Series 937B Vacuum System Controller

Operation and Maintenance Manual

Instruction Manual p/n: 100016467
Rev F, August 2020

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Package Contents

Before unpacking the 937B Controller, check all surfaces of the packing material for shipping damage. Check to be sure that the 937B system contains the following items:

- 1 Series 937B Controller (with selected modules installed)
- 1 female, 25-pin D-sub connector for relay output connection
- 1 male, 37pin D-sub connector for analog output connection
- 1 10-foot power cord (US customer only)

Service and Warranty Guidelines

Some minor problems are readily corrected on site. If the product requires service, contact the MKS Technical Support Department at +1-833-986-1686. If the product must be returned to the factory for service, request a Return Material Authorization (RMA) from MKS. Do not return products without first obtaining an RMA. In some cases a hazardous materials disclosure form may be required. The MKS Customer Service Representative will advise you if the hazardous materials document is required.

When returning products to MKS, be sure to package the products to prevent shipping damage. Shipping damage on returned products due to inadequate packaging is the Buyer's responsibility.

For Customer Service / Technical Support:

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Andover MA, 01810 USA
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Warranty Information

MKS Instruments, Inc. provides an eighteen (18) month warranty from the date of shipment for new MKS products. The MKS Instruments, Inc. general terms and conditions of sale provide the complete and exclusive warranty for MKS products. This document is located on our web site at www.mksinst.com, or may be obtained by a contacting an MKS customer service representative.

1 Safety Information

1.1 Symbols Used in this Manual and their definitions

CAUTION: Risk of electrical shock.

CAUTION: Refer to manual. Failure to read message could result in personal injury or serious damage to the equipment or both.

CAUTION: Hot surface.

Calls attention to important procedure, practice, or conditions.

Failure to read message could result in damage to the equipment.

1.2 Safety Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards for the intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

Properly Ground the Controller.

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input terminals. A protective ground connection through the grounding conductor in the power cord is essential for safe operation.

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

All components of a vacuum system used with this or any similar high voltage product must be maintained at Earth ground for safe operation. Be aware, however, that grounding this product does not guarantee that other components of the vacuum system are maintained at earth ground. Connecting the power cable only to a properly grounded outlet is necessary but not sufficient for safe operation of a vacuum system with this or any similar high voltage producing product. Verify that the vacuum port to which the sensors are mounted is electrically grounded.

Some of the sensors operated by the 937B Controller are highly gas sensitive and were calibrated with a specific gas. When used with other gases, the true pressure could be much higher than the indicated pressure. Read and understand the information provided in this manual about setting up, installing and operating each sensor type with different gases.

Do not substitute parts or modify the instrument.

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

Use proper electrical fittings.

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

The Series 937B Controller contains lethal voltages when on.

High voltage is present in the cable and a Cold Cathode sensor when the Controller is turned on.

Use the proper power source.

This product is intended to operate from a power source that applies a voltage between the supply conductors, or between either of the supply conductors and ground, not more than that specified in the manual.

Use the proper fuse.

Only use a fuse of the type, voltage rating, and current rating specified for your product.

Do not operate in explosive environment.

To avoid explosion, do not operate this product in an explosive environment unless it has been specially certified for such operation.

Service by qualified personnel only.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must only be made by qualified service personnel.

Use proper power cord.

Only use a power cord that is in good condition and that meets the input power requirements specified in the manual.

Only use a detachable cord set with conductors having a cross-sectional area equal to or greater than 0.75 mm^2. The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

2 Specifications[1]

2.1 Controller

Pressure measuring range[2]	1×10^{-11} to $1.0 \times 10^{+4}$ Torr 1×10^{-11} to $1.3 \times 10^{+4}$ mbar 1×10^{-9} to $1.3 \times 10^{+6}$ Pa
Relay set point range[3]	
CC (Cold Cathode)	2.0×10^{-10} to 5.0×10^{-3} Torr 2.7×10^{-10} to 6.5×10^{-3} mbar 2.7×10^{-8} to 6.5×10^{-1} Pa
HC (Hot Cathode)	5.0×10^{-10} to 5.0×10^{-3} Torr 6.5×10^{-10} to 6.5×10^{-3} mbar 6.5×10^{-8} to 6.5×10^{-1} Pa
Pirani	2.0×10^{-3} to $9.5 \times 10^{+1}$ Torr 2.7×10^{-3} to $1.2 \times 10^{+2}$ mbar 2.7×10^{-1} to $1.2 \times 10^{+4}$ Pa
CP (Convection Pirani or Convectron)	2.0×10^{-3} to $9.5 \times 10^{+2}$ Torr 2.7×10^{-3} to $1.2 \times 10^{+3}$ mbar 2.7×10^{-1} to $1.2 \times 10^{+5}$ Pa
CM (Absolute Manometer)	0.2% to 100% of the measurement range of the head (e.g. 1 Torr head is 2.0×10^{-3} to $1.0 \times 10^{+0}$ Torr)

Allowed range within which a control sensor may switch on a Cold or Hot Cathode

Pirani	5.0×10^{-4} to 9.5×10^{-1} Torr 6.5×10^{-4} to 1.3×10^{-1} mbar 6.5×10^{-2} to 1.3×10^{1} Pa
CP (Convection Pirani)	2.0×10^{-3} to 1.0×10^{-2} Torr 2.7×10^{-3} to 1.3×10^{-1} mbar 2.7×10^{-1} to 1.3×10^{1} Pa
CM (≤2T head)	1.0×10^{-1} to 0.2% of FS Torr 1.3×10^{-1} to 0.2% of FS mbar $1.3 \times 10^{+1}$ to 0.2% of FS Pa
Protection set point[4]	
CC & HC	1.0×10^{-5} to 1.0×10^{-2} Torr, default setting: 5.0×10^{-3} Torr
Operating temperature range	5° to 40°C (41° to 104°F)

[1] Specifications subject to change without notice.
[2] The measurement range depends upon the sensor options selected.
[3] Relay set point values are automatically adjusted when pressure unit is changed.
[4] The protection set point is always enabled in 937B.

Storage temperature range	-10° to 55°C (14° to 131°F)
Relative humidity	80% maximum for temperatures less than 31°C, decreasing linearly to 50% maximum at 40°C
Altitude	2000 m (6561 ft) maximum
Insulation coordination	Installation (Over-voltage) Category II, Pollution Degree 2
Power requirement (nominal)	100 - 240 VAC, 50/60 Hz
Mains voltage	Fluctuations not to exceed ±10% of nominal
Power consumption	150 W maximum
Fuse rating, size	2X2A, 250V, Ø 5 mm x 20 mm
Process control relay	12 nonvolatile relays, (4 for each sensor module)
Relay rating	SPDT, 2 A @ 30 V resistive
Relay response	150 msec maximum
Analog outputs[5]	One Buffered and one Logarithmic ($\mathrm{V = A \times Lg(p) + B}$) or Linear ($\mathrm{V = A \times p}$) for each channel, up to two (2) wide-range combination logarithmic outputs. Output impedance = 100 ohms
Number of channels	Up to 6
Front panel controls	Power ON-OFF switch, keypad for setup and operational commands.
Display	320x240 color LCD with back lighting.
Pressure units	Torr, mbar, Pascal or microns
Update rate	LCD display is updated 3 times per second. The pressure signals are updated every 50 msec.
Sensor module slots	3
Sensor modules	**channels/module**
Cold Cathode	single
Hot Cathode	single
Pirani/Convection Pirani	dual
Capacitance Manometer	dual
COM modules	Profibus (optional)
Computer interface	*Serial* – RS-232 and RS-485 (standard); 9600, 19200, 38400, 57600,115200 baud rate selectable
Electronic casing	Aluminum
Dimensions (W x D x H)	9½" x 12¼" x 3½" (241 mm x 311 mm x 88 mm)
Size	½ rack, 2U high

[5] Logarithmic/linear and combined logarithmic analog outputs can be customized using the system setup menu.

Typical weight	8.0 lb (3.6 kg)
CE certification	EMC Directive: 2004/108/EEC Low Voltage Directive: 73/23/EEC

2.2 Pressure Sensors

Sensor type

CC (Cold Cathode)	Series 431 and 422 inverted magnetron Series 423 I-Mag
HC (Hot Cathode)	Bayard-Alpert (BA) type ionization sensors including MKS MIG (Miniature Ionization Gauge), or LPN (Low Power Nude)
Pirani	Series 345 Pirani
CP (Convection Pirani)	Series 317 Convection Pirani Series 275 Convectron®
CM (Capacitance Manometer)	MKS unheated Baratron® or MKS 45 C heated Baratron, with suitable cable connections and full-scale ranges. Each CM module operates up to two Capacitance Manometers, and the total current requirement of operating sensor(s) must be 1 amp or less.

Pressure measurement ranges

CC (Cold Cathode)	1.0×10^{-11} to 1.0×10^{-2} Torr 1.3×10^{-11} to 1.3×10^{-2} mbar 1.3×10^{-9} to $1.3 \times 10^{+0}$ Pa
HC (Hot Cathode)	1 .0x 10^{-10} to 1.0×10^{-2} Torr 1.3×10^{-10} to 1.3×10^{-2} mbar 1.3×10^{-8} to $1.3 \times 10^{+0}$ Pa
Pirani	5.0×10^{-4} to $4.0 \times 10^{+2}$ Torr 6.5×10^{-4} to $5.2 \times 10^{+2}$ mbar 6.5×10^{-2} to $5.2 \times 10^{+4}$ Pa
CP / (or Convectron)	1.0×10^{-3} to $1.0 \times 10^{+3}$ Torr 1.3×10^{-3} to $1.3 \times 10^{+3}$ mbar 1.3×10^{-1} to $1.3 \times 10^{+5}$ Pa
CM (Capacitance Manometer)	Three decades below full scale of head, (e.g., 10 Torr head is 1.0×10^{-2} to $1.0 \times 10^{+1}$ Torr)

Response time (Buffered analog output)

CC	<40 msec[6]
HC	<50 msec
Pirani, CP	<80 msec
CM	<40 msec

Response time (Log/Lin analog output)

CC	<50 msec

[6] A fast response (<10 msec) Cold Cathode module is also available. Consult MKS for details.

HC	<50 msec
Pirani, CP	<80 msec
CM	<80 msec

Resolution[7]

CC	2 significant digits between 10^{-10} and 10^{-2} Torr, 1 significant digit in 10^{-11} Torr decade
HC	2 significant digits between 10^{-9} and 10^{-2} Torr; 1 significant digit in 10^{-10} Torr decade
Pirani	1 significant digit from 450 to 100 Torr; 2 significant digits between 10^{-4} and 100 Torr
CP, Convectron	2 significant digits over the entire range.
CM	4 significant digits from 10 to 100% FS, 3 significant digits from 1 to 10% FS, 2 significant digits from 0.1 to 1% FS, 1 significant digit from 0.01 to 0.1% FS.

Repeatability

CC, HC, Pirani, CP	5% of indicated pressure at constant temperature
CM	0.25% of indicated pressure at constant temperature

Calibration gas

CC, HC	Nitrogen, Argon
Pirani, CP	Air/nitrogen, Argon, Helium
CM	Any (gas independent)

Installation orientation

CC, HC, CM, Pirani,	Any (port down suggested)
CP	Body horizontal only

Materials exposed to vacuum may include

CC	Series 431 and 422 – SS 304, Al 6061, silver-copper brazing alloy, alumina ceramic, Elgiloy®, OFHC® copper
	Series 423– SS 302, SS 304, glass, Al, Inconel X-750, alumina ceramic
HC	304 SS, Inconel® X750®, glass, tungsten, platinum clad molybdenum, tantalum, nickel, braze alloy, either yttria coated iridium or tungsten filament
Pirani	300 series stainless, platinum, glass, alumina ceramic, silver brazing alloy, nickel 200
CP	300 series stainless, nickel, glass, platinum

[7] Trailing zeros displayed on LCD screen do not reflect the resolution of the pressure reading.

Convectron	304 stainless steel, borosilicate glass, Kovar®, Alumina, NiFe alloy, polyimide
CM	Inconel®

Internal volume[8]

CC	Series 431 and 422 - 1.8 in^3 (30 cm^3) Series 423 - 0.9 in^3 (15 cm^3)
HC	Low power nude tube – zero Mini BA - 1.4 in^3 (23 cm^3)
Pirani	0.5 in^3 (8 cm^3)
CP	2.0 in^3 (33 cm^3)
Convectron	2.2 in^3 (35 cm^3)
CM	Approximately - 0.38 $in.^3$ (6.3 cm^3). Exact volume depends on the Series of CM in use.

Operating temperature range

CC	Series 431 - 0° to 70°C (32° to 158°F) Series 422--Versions available that operate up to 250°C Series 423 - 0° to 70°C (32° to 158°F)
HC & Pirani	0° to 50°C (32° to 122°F)
CP	10° to 50°C (50° to 122°F)
CM	0° to 50°C (32° to 122°F)

Maximum sensor bakeout temperature (without cables)

CC	Series 431 – 250°C (482°F) when backshell subassembly removed, otherwise 125°C (257°F) Series 423 – 400°C (752°F) CF flange version only with magnet removed. Series 422 versions bakeable and operable to 250°C are available.
HC	60ºC (104°F) with cable attached 300ºC (572°F) max with CF and cable removed 150ºC (302°F) with KF and Viton® seal and cable removed
Pirani	50°C (122°F)
CP	100°C (212°F) plastic shell internally coated for RF shielding 250°C (482°F) on aluminum housing for RF shielding version.
Convectron	150°C (302°F)
CM	N/A

Hot cathode sensitivity

LPN	9 $Torr^{-1}$ (±20%)
Mini BA	12 $Torr^{-1}$ (±20%)

[8] Volume will vary with the type of vacuum connection selected

Hot Cathode filament type

LPN	Tungsten (W) or Yttria (Y_2O_3) coated iridium
Mini BA	Yttria (Y_2O_3) coated iridium

Hot Cathode degas power (E-beam, at grid)

LPN	20 W max
Mini BA	5 W max

Operating voltages

HC	Grid: 180 VDC (normal operation); up to 600 V during degas Filament bias: 30 VDC Filament: 1.8 VDC @ 2A
CC	4.0 kVDC

Hot Cathode X-ray limit

LPN & Mini BA	$3x10^{-10}$ Torr

Dimensions

CC	Series 431 and 422 – ∅2.2×6.3 in (∅56×160 mm) Series 423 – ∅2.6×3.4 in (∅66×86 mm)
Mini BA	∅1.12X2.37 in (∅28×60 mm) with 2-3/4” CF flange
LPN	∅3.3X1.0 in (∅83 mm×25) with 2-3/4 CF flange, can be inserted into NW40 tube.
Pirani	∅1.3X4.4 in (∅34×112 mm)
CP	∅1.6X4.4 in (∅41×112 mm)
CM	Types 622C and 626C - ∅2.6×4.8 in. (∅66×121 mm) Type 722B- ∅1.5×3.9 in (∅38×99 mm)

Typical Weight

CC (with 2-3/4” CF flange)	Series 431 and 422 - 2.4 lb (1.1 kg) Series423 - 1.8 lb (0.8 kg)
LPN	0.9 lb (0.40 kg) with CF flange
Mini BA	0.816 lb (0.36 kg) with CF flange
Pirani	0.5 lb (0.2 kg)
CP (w/ KF Flange)	0.5 lb (0.2 kg)

2.3 Controller Display

2.3.1 Display Message

X.X0E±ee	Normal pressure for the Pirani, CP/Convectron, CC, and HC
X.XXXE±e	Normal pressure for the Baratron
OVER	The pressure is over upper limit (for CC and HC when p > 1x10^{-2} Torr)
ATM	Atmospheric pressure for the Pirani sensor
>1.100E±e	CM pressure is over 10% of the full scale
LO<E-11	The CC pressure is below its lower limit, or no CC sensor is connected
LO<E-10	The HC pressure is below its lower limit
LO<E-04	The Pirani pressure is below its lower limit
LO<E-03	The CP pressure is below its lower limit
OFF	Power is OFF to HC/CC/CP/PR sensor.
WAIT	CC and HC startup delay
Low EMIS	The HC OFF due to low emission current
CTRL OFF	The HC or CC are turned OFF by the control channel or sensor
PROT OFF	The HC or CC are in a protected state
RP OFF	The sensor power is turned OFF remotely
REDETECT	Detecting the sensor type for PR/CP
_ _ _ _	No Pirani/CP/HC sensor is detected on the inserted Pirani/CP board
NOBOARD	No board is detected in the slot, display only last 5 secs
N2, AR, He	Gas type
U	User calibration
SPn	Activated relay channel (n=1 to 12)
_ _	A relay is enabled, but not activated.
Ctrl	The CC/HC is controlled by another gauge (PR/CP)
AZ	PR/CP/BR may be auto-zeroed by its control sensor
F1, F2	Active filament
DG	The HC is degassing
An, Bn, Cn	The channel where the control sensor is installed (n=1, 2)

2.3.2 Display Resolutions

Resolution of the pressure values displayed on a 937B Vacuum System Controller front panel varies with the type of sensor connected, and range of measurement. In addition, three display formats are available: Default, HighR[9] (high resolution), and PatchZ (patch zero) and can be selected based on preference.

	PatchZ	**Default/HighR**
Percentage of Full-Scale	Displayed Resolution	Displayed Resolution
>110% FS	>(110%*FS value)	>(110%*FS value)
110% to 10%	X.XXXE+X	X.XXXE+X
10% to 1%	X.XX0E+X	X.XXE+X
1% to 0.1%	X.X00E+X	X.XE+X
<0.1%	X.000E+X	XE+X

Table 2-1 Capacitance Manometer with Exponential Display Format

Table 2-1 shows the exponential display format for Capacitance Manometer. If a Capacitance Manometer measurement range is between 10^4 and 10 (regardless of pressure unit), it is possible to toggle between the decimal and exponential formats. To do this, select the desired CM channel with the up down keys until the LED indicator on the front panel is opposite the channel and press the ***Degas ON/OFF*** button.

Pressure Range	**Convection Pirani**		**Pirani**		**Hot Cathode**			**Cold Cathode**		
Torr	**PatchZ**	**Default HighR**	**PatchZ**	**Default HighR**	**PatchZ**	**Default**	**HighR**	**PatchZ**	**Default**	**HighR**
10^3	X.X0E+03	X.XE+03	ATM	ATM						
10^2	X.X0E+02	X.XE+02	X.00E+02 (X=1,2,3,4)	X.XE+02						
10	X.X0E+01	X.XE+01	X.X0E+01	X.XE+01						
1	X.X0E+00	X.XE+00	X.X0E+00	X.XE+00						
10^{-1}	X.X0E-01	X.XE-01	X.X0E-01	X.XE-01						
10^{-2}	X.X0E-02	X.XE-02	X.X0E-02	X.XE-02	X.X0E-02	XE-02	X.XE-02	X.X0E-02	XE-02	X.XE-02
10^{-3}	X.X0E-03	X.XE-03	X.X0E-03	X.XE-03	X.X0E-03	X.XE-03	X.XXE-03	X.X0E-03	X.XE-03	X.XXE-03
10^{-4}	LO<E-03	LO<E-03	X.X0E-04 (X.X down to 1.3)	X.XE-04 (>5.0E-04)	X.X0E-04	X.XE-04	X.XXE-04	X.X0E-04	X.XE-04	X.XXE-04
10^{-5}			LO<E-04	LO<E-04	X.X0E-05	X.XE-05	X.XXE-05	X.X0E-05	X.XE-05	X.XXE-05
10^{-6}					X.X0E-06	X.XE-06	X.XXE-06	X.X0E-06	X.XE-06	X.XXE-06
10^{-7}					X.X0E-07	X.XE-07	X.XXE-07	X.X0E-07	X.XE-07	X.XXE-07
10^{-8}					X.X0E-08	X.XE-08	X.XXE-08	X.X0E-08	X.XE-08	X.XXE-08
10^{-9}					X.X0E-09	X.XE-09	X.XE-09	X.X0E-09	X.XE-09	X.XXE-09
10^{-10}					X.00E-10	XE-10	XE-10	X.X0E-10	X.XE-10	X.XE-10
10^{-11}								X.00E-11	XE-11	XE-11

Table 2-2 937B Pressure Display Format for Indirect Gauges including CP, PR, CC and HC

9 When HighR mode is selected, the controller displays extra digit for ion gauge pressure to assist the monitoring of pressure changes.

Table 2-2 shows that display format for indirect gauge including Pirani, Convectional Pirani, Cold Cathode and Hot Cathode sensors.

2.3.3 Serial Communication Response Format

CM and Piezo	Diff Baratron	Pirani	Convection	Hot Cathode	Cold Cathode
X.XXXE+X	X.XXXE+X	X.XXE-XX	X.XXE-XX	X.XXE-XX	X.XXE-XX
	-X.XXE+X				

Table 2-3 937B Serial Communication Response Format

Table 2-3 shows the serial communication (RS232/485) response format. In order to keep the communication response string length consistent, 0 will be added or patched to the end if needed.

3 Feature, Control Locations and Dimensions

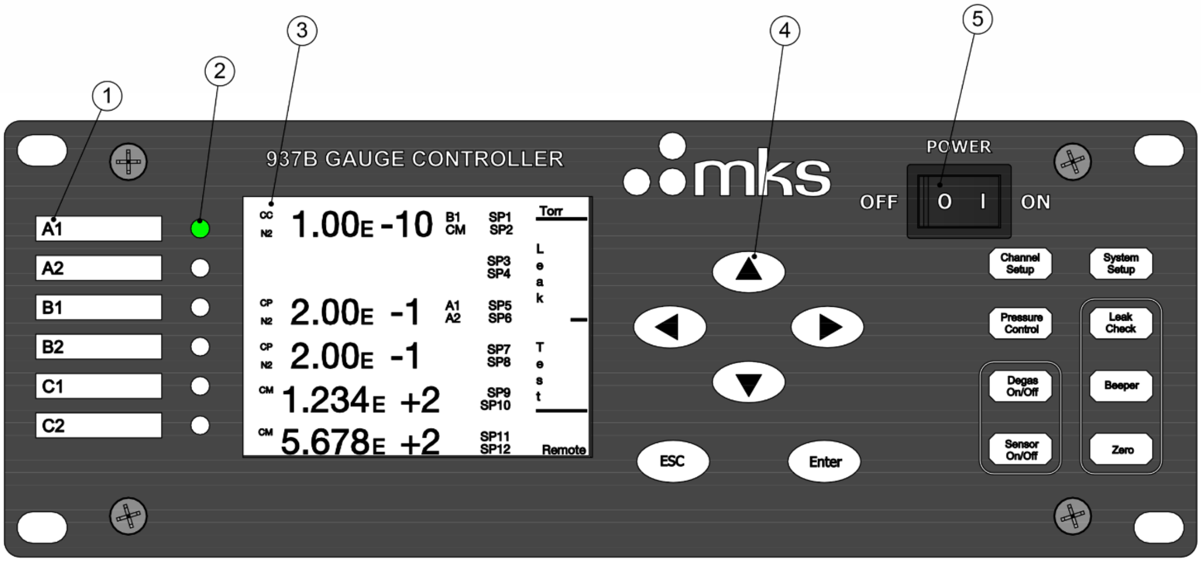


Figure 3-1 937B Front Panel

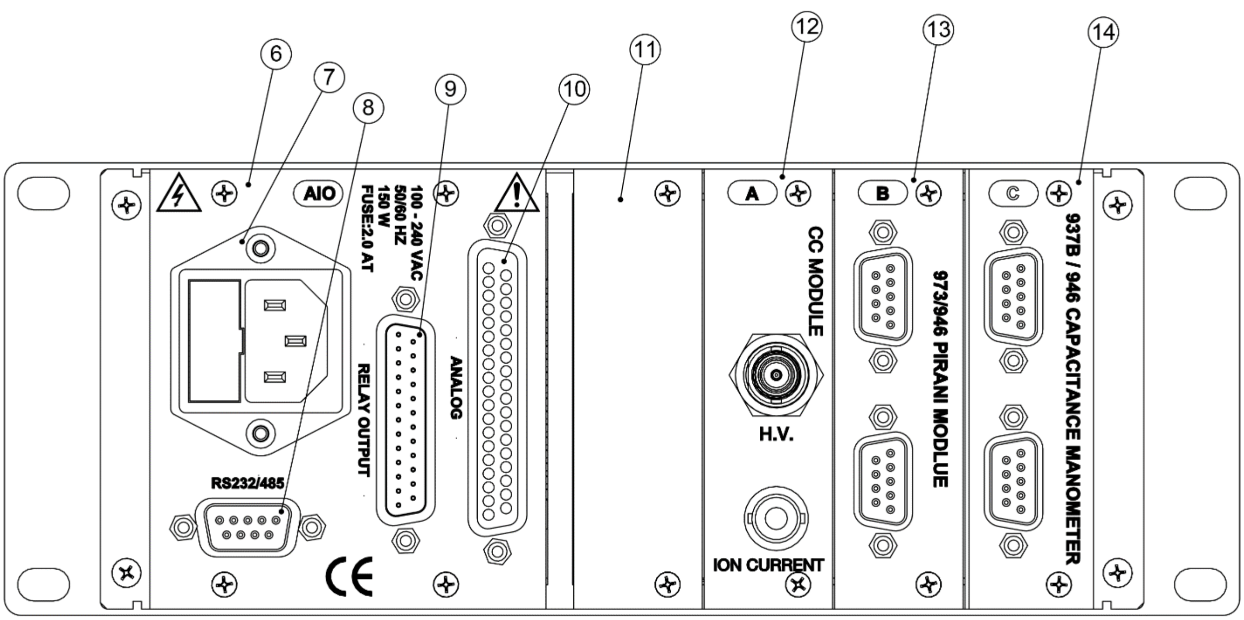


Figure 3-2 937B Rear Panel Example

1	Channel Label
2	LED, Indicating Active Channel
3	Liquid Crystal Display
4	Push Buttons for Menu Navigation
5	Power Switch
6	AIO Module
7	AC Power Inlet
8	RS232/485 Communication Port
9	Relay Output Port
10	Analog Output Port
11	For optional Profibus Module
12	Cold Cathode Module
13	Pirani Module
14	Capacitance Manometer Module

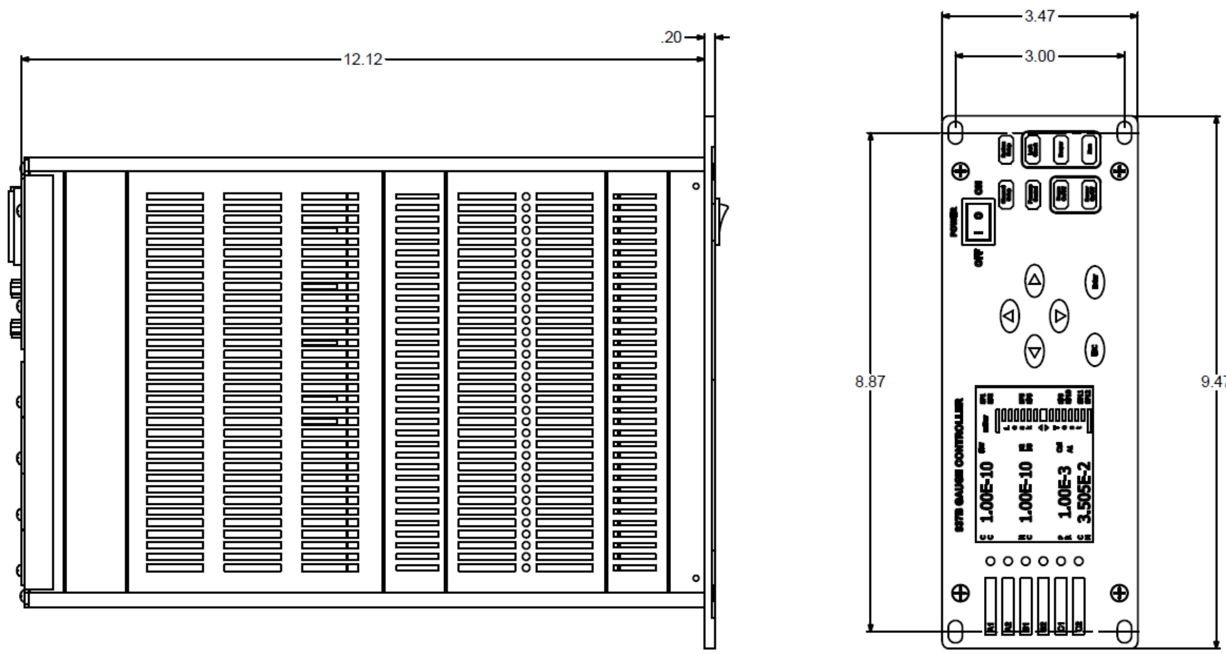


Figure 3-3 937B External Dimensions (inches)

4 Typical Applications for the Series 937B Controller

- Wide pressure measurement range including high vacuum and ultra-high (UHV) vacuum pressures.
- Pressure measurements with multiple sensing methods (ionization, thermal conductivity, capacitance manometer).
- Where a single analog output is needed over a wide range from multiple sensors.
- Pumpdown and process sequencing using relay set points.
- Pressure control in vacuum systems using relay set points.
- Sensing abnormal pressure situations and initiating appropriate security measures using the relay set points.
- Controlling system pressure by using the analog output as the input to an automatic pressure controller.
- Starting, stopping, or sequencing system processes using relay set points.
- Measuring backfill pressures.
- Leak testing vacuum systems.
- Controlling accelerator and light source vacuum systems.
- Maintaining smooth control of a wide range of pressures through the use of the combined analog outputs of up to 3 sensors.
- Using averaged analog output from up to 3 Capacitance Manometers with the same range for critical process control.
- Fast relay control by a Cold Cathode sensor for high vacuum protection.

5 MKS Series 937B Vacuum System Controller

The MKS Series 937BVacuum System Controller provides accurate and reliable pressure measurement between 1×10^{-11} Torr to $1\times10^{+5}$ Torr. A number of different MKS pressure sensors can be connected to the 937B.

