

## 905 MicroPirani™ Sensor Kit

RS232 / RS485

Design Guide

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### Warranty Performance

To obtain warranty satisfaction, contact the following:

#### US & ASIA:

MKS Instruments, Inc., HPS™ Products, Inc., 5330 Sterling Drive, Boulder, CO 80301, USA, Phone: (303) 449-9861.

#### EUROPE:

MKS Denmark ApS, Ndr. Strandvej 119G, DK3150 Hellebaek, Denmark, Phone: +45 44 92 92 99, Email: mksdenmark@mksinst.com

<b>Part number:</b>	<b>905-00</b> _ _
<b>Serial number:</b>	_ _ _ _ _ _ _ _ _ _
Please fill in this number and have it readily available when calling for service or additional information. The part number can be found on your packing slip, and both the part number and serial number are located on the electronics module.	

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# Symbols used in this manual



Failure to read message could result in damage to the equipment



Calls attention to important procedures, practices or conditions.

## Package contents

Before unpacking the 905 MicroPirani™ Sensor Kit, check all surfaces of the packaging material for shipping damage. Please make sure that your package contains the following items with respect to the last four digits of the part number:

Partnumber	TO-5	Sensor board	Sensor cable	Flange	Electronics module	Evaluation board	Power supply	Short doc.	Design guide
905-0001	1	1	1	KF16	1	1	-	1	1
905-0002	1	1	1	KF16	1	1	1	1	1
905-0003	1	-	-	-	1	-	-	1	-
905-0004	1	1	1	-	1	-	-	1	-

If any items are missing, please call MKS Customer Service at (800)345-1967 or (303)449-9861 or your local MKS sales office or distributor. Inspect for visible damage. If found, notify the carrier immediately.

Use caution when unpacking the 905 MicroPirani™ Sensor Kit and note the following:

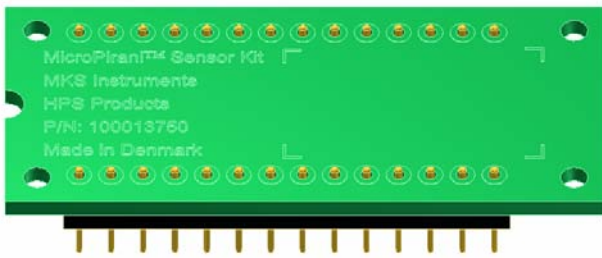


The TO-5 sensor is very delicate and should never be touched on its surface, as this will damage the bonding wires and/or sensor element.



The electronics module and evaluation board are sensitive to static electricity. Observe all ESD safety precautions while handling these parts. Failure to follow ESD safety precautions could result in damage to the electronics.

# About the 905 MicroPirani™ Sensor Kit



The 905 MicroPirani™ Sensor Kit is an ultra compact wide range vacuum pressure transducer designed for OEM system integration. The transducer is based on well proven thermal conductivity MEMS (Micro-ElectroMechanical System) sensor technology and meets the equipment market demand for integrated vacuum solutions.

## Features and benefits

- Wide measuring range, from atmosphere to  $10^{-5}$  Torr
- Integration with equipment electronics
- Three open collector set points for advanced process control
- User-friendly digital control via host processor or computer
- Analog output with 0.5VDC / decade
- Analog / digital remote zero calibration provides ease of operation
- Ultra compact dimensional design simplifies installation
- Standard DIP 28 pin footprint for easy integration
- RoHS compliant

The 905 MicroPirani™ Sensor Kit is a calibrated plug and play vacuum pressure transducer solution for OEM system integration. The kit consists of a MEMS-based pressure sensor and a measuring electronics and processor module. The electronics module fits a standard 28 pin DIP socket and can easily be integrated on a printed circuit board together with other electronics. The sensor module can either be wired through the circuit board or connected by a flexible flat cable from the electronics module. The MicroPirani™ sensor element consists of a silicon chip construction, where thermal conductivity is measured in a small cavity where gas is passed by diffusion instead of flow (see appendix). The MicroPirani™ offers a wide measuring range of 1-2 decades lower than traditional wire based pirani and convection gauges. The sensor can be mounted in any orientation without compromise of measurement performance. The advanced electronics module offers a wide selection of interface possibilities including an analog voltage output of 0.5 VDC / decade, digital communication via TTL UART interface and three independent open collector set points. The digital interface can transfer real time measuring data directly to a host processor or be used for configuration of set point parameters and user calibration.

## Applications

The 905 MicroPirani™ Sensor Kit can be used in a variety of applications and systems, including:

- Gas analysis – Mass spectrometry
- Scanning electron microscopes
- Vacuum pumping systems
- Gas leak detectors
- Semi surface and thin film analysis
- Space flight systems
- Vacuum valves
- Freeze drying
- UHV gauges
- Gyroscopes

## Applications (continued)

The following are some of the more common applications for the MicroPirani™ Sensor Kit:

### Gas leak detection

The portable MKS Pico helium leak detector uses MicroPirani™ sensor kit technology for inlet vacuum measurement and protection of the helium mass spectrometer.



Figure 1 - MKS Pico helium detector

### Mass spectrometers

In a mass spectrometer, the mean distance between molecules must reach a certain distance before activating the analyzing cell. The MicroPirani™ Sensor Kit can be used to measure pressure and thereby determine adequate mean free path of molecules. The size of mass spectrometers is constantly shrinking and the sensor kit significantly reduces space taken by traditional vacuum gauges, allowing more compact equipment design.

### Pumping systems

Traditional vacuum gauges occupy significant space in a pumping system. The compact size of the sensor kit allow pump manufacturers to integrate vacuum measurement solutions in pumping systems like multi-stage turbo molecular pumping systems.



Figure 2 - Generic molecular pump

### Space flight systems

The low weight and highly robust MEMS sensor design allows use in demanding applications and extreme environments like equipment for use in space flight. The electronics and sensor element are designed to withstand the extreme g-forces and intense vibrations experienced during rocket launch.

## 905 MicroPirani™ Sensor Kit specifications

Measurement range	1 × 10 <sup>-5</sup> to 760 Torr <sup>1</sup> 1 × 10 <sup>-5</sup> to 1000 mbar 1 × 10 <sup>-3</sup> to 1 × 10 <sup>+5</sup> Pascal
Measurement accuracy	5% <sup>2</sup>
Pressure units (user selectable)	Torr, mbar, Pascal
Supply voltage	+5VDC (±2%)
Supply current	45 mA
Digital user interface	Serial UART, TTL level
Analog output range	0.5 VDC - 4.5 VDC
Analog output impedance	100 Ohms
Set point outputs	3 (open collector)
Set point sink current	50 mA
Operating temperature	5° to 40°C (41° to 104°F)
Storage temperature	-10° to 55°C (14° to 131°F)
Sensor bakeout temperature	130°C (266°F)
Material exposed to vacuum	Silicon, SiO <sub>2</sub> , SiN <sub>4</sub> , Epoxy, Gold
Weight (electronics module)	9 grams
Mounting electronics	DIP 28 Pin socket
Mounting electronics pins	0.45 mm diameter
Sensor cable connector	Omron Rotary backlock type P/N: XF2M-1015-1A 0.5mm pitch, 10 pins, gold plated contacts.
Sensor cable	Flexible flat cable with 0.5mm pitch and 10 pins. (See documentation for the cable connector)
Electronics dimensions	47.8 × 20.8 mm (1.882 × 0.820 in)

## MicroPirani™ electronics module pinout.

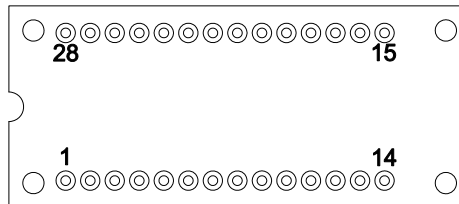


Figure 3 - Electronics module (seen from above)

1. MP Sensor pin1	12. Set point 1, open collector	23. N/C <sup>4</sup>
2. AGND	13. Set point 2, open collector	24. N/C <sup>4</sup>
3. MP Sensor pin2	14. Set point 3, open collector	25. N/C <sup>4</sup>
4. AGND	15. GND	26. N/C <sup>4</sup>
5. MP Sensor pin3	16. RS485 enable	27. N/C <sup>4</sup>
6. Differential analog Out+	17. +5V supply	28. N/C <sup>4</sup>
7. Differential analog Out- <sup>3</sup>	18. +5V supply	
8. Activity LED	19. Remote zero switch	
9. GND	20. TxD (TTL)	
10. GND	21. RxD (TTL)	
11. µP PSEN	22. Microprocessor reset	

<sup>1</sup> Zero offset can impact measurement accuracy in the 10<sup>-5</sup> and low 10<sup>-4</sup> Torr/mbar decade and consequently zero adjustment may be required in some applications for repeatable measurement.

<sup>2</sup> Typical measuring accuracy from 1 × 10<sup>-3</sup> to 100 Torr Nitrogen pressure measured at 25°C.

<sup>3</sup> This pin is actually analog ground, but is referred to as the negative analog output.

<sup>4</sup> Reserved for future use. Do not connect.

