Laboratory Exercise: Strain Gauge System

Introduction

Measurement of strain is a fundamental tool used by engineers in both research and design. Strain measurements are often used in systems where force or pressure measurements are required. The most widely used gauge consists of very fine metallic foil arranged in a grid pattern. The grid pattern maximizes the amount of foil subject to strain in the parallel direction (Figure 1). The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen.

A convenient and accurate method of measuring resistances of widely different values is by means of the Wheatstone bridge. It is used for finding the value of an unknown resistance by comparing with a known one. A basic Wheatstone bridge is a circuit consisting of four resistors, a constant voltage input, and a voltage gauge, arranged as shown in Figure 2. The resistors are arranged so that the electric current is split into two paths, each of these paths consisting of 2 resistors. In this resistance type strain gauge, strain is measured by detecting the change of resistance in the gauge as it undergoes deformation.

A quarter Wheatstone bridge has one unknown resistor and the other three are fixed. A half bridge has two unknown resistors and the other two legs are utilized with potentiometers. A full bridge consists of all unknown resistances.

In this laboratory, you will assemble both a half Wheatstone bridge circuit and measure the strain for a series of loads on a metal bar. You will then be able to create a calibration curve in MATLAB and use this equation to find an unknown weight.

Objectives

- Design a Wheatstone bridge and strain measuring system.
- Use MATLAB to create a calibration curve
- Understand the advantages/disadvantages of different Wheatstone bridges.
- Understand how the mounting of a strain gauge affects a system.
Required Supplies

- Students must have both MATLAB2009a and “Measurement and Automation” already installed on their computers.
- TA will have 6 strain gauges mounted onto metal bars before lab.
- Wheatstone bridge supplies: breadboard, three 120 ohm resistors, 5V battery, potentiometer, banana clips
- A set of weights in increments of 50 grams (max weight needed = 400 grams)
- An object with an unknown weight (example: candy bar)

Procedure

- Get into groups of three for this lab.

**Part 1. Construction of Wheatstone Bridge**
1. Assemble a Wheatstone bridge on the breadboard with three 120 ohm resistors.
2. Connect the battery to the Wheatstone bridge using the banana clips. Also, connect the potentiometer and strain gauge bar.
3. Make sure that “readFlukeFile.m” is saved in the appropriate MATLAB folder on your computer. This is the same file that was used during the Temperature Lab. The file is located on Scholar.
4. Set the Fluke multi-meter to the ‘mV’ reading. Verify that a reading of zero voltage (or very close) equals zero weight applied by connecting the ends of the potentiometer to the Fluke multi-meter.

**Part 2. MATLAB Calibration Curve**
1. Similar to the Temperature Lab, recordings should be made with the m-file. Record the voltage reading on the multi-meter with 0 grams in Table 1. Add 50 grams and record the weight. Repeat for all weights in the table.

<table>
<thead>
<tr>
<th>Weight (g)</th>
<th>Voltage (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
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<tr>
<td>200</td>
<td></td>
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<tr>
<td>250</td>
<td></td>
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<tr>
<td>300</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

2. Create vectors for Weight and Voltage in MATLAB. Create a scatter plot with Weight on the x-axis and Voltage on the y-axis. Label appropriately. Establish a line of best fit. The equation is your calibration curve. Your coding/process
needs to be included in your appendix. Refer to the tutorials in Lab 1 for assistance.

Part 3. Unknown Weight
1. Place the unknown weight on the bar and record the voltage reading. Using the calibration curve you have created, calculate the weight. Verify this number with your instructor.

Results Section Should Include:
1. Plot created in MATLAB. This should include the line of best fit and appropriate labels.
2. An explanation of the determination of the unknown weight.

Discussion Questions:
1. What is the difference between a quarter, half, and full Wheatstone bridge?
2. Explain the significance in where a strain gauge is mounted on a bar.
3. If you had a ten kilogram weight, how would you alter this strain gauge setup in order to accurately perform this experiment?
4. Describe a real world scenario in which this strain gauge setup would be useful.

Appendix Should Include:
1. Table of weights and voltages (including unknown weight data).
2. All MATLAB coding used should be published into a Word document. If MATLAB tools were used in place of certain lines of code, briefly explain your non-coded steps.