Laboratory Assignment 6a

NAME:
ROLL NO:

Marks: **Q1: /1 Q2: /2 Q3: /2 Q4: /3 Exp: /8 Tot= /15**

Goal:

This assignment completes the task started in assignment 7. Recall that the task in assignment was to build an instrumentation amplifier with a very high CMRR that can be dc-coupled to a measurement system. Today we will use that device to perform a physical measurement.

Strain gauge: Measuring tiny changes in the resistance of a wire due to stretch:

Recall that the resistance of a cylindrical piece of wire is given by $R = \rho \frac{L}{A}$
where L & A are the lengths and cross-section of the wire
and ρ is it's specific resistance – an intrinsic property that will not be of interest to us today.
What matters in today's experiment is that by stretching a piece of wire, we can change it's cross-sectional area A (make it thinner) and it's length L.
This is the basic principle on which a device used to measure strain works
Consider the circuit shown in Fig 1, which can be built on the bakelite board provided to you:

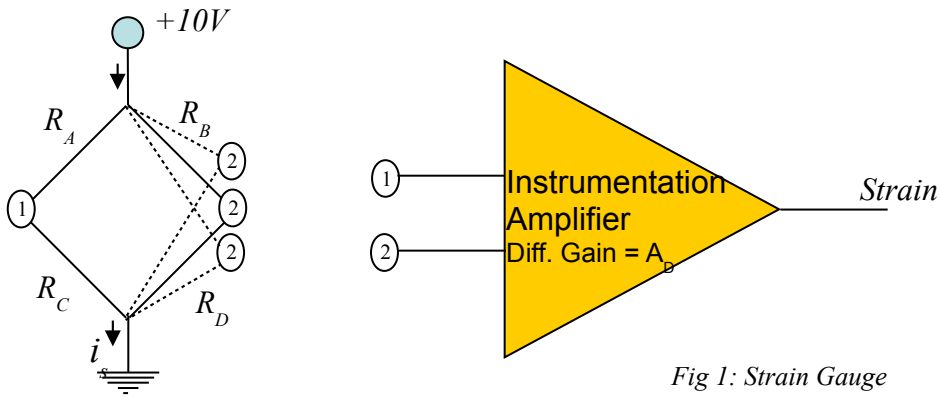

Fig 1: Strain Gauge

The 'bridge' shown on the left is made of a single loop of wire strung *tightly* around four equidistant points. Nominally $R_A = R_B = R_C = R_D$ up to mechanical tolerances of how the parts are laid out on your board.
When you shift the position of the point labelled (2) up or down, the wire in the right half of the bridge stretches (so it's cross-sectional area decreases and the length changes) – so you expect the bridge to become unbalanced.

Experiment Design Questions

1) The circuit diagram for the bridge is missing an important part! Indicate it and include a part of appropriate value at the point
Hint: $(R_A+R_C) \,||\, (R_B+R_D)$ is very small for a thin wire! Do you want to connect +10V to ground with a thin wire? Does the value of the component you choose matter?

2) What is the common-mode voltage you expect to measure at points (1) and (2) ? You can measure this simply with your multimeter and check.
~ 5V

3) When point (2) is moved up or down stretching the wire, what is the order of magnitude of voltage imbalance you expect to get ? This will give you an idea of the differential voltage signal you expect from your experimental setup. You can take typical values for $\rho \sim 10^{-8}\ \Omega m$ and $A \sim 10^{-7} m^2$ *For L change of ~ 1cm, R should change by ~ mΩ, i.e. ΔV should be ~ 10 mV*

4) Based on questions 2 and 3, what is the CMRR you need from your instrumentation amplifier to get a reasonable signal measurement? *CMRR needed ~ 5V/10mV ~ 90 dB*

NAME:

Experiment

Based on your answer to question 4) above, set the differential gain of your instrumentation amplifier to an appropriate value, and obtain a measurement of the 'strain' or imbalance produced in the resistances R_B & R_D as the position of the point labelled (2) in Fig 1 changes in terms of the amplified voltage signal observed at the output of the instrumentation amplifier.

Physics Experiment – following is expected:

a) Design (based on specifications determined in q.1-4 above)
b) Construction of the circuit and the wire-stretching apparatus
c) Measurement
d) Justification that a reasonable result has been obtained

Note: Calibration of the voltage signal to get a physical measurement of applied force v/s strain would require a separate measurement of the applied force – which is not performed in this experiment.
A device like this is typically used to measure the *weight* of objects : a heavy object attached to point (2) in Fig 1 (and the entire setup placed in a vertical plane) would cause imbalance of the resistance bridge by stretching the wire and produce a voltage signal. Putting pre-calibrated weights in (*eg.* 1 kg, 10 kg, 100 kg etc) would allow a calibration of the voltage v/s force applied.