Series 390

Granville-Phillips® Series 390 Micro-Ion® ATM, Four-Sensor Combination Vacuum Gauge Module with RS-485 Interface and Analog Output

Instruction Manual

Instruction manual part number 390001

Revision H - November 2016

Series 390

Granville-Phillips® Series 390 Micro-Ion® ATM, Four-Sensor Combination Vacuum Gauge Module with RS-485 Interface and Analog Output

This Instruction Manual is for use with all Granville-Phillips Series 390 Micro-Ion ATM Modules with RS-485 Interface and Analog Output. A list of applicable catalog numbers is provided on the following page.

These products are RoHS compliant.

Customer Service / Technical Support:

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Instruction Manual

Granville-Phillips® Series 390 Micro-Ion® ATM, Four-Sensor Combination Vacuum Gauge Module with RS-485 Interface and Analog Output

Catalog numbers for Series 390 Micro-Ion ATM Modules

Power supply and cable are not included.

Analog output only - no display:	390410 - 0 - # # - #
Analog output only - with digital display:	390411 - 0 - # # - #
RS-485 interface & analog output - no display:	390510 - # - # # - #
RS-485 interface & analog output - with digital display:	390511 - # - # # - #

Setpoints:

None	0
Two	2
Three	3

Ion Gauge Filaments:

Yttria-coated iridium	Y
Tungsten	T

Flange/Fitting:

NW16KF	D
NW25KF	E
NW40KF	K
1.33 inch (NW16CF) Conflat-type	F
2.75 inch (NW35CF) Conflat-type	G
1/2 inch VCR-type male	H

Measurement Units:

Torr	T
mbar	M
Pascal	P

Table of Contents

Chapter 1 Before You Begin

1.1 About these instructions

These instructions explain how to install, operate, and maintain the Granville-Phillips® Micro-Ion® ATM vacuum gauge module.

The module may have an RS-485 interface and one or two analog outputs. The module with an RS-485 interface may have no trip point relays, two trip point relays, or three trip point relays. Installation and operating procedures depend on the outputs.

- *This chapter* explains caution and warning statements, which must be adhered to at all times; explains your responsibility for reading and following all instructions; defines the terms that are used throughout this instruction manual; and explains how to contact customer service.
- *Chapter 2* explains how to install the module.
- *Chapter 3* is an operational overview of the module.
- *Chapter 4* explains analog output operation.
- *Chapter 5* explains RS-485 interface and relay operation.
- *Chapter 6* explains how to use the optional display.
- *Chapter 7* explains troubleshooting; Micro-Ion gauge testing, removal and replacement; and module return procedures.
- *Appendix A* provides specifications for the module.
- *Appendix B* explains how the Micro-Ion gauge, Conductron® heat-loss sensor, atmospheric pressure diaphragm sensor, and vacuum pressure diaphragm sensor measure pressure.

1.2 Caution and warning statements

This manual contains caution and warning statements with which you *must* comply to prevent inaccurate measurement, property damage, or personal injury.

> **⚠ CAUTION**
>
> **Caution statements alert you to hazards or unsafe practices that could result in inaccurate measurement, minor personal injury or property damage.**
>
> Each caution statement explains what you must do to prevent or avoid the potential result of the specified hazard or unsafe practice.

⚠ WARNING

Warning statements alert you to hazards or unsafe practices that could result in severe property damage or personal injury due to electrical shock, fire, or explosion.

Each warning statement explains what you must do to prevent or avoid the potential result of the specified hazard or unsafe practice.

Caution and warning statements comply with American Institute of Standards Z535.1–2002 through Z535.5–2002, which set forth voluntary practices regarding the content and appearance of safety signs, symbols, and labels.

Each caution or warning statement explains:

a. The specific hazard that you *must* prevent or unsafe practice that you *must* avoid,

b. The potential result of your failure to prevent the specified hazard or avoid the unsafe practice, and

c. What you *must* do to prevent the specified hazardous result.

1.3 System Grounding

Grounding, though simple, is very important! Be certain that ground circuits are correctly used on your ion gauge power supplies, gauges, and vacuum chambers, regardless of their manufacturer. Safe operation of vacuum equipment, including the Series 390 ATM Module, requires grounding of all exposed conductors of the gauges, the controller and the vacuum system. **LETHAL VOLTAGES** may be established under some operating conditions unless correct grounding is provided.

Ion producing equipment, such as ionization gauges, mass spectrometers, sputtering systems, etc., from many manufacturers may, under some conditions, provide sufficient electrical conduction via a plasma to couple a high voltage electrode potential to the vacuum chamber. If exposed conductive parts of the gauge, controller, and chamber are not properly grounded, they may attain a potential near that of the high voltage electrode during this coupling. Potential fatal electrical shock could then occur because of the high voltage between these exposed conductors and ground.

1.4 Implosion / Explosion

Danger of injury to personnel and damage to equipment exists on all vacuum systems that incorporate gas sources or involve processes capable of pressuring the system above the limits it can safely withstand.

For example, danger of explosion in a vacuum system exists during backfilling from pressurized gas cylinders because many vacuum devices such as ionization gauge tubes, glass windows, glass bellfars, etc., are not designed to be pressurized.

Do not attach cables to glass gauge pins while the gauge is under vacuum. Accidental bending of the pins may cause the glass to break and implode. Cables, once installed, should be secured to the system to provide strain relief for the gauge tube pins.

Install suitable devices that will limit the pressure from external gas sources to the level that the vacuum system can safely withstand. In addition, install suitable pressure relief valves or rupture disks that will release pressure at a level considerably below that pressure which the system can safely withstand.

Suppliers of pressure relief valves and pressure relief disks can be located via an on-line search, and are listed on ThomasNet.com. ***Confirm that these safety devices are properly installed before installing the Series 390 Micro-Ion Module***.

In addition, check that (1) the proper gas cylinders are installed, (2) gas cylinder valve positions are correct on manual systems, and (3) the automation is correct on automated systems.

1.5 Operation

It is the installer's responsibility to ensure that the automatic signals provided by the process control module are always used in a safe manner.

Carefully check manual operation of the system and the setpoint programming before switching to automatic operation. Where an equipment malfunction could cause a hazardous situation, always provide for fail-safe operation. As an example, in an automatic backfill operation where a malfunction might cause high internal pressures, provide an appropriate pressure relief device.

1.6 Reading and following instructions

You must comply with all instructions while you are installing, operating, or maintaining the module. Failure to comply with the instructions violates standards of design, manufacture, and intended use of the module. MKS Instruments, Inc. / Granville-Phillips disclaim all liability for the customer's failure to comply with the instructions.

- *Read instructions* – Read all instructions before installing or operating the product.
- *Follow instructions* – Follow all installation, operating and maintenance instructions.
- *Retain instructions* – Retain the instructions for future reference.
- *Heed warnings and cautions* – Adhere to all warnings and caution statements on the product and in these instructions.
- *Parts and accessories* – Install only those replacement parts and accessories that are recommended by Granville-Phillips. Substitution of parts is hazardous.

1.7 Definitions of terms

The terms listed in Table 1-1 are used throughout this manual in reference to the Micro-Ion ATM vacuum gauge module.

Table 1-1 Terms describing Micro-Ion ATM module and components

Term	Description
Module	The entire Micro-Ion ATM product, which includes the housing, gauge assembly, and electronics assembly.
Gauge assembly	A removable assembly that contains a hot filament Micro-Ion gauge (Bayard-Alpert type ionization gauge), a Conductron heat-loss sensor, a vacuum pressure diaphragm sensor, and the vacuum chamber connection.
Electronics assembly	An assembly that contains the electronic circuitry, signal processing microcircuitry, and atmospheric pressure diaphragm sensor.
Micro-Ion® gauge	The Bayard-Alpert type ionization gauge, which indicates pressure by producing a current that is proportional to gas density.
Conductron® sensor	The heat-loss sensor, which measures pressure as a function of heat loss from the gold-plated tungsten sensing wire.
Vacuum pressure diaphragm sensor	A Piezo resistive diaphragm sensor that measures vacuum pressure. Vacuum pressure is compared to atmospheric pressure to determine the differential between atmospheric and vacuum pressures.
Atmospheric pressure diaphragm sensor	A Piezo resistive diaphragm sensor that measures atmospheric pressure. Atmospheric pressure is compared to vacuum pressure to determine the differential between atmospheric and vacuum pressures.
Vacuum pressure	The pressure of the process gas inside the vacuum chamber, measured by the Micro-Ion gauge, Conductron sensor, and vacuum pressure diaphragm sensor.
Atmospheric pressure	The ambient air pressure of the atmosphere outside the module, measured by the atmospheric pressure diaphragm sensor.
Differential pressure	The difference between atmospheric pressure and vacuum pressure. Differential pressure zero is the pressure value at which vacuum pressure equals atmospheric pressure.

1.8 Customer service

For Customer Service / Technical Support:

MKS Pressure and Vacuum Measurement Solutions
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Email: mks@mksinst.com

Chapter 2 Installation

2.1 Module components

The Micro-Ion ATM Module contains a Micro-Ion gauge (Bayard-Alpert type ionization gauge), a Conductron heat-loss sensor, an atmospheric pressure diaphragm sensor, and a vacuum pressure diaphragm sensor.

⚠ WARNING

Using the module to measure the pressure of flammable or explosive gases can cause a fire or explosion resulting in severe property damage or personal injury.

Do not use the module to measure the pressure of flammable or explosive gases.

⚠ WARNING

Exposing the module to moisture can cause fire or electrical shock resulting in severe property damage or personal injury.

To avoid exposing the module to moisture, install the module in an indoor environment. Do not install the module in any outdoor environment.

2.2 Pressure relief devices

Before you install the module, you should install appropriate pressure relief devices in the vacuum system.

Granville-Phillips does not supply pressure relief valves or rupture disks. Suppliers of pressure relief valves and rupture disks are listed in the *Thomas Register* under “Valves, Relief” and “Discs, Rupture.”

⚠ CAUTION

Operating the module above 1000 Torr (1333 mbar, 133 kPa) true pressure could cause pressure measurement error or product failure.

To avoid measurement error or product failure due to overpressurization, install pressure relief valves or rupture disks in the system if pressure substantially exceeds 1000 Torr (1333 mbar, 133 kPa).

2.3 Installation procedure

The module installation procedure includes the following steps:

1. Determine the location of the module on the vacuum chamber.
2. Attach the module's flange/ fitting to its mating fitting on the vacuum chamber.
3. Assemble and connect the module wiring.
4. Calibrate the module at atmospheric pressure.

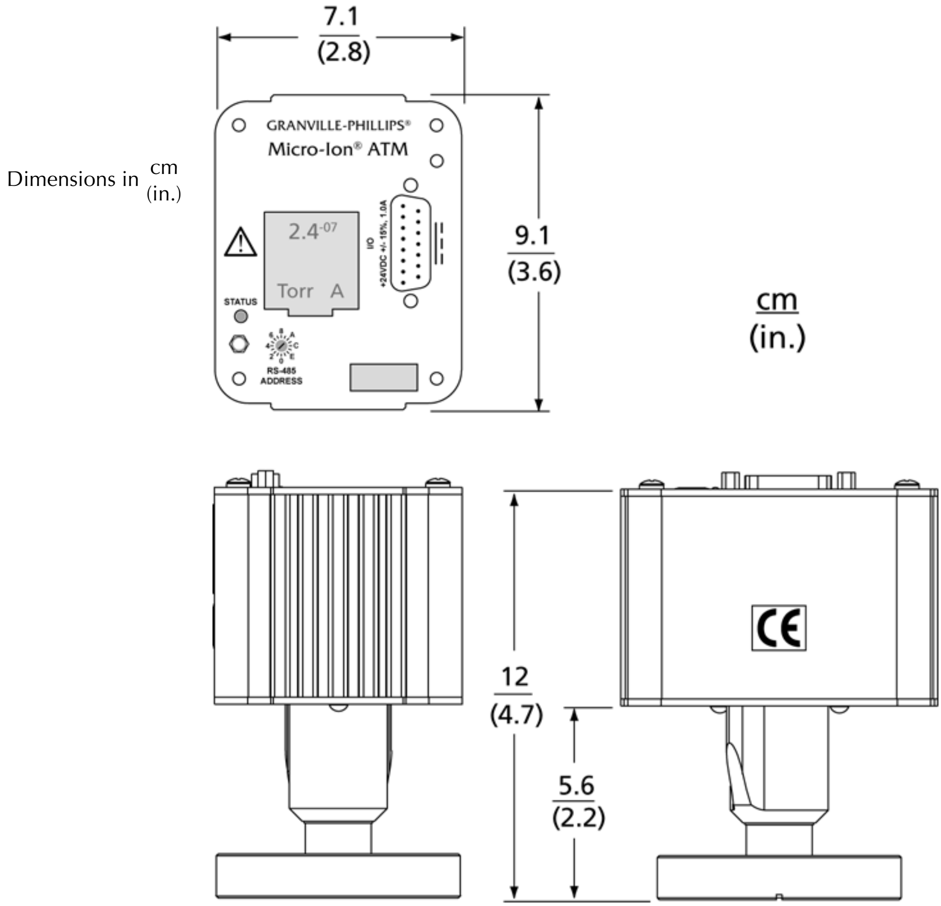
This chapter also explains what to do if radio frequency interference (RFI) disrupts operation of RS-485 version of the module.

Step 1 *Locate the module*

To locate the module, refer to Figure 2-1 and follow the guidelines below.

- For greatest accuracy and repeatability, locate the module in a stable, room-temperature environment. Ambient temperature should never exceed 40 °C (104 °F) operating, non-condensing, or 85 °C (185 °F) non-operating. Bakeout temperature with the electronics removed from the module is 105 °C (221 °F).
- Locate the module away from internal and external heat sources and in an area where ambient temperature remains reasonably constant.
- Do not locate the module near the pump, where gauge pressure might be lower than system vacuum pressure.
- Do not locate the module near a gas inlet or other source of contamination, where inflow of gas or particulates causes atmospheric pressure to be higher than system atmosphere.
- Do not locate the module where it will be exposed to corrosive gases such as mercury vapor or fluorine.

Figure 2-1 Dimensions



Step 2 *Attach module to vacuum chamber*

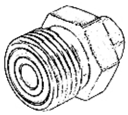
Attach the module's flange/fitting to its mating fitting on the vacuum chamber.

⚠ CAUTION

Twisting the module to tighten the fitting to the vacuum chamber can damage the module's internal connections.

- Do not twist the module to tighten the fitting.
- Use appropriate tools to tighten the fitting.

VCR type fitting



VCR type fitting:

a. Remove the bead protector cap from the fitting.

b. Place the gasket into the female nut.

c. Assemble the components and tighten them to finger-tight.

d. While holding a back-up wrench stationary, tighten the female nut 1/8 turn past finger-tight on 316 stainless steel or nickel gaskets, or 1/4 turn past finger-tight on copper or aluminum gaskets. *Do not twist the module to tighten the fitting*.

KF flange

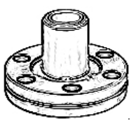
KF flange

The KF mounting system requires O-rings and centering rings between mating flanges.

a. Tighten the clamp to compress the mating flanges together.

b. Seal the O-ring.

ConFlat flange



ConFlat flange

To minimize the possibility of leaks with ConFlat® flanges, use high strength stainless steel bolts and a new, clean OFHC copper gasket. Avoid scratching the seal surfaces. To avoid contamination, install new metal gaskets.

a. Finger tighten all of the bolts.

b. Use a wrench to continue tightening 1/8 turn at a time in crisscross order (1, 4, 2, 5, 3, 6) until flange faces make contact.

c. Further tighten each bolt about 1/16 turn.

Step 3 *Assemble and connect wiring*

Connecting cable

Cable is user-supplied. Granville-Phillips does not supply cable.

- CE Mark compliance requires metal connector housings and cable with a braided shield.
- To prevent ground loops, connect the shield only to the outer shell of the subminiature D connector on the module. Do not connect the shield to the receiver or output device.

Power supply wiring

Connect the power supply to terminals 5 and 8.

- Terminal 5 (ground) is negative (–).
- Terminal 8 (input) is positive (+).

The power supply requirement is 24 Vdc +10% to –15%, 1 amp, 22 W nominal. Maximum inrush current is 2 amps, 48 W, for 0.5 seconds.

The power supply must supply at least 2 amps (48 W) of current for at least 0.5 seconds during Micro-Ion gauge start up. The Micro-Ion gauge will not activate and an emission error will occur if insufficient power is supplied during Micro-Ion gauge activation.

Gauge/degas wiring

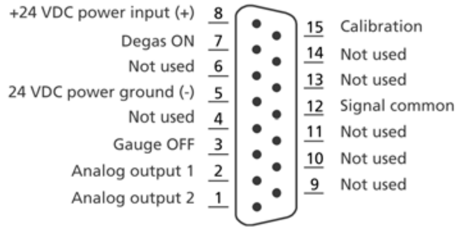
Install a switch between terminals 3 and 5 and between terminals 7 and 8 to enable Micro-Ion gauge degas and to switch the Micro-Ion gauge ON or OFF. See Figures 2-2 through 3-5.

Wiring terminals

Wiring terminations depend on the output type.

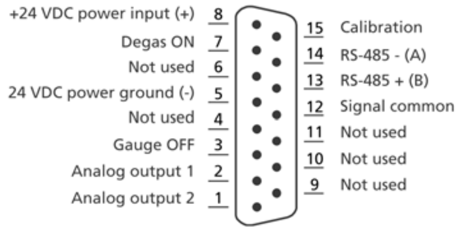
- If the module has two analog outputs, see Figure 2-2.
- If the module has RS-485 interface, analog output and no relays, see Figure 2-3.
- If the module has RS-485 interface, analog output and two trip point relays, see Figure 2-4. Relays are normally open/normally closed.
- If the module hasRS-485 interface, analog output and three trip point relays, see Figure 2-5. Relays are normally open.

