InstruTech®

CVM211 Convection Vacuum Gauge Module

The Stinger™

User Manual

(Unit of measure in bar / mbar)

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p/n 000452-110

Important User Information There are operational characteristic differences between solid state equipment and electromechanical equipment. Because of these differences, and because there are a variety of uses for solid state equipment, all persons that apply this equipment must take every precaution and satisfy themselves that the intended application of this equipment is safe and used in an acceptable manner.

In no event will InstruTech be responsible or liable for indirect or consequential damages that result from the use or application of this equipment.

Any examples or diagrams included in this manual are provided solely for illustrative purposes. Because of the many variables and requirements imposed on any particular installation, InstruTech cannot assume responsibility or liability for any actual use based on the examples and diagrams.

No patent liability is assumed by InstruTech with respect to use of information circuits, equipment, or software described in this manual.

Throughout this manual we use notes, notices and apply internationally recognized symbols and safety messages to make you aware of safety considerations.

⚠ WARNING

Identifies information about practices or circumstances that can cause electrical or physical hazards which, if precautions are not taken, could result in death or serious injury, property damage, or economic loss.

⚠ CAUTION

Identifies information about practices or circumstances that can cause electrical or physical hazards which, if precautions are not taken, could result in minor or moderate injury, property damage, or economic loss.

NOTICE

Identifies information that is critical for successful application and understanding of the product.

SHOCK HAZARD

Labels may be located on or inside the device to alert people that dangerous voltages may be present.

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1 Introduction / General Information

1.1 Description

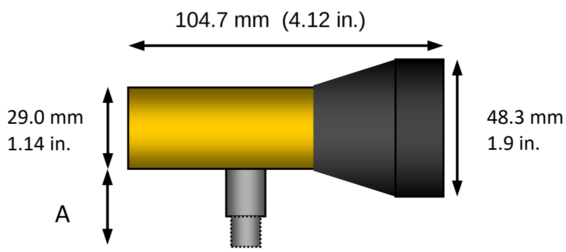
Thermal conductivity gauges measure pressure indirectly by sensing the loss of heat from a sensor to the surrounding gases. The higher the pressure of the surrounding gas, the more heat is conducted away from the sensor. Pirani thermal conductivity gauges maintain a sensor (usually a wire) at some constant temperature, and measure the current or power required to maintain that temperature. A standard Pirani gauge has a useful measuring range of about 10^{-4} mbar to 10 mbar. By taking advantage of convection currents that are generated above 1 mbar, *convection-enhanced* Pirani gauges increase the measuring range to just above atmosphere.

The InstruTech® CVM211 *Stinger*™ module provides the basic signal conditioning required to turn a convection vacuum gauge into a complete measuring instrument. There are two different models of *Stinger*. One model provides a non-linear analog output, and one setpoint relay. The non-linear analog output is identical to the MKS Instruments / Granville-Phillips® "S-curve". The other model provides a Log-linear analog output, and one setpoint relay. A built-in display provides a convenient user interface for setup and operation of the vacuum gauge. This User Manual is intended to be used with CVM211 displaying pressure in bar / mbar units of measure.

1.2 Specifications

measurement range	1.3×10^{-4} to 1,333 mbar / 1×10^{-4} to 1,000 Torr / 1×10^{-2} Pa to 133 kPa
accuracy - N_2 (typical)	1.3×10^{-4} to 1.3×10^{-3} mbar; 0.1×10^{-3} mbar resolution 1.3×10^{-3} to 530 mbar; ± 10% of reading 530 to 1,333 mbar; ±2.5% of reading
repeatability - (typical)	± 2% of reading
display	3 digit LED from 1.33 bar to 10.0×10^{-3} mbar 2 digit LED from (9.9 to 1.0) x (10^{-3} mbar), 1 digit LED from (0.9 to 0.1) x (10^{-3} mbar)
materials exposed to gases	gold-plated tungsten, 304 & 316 stainless steel, glass, nickel, Teflon®
internal volume	26 cm^3 (1.589 in^3)
internal surface area	59.7 cm^2 (9.25 in^2)
weight	136 g (4.8 oz.)
housing (electronics)	molded plastic
operating temperature	0 to +40 °C
storage temperature	-40 to +70 °C
bakeout temperature	+70 °C max
humidity	0 to 95% relative humidity, non-condensing
altitude	operating; 8,200 ft. (2,500 m) max storage; 41,000 ft. (12,500 m) max
mounting orientation	horizontal recommended (orientation has no effect on measurements below 1 Torr)
analog output	log-linear 1 to 8 Vdc , 1 V/decade, or non-linear analog S-curve 0.375 to 5.659 Vdc (Granville-Phillips® compatible)
input power	12 to 28 Vdc, 2 W protected against power reversal and transient over-voltages
setpoint relay	one, single-pole double-throw relay (SPDT), 1 A at 30 Vdc resistive, or ac non-inductive
connector	9-pin D-sub male
CE compliance	EMC Directive 2014/30/EU, EN55011, EN61000-6-2, EN61000-6-4, EN61326-1, EN61010-1
environmental	RoHS compliant

1.3 Dimensions



fitting	dimension A
1/8 in. NPT male - 1/2 in. tube	25.4 mm (1.00 in.)
NW16KF	33.0 mm (1.30 in.)
NW25KF	33.0 mm (1.30 in.)
NW40KF	33.0 mm (1.30 in.)
1 1/3 in. Mini-Conflat®	27.4 mm (1.08 in.)
2 3/4 in. Conflat®	37.3 mm (1.47 in.)
1/4 in. Cajon® 4VCR®	47.2 mm (1.86 in.)
1/2 in. Cajon® 8VCR®	44.5 mm (1.75 in.)

1.4 Part Numbers

CVM211 Fittings / Flanges	*With Log-Linear Analog Output*	*With Non-Linear Analog Output*
Combination 1/8 in. NPT male - 1/2 in. tube (use 1/8 in. NPT male or 1/2 in. O.D. O-ring compression)	CVM211GAA-B-L	CVM211GAA-B-NL
NW16KF	CVM211GBA-B-L	CVM211GBA-B-NL
NW25KF	CVM211GCA-B-L	CVM211GCA-B-NL
NW40KF	CVM211GDA-B-L	CVM211GDA-B-NL
1 1/3 in. Mini-CF / NW16CF Mini-Conflat®	CVM211GEA-B-L	CVM211GEA-B-NL
2 3/4 in. CF / NW35CF Conflat®	CVM211GFA-B-L	CVM211GFA-B-NL
1/4 in. Cajon® 4VCR® female	CVM211GGA-B-L	CVM211GGA-B-NL
1/2 in. Cajon® 8VCR® female	CVM211GHA-B-L	CVM211GHA-B-NL

1.5 Options & Accessories

Optional Wall Mount AC-DC
PS401 Power Supply
Input: 100 - 240 Vac
Output: 24 Vdc @ 750 mA (18 W)
Various AC plugs, 6 ft. cable length

		Part Number
with North American AC Plug		PS401-A
with Universal European AC Plug		PS401-EU
with UK AC Plug		PS401-UK
with China AC Plug		PS401-C
with Australian AC Plug		PS401-SP

Options &* Accessories *Continued | ***Part Number***

PS401-UX For Use With User Supplied AC Power Cord

This variation of the PS401 power supply may be used when an AC plug that is not listed above is required. The conventional IEC60320 AC power entry receptacle allows use with any user supplied AC mains power cord set available worldwide.

Input: 100 - 240 Vac
Output: 24 Vdc @ 2.5 A (60 W)
Cable Length: 6 ft.

PS401-UX

2 Important Safety Information

InstruTech has designed and tested this product to provide safe and reliable service, provided it is installed and operated within the *strict safety guidelines provided in this manual*. **Please read and follow all warnings and instructions.**

⚠ **WARNING**

To avoid serious injury or death, follow the safety information in this document. Failure to comply with these safety procedures could result in serious bodily harm, including death, and or property damage.

Failure to comply with these warnings violates the safety standards of installation and intended use of this instrument. InstruTech disclaims all liability for the customer's failure to comply with these instructions.

Although every attempt has been made to consider most possible installations, InstruTech cannot anticipate every contingency that arises from various installations, operation, or maintenance of the module. If you have any questions about the safe installation and use of this product, please contact InstruTech.

