Lab 3. Strain Gauge Part II

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In order to legitimize the theoretical model of the RC circuit, experimental and theoretical data were plotted against each other:

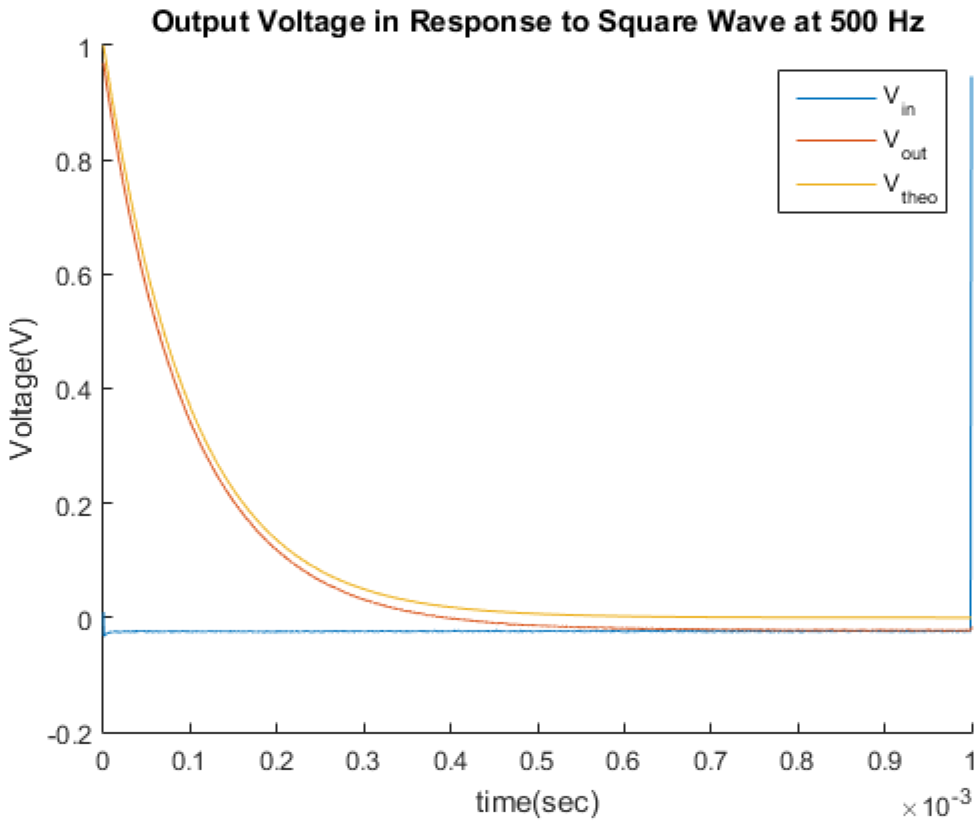


Figure 1. The graph of input, output, and theoretical voltage over 1 millisecond; although not apparent in the graph, V_{in} is tangent to the y axis at x=0.

As depicted above, the theoretical Voltage calculated from $V = e^{-t/(RC)}$ is a close approximation to the experimental value, with rather trivial deviation. This graph was implemented as follows:

```
t = linspace(0,.001);
R = 1000; %Ohms
C = 0.1 / 1000 / 1000; %farads
V_theo = exp(-t/R/C);
plot(t,V_theo);
```

It is thus verified that the output voltage, through the capacitor, adheres to the input voltage logarithmically: a result consistent with the anticipation.

Next, the resultant current was calculated from the respective values according to the relation $I = \Delta V/R$, where $\Delta V = V_{in} - V_{out}$ (experimental), or $-V_t$ (theoretical). Alternatively, for the theoretical model, solving $I = C * \frac{dV}{dt}$ yields an equivalent relationship, although the same technique cannot be applied to experimentally obtained data. The resultant plot is shown below:

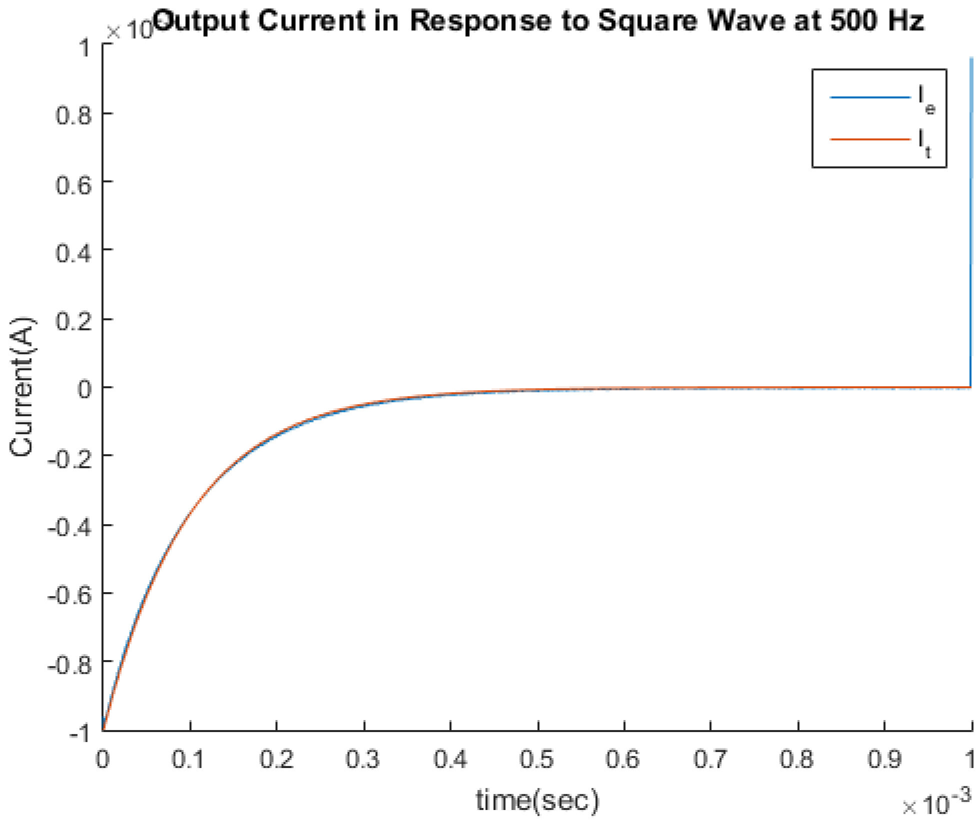


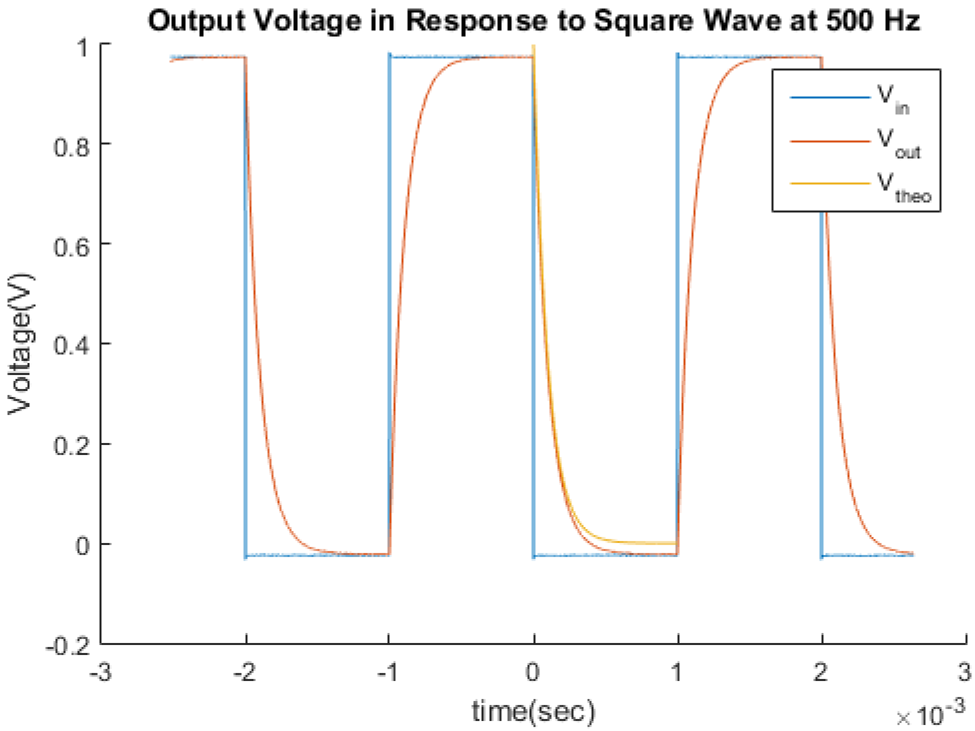
Figure 2. The current calculated from the voltage data obtained in the previous section.

