EE230: Labwork-9
Instrumentation Amplifier on load cell sensor

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1 Overview of the experiment

1.1 Aim of the experiment

To implement instrumentation amplifier to amplify output from a load cell sensor by:

1. Building instrumentation amplifier using TL084 IC.
2. Implementing instrumentation amplifier using INA128 IC.

1.2 Methods

In this experiment, we design a circuit to measure the weight of any object. We achieve the same by using a load cell and an instrumentation amplifier. The load cell is based on Wheatstone bridge and the arrangement allows us to measure very small in resistance R.

2 Design

In this experiment, we are going to construct a circuit consisting of the load cell as well as the instrumentation amplifier.
The load cell is based on the Wheatstone bridge and changes it's resistance on exposure to physical deformation.

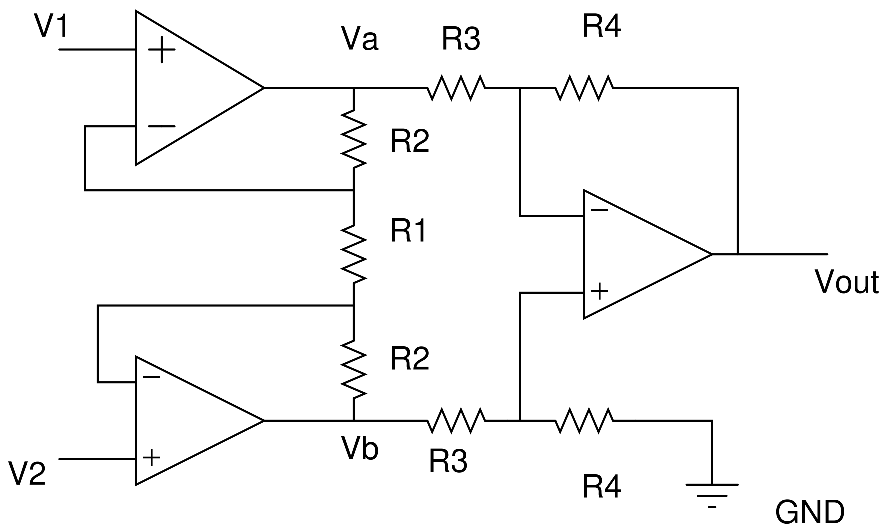


Figure 1: Instrumentation amplifier

The instrumentation amplifier consists of three amplifiers as shown in the figure 1 above. It is a type of differential amplifier used to achieve high accuracy and stability.

3 Theory

Applying KCL on the input of op-amps:

$$V_a = V_1(1 + \frac{R_2}{R_1}) + V_2(\frac{R_2}{R_1}) \tag{1}$$

$$V_b = -V_1(\frac{R_2}{R_1}) + V_2(1 + \frac{R_2}{R_1}) \tag{2}$$

From the above two equations and using superposition theorem:

$$V_{out} = \frac{R_4}{R_3}(1 + 2\frac{R_2}{R_1})(V_2 - V_1) \tag{3}$$

Therefore, we get the gain as follows:

$$A_v = \frac{R_4}{R_3}(1 + 2\frac{R_2}{R_1}) \tag{4}$$

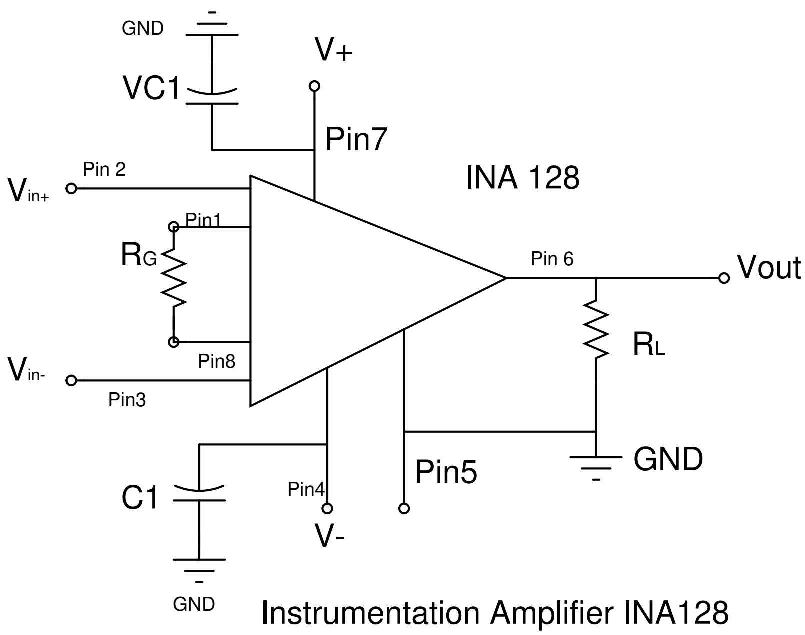


Figure 2: INA128

Selecting the values of resistors for part-1:
The load resistance was taken as **10k ohms**
In order to obtain a gain of 300,