2.1 Safety Precautions - General

⚠ **WARNING!** There are no operator serviceable parts or adjustments inside the product enclosure. Refer servicing to service trained personnel.

Do not modify this product or substitute any parts without authorization of qualified InstruTech service trained personnel. Return the product to an InstruTech qualified service and repair center to ensure that all safety features are maintained. Do not use this product if unauthorized modifications have been made.

⚠ **WARNING!** Source power must be removed from the product prior to performing any servicing.

After servicing this product, ensure that all safety checks are made by a qualified service person. When replacement parts are required, ensure that the parts are specified by InstruTech. Substitutions of non-qualified parts may result in fire, electric shock or other hazards. Use of unauthorized parts or modifications made to this product will void the warranty.

To reduce the risk of fire or electric shock, do not expose this product to rain or moisture. These products are not waterproof and careful attention must be paid to not spill any type of liquid onto these products. Do not use these products if they have been damaged. Immediately contact InstruTech to arrange return of the product if it is damaged.

Due to the possibility of corrosion when used in certain environmental conditions, it is possible that the product's safety could be compromised over time. It is important that the product be periodically inspected for sound electrical connections and equipment grounding. Do not use if the equipment grounding or electrical insulation has been compromised.

2.2 Safety Precautions - Service and operation

Ensure that the vacuum port on which the CVM211 vacuum gauge is mounted is electrically grounded.

Use an appropriate power source of 12 to 28 Vdc, 2 W.

Turn off power to the unit before attempting to service the module.

Turn off power to the unit if a cable or plug is damaged or the product is not operating normally according to this User Manual. Contact qualified InstruTech service personnel for any service or troubleshooting condition that may not be covered by this User Manual.

It is important that the product be periodically inspected for sound electrical connections and equipment grounding. Do not use if the equipment grounding or electrical insulation has been compromised.

Do not use if the unit has been dropped or the enclosure has been damaged. Contact InstruTech for return authorization and instructions for returning the product to InstruTech for evaluation.

2.3 Electrical Conditions

⚠ **WARNING!** When high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed electrical conductors are maintained at earth ground potential. This applies to all products that come in contact with the gas contained in vacuum chambers. An electrical discharge within a gaseous environment may couple dangerous high voltage directly to any ungrounded conductor of electricity. A person could be seriously injured or killed by coming in contact with an exposed, ungrounded electrical conductor at high voltage potential. This condition applies to all products that may come in contact with the gas inside the vacuum chamber (vacuum/pressure containment vessel).

2.3.1 Proper Equipment Grounding

⚠ **WARNING!** Hazardous voltages that could seriously injure or cause death are present in many vacuum processes. Verify that the vacuum port on which the CVM211 vacuum gauge module is mounted is electrically grounded. Consult a qualified Electrician if you are in doubt about your equipment grounding. Proper grounding of your equipment is essential for safety as well as intended operation of the equipment. The CVM211 module vacuum gauge must be connected directly to a good quality earth ground. Use a ground lug on the CVM211 gauge vacuum connection / flange if necessary.

⚠ **WARNING! In order to protect personnel from electric shock and bodily harm, shield all conductors which are subject to potential high voltage electrical discharges in or around the vacuum system.**

2.3.2 Electrical Interface and Control

It is the user's responsibility to ensure that the electrical signals from this product and any connections made to external devices, for example, relays and solenoids, are used in a safe manner. Always double check the system set-up before using any signals to automate your process. Perform a hazardous operation analysis of your system design and ensure safeguards and personnel safety measures are taken to prevent injury and property damage.

2.4 Overpressure and use with hazardous gases

⚠ **WARNING!** Install suitable protective devices that will limit the level of pressure inside your vacuum chamber to less than what the vacuum chamber system components are capable of withstanding. InstruTech gauges should not be used at pressures exceeding 1333 mbar absolute pressure.

In cases where an equipment failure could cause a hazardous condition, always implement fail-safe system operation. For example, use a pressure relief device in an automatic backfill operation where a malfunction could result in high internal pressures if the pressure relief device was not installed on the chamber.

The CVM211 vacuum gauge module is not intended for use at pressures above 1333 mbar (20 psia); DO NOT exceed < 2 ½ bars (35 psig) pressure inside the sensor. If your chamber goes to higher pressures, you should install an isolation valve or pressure relief device to protect the gauge tube from overpressure conditions. With some fittings, actual safe overpressure conditions may be lower; for example, a quick-connect, O-ring compression fitting may forcibly release the gauge tube from the vacuum chamber fitting with only a few psi over local uncorrected barometric (atmospheric) pressure.

⚠ **CAUTION! If the internal pressure of a vacuum gauge device is allowed to increase above local uncorrected barometric pressure (atmospheric pressure side), vacuum fittings may release and possible overpressure conditions may cause leaks that would allow the gas inside the gauge tube to release into the atmosphere of the surrounding environment. Toxic, pyrophoric and flammable gases are examples of hazardous gases that if allowed to leak out of the vacuum/pressure containment vessel into the atmospheric environment, could cause bodily injury and possible damage to equipment. Never expose the gauge tube internal volume to pressure above local atmospheric pressure when using hazardous gases.**

2.5 Gases other than Nitrogen / air

⚠ **WARNING!** Do not attempt to use with gases other than nitrogen (N_2) or air without referring to correction factor data tables. InstruTech gauges and modules are calibrated for direct readout of nitrogen or air. Do not attempt to use with other gases such as argon (Ar) or carbon dioxide (CO_2) unless accurate conversion data for N_2 to other gas is properly used. Refer to sections titled "Using the gauge with different gases", "Display" and "Analog Output" for a more complete discussion.

⚠ **WARNING!** Do not use this device in an explosive atmosphere or in the presence of flammable gases, vapors or fumes. Do not use this device to measure the pressure of explosive or combustible gases or gas mixtures. The sensor wire in the gauge normally operates at 125 ^{o}C, but if malfunction should occur, the wire temperature could exceed the ignition temperature of certain combustible gases and gas mixture. This could cause an explosion which could result in serious injury or death.

3 Installation

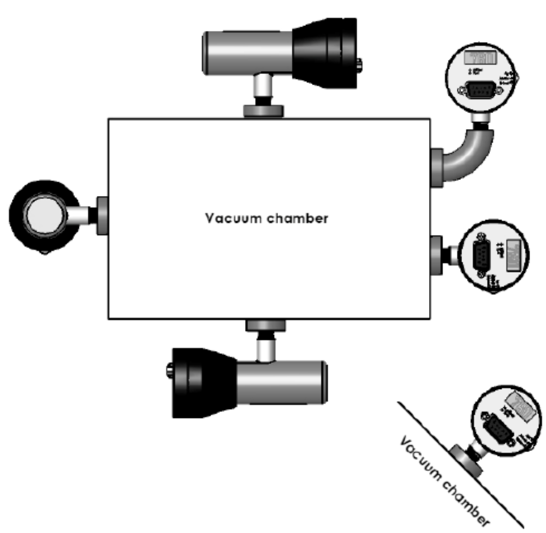
3.1 Mechanical Installation

Mount the CVM211 as close as possible to the pressure you want to measure. Long or restricted, small diameter tubing will create a pressure difference between your process chamber and the gauge. This may cause a delay in response to pressure changes.

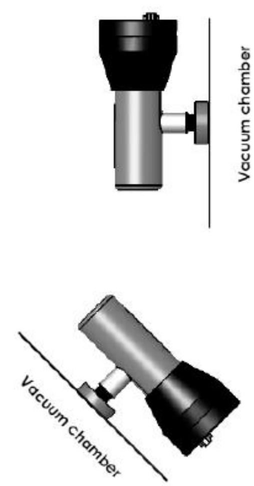
Mounting the CVM211 too close to a gas source inlet may also cause measurement and control instability. Do not mount the CVM211 near a source of heating or cooling, such as heaters or air conditioning vents.

Mount the CVM211 with its main axis horizontal (see diagram below). Pressure reading errors may occur above 1 mbar if the unit is not mounted horizontally. Below 1 mbar, mounting position has little to no effect.

For Accurate Measurements Above 1 mbar, Mount the Gauge Axis Horizontally as Shown Below



Correct Orientation



Incorrect Orientation

Mount the CVM211 with port down, if possible, to help minimize the effect of any particles or condensation from collecting in the gauge.

