Notes on Interfacing the MKS 925 MicroPirani™ Gauge Analog and RS232 Ports

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This document describes how to interface the MKS 925 MicroPirani transducer to several measurement, datalogging and control applications. This material is drawn from the VPAL-A manual as well as unpublished construction information that was provided to the manufacturer.

Part 1 covers the physical interface from the pressure tranducer to the voltage measurement and RS232 computer interfaces. **Part 2** covers the set up and use of the pressure transducer and software.

Part 1: MKS Gauge Connection Cable

This part covers the construction of a cable set for the MKS 925 transducer. It provides power to the unit, a scaled analog output for use with a datalogger (e.g. Vernier Logger *Pro* 3 with the differential voltage probe DVP-BTA) and a serial connection for setup and readout via a Windows PC using software provided by MKS Instruments.

It is important to note that the analog output of the 925 is not compatible with single ended voltage measurement devices. A differential sensor must be used.

Figure 1 is the schematic.
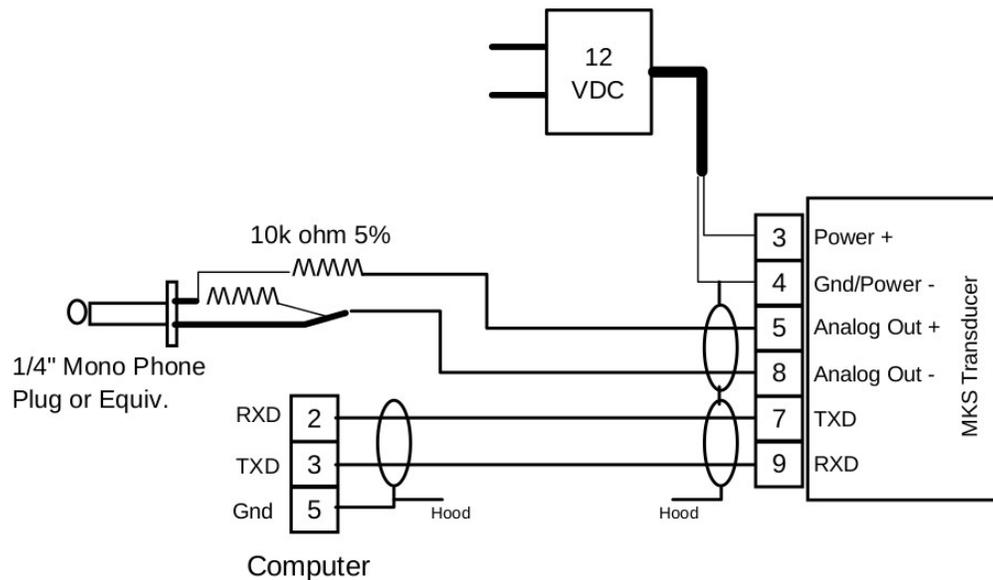
Figure 1. Interface cable schematic.

The serial connection is made via metal shell 9 pin female DSUB connectors wired as shown in the figure. The cable can be 2 conductor shielded microphone cable (2 cond + shield), 6 ft. length.

The analog output can use same type cable, length only needs to be 2-3 ft. Since the output of the transducer is 1-9 volts and the Vernier differential voltage sensor is only rated for 6 volts, the

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925's analog out must be divided. Here a pair of 10k ohm 1/4 watt resistors are used to divide the output by 2. 5% tolerance is acceptable as the Vernier software is used to make any needed corrections to the analog output (by comparison to the digital output). The figure shows a male 1/4" phone plug. Any polarized 2 pin connector can be used but the housing should be nonconductive.

The Vernier differential voltage probe is provided with a pair of leads with alligator clips. These may be replaced with a mating connector.

Shields for the serial and analog cables should be tied together and attached to the metallic DSUB hoods plus Pin 4 (transducer side) and Pin 5 (computer side).

As noted above, neither analog output pin can be grounded. They must float or there will be reading errors.

The wall adapter power supply is 12 volts dc with a rating of 250mA.