- MKS Baratron Capacitance Manometers with ranges from 0.02 to 10,000 Torr (up to 6)
- MKS Series 423 I-Mag or Series 431/422 Cold Cathode sensors (up to 3)
- MKS Low Power Nude gauge or Mini BA Hot Cathode sensors (up to 3)
- MKS Series 317 Convection Pirani sensors (up to 6)
- MKS Series 275 Convectron sensors (up to 6)

Figure 5-1 937B Front View

With 3 module slots available and the ability to configure a variety of sensor combinations, the Series 937B Vacuum System Controller can accommodate many unique requirements and applications. It is designed with versatility and ease-of-use in mind, with a large LCD screen that displays:

- Pressure readings for all sensors connected to the controller (up to 6)
- Units of the indicated pressures--Torr, mbar, Pa, microns
- The type of pressure sensor in operation
- Turn ON / Turn OFF of hot or cold cathode sensors by a higher pressure sensor
- Relay status (enabled and activated relays are displayed)
- The operating status of Hot Cathode sensor (active filament, degas)
- The control status of hot and cold cathode pressure sensors
- The auto zero channel for Pirani/CP/CM sensors
- Leak checking mode (activated by the leak check button)
- System self-checking information (module status, sensor status, pressure range, and etc.)
- Front panel control lockout is possible to prevent unintended set up changes

Controller operation is straightforward. For example, to access the system setup screen, simply push the System Setup button and many system parameters can be viewed or changed. The settings of a specific channel can be viewed or changed by first selecting the channel with the up and down keys until the green front panel LED on the desired channel is illuminated and then pushing the Channel Setup button.

In addition to the pressure values displayed on the screen, three types of analog signals are available on the back panel:

- Buffered analog outputs for each sensor (up to 6). These buffered analog signals respond immediately to sensor signal changes and can be used in critical fast control applications.
- Logarithmic/linear analog outputs for each pressure sensor (up to 6) ranging from 0 to 10 V. The scale for these analog outputs can be adjusted as desired. While these linear signals are somewhat simpler to deal with than the sensor-dependent buffered analog signals, there is a longer time delay (<100 msec) due to the signal processing by the microprocessor.
- There are also combined logarithmic analog outputs available. By combining the sensors with different measurement ranges (such as Convection Pirani and Cold Cathode sensors), analog signals with much wider range are available. This eliminates the requirement for switching or selecting the sensor. The time delay for these analog outputs is around 100 msec.

Twelve (12) mechanical relays with independently adjustable set points allow the 937B to control the operation of critical components in a vacuum system such as valves or a pump. The set point parameters are nonvolatile, remaining unchanged after powering down or during a power failure. They may be set or disabled from either the front panel or RS232/485 communication.

The Controller also has control set points to turn OFF either hot or cold cathode sensors at higher pressures, extending the operating lifetime before maintenance is required.

Direct computer communication is available to change set up configurations or read pressure and other information remotely. A RS232/485 serial port is standard, and the communication protocol can be selected from the System Setup panel.

6 Operating the Series 937B Controller

6.1 Power

937B Vacuum System Controller can be powered by universal AC voltage (100 to 240 V, 50/60 Hz). The power can be switched ON and OFF using the *Power* switch on the front panel. It is recommended to power OFF the controller when not in use.

6.2 Front Panel Control Lock

All front panel keys can be made inactive when the controller's front panel controls are locked. **REMOTE** is then displayed at bottom right corner of the LCD display.

Simultaneously press the Left and Right arrow keys to lock or unlock the front panel controls or to display the lock status.

The front panel can also be locked or unlocked with serial communications commands. See *RS232/RS485 Communications Commands* for more information.

6.3 Front Panel Display

6.3.1 Standard Front Panel Display

A 3.6-inch 320x240 pixel color LCD displays the pressure, relay information, sensor type, and other operational and set up information.

A label on the left-hand side of the front displays identifies the name of the channel (A1, A2, B1, B2, C1, C2). An illuminated green LED shows the active channel for channel setting purpose. A front panel display for the 937B is shown in Figure 6-1.

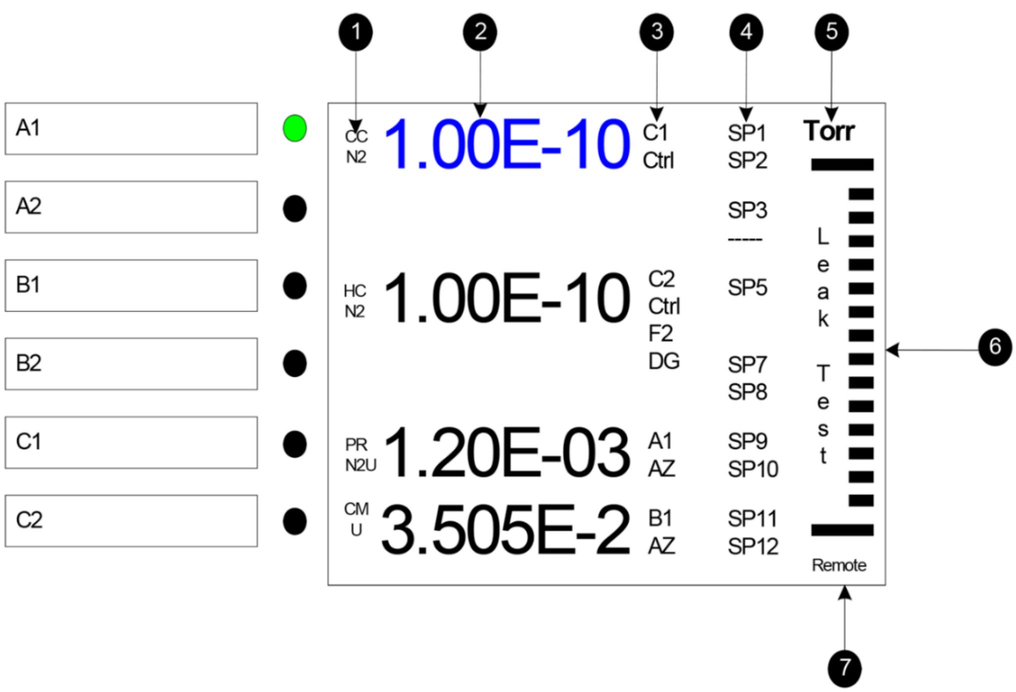


Figure 6-1 937B LCD Front Panel Display for Pressure Measurement in Leak Detection Mode

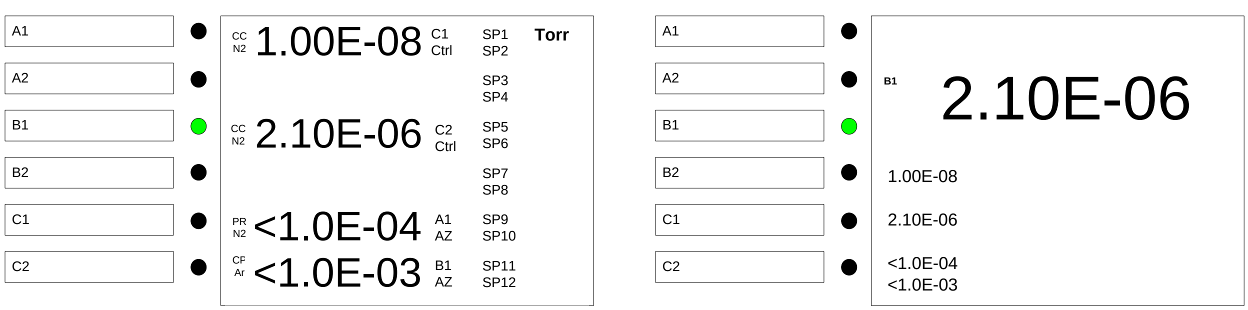
1. Type of sensor detected (CC = Cold Cathode, HC = Hot Cathode, PR = Pirani, CP = Convection Pirani or Convectron, CM = Capacitance Manometer or 902B Piezo,); N_2, AR, He = Gas type; U = User Calibrated or Zeroed
2. Pressure readings for all of the detected sensors.
3. Control information which includes:
   - For a Cold or Hot Cathode sensor, Cx Ctrl means the sensor is controlled by channel Cx.
   - For a Hot Cathode sensor, F2 means filament 2 is the active filament, DG means the HC is degassing.
   - For PR/CP/CM, Ax AZ means the PR/CP/CM will be auto-zeroed by the gauge on Channel Ax (typically, a CC or HC).
4. Relay status: displayed channel = activated relay;
   ---- = enabled, but not activated relay;
   blank = relay is not yet set.
5. Pressure units (Torr, Pascal, mBar, Microns)
6. Bar graph for leak detection.
7. Front screen is locked when REMOTE is displayed.

6.3.2 Large Font Display

A special large font pressure display of a single channel is also available to ensure the pressure readings can be seen at a distance. To enter this mode:

1. While in the standard display mode, press the UP or DOWN arrow key to select the desired channel, as indicated by the green LED.
2. Enter the large font display mode by pressing the ENTER key.
3. To exit the large font display mode, press the ENTER key.

Figure 6-2 shows a comparison between pressure measurement display in the standard mode and in the large font mode. When the large font display is selected, one channel is displayed as large font (B1 as shown in the figure) and the pressure readings for all the detected sensors are displayed in smaller font of the left side of the LCD.



Standard Display **Large Font Display**

Figure 6-2 A Comparison between Standard Display Mode and Large Font Display Mode for the 937B LCD Display During Pressure Measurement.

6.4 System Setup

6.4.1 Overview of 937B System Setup

An overview of the 937B system setup parameters is shown in Figure 6-3 with the default values and the selection ranges.

The system setup allows settings of parameters such as pressure unit, communication protocol, communication address, disable/enable set parameter, user calibration, define PID control and MFC ratio control recipes, and view firmware versions for the controller and modules.

In addition, the logarithmic/linear analog output for individual channels and combined logarithmic analog output can be scaled by setting the DAC parameters.

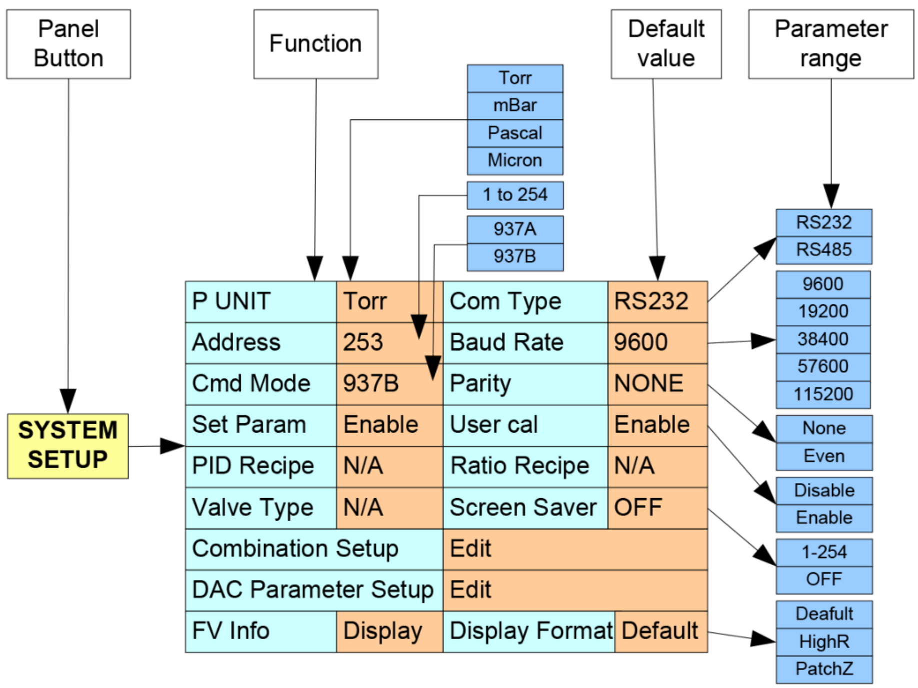


Figure 6-3 937B System Setup Parameters, their Default Values and Ranges

6.4.2 Display System Setup Parameters

To display the 937B system setup, press the SYSTEM SETUP key; the LCD display will switch to the system setup mode, as shown in Figure 6-4. The shaded area in the figure shows the cursor position. The cursor position is controlled by the arrow keys on the front panel. A parameter indicated in red indicates that the value has been modified, but not yet saved.

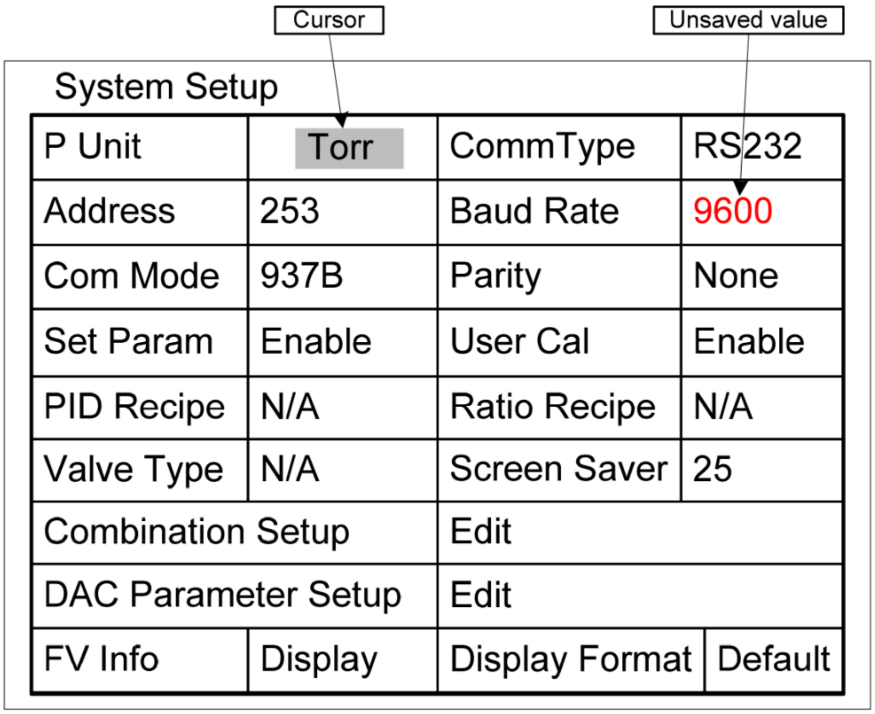


Figure 6-4 System Setup Information Displayed

When a parameter value is indicated in red, it means the value has been changed, but not yet saved. If the setup mode is exited without performing a save, the previous unchanged parameter will be used.

6.4.3 Change and Save a Parameter Value

To change and save a system setup parameter value, use the following procedure:

1. Press any of the UP, DOWN, LEFT, or RIGHT keys to move the cursor to the parameter to be changed.
2. Press the ENTER key to highlight this parameter value. For example, Torr will change to Torr.
3. Press the UP or DOWN arrow key to change the parameter value (i.e. to change Pascal to mBar).
4. Pressing the ENTER key at this point will restore the original parameter. If the cursor is moved away from the parameter with the LEFT or RIGHT arrow keys, the color of the parameter value will change to red, and it will not be saved. When either ESC or ENTER is next pushed, the original value will again be displayed and used.
5. To save an updated value, press the ENTER key while the background of the parameter value is black (i.e. Pascal in this example). After ENTER is pressed, the background of the selected parameter will turn gray (Pascal in this example). This indicates that the new value has been saved.
6. To return to the normal front panel display mode, press the ESC key once after the parameter values have been changed.

☞ **The above procedure for changing a pressure unit applies equally to changing all other parameters.**

6.4.4 Description of the System Setup Parameters

1. Pressure Unit

   This determines the units used for the pressure displayed on the front panel, the pressure queried from serial communication, and the pressure set point. There are four choices: Torr, mBar, Pascal, and Microns.

2. Communication Type

   This sets the Serial communication protocol, either RS232 or RS485. Default value is RS232.

   When the serial communication protocol is changed, the power of the 937B Controller must be reset for the change to take effect.

3. Address

   This is the address for RS485 and RS232 communication. The valid range is from 1 to 253. The default value is 253. 254 is reserved for broadcasting only.

4. Baud Rate

   This sets the baud rate for serial communication. Valid values are 9600, 19200, 38400, 57600, 115200. The default value is 9600.

5. Command Mode

   This allows the use of either 937B or old 937A serial communication protocols.

6. Parity

   Define the parity for serial communication protocol. Valid values are NONE, EVEN and ODD. The default setting is NONE.

   ☞ *When the serial communication protocol is changed, the power of the 937B Controller must be reset for the change to take effect.*

7. Set Parameter

   When Set Parameter is disabled, none of the system or channel setup change commands can be executed. However, parameter values can still be viewed from the display, or queried using serial communication.

8. User Calibration

   When User Calibration is disabled, the following commands cannot be executed through the keypad or through serial communications:

   CC User Calibration

   HC User Calibration and Sensitivity

   PR/CP Factory Default, Manual Zero, and Manual ATM

   CM Factory Default and Manual Zero

9. PID Recipe

   The 937B does not have pressure control capabilities. This function is disabled in 937B as there is no MFC or pressure control valve capability. It is available in the 946 Vacuum System Controller.

10. Ratio Recipe

    This function is disabled in 937B as there is no MFC capability. It is available in 946 Vacuum System Controller. This function for direct valve control is disabled in the 937B. It is available in 946 Vacuum System Controller*.* This function is disabled in 937B as there is no MFC or direct valve control capability. It is available in the 946 Vacuum System Controller

11. Screen Saver

    Screen saver turns OFF the front panel display. The front panel display can be re-activated by pressing any button on the front panel. The value of the screen saver is the time in minutes (1 to 254) for time of inactivity after which the screen saver is activated. To disable this function, set the value to zero. Remote operations are not affected by the Screen Saver setting. Default setting is OFF (0).

12. Combination Setup

    Two analog output combination channels are available on the 937B. Up to 3 vacuum pressure sensors can be assigned to each combination channel. Refer to section 8.4 for a more detailed discussion of the settings for the combination channels.

13. Set DAC Parameter

    Scaling of the Log/Linear analog output for each individual channel, as well as the combination analog output can be changed by adjusting the DAC parameter. To view or modify the DAC parameter, press SYSTEM SETUP and move the cursor to Set DAC Parameter. Select Edit and press ENTER. The DAC parameters used in scaling the logarithmic/linear analog output are displayed as shown in Figure 6-5.

    Both values for slope A and offset B must be selected when a logarithmic linear equation is used. The slope A is the voltage per decade, and the offset B is the voltage when the pressure is 1 Torr. The valid range for A is from 0.5 to 5, while the valid range for B is from –20 to +20 V. The default settings are 0.6 and 7.2 for A and B, respectively, which provides for a 0.6 to 9.6 Volt output over the maximum pressure range covered by the Controller. If a single channel module is present in (HC or CC), only one equation is displayed (Channel A example in Figure 6.6).

    Linearized analog output can be used when high analog output resolution is required over a narrow pressure range. When a linear equation is used, the parameter B is always set to zero as it indicates zero voltage output at high vacuum. The A value can be calculated using the equation:

    $$\mathrm{A} = \frac{10}{P_{max}}$$

    Here, P_{max} is the maximum pressure when analog output voltage is 10 V. For a Capacitance Manometer, the full range of the Manometer is normally selected for P_{max}. For example, if a 1000 Torr manometer is connected (P_{max}=1000), 1×10^{-2} should be selected for A. For other types of gauges (such as CC, HC, PR, CP), linear analog output can be used to magnify the analog out over a special range. For example, if the pressure range from 10 to 10^{-1} Torr needs higher resolution, (P_{max}=10), a value of 1 can be selected for A which results in 10 V analog output at 10 Torr.

Set DAC Parameter (P unit is torr in Eq)

	Equation	A	B
Channel A1	V=AlogP+B	6.00E-1	7.20E+0
Channel A2			
Channel B1	V=AP	1.00E+2	
Channel B2	V=AlogP+B	6.00E-1	7.20E+0
Channel C1	V=AlogP+B	6.00E-1	7.20E+0
Channel C2	V=AP	1.00E+3	
Combined	V=AlogP+B	6.00E-1	7.20E+0

Figure 6-5 Setting DAC Logarithmic and Linear Analog Output [10]

When selecting A from the front panel, only multiples of 1, 2, and 5 are allowed. Following are some examples for A corresponding to P_{max}.

P_{max}	1×10^{-3}	2×10^{-3}	5×10^{-3}	1×10^{-2}	1×10^{2}	2×10^{2}	5×10^{2}	1×10^{3}	1.5×10^{3}
A	1E+4	5E+3	2E+3	1E+3	1E-1	5E-2	2E-2	1E-2	8.4E-3

If a 10V linear output is needed at a pressure different from that given above, it can be entered via serial communication using the DLAn and DLT commands outlined in Section. 9.14.

14. FV (firmware version) Information

The firmware version for all of the modules installed in the 937B is displayed when Display is selected. The serial numbers for all detected modules are also displayed, as shown in Figure 6-6.

Firmware Version and SN

Slot A	CC	1.00	1102114509
Slot B	CM	1.00	1103104503
Slot C	PR	1.00	1105083309
Analog IO	AIO	1.00	1101154102
Comm	Com	1.00	1102104501
Main	Main	1.00	1106031428

Detected board — Firmware Version — Serial Number

Figure 6-6 System Firmware and Serial Number Information Displayed

[10] To keep the analog output unaffected by the pressure unit change, the pressure unit in these equations is fixed to Torr.

15. Display format

    Display format allows selection of the front panel display format. There are three options: Default, PatchZ, and HighR.

    Default format: only significant digits are displayed.

    PatchZ format: Zero(s) will be patched to enable 4-digit display for CM, and 3-digit display for CC or HC and Pirani or Convection Pirani.

    HighR format will display extra digit for CC and HC which may assist to identify pressure changes.

6.5 Channel Setup for Pressure Measurement

6.5.1 Overview of 937B Channel Setup

Front panel setting of the parameters associated with devices connected to the 937B Controller such as calibration, gas selection, relay set point, control set point, and control channel selection are accomplished using Channel Setup.

Figure 6-7 shows the channel setup parameters for all of the sensors and devices operated by the 937B controller. The default values are shown in the brown boxes while the ranges for setup are shown in the blue boxes. The 937B automatically shows the parameters available for the sensor in operation on the channel selected.

To perform a Channel Setup:

- Select the desired channel by pressing the UP or DOWN arrows on the front panel until the green LED on the left side of the display is aligned with the desired channel.
- Once the channel (sensor) is selected, the setup panel is displayed by pressing CHANNEL SETUP. The UP, DOWN, LEFT, and RIGHT arrow keys are used to select the parameter to be changed.
- Press ENTER to highlight the parameter value, then press either the UP or DOWN arrow to change the parameter value.
- Press ENTER to save the new value.

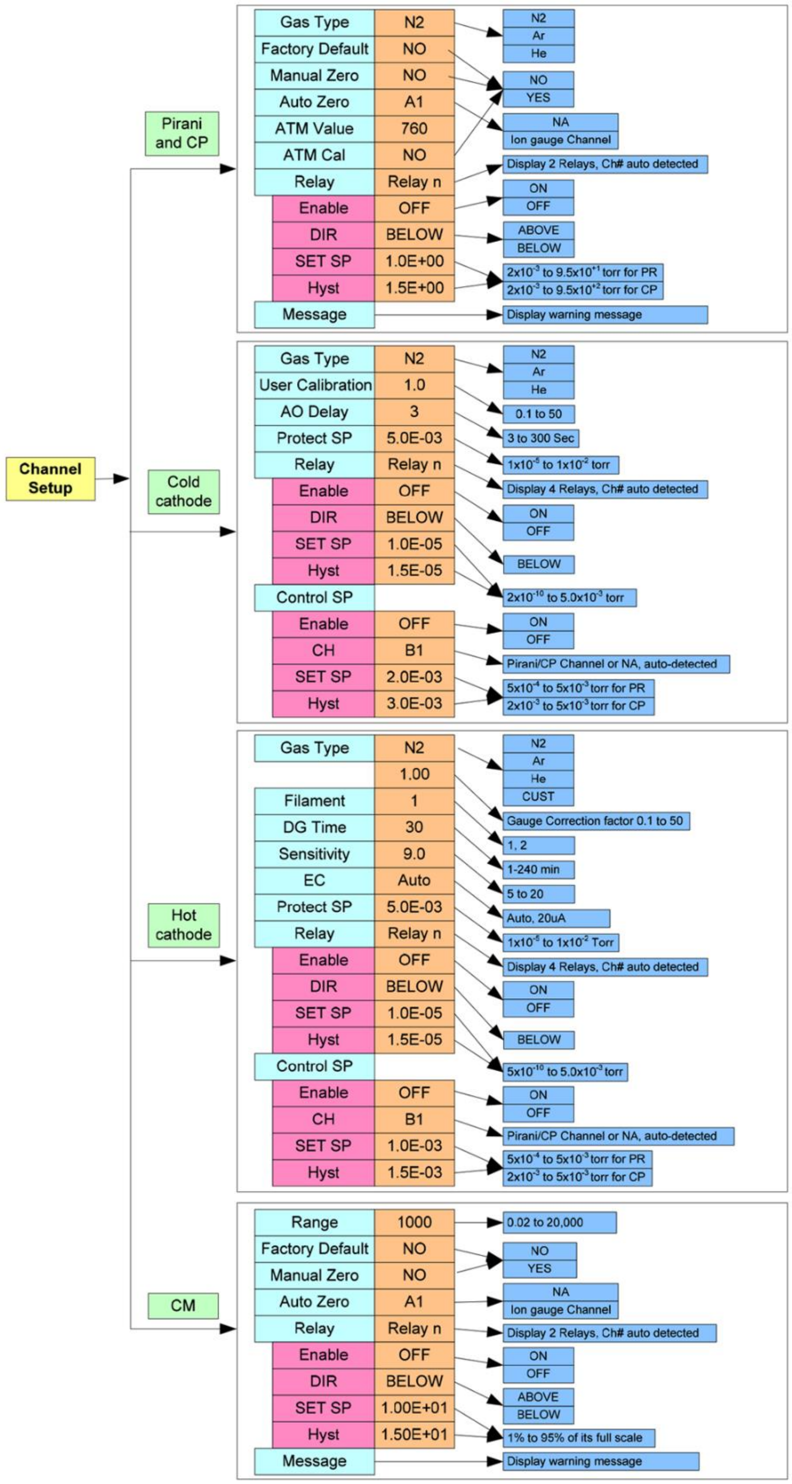


Figure 6-7 937B Channel Setup Setting Parameters, their Default Values and Ranges

6.5.2 Setup for a Capacitance Manometer

A capacitance manometer module will be automatically detected on power-up. At the same time, the connection of the capacitance manometer to the module will be checked. If no capacitance manometer is connected, - - - - will be displayed. A CM module operates up to two Capacitance Manometers, and the total combined current requirement of operating sensor(s) must be 1 amp or less.

Refer to Figure 6-8 in setting up a capacitance manometer.

1. CM Type
   ABS (absolute) can be selected.

2. Input Voltage

   The Input Voltage for the controller is same as the maximum analog output voltage of the capacitance manometer. To select, move the cursor to the Input Voltage box and press ENTER to highlight the parameter. Use the UP or DOWN arrow keys to select the correct voltage. Press ENTER to save the setting, either 10 or 5 V.

3. Range

   The full-scale pressure range of the capacitance manometer needs to be set. Capacitance manometers with full scale (ranges) from $1x10^{-2}$ to $1x10^{+4}$ Torr can be operated. Only 3 selections are available in each decade (1, 2, and 5), except between 1,000 to 10,000 Torr where 1500 Torr is allowed.

   For a manometer with pressure unit other than Torr (such as 1,333 mBar full scale), the full-scale Torr equivalent must be set before changing the controller pressure unit to match the pressure unit of the manometer (such as mBar). The full-scale value is then automatically converted to the new unit.

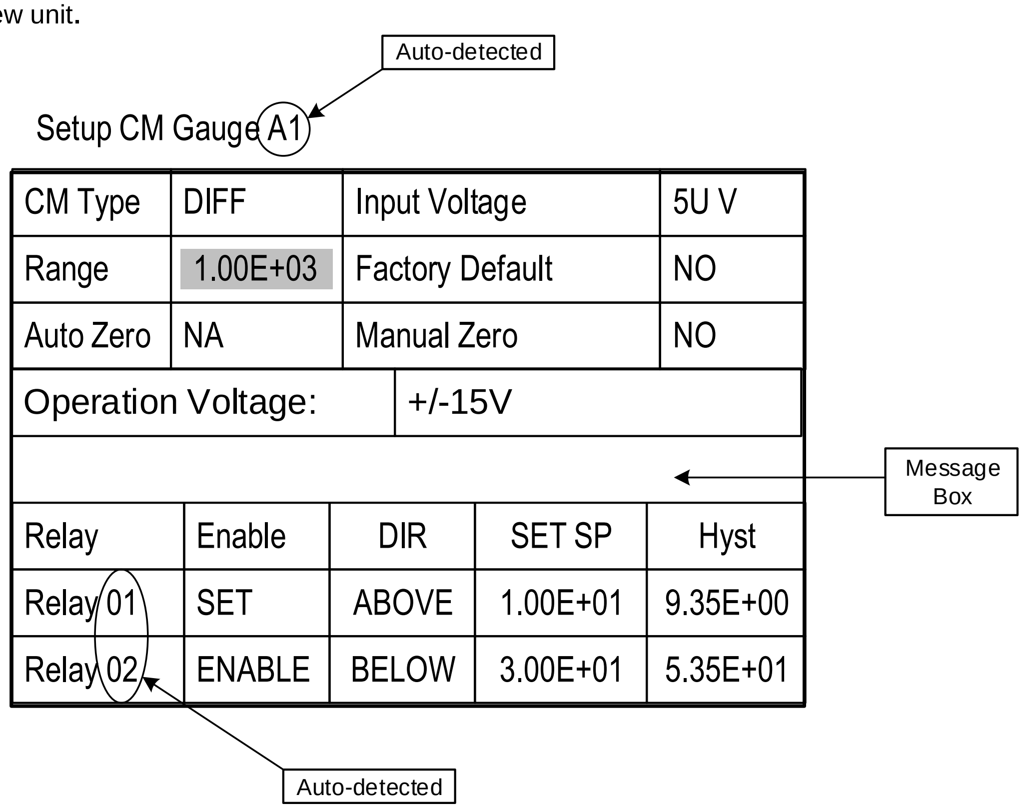


Figure 6-8 Capacitance Manometer Setup Information Screen

4. Factory Default

   When YES is selected and entered for Factory Default, any Manual Zero data is removed.