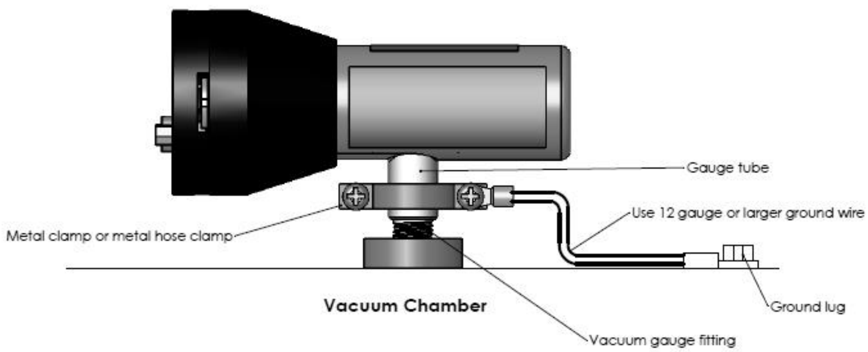
Do not mount the CVM211 where it will be subjected to excessive vibration. Vibrations may cause unstable readings, measurement errors and possible mechanical stress to components in the CVM211.

Flanges/ Fittings - follow the manufacturer's recommendations and note the following:
- NPT fittings: When connecting the device using a NPT fitting, apply a thread sealant compound or wrap the threaded portion of the tubing with one-and-a-half to two wraps of pipe thread seal tape such as PTFE (Teflon®) tape and hand tighten the gauge into the gauge port. Do not use a wrench or other tool which may damage the gauge.

3.2 Electrical Installation

3.2.1 Grounding

⚠ Be sure the vacuum gauge and the rest of your vacuum system are properly grounded for safety as well as intended operation of the equipment. When using KF flanges, metal clamps must be used to ensure proper grounding. Be aware that some vacuum fittings such as NPT connections installed using Teflon tape may not allow for metal-to-metal contact between the vacuum gauge and the vacuum chamber. If such is the case, use a 12 gauge or larger copper wire to connect the vacuum gauge to a ground lug on your vacuum chamber as shown below.



3.2.2 Electrical Connections

A good recommended practice is to remove power from any cable prior to connecting or disconnecting it.

The InstruTech CVM211 will directly replace Granville-Phillips® Mini-Convectron® modules that have a 9-pin D-sub connector (DE-9P), and you can use your existing cables and electronics.

For new installations, fabricate a cable to connect to the signals/functions you want to use. Signals and pin assignments are described below:

Connector and Pinout

PIN NUMBER	PIN DESCRIPTION
1	Relay 1 Normally Open
2	Relay 1 Normally Closed
3	Power Input (12-28 Vdc)
4	Power Ground
5	Analog Output (Log-Linear 1-8 V, or Non-linear Granville-Phillips® compatible)
6	Relay 1 Common
7	Relay Disable (Disables Relay 1 when connected to pin 4 - Ground)
8	Analog Ground
9	

4 Setup and Operation

4.1 Initial Setup

Two of the most important steps for the initial setup of the gauge are to set zero and set span (atmosphere) as described in the *Programming* section 4.3 below. This will ensure proper operation of the gauge and accurate pressure measurements. The gauge is calibrated at the factory using nitrogen. Furthermore, the gauge is also installed in a certain orientation when calibrated at the factory. Without setting zero and atmosphere after the gauge is installed in your system, the gauge may not display the expected and correct pressures. This could be caused by the fact that you may be using a different gas than Nitrogen such as air to setup and calibrate the gauge (most commonly the case) and the gauge orientation is different than the orientation used at the factory. As such, it is very important to perform your own initial setup and calibration by setting zero and span (atmosphere) with the gauge installed in your actual system. Please note the following:

Setting Zero (vacuum)
Setting zero optimizes performance of the gauge when operating at a low pressure range of 1.33×10^{-4} mbar to 1.33×10^{-3} mbar. If your minimum operating pressure is higher than 1.33×10^{-3} mbar, it is not normally necessary to set zero and thus setting atmosphere should be adequate. If you are able to evacuate your system to below 1.33×10^{-4} mbar, it is always a good practice to check and set zero if necessary. See zero adjustment in section 4.3

Setting Span (atmosphere)
Setting span (atmosphere) is the most important step for a newly installed gauge. If you prefer to use air to set atmosphere, vent your vacuum system chamber to expose the gauge to the local atmospheric pressure (air) and set atmosphere to match your known local uncorrected barometric pressure (air). This is the reading of ambient air pressure you will expect if you were to vent and open your vacuum chamber to the atmosphere surrounding the outside of your chamber. At sea level, this pressure is usually near 1.01 bar. At elevations above sea level, the pressure decreases. Check your local aviation authority or airport web sites or your current local weather conditions online to help find your local uncorrected barometric pressure if you do not have this information. See *span* adjustment in section 4.3

Note - Setting zero and atmosphere is normally required only once during the initial setup and maybe checked by the user periodically. After power has been applied to the gauge during the initial setup, allow five minutes for the gauge to stabilize (warm-up) before setting zero and atmosphere.

4.2 User Interface Basics

The user interface is designed for easy operation and a natural progression of setup parameters. This section gives a brief explanation of operation and programming parameters. A complete user interface map is provided following this section.

The CVM211 *Stinger* module has four settings that can be programmed by the user with a 3 position switch located on the side of the module housing. Pressing the switch straight in is referred to as pressing the <select> key. Pressing the switch upward is referred to as pressing the <up> key. Pressing the switch downward is referred to as pressing the <down> key. During setup, and operation, be sure to consider the bar/mbar LEDs.

It is important to note the unit of measure (engineering units) LED status on the front panel of the CVM211 to correctly interpret the displayed pressure. The following table summarizes the mbar/bar LED indicator status:

Pressure Units	**Green LED Illuminated**	**Red LED Illuminated**
10^{-3} mbar	YES	YES
mbar	YES	NO
bar	NO	YES

4.3 Programming

1. With the CVM211 in the normal pressure display mode, press and hold <select> for 3 seconds.

2. The readout displays the value of the '*setpoint turn-on'* pressure. The relay energizes when the pressure is *below* this value [Factory default = 0.1 mbar].

3a. To keep this value and proceed to the next step, press <select>.

3b. To change the value, use the <up> <down> keys. Then press <select> to save and go to the next step.

4. The readout displays the value of the *'setpoint turn-off'* pressure. The relay de-energizes when the pressure is *above* this value [Factory default = 0.2 mbar].

5a. To keep this value and proceed to the next step, press <select>.

5b. To change the value, use the <up> <down> keys. Then press <select> to save and go to the next step.

6. The readout will display ‘000’ to indicate the unit is in the *"zero adjust"* mode. To properly set "*zero*", with the CVM211 installed on your vacuum system, the gauge should be evacuated to a pressure below 1.33×10^{-4} mbar [Factory default = 000 mbar].

7a. If the gauge is *not* evacuated to a pressure below 1.33×10^{-4} mbar, press <select> to proceed to the next step, *without* saving a new "*zero*" value.

7b. If the gauge *is* evacuated to a pressure below 1.33×10^{-4} mbar, press <down> to save the new user "*zero*" and proceed to the next step.

8. The readout will display the current "*span*" value. To set the atmospheric pressure reading (also known as the “span” adjustment), flow nitrogen gas or air into your closed vacuum chamber to allow the pressure to rise to a known value above 530 mbar. Alternatively, if your local uncorrected barometric pressure (air) is known, simply vent your vacuum system chamber to expose the gauge to the local atmospheric pressure. [Factory default = 1.01 bar].

9a. If you do *not* have a known pressure in the gauge, press <select> <u>briefly</u> (less than 3 seconds) to exit the setup menu and return to the normal pressure display *without* saving a new "*span*" value.

9b. If you *do* have a known pressure in the gauge, use the <up> <down> keys to change the displayed value to agree with the known pressure. Press and hold <select> for 3 seconds until the displayed pressure switches to the new value. This will save the new "span" setting and return to the normal pressure display.