Figure 2 shows the voltage divider assembly. On the left is the phone plug before an insulation sleeve is placed on the second resistor. The photo on the right shows the divider after the resistor has been insulated and soldered to the cable.

Figure 2. Voltage divider assembly.

Figure 3 shows the entire cable assembly with the pressure transducer attached.
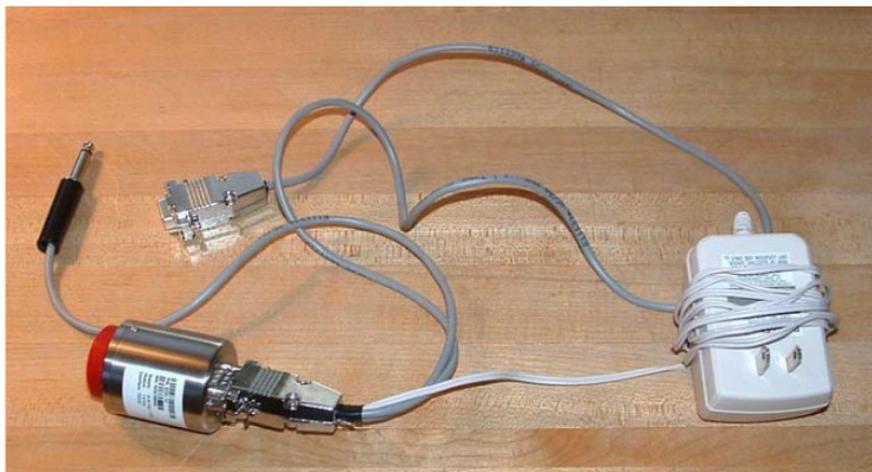
Figure 3. Cable assembly with 925 pressure transducer.

Part 2. Set Up and Operation

Note: the VPAL-A was originally provided with a MKS 925C pressure transducer. There are now several options in the 925 family including a version with a local LED pressure display, Additionally, the family of transducers now includes cold cathode ion gauges as well as a nunber of other digital interface options including EtherCAT®. More information on the 925 is at https://www.mksinst.com/f/925-micro-pirani-vacuum-transducer

Pressure Transducer Connections

The set up procedures in this section are performed at atmospheric pressure.

The MKS 925 is a wide range vacuum gauge that is based on the principle that a gas's thermal conductivity changes with pressure. The sensing element is a micromachined heating element that changes resistance with pressure. Electronics circuitry controls and monitors the heater power that is then converted to a scaled pressure output.

The 925 has two outputs. One is an RS232 connection that may be used with an MKS provided program to set up and monitor the transducer. This program also has basic data logging capabilities. The second is an analog output (0-9 volts) that can be used with a variety of data logging devices.

For ease of setup and maximum flexibility in the classroom, using both methods is recommended. The RS232 port with MKS software is necessary for set up and basic monitoring. The analog output with a full featured data logging application as exemplified by Vernier Software & Technology's Logger *Pro* 3 with associated Vernier hardware is ideal for analysis.

To install the MKS 925C transducer on the VPAL-A manifold:

- Connect the transducer to the vacuum system using a KF16 center-ring and clamp..
- Locate the power supply and cable assembly for the gauge and attach the 9 pin connector to the gauge. (There are two 9 pin connectors – the gauge connector is the one with 3 cables emerging from it.) Secure the connector by tightening the 2 screws.
- The other 9 pin connector may now be connected to the RS232 port of a computer, either directly or through a RS232 to USB adapter. This will be covered in detail in "Using the MKS Software."
- The phone plug connector contains a voltage divider (÷2) for the analog output. Use of this will be covered in "Using the Vernier Hardware and Software."

Using the MKS Software

Install the MKS software "MKS 900 Series V 1.6.4" (or latest version). This is available at http://www.mksinst.com/vtsw/

Plug in the 12 volt wall adapter. The green LED near the 925's connector should light.