# Electronics module dimensions

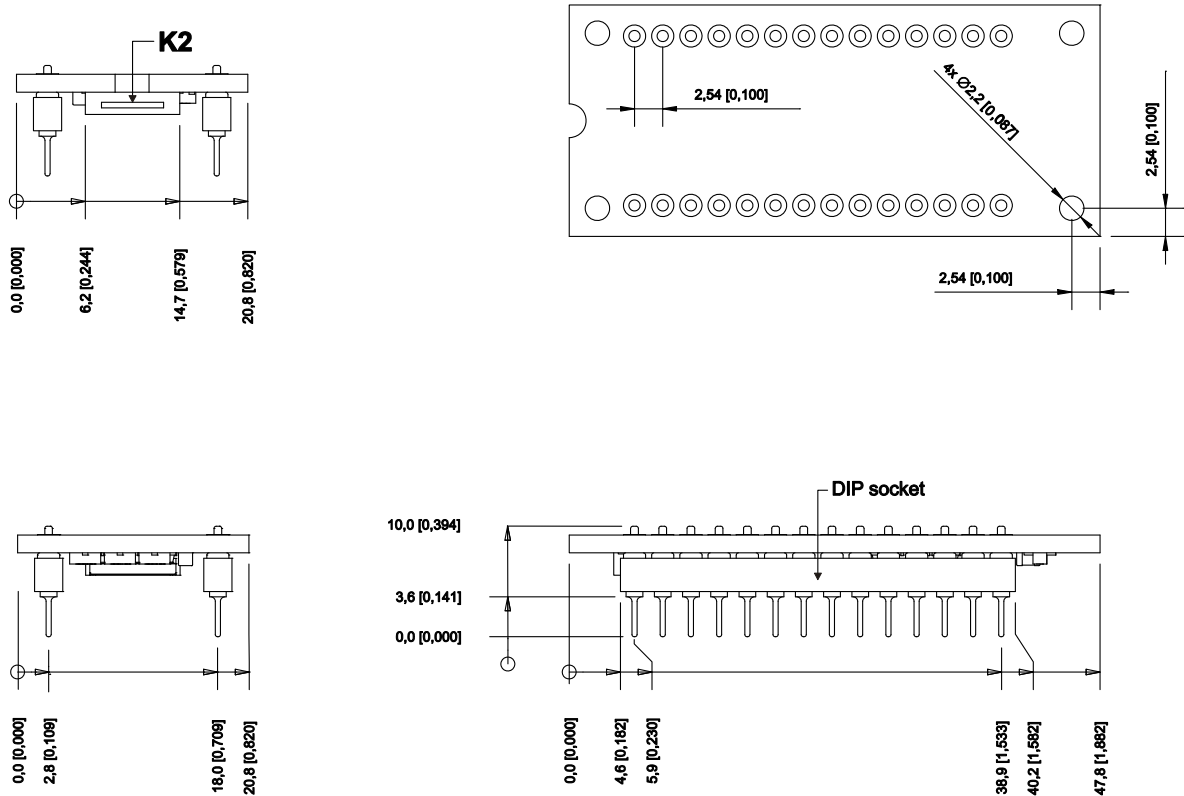


Figure 4 - Dimensions: millimeters [inches]

# MicroPirani™ sensor and board dimensions

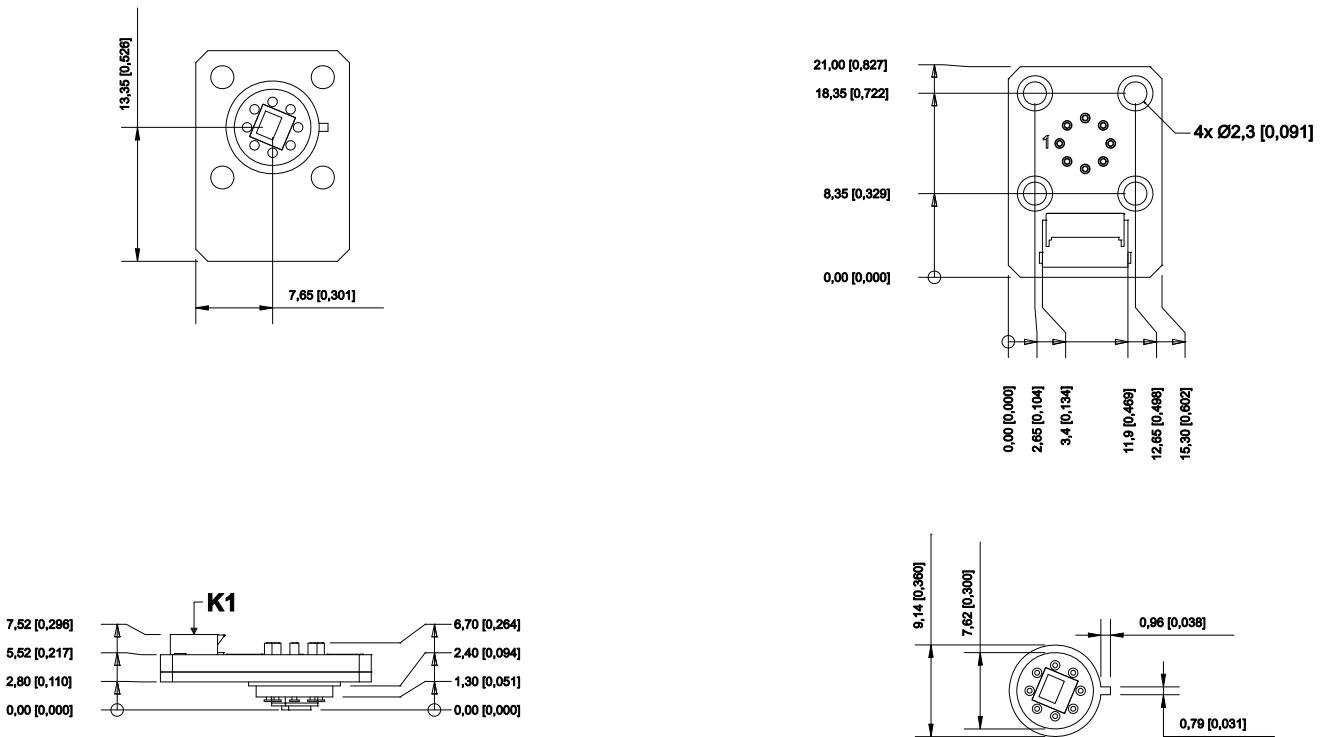
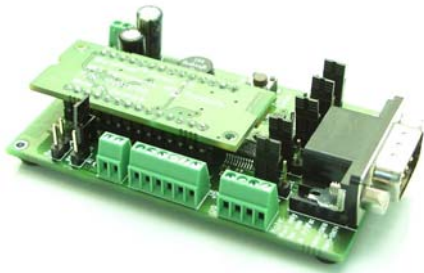


Figure 5 - Dimensions: millimeters [inches]

## About the evaluation board



The MicroPirani™ Sensor Kit is designed for a high level of integration, but the evaluation board can get the MicroPirani™ sensor kit up and running in minutes. The evaluation board offers both RS232 and RS485 digital communication and can be connected directly to a PC for real time pressure data logging and setup of digital parameters. For easy connectivity, all Sensor Kit I/O pins are available through screw terminals on the evaluation board.

The evaluation board is also compatible with the PDR900<sup>5</sup> controller which can be used for pressure readout and setup of digital parameters.

### Features and benefits

- Screw terminals for easy hookup to external components (MicroPirani™ sensor / communication etc.)
- RS232 or RS485 communication easily selectable via jumpers.
- Remote zero switch
- Activity LED
- Power supplied via DSUB connector or via screw terminals (jumper selectable)
- Onboard 5V switchmode powersupply with wide voltage range input.
- Microprocessor reset switch (for external watchdog)
- 9 pin DSUB connector for connection to a PDR900 or serial terminal.

### Description

The evaluation board is used as a link between the electronics module and a PDR900 or a standard serial terminal. The board is easily configured using the onboard jumpers and all terminals have associated text indicating their function.

The evaluation board allows users to quickly evaluate the features of the 905 MicroPirani™ Sensor Kit without having to build an electronic interface from scratch. When the sensor kit is implemented in the customers system only the electronics module and sensor (with optional cabling) is used.

The serial communication (RS232 or RS485) follows the traditional series 900 transducer command set and the complete list of commands is located in the command set chapter.

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<sup>5</sup> For more information about the PDR 900, see the following URL:  
<http://www.mksinst.com/product/product.aspx?ProductID=450>

# Evaluation board overview

## Connections

The following symbols refer to the picture:

Symbol:	Description:
V+ / Gnd	Optional power supply connection.
Vsupply	Choose supply voltage from the DSUB connector or screw terminals (Vext).
Activity LED	Indicates current system status.
Zero Switch	Used to zero the pressure readout at vacuum
Reset	Short circuit and release to reset the microcontroller on the electronics module.
S.Pin1 / 2 / 3	Can be used to connect the MicroPirani™ sensor to the socket pins of the electronics module. Each sensor connection has an associated ground connection.
A+	Differential analog+ output.
A-	Differential analog- output.
R1 / R2 / R3	Set point outputs.
RxD	Data receive pin when configured to external communication.
TxD	Data transmit pin when configured to external communication.
485	RS485 enable pin.
DSUB	9 pin DSUB communications port.
RxD int / ext	Chooses between the 'RxD' screw terminal (TTL directly from the module) or DSUB connector (RS232 or RS485) as receiver.
TxD int / ext	Chooses between the 'TxD' screw terminal (TTL directly from the module) or DSUB connector (RS232 or RS485) as transmitter.
232 / 485	Chooses between RS232 and RS485 communication. All three jumpers must be in either the 1-2 or 2-3 position.
Electronics module	Mount the electronics module here, notch facing board edge as shown.

