UNIVERSITY OF WEST LONDON

Instrumentation and Measurements

Strain gauge assignment

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Introduction

For this assignment, the task was to design and build a strain gauge measuring system, by using an ELVIS II board and the strain gauge provided in the QNET mechatronics board, in order to design the circuit needed to measure the strain of the strain gauge. All the measurements must be recorded in a LabVIEW program that acquires the readings from the ELVIS II board and displays them in a graph, then the offset of this signal must be nulled either by using a LabVIEW algorithm or by using a shunt resistor and calculating the values needed to null the signal. The learning outcomes of this assignment were to understands the basics of working and designing circuit containing sensors and transducers, learn how to use LabVIEW program to acquire and analyze data, acquire the abilities to measure and analyze electrical signals and understand their sources and nature.

Experimental Procedure

The first part of this assignment a circuit was designed to measure the strain of a strain gauge, this was done by using a Wheatstone bridge in the quarter bridge configuration, shown in figure 1. A Wheatstone bridge was used because it allows for higher measurement sensitivity and lower measurement error, the quarter bridge configuration consists of using three fixed resistors of 350Ω and one active strain gauge which has a resistance of 350Ω in its unstrained state, this configuration was used because it allows for the lowest measurement sensitivity.

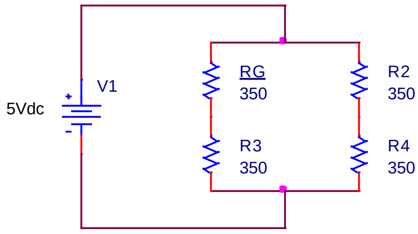

Figure 1: shows the quarter bridge used

This circuit works by using the change in resistance of strain gauge when strained to unbalance the Wheatstone bridge and allow a small voltage to flow, this voltage is an extremely small voltage in the range of microvolts so it must be amplified for this application, this uses Equation 1 shown below.

$$Vo = Vex\,(\frac{R3}{R3 + RG} - \frac{R4}{R4 + R2})$$

Equation 1: shows the formal for Wheatstone bridge

After the circuit was designed and tested, by probing between the resistors to get the output voltage and measuring it by using a LabVIEW program, the signal voltage output was nulled as close as possible to 0, in this assignment this was done in two methods, the first method was by subtracting the offset of the signal to the output voltage signal using LabVIEW, the second method was by connecting a variable 50kΩ resistor in parallel to the strain gauge and by using a voltmeter to record the output voltage offset, then by slowly turning the notch of the variable resistor to increase the resistance until the voltmeter records an offset as close as possible to 0. The signal was nulled to display better in the graph in LabVIEW.

LabVIEW

The LabVIEW program shown in figure 2, acquires the output voltage signal of the quarter bridge circuit form the ELVIS II board using the DAQ assistant set on acquiring voltage signal, this is enclosed in a while loop to acquire a continuous signal. This signal is first amplified by a gain of 1000, then the offset of the signal is nulled by having the user enter the offset in a numeric controller and subtracting it to the initial voltage signal, the signal is then displayed in voltage over time graph and by using a numerical indicator to display the value. To calculate the strain the formula in equation 2 was used, the voltage output was taken from the DAQ assistant and gauge factor entered by the user in the numeric control, the output of this operation is then taken to measure the change in length by multiplying the strain by the length of the beam, and from that the change in resistance of the strain gauge is calculated by multiplying by the gauge factor and the resistor value. In the and the output voltage is filtered to remove the noise from the signal.