Start the program. A window will appear that will ask for a filename for data logging (default is "P Reading.xls"). Either keep the default name or assign a new name and click "OK." The program will now open and will display the part number of the transducer. There are four tabs as shown in **Figure 4**.
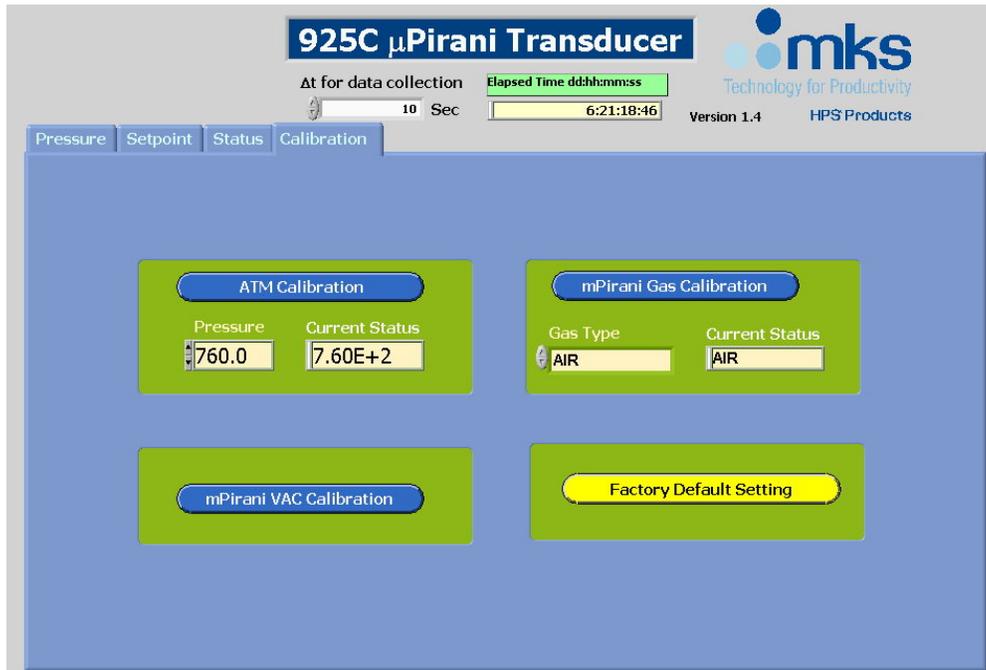
Figure 4. MKS 900 series software showing the Calibration screen.

Begin with the **Calibration** screen as shown in **Figure 4**. The system must be at atmospheric pressure.

- Under "Atmosphere (ATM) Calibration" set the ambient pressure. The default is 760 Torr (mmHg). Use this if your location is at or near sea level and you don't have an accurate measurement of the local pressure. The 925 will mostly be used at pressures well under 100 Torr. Errors in the Atm setting have only a small bearing in the accuracy of pressures under 100 Torr. When the current or default pressure has been entered in the left window, click the "Atm Calibration" button and the confirmation will appear in the right window.

- The 925C is an indirect gauge. It measures pressure based on the thermal conduction properties of the gas as opposed to measuring true pressure as defined as force per unit area. Since different gases have different thermal conductivity characteristics, the 925C's readings will depend upon gas type. The MKS software has calibration parameters built in for several gases: air, nitrogen, helium, argon, and water vapor. Air and nitrogen calibrations are essentially the same. Since the system is vented to air, select "Air."

- The "µPirani VAC Calibration" function should only be used if the gauge is connected to a vacuum system that is at or below 10^{-5} Torr. For mechanically pumped systems this adjustment should not be used.