$$A_v = \frac{R_4}{R_3}(1 + 2\frac{R_2}{R_1}) = 300 \tag{5}$$

Choosing:

$$R_1 = 1kohms \tag{6}$$

$$R_2 = 1kohms \tag{7}$$

$$R_3 = 1kohms \tag{8}$$

$$R_4 = 100kohms \tag{9}$$

Selecting the values of resistors for part-3:

$$R_G = 220ohms \tag{10}$$

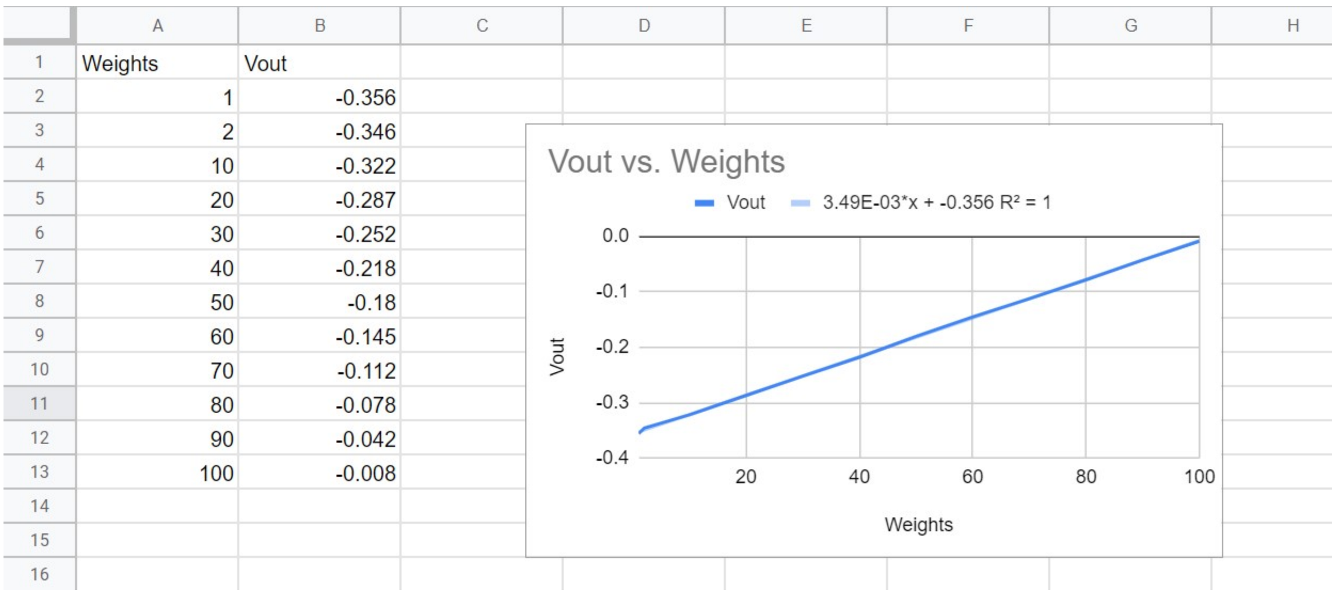
$$R_L = 10kohms \tag{11}$$

4 Experimental results

$$sensitivity = \frac{V_2 - V_1}{W_2 - W_1} V/gm \tag{12}$$

4.1 Part-1

V_{out}(V) vs Weights(grams)



Weights	Vout
1	-0.356
2	-0.346
10	-0.322
20	-0.287
30	-0.252
40	-0.218
50	-0.18
60	-0.145
70	-0.112
80	-0.078
90	-0.042
100	-0.008

Figure 3: V_{out}(V) vs Weights(grams)

The observed sensitivity in mV/gm from the above graph is:**3.29** We need to find the value of R_1 such that the sensitivity doubles.
On adjusting the value of R_1 to double the sensitivity, we obtained a value of:

$$R_1 = 400ohms \tag{13}$$

Where R_1 was initially 1k ohms.

4.2 Part-3

V_{out}(V) vs Weights(grams)