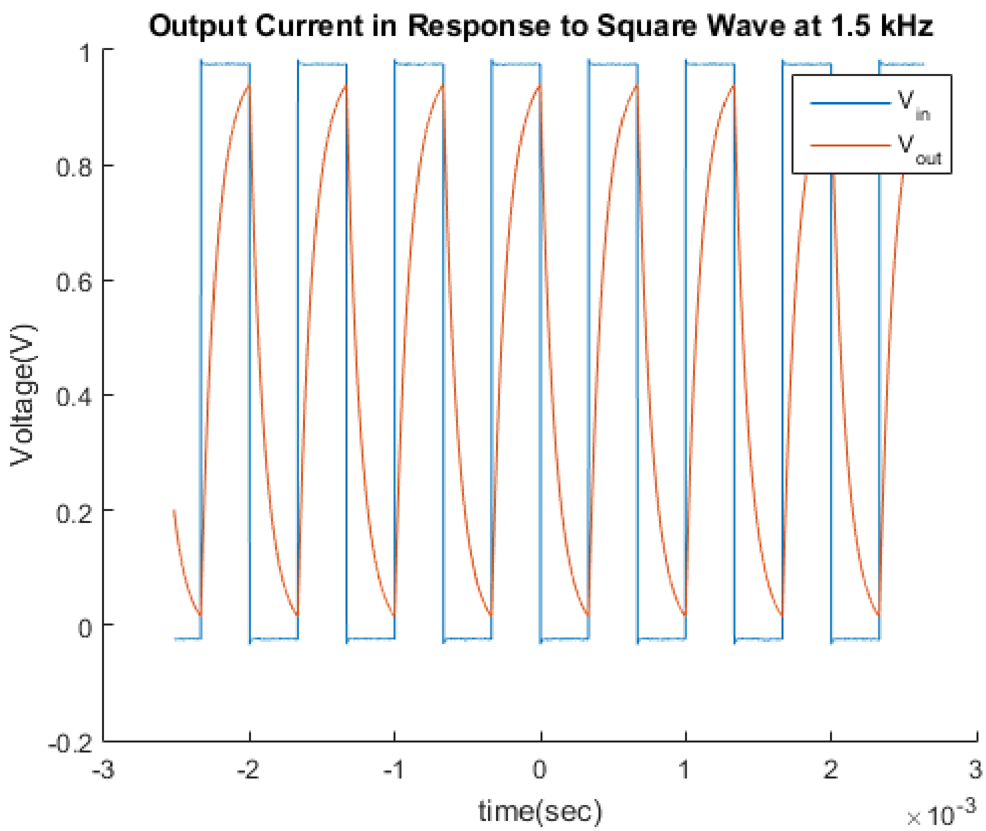
The two plots are nearly overlapping, which clearly illustrates that the theoretical model accurately describes the relationship. The following is its implementation, with variable values consistent with the aforementioned script.

```
I_e = (V_in - V_out)/ R;
I_t = -V_theo/R;

figure;
hold on;
plot(time,I_e);
plot(t, I_t);
```