5. Auto Zero

   This selects a sensor for autozeroing of the capacitance manometer. Suitable sensors and their channels are autodetected. NA which can be selected if Auto Zero is not required.

   The Auto Zero will be executed only when:

   (1) System pressure is less than $10^{-5}xP_{FS}$ (5 decades lower than the full scale)

   (2) The CM reading is between $5x10^{-4}xP_{FS}$ and $0.05xP_{FS}$ (0.05% to 5% of the full scale)

   When a Capacitance Manometer has been zeroed, a U will be displayed under the gauge type indicator (CM) of the zeroed channel to indicate this.

   Table 6-1 shows the valid gauges that can be used for autozeroing based on the full-scale rating of the capacitance manometer.

Full scale of CM	CP	PR	CC	HC
≥ 1000 Torr	Yes	Yes	Yes	Yes
100 Torr	No	Yes	Yes	Yes
≤ 20 Torr	No	No	Yes	Yes

Table 6-1 Valid Gauges for Autozeroing Capacitance Manometers

☞ **The Capacitance Manometer and the reference auto-zero sensor must be connected to the same chamber at all times.**

6. Manual Zero

   This allows for manual zeroing of the CM from the front panel. To perform a manual zero, highlight the 'NO' in the box after Manual Zero, and then change to 'YES' with the up/down keys and push ENTER. The indicator will change to 'NO', but a U will be displayed under the gauge type indicator (CM) to indicate that it is user zeroed.

   For accurate zeroing, the system pressure must be less than 10-5xP_{FS} (5 decades less than the full scale). The Manual Zero function will abort if the overall offset is greater than 5% of the full-scale.

7. Operation Voltage

   The operation voltage from the 937B is fixed at +/-15 Volts. This limits the selection of capacitance manometers to only those requiring +/-15 Volts operating power.

8. Relay

   Each capacitance manometer channel has two preassigned relays as shown below. The controller auto-detects the correct relays corresponding to where the sensor module is installed.

Sensor location	A1	A2	B1	B2	C1	C2
Relay assigned	1 & 2	3 & 4	5 & 6	7 & 8	9 &10	11 & 12

9. Enable

   There are three 'ENABLE' settings available for a relay:

   a. SET: forces the relay to stay in the activated (closed) state regardless of pressure and set point values

   b. CLEAR: forces the relay to stay in the deactivated (open) state regardless of pressure and set point values.

   c. ENABLE: the relay status is determined by the pressure, set point value, and direction.

10. DIR

    DIR determines when the relay is activated. If ABOVE is selected, the relay will be activated when the pressure is above (greater than) the set point. If BELOW is selected, the relay will be activated when the pressure is below (less than) the set point. The default setting for DIR is BELOW.

    See Figure 8-1 and Section 8.2 for a more detailed description of the DIR setting.

11. SET SP

    Displays the entered and saved set point trip value. To change the value, scroll to the value to be changed, highlight by pressing ENTER, and then adjust to the desired value with the UP or DOWN arrow keys. Confirm the change by pressing ENTER. The range is 1% to 95% of the manometer's full scale. When entering the value, the speed of the value change can be increased by continuously pressing the UP or DOWN arrow keys.

12. Hyst

    When a set point value is changed, the hysteresis value will be changed automatically. If DIR is set to ABOVE, the hysteresis is automatically set to 0.9xSet point; if DIR is set to BELOW, the hysteresis is automatically set to 1.1xSet point.

    To modify the hysteresis, move the cursor to the hysteresis value and press ENTER. Use the UP or DOWN arrow keys to change the value, then press ENTER again to set the value. When DIR has been set to ABOVE, the maximum hysteresis value permitted for a Capacitance Manometer is 0.99xSet point; when DIR is set to BELOW, the minimum hysteresis value is 1.01xSet point.

6.5.3 Setup for a CP (Convection Pirani), Convectron, or PR Sensor

⚠ ***Do not use Convection Pirani or Convectron gauges above 1000 Torr true pressure. Series 937B Controllers are furnished calibrated for N_2. They also measure the pressure of air correctly within the accuracy of the instrument. Do not attempt to use a Convection Pirani or Convectron gauge calibrated for N_2 to measure or control the pressure of other gases such as argon or CO_2, unless the gas type setting or accurate conversion data for N_2 to the other gas is properly used. If accurate conversion data is not used or improperly used, a potential overpressure explosion hazard can be created under certain conditions.***

For example, at 760 Torr of argon gas pressure, the indicated pressure on a Convection Pirani or Convectron gauge calibrated for N_2 is 24 Torr. At an indicated pressure of 50 Torr, the true pressure of argon is considerably above atmospheric pressure. If the indicated pressure is not accurately converted to true pressure, it is possible to overpressure the vacuum system. Overpressure may cause glass components to shatter

dangerously, and if high enough may cause metal parts to rupture thus damaging the system and possibly injuring personnel. Read this Section for proper use of conversion data.

A pressure relief valve should be installed in the system if the possibility of exceeding 1000 Torr exists. For some gases, be aware the indicated pressure will be higher than the true pressure. For example, at a true pressure of 9 Torr for helium the indicated pressure on a Convectron gauge calibrated for N_2 is 760 Torr. The safe way to operate the gauge is to properly use accurate conversion data.

Refer to Figure 6-9 for setting up a Pirani or Convection Pirani sensor.

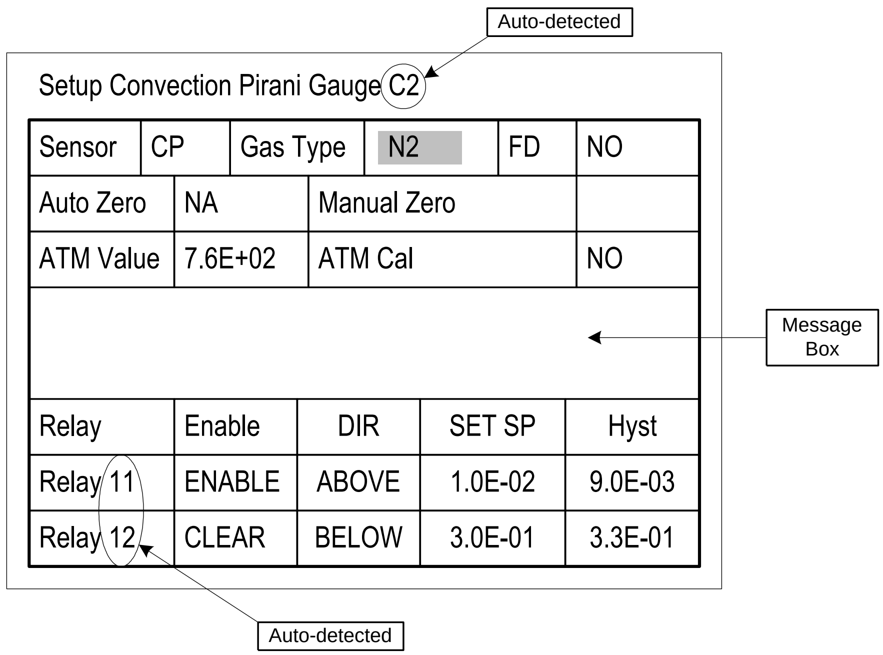


Figure 6-9 Pirani/Convention Pirani Setup Information Screen

1. Sensor

   The Sensor Type (Convection Pirani or Pirani) is often auto-detected during the initial power up. If the sensor type is auto-detected, the sensor type cannot be changed from the front panel. Should the auto-detect fail, the sensor type can be selected manually, and stored in the memory. This information will be used as the default sensor type if sensor power is cycled.

   Note that a Sensor ON/OFF sequence should be performed after manually entering the gauge type.

2. Gas Type

   Select the gas type by moving the cursor to the Gas Type box and press the Enter key. Use the UP or DOWN arrow keys to select the gas type being used with the sensor. Three gas types (N_2, Ar and He) can be selected. The default setting is N_2 which is also used for air.

3. FD (Factory Default)

   When YES is selected and entered for Factory Default, any Manual Zero and ATM Cal values are removed and the Zero and ATM values restored to the factory default ones.

   A small **U** under the sensor type indicator (PR or CP) on the front panel LCD display will be removed when default values are restored.

4. Auto Zero

   Use the UP or Down arrow keys to select a valid gauge for autozeroing the Pirani (PR) or Convection Pirani (CP). Only cold or hot cathode sensors can be used as the zero reference.

   The zero will be executed only when:

   (1) The system pressure per the CC/HC is less than $1X10^{-5}$ Torr ($1x10^{-6}$ Torr for the PR).

   (2) The Convection Pirani (or PR) reading is lower than $1x10^{-2}$ Torr.

   Ensure that the Convection Pirani/PR and the reference auto-zero CC/HC sensor are connected to the same chamber at all times.

5. Manual Zero

   The Convection Pirani or Pirani sensor can be manually zeroed. To do this, select YES in the box next to Manual Zero and then push ENTER. A small **U** will appear under the sensor identifier on the main display. Ensure that the system pressure is less than$1x10^{-5}$ Torr ($1x10^{-6}$ Torr for PR) before executing a Manual Zero. The Manual Zero function will abort if the overall offset is over $1x10^{-2}$ Torr.

6. ATM Value

   The entered value is used for the atmospheric reading of the Pirani/CP when an ATM Cal is performed. The default value is 760 Torr. Recall that elevation and weather will affect local atmospheric pressures.

7. ATM Cal

   To perform an ATM Cal, after entering the ATM Value above, select YES in the box next to ATM Cal and then push ENTER. The ATM Value will be used as the reference pressure for the ATM reading. A small **U** will appear under the sensor identifier on the main display.

8. Relay

   Each CP/Convectron/Pirani channel has two preassigned relays as shown below. The controller auto-detects the correct relays corresponding to where the sensor module is installed.

Module location	A1	A2	B1	B2	C1	C2
Relay assigned	1 & 2	3 & 4	5 & 6	7 & 8	9 &10	11 & 12

9. Enable

   There are three ‘ENABLE’ settings available for a relay:

   - SET: forces the relay to stay in the activated (closed) state regardless of pressure and set point values
   - CLEAR: forces the relay to stay in the deactivated (open) state regardless of pressure and set point values.
   - ENABLE: the relay status is determined by the pressure, set point value, and direction.

10. DIR

    DIR determines when the relay is activated. If ABOVE is selected, the relay will be activated when the pressure is above (greater than) the set point. If BELOW is selected, the relay will be activated when the pressure is below (less than) the set point. The default setting for DIR is BELOW.

    See Figure 8-1 and Section 8.1.2 for more a detailed description of the DIR setting.

11. SET SP

    SET SP displays the entered and saved set point trip value. To change the value, scroll to the value to be changed, highlight by pressing ENTER, and then adjust to the desired value with the UP or Down arrow keys. Confirm the change by pressing ENTER. The set point pressure can be between $2x10^{-3}$ to $9.5x10^{+2}$ Torr for Convection Pirani sensors and $2x10^{-3}$ to $9.5x10^{+1}$ Torr for Pirani sensors. The speed of the value change can be increased by continuously pressing the UP or Down arrow keys.

12. Hyst

    When a set point value is changed, the hysteresis value will be changed automatically. If DIR is set to ABOVE, the hysteresis will automatically be set to 0.5xSet point; if DIR is set to BELOW, the hysteresis is automatically set to 1.5xSet point.

    To modify the hysteresis, move the cursor to the hysteresis value, press ENTER and use the UP or DOWN arrow keys to change the value, then press ENTER again to set the value. The maximum hysteresis value permitted for PR/CP gauges is 0.9xSet point when DIR is set to ABOVE; the minimum hysteresis is 1.1xSet point when DIR is set to BELOW.

13. Power Control of a Convection Pirani or Pirani Sensor

    Pirani or Convection Pirani gauges can be turned ON or OFF using the Power ON/OFF key.

    Note that when a pyrophoric gas is encountered (such as during the degeneration of a cryo pump), it is strongly recommended that the power of the Pirani, CP or Convectron be turned OFF to avoid any potential for ignition of the gas.

    The power to these sensors should also be turned OFF when the sensor’s cables are disconnected to avoid any potential for sensor damage. “Hot Swaps” should be avoided.

    If the power for a Pirani or Convection Pirani is turned OFF while it is controlling (in either AUTO or SAFE) a hot or cold cathode sensor, the HC or CC will be switched OFF immediately. To avoid this, disable the control of the HC or CC sensor first before powering OFF a Convection Pirani or Pirani sensor.

    When the power to a CP, Convectron, or Pirani sensor is turned ON, a time delay is added before activating control or relay set points. This helps to avoid turning ON a controlled hot or cold cathode sensor at high pressure due to any transient and inaccurate pressure indication that may occur during the power-up.

6.5.4 Setup a Cold Cathode Sensor

Refer to Figure 6-10 for the Cold Cathode Sensor set up screen.

1. Gas Type (GT)

    To change the gas type, move the cursor to the **GT** box, press ENTER, then use the UP or DOWN arrow keys to select the gas type in use with the sensor. Three gas types (N_2, Ar, and He) can be selected.

2. User Input Calibration Gas Correction Factor (U Cal)

   This allows the entering of different correction factors for Cold Cathode sensors. This is useful, when the calibration gas used is not one of these listed above (N_2, Ar or He). The valid range is 0.1 to 50, and the default setting is 1.0.

   To change the Gas correction factor, scroll to the box after UCal and highlight the value by pressing ENTER**.** Use the UP or DOWN arrow keys to select the desired value. Then press ENTER to save the new value.

Setup CC Gauge A1

GT	N2	U Cal	1.0E+00	AO Delay	3
Fast Relay SP	1.0E-05	Prot SP	5.0E-03		

Relay	Enable	Dir/Ch	SET SP	Hyst
Relay 01	SET	BELOW	1.0E-06	9.0E-07
Relay 02	CLEAR	BELOW	3.0E-05	3.3E-05
Relay 03	ENABLE	BELOW	2.0E-08	1.8E-09
Relay 04	CLEAR	BELOW	5.0E-07	5.5E-07
Control SP	AUTO	B1	1.0E-03	1.2E-03

Figure 6-10 Cold Cathode Setup Information Screen

3. AO Delay

   The Analog Out (**AO**) Delay function prevents the activation of the Cold Cathode sensor's set point relays on sensor power up, maintaining their outputs in the OFF state, until the delay has expired. The delay can be adjusted from 3 to 300 seconds and the default value is 3 seconds. When the AO delay is active, WAIT will be displayed on the front panel rather than a pressure reading.

   To change the AO Delay, scroll to the box after AO Delay and highlight the value by pressing ENTER. Use the up and down keys to select the desired value. Then press ENTER to save the new value.

4. Fast Relay SP

   Note: FAST relay SP is available only when the special cold cathode module with fast control output (CL) is installed.

   For fast protection of a vacuum system such as closing a valve rapidly, a special cold cathode control module with a fast logic output is available. The response time is typically less than 15 msec. This fast control is achieved by comparing the buffered analog output signal with an internal DAC output determined by the Fast Relay SP value entered or set via a serial command. The comparator controls an opto-isolated solid-state relay, which enables the fast control of an external device. When installed, the control set point for this fast relay is set via the Fast Relay SP parameter. The hysteresis is approximately 15% of the set point value. The relay will be re-energized when the system pressure is 15% below the set point.

5. Protect SP

The Protect Set Point feature will turn OFF the Cold Cathode high voltage at the specified pressure. The Protect Set Point range for a Cold Cathode is 1.0×10^{-5} Torr to 1.0×10^{-2} Torr. The default value is 5.0×10^{-3} Torr. It can be disabled by continuing to press UP key when the set point value reaches 1.0×10^{-2} Torr.

☞ **Once the Protect Set Point is triggered and the sensor turned OFF, the auto control via the Control SP is disabled. The gauge can only be turned back on manually or by serial command. When control mode is used, the Control SP should be set to a pressure lower than the Protect Set Point to ensure the cold cathode is controlled by the higher-pressure sensor. Tripping of the Protect Set Point may indicate that the control set point is not functioning properly, such as due to a control sensor malfunction or both sensors are not connected to the same volume.**

6. Relay

Each Cold Cathode module has four preassigned relays as shown below. The 937B controller auto-detects the correct relays corresponding to where the CC module is installed.

Module location	A1	B1	C1
Relay assigned	1 & 2 & 3 & 4	5 & 6 & 7 & 8	9 &10 & 11 & 12

7. Enable

There are three ways to set a relay:

- SET: forces the relay to stay in the activated (closed) state regardless of pressure and set point values
- CLEAR: forces the relay to stay in the deactivated (open) state regardless of pressure and set point values.
- ENABLE: the relay status is determined by the pressure, set point value, and direction.

8. DIR

The DIR (Direction) for relays actuated by a cold cathode are permanently set to BELOW. The relays are closed whenever the pressure is below the set point.

See Figure 8-1 and Section 8.1.2 for more a detailed description of the direction setting.

9. SET SP

SET SP displays the entered and saved set point trip value. To change the value, scroll to the value to be changed, highlight by pressing ENTER, and then adjust to the desired value with the UP or DOWN arrow keys. Confirm the change by pressing ENTER. The set point pressure can be between 2×10^{-10} to 5×10^{-3} Torr. When entering the value, the speed of the value change can be increased by holding the UP or DOWN arrow key.

10. Hyst

When a set point value is changed, the hysteresis value will automatically be changed. Since the direction is always set to BELOW for Cold Cathode sensors, the hysteresis will be automatically set to 1.5x set point.

To modify the hysteresis, move the cursor to the hysteresis value and press ENTER. Use the UP or DOWN arrow keys to change the value, then press ENTER again to set the value. The minimum hysteresis value for a Cold Cathode is 1.1xSet point; DIR is set to BELOW at all times.

11. Control SP

The Control Set point is used to turn the Cold Cathode sensor on or off with a higher-pressure sensor, typically a Convention Pirani, Convectron or a Capacitance Manometer (must be ≤2 Torr full scale). This prevents the cold cathode from operating at high pressure, extending the service life. The adjustable Control SP range depends upon the sensor used for control.

$2x10^{-3}$ to $1x10^{-2}$ Torr for a Convection Pirani or Convectron sensor
$5x10^{-4}$ to $1x10^{-2}$ Torr for a Pirani
0.2% of full scale to $2x10^{-2}$ Torr for capacitance manometer (must be ≤2T f.s.)

The default Control Set Point value is $5x10^{-3}$ Torr. Extended operation of the cold cathode at higher pressures will shorten the CC sensor's lifetime.

When the power to a PR/CP used as a control sensor is turned OFF, or the cable is unplugged, the CC will be turned OFF if the control set point is enabled.

When a capacitance manometer (must be ≤2T f.s.) is used to control a cold cathode sensor, it is recommended to enable the AUTOZERO of capacitance manometer as a zero shift of the manometer may cause the control function to occur a higher actual pressure, possibly damaging sensor.

The $1x10^{-2}$ Torr upper limit can be extended to $9.5x10^{-1}$ Torr by using a @254XCS!ON;FF serial command in special situations such as when the PR/CP/CM and CC are installed at different locations. For example, when the PR/CP/CM is installed on the foreline between the mechanical and turbo pumps monitoring the mechanical pump pressure, and the CC is installed on the high vacuum chamber.

To set the Control SP, first select the control channel in the box under the Dir/Ch heading. Once an allowed channel has been selected, the Control SP can be enabled. There are three choices:

- AUTO: The high voltage for a cold cathode is controlled solely and automatically by the controlling sensor. In **AUTO** it will be tuned both ON and OFF by the control sensor as appropriate. However, if the protection set point is triggered, the auto control will be disabled, and the CC sensor can then only be turned ON manually.
- SAFE: The high voltage for a cold cathode sensor will be automatically turned OFF by the controlling sensor and remain OFF until the CC is turned ON manually.
- OFF: The Cold Cathode must be turned ON/OFF manually. Even if a control channel is selected, the CC will not be turned ON or OFF.

6.5.5 Setup a Hot Cathode Sensor

Refer to Figure 6-11 in setting up a Hot Cathode Sensor.

1. Gas Type

To change the gas type, move the cursor to the **GT** box, press ENTER, and use the UP or DOWN arrow keys to select the gas type in use with the sensor. Four gas types (N_2, Ar, He and **Custom**) can be selected.

When N_2, Ar, and He are selected, the corresponding gas correction factor is displayed on the right-hand side of the **Gas Type** box, and this value cannot be modified. However, when **Custom** is selected, a customized gas factor can be entered, ranging is from 0.1 to 50.

Relative sensitivities shown in Table 6-2 may be used to determine the gas factor if the type of gas inside the vacuum chamber is known.

The gas factor G_f is given by $G_f = 1/R_S$

2. Filament

Indicates the filament in use. The choices are 1 or 2.

Setup HC Gauge A1

Gas Type	N2	1.0	Filament	1
DG Time	30	Sensitivity		9.0
EC	20 uA	Protect Setpoint		5.0E-03
Relay	Enable	Dir/Ch	SET SP	Hyst
Relay 01	SET	BELOW	1.0E-06	9.0E-07
Relay 02	CLEAR	BELOW	3.0E-05	3.3E-05
Relay 03	ENABLE	BELOW	2.0E-08	1.8E-09
Relay 04	CLEAR	BELOW	5.0E-07	5.5E-07
Control SP	SAFE	B1	1.0E-03	1.2E-03

Figure 6-11 Hot Cathode Setup Information Screen

Gas	***Symbol***	***Relative correction factor to N_2***
Air		1.00
Argon	Ar	1.29
Carbon Dioxide	CO_2	1.42
Deuterium	D_2	0.35
Helium	He	0.18
Hydrogen	H_2	0.46
Krypton	Kr	1.94
Neon	Ne	0.30
Nitrogen	N_2	1.00
Nitrogen Oxide	NO	1.16
Oxygen	O_2	1.01
Sulfur Hexafluoride	SF_6	2.50
Water	H_2O	1.12
Xenon	Xe	2.87

Table 6-2 Relative Sensitivities (to N_2) for Different Gases

3. DG Time

Length of time for a degas cycle of a hot cathode sensor. The value can be set from 5 to 240 minutes in 1-minute increments. The default value is 30 min.

4. Sensitivity

The sensitivity value in use with the hot cathode is displayed. For a definition of sensitivity, see Section 11.3.1.

Nominal Sensitivity values are 9 Torr^{-1} for the MKS Low Power Nude sensor, and 12 Torr^{-1} for the Mini BA sensor. These values will be automatically selected based on the type of sensor detected on power up, if no user-defined sensitivity value has been stored. Sensitivity values from 1 to 50 Torr^{-1} can be entered from the front panel or over communications.

Once a user-defined sensitivity is saved, this value will become the default value when powering up the same type of hot cathode.

If a sensitivity is entered without a hot cathode being connected, this user-defined sensitivity value will be saved as the default sensitivity for all the HC sensor types.

5. EC

The Emission Current can be set to 20 uA, 100 uA, Auto20, or Auto100. When Auto 20 or Auto100 is selected, the emission current is either 20 uA or 100 uA respectively when the pressure is higher than $1x10^{-4}$ Torr, and automatically switched to 1 mA when pressure is below $1x10^{-4}$ Torr.

6. Protect SP

The Protect Set Point is turns off the hot cathode operating voltages based on its own pressure readings. The Protect Set point is always enabled on the 937B but can be set within the range $1.0x10^{-5}$ Torr to $1.0x10^{-2}$ Torr.

☞ **Once the Protect Set Point is triggered and the sensor turned OFF, the auto control via the Control SP is disabled. The gauge can only be turned back ON manually or by serial command. When control mode is used, the Control SP should be set to a pressure lower than the Protect Set point to ensure the hot cathode is controlled by the higher-pressure sensor. Tripping of the Protect Set Point may indicate that the control set point is not functioning properly, such as due to a control sensor malfunction or both sensors are not connected to the same volume.**

7. Relay

Each Hot Cathode module has four preassigned relays as shown below. The controller auto-detects the correct relays corresponding to where the HC module is installed.

Module location	A1	B1	C1
Relay assigned	1 & 2 & 3 & 4	5 & 6 & 7 & 8	9 &10 & 11 & 12

8. Enable

There are three ways to enable a relay:

- SET: force the relay to activate (close) regardless of pressure and set point values
- CLEAR: force the relay to deactivate (open) regardless of pressure and set point values.
- ENABLE: relay status is determined by the pressure, set point value, and direction.

9. DIR

To prevent the Hot Cathode from being turned ON at high pressure, the DIR for a Hot Cathode is permanently set to BELOW.

Refer to Figure 8-1 and Section 8.1.2 for a more detailed description of the direction setting.

10. SET SP

SET SP displays the entered and saved set point trip value. To change the value, scroll to the value to be changed, highlight by pressing ENTER, and then adjust to the desired value with the UP or DOWN arrow keys. Confirm the change by pressing ENTER. The set point pressure can be between 5x10^{-10} to 5x10^{-3} Torr. When entering the value, the speed of the value change can be increased by holding the UP or DOWN arrow keys while changing the value.

11. Hyst

When a set point value is changed, the hysteresis value will be changed automatically. Since the direction is set to BELOW for the Hot Cathode sensor only, the hysteresis will automatically be set to 1.5x Set point.

To modify the hysteresis, move the cursor to the hysteresis value, press ENTER, use the UP or DOWN arrow keys to change the value, and press ENTER. to set the value. The minimum allowed hysteresis for the Hot Cathode is1.1x Set point when direction is set to BELOW.

12. Control SP

The Control set point is used to turn the Hot Cathode ON or OFF with a higher-pressure sensor, typically a Convention Pirani, Convectron, or a Capacitance Manometer (must be ≤2 Torr full scale). This prevents the hot cathode from operating at high pressure, extending the service life. The adjustable Control SP range depends upon the sensor used for control:

- 2x10^{-3} to 1x10^{-2} Torr for a Convection Pirani or Convectron
- 5x10^{-4} to 1x10^{-2} Torr for a Pirani
- 0.2% of full scale to 2x10^{-2} Torr for a Capacitance Manometer (≤2T full scale)
- The default control set point value is 5x10^{-3} Torr. Extended operation of the Hot Cathode at higher pressures will shorten the HC sensor's lifetime

When the power to a PR/CP used as a control sensor is turned OFF, or the cable is unplugged, the HC will be turned off if the control set point is enabled.

The 1x10^{-2} Torr upper limit can be extended to 9.5x10^{-1} Torr by using a @254XCS!ON;FF serial command in special situations such as when the PR/CP/CM and HC are installed at different locations. For example, when the PR/CP/CM is installed on the foreline between the mechanical and turbo pumps monitoring the mechanical pump pressure, and the HC is installed on the high vacuum chamber.

When a capacitance manometer (must be ≤2T f.s.) is used to control a Hot Cathode, it is recommended to enable the AUTOZERO of capacitance manometer as a zero shift of the manometer may cause the control function to occur a higher actual pressure, possibly damaging the sensor.

To set the Control SP, first select the control channel in the box under the Dir/Ch heading. Once an allowed channel has been selected, the Control SP can be enabled. Three options are available:

- AUTO: The filament for a hot cathode is controlled solely and automatically by the controlling sensor. In **AUTO** it will be tuned both ON and OFF by the control sensor as appropriate. However, if the protection set point is triggered, the auto control will be disabled, and the HC sensor can then only be turned ON manually.

- SAFE: The filament for a Hot Cathode sensor will be automatically turned OFF by the controlling sensor, but the HC can be turned ON manually.
- OFF: The Hot Cathode must be turned ON/OFF manually. Even if a control channel is selected, the HC will not be turned ON or OFF.

6.6 Power Control of a Pressure Sensor

If flammable or explosive gas is used or present (such as during a regeneration of a LN_2 cooled cold trap), the Convection Pirani, Convectron or Pirani sensor must be turned OFF to avoid potential explosion.

Only the Pirani (PR), the Convectional Pirani (CP), the Cold cathode (CC) and the Hot Cathode (HC) can be turned off from the front panel.

6.6.1 Power (including degas) Control of a Sensor using Front Panel Control Button

To turn ON or OFF a sensor (PR/CP/CC/HC) using the front panel button:

1. Use the UP or DOWN arrow keys to select the desired sensor (PR/CP/CC/HC) to be turned ON or OFF. The active channel (sensor) is indicted by the illuminated green LED to the left of the sensor's displayed pressure.
2. For either a cold or Hot Cathode sensor, make sure it is not controlled automatically by another sensor. If it is in the AUTO control mode, disable the control set point before using the front panel key to switch the sensor.
3. The Sensor ON/OFF key switches the corresponding sensor ON and OFF.

   When a Hot Cathode is turned ON, the filament power may turn OFF automatically if the pressure is higher than the protection set point.

   When Cold Cathode sensors are turned ON at very low pressures, the sensor may take time to start as the discharge current does not build up immediately.

   Prolonged operation of cold cathode sensors at higher pressures will degrade their performance due to sputtering inside the cell reducing the operating service time before cleaning. Additionally, operation at pressures above $5x10^{-1}$ Torr can result in the sensor falsely indicating a much lower pressure. This phenomenon is called rollback and is due to high concentrations of charge particles making gas conductive at high pressure. With the protect set point feature, the possibility of operating in 'rollback' is minimized.

   Operation of Hot Cathode sensors at high pressure may lead to filament burnout. For this reason, the Protection Set Point is always enabled for HC sensor, so they are automatically turned OFF once pressure exceeds the protection set point.

4. The Degas ON/OFF key switches the degassing of a hot cathode sensor ON and OFF.

   To turn ON/OFF degas for a hot cathode gauge; the procedure is almost identical to the sensor power control, except that the DEGAS ON/OFF key is used. When a HC is in degas, a small **DG** indicator will appear on the display line of the HC. Below the **DG** will be a timer indicating the remaining time for degas.

☞ **Up to 3 MKS low power nude or Mini BA sensors can be degassed simultaneously.**

☞ **The pressure must be below 1x10^{-5} Torr in order for the degas cycle to begin. If degas is attempted at a higher pressure, the Controller will display HIGH PRES for 10 seconds and will not start degas.**

6.6.2 Power (including degas) Control of a Sensor via 37 pin AIO D-sub Connector

A connected pressure sensor can also be turned ON/OFF by sending a control signal to pins on the 37pin D-sub connector located on the back of the AIO module as shown in Table 6-3.

To turn OFF a sensor, pull the appropriate pin per Table 6-3 to the ground. The sensor power is turned OFF when the microprocessor detects a falling edge on the input pin. Cycling gauge channel power, controller power or removing ground from the pin turns the gauge power back ON. Sensor power is turned ON when a rising edge is detected.

