LabVIEW based Strain gauge measurement system

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Introduction

This project involves both hardware and software components and highlights the importance of measuring and displaying the amount of strain a material is under.

The amount of strain a material is under directly proportional to the amount of stress the material is under. Measuring the strain of a material is critical in the development of commercial buildings, automobiles and electronic devices. Measuring these strains can allow the use of less material when constructing new buildings, designing new aircrafts / automobiles, and will allow for stress testing of devices and electronic devices.

Aim

To design a system that can be used to determine the strain of steel when its subjected to a force and process all the results using LabVIEW.

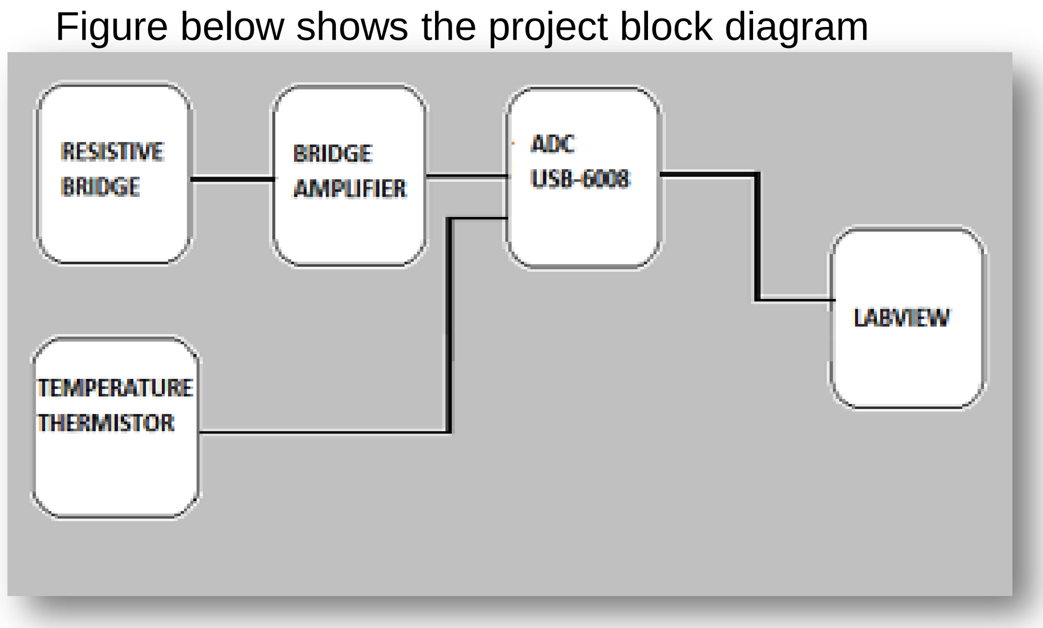
Using a length of steel, a force is applied to the steel a voltage output will be seen in a Wheatstone resistive full bridge converted to a digital signal, creating a program in which the force is measured and converted to strain displaying and compared the resulting strain to its theoretical strain, in real time.

Method

The steps in creating this project are briefly described :

- Connect and mount foil stain gauges, in a Wheatstone configuration to a length of steel..
- Amplify the strain voltage output.
- Allow for temperature adjustment with the use of a thermistor.
- Convert both signal to a digital signal.
- Display the converted signal allowing for control over the bridge supply and for zeroing of the bridge to compensate for the weight of the steel with no force manually is applied.
- Display these and show the strain with temperature compensation in real time while applying 100 grams weights up to 1 kilogram of weight to the steel.

