

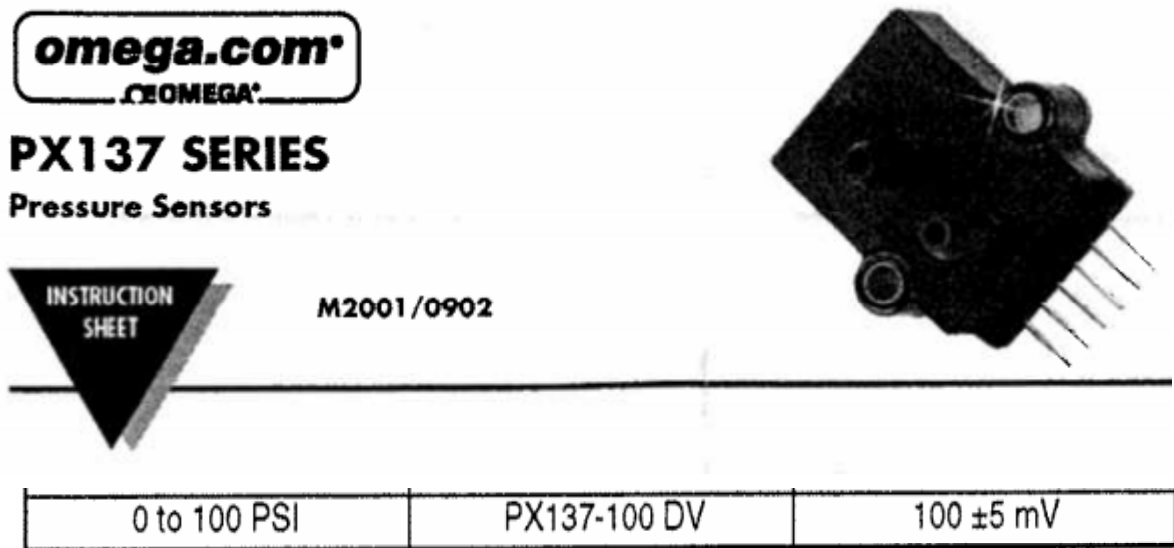
MEC751
Measurement Lab 4
Pressure Control Lab

Goal:

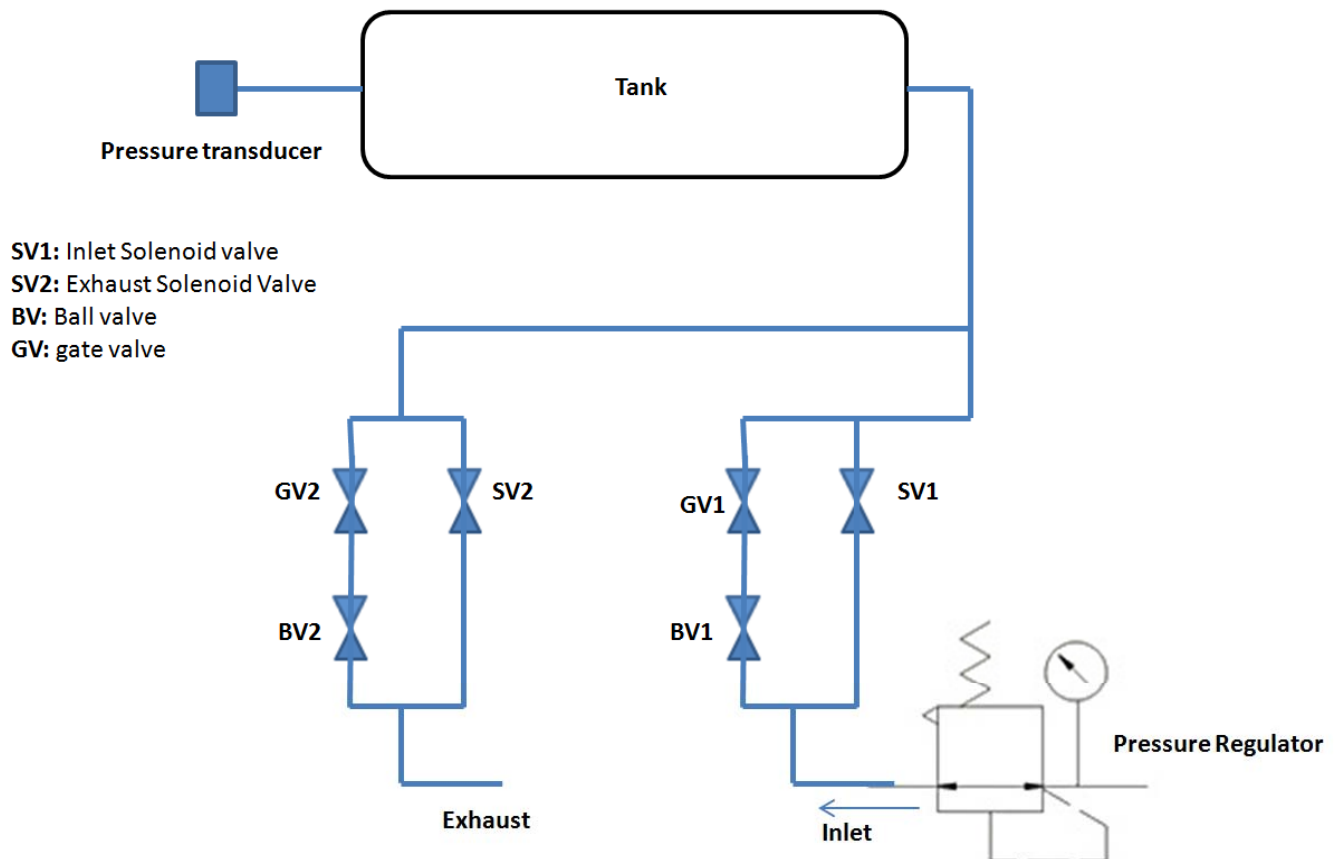
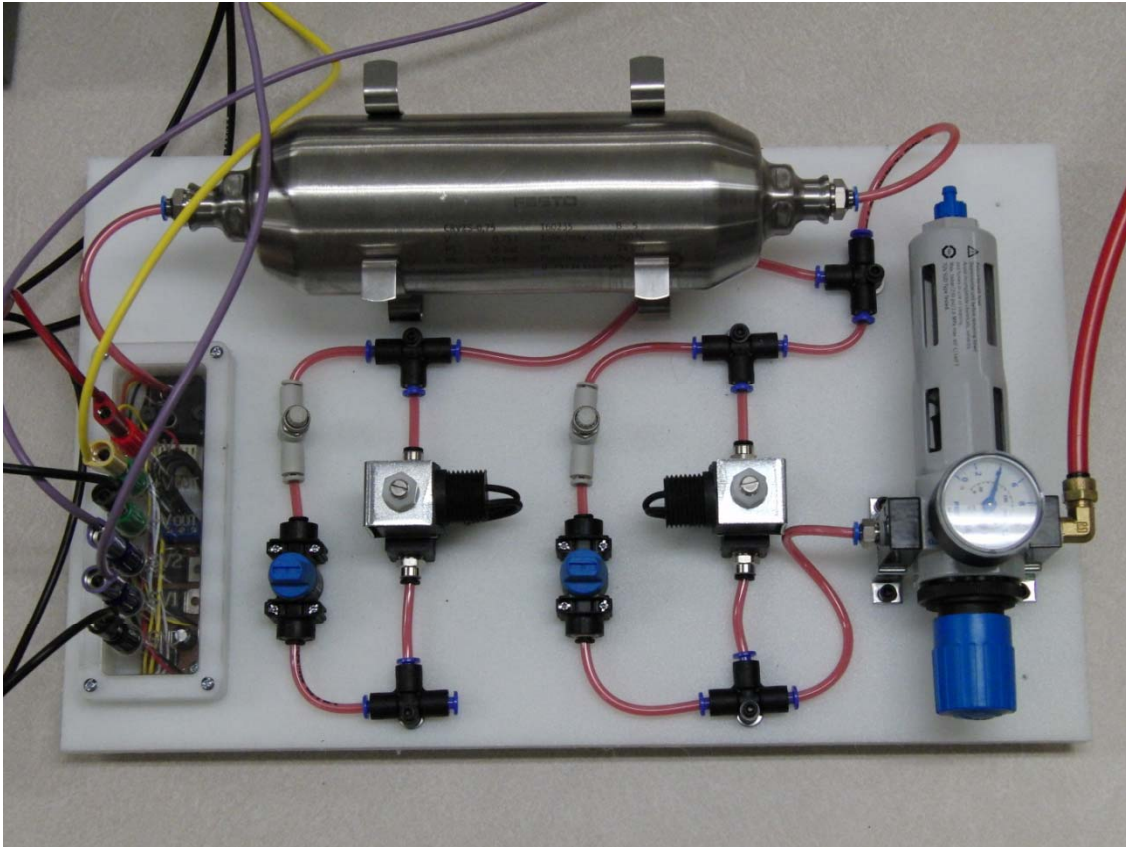
1. To perform pressure measurements.
2. To implement a simple pressure control system using digital output.