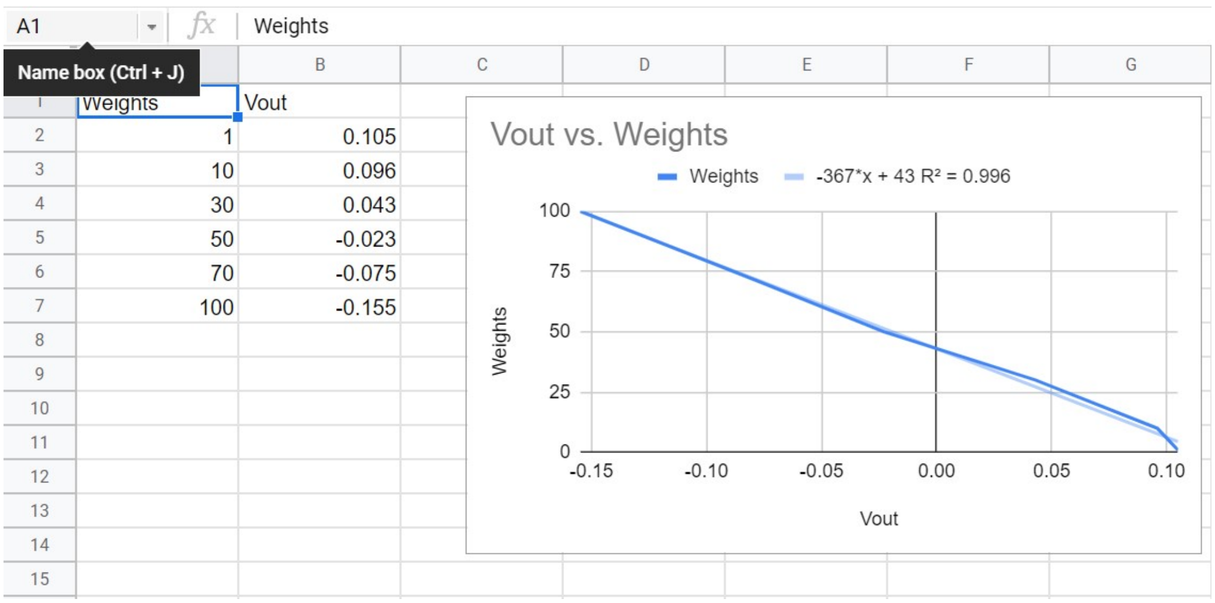
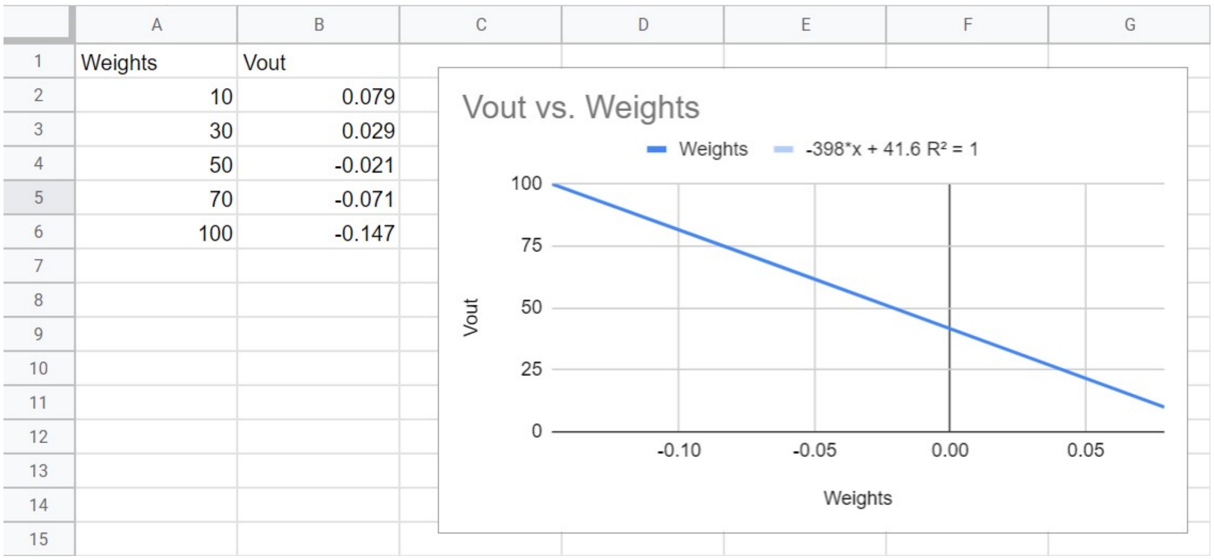


Figure 4: V_{out}(V) vs Weights(grams)

The observed sensitivity in mV/gm from the above graph is:**-0.367**

V_{out}(V) vs Weights(grams):



Weights	Vout
10	0.079
30	0.029
50	-0.021
70	-0.071
100	-0.147

Figure 5: V_{out}(V) vs Weights(grams)

Here, we were asked to adjust the value of Rg to obtain a sensitivity of -0.4. The observed sensitivity in mV/gm from the above graph is: **-0.398** We need to adjust the value of R_G such that the sensitivity doubles:
By adjusting the potentiometer, we found the value of R_G to be 102 ohms, which was initially 220 ohms.

Conclusion:
The output voltage Vout varies linearly with the weights placed on the load cell as can be observed from the plots above.

5 Experiment completion status

All parts of the experiment were successfully completed (part-1 and part-3) and various parameters were recorded for making observations.