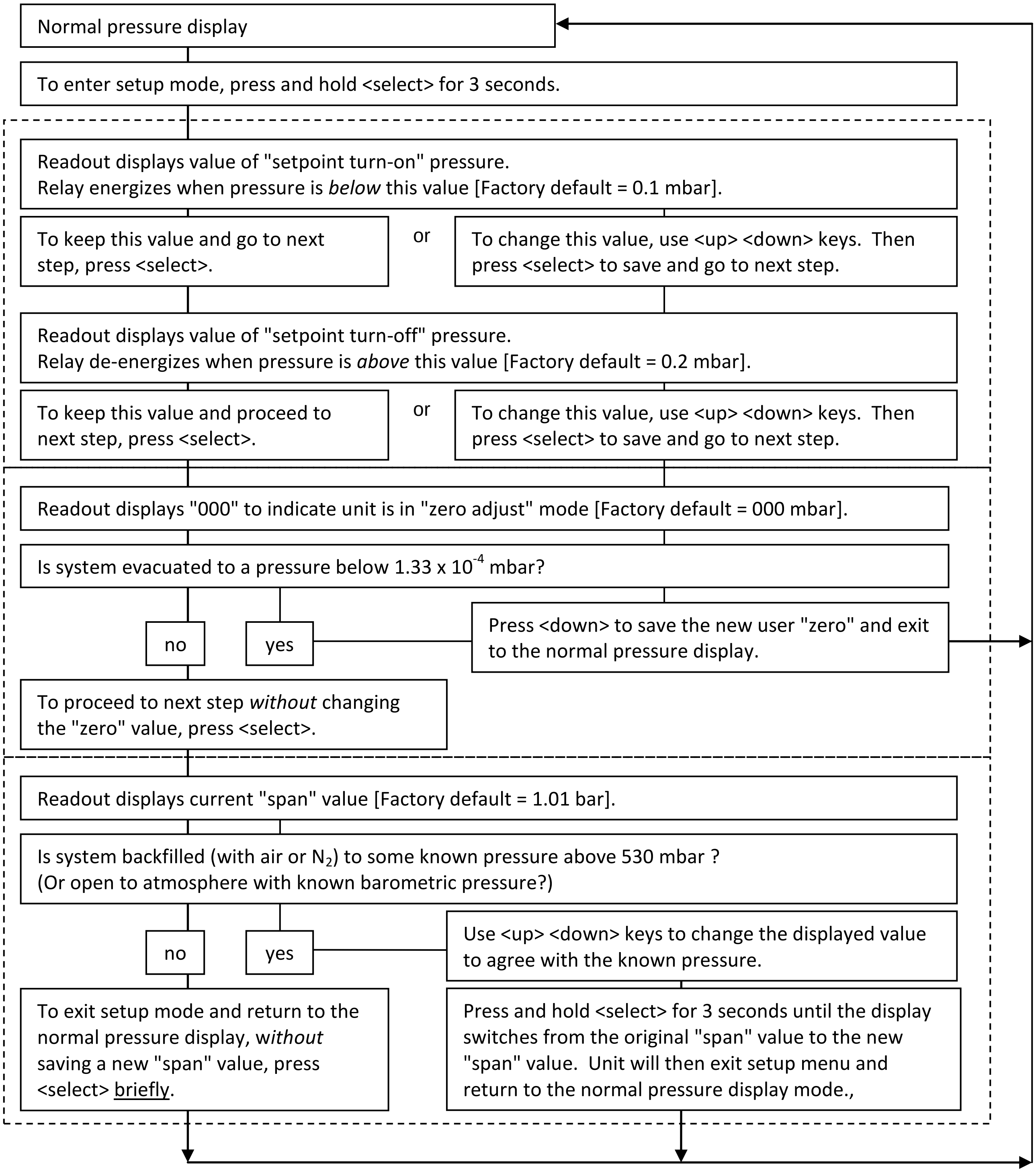
It is good practice to perform the sequence of checking and adjusting span (ATM) then zero (VAC) and then, finally re-checking the span setting to ensure that the circuitry is properly balanced for use in measuring pressure throughout the intended measurement range.

4.4 Return to Factory Default Settings

You can reset all values to the original factory default settings by holding the <up> key for 5 seconds. The display will read "dEF" until 5 seconds has passed, at which point *all user settings will be replaced by the original factory default values* and the display will return to the normal pressure display. If you release the <up> key before 5 seconds has passed, the display will return to normal pressure display without resetting to factory defaults.

If you reset all values to original factory default settings, you would need to repeat the initial setup procedure as described in section 4.1 and reprogram other parameters as required.

User Interface Map



To return all settings to original factory defaults, press <up> key and hold for 5 seconds. Display will read "dEF". After 5 seconds, factory default settings will replace all user-settings, and readout will return to normal pressure display.

5 Using the gauge with different gases

A thermal conductivity gauge senses heat loss which depends on the thermal conductivity of the gas surrounding the sensor. Since different gases, and mixtures, have different thermal conductivities, the indicated pressure readings and outputs will also be different. InstruTech convection gauges (and most other thermal conductivity gauges) are calibrated using nitrogen (N_2). When a gas other than N_2 / air is used, correction must be made for the difference in thermal conductivity between nitrogen (N_2) and the gas in use. The charts and tables on the following pages indicate how different gases affect the display and output from an InstruTech convection gauge.

⚠ **WARNING!** Using a thermal conductivity gauge with gases other than that for which it is calibrated could result in death or serious injury. Be sure to use gas correction data in this manual when measuring pressures of gases other than N_2 / air.

For N_2 the calibration shows excellent agreement between indicated and true pressure throughout the range from 1×10^{-4} mbar to 1.33 bar. At pressures below 1 mbar, the calibration curves for the different gases are similar. The difference in readings at these low pressures is a constant, a function of the difference between thermal conductivities of the gases.

At pressures above 1 mbar, indicated pressure readings may diverge significantly. At these higher pressures convection currents in the gauge become the predominant cause of heat loss from the sensor and calibration depends on gauge tube geometry and mounting position as well as gas properties.

Generally, air and N_2 are considered the same with respect to thermal conductivity, but even N_2 and air will exhibit slight differences in readings at higher pressures. For example, when venting a system to atmosphere using N_2, you may see readings change by 40 to 55 mbar after the chamber is opened and air gradually displaces the N_2 in the gauge. For most other gases the effect is much more significant and may result in a hazardous condition as described below.

Other considerations when using gases other than N_2 / air

Flammable or explosive gases

⚠ **WARNING!** InstruTech convection gauges are neither intrinsically safe nor explosion proof and are not intended for use in the presence of flammable or explosive gases or vapors.

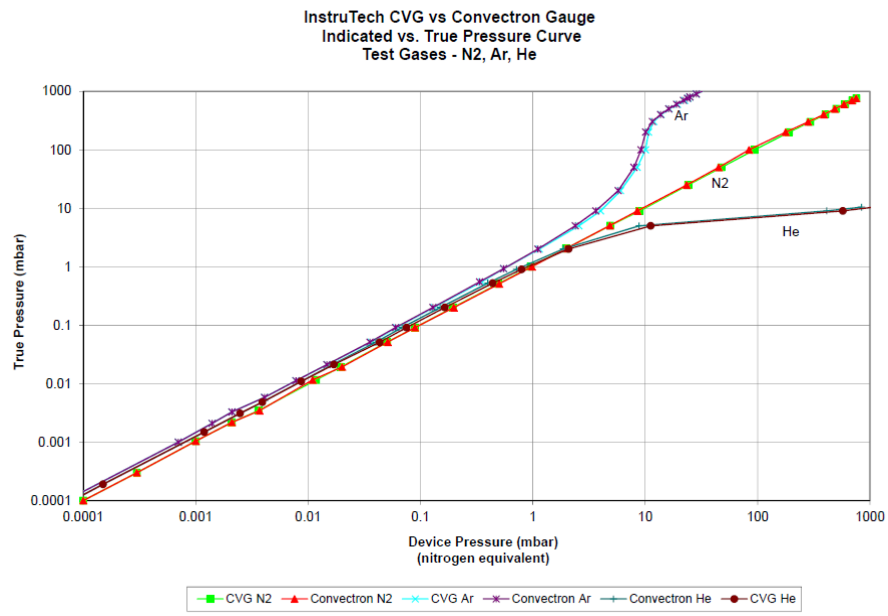
Under normal conditions the voltages and currents in InstruTech convection gauges are too low to cause ignition of flammable gases. However, under certain failure conditions, sufficient energy could be generated to cause flammable vapors or gases to ignite or explode. Thermal conductivity gauges like the InstruTech convection gauges are not recommended for use with flammable or explosive gases.

