

## 5.11 Hints on using ion gauge measurements

The IGC5 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 hints/suggestions regarding operation of ion gauges in general and with the IGC5 specifically.

### 5.11.1 Vacuum Pressure Measurements

For normal vacuum system pressure measurements, use Auto-emission. The IGC5 will ensure optimal emission current setting to provide good measurement accuracy commensurate with the pressure.

### 5.11.2 New Filaments - Degassing

Previously unused Iridium filaments require "conditioning" as the coating is not initially active in reducing the work-function of the filament. For example, whereas a used filament may need ~28% filament power for emission, a new filament may need 40% or more. In addition, the first time a filament is run, it degasses heavily which can cause problems with poorly pumped systems, for example causing an ion pump to trip out. At 0.1mA emission, it can take several hours for the filament power to decrease to a value consistent with a "conditioned" filament.

To reduce the impact on a vacuum system and pumps of degassing from a new filament (or gauge head), the IGC5 provides an option for an extra slow power up. The **NewFilamentRamp** Parameter (Ion Gauge menu) selects between normal power up (which typically takes 10-20 seconds) or slow ramp (which typically takes between 2 and 4 minutes). The settings available are **Off** (normal ramp), **Once**, **Twice** and **Always**. In the case of 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 initially. In the case of the Always setting, the slow ramp is always used.

The impact of gauge head conditioning can be further reduced:

- Use the Auto emission feature – the IGC5 will control the emission as the pressure allows
- Once the gauge head has been operated for several minutes, degas the filament at the Low degas setting, using a long (30-60minute) degas ramp up time.
- Note that both filaments need to be conditioned independently.

### 5.11.3 Degas

After air exposure, it is essential to degas the gauge head thoroughly; a long degas (>30minutes ramp and >10 minutes at DegasHi) is recommended. This is best affected after bake-out of the UHV system, and preferably whilst the system is still warm and cooling (>100°C); this can be automated by the IGC5 - see section 8. If the process can

tolerate it, occasional short degas sequences (5+5 minutes at lower degas power) can keep the gauge operating optimally.

Note that degassing only affects the currently selected filament. If, a UHV system is to be under vacuum for an extended period, or the process is prone to filament burn out (e.g. operation at high introduced gas pressures), degassing of the second filament after air exposure (prior to bake-out) will minimize subsequent disruption to the vacuum integrity should the second filament be required.

## 5.12 Beam Flux Measurements

### 5.12.1 Measurement Method

As well as converting the collector current to a pressure, the IGC5 has several features that make it uniquely useful for Beam Flux Measurement (BFM) in MBE and related deposition equipment.

Conventionally, the ion gauge controller is used solely to provide a stable emission current; the collector current is taken to an external precision picoAmmeter for processing. The main shortcoming of this method is that fluctuations/drift in emission current cannot be accounted for in the measured current.

The IGC5 continually monitors emission current allowing correction to the measurement for changes in emission. In addition, the design of the electrometer means that the displayed value, or available from the analogue output can be used directly, thereby eliminating the need for external equipment.

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 it to stabilize thermally.
- Leave the controller on even when the ion gauge is off. This maintains a constant thermal environment within the controller to keep the electrometer at peak stability
- Turn the ion gauge on at least 10 minutes before measurements are required to be taken to allow the gauge head and electronics to reach stable operation.

### 5.12.2 Measuring as Current

For normal pressure measurement, the IGC5 provides access to units of mBar, Torr or Pascal; all vacuum gauges indicate pressure in the selected units. However, software version 1.08 added the facility to display the collector current in Amps. Selection of pressure units is therefore separate from selection of pressure or current display for the ion gauge; both are available in the Setup Menu.

When current measurement is selected, the display auto-ranges the units and data format to provide a simple non-exponential display accurate to 4 significant digits. Thus the units are indicated as pA, nA,  $\mu$ A or mA and the data formats x.xxx, xx.xx, xxx.x as appropriate.

## 6 Secondary Gauging

*The IGC5 supports 2 levels of Secondary Gauging:*

- Built-in support for one Thyracont VSP84x or VSP85x Pirani gauge head ( $10^{-4}$  to  $\sim 200$ mBar).
- Installation of one of a range of optional modules supporting a wider range of gauge types. These include an additional VSP84x or VSP52x, VG Pirani, mini-Convector, Stinger, Baratron... and almost any linearized output active gauge is supported (many powered from the module).

### 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  $\frac{1}{8}$ "NPT) and whether metal sealed.

#### 6.1.2 Selecting the gauge type within the IGC5.

Although the VSP84x and VSP52x gauge heads are physically identical, their pressure measurement and temperature compensation characteristics differ (requiring different electronics) and the pin assignments on their connectors are also different (requiring different cables). Before using a gauge, it is important:

- To set-up the IGC5 for the gauge type being used. Controllers are generally factory shipped configured for VSP84x gauge heads, unless otherwise requested. The type set can be checked from within the **Calibration Menu** of the controller.
- To ensure you are using the correct cable. A 3m cable is provided for both gauge types; 2m "extensions" can be daisy chained as required where longer lengths are required.

### 6.1.3 Hardware settings for the Pirani gauge

To set the correct electronics for the Pirani gauge head, the IGC5 has 5 internal "jumpers". *The positions for the jumpers are clearly labelled with legends for the two types of gauge.*

To set the jumpers:

- If you have an earthing wrist strap, we recommend its use during this procedure.
- Disconnect **ALL** leads the IGC5. Whilst performing the following steps, do NOT connect any lead to the instrument.
- 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.
- Remove the 3 screws on each side of the controller. **Carefully raise the lid since there is an earth wire attaching the cover to the base of the unit.**
- There are static sensitive components within the controller. Avoid touching any component on the mother board. Handle modules by the edges - do not touch any components on the module.
- Place the controller so the front panel is facing you.
- (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.

To verify correct jumper configuration, go to the **Calibration Menu** and check the **Pirani Type** parameter.

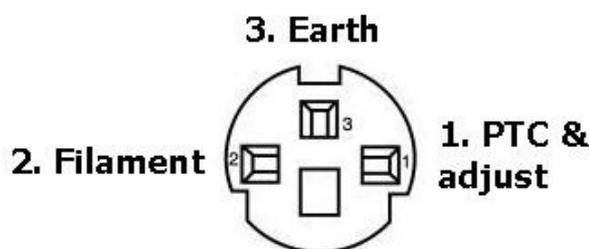
### 6.1.4 Pirani Calibration

Due to their construction, the resistance of the Pirani filament varies considerable between units leading to large differences in indicated pressure, particularly at the extremes of their pressure range where sensitivity is low. The IGC5 provides a simple procedure to correct for the variation in filament resistance to ensure accurate measurement by applying "calibration" settings to match any specific head. This is available from within the **Calibration Menu** - for further information, please see section 10.

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

### 6.1.5 Pirani gauge Connector

The connector for the Pirani gauge head is a 3-pin mini-DIN, as shown (viewed looking into the connector on the rear panel). Although the connector assignments are the same at the IGC5 for both the VPS84x and VSP52x, the connections are different at the gauge head. Appropriate cables are available for both Pirani types.



## 6.2 Optional Gauge Modules

### 6.2.1 What are Modules?

The IGC5 provides one module "slot" allowing a range of small PCB's (modules) to be installed to provide support for additional gauges. The IGC5 will automatically detect the type of module installed (at power up) and may, if necessary, modify the menus to take account of additional functionality.

All modules available for the IGC range are supported by the IGC5. They comprise small PCB's with an 8-pin connector that plugs into the IGC5 motherboard. Note that the IGC5 provides a 13-pin socket (as opposed to the IGCi and IGCiDuo which have 8-pin sockets); the IGC5 provides support for a range of "extended" modules currently under development. It should not be possible to install 8 pin modules into the 13 pin socket wrongly because of the position of the support pillar (into which a screw fits to secure the module) and the need to match the connector at the rear panel.

Modules are easy to install and require no "configuration". Any additional features or requirements for the module (such as specific parameters associated with the supported device) will be automatically provided by the IGC5 software.

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

### 6.2.2 The "E" Module: VSP52x

The "E" module supports an additional VSP52x Pirani gauge head. The module provides a connector identical to the standard one built into the IGC5 – see section 6.1.6.

The IGC5 reports **No Pirani** if no Pirani head is attached to the "E" module.

### 6.2.3 The "F" Module: VSP84x

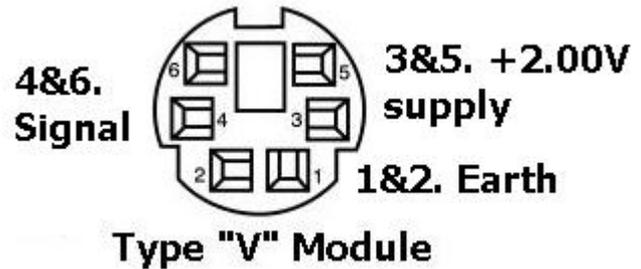
The "F" module supports an additional VSP84x Pirani gauge head. The module provides a connector identical to the standard one built into the IGC5 - see section 6.1.6.

The IGC5 reports **No Pirani** if no Pirani head is attached to the "F" module.

### 6.2.4 The "V" Module: VG Pirani gauge heads

The "V" module supports the VG range of Pirani gauge heads. The module provides a 6 pin mini-DIN connector, as shown. Since the cable from the VG Pirani's terminate in a 5 pin standard-DIN socket, a converter cable is provided with the module.

The IGC5 reports **Atm** (atmosphere) if no Pirani head is attached to the "V" module.



### 6.2.5 The "U" Universal Module: Linearized gauges

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 IGC5 software provide the following:

- A differential analogue input (pins 2 and 1) allows the pressure to be deduced 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.
- The module can, optionally, provide power to the device. The power supply on the module provides a nominal +14.5Vdc (pin 5), -14.5Vdc (pin 6), both current limited to ~120mA, with reference to 0V (earth) at pins 3 and 4. This is sufficient for many devices, such as the mini-Convectron, Instrutech Stinger, Thyracont VSP62x, MKS121... If higher voltage or current are required, a separate power supply will be required.
- The pressure range and voltage input limits can be set in software to match the operating range of the device being monitored. This allows virtually any device to be supported, even the output from another UHV ion gauge - see the example below.
- The relationship between the pressure and input voltage can be set to either logarithmic or linear, as appropriate to the device.

As an example, the following wiring will monitor the output *and* provide power to a Instrutech CVM-211

Stinger:

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

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

## 7 Interlock Hub: Digital I/O and Analogue Output

*The Interlock Hub (comprising user-definable digital output trips, digital inputs and an analogue output) aids system management and can simplify inter-wiring between vacuum measurement, system equipment (pumps, valves...) and process devices (heaters, gas lines...). It can provide automation of many aspects of system operation, such as pump-*

down and bake-out, as well as a way to control/monitor external equipment. The Interlock Hub interacts with the ion gauge and secondary pressure monitoring facilities.