☞ **Any of the three turn ON/OFF methods can be over-ridden by the other. For instance, front panel ON/OFF can control a sensor last turned ON/OFF at the rear panel or via serial commands**.

Since Hot Cathode modules operate a single sensor, pins 16, 18, 20 are used to control degas power.

	Description	Pin	Description
1	Buffered Aout A1	11	Log/Lin Aout C1
2	Buffered Aout A2	12	Log/Lin Aout C2
3	Buffered Aout B1	13	Combination Aout 1
4	Buffered Aout B2	14	Combination Aout 2
5	Buffered Aout C1	15	Power A1
6	Buffered Aout C2	16	Power A2/Degas A1
7	Log/Lin Aout A1	17	Power B1
8	Log/Lin Aout A2	18	Power B2/Degas B1
9	Log/Lin Aout B1	19	Power C1
10	Log/Lin Aout B2	20	Power C2/Degas C1
		21 to 37	Ground

Table 6-3 Pin Out for Analog Outputs and HC/CC Remote Control

☞ **Control pins 15-20 are pulled up by internal circuitry. No external voltage source is required to pull up the pin.**

6.6.3 Power (including degas) Control of a Sensor using Serial Communication Commands

Power to sensors can also be turned ON/OFF via serial communications. Commands for this are given in Section 9 under each gauge type.

Degas of a HC sensor can also be controlled via serial commands. The commands are given in Section 9.8.

6.7 Leak Testing Using the 937B Controller

6.7.1 Leak test principle applied for the 937B

The Series 937B Controller offers a simple and inexpensive method for locating leaks in high vacuum systems. It is not intended to replace mass spectrometer leak detectors. Under ideal conditions, a Pirani sensor can detect leaks as small as $1x10^{-4}$ Torr l/s and the cold/hot cathode sensor can be used to detect leaks as small as $1x10^{-7}$ Torr l/s.

The principle for detecting a leak with the 937B controller is based on the gas dependency of the pressure reading for the Pirani/Convection, hot or cold cathode. When different gases (such as helium or argon) enter into the vacuum system, a change in gas composition will lead to a change in “indicated pressure”, indicating a leak in the system. For heat loss sensors this is due to thermal conductivity differences between gases and with hot or cold cathode sensors it is due to the difference in the ionization probability in the gases.

Leak Test Mode will work with all sensors except the capacitance manometer, which is not gas dependent. The leak test mode and bar graph will not be displayed if the 937B Controller detects that the requested sensor for leak testing is a capacitance manometer.

6.7.2 Procedures for a leak test with the 937B

1. With the Controller ON, use the UP or DOWN keys to select the desired sensor (*must be a gas dependent sensor such as a Pirani, Convection Pirani, CC, or HC*) with the assistance of the Green LED.
2. Pump down the system and make sure the system is stabilized.
3. Press the LEAK CHECK key to display the leak bar graph on the LCD screen. Once the Leak Check is pressed, the pressure for the corresponding leak checking channel will turn blue.
4. Press BEEPER to provide audible assistance for leak checking.
5. Slowly and methodically probe with a small amount of leak checking gas such as He or Ar (*the probe gas must be different from the gas inside the chamber*). Flooding the leak with gas or moving the gas quickly past the leak can decrease effectiveness of the search since system time lags may be significant.
6. 24-segment, centered-zero bar graph shows pressure changes in the system with greater sensitivity than the numerical display. The more the bars showing on the graph, the larger the leak size. The black bar at the center is zero. The green bar indicates a relatively slow leak, while the red bar indicates a large leak in the vacuum system.
7. If the pressure has drifted during the leak checking process, press the ZERO key to set the bar graph and beeper for a new background pressure.
8. To exit the leak checking mode, press the LEAK CHECK key.

The bar graph resolution is non-linear. The first segment displayed from the center is highly sensitive with subsequent segments decreasing in sensitivity.

Disable any process control while probing the vacuum system. The set points remain active in the Leak Test function and probe entering gas may change the indicated pressure enough to switch the relay state.

As with any leak testing, many factors can influence the sensitivity of the test. These include the chamber volume; system pressure; probe gas; type of vacuum pump; relative location of the sensor, leak, and pump; and others such as pumping speed and system tube size.

- Reducing the search area, such as by valving off sections of the system (minimizing the chamber volume) will increase the efficiency of the test.
- Sensitivity to gas leaks is also pressure dependent. In general, leak test sensitivity is greater for lower system pressures.
- The CP or Pirani Sensor is sensitive to any probe gas leak lighter or heavier than the gas in the system. For optimal sensitivity, select a probe gas with the largest difference between its molecular weight and that of the system gas.

The type of vacuum pump used can also affect the accuracy of the leak test. For moderate size leaks, pump down the system with a high vacuum pump such as a diffusion or turbo pump if possible (ion and cryo pumps are not recommended). Leak testing can be done with a mechanical pump; however, they may cause cyclical variations in pressure with the rotation of the vanes. This shows up as a large background noise signal possibly masking the leak signal.

Place the pump away from the suspected leak source and place the sensor between the leak and the pump to reduce the sensor response time. Vacuum tubing between the suspected leak and the sensor should be as short and wide as possible to shorten the time required for the probe gas to reach the sensor.

If the above leak detection method fails to indicate the location of a leak, unexpected high pressures may be caused by a virtual leak, i.e., outgassing of a system component. You can locate outgassing parts, or “virtual leaks,” as well as true gas leaks using the *rate-of-pressure-rise* method below.

1. With the Controller ON, pump down the system to a base pressure.
2. Close a valve to isolate the pump.
3. Measure the rise of the pressure over a time interval. A very fast rise indicates a leak.
4. Repeat this procedure as often as necessary.

7 Installing Vacuum Sensors

7.1 Over Pressure Conditions

⚠ ***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 belljars, etc., are not designed to be pressurized.

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 online search. Confirm that these safety devices are properly installed before installing and operating the product.

Ensure the following precautions are complied with at all times:

(1) the proper gas cylinders are installed,

(2) the gas cylinder valve positions are correct on manual systems,

(3) the automation is correct on automated gas delivery systems.

7.2 Installing Cold Cathode Sensors

⚠ ***Verify that the vacuum port to which the CC sensor is mounted is electrically grounded. It is essential for personnel safety as well as proper operation that the envelope of the sensor be connected to a facility ground.***

Be aware that an electrical discharge through a gas may couple dangerous high voltage directly to an ungrounded conductor almost as effectively as would a copper wire connection. Personnel may be seriously injured or even killed by merely touching an exposed ungrounded conductor at high potential. This hazard is not unique to this product.

7.2.1 Locating a Cold Cathode Sensor

Locate Cold Cathode sensors in a position suitable for the measurement of process chamber or manifold pressures. Install the sensor away from pumps, gas sources, and strong magnetic fields to ensure the most representative data. Place and orient the sensor such that contamination is minimized. For example, if a sensor is installed directly above a diffusion pump oil vapor can contaminate the cathode, anode, and other vacuum wetted components, causing calibration drift.

7.2.2 Orienting a Cold Cathode Sensor

A Cold Cathode sensor can be installed with the body set in any direction. The operating position does not affect accuracy. As with any sensor, installation with the vacuum port facing down is preferable since this helps to prevent contaminants from falling into the sensor.

7.2.3 Managing Contamination in a Cold Cathode Sensor

Do not operate a Cold Cathode gauge at pressures above 10^{-3} Torr for extended periods. This will increase the likelihood of contamination due to higher sputtering rates. If pressure readings appear erratic, the sensor may be contaminated. In such a case, it should be visually inspected and, if contamination is visible, the internal components should be cleaned or replaced using an Internal Rebuild Kit.

7.2.4 Connecting the Series 431/422 Sensor

Mount the sensor to a grounded vacuum system. KF 25 or KF 40 flanged sensors must be attached with a conductive, all-metal clamp to ensure the sensor body is grounded. On sensors with CF flanges, a ground lug on a flange bolt could be used to attach a ground if necessary.

Connect the cables to the sensor and to the Controller before turning ON. Connections on the rear panel of the Controller are H.V. (SHV connector) and Ion Current (BNC connector). The sensors also have H.V. and current connections. Note that some Series 422 sensors have LEMO connectors rather than SHV and BNC connectors.

If there is any potential for strain on the cable, use separate strain relief to avoid damage to the sensor, cable, or the Controller.

Cables are available from the factory in standard lengths of 10, 25, 50, and 100 feet and in custom lengths up to 300 ft.

7.2.5 Connecting the 423 I-Mag Sensor

Mount the sensor to a grounded vacuum system. KF 25 or KF 40 flanged sensors must be attached with a conductive, all-metal clamp to ensure the sensor body is grounded.

If the I-Mag Sensor has a CF flange, remove the magnet first to allow clearance for bolt installation. To remove the magnet, undo the two Phillips head screws in the center of the magnet housing. When replacing the magnet, note that it is keyed to the sensor body to protect the feed-through pins from damage. The pins should be straight and centered.

Connect the cable to the sensor and to the Controller before turning ON. Tighten the thumbscrew on top of the cable to make sure that it is securely in place.

7.3 Installing Hot Cathode Sensors

7.3.1 Locating a Hot Cathode Sensor

Locate the sensor in a position appropriate for the measurement of process chamber or manifold pressure. Installing the sensor away from pumps and gas sources gives the most representative pressure measurement. In the case of a nude sensor, ensure that there is nothing in the system or mounting location that could damage the electrode structure. Special consideration should be given to any moving mechanism within the vacuum system to ensure the mechanism cannot inadvertently damage the sensor.

7.3.2 Preventing Contamination in a Hot Cathode Sensor

Locate the sensor where contamination is least likely. For example, if the sensor is mounted directly above a source of evaporation, the vapor could contaminate the structure or feed-through and cause calibration shift.

7.3.3 Orienting a Hot Cathode Sensor

A Hot Cathode sensor can be installed and operated in any direction without compromising the gauge accuracy. However, it is recommended that, whenever possible, the sensor be installed with the vacuum port facing down to keep contaminants from falling into the sensor.

7.3.4 Connecting a Hot Cathode Sensor to the Vacuum System

⚠ ***Verify that the vacuum port to which the HC sensor is mounted is electrically grounded. It is essential for personnel safety as well as proper operation that the envelope of the sensor be connected to a facility ground.***

Be aware that an electrical discharge through a gas may couple dangerous high voltage directly to an ungrounded conductor almost as effectively as would a copper wire connection. Personnel may be seriously injured or even killed by merely touching an exposed ungrounded conductor at high potential. This hazard is not unique to this product.

MKS sensors are available with either a CF type metal sealed flange, a KF type flange, or tubulation. Mount the sensor to a grounded vacuum system. KF 25 or KF 40 flanged sensors must be attached with a conductive, all-metal clamp to ensure the sensor body is grounded. On sensors with CF flanges, a ground lug on a flange bolt could be used to attach a ground if necessary.

Note: Attaching tubulated sensors with compression type (quick connect) adaptors is discouraged since in an overpressure condition the gauge could be forced out of the adaptor and thus constitute a safety hazard. Additionally, the use of an elastomer seal is not recommended for high vacuum as outgassing and/or permeation through the elastomer can cause errors in pressure measurement. A sensor with a KF flange and elastomer O-ring seal is suitable only for pressure measurement down to $1x10^{-7}$ Torr.

When inserting a nude sensor into a port, do not bend, damage, move the electrodes or feed-through pins. Do not short the elements to one another, the chamber, or any components inside the chamber. If there is any question of clearance for the electrode structure or of possible damage to the electrode structure, it is recommended that the nude sensor be mounted in a nipple, (i.e. MKS p/n 100883069). The MKS nipple includes a screen that helps to prevent ion coupling. This mounting is also recommended to assure the nominal rated sensitivity.

7.3.5 Connecting a Hot Cathode Sensor to the 937B Controller

A sensor cable with a D-sub connector (Figure 7-1) for the module connections and molded plug for the hot cathode sensor is required for operation.

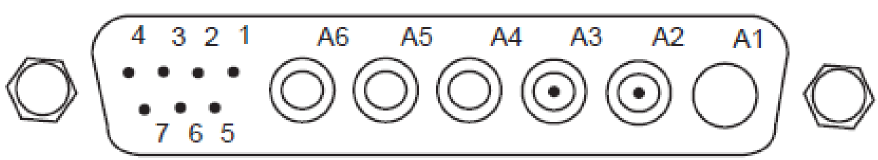


Figure 7-1 Connector on the Back of the HC Module

Pins 5, 6, and 7 are used for sensor identification. The cable needs to be matched to the type of hot cathode so proper operating parameters like maximum degas power will be selected.

Table 7-1 shows the cable pinouts for Low Power Nude and Mini BA sensors.

Since high power is required to operate a Hot Cathode, especially, during degas, the maximum allowed cable length is 50 ft (15 m), significantly shorter than for a cold cathode sensor.

937B Connector End	Low Power Nude (LPN)
A2	C (Collector)
A3	G (Grid, 2x)
A4	F2
A5	FC (Fil. Comm.)
A6	F1
1--Jumpered to 2	
2--Jumpered to 1	
5--Jumpered to 6	
6--Jumpered to 5	
7--no connect	

937B Connector End	Mini Ionization Gauge (MIG)
A2	7 (Collector)
A3	2, 5 (Grid)
A4	4 (Fil. 2)
A5	3, 6 (Fil.Comm.)
A6	1 (Fil. 1)
1--Jumpered to 2	
2--Jumpered to 1	
5	
6--Jumpered to 7	
7--Jumpered to 6	

Table 7-1 Pin Assignments for HC Sensor (LPN on left, MIG on right)

If there is the possibility of forces on the cable, use a separate strain relief to prevent damage to the sensor or controller. Cables are available in standard lengths of 10, 25 & 50 feet only. Tighten the cable jackscrews into the mating screw locks to ensure proper electrical connection and prevent stress on the connector.

☞ **Remove power from the controller before connecting or disconnecting the cable from the sensor or controller.**

7.4 Installing Convection Pirani, Convectron, or Pirani Sensors

7.4.1 Locating the Sensor

Locate a Pirani sensor appropriately for measuring a chamber or manifold pressure. Install the sensor away from pumps and gas sources for the most representative data. Place the sensor in a location with minimal vibration.

7.4.2 Preventing Contamination in a Pirani Sensor

Locate and orient the heat-loss sensor to avoid contaminants that might affect the tube's element. For example, if a sensor is installed directly above a roughing pump oil vapor could contaminate the filament wire and cause incorrect readings.

Install the sensor with the vacuum port facing downward whenever possible. This helps to prevent particulates and liquids from entering the sensor. The use of a screen or porous filter at the port can be helpful, such as MKS seal and centering ring assembly with screen.

7.4.3 Orienting the Series 317Convection Pirani or Convectron Sensor

STOP **When measuring pressures greater than 1 Torr, the Series 317 or Series 275 Convectron sensors must be mounted with their axis horizontal.**

Measurements below 1 Torr are less affected by position, but readings will be incorrect at higher pressures. The sensors are calibrated with the tube axis horizontal. Incorrect mounting could result in under- or over-pressure, damaging equipment, or injury.

Mount the Sensor with the vacuum port facing downward to reduce particulates and liquids falling or flowing into it. The sensors are calibrated in this position.

7.4.4 Orienting the Series 345 Pirani Sensor

Operating position has no effect on accuracy. The Pirani Sensor was designed to minimize the effects of convection. With a standard Pirani, the output of the sensor changes very little in going from the horizontal to vertical position.

The Series 345 Pirani Sensor exhibits slight convection characteristics near atmospheric pressure. Above 30 Torr the best accuracy can be achieved by performing an **ATM Cal** with the sensor in a vertical position with the port facing down. This can be done at any pressure between 600 and 1000 Torr.

7.4.5 Connecting Convection Pirani, Convectron, or Pirani Sensors

To install the Sensor with a 1/8" NPT, do not apply torque to the case to tighten the connection. The sensor's vacuum tubing has 9/16" hex flats for tightening. Wrap about two turns of Teflon® tape on the threads of the Sensor in the direction of the threading to ensure a leak-free seal. Note: positive pressures can blow the sensor out of a compression fitting, damaging equipment and possibly injuring personnel.

⚠ **Do not use a compression mount (quick connect) to attach the sensor to a system in positive pressure applications.**

⚠ **A solid electrical connection between the sensor and the grounded vacuum system must be provided.**

Use an MKS adaptive centering ring (MKS p/n 100315821) to fit a KF 16 port to a KF 10 port.

In applications where the system may be subject to large voltage fluctuations, a metal centering ring with a screen should be installed. The clamp must be tightened properly so that the flange contacts the centering ring and the sensor port or clamp grounded.

The sensor cable is connected to the Controller with the 9-pin "D" connector. Tighten the cable jackscrews into the mating screw locks on the controller to ensure proper electrical connection and prevent stress on the connector.

Function	937B/937B Module Connector Pin	Series 317: 10, 25, and 50 foot cables; Pin at sensor	Series 317: custom length cables: Pin at sensor	Series 275: 10, 25, and 50 foot cables; Pin at sensor
Bridge Drive +	1	1	1,6	1
Chassis Ground	2	2	No Connect	
Signal +	3	3	3	1
Signal -	4	4	4	3
Bridge Drive -	5	5	5,9	3
Bridge Drive +	6	6	No Connect	1
Bridge Sensor Leg	7	7	7	2
Bridge Ref. Leg	8	8	8	5
Bridge Drive -	9	9	9	3

Table 7-2 Pin Assignments for Convetion Pirani and Convectron Sensor

If excess stress is applied to the cable, use separate strain relief to prevent damage to the sensor, cable or the Controller. Cables are available from MKS in standard lengths of 10, 25, 50, and 100 feet and in custom lengths up to 500 feet.

7.4.6 Preparing the 317 Sensor for Bakeout

The Series 317 Convection Pirani Sensor with a black plastic housing can be baked up to 100°C after the electronics module is removed. A 317 with an aluminum housing can be baked to 250°C after the electronics module is removed.

☞ Th**e electronics modules are matched to the sensor during manufacturing and must not be interchanged.**

Prior to removing the module, the Series 317 Sensor should first be turned off. Remove the cable from the Sensor. Using a #1 Phillips screwdriver, remove the two screws at the end of the connector/electronics subassembly and separate it from the sensor. Leaving or replacing the electronics module on the cable connector may help to prevent loss or interchange of the module on reassembly.

7.5 Installing Capacitance Manometers - MKS Baratron

The Series 937B Controller supports a number of Capacitance Manometers, including the MKS unheated Baratrons and MKS 45 C heated Baratrons. They are available in full scale ranges from 0.02 to 10,000 Torr, each with a 3-decade range. A CM module operates up to two Capacitance Manometers, and the total combined current requirement of operating sensor(s) must be 1 amp or less.

See an MKS Baratron instruction manual for complete information on using these capacitance manometers.

The Series 937B Controller also supports the gas-independent Series 902B Piezo resistive gauges. Refer to Section 7.5 for more information.

⚠ **Do not connect heated Baratrons with controlled temperatures higher than 45ºC. It may damage the Capacitance Manometer**.

7.5.1 Installing a Capacitance Manometer

In general Capacitance Manometers may be mounted in any position although the most sensitive units (i.e. those with the lowest full-scale value) may require a specific orientation to meet factory calibration specifications. Consult the information supplied with the Capacitance Manometer, However, it is recommended that capacitance manometers in general be installed with the measuring port facing down to allow contamination to fall away from the pressure sensing diaphragm. The sensor port will easily carry the weight of the transducer.

☞ **Due to the failure of many users to follow the proper tightening procedures for single or double metal ferrule compression vacuum fittings and the resulting damage to the pressure sensor, MKS does not warrant this product when such fittings are used.**

7.5.2 Connecting a Capacitance Manometer

A shielded cable with 9 pin male d-sub on the controller end and a 9 or 15 pin male d-sub end on the Baratron end is required to connect the Baratron to the module on the controller. The pin-outs for the D-Sub connectors on the CM cables is shown in Table 7-4. Part numbers of cables are given in the Accessory Section of this manual.

Function	937B/937B Module Connector Pin	Baratron (CM) Connector Pin (15 pin D-sub)	Baratron (CM) Connector Pin (9 pin D-sub)
-15 V	1	6	
+15 V	5	7	4
Chassis Ground	6		
Signal -	7	12	8
Signal +	8	2	1
+/- 15V Return	9	5	9

Table 7-3 Pin Out of the 9 Pin D-sub Connector on CM Module.

7.6 Series 902B Piezo

The Controller also supports the gas-independent Series 902B Piezo resistive gauges. The 9-pin versions can be operated off the Capacitance Manometer module using the cables listed in the Spare Parts and Accessory section. The CM module needs to simply be set up for an absolute (ABS) gauge with 10V input and 1000 Torr full scale value. The same considerations in mounting and orienting a Capacitance Manometer apply to the 902B.

8 Connecting Relay and Analog Outputs

☞ **Relay and analog outputs require 2.5 sec time delay to stabilize after power application.**

8.1 Connecting 937B Relay Outputs

There are twelve relays available in the 937B Controller which can be used to control the operation of devices associated with a vacuum system. Relay contacts can be accessed through the 25 pin “Relay Output” D-sub connector on the back of the AIO module.

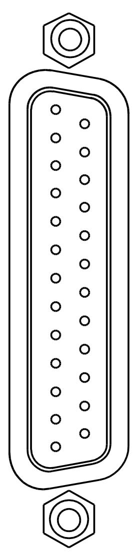
Relays used in the 937B are normally open (NO) SPDT relays. During the power-up process, a 2.5 sec. delay is implemented to ensure that all relays remain in the normally open state until reliable control signals are available.

If normally closed relay outputs are required, an external conversion is required.

The relays are controlled with signals from the main microprocessor. The time required to process a pressure signal results in a relay activation time delay of between 50 to 100 msec.

8.1.1 Pin Out for the 937B Relay Output

Table 8-1 identifies the pins for the 25-pin "D" connector on the AIO/Power module that provides the connection to the relay outputs. 12 relays are built into the controller and 4 relays are assigned to each sensor module slot. If a single sensor module such as a CC or a HC is present, all four of these relays are assigned to the one sensor. If a dual sensor module such as a Pirani, CP, or Capacitance Manometer is used, 2 relays are assigned to each sensor.



Pin	Description	Pin	Description
1	Relay 1 NO	14	Relay 7 NO
2	Relay 1 Common	15	Relay 7 Common
3	Relay 2 NO	16	Relay 8 NO
4	Relay 2 Common	17	Relay 8 Common
5	Relay 3 NO	18	Relay 9 NO
6	Relay 3 Common	19	Relay 9 Common
7	Relay 4 NO	20	Relay 10 NO
8	Relay 4 Common	21	Relay 10 Common
9	Relay 5 NO	22	Relay 11 NO
10	Relay 5 Common	23	Relay 11 Common
11	Relay 6 NO	24	Relay 12 NO
12	Relay 6 Common	25	Relay 12 Common
13	No Connection		

Table 8-1 Pin Out for the Relay Output

8.1.2 Proper Setting of a Relay

Several parameters need to be correctly set to properly use the relays in a 937B Controller. Figure 8-1 shows that manner in which these parameters are defined.

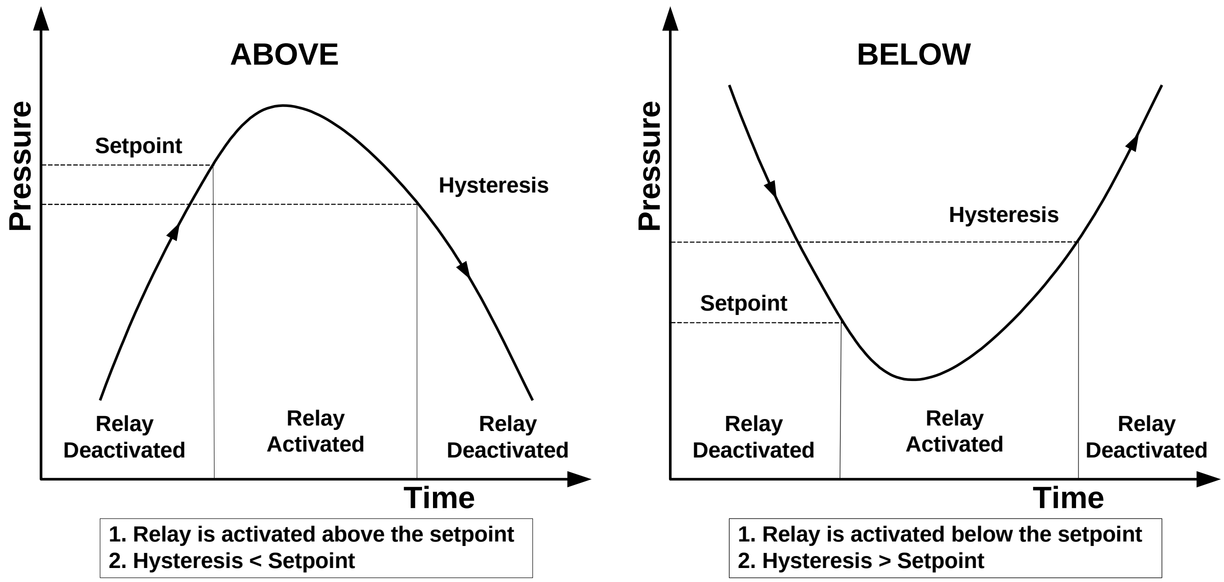


Figure 8-1 Definition of the Parameters used for Relay Control

1. Direction

   Direction indicates the direction relative to the set point when the relay is activated. There are two choices: ABOVE and BELOW.

   When ABOVE is selected, the relay will be activated when the pressure is higher than the set point. All relays in the 937B are normally open so ABOVE must be selected to close a relay when the pressure rises above a defined value. For example, a relay set to 'above' can be used to control a normally closed (NC) roughing by-pass valve in a vacuum system. If the pressure is above the set point value, a relay can be activated (i.e. closed) so that power is supplied to the solenoid of the NC roughing valve, opening the valve until the set point pressure is reached and the valve is then closed.

   When BELOW is selected, the relay will be activated (closed) when the measured pressure is lower than the set point. For example, using relay activation in the BELOW mode, a normally closed isolation valve can be opened only when the pressure is below its set point.

   ☞ **Since a hot or cold cathode sensor is turned OFF when the pressure is above its protection or control set point, only the BELOW direction is permitted for these sensors.**

2. Hysteresis

   Hysteresis is designed to prevent chattering of the relay. System pressure may fluctuate slightly, and if the hysteresis is set too close to the set point value there is a potential for undesired relay activation.

   For example, when a high vacuum isolation valve is opened, a small pressure rise may occur in the vacuum system. If the hysteresis is close to or identical with the pressure set point, the controller will try to shut the valve, then reopen once the pressure drops, causing another rise and the sequence repeating. Such an operation is detrimental to system control and should be avoided.

When direction is set to ABOVE, the hysteresis must be lower than the set point, while when the direction is set to BELOW, the hysteresis must be higher than the set point.

When Direction is changed, hysteresis is set to a default value (of about 10%). Depending on the application, this value may need to be optimized. Default values depend upon the sensor type. Information on specific defaults is given in Section 6-5 for each sensor.

8.1.3 Relay Inductive Loads and Arc Suppression

If the set point relay is used to switch inductive loads, e.g., solenoids, relays, transformers, etc., arcing of the relay contacts may interfere with the controller operation or reduce relay contact life. In these situations, an arc suppression network, shown schematically in Figure 8-2, is recommended.

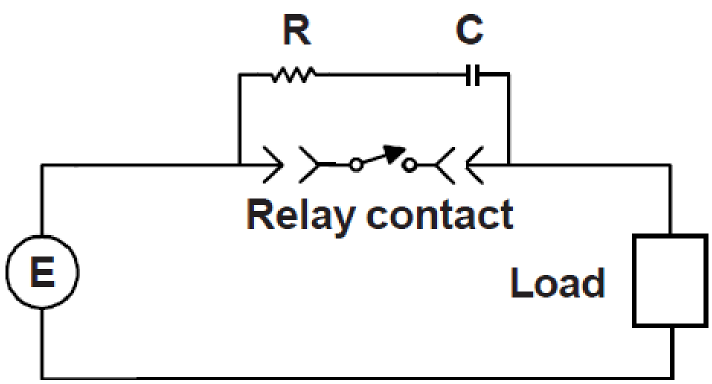


Figure 8-2 Relay Arc Suppression Network

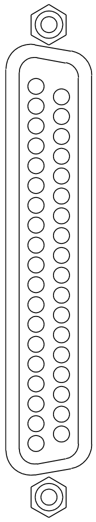
The values of the capacitance *C* and the resistance *R* are calculated using the equations:

$$C = \frac{I^2}{10} \;\; ; \;\; R = \frac{E}{10 \times I^a} \quad and \quad a = 1 + \frac{50}{E}$$

where *C* is in µF, *R* is in Ω, *I* is the DC or AC_{peak} load current in amperes, *E* is the DC or AC_{peak} source voltage in volts. C_{min} = 0.001µF and R_{min} = 0.5 Ω.

8.2 Connecting the 937B Analog Output

Analog output signals, which can be sent to a data acquisition system, are available from each sensor. These signals can be accessed from the 37 pin D-sub analog connector on the back of the controller. They include buffered, logarithmic, and combination logarithmic output. Buffered and logarithmic analog outputs are simultaneously available from all sensors. The detailed assignment for these pins is described in Table 8-2.



Pin	Description	Pin	Description
1	Buffered Aout A1	11	Log/Lin Aout C1
2	Buffered Aout A2	12	Log/Lin Aout C2
3	Buffered Aout B1	13	Combination Aout 1
4	Buffered Aout B2	14	Combination Aout 2
5	Buffered Aout C1	15	Power A1
6	Buffered Aout C2	16	Power A2/Degas A1
7	Log/Lin Aout A1	17	Power B1
8	Log/Lin Aout A2	18	Power B2/Degas B1
9	Log/Lin Aout B1	19	Power C1
10	Log/Lin Aout B2	20	Power C2/Degas C1
		21 to 37	Ground

Table 8-2 Pin Out for 937B Analog Output

8.2.1 Buffered Analog Output

A buffered analog signal responds immediately to sensor signal changes and is suitable for fast controlling applications.

