Laboratory Exercise: Pressure Transducers

Introduction
Pressure transducers are used in a variety of industrial and research applications. One common application is to measure water depth (commonly known as stage) in a reservoir or stream (similar to a tank or pipe). Changes in water level recorded by the pressure transducer can be used in a stream system to estimate volumetric flow rate when attributes of the cross-sectional area and flow velocity have been recorded in the field. In other applications, changes in liquid level monitored by pressure transducers can be used to alert workers if a tank is getting too low or about to overflow. For example, at the Dairy on Virginia Tech’s campus, pressure transducers are used to monitor the water level in the flush tanks of the waste flushing system to analyze water consumption.

Objectives
- Become familiar with the practical application of pressure transducers.
- Understand how to connect a pressure transducer to a National Instruments DAQ board.
- Understand sensor placement within a system.
- Use MATLAB to communicate with the sensor and bring data directly into the software.
- Create a calibration curve using basic MATLAB capabilities.

Required for this Lab
- Equipment: NI USB 6008, Storage Tank, Meter stick, Pressure Transducer (KPSI Level and Pressure Transducer), power supply
Hardware: Students must have both MATLAB R2009a and National Instruments “Measurement and Automation Explorer” (Start Menu -> Programs -> National Instruments -> Measurement and automation) already installed on their computers. All necessary MATLAB m-files should be downloaded from Scholar into their MATLAB folder. See Lauren for assistance ahead of lab time.

Software: Get_Depth_Measurement.m
Find_NI_6008.m

Procedure
- Get into groups of 4 for this lab.

Part 1. Sensor Set-up
1. Build sensor connection on breadboard. Connect the positive wire of the power supply to the positive slot on the breadboard. Connect the negative wire of the power supply to the negative slot on the breadboard. Make sure the power supply is set to ~ 12V, and that output is not yet turned on. Connect the red wire of the pressure transducer to the positive power slot on the breadboard.
2. Connect a jumper wire from the negative slot on the breadboard to one of the numbered middle slots. Connect the black wire of the pressure transducer into this same slot. Connect a breadboard wire from this same slot to the Ai0- port on the DAQ board.
3. Connect silver wire of the pressure transducer to ground on DAQ (Slot 4).
4. Connect white wire of the pressure transducer to the Ai0 positive port.
5. Connect the DAQ board to your computer using the USB cable.
6. Open “Measurement and Automation”. Click “+” next to Devices and Interfaces. Click “+” next to NI-DAQmx Devices. You should see “NI USB-6008: Dev1”. Right click, and run a Self-test. Connection to the NI-DAQmx is now working correctly.
7. Open MATLAB. Run “find_ni_usb_6008.m”. This will simply ensure MATLAB’s connection to the sensor. If it identifies the device, it should output for example “Dev1”. If the program is unable to find the NI device, it will say “Unable to find NI USB-6008. If this occurs, talk to Lauren for assistance.

Part 2. Data Collection
1. Begin filling bucket with water, and place sensor inside bucket. After a few inches have accumulated, stop the running water.
2. In MATLAB, go to File → New → Variable. Using a meter stick, measure the current depth of the water (cm) and record it in the new variable you just created. Run Get_Depth_Measurement.m to find the transducer voltage at this depth. Repeat running Get_Depth_Measurement 4 more times at different depths so that you have 5 data points to plot a calibration curve. Record this data in a new column in the variable you have created. Save this variable as PressureLab.mat for later use.

**Note:** The pressure sensor only recognizes changes in depths >1/10 of a foot. Make sure you are creating a large enough depth difference for each sample.

**Part 3. Calibration Curve**

1. On your own, use the data from part 2 to plot a calibration curve in MATLAB. Open PressureLab.mat. Right click on the column of measured depths, and select “Create variable from selection”. Name it “Depth”. Follow the same procedure for the column of measured voltage, and label it “mV”. Create a scatter plot of these two variables. Use the Basic Fitting Tool in MATLAB to create a line of best fit (linear), which will serve as your calibration curve. Review the tutorials from Lab 1 for assistance.

**Results section should include:**

1. Plot with calibration curve created in MATLAB. Make sure this includes the linear equation. Be sure to include $R^2$ value or the plot residuals to ensure it is a good fit.

**Discussion Questions:**

1. Using your calibration curve, discuss what the pressure would be at the bottom of a 5-foot pool. What about a 100 foot lake? (You can use MATLAB’s basic fitting tool to evaluate points given by the user)
2. How would you use a pressure transducer (measuring depth) to measure flow rate?
3. What possible errors could have occurred during this lab?

**Appendix should include:**

1. Get_Depth_Measurement.m output data.
2. Coding for creating calibration curve created in Part 3. If the Basic Fit tool was used, briefly explain the steps you went through.
3. Calculations for Discussion Question #1.