Instrumentation and Measurement

Lab 4

Differential Pressure Transmitter Calibration

Date the Lab was performed (mm-dd-yy): 02/02/2024

Name of student: Michaël McCorkell Student Number: N01500049

Revision Number: Winter 2024

Submission Instruction:

Review the lab report before submitting and put a check mark (√) in the appropriate check box on the left if the item has been duly completed in your lab report. The bracket on the right side will be filled out by your instructor with your gained mark.

1. Scan and create .pdf of all pages.
2. Combine ALL pages of your lab report into a SINGLE .pdf file. Meaning, do not submit each Page of your lab report as a separate file
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Every 20 minutes late is subjected to 10 marks deduction from attendance.

Lab 4: Differential Pressure Transmitter Calibration

Objective:

1) Perform a sensor calibration
2) Check a sensor linearity

Preparation:

1) Fluid (Either Gas or Liquid) pressure is the force per unit area applied by the fluid to the fluid surrounding area. There are different units to measure the pressure. The one which is used today is psi which stands for pound-force per square inch. For example if the water pressure inside the hose is measured by a pressure gauge as 10 psi, it means the water applies 10 pound-force to every 1 square inch of the hose inner surface.

2) Figure (L4-1) shows a differential pressure transmitter and its components. A differential pressure transmitter measures the difference between high pressure side and low pressure side. In this experiment the low pressure is connected to open air, therefore the measured pressure is referenced to atmospheric pressure. This type of pressure measurement is called relative or gauge pressure versus the absolute pressure which is referenced to vacuum.

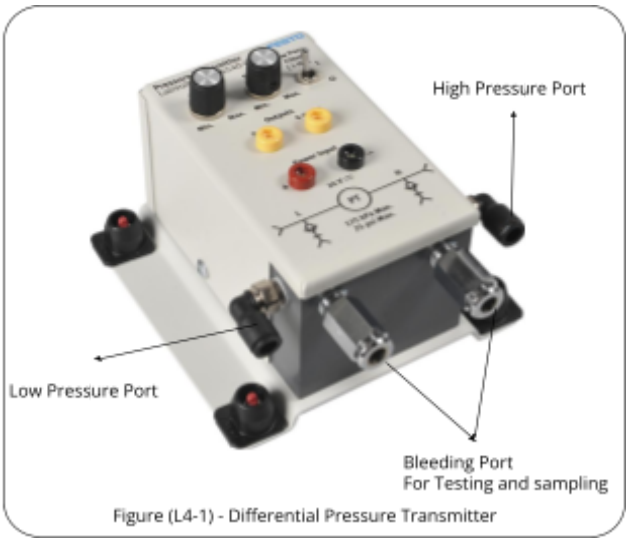

Figure (L4-1) - Differential Pressure Transmitter

$$P_{differential} = P_{High} - P_{Low}$$

$$P_{Gauge} = P_{High} - P_{atmospheric}$$

$$P_{Absolute} = P_{High} - P_{Vacuum} = P_{High} - 0$$

3) There are two adjustment knobs labeled as "Zero" and "Span" on the pressure transmitter in Figure (L4-1). The Zero is used to match the low electrical output signal with the minimum of the measurement range. The span knob is used to match the high electrical output with the maximum of measurement range. For example let's assume there is a pressure transmitter to measure 0 to 15 psi and make output of 4-20 mA. When the pressure is 0, the transmitter is supposed to provide 4 mA but instead is giving out 5 mA. To correct this output, the zero knob can be used. Also when the pressure is 15 psi it is supposed to deliver 20 mA but when it is measured by multimeter the output current is 21 mA. In this case the span knob can be turned to make the output 20 mA. The zero and span knob *might not be independen*t from each other, it means turning span knob will affect zero value and turning zero will change the span. To get correct output, the adjustment of zero and span should be repeated a few times. This adjustment is also known as calibration. Please be mindful that the knobs should not be turned after calibration otherwise the transmitter will be out of adjustment.

1) Calibration:

1-1) Get a pressure transmitter, a pressure Gauge and a multimeter from the cabinet. Mount the transmitter on the vertical work surface.

1-2) Wire and power up the pressure transmitter, connect the voltmeter to the transmitter 0-5 V output to measure the output voltage.

1-3) On the pressure transmitter, turn the zero and span knob to get max voltage (clockwise to the end). Then turn on the low pass filter switch.

1-4) Do not connect the High and low side of the transmitter to anywhere. The pressure transmitter low and high side sense the ambient pressure therefore their difference will be zero. The differential pressure transmitter senses the 0 psi now. Turn the zero knob counterclockwise to get 0.2 volt from the output.