**Note: The IGC5 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 IGC5.**

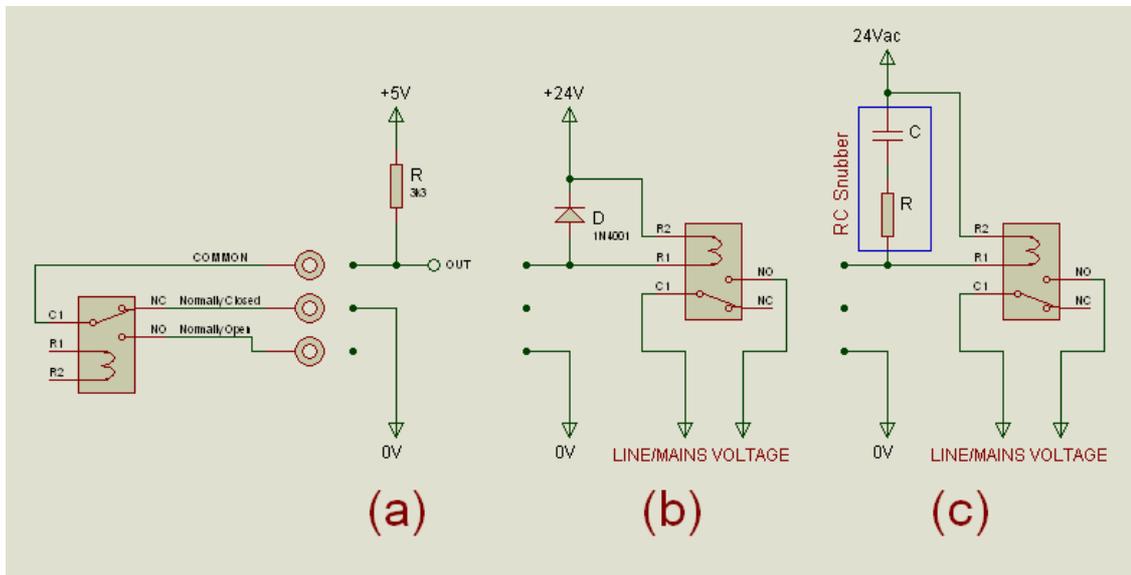
## 7.1 Trips (Digital Outputs)

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

### 7.1.1 Relay-based Trip Hardware

Trips 1 to 4 are 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, methods for suppression of back emf or current surges MUST be employed:

(a) Drive to a resistive load, in this case to drive a 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 instead of the normally closed to invert the signal. (b) Switches a mains contactor, for example a heater. To comply with the 1A contact current limit, the resistance of the external relay coil should be >30Ω. Note the reverse biased diode MUST

BE PRESENT to suppress the back emf generated by the inductive load presented by the relay coil; this diode should have a reverse voltage rating well in excess of the +24V supply, and a current rating at least twice that consumed by the relay coil. The 1N4001 shown is rated at 1A, and is suitable for supplies up to about 40V.

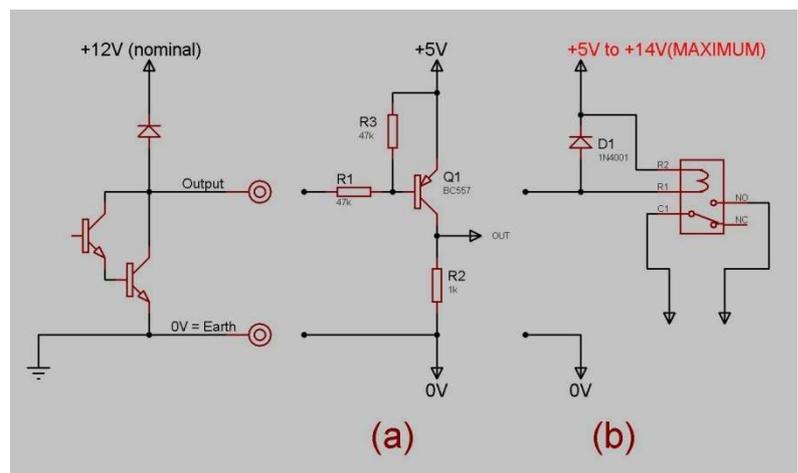
(c) Wiring of a relay with an ac coil. The same rules apply as for (b), except an RC snubber network MUST BE used for back-emf suppression. Typical R and C values are 100Ω and 0.1μF; composite snubber components are available from most electronic suppliers.

### 7.1.2 Open Collector-based Trip Hardware

Trips 5 to 7 are open-collector Darlington transistor output, each capable of sinking 250mA at 12Vdc. **Only dc devices can be driven with these outputs, and note that the outputs are 0V (earth) referenced.**

A schematic of the output configuration is shown on the left of the diagram. Note the built-in protection diode to the internal power supply; this limits the maximum voltage of any driven devices to just over 12Vdc.

(a) shows a scheme for driving a 5V TTL, or similar, load. The output from a Darlington transistor can be 1V (or higher) when on, and this exceeds the low logic threshold of some logic families; the use of the buffer shown addresses



this, and in addition, 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.

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

### 7.1.3 Trip Assignments

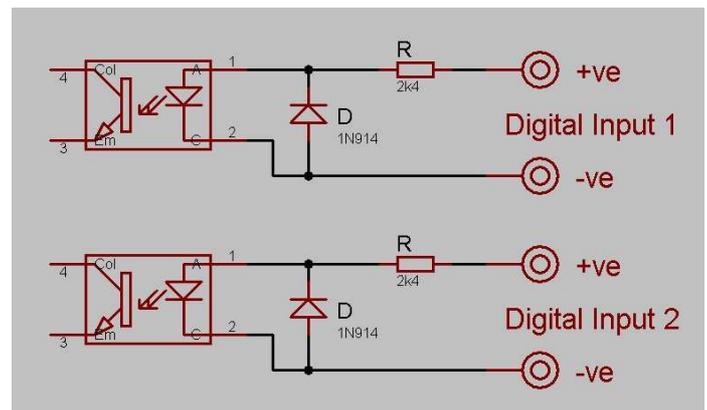
Each trip operates independently and can be assigned to a wide range of functions. These include reacting to the ion or any secondary gauge, indicating gauge operating or degas state, thermocouple temperature, bake-out control, or programmed pump-down or communications event.

## 7.2 Digital Inputs

### 7.2.1 Digital Input Hardware

The equivalent circuit of the 2 digital inputs is shown right:

- Each input is opto-isolated from the other and from earth.
- The inputs will respond to a voltage input of between 3 and 30Vdc.
- The equivalent resistance of the inputs are  $\sim 2k4\Omega$ ; above 30V, the dissipation of the resistors will be exceeded. It is recommended that if voltages higher than 24V are applied, an external series resistor should be used to limit the input current to 10mA. Resistor values can be calculated using  $R_{ext} = (V / 0.01) - 2400 (\Omega)$ . Thus to use a 48V power supply, an external resistor of  $\sim 2400\Omega$  is required (standard values of  $2k2\Omega$  or  $2k7\Omega$  would suffice); power dissipation would be  $(I^2R) 0.01 * 0.01 * 2400 = 0.24W$ , so a standard 0.5W or 0.6W resistor is recommended.
- The opto-isolator inputs are protected against reverse biasing by diodes (D).



### 7.2.2 Digital Input Assignments

Each digital input operates independently and can be assigned to one or more functions simultaneously. These include: trip the ion gauge in response to an external event, start/stop the ion gauge operation (either by holding the digital input or by toggling the input), inhibit/abort bake-out and pump-down.

## 7.3 Analogue Output

### 7.3.1 Overview

The final component of the Interlock Hub is the analogue output. This comprises:

- A precision-reference based analogue output capable of sourcing/sinking 20mA.
- The nominally 0-10V output range has a resolution of 12 bits extended over the range -0.03V (0 counts) to +10.2V (4095 counts) to allow correction for external offsets.
- The minimum and maximum voltage can be user-configured as required and assigned to any analogue signal processed by the IGC5.

### 7.3.2 Parameters

As well as the value to which the analogue output is allocated, there are 5 parameters associated with the analogue output which provide complete flexibility over its use:

- The minimum and maximum voltage output can be set by the **AO OutPMin** and **AO OutPMax** parameters. These parameters are defined in terms of the 12bit output counts (0 to 4085). While these parameters are being set, the analogue output outputs the voltage so it can be measured to match and set to requirement.
- The minimum and maximum pressure (or temperature) value corresponding to the min and max voltage output values (set by the **AO PrMin** and **AOI PrMax** parameters). These can be set over a large range of  $1e-13$  to  $1e+6$ . Note that **AO PrMin** CAN EXCEED **AO PrMax** to allow negative as well as positive slope relationships to be supported.
- The pressure/temperature to voltage output relationship can be set to be linear or logarithmic using the **AD Function** parameter.

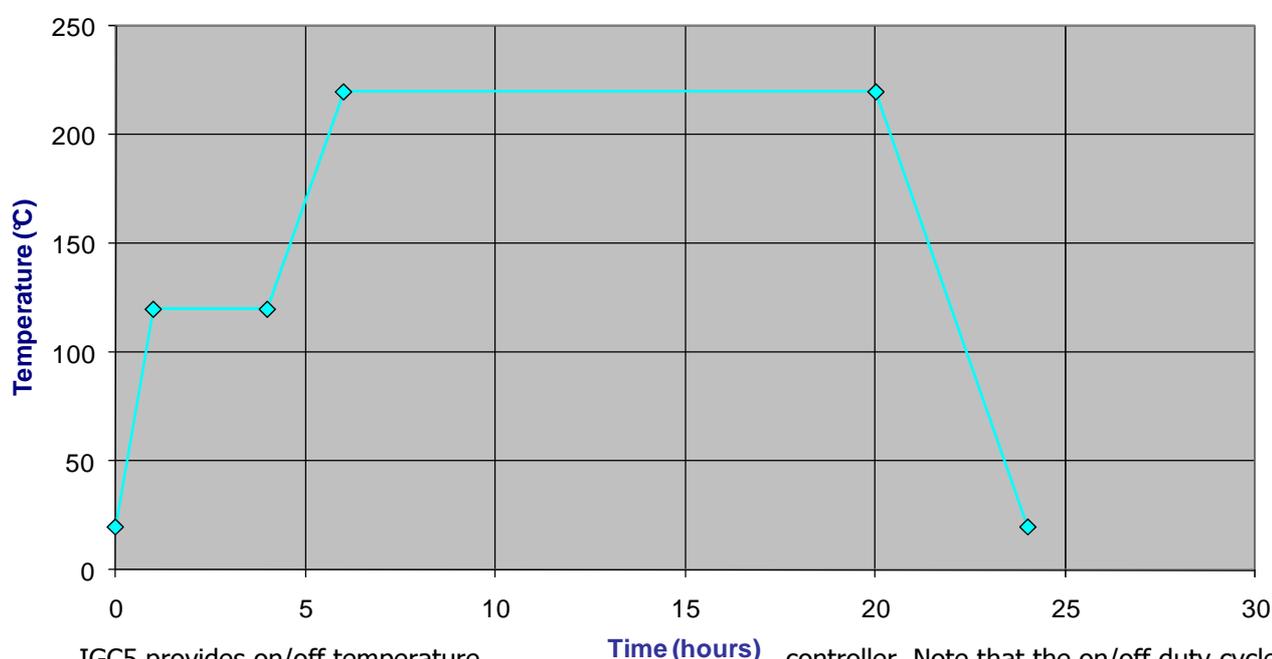
## 8 Bake-out

*The bake out function integrates control over system baking with pressure and external interlocking. Each of the 6 bake sequence steps can ramp to, or hold a temperature. "Gentle" ramped thermal conditioning of the system avoids sudden pressure bursts. The ion gauge and digital inputs can be configured to act as protection trips, and the ion gauge can be programmed to degas automatically at the end of the sequence.*

### 8.1 Overview

Bake-out is facilitated by connection of a type K thermocouple and configuring one or more trips to switch power on and off to the heaters. The end-of-step temperature and the duration of up to 6 steps can be defined; a step with zero duration is skipped. A sample 5-step sequence is shown:

**Bake-out Temperature Profile**



IGC5 provides on/off temperature controller. Note that the on/off duty cycle is approximately 1 second; if switching at this rate is too high, the Hysteresis parameter can be used to reduce the on temperature.

The output from the temperature control can be assigned one or more of the 7 Trips; for example, assigning 3 trips to bake-out could be used to control 3 $\Phi$  power using 3 single  $\Phi$  relays.

Operation of the bake-out can be interlocked to:

- Ion gauge pressure. To avoid excess degassing, define a pressure value above which the heating is turned off, the bake-out countdown optionally suspended, or the bake terminated.
- Either or both digital inputs. External events can suspend heating, bake-out timing, or terminate the bake. Finally, at the end of the bake-out, the ion gauge can be optionally set to perform a degas sequence. All aspects of a bake-out sequence are set from within the **Bake-out** Menu.

### 8.2 Operating the Bake-out

Once a bake-out sequence has been defined, bake-out can be started at any time. However, please note that unless a thermocouple is connected and the ion gauge is on to allow any pressure interlocking, no trip outputs (and thus heating) is likely to occur.