Figure 2-2 Wiring terminals for Micro-Ion ATM module with two analog outputs, and no trip-point relays



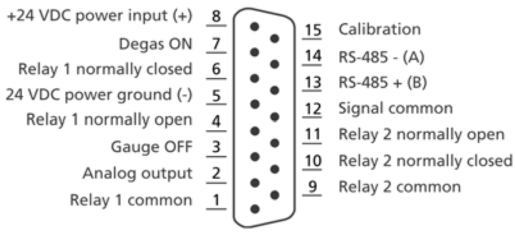
for Module Catalog #
390410-0-##-#
390411-0-##-#

Figure 2-3 Wiring terminals for Micro-Ion ATM module with RS-485 interface, two analog outputs, and no trip-point relays



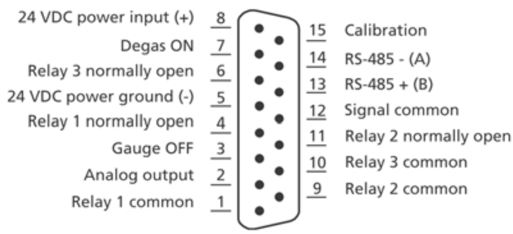
for Module Catalog #
390510-0-##-#
390511-0-##-#

Figure 2-4 Wiring terminals for Micro-Ion ATM module with RS-485 interface, one analog output, and two trip-point relays



for Module Catalog #
390510-2-##-#
390511-2-##-#

Figure 2-5 Wiring terminals for Micro-Ion ATM module with RS-485 interface, one analog output, and three trip-point relays



for Module Catalog #
390510-3-##-#
390511-3-##-#

Chassis Ground

> **⚠ WARNING**
>
> **Improper grounding could cause severe product failure or personal injury.**
>
> Follow ground network requirements for the facility.
>
> - Maintain all exposed conductors at earth ground.
> - Ground the module housing to the vacuum chamber as illustrated below.
> - Make sure the vacuum port to which the module is mounted is properly grounded.

If the module has a VCR type fitting or ConFlat flange, the module will be properly grounded via the vacuum chamber connection.

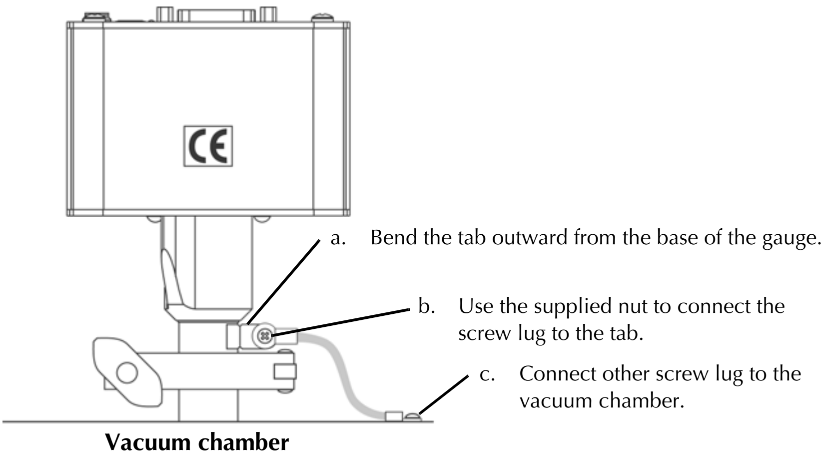
If the module has a KF flange, the module is shipped with a 3-foot length of braided copper wire, which has a screw lug on each end, and a screw and nut for connecting the copper wire to the gauge base. If a metal clamp and metal gasket will not be installed, follow this procedure to ground the module:

a. The gauge base has a tab that allows a connection to the copper wire. Bend the tab outward from the gauge base (see Figure 2-6).

b. Use the supplied screw and nut to connect one screw lug on the braided copper wire to the tab.

c. Connect the other screw lug to an appropriately grounded point on the vacuum system.

Figure 2-6 Vacuum chamber ground connections



Step 4 *Calibrate module at atmospheric pressure*

- To calibrate the module at atmospheric pressure using a momentary switch installed between pins 15 and 5 on the 15-pin connector, see page 31.
- To calibrate the module at atmospheric pressure using an RS-485 command, see page 61.

Atmospheric pressure calibration and differential pressure zero are performed at the factory before the module is shipped. The module will not operate properly unless you reset the atmospheric pressure calibration and differential pressure zero at the ambient operating pressure.

2.4 Eliminating radio frequency interference

The module has been tested and complies with U.S. Federal Communications Commission (FCC) limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits provide reasonable protection against harmful interference when the module operates in a commercial environment.

The module generates and can radiate radio frequency energy. If not installed and used in accordance with the instructions in this manual, the module may cause harmful interference to other electrical equipment.

Chapter 3 Operation Overview

3.1 Analog operation

Table 3-1 lists tasks that may be performed if the module has one or two analog outputs

3.2 RS-485 operation

Table 3-2 lists tasks that may be performed if the module has an RS-485 interface. Process control (PC) commands may be performed only if the module has trip point relays.

Table 3-1 Tasks and page references for analog operation

Task	Instructions:
Use the LED status indicator	Page 26
Read vacuum pressure	Page 27
Read differential pressure (if module has two analog outputs)	Page 28
Turn OFF the Micro-Ion gauge	Page 30
Initiate or terminate Micro-Ion gauge degas	Page 30
Calibrate the module at atmospheric pressure	Page 32
Calibrate the module at vacuum pressure	Page 32

Table 3-2 Commands, tasks, and page references for RS-485 operation

Command	Task	Instructions:
TLU	Toggle functions to locked or unlocked state	Page 41
UNL	Unlock interface functions	Page 41
SA	Set address offset	Page 42
yuiop	Set RS-485 communication to default values	Page 43
SB	Set baud rate	Page 43
SU	Set pressure unit	Page 43
SD	Set pressure indication for optional display	Page 43
RU	Read pressure unit	Page 43
RD	Read vacuum pressure	Page 44
RDD	Read differential pressure	Page 44
PC	Set or read relay trip points and activation direction	Page 45
PCG	Set relay assignments	Page 49
PCE	Set or read disabled/enabled state of relays	Page 49
RPCS	Read activation or deactivation status of relays	Page 50
IG	Set Micro-Ion gauge ON or OFF state	Page 50
IGM	Set or read gauge and sensor ON/OFF mode	Page 51
IGS	Read Micro-Ion gauge ON/OFF state	Page 50
IOD	Set Micro-Ion gauge delay ON/OFF state	Page 52
IDT	Set Micro-Ion gauge delay time	Page 53
SF	Set Micro-Ion gauge filament mode	Page 61
RF	Read Micro-Ion gauge filament status	Page 58
DG	Set Micro-Ion gauge degas ON or OFF state	Page 58
DGS	Read Micro-Ion gauge degas ON/OFF state	Page 58
DGT	Set or read Micro-Ion gauge degas time	Page 59
SER	Set emission current switch point for Micro-Ion gauge	Page 59
RE	Read Micro-Ion gauge emission current	Page 61
TS	Calibrate module at atmospheric pressure	Page 61
TZ	Calibrate module at vacuum pressure	Page 62
ATM	Set or read atmospheric pressure indicated by analog and RS-485 outputs	Page 63
RS	Read RS-485 character strings indicating module status	Page 63
RSX	Read 8-digit hexadecimal codes indicating module status	Page 65
RST	Reset module to power-up state	Page 68
FAC	Reset values to factory defaults	Page 68
VER	Read firmware version for module	Page 68

3.3 Automatic filament selection

As the vacuum system pumps down from atmosphere, the Conductron sensor measures pressure until a sufficiently low pressure level is achieved, then automatically turns ON the Micro-Ion gauge. The filaments in the Micro-Ion gauge can burn out if they turn ON at a pressure that is too high.

Tungsten filaments are more likely than yttria-coated iridium filaments to burn out if they turn ON at a pressure that is too high. To reduce the risk of burnout, the default behavior of Micro-Ion gauge depends on the filament material.

If a rapid increase in pressure from high vacuum levels to pressures of 1 Torr (1.33 mbar, 133 Pa) or higher pressure occurs, tungsten filaments are almost certain to burn out. This risk is not unique to the Micro-Ion gauge and exists for all ion gauges containing tungsten filaments.

- At startup, the module software detects the filament material and sets the behavior of the Micro-Ion gauge accordingly, as listed in Table 3-3.
- If the gauge assembly is replaced, the module software automatically sets the behavior of the Micro-Ion gauge according to the filament material.
- If the module has one or two analog outputs without RS-485 communications, you cannot change the behavior of the Micro-Ion gauge.
- If the module has RS-485 communications, you can use the IOD, IDT, and SF commands to change the behavior of the Micro-Ion gauge. See pages 52–58.

Table 3-3 Defaults for Micro-Ion gauge filament material

Function	Default for tungsten filaments	Default for yttria-coated iridium filaments
Micro-Ion gauge delay time	Module software determines the appropriate amount of time to wait before the Micro-Ion gauge turns ON with decreasing pressure	Micro-Ion gauge turns ON, without delay, as soon as operational pressure is achieved with decreasing pressure.
Micro-Ion gauge added delay time	Micro-Ion gauge waits an additional 2 seconds, beyond software-defined delay time, to turn ON with decreasing pressure.	

Chapter 4 Analog Operation

4.1 Output functions

The module may have two analog outputs with no RS-485 interface, two analog outputs with RS-485 interface, or one analog output with RS-485 interface.

If the module has two analog outputs, analog output 1 indicates vacuum pressure, and analog output 2 represents differential pressure.

If the module has one analog output with RS-485 interface, the analog output represents vacuum pressure. You may use RS-485 commands to read vacuum pressure or differential pressure and configure the module.

WARNING

Using the module to measure the pressure of flammable or explosive gases can cause a fire or explosion resulting in severe property damage, personal injury, or death.

Do not use the module to measure the pressure of flammable or explosive gases.

4.2 Preparing to operate the module

Before putting the module into operation, you must perform the following procedures:

1. Install the module in accordance with the instructions on pages 13–20.
2. Develop a logic diagram of the process control function.
3. Develop a circuit schematic that specifies exactly how each piece of system hardware will connect to the module relays.
4. Attach a copy of the process control circuit diagram to this manual for future reference and troubleshooting.

If you need application assistance, phone a Granville-Phillips application engineer at 1–303–652–4400 or 1–800–776–6543.

4.3 Operational tasks

Once the module is operating, you may perform the tasks listed in Table 3-1 on page 21.

4.4 LED status indicator

- Figure 4-1 illustrates the LED status indicator. The LED behavior indicates the status of the module and Micro-Ion gauge.
- Table 4-1 lists states indicated by the LED.

Figure 4-1 LED status indicator

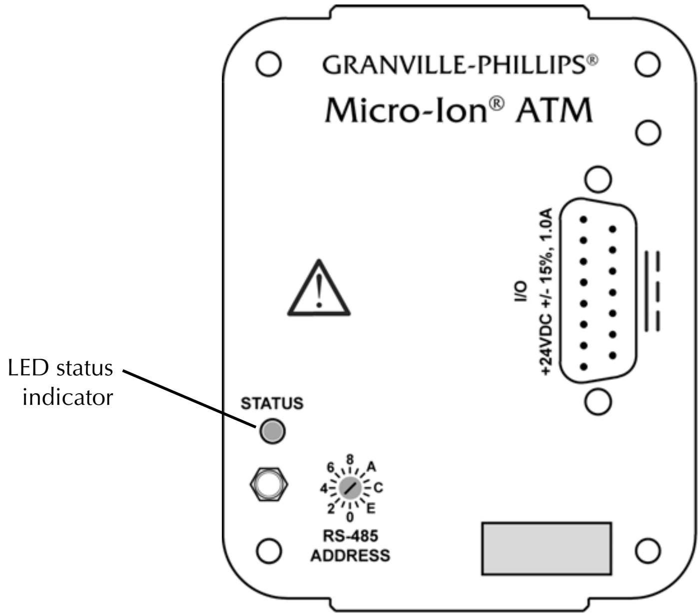


Table 4-1 LED status indications

LED behavior	Indicated condition:
OFF	Module power supply is OFF (see page 17)
Solid green	Power is ON, Micro-Ion gauge is OFF (see page 30)
Blinking green	Micro-Ion gauge is ON (see page 30)
Solid amber	Micro-Ion gauge is ON but one filament is inoperable
Blinking amber	• Both Micro-Ion gauge filaments are inoperable; replace gauge assembly (see page 79) • Electronics may be defective; return module to factory (see page 79)

4.5 Reading pressure

Use the module's 15-pin connector to read voltage that indicates vacuum pressure or differential pressure.

- Regardless of the number of analog outputs, the voltage across pins 2 and 12 indicates vacuum pressure.
- If the module has two analog outputs, the voltage across pins 1 and 12 indicates differential pressure.
- Output impedance is 100 Ω.

Reading vacuum pressure

Regardless of the number of analog outputs, the voltage across pins 2 (analog output 1) and 12 (signal common) represents vacuum pressure, as illustrated in Figure 4-2. Use one of the following equations to calculate vacuum pressure as a function of voltage:

$$P\ vacuum_{Torr} = 10^{[(2 \times V_{out}) - 11]}$$

$$P\ vacuum_{mbar} = 1.33 \times 10^{[(2 \times V_{out}) - 11]}$$

$$P\ vacuum_{Pa} = 133 \times 10^{[(2 \times V_{out}) - (11)]}$$

Voltage is in linear proportion to the logarithm of vacuum pressure. For example, a vacuum pressure of 1 x 10^{-3} Torr (1.33 x 10^{-3} mbar, 1.33 x 10^{-1} Pa) produces a 4 Vdc analog output, as illustrated in Figure 4-3.

Figure 4-2 Pins 2 and 12: Voltage indicating vacuum pressure

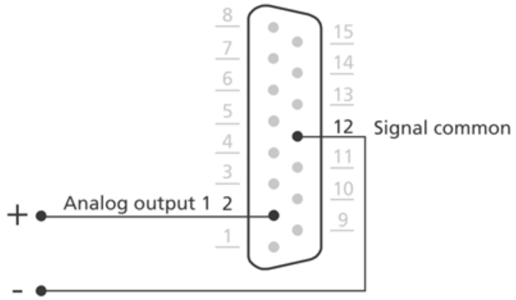
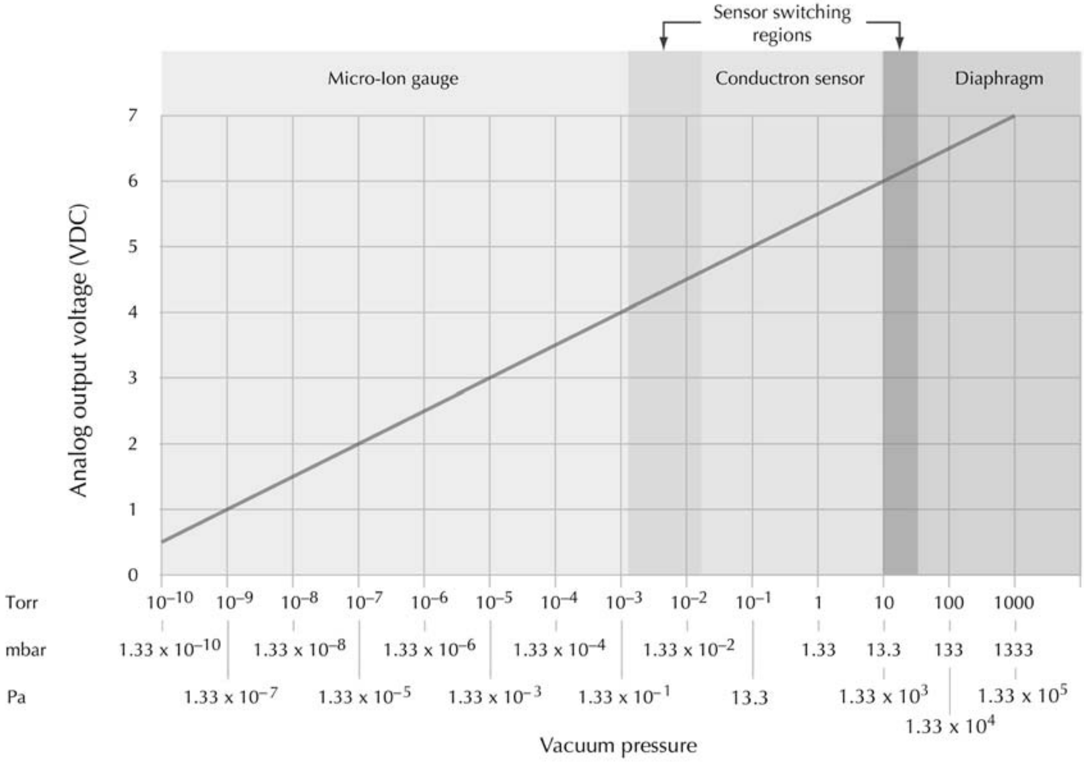


Figure 4-3 Analog output indicating vacuum pressure



Reading differential pressure

If the module has two analog outputs, the voltage across pins 1 (analog output 2) and 12 (signal common) represents differential pressure, as illustrated in Figure 4-4. Use one of the following equations to calculate differential pressure as a function of voltage:

$$P\ differential_{Torr} = 250(V_{out} - 4)$$

$$P\ differential_{mbar} = 1.33 \times [250(V_{out} - 4)]$$

$$P\ differential_{Pa} = 133 \times [250(V_{out} - 4)]$$

Voltage is in linear proportion to differential pressure. For example, a differential pressure of –250 Torr (–333 mbar, -3.33×10^4 Pa) produces a 3 Vdc analog output, as illustrated in Figure 4-5.