1-5) Connect the air pressure regulator to a gauge and adjust the air pressure to 100 KPa (14.5 psi) then connect air pressure to the high port of the pressure transmitter. Turn the span knob counterclockwise to make output voltage 5 Volt. The air pressure regulator is pre-mounted near the expanding work surface.

1-6) The zero and span knob are not independent from each other, turning one will affect the other. After step 5 the zero pressure output is not going to be 0.2 volt probably. Therefore it is needed to repeat steps 4 and 5 a few times until you get 0.2 for the ambient pressure and 5 volt for 100 KPa.

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2) Pump pressure measurement:

2-1) Setup the system as shown in Figure (L4-2).

2-2) On the pump unit,

a) Open HV1 completely (turn the handle fully counterclockwise)
b) Close HV2 completely (turn handle fully clockwise)
c) Set HV3 for directing the full reservoir flow to the pump inlet (turn handle fully clockwise)
d) Open the HV4 fully

2-3) Wire the pump unit to the interface module and provide power supply for the pressure transmitter and the interface unit.

2-4) Run the pump at 50% speed and start closing HV-4 slowly. You should be able to see the dial on PI-1 moves. If you do not see, review your piping and wiring to troubleshoot.

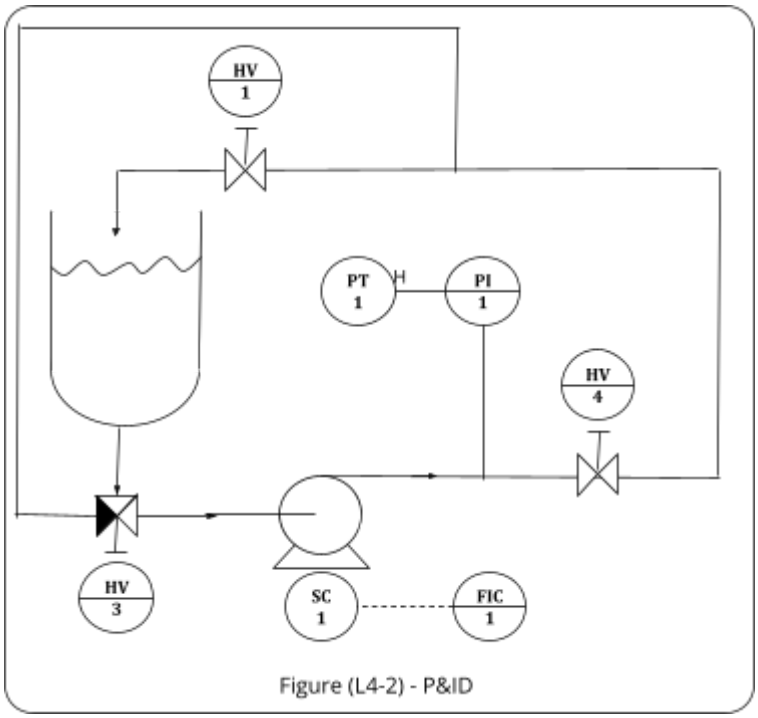

Figure (L4-2) - P&ID

2-5) Make the pump speed 100%. Measure the output voltage from the transmitter and write down the pressure indicator value as follows. (0.2 - 5 volt output)

Transmitter Voltage output (HV4 open): 2.5 V 7 psi

Transmitter Voltage output (HV4 half open) : 4.03 V 11.3 psi

Transmitter Voltage output (HV4 Close) : 4.95 V 14.1 psi

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3) Transmitter Linearity:

3-1) Run the pump at 100% and open the HV4 fully. Write down the pressure gauge value for the question mark and transmitter voltage in Table (L4-1).

3-2) Start to close the valve and set the water pressure for 6 psi. Measure the pressure transmitter output in volt and fill out the table. Then repeat this step for 8, 10 and 12 psi.

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Pressure in psi	Measured Transmitter output voltage
??? 7	2.5
6	
8	2.9
10	3.6
12	4.2

Table (L4-1)

4) Assignment:

4-1) From the data recorded in Table (L4-1) place the measurement points in Figure (L4-3) and connect the points. Are these points located in a straight line? If your answer is yes, find the equation of the line. If your answer is no, draw a straight line which fits best to the points. Find the equation of the line. *(10 Marks)*

