Experiment 7: RC Circuits

Introduction

Capacitors are used in timing circuits in many devices. The time that your dome lights inside your car stay on after you turn o your cars ignition at night is one example of how a capacitor can be used to maintain the lighting long enough for you to remove the keys and collect your things before exiting. The value we use to characterize these kinds of circuits is given by the time constant de ned as: $= RC$, where R is the circuit resistance (your dome light in this case) and C is the capacitance, in Farads (F). In this lab, we will measure the time constant of di erent capacitors in two situations - one where the time constant is several seconds long, and the other for time constants on the order of several milliseconds long. Consider

Charge the capacitor by connecting it to a 9 Volt battey. This should take only a few milliseconds for the voltage reading to go beyond 9V since there is almost zero resistace between the battery and the capacitor. Disconnect the battery and click the Record button in the control tab, when the voltmeter reads exactly 9 V (i.e. $V_o = 9V$) record the time from the second column of the table on your data sheet. Then record subsequent times for voltages from 8.0 V- 2.0 V in one volt increments, subtracting to find the elapsed times. Recharge the capacitor and repeat as often as necessary. Create a two-column data table. The first column for V(t) and the second column for elapsed time. Be sure to record the values of capacitance and resistance (C and R) for use later.

Answer the following questions in your lab report:

1. Equation 2 can be written as $lnV(t) = lnV_o - t/\tau$. This means that if we plot lnV(t) versus t, the slope will correspond to $-1/\tau$. Find the natural logarithm of V(t) from your data and plot lnV(t) versus t.

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.

Part 2 - Measurement of a Short Time Constant

In this part, we measure the short time constant of another RC circuit by continuously charging and discharging the capacitor. We accomplish this by connecting the RC combination to a power supply

2. Switch on the function generator and set it to 900 Hz. Turn on the digital oscilloscope and adjust the vertical and horizontal positioning knob, the time/div scale, and the V/div scale for Channel 1 until you obtain the charging/discharging trace. Press the autoset button on the upper right of the oscilloscope if it takes you more than a few minutes to get a display. Expand the trace and adjust the amplitude of the function generators square wave amplitude so that it extends across the whole 8 divisions of the screen, only making visible one or two complete periods of the square wave. The screen on your oscilloscope should look similar to the dashed line of Figure 4.

3. Now record the time (t) it takes for the voltage of the capacitor to reach 63% of the highest voltage. Similarly, record the time when the discharging voltage decreases 63% from its highest voltage. These two values should be roughly identical. Find the average and use this as the experimental time constant.

4. Plot the oscilloscope trace and include it in your laboratory report. Illustrate in your sketch how you obtained the time constant and the values you used.

5. Monitor the voltage applied from the function generator using the oscilloscope probe and any other provided cables (via Ch 2). Use the autoset function on the oscilloscope and see if you can reproduce the display shown in Figure 4. This will require moving one of the channels vertically to align it with the other channel. The amplitudes should match. Switch to 4.0 kHz for the frequency of the function generator and note what happens to the voltage across the capacitor.