Figure 4-4 Pins 1 and 12: Voltage indicating differential pressure

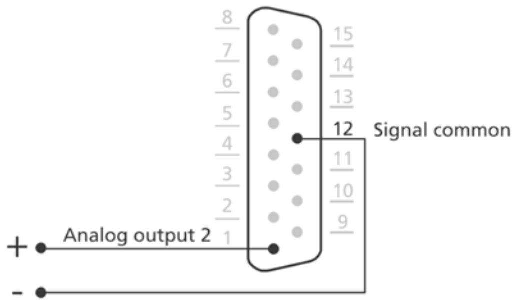
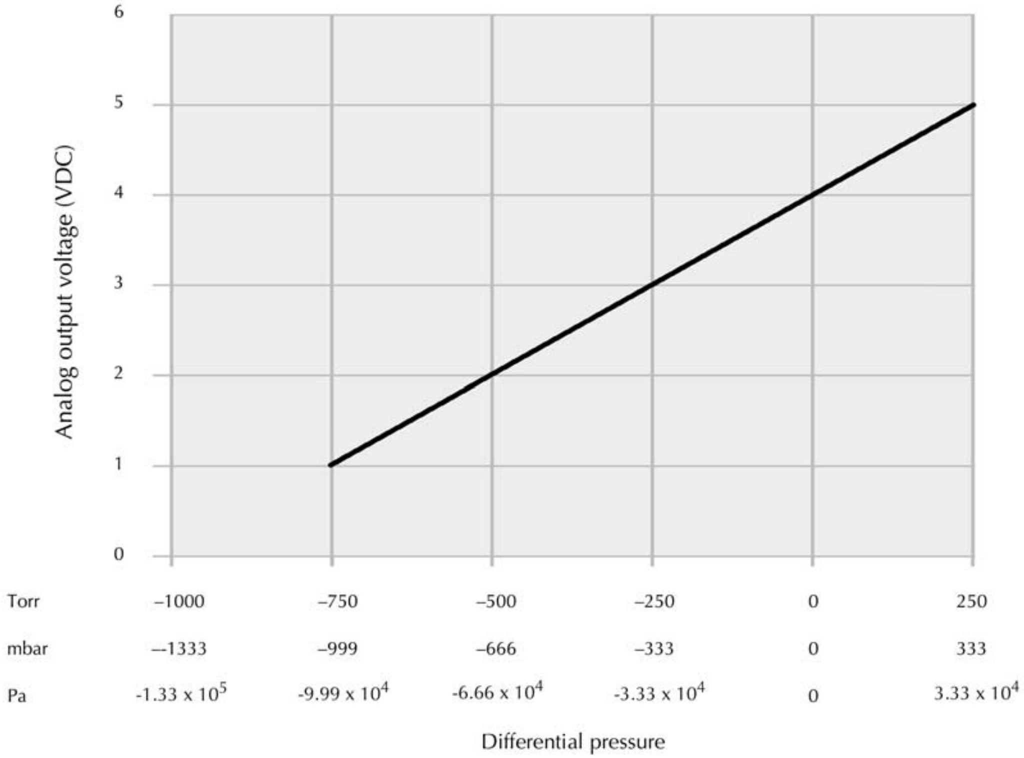


Figure 4-5 Analog output indicating differential pressure



4.6 Micro-Ion gauge OFF

When power is supplied to the module, the Conductron sensor is ON. As pressure decreases to a level that allows the Micro-Ion gauge to operate, the sensor automatically turns the gauge ON. The LED status indicator blinks green when the Micro-Ion gauge is ON. In some instances, you might need to turn the Micro-Ion gauge OFF.

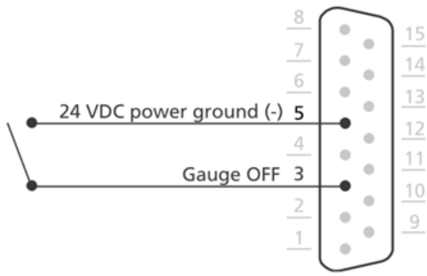
- If the module does not have RS-485 communications, the module outputs pressure values from the Conductron sensor and diaphragm sensor when the Micro-Ion gauge is OFF.
- If the module has RS-485 communications, you may program the module to turn OFF all pressure outputs when the Micro-Ion gauge is OFF or to output pressure values from the Conductron sensor and diaphragm sensor when the Micro-Ion gauge is OFF (see page 51).

If the Micro-Ion gauge has tungsten filaments and one filament fails, you must turn the gauge OFF, then back ON to switch to the other filament.

To turn the Micro-Ion gauge OFF and ON, install a switch between pins 5 (24 Vdc power ground) and 3 (gauge OFF) on the 15-pin connector, as illustrated in Figure 4-7.

- Close the switch to turn the gauge OFF.
- Open the switch to turn the gauge ON.

Figure 4-6 Pins 5 and 3: Switch for Micro-Ion gauge OFF

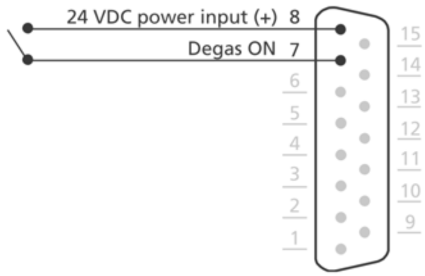


4.7 Micro-Ion gauge degas

To enable initiation and termination of the degas cycle for the Micro-Ion gauge, install a switch between pins 8 (24 Vdc power input) and 7 (degas ON) on the 15-pin connector, as illustrated in Figure 4-6.

- Close the switch between pins 8 and 7 to initiate the degas cycle. After initiation, the degas cycle continues for two minutes.
- The degas cycle ends immediately if you open the switch.
- During degas the module continues to output a pressure signal, but the indicated value may be affected by the degas function and indicate a less accurate pressure.

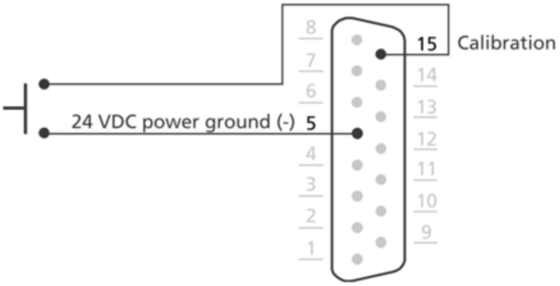
Figure 4-7 Pins 8 and 7: Switch for Micro-Ion gauge degas ON



4.8 Calibration

You may install a momentary contact switch between pins 15 (calibration) and 5 (24 Vdc power ground) to enable calibration at atmospheric or vacuum pressure. See Figure 4-8.

Figure 4-8 Pins 15 and 5: Switch for calibration



Atmospheric pressure calibration

Atmospheric pressure calibration and differential pressure zero are performed using N_2 at the factory before the module is shipped. Differential pressure zero is the pressure value at which atmospheric and vacuum pressures are equal. The factory calibration sets the differential pressure zero to approximately 760 Torr (1013 mbar, 1.01×10^5 Pa). The module will not operate properly unless you reset the atmospheric pressure calibration and differential pressure zero at the ambient operating pressure.

If the atmospheric pressure calibration value is too low, the Micro-Ion gauge will not turn ON.

Use N_2 or air to calibrate the module at atmospheric pressure. Minimum valid calibration pressure is 500 Torr (666 mbar, 6.66×10^4 Pa).

1. To ensure accurate calibration, make sure the differential pressure sensor is vented and open to atmosphere when you calibrate the module at atmospheric pressure.
2. Shut the pump OFF and, using N_2 or air, allow the vacuum pressure to increase until it equals atmospheric pressure.
3. Momentarily close the switch between pins 15 and 5.

Vacuum pressure calibration

Ordinarily, the Conductron sensor turns the Micro-Ion gauge ON when pressure decreases to 2×10^{-2} Torr (2.66×10^{-2} mbar, 2.66 Pa). However, if the Conductron sensor calibration has shifted so that the Micro-Ion gauge cannot turn ON, you can recalibrate the module for vacuum pressure.

Use N_2 or air to calibrate the module at vacuum pressure. Maximum valid calibration pressure is 3.00×10^{-2} Torr (3.99×10^{-2} mbar, 3.99 Pa).

1. Turn the pump ON and, using N_2 or air, allow the vacuum chamber to decrease to the optimal calibration pressure of 1×10^{-4} Torr (1.33×10^{-4} mbar, 1.33×10^{-2} Pa) or a lower pressure.
2. Momentarily close the switch between pins 15 and 5.

Chapter 5 RS-485 Operation

5.1 Pressure output and relay functions

A module with RS-485 communications may have one or two analog outputs.

- If the module has no trip point relays, it has two analog outputs.
- If the module has two or three set point relays, it has one analog output.

If the unit has one analog output, the output represents vacuum chamber pressure. If the module has two analog outputs, analog output 1 indicates vacuum chamber pressure, and analog 2 represents differential pressure.

You may use RS-485 commands to read vacuum pressure or differential pressure, assign trip point relays to vacuum pressure or differential pressure, and configure the module.

WARNING

Using the module to measure the pressure of flammable or explosive gases can cause a fire or explosion resulting in severe property damage, personal injury, or death.

Do not use the module to measure the pressure of flammable or explosive gases.

5.2 Preparing to operate the module

Before putting the module into operation, you must perform the following procedures:

1. Install the module in accordance with the instructions on pages 13–20.
2. Develop a logic diagram of the process control function.
3. Develop a circuit schematic that specifies exactly how each piece of system hardware will connect to the module relays.
4. Attach a copy of the process control circuit diagram to this manual for future reference and troubleshooting.
5. If the module has two or three trip point relays, use Table 5-1 to record the proposed activation and deactivation trip points (in Torr, mbar, or Pascal) and assignments for each relay.

If you need application assistance, phone a Granville-Phillips application engineer at 1-303-652-4400.

Table 5-1 Relay trip points and assignments

Relay	Activation trip point (Torr, mbar, or Pa)	Deactivation trip point (Torr, mbar, or Pa)	Relay assignment
Relay 1			☐ Vacuum pressure ☐ Differential pressure
Relay 2			☐ Vacuum pressure ☐ Differential pressure
Relay 3 (if present)			☐ Vacuum pressure ☐ Differential pressure

5.3 RS-485 physical layer

Table 5-2 lists specifications for the RS-485 physical layer.

Table 5-2 RS-485 physical layer specifications

Function	Description
Arrangement	2-wire half duplex
Address range	0 to 63
Default address	01
Method for setting 00 to 30_{hex} value in address	Use SA command (see page 42)
Method for setting 0 to F_{hex} offset value in address	Use address switch (see page 42)
Maximum cable length	• 4000 feet (1610 meters) • A common ground wire should connect all network devices for long cable runs
Maximum number of devices in network	32 devices
Default baud rate	19200 baud (19.2 kbaud)
Data bits	8 data bits
Stop bits and parity	1 stop bit, no parity

5.4 Operational tasks

Once the module is operating, you may use RS-485 commands to perform the tasks listed in Table 3-2 on page 22.

5.5 Error responses

If a command cannot be processed, the module returns one of the error responses listed in Table 5-3.

Table 5-3 RS-485 error responses

Response	Possible causes	Solution
`RANGE ER`	1. Pressure value in TS calibration command is outside valid limits. 2. Pressure value in TZ calibration command is outside valid limits. 3. Pressure value in ATM set command is outside valid limits. 4. Ion gauge on-delay time (IDT) is out of range. 5. Degas duration (DGT) is out of range. 6. Emission current switch point is out of range. 7. Relay trip point is out of range (ABS). 8. Relay trip point is out of range (DIFF).	1. Make sure atmospheric pressure is > 500 Torr (666 mbar, 6.66 x 10^4 Pa). See page 61. 2. Make sure vacuum pressure < 3.00 x 10^{-2} Torr (3.99 x 10^{-2} mbar, 3.99 Pa). See page 62. 3. Make sure the setting is reasonable (250-1000 Torr). 4. Make sure the ion gauge delay time is between 0 and 600 seconds. 5. Make sure the degas duration setting is between 10 and 120 seconds. 6. Make sure current switch point is set correctly. See SER on page 59. 7. Make sure the trip point is between 1E-10 and 1000 Torr, and hysteresis is between 5 and 10,000%. 8. Make sure the trip point is between -800 and +300 Torr, and hysteresis is between 5 and 800 Torr.
`SYNTX ER`	• Command was improperly entered. • Module does not recognize command syntax. • UNL command was sent when software functions were already unlocked.	• Re-enter command using proper character string (see page 37).
`9.99E+09`	• Module cannot indicate a valid pressure value. • IG0 command has been sent.	• Send RS or RSX command to determine module status (see page 63). • If necessary, replace the gauge assembly. • If IG0 command has been sent, send IG1 command (see page 50).
`LOCKED`	Interface function is locked.	• Send TLU or UNL command to unlock interface function (see page 41).
`INVALID`	• IG1 command sent while IG ON I/O line not asserted. • Micro-Ion gauge or Conductron sensor is defective. • Vacuum pressure is too high for gauge degas.	• Assert the IG ON I/O line or disconnect from ground. • If the Micro-Ion gauge or Conductron sensor is defective, replace the gauge assembly. • Decrease the pressure to < 5 x 10^{-5} Torr . See DG on page 58.

5.6 Data timing and response

The module communicates using half-duplex mode. Neither the module nor the host can send and receive signals at the same time. The host issues a command then waits for a response from the module.

Figure 5-1 illustrates the request and response data timing sequence, including:

- The request sent by the host, response sent by the module.
- Minimum and maximum time duration from the end of the receipt of the request to the start of the response (T_D).
- Time required for the module to process and respond with the data (T_R).
- Time for the module to switch between transmit and receive modes (D).

Table 5-4 lists data timing and response delay limits. The time required for the module to process and send the response depends on the baud rate, as listed in Table 5-5. The minimum response time of the module to a request is 500 µsec. The host must switch from transmit to receive mode in 500 µsec or less to ensure proper receipt of response data packets from the module. The host must wait a minimum of 200 µsec after receiving the response before sending a new request command.

Figure 5-1 Data timing and response delays

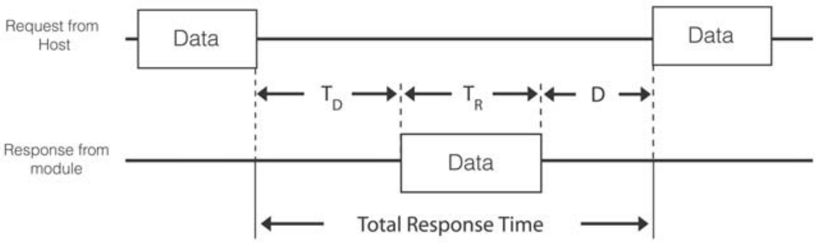


Table 5-4 Data timing and response delay limits

Timing segment	Time limit
Time T_D (time for host to switch from transmit to receive)	• Read commands: 500 µsec minimum, 25 msec maximum • Reset to factory defaults (FAC) command: 12.0 msec + maximum 32.0 msec

Table 5-4 Data timing and response delay limits

Timing segment	Time limit
Time T_R (data processing and response time)	$\frac{1}{\text{Baud}}$ ¥ 130
Time D (time for module to switch from transmit to receive)	200 µsec
Total response time	Time T_D + $\left(\frac{1}{\text{Baud}}\right.$ ¥ 130$\left.\right)$ + Time D

Table 5-5 Baud rate and data typical response time

Baud rate	Data response time (T_R)
1200 baud	108 msec
2400 baud	54 msec
4800 baud	27 msec
9600 baud	13.5 msec
19200 baud (default)	6.75 msec
38400 baud	3.3 msec

5.7 RS-485 commands

RS-485 commands require entry of integer values, hex code values (such as “0F”), values in engineering notation (such as “2.00E+02”), and alphanumeric character strings.

Command structure

Table 5-6 explains the RS-485 command structure. The command should *not* include a line feed with the carriage return. Including a line feed adds an extra character and may cause a garbled response from the module.

Each response includes 13 characters, beginning with the asterisk (*) or (?) and ending with carriage return (↵).

Symbols used in this manual

The ↵ symbol at the end of the command represents the carriage return (CR), which is entered as hex code 0D or, if you're using a terminal, by simultaneously pressing the "Control" and "M" keys.

The response will have a space between the address and the text of the response. For example: `*02 PROG OK↵`

Table 5-6 RS-485 command structure

Address field	Command field	Data field	Carriage return
#XX	Character string for command from host	Character string data required to execute command	↵
"XX" is 2-digit address of module	First character is: • D = Degas • I = Ion gauge • PC = Process control • R = Read • S = Set • T = Calibrate or toggle • U = Unlock • V = Firmware version	Data may include: • Hex code *or* • Pressure value in engineering notation *or* • Alphanumeric character string	• Enter hex code "0D" *or* • If using a terminal, simultaneously press "Control" and "M" keys

5.8 RS-485 command set

Table 5-7 lists RS-485 commands that provide pressure values or other information without affecting module operation.

Table 5-8 on page 40 lists RS-485 commands that may affect module operation and have default values.

The instructions on pages 41–68 explain how to use the RS-485 command set to configure and operate the module.

Table 5-7 RS-485 command set for values not affecting module operation

Command	Set by command	Non-volatile	Change after reset	Data returned	Can be locked
RD	No	No	No	Vacuum pressure	No
RDD	No	No	No	Differential pressure	No
RU	No	No	No	Pressure unit	No
RPCS	No	No	No	Relay state	No
IGS	No	No	No	Micro-Ion gauge ON/OFF state	No
DGS	No	No	No	Degas ON/OFF state	No
RE	No	No	No	Emission current	No
RF	No	No	No	Filament operation state	No
RS	No	No	No	Module status RS-485 string	No
RSX	No	No	No	Module status hexadecimal bits	No
VER	No	Yes	No	Software version	No

Table 5-8 RS–485 command set for commands affecting module operation

Command	Set by command	Non-volatile	Default	Change after reset	Data returned	Can be locked
TLU	Yes	Yes	OFF (0)	No	Confirm	No
UNL	Yes	Yes	OFF (0)	No	Confirm	No
SA	Yes	Yes	00	Yes	Confirm	Yes
SB	Yes	Yes	19200 baud	Yes	Confirm	Yes
yuiop	Yes	Yes	• 19200 baud • Address offset 0	No	None	No
SU	Yes	Yes	Torr	No	Confirm	Yes
SD	Yes	Yes	Absolute pressure	No	Confirm	No
PC	Yes	Yes	Out of range	No	Confirm or state	No
PCG	Yes	Yes	Disabled	No	Confirm or state	No
PCE	Yes	Yes	Disabled	No	Confirm or state	No
IG	Yes	No	ON (1)	No	Confirm or state	No
IGM	Yes	Yes	Enabled (1)	No	Confirm or state	Yes
IOD	Yes	Yes	• ON (1) for tungsten • OFF (0) for yttria-coated iridium	No	Confirm or state	No
IDT	Yes	Yes	00 sec	No	Confirm or state	Yes
DG	Yes	No	OFF (0)	No	Confirm or state	No
DGT	Yes	Yes	120 sec	No	Confirm or state	No
SF	Yes	Yes	• Manual (MAN) for tungsten • Alternating (ALT) for yttria-coated iridium	No	Confirm	Yes
SER	Yes	Yes	5×10^{-6} Torr 6.66×10^{-6} mbar 6.66×10^{-4} Pa	No	Confirm or state	Yes
TS	Yes	Yes	760 Torr 1013 mbar 1.01×10^{5} Pa	No	Confirm	No
TZ	Yes	Yes	1×10^{-4} Torr 1.33×10^{-4} mbar 1.33×10^{-2} Pa	No	Confirm	No
ATM	Yes	Yes	760	No	Confirm or state	Yes
RST	Yes	No	Values at last power-up	Yes	None	No
FAC	Yes	Yes	Factory defaults	Yes	Confirm	Yes

TLU **Toggling locked functions**

In default operating mode, all interface functions are unlocked.

Use the toggle lock/unlock (TLU) command to lock or unlock any of the interface functions listed in Table 5-9.