Hardware:

- Data Acquisition Board:
 - NI-PCI-6321
 - 16 analog inputs, 250 kS/s, 16-bit resolution, ± 10 V
 - Two analog outputs, 90 kS/s, 16-bit resolution, ± 10 V
- Connector Block - Screw Terminal (SCB-68).
- Cable – Shielded (SHC68-68-EPM) Cable.
- Pressure transducer.
- Tank, gate valves, ball valves, pressure regulator.
- Solenoid valves: the valves used can be either fully closed when there is no voltage applied to them or fully open with a 5-12 V signal.




Setup



Setup(continued)

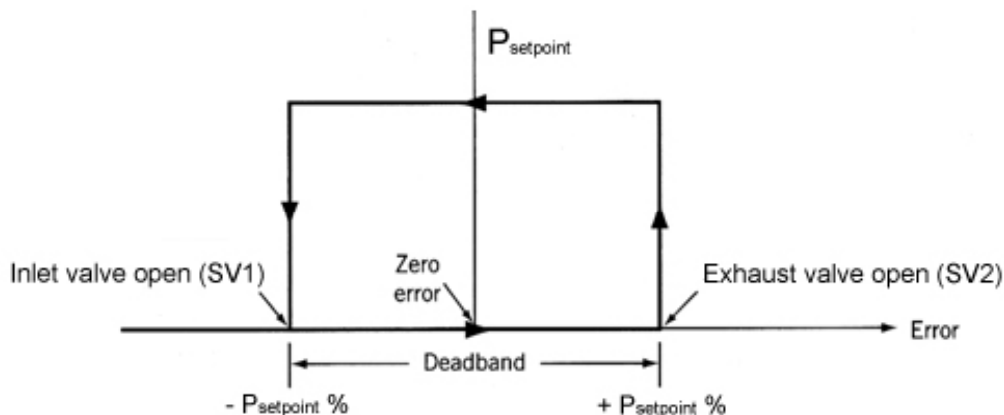
- Complete the required wiring:
 - power source to signal conditioning
 - Pressure transducer to ai0 and ai8 for differential voltage acquisition
 - Solenoid Valve 1 to DO0
 - Solenoid Valve 2 to DO1
 - DGND from the connector block to GND
- **Get TA's signature before proceeding**

Pressure Reading

- Launch Labview and start a blank VI.
- Create a while loop and add DAQ Assistant inside the loop.
- Configure DAQ Assistant to acquire differential voltage signal from ai0 in ± 0.2 V range, 1 Sample (on Demand). Check the wiring diagram to ensure proper wiring.
- Run the VI.
- The voltage signal from pressure transducer has a nominal sensitivity of 1 mV/psi. Stop the VI, make the necessary changes so that you can graph the pressure in psi (use Waveform Chart).
- Please note that the “data” from DAQ Assistant is of dynamic data type (dark blue). Most other VIs and functions that ship with LabVIEW do not accept this data type. To use a built-in VI or function to process the data you must convert the dynamic data type. Go to Express> Sig Manip> from DDT. Once you insert the converter, configure it so that the output is a scalar. 
- Add a numerical indicator for pressure to front panel also.
- **Get TA's signature at this stage (Pressure Reading)**

Pressure Control (on-off control)

- The goal for this part of the lab is to control the pressure of the tank by using two solenoid valves: inlet (SV1) and exhaust (SV2).
- An on-off control system requires a dead band to perform properly (see figure below). The error for the pressure is defined as: $\text{error} = P_{\text{measured}} - P_{\text{set point}}$.
- The size of dead band is usually defined as $\pm\%$ of $P_{\text{set point}}$.



- You will use digital output signals from the DAQ board to open and close the valves as needed (e.g., if error > dead band , open exhaust).
- Add a second DAQ Assistant to the while loop.
- Configure this DAQ Assistant for two digital outputs: Generate Signals-> Digital Output -> Line Output -> port0/line0 and port0/line1. Generating Mode should be “ 1 Sample (on Demand)”.
- Add two controls to “front panel” for setting the target pressure, $P_{\text{set point}}$ and $\pm\%$ for the dead band.
- For a given $P_{\text{set point}}$, perform the pressure control with dead band of $\pm\% 10$ and $\pm\% 1$ of the target pressure.
- Is the control effort the same for each case?
- Collect enough data and graphs for your lab report (use appropriate methods for recording the data) so that you can discuss the effect of the dead band on control effort. (You can use ‘Write to measurement file’ block inside the loop, and add shift registers for the measured pressure).
- **Get TA’s signature at this stage (Pressure control)**
- **Save the VI as PressureControl.VI and upload it on the blackboard.**

