Measurement, Instrumentation and Experiment Design

PHYS 352 – Lab 3
Strain Gauge Signal Conversion
Winter Term, 2010
Lab Overview

Objectives:

• Use a strain gauge in a $\frac{1}{4}$-bridge configuration
• Design and construct the amplifier circuits to:
  ➢ Produce a 0 - 2.5 V voltage output
  ➢ Measure the deflection and from the voltage signal do a “reverse” calculation for the theoretical deflection
  ➢ Calculate the load to produce the “yield stress”
The ¼-bridge circuit uses just one strain gauge

- Requires high-quality amplifiers to avoid problems with op-amp characteristics, e.g. offset voltage and drift, hence the AD623 and TLC272
- Outputs circuits to be designed for $0-2.5$ V (simpler circuit, using just a 5 V supply)
- The ¼-bridge outputs the smallest signal to be amplified
Deflection of a beam with a strain gauge

\[ \Delta s = \frac{2L^3\varepsilon_x}{3lh} \]

- Strain does not appear in the equation, but the stress \((\varepsilon_x)\) does, and stress and strain are related by Hooke’s Law.
- The strain produces a change in resistance of the foil.
- The change in resistance is detected by a bridge circuit – as a small voltage in the millivolt range (refer to lab handout).
Amplification of the Bridge Circuit signal

The signal from the bridge is fed to an instrumentation amplifier:-
• Single resistor (RG) for gain -- ~634 in this case
• Output set internally to the reference voltage (pin 5) for zero input
• Circuit modification allows output “zero”, set by RV1
• Set the voltage at the OUT pin to the “zero” level, apply the maximum load to the beam and determine the voltage swing, $\Delta V_{\text{OUT}}$
• This change in voltage allows you to determine the gain of the second stage amplifier.
Points to note:-

- Use the TLC272 op-amp in a N.I. Amplifier configuration.
- Determine Rf, Ri and RV2 from $\Delta V_{OUT}$ of first stage, and the eventual 2.5 V output to set the gain of this stage
- Use RV2 to set the max. output of 2.5 V
- Load beam alternately with 0 gm and 1000 gm to set 0 V and 2.5 V. [Note that the “zero” will be about 20-30 mV.]
Circuit building Tips

1) Pin numbers on the circuit diagram

Example:

2) Use color coding

3) Use power strips

4) Separate components from chip
   - use insulated wire back to chip

5) Scope probes - to scope (ground)
   BNC cable - from signal generator

6) Build and check in sections
A. Why is a 3-wire connection required for quarter-bridge strain gauge circuits, but not for half- or full-bridge circuits?

B. Given that the yield stress, the maximum stress within the elastic region, is 200 MPa, calculate the maximum load in kilograms that can be applied safely to the beam, i.e. without deforming the beam.

Use Eq. A2 in Appendix 1. The cross sectional inertia of the beam is:

\[ I = \frac{bh^3}{12} \]

C. List the potential sources of error when using strain gauges.