Table 5-9 Interface functions affected by TLU command

Command	Interface function	Instructions:
SA	Set address offset	Page 42
SB	Set module baud rate	Page 43
SU	Set pressure unit	Page 43
IGM	Set gauge and sensor ON/OFF mode	Page 51
IDT	Set Micro-Ion gauge delay time	Page 53
DGT	Set Micro-Ion gauge degas time	Page 59
SER	Set emission current switch point for Micro-Ion gauge	Page 59
SF	Set Micro-Ion gauge filament mode	Page 61
FAC	Reset values to factory defaults	Page 68

The module processes the command, then returns a character string that indicates whether or not interface functions are unlocked.

TLU command from host: `#01TLU↵`
Response from module: `*01 1 UL  ON↵`

- The “1 UL ON” response means interface functions are locked.
- The “0 UL OFF” response means interface functions are unlocked.

UNL **Unlock interface functions**

If you’ve used the TLU command to lock interface functions listed in Table 5-9, you must send the unlock interface functions (UNL) command to unlock a function before reprogramming it.

UNL command from host: `#01UNL↵`
Response from module: `*01 PROGM OK↵`

- If you send the UNL command while interface functions are already unlocked, the module returns a “SYNTX ER” response (see page 35).
- You can unlock all locked functions by sending the TLU command.
- If you attempt to reprogram a locked function without sending the UNL or TLU command, the module returns a “LOCKED” response (see page 35).

SA **Set address offset**

You *must* assign an address to enable the module to communicate with the host. The module may use any address from 0 to 63.

The address consists of the hexadecimal switch setting plus the hexadecimal SA (set address offset) value. For example, to set a value of 60 for the address, set the switch to C_{hex} (12), then send an SA value of 30_{hex} (48).

To set the address, follow these steps:

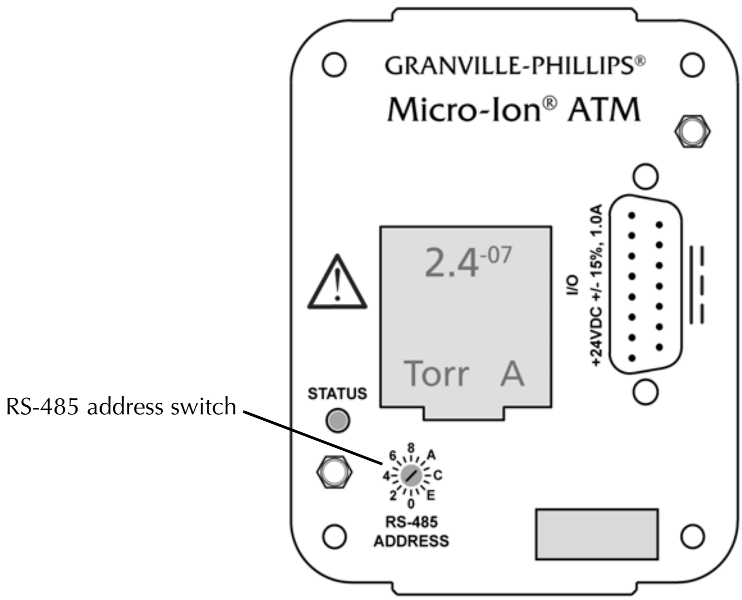
1. Use the rotary switch located on the top of the module to set a value of 0 to 15 (see Figure 5-2).
    - Set the switch on one of the unlabeled marks for the values 1, 3, 5, 7, 9, B_{hex} (11), D_{hex} (13), or F_{hex} (15).
    - Set the switch on one of the labeled marks for the values 0, 2, 4, 6, 8, A_{hex} (10), C_{hex} (12), or E_{hex} (14).
2. Send an SA (set address offset) command to the module.
3. Cycle power to the module.

The example SA command sets the address to 60 if the switch is set to C:

Example SA command from host: `#01SA30↵`
Response from module: `*01 PROGM OK↵`

Valid SA command values are 00, 10_{hex} (16), 20_{hex} (32), or 30_{hex} (48).

Figure 5-2 Address switch



SB **Set baud rate**

The example set baud rate (SB) command sequence sets the baud rate to 2400 baud:

Example SB command from host: `#01SB2400↵`
Response from module: `*01 PROGM OK↵`

Valid values are 1200, 2400, 4800, 9600, 19200 (default), or 38400 baud.

yuiop **Restore RS-485 communication defaults**

The lower-case yuiop command restores the address offset to 0 and the baud rate to 19200 baud within the first few seconds after power is applied.

yuiop command from host: `yuiop↵`
Response from module: None

SU **Set pressure unit**

The example set unit (SU) command sets the pressure unit to Torr:

Example SU command from host: `#01SUT↵`
Response from module: `*01 PROGM OK↵`

- An SUT command sets the pressure unit to Torr.
- An SUM command sets the pressure unit to mbar.
- An SUP command sets the pressure unit to Pa.

SD **Set pressure indication for optional display**

The SD command determines whether the optional display indicates vacuum pressure, differential pressure, or both vacuum and differential pressure. The example set display (SD) command sets the display to indicate vacuum pressure:

Example SD command from host: `#01SDA↵`
Response from module: `*01 PROGM OK↵`

- An SDA command sets the display to indicate vacuum (absolute) pressure.
- An SDD command sets the display to indicate differential pressure.
- An SDB command sets the display to indicate both vacuum and differential pressure. If both vacuum and differential pressure are indicated, the display indicates vacuum pressure when pressure is less than 250 Torr (333 mbar, 3.33×10^4 Pa) or differential pressure when pressure is equal to or greater than 250 Torr (333 mbar, 3.33×10^4 Pa).

RU **Read pressure unit**

The example read unit (RU) command causes the module to return a character string that identifies Torr as the pressure unit.

RU command from host: `#01RU↵`
Example response from module: `*01 TORR↵`

- A "TORR" response designates Torr as the pressure unit.
- An "MBAR" response designates mbar as the pressure unit.
- A "PASCAL" response designates pascal as the pressure unit.

RD **Read vacuum pressure**

The example read pressure (RD) command causes the module to return a value that indicates vacuum pressure is 1.50 x 10^{-2}:

Example RD command from host: `#01RD↵`
Example response from module: `*01 1.50E-02↵`

The returned value is in the pressure unit that you've set for the module.

If the returned value is not a valid representation of pressure, see page 76.

RDD **Read differential pressure**

The example read differential pressure (RDD) command causes the module to return a value indicating a negative differential of 7.34 x 10^{2} between vacuum and atmospheric pressures:

Example RD command from host: `#01RDD↵`
Example response from module: `*01-7.34E+02↵`

The returned value is in the pressure unit that you've set for the module. See page 43.

In the response, the + or – sign that *precedes* the pressure value indicates whether the pressure differential is positive or negative.

- A + sign indicates a positive pressure differential (vacuum pressure is greater than atmospheric pressure).
- A – sign indicates a negative pressure differential (vacuum pressure is less than atmospheric pressure).

The + or – that *follows* the "E" character is the sign of the exponent. For example, a pressure value of "2.00E–2" equals 2 x 10^{-2} pressure units, and a pressure value of "2.00E+2" equals 2 x 10^{2} pressure units.

If the returned value is not a valid representation of pressure, see page 76.

PC **Process control relay trip points**

The module may have two single-pole double-throw (normally open/normally closed) relays or three single-pole single-throw (normally open) relays. Each relay can be independently assigned to vacuum or differential pressure. Each relay has programmable activation and deactivation trip points. The trip point is a programmable value representing pressure at which the relay activates or deactivates.

- When the module is shipped from the factory, relay trip points are out of range, disabled, and will not operate.
- You must configure relays to make them operable.
- After relays have been made operable, you may send a process control disable (PCE) command to disable any specified relay. See page 49.

The example process control (PC) command sequence causes relay 1 to activate when positive differential pressure decreases to -455 pressure units and deactivate when positive differential pressure increases to -445 pressure units:

Example PC command from host: `#01PC1A-455↵`
Response from module: `*01 PROGM OK↵`

Example PC command from host: `#01PC1D-445↵`
Response from module: `*01 PROGM OK↵`

The “PC1” value identifies process control relay 1.

The "A" (activation) and "D" (deactivation) pressure values determine activation and deactivation direction, as listed in Table 5-10.

Table 5-10 Activation/deactivation direction

Activation versus deactivation	Effect on relay operation
If A > D	Relay activates with increasing pressure (see Figure 5-4)
If D > A	Relay activates with decreasing pressure (see Figure 5-3)
If D = A	Software increases "D" value by minimum software defined hysteresis

Table 5-11 lists minimum hysteresis for trip point relays based on the relay assignment.

Table 5-11 Relay assignments and minimum hysteresis

Relay assignment	Hysteresis
Vacuum pressure	5%
Differential pressure	5 Torr 6.66 mbar 666.6 Pa

Figure 5-3 Default behavior of relays activating with decreasing pressure (D > A)

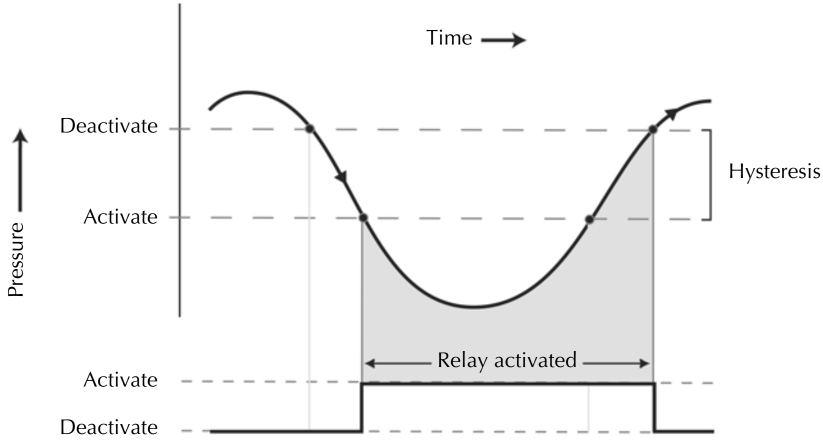
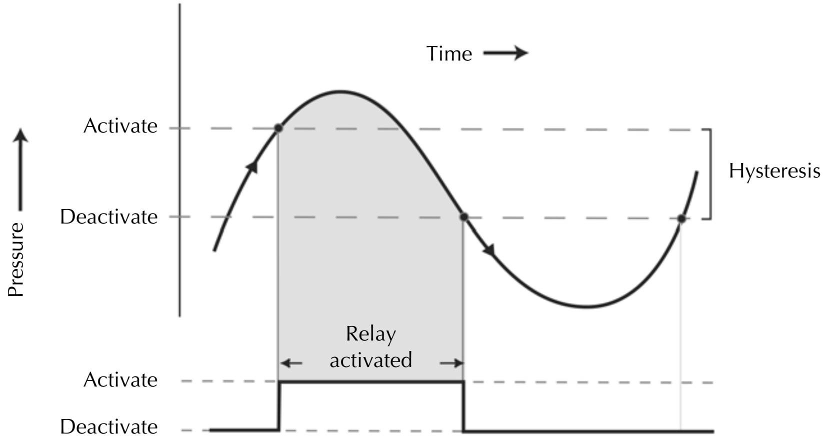


Figure 5-4 Default behavior of relays activating with increasing pressure (A > D)



RS-485 Operation

The plus (+) or minus (–) sign that *precedes* the pressure value is meaningful only if the relay indicates differential pressure.

If the relay is assigned to vacuum pressure, do not enter a + or – sign preceding the "A" and "D" pressure values.

- The + sign causes the relay to switch states when differential pressure is positive (vacuum pressure is greater than atmospheric pressure).
- The – sign causes the relay to switch states when differential pressure is negative (atmospheric pressure is greater than vacuum pressure).

The + or – that *follows* the "E" character is the sign of the exponent. For example, a pressure value of "2.00E–2" equals 2×10^{-2} pressure units, and a pressure value of "2.00E+2" equals 2×10^{2} pressure units.

Enter the "A" and "D" pressure values in the pressure units you've set for the module. See page 43.

To read activation or deactivation pressure for a relay, send a PC command without the pressure value.

The example process control (PC) command sequence causes the module to return values indicating that relay 1 activates at 1.01×10^{-1} pressure units and deactivates at 2.00×10^{-1} pressure units:

Example PC command from host: `#01PC1A↵`
Example response from module: `*01 1.01E-01↵`

Example PC command from host: `#01PC1D↵`
Example response from module: `*01 2.00E-01↵`

The "PC1" value identifies relay 1.

The returned value is in the pressure unit that you've set for the module.

The "A" or "D" value in the PC command designates the pressure value that is being read:

- The "A" value is the indicated pressure at which the relay activates.
- The "D" value is the indicated pressure at which the relay deactivates.

The same command structure applies to both relays (PC1 and PC2) if the module has two relays, or to all three relays (PC1, PC2, and PC3) if the module has three relays.

PCG **Set trip point relay assignments**

Use the process control gauge (PCG) command to assign any relay to vacuum pressure or to differential pressure.

> ⚠ **WARNING**
>
> **Failure to adjust relays for the gas that is being used can cause an explosion due to overpressurization.**
>
> If relays are re–assigned, do not use the module to measure the pressure of gases other than N_2 or air without adjusting relay trip points for the process gas that will be used.

The example PCG command sequence assigns relay 1 to vacuum pressure and assigns relays 2 and 3 to differential pressure:

Example PCG command from host: `#01PCGADD↵`
Response from module: `*01 PROGM OK↵`

The 3-character string following “PCG” assigns relays in ascending numerical order.

- An “A” value assigns the specified relay to vacuum pressure.
- A “D” value assigns the specified relay to differential pressure.

In the example, “A” is the assignment for relay 1, and “D” and “D” are the assignments for relays 2 and 3.

PCE **Set or read disable/enable state of relays**

If relays have been made operable, you may send the process control disable (PCE) command to disable or enable relays.

Example PCE command from host: `#01PCE011↵`
Response from module: `*01 PROGM OK↵`

The 3-character string following “PCE” disables or enables relays in ascending numerical order.

- A value of 0 disables the specified relay (1, 2, or 3).
- A value of 1 enables the specified relay (1, 2, or 3).

In the example, “0” disables relay 1, and “1” and “1” enable relays 2 and 3.

If you disable a relay, you must re-enable it to make it operable. You must reconfigure the relay to re-enable it. See pages 45–49.

To read disabled/enabled status of relays, send a PCE command without the disable (0) or enable (1) values.

Example PCE command from host: `#01PCE↵`
Example response from module: `*01 011↵`

The example response means relay 1 is disabled and relays 2 and 3 are enabled.

RPCS **Read trip point relay status**

The read process control relay status (RPCS) command causes the module to return a numeric value that represents the status of both relays if the module has two relays or all three relays if the module has three relays.

RPCS command from host: `#01RPCS↵`
Example response from module: `*01 100↵`

- A value of 1 means the specified relay (1, 2, or 3) is activated.
- A value of 0 means the specified relay (1, 2, or 3) is deactivated.

The example response means relay 1 is activated and relays 2 and 3 are deactivated.

IG **Turn Micro-Ion gauge ON or OFF**

When the module starts up, the Conductron sensor is ON. As pressure decreases to a level that allows the Micro-Ion gauge to operate, the sensor turns the gauge ON. In some instances, you might need to turn the Micro-Ion gauge OFF.

The command includes the alpha characters “I” and “G” and the numeric value 0 (OFF) or 1 (ON).

Send the ion gauge off (IG0) command to turn the Micro-Ion gauge OFF.

IG0 command from host: `#01IG0↵`
Response from module: `*01 PROGM OK↵`

If you send the IG0 command:

- The response to an RD (read pressure) command depends on the value in the IGM command (see page 51).
- The Micro-Ion gauge remains OFF until you send an IG1 command.

Send the ion gauge on (IG1) command to turn the Micro-Ion gauge ON.

IG1 command from host: `#01IG1↵`
Response from module: `*01 PROGM OK↵`

If the Micro-Ion gauge is in manual filament mode and one filament is inoperable, you must switch to the other filament by sending the IG0 command, then sending the IG1 command.

IGS **Read Micro-Ion gauge ON/OFF status**

If you send the ion gauge status (IGS) command, the module returns a character string that indicates the ON/OFF status of the Micro-Ion gauge.

IGS command from host: `#01IGS↵`
Example response from module: `*01 1 IG  ON↵`

- The “1 IG ON” response means the Micro-Ion gauge is ON.
- The “0 IG OFF” response means the Micro-Ion gauge is OFF.

IGM **Set or read pressure indication when Micro-Ion gauge is OFF**

If the Micro-Ion gauge has been turned OFF using the IG0 command or wiring terminals 3 and 5, use the IGM (ion gauge mode) command to enable or disable pressure indications from the Conductron sensor.

Example IGM command from host: `#01IGM1↵`
Response from module: `*01 PROGM OK↵`

The command includes the alpha characters “I”, “G”, and “M” and the alphanumeric 0, 1, or “S” switch.

- The 1 switch enables pressure indications from the Conductron sensor while the Micro-Ion gauge is turned OFF.
- The 0 switch disables pressure indications from the Conductron sensor while the Micro-Ion gauge is turned OFF.

Use the “S” switch to read the pressure output configuration.

IGMS command from host: `#01IGMS↵`
Example response from module: `*01 0    ALL↵`

- The “0   ALL” character string means all pressure indications are disabled when the Micro-Ion gauge is turned OFF.
- The “0   IG” character string means pressure indications are *enabled* when the Micro-Ion gauge is turned OFF.

IOD **Set or read Micro-Ion gauge delay ON/OFF state**

The ion gauge delay (IOD) command reduces the possibility that the Micro-Ion gauge filaments will burn out if the gauge turns ON at a pressure that is too high. The IOD command functions by delaying the time at which the Micro-Ion gauge turns ON with decreasing pressure.

If the IOD command is set to ON, at initial startup, the module software determines how long the Micro-Ion gauge should wait to turn ON after pressure has decreased to a point where the gauge can operate.

The command includes the alpha characters “I”, “O”, and “D” and the numeric value 0 (OFF) or 1 (ON).

The example IOD command sets the delay time to OFF. (The Micro-Ion gauge turns ON, without delay, at the pressure at which the gauge can operate.)

Example IOD command from host: `#01IOD0↵`
Response from module: `*01 PROGM OK↵`

- if the Micro-Ion gauge has tungsten filaments, the default setting for the IOD command is ON (1).
- If the Micro-Ion gauge has yttria-coated iridium filaments, the default setting for the IOD command is OFF (0).

If the gauge assembly is replaced, the module software automatically sets the Micro-Ion gauge delay state according to the filament material.