Moisture / water vapor

In some processes (lyophilization, for example) the gas composition may not change significantly, except for moisture content. Water vapor can significantly change the response of a thermal gauge and correction should be made, as you would for any other gas.

Other contaminants

If your gases condense, coat, or corrode the sensor, the gauge calibration and response to different gases will change. Generally, if the gauge can be "calibrated" ("zero" and "span" settings), these changes are small enough to be ignored. If you can't set zero and span, the gauge should be replaced or return to factory for evaluation and possible cleaning.



Gas Correction Chart

The Y- axis of the above chart is actual pressure as measured by a capacitance manometer, a diaphragm gauge that measures true total pressure independent of gas composition. The X-axis is the pressure reading indicated by the convection gauge under test. This chart shows readings for an InstruTech convection gauge (CVG) and Granville-Phillips® Convectron® gauge to illustrate that the difference in the response for both of these types of gauges is virtually indistinguishable.

CAUTION! Do not assume this data applies to other convection gauges, which may or may not be the same. Refer to the table in section 6 and note the following examples:

Ex A: If the gas is nitrogen (N_2), when the true total pressure is 533 mbar, the gauge will read 533 mbar.

Ex B: If the gas is argon (Ar), when the true pressure is 133 mbar, the gauge will read about 11.7 mbar. If you are backfilling your vacuum system with Ar, when your system reaches a pressure of 1.01 bar true pressure, your gauge will be reading about 31.5 mbar. Continuing to backfill your system, attempting to increase the reading up to 1.01 bar, you will over pressurize your chamber which may present a hazard.

Ex C: If the gas is helium (He), the gauge will read 1.33 bar when pressure reaches about 13.3 mbar true pressure and opening the chamber to atmosphere prematurely may present other hazards for both people and product.

CAUTION! What these examples illustrate is that using gases other than nitrogen (N_2) without using accurate gas conversion data and other proper precautions could result in injury to personnel and/or damage to equipment.

Suggested precautions when using gases other than nitrogen (N_2):

Install a pressure relief valve or burst disk on your chamber, to protect it from overpressure. Post a warning label on your gauge readout that states "Do Not Exceed ____ mbar Indicated Pressure" (fill in the blank for maximum indicated pressure for the gas you use) so that an operator using the gauge will not exceed a safe pressure

6 Display

The table below shows the displayed readings at various pressures for selected gases.

Displayed Pressure Readings vs. True Pressure for selected gases

Pressures shown in bold italic font in the shaded areas are in x 10^{-3} mbar. Note both the green and red LEDs are illuminated.
Pressures shown in normal font and in non-shaded areas are in mbar. Note only the green LED is illuminated.
Pressures shown in normal bold font with an asterisk(*) in the shaded areas are in bar. Note only the red LED is illuminated.

True	Pressure	N_2	Ar	He	O_2	CO_2	KR	Freon12	Freon22	D_2	Ne	CH_4
0	***x 10^{-3} mbar***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***
0.1	***x 10^{-3} mbar***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***
0.3	***x 10^{-3} mbar***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***	***0.3***
0.6	***x 10^{-3} mbar***	***0.6***	***0.6***	***0.6***	***0.6***	***0.6***	***0.4***	***0.6***	***0.6***	***0.6***	***0.6***	***0.6***
1.33	***x 10^{-3} mbar***	***1.3***	***0.9***	***1.06***	***1.33***	***1.46***	***0.5***	***2.00***	***2.00***	***1.73***	***0.9***	***2.26***
2.67	***x 10^{-3} mbar***	***2.7***	***1.86***	***2.13***	***2.66***	***3.06***	***1.33***	***4.13***	***4.13***	***3.19***	***2.00***	***4.39***
6.67	***x 10^{-3} mbar***	***6.7***	***4.40***	***5.33***	***6.66***	***5.86***	***3.06***	***10.1***	***9.33***	***7.99***	***4.66***	***10.2***
13.3	***x 10^{-3} mbar***	***13.3***	***8.79***	***10.7***	***12.9***	***14.6***	***6.39***	***19.5***	***17.9***	***16.1***	***9.46***	***20.3***
26.6	***x 10^{-3} mbar***	***26.6***	***17.4***	***21.4***	***26.3***	***29.5***	***12.6***	***39.8***	***36.2***	***32.3***	***18.7***	***40.5***
66.6	***x 10^{-3} mbar***	***66.6***	***43.1***	***53.9***	***65.5***	***73.1***	***31.3***	***96.6***	***91.9***	***79.9***	***46.3***	0.10
0.13	mbar	0.13	***85.7***	0.11	0.12	0.14	***62.3***	0.19	0.18	0.16	0.1	0.21
0.26	mbar	0.26	0.16	0.21	0.25	0.27	0.12	0.36	0.34	0.33	0.18	0.41
0.66	mbar	0.66	0.41	0.57	0.64	0.65	0.28	0.81	0.79	0.91	0.47	1.04
1.33	mbar	1.33	0.79	1.25	1.29	1.26	0.53	1.39	1.38	2.06	0.99	2.13
2.66	mbar	2.66	1.51	2.95	2.58	2.27	0.93	2.15	2.21	5.5	2.11	4.43
6.66	mbar	6.66	3.26	17.9	6.63	4.45	1.70	3.26	3.49	327	6.98	10.0
13.3	mbar	13.3	5.33	OP	13.7	6.62	2.37	3.94	4.51	OP	28.6	37.1
26.6	mbar	26.6	7.73	OP	29.7	8.78	3.05	4.42	4.95	OP	778	473
66.6	mbar	66.6	10.4	OP	103	10.9	3.42	5.05	5.51	OP	OP	1.12*
133	mbar	133	11.7	OP	278	12.3	3.65	6.23	6.54	OP	OP	OP
266	mbar	266	13.0	OP	393	16.3	4.42	7.98	8.55	OP	OP	OP
400	mbar	400	15.0	OP	506	22.5	4.78	9.18	10.0	OP	OP	OP
533	mbar	533	17.9	OP	646	29.8	5.25	10.1	11.2	OP	OP	OP
666	mbar	666	21.4	OP	805	38.2	5.61	11.0	12.2	OP	OP	OP
800	mbar	800	25.0	OP	973	48.5	5.91	11.8	13.2	OP	OP	OP
933	mBar	933	29.0	OP	1.14*	61.4	6.19	12.5	14.2	OP	OP	OP
1.01	Bar	1.01*	31.5	OP	1.25*	71.8	6.33	13.0	14.7	OP	OP	OP
1.06	Bar	1.06*	33.4	OP	1.32*	79.1	6.45	13.2	15.1	OP	OP	OP
1.19	Bar	1.19*	37.9	OP	OP	105	6.65	13.9	16.0	OP	OP	OP
1.33	Bar	1.33*	43.3	OP	OP	147	6.77	14.7	16.9	OP	OP	OP

Notes: OP = Overpressure indication; display will read 1.33 bar.

Examples:

1) Gas used is nitrogen. Display shows pressure measurement of 13.3 mbar. True pressure of nitrogen is 13.3 mbar.

2) Gas used is argon. Display shows pressure measurement of 11.7 mbar. True pressure of argon is 133 mbar.

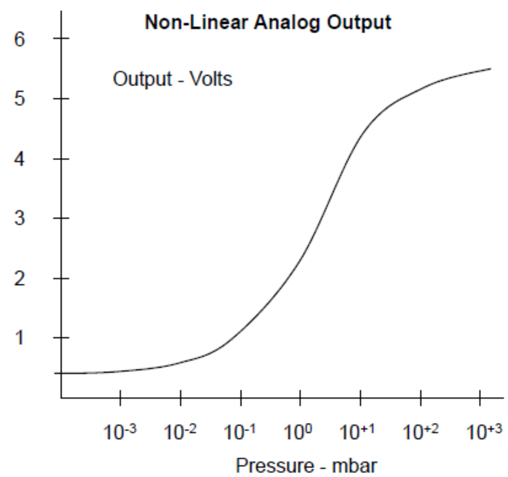
3) Gas used is CO_2. Display shows pressure measurement of 73.1 x 10^{-3} mbar. True pressure of CO_2 is 66.6 x 10^{-3} mbar.