- The factory default settings may be restored with the button at the lower right corner of the screen.
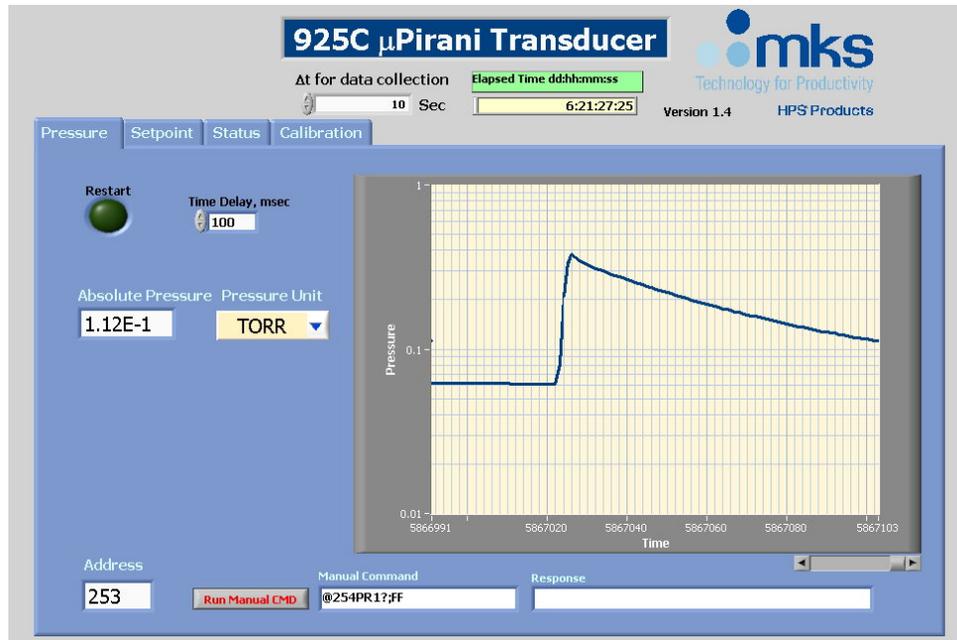
Figure 5. MKS 900 series software showing the Pressure screen.

Now move to the **Pressure** screen. This is shown in **Figure 5**.

- The main feature of this screen is the strip chart. This gives a fast moving pressure vs time plot. There is a slider below the strip chart that can be used to review the record.

- The current pressure is indicated in a window at the left along with the associated pressure unit. Pressure units may be changed at any time (options are Torr, millibar and Pascal).

- Data logging may be initiated by clicking on the "Data Logging" button. The sampling interval may be entered in the window next to the button (minimum is 1 second). The resulting data log file can be used with a spreadsheet program.

- The "Restart" button will interrupt the program and ask for a new data logging file name.

- Manual RS232 commands may be entered and sent to the 925C via the section at the bottom of the screen (see the manual for the 925 for further details).

The other two tabs ("Setpoint" and "Status") are not used with vacuum trainering equipment.

Using the 925 Analog Output with Vernier Software & Technology's Logger *Pro* 3

Since the 925 transducer has a differential voltage output, we will interface the 925 to the computer using Vernier's DVP-BTA Differential Voltage Probe and a compatible USB interface (Go!Link or LabPro).

In order to provide a reading in true pressure units, the output of the 925 has to be scaled. The voltage to pressure relationship for the 925 is:

$$P_{(Torr)} = 10^{(V-6)}$$

As noted in **Section 1**, the output of the 925 has to be reduced as the DVP-BTA has a range of only ±6 volts. This is accomplished by a ÷2 voltage divider that is contained within the analog output cable's phone plug. The voltage to pressure relationship is now:

$$P_{(Torr)} = 10^{(2V-6)}$$

With the analog output cable connected to the DVP-BTA, connect this to your Vernier interface, either the Go!Link or LabPro. The interface is then connected to one of your computer's USB ports.

When Logger *Pro* 3 is opened, the voltage probe will be recognized and the voltage will be displayed.

Initial Pressure Scaling and Graph Set Up :

Click on "Data" and select "New Calculated Column." This opens a dialog box.
Select the "Column Definitions" tab and enter:

- Name: Pirani Gauge (or similar identifier)
- Short Name: Pirani
- Units: Torr
- Equation: 10^((2*"Potential")-6)

Select the "Options" tab and set the decimal places to 2 and check "Display during live read-outs." Click "Done."