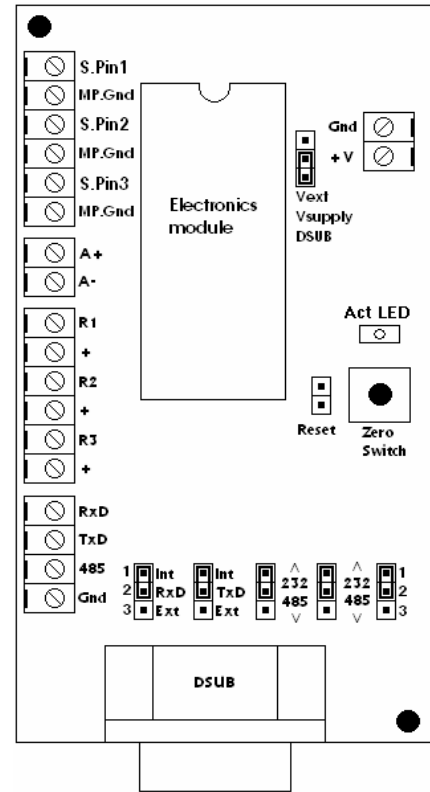


Figure 6 – The evaluation board

## D-SUB male connector pinout

1. <Not used>
2. <Not used>
3. Power supply +
4. Power supply ground
5. Analog output +
6. <Not used>
7. RS232 transmit or RS485-
8. Analog output -
9. RS232 receive or RS485+

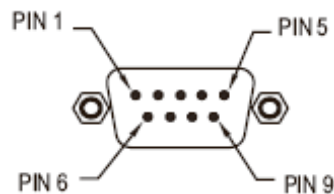


Figure 7 - 9 pin D-SUB interface (at the connector)

## Specifications

Supply voltage	9-30VDC via DSUB connector or screw terminals
Dimensions	Approx. 48 x 87mm (1.89 x 3.43 in)
Communication	RS232 / RS485 (9 pin DSUB) or TTL level (via screw terminals)
Sensor connection	Screw terminals or connector on the electronics module
Set point outputs	3 with onboard shunt diodes for use with relays.
Zero switch	Onboard

# Getting started with the 905 MicroPirani™ Sensor Kit

This guide describes how to install and operate the MicroPirani™ Sensor Kit with the evaluation board. For a complete description of how to integrate the 905 in a system see the next chapters.

Please read the guide carefully, and note the following:



Make sure power is disconnected before connecting the MicroPirani™ sensor. Otherwise the MicroPirani™ sensor element will be destroyed. Also, don't measure the resistors on the sensor as they will be destroyed by a regular ohmmeter.



Be careful when handling the MicroPirani™ sensor. Never touch the surface of the sensor itself because the bonding wires are easily damaged.

## Installing the electronics module

Unpack the evaluation board and the electronics module. Insert the flexible flat cable into the connector (marked 'K2' on figure 4) on the electronics module, lock it tight, and position the module with the notch facing the edge of the evaluation board. Gently insert the module into the socket, making sure not to bend the pins.

**Note:** The flexible flat cable can be inserted every way possible (both on the electronics module and/or the sensor board). This has been done to ensure that a correct connection is established regardless of the way the cable is mounted, which allows total freedom when connecting the sensor to the electronics.

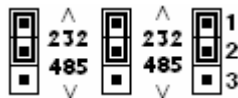
## Connecting the electronics module with the sensor

With the power disconnected, insert the flexible flat cable into the connector (marked 'K1' on figure 5) on the sensor board and lock it tight. Mount the KF16 flange on your vacuum system.

Read the chapter "MicroPirani™ electrical connections" for information on how to use the sensor screw terminals (S.Pin1-3).

## Choosing communication standard

Choosing RS232 or RS485 communication is easily done using the jumpers on the evaluation board. There are three separate jumpers next to the DSUB connector, and these should be in position 1-2 (all three) when using RS232 and 2-3 (all three) when using RS485:



**Note 1:** It is not necessary to power off the system in order to change communication standard.

**Note 2:** Make sure, that the RxD and TxD jumpers are set to 'Int'. If they are set to 'Ext' the communication doesn't go through the DSUB connector.

## Connecting the communication cable

Connect a suitable cable to the evaluation board and a host system of your choice (don't turn on the PDR900 or plug in the power supply at this time). The PDR900 is capable of changing all user commands on the 905. A standard terminal program can also be used to communicate with the 905 directly.

## Powering up the system

Make sure, that the Vsupply jumper is set to 'DSUB':



**PDR900:** Power on the PDR900 and wait a few seconds. The MicroPirani™ Sensor Kit will present itself as a 905 transducer on the PDR900 display. Refer to the PDR900 manual for configuration and operating instructions.

**Standard terminal:** This requires the cable with attached power supply (see ordering information). Plug in the power supply, and choose the connected communication port (usually COM1 or 2) and set it to 9600bps, 8 bits, no parity, 1 stop bit and no flow control. If possible, turn on “local echo” which enables the user to see what is being typed.

Type in the following command to verify that the connection is working:

Query: @254MD? ; FF

Query Response: @253ACK905 ; FF

The MicroPirani™ Sensor Kit should return the above statement.

Refer to the chapter “RS232 / RS485 command set” for a complete list of commands.

## Analog output

The analog output of the MicroPirani™ Sensor Kit can easily be evaluated with a differential voltmeter connected to the A+ and A- terminals. See the chapter “Analog Output” for more information on how to utilize this output.

## Integrating the 905 MicroPirani™ Sensor Kit

This chapter deals with the integration of the 905. Every aspect of the integration is covered, such as how to connect the sensor and how to choose the external components needed to make the 905 operate at peak performance.

These major steps need to be completed in order to integrate basic functionality of the 905:

1. Choosing a power supply
2. Making the electric connections of the MicroPirani™ sensor
3. Making the mechanical (vacuum) connection of the MicroPirani™ sensor
4. Establishing communication to/from the electronics module
5. Integrating the electronics module onto a printed circuit board

A thorough description of the above steps follow, as well as the other features of the 905.

### Choosing a power supply

The power supply for the 905 should be a stabilized noise-free 5VDC  $\pm$  2% supply. There are many types of switch mode power supplies which will be adequate for this purpose, but avoid charge pump power supplies, because they generate too much noise on the output. The evaluation board utilizes an LM2594-5.0 IC which is a Buck (step-down) converter from National Semiconductor. Its basic configuration can be seen on the picture below. It can accept a voltage input between 9 and 30V. More information on this, and other, switch mode IC's can be found on National's homepage.

The 905 can also be driven from a standard linear regulator as long as the voltage stays within the  $\pm$  2% limit and voltage ripple is minimal. Regulator losses are expected to be higher than with switch mode supplies though, because the efficiency drops from around 80% (or more) to around 50% for linear regulators, which could be a concern for handheld devices.

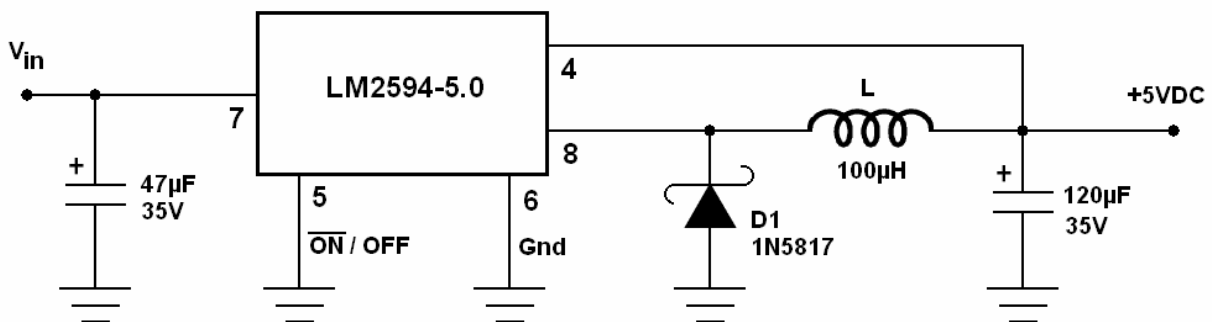


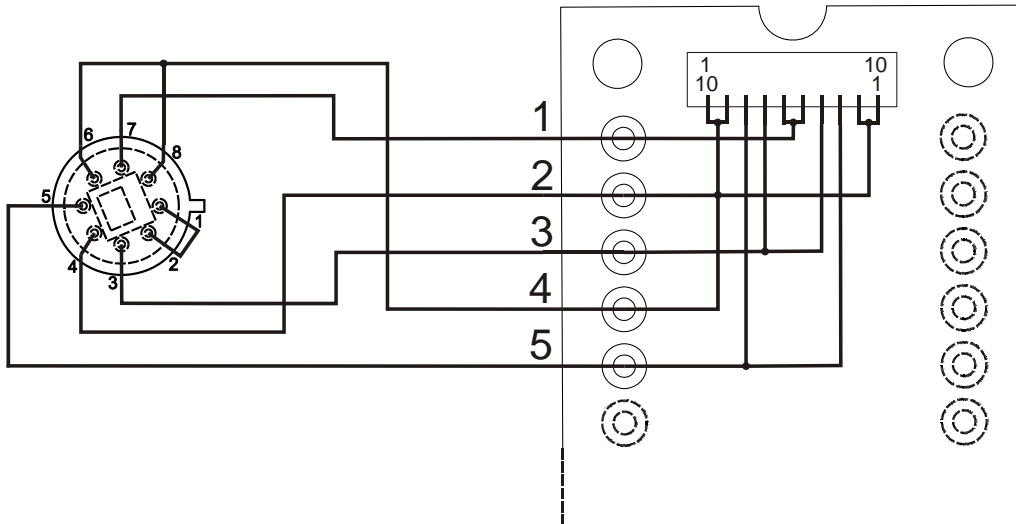
Figure 8 - Switch mode power supply based on a National LM2594 IC

The electronics module should be connected to the 5V power supply using pin 17 or 18 (or both) and a ground connection to pin 15. No further filtering of the 5V supply is needed, as the electronics module has its own filter to provide the voltage for the analog circuits (for the measurements).

If it is desired to be able to switch the 905 on and off, a power supply with enable pin can be used for this purpose. The LM2594 has a special ON/OFF pin which makes this easy. If pin 5 is held high the output voltage will drop to 0VDC until it is pulled low again. This also has the advantage, that it reduces the current consumption of the LM2594 to  $<$ 0.5mA.

## MicroPirani™ electrical connections

The MicroPirani™ sensor can be connected to the electronics module in two different ways. The simplest way is to use the flexible flat cable connector to connect the sensor board to the electronics module, but it's also possible to use the pins in the DIP socket instead. If a custom connection is desired, refer to the figure below when connecting the sensor:

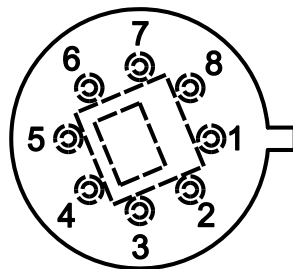


**Figure 9 - MicroPirani™ connection details (bottom view of sensor)**

The picture also shows the relationship between the DIP socket and the FPC connector. The FPC connections have been made symmetrical, which eliminates wrong connections with the flexible flat cable. The analog ground wires are pins 2 and 4 on the DIP socket, and 1,2,9 and 10 in the FPC connector.