The main display shows a °C symbol for the duration of the bake-out and the bake-out view provides information about the bake-out status (see section 11.2). Any trip condition causing bake-out suspend and its effect are also displayed.

If set, automatic ion gauge degassing will occur as soon as the bake-out terminates.

The bake-out can be stopped at any time by issuing the **Stop** command from the **Bake-out** Menu.

## 9 Auto Pump-Down

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*For Auto Pump-Down of a chamber/system, the IGC5 integrates Pirani pressure measurement; with control/monitoring of external devices (e.g. valves, signals) via the Interlock Hub, and safely auto-starts the ion gauge.*

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### 9.1 Overview

On starting the Pump-Down from the PumpDown menu, the pressure of the built-in Pirani channel is monitored. Any trips are activated in accordance with their allocation (for example, to open and close valves above/below defined values). On reaching the Ion Gauge Start Pressure (`PDStartPressure`), the IGC5 waits for a user-defined period (`PDStartDelay`) before attempting to start the ion gauge. If the ion gauge does not start, the IGC5 waits a for the user-defined period before trying again; this is repeated up to 9 times (as set by the user using `PDNumberAttempts`).

Notes:

- The option to start Pump-Down is only available if the ion gauge is off; if the ion gauge is on, the system is "assumed" to be pumped down.
- Trips assigned to pump-down only operate during the pump-down sequence; they turn off when the pump-down terminates (e.g. the ion gauge is on, or the number of attempts to turn it on has been exceeded). For trip control which is independent of pump down (for example, for operating a pump based on a ballast pressure), trips should be assigned directly to the Pirani head.

## 10 Calibration

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*Most devices do not provide absolute measurement of natural phenomena due to the physical principles behind their operation, manufacturing tolerances in their geometry or component parts, or ambient environmental variations. Vacuum gauges, thermocouples and indeed, control electronics are no exception. However, through careful design (to address long term stability) and calibration against known standards, these "tolerance" variations can largely be compensated for to provide accurate and consistent measurements.*

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### 10.1 Ion Gauge Calibration

Ion gauges are not absolute measurement devices; most gauge types have a well-established generic measure of their effectiveness, defined as the "Sensitivity" factor, established by comparison with "standards" - see section 5. However, constructional tolerances as well as "ageing" processes, exposure to atmosphere and physical differences result in gauge-to-gauge variations. As such, there are few things a user can do to influence measurement accuracy. However, consistent measurements can be obtained by well-established techniques, such as ensuring gauge orientation to minimize the effects of filament sag, thorough, and if necessary, repeated, degassing of the head, and careful management to reduce variations in operating conditions.

The IGC5 helps by:

- Providing a constant current filament drive and PID control over emission current to maximize stability over the gauge operating conditions.
- Calibration of the emission circuitry and the electrometer to minimize environmental effects and non-linearities.

### 10.2 Pirani Gauge calibration

Pirani gauges are based on resistance measurements of a filament in vacuum. They are exceptionally prone to variations in the ambient temperature (compensated for by temperature sensors) and physical variations between filament lengths; these potentially lead to considerable difference in measurement between gauge heads.

The IGC5 provides a simple user-oriented method for "calibrating" the controller to match any given Pirani gauge head, through the `Calibration Menu`. This applies to the built-in support for VSP84x and VSP52x gauges, as well

as to modules that support these and other gauge heads. In each of these cases, the procedure is executed through the **Calibration Menu**:

- 1) Ensure that the IGC5 is appropriately configured for the gauge of interest.
- 2) Mount the Pirani gauge and connect to the IGC5 built-in Pirani or module input.
- 3) Expose to atmosphere (or N<sub>2</sub> or usual venting gas at atmospheric pressure).
- 4) Allow the gauge to settle for a few minutes. The IGC5 should indicate either atmosphere, or a "high" pressure value.
- 5) From the **Calibration Menu** select the **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. This will set the correction factor required to ensure accurate measurement at atmosphere. The indicated pressure should then be atmosphere. [Version 2.18 and above, the message reads "DONE"]
- 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). From the **Calibration Menu** 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 12.13.

### 10.3 Thermocouple Input Calibration

Temperature measurement using thermocouples (type K for the IGC5 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**. The procedure:

- 1) Short-circuit the thermocouple input and allow a couple of minutes to ensure thermal stability. From the **Calibration menu**, select **SetTC@0mV** and press the OK button. This calibrates 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. From the **Calibration menu**, select **SetTC@10mV** and press the OK button. This provides a "high" temperature calibration point.
- 3) Note: this input should not normally need adjustment since it is factory calibrated.

### 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.

## 11 Operating the IGC5

*All aspects of the IGC5 can be operated either from the front panel or via the RS232/RS485 communications link. This section describes the display types, menu system and manual operation.*

### 11.1 Manual Operation

The front panel displays and operation via the 5 control buttons was described in section 3.3. On powering up, the IGC5 goes through a sign-on screen whilst all parameters are loaded, and the module is identified. All aspects of the operation and parameter editing is by navigating a simple MENU structure in which all related parameters are grouped for intuitive access (section 12).

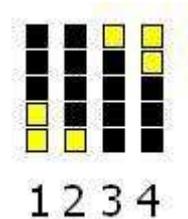
### 11.2 "Primary" Display

The "Primary" display is a 100x16 pixel graphics display:



The two examples show various aspects of the display:

- The 4 character user-defined name of the gauge whose data is currently being displayed is shown top left. For gauge naming, please refer to section 12.5.9, [IonGauge Name](#), [Pirani Name](#) and [Module Name](#) parameters.
- Bottom left are 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. As can be seen, trips 1 and 2 are on for the examples above.
- **Ion Gauge OFF.** When the ion gauge is off and the [MainDisplayFunc](#) parameter is set to [IonGauge Only](#), information messages relating to the ion gauge/unit status/error conditions are displayed in inverted text – see section 5.9 for a complete list. Note, these messages are also available in the Secondary display.  
If the [MainDisplayFunc](#) parameter is set to [IonG & Pirani](#) or [IonG & Module](#), the pressure values from these sources is presented and the name (top left) will be the user-defined ones.
- **Ion Gauge ON.** When the ion gauge is on, pressure is indicated in large characters in the decimal format, as shown. The pressure units (mB, T or Pa) are also displayed. If current measurement is selected, the value is always displayed to 4 significant digits with auto-scaling of decimal places and units ( $\mu\text{A}$ , nA, pA) as required.
- The top right-hand pixel of the display flashes briefly whenever valid data is received over the communications bus and the IGC5 has replied.



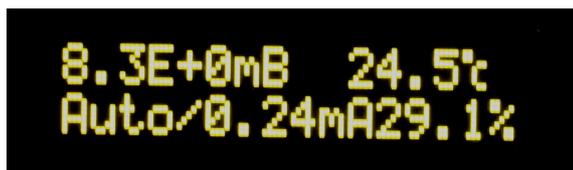
### 11.3 “Data Edit” Display

The right hand display is a 2 line, 16 character display which has 2 functions:

- Pressing UP  or DOWN  buttons scrolls the display between 4 pages: The Secondary/Emission page (section 11.4), the Module/Emission page (section 11.4), the Pump-Down page (section 11.5) and the Bake-out page (section 11.6).
- Pressing MENU  button provides access to the Menu system for controlling operation of the controller and editing parameters – see section 12.

### 11.4 The Secondary/Emission and Module/Emission Display Pages

The Secondary/Emission and Module/Emission pages are the default condition for the right hand display; on entering any other display or the menu system, IGC5 automatically returns to the last displayed of these 2 pages if no button is pressed for more than ~100 seconds.

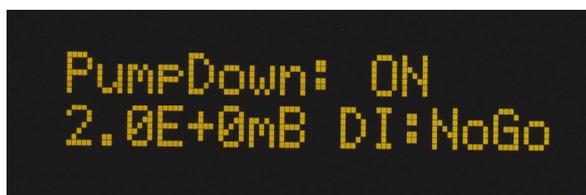


- For the Secondary/Emission page, the top line shows the pressure measured by the Pirani gauge head and the temperature monitored by the thermocouple input. If no Pirani is connected, “No Pir” is indicated. If no thermocouple is connected, “No T/C” is indicated. Note, v2.20 and above, if Quiet mode is set, these values are

absent if the Pirani or thermocouple are not connected.

- For the Module/Emission page, the top line shows the used-defined 4 character name assigned to the module and the measured value.
- For both pages, the bottom line shows the current emission state of the ion gauge. In the example above, the emission is set to “Auto”, the current measured emission is 0.24mA and the filament power being drawn as controlled by the PID is 29.1%. If a fixed emission current is user selected, this value takes the place of the “Auto” legend.
- During degas, the selected degas power and remaining time are alternately displayed in place of the “Auto” legend.
- During bake-out or pump-down, the bottom line toggles between the emission condition and status information about the bake-out or pump-down.

### 11.5 The Pump-down Display Page



- If pump-down is not underway, the top line reads “PumpDown: OFF”.
- When pump-down is started, the bottom line indicates the current Pirani pressure value. If digital input interlocking

has been enabled, the digital input condition (Go or NoGo) is also indicated.

- When the Pirani gauge reaches the ion gauge start pressure, the bottom line changes to indicate the number of attempts that are tried to start the ion gauge.
- If the ion gauge starts, or fails to start after the set number of attempts, pump-down terminates.

## 11.6 The Bake-out Display page



temperature.

- If bake-out is not underway, the top line reads "BO: OFF" and the bottom line shows the currently measured temperature.
- During bake-out, the remaining time is displayed on the top line. The bottom line shows the current step, the setpoint temperature and the currently measured

## 11.7 Screen-Saver and Quiet Modes

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

- When switched on (**Screen Saver Mode**), the controller only displays the ion gauge pressure/status as moving text on the right hand display. The left-hand display is blanked. Screen Saver Mode is entered after no button action has occurred for a period greater than that defined by the **Screen Saver Time** parameter. When in screen saver mode, pressing any of the buttons causes full display operation to occur immediately.
- Quiet mode is turned on and off using the **Quiet Mode** parameter. In quiet mode, 521 and 841 Pirani values are not displayed if the Pirani head is disconnected from the controller. If the thermocouple is disconnected, no temperature is indicated. If no Module present, the module secondary display page cannot be accessed.

# 12 Parameters

*This section provides full details of all the IGC5 parameters accessible manually and via the communications bus.*

## 12.1 Parameters and the Menu Structure

Operation of the IGC5 is by changing the settings of "Parameters". 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 IGC5 is off, for example, the allocation of a Trip).

Parameters are grouped together under **Menu** Headings; for example, all parameters associated with the ion gauge can be found under the Ion Gauge Menu, and those for Trip 5 under the Trip 5 Menu.

All Parameter editing is displayed on the 2 line Data Edit display; the top line always shows 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 IGC5 through the menu headings:

Data Edit Pages  Set Emission  Ion Gauge Menu  Trip 1 Menu  ...  Trip 7 Menu   
 Digital Input 1 Menu  Digital Input 2 Menu  Analogue Out Menu  Bake-out Menu   
 Pump-Down 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 viewing a parameter and its value, the last character either shows '=' indicating if it can be edited or a key symbol (see below), indicating it is "locked". Some parameters are locked if for information only (such as software version), or are temporarily locked due to current status, 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 that holding the UP or DOWN buttons will cause the parameters to change continually, and that the speed of increment/decrement of the parameter value will increase the longer 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 all the IGC5 parameters within each Menu. For each parameter, the display mnemonic, its description and full details of the range or options available is provided. In addition, the "stored" column indicates whether the value is retained even during power off (Yes or No) and in some cases, whether the parameter is provided for information purposes only.