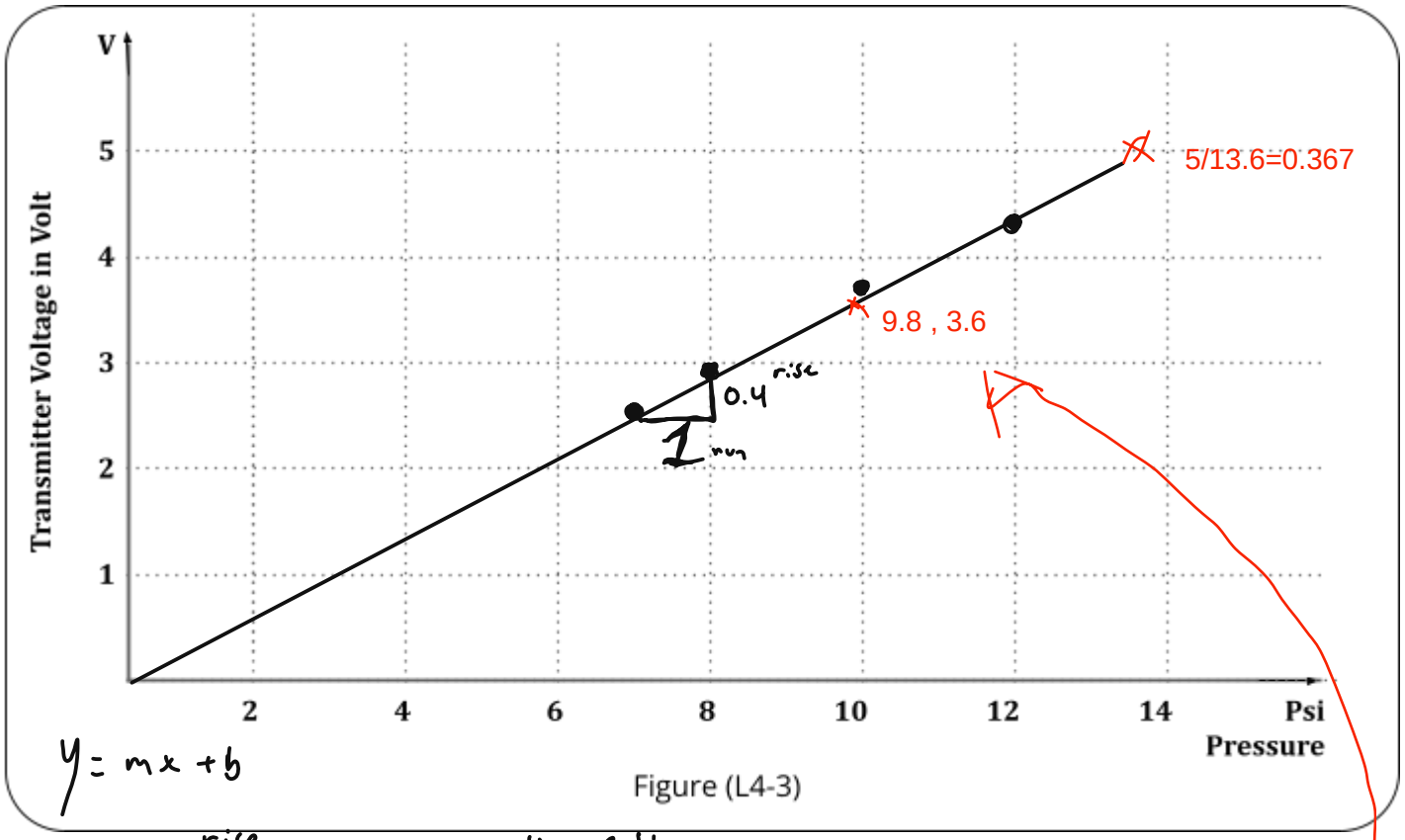

Figure (L4-3)

$m = \frac{rise}{run}$

$m = \frac{0.4}{1}$

$m = 0.4$

equation of line

$y = 0.4x + 0$ -10

4-2) Use the data of L4-1 and the straight line found in the previous step to calculate the pressure and fill out the Table L4-2. Then calculate the non-linearity as percentage of full range of measurement *(20 Marks)*

True Pressure in psi Measured by Gauge	Measured Transmitter Output Volt	Calculated pressure from the best fit line	Error= True - Calculated
??? 7	2.5	6.25	0.75
[redacted]			
8	2.9	7.25	0.75
10	3.6	9	1
12	4.2	10.5	0.75

Table (L4-2)

$\frac{y}{0.4} = x$

$x = \frac{2.5}{0.4} = 6.25 psi$ $x = \frac{2.9}{0.4} = 7.25 ps.$ $x = \frac{3.6}{0.4} = 9 ps.$ $x = \frac{4.2}{0.4} = 10.5 ps.$

$$Non - Linearity = \frac{Max\ error}{Max - min\ (pressure\ measured\ by\ gauge)} \times 100$$

Non-Linear $= \frac{0.75}{14.5 - 7} \times 100 = 10\%$

Non-Linear $= \frac{0.75}{14.5 - 7} \times 100 = 10\%$

Non-Linear $= \frac{1}{14.5 - 7} \times 100 = 13.33\%$

Non-linear $= \frac{1.5}{14.5 - 7} \times 100 = 20\%$