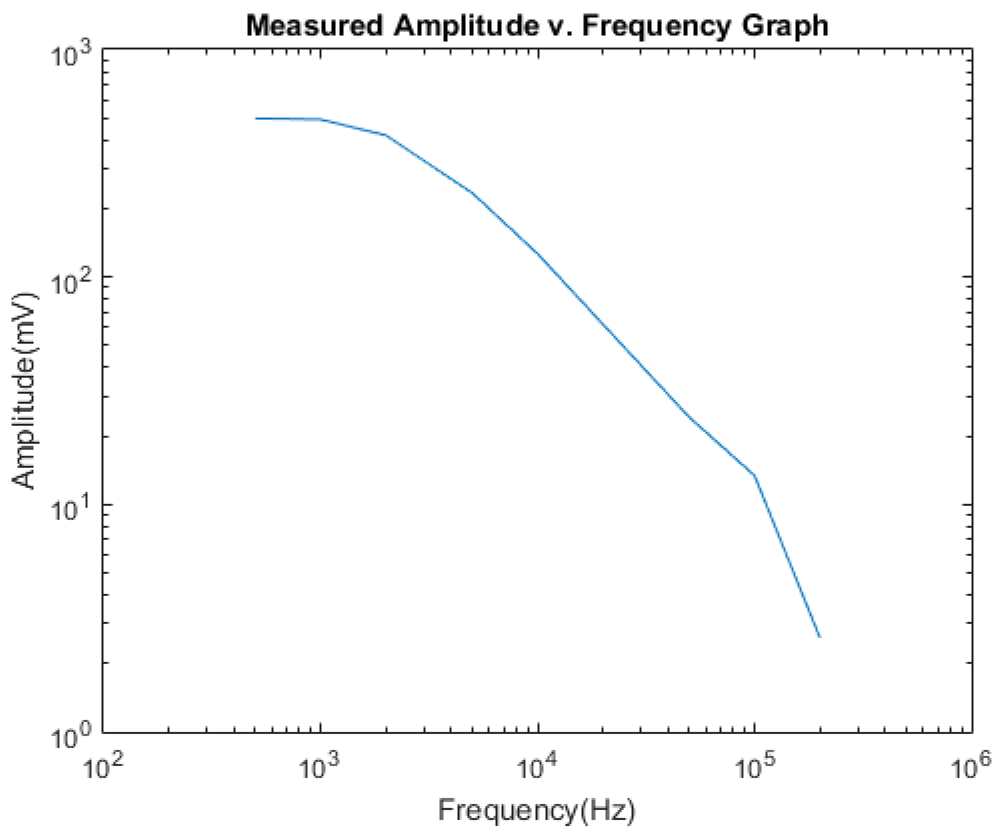
Now, to further emphasize the relationship between frequency, voltage and amplitude, the two graphs at 500Hz and 1.5kHz were plotted on the same scale applied to each axes:



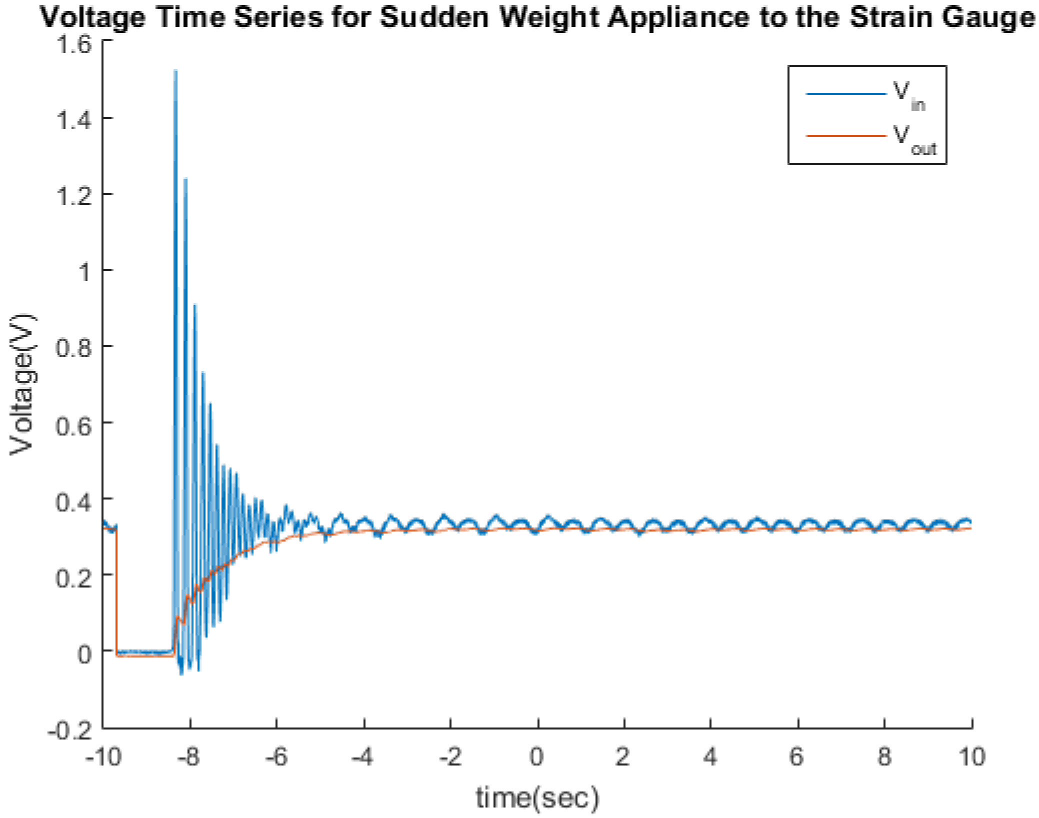


It is clear that the response of the output voltage at higher frequency – 1.5kHz – cannot quite reach the full amplitude, which is coherent with the model: the delay incurred upon the capacitor renders it unable to get fully charged.