### 12.5.1 Emission

Parameter	Store	Description
Emission	N	<b>Emission Value</b> 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	<b>Duration of Degas Ramp</b> 1 to 999 mins. Default = 10 mins
DegasHoldTime	Y	<b>Duration of Degas Hold</b> 1 to 999 mins. Default = 10 mins
AutoDegasLevel	Y	<b>Level for Auto-Degas Functions</b> This parameter relates only to automatic functions related to degas; for example, this is 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	<b>Pressure at which Degas timer is suspended</b> If the pressure exceeds this value, degas ramp is halted and timing is suspended 1e-13 to 1e6
MinEmission	Y	<b>Minimum Emission Level</b> Minimum emission level that can be accessed by the user or Auto-emission. 0.05mA to MaxEmission Parameter value. Default = 0.05mA. <i>This parameter is locked during ion gauge operation.</i>
MaxEmission	Y	<b>Maximum Emission Level</b> Maximum emission level that can be accessed by the user or Auto-emission. MinEmission Parameter value to 10mA. Default = 10mA. <i>This parameter is locked during ion gauge operation.</i>
MinFilamentPower	Y	<b>Minimum Filament Power used by emission control PID loop</b> It is also the value that is ramped to on powering up the ion gauge. This parameter should be set to ~70% of the value needed to achieve Minimum emission. 0 to MaxFilamentPower Parameter value. Default = 25%
MaxFilamentPower	Y	<b>Maximum Filament Power used by emission control PID loop</b> 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	<b>The Proportional Band value used by the Emission Control PID loop</b> Note: this parameter is dimensionless. 1 to 99. Default = 25 (this should operate with most ion gauge heads)
IonG Damp	Y	<b>This parameter sets the Integral and Derivative terms for the Emission Control PID loop.</b> Note that this parameter is dimensionless. 1 to 99. Default = 25 (this should operate with most ion gauge heads)
DigIn1Mode	Y	<b>Action of Digital Input 1 on ion gauge operation</b> - <b>None</b> . No effect. - <b>Interlock</b> . Used to interlock ion gauge operation. If fails, turns ion gauge off - <b>EmissionOn</b> . When set, the ion gauge is powered up under Auto-emission setting. If the digital input fails, the ion gauge switches off. <i>Note: use with caution since the ion gauge cannot be turned on manually if this option is set and the digital input is off.</i> - <b>EmissionToggle</b> . A brief (~ 1 second) on-off pulse at the digital input turns the ion gauge on (if off) or off (if on). Default = None.
DigIn2Mode	Y	<b>Action of Digital Input 2 on ion gauge operation</b> Range as for <b>DigIn1Mod</b> .
Filament #	Y	<b>Filament Selection</b> This selects filament 1 or filament 2. If set to AUTO, the IGC5 will attempt to establish emission using filament 1, and if this fails, switch to filament 2. 1, 2, AUTO. Default = 1 <b>This parameter is locked during ion gauge operation.</b>
NewFilamentRamp	Y	<b>Ramping of new filament/gauge heads during gauge power up</b> – see 5.11.2 - <b>Off</b> . Normal ramp condition (Default). - <b>Once</b> . Slow ramp on next power-up of the ion gauge head. Clears once executed - <b>Twice</b> . Slow ramp for next 2 power-ups of the ion gauge head. Decrements on each execution. - <b>Always</b> . Always uses slow ramp.
Sensitivity [mB-1]	Y	<b>The sensitivity factor for the ion gauge</b> Note, regardless of the selected display units, this parameter should be entered in units of $\text{mB}^{-1}$ . If given by the manufacturer in $\text{Torr}^{-1}$ or $\text{Pascal}^{-1}$ , convert the value using the Torr (x1.32) or Pascal (x0.001) to mB conversion factor. 0.1 to 99.9. Default = 19.0
FilterTime	Y	<b>Filter time constant for collector measurement</b> Filters the measured ion current when calculating the pressure to remove noise. Note that to ensure rapid response to pressure bursts, this parameter only operates for small variations in the measured ion current. OFF, 0.1 to 9.9 seconds. Default = 1.0.
DecimalPlaces	Y	<b>Number of decimal places to display ion gauge pressure</b> Note: This only applies when ion gauge reading is in pressure units and not when indicating collector current 1 or 2. Default = 1
IonGRunTime	Y	<b>The cumulative time (hours) the ion gauge has been powered up since last reset</b> Time(h) or <b>Reset</b> . 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 <i>x</i> State	Y	<b>Control of Trip</b> - <b>Trip</b> . Dictated by current trip allocation (Default) - <b>Inhibit</b> . Trip is permanently OFF - <b>OvrRide</b> . Over-ride; trip is permanently ON
Trip <i>x</i> Allocation	Y	<b>Trip Allocation</b> - <b>None</b> . Trip not used (Default) - <b>IonGauge</b> . The trip state is determined by the ion gauge pressure, and can be on or off depending on the <b>Trip <i>x</i> Direction</b> and <b>Trip <i>x</i> at</b> parameter values. - <b>Pirani</b> . The trip state is determined by the Pirani gauge pressure, and can be on or

		<p>off depending on the <b>Trip x Direction</b> and <b>Trip x at</b> parameter values.</p> <ul style="list-style-type: none"> <li>- <b>BakeOut</b>. The trip is allocated to the bake-out and its state depends on the bake-out temperature controller algorithm.</li> <li>- <b>Module</b>. The trip state is determined by the module measured parameter, and can be on or off depending on the <b>Trip x Direction</b> and <b>Trip x at</b> parameter values.</li> <li>- <b>PumpDown</b>. The trip is controlled by the pump-down sequence.</li> <li>- <b>IonGauge On</b>. The trip is set when the ion gauge is on.</li> <li>- <b>Degas On</b>. The trip is set when the ion gauge is degassing</li> </ul>
<b>Trip x Direction</b>	Y	<p><b>Selects whether trip operates above or below the Trip Level</b></p> <p>If allocated to the ion gauge, Pirani gauge or module, determines whether the trip is on when less than or greater than the value set into the <b>Trip x at</b> parameter. &lt; (less than) or &gt; (greater than). Default: &lt;.</p>
<b>Trip x at</b>	Y	<p><b>Trip Level</b></p> <p>The level at which the trip will operate; used in conjunction with <b>Trip x Direction</b>. 1e-13 to 1e+6. Default 1e+3.</p>
<b>Trip Hysteresis [x]</b>	Y	<p><b>The Hysteresis Level for ALL trips - this parameter applies to all Trips.</b></p> <p>Defines a band between which the trip will turn on and turn off to avoid "cycling" due to noise or operation. 1.0x (no hysteresis) to 99.9x (where off occurs at 99.9 times the trip level). For example, for a trip level of 1x10<sup>-6</sup>mBar and a Trip hysteresis of 2.0, the trip will energize at 1x10<sup>-6</sup>mBar but de-energize at 2x10<sup>-6</sup>mBar. Default: x1.1</p>

#### 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
<b>DigIn x State</b>	Y	<p><b>Control of Digital Input</b></p> <ul style="list-style-type: none"> <li>- <b>Trip</b>. Dictated by external input (Default)</li> <li>- <b>Inhibit</b>. The digital input is permanently OFF regardless of input</li> <li>- <b>OvrRide</b>. Over-ride; the digital is permanently ON regardless of input</li> </ul>

#### 12.5.5 Analogue Out Menu

Parameter	Store	Comments/Range
<b>AnalogOutAllocate</b>	Y	<p><b>Allocation for the Analogue Output</b></p> <ul style="list-style-type: none"> <li>- <b>SetToMinimum</b>. Continually outputs the voltage corresponding to the <b>AnalogOutDAMin</b> parameter value.</li> <li>- <b>IonGauge</b>. Output depends on Ion Gauge pressure. If the ion gauge is off, the voltage output corresponds to the <b>AnalogOutDAMax</b> parameter value. (Default)</li> <li>- <b>Pirani</b>. Output depends Pirani pressure value.</li> <li>- <b>BakeTemp</b>. Output depends on thermocouple input value.</li> <li>- <b>IonG&amp;Pirani</b>. Output depends on the ion gauge pressure (if on) or the Pirani pressure (if ion gauge off). The <b>AnalogOutPressMin</b> and <b>AnalogOutPressMax</b> Parameters are treated as full pressure range.</li> <li>- <b>CommsExternal</b>. Output is set over the communications bus.</li> <li>- <b>Module</b>. Output depends on measured value obtained from the module.</li> <li>- <b>SetToMaximum</b>. Continually outputs the voltage corresponding to the <b>AnalogOutDAMax</b> parameter value.</li> </ul>
<b>AnalogOutPressMin</b>	Y	<p><b>Pressure that minimum analogue output corresponds to</b> 1e-13 to <b>AnalogOutPressMax</b> parameter value. Default: 1e-13</p>
<b>AnalogOutPresMax</b>	Y	<p><b>Pressure that maximum analogue output corresponds to</b> <b>AnalogOutPressMin</b> parameter value to 1e+6. Default: 1e+3</p>
<b>AnalogOutDAMin</b>	Y	<p><b>Minimum D/A converter output</b></p> <p>Voltage output corresponding to the <b>AnalogOutPressMin</b> parameter value. 0 to 4095 (12 bit range). Note: <b>AnalogOutPressMin</b> can exceed <b>AnalogOutPressMax</b>. <b>NOTE: Whilst this parameter is displayed, the output generates the voltage corresponding to the AnalogOutDAMin parameter value to allow the user to set the voltage output.</b></p>
<b>AnalogOutDAMax</b>	Y	<p><b>Maximum D/A converter output</b></p> <p>Voltage output corresponding to the <b>AnalogOutPressMax</b> parameter value. 0 to 4095 (12 bit range). Note: <b>AnalogOutPressMin</b> can exceed <b>AnalogOutPressMax</b>.</p>

		<b>NOTE: Whilst this parameter is displayed, the output generates the voltage corresponding to the <a href="#">AnalogOutDAMin</a> parameter value to allow the user to set the voltage output.</b>
<a href="#">AnalogOutFunction</a>	Y	<b>Relationship between pressure and output voltage</b> <a href="#">logarithmic</a> (Default) or <a href="#">linear</a> .

### 12.5.6 Bake Out Menu

Parameter	Store	Comments/Range
<a href="#">BakeOut</a>	N	<b>Start/Stop Bake-out</b> If bake-out is prohibited (e.g. ion gauge is OFF), "----" is displayed. If conditions permit bake-out and bake-out is not running, "Start" is available If bake-out is running, "Stop" is available
<a href="#">BakeTemp 1...</a> <a href="#">...BakeTemp 6</a>	Y	<b>Final temperature for the bake-out step</b> 0 (Default) to 500°C
<a href="#">BakeTime 1...</a> <a href="#">...BakeTime 6</a>	Y	<b>Duration of the bake-out step</b> 0.0 (Default) to 99.9hours
<a href="#">BakePressTrip</a>	Y	<b>Ion Gauge pressure trip point for Bake-out</b> Pressure limit for the bake-out. With <a href="#">BakePressAction</a> parameter determines what happens when the pressure exceeds the limit 1e-13 to 1e+6. (Default: 1e+3)
<a href="#">BakePressAction</a>	Y	<b>Action when ion gauge pressure exceeds pressure trip point</b> - <a href="#">None</a> . No Action (Default) - <a href="#">Normal</a> . Trips are set to off. Temperature ramp and time countdown continues. - <a href="#">Suspend</a> . Trips are set to off. Temperature ramp and time countdown suspended. - <a href="#">Abort</a> . Bake-out is aborted. Auto-degassing is ignored.
<a href="#">BakeDigInProtect</a>	Y	<b>Selects Digital Input Interlocking</b> - <a href="#">None</a> . No DI interlock protection (Default) - <a href="#">DigIn 1</a> . Digital input 1 interlock protection - <a href="#">DinIn 2</a> . Digital input 2 interlock protection - <a href="#">DigIn 1&amp;2</a> . Both Digital Inputs provide interlock protection
<a href="#">BakeDigInAction</a>	Y	<b>Action when digital input interlocking fails</b> - <a href="#">None</a> . No Action - <a href="#">Normal</a> . Trips set to off. Temperature ramp & time countdown continues. (Default). - <a href="#">Suspend</a> . Trips set to off. Temperature ramp & time countdown suspended. - <a href="#">Abort</a> . Bake-out is aborted. Auto-degassing is ignored.
<a href="#">BakeTHysteresis</a>	Y	<b>Temperature Control hysteresis for bake-out</b> Avoids possible on/off cycling 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
<a href="#">BakeAutoDegas</a>	Y	<b>Auto Degas ion gauge at end of bake-out sequence</b> The ion gauge is set to degas at the <a href="#">AutoDegasLevel</a> for the duration of the <a href="#">DegasRampTime</a> and <a href="#">DegasHoldTimeT</a> parameters, as set in the Ion Gauge Menu <a href="#">Off</a> (Default), <a href="#">On</a> .