☞ **Buffered analog signals are non-linear and strongly sensor dependent.**

For capacitance manometers, Pirani type or cold cathode sensors, the buffered outputs are analog signals without microprocessor processing. However, the buffered output from a hot cathode sensor at pin 1, 3 or 5 in the table 8-2 is a microprocessor formed output. This is because the hot cathode sensor uses different emission currents to cover the pressure range, necessitating microprocessor scaling. The equation for this output is V = 0.6 * log (P) + 7.2. (see Figure 8-4).

Normal buffered output for the 937B is 0 to 10 V. If a negative buffered voltage is observed, it may be caused by:

- No discharge for a Cold Cathode, or a pressure reading of less than $1x10^{-11}$ Torr.
- A reading below zero for a Capacitance Manometer (zero adjustment may be required).

The buffered analog outputs for variety of pressure sensors in an unpowered state are shown in Table 8-3.

Sensor	Buffered Analog Output when power is OFF
Cold Cathode (CC)	> 10 V
Hot Cathode (HC)	> 10V
Pirani (PR)	0
Convection Pirani (CP)	0

Table 8-3 Buffered Analog Output when Sensor Power is OFF.

Buffered analog outputs for the Cold Cathode, Hot Cathode, Pirani, Convection Pirani and Capacitance Manometers are shown in following figures and tables.

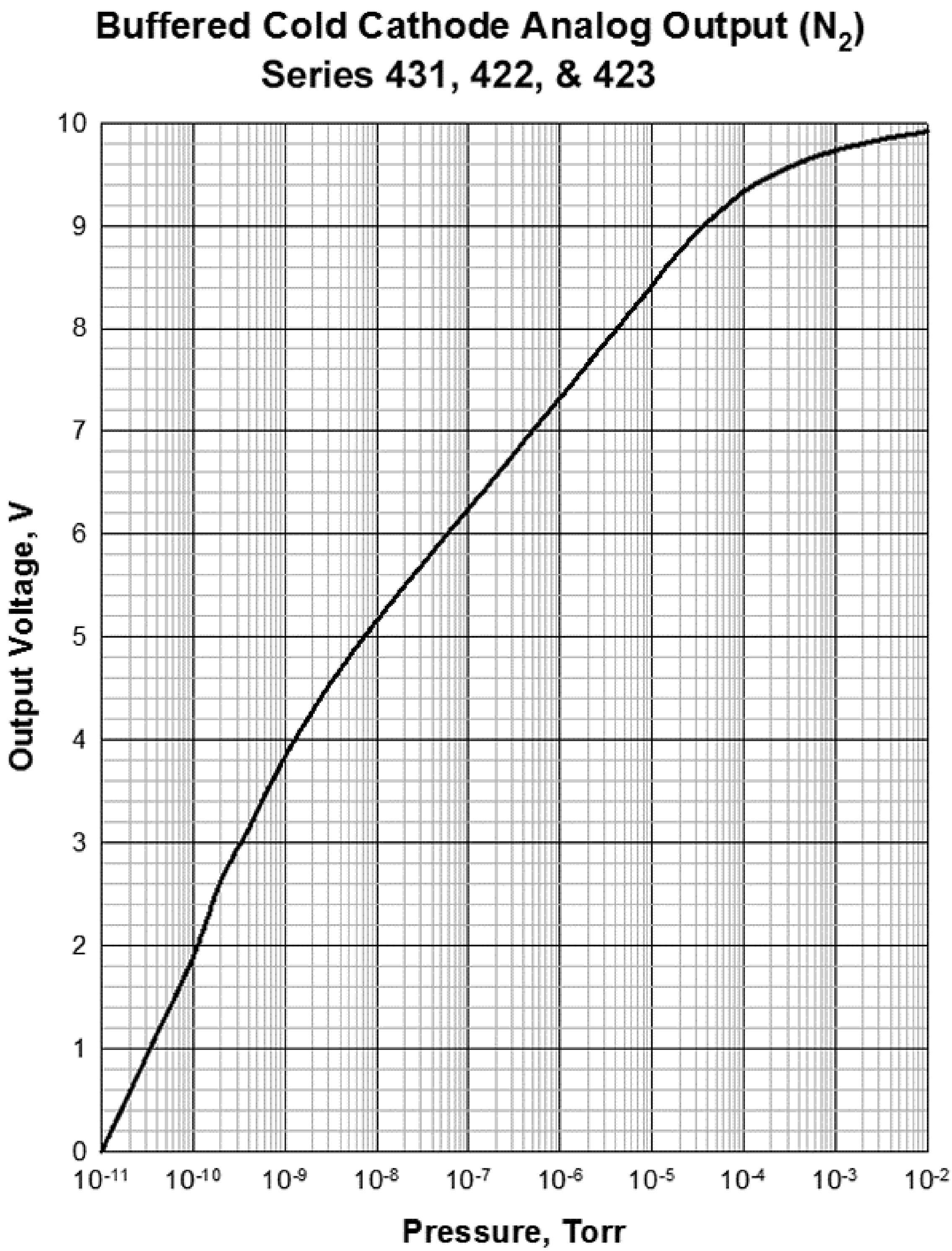


Figure 8-3 Buffered Analog Output for Cold Cathode Sensors (431/422/423) in N_2

Pressure, Torr	Buffered Vout, V	Pressure, Torr	Buffered Vout, V
1.0E-11	0.0000	4.0E-07	6.8993
1.5E-11	0.3286	6.0E-07	7.0871
2.0E-11	0.5634	8.0E-07	7.2222
3.0E-11	0.8994	1.0E-06	7.3247
4.0E-11	1.1416	1.5E-06	7.5140
6.0E-11	1.4585	2.0E-06	7.6551
8.0E-11	1.7035	3.0E-06	7.8469
1.0E-10	1.8882	4.0E-06	7.9769
1.5E-10	2.3241	6.0E-06	8.1714
2.0E-10	2.6299	8.0E-06	8.3064
3.0E-10	2.9358	1.0E-05	8.4136
4.0E-10	3.1342	1.5E-05	8.6166
6.0E-10	3.4587	2.0E-05	8.7446
8.0E-10	3.6700	3.0E-05	8.9177
1.0E-09	3.8409	4.0E-05	9.0275
1.5E-09	4.1006	6.0E-05	9.1665
2.0E-09	4.2838	8.0E-05	9.2614
3.0E-09	4.5248	1.0E-04	9.3297
4.0E-09	4.6807	1.5E-04	9.4255
6.0E-09	4.8991	2.0E-04	9.4826
8.0E-09	5.0452	3.0E-04	9.5605
1.0E-08	5.1579	4.0E-04	9.6076
1.5E-08	5.3563	6.0E-04	9.6708
2.0E-08	5.4924	8.0E-04	9.7034
3.0E-08	5.6809	1.0E-03	9.7325
4.0E-08	5.8185	1.5E-03	9.7703
6.0E-08	6.0096	2.0E-03	9.7975
8.0E-08	6.1423	3.0E-03	9.8340
1.0E-07	6.2431	4.0E-03	9.8575
1.5E-07	6.4281	6.0E-03	9.8823
2.0E-07	6.5683	8.0E-03	9.8997
3.0E-07	6.7570	1.0E-02	9.9178

Table 8-4 Buffered Analog Output for the Cold Cathode Sensors (431/422/423) in N_2.

Range	Equation
V<2.2V	$P = \exp(-25.3546 + 3.3941V - 0.9901V^2 + 0.4259V^3)$
2.2 V< V <3.71 V	$P = \exp\left(\frac{V - 5.7722}{0.1969}\right)$
V>3.71 V	$P = \exp\left(\frac{V - 4.2157}{0.3161 - 0.0721557V}\right)$

Table 8-5 Equations for Cold Cathode Sensors (N_2) Raw Analog Output

NOTE: The analog voltage from the 937B needs to be divided by 2.4 before equations can be used.

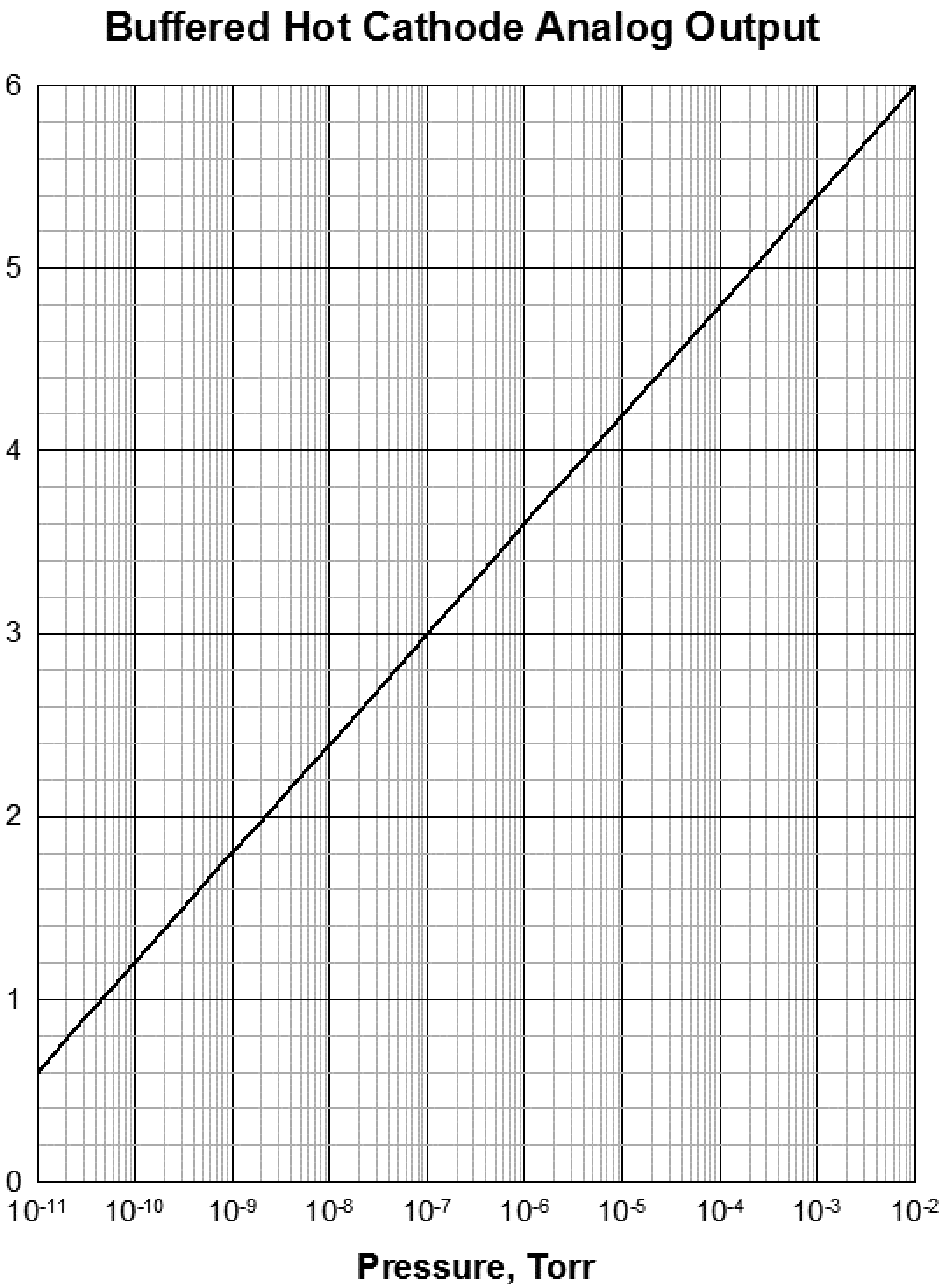


Figure 8-4 Buffered Analog Output for Hot Cathode Sensors

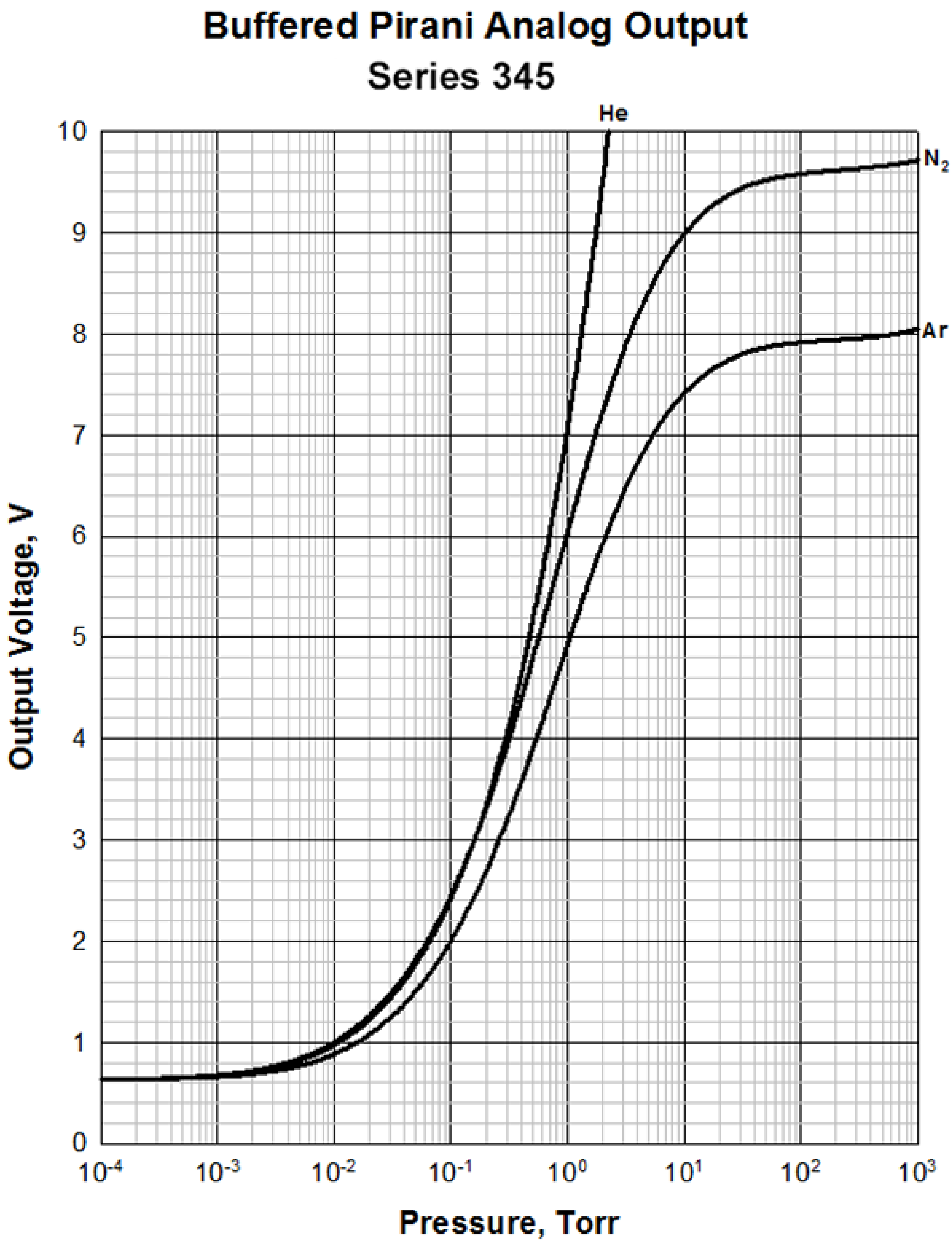


Figure 8-5 Buffered Analog Output for a 345 Pirani Sensor

Pressure, Torr	Buffered N_2 Vout, V	Buffered Ar Vout, V	Buffered He Vout, V
1.0E-04	0.6323	0.6324	0.6340
1.5E-04	0.6347	0.6339	0.6362
2.0E-04	0.6372	0.6355	0.6384
3.0E-04	0.6420	0.6385	0.6426
4.0E-04	0.6468	0.6414	0.6469
6.0E-04	0.6563	0.6474	0.6553
8.0E-04	0.6656	0.6533	0.6636
1.0E-03	0.6747	0.6591	0.6718
1.5E-03	0.6970	0.6734	0.6919
2.0E-03	0.7185	0.6875	0.7115
3.0E-03	0.7597	0.7147	0.7490
4.0E-03	0.7985	0.7408	0.7847
6.0E-03	0.8707	0.7905	0.8517
8.0E-03	0.9371	0.8371	0.9138
1.0E-02	0.9988	0.8812	0.9718
1.5E-02	1.1376	0.9824	1.1036
2.0E-02	1.2602	1.0735	1.2211
3.0E-02	1.4727	1.2344	1.4271
4.0E-02	1.6557	1.3751	1.6066
6.0E-02	1.9652	1.6162	1.9148
8.0E-02	2.2254	1.8213	2.1788
1.0E-01	2.4526	2.0015	2.4131
1.5E-01	2.9255	2.3794	2.9143
2.0E-01	3.3095	2.6885	3.3370
3.0E-01	3.9177	3.1815	4.0419
4.0E-01	4.3922	3.5686	4.6294
6.0E-01	5.1070	4.1556	5.5955
8.0E-01	5.6323	4.5898	6.3873
1.0E+00	6.0405	4.9289	7.0651
1.5E+00	6.7597	5.5295	8.4399
2.0E+00	7.2342	5.9282	9.5215
3.0E+00	7.8281	6.4295	11.1701
4.0E+00	8.1874	6.7340	
6.0E+00	8.6026	7.0869	
8.0E+00	8.8363	7.2858	
1.0E+01	8.9862	7.4136	
1.5E+01	9.1992	7.5950	
2.0E+01	9.3119	7.6909	
3.0E+01	9.4294	7.7908	
4.0E+01	9.4846	7.8398	
6.0E+01	9.5377	7.8835	
8.0E+01	9.5638	7.9034	
1.0E+02	9.5795	7.9149	
1.5E+02	9.6017	7.9306	
2.0E+02	9.6146	7.9400	
3.0E+02	9.6319	7.9539	
4.0E+02	9.6454	7.9664	
6.0E+02	9.6693	7.9922	
8.0E+02	9.6925	8.0200	
1.0E+03	9.7157	8.0502	

Table 8-6 Buffered Analog Output for the 345 Pirani Sensor

Range	Equation
Nitrogen	
0.63<V<9.3 V *1×10^{-4}<p <20 Torr*	$p=\left(\dfrac{1.585}{\dfrac{93.303}{V^2-0.3935}-1}\right)^{1.007}$
9.3 V< V <9.72 V *20 <p< 1×10^3 Torr*	$p=4123\times\left[(V-9.621)+\sqrt{(V-9.621)^2+1.34\times10^{-3}}\right]^{0.8696}$
Argon	
0.63<V<7.79 V *1×10^{-4} <p<20 Torr*	$p=\dfrac{1.663}{\dfrac{63.63}{V^2-0.3961}-1}$
7.79 V< V <8.05 V *30 <p< 1×10^3 Torr*	$p=2959\times\left[(V-7.9386)+\sqrt{(V-7.9386)^2+5.464\times10^{-4}}\right]^{0.729}$
Helium	
0.63<V<10 V *1×10^{-4} <3 Torr*	$p=\dfrac{9.287}{\dfrac{509.4}{V^2-0.3965}-1}$

Table 8-7 Equations for the 345 Pirani Sensor

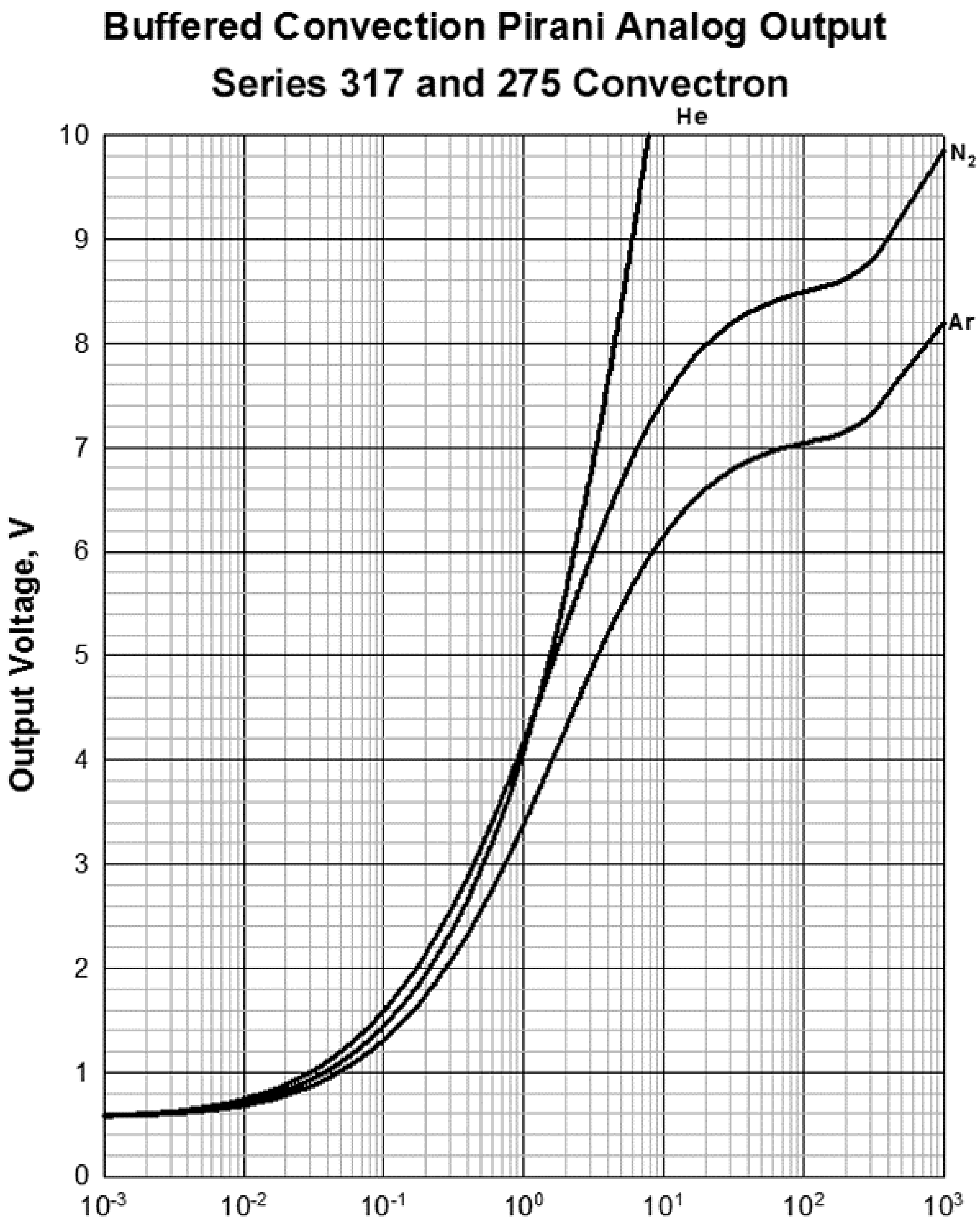


Figure 8-6 Buffered Analog Output for the 317 Convection Pirani Sensor or 275 Convectron Sensor

Pressure, Torr	Buffered N_2 Vout, V	Buffered Ar Vout, V	Buffered He Vout, V
1.0E-04	0.5639	0.5674	0.5654
1.5E-04	0.5650	0.5680	0.5663
2.0E-04	0.5660	0.5687	0.5671
3.0E-04	0.5681	0.5699	0.5688
4.0E-04	0.5702	0.5712	0.5705
6.0E-04	0.5744	0.5737	0.5738
8.0E-04	0.5785	0.5762	0.5771
1.0E-03	0.5825	0.5787	0.5803
1.5E-03	0.5925	0.5849	0.5883
2.0E-03	0.6023	0.5909	0.5961
3.0E-03	0.6213	0.6029	0.6114
4.0E-03	0.6397	0.6147	0.6262
6.0E-03	0.6748	0.6375	0.6547
8.0E-03	0.7081	0.6594	0.6818
1.0E-02	0.7397	0.6807	0.7077
1.5E-02	0.8130	0.7309	0.7685
2.0E-02	0.8799	0.7778	0.8244
3.0E-02	0.9993	0.8635	0.9256
4.0E-02	1.1050	0.9410	1.0161
6.0E-02	1.2884	1.0782	1.1755
8.0E-02	1.4465	1.1985	1.3147
1.0E-01	1.5870	1.3066	1.4398
1.5E-01	1.8866	1.5399	1.7110
2.0E-01	2.1371	1.7370	1.9427
3.0E-01	2.5480	2.0637	2.3341
4.0E-01	2.8825	2.3318	2.6645
6.0E-01	3.4139	2.7612	3.2168
8.0E-01	3.8301	3.1003	3.6784
1.0E+00	4.1716	3.3801	4.0811
1.5E+00	4.8207	3.9161	4.9231
2.0E+00	5.2897	4.3067	5.6142
3.0E+00	5.9352	4.8489	6.7300
4.0E+00	6.3647	5.2126	7.6243
6.0E+00	6.9069	5.6749	9.0227
8.0E+00	7.2375	5.9585	10.0998
1.0E+01	7.4611	6.1510	10.9720
1.5E+01	7.7955	6.4399	
2.0E+01	7.9814	6.6008	
3.0E+01	8.1820	6.7747	
4.0E+01	8.2885	6.8671	
6.0E+01	8.3954	6.9637	
8.0E+01	8.4563	7.0109	
1.0E+02	8.4917	7.0396	
1.5E+02	8.5547	7.0943	
2.0E+02	8.6178	7.1523	
3.0E+02	8.7804	7.3037	
4.0E+02	9.0106	7.5176	
6.0E+02	9.3827	7.8191	
8.0E+02	9.6467	8.0330	
1.0E+03	9.8515	8.1989	

Table 8-8 Buffered Analog Output for the 317 CP & 275 Convectron Sensors

Range	Equation
Nitrogen	
0.56<V<8.3 V *1×10^{-4}<p <40 Torr*	$p=\left(\dfrac{3.35}{\dfrac{74.327}{V^2-0.3156}-1}\right)^{1.01}$
8.3 V< V <8.8 V *40 <p< 300 Torr*	$p=399.5\sqrt{(V-8.503)+\sqrt{(V-8.503)^2+5.372\times10^{-3}}}$
p>300 Torr	$p=\exp\left(\dfrac{V-3.512}{0.9177}\right)$
Argon	
0.56<V<7.00 V *1×10^{-4}<p <60 Torr*	$p=\left(\dfrac{3.6}{\dfrac{51.083}{V^2-0.3205}-1}\right)^{1.002}$
7.00 V< V <7.4 V *60 <p< 300 Torr*	$p=411.2\sqrt{(V-7.042)+\sqrt{(V-7.042)^2+3.789\times10^{-3}}}$
P>300 Torr	$p=\exp\left(\dfrac{V-3.063}{0.7436}\right)$
Helium	
0.63<V<10 V *1×10^{-4} <4 Torr*	$p=\left(\dfrac{26.93}{\dfrac{456.3}{V^2-0.3177}-1}\right)^{1.017}$

Table 8-9 Equations for the 317 CP and 275 Convectron Sensors

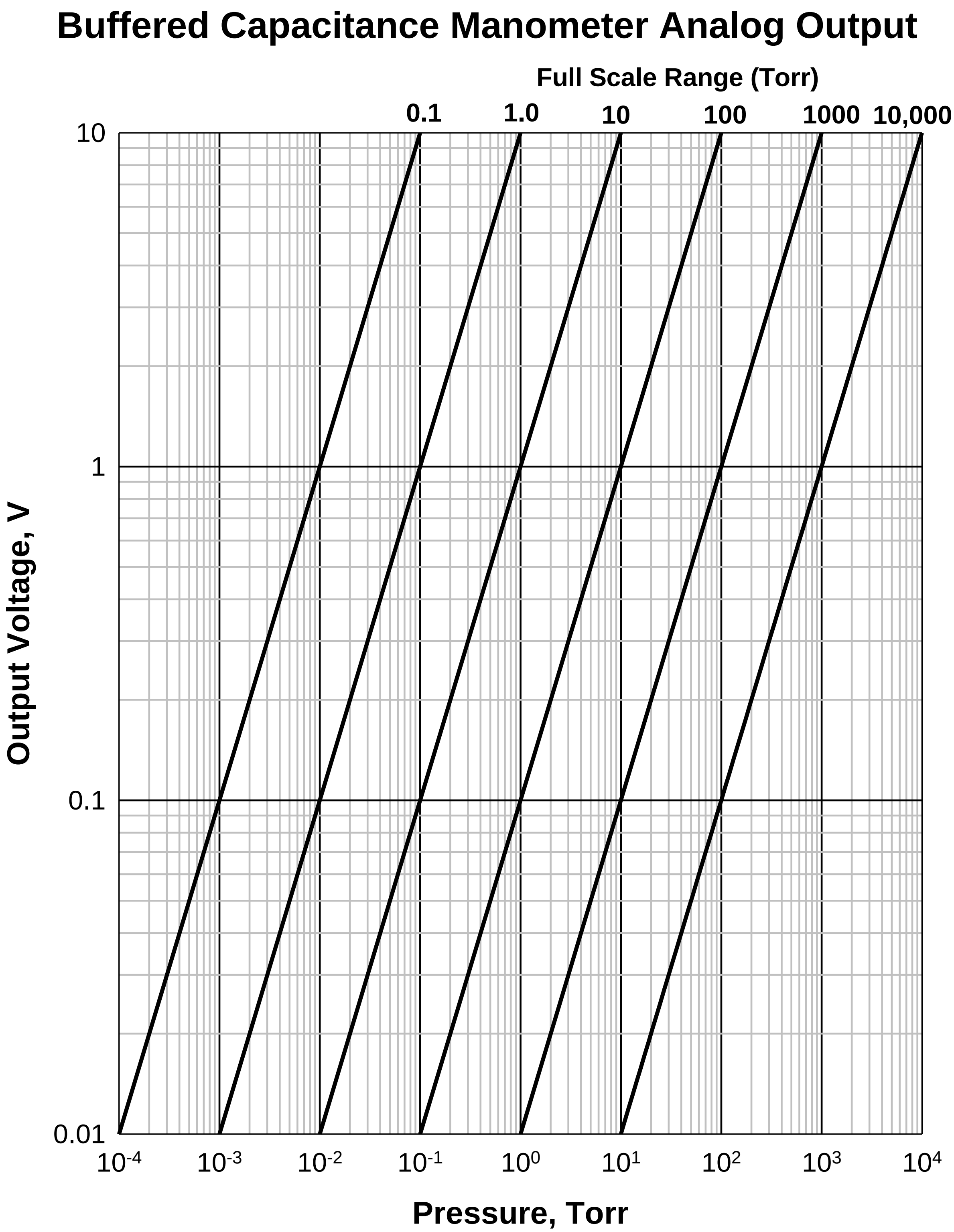


Figure 8-7 Buffered Analog Output for Capacitance Manometers

8.3 Logarithmic/Linear and Combination Analog Output

Since most of the buffered analog outputs are non-linear, logarithmically linearized or linear analog outputs are also provided for each individual sensor. However, since the logarithmic/linear analog outputs are processed by the microprocessor, these are updated only every 50 msec, regardless of the number of sensors being connected to the controller.

