ILLINOIS INSTITUTE OF TECHNOLOGY - PHYS 221 L03

Lab Report - Lab 07: RC Circuits

October 28, 2020

Daniel Ayabe

Daniel Ayabe
Phys 221-L03
Lab 07
TA: Alex Brueske

Lab 05: RC Circuits

Introduction

In this lab, we will observe the behavior of RC circuits in terms of voltage, capacitance, and the time constant through constructing an actual RC circuit and using an oscilloscope. Using the potential difference equations shown below, we were able to effectively analyze RC circuits.

Equations:

1. $V(t) = V_0(1 - e^{-t/\tau})$
2. $V(t) = V_0(-e^{-t/\tau})$

Experimental Methods

Part 1:

First, measure the capacitance of the capacitor using the capacimeter. Then, construct the circuit as shown in Figure 1 below.

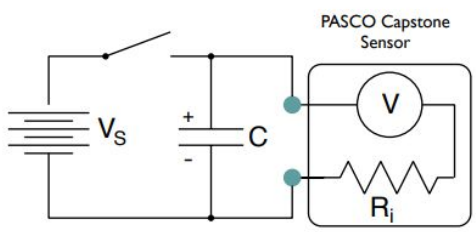


Figure 1: Setup for the RC Circuit for part 1.

Then, charge up the capacitor to 9V from a 9V battery connected to the breadboard. Set up the PASCO software to measure voltage and time. After the voltmeter reads 9V, disconnect the battery and click record. Then, record the voltage and time as the voltage drops from 8V to 2V in one volt increments, and subtract to find the elapsed time. Recharge the capacitor and repeat if necessary to get accurate data. Make a table that contains V(t) and elapsed time, and make sure to record the values of resistance and capacitance for later, and lastly, answer the questions pertaining to part 1.

Part 2:

Measure the capacitance and the resistance of the capacitor using the capacimeter the ohmmeter. Then construct the RC circuit as shown in Figure 2 below.

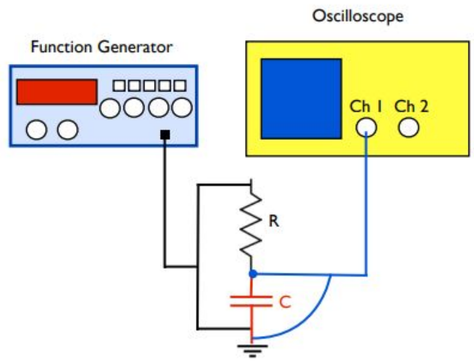


Figure 2: Setup for the RC Circuit for part 2.

Then, set the function generator at 900 Hz, and then turn on the digital oscilloscope and adjust the positioning knobs, the time/div scale, and the V/div scale in Channel 1 until a trace is obtained. After, expand the trace and adjust the amplitude so that all 8 divisions of the screen are visible. Next, record the time it takes the capacitor to reach 63% of highest voltage. Also record the time it takes to discharge enough voltage to reach a decrease of 63% of the max voltage, and verify that the values are almost identical. Take the average, and use this as the experimental time constant. Plot the oscilloscope and show how the time constant was gathered. Lastly, Take note of the voltage from the function generator with the oscilloscope probe, and see if the display is able to match the graph shown in Figure 3 below.