The evaluation board has screw terminals to quickly connect a sensor to the electronics module. The designation (on the evaluation board) 'S.Pin1' (sensor pin 1) corresponds to pin 1 on the electronics module, S.Pin2 to pin 3 and S.Pin3 to pin 5, respectively. The 'MPGND' connections connect to pins 2 and 4 on the electronics module.

This is how the pins on the MicroPirani™ have been placed:



**Figure 10 - MicroPirani™ sensor connections (bottom view)**

The cable or printed circuit board connections between the MicroPirani™ sensor and the electronics module can be chosen arbitrarily in length, but keep the distance as short as possible to avoid noise to interfere with the pressure measurements. It is not possible to specify a maximum cable length as this depends on the system in question. The MicroPirani™ sensor is especially sensitive when measuring at vacuum (and atmospheric pressure). The entire  $10^{-5}$  decade (Torr / mbar) only spans around 1mV. The following are general guidelines when using the different connections:

### Flexible flat cable

The flexible flat cable fits directly in the connector on the electronics module and provides a firm connection of the MicroPirani™ sensor. Use the cable provided by MKS or a 10 pin FFC cable with 0.5mm pitch and gold plated contacts. See the specifications for the P/N of the connector the cable should be made to fit in. Shielded flexible flat cables exist, and could be necessary if the 905 is to be used in very noisy environments. Under normal circumstances a regular flexible flat cable will suffice.

## Regular cable

A regular round cable can be used if the DIP socket connections have been chosen, but the printed circuit board (where the electronics module is mounted) does not extend all the way to the sensor. Use a shielded cable if possible and optimise for minimal length to minimise measuring noise.

## Printed circuit board connection

If a connection through a printed circuit board is desired to connect the MicroPirani™ sensor to the electronics module, there are a few rules to follow. The sensor wire traces should be kept closely together on the same side of the printed circuit board, and an analog ground plane should cover the underside of the traces. If the signals are allowed to flow close to digital signals, or digital power planes, measuring noise could result from this.

Refer to figure 9 when laying out connections between the MicroPirani™ sensor and the electronics module. The connections should be kept close together and a trace width of minimum 0.3mm (0.012 inches) is recommended. Below these wires an analog ground plane (/copper area) should be laid out and it should cover the sensor connection traces. The analog ground plane should be connected to pin 2 and 4 on the electronics module and not the sensor grounds, to avoid ground loops. Also, do not connect this groundplane to the ground found on pins 9 and/or 10.



The MicroPirani™ and the electronics module have been calibrated as a matched pair. It is not possible to interchange sensor or electronics module without a complete factory recalibration.

## Installing the MicroPirani™ sensor

The MicroPirani™ sensor can be mounted in any direction because the sensor was designed to minimize convection so that the operation is possible in any position without compromising accuracy. It should be located where it can measure chamber or manifold pressure. Install it away from pumps and gas sources and where vibration is minimal. Also, locate and orient the 905 where contamination is least likely. Avoid installation where the sensor could be contaminated, such as above a roughing pump where oil vapor could enter the MicroPirani™ and cause the calibration to shift.

The recommended sensor hole dimensions are on the following picture. Note the small hole leading to the cavity where the MicroPirani™ is located. This has been done to mechanically shield the sensor from possible heat sources which could lead to wrong pressure readings. Always avoid direct line-of-sight heat sources.

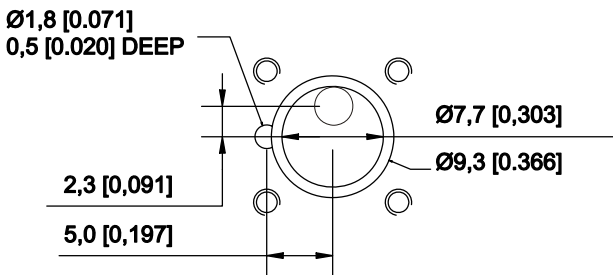


Figure 11 - Mounting hole (seen from above)

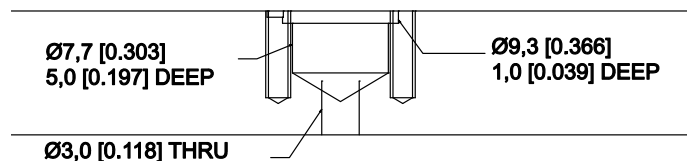


Figure 12 - Mounting hole (side view)

When mounted this way the sensor o-ring has been compressed to achieve a tight fit with about 30% compression. We generally recommend between 20 and 30% compression. The sensor board is then flush with the surface which ensures that the o-ring can not be overstrained when tightening the mounting screws.



Note: Mount the o-ring on the MicroPirani™ sensor before assembly, not in the groove of the mounting hole.

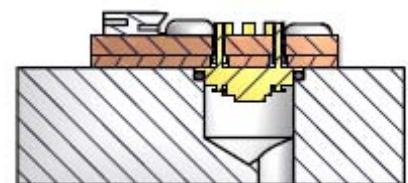


Figure 13 - Mounted sensor

After the assembly of the complete vacuum setup it's important to leak test the system. Helium is suitable for probing a system which pumps air or nitrogen. If the MicroPirani™ installation is found not to be vacuum tight there are a few causes worth mentioning:

- Dirt on the o-ring (for instance a hair). Clean or replace o-ring and groove.
- O-ring damaged due to incorrect mounting. Replace o-ring.
- Screws not fully tightened. The sensor board spacer should be flush with the surface.

## Communication

The electronics module sends and receives TTL level signals directly from the microcontroller. How these signals should be integrated with the rest of the setup depends on the user configuration and application.

If the 905 is to communicate directly with another microcontroller no signal conversion is necessary and TxD/RxD (pins 20 and 21 respectively) can be connected directly. This means, that the communication is TTL level all the way.

If the 905 is to be hooked up using an RS232 connection then a driver IC (transceiver) is to be used. This can be achieved with a standard RS232 transceiver IC. These ICs have built-in voltage conversion, which only requires external capacitors (usually between 1 and 4 pcs.).

The 905 can also be used on a RS485 network with half duplex capability. This requires the use of RS485\_ENABLE (pin 16) and the purpose of this pin is described in the following section.

### Example configuration for RS232 and RS485

The evaluation board utilizes an IC which is capable of both RS232 (full duplex) and RS485 (in half duplex mode) communication. The LTC1387 from Linear Technology is ideal for this purpose, because it can be configured for both types of communication with three pins.

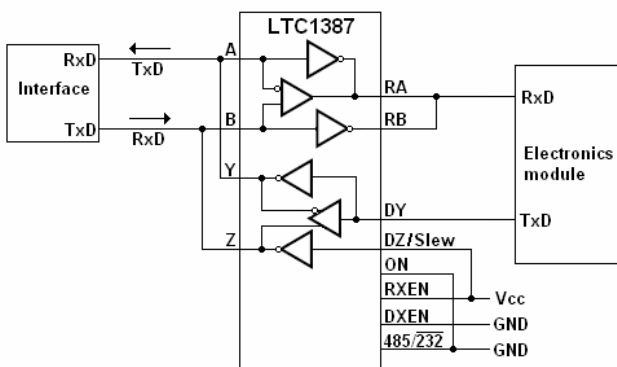


Figure 14 - RS232 configuration

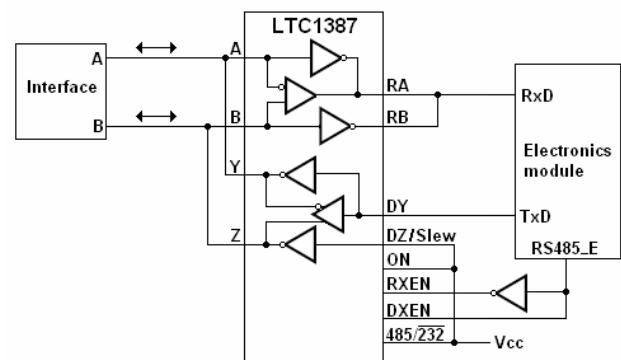


Figure 15 - RS485 configuration

The picture above shows the configuration for each type of communication. To configure for RS-232 mode connect the IC as shown on the first picture. This provides one master and one slave.

To configure for RS485 communication use the setup on the second picture. The change between these two states have been implemented using jumpers on the evaluation board, but the pins can also be connected to the host system, making it capable of changing the state.

### The signal 'RS485\_ENABLE'

When using RS485 communication the RS485\_ENABLE signal must be used. This signal is a logical '1' when the electronics module is driving the RS485 network and a logical '0' at all other times. When RS485\_ENABLE is active (high) only this device is able to send on the network. When RS485\_ENABLE is inactive (low) the output of the transceiver is tristated<sup>6</sup> and other devices are able to send data. The 905 is configured to always listen for commands on the network and respond if the correct address is spoken to.

<sup>6</sup> An output on an integrated circuit can be in one of three states: low, high or tri-stated. When tristated the output does not pull the signal in either direction so it does not interfere with signals using the same wire.

## Analog Output

The analog voltage output can be used for connection to external analog measuring equipment for pressure reading and data logging. The analog output must be connected to a true differential input voltmeter or an analog to digital (A/D) converter with a differential input in a system controller.

The analog output will change scale when the pressure unit is changed and will always provide 0.5VDC per decade whether Torr, mbar or Pascal is selected.