### 12.5.7 Pump Down Menu

Parameter	Store	Comments/Range
<a href="#">PumpDown</a>	Y	<b>Start/Stop Auto Pump-down</b> If pump-down precluded (e.g. no ion gauge connected), "----" is displayed. If conditions permit pump-down, "Start" is available If pump-down is operating, "Stop" is available
<a href="#">PDDigInProtect</a>	Y	<b>Selects Digital Input Interlocking</b> - <a href="#">None</a> . No DI interlock protection (Default) - <a href="#">DigIn 1</a> . Digital input 1 interlock protection - <a href="#">DigIn 2</a> . Digital input 2 interlock protection - <a href="#">DigIn 1&amp;2</a> . Both Digital Inputs provide interlock protection
<a href="#">PDStartPressure</a>	Y	<b>Pirani Pressure below which to attempt to start the ion gauge</b> 1e-13 to 1e+6 (Default: 1e-2)

PDStartDelay	Y	<b>Delay Time before starts ion gauge</b> The time in seconds before which an attempt to start the ion gauge when the Pirani has reached PDStartPressure. Also the time between attempts to start the ion gauge. 1 to 999 seconds. (Default: 10 secs)
PDNumberAttempts	Y	<b>Number of attempts to make to start the ion gauge</b> 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	<b>Allow Calibration menu to operate</b> On EACH entry into this menu, must be set to "YES" to allow parameter change to avoid accidental changes. If this parameter is <b>not</b> set to YES, all menu items will indicate the locked symbol NO (Default), YES.
PiraniType	Y	<b>Indicates Pirani Type</b> For information only; IGC5 auto-detects whether the internal jumpers have been set to VSP84x or VSP52x gauge type.
SetPir@Atmos	Y	<b>Sets the calibration correction offset for the Pirani head at atmosphere - see section 10.</b> <b>Ensure the Pirani gauge head is at atmosphere before proceeding.</b> NO (Default), YES.
SetPir@Vacuum	Y	<b>Sets the calibration correction at the user adjusted pressure.</b> This parameter displays the current Pirani Pressure. This is adjusted to match the actual value using the UP and DOWN buttons. Once a match is found, press OK - see section 10 for further details.
SetTC@0mV	Y	<b>Set the calibration correction when thermocouple input is 0mV (or short-circuited)</b> Sets the calibration correction offset for the thermocouple when the input is short-circuited (zero input) - see section 10. NO (Default), YES.
SetTC@10mV	Y	<b>Sets the calibration correction when thermocouple input against a 10mV reference input.</b> 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	<b>Sets the calibration correction offset for the gauge attached to the module head at atmosphere - see section 10. Ensure the gauge head is at atmosphere before proceeding.</b> NO (Default), YES.
SetMod@Vacuum	Y	<b>Sets the calibration correction at the user adjusted pressure.</b> This parameter displays the current Module Pressure. This is adjusted to match the actual value using the UP and DOWN buttons. Once a match is found, press OK - see section 10 for further details.

#### "U" module:

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

InputMax	Y	<b>Maximum voltage input</b> 0.000 to 9.999V. Note that if the module jumpers are set to 3V or 1V full-scale, the parameter values entered must 3.333x or 10x required. (Default: 9.999V)
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### 12.5.9 Setup Menu

This menu encompasses miscellaneous and global parameters as well as IGC5 information.

Parameter	Store	Comments/Range
IonGauge Name	Y	<b>4 character Name (shown on primary display when ion gauge data shown)</b> This parameter behaves differently from all others in that changes are made to one character at a time, pressing the OK button to move to the next parameter.
Pirani Name	Y	<b>4 character Name (shown on primary display when Pirani data shown)</b> See <a href="#">IonGauge Name</a> Parameter
Module Name	Y	<b>4 character Name (shown on primary display when module data shown)</b> See <a href="#">IonGauge Name</a> Parameter
IonGaugeUnits	Y	<b>Measurement units for the ion gauge</b> Pressure (as defined in <a href="#">PressureUnits</a> parameter) or collector current (auto-ranging units (pA, nA, $\mu$ A or mA) and format (x.xxx, xx.xx or xxx.x))
PressureUnits	Y	<b>Units for display of pressure information</b> mBar, Torr, Pascal. (Default: mBar)
Display Mode	Y	<b>Parameter display option</b> Selects whether data/screens related to secondary devices (Pirani, thermocouple, module) are shown/available Full, Quiet (Default: Full)
ScreenSaver Mode	Y	<b>Turns screen save on or off</b>
ScreenSaver Time	Y	<b>Time after a button press before screen saver initializes</b> 1-999 minutes
MainDisplayFunc	Y	<b>Controls Primary Display</b> - <a href="#">IonGauge Only</a> . Always shows ion gauge status with ion gauge name top left. - <a href="#">IonG &amp; Pirani</a> . When the ion gauge is off, shows the Pirani gauge pressure with the Pirani gauge name top left. - <a href="#">IonG &amp; Module</a> . When the ion gauge is off, shows slot module measured value with Module Name top left.
Comms Address	Y	<b>Communications Bus Address</b> 1 (default) to 99. Unique IGC5 on RS232 or RS485 bus
Comms Protocol	Y	<b>Communications Protocol</b> <a href="#">MODBUS:LITend</a> (default), <a href="#">MODBUS:BIGend</a> , <a href="#">QUICKComm</a>
Comms BaudRate	Y	<b>Communications Baud Rate</b> <a href="#">9600</a> , <a href="#">4800</a> , <a href="#">19200</a> (Default), <a href="#">38400</a> , <a href="#">57600</a> , <a href="#">115200(RS485)</a> All IGC5 on an RS232 or RS485 bus MUST use same Baud Rate
Comms Parity	Y	<b>Communications Parity</b> <a href="#">None</a> (Default), <a href="#">Even</a> , <a href="#">Odd</a> . All IGC5 on an RS232 or RS485 bus MUST use same Parity setting
(Version)	Info	<b>Software Version</b> In form: <i>x.yy</i> where <i>x</i> is major release version and <i>yy</i> minor release version
(HeatsinkTemp)	Info	<b>Internal Heatsink Temperature</b> INFORMATION ONLY: Indicates the current temperature of the heatsink, as measured by the thermal protection sensor.

## 13 Troubleshooting

This section lists some commonly encountered problems along with possible solutions. If after reference to this section, 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. <b>Solution:</b> 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 connected together
No HiVoltage message on front panel	Fault on either the grid or filament bias power supply: 1. Check the ion gauge head for short-circuit between grid/filament/ground. 2. Check the high voltage grid fuse (100mA - MUST be replaced with type "F" (fast) 3. Check the ion gauge lead for damage.
OverTemp or UnderTemp message	Over or Under temperature. Check heatsink temperature in the Setup menu. If under temperature, usually caused by IGC fault. If over temperature, ensure fan operates.
Ion gauge emission cannot be established or has failed: EmFail message Ion gauge will not start	1. Filament blown. Change filaments. On dual filament head gauges, try other filament. Check filament integrity 2. Check 5A(F) filament fuse(s). MUST be replaced with type F (fast) 3. Check that filament type being used is Ir-based. The IGC5 may not work with some high current Tungsten filament assemblies 4. Check status of digital inputs if assigned to interlock the gauge
OverPress message	1. Ensure that vacuum system is being pumped and is operating under correct vacuum conditions for the gauge 2. Check Sensitivity parameter is set to correct value
MaxPower Er message (added v2.08)	1. Max power setting too low to allow requested emission or degas levels. Increase max power value 2. If max power value is already high (>50%), problem with filament. Replace filament
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. Allow a long degas ramp time to permit thorough degas at reduced powers before higher power degas occurs 2. Check that there is good electrical isolation from the grid to the filaments and to ground at the gauge connector. Clean gauge thoroughly. 3. Check status of digital inputs if assigned to interlock the gauge

## 13.3 Digital Output Trips

Symptom	Cause
Does not operate as expected	1. Check the trip menu parameter allocations and values 2. Ensure that the direction, trip level and hysteresis parameters are correctly set
Trip on and off pressures different Trip cycles between on and off ("chattering")	1. Check and set the 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")

Symptom	Cause
Connector type from VG Pirani does not	An adaptor cable is available to connector old-style VG Pirani heads to

match "V" module	IGC
Device powered by type "U" module does not operate correctly.	1. If powered from "U" 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

## 13.6 Thermocouple/Bake-out

Symptom	Cause
Persistent sensor break indication	1. Check the thermocouple integrity and lead 2. Check connection – see section 6.2
Wrong temperature indication	Ensure that type K thermocouple is used
Cannot start bake-out No heating	1. Ensure ion gauge is on, and that any 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 too quickly 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	1. Add a final bake-out step of an hour or more that ramps the system down to <half the bake-out temperature to allow system pressure and any temperature related electrical leakage to recover

## 13.7 Analogue output

Symptom	Cause
The output voltage does not correspond to the pressure The output voltage range is too large/too small for the voltage monitor	1. Adjust the minimum and maximum digital output values to correspond to the minimum and maximum required output 2. Ensure log/lin function is set appropriately.

# 14 Serial Communications

*Computer control over the IGC5 is available via 2 different protocols. EMCOMM is MODBUS-based and provides fast full control over all aspects of the device. QUICKComm is a simple ASCII-based protocol which provides monitoring and control over the most commonly required features.*

## 14.1 Introduction

### 14.1.1 Hardware

- RS232 and RS485 (3 wire) interfaces as standard. Both are "multi-drop" allowing several IGC5's to share the same port. See section 3.9.
- Two RJ56 sockets allow ease of daisy-chaining.
- Baud rate options for RS232 & RS485: 2400, 4800, 9600, 19200, 38400 and 57600. RS485 additionally supports 115200 baud.
- Parity options: None, Even, Odd
- 8 bits, 1 start bit, 1 stop bit
- Address range 1 to 99.
- Communication latency (i.e. the response time of the controller to a command): at 4800 baud, typically 40ms (100ms max); at 57600 baud typically, 15ms (50ms max).

### 14.1.2 Timing Restriction

If using multiple daisy-chained IGC5's on a bus, please note:

- If one or more of the controllers are running software **versions 2.10 or below**, there is a slight delay in clearing the bus after each send/receive cycle. It is recommended that a 150ms break between receipt of a

response and issue of the next command is implemented in the control timing. Alternatively, use RS232-specific daisy-chain leads, as described in section 3.9.3.

- This restriction does NOT apply to controllers running **version 2.11 or above**.

## 14.2 Communication Protocols

The IGC5 provides 2 protocols:

- **EMComm**. This is based on the MODBUS protocol. Key features are: complete control over IGC5 operation, reading and writing multiple parameters within a single message, high efficiency and speed, high integrity and capability of direct floating point data transfer. Both Big and Little Endian data transfer formats are supported. For more information and full worked code, please refer to the **EMComm Handbook** available from your IGC5 distributor.
- **QUICKComm**. This is a simple ASCII character based protocol designed for data acquisition and to provide basic control of the IGC5. Introduced at software version 2.04.
- The protocol (including whether to use Big or Little Endian representation) is selected in the Setup Menu.