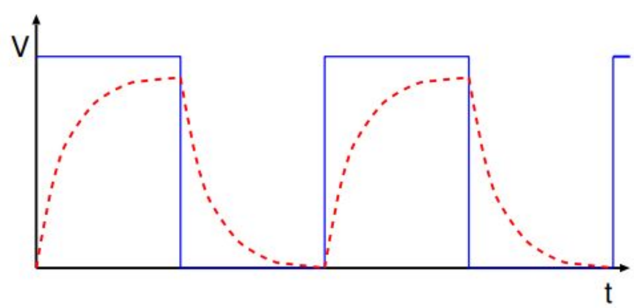


Figure 3: Square wave and voltage across capacitor graph vs. time

Results and Discussion

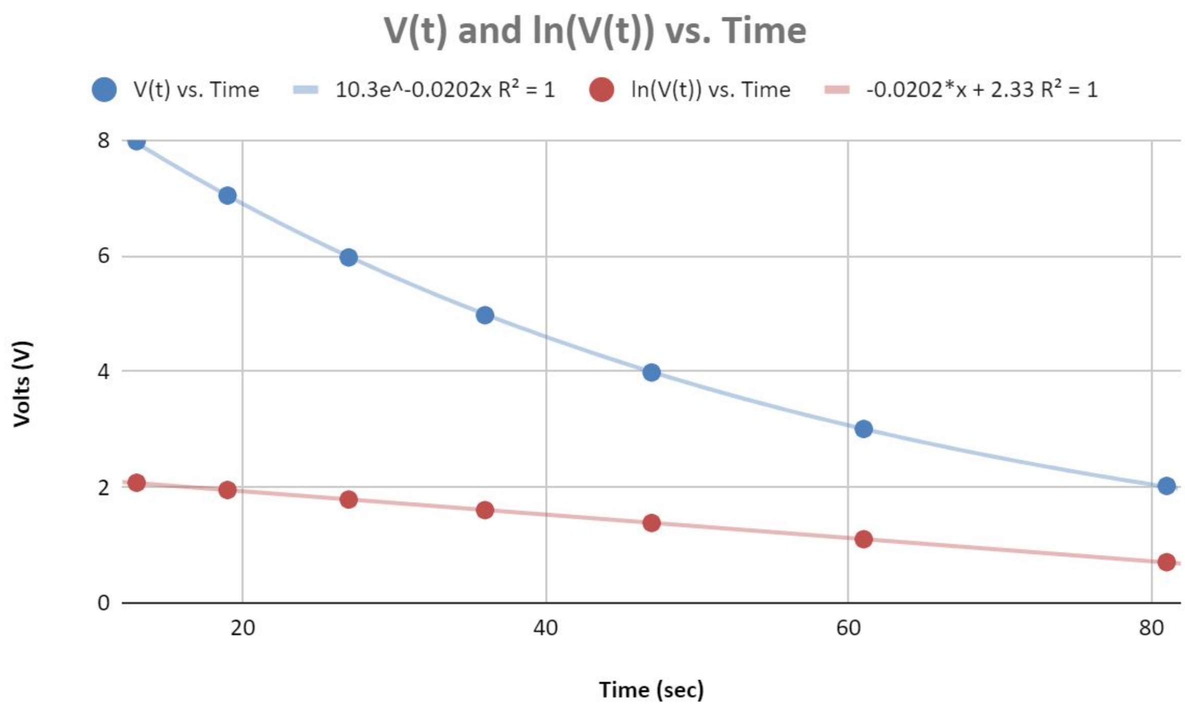
Part 1:

As said in part 1 of the experimental method, we were tasked to create a table for voltage, time, and the natural log values of voltage, which is shown below in Table 1.

Table 1:

V	t	ln(V)
7.98	13	2.076938411
7.041	19	1.951750206
5.972	27	1.78708188
4.973	36	1.60402328
3.983	47	1.382035304
3.007	61	1.100942904
2.022	81	0.7040871206

Table 1 shows the recorded voltages and times from 8 to 2 seconds, as well as the calculated ln(V). Using this, we can graph V(t) vs. time along with ln(V(t)) vs. time, which is shown in Graph 1 below.
Graph 1:



1. Equation 2 can be written as $\ln V(t) = \ln V_0 - t/\tau$. This means that if we plot $\ln V(t)$ versus t, the slope will correspond to $-1/\tau$. Find the natural logarithm of V(t) from your data and plot $\ln V(t)$ versus t.
    a. The natural log of V(t) is shown in data Table 1, and the plot of ln(V(t)) is shown in the Graph 1 above.
2. Find the slope of the best-fit line and thus obtain the experimentally measured value of the time constant. Compare the time constant obtained from this slope with the predicted value of τ using $\tau = RC$ and the values of R_i and C obtained previously.
    a. In the data table, the slope of ln(V(t)) vs. Time is -0.0202, which represents $-1/\tau$. Therefore the time constant $\tau = -1/-0.0202$ which equals 49.505 seconds.

Part 2:

For part 2 of the experiment, we used an oscilloscope to obtain the measurement of the time (τ) it took the capacitor to reach 63% of its final voltage. The maximum obtained voltage was about 9.45V. The capacitor's voltage reaches about 63% of this when the time change is 134μs, which represents the time constant of the capacitor.

Questions

1. Compare your measured value with the product of RC obtained from the individual values of R and C measured earlier and equation $\tau = RC$.
   a. Using our measured values of R = 1M and C = 46.4μF and the equation $\tau = RC$, we obtain a time constant of 46.4 seconds. Our calculated value for the time constant was 49.505 seconds, leaving us with a % error of 6.692%.
2. Using Equation 2, show the mathematical reasoning behind why the time constant, τ , represents a 63% decrease in the initial voltage for a discharging capacitor.
   a. $V(t) = V_0e^{-1}$ $\quad e^{-1} \approx 0.37$
      $V(t) = 0.37V_0 = (1 - 0.63)V_0$, which shows a 63% decrease.

Conclusion

Using resistors and capacitors in circuits we were able to see the relationship with the resistance and capacitance in the circuits and how they form a relationship with the time constant when looking at the change in voltage over time.