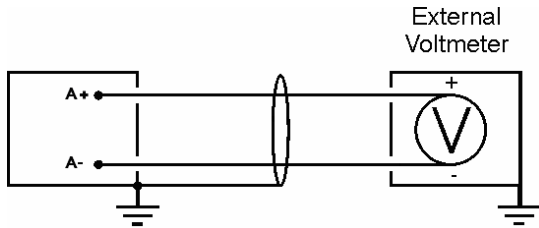


Figure 16 - Correct setup

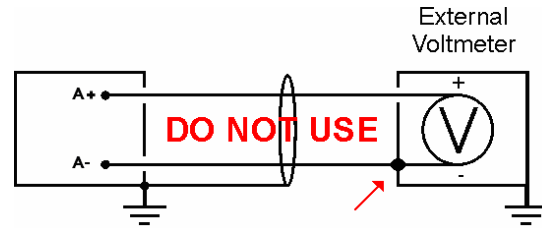


Figure 17 - Incorrect setup

**Note:** Do not connect the negative side of the analog output to the chassis / ground or to any other ground. Measurement errors in the output voltage may be seen due to the voltage drop from this current loop flow. The longer the cable, the worse the error will be.

If the analog output is improperly connected, shorted to ground or heavily loaded, the pressure transducer performance and consequently pressure reading can be affected.

The graph below shows the correlation of linear analog output to pressure.

To calculate pressure (Torr/mbar) from voltage:

$$P(V_{out}) = 10^{(2V_{out} - 6)}$$

To calculate pressure (Pascal) from voltage:

$$P(V_{out}) = 10^{(2V_{out} - 4)}$$

To calculate voltage from pressure (Torr/mbar):

$$V_{out}(P) = \frac{\text{Log}(P) + 6}{2}$$

To calculate voltage from pressure (Pascal):

$$V_{out}(P) = \frac{\text{Log}(P) + 4}{2}$$

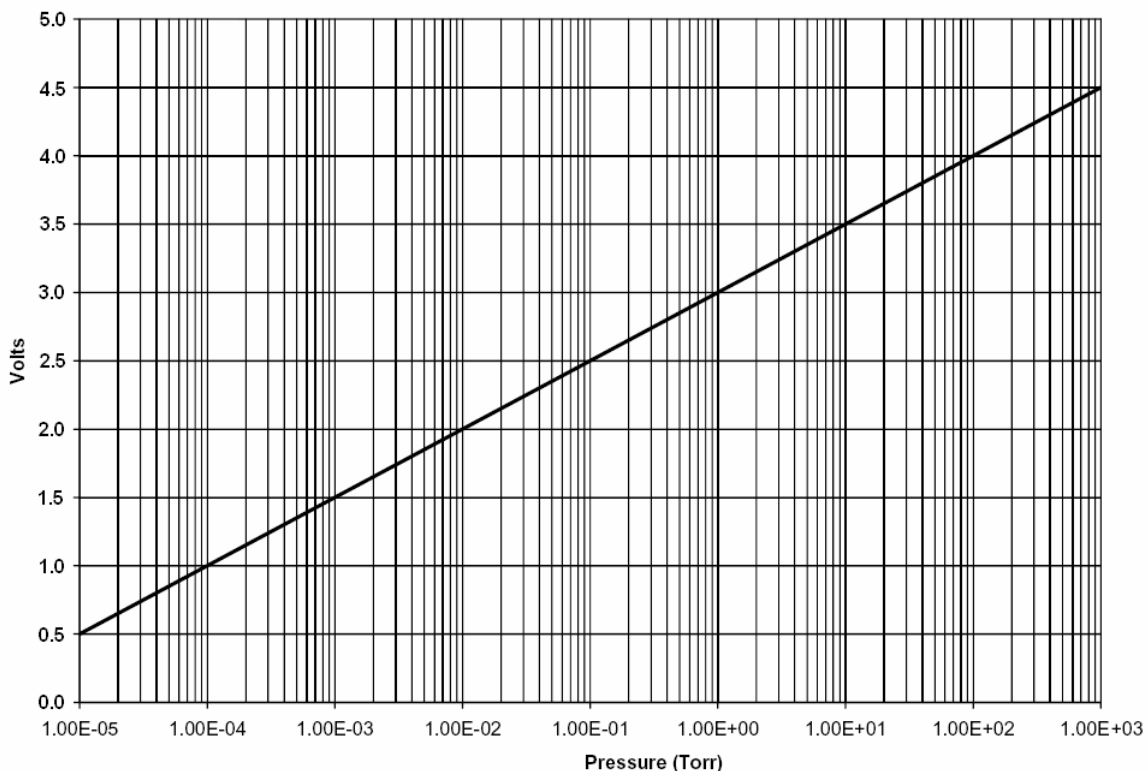


Figure 18 - Analog output (in VDC) vs. pressure (in Torr / mbar)

## Pressure to voltage table

Pressure [Torr/mbar]:	Output [V]	Pressure [Torr/mbar]	Output [V]
$1.0 \times 10^{-5}$	0.500V	$1.0 \times 10^{-1}$	2.500V
$2.0 \times 10^{-5}$	0.651V	$2.0 \times 10^{-1}$	2.651V
$4.0 \times 10^{-5}$	0.801V	$4.0 \times 10^{-1}$	2.801V
$6.0 \times 10^{-5}$	0.889V	$6.0 \times 10^{-1}$	2.889V
$8.0 \times 10^{-5}$	0.952V	$8.0 \times 10^{-1}$	2.952V
$1.0 \times 10^{-4}$	1.000V	$1.0 \times 10^0$	3.000V
$2.0 \times 10^{-4}$	1.151V	$2.0 \times 10^0$	3.151V
$4.0 \times 10^{-4}$	1.301V	$4.0 \times 10^0$	3.301V
$6.0 \times 10^{-4}$	1.389V	$6.0 \times 10^0$	3.389V
$8.0 \times 10^{-4}$	1.452V	$8.0 \times 10^0$	3.452V
$1.0 \times 10^{-3}$	1.500V	$1.0 \times 10^{+1}$	3.500V
$2.0 \times 10^{-3}$	1.651V	$2.0 \times 10^{+1}$	3.651V
$4.0 \times 10^{-3}$	1.801V	$4.0 \times 10^{+1}$	3.801V
$6.0 \times 10^{-3}$	1.889V	$6.0 \times 10^{+1}$	3.889V
$8.0 \times 10^{-3}$	1.952V	$8.0 \times 10^{+1}$	3.952V
$1.0 \times 10^{-2}$	2.000V	$1.0 \times 10^{+2}$	4.000V
$2.0 \times 10^{-2}$	2.151V	$2.0 \times 10^{+2}$	4.151V
$4.0 \times 10^{-2}$	2.301V	$4.0 \times 10^{+2}$	4.301V
$6.0 \times 10^{-2}$	2.389V	$6.0 \times 10^{+2}$	4.389V
$8.0 \times 10^{-2}$	2.452V	$8.0 \times 10^{+2}$	4.452V
		$1.0 \times 10^{+3}$	4.500V

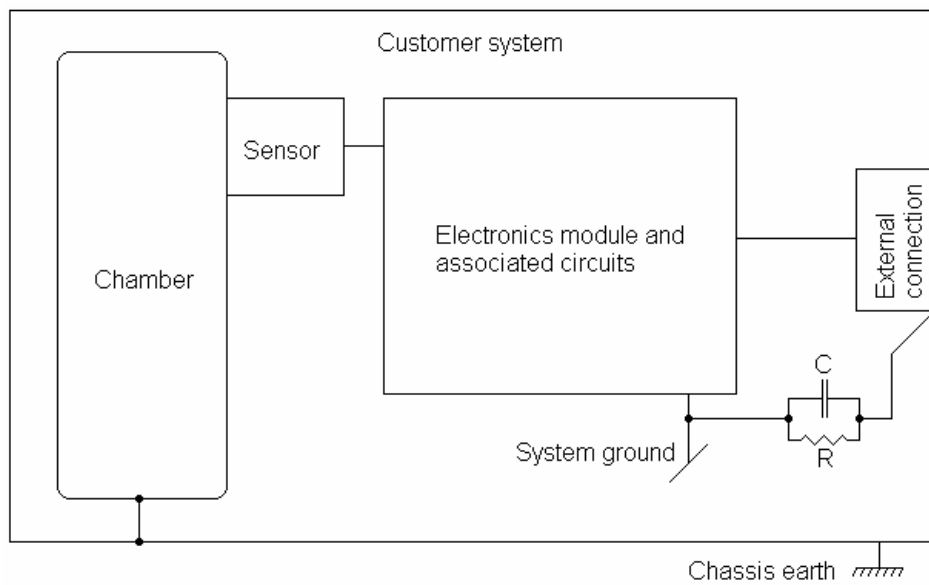
## Utilization of remote zero

The electronics module has a remote zero function (pin 19) which allows the user or system setup to manually perform zero adjustment. Pressing remote zero on the evaluation board is equal to sending the VAC-command as described in the command set. The zero adjustment should be performed when at a pressure lower than  $8 \times 10^{-6}$  Torr.

When a zero adjustment is required, simply pull the zero switch pin low briefly, or send the VAC-command. The activity LED will blink twice if the calibration was successful, and once if the pressure was too high for calibrating zero. On the evaluation board the switch simply connects the pin to ground when pressed down.

## Ground to earth connection

When installing the electronics module in a system the grounding scheme must be carefully chosen, otherwise measuring errors can occur. We strongly suggest that the MicroPirani™ Sensor Kit ground (found on pin 15) is connected to earth in one location only, which, as an example, could be at an external connection such as a DSUB connector. The ground connection is made to chassis earth through a capacitor and a resistor in parallel. The suggested values for these two components are 10nF and 22.6kΩ. The picture depicts the grounding scheme for the complete system. It can be seen, that there is only one connection to chassis earth. The sensor board has a copper area which is most likely earthed (due to its connection to the vacuum chamber through the mounting screws), but this is not important, because this is not connected to the cable or MicroPirani™ sensor.



**Figure 19 – Example grounding scheme in a complete system**

The electronics module is supplied with 5VDC from the power supply. This voltage is both used to supply the microprocessors digital I/O and the analog part with MicroPirani™ bridge circuit, ADC and analog output. The analog voltage is filtered to avoid noise from the digital circuits, which entails that the analogue and supply (digital) ground must not be connected together. That is, pins 2,4 and 7 must not be connected to 9, 10 and 15 on the electronics module.