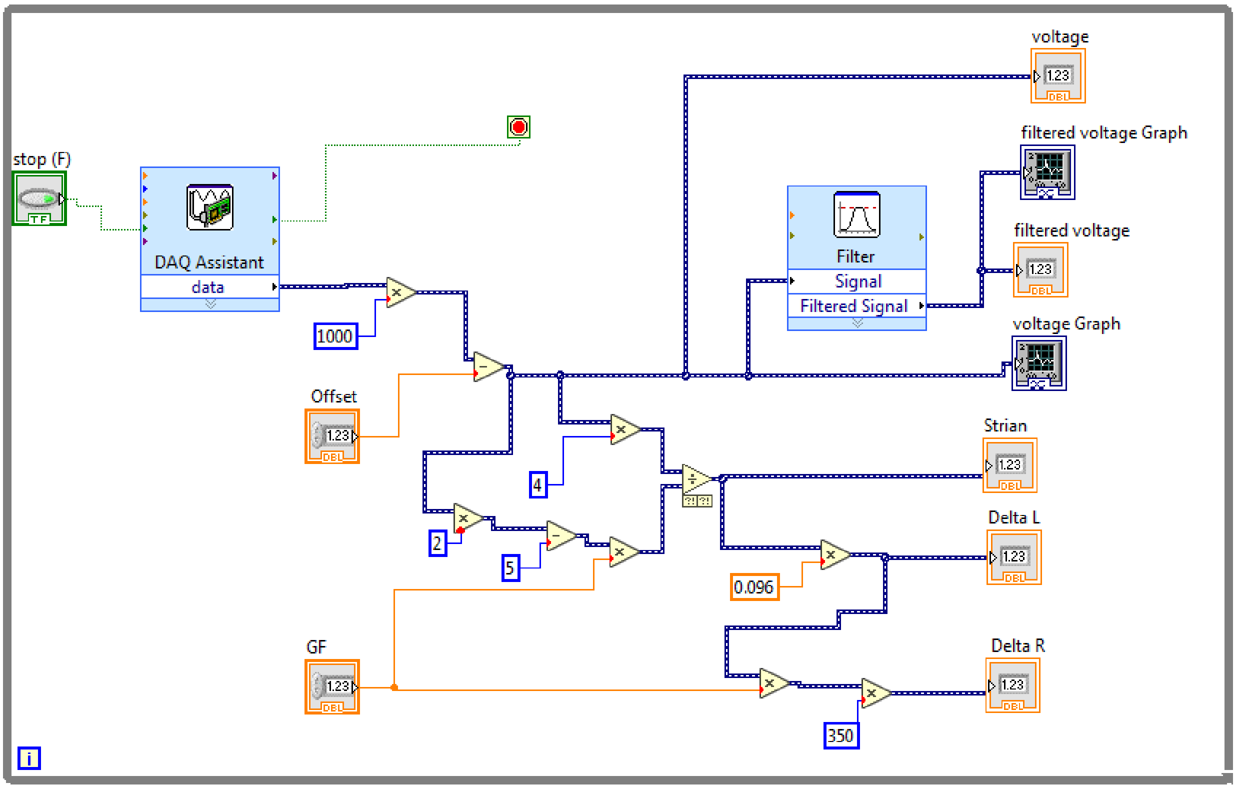

Figure 2: shows a LabVIEW program

Discussion and Results

Test

In figure 3 shows a test of the LabVIEW to illustrates that it is, in fact, recording the values acquired from the ELVIS II board. This was done by running the simulation and moving the strain gauge, as shown below the LabVIEW works as expected.

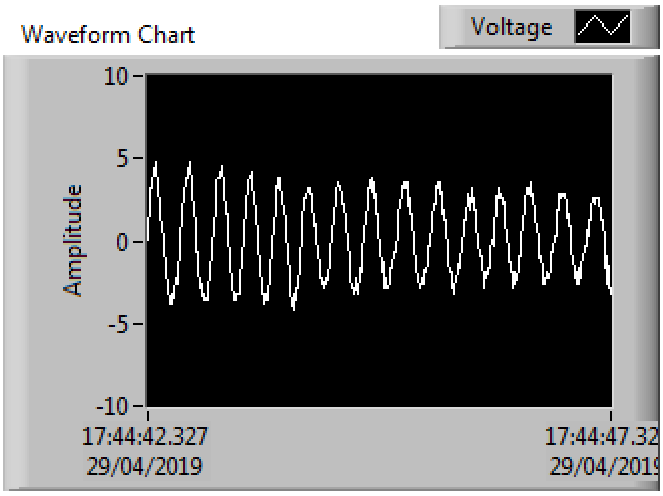

Figure 3: shows a test of the DAQ

Calculation of values

This section shows a recording of the values of strain, change in length and the change in resistance as shown in figure 4, this was done to verify the results and compare them with calculated values. The first value that was verified was the strain, which was done by using the equation 2, where the voltage output was set to 4.51V as shown in figure 4, and the gauge factor was set to 2, the calculation below shows that the answer agrees with the results in figure 4.

$$\mathcal{E} = \frac{4 * Vo}{GF * (5 - 2 * Vo)}$$

Equation 2: strain formula

$$\mathcal{E} = \frac{4 * 4.51}{2 * (5 - 2 * 4.51)} \rightarrow \mathcal{E} = 2.24$$

The change in length was then calculated using equation 3, by using the output of the strain formula calculated by multiplying it by the length of the strain gauge, which was measured to be 9.6 cm.

$$\Delta L = \mathcal{E} * L$$

Equation 3:change in length

$$\Delta L = 2.24 * 0.096 \rightarrow \Delta L = 0.215$$

After-wards the change in resistance was calculated using the output of the change in length and by using equation 4, here again, the gauge factor was entered by the user and set to 2 and the resistor value used was 350Ω. As shown below all the results agree with the result recorded in figure 4.