## 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.

However, because of the parameter structure of the IGC5, implementation of the protocol differs from the standard in the following ways:

- Only Function Code hexadecimal 17h (decimal 23) is used allowing writing to and reading of data within a single message transaction. All other function codes ("coils" etc) are NOT implemented.
- To facilitate floating point access, all IGC5 parameters (including integer and flag parameters) take up 2 MODBUS registers, i.e. each parameter is 32 bits (2x 16bit MODBUS register WORDs, or 4x 8 bit BYTES); thus all IGC5 register parameter addresses are even (i.e. address 0, 2, 4, 6...)
- The programmer can select between transfer data using **LITTLE ENDIAN** (least significant byte first) or **BIG ENDIAN** (most significant byte first) representation. In the examples given, LITTLE ENDIAN representation is used.
- Up to 16 parameters that can be read and/or written within a single message.
- Implementation of an "INVALID" data parameter value to allow 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 IGC5 (the server) is ALWAYS initiated by the client sending a message. IGC5 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 activity on the bus for more than 3.5 times the amount of 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 IGC5.
- The second byte is the function code, and is ALWAYS 17h.
- The Data Package follows, containing information about the address of the parameter(s) to be written to/read from, the data itself and the amount of data enclosed.
- A 2 BYTE Cyclical Redundancy Check (CRC) is appended to the frame. The CRC is a highly efficient method of detecting whether any errors occur during transmission of a Frame.

### 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 IGC5 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 Message Structure from the Client (the Command)

A communication is initiated by the PC/PLC sending data to and/or requesting data from the IGC5 by transmitting a Frame.

#### 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 IGC5. 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	<i>n</i> BYTES

Note:

- Since each parameter uses 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, five BYTES with a value of Zero MUST be sent with no data.
- 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.
- When constructing the data package, BYTE order must correspond to the selected ENDIAN representation.

### 14.3.6 The "Invalid" Parameter Value - FFFFFFFFh

To avoid having to know all parameter values during a multi-parameter write, parameters that are not to be changed can be indicated by sending the "invalid" value FFFFFFFFh. This implies that no parameter has a "valid" value of FFFFFFFFh.

### 14.3.7 Message Structure From the Server (the Response)

On receiving a transmission:

- The IGC5 checks the first byte for compliance of the address with its own settings. If this agrees...
- It checks the next BYTE is 17h, i.e. Function Code 23 (17h). If not, it sends back an error message - see section 14.3.8. If it agrees...
- It checks the validity of the message by comparing the received CRC value with the CRC it calculates. If not, no further action is taken. If this agrees...
- It looks to see if any parameters are to be written. If so, parameters are checked for validity; any parameter values of FFFFFFFFh (see 14.3.6) are ignored. If an error of invalid value is sent to a parameter, an error message is generated - see section 14.3.8.
- If all parameters were correctly written, then 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.
- Finally a CRC is created.

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	<i>n</i> BYTES	2 BYTES
01h-63h (1-99)	17h (decimal 23)	(0,4,8,12...)		

Note:

- The Client programme should check that the address in the response corresponds to that which was sent to 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; each parameter value is sent least significant BYTE first (see section 14.2).
- 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 IGC5 are 32 bit. The IGC5 deals with 3 parameter types:

- **Integer Parameters.** These store 32 bit integer values. They can either be real integers (-2147483648 to +2147483647) or unsigned integer types (0 to 4294967295)
- **Flag Parameters** are unsigned integer types that store flags or combinations of flags, for example, to indicate the status of a device. 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 "casting" to type (**float**). 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 <sup>7</sup> to 2 <sup>0</sup>	2 <sup>-1</sup> to 2 <sup>-23</sup>

Conversion from the byte string to the floating point value is implemented by placing the string in memory and casting to the 32-bit "float" type. Note, the BYTE order must conform to the Endian representation selected.

**For more information and full worked code, please refer to the EMComm Handbook available from your IGC5 distributor.**

### 14.3.10 Parameter Listing

The following table lists and describes the parameters in detail:

**Parameter Address** gives the decimal and hexadecimal value of the parameter address; e.g. 42 – 2Ah means that the parameter at address 42 (2Ah) is the measured value.

**Parameter Name** relates the parameter to its function – see IGC Handbook for details. **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. Note that unassigned parameters can be used by the programmer to store temporary data.

**Description** provides a detailed breakdown of the parameter function.

Parameter Address	Parameter Name	Type	R / W	Description
<b>GROUP 1</b>				
0 – 00h	<i>Global ID</i>	int	R	Returns a value of 58435650h [ASCII representation of "IGC5"].
2 – 02h	<i>Firmware Version</i>	int	R	Returns a value of 4558xxyyh, 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 as an IGC5
4 – 04h	<i>[Unassigned]</i>	int	R	
6 – 06h	<i>[Unassigned]</i>	int	R	
8 – 08h	<i>Communications</i>	int	R	For internal use only. Holds information about comms address, settings, protocol.
10 – 0Ah	<i>[Internal]</i>	int	R	
12 – 0Ch	<i>[Unassigned]</i>	int	R	
14 – 0Eh	<i>Safety Status</i>	int	R	Internally used.
<b>GROUP 2</b>				
16 – 10h	<i>Ion Gauge Name</i>	int	R/W	A 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 character in the range 21h to 7Ah. Example: the name Si would be 20206953h. Default is "IG ".
18 – 12h	<i>User ID</i>	int	R/W	USER DEFINED IDENTIFIER. Can be used, for example, to automatically configure or identify specific units with a software object.
20 – 14h	<i>Module Name</i>	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	<i>Pirani Name</i>	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	<i>Degas Ramp Time</i>	int	R/W	<b>0 to 999 minutes.</b> DURATION OF DEGAS POWER RISE
26 – 1Ah	<i>Degas Time</i>	int	R/W	<b>0 to 999 minutes.</b> DURATION OF DEGAS.
28 – 1Ch	<i>Degas Power</i>	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. <b>IGC5:</b> Values are IGS_EM_DEGASLO (0Dh), IGS_EM_DEGASMID (0Eh) or IGS_EM_DEHASHI (0Fh).
30 – 1E	<i>[Unassigned]</i>	int	R/W	
<b>GROUP 3</b>				
32 – 20h	<i>[Unassigned]</i>	int	R/W	
34 – 22h	<i>[Unassigned]</i>	int	R/W	
36 – 24h	<i>Display Settings v2.20 onwards</i>	int	R/W	<b>Bits 000000Fh</b> – Display Screen Saver on/off. DS_SAVER_VALID (00000008h). Must be set to write value. Bits 00000001h turns on/off: DS_SAVER_OFF (00000000h), DS_SAVER_ON (00000001h) <b>Bits 0000F00h</b> – 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

Parameter Address	Parameter Name	Type	R / W	Description
				(00000100h)
38 – 26h	<i>Display Saver Time v2.20 onwards</i>	int	R/W	<b>1 to 999 minutes.</b> Time between last key press and start of Display Screen Saver mode. Default: 5mins.
40 – 28h	<i>Remaining Degas Time</i>	int	R	REMAINING DEGAS TIME: (Seconds). 0 if not in degas [v2.06 and above]
42 – 2Ah	<i>Ion Gauge running time</i>	int	R/W	CUMULATIVE RUNNING TIME FOR ION GAUGE: (Minutes) R/W v2.08 and above. Otherwise Read only
44 – 2Ch	<i>Unit Running Time</i>	int	R	CUMULATIVE POWERED UP TIME: (Minutes) [v2.06 and above]
46 – 2Eh	<i>[Unassigned]</i>	int	R	
<b>GROUP 4</b>				
48 – 30h	<i>Pirani Vacuum Level Calibration</i>	int	R	PIRANI GAUGE CALIBRATION PARAMETER set by the controller when calibrating for VACUUM. Range 200 to 800, default 500. [Can only be set manually]
50 – 32h	<i>Pirani Atmospheric Level Calibration</i>	int	R	PIRANI GAUGE CALIBRATION PARAMETER set by the controller when calibrating for ATMOSPHERE. Range 200 to 800, default 500. [Can only be set manually]
52 – 34h	<i>Thermocouple Low Calibration</i>	int	R	THERMOCOUPLE CALIBRATION PARAMETER set by the controller when calibrating with SHORTED INPUT (0mV). Range 200 to 800, default 500. [Can only be set manually]
54 – 36h	<i>Thermocouple High Calibration</i>	int	R	THERMOCOUPLE CALIBRATION PARAMETER SET by the controller when calibrating for 10.00mV INPUT. Range 200 to 800, default 500. [Can only be set manually]
56 – 38h	<i>Slot Low Level Calibration</i>	int	R	For "V", "E" & "F" modules, the PIRANI GAUGE PARAMETER set by the controller when calibrating for VACUUM. Range 200 to 800, default 500. [Can only be set manually]
58 – 3Ah	<i>Slot High Level Calibration</i>	int	R	For "V", "E" & "F" modules, the PIRANI GAUGE PARAMETER set by the controller when calibrating for ATMOSPHERE. Range 200 to 800, default 500. [Can only be set manually]
60 – 3Ch	<i>[Unassigned]</i>	int	R	
62 – 3Eh	<i>[Unassigned]</i>	int	R	
<b>GROUP 5</b>				
64 – 40h	<i>Global Settings</i>	int	R/W	GLOBAL FLAGS <b>Bits F0000000h</b> – Display setting. Selects what IGC 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 <b>Bits 00F00000h</b> – Display Brightness GS_BRIGHTNESS_VALID (00800000h) Must be set to write value. Bits 00300000h indicate the brightness level: GS_BRIGHTNESS_25 (00000000h) default 25%, GS_BRIGHTNESS_50 (00100000h) 50%, GS_BRIGHTNESS_75 (00200000h) 75%, GS_BRIGHTNESS_100 (00300000h) 100% <b>Bits 00000F00h</b> - Ion gauge display Units. Selects between ion gauge measurement being displayed in the pressure units in GS_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 <b>Bits 000000F0h</b> – 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) <b>Bits 0000000Fh</b> – 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, the ion gauge value is automatically displayed to 3 decimal places and this setting is ignored.
66 – 42h	<i>Slot A ID</i>	int	R	TYPE OF MODULE IN SLOT A <b>Bits 000000Fh</b> – 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

Parameter Address	Parameter Name	Type	R / W	Description
			R/W	TYPE_EMPIRANI (00000004h) "T" module for EM and Thyracont Pirani gauge head TYPE_UNIVERSAL (00000005h) "U" module for universal input range <b>Bits 00FF0000h</b> – Universal flags ("U" module only, otherwise ignored) TYPE_UNIVERSAL_LOG (00000000h) logarithmic input to pressure relationship (default) TYPE_UNIVERSAL_LIN (00010000h) linear input to pressure relationship
68 – 44h	[Unassigned]	int	R	
70 – 46h	Pump Down Flags	int	R/W	PUMP-DOWN SETTINGS <b>Bits 00F00000h</b> – Start/Stop Pump Down PDF_SS_VALID (00800000h) Must be set to write value. PDF_SS_START (00100000h) start pump down PDF_SS_STOP (00200000h) stops pump down <b>Bits 0000F000h</b> – Digital Inputs assignment PDF_DI_VALID (00008000h) Must be set to write value. Bits 00003000h set which digital inputs interlock Pump-down: PDF_DI_1 (00001000h) digital input 1 interlocks pump down, PDF_DI_2 (00002000h) digital input 2 interlocks pump down (Note: both can be set) <b>Bits 0000FF0h</b> – Internally used for status indication PDF_VALID (00000800h) always set Remaining bits are set in combination as pump-down progresses: PDF_PUMPDOWN (00000010h) pump down started, PDF_INITED (00000020) initialisation flag, PDF_INDELAY (00000040h) in delay time, PDF_IGSTART (00000080h) attempting to start the ion gauge, PDF_DIINHIBITED (00000100h) pump down inhibited by one or both digital inputs <b>Bits 000000Fh</b> – Attempt count The number of attempts made to start the ion gauge (value between 0 and 9) <i>[see also PD IG Start Pressure, PD IG Delay, PD IG Attempts]</i>
72 – 48h	Bake Out Flags	int	R/W	BAKE-OUT FLAGS <b>Bits F0000000h (Version 2.07 and above)</b> - 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 <b>Bits 0F000000h</b> – 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 <b>Bits 00F00000h</b> – Action of assigned digital inputs on Bake-out BOF_DIS_VALID (00800000h) Must be set to write value Bits 00300000h select action: BOF_DIS_NORMAL (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. <b>Bits 000F0000h</b> – Action of ion gauge pressure on Bake-out BOF_IGS_VALID (00080000h) Must be set to write value Bits 00030000h select action: BOF_IGS_NORMAL (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. <b>Bits 0000F000h</b> – 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]. <b>Bits 0000F00</b> – Start/Stop Bake-Out BOF_SS_VALID (00000800h) Must be set to write value BOF_SS_START (00000100h) starts bake-out, BOF_SS_STOP (00000200h) stops bake-out <b>Bits 00000FFh</b> – 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_ON (00000010h) bake-out output is on. <i>[See also BO Step temperatures 1-6, BO Step times 1-6, BO IG Pressure Limit, BO Hysteresis]</i>
74 – 4Ah	[Unassigned]	int	R/W	
76 – 4Ch	Digital Input 1 Flags	int	R/W	DIGITAL INPUT 1 FLAGS <b>Bits 0000000Fh</b> DI_STATUS_VALID (00000008h) Must be set to write value DI_STATUS_ON (00000001h) Digital input 1 is on (read only bit),