## Reset switch

Under normal circumstances and operation the MicroPirani™ Sensor Kit does not require a reset of the microprocessor, but even so a reset jumper has been implemented (pin 22). The reset pin makes it possible to implement an external watchdog in a host system where guaranteed functionality under all circumstances is required.

The applied reset signal should briefly pull the reset-pin high (+5VDC) which is equal to cycling the power on the MicroPirani™ Sensor Kit. This could be implemented simply by connecting the reset pin to a port in the host system and controlling it from software.

The microprocessor on the electronics module features internal power-on reset, so no circuitry is needed to reset the electronics at startup.

## Activity LED

The activity LED of the MicroPirani™ Sensorkit has the same function as on the other series 900 transducers. During start up the LED flashes and then becomes permanently on.

### Other functions of the LED:

#### When using the VAC command or zero adjusting:

The LED blinks twice if successful, once if not. See the VAC-command for more information.

#### When using the TST command:

The LED blinks continuously until turned off.

See the TST-command for more information.

The LED circuit is simple. The microprocessor sinks current through the LED and a 825 ohm resistor when the LED is on, as seen on the picture. The actual size of the resistor varies with the chosen LED and the amount of light needed.

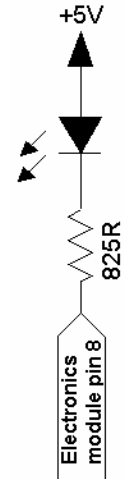


Figure 20 - Activity LED

## Set point outputs

The 905 MicroPirani™ Sensor Kit has three independent set point outputs located on pins 12,13 and 14 on the electronics module. A relay (three in all) connect between the output (respectively 1, 2 and 3 on the evaluation board) and a 5V connection. This schematic shows how the outputs are made. A suitable damper diode has been integrated on the evaluation board and will have to be added when the electronics module is integrated in a system. Otherwise the spikes from the relay coil will damage the transistor and/or microcontroller on the electronics module.

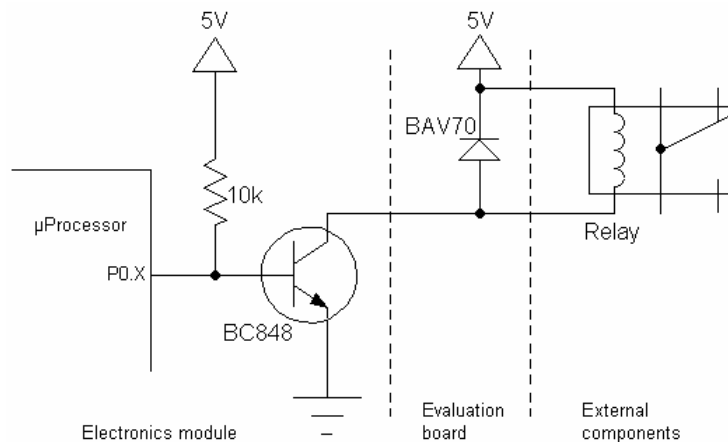


Figure 21 - A relay connected to the 905

The set point output sink current is rated at 50mA. Above this value it cannot be guaranteed that the relay will work or that damage to the set point output will not occur.

## Integrating the electronics module onto a printed circuit board

At this point the integration is entering the final stage. The electronics module fits in a standard DIP socket with 28pins (2.54mm / 0.1 inch pin spacing) which is commonly available. Although the electronics module can be soldered directly onto a printed circuit board we recommend mounting it in a socket which makes it easy to service or replace the kit in case of contamination of the sensor.

The electronics module has four mounting holes which can be used to firmly attach it onto a printed circuit board. It should not be necessary under normal circumstances, but it could prove useful if the system is to be subjected to vibrations etc. Although the board is quite rigid spacers should be used to avoid bending the electronics module.

## Updating the firmware

The electronics module is factory programmed with a firmware. However, if an update is needed it is easy to program a new firmware into the microprocessor on the electronics module using the supplied downloader. Under normal circumstances the firmware does not need upgrading, but it enables upgrading units if custom features have been implemented or a issue has been fixed.

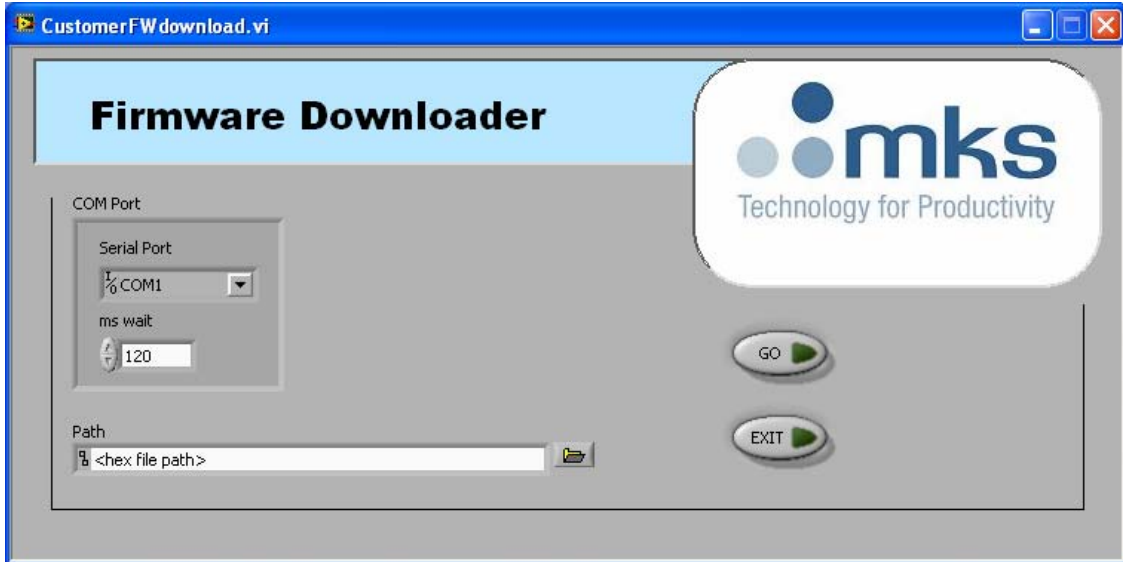


Figure 22 - The MKS firmware downloader

As can be seen above the firmware downloader user interface is simple. The user needs to choose serial port and path to the supplied firmware (only an RS232 connection can be used to upgrade the firmware). Before the firmware can be programmed the electronics module (microprocessor) needs to be put into programming mode. Press, and hold, the remote zero switch on the evaluation board while resetting the electronics module (short circuit the two pins of the reset connector briefly). Now the activity LED is off and the firmware download can begin by pressing the 'go' button. After the upgrade is completed the LED flashes and the electronics module is ready with the new firmware installed. If a communications error occur it may be necessary to increase the parameter "ms wait". This communications delay is system dependent but 120ms is usually sufficient to allow a firmware download.

The microprocessor is put into programming mode by shorting the pin PSEN to ground while powering on or resetting the module. On the evaluation board the PSEN-circuit is designed as shown on the figure. The resistor (1kohm) and the diode (standard signal diode, BAV70, 1N4148 or similar) are needed to separate the PSEN pin from the remote zero pin and keeps PSEN low when activating the switch. Now the microprocessor reset pin (22) should be briefly pulled low to activate programming mode (or the power cycled).

The mentioned circuit has a big advantage, because it allows the firmware to be upgraded without disassembling the unit. It only requires access to the transmit/receive pins and the remote zero switch. Otherwise the electronics module has to be removed from the system and updated.

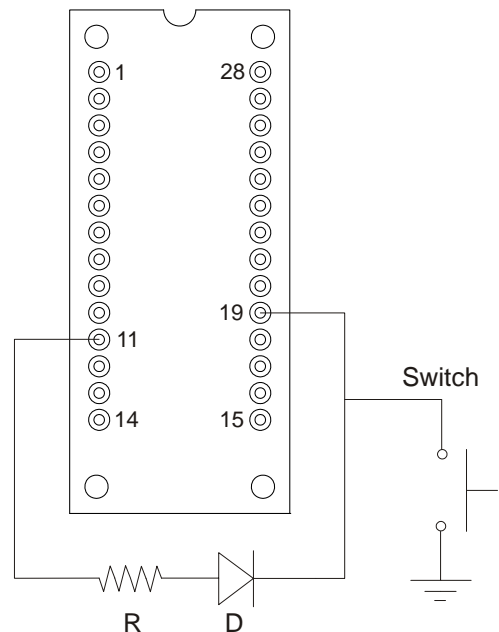


Figure 23 - Circuit used to enable programming mode



The programming mode is only possible to enter when resetting or powering on the system. The shown circuit will not affect normal use of the MicroPirani™ Sensor Kit.

# Manual procedures for the 905

## Adjustment for Zero

Though factory calibrated, the MicroPirani™ Sensor Kit calibration may change due to reasons such as filament contamination or aging of the electronic components. If necessary, the user can adjust zero calibration of the MicroPirani™ Sensor Kit. The user can adjust zero calibration by using the Vacuum Calibration – VAC command, or by pressing the ZERO adjust button (located on the evaluation board, or implemented by the designer), as follows:



For best results, leave the 905 at the calibration pressure for at least 20 minutes before pressing the ZERO adjust button.

1. Connect the analog output to a differential input voltmeter or an analog-to-digital (A/D) converter with a differential input in the system controller.
2. Pump the system to a pressure below  $8 \times 10^{-6}$  Torr. Then press the ZERO adjust button for a voltmeter reading of 0.5 VDC.
3. The LED will blink twice when the zero calibration is executed. The LED will blink once if the pressure is too high for calibrating zero.

## Venting to Atmosphere

The MicroPirani™ sensor can be vented to atmosphere very rapidly without damage to the sensor element. This is an improvement over the traditional pirani sensor, which uses a very small diameter filament wire, which can be broken or damaged during sudden venting to atmosphere.