In addition to these Log/Lin analog outputs, 2 combination analog outputs are also available. Up to 3 sensors can be selected for a combination analog output.

8.3.1 Logarithmic/Linear Analog Output

There are two types of analog output that can be selected for each channel: logarithmic ($V = A \bullet \log(p) + B$) or linear ($V = A \bullet p$). These analog outputs are determined by the DACs inside the controller and can be modified by setting appropriate DAC parameters in the System Setup screen shown in Figure 6-6.

The default analog output for the controller is logarithmic having a slope of 0.6V per decade and an offset of 7.2 V ($V = 0.6 Log(p) + 7.2$). This provides an analog output ranging from 0.6 to 9.6 V (equivalent to a pressure range from $1X10^{-11}$ to $1X10^{4}$ Torr).

For detailed setting of the DAC parameters, refer to System Setup, Section 6.4.

8.3.2 Combination Analog Output

In addition to the logarithmic analog output for each individual sensor, two combination analog outputs are available. These can provide a wider pressure range coverage since the combination output combines the measurement ranges of multiple gauges.

When Capacitance Manometers are used in combination, no smoothing is provided in the overlap range. The 95% rule is used in switching the Capacitance Manometers. Once the reported pressure on the lower range Manometer is greater than 95% of its full scale, the combined analog output will be off the upper range Manometer.

A Pirani/Convection Pirani and capacitance manometer with a full scale of 500 torr or more, or a 902B piezo sensor, can be used in combination. When the Convection Pirani reading is greater than 5% of the full scale of the capacitance manometer the combined analog output will be based off the capacitance manometer.

When a capacitance manometer and a hot or cold cathode sensor are used in combination, the HC/CC pressure will be used as the combined analog output. The combined output will switch to the capacitance manometer only when the HC/CC is turned OFF.

If a Pirani/Convection Pirani and an HC/CC are used in combination, a smoothing formula is used where sensor ranges overlap (10^{-3} to 10^{-4} Torr). The combination output is 10V when power is ON but the combination option is disabled if a fault is detected when three gauges are used in combination. Possible faults include filament failure or cable disconnected.

To set the combination analog output from the panel, press the SYSTEM SETUP button, then move the cursor to Set Combination Ch Parameter and change to ON and press ENTER. A setup screen will appear as shown in Figure 8-8.

Set Combination Channel Parameter

	High	Middle	Low	Enable
Combo #1	C2	B1	A1	Enable
Combo #2	NA	NA	NA	Disable

Figure 8-8 Setup Screen for Setting Combination Channel Parameters

Once the combination sensors are selected, enable the combined analog output. If invalid channels are selected, the Enable indicator will stay in the Disabled mode.

The following rules may be used to simplify the combination configuration.

- The combination must include at least two pressure sensors.
- NA is when no sensor is assigned
- If either a Cold Cathode or Hot Cathode is included in the combination, it must be assigned as the low-pressure range sensor (“Low” in Figure 8.8).
- If a Pirani or Convection Pirani sensor is included in the combination, it must be assigned as the middle pressure range sensor (“Middle” in Figure 8.8).
- When a Pirani or Convection Pirani is used in combination, only HC/CC can be assigned to the low-pressure range sensor.
- Only capacitance manometer can be assigned as the high-pressure range sensor.
- If two or more capacitance manometers are used in a combination, the full scale (f.s) of the high range CM must be greater than or equal to the f.s. of the middle range CM, which in turn must have a f.s. greater or equal to the f.s. of the CM used for low range.
- When multiple capacitance manometers with same full-scale ranges are set in combination, the output is the average of the outputs from the CMs in combination.
- Only logarithmic analog output is available for combined analog output.

Combination pressure settings can also be accomplished using following serial commands:

- Query the pressure

  @254PC1?;FF for corresponding pressure of combined Aout 1 and **@254PC2?;FF** for the pressure of combined Aout 2.

- Set the sensor combination

  @254SPC1!HH,MM,LL;FF and **@254SPC2!HH,MM,LL;FF .** Here, **HH, MM** and **LL** are the channels **(A1, A2, B1, B2, C1, C2, NA)** corresponding to the sensor assigned to High, Middle, and Low range segments.

- Query the gauge combination

  @254SPC1?;FF and **@254SPC2?;FF .**

- Enable/disable the combined analog output

  @254EPC1!Enable;FF and **@254EPC1!Disable;FF .**

8.3.3 Logarithmic/Linear Analog Output when the Sensor Power is Turned OFF

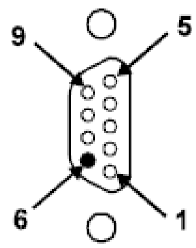
The following table shows the expected logarithmic/linear analog output when the sensor power is turned OFF or the combined analog output is disabled.

	Analog Out (Volts)	**Linear Out (volts)**	**Log-Linear Out (Volts)**
937B Power OFF	0	0	0
CP/Convectron channel OFF incl. gauge OFF via RP	0	10	10
CP/Convectron below range	See Analog Out Chart for CP Sensor	0	0.2
CP/Convectron filament failed	0	10	10
CP/Convectron cable disconnected	0	>10	>10
CC OFF from front panel; rear panel; via 'control' or 'protect'	11.5	10.5	10.5
HC OFF from front panel; rear panel; via 'control', 'protect', disconnected cable, or failed filament	10	10	10
CM (Absolute) below range	0	0	0.2
CM (Absolute) disconnected cable	-11	0	0.2
CM above range	11	10	9.8

Table 8-9 Expected Logarithmic/Linear Analog Output Values

9 RS232/485 Serial Communication Commands

9.1 Serial Communication Wiring Diagram



Pin	Description
2	RS485(-)/RS232TxD/(B)
3	RS485(+)/RS232RxD/(A)
5	Ground

Table 9-1 937B Serial Communication Wiring Diagram

9.2 Communication Protocols

Cable length with RS232 signals	50 ft (15 m)
Cable length with RS485 signals	4000 ft (1200 m)
Baud rate	9600, 19200, 38400, 57600, 115200
Character format	8 data bits, 1 stop bit, No parity, No hardware handshaking
Query format	**@<aaa><Command>?;FF** The corresponding response is **@<aaa>ACK<Response>;FF** Here, **<aaa>**: Address, 1 to 254 **<Command>**: Commands as described in 9.3 to 9.14 **<Response>** Responses as described in 9.3 to 9.14 For example, to query pressure on channel A1, use **@003PR1?;FF** and the corresponding response is **@003ACK7.602E+2;FF** Here**, <aaa>=003; <Command>=PR1; <Response>=7.602E+2**
Set format	**@<aaa><Command>!<parameter>;FF** The corresponding response is **@<aaa>ACK<Response>;FF** Here, **<aaa>**: address, 1 to 254 **<Command>** Commands as described in 9.3 to 9.13 **<Parameter>** Parameter as described in 9.3 to 9.13 **<Response>** Responses as described in 9.3 to 9.13 For example, to set new baud rate, use **@001BR!19200;FF** and the corresponding response is **@001ACK19200;FF** Here**, <aaa>=001; <Command>=BR; <Parameter>=19200; <Response>=19200**

Table 9-2 937B Serial Communication Command Protocol

9.3 Pressure Reading Commands

<table>
<tr><th>Command</th><th>Function</th><th>Response</th><th colspan="4">Meaning</th></tr>
<tr><td colspan="7">Single Channels</td></tr>
<tr><td rowspan="17">PRn
(n=1 to 6)</td><td rowspan="17">Read pressure on Channel n</td><td>d.d0E±ee
(d,e=0 to 9)</td><td colspan="4">Pressure in selected units for PR, CP, CC & HC</td></tr>
<tr><td>d.dddE±e
(d,e =0 to 9)</td><td colspan="4">Pressure in selected units for CM</td></tr>
<tr><td>-d.ddE±e
(d,e=0 to 9)</td><td colspan="4">CM, when CM output is negative.</td></tr>
<tr><td rowspan="5">LO<E-e</td><td>Sensor</td><td>e(Torr/mbar)</td><td>e(Pascal)</td><td>e(micron)</td></tr>
<tr><td>PR</td><td>4</td><td>2</td><td>1</td></tr>
<tr><td>CP</td><td>3</td><td>1</td><td>0</td></tr>
<tr><td>CC</td><td>11</td><td>9</td><td>8</td></tr>
<tr><td>HC</td><td>10</td><td>8</td><td>7</td></tr>
<tr><td>ATM</td><td colspan="4">PR when p>450 Torr</td></tr>
<tr><td>OFF</td><td colspan="4">Cold cathode HV is OFF, or HC/PR/CP power is OFF.</td></tr>
<tr><td>RP_OFF</td><td colspan="4">HC and CC power is turned OFF from rear panel control</td></tr>
<tr><td>WAIT</td><td colspan="4">CC or HC startup delay</td></tr>
<tr><td>LowEmis</td><td colspan="4">HC OFF due to low emission</td></tr>
<tr><td>CTRL_OFF</td><td colspan="4">CC or HC is OFF in controlled state</td></tr>
<tr><td>PROT_OFF</td><td colspan="4">CC or HC is OFF in protected state</td></tr>
<tr><td>MISCONN</td><td colspan="4">Sensor improperly connected, or broken filament (PR, CP only)</td></tr>
<tr><td>NO_GAUGE</td><td colspan="4">Controller unable to determine sensor connection.</td></tr>
<tr><td>PRZ</td><td>Read pressures on all channel</td><td>6 of above, separated by spaces</td><td colspan="4">Same as above</td></tr>
<tr><td colspan="7">Combination Channels</td></tr>
<tr><td rowspan="2">PCn
(n=1 or 2)</td><td rowspan="2">Read pressure on channel n and its combination sensor</td><td>d.d0E±ee
(d,e=0 to 9)</td><td colspan="4">Combined pressure in selected units</td></tr>
<tr><td>NAK181</td><td colspan="4">Combination disabled</td></tr>
</table>

Table 9-3 937B Pressure Reading Commands

9.4 Relay and Control Setting Commands

Command	Parameter	Response	Function
SPm (m=1 to 12)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query or set a set point for relay m, response with the current setting value. If 0 is used as the parameter, the set point will be set as its low limit value.
SHm (m=1 to 12)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query or set a hysteresis for relay m, response with the current setting value.
SDm (m=1 to 12)	**ABOVE** or **BELOW**	**ABOVE** or **BELOW**	Query or set the direction for relay m, response with the current setting value. For CC and HC, only BELOW can be selected.
		NAK162	For CC and HC as the relay direction is fixed to BELOW.
ENm (m=1 to 12)	**SET, ENABLE,** or **CLEAR**	**SET, ENABLE,** or **CLEAR**	Query or set status for relay m. Response with current Enable status. **ENABLE** enables the relay, its status depends on the pressure and set point value, **SET** forces relay activation, regardless of pressure, and **CLEAR** disable relay.
SSm (m=1 to 12)		**SET** or **CLEAR**	Query all the relay setting status, **SET** is activated, and **CLEAR** is disabled.
ENA		**ddd..ddd** (d=0,1,2)	Query single relay set point status (relay1 relay 2 …relay 12). 0: clear; 1: set; 2: enable.
SSA		**ddd..ddd** **(d=0,1)**	Query all 12 relay set point status (relay1 relay 2 relay 12). 0: clear; 1: set.

Table 9-4 937B Relay and Control Serial Setting Commands

9.5 Capacitance Manometer Control Commands

Command	Parameter	Response	Function
RNGn (n=1 to 6)	**d.dd E±ee**	**d.dd E±ee**	Query or set the full-scale pressure measurement range for a capacitance manometer. Valid range is from 0.01 to 10000, and default range is 1000 Torr.
CMTn (n=1 to 6)	**ABS** or **Diff**	**ABS** or **Diff**	Query or set the Capacitor Manometer type, either absolute or differential.
BVRn (n=1 to 6)	**5 or 10** for ABS **1B, 5B, 1U, 5U or 10U** for Diff	**5 or 10** for ABS **1B, 5B, 1U, 5U or 10U** for Diff	Query or set the full scale voltage output range for a capacitance manometer. Default = 10V.
ATZn (n=1 to 6)		**OK** or **NAK**	Zero a differential Capacitance Manometer on channel n.
VACn (n=1 to 6)		**OK** or **NAK**	Zero a capacitance manometer on channel n. Execute only when the signal is less than 5% of the full scale.
AZn (n=1 to 6)	**A1, B1, A2, B2, C1, C2, NA**	**A1, B1, A2, B2, C1, C2, NA**	Query or set capacitance manometer autozero control channel n, or disable autozero (NA). Execute only when the signal is less than 5% of the full scale.

Table 9-5 937B Capacitance Manometer Serial Commands

9.6 Convection Pirani, Convectron and Pirani Control Commands

Command	Parameter	Response	Function
ATMn (n=1 to 6)	**d.ddE+ee** (ambient pressure)	**d.ddE+ee**	Send an atmospheric pressure to perform ATM calibration. The PR/CP must be at atmospheric pressure when running ATM calibration. Valid range is from 100 to 1000.
VACn (n=1 to 6)		**OK** or **NAK**	Zero a PR/CP on channel n. Execute only when the pressure reading is less than $1X10^{-2}$ Torr.
AZn (n=1 to 6)	**A1, B1, A2, B2, C1, C2, NA**	**A1, B1, A2, B2, C1, C2, NA**	Query or set an autozero (CC or HC) control channel n for a PR/CP, or disable autozero (NA). Execute only when the pressure reading is less than $1X10^{-2}$ Torr.
GTn (n=1 to 6)	**Nitrogen** **Argon** **Helium**	**Nitrogen** **Argon** **Helium**	Query or set a gas type for PR/CP on channel n.
CPn (n=1 to 6)	**ON** or **OFF**	**ON** or **OFF**	Query the channel power status for PR, CP, HC or high voltage status for CC. Turn ON/OFF the channel power for PR, CP, HC, or high voltage for CC).
PTn (n=1 to 6)	**AUTO** **PR** **CP**	**AUTO** **PR** **CP** **AUTO-PR** **AUTO-CP**	Query or set Pirani sensor type on channel n. If Pirani type is set to PR or CP, the PTn command will respond PR or CP. If the Pirani is set to AUTO, the PTn command will response with the Pirani type it auto detects, i.e. AUTO-PR, when it detects the PR.

Table 9-6 937B Pirani and Convection Pirani Control Commands

9.7 Cold Cathode Control Commands

Command	Parameter	Response	Function
PROn (n=1, 3, 5)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query or set protection set point value for sensor on channel n. The valid PRO range is $1x10^{-5}$ to $1x10^{-2}$ Torr. Use 0.0 to disable the protect set point control. Default value is $5x10^{-3}$ Torr.
CSPn (n=1, 3, 5)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query and set control set point value for a CC sensor on channel n. Valid CSP range is $5x10^{-4}$ to $1x10^{-2}$ Torr for Pirani, $2x10^{-3}$ to $1x10^{-2}$ Torr for convention Pirani, and 0.2% of Full scale to 0.02 Torr for Capacitance Manometer. Capacitance Manometer full scale range has to be =< 2 Torr. Control channel (CSE command) needs to be set to a valid channel prior to setting this command.
XCSn (n=1, 3, 5)	**ON** or **OFF**	**ON** or **OFF**	Query or set the upper control set point status. If “ON” the range extended from $1x10^{-2}$ Torr to $9.5x10^{-1}$ Torr.
CHPn (n=1, 3, 5)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query and set control set point hysteresis value for a CC sensor on channel n. Valid CHP range is 1.2×CSP to $1.1x10^{-2}$ Torr for Convention Pirani and Pirani, and 1.2×CSP to 0.03 Torr for Capacitance Manometer. Default value is 1.5X the control set point value.
CSEn (n=1, 3, 5)	**A1, B1, A2, B2, C1, C2, OFF**	**A1, B1, A2, B2, C1, C2, OFF**	Query, enable/disable the control channel status for a CC gauge on channel n.
CTLn (n=1, 3, 5)	**AUTO, SAFE, OFF**	**AUTO, SAFE, OFF**	AUTO: CC sensor can be turned ON & OFF by the controlling sensor. SAFE, CC sensor can be turned OFF, but not be turned ON by the controlling sensor.
UCn (n=1,3, 5)	**dd.d** (d=0 to 9)	**dd.d** (d=0 to 9)	Query or set a gas correction factor for a CC on Channel n. Valid range is from 0.1 to 10.0.
CPn (n=1,3, 5)	**ON** or **OFF**	**ON** or **OFF**	Query the channel power status for PR, CP, HC or high voltage status for CC. Turn ON/OFF the channel power for PR, CP, HC, or high voltage for CC).
GTn (n=1,3, 5)	**Nitrogen** **Argon** **Helium**	**Nitrogen** **Argon** **Helium**	Query or set a gas type for HC/CC on channel n.
Tn (n=1,3, 5)		**W, O, G, P, C, R, H, L**	Sensor status query. W = WAIT; P = PROTECT O = OFF; R = Rear panel Ctrl OFF G = GOOD; H = High C = Control; L = LOW
TDCn (n=1,3, 5)	**ddd** (d=0 to 9)	**ddd** (d=0 to 9)	Time delay until relays and output for CG are active, 3 to 300 secs
FRCn (n=1,3,5)	**d.d E±ee** (d,e=0 to 9)	**d.d E±ee** (d,e=0 to 9)	Query or set the pressure to trigger fast relay control output. Only available for special CC board with fast relay, and the set point value needs to be between $5x10^{-5}$ to $2x10^{-10}$ Torr.

Table 9-7 937B Cold Cathode Control Commands

9.8 Hot Cathode Control Commands

Command	Parameter	Response	Function
PROn (n=1, 3, 5)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9) **DISABLE**	Query or set protection set point value for sensor on channel n. The valid PRO range is $1x10^{-5}$ to $1x10^{-2}$ Torr. Use 0.0 to disable the protect set point control. Default value is $5x10^{-3}$ Torr.
CSPn (n=1, 3, 5)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query and set control set point value for a sensor on channel n. Valid CSP range is $5x10^{-4}$ to $1x10^{-2}$ Torr for Pirani, $2x10^{-3}$ to $1x10^{-2}$ Torr for Convention Pirani, and 0.2% of Full scale to 0.02 Torr for Capacitance Manometer. Capacitance Manometer full scale range has to be =< 2 Torr. Control channel (CSE command) needs to be set to a valid channel prior to setting this command.
XCSn (n=1, 3, 5)	**ON** or **OFF**	**ON** or **OFF**	Query or set the upper control set point status. If "ON" the range extended from $1x10^{-2}$ Torr to $9.5x10^{-1}$ Torr.
CHPn (n=1, 3, 5)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query and set control set point hysteresis value for an HC sensor on channel n. Valid CHP range is 1.2×CSP to 1.1×10^{-2} Torr for Convention Pirani and Pirani, and 1.2×CSP to 0.03 Torr for Capacitance Manometer. Default value is 1.5X the control set point value.
CSEn (n=1, 3, 5)	**A1, B1, A2, B2, C1, C2, OFF**	**A1, B1, A2, B2, C1, C2, OFF**	Query, enable/disable the control channel status for an HC sensor on channel n.
CTLn (n=1, 3, 5)	**AUTO, SAFE, OFF**	**AUTO, SAFE, OFF**	AUTO: HC/CC can be turned ON & OFF by the controlling sensor (PR/CP). SAFE Sensor can be turned OFF, but not be turned ON by the controlling sensor. If no PR/CP exists, this function cannot be enabled.
AFn (n=1,3, 5)	**1 or 2**	**1 or 2**	Query or set active filament for HC.
ECn (n=1,3, 5)	**20UA** **100UA** **AUTO20** **AUTO100**	**20UA** **100UA** **AUTO20** **AUTO100**	Query or set emission current.
GCn (n=1,3, 5)	**d.dd** (d =0 to 9)	**d.dd** (d =0 to 9)	Query or set a gas correction factor for an HC sensor on Channel n. Valid range is from 0.1 to 50.0. GT must be set to CUSTOM.
CPn (n=1,3, 5)	**ON** or **OFF**	**ON** or **OFF**	Query the channel power status for PR, CP, HC or high voltage status for CC. Turn ON/OFF the channel power for PR, CP, HC, or high voltage for CC).
SENn (n=1,3, 5)	**d.dd** (d =0 to 9)	**d.dd** (d =0 to 9)	Query or set a gas sensitivity for an HC sensor on Channel n. Valid range is from 1 to 50.0.
DGn (n=1,3, 5)	**ON** or **OFF**	**ON** or **OFF**	Query the HC degas status Turn ON/OFF degas
DGTn (n=1,3, 5)	**ddd** (d=5-240)	**ddd** (d=5-240)	Query and set the HC degas time.
GTn (n=1,3, 5)	**Nitrogen** **Argon** **Helium** **Custom**	**Nitrogen** **Argon** **Helium** **Custom**	Query or set a gas type for HC/CC on channel n. When Custom is selected, one can select GC value other than N_2, Ar or He.
Tn (n=1,3, 5)		**W, O, P, D, C, R, F, N, H**	HC sensor status query. W = WAIT O = OFF P = PROTECT D = DEGAS C = Control R = Rear panel Ctrl OFF F = HC filament fault N = No sensor

Table 9-8 937B Hot Cathode Control Commands

9.9 System Commands

Command	Parameter	Response	Function
AD	**aaa** (**aaa**=001 to 253)	**aaa** (**aaa**=001 to 253)	Query or set controller address (1 to 253) 254 is reserved for broadcasting. Default = 253.
BR	#	#	Query or set baud rate (valid # = 9600, 19200, 38400, 57600, 115200), default = 9600.
PAR	**NONE** **EVEN** **ODD**	**NONE** **EVEN** **ODD**	Query or set the parity for the controller. Default=NONE.
DLY	**t** msec	**t** msec	485 time delay, t must ≥ 1 for reliable 485 communication. Default = 8 msec.
U	**Unit**	**Unit**	Pressure unit, Unit=Torr, MBAR, PASCAL, Micron
DM	**STD** or **LRG**	**STD or LRG**	Display mode: either standard display, or large font display. Default = STD.
DF	**Default** **PatchZ** **HighR**	**Default** **PatchZ** **HighR**	Display format: either default, patch zero, or high resolution (only for HC and CC). Default = Default.
LOCK	**ON** or **OFF**	**ON** or **OFF**	Enable (ON) or disable (OFF) front panel lock
CAL	**Enable** **Disable**	**Enable** **Disable**	Enable or disable User Calibration, default = Enable.
SPM	**Enable** **Disable**	**Enable** **Disable**	Enable or disable parameter setting, default = Enable.
MT		**T1,T2,T3,T4**	Display the sensor module type. T1, T2, T3=(CC, HC, CM, PR, FC, NC). NC= no connection. T4=(NA, PF for PROFIBUS, PC)
STn **(n=A, B, C)**		**S1S2**	Display the connected sensor type on the specified module (A, B, or C). S1,S2=CC,PR,CP,CM,FC,HC, NG. NC=no connection.
MD		**937B** or **937B**	Type of controller, either 937B, or 937B.
FDn (n=1 to 6)		**OK**	Factory default for sensor module. This will reset the user calibration to factory default.
FDS		**OK**	Factory default for system setup (including address, unit, baud rate, recipes, combination, display format, screen saver)
FVn (n=1 to 6)		**d.dd** (d=0 to 9)	Firmware version n=1=Slot A; n=2=Slot B; n=3=Slot C n=4=AIO; n=5=COMM; n=6=Main
SN		**10 digit SN**	Display the serial number of the unit.
SNn (n=1 to 6)	**Read serial number in slot n**	**10 digit SN**	Display the serial number of the card in slot A, B, C, CO M, Analog and Main
SPCn (n=1 or 2)	**HH,MM,LL**	**HH,MM,LL**	Set or query the combination channel setting. HH: The channel for HP sensor. MM: The channel for MP sensor. LL: The channel for LP sensor. Valid values for HH, MM, or LL are A1, A2, B1, B2, C1, C2, or NA. Default is NA.
EPCn (n=1 or 2)	**Enable** **Disable**	**Enable** **Disable**	Enable or disable the combination channel. When the combination channel is disabled, the output is 10 V.

DLTn (n=1 to 6)	**LIN** or **LOG**	**LIN** or **LOG**	Query or set the type of DAC linear (LIN, V=A*P) of logarithmic linear (LOG, V=A*LogP+B) output. Default setting is LOG. (Only LOG is allowed for combined output)
DLAn (n=0 to 6)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query or set the DAC slope parameter A. Default value is 0.6. Use n=0 for combination output. Valid range is from 0.5 to 5 when DLT is set to LOG, and 1E-4 to 1E+8 when DLT is set to LIN.
DLBn (n=0 to 6)	**d.dd E±ee** (d,e=0 to 9)	**d.dd E±ee** (d,e=0 to 9)	Query or set the DAC offset parameter B. Default value is 7.2. Use n=0 for combination output. Valid range is from –20 to 20 when DLT is set to LOG, and always equals to zero when DLT is set to LIN.
IU	**ON** or **OFF**	**ON** or **OFF**	Force the use of international pressure unit (Pascal).
XDL			Erase the first page of the memory for preparing the firmware downloading using Sam-BA after power cycle of the controller.
SEM	**TXT** or **CODE**	**TXT** or **CODE**	Set the NAK error code response. An error text string is returned if it is set to TXT, while an error code is returned if it is set to CODE.
SST	**0** to **240**	**OFF, 1** to **240**	Set and query the screen saver time (in minute) when sleep mode (turn OFF front panel display) is activated. 0 means the screen saver mode is disabled.

Table 9-9 937B System Commands

9.10 Error Codes

When serial commands are used in communicating with 937B, an error code will be returned if an invalid command or an invalid parameter is sent. The error code can be displayed in either in TXT or CODE mode, and can be selected by using @254SEM!TXT;FF or @254SEM!CODE;FF command, respectively.

937B Error Codes	
CODE	**TXT**
150	WRONG_GAUGE
151	NO_GAUGE
152	NOT_IONGAUGE
153	NOT_HOTCATHODE
154	NOT_COLDCATHODE
155	NOT_CAPACITANCE_MANOMETER
156	NOT_PIRANI_OR_CTP
157	NOT_PR_OR_CM
158	NOT_MFC
159	NOT_VLV
160	UNRECOGNIZED_MSG
161	SET_CMD_LOCK
162	RLY_DIR_FIX_FOR_ION
163	INVALID_CHANNEL
164	DIFF_CM
165	INVALID_PID_PARAM
166	PID_IN_PROGRESS
167	INVALID_RATIO_PARAM
168	NOT_IN_DEGAS
169	INVALID_ARGUMENT
172	VALUE_OUT_OF_RANGE
173	INVALID_CTRL_CHAN
175	CMD_QUERY_BYTE_INVALID
176	NO_GAS_TYPE
177	NOT_485
178	CAL_DISABLED
179	SET_POINT_NOT_ENABLED
181	COMBINATION_DISABLED
182	INTERNATIONAL_UNIT_ONLY
183	GAS_TYPE_DEFINED
191	NOT_RATIO_MODE
195	CONTROL_SET_POINT_ENABLED
199	PRESSURE_TOO_HIGH_FOR_DEGAS

Table 9-10 937B Serial Communication Error Codes

9.11 937B ProfiBus communication protocol and commands

9.11.1 Electrical Connections

Pin Number	Description
3	RxD/TxD+
8	RxD/TxD-
6	V+ (+5Vdc)
5	Ground

Table 9-11 937B PROFIBUS electrical connections.

The address for PROFIBUS ranges from 00 to 99 (decimal) and can be selected from two switches on the rear panel of the optional 937B PROFIBUS module.

9.11.2 937B PROFIBUS GSD protocol

The GSD File name is 937B0D72.GSD, the ID Number is 0D72 hex. The PROFIBUS commands are a subset of RS232/485 serial commands and are listed in the following table.

Although this GSD protocol lists commands for MFCs, MFCs cannot be operated by the 937B.

