Strain gauge – part 2

In this lab, you will use a capacitor to build an averaging circuit for your strain gauge. You will use the same circuit from last week as the starting point. You will add a simple resistor-capacitor (RC) circuit to average out all the electrical noise and as well as bouncing from the mass swinging around.

Before working with the strain gauge, let's do a few simple experiments with a simple RC averaging circuit to explore the behavior in a more controlled setting. After that we will conduct the strain gauge experiment.

Part 1: RC

On your bread-board (you don't need the green power supply yet). Place a 1K Ω resistor in series with a 0.1 micro-farad (μF) capacitor. Place two of the header pins from the Analog Discovery on the resistor, three on the capacitor and one on the node between the two parts. Place the yellow wire on the Analog Discovery (w1) on the resistor and one of the black ground wires on the capacitor. Finally measure the voltage across the whole circuit with input channel 1 (orange wires) and the voltage across the capacitor with input channel 2 (blue wires). The negative side of both input channels (the orange/white and blue/white wires) should be connected to the ground. The progression described is shown below in Figure 1 and the schematic for the circuit is shown in Figure2.
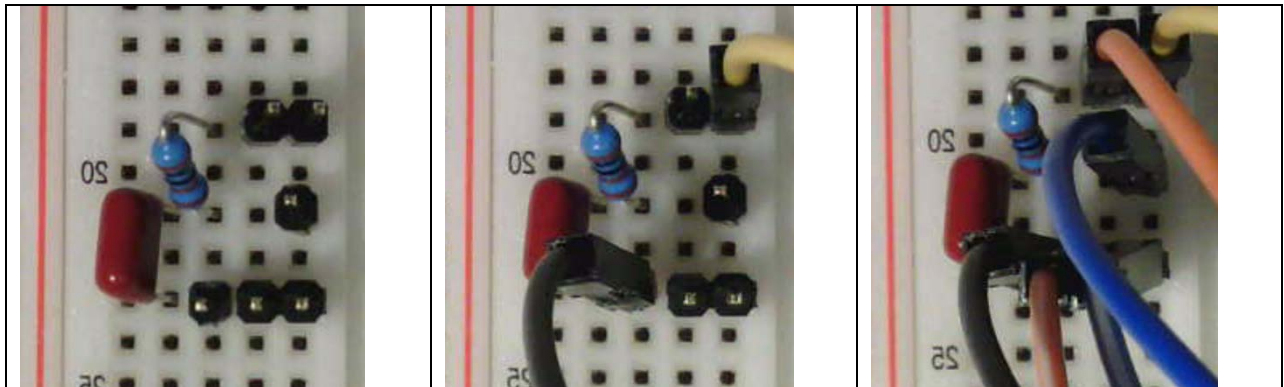

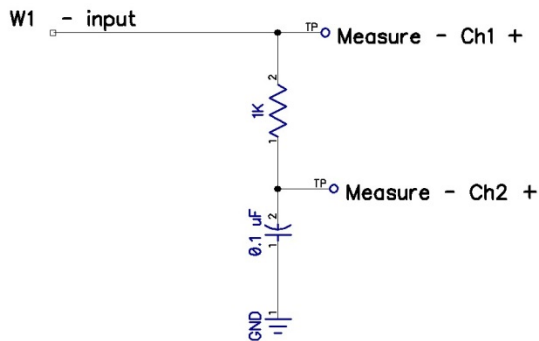Figure 1: Connection for the first experiment with an RC circuit using the Analog Discovery

Figure 2: Simple RC circuit.

Open the Waveforms software. Open "WaveGen" on the main screen. "WaveGen", the Arbitrary Waveform Generator, will allow you to set an output waveforms type (square, sine, triangle), amplitude and frequency. Set the waveform type to a square wave. Set the frequency to 500 Hz. Set the amplitude to 500 mV. Set the offset to 500 mV. This will create a 0 to 1 volt square wave with a frequency of 500 Hz. Hit the button – "Run AWG1" such that the Analog Discovery will begin to output this signal on the W1 (yellow) wire.

Now open the Scope. On the right, turn both channel 1 and channel 2 on. Set the time scale to 500 µs per division, the voltage scale to 500 mV/division and the voltage offsets to zero. If the signal is scrolling by on the screen, you may need to adjust the Scope's trigger (we can explain this in class). To set the trigger, look to the right of the Run/Stop button. Through the pull down menus; set the mode to auto, source to Channel 1, condition to falling and the level to 500 mV. These settings tell the scope to find when Channel 1 passes 500 mV while rising and center the scope's time=0 onto that condition.

Once you have everything set, export the data. Hit the export button, change the source to "Main Window", type to "CSV", and turn the comments and header off. This will allow you to load the data in MATLAB as described in Lab 1. You will need a plot of this data for your lab report.