## Leak Detection

Its inherent sensitivity to gas type makes the 905 useful for detecting leaks, at rates greater than  $10^{-4}$  std cc/sec of helium, in foreline and roughing systems. It is a useful complement to a mass spectrometer leak detector, which help locate smaller leaks. Probe the suspected leak areas with a gas that has a molecular weight different from that of the system gas. Helium is suitable for probing a system pumping air or nitrogen.

1. Pump the vacuum system to a base pressure.
2. Slowly and methodically probe with a small amount of the tracer gas (helium).
3. Note the pressure reading. The pressure readout will rise or fall, depending upon the thermal conductivity of the probe gas relative to the system gas. The largest change in the value indicates the probe gas is nearest the leak location.
4. Repeat the test to confirm.

## Operation

The MicroPirani™ Sensor Kit operation parameters are preset at the factory. The table below shows the factory default settings. The user interface and the commands described on the following pages can be used to change parameter settings as necessary. The user interface to the MicroPirani™ Sensor Kit is through either TTL, RS232 or RS485 serial communication (all available on the evaluation board). All forms of communication uses the same commands to communicate with the kit; however, RS485 allows communication with multiple transducers, whereas RS232 allows communication with only a single transducer.

### MicroPirani™ Sensor Kit factory defaults table

<b>Setting:</b>	<b>Default:</b>
Address	253
Baud Rate	9600
RS Delay	Off
Pressure Unit	Torr
Set Points	$1.00 \times 10^0$ Torr
Hysteresis	$1.10 \times 10^0$ Torr
Set Point Directions	Below
Enable Set Points	Off
Gas Type	Nitrogen
User Tag	MKS0

## RS-485 Protocol

The 905 supports 2400, 4800, 9600, 19200, 38400 and 115200 baud rates (factory default: 9600). The data format is 8 data bits, no parity, and one stop bit.

### Standard Addresses

Valid addresses are 3 digits, 001 to 253 (factory default: 253).

### Universal Addresses

The 905 receives and responds to commands sent to address 254. For example, use 254 to communicate with a device if its address is unknown. The 905 receives and acts upon commands sent to address 255, but does not respond; use 255 to broadcast messages to multiple devices attached to the same system. For example, use 255 to change the baud rate for all devices.

### Query and Command Syntax

Queries return current parameter settings; commands change the parameter setting according to the value the user types in the command syntax. Each query or command must begin with the attention character @ and end with the termination string ;FF.

Syntax required for a query is:

```
@<device address><query>?;FF
```

Syntax required for a command is:

```
@<device address><command>!<parameter>;FF
```

Examples:

Query current baud rate: @253BR?;FF

Change baud rate to 19200: @253BR!19200;FF

where:

@ <attention character>

253 <device address>

BR? <query> (for query syntax)

BR!19200 <command>!<parameter> (for command syntax)

;FF <terminator>

### Response Syntax (ACK/NAK)

The ASCII characters 'ACK' or 'NAK' preface the query or command response string. The ACK sequence signifies the message was processed successfully. The 'NAK' sequence indicates there was an error.

The response to a query or a successful command is:

```
@<device address>ACK<data>;FF
```

The response to a message with an error is:

```
@<device address>NAK;FF
```

Examples:

ACK response: @253ACK9600;FF (baud rate changed to 9600)

NAK response: @253NAK;FF

# RS232 / RS485 Command Set

The query and command formats shown in this section are examples; the values may vary for the user's installation.

## Set Up Commands

### Address – AD

The AD command returns or sets the 905 address. Note: If multiple devices are installed on the system, an address query using 254 (shown in the query example below) can only determine the address of one of the devices.

Values: 001 to 253 (default: 253)

Query: @254AD? ; FF

Query Response: @001ACK001 ; FF

Command: @001AD!002 ; FF

Command Response: @002ACK002 ; FF

### Baud Rate – BR

The BR command returns or sets the baud rate of the communications protocol. The 905 responds to this command at the present baud rate; however, the user will need to change the baud rate on the host to ensure future commands are sent at the same rate.

Values: 2400, 4800, 9600, 19200, 38400, 115200 (default: 9600)

Query: @253BR? ; FF

Query Response: @253ACK9600 ; FF

Command: @253BR!19200 ; FF

Command Response: @253ACK19200 ; FF

### Factory Default – FD

The basic FD command sets all 905 parameter values to the factory default settings shown in the factory defaults table, except set points. For a complete factory default use the command FD!ALL instead. Both factory default commands also reset atmospheric calibration and vacuum adjustment.

Note: The FD!ALL command overrides all parameter values the user sets including set points; use with caution! The address and baud rate reset to 253 and 9600, respectively, with both types of factory default. The user must change the address and baud rate to these values on the host to communicate with the transducer after using the FD command.

Small factory default (without set points):

Command: @253FD! ; FF

Command Response: @253ACKFD ; FF

Complete factory default (with set points):

Command: @253FD!ALL ; FF

Command Response: @253ACKFD ; FF

## RS Delay – RSD

The RSD command enables or disables a delay of up to 5 milliseconds between receive and transmit mode. Some RS485 to RS232 converters requires this delay in order to operate.

Values: OFF, ON (default OFF)

Query: @253RSD? ; FF

Query Response: @253ACKOFF ; FF

Command: @253RSD!ON ; FF

Command Response: @253ACKON ; FF

## Test RS485 – TST

The TST command flashes the activity LED ON and OFF, in order to visually identify the unit.

Values: ON, OFF

Query: @253TST? ; FF

Query Response: @253ACKOFF ; FF

Command: @253TST!ON ; FF

Command Response: @253ACKON ; FF

## Unit – U

The U command returns or sets the pressure unit to Torr, mBar, or Pascal. The units affect all pressure measurements and the set point values. The analog output will change scale when the pressure unit is changed and will always provide 0.5VDC per decade whether Torr, mbar or Pascal is selected.

Values: TORR, MBAR, PASCAL (default: TORR)

Query: @253U? ; FF

Query Response: @253ACKTORR ; FF

Command: @253U!MBAR ; FF

Command Response: @253ACKMBAR ; FF

## User Tag – UT

The UT command is used to query the 905 for the user tag information or to assign a user tag to the 905.

Values: Up to 15 ASCII characters

Query: @253UT? ; FF

Query Response: @253ACKCHAMBER1 ; FF

Command: @253UT!CHAMBER2 ; FF

Command Response: @253ACKCHAMBER2 ; FF

## Status Commands

### Device Type – DT

The DT command returns the transducer device type.

Query: @253DT? ; FF

Query Response: @253ACKMICROPIRANI ; FF

### Firmware Version – FV

The FV command returns the 905 firmware version.

Query: @253FV? ; FF

Query Response: @253ACK1.00 ; FF

### Hardware Version – HV

The HV command returns the 905 hardware version.

Query: @253HV? ; FF

Query Response: @253ACK1.00 ; FF

### Manufacturer – MF

The MF command returns the 905 manufacturer.

Query: @253MF? ; FF

Query Response: @253ACKMKS DENMARK ; FF

### Model – MD

The MD command returns the 905 model number.

Query: @253MD? ; FF

Query Response: @253ACK905 ; FF

### Pressure Reading – PR1

The pressure reading command returns the measured pressure from the MicroPirani™.

Query: @253PR1? ; FF

Query Response: @253ACK9.00E+2 ; FF

### Serial Number – SN

The SN command returns the 905 serial number.

Query: @253SN? ; FF

Query Response: @253ACK0720012345 ; FF

## Time On – TIM

The TIM command returns the number of hours the 905 has been on.

Query: @253TIM? ; FF

Query Response: @253ACK000000001 ; FF

## Transducer Temperature – TEM

The TEM command returns the MicroPiranis on-chip sensor temperature in °C.

Query: @253TEM? ; FF

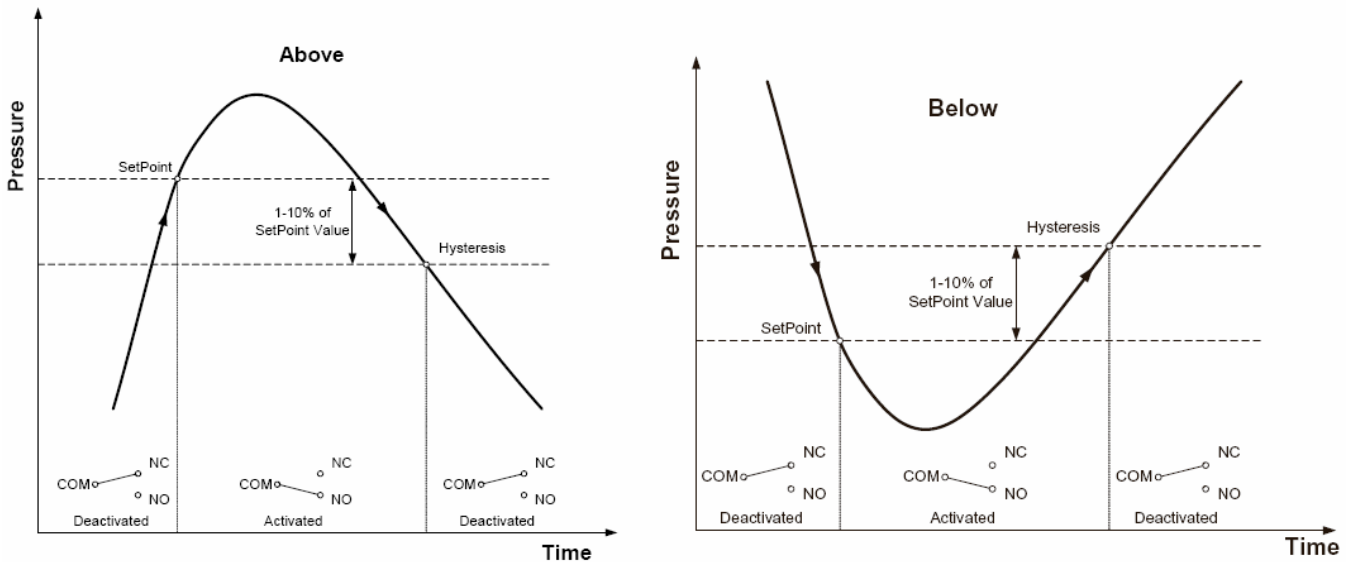
Query Response: @253ACK2.10E+1 ; FF

## Set Point Commands

The 905 has three independent set points which can be used for process control or surveillance. The set points can be turned on or off with the Enable set point command. The 905 automatically sets and overwrites any user setting of the hysteresis value when a set point value is entered or the set point direction is changed.

