Governing Equations

The change in resistance in a strain gauge due to an applied strain is given in Equation 1 below:

1. $\Delta R = R_0 * \epsilon * GF$

The output voltage of an 8-resistor wheatstone bridge (Figure 2) is given in Equation 2 below:

2. $V_0 = \left(\frac{R_2+R_6}{R_2+R_6+R_3+R_4} - \frac{R_7+R_4}{R_7+R_4+R_1+R_5}\right) V_i$

Validation of Load Case

The first problem encountered when we began to test our specimen was the correct way to load our specimen. The first method we tried was applying a bending moment around the horizontal axis, perpendicular to the central axis of the device. In Figure 2, plus signs over the resistor indicate an increase in resistance, and minus signs indicate a decrease in resistance.

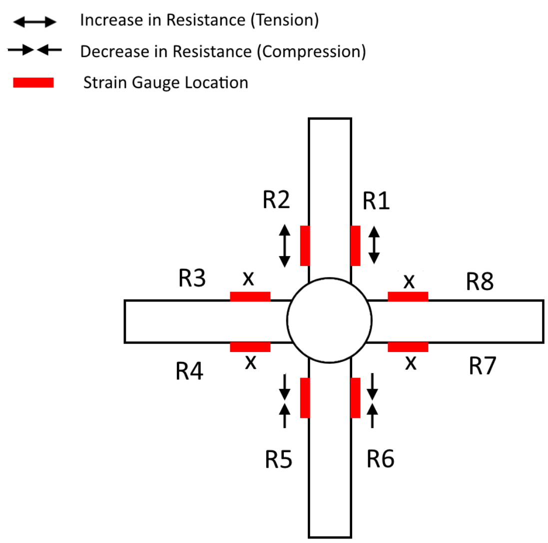

Figure 1: Structure Layout (Bending Moment)

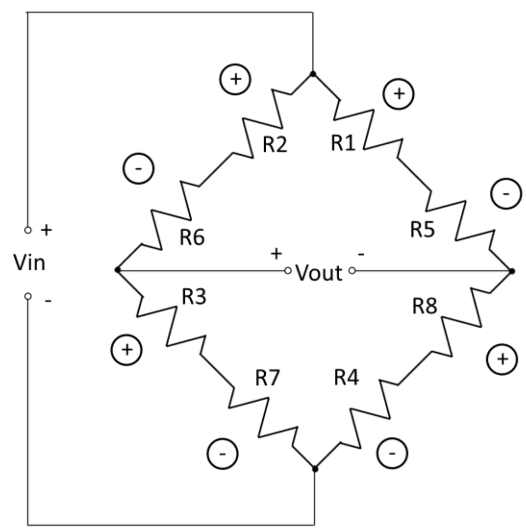

Figure 2: Wheatsone Layout (Bending Moment)

However, when a bending moment is applied with the wheatstone configuration used in our device, the changes in resistance cancel each other out when plugged into Equation 2. Knowing this, we switched our load case to a torsional load applied about the central axis of our device. This configuration will give us the maximum boost in output voltage and is most like the real-life use case for our device.

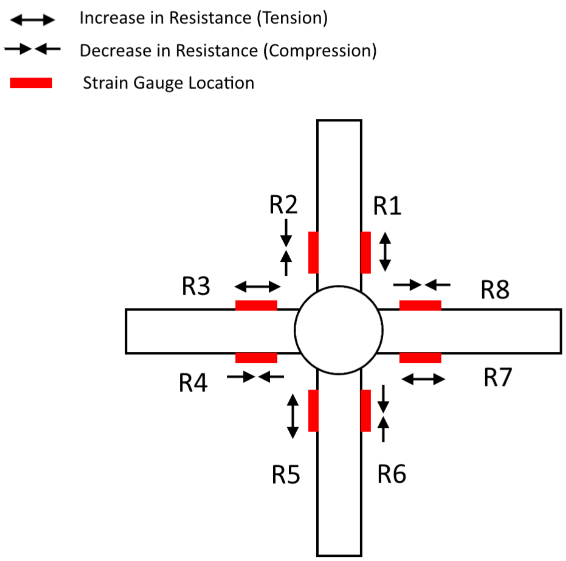

Figure 3: Structure Layout (Torsional Load)