Parameter Address	Parameter Name	Type	R / W	Description
				DI_STATUS_INHIBIT (00000002h) Inhibit digital input 1, DI_STATUS_OVERRIDE (00000004h) Override Digital input 1 [See also <i>Digital Input 1-2 Status Summary</i> ]
78 – 4Eh	<i>Digital Input 2 Flags</i>	int	R/W	DIGITAL INPUT 2 FLAGS See <i>Digital Input 1 flags for bit assignments</i>
<b>GROUP 6</b>				
80 – 50h	<i>Trip1 Flags</i>	int	R/W	TRIP 1 FLAGS <b>Bits 0000F000h</b> – 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_PUMPDOWN (00005000h) trip 1 is set whilst pump down is operating, DO_ASSIGN_IGON (00006000h) trip 1 set whilst ion gauge is on, DO_ASSIGN_DEGAS (00007000h) trip 1 is set to “on” during degas. <b>Bits 0000F00h</b> – 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. <b>Bits 000000Fh</b> – 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 <i>Global Settings (for ion gauge degas protect), Trip 1 Level, Trip Hysteresis, Trip 1-7 Status Summary</i> ]
82 – 52h	<i>Trip 2 Flags</i>	int	R/W	TRIP 2 FLAGS See <i>Trip 1 Flags for all bit assignments</i>
84 – 54h	<i>Trip 3 Flags</i>	int	R/W	TRIP 3 FLAGS See <i>Trip 1 Flags for all bit assignments</i>
86 – 56h	<i>Trip 4 Flags</i>	int	R/W	TRIP 4 FLAGS See <i>Trip 1 Flags for all bit assignments</i>
88 – 58h	<i>Trip 5 Flags</i>	int	R/W	TRIP 5 FLAGS See <i>Trip 1 Flags for all bit assignments</i>
90 – 5A	<i>Trip 6 Flags</i>	int	R/W	TRIP 6 FLAGS See <i>Trip 1 Flags for all bit assignments</i>
92 – 5C	<i>Trip 7 Flags</i>	int	R/W	TRIP 7 FLAGS See <i>Trip 1 Flags for all bit assignments</i>
94 – 5E	<i>D/A Flags</i>	int	R/W	DIGITAL/ANALOGUE CONVERTER SETTINGS <b>Bits 0000F00h</b> – 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) <b>Bits 000000Fh</b> – 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_WIDERANGE (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
<b>GROUP 7</b>				
96 – 60h	<i>Minimum Ion Gauge Emission</i>	int	R/W	MINIMUM ION GAUGE EMISSION. Range IGS_EM_50uA to maximum ion gauge emission value. <b>Bits 000000Fh</b> 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	<i>Maximum Ion</i>	int		MAXIMUM ION GAUGE EMISSION. Range minimum ion gauge emission value to IGS_EM_10mA.

Parameter Address	Parameter Name	Type	R / W	Description
	<i>Gauge Emission</i>		R/W	Bits 000000FFh See Minimum ion gauge emission for possible values.
100–64h	<i>Minimum % Filament Current</i>	int	R/W	MINIMUM % FILAMENT CURRENT DURING PID CONTROL OVER EMISSION Range: 0% to Maximum filament current setting, default 20%
102–66h	<i>Maximum % Filament Current</i>	int	R/W	MAXIMUM % FILAMENT CURRENT DURING PID CONTROL OVER EMISSION Range Minimum filament current setting to 100%, default 100%
104–68h	<i>Emission Control Prop Band</i>	int	R/W	PROPORTIONAL BAND SETTING FOR PID CONTROL OVER EMISSION Range 1 to 99, default 25.
106–6Ah	<i>Emission Control Damp</i>	int	R/W	DAMP PARAMETER; SETS THE INTEGRAL AND DIFFERENTIAL TERMS FOR PID CONTROL OVER EMISSION Range 1 to 99, default 25.
108–6Ch	<i>[Unassigned]</i>	int	R/W	
110–6Eh	<i>[Unassigned]</i>	int	R/W	
<b>GROUP 8</b>				
112–70h	<i>[Unassigned]</i>	int	R/W	
114–72h	<i>[Unassigned]</i>	int	R/W	
116–74h	<i>[Unassigned]</i>	int	R/W	
118–76h	<i>[Unassigned]</i>	int	R/W	
120–78h	<i>[Unassigned]</i>	int	R/W	
122–7Ah	<i>[Unassigned]</i>	int	R/W	
124–7Ch	<i>[Unassigned]</i>	int	R/W	
126–7Eh	<i>[Unassigned]</i>	int	R	
<b>GROUP 9</b>				
128–80h	<i>Trip 1-7 Status Summary</i>	int	R	SUMMARY OF STATUS OF ALL 7 TRIPS Each group of 4 bits summarises the status of one of the trips. 000000Fh for trip 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	<i>Digital Input 1-2 Status Summary</i>	int	R	SUMMARY OF STATUS OF BOTH DIGITAL INPUTS Bottom 2 groups of 4 bits indicate the status of the digital inputs. 000000Fh 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] <b>Added v2.08:</b> 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' and 'F' modules, no Pirani connected
132–84h	<i>[Unassigned]</i>	int	R	
134–86h	<i>[Unassigned]</i>	int	R	
136–88h	<i>Ion Gauge Status</i>	int	R	STATUS OF ION GAUGE – This parameter reports status of ion gauge (1). <i>Note that parameters that can be changed are written to through the Ion Gauge Settings parameter (8Eh).</i> 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

Parameter Address	Parameter Name	Type	R / W	Description
			R	(04000000h) ion gauge lead interlock not made, IGS_OP_EMTRIP (02000000h) emission tripped, IGS_OP_FILTRIP (01000000h), filament over-current trip [**Added v2.08] <b>Bits 000F0000h</b> – 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 <b>Bits 0000F000h</b> – Measurement error IGS_IND_VALID (00008000) IGS_IND_MINLIMIT (00004000h) if electrometer input below measurement limit (e.g. collector lead disconnected) <b>Bits 00000F00h</b> – Ion gauge pressure trend IGS_TREND_VALID (00000800) IGS_TREND_UP (00000100) pressure is rising. IGS_TREND_DOWN (00000200) pressure is falling <b>Bits 000000FFh</b> – 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 where the value indicates the current emission value. [See also Ion Gauge Settings: 8Eh]
138–8Ah	Fan Status	int	R	FAN STATUS <b>Bits 0000000Fh</b> – 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	EXTENDED ION GAUGE SETTINGS <b>Bits 0000000Fh</b> – 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. <b>Bits 000000F0h</b> – 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	R/ W	ION GAUGE SETTINGS – This parameter sets changes to the ion gauge. <i>To obtain latest status information about the ion gauge, use the Ion Gauge Status Parameter (88h)</i> <b>Bits 00F00000h</b> – 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). <b>Bits 000F0000h</b> – 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. <b>Bits 000000FFh</b> – 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]
<b>GROUP 10</b>				
144–90h	Pirani Pressure	float	R	INDICATED PIRANI GAUGE PRESSURE
146–92h	Thermocouple Temperature	float	R	THERMOCOUPLE TEMPERATURE (with cold junction compensation applied)

Parameter Address	Parameter Name	Type	R / W	Description
148–94h	<i>Module Value</i>	float	R	SLOT MEASURED VALUE 1.
150–96h	<i>Emission Setpoint Value</i>	float	R	CURRENT EMISSION CURRENT SETPOINT value used by emission PID control in mA.
152–98h	<i>Measured Emission Value</i>	float	R	CURRENT MEASURED EMISSION CURRENT VALUE (process value) in mA.
154–9Ah	<i>Ion Gauge Pressure</i>	float	R	ION GAUGE PRESSURE Range $1 \times 10^{-14}$ to $1 \times 10^{+3}$ . $1 \times 10^{+3}$ returned when ion gauge is off. The values are corrected for the sensitivity factor and are returned in the selected display units
156–9Ch	<i>Ion Gauge Sensitivity Factor</i>	float	R/W	ION GAUGE SENSITIVITY FACTOR Range: 1.0 to 99.9. IGC rounds the value to closest 0.1. Default = 19
158–9Eh	<i>Ion gauge Low Pass Filter</i>	float	R/W	ION GAUGE LOW PASS FILTER Range: 0.0 (OFF) to 9.9 seconds. IGC rounds value to closest 0.1. Default = 1.5
<b>GROUP 11</b>				
160–A0h	<i>Trip 1 Level</i>	float	R/W	TRIP 1 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
162–A2h	<i>Trip 2 Level</i>	float	R/W	TRIP 2 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
164–A4h	<i>Trip 3 Level</i>	float	R/W	TRIP 3 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
166–A6h	<i>Trip 4 Level</i>	float	R/W	TRIP 4 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
168–A8h	<i>Trip 5 Level</i>	float	R/W	TRIP 5 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
170–AAh	<i>Trip 6 Level</i>	float	R/W	TRIP 6 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
172–ACh	<i>Trip 7 Level</i>	float	R/W	TRIP 7 LEVEL. Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device that trip is allocated to.
174–AEh	<i>Trip Hysteresis Level</i>	float	R/W	TRIP HYSTERESIS. Range: 1.0 to 99.0. IGC round value to closest 0.1. Default = 1.1x
<b>GROUP 12</b>				
176–B0h	<i>D/A Output Min value</i>	float	R/W	MINIMUM D/A SETTING Range 0 to 4095. Usually set to correspond to 0V output ( $\approx 20$ ). However, can be made larger than D/A Output Max value if reverse D/A output action required.
178–B2h	<i>D/A Output Max value</i>	float	R/W	MAXIMUM D/A SETTING Range 0 to 4095. Usually set to correspond to 10V output ( $\approx 4026$ ). However, can be made smaller than D/A Output Min value if reverse D/A output action required.
180–B4h	<i>D/A Min Pressure value</i>	float	R/W	D/A MINIMUM Parameter value (pressure or temperature) Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units set to the device that D/A is allocated to. Note can be
182–B6h	<i>D/A Max Pressure value</i>	float	R/W	D/A MAXIMUM Parameter value (pressure or temperature) Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units set to the device that D/A is allocated to.
184–B8h	<i>D/A Output</i>	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	<i>Heatsink Temperature</i>	float	R	HEATSINK TEMPERATURE in °C
188–BCh	<i>[Unassigned]</i>	int	R	
190–BEh	<i>[Unassigned]</i>	int	R	
<b>GROUP 13</b>				
192–C0h	<i>Pump Down Start Pressure</i>	float	R/W	PUMP DOWN START PRESSURE Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ . Units to suit device in slot A.
194–C2h	<i>Pump Down Delay</i>	float	R/W	PUMP DOWN DELAY TIME Range: 0 to 999 seconds
196–C4h	<i>Pump Down num. attempts</i>	float	R/W	NUMBER OF ATTEMPTS TO MAKE TO PUMP DOWN Range: 1 to 9
198–C6h	<i>[Unassigned]</i>	float	R	
200–C8h	<i>[Unassigned]</i>	float	R	
202–CAh	<i>[Unassigned]</i>	float	R	