The correct procedure for setting up the set point parameters are:

1. Enter set point value: SPx
2. Select set point direction: SDx
3. Enter set point hysteresis value, if other than +/- 10% of set point value is required: SHx
4. Enable set point: ENx



### **Set Value – SP1,SP2,SP3**

The set point value command returns or sets the set point value. The set point value is the pressure either below or above which the set point will be activated. The direction of the set point (ABOVE or BELOW) is configured using the Set Point Direction – SD1,SD2,SD3 command. The set point must be enabled for the set point command to function (see the Enable Set Point – EN1,EN2,EN3 command).

The set point hysteresis value is automatically set to +10% of set point value, if set point direction is set to below or -10% of set point value, if set point direction is set to above. The set point hysteresis value always overwrites the current value when a set point value is entered.

Values: Two- or three-digit scientific notation (default: 1.00E0 Torr)

Query: @253SP1?;FF

Query Response: @253ACK1.00E-2;FF

Command: @253SP1!1.00E-3;FF

Command Response: @253ACK1.00E-3;FF

### **Hysteresis Value – SH1, SH2, SH3**

The hysteresis value command returns or sets the pressure value at which the set point will be deactivated. If the hysteresis and set point are the same value, or nearly the same value, the set point may flick a few times when the system pressure is near the set point. The set point hysteresis is automatically set to +10% of set point value if set point direction is below and -10% of set point value if set point direction is above. The set point hysteresis is overwritten if set point direction is changed or if set point value is changed.

Values: Two- or three-digit scientific notation  
(default: 1.00E0 Torr)

Query: @253SH1?;FF

Query Response: @253ACK1.10E-2;FF

Command: @253SH1!1.10E-3;FF

Command Response: @253ACK1.10E-3;FF

### **Set Point Direction – SD1, SD2, SD3**

The set point direction command returns or sets the direction of the set point. BELOW activates the set point when the pressure is below the set point value; ABOVE activates the set point when the pressure is above the set point value. Whenever the SD command is implemented the set point hysteresis is automatically set to +10% of set point value if set point direction command is below and -10% of set point value is if set point direction command is above. (See Set Point Value – SP1, SP2, SP3 and Hysteresis Value – SH1, SH2, SH3, above.)

Values: BELOW, ABOVE (default: BELOW)

Query: @253SD1?;FF

Query Response: @253ACKBELOW;FF

Command: @253SD1!ABOVE;FF

Command: @253ACKABOVE;FF

### **Enable Set Point – EN1, EN2, EN3**

The enable set point command returns enable status or disables the set point.

Values: ON,OFF (default: OFF)

Query: @253EN1?;FF

Query Response: @253ACKOFF;FF

Command: @253EN1!ON;FF

Command: @253ACKON;FF

### **Set Point Status – SS1, SS2, SS3**

The set point status command returns the status of the set point.

Values: SET, CLEAR

Query: @253SS1?;FF

Query Response: @253ACKCLEAR;FF

## Calibration and Adjustment Commands

### Atmospheric Calibration – ATM

The ATM command sets full scale readout for the MicroPirani™. Vent the transducer to atmospheric pressure before performing atmospheric calibration. Optionally, the user can manually vent to atmosphere, as described in the section Venting to Atmosphere.

Values: Pressure value in scientific notation

Command: @253ATM!7.60E+2;FF

Command Response: @253ACK7.60E+2;FF

### Gas Type Calibration – GT

The GT command sets gas type for measurement. The MicroPirani™ measures thermal conductivity; using the gas calibration compensates for gas errors.

Values: NITROGEN, AIR, ARGON, HYDROGEN, HELIUM, H2O (default: NITROGEN)

Query: @253GT?;FF

Query Response: @253ACKAIR;FF

Command: @253GT!NITROGEN;FF

Command Response: @253ACKNITROGEN;FF

### Vacuum adjustment – VAC

The VAC command zeroes the MicroPirani™ readout. Evacuate the transducer to a pressure below  $8 \times 10^{-6}$  Torr before performing vacuum adjustment. Optionally, the user can adjust for zero by pressing the ZERO switch on the evaluation board, as described in the section Adjustment for Zero.

Command: @253VAC!;FF

Command Response: @253ACKVAC;FF

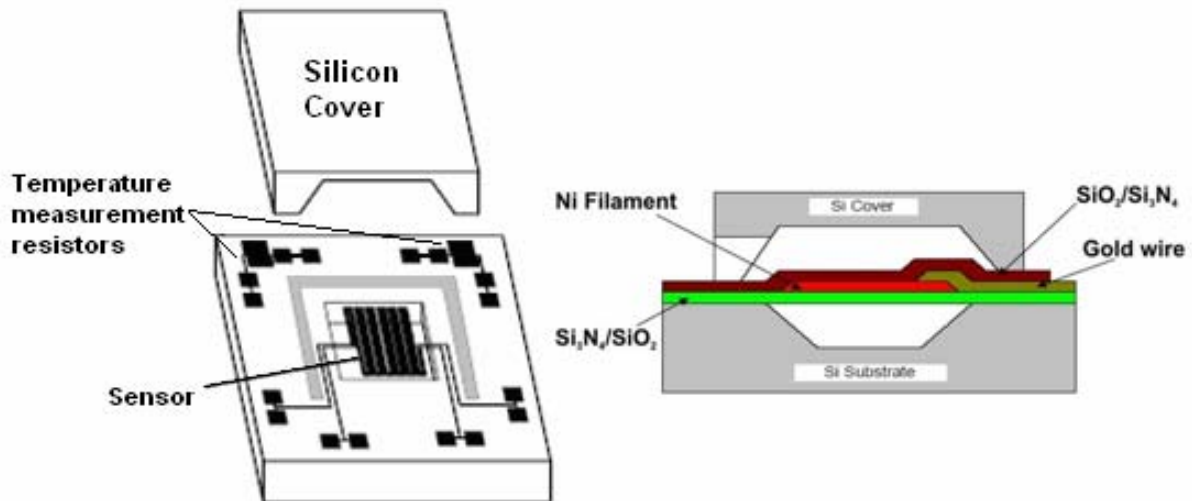
# How the MicroPirani™ Sensor Works

The Pirani principle, first described in 1906 by Marcello S. Pirani, has been widely adopted for pressure measurements in the medium vacuum range. Its advantages are the rather simple sensor element and the broad measuring range.

A traditional Pirani sensor typically consists of a thin tungsten wire which is suspended along the axis of a surrounding tube. The wire is heated by an electric current, whereas the tube is at ambient temperature. According to the temperature difference between wire and tube, a heat transport by the gas within the tube takes place.

Being based on the pressure-dependent thermal conductivity of the gas, any Pirani sensor will be gas and gas concentration dependent, i.e. a specific calibration is required for each gas to be measured.

The traditional Pirani sensor suffers from various problems. According to its functional principle, this type of sensor is sensitive to changes in ambient temperature.



**Figur 1 - The MicroPirani™ sensor**

The MicroPirani™ sensor element consists of a silicon chip construction, where thermal conductivity is measured in a small cavity where gas is passed by diffusion and not flow. Because of the small dimensions convection can not take place inside the cavity and consequently the MicroPirani™ measurement is independent of mounting position.

The sensor design has integrated two resistor elements for measurement of the thermal conductivity and two resistors for measurement of ambient temperature. The MicroPirani™ can be exposed to continuously vibrations and high G-forces without failure, because of its small geometry and mass.

Due to the design the MicroPirani™ eliminates or significantly reduces a number of performance issues known from the traditional wire based Pirani gauge.

# Ordering information

## 905 MicroPirani™ Sensor Kits

Part Number	Description
905-0001	905 Evaluation Board, KF16 Flange (without Power Supply)
905-0002	905 Evaluation Board, KF16 Flange (with Power Supply)
905-0003	905 Electronics Module, Nude Sensor
905-0004	905 Electronics Module, Sensor Board, 200mm Flexible Flat Cable

## Sensor Cables

Part Number	Description
100013955	Sensor Cable, FFC, 50mm
100013956	Sensor Cable, FFC, 100mm
100013811	Sensor Cable, FFC, 200mm
100013957	Sensor Cable, FFC, 300mm

## Manual

Part Number	Description
100013905	Design Guide
100013818	Short Documentation

## Accessories

Part Number	Description
PDR900-11-US	PDR 900 Single Channel Controller, RS232/RS485, US
PDR900-11-EU	PDR 900 Single Channel Controller, RS232/RS485, EU
PDR900-11-UK	PDR 900 Single Channel Controller, RS232/RS485, UK
PDR900-11-JP	PDR 900 Single Channel Controller, RS232/RS485, JP
100013613	Cable, RS232, PDR900, 9 pin, 10 ft. (3m)
100013614	Cable, RS232, PDR900, 9 pin, 16 ft. (5m)
100013515	Cable, RS232, PDR900, 9 pin, 25 ft. (7.6m)
100013616	Cable, RS232, PDR900, 9 pin, 33 ft. (10m)
100013903	Series 900 Transducer Data Logger Software
100013782	MicroPirani™ Sensor Viton O-Ring
100013951	MicroPirani™ Sensor Protection Cap

Note: 905 evaluation units contains the items mentioned in “Package contents” on page 2.



Figure 24 - The PDR900 single channel controller

**P/N: 100013905**  
**Revision: A, September, 2007**