$$\Delta R = \Delta L * R * GF$$

Equation 4:change in resistance

$$\Delta R = 0.215 * 350 * 2 \rightarrow \Delta R = 150.5\Omega$$

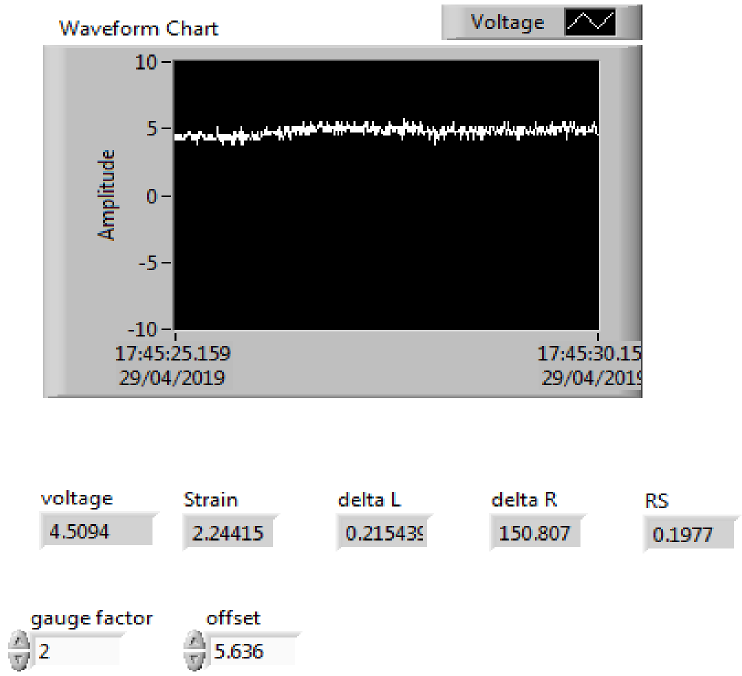

Figure 4: shows LabVIEW recorded values

All calculations were repeated with a different voltage output to assess the validity of the results, as shown in figure 5, and the calculations below. All the results agree with the recorded results.

$$\mathcal{E} = \frac{4 * 6.44}{2 * (5 - 2 * 6.44)} \rightarrow \mathcal{E} = 1.634$$

$$\Delta L = 1.634 * 0.096 \rightarrow \Delta L = 0.156$$

$$\Delta R = 0.156 * 350 * 2 \rightarrow \Delta R = 109\Omega$$

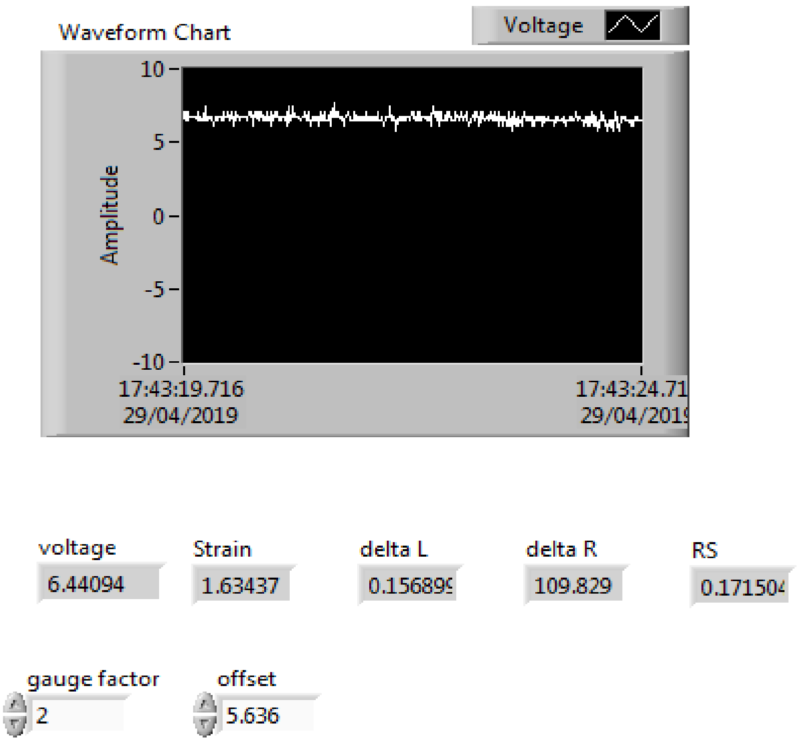

Figure 5: recorded values

Nulled value

The offset of the output voltage recorded form the ELVIS II was nulled with 2 different methods, better display the change in voltage when the strain gauge is moved, this was done in the first example in figure 6, by using a shunt resistor connected in parallel with the gauge strain and by turning the notch of the potentiometer until the voltage value recorded by the voltmeter connected to the shunt resistor display a values as closest as possible to 0, in this test the closest value that was possible to obtain with a 5 kΩ variable resistor was 2.4 mV, the graph in figure 6 display -2V because the signal recorded was amplified by a factor of 1000.