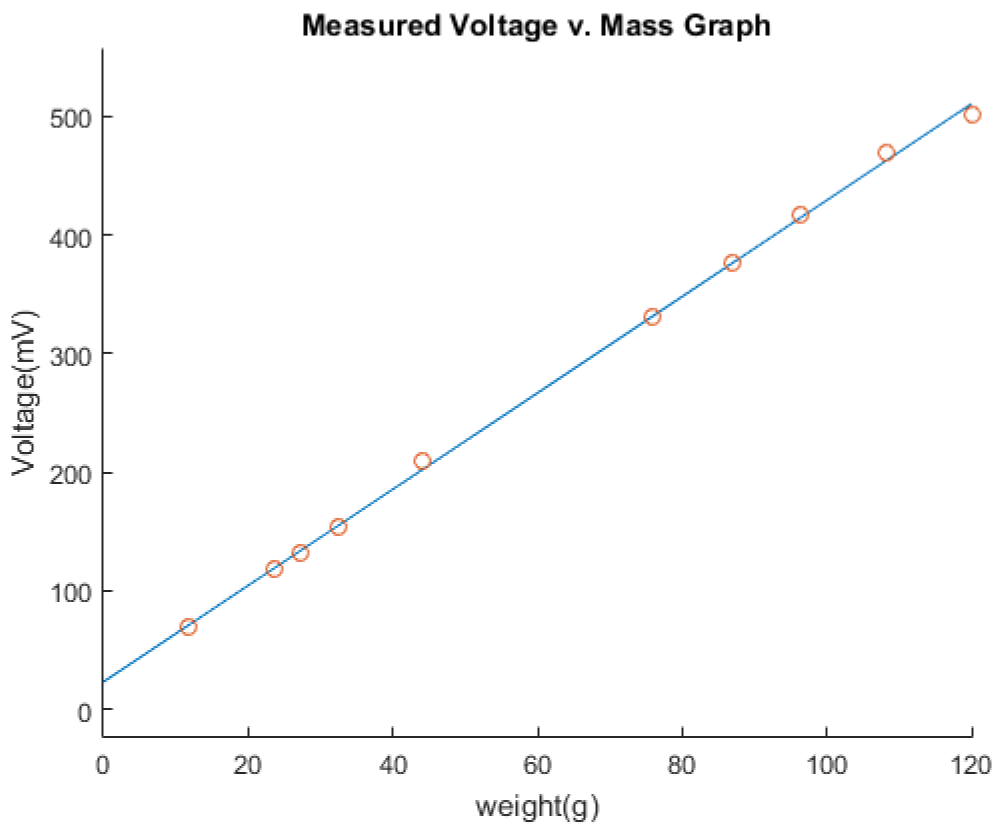
The characteristic frequency of the circuit is $1/(R * C * 2 * \pi)$ to convert from radians, which yields 1592 Hz. As the circuit is built in a low-pass filter scheme, 1500 Hz is under the cutoff frequency; therefore, its amplitude is relatively preserved from corruption, although its proximity to the cutoff frequency – and the imperfection of the filter – renders it not quite able to reach full amplitude.



This figure illustrates the steepening of the curve after the cutoff frequency, albeit with deviations and shortage in the measurements to the lower and higher registers: to elaborate, it can be seen that the graph begins to fall around the 1.6 kHz region, which is approximately the cutoff frequency.



The same pattern seen from the square-wave measurements reappear, though with much greater smoothing in the fluctuation of the curve. Because the curve is a diminishing sinusoidal wave with variant frequencies and amplitudes with respect to time, no quantitative conclusion can quite be drawn from the plot; the tendency of the capacitor to remain level to the rapid fluctuations persist, however, and provide insight that the circuit is still true to the principles we had hereto explored.



The best fit line was $4.06\,{}^{mV}\!/_{g} * \text{weight} + 22.9729\text{ mV}$, which indicates that the calibration value for mass at 0 grams is 22.9729 mV. Generally, the relationship is clearly defined as linear, and 4.06 mV will be administered per every gram. Since the Analog Discovery documentation states the device can measure down to 300 µV, this translates to .07 grams in terms of the smallest measurable gram value.