During the delay, outputs indicate pressure as measured by the Conductron sensor.

If you send the IOD command without the ON or OFF value, the module returns a character string that represents the Micro-Ion delay ON/OFF state.

IOD command from host: `#01IOD↵`
Example response from module: `*01  1  ON↵`

- The “1   ON” response means the Micro-Ion gauge delay is ON.
- The “0 OFF” response means the Micro-Ion gauge delay is OFF.

If the IOD command is set to ON (1), within the pressure range of 1.00×10^{-3} to 3.00×10^{-2} Torr (1.33×10^{-3} to 39.9×10^{-2} mbar, 1.33 to 3.99 Pa), the pressure output might not be within the specified accuracy of ± 15% of reading.

Whether or not the IOD command is set to ON (1), some signal fluctuation occurs if the Micro-Ion gauge has tungsten filaments.

IDT **Set or read Micro-Ion gauge delay time**

Whether or not the IOD command is set to ON, you may send the ion delay time (IDT) command to add to, determine, or read the amount of time the Micro-Ion gauge waits to turn ON after pressure has decreased to a point where the gauge can operate.

The example IDT command sets the delay time to 20 seconds.

Example IDT command from host:	`#01IDT 20↵`
Response from module:	`*01 PROGM OK↵`

- The command includes the alpha characters “I”, “D”, and “T” and the numeric value representing the number of seconds.
- Valid values are 0 to 600 seconds.

If the IOD command is set to ON (1), the number of seconds specified in the IDT command is *added to* the time the module software has determined that the Micro-Ion gauge should wait to turn ON with decreasing pressure, as expressed in the following equation:

$$\text{Total time delay} = \text{Time}_{IOD} + \text{Time}_{IDT}$$

If the IOD command is set to OFF (0), the number of seconds specified in the IDT command is the *exact amount* of time that the Micro-Ion gauge will wait to turn ON with decreasing pressure.

If you send the IDT command without the time value, the module returns a character string that represents the Micro-Ion gauge delay time.

DGT command from host:	`#01IDT↵`
Example response from module:	`*01  60  IDT↵`

The example response means the delay time is set to 60 seconds. If the IOD command is set to ON (1), the response does *not* include the delay time determined by the module software.

During the delay, outputs indicate pressure as measured by the Conductron sensor.

If the gauge assembly is replaced, the module software automatically sets the Micro-Ion gauge delay time according to the filament material.

- If the replacement gauge contains tungsten filaments, the Micro-Ion gauge waits an additional 2 seconds, beyond software-defined delay time, to turn ON with decreasing pressure.
- If the replacement gauge contains yttria-coated iridium filaments, the Micro-Ion gauge turns ON, without delay, as soon as operational pressure is achieved with decreasing pressure.

SF **Set Micro-Ion gauge filament mode**

The Micro-Ion gauge contains two filaments, and can operate in automatic, alternating, manual or both-filament mode of operation. The both-filament mode works at low-emission only, and is factory configured.

The example set filament (SF) command sets the gauge to manual mode.

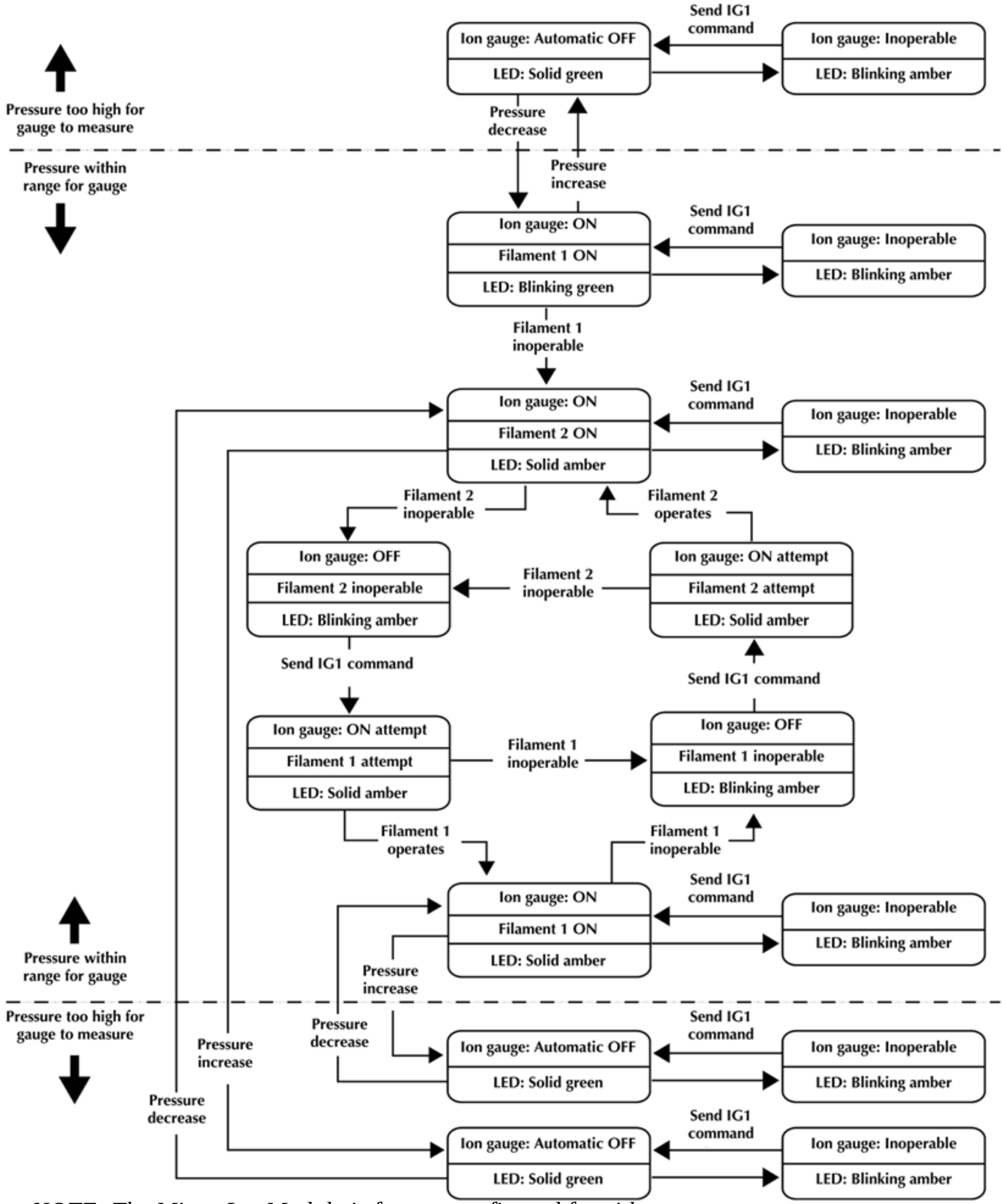
Example SF command from host: `#01SFMAN↵`
Response from module: `*01 PROGM OK↵`

- The SFMAN command sets the gauge to manual mode (default for Micro-Ion gauge with tungsten filaments).
- The SFALT command sets the gauge to alternating mode (default for Micro-Ion gauge with yttria-coated iridium filaments).
- The SFAUTO command sets the gauge to automatic mode.
- Table 5-12 describes operation of the filaments in automatic, alternating, both, and manual modes.
- Figure 5-5, Figure 5-6, and Figure 5-7 are flow charts showing switching patterns for each mode.

Table 5-12 Micro-Ion gauge filament modes

Filament mode	Description
Manual (default for Micro-Ion gauge with tungsten filaments)	• Filament 1 operates each time the Micro-Ion gauge turns ON • If filament 1 is inoperable, send IG0 command to turn Micro-Ion gauge OFF, then send IG1 command to switch to filament 2 (see page 50) • If both filaments are inoperable, Micro-Ion gauge turns OFF and value in IGM command determines whether or not module indicates pressure (see page 51)
Alternating (default for Micro-Ion gauge with yttria-coated iridium filaments)	• Operation alternates between filament 1 and filament 2 each time Micro-Ion gauge turns ON • If one filament is inoperable, Micro-Ion gauge operates using the other filament • If both filaments are inoperable, Micro-Ion gauge turns OFF and value in IGM command determines whether or not module indicates pressure (see page 51)
Automatic	• Filament 1 operates each time Micro-Ion gauge turns ON • If filament 1 is inoperable, Micro-Ion gauge switches to filament 2 • If both filaments are inoperable, Micro-Ion gauge turns OFF and value in IGM command determines whether or not module indicates pressure (see IGM on page 51)
Both	• Filament 1 and filament 2 operate at the same time • If one of the filaments cannot turn ON, the Micro-Ion gauge will operate using the other filament • If both filaments are inoperable, the Micro-Ion gauge turns OFF and the value in the IGM command determines whether or not the module indicates pressure (see IGM on page 51)

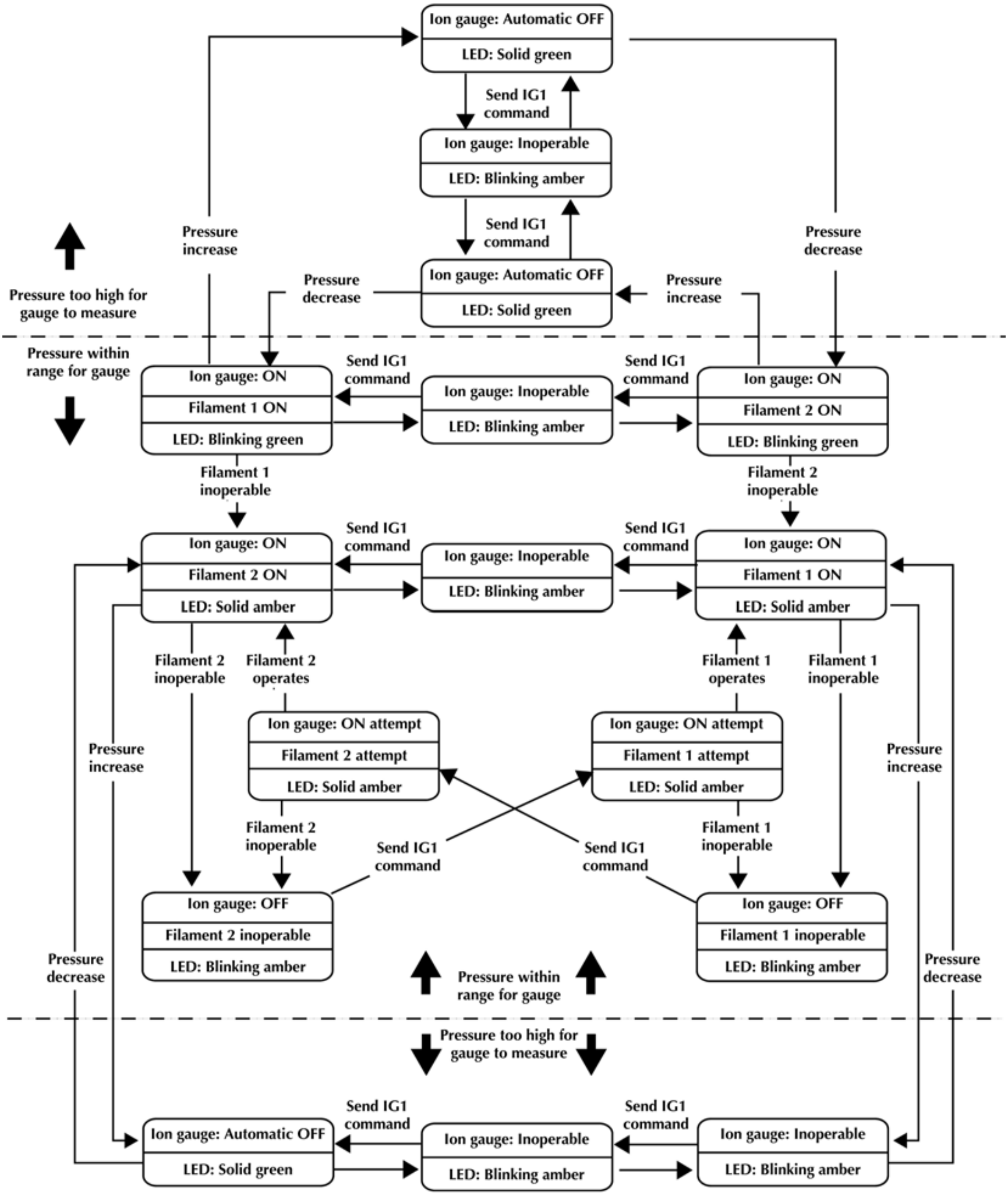
Figure 5-5 Automatic filament switching flow chart



NOTE: The Micro-Ion Module is factory configured for either single-filament or both-filament operation at low emission.

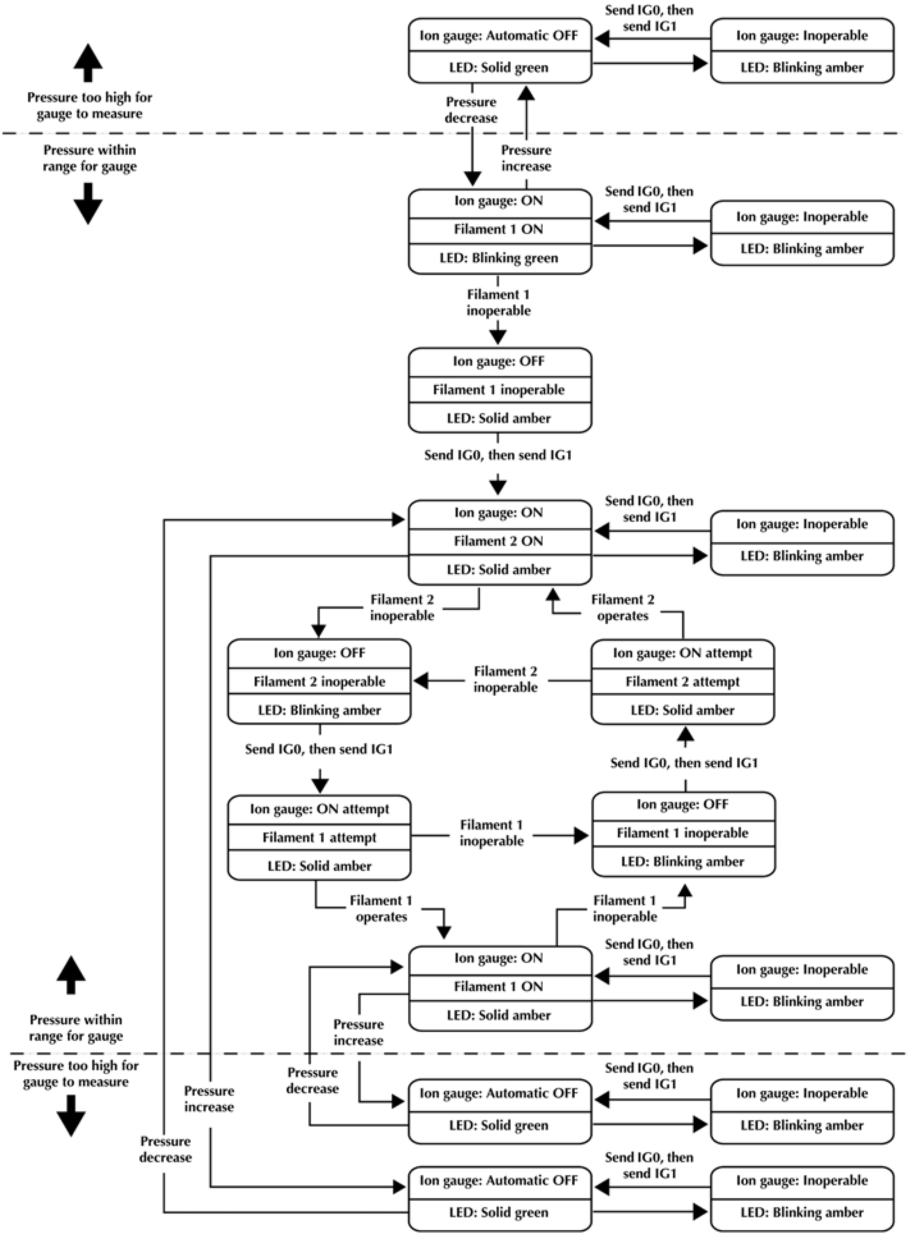
RS-485 Operation

Figure 5-6 Alternating filament switching flow chart



NOTE: The Micro-Ion Module is factory configured for either single-filament or both-filament operation at low emission.

Figure 5-7 Manual filament switching flow chart



NOTE: The Micro-Ion Module is factory configured for either single-filament or both-filament operation at low emission.

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RF **Read Micro-Ion gauge filament status**

The read filament (RF) command causes the module to return an example character string indicating filament 1 is operating.

RF command from host: `#01RF↵`
Example response from module: `*01 FIL SF1↵`

- The “FIL SF1” response means filament 1 is operating.
- The “FIL SF2” response means filament 2 is operating.
- The "FIL SFB" response means both filaments (1 & 2) are operating.

DG **Degas Micro-Ion gauge**

Use degas gauge (DG) commands to initiate or terminate a Micro-Ion gauge degas cycle, read the degas ON/OFF state, or set the gauge degas time.

The command includes the alpha characters “D” and “G” and the numeric value 0 (terminate) or 1 (initiate).

To degas the Micro-Ion gauge, follow these steps:

1. Turn the Micro-Ion gauge ON.
2. Make sure vacuum pressure is lower than 5 x 10^{-5} Torr (6.66 x 10^{-5} mbar, 6.66 x 10^{-3} Pa).
3. Send the degas gauge initiate (DG1) command to initiate the Micro-Ion gauge degas cycle. The default time for gauge degas is two minutes.

   DG1 command from host: `#01DG1↵`
   Response from module: `*01 PROGM OK↵`
4. *If you wish to terminate the Micro-Ion gauge degas cycle before it is completed*, send the degas gauge terminate (DG0) command.

   DG0 command from host: `#01DG0↵`
   Response from module: `*01 PROGM OK↵`

DGS **Read Micro-Ion gauge degas status**

At any time, you may send the degas gauge status (DGS) command to read the Micro-Ion gauge degas state.

DGS command from host: `#01DGS↵`
Example response from module: `*01 1 DG ON↵`

- The “1 DG ON” response means a degas cycle is in progress.
- The “0 DG OFF” response means gauge degas is OFF.

DGT **Set or read Micro-Ion gauge degas time**

The Micro-Ion gauge degas cycle runs for two minutes unless you adjust the degas time by sending a degas gauge time (DGT) command.

The example DGT command sets the degas time to 60 seconds.