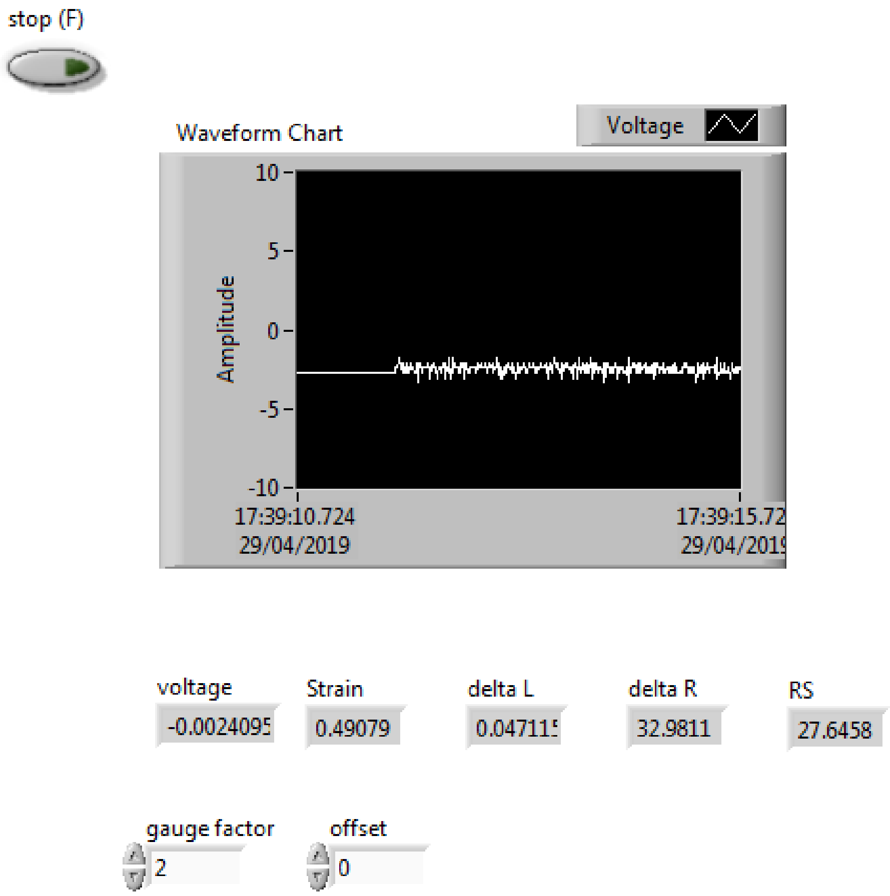

Figure 6: nulled by a shunt resistor

The second method for which the offset output signal was nulled was using a LabVIEW algorithm, by first recording the offset value of the voltage and then having the user enter the value into the numeric control in LabVIEW to subtract that value to the supplied signal, the lowest value obtained this method was 2.48mV as shown in figure 7.