7 Analog Output

The CVM211 is provided with either a non-linear or a log-linear analog output.

Non-Linear Output

The first Convectron® gauge controllers produced a non-linear output signal of 0.375 to 5.659 Vdc for 0 to 1000 Torr of N_2, roughly in the shape of an "S" curve, as shown at right. Granville-Phillips® adopted the same output curve for most of their Mini-Convectron® modules and controllers with non-linear output (although in recent years, some Granville-Phillips® controllers may output variations of the original S-curve).

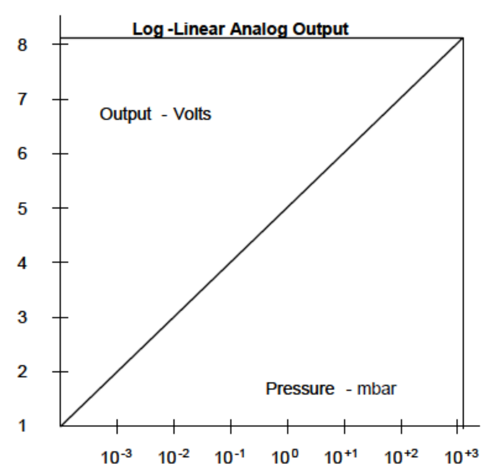


The non-linear output from InstruTech convection gauges, modules, and controllers duplicates the original S-curve of 0.375 to 5.659 Vdc for 0 to 1.33 bar.

The table shown in section 7.1 contains the lookup data for converting the ***non-linear*** output voltage into pressure values for nitrogen and various other gases.

Log-Linear Output

Many InstruTech modules and controllers also provide a log-linear output signal, as an alternative to the non-linear signal described above. This output, shown at right, is a 1 Volt per decade signal that may be easier to use for data logging or control.



The table shown in section 7.2 contains the lookup data and provides the formulas for converting the ***log-linear*** output voltage into pressure values for nitrogen and various other gases.

7.1 Non-Linear Analog Output

The following table is for use with CVM211 Stinger part numbers ending with the letter “NL” providing a non-linear analog output.

Non-Linear analog output for CVM211GAA-B-NL through CVM211GHA-B-NL

True Pressure	N_2	Ar	He	O_2	CO_2	KR	Freon12	Freon22	D_2	Ne	CH_4
0×10^{-3} mbar	0.3751	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
0.1×10^{-3} mbar	0.3759	0.3757	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.3757	0.3766
0.3×10^{-3} mbar	0.3768	0.376	0.377	0.377	0.377	0.377	0.378	0.378	0.377	0.3763	0.378
0.6×10^{-3} mbar	0.3795	0.378	0.379	0.38	0.381	0.377	0.382	0.381	0.381	0.3782	0.3825
1.33×10^{-3} mbar	0.384	0.381	0.382	0.384	0.385	0.379	0.388	0.388	0.386	0.381	0.3896
2.67×10^{-3} mbar	0.3927	0.387	0.389	0.392	0.395	0.384	0.401	0.4	0.396	0.388	0.403
6.67×10^{-3} mbar	0.4174	0.403	0.409	0.417	0.412	0.395	0.437	0.432	0.425	0.405	0.438
13.3×10^{-3} mbar	0.4555	0.429	0.441	0.453	0.462	0.415	0.488	0.48	0.47	0.433	0.492
26.6×10^{-3} mbar	0.5226	0.477	0.497	0.521	0.536	0.451	0.581	0.566	0.549	0.484	0.584
66.6×10^{-3} mbar	0.6819	0.595	0.637	0.679	0.705	0.544	0.778	0.764	0.727	0.608	0.796
0.13 mbar	0.878	0.745	0.814	0.868	0.9	0.668	1.009	0.99	0.944	0.768	1.053
0.26 mbar	1.1552	0.962	1.068	1.141	1.179	0.847	1.315	1.291	1.265	1.002	1.392
0.66 mbar	1.6833	1.386	1.589	1.664	1.668	1.194	1.826	1.805	1.914	1.469	2.014
1.33 mbar	2.2168	1.818	2.164	2.195	2.172	1.536	2.257	2.247	2.603	1.976	2.632
2.66 mbar	2.8418	2.333	2.939	2.814	2.695	1.921	2.647	2.666	3.508	2.631	3.313
6.66 mbar	3.6753	3.028	4.387	3.672	3.316	2.429	3.029	3.09	5.059	3.715	
13.3 mbar	4.2056	3.48	5.774	4.225	3.67	2.734	3.204	3.33	6.361	4.605	4.699
26.6 mbar	4.5766	3.801	7.314	4.62	3.903	2.966	3.308	3.414		5.406	5.172
66.6 mbar	4.8464	4.037		4.916	4.071	3.075	3.43	3.509		6.159	5.583
133 mbar	4.9449	4.122		5.026	4.154	3.134	3.618	3.66		6.483	5.72
266 mbar	5.019	4.192		5.106	4.336	3.269	3.827	3.883		6.661	5.86
400 mbar	5.1111	4.283		5.2	4.502	3.384	3.938	4.005		6.726	
533 mbar	5.2236	4.386		5.315	4.621	3.466	4.016	4.088		6.767	6.103
666 mbar	5.3294	4.477		5.422	4.708	3.526	4.076	4.151		6.803	
800 mbar	5.4194	4.55		5.515	4.775	3.573	4.124	4.203		6.843	6.342
933 mbar	5.4949	4.611		5.592	4.83	3.613	4.166	4.247		6.89	
1.01 Bar	5.534	4.643		5.633	4.86	3.632	4.19	4.271		6.92	
1.06 Bar	5.5581	4.663		5.658	4.877	3.645	4.203	4.286		6.942	6.519
1.19 Bar	5.6141	4.706		5.713	4.919	3.674	4.237	4.321		7	
1.33 Bar	5.6593	4.745		5.762	4.955	3.69	4.270	4.354		7.056	6.642

Values listed under each gas type are in volts.

Note: By design, these values are identical to the outputs from MKS Instruments / Granville-Phillips® Convectron® gauges, Mini-Convectron® modules and controllers so that equivalent units can be interchanged without affecting your process system or software.

An analog output of less than 0.01 volts to near 0 volt indicates a damaged or faulty sensor.

Refer to the next page if you have a CVM211 *Stinger* with a log-linear analog output.

7.2 Log-Linear Analog Output

The following table is for use with CVM211 Stinger part numbers ending with the letter "L" providing an output voltage that is linear with respect to the log of pressure.