While the Scope is running, go back to the WaveGen "Arbitrary Waveform Generator". Turn the frequency up to 1.5 kHz and see what happens. Capture this data in the same way as the 500 Hz data. Now, try adjusting the frequency slider up and down to observe what happens to the output signal as frequency increases. Turn on a measurement of channel 2's amplitude. Select "view", "measurements", "Add measurement", select "Channel 2", "vertical", "amplitude". Now adjust the frequency, 500 Hz, 1 kHz, 2 kHz, 5 kHz, 10 kHz, 20 kHz, 50 kHz, 100 kHz and 200 kHz. Record (on a piece of paper) the frequency and amplitude of channel 2 at these 9 frequencies. For your lab report you will plot this data on a log-log plot. To create a log scale plot in MATLAB type,

- `loglog([500 1e3 23e 5e3 1e4 2e4 5e4 1e5 2e5],[x x x x x x x x x ])`

where "x" are your recorded values of amplitude. You will need this plot (with appropriate labels) in your lab report.

Part 2 – Scale;

Now, go back to the circuit you created last week and add an RC averaging circuit to the end as shown in Figure 3.
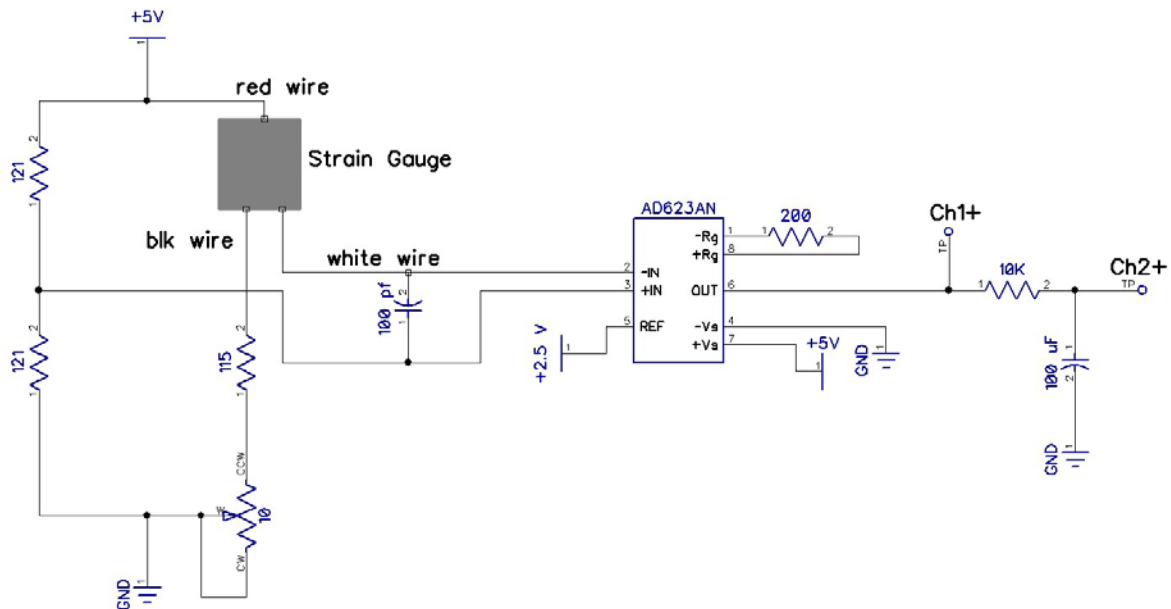
Take some fishing line and tie a string to the end of the beam with the attached strain gauge. Add a paper clip "hook" to the end of the string. Note that you may need to balance the bridge by adjusting the potentiometer so that you have close to zero volts with no load. Take one of the large washers and suddenly load the beam while monitoring the voltage at the test points shown above for Channel 1 and Channel 2. You should see that the response looks similar to what we found in Part 1 of this lab. Channel 1 should have some vibration which is smoothed out by the RC on the amplifier output. The value at Channel 2 should represent the average value of channel 1. The average value should change more slowly and should remove the electrical noise seen on Channel 1. Record/export the data for a sudden loading for your lab report.

Now, take a series of washers. The washers have been weighed. Takes a series of about 10 measurements (don't go above 300 grams) adding weights. Use the average output at channel 2 to make your measurements. Record the voltage versus mass. In MATLAB make a scatter plot of voltage versus mass and fit a line through the data (See Lab 1).

Deliverables:

The plots/results you need to save are highlighted in RED in the lab above. The summary of what you should turn in is listed below.

- Part1 RC: Plot the result of the 1 volt square wave at 500 Hz into the RC circuit. Compare the measured time response (voltage versus time) of the decay from 1 to 0 volts (you can just use the first millisecond of measured data) to the predicted response we discussed in class. $V = e^{-t/RC}$.

- Part 1 RC: Using the same data from the plot above, plot the **current** through the circuit as a function of time. Compare this data to an analytical expression for the current.

- Part1 RC: Plot of voltage versus time when the input frequency is 1500 Hz. Compute the characteristic frequency of the circuit (1/RC). This frequency is in radian/sec and should be divided by 2π to get Hz (cycles/sec). Comment on the relationship between the compute "characteristic frequency" and the response seen at 1500 Hz.

- Part 1 RC: log-log plot of amplitude of the output as a function of frequency. Provide some comment on what this result is telling you.

- Part2 Strain Gauge: Plot of the suddenly loaded beam. Comment on how these results compare/contrast with the results obtain with the basic RC circuit driven by the square wave in Part 1 of this lab.

- Part 2 Strain Gauge: Plot of output voltage versus mass. State the best fit line for your data. Comment on how small a mass you believe you can measure.