Component Level Laboratory

Mechanical Sensor Fundamentals: Strain Gauge and Load Cell

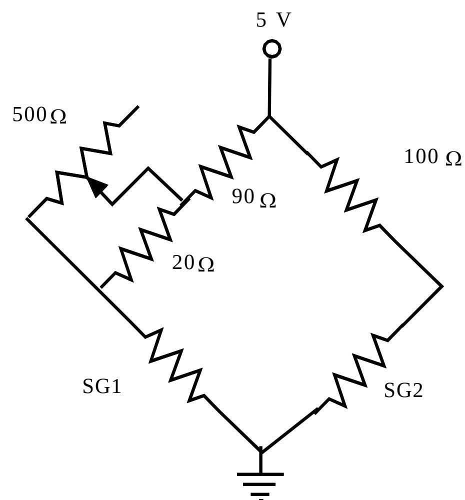
Objective

The objective of this experiment is to study the strain gauge's characteristic and apply it as a load cell in a weighing scale made from a cantilever beam. LabVIEW will be used to collect data and display the weight and time response of the strain gauge.

Exercise 1. Use the strain gauge as load cell

Step 1: Signal Conditioning

A. Identify the active and dummy strain gauge. Decide on where these two strain gauge will locate in the bridge circuit you designed.



B. Construct the bridge circuit designed. Apply power and adjust the 500 □ variable resistor for the best null you can achieve with no weight in the pan.

The minimum null voltage you can achieve:

□V_{min} = __________

C. Construct the input-offset compensated differential amplifier with a gain of about 500 on the breadboard. Make sure the output is zero when the two inputs are shorted. Record the minimum output voltage you can achieve:

V_{min} = _____________

D. Connect the bridge to the differential amplifier. Ideally the output should be zero volts with no weight in the pan but this will probably not be so. Adjust the input-offset variable resistor of the op amp until the output is as close to zero as you can get. Make sure that when the beam is *gently* deflected down the output voltage becomes positive.

E. Electrical noise can be a problem with such small voltages and high gains. Construct a low-pass RC filter with a critical frequency of about 0.5 Hz you designed. Place the filter on the output of the amplifier. Make sure that the output voltage still becomes positive as the beam is gently deflected.

Step 2: Calibration

For calibration we need to determine the number of *grams per volt* resulting from the cantilever beam, bridge circuit and the amplifier. To do this we will place 10 nickels, each of which has a mass of 2.63 grams, onto the scale and measure the voltage.

A. Place ten nickels on the scale and record the resulting voltage.

Vout = ____________

B. Divide the mass of the nickels by the voltage to determine the scale factor of the weighing system in *grams/volt*. (Reminder: write the equation and remember the unit.)

Fscale = ___________

Step 3. Construct the weighing system in LabView

A. Construct a VI that has on the front panel a meter to display weight along with a digital readout of the weight. Include an input for the scale factor found in Step 2. A single sample AI should be used to take the amplifier voltage as input. The VI then will multiply it by the scale factor and display the result weight on the meter and digital readout.

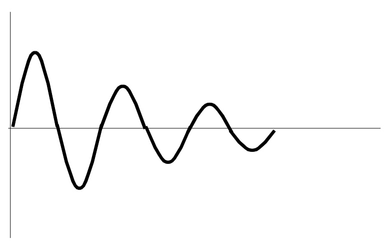
B. Determine the weight of a nickel, dime and quarter. You may have to use several coins at once to get reliable readings.

C. Obtain the scale reading for as many nickels as you can place on the scale, one at a time. This will be used to make a plot of indicated scale weight versus number of nickels to evaluate the linearly of the scale.

Number of nickels	Voltage reading	Weight
5		
10		
15		
20		
25		
30		
35		
40		

Exercise 2: Second Order Time Response of Strain Gauge

The strain gauge exhibits 2nd order time response. This means that a sudden change in input will produce decaying oscillations of the output. The response is characterized by a natural frequency of oscillation, f_N, and a decay constant, α



$$v(t) = V_0 e^{-\alpha t} \sin(2\pi f_N t)$$

A. Set up a VI which will take 1000 samples of the amplifier output *without the RC filter*. Take the samples over a 5 second period. Gently press the beam down and then release it so that oscillations start. Start the VI and then release the beam. Take at least 1000 samples after the release of the beam and display them on the graph. The output should be sent to a graph which has been bundled so that the horizontal axis is in seconds. Copy the graph here.

B. From the data determine the frequency of oscillation and the decay constant. Note that each peak occurs when the $\sin(2\pi f_N t) = 1$, so each peak is given by $v(t) = V_0 e^{-\alpha t}$

Post Lab Questions:

1) In your report, explain three reasons of designing signal conditioning circuits in building data acquisition systems.
2) Show a good graph of the measured weight versus number of pennies. Comment on the linearity of the relationship.
3) Determine the natural frequency and decay constant of the strain gauge and show the detail steps.