Log-Linear analog output for CVM211GAA-B-L through CVM211GHA-B-L

True Pressure (mbar)	N_2	Ar	He	O_2	CO_2	KR	Freon12	Freon22	D_2	Ne	CH_4
0.0001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.0002	1.301	1.301	1.301	1.301	1.301	1.301	1.301	1.301	1.301	1.301	1.301
0.0005	1.699	1.699	1.699	1.699	1.699	1.523	1.699	1.699	1.699	1.699	1.699
0.0010	2.000	1.903	1.938	2.000	2.028	1.668	2.125	2.125	2.080	1.903	2.167
0.0020	2.301	2.146	2.204	2.301	2.355	1.970	2.487	2.487	2.392	2.166	2.523
0.0050	2.699	2.524	2.602	2.699	2.672	2.370	2.883	2.855	2.778	2.551	2.893
0.0100	3.000	2.820	2.908	2.991	3.012	2.675	3.172	3.136	3.082	2.849	3.186
0.0200	3.301	3.188	3.208	3.294	3.345	2.979	3.473	3.434	3.385	3.150	3.484
0.0500	3.699	3.512	3.607	3.693	3.741	3.372	3.863	3.837	3.779	3.543	3.886
0.1000	4.000	3.809	3.928	3.989	4.033	3.671	4.157	4.136	4.082	3.844	4.197
0.2000	4.301	4.103	4.217	4.288	4.325	3.963	4.445	4.424	4.393	4.148	4.500
0.5000	4.699	4.495	4.634	4.686	4.696	4.341	4.798	4.783	4.828	4.553	4.893
1.0000	5.000	4.784	4.962	4.987	4.982	4.614	5.044	5.037	5.174	4.867	5.201
2.0000	5.301	5.064	5.324	5.288	5.249	4.865	5.250	5.255	5.579	5.192	5.517
5.0000	5.699	5.404	6.070	5.695	5.550	5.141	5.447	5.471	7.288	5.696	5.877
10.0000	6.000	5.633	8.125	6.008	5.743	5.309	5.556	5.602	8.125	6.252	6.374
20.0000	6.301	5.815	8.125	6.337	5.886	5.433	5.621	5.675	8.125	7.608	7.409
50.0000	6.699	5.969	8.125	6.862	6.002	5.514	5.680	5.722	8.125	8.125	7.930
100.0000	7.000	6.045	8.125	7.282	6.065	5.548	5.751	5.780	8.125	8.125	8.125
200.0000	7.301	6.093	8.125	7.526	6.157	5.606	5.851	5.877	8.125	8.125	8.125
300.0000	7.477	6.131	8.125	7.625	6.253	5.654	5.918	5.950	8.125	8.125	8.125
400.0000	7.602	6.178	8.125	7.705	6.353	5.679	5.962	6.000	8.125	8.125	8.125
500.0000	7.699	6.237	8.125	7.786	6.448	5.710	5.996	6.038	8.125	8.125	8.125
600.0000	7.778	6.295	8.125	7.861	6.532	5.734	6.025	6.070	8.125	8.125	8.125
700.0000	7.845	6.349	8.125	7.928	6.611	5.754	6.050	6.097	8.125	8.125	8.125
760.0000	7.881	6.380	8.125	7.965	6.658	5.765	6.063	6.112	8.125	8.125	8.125
800.0000	7.903	6.399	8.125	7.988	6.687	5.772	6.072	6.122	8.125	8.125	8.125
900.0000	7.954	6.488	8.125	8.042	6.766	5.787	6.092	6.146	8.125	8.125	8.125
1000.0000	8.000	6.494	8.125	8.092	6.847	5.799	6.111	6.167	8.125	8.125	8.125
1100.0000	8.041	6.539	8.125	8.125	6.936	5.812	6.128	6.187	8.125	8.125	8.125
1200.0000	8.079	6.580	8.125	8.125	7.028	5.822	6.146	6.204	8.125	8.125	8.125
1300.0000	8.114	6.624	8.125	8.125	7.140	5.828	6.164	6.222	8.125	8.125	8.125
1333.0000	8.125	6.636	8.125	8.125	7.169	5.830	6.169	6.228	8.125	8.125	8.125

Values listed under each gas type are in volts.

The log-linear output signal and pressure are related by the following formulas:

$$\mathbf{P = 10^{(V - 5)}} \qquad \mathbf{V = \log_{10}(P) + 5}$$

where P is the pressure in mbar, and V is the output signal in Volts.

An analog output of less than 0.01 volts to near 0 volt indicates a damaged or faulty sensor.

The chart on the following page shows the graphical results of the table and formulas given above for nitrogen. True pressure (N_2) is plotted on the X-axis with a log scale. The output signal is plotted on the Y-axis on a linear scale.

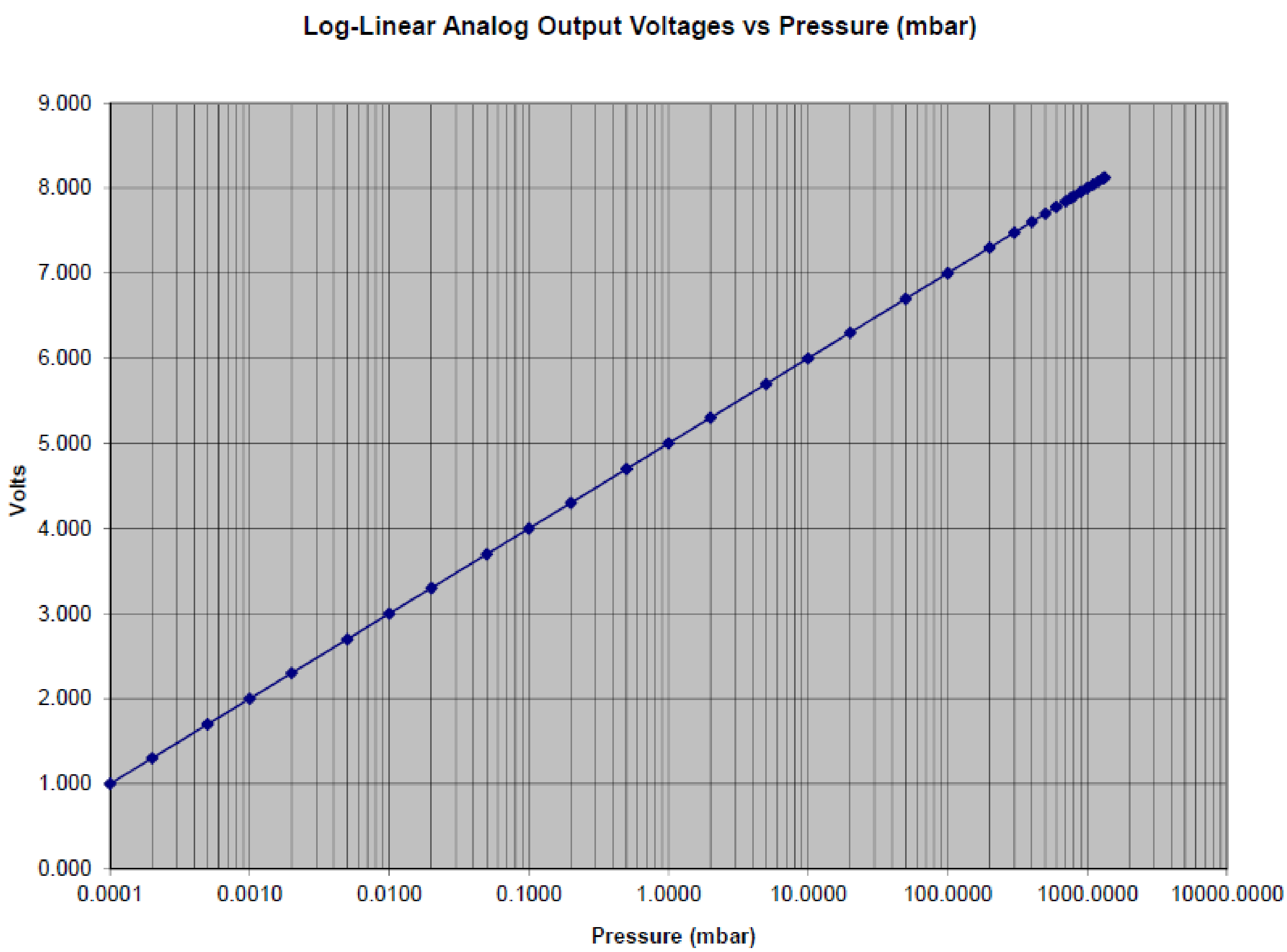


Chart of the calculated pressures using the formulas and data for the log-linear output signal for nitrogen from the previous page.

8 Service

8.1 Calibration

Every InstruTech module is calibrated prior to shipment using nitrogen (N_2). However, you can calibrate the instrument by adjusting zero and span (atmosphere) using the procedure described previously in section 4.3 titled "programming" (also see User Interface Map). Zero and span (atmosphere) calibration affect the displayed value and the output signal. Zero calibration optimizes performance of the gauge when operating at a low pressure range of 1.33×10^{-4} mbar to 1.33×10^{-3} mbar. If your minimum operating pressure is higher than 1.33×10^{-3} mbar, it is not normally necessary to perform calibration at zero and thus span calibration should be adequate. If you are able to evacuate your system to below 1.33×10^{-4} mbar, it is always a good practice to check and set zero if necessary. This will also improve performance in cases where gauge contamination is causing higher readings than 1.33×10^{-4} mbar, even though the system has been evacuated to below 1.33×10^{-4} mbar. Care should be exercised when using gases other than nitrogen (N_2).

8.2 Maintenance

In general, maintenance is not required for your InstruTech module. Periodic performance checks may be done by comparing the gauge to a known reference standard.