Figure below shows the project block diagram



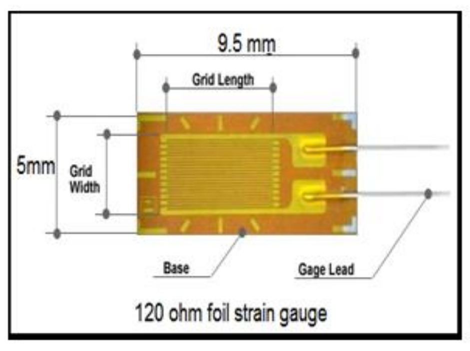


Figure 1

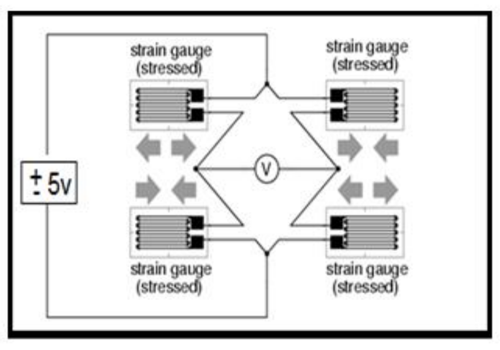


Figure 2

In figure 1, a foil strain gauge and in figure 2 a wheatstone resistive bridge.

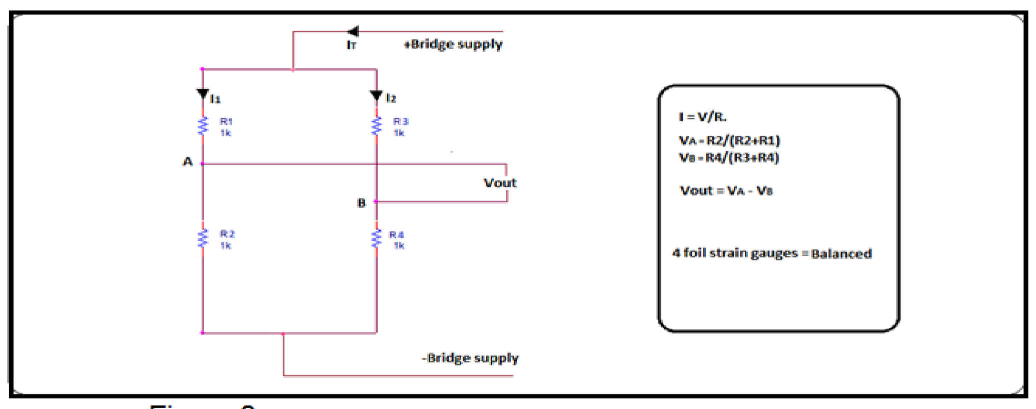


Figure 3

Figure 3 shows the Wheatstone Resistive Bridge.

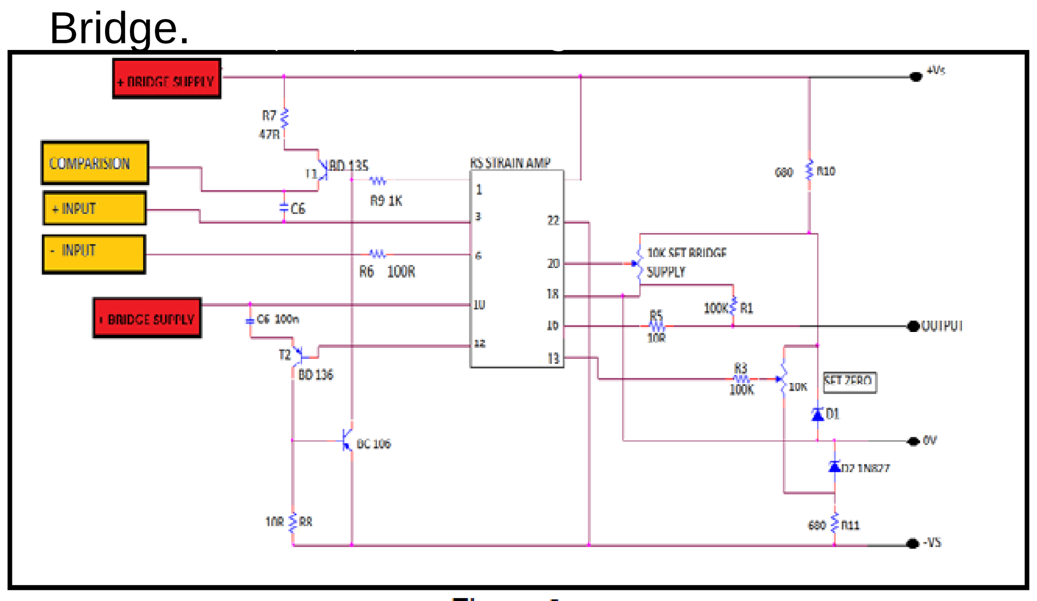


Figure 6

Figure 6 shows the strain gauge amplifier. Here the bridge supply can be set, and the bridge can be set to zero. The output is a voltage which is the difference between the set of foil gauges and has a gain of 1000.