PROFIBUS Command	Equivalent RS232 Cmd	Parameter Data Byte	Parameter values/range
Autozero Ch A1	AUTZ1	3	Disable Ch A1, CH A2 Ch B1, CH B2 Ch C1, CH C2 Local Setting
Autozero Ch A2	AUTZ2	4	
Autozero Ch B1	AUTZ3	5	
Autozero Ch B2	AUTZ4	6	
Autozero Ch C1	AUTZ5	7	
Autozero Ch C2	AUTZ6	8	
Gas Type Ch A1	GT1	9	Nitrogen Argon Helium Custom (HC only) Local Setting
Gas Type Ch A2	GT2	10	
Gas Type Ch B1	GT3	11	
Gas Type Ch B2	GT4	12	
Gas Type Ch C1	GT5	13	
Gas Type Ch C2	GT6	14	
Front Panel	LOCK	15	Disable/Enable/ Local Setting
Set Parameter	SPM	16	Disable/Enable/ Local Setting
Unit	U	17	Torr/Mbar/Pascal/ Local Setting
Protection Set point Ch A1	PRO1	18	1E-5, 2E-5, 4E-5, 8E-5, 1E-4, 2E-4, 4E-4, 8E-4, 1E-3, 2E-3, 4E-3, 8E-3, 1E-2, Local Setting
Protection Set point Ch A2	PRO2	19	
Protection Set point Ch B1	PRO3	20	
Protection Set point Ch B2	PRO4	21	
Protection Set point Ch C1	PRO5	22	
Protection Set point Ch C2	PRO6	23	
Ctrl Chan For Ch A1	CSE1	24	Disable/Ch A1/Ch A2/Ch B1/Ch B2/Ch C1/Ch C2, Local Setting
Ctrl Chan For Ch A2	CSE2	25	
Ctrl Chan For Ch B1	CSE3	26	
Ctrl Chan For Ch B2	CSE4	27	
Ctrl Chan For Ch C1	CSE5	28	
Ctrl Chan For Ch C2	CSE6	29	
Ctrl Set point Ch A1	CSP1	30	4E-4, 8E-4, 1E-3, 2E-3, 4E-3, 8E-3, 1E-2, Local Setting
Ctrl Set point Ch A2	CSP2	31	
Ctrl Set point Ch B1	CSP3	32	

Ctrl Set point Ch B2	CSP4	33	
Ctrl Set point Ch C1	CSP5	34	
Ctrl Set point Ch C2	CSP6	35	
Ctrl Enable Ch A1	CTL1	36	Off/Safe/Auto/ Local Setting
Ctrl Enable Ch A2	CTL2	37	
Ctrl Enable Ch B1	CTL3	38	
Ctrl Enable Ch B2	CTL4	39	
Ctrl Enable Ch C1	CTL5	40	
Ctrl Enable Ch C2	CTL6	41	
Fast Relay Ctrl Ch A1	FRC1	42	1E-7, 2E-7, 4E-7, 8E-7, 1E-6, 2E-6, 4E-6, 8E-6, 1E-5, 2E-5, 4E-5, 8E-5, 1E-4, Local Setting
Fast Relay Ctrl Ch B1	FRC3	43	
Fast Relay Ctrl Ch C1	FRC5	44	
HC degas time Ch A1	DGT1	45	3 TO 240
HC degas time Ch A2	DGT2	46	
HC degas time Ch B1	DGT3	47	
HC degas time Ch B2	DGT4	48	
HC degas time Ch C1	DGT5	49	
HC degas time Ch C2	DGT6	50	

Table 9-12 937B PROFIBUS command list.

9.11.3 937B PROFIBUS output buffer map

NOTE: Commands relating to MFCs or flow are not available on the 937B Controller.

OUTPUT Buffer Map				
Offset	**Size**	**Format**	**Description**	
0	1	Bit field	Bit 0	Enable / Clear Set point Relay 1
			Bit 1	Enable / Clear Set point Relay 2
			Bit 2	Enable / Clear Set point Relay 3
			Bit 3	Enable / Clear Set point Relay 4
			Bit 4	Enable / Clear Set point Relay 5
			Bit 5	Enable / Clear Set point Relay 6
			Bit 6	Enable / Clear Set point Relay 7
			Bit 7	Enable / Clear Set point Relay 8
1	1	Bit field	Bit 0	Enable / Clear Set point Relay 9
			Bit 1	Enable / Clear Set point Relay 10
			Bit 2	Enable / Clear Set point Relay 11
			Bit 3	Enable / Clear Set point Relay 12
			Bit 4	N/A
			Bit 5	N/A
			Bit 6	N/A
			Bit 7	N/A
2	1	Bit field	Bit 0	Power CC/HC/PR Channel A1
			Bit 1	Power CC/HC/PR Channel A2
			Bit 2	Power CC/HC/PR Channel B1
			Bit 3	Power CC/HC/PR Channel B2
			Bit 4	Power CC/HC/PR Channel C1
			Bit 5	Power CC/HC/PR Channel C2
			Bit 6	N/A
			Bit 7	N/A
3	1	Bit field	Bit 0	Set point/Close Mode for MFC on Channel A1
			Bit 1	Set point/Close Mode for MFC on Channel A2
			Bit 2	Set point/Close Mode for MFC on Channel B1
			Bit 3	Set point/Close Mode for MFC on Channel B2
			Bit 4	Set point/Close Mode for MFC on Channel C1
			Bit 5	Set point/Close Mode for MFC on Channel C2
			Bit 6	N/A
			Bit 7	**PID control enable/disable**
4	1	Bit field	Bit 0	Degas HC Channel A1
			Bit 1	Degas HC Channel A2
			Bit 2	Degas HC Channel B1
			Bit 3	Degas HC Channel B2
			Bit 4	Degas HC Channel C1
			Bit 5	Degas HC Channel C2
			Bit 6	N/A
			Bit 7	N/A

5	1	Bit field	Bit 0	Active Filament Select HC Channel A1
			Bit 1	Active Filament Select HC Channel A2
			Bit 2	Active Filament Select HC Channel B1
			Bit 3	Active Filament Select HC Channel B2
			Bit 4	Active Filament Select HC Channel C1
			Bit 5	Active Filament Select HC Channel C2
			Bit 6	N/A
			Bit 7	N/A
6	1	Bit field	Bit 0	Manual Zero PR/CM/MFC Channel A1
			Bit 1	Manual Zero PR/CM/MFC Channel A2
			Bit 2	Manual Zero PR/CM/MFC Channel B1
			Bit 3	Manual Zero PR/CM/MFC Channel B2
			Bit 4	Manual Zero PR/CM/MFC Channel C1
			Bit 5	Manual Zero PR/CM/MFC Channel C2
			Bit 6	N/A
			Bit 7	N/A
7	1	Bit field	Bit 0	Factory Default Channel A1
			Bit 1	Factory Default Channel A2
			Bit 2	Factory Default Channel B1
			Bit 3	Factory Default Channel B2
			Bit 4	Factory Default Channel C1
			Bit 5	Factory Default Channel C2
			Bit 6	N/A
			Bit 7	N/A
8	4	Float		Relay Set point Pressure for Relay 1
12	4	Float		Relay Set point Pressure for Relay 2 Flow Set point for Channel A1 (MFC only)
16	4	Float		Relay Set point Pressure for Relay 3
20	4	Float		Relay Set point Pressure for Relay 4 Flow Set point for Channel A2 (MFC only)
24	4	Float		Relay Set point Pressure for Relay 5
28	4	Float		Relay Set point Pressure for Relay 6 Flow Set point for Channel B1 (MFC only)
32	4	Float		Relay Set point Pressure for Relay 7
36	4	Float		Relay Set point Pressure for Relay 8 Flow Set point for Channel B2 (MFC only)
40	4	Float		Relay Set point Pressure for Relay 9
44	4	Float		Relay Set point Pressure for Relay 10 Flow Set point for Channel C1 (MFC only)
48	4	Float		Relay Set point Pressure for Relay 11
52	4	Float		Relay Set point Pressure for Relay 12 Flow Set point for Channel C2 (MFC only)

Table 9-13 937B PROFIBUS output buffer map.

9.11.4 937B PROFIBUS input buffer map

INPUT Buffer Map				
Offset	**Size**	**Format**	**Description**	
0	4	Float		Pressure Channel 1
4	4	Float		Pressure Channel 2
8	4	Float		Pressure Channel 3
12	4	Float		Pressure Channel 4
16	4	Float		Pressure Channel 5
20	4	Float		Pressure Channel 6
24	1	Byte	Status for Channel 1	
			1	NOGAUGE
			2	NEGATIVE
			3	CONTROL
			4	HI
			5	LO
			6	OFF
			7	AA
			8	PROTECT
			9	WAIT
			10	RP_OFF
			11	Degas
			12	FAULT
			13	OPEN (for MFC only)
			14	CLOSE(for MFC only)
			15	SET POINT(for MFC only)
			16	PID(for MFC only)
25	1	Byte	Status for Channel 2	
			1	NOGAUGE
			2	NEGATIVE
			3	CONTROL
			4	HI
			5	LO
			6	OFF
			7	AA
			8	PROTECT
			9	WAIT
			10	RP_OFF
			11	Degas
			12	FAULT
			13	OPEN (for MFC only)
			14	CLOSE(for MFC only)
			15	SET POINT(for MFC only)
			16	PID(for MFC only)
26	1	Byte	Status for Channel 3	
			1	NOGAUGE
			2	NEGATIVE
			3	CONTROL
			4	HI

			5	LO
			6	OFF
			7	AA
			8	PROTECT
			9	WAIT
			10	RP_OFF
			11	Degas
			12	FAULT
			13	OPEN (for MFC only)
			14	CLOSE(for MFC only)
			15	SET POINT(for MFC only)
			16	PID(for MFC only)
27	1	Byte	Status for Channel 4	
			1	NOGAUGE
			2	NEGATIVE
			3	CONTROL
			4	HI
			5	LO
			6	OFF
			7	AA
			8	PROTECT
			9	WAIT
			10	RP_OFF
			11	Degas
			12	FAULT
			13	OPEN (for MFC only)
			14	CLOSE(for MFC only)
			15	SET POINT(for MFC only)
			16	PID(for MFC only)
28	1	Byte	Status for Channel 5	
			1	NOGAUGE
			2	NEGATIVE
			3	CONTROL
			4	HI
			5	LO
			6	OFF
			7	AA
			8	PROTECT
			9	WAIT
			10	RP_OFF
			11	Degas
			12	FAULT
			13	OPEN (for MFC only)
			14	CLOSE(for MFC only)
			15	SET POINT(for MFC only)
			16	PID(for MFC only)
29	1	Byte	Status for Channel 6	
			1	NOGAUGE

			2	NEGATIVE
			3	CONTROL
			4	HI
			5	LO
			6	OFF
			7	AA
			8	PROTECT
			9	WAIT
			10	RP_OFF
			11	Degas
			12	FAULT
			13	OPEN (for MFC only)
			14	CLOSE(for MFC only)
			15	SET POINT(for MFC only)
			16	PID(for MFC only)
30	1	Bit Field	Bit 0	Set point Relay State Relay 1
			1	Set point Relay State Relay 2
			2	Set point Relay State Relay 3
			3	Set point Relay State Relay 4
			4	Set point Relay State Relay 5
			5	Set point Relay State Relay 6
			6	Set point Relay State Relay 7
			7	Set point Relay State Relay 8
31	1	Bit Field	Bit 0	Set point Relay State Relay 9
			1	Set point Relay State Relay 10
			2	Set point Relay State Relay 11
			3	Set point Relay State Relay 12
			4	N/A
			5	N/A
			6	N/A
			7	N/A
32	4	Float		Set point Relay State Relay 1
36	4	Float		Set point Relay State Relay 2
40	4	Float		Set point Relay State Relay 3
44	4	Float		Set point Relay State Relay 4
48	4	Float		Set point Relay State Relay 5
52	4	Float		Set point Relay State Relay 6
56	4	Float		Set point Relay State Relay 7
60	4	Float		Set point Relay State Relay 8
64	4	Float		Set point Relay State Relay 9
68	4	Float		Set point Relay State Relay 10
72	4	Float		Set point Relay State Relay 11
76	4	Float		Set point Relay State Relay 12
80	4	Byte		Reserved
81	4	Byte		Reserved

Table 9-14 937B PROFIBUS Input Buffer Map.

10 Maintenance of Series 937B Controller Modules

Lethal voltages are present in the controller when it is powered. Disconnect the power cable before disassembly. Do not connect or disconnect any electrical connectors while power is applied to the equipment (hot swapping). Doing so may cause damage to the equipment or severe electrical shock to personnel. This hazard is not unique to this product.

The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.

Suitable ESD handling precautions should be followed while installing, configuring or adjusting the instrument or any modules.

There are 3 sensor module slots (A, B, and C) available in the 937B Controller. Sensor module plug-in boards (Pirani/CP, Capacitance Manometer, Cold Cathode, Hot Cathode) can be inserted into any available slot and the controller will automatically recognize the type of the module in the slot. Typically, 937B Controllers are shipped with customer-specified sensor modules.

To change the controller configuration by removing and installing modules, follow the steps shown below.

10.1 Removing and Installing a Sensor Module

To remove a module:

1. Assure that the 937B power is OFF, and the power cord is disconnected.
2. Use a #1 Phillips screwdriver to remove the two screws on the top and bottom of the rear panel of the module.
3. Use a small, flat-blade screwdriver to gently pry the module away from the rear panel frame until it slides freely.
4. **Carefully** slide the module out.
5. Place the module on a static-protected workbench.

To install a module:

☞ ***A pressure sensor module (with 32-pin DIN) can only be inserted into slots A, B or C. It will not fit into the COM slot!***

1. Make sure that the controller power is OFF and the power cord is disconnected.
2. If there is a blanking panel over the slot, use a #1 Phillips screwdriver to remove the two screws on the top and bottom of the blank panel.
3. Align the module to fit and slide freely in the **card guides**, with the internal 32-pin DIN connector end first.
4. Gently slide the module forward.
5. Use a #1 Phillips screwdriver to tighten two screws on the top and bottom of the rear panel of the module.

10.2 Removing and Installing AIO Module

The power cord receptor, the RS232/485 communication 9-pin D-Sub connector, the 25 pin D-Sub Relay output connector, and the 37-pin D-Sub Analog output connectors are located on the back panel of the AIO (Analog Input/Output) module.

To remove the AIO module:

Lethal voltages are present in the controller when it is powered. Disconnect the power cable before proceeding.

Suitable ESD handling precautions should be followed while installing, configuring or adjusting the instrument or any modules.

1. Assure that the controller power is OFF and the power cord is disconnected.
2. Use a #1 Phillips screwdriver to remove the four (4) screws on the four corners of the rear panel of the AIO module.
3. Place a small, flat-bladed screwdriver at the top right corner of the AIO module (as shown below) and gently pry the AIO module away from the rear panel frame until it slides easily.

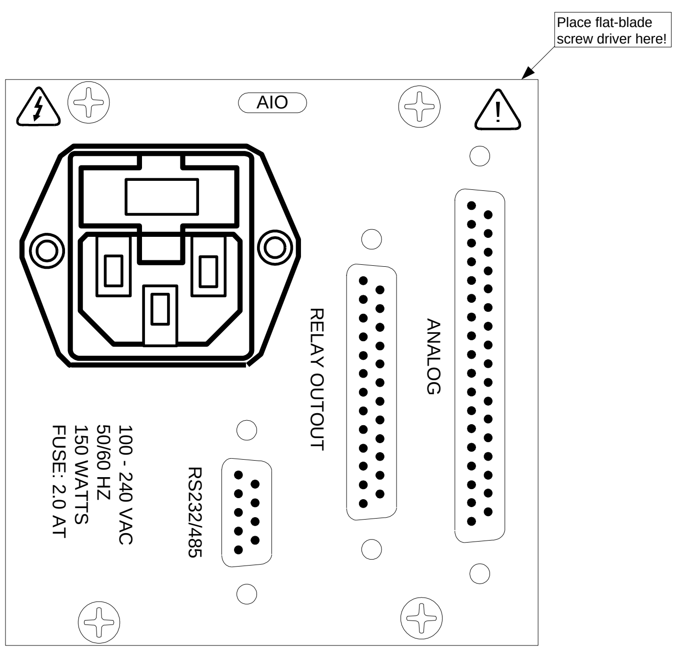


Figure 10-1 Instructions for Removing AIO Module

4. Pull the AIO board out by about 2 inches (5 cm).
5. Use needle-nose pliers to remove the 3 wires (Blue, Brown, and Green/Yellow) connected to the back of the power cord receptor.
6. Carefully slide the module out.
7. Place the module on a static-protected workbench.

To install the AIO module:

1. Assure that the controller power is OFF and the power cord is disconnected.
2. Align the module to fit and slide freely in the **card guides**, with the internal 48-pin DIN connector end first.
3. Gently slide the module forward until the back panel of the module is about 2 inches (5 cm) away from the back panel frame.
4. Connect 3 wires to the back of the power cord receptor as show below.

Back View of the
Power Cord Receptor

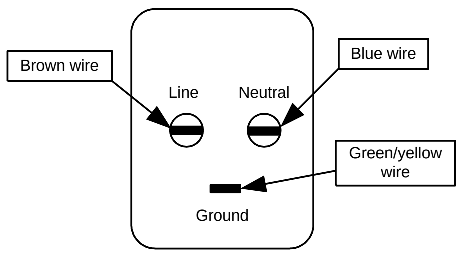


Figure 10-2 Wire Connects on the Back of the Power Cord Receptor

5. Gently slide the module forward and make sure the internal 48-pin DIN connector is engaged.
6. Use a #1 Phillips screwdriver to install and tighten the four (4) screws on the four corners of the rear panel of the module.

10.3 Removing and Installing Profibus Control Module

In the 937B Controller, the slot labeled "COM" can only be used for the PROFIBUS communications module. The PROFIBUS module has a different DIN connector for internal connection than the other modules.

Lethal voltages are present in the controller when it is powered. Disconnect the power cable before proceeding.

Suitable ESD handling precautions should be followed while installing, configuring or adjusting the instrument or any modules.

A PROFIBUS module (with 48-pin DIN connector) can only be inserted into the slot labeled COM. It will not fit into a sensor module slot!

To remove a PROFIBUS Module:

1. Assure that the controller power is OFF, and the power cord is disconnected.
2. Use a #1 Phillips screwdriver to remove the two screws on the top and bottom of the rear panel of the PROFIBUS module.
3. Use a small, flat-blade screwdriver to gently pry the module away from the rear panel frame until it slides freely.
4. **Carefully** slide the module out.
5. Place the module on a static-protected workbench.

To install a PROFIBUS module:

1. Assure that the controller power is OFF and the power cord is disconnected.
2. If there is a blanking panel over the COM slot, use a #1 Phillips screwdriver to remove the two screws on the top and bottom of the blank panel.
3. Align the module to fit and slide freely in the card guides, with the internal 48-pin DIN connector end first.
4. Gently slide the module forward.
5. Use a #1 Phillips screwdriver to tighten the two screws on the top and bottom of the rear panel of the module.

RS232/485 serial communication is always available on the 937B controller. The 9 pin D-Sub communications connector is located on the back panel of the AIO/Power module

10.4 Mounting the Controller

The 937B Controller was designed for both rack mounting and bench top use. In both cases, leave at least 1 inch (25mm) open above the perforated panels to ensure adequate ventilation of the controller. Side clearance is not required.

To accommodate connectors and cables, leave open about 3 inches (75mm) clearance behind the rear panel.

Adhesive backed rubber pads are provided for bench top use. Remove the adhesive backing from each pad and apply one to each corner of the bottom surface.

Optional mounting hardware is available for mounting the 937B Controller in a 19-inch rack.

- **Mounting a single 937B Controller into a 19" rack using MKS half-rack mounting kit part number 100005651:**

    1. Attach the faceplate (3.5"x5.5") to each side of the 937B front panel using the four 10-32 screws provided. Secure the screws with the nuts included in the kit.

    2. Secure this assembly to the rack using the ¼" screws provided. It may be necessary to loosen the 10-32 screws securing the faceplates to align the holes with the mounting holes on the rack.

- **Mounting the 937B Controller with another half-rack instrument using MKS half-rack mounting kit part number 100007700:**

1. Attach the half-rack instrument to the 937B Controller using the small splicing plate and the four 10-32 screws provided. The splicing plate is used to connect the front panel of each instrument together.

2. Secure this assembly to the rack using the ¼"screws provided. It may be necessary to loosen the 10-32 screws securing the splicing plate to align the holes with the mounting holes on the rack.

☞ **All items in the kit may not be needed, depending on the mounting configuration.**

Contact an MKS Applications Engineer for solutions to other mounting configurations.

10.5 AC Power Cord

The Controller has a standard female IEC 60320 connector for connecting to a 100-240 VAC, 50/60 Hz power source. Use only a harmonized, detachable cord set with conductors having a cross-sectional area equal to or greater than 0.75 mm^2. The power cord should be approved by a qualified agency such as UL, VDE, Semko, or SEV.

⚠ **Properly ground the controller and vacuum system.**

The 937B Controller is grounded through the ground conductor of the power cord. If the protective ground connection is lost, all accessible conductive parts may pose a risk of electrical shock. Plug the cord into a properly grounded outlet only.

⚠ **Do not exceed the manufacturer's specifications when applying voltage. Electrical shock may result.**

11 Maintenance and Service of MKS Vacuum Sensors

11.1 422, 423 and 431 Cold Cathode Sensors

Cold Cathode Theory

Ambient gas molecules are ionized by a high voltage discharge in Cold Cathode sensors and sensitivity is enhanced by the presence of a magnetic field. MKS Cold Cathode sensors utilize an inverted magnetron design that includes an isolated collector, as shown in Figure 11-1. This makes the sensor less susceptible to contamination and allows a wider range of pressure measurement.

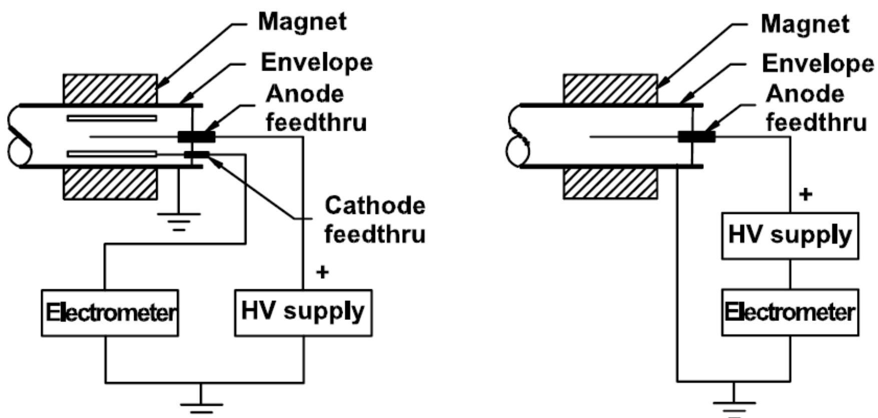


Figure 11-1 A comparison of Inverted Magnetron Cold Cathode Geometries. Isolated collector design is shown on the left.

Cold Cathode ionization sensors have inherent advantages over Hot Cathode sensors. These include:

- No filament to break or burn out, which makes the gauge immune to inrushes of air. It is also relatively insensitive to damage due to vibration.
- No X-ray limit for lower pressure measurements.
- No adjustment for emission current or filament voltage is needed.
- Degassing is not needed.
- Sensor tubes can often be cleaned and reused almost indefinitely.
- The control circuit is simple and reliable, having only one current loop, as compared with a Hot Cathode sensor which has three.
- Less power consumption enables the use of significantly longer cables between the controller and the sensor.

A Cold Cathode sensor consists of a cathode and an anode with a potential difference of several kilovolts between them. The electrodes are surrounded by a magnet, arranged so the magnetic field is perpendicular to the electric field. The crossed electric and magnetic fields cause electrons to follow long spiral trajectories within the sensor, increasing the chance of collisions with gas molecules, thereby providing a significant increase in ionization efficiency over a Hot Cathode sensor.

In operation, a near constant circulating electrical current is trapped by the crossed fields in which the collisions between electrons and residual gas molecules produce ions that are collected by the cathode. The relationship between sensor current and pressure is $i = kP^n$, where i is the sensor ion current, k is a constant, P is the pressure, and n is a constant (in the range of 1.00 to 1.15). This equation is valid for pressures ranging from 10^{-3} to 10^{-8} Torr, depending on the series resistor used. At pressures around 10^{-6} Torr, the sensitivities of 1 to 10A/Torr are not unusual.

The initiation of electron impact events within a Cold Cathode sensor depends upon certain chance events such as field emission or cosmic ray production of the first free electron. Electron-molecule collisions thereafter produce additional electron/ion pairs during the electrons' transit between the electrodes. The discharge rapidly builds to a stable value. Start of the discharge normally requires a very short time at 10^{-6} Torr or above, a few minutes at 10^{-8} Torr, and longer times at lower pressures.

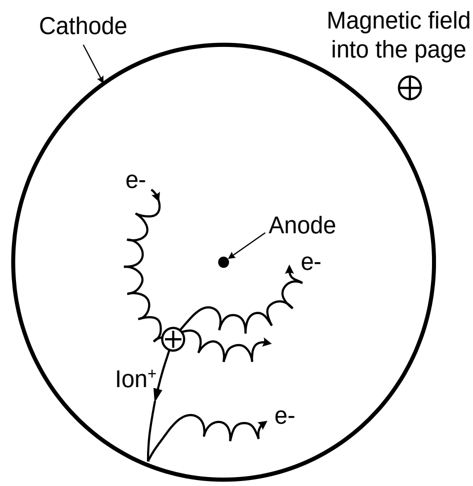


Figure 11-2 Electron Orbits and Ion Production in an Inverted Magnetron

MKS Cold Cathode sensors use an inverted magnetron with separate feedthroughs for the anode high voltage and the cathode current. This configuration has a cylindrical cathode, a central wire anode, and an external cylindrical magnet which provides an axial field. The cathode is isolated from the grounded metal housing. The inverted magnetron geometry produces more stable signal output, and also works well to low pressure without risk of extinguishing the discharge. The range of the MKS Instrument's cold cathode sensors is extended to 10^{-2} Torr by using a large series resistor to decrease sputtering within the sensor. Additionally, the voltage across the tube is pressure dependent in the range between 10^{-4} to 10^{-2} Torr and this is used in determining the pressure reading.

11.2 Maintenance of Series 431/422 Cold Cathode Sensor

11.2.1 Disassemble the Series 431/422 Sensor

The Series 431/422 sensor consists of three subassemblies – the backshell; the internal; and the body. Only the internal and body subassemblies are exposed to vacuum.

To disassemble the sensor, remove the backshell subassembly as follows (Steps 1 through 4 are not necessary when replacing internal parts):

1. Remove the two 4-40 x ¼" Phillips head SEMS screws (2) and slide the backshell (9) off the sensor.
2. Remove the two 4-40 x ¼" button head screws (1)
3. Use needle nose pliers to pull the #22 contact (8) carefully off the ion current feed-through (17).
4. Pull the #20 contact (7) off the 5kV feed-through (12) taking the entire bulkhead (4) with it (do not remove the SHV and BNC connectors from the bulkhead).

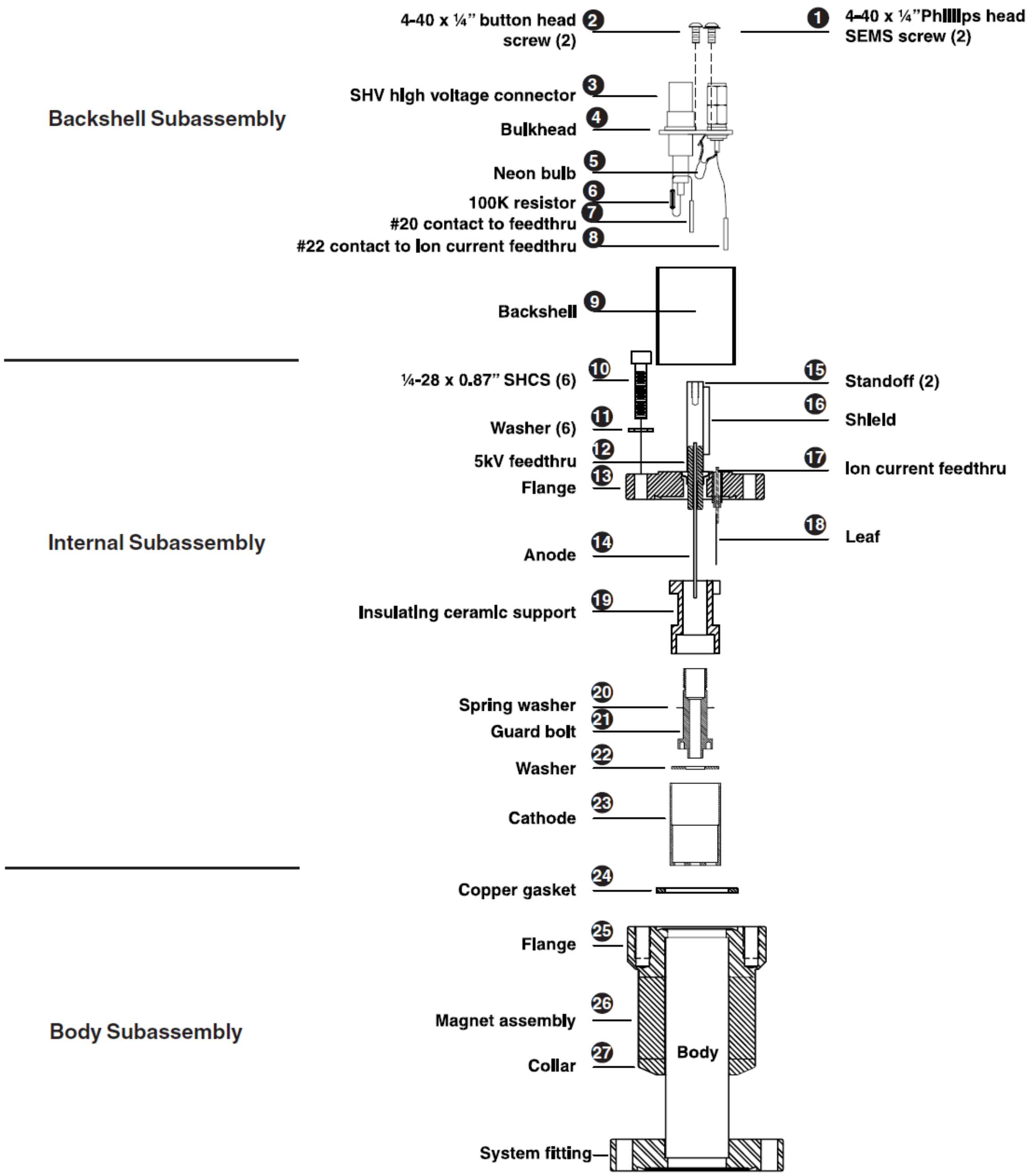


Figure 11-3 Exploded View of the 431/422 Cold Cathode Gauge Assembly

5. Remove the six 1/4-28 x 0.875" socket head cap screws (10) and pull the back flange (13) free. Note that these screws are silver-plated for lubricity and should be used only once. They may be re-lubricated with a dry lubricant such as molybdenum disulfide, though new silver-plated screws are recommended. The copper gasket (24) must be replaced with a standard 2-1/8" CF flange gasket.

The cathode and anode assemblies are attached to the flange. Disassembly should proceed from the bottom to the top of the internal assembly drawing.

6. To remove the cathode (23), release the two integral, spring-loaded ears that are hooked over the shoulder of the ceramic insulating support (19).

7. Gently pull up on the ear until it just clears the outer diameter of the ceramic insulating support (19).

Note the small Elgiloy® leaf (18) **used to connect the ion current feed-through** (17) **to the *cathode* and its position. The rotational position of the *cathode* with respect to the *leaf* is not critical, however, be careful not to bend the *leaf*.**

8. Slide the cathode (23) and washer (23) off the insulating support.

9. The insulating support is captured by the guard bolt (21). Remove this using a spanner wrench (see accessory section) and unscrew the guard bolt from the flange (13).