Example DGT command from host: `#01DGT60↵`
Example response from module: `*01 PROGM OK↵`

Valid time values are 10 to 120 seconds.

If you send the DGT command without the time value, the module returns a character string that represents the Micro-Ion gauge degas time.

DGT command from host: `#01DGT↵`
Example response from module: `*01  60  DGT↵`

The example response means the gauge degas time is set to 60 seconds.

SER **Set emission current switch point**

The Micro-Ion gauge can operate at either of two emission current levels.

- In low-emission mode, the current level is 0.02 mA.
- In high-emission mode, the current level is 4 mA.

As the vacuum pump removes gas from the system, the Conductron sensor measures pressure until it has decreased to a pressure at which the Micro-Ion gauge can operate. At this gauge pressure, the Conductron sensor turns the Micro-Ion gauge ON at the low emission current level.

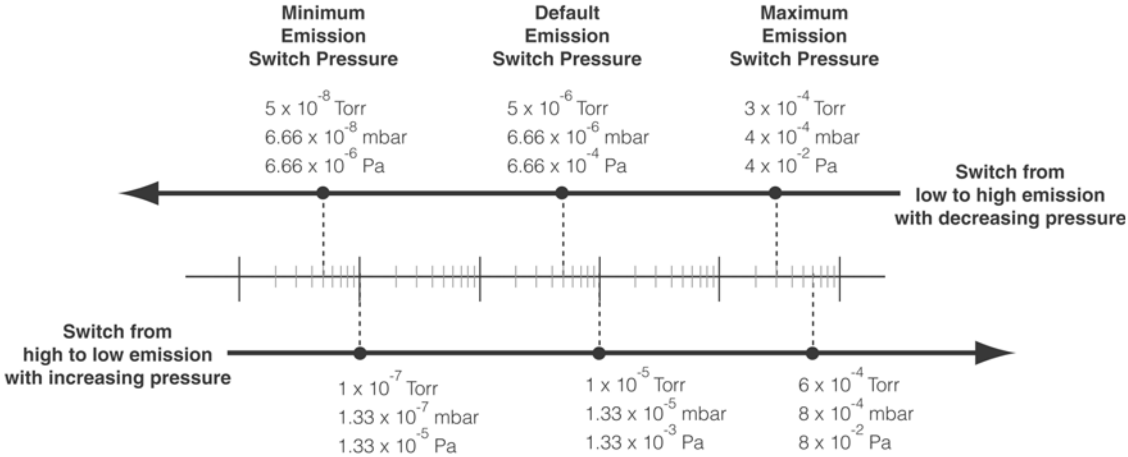
As pressure continues to decrease, the Micro-Ion gauge switches from low emission current to high emission current (4 mA). If pressure increases after the current level has gone from low to high, the gauge switches back to low emission current. Table 5-13 lists default, minimum, and maximum pressure values at which the gauge switches emission current levels.

Table 5-13 Micro-Ion gauge emission current pressure values

Emission current setting	Default switch points	Default Filament Mode	Maximum switch points	Minimum switch points
Switch to high emission current (4 mA) with decreasing pressure	5×10^{-6} Torr 6.66×10^{-6} mbar 6.66×10^{-4} Pa	ALT	3×10^{-4} Torr 3.99×10^{-4} mbar 3.99×10^{-2} Pa	5×10^{-8} Torr 6.66×10^{-8} mbar 6.66×10^{-6} Pa
Switch to low emission current with increasing pressure	1×10^{-5} Torr 1.33×10^{-5} mbar 1.33×10^{-3} Pa	SFB	6×10^{-4} Torr 7.99×10^{-4} mbar 7.99×10^{-2} Pa	1×10^{-7} Torr 1.33×10^{-7} mbar 1.33×10^{-5} Pa

The switch back to low emission current with increasing pressure is 100% greater than the switch to high emission current with decreasing pressure, as illustrated in Figure 5-8. For example, in default mode, the current level switches from low to high emission at 5 x 10^{-6} Torr (6.66 x 10^{-6} mbar, 6.66 x 10^{-4} Pa), then switches back to low emission at 1 x 10^{-5} Torr (1.33 x 10^{-5} mbar, 1.33 x 10^{-3} Pa).

Figure 5-8 Example emission current switch points



Use the set emission range (SER) command to set or read the pressure at which the Micro-Ion gauge switches from low to high emission current with decreasing pressure.

Example SER command from host: `#01SER 1.00E-06↵`
Response from module: `*01 PROGM OK↵`

The example SER command sets a value of 1 x 10^{-6} pressure units for the pressure at which the Micro-Ion gauge switches from low to high emission current.

To read the emission current switch point, send an SER command without the pressure value.

Example SER command from host: `#01SER↵`
Example response from module: `*01 5.00E-05↵`

The returned value is in the pressure unit that you've set for the module. See page 43.

RE **Read Micro-Ion gauge emission current**

Send the read emission (RE) command to read the Micro-Ion gauge emission current.

RE command from host: `#01RE↵`
Example response from module: `*01 4.0MA EM↵`

Table 5-14 lists module responses to the RE command.

Table 5-14 Responses to RE command

Response	Description
`4.0 mA EM`	The Micro-Ion gauge is in high-emission mode (4.0 mA current)
`0.02 mA EM`	The Micro-Ion gauge is in low-emission mode (0.02 mA current)
`15mA EM`	The Micro-Ion gauge degas cycle is in progress (see page 58)
`0 IG OFF`	The Micro-Ion gauge is OFF (see page 50)

TS **Calibrate module at atmospheric pressure**

Atmospheric pressure calibration and differential pressure zero are performed using N_2 at the factory before the module is shipped. Differential pressure zero is the pressure value at which atmospheric and vacuum pressures are equal. The factory calibration sets the differential pressure zero to approximately 760 Torr (1013 mbar, 1.01 x 10^5 Pa). The module will not operate properly unless you reset the atmospheric pressure calibration and differential pressure zero at the ambient operating pressure.

If the atmospheric pressure calibration value is too low, the Micro-Ion gauge will not turn ON.

Use N_2 or air to calibrate the module at atmospheric pressure. Minimum valid calibration pressure is 500 Torr (666 mbar, 6.66 x 10^4 Pa).

1. To ensure accurate calibration, make sure the differential pressure sensor is vented and open to atmosphere when you calibrate the module at atmospheric pressure.
2. Shut the pump OFF and, using N_2 or air, allow the vacuum pressure to increase until it equals atmospheric pressure.
3. Send a calibration at system pressure (TS) command.

   Example TS command from host: `#01TS↵`
   Example response from module: `*01 PROGM OK↵`

If the module returns a message other than “PROGM OK” in response to the TS command, the atmospheric calibration has failed. See page 76 to troubleshoot the problem.

TZ **Calibrate module at vacuum pressure**

Ordinarily, the Conductron sensor turns the Micro-Ion gauge ON when pressure decreases to 2×10^{-2} Torr (2.66×10^{-2} mbar, 2.66 Pa). However, if the Conductron sensor calibration has shifted so that the Micro-Ion gauge cannot turn ON, you can recalibrate the module for vacuum pressure.

Use N2 or air to calibrate the module at vacuum pressure. Maximum valid calibration pressure is 3.00×10^{-2} Torr (3.99×10^{-2} mbar, 3.99 Pa).

1. Turn the pump ON and, using N2 or air, allow the vacuum chamber to decrease to the optimal calibration pressure of 1×10^{-4} Torr (1.33×10^{-4} mbar, 1.33×10^{-2} Pa) or a lower pressure.
2. Send the calibration at vacuum pressure (TZ) command.

   Example TZ command from host: `#01TZ↵`
   Example response from module: `*01 PROGM OK↵`

If the module returns a message other than “PROGM OK” in response to the TZ command, the vacuum pressure calibration has failed. See page 76 to troubleshoot the problem.

ATM **Set or read atmospheric pressure output**

Use the atmospheric pressure output (ATM) command to set or read the pressure value that the module will indicate each time the module senses zero differential between atmospheric and chamber pressures.

The ATM command followed by the character string “ACTUAL” sets the output to indicate actual atmospheric pressure whenever the module senses zero differential between atmospheric and chamber pressure.

Example ATM command from host: `#01ATM ACTUAL↵`
Example response from module: `*01 PROGM OK↵`

The ATM command followed by a 3-digit value specifies a value that will be indicated whenever the module senses zero differential between atmospheric and chamber pressure.

Example ATM command from host: `#01ATM 760↵`
Example response from module: `*01 PROGM OK↵`

The example ATM command sets outputs to indicate atmospheric pressure of 760 whenever the module senses zero differential between atmospheric and chamber pressure.

You can use the ATMS command to read the value that has been set using the ATM command.

ATMS command from host: `#01ATMS↵`
Example response from module: `*01 650↵`

The example response means the output will indicate a value of 650 pressure units whenever the module senses zero differential between atmospheric and chamber pressure.

The “ACTUAL ” response means the output will indicate the actual atmospheric pressure whenever the module senses zero differential between atmospheric and chamber pressures.

RS **Read module status RS–485 strings**

Send the read status (RS) command to read RS–485 character strings that indicate the module operating status.

RS command from host: `#01RS↵`
Example response from module: `*01 00 ST OK↵`

The example response indicates the module is operating normally.

Table 5-15 lists module responses to the RS command. To find out if more than one status condition exists, send another RS command. Repeatedly sending the RS command causes the responses to cycle through the entire list of existing status conditions as many times as necessary while you diagnose and remedy all existing status conditions.

Table 5-15 Module status RS–485 strings

Response	Cause	Solution
`00 ST OK`	Module is operating normally.	No solution necessary.
`01 CGBAD`	Conductron sensor is inoperable.	Replace gauge assembly (see page 79).
`02 DGBAD`	Pressure diaphragm sensor is inoperable.	
`03 OVTMP`	Measured temperature > 80 º C.	Decrease ambient temperature.
`04 IGDIS`	Micro-Ion gauge is disabled.	Send IGM1 command or open the switch between pins 3 and 5 on the subminiature D connector to turn the Micro-Ion gauge ON (see page 30 or 51).
`05 IG HV`	Micro-Ion gauge grid voltage failure.	Cycle power to module or send IG1 command to clear status response (see page 50).
`06 IG EM`	Micro-Ion gauge emission failure.	
`07 IGFIL`	One Micro-Ion gauge filament is open.	• If SF command is set to AUTO or ALT, operation automatically switches to the other filament (see page 50). • If SF command is set to MAN, send IG0 command, then send IG1 command to switch filaments (see page 50).
`08 POWER`	Power cycle has occurred, module is starting up.	No solution necessary. The "`00 ST OK`" string will be generated next if the module is operating properly.
`09 NVRAM`	Module NVRAM is invalid due to electronics failure.	Return module to factory (see page 79).
`10 GVRAM`	Micro-Ion gauge electronics failure.	Send FAC command to set values to factory defaults (see page 68). Pressure readings may be inaccurate.
`11 DGCAL`	Atmospheric pressure diaphragm sensor cannot be calibrated.	Make sure vacuum pressure = atmospheric pressure, then re-send TS command (see page 61).
`12 CGCAL`	Conductron sensor cannot be calibrated.	Make sure vacuum pressure ≤ 1 x 10^{-4} Torr (1.33 x 10^{-4} mbar, 1.33 x 10^{-2} Pa), then re-send TZ command (see page 61).
`13 BGBAD`	Atmospheric pressure diaphragm sensor failure.	Return module to factory (see page 79).

If more than one ERROR exists, the first error will respond with the first RS command; the second will respond with the second RS command; and so on until all errors are shown; then the list will repeat.

RSX **Read module status hexadecimal bits**

Send the read status hexadecimal (RSX) command to read hexadecimal bits that indicate the module operating status.

RSX command from host: `#01RSX↵`
Example response from module: `*01 000000A0↵`

The example response indicates that ambient temperature > 80 º C and a Micro-Ion gauge grid voltage failure has occurred.

The module returns a 32-bit hexadecimal value. Each bit stands for a specific error condition. Each bit has a value of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A_{hex} (10), B_{hex} (11), C_{hex} (12), D_{hex} (13), E_{hex} (14), or F_{hex} (15). To clear hexadecimal status bits, cycle power to the module.

To determine the error conditions indicated by a hexadecimal value, refer to Table 5-16, Table 5-17, and Table 5-18, and follow these steps:

1. Convert the “A” to the binary value 1010. (With binary data, each digit has a value of 1 or 0).

   1xxx binary = 8_{hex}
   xx1x binary = 2_{hex}

2. So, the response “000000A0” can be separated into 00000080 (Micro-Ion gauge grid voltage failure) and 00000020 (ambient temperature > 80 ºC).

Bits can represent fatal errors, warnings, or information.

- A fatal error bit means the module has stopped operating. Table 5-16 lists hexadecimal fatal error bits.
- A warning bit means the module can operate but measurements may be inaccurate. Table 5-17 lists hexadecimal warning bits.
- An informational bit means the module is operating normally. Table 5-18 lists hexadecimal informational bits.

Table 5-16 Hexadecimal fatal error bits: Module has stopped operating

Fatal error bit	Cause	Solution
0_{hex}00000001	• Conductron sensor is inoperable. • Module electronics failure.	• If Conductron sensor is inoperable, replace gauge assembly (see page 79). • If electronics failure, return the module to the factory (see page 79).
0_{hex}00000002		
0_{hex}00000004		
0_{hex}00000040	• Grid in Micro-Ion gauge is shorted. • Module electronics failure.	• If Micro-Ion gauge grid is shorted or filaments are open, send IGM1 command to enable pressure readings from Conductron sensor and pressure diaphragm sensors (see page 51). • If electronics failure, return the module to the factory (see page 79).
0_{hex}00000080	• Micro-Ion gauge grid voltage failure. • Module electronics failure.	
0_{hex}00000800	Module NVRAM is invalid during Initial startup or due to electronics failure.	Return the module to the factory. See page 79.
0_{hex}00020000	Barometric gauge defective (temperature out of range).	Return the module to the factory. See page 79.
0_{hex}00040000	Barometric gauge defective (pressure out of range).	Return the module to the factory. See page 79.
0_{hex}00080000	No communication from the barometric gauge.	Return the module to the factory. See page 79.
0_{hex}00100000	Barometric gauge defective (gain out of range).	Return the module to the factory. See page 79.
0_{hex}00200000	PRD wrong type.	Return the module to the factory. See page 79.

Table 5-17 Hexadecimal warning bits: Module can operate but measurements may be inaccurate

Warning bit	Cause	Solution
$0_{hex}00000008$	Vacuum pressure diaphragm sensor is inoperable.	Pressure readouts will indicate pressure as measured by Conductron sensor. Module will not indicate differential pressure, Micro-Ion gauge failure, or electronics failure.
$0_{hex}00000010$	Atmospheric pressure diaphragm sensor is inoperable.	
$0_{hex}00001000$	Micro-Ion gauge NVRAM is invalid.	Send FAC command to set values to factory defaults (see page 68). Pressure readings may be inaccurate.
$0_{hex}00002000$	A pressure diaphragm sensor is inoperable.	Pressure readouts will indicate pressure as measured by Conductron sensor. Module will not indicate differential pressure, Micro-Ion gauge failure, or electronics failure.
$0_{hex}00004000$	Differential pressure zero cannot be calibrated.	Make sure vacuum pressure = atmospheric pressure, then re-send TS command (see page 61).
$0_{hex}00008000$	Conductron sensor cannot be calibrated at vacuum pressure.	Make sure vacuum pressure ≤ 1 x 10^{-4} Torr (1.33 x 10^{-4} mbar, 1.33 x 10^{-2} Pa), then re-send TZ command (see page 61).
$0_{hex}00010000$	Conductron sensor cannot be calibrated at atmospheric pressure.	Make sure atmospheric pressure = vacuum pressure, then re-send TS command (see page 61).
$0_{hex}00020000$	Barometric gauge temperature out of range (<-40° or >120°)	Return the module to the factory. See page 79.
$0_{hex}00040000$	Barometric gauge pressure out of range (<500 or >900)	Return the module to the factory. See page 79.
$0_{hex}00080000$	No communication from the barometric gauge	Return the module to the factory. See page 79.
$0_{hex}00100000$	Unable to set the Gain for the Barometric gauge (<500 or >900 when P_{diff} = 0)	Return the module to the factory. See page 79.

Table 5-18 Hexadecimal informational bits: Module is operating normally

Response	Cause	Solution
$0_{hex}00000000$	Module is operating normally.	No solution necessary.
$0_{hex}00000100$	One Micro-Ion gauge filament is open.	• If SF command is set to AUTO or ALT, operation automatically switches to the other filament (see page 50). • If SF command is set to MAN, send IG0 command, then send IG1 command to switch filaments (see page 50).
$0_{hex}00000400$	Power cycle has occurred, module is starting up.	No solution necessary.
$0_{hex}00000020$	Measured temperature > 80 ° C.	Decrease ambient temperature.

RST **Reset module to power-up state**

The reset (RST) command resets the module to power-up status.

RST command from host: `#01RST↵`
Response from module: None

Sending the RST command has the same effect as cycling power to the module. Communication is re-enabled two seconds after you've sent the RST command.

FAC **Reset values to factory defaults**

Table 5-19 lists default settings for the module. After you've reconfigured the module, you may restore parameters to their default values by sending a factory reset (FAC) command.

FAC command from host: `#01FAC↵`
Response from module: `*01 PROGM OK↵`

Reset command from host: `#01RST↵`
Response from module: None

Table 5-19 Factory default settings affected by FAC command

Parameter	Default Setting
Digital communication	Baud rate: 19200 baud
Vacuum calibration pressure	1 x 10^{-4} Torr (1.33 x 10^{-4} mbar, 1.33 x 10^{-2} Pa)
Atmospheric calibration pressure	760 Torr (1013 mbar, 1.01 x 10^{5} Pa)
Differential pressure zero	760 Torr (1013 mbar, 1.01 x 10^{5} Pa)
Micro-Ion gauge emission current switch point	• With decreasing pressure: 5 x 10^{-6} Torr 6.66 x 10^{-6} mbar 6.66 x 10^{-4} Pa • With increasing pressure: 1 x 10^{-5} Torr 1.33 x 10^{-5} mbar 1.33 x 10^{-3} Pa
Locked interface functions	OFF

VER **Read firmware version**

The read firmware version (VER) command causes the module to return a value that represents the internal part number and firmware version for the module. The example response indicates the internal part number is 16781 and the firmware version is 07

VER command from host: `#01VER↵`
Example response from module: `*01 16781-07↵`

- The first five digits (preceding the dash) are the internal part number.
- The last two digits (following the dash) are the firmware version.