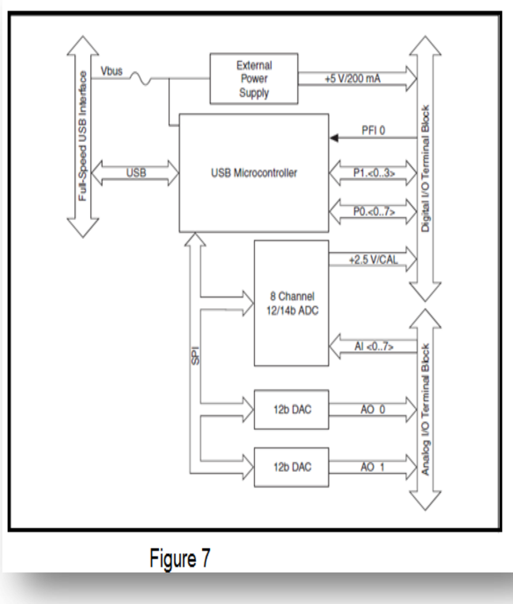


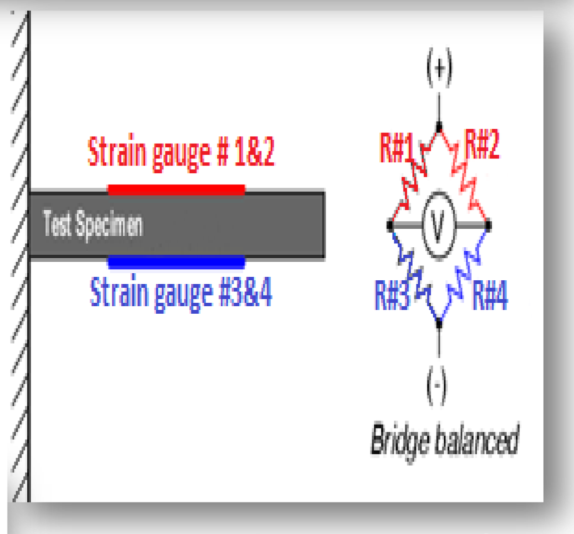
Figure 7

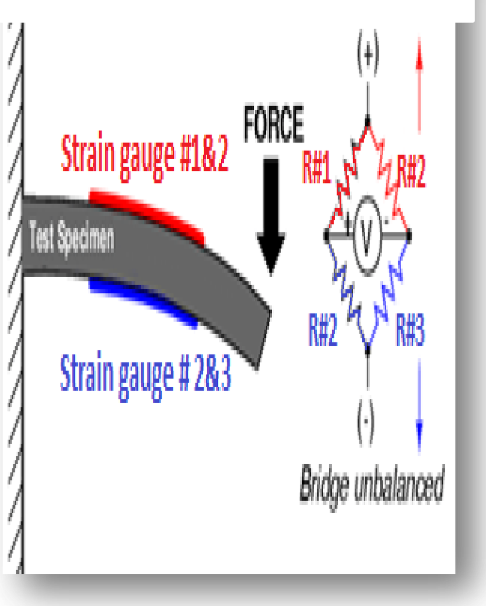
Figure 7 shows the successive approximation NI USB-6008 ADC which is used to convert the voltage output amplifier and temperature potential divider in to digital signal for interaction with LabVIEW