The graph for "Potential" will be open.

- Right click on the y-axis label "Potential (V)"
- Select "Graph options" and click on the "Axis options" tab.
- Deselect "Potential (V)" and select "Pirani Gauge."

Now enter the y and x-axis scaling parameters. These are only suggested initial parameters and may be adjusted as necessary.

y-axis

- Scaling: Manual
- Top: 800
- Bottom: 0

x-axis

- Time unit: Seconds (except for long term monitoring)
- Left: 0
- Right: 600

Log scaling of either axis may be implemented by checking the "Log axis" box

Now set up the data collection.

Click on "Experiment" and select "Data Collection." In the dialog box set the length to equal the x-axis period (600 seconds in this case). Set the sample rate to 4 samples/sec.

Final Scaling of the 925: Matching the Analog and Digital Outputs

The next step is to compare the analog pressure reading as indicated by the Logger *Pro* 3 software with the digital readout as indicated by the MKS software. Invariably there will be a difference and the error lies mainly in the voltage divider. To bring the two into concurrence, the scaling parameter in the Pirani gauge equation will have to be adjusted.

Perform this adjustment at atmospheric pressure after the MKS 925C has been mounted to the manifold. At high pressures the 925C is slightly attitude sensitive.

As an example, the MKS software may indicate 762 Torr and Logger *Pro* 3 may show 833 Torr.

- Select "Data" then "Column Options" then "Column Definition."
- Adjust the "2" multiplier up or down in a small increment. This might be 1.99 as, in this example, Logger *Pro* 3 is reading higher. A few iterations may be required. Once the right factor has been determined, make a note of the scaling value for future reference.

Sampling and Noise Reduction

The logarithmic scaling of the 925C's output results in relatively large changes in the pressure reading for small changes in voltage. As a result the graphical data as displayed by Logger *Pro* 3 may appear noisy. One way to reduce the noise is to implement the "smoothAve" function in the scaling formula.

Return to the "Column Definition" dialog box and rewrite the equation as:

10^((smoothAve(2*"Potential"))-6)

(Substitute the previously determined scaling factor for the "2" in the above.)

Under "File" click on "Settings" and set the "Points for Smoothing" box to 4.

Dual Axis Graphs

Logger *Pro* 3 can show multiple plots. For example, in an evaporative cooling experiment it would be desirable to monitor pressure and temperature with time. In this case the software would generate two graphs, one for the pressure input and one for the temperature input.

The software also has the capability of showing two plots on one graph. This is especially valuable if there is a parameter that is based on an existing parameter.

For example, the pressure vs time plot of a pumpdown cycle is an exponential curve. It can be valuable to also show LnP(t) since the slope of this curve (which appears as a straight line) is directly related to the ratio of pumping speed to system volume thus to the system time constant. To add this function:

Under "Data" select "New Calculated Column." Name it "Ln Pressure." In the equation box type:

Ln("Pirani Gauge")

After saving the new column information right click on the graph's y-axis label. In the dialog box select "Graph Options" and "Axis Options." Check the box to add a right axis and select select "Ln Pressure." Set the scale manually as appropriate (e.g. 0-8).

Now the single graph will plot pressure and ln pressure.

Use with Other Gauges

Vernier supplies a simple pressure probe that uses a piezoresistive element, model GPS-BTA. It has a range of 0-1600 Torr with a resolution of 1 Torr. This is useful for providing pump down curves, performing upleak checks and a number of other applications where sub-Torr measuremetns would not be required.

Capacitance diaphragm gauges are also frequently used with training apparatus. These have either a 0-10 volt or 0-5 volt output that scales directly with pressure. The analog outputs of these may be sampled using the simple single-ended Vernier voltage probe VP-BTA. Connect the probe between the analog signal output pin and the signal common.

Some Examples

The video tutorials that are listed at http://www.belljar.net/gallery.html provide some examples of how Vernier's Logger *Pro* 3 software can be used with vacuum training systems.