8.3 Troubleshooting

Indication	***Possible Cause***	***Possible Solution***
Display is off / blank	No power	Check power supply & power cable
Readings appear very different from expected pressure	The process gas is different from the gas used to calibrate the CVM211 Module has not been calibrated or has been calibrated incorrectly	Correct readings for different gas thermal conductivity. See section 5 on using the gauge on different gases Check that zero and span are adjusted correctly
Readings are noisy or erratic	Loose cables or connections Contamination Vibration	Check and tighten connections Inspect gauge for signs of contamination such as particles, deposits, discoloration on gauge inlet. Return to factory for possible cleaning Ensure gauge is not mounted where excessive vibration is present
Gauge cannot be calibrated - zero and span can't be adjusted	Contamination Sensor failure for other cause	Return to factory for possible cleaning Return to factory for evaluation
Setpoint does not actuate	Incorrect setup	Check setpoint setup
Display shows "bAd"	Sensor wire damaged	Return to factory for evaluation
Atmospheric pressure reads too high and can't be set to correct value	Contamination Sensor wire damaged	Return to factory for possible cleaning Return to factory for evaluation
Atmospheric pressure reads too low and can't be set to correct value	Sensor wire damaged Contamination	Return to factory for evaluation Return to factory for possible cleaning

8.4 Contamination

The most common cause of all vacuum gauge failures is contamination of the sensor. Noisy or erratic readings, the inability to set zero or atmosphere and total gauge failure, are all possible indications of gauge contamination.

Contamination can be generally characterized as either:

A) a reaction of process gases with sensor elements, or
B) an accumulation of material on the sensor elements. Sensors that fail due to chemical reaction are generally not salvageable. Sensors that fail due to condensation, coatings, or particles may possibly be restored by cleaning.

A) Reactive Gases

If process gases react with the materials of construction of the sensor, the result is corrosion and disintegration of the sensor over time. The chemistry of the gases used for plasma etching and other reactive semiconductor processes are examples where this failure mode is possible. In this case, cleaning can't solve the problem because the sensor has been destroyed. The sensor or module must be replaced.

If you experience this failure mode quickly or frequently, you should consider a different vacuum gauge for your application. Thermal vacuum gauges may be available with different sensor materials that are not as reactive with your particular process gases. The standard gold plated tungsten sensor used in the InstruTech convection gauge is offered for use with air and inert gases such as N_2, argon, etc. InstruTech also offers platinum sensors for applications not compatible with gold plated tungsten.

There is no material that is universally chemical resistant; your choice of vacuum gauge (as well as all other vacuum components) should take into consideration the potential reactions between your process gases and the materials of construction. Consider what effect water vapor will have when combined with your process gases because a finite amount of water will enter the chamber during venting to atmosphere with air.

B) Oil, Condensation, Coatings, and Particles

If the failure is due to an accumulation of material in the gauge, we may be able to restore your gauge or module by cleaning. Contamination may be as simple as condensed water, or as difficult as solid particles.

Oils and hydrocarbons: Exposure of the gauge internal surfaces to oils and hydrocarbons can result in sensor contamination. Some of these types of contamination may be removed by cleaning the gauge. If there is the possibility of oil back streaming from wet vacuum pumps, it is recommended that a filter or trap be installed to prevent contamination of components of your vacuum system.

Condensation: Some gases (such as water vapor) can condense on sensor surfaces, forming a liquid coating that changes the rate at which heat is removed from the sensor (which changes the calibration). The sensor can often be restored simply by pumping on the gauge between process cycles. A dry N_2 purge will help speed up drying, or the gauge may be gently heated provided temperature doesn't exceed the specified limit of 40 ^{o}C, operating.

Coatings: Some gases can condense on sensor surfaces, forming a solid coating, which changes the rate at which heat is removed from the sensor. Some of these coatings may be removed by cleaning the gauge.

Particles: Particles generated by the process may enter the gauge during the process cycle or during the venting cycle. The result is interference with heat removal from the sensor. In this case cleaning may be able to remove particles from the gauge. However, particulate contamination is the most difficult to remove as particles can become stubbornly trapped inside the gauge. In some processes, solid particles are created during the process throughout the chamber including inside the gauge. Particles tend to form on cooler surfaces such as in a gauge at room temperature. You may slow down the build-up of particles in the gauge by keeping the gauge warm (within specified limits) during the process cycle.

Particles in the process chamber may be swept into the gauge during the vent cycle. The CVM211 has a screen built into the gauge port to help keep the largest particles out of the gauge. In very dirty applications, or where particles are small enough to get through the screen, an additional filter installed on the inlet may help prolong the gauge life.

In some vacuum processes, desorbed and sputtered materials from the process may enter vacuum components connected to the process vacuum chamber by line-of-sight transport especially under high vacuum conditions, i.e., in the molecular flow regime. To prevent materials that may be transported via line-of-sight momentum from entering your vacuum gauge or other components, it is advisable to install some form of apparatus that will block the line-of-sight. In many cases a simple 90^{o} elbow may help prevent or reduce the transport of particles from entering your vacuum gauge.

In the event of gauge contamination please contact the factory to return the gauge for possible cleaning if the gauge has not been exposed to hazardous materials.

8.5 Module and sensor replacement

The CVM211 module is factory calibrated for the specific sensor (gauge tube) installed in it. If the device fails for any reason, return the CVM211 to the factory to determine if either the sensor or the electronics could be replaced or if the entire module should be replaced.

9 Factory Service and Support

If you need help setting up, operating, troubleshooting, or obtaining a return materials authorization number (RMA number) to return the module for diagnosis, please contact us during normal business hours (8:00am to 5:00pm Mountain time) Monday through Friday, at 303-651-0551. Or e-mail us at support@instrutechinc.com.

For the safety of our employees, you must down load a material disclosure form from our website at www.instrutechinc.com Please use this form to provide a history of the gauge detailing what gases have been used. We cannot work on gauges that have been exposed to hazardous materials.

10 Warranty

SELLER warrants that its products are free of defects in workmanship and material and fit for the uses set forth in SELLER's catalog or product specifications, under the normal use and service for which they are intended.

The entire warranty obligation of SELLER is for the repair or replacement, at SELLER's option, of products or parts (examination of which shall disclose to SELLER's satisfaction that it is defective) returned, to SELLER's plant, properly identified within twenty four (24) months (unless otherwise noted) after the date of shipment from InstruTech Plant. BUYER must obtain the approval of SELLER and a return authorization number prior to shipment.

Alteration or removal of serial numbers or other identification marks renders this warranty void. The warranty does not apply to products or components which have been abused, altered, operated outside of the environmental specifications of the product, improperly handled or installed, or units which have not been operated in accordance with SELLER's instructions. Furthermore the warranty does not apply to products that have been contaminated, or when the product or part is damaged during the warranty period due to causes other than ordinary wear and tear to the product including, but not limited to, accidents, transportation, neglect, misuse, use of the product for any purpose other than that for which it was designed.

THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THIS WARRANTY EXTENDS ONLY IN FAVOR OF THE ORIGINAL BUYER. THE BUYER'S SOLE REMEDY SHALL BE THE REPAIR OR REPLACEMENT, AS IS EXPRESSLY PROVIDED HEREIN, OF ANY WARRANTED DEFECTIVE PRODUCT OR PART, AND UNDER NO CIRCUMSTANCE SHALL SELLER BE LIABLE TO BUYER OR ANYONE ELSE FOR ANY CONSEQUENTIAL DAMAGES TO PERSONS OR PROPERTY, FOR INCIDENTAL DAMAGES OR LOSS OF TIME, FOR ANTICIPATED OR LOST PROFITS, OR ANY OTHER LOSS INCURRED BY THE BUYER RELATED TO THE PRODUCT COVERED BY THIS WARRANTY. THIS EXCLUSIVE REMEDY SHALL NOT BE DEEMED TO HAVE FAILED OF ITS ESSENTIAL PURPOSE SO LONG AS SELLER IS WILLING AND ABLE TO REPAIR OR REPLACE DEFECTIVE PARTS IN THE PRESCRIBED MANNER. THIS LIMITED WARRANTY MAY NOT BE MODIFIED BY SELLER UNLESS SUCH MODIFICATION OR WAIVER IS IN WRITING, EXECUTED BY AN AUTHORIZED OFFICER OF SELLER.

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