Parameter Address	Parameter Name	Type	R / W	Description
204-CCh	<i>Degas Pressure Suspend Limit</i>	float	R/W	DEGAS SUSPEND VALUE Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ .
206-CEh	<i>Ion Gauge Power</i>	float	R	OUTPUT POWER TO ION GAUGE FILAMENT Range: 0.1 to 99.9%
<b>GROUP 14</b>				
208-D0h	<i>Bake-out Temp 1</i>	float	R/W	BAKE-OUT TEMPERATURE FOR STEP 1. Range: 0 to 500°C
210-D2h	<i>Bake-out Temp 2</i>	float	R/W	BAKE-OUT TEMPERATURE FOR STEP 2. Range: 0 to 500°C
212-D4h	<i>Bake-out Temp 3</i>	float	R/W	BAKE-OUT TEMPERATURE FOR STEP 3. Range: 0 to 500°C
214-D6h	<i>Bake-out Temp 4</i>	float	R/W	BAKE-OUT TEMPERATURE FOR STEP 4. Range: 0 to 500°C
216-D8h	<i>Bake-out Temp 5</i>	float	R/W	BAKE-OUT TEMPERATURE FOR STEP 5. Range: 0 to 500°C
218-DAh	<i>Bake-out Temp 6</i>	float	R/W	BAKE-OUT TEMPERATURE FOR STEP 6. Range: 0 to 500°C
220-DCh	<i>Bake-out Temp Hysteresis</i>	float	R/W	HYSTERESIS APPLIED TO BAKE-OUT TEMPERATURE. Range: 0 to 99°C
222-DEh	<i>Ion Gauge Bake-out Pressure Trip</i>	float	R/W	ION GAUGE BAKE-OUT PRESSURE LIMIT Range: $1 \times 10^{-13}$ to $1 \times 10^{+6}$ in currently selected pressure units
<b>GROUP 15</b>				
224-E0h	<i>Bake-out Time 1</i>	float	R/W	BAKE-OUT TIME FOR STEP 1. Range: 0 to 99.9 hours
226-E2h	<i>Bake-out Time 2</i>	float	R/W	BAKE-OUT TIME FOR STEP 2. Range: 0 to 99.9 hours
228-E4h	<i>Bake-out Time 3</i>	float	R/W	BAKE-OUT TIME FOR STEP 3. Range: 0 to 99.9 hours
230-E6h	<i>Bake-out Time 4</i>	float	R/W	BAKE-OUT TIME FOR STEP 4. Range: 0 to 99.9 hours
232-E8h	<i>Bake-out Time 5</i>	float	R/W	BAKE-OUT TIME FOR STEP 5. Range: 0 to 99.9 hours
234-EAh	<i>Bake-out Time 6</i>	float	R/W	BAKE-OUT TIME FOR STEP 6. Range: 0 to 99.9 hours
236-ECh	<i>Bake-out Setpoint</i>	float	R	CURRENT 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	<i>Remaining bake-out time</i>	float	R	TOTAL REMAINING BAKE-OUT TIME Range: 0 to 599.4 hours
<b>GROUP 16</b>				
240-F0h	<i>"U" Module Min Pressure</i>	float	R/W	UNIVERSAL "U" MODULE MINIMUM PRESSURE SETTING (corresponding to minimum output) Range: $10^{-13}$ to module maximum pressure setting
242-F2h	<i>"U" Module Max Pressure</i>	float	R/W	UNIVERSAL "U" MODULE MAXIMUM PRESSURE SETTING (corresponding to maximum output) Range: Module minimum pressure setting to $10^6$ .
244-F4h	<i>"U" Module Min Input</i>	float	R/W	UNIVERSAL "U" MODULE MINIMUM INPUT SETTING Range: 0.000V to 9.999V
246-F6h	<i>"U" Module Max Input</i>	float	R/W	UNIVERSAL "U" MODULE MAXIMUM INPUT SETTING Range: 0.000V to 9.999V
248-F8h	<i>[Unassigned]</i>	float	R	
250-FAh	<i>[Unassigned]</i>	float	R	
252-FCh	<i>[Unassigned]</i>	float	R	
254-FEh	<i>[Unassigned]</i>	float	R	

## 14.4 QUICKComm Protocol

### 14.4.1 Introduction

QUICKComm (introduced with software 2.04) provides a conventional ASCII-based, single parameter transfer protocol:

- Provides access to IGC5 devices (ion gauge, Pirani...) and status information (e.g. bake-out status).
- Allows the most commonly accessed parameters to be changed, e.g. ion gauge emission, trip states...

### 14.4.2 Messages

Communication from the PC/PLC (the client) to the IGC5 (the server) is ALWAYS initiated by the client sending a message. IGC5 CANNOT initialize a communication.

### 14.4.3 QuickComm Message Structure

#### Sending messages to the IGC5

- **1 Start BYTE:** Message to IGC5 ALWAYS starts with '>' (ASCII character 62/3Eh)
- **2 Address BYTES:** In the range "01" to "99".
- **3 Mnemonic BYTES:** See section 14.4.5
- **/N DATA BYTES:** Included only when data is being written to IGC5.
- **2 Checksum BYTES:** These can either be: EMComm CRC check sum performed on all preceding characters (as shown in section 14.3.4), or if user prefers NOT to use checksum, replaced with "@@" (i.e. ASCII character 64/40h twice)
- **1 Termination BYTE:** Always '!' (ASCII character 33/21h)

*Example 1: (Send) >05?Em@@!*

IGC5 address 5 ("05"); get ion gauge emission setting ("?Em"); don't check CRC ("@@").

*Example 2: (Send) >13TD=00VN000VV{F4h}{FDh}!*

IGC5 address 13 ("13"); set trip 3 to Override, trip 4 to Inhibit, digital inputs 1 and 2 to Override; the two CRC check sum characters are F4h and FDh.

*Example 3: (Send) >01???@@!*

Request Data Dump from IGC5 address 1. Don't use check-sum.

#### Response message from the IGC5

On receiving the message, checking the address agrees and verifying the CRC check-sum (if not set to "@@"), the IGC5 processes the message. It then amends the message in preparation for return:

- Changes the first character from '>' to '<' (ASCII character 60/3Ch) to indicate that the message has been processed.
- Removes the last 3 bytes from the message (i.e. the check sum and '!' terminator). Then...
- Adds ':' (ASCII character 58/3Ah) to the end of the message to indicate start of response.
- Adds the response. For **Write** commands, this will be either "OK" or "Error" (see 14.4.4). For **Read** commands, the requested data (see 14.4.5).
- **2 Checksum BYTES:** IGC5 ALWAYS responds with CRC check sum (as calculated in section 14.3.4.); the programmer may optionally use this to verify that the message was correctly received.
- **1 Termination BYTE:** Always '!' (ASCII character 33/21h)

*Example 1: (Response) <05?Em:A{34h}{A8h}!*

IGC5 address 5 ("05") responds to request for ion gauge emission setting ("?Em"); emissions setting is 'A' – ion gauge off (":A"); check sum BYTES are 34h A8h.

*Example 2: (Response) <13TD=00VN000VV:OK{F4h}{D0h}!*

IGC5 address 13 ("13") responds to setting of trips and digital inputs as successful (":OK"); check sum BYTES are F4h and D0h.

*Example 3: (Response) <01???0:0:Q:1.34:1.9E-8:No Pir:18.2:1.0E+3:100000000{26h}{2A}!*

IGC5 address 1 responds with concatenated data – see section 14.4.5 for each parameter

### 14.4.4 QUICKComm Mnemonics - Write Commands

The third character in all write command mnemonics is '=' (ASCII 61/3Dh)

Mnemonic	Function	Data Size	Comments
"Em="	Set ion gauge	1	The byte has one of the following settings: 'A' = ion gauge off, 'B' = 0.05mA, 'C' = 0.1mA 'D' = 0.15mA, 'E' = 0.25mA, 'F' = 0.4mA, 'G' =

	emission		0.6mA, 'H' = 1mA, 'I' = 1.5mA, 'J' = 2.5mA, 'K' = 4mA, 'L' = 6mA, 'M' = 10mA, 'N' = Degas Low, 'O' = Degas Medium, 'P' = Degas High, 'Q' = Auto-emission. An error response will occur if: (i) data BYTE not in range 'A' to 'Q', (ii) an attempt is made to switch to degas if ion gauge off or pressure too high, (iii) requested emission is not outside the min to max emission range.
"TD="	Set Trips and Digital Inputs	9	The 9 BYTE's represent the 7 trips followed by the 2 digital inputs. Each BYTE should be set to one of the following modes of operation: 'T' – in trip mode; 'N' – in iNhibit; 'V' – in oVerride; any other character – do not change mode. Note, do not use any of the reserved characters (such as '!', '=', ':', '<', '>') for the do not change options, use of '0' is recommended.
"BO="	Start/Stop Bake-out	1	'0' stops the bake-out sequence. '1' starts the bake-out sequence.
"PD="	Start/Stop Pump Down	1	'0' stops the Pump Down sequence. '1' starts the Pump Down sequence.

#### 14.4.5 QUICKComm Mnemonics - Read Commands

The first character in all write command mnemonics is '?' (ASCII 63/3Fh)

Mnemonic	Function	Data Size	Comments
"?Em"	Ion Gauge emission Setting	1	A BYTE in the range 'A' to 'Q'. See "Em=" in section 14.4.4.
"?TD"	Trips and Digital States	9	The 9 BYTE's represent the 7 trips followed by the 2 digital inputs. Each BYTE will have one of the following values: '0' – if off in trip mode; '1' – if on in trip mode; 'N' – in iNhibit; 'V' – in oVerride.
"?Ip"	Ion Gauge Pressure	Variable	If ion gauge is off, state or error message: "Iongauge OFF", "HiVoltage Er", "NO Ion Gauge", "A/D Error", "Filament Er", "Emission Er", "OverPressure", "DIError", "OverTemp", "UnderTemp", "PowerMax Er" If ion gauge on: Pressure value, e.g. "1.4E-10" or "2.34E-6". Note, the number of decimal places is as set for ion gauge Decimal Places Parameter, and the exponent value may be 1 or 2 characters, depending on the pressure value.
"?Pm"	Pirani Gauge Measured Pressure	Variable	If Pirani gauge is disconnected: "No Pir". If at minimum limit: " LOW " If at atmosphere "Atm" Otherwise value, e.g. "2.3E-2".
"?Mm"	Module Measured Reading	Variable	Message may depend on module (e.g. " LOW ", "Atm"...) Otherwise value, e.g. "4.3E-8".
"?Ie"	Ion Gauge Measured Emission Current	4	If ion gauge off, returns "0.00". Otherwise rolling format to fit 4 BYTES: e.g. "2.54", "12.0"...
"?BO"	Bake-out	1	'0' if bake-out off. '1' if bake-out on.
"?Bp"	Bake-out Step	1	Current step in range '1' to '6'. If bake-out is off, '0'.
"?Bs"	Bake-out Setpoint	3-5	Setpoint with 0.1° resolution. Format varies with temperature, e.g. "23.4", "156.4"...
"?Bm"	Thermo-couple (bake-out) Value	3-5	Setpoint with 0.1° resolution. Format varies with temperature, e.g. "23.4", "156.4"...
"?Bt"	Bake-out time	2-3	Remaining time in hours, e.g. "2.3", "12", "123"
"?PD"	Pumpdown	1	'0' if bake-out off. '1' if bake-out on.
"?Un"	Pressure Units	1	'0' – mBar, '1' – Torr, '2' – Pascal
"?Iu"	Ion gauge	1	'0' – ion gauge value in pressure units, '1' – ion gauge value as current.

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	Units		
"???"	Data Dump	Variable (72 max)	The 9 most frequently required parameters are concatenated into a single response. Each new data field is preceded by `:`. The order is: ?Un : ?Iu : ?Em : ?Ie : ?Ip : ?Pm : ?Bm : ?Mm : ?TD