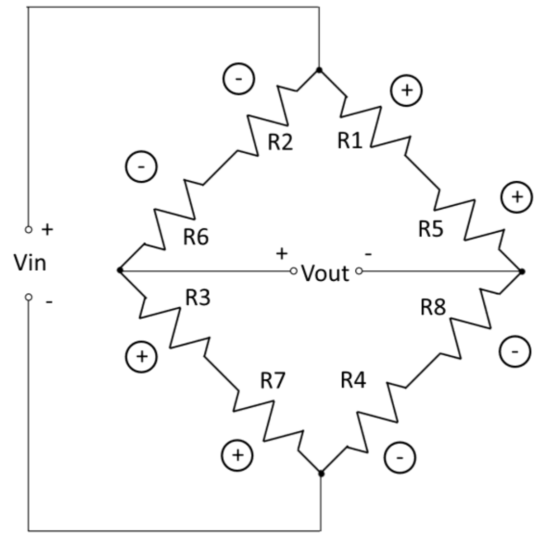

Figure 4: Wheatstone Layout (Torsional Load)

Cantilever Beam Test

In order to verify that our strain gauges could measure the amount of strain expected during the minimum load case, a cantilever beam test was performed with a thin sheet of aluminum as seen in Figure 5. Two strain gauges were used in series with a 100Ω resistor to act as one leg of the wheatstone bridge. The other 3 legs were simulated using two 350Ω resistors and a 100Ω resistor in series. The strain gauges were placed on the structure in a location where they would experience strains that the gauges on our structure would experience during a maximum load case.

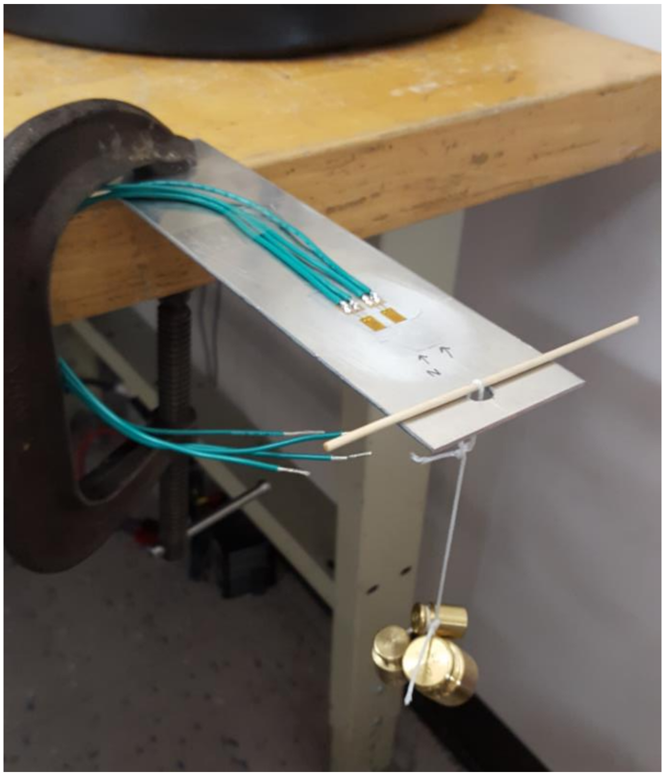

Figure 5: Cantilever Beam Test

During the test, the weight was removed and placed back on the beam in order to get three separate trials. The output voltage from the wheatstone bridge was measured both before and after the load was applied. The results from the test are summarized in Figure 6. Using the measured resistances of the strain gauges and resistors, the output voltage was calculated for an unloaded condition and a loaded condition then compared against experimental results. As seen in the table, the % error in voltage change from the unloaded to the loaded condition varies wildly in between tests, giving us inconclusive results. Since the focus of a wheatstone bridge is on the change of output voltage between unloaded and loaded conditions, not the accuracy output voltages to predicted values, the test shows that there is something wrong in our experimental set-up that is causes this lack of precision.

Trial	**Unloaded Vo (mV)**	**Loaded Vo (mV)**	**Delta (mV)**	**% Error in Delta**
Theoretical	*12.290*	*12.379*	*0.0888*	-
1	12.278	12.348	0.0700	21.1%
2	12.268	12.260	-0.0080	91.0%
3	12.240	12.260	0.0200	77.5%

Figure 6: Cantilever Beam Test Results