There is a small curved spring washer (20) **under the head of the guard bolt. This spring washer holds the insulating support tight, preloads the guard bolt to resist unscrewing due to possible vibration, and provides compliance for differential thermal expansion during bakeout.**

11.2.2 Cleaning the Series 431/422 Sensor

Depending on the degree of contamination and application of the sensor, the internal parts may be cleaned — either ultrasonically, with mild abrasives, or chemically.

Do not touch any vacuum exposed part after cleaning unless wearing gloves.

Ultrasonic cleaning should use only high-quality detergents compatible with aluminum (e. g. ALCONOX®). Scrub surfaces with a mild abrasive to remove most contamination. Scotch-Brite™ or fine emery cloth may be effective. Rinse with alcohol.

Clean aluminum and ceramic parts chemically in a wash (not recommended for semiconductor processing), such as a 5 to 20% sodium hydroxide solution, at room temperature (20°C) for one minute. Follow with a preliminary rinse of deionized water. Remove smut (the black residue left on aluminum parts) in a 50 to 70% nitric acid dip for about 5 minutes.

Each of the cleaning methods described above should be followed with multiple rinses of deionized water. Dry all internal components in a clean oven set at 150°C. The ceramic parts are slightly porous and will require longer drying time in the oven to drive off the absorbed water.

11.2.3 Assemble the Series 431/422 Sensor

To reassemble the sensor, reverse the order of procedures used during disassembly. Note the following tightening procedure for the guard bolt. The bolt has a 3/8-40 thread design that is delicate.

1. Finger tighten the guard bolt to compress the spring washer and then back off one turn. Do not over tighten as this will remove all compliance from the spring washer and possibly damage the aluminum 3/8-40 thread.

2. Verify that the anode (14) is well-centered within the bore of the guard bolt.

3. If it is off center, carefully bend it back into position and continue with the assembly.

11.2.4 Preparing the Sensor for Bakeout

To prepare a Series 431 sensor for bakeout up to 125°C, remove the high voltage and ion current cables only. Series 431 sensors can be baked up to 250 C after the backshell subassembly is removed. Refer to section 11.1.2.1 above and follow steps 1 to 4 for the backshell subassembly removal.

The bakeout temperature of a fully assembled Series 422 sensor depends upon the exact catalog part number of the sensor. Some versions are limited to 100°C with the backshell attached, others 250°C. Series 422 sensors with high temperature connectors may be operated during bakeout if cables and connectors with appropriate temperature ratings are used. Cables or connectors rated to temperatures less than the bakeout temperature need to be disconnected from the sensor for bakeout.

11.2.5 Testing a Cold Cathode Sensor

MKS cold cathode sensors contain anode and cathode (collector) electrodes. Test the sensor with an ohmmeter. There should be no shorts between the electrodes or from the electrodes to the sensor body.

11.3 Maintenance of Series 423 I-Mag Cold Cathode Sensor

11.3.1 Disassemble the I-Mag Sensor

1. Clean tweezers and clean smooth-jaw, needle-nose pliers are required.
2. Turn OFF the power to the 937B Controller.
3. Loosen the thumbscrew on top of the sensor cable and remove the cable. After safely venting/backfilling the vacuum system, remove the sensor from the system.
4. Loosen the two flat head screws (15)*. See Figure 11-4.*
5. Remove the magnet (14).
6. Using the smooth-jaw, needle-nose pliers, firmly grab the compression spring (3) at the tip closest to the flange.
7. Pull on the compression spring (3) while rotating it to free it from the formed groove of the sensor body (9). Continue to pull until the compression spring (3) is completely free.
8. With the vacuum port facing up, carefully remove the remaining components (4 through 8) from the sensor body.

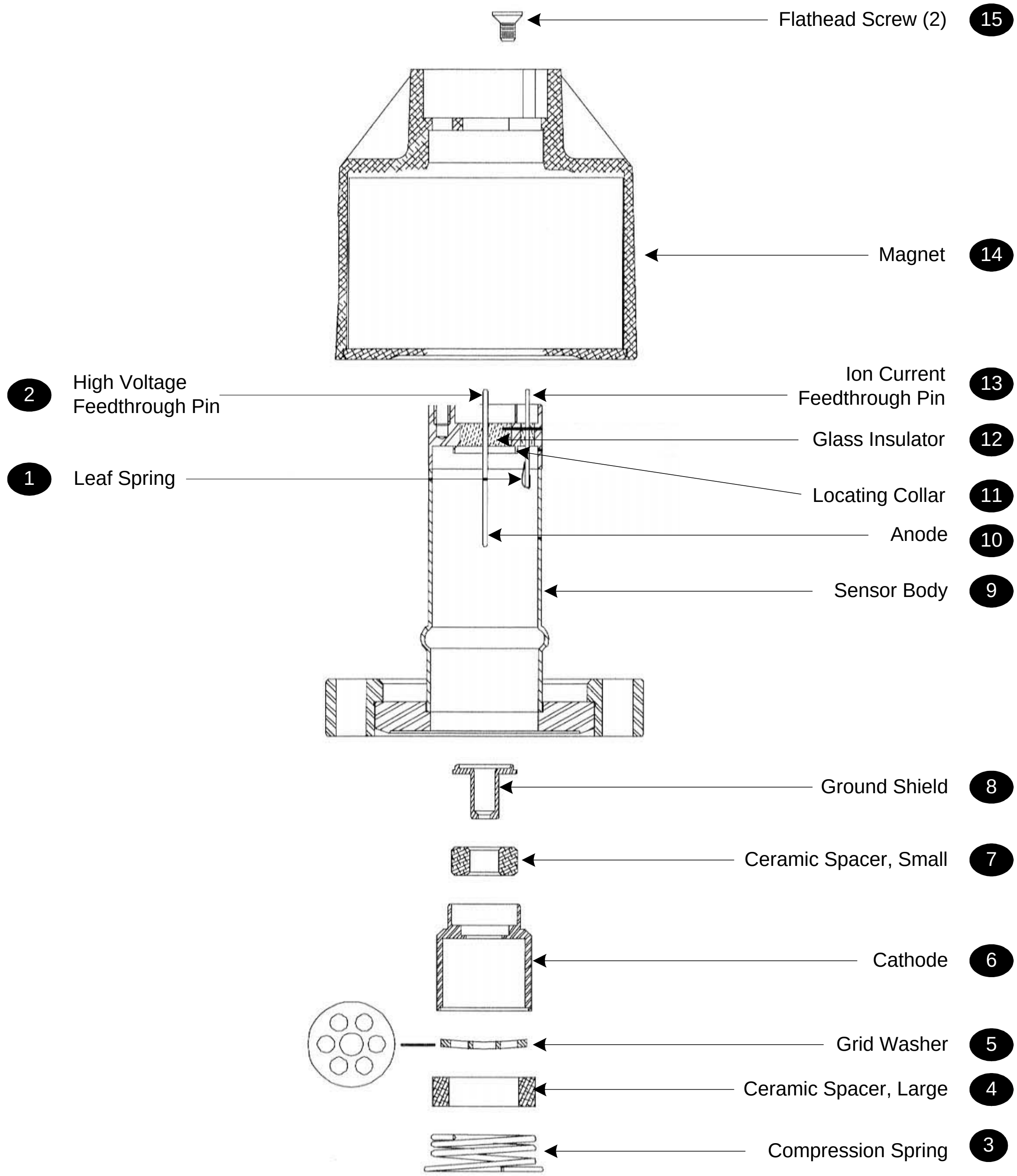


Figure 11-4 Exploded View of the Series 423 I-Mag Cold Cathode Gauge Sensor

STOP **Do not bend the anode (10) or the leaf spring (1) on the ion current feed-through pin when assembling or disassembling the sensor.**

11.3.2 Clean the I-Mag Sensor

Depending on the degree of contamination and the application of the sensor, the internal parts may be cleaned — either ultrasonically, with mild abrasives, or chemically.

☞ **Do not touch any vacuum-exposed part after cleaning unless wearing gloves.**

Ultrasonically clean surfaces using only high-quality detergents compatible with aluminum (i.e. ALCONOX®).

Scrub with a mild abrasive to remove most contamination. Scotch-Brite™ or fine emery cloth may be effective. Rinse with alcohol.

Clean aluminum and ceramic parts chemically in a wash (not recommended for semiconductor processing), such as a 5 to 20% sodium hydroxide solution, at room temperature (20°C) for one minute. Follow with a preliminary rinse of deionized water. Remove the black residue left on aluminum parts in a 50 to 70% nitric acid dip for about 5 minutes.

☞ **Chemical cleaning should not be used to clean the anode; mild abrasives or ultrasonic cleaning are acceptable.**

STOP **Do not damage the leaf spring (1) while cleaning or assembling the sensor.**

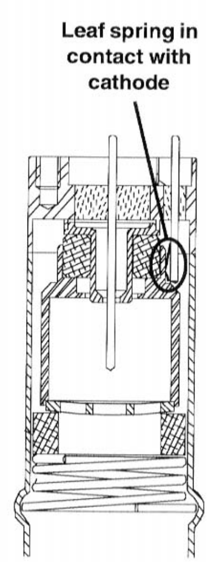
Each of the cleaning methods described above should be followed with multiple rinses of deionized water.

Dry all internal components and the sensor body (9) in a clean oven set at 150°C. The two ceramic spacers, (4) and (7), are slightly porous and will require longer drying time in the oven to drive off the absorbed water.

11.3.3 Assemble the I-Mag Sensor

☞ **Wear gloves and assemble with clean tools.**

1. Roll the sensor body (9) on a flat surface and, looking down the port, check the anode (10) for any radial runout motion. It should be straight and centered with the sensor body (9) for proper operation.
2. Install the ground shield (8) using tweezers. Make sure that the ground shield (8) drops into the locating collar (11).
3. Slide the small ceramic spacer (7) over the small end of the ground shield (8).
4. Check that the leaf spring (1) will contact the base of the cathode (6), as shown to the right. If not, remove the small ceramic spacer (7) and the ground shield (8), and gently bend the leaf spring (1) towards the anode (10) and then replace the ground shield (8) and ceramic spacer (7).
5. Slide the cathode (6), the grid washer (5), and the large ceramic spacer (4) into place. The grid washer (5) has a concave shape. Refer to the figures to see its installation orientation.
6. Insert the small end of the compression spring (3) into the sensor body (9).



7. Using your thumbs, push the larger end of the spring into the sensor body (9) until it is contained within the tube's inside diameter.

8. Using the smooth-jaw, needle-nose pliers, work the compression spring (3) down into the sensor body (9) until it is fully seated in the formed groove.

9. Inspect the ground shield (8) and the grid washer (5) to verify they are centered with respect to the anode (10).

10. If adjustment is needed, gently reposition the grid washer/cathode assembly, taking care not to scratch the grid washer (5).

It is recommended that the resistance between the ion current feed-through pin (13) and the grid washer (5) be measured to verify that the leaf spring (1) is in contact with the cathode (6). The measurement should indicate a short circuit between them. There should be an open circuit between the ion current feed-through pin (13) and both the high voltage feed-through pin (2) and the sensor body (9).

Once this procedure is complete, the I-Mag Sensor is ready for installation. If it is not to be installed immediately, cover the flange with clean, vacuum grade aluminum foil and cap with a flange protector.

11.3.4 Preparing the Sensor for Bakeout

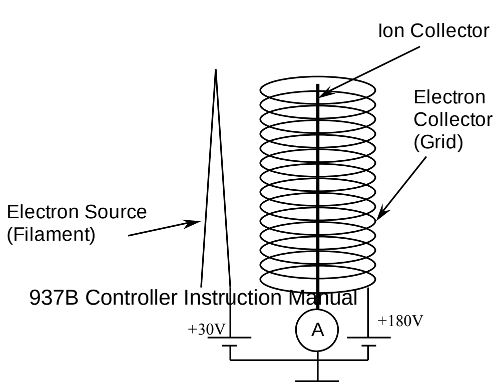
To prepare the sensor for bakeout at up to 400°C (when the sensor has a CF flange and is sealed with a metal seal), remove the sensor cable and magnet assembly as described in "Disassemble the I-Mag sensor".

11.4 Maintenance of Low Power Nude and Mini BA Hot Cathode Sensors

Hot Cathode Theory

Hot Cathode Ionization sensors use the electrons emitted from a hot filament (thermionic electrons) to create ions in a surrounding gas. The ion numbers are in proportion to the ambient gas pressure. Electrons are accelerated through the structure by a potential difference between the hot, emitting filament and a positively charged surrounding grid (anode). The energy acquired by the electrons as they are accelerated by the electric field is sufficient to ionize resident ambient gas molecules. The positively charged ions created by this collision ionization are attracted to the negatively biased ion collector where they are neutralized by an electron current. The gas molecules are singly ionized and there is a one–to-one correspondence between the number of ions neutralized and the magnitude of the neutralizing electron current. Hence the electron current is often called the “ion current” and this is proportional to the pressure in the sensor. The “ion current” is measured by the electrometer and converted to a pressure indication on the display.

The Bayard Alpert (BA) geometry is one of the most popular types of hot cathodes sensors. The main advantage of the BA configuration is its reduced susceptibility to X-ray induced errors. This is achieved through the adoption of a small diameter ion collector that minimizes the area exposed to the soft X-ray emitted from the grid. X-ray emission from the grid is an undesirable side effect of electron impact upon the grid surface. Some of these emitted X-rays strike the ion collector, releasing electrons by the photoelectric effect. This photoelectric current is not related to the pressure but is nevertheless added to the measurement of current determined by the electrometer. The photoelectric current can fully mask the ion current at low pressure (around 1×10^{-10} Torr) which limits the pressure measurement capabilities.



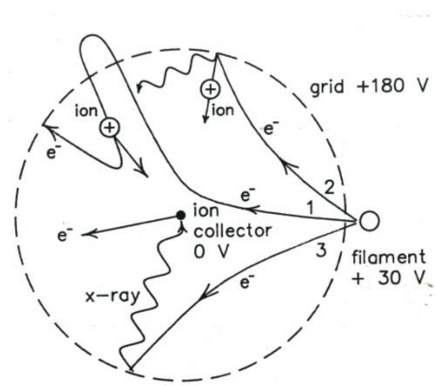


Figure 11-5 Bayard Alpert Gauge Structure and Electron Processes

The collection ion current i_+ is related to the pressure P and emission current i_- by the equation $i_+ = kPi_-$ where, k is the sensitivity factor which depends strongly upon the electron accelerating structure and operating condition. Typical sensitivity factor for nitrogen is around 7.5 to 15 $Torr^{-1}$.

To reduce the outgassing within the hot cathode to a negligible level and minimize the effect of ESD (electron stimulated desorption) on high vacuum measurement, high temperature degassing techniques are used to drive off any adsorbed gas molecules from the surface of the anode grid. Electrode heating during the degas process is accomplished either by electron bombardment (EB degas) or by passing a high current through the grid (I^2R degas). EB degas technique is accomplished in the 937B Controller by increasing the emission current from the filament.

11.4.1 Cleaning the Hot Cathode Sensor

Pump oils and other fluids that condense and/or decompose on surfaces such as the grid and collector, contaminate the sensor and can cause calibration shift. Degassing of the electrode structure can remove surface contamination on the grid and collector. Severe contamination of the grid structure may require a replacement of the sensor.

Although the feed-through insulators are shielded, in some applications conducting films or other forms of electrically conductive pathways may be formed on insulator surfaces. When this happens, it creates a leakage path on the insulator that can produce false low pressure reading. In these cases, the sensor may have to be replaced.

Unlike with Cold Cathode Sensors, it is not advisable to the clean the Hot Cathode sensor. Attempts to clean the sensor it may either deform or break the gauge structure.

11.4.2 Testing the Hot Cathode Sensor

This test will only identify a non-functional sensor. It will not detect damage from contamination, misuse or rough handling that can affect the calibration of a Hot Cathode gauge.

The most common cause of sensor failure is filament failure. To check for this, test the sensor using an ohmmeter with less than 5 mA of current. The resistance readings of a normal hot cathode sensor are show in Table 11-1. The resistance between the two pins of each filament is important.

Pin Numbers	Resistance (Ohm) for a good sensor	Resistance (Ohm) for a bad sensor
Between F1 pins	0 - 5	Open (>100 Ohm)
Between F2 pins	0 - 5	Open (>100 Ohm)
Any pin to ground/shell	$>10^6$ Ohm	$<10^6$ Ohm

Table 11-1 Resistance Readings of a Normal HC Sensor

F1 and F2 are identified on the Low Power Nude sensor (HC). For a Mini BA, use the drawing in Figure 11-6 to locate F1 and F2.

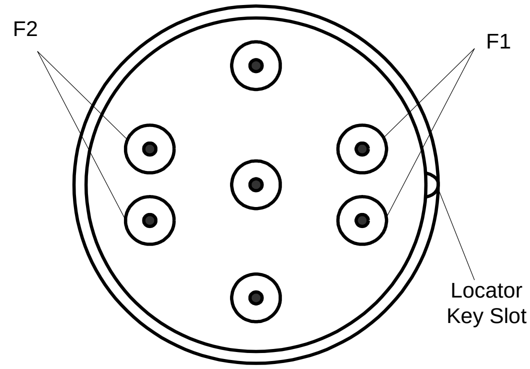


Figure 11-6 Filament Pin Locator for LPN and Mini BA Hot Cathodes

11.5 Maintenance of a Pirani Sensor

Theory of a Pirani Pressure Sensor

Measurement of pressure with any type Pirani sensor is based on the thermal conductivity of the gas type and amount in the vacuum environment. A wire, sometimes referred to as a filament, suspended from supports (see Figure 11-7) is heated and maintained at a constant temperature during the measurement process.

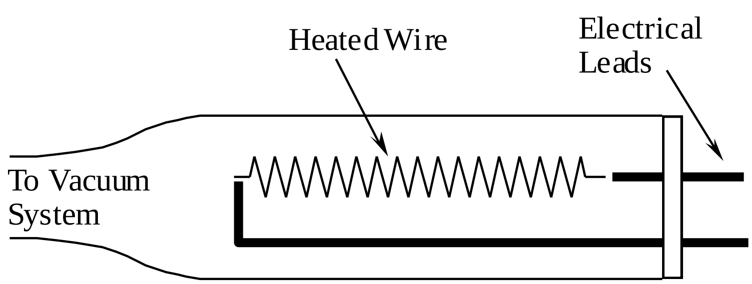


Figure 11-7 Schematic of a Pirani Thermal Conductivity Sensor

The amount of heat exchanged between the hot wire and a colder environment (wall of the sensor) is a function of the pressure when the distance between the hot wire and the cold (cooler) environment is comparable to, or less than, the mean free path of the gas molecules. When gas pressure is higher, the gas thermal conductivity becomes pressure insensitive and natural convective heat transfer must be employed to improve the sensitivity. This demands the horizontal placement of the sensor tube (see Figure 11-8) for a convention enhanced Pirani used to measure pressures greater than 100 Torr.

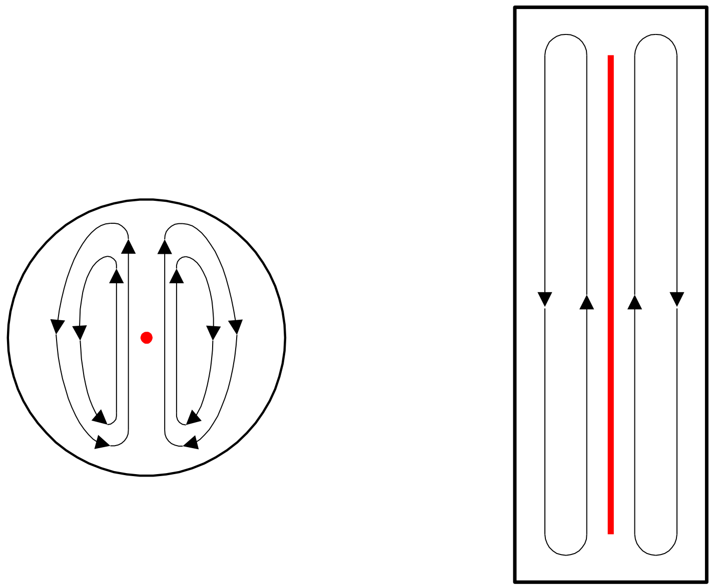


Figure 11-8 Natural Convection Heater Transfer in Horizontal (left) and Vertical (right) Sensor Tubes.

The size of gas molecules has significant impact on the Pirani sensor. Since smaller molecules (such as helium) move faster in the gas, this gas can transfer more heat energy under the same pressure as compared with a gas composed of heavy molecules (e.g. Argon). This explains the gas sensitivity of these sensors shown in Figures 8-5 and 8-6.

The standard Pirani sensor will read continuously between 5 x 10^{-4} to 100 Torr, and, with lower resolution, up to atmospheric pressure.

The Convection Pirani and Convectron sensor design enhances heat transfer at higher pressures through convection. This sensor will read continuously with full resolution from 1.0 x 10^{-3} to 1000 Torr.

11.5.1 Cleaning the Series 345 Sensor

Roughing pump oils and other fluids condensing or decomposing on the heated filament can contaminate the sensor. This changes the emissivity of the filament, which in turn can cause the calibration to change, especially at low pressure.

STOP It is not advisable to clean the sensor. Attempts to clean it may either deform or break the filament. The deformed filament can further shift the sensor's output, increasing the errors in reading.

Replace the sensor if it becomes contaminated.

11.5.2 Testing the Series 345 Sensor

☞ This procedure tests function only. Lower levels of sensor damage that are due to contamination or rough handling can affect calibration, but the tube may still be functional.

The most common cause of sensor failure is a broken filament.

Test the sensor using an ohmmeter with less than 5 mA of current. The resistance readings of a normal Series 345 Sensor measured at atmospheric pressure and at room temperature (20°C) are shown in Table 11-2.

345 D-sub Pin #	Resistance (Ω)
4 to 7	39
4 to 8	114
6 to 7	31
6 to 8	114
5 to 6	62
3 to 5	345

Table 11-2 Bridge Resistance Value for a Normal 345 Pirani Sensor

11.5.3 Cleaning the Series 317 Sensor

Roughing pump oils and other fluids condensing or decomposing on the heated filament can contaminate the sensor. This changes the emissivity of the filament, which in turn can cause the calibration to change, especially at low pressure.

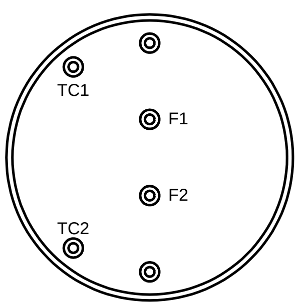
It is not advisable to clean the Sensor. Attempts to clean it may either deform or break the filament wire. The deformed filament wire can further shift the sensor's output, increasing the errors in reading.

Replace the sensor if it becomes contaminated.

11.5.4 Testing the Series 317 Sensor

The most common cause of sensor failure is a broken filament. This might be caused by physical abuse or sudden venting of the sensor to atmosphere at the inlet port.

1. Using a #1 Phillips head screwdriver, remove the two screws to separate the connector/electronics subassembly from the end of the sensor.
2. Check the resistance on the sensor's pins listed in the first column in Table 11-3. Test the sensor using an ohmmeter with less than 5 mA of current. The resistance readings for a normal sensor measured at atmospheric pressure and at room temperature (20°C) are listed in the middle column. If the condition shown in the right column exists, the sensor should be replaced.



Sensor Tube

Check	Resistance (Ω)	Results
F1 to F2	20	If higher, filament is broken or burned out.
F1 to sensor port F2 to sensor port	$>20 \times 10^6$	If lower, sensor is damaged or contaminated.
TC1 to TC2	27	If higher, temperature compensation winding is broken.
TC1 to sensor port TC2 to sensor port	$>20 \times 10^6$	If Lower, temperature compensation winding is broken.

Table 11-3 Resistance Values for a Normal 317 Convection Enhanced Pirani Sensor

11.5.5 Testing the Series 275 Convectron Sensor

Even a small amount of voltage can damage the small diameter sensing or filament wire inside the Convectron sensor. To determine if the sensing wire inside a Convectron has been damaged, use a low-voltage (maximum 0.1 V) ohmmeter to check resistance values across the pins on the base of the sensor.

Pin numbers are embossed on the base. The resistance across the pins should be within the ranges listed in Figure 11-4. If resistance across pins 1 and 2 is not approximately 20 to 30 Ω or if other listed resistance values are greater than the listed values, the sensor tube is defective.

- Pins 1 to 2: 19 to 22 ohms
- Pins 2 to 3: 50 to 60 ohms
- Pins 1 to 5: 180 to 185 ohms

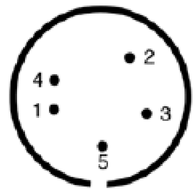


Figure 11-9 Series 275 Convectron Sensor Base Pinout

11.6 Maintenance of a Capacitance Manometer

Theory of a Capacitance Manometer

The MKS Capacitance Manometer head contains a sensor and signal conditioner. The sensor is made up of a tensioned metal diaphragm, one side of which is exposed to the media whose pressure is to be measured. The other (reference) side contains an electrode assembly placed in a reference cavity (see Figure 11-9). Absolute transducers have the reference side factory-sealed under high vacuum (10^{-7} Torr). The diaphragm deflects with changing pressure — force per unit area — causing a capacitance change between the diaphragm and the adjacent electrode assembly. The high level output signal, current, or DC voltage is linear with pressure, amplified, and self-compensated for thermal stability with ambient temperature changes. Capacitance Manometers should be zeroed on installation. This zero adjustment has no effect on the internal calibration.

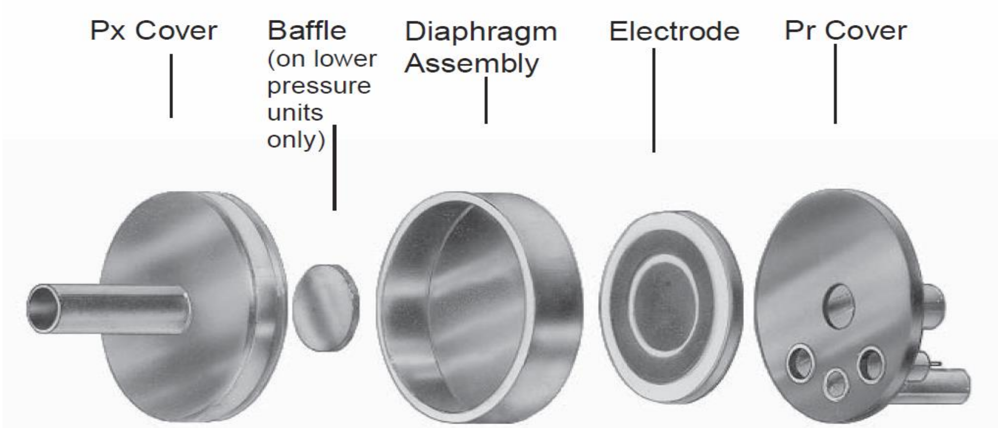


Figure 11-10 Exploded View of a MKS Capacitance Manometer Sensor

Repairing the Baratron Capacitance Manometer

Repair by the user is not recommended since replacement or movement of PC board components may require complete calibration of the unit. Return the product to MKS for repair.

12 Spare Parts and Accessories

	Part #
Accessories	
USA power cable	103150001
Half rack mounting kit	100005651
Full rack mounting kit	100007700
937B Instruction Manual	100016467
Rebuild kit for Series 431 or 422	100006734
Spanner Wrench for 431 or 422 tube rebuild	100005279
Rebuild kit for Series 423 I-Mag	100002353
Adapter, SMA-F to BNC-M	100016120
Adapter, Connector, SMA-M to BNC-F	100016121
Fuse (2X) inside the inlet power connector	100015755
Module, plug-in	
Cold Cathode	100018446
Cold Cathode with TTL	100018448
Hot Cathode (MIG/LPN)	100015641
Dual Capacitance Manometer/Piezo	100015267
Dual Standard Convection Pirani or Convectron	100015132
Pressure control	100016609
Cable for Capacitance Manometer, Type 722B	
10 ft (3.0 m)	100016951
25 ft (7.6 m)	100016952
50 ft (15.2 m)	100016953
Cable for Capacitance Manometer, Type 626B/627D	
10 ft (3.0 m)	100007555
25 ft (7.6 m)	100007556
50 ft (15.2 m)	100007557
Custom to 50 ft (15.2 m)	100007558
Cable for Series 902B Piezo with 9-oin D-sub connector only	
10 ft (3.0 m)	100011869
25 ft (7.6 m)	100011870
50 ft (15.2 m)	100011871
Custom (maximum length 50 ft)	100011872
Cable for Cold Cathode Sensor, Series 431	
10 ft (3.0 m)	100016217
25 ft (7.6 m)	100016218
50 ft (15.2 m)	100016219
100 ft (30.5 m)	100016220
Custom to 300 ft (91.4 m)	100016221
Cable for Cold Cathode Sensor, Series 423 I-Mag	
2 ft (0.6 m)	100016295
10 ft (3.0 m)	100016296
25 ft (7.6 m)	100016297
50 ft (15.2 m)	100016298
Custom to 300 ft (91.4 m)	100016299
Cable for Hot Cathode, Mini BA Gauge	
10 ft (3.0 m)	100011106
25 ft (7.6 m)	100011107
50 ft (15.2 m)	100011108

Cable for Hot Cathode, Low Power Nude

10 ft (3.0 m)	100010909
25 ft (7.6 m)	100010910
50 ft (15.2 m)	100010911

Cable for 317 Convection Pirani & 345 Pirani Sensor

10 ft (3.0 m)	103170006SH
25 ft (7.6 m)	103170007SH
50 ft (15.2 m)	103170008SH
100 ft (30.5 m)	103170017SH
Custom to 500 ft (152.4 m)	103170009SH

Cable for 275 Convectron Sensor

10 ft (3.0 m)	100016890
25 ft (7.6 m)	100016891
50 ft (15.2 m)	100016892

Contact the MKS Customer Service Department to order any of these parts or for technical support.

Series 937B Vacuum System Controller

Operation and Maintenance Manual

Instruction Manual p/n: 100016467
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