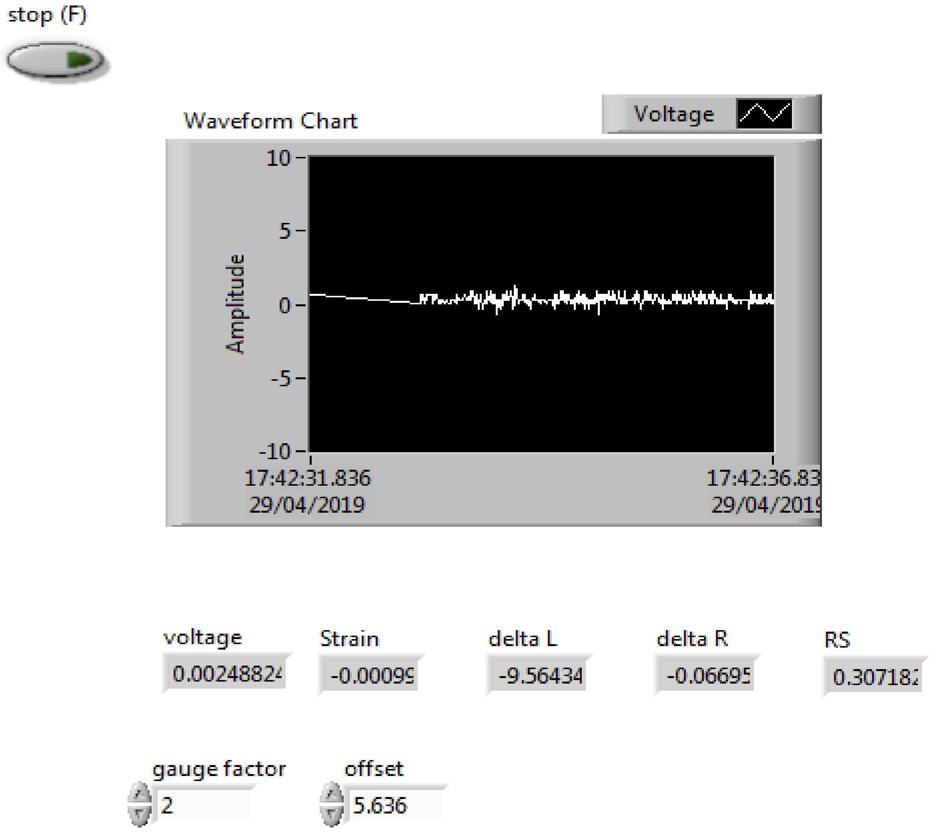

Figure 7: nulled by LabVIEW code

Filtering the output voltage

After the output voltage was nulled, a low pass filter was used in LabVIEW to remove the noise and to make the signal more linear, so the recorded values could be better represented in the graph, as shown in figure 8, where the non-filtered signal and the filtered signal were compared. The signal had to be filtered at the end because the filter function turned the signal into a contentious signal instead of maintaining it as an array of values and this conflicted with the other functions that required an array of values to perform the calculations.

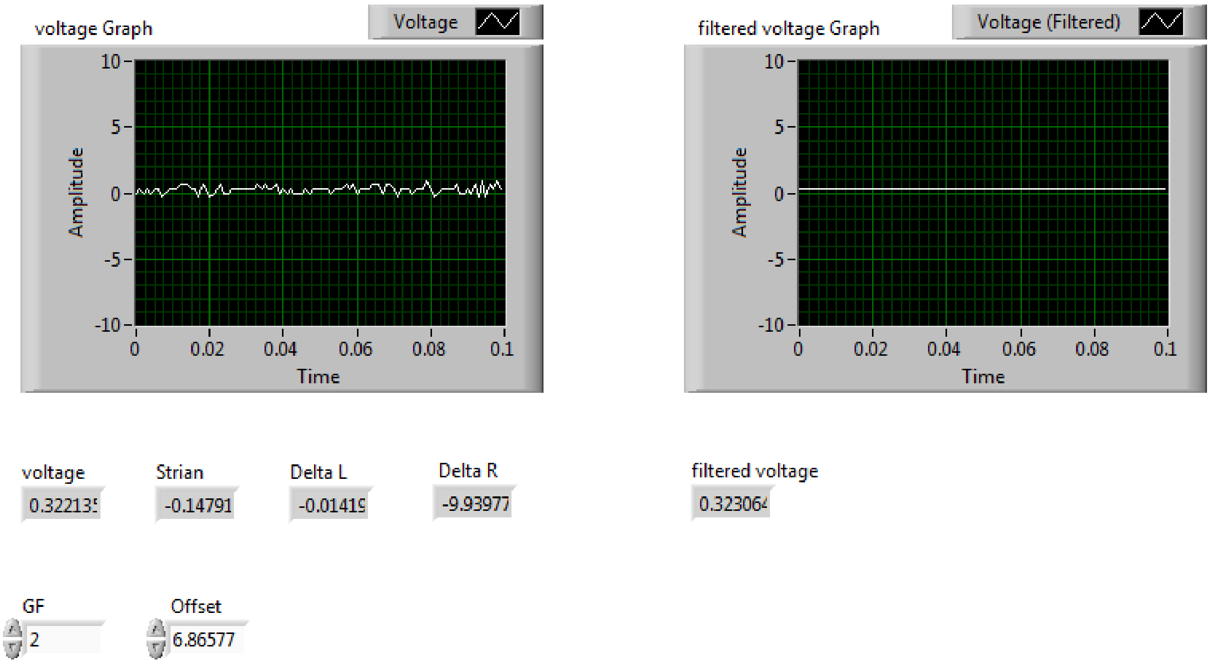

Figure 8: shows the comparing of signals