Disturbances

- With dead band sizes of $\pm\% 10$ and $\pm\% 1$, evaluate the effect of various disturbance on your system:
 - Closing and opening ball valves
 - Adjusting gate valves
 - Shutting down the regulator
- Collect enough data and graphs for your lab report (use appropriate methods for recording the data).
- **Get TA’s signature at this stage (Disturbances)**

Effect of Time delay

- Add a “Wait Until Next ms Multiple Function” to your While loop. Introduce time delays of 0.05s , 0.25s and 1s in the loop.
- With dead band sizes of $\pm\% 10$ and $\pm\% 1$, observe the effect especially when disturbances are introduced.
- Collect enough data and graphs for your lab report (use appropriate methods for recording the data)
- **Get TA’s signature at this stage (Time Delay)**



Appendix B

DAQ Board Specs

MIO X Series Device	Input Range	Nominal Resolution Assuming 5% Over Range
NI PCIe-6321	–10 V to 10 V	320 μ V
	–5 V to 5 V	160 μ V
	–1 V to 1 V	32 μ V
	–200 mV to 200 mV	6.4 μ V

AI Absolute Accuracy Table PCIe6321

<http://sine.ni.com/ds/app/doc/p/id/ds-152/lang/en>

Nominal Range		Residual Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco (ppm/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	INL Error (ppm of Range)	Random Noise, σ (μ Vrms)	Absolute Accuracy at Full Scale ¹ (μ V)
Positive Full Scale	Negative Full Scale								
10	–10	65	7.3	5	13	24	60	229	2200
5	–5	72	7.3	5	13	25	60	118	1140
1	–1	78	7.3	5	17	37	60	26	257
0.2	–0.2	105	7.3	5	27	93	60	12	69

AbsoluteAccuracy = Reading · (GainError) + Range · (OffsetError) + NoiseUncertainty

GainError = ResidualGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

OffsetError = ResidualOffsetError + OffsetTempco · (TempChangeFromLastInternalCal) + INL_Error

NoiseUncertainty = $\frac{\text{RandomNoise} \cdot 3}{\sqrt{10,000}}$ For a coverage factor of 3 σ and averaging 10,000 points.

¹ Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

TempChangeFromLastExternalCal = 10 °C

TempChangeFromLastInternalCal = 1 °C

number_of_readings = 10,000

CoverageFactor = 3 σ

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

GainError = 65 ppm + 7.3 ppm · 1 + 5 ppm · 10

GainError = 122 ppm

OffsetError = 13 ppm + 24 ppm · 1 + 60 ppm

OffsetError = 97 ppm

NoiseUncertainty = $\frac{229 \mu\text{V} \cdot 3}{\sqrt{10,000}}$ NoiseUncertainty = 6.9 μ V

AbsoluteAccuracy = 10 V · (GainError) + 10 V · (OffsetError) + NoiseUncertainty

AbsoluteAccuracy = 2,200 μ V

Accuracies listed are valid for up to one year from the device external calibration.



Specifications

Excitation Voltage:	12 Vdc (16 max.)
Linearity and Hysteresis:	±0.1 % FS typical / 0.5% max. ±0.5% / 1% for 0.3 PSI range
Repeatability:	±0.1 % FS typical (0.3% max.)
Zero Balance:	±1 mV (±3 mV for 0.3 PSI range)
Input Resistance:	10 k Ohms
Storage Temp.:	-40 to 125°C (-40 to 257°F)
Operating Temp.:	0 to 70°C (32 to 158°F)
Span Temp. Effects:	0 to 50°C, ±1.5% FS 50 to 70°C, ±0.5% FS
Zero Temp. Effects:	0 to 50°C, ±0.8 mV; 50 to 70°C, ±0.2 mV For 0.3 PSI range 0 to 50°C, ±1.0 mV, 50 to 70°C, ±0.5 mV
Proof Pressure:	>3X FS Pressure
Burst Pressure:	>5X FS Pressure
Common Mode Pressure:	50 PSI
Media Compatibility:	For use with gases compatible with silicon, glass-filled nylon, and alumina ceramic

TA's signature

Setup

Pressure reading

Pressure Control

Disturbances

Time Delay

Team members