Results

Picture above showns the final Product

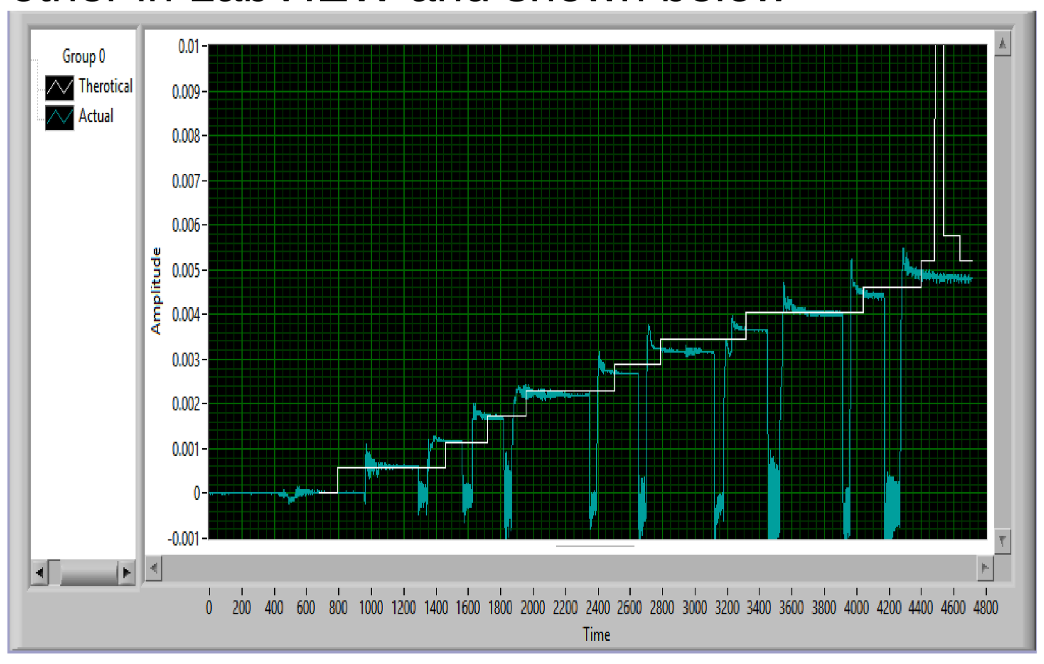
The strain gauges are placed on the steel as shown in the figure across, when weight is applied to the steel and force is calculated with the LabVIEW http://www.instrumentationtoday.com/strain-gauge/2011/08/.





When the force is applied the foil gauges R1/R2 under tension and R3/R4 under compress the change in length will cause an resistance change. Applying a voltage to both sides of the bridge will show a voltage difference between both set of gauges.

A succession of 100grams weight were added to the steel and compared to the calculated strain. The results are plotted against each other in LabVIEW and shown below



It can be seen in plot 1 the actual strain (blue line) and the calculated stain (grey line). As the weight is increased by 100 grams the strain actual and calculated increase by 5 micro strain until the final weight of a 1kg. The actual strain oscillates as the weight added moves the steel and settles down after a short time. The dip shown the removal of the weight to add an extra 100 grams. The accuracy of the system is 95% of the real strain with temperature compensation.

Strain can be affected by the increase or decrease in temperature. The thermistor resistance will change with an increase in temperature the voltage divider will convert the resistance to a voltage the DAQ will convert the voltage to digital and LabVIEW program will compensate for the change in temperature that affects the stain measurement. As temperature increases or decreases a change in resistance between the resistive bridge will be seen.

Conclusion

Strain(ε) is defined as $\frac{\Delta L}{L}$ (L = Length)

- There is a relationship between strain and stress. This is know as **Hook's Law** $\sigma = E\varepsilon$. E is Young's Modules of Elasticity, where E has units of force per unit area (same as stress).
- Strain can be affected by temperature which produce expansion or compression of the material. $\varepsilon_T = \alpha \Delta T$

- α = coefficient of thermal expansion
- ΔT = change in temperature

Personal reflection

In this project covers both hardware and software components which proved throughout this project to be constantly testing the acquired skills, from researching and reviewing discrete components, finding data sheets, building PCB, soldering components ,testing the individual circuits, converting signals from analog to digital, to developing and debugging software to implement the outputs from the circuits to display and to use the signals.

Acknowledgements

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