Chapter 6 Optional Display

6.1 Display capabilities

The optional display is a backlit, 72-dot by 48-dot matrix that can indicate vacuum pressure, differential pressure, and error conditions.

Using the RS-485 interface, you can send a set display (SD) command that enables the display to indicate vacuum (absolute) pressure when pressure is less than 250 Torr (333 mbar, 3.33 x 10^4 Pa) and differential pressure when pressure is equal to or greater than 250 Torr (333 mbar, 3.33 x 10^4 Pa). See page 43.

The display pressure range is 0.1 x 10^{-10} to atmosphere.

The display also indicates Torr "(TORR"), mbar ("MBAR"), or pascal ("PA") as the unit of pressure. The "A" or "D" to the right of the pressure unit indicates vacuum (absolute) pressure ("A") or differential pressure ("D").

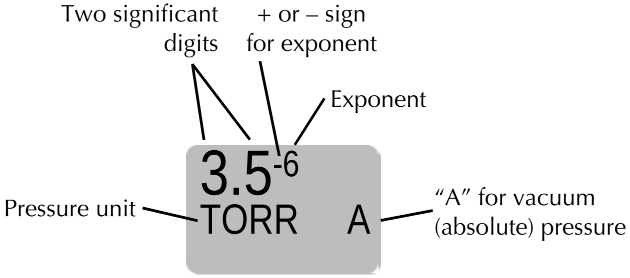
Vacuum pressure display

For vacuum pressure, the X.X±Y display format includes two significant digits, a 1-digit exponent, and a ± sign for the exponent. See Figure 6-1.

Differential pressure display

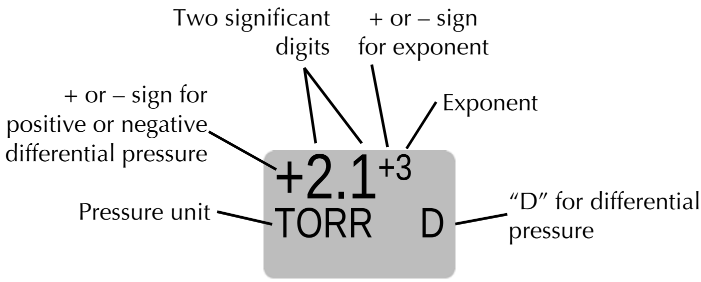
For differential pressure, the ±X.X±Y display format includes a ± sign for positive or negative differential pressure, two significant digits, a 1-digit exponent, and a ± sign for the exponent. See Figure 6-2.

Figure 6-1 Optional display indicating vacuum pressure



Optional Display

Figure 6-2 Optional display indicating differential pressure



6.2 Display resolution

Pressure values in the 10^{-10} range (such as 6 x 10^{-10}) will appear as "0.6^{-9}". The resolution of the numeric display changes over the operating range of the module. See Table 6-1.

Table 6-1 Display resolution versus measured pressure

Measured pressure			
Torr	**mbar**	**Pa**	**Display resolution**
Less than 50	Less than 66	Less than 6.6 x 10^3	Two digits
50 to 100	66 to 133	6.6 x 10^3 to 1.33 x 10^4	10 pressure units
100 to 1000	133 to 1.3 x 10^3	13.3 x 10^4 to 1.33 x 10^5	100 pressure units

6.3 Error conditions

If an error condition exists, the display indicates the condition, as illustrated in Figure 6-3.

If more than one error condition exists, the display indicates the first condition, then reverts to indicating the pressure unit, then indicates the second condition, etc. The display continues scrolling through the error indications until all conditions have been diagnosed and eliminated.

To troubleshoot error conditions indicated by the display, see Table 6-2.

Figure 6-3 Optional display indicating an error condition

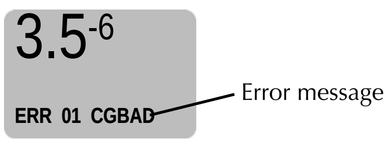


Table 6-2 Error conditions indicated by optional display

Error message	Cause	Solution
GAUGE OK	Module is in startup mode and operating normally.	No solution necessary.
ERR 01 CGBAD	Conductron sensor is inoperable.	Replace the gauge assembly (see page 79).
ERR 02 DGBAD	Pressure diaphragm sensor is inoperable.	
WAR 03 OVTMP	Measured temperature > 80 °C.	Decrease the ambient temperature.
ERR 05 IG H	Micro-Ion gauge grid voltage failure.	Cycle power to the module.
ERR 06 IG EM	Micro-Ion gauge emission failure.	
WAR 07 IGFIL	One Micro-Ion gauge filament is open.	• If the filament mode is automatic or alternating, operation automatically switches to the other filament (see page 54). • If the filament mode is manual, turn the Micro-Ion gauge OFF, then back ON to switch the filaments (see page 54).
WAR 09 NVRAM	Module NVRAM is invalid due to electronics failure.	Return the module to the factory (see page 79).
WAR 10 GVRAM	Micro-Ion gauge electronics failure.	Set the programmable values to the factory defaults (see page 68). Pressure readings may be inaccurate.
WAR 11 DGCAL	Module cannot be calibrated at atmospheric pressure.	Make sure the vacuum pressure = atmospheric pressure, then re-calibrate at atmospheric pressure (see page 32 or page 61).
WAR 12 CGCAL	Module cannot be calibrated at vacuum pressure.	Make sure the vacuum pressure ≤ 1 x 10^{-4} Torr (1.33 x 10^{-4} mbar, 1.33 x 10^{-2} Pa), then re-calibrate at vacuum pressure (see page 32 or page 62).
ERR 13 BGBAD	Atmospheric pressure diaphragm sensor failure.	Return the module to the factory (see page 79).

Chapter 7 Maintenance

7.1 Customer Service

Some minor problems are readily corrected on site. If the product requires service, contact the MKS, Granville-Phillips Division Technical Support Department at 1-303-652-4400 or 1-800-776-6543 for troubleshooting help over the phone.

If the product must be returned to the factory for service, request a Return Material Authorization (RMA) from Granville-Phillips. Do not return products without first obtaining an RMA. In some cases a hazardous materials disclosure form may be required. The MKS/Granville-Phillips Customer Service Representative will advise you if the hazardous materials document is required.

When returning products to Granville-Phillips, be sure to package the products to prevent shipping damage. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

For Customer Service / Technical Support:

MKS Pressure and Vacuum Measurement Solutions
MKS Instruments, Inc., Granville-Phillips® Division
6450 Dry Creek Parkway
Longmont, Colorado 80503 USA
Tel: 303-652-4400
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MKS Instruments, Inc.
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Andover, MA 01810 USA
Tel: 978-645-5500
Fax: 978-557-5100
Email: mks@mksinst.com

7.2 Troubleshooting

Precautions

Because the module contains static-sensitive electronic parts, follow these precautions while troubleshooting:

- Use a grounded, conductive work surface. Wear a high impedance ground strap for personal protection.
- Do not operate the module with static sensitive devices or other components removed from the product.
- Do not handle static sensitive devices more than absolutely necessary, and only when wearing a ground strap.
- Rely on voltage measurements for troubleshooting module circuitry. Do not use an ohmmeter.
- Use a grounded, electrostatic discharge safe soldering iron.

WARNING

Substitution or modifying parts can result in severe product damage or personal injury due to electrical shock or fire.

- Install only those replacement parts that are specified by Granville−Phillips.
- Do not install substitute parts or perform any unauthorized modification to the module.
- Do not use the module if unauthorized modifications have been made.

WARNING

Failure to perform a safety check after the module has been repaired can result in severe property damage or personal injury due to electrical shock or fire.

If the module has been repaired, before putting it back into operation, make sure qualified service personnel perform a safety check.

Symptoms, causes, and solutions

Table 7-1 lists failure symptoms, causes, and solutions indicated by something other than an RS-485 error message from the module.

Table 7-1 Failure symptoms, causes, and solutions

Symptom	Possible causes	Solution
Analog output voltage = 0 V	Power supply cable is improperly connected or faulty.	Repair or replace the power supply cable (see page 17).
Pressure reading is too high.	• Conductance in connection to vacuum chamber is inadequate. • Plumbing to module leaks or is contaminated. • Chamber pressure is too high due to leak, contamination, or pump failure. • Power supply or output cable is improperly connected or faulty.	• If the conductance is inadequate, reconnect the Conductron sensor port to a larger conductance port on the vacuum chamber, or install larger conductance plumbing. • If the plumbing leaks or is contaminated, clean, repair or replace the plumbing. • If the pump failed, repair or replace it. • If the cable is improperly connected or faulty, repair or replace the cable (see page 17).
Pressure reading is inaccurate.	• Micro-Ion gauge is contaminated. • Micro-Ion gauge, Conductron sensor, or vacuum pressure diaphragm sensor is damaged (for example, by reactive gas) or contaminated. • Temperature or mechanical vibration is extreme.	• If the Micro-Ion gauge is contaminated, degas the gauge (see page 30 or page 58). • If the Micro-Ion gauge, Conductron sensor, or vacuum pressure diaphragm sensor is contaminated, replace the gauge assembly (see page 79). • If the temperature or vibration is extreme, relocate the module or eliminate the source of the heat or vibration.
Indicated pressure is different than pressure indications from other measurement devices.	• Conductron sensor is defective. • Micro-Ion gauge is defective	Replace the gauge assembly (see page 79).
LED status indicator is solid amber.	A Micro-Ion gauge filament is inoperable.	If possible, switch to the other filament (see page 50).
LED status indicator is blinking amber.	Both Micro-Ion gauge filaments are inoperable.	Return module to the factory (see page 79).
• Relay will not activate. • Output voltage is > 10 V.	• A circuit board is faulty. • Conductron sensing wire is open.	Return the module to the factory (see page 79).

RS-485 error responses

Table 7-2 lists error responses that the module returns if you enter a command improperly or if the module non-volatile memory (NOVRAM) cannot process a command.

Table 7-2 Troubleshooting RS–485 error responses

Response	Possible causes	Solution
RANGE ER	1. Pressure value in TS calibration command is outside valid limits. 2. Pressure value in TZ calibration command is outside valid limits. 3. Pressure value in ATM set command is outside valid limits. 4. Ion gauge on-delay time (IDT) is out of range. 5. Degas duration (DGT) is out of range. 6. Emission current switch point is out of range. 7. Relay trip point is out of range (ABS). 8. Relay trip point is out of range (DIFF).	1. Make sure atmospheric pressure is > 500 Torr (666 mbar, 6.66 x 10^4 Pa). See page 61. 2. Make sure vacuum pressure < 3.00 x 10^{-2} Torr (3.99 x 10^{-2} mbar, 3.99 Pa). See page 62. 3. Make sure the setting is reasonable (250-1000 Torr). 4. Make sure the ion gauge delay time is between 0 and 600 seconds. 5. Make sure the degas duration setting is between 10 and 120 seconds. 6. Make sure current switch point is set correctly. See SER on page 59. 7. Make sure the trip point is between 1E-10 and 1000 Torr, and hysteresis is between 5 and 10,000%. 8. Make sure the trip point is between -800 and +300 Torr, and hysteresis is between 5 and 800 Torr.
SYNTX ER	• Command was improperly entered. • Module does not recognize command syntax. • UNL command was sent when software functions were already unlocked.	• Re-enter command using proper character string (see page 37).
9.99E+09	• Module cannot indicate a valid pressure value. • IG0 command has been sent.	• Send RS or RSX command to determine module status (see page 63). • If necessary, replace the gauge assembly. • If IG0 command has been sent, send IG1 command (see page 50).
LOCKED	Interface function is locked.	• Send TLU or UNL command to unlock interface function (see page 41).
INVALID	• IG1 command sent while IG ON I/O line not asserted. • Micro-Ion gauge or Conductron sensor is defective. • Vacuum pressure is too high for gauge degas.	• Assert the IG ON I/O line or disconnect from ground. • If the Micro-Ion gauge or Conductron sensor is defective, replace the gauge assembly. • Decrease the pressure to < 5 x 10^{-5} Torr . See DG on page 58.

7.3 Micro-Ion gauge continuity test

If a problem with pressure measurement is traced to the module, the Micro-Ion gauge can be tested with an ohmmeter. This test can detect open filaments or shorts between gauge elements, but may not detect inaccurate pressure measurement associated with vacuum leaks or adsorbed gases within the gauge.

The gauge may be left on the system for the test. The electronics assembly will be removed to gain access to the pins on the gauge.

1. Turn OFF power and disconnect all electrical connections to the Micro-Ion ATM module.
2. Unscrew the four Phillips-head screws until they disengage from the end plate of the gauge assembly. See Figure 7-1.
3. *Carefully* unplug the electronics assembly from the gauge assembly.

Figure 7-1 Removing Micro-Ion ATM gauge assembly

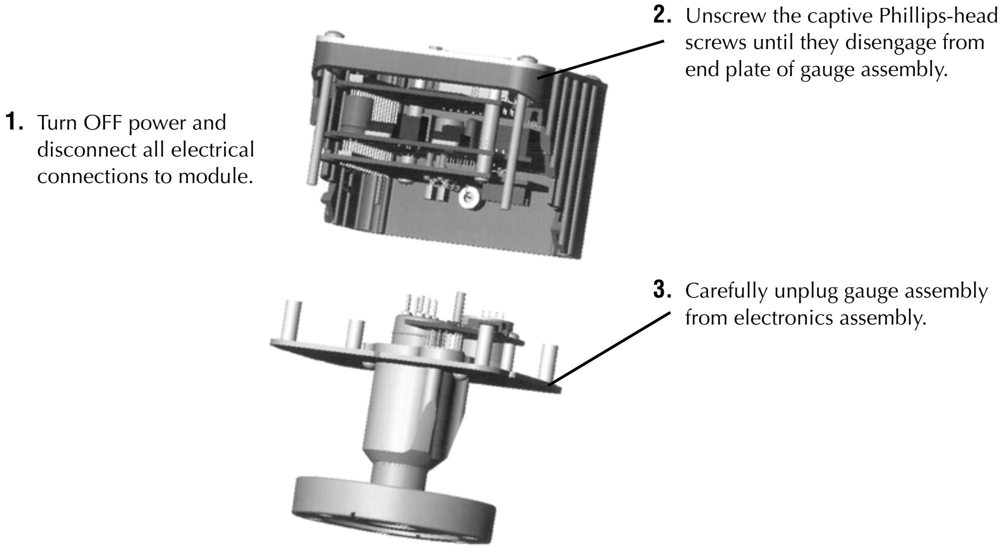
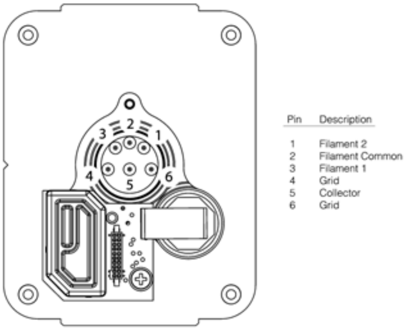


Figure 7-2 Micro-Ion gauge pins



4. Use a digital multimeter to measure the resistance between pins 2 and 3 (the filament pins), and between pins 1 and 2. See Figure 7-2. The readings should be 0.2 Ω.
5. Measure the resistance of filament pins 1, 2, or 3 to any of pins 4, 5, or 6, or the gauge case. The reading should be > 100 MΩ.
6. Measure the resistance between pins 4 and 6 (the grid pins). The reading should be < 0.1 Ω.
7. Measure the resistance of the grid pins to any of pins 1, 2, 3, or 5, or to the gauge case. The reading should be > 100 MΩ.
8. Measure the resistance of pin 5 (the collector pin) to the gauge case. The reading should be > 100 MΩ.
9. If any of the tests result in different readings than listed above, Contact Granville-Phillips customer service to order a replacement gauge.

Table 7-3 Test resistance values

Pins	Normal values
1 to 2 or 2 to 3	< 0.2 Ω
1, 2 or 3 to pins 4, 5, or 6	> 100 MΩ
4 to 6	< 0.1 Ω
4 or 6 to pins 1, 2, 3, or 5	> 100 MΩ
pin 5 to case	> 100 MΩ

7.4 Replacing the gauge assembly

Do not plug in or unplug any connectors with power applied to the module. Disconnect power from the module before replacing the gauge assembly.

1. Turn OFF power and disconnect all electrical connections to the Micro-Ion ATM module.
2. Disconnect the module from the vacuum chamber.
3. Unscrew the four captive Phillips-head screws until they disengage from the end plate of the gauge assembly. See Figure 7-1.
4. *Carefully* unplug the electronics assembly from the gauge assembly.
5. Insert the new gauge assembly into the electronics assembly by gently inserting the gauge pins into the socket on the circuit board. Examine the gauge pin arrangement to make sure the replacement gauge assembly and electronics assembly are aligned.
6. Tighten the four Phillips-head screws.
7. Install the module on the vacuum chamber.
8. Calibrate the module at atmospheric pressure (see page 32 or page 61).

7.5 Returning a Micro-Ion module for service

If the product must be returned to the factory for service, request a Return Material Authorization (RMA) from Granville-Phillips. Do not return products without first obtaining an RMA. In some cases a hazardous materials document may be required. The MKS/Granville-Phillips Customer Service Representative will advise you if the hazardous materials document is required.

When returning a products to Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the gauge assembly must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

For Customer Service / Technical Support:

MKS Pressure and Vacuum Measurement Solutions
MKS Instruments, Inc., Granville-Phillips® Division
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Longmont, Colorado 80503 U.S.A.
Tel: 303-652-4400
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Appendix A Specifications & Compliance

Pressure Measurement Specifications

Absolute Pressure for N_2 or Air

Atmospheric value is based on calibration at time of use.

Measurements will change with different gases and mixtures.

Absolute Pressure Range

Torr	1 x 10^{-9} to atmosphere
mbar	1.33 x 10^{-9} to atmosphere
Pascal	1.33 x 10^{-7} to atmosphere

Accuracy for N_2 or Air

Accuracy (the difference between the gauge reading and a calibrated reference standard) is determined statistically and includes the combined performance of the gauge, sensors, and electronics.

1 x 10^{-8} Torr to 100 mTorr	±15% of reading
1.33 x 10^{-8} to 0.133 mbar	±15% of reading
1.33 x 10^{-6} to 13.3 Pa	±15% of reading
100 mTorr to 150 Torr	±10% of reading
0.133 to 200 mbar	±10% of reading
13.3 to 2.00 x 10^4 Pa	±10% of reading
150 to 1,000 Torr	±2.5% of reading
200 to 1,333 mbar	±2.5% of reading
2.00 x 10^4 to 1.33 x 10^5 Pa	±2.5% of reading

Repeatability

Repeatability refers to the ability of the same module to read the same pressure at different times.

1 x 10^{-8} Torr to 100 mTorr	±5% of reading
1.33 x 10^{-8} to 0.133 mbar	±5% of reading
1.33 x 10^{-6} to 13.3 Pa	±5% of reading
100 mTorr to 150 Torr	±2.5% of reading
0.133 to 200 mbar	±2.5% of reading
13.3 to 2.00 x 10^4 Pa	±2.5% of reading
150 to 1,000 Torr	±1.0% of reading
200 to 1,333 mbar	±1.0% of reading
2.00 x 10^4 to 1.33 x 10^5 Pa	±1.0% of reading

X-ray Limit	X-ray limit is the absolute lowest indication from the gauge. It is not possible to make repeatable measurements near the x-ray limit.	
	Torr	$< 3 \times 10^{-10}$
	mbar	$< 4 \times 10^{-10}$
	Pascal	$< 4 \times 10^{-8}$

Differential Pressure

Differential Pressure Range	Torr	–750 to +250
	mbar	–999 to 333
	kPa	–99.9 to 33.3

Accuracy
±(2.5 Torr + 2.5% of reading)
±(3.3 mbar + 2.5% of reading)
±(0.33 kPa + 2.5% of reading)

Response Time < 25 msec

Temperature Specifications

Operating Temperature 10 to 40 ºC (50 to 104 ºF), non-condensing

Storage Temperature –40 to +70 ºC (–40 to +158 ºF)

Bakeout Temperature 105 ºC (221 ºF) maximum with electronics removed

Outputs and Indicators

Available Output Options The module is available with RS-485 interface and one or two analog outputs. The module also has an LED status indicator.

Analog Outputs

Vacuum Pressure Logarithmic, 0.5 to 7.0 Vdc, 0.5 volt per decade

Differential Pressure Linear, 1.0 to 5.0 Vdc, –750 to +250 Torr (–1000 to +333 mbar, –100 to +33 kPa)

Digital RS–485 Output

Interface RS-485 two-wire, half-duplex

Communications Format ASCII format, eight data bits, no parity, one stop bit

Baud Rates 1200, 2400, 4800, 9600, 19200 (default), or 38400 baud

Address 0 to 63, selected by using address switch and RS–485 command

LED Status Indicator The status indicator illuminates to indicate the Micro-Ion sensor status:

LED is solid green to indicate power is ON and Micro-Ion sensor is OFF.

LED blinks green when Micro-Ion sensor is ON.

LED is solid amber if Micro-Ion sensor is ON but one filament is inoperable.

LED blinks amber if both Micro-Ion sensor filaments are inoperable.

Optional Display	Backlit, 72-dot by 48-dot matrix can indicate vacuum pressure, differential pressure, and error conditions. RS-485 interface enables display to indicate vacuum (absolute) pressure when pressure is < 250 Torr (333 mbar, 3.33×10^4 Pa) and differential pressure when pressure ≥ 250 Torr (333 mbar, 3.33×10^4 Pa).
Pressure Range	0.1×10^{-10} to atmosphere
Display Resolution	The resolution of the numeric display changes over the operating range of the module. Pressure values in the 10^{-10} range (such as 6×10^{-10}) will appear as "0.6^{-9}".
Pressure Units	Display indicates Torr "(TORR"), mbar ("MBAR"), or Pascal ("PA") as the unit of pressure. The "A" or "D" to the right of the pressure unit indicates vacuum (absolute) pressure ("A") or differential pressure ("D").
Vacuum Pressure Display	For vacuum pressure, X.X±Y display format includes two significant digits, a 1-digit exponent, and a ± sign for the exponent. "A" to the right of the pressure unit indicates vacuum (absolute) pressure.
Differential Pressure Display	For differential pressure, ±X.X±Y display format includes a ± sign for positive or negative differential pressure, two significant digits, a 1-digit exponent, and a ± sign for the exponent. "D" to the right of the pressure unit indicates differential pressure.
Error Conditions	If an error condition exists, the display indicates the condition. If more than one error condition exists, the display indicates the first condition, then reverts to indicating the pressure unit, then indicates the second condition, etc. The display continues scrolling through the error indications until all conditions have been diagnosed and eliminated.

Optional Trip Point Relays

Relay Type Two single-pole double-throw (normally open/normally closed) or three single-pole single-throw (normally open) relays. Each relay can be independently assigned to vacuum or differential pressure.

Relay Contact Ratings

Maximum 1 A at 30 Vdc, resistive load

Minimum 5 mA at 5 Vdc, resistive load

Relays Assigned to Vacuum Pressure

Minimum Hysteresis 5%

Range 1.0×10^{-9} to 1000 Torr
1.33×10^{-9} to 1333 mbar
1.33×10^{-7} to 1.33×10^{5} Pa

Relays Assigned to Differential Pressure

Minimum Hysteresis 5% vacuum pressure
5 Torr (6.66 mbar, 666.6 Pa) differential pressure

Range –500 to +250 Torr
–666 to +333 mbar
-6.66×10^{-4} to $+3.33 \times 10^{4}$ Pa

Default Activation Pressure Default activation pressures are out of range and require configuration.

Micro-Ion Sensor

Emission Current	0.02 mA or 4 mA, automatically set Use RS–485 commands to set switch point for high and low emission currents.
Default control settings	
Gauge ON	2 x 10^{-2} Torr with decreasing pressure 2.66 x 10^{-2} mbar with decreasing pressure 2.66 Pa with decreasing pressure
Gauge OFF	3 x 10^{-2} Torr with increasing pressure 3.99 x 10^{-2} mbar with increasing pressure 3.99 Pa with increasing pressure
Switch to High Emission	5 x 10^{-6} Torr with decreasing pressure 6.66 x 10^{-6} mbar with decreasing pressure 6.66 x 10^{-4} Pa with decreasing pressure
Switch to Low Emission	1 x 10^{-5} Torr with increasing pressure 1.33 x 10^{-5} mbar with increasing pressure 1.33 x 10^{-3} Pa with increasing pressure
Gauge Degas	Electron bombardment; 3 W for default time of 1minute per filament. Degas time is programmable from 10 to 120 seconds.
Filaments	Solid tungsten or yttria-coated iridium
Filament Operation Mode	
Alternating Mode	Module alternates between filaments with each activation of the gauge.
Automatic Mode	Filament 1 is used until it becomes inoperable, then the module automatically switches to filament 2.
Manual Mode	Filament 1 is used until it becomes inoperable, then manual intervention is required to activate filament 2.
Both Mode	Both filament 1 and filament 2 are ON until one of the filaments becomes inoperable, then the operable filament continues to function. ***NOTES: During low-emission operation in the Both mode, (the default for yttria-coated iridium filaments) both filaments are operating (ON). During high-emission operation of yttria-coated filaments, the default is "alternating mode; during high-emission operation with Tungsten filaments, the default mode is "manual" mode.***

Conductron Heat-Loss Sensor

Sensing Wires	Gold-plated tungsten

Electrical Connectors

I/O Connector	15-pin subminiature D male
Power Requirements	Power supply requirement is 24 Vdc +10% to –15%, 1 A, 22 W nominal. Maximum inrush current is 2 amps, 48 W, for 0.5 seconds. Power supply must supply at least 2 amps (48 W) of current for at least 0.5 seconds during Micro-Ion sensor start up. The Micro-Ion sensor will not activate and an emission error will occur if insufficient power is supplied during Micro-Ion sensor activation. Power inputs are reverse-biased protected.

Compliance

Compliance with CE Mark requires metal connector housings and cable with a braided shield. The braided shield must be connected only to the outer shell of the subminiature D connector on the module, not to the receiver or output device.

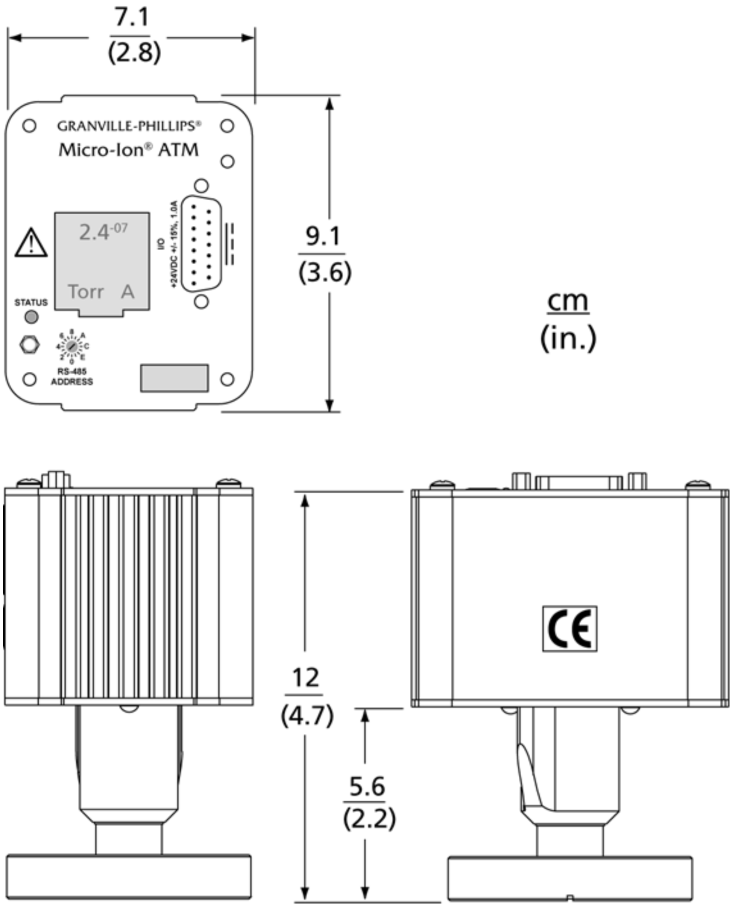
EMC	EN61326-1
Product Safety	EN61010-1
IP Rating	IP20
Environmental	RoHS Compliant

Physical specifications

Weight	728.5 g (25.7 oz.) with 2.75-inch ConFlat flange
Case material	Powder-coated extruded aluminum
Materials exposed to vacuum	304 stainless steel, tantalum, tungsten, yttria-coated iridium, alumina, CuAg eutectic, Kovar, gold-plated and nickel-plated Kovar, borosilicate glass

Dimensions

Dimensions in cm (in.)



Appendix B Theory of Operation

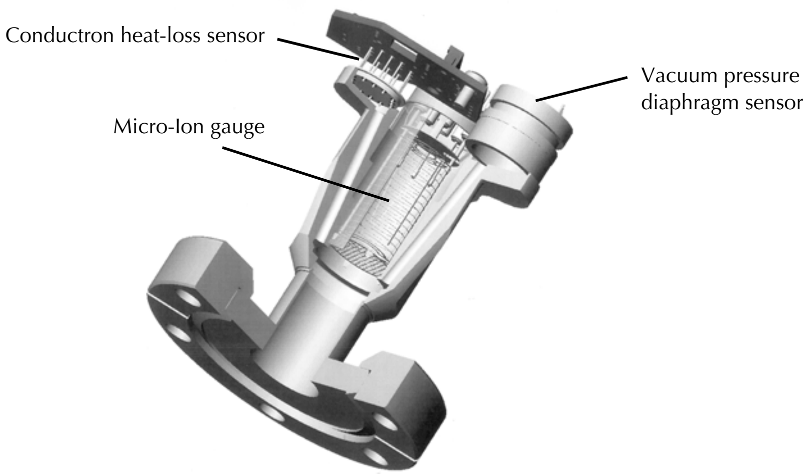
B.1 Module Operation

The Micro-Ion ATM vacuum gauge module consists of four separate pressure measuring devices: a Micro-Ion gauge (Bayard-Alpert type ionization gauge), a Conductron heat-loss sensor, and two Piezo resistive pressure diaphragm sensors.

One Piezo resistive diaphragm sensor measures atmospheric pressure, and one Piezo resistive diaphragm sensor measures vacuum pressure. Used together, the two pressure diaphragm sensors determine the differential between atmosphere and vacuum pressures.

Figure B-1 illustrates the Micro-Ion gauge, Conductron sensor, and vacuum pressure diaphragm sensors. The atmospheric pressure diaphragm sensor is located in the module's electronics assembly, illustrated on page 77.

Figure B-1 Micro-Ion Gauge, Conductron Sensor, and Pressure Diaphragm Sensors

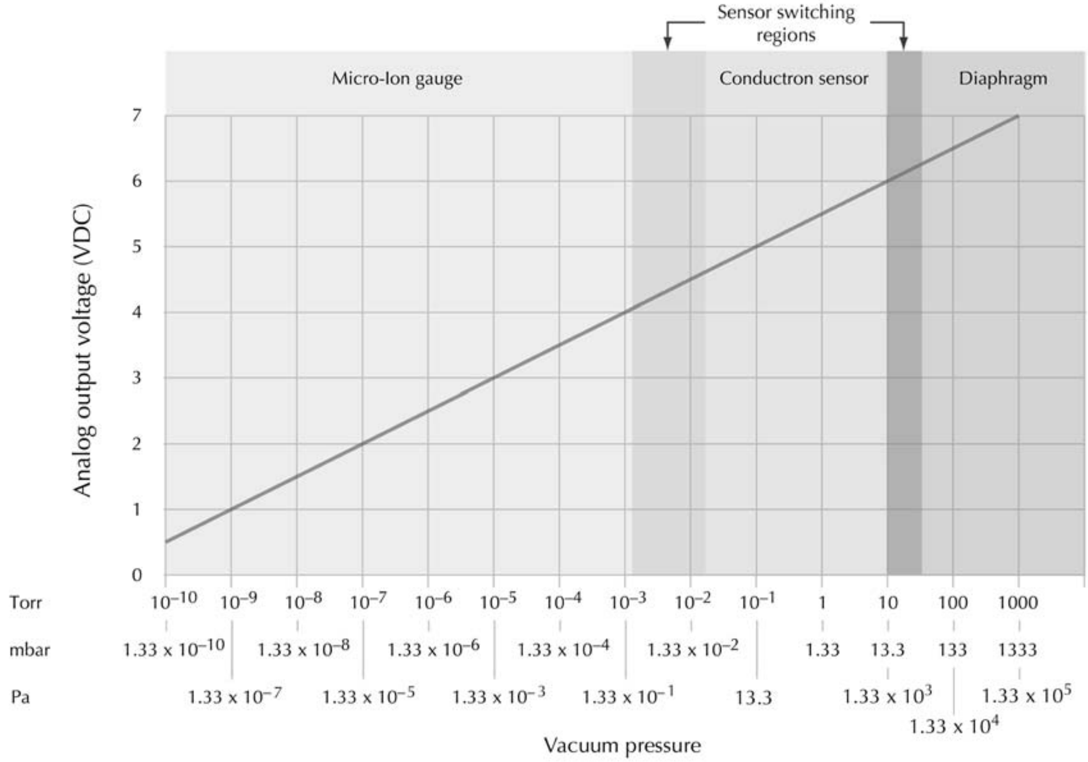


B.2 Auto ranging

As the vacuum system pumps down from atmosphere, the Conductron sensor measures pressure until a sufficiently low pressure level is achieved, then automatically turns ON the Micro-Ion gauge in the low emission mode. As pressure decreases, the Micro Ion gauge switches from low emission to high emission. As pressure increases, the opposite occurs at slightly higher pressures.

Whenever pressure is within the measurement range of both the Conductron sensor and the Micro-Ion gauge, the control electronics switches sensors, as illustrated in Figure B-2.

Figure B-2 Auto ranging Actuation Points



B.3 Micro-Ion Gauge Operation

The functional parts of the Micro-Ion gauge are the filaments (cathodes), grid (anode) and ion collectors. These electrodes are maintained by the controller at +30, +180, and 0 volts, relative to ground, respectively.

The filaments are heated to such a temperature that electrons are emitted and accelerated toward the grid by the potential difference between the grid and filaments. All of the electrons eventually collide with the grid, but many first traverse the region inside the grid many times.

When an electron collides with a gas molecule, an electron is dislodged from the molecule, leaving the molecule with a positive charge, thereby transforming the molecule into a positive ion. Most ions then accelerate to the ion collectors. The rate at which electrons collide with the ion collectors is proportional to the density of the gas molecules; therefore, ion current is proportional to gas density (or pressure, at constant temperature).

The amount of ion current for a given emission current and pressure depends on the Micro-Ion gauge design. This gives rise to the definition of ionization gauge sensitivity, frequently denoted by “S”:

$$S = \frac{\text{Ion current}}{\text{Emission current ¥ Pressure}}$$

The module electronics for the gauge varies the heating current to the filament to maintain a constant electron emission and measures the ion current to the ion collectors. The pressure is then calculated from these data.

Micro-Ion gauge degas is accomplished by increasing the emission current to 15 mA and raising the grid bias to 250 Vdc, resulting in an increased grid temperature to drive off adsorbed gases.

B.4 Conductron Sensor Operation

The Conductron heat-loss sensor uses Granville-Phillips’ Conductron sensor proprietary geometry and control circuitry. The sensor is comprised of two coplaner wire elements: a sensing wire, and a compensating wire that corrects for ambient conditions. The resistance of the sensing wire increases as its temperature increases. The controller continually adjusts a heating current that flows through the sensing wire to keep the sensor at a regulated temperature.

If pressure increases, the heat loss through gas conduction from the sensor increases, and the sensor temperature decreases, causing the resistance of the sensor to decrease. As this occurs, an error amplifier senses a change in the resistance differential between the sensor element and the compensation element, and generates an increase in the heating current through the sensor. The increased current through the sensor increases its temperature (and its resistance), and the resistance differential between the two elements is reestablished at a higher sensor input voltage and current. When calibrated, using a series of pressures and ambient temperatures, the input voltage and current are measured as an indication of the system pressure.

B.5 Piezo resistive Diaphragm Sensor Operation

The module contains two Piezo resistive pressure diaphragm sensors.

One Piezo resistive diaphragm sensor measures atmospheric pressure, and one Piezo resistive diaphragm sensor measures vacuum pressure. The comparison of the pressures measured by the two pressure diaphragm sensors determines the differential between atmosphere and vacuum pressures.

Changes in differential pressure cause activation and deactivation of relays at programmable trip points that correspond to increasing and decreasing differential pressures.

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Series 390

Granville-Phillips® Series 390 Micro-Ion® ATM, Four-Sensor Combination Vacuum Gauge Module with RS-485 Interface and Analog Output

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Instruction Manual

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