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ME 646

LAB 3 – STRAIN GAUGES AND VIBRATION

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Ink Drawings
BEAM AND STRAIN GAUGE RESPONSE

**Diagram of the Physical Setup:**

**Determination of Bridge Sensitivity Using Shunt Resistors:**

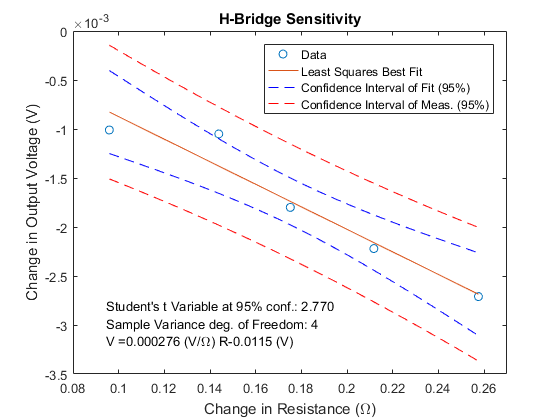


Figure – Experimental response of the Wheatstone bridge. The large confidence interval was caused by an anomalous point, data for subsequent portions of this experiment will be borrowed from Jesse Feng.

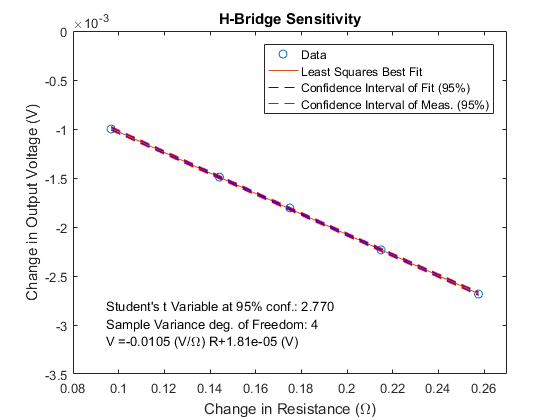


Figure – The data of Figure 1 were replaced with cleaner data.

**V = .0115 (V/Ω)+2.76e-4 (V)**



**Comparison of Measured Bridge Sensitivity with Calculated Bridge Sensitivity**

The measurements of bridge sensitivity were taken by adding a shunt resistor to one of the legs of the Wheatstone bridge. The calculations of the bridge sensitivity are made using the quarter Wheatstone bridge model. The voltage supplied to the Wheatstone bridge was 5 V – this value is represented by Ei in the equations below. Eo represents the output voltage across the Wheatstone bridge (see equation 1).

(1)

Since only one resistor is being changed in value, the following is true:

(2)

(3)

With the introduction of changes in voltage and resistance the equation for output voltage of the Wheatstone bridge is shown as:

(4)

The input voltage is approximated as:

(5)

If the output voltage is assumed to be zero at the point where there is no change in resistance. Strain is represented by , and gauge factor is represented by GF.

(6)

Solving for the bridge sensitivity by rearranging equation 6:

(7)

The experimental bridge sensitivity had an error less than 1% using the data of Jesse Feng. Using the original data, the error percentage was 11%.

**Solving for Strain Given Gauge Factor and Amplifier Output**

The experimental Wheatstone bridge was a half bridge – there were two strain gauges and two static 120 Ω resistors.

(8)

Strains three and four are equal to zero (since there are only two strain gauges – one on top of the beam and one below the beam). Strains one and two are equal to the bending strain plus the thermal strain (which is comparatively small) strain one is roughly equal in magnitude to strain two if they are on opposing sides of the beam. Equation 8 reduces to:

(9)

Rearranging equation 9, and accounting for gain allows for the isolation of strain, which can now be solved for given a change in output voltage.

(10)

**Determining Strain vs. Load and Strain vs. Displacement**

The strain in a beam can be calculated by equation 11.

(11)

Where ‘E’ is the Young’s modulus, ‘Thickness’ is the thickness of the beam (smallest dimension measured), and ‘Width’ is the width of the beam (second smallest dimension measured). Length is the distance between the hook and strain gauges. Force can be determined either through equation 12 (mass) or through equation 13 (displacement).

(12)

(13)

Where m is the mass suspended by the beam, g is the gravitational acceleration constant on Earth, and deflection is the amount the beam was displaced by the micrometer. Substituting equation 13 into equation 11 causes the moment of inertia and Young’s modulus to cancel, yielding:

(14)

The comparison between the values recorded by the strain gauges and the predictions derived from Mass (Figure #) and from displacement (Figure #) is shown below.

**Determination of Hysteresis for the Displacement Measurements**

Hysteresis is the difference between the y values f(x) for any function of x. In this lab the hysteresis will be the average measured distance between the points of the linear least squares best fit line derived from the beam being pressed downwards by the micrometer, and the linear least squares best fit line derived from the beam springing back up as the micrometer retreats [1]. Table 1 shows the difference between each *point* corresponding to a specific displacement, as well as the total hysteresis.

|  |  |  |
| --- | --- | --- |
| Total Hysteresis (ε): |  | |
| Displacement (inches): | Press – Release (ε): | Hysteresis (ε): |
| 0 |  |  |
| .025 |  |  |
| .050 |  |  |
| .075 |  |  |
| .100 |  |  |
| .125 |  |  |
| .150 |  |  |
| .175 |  |  |
| .200 |  |  |
| .225 |  |  |
| .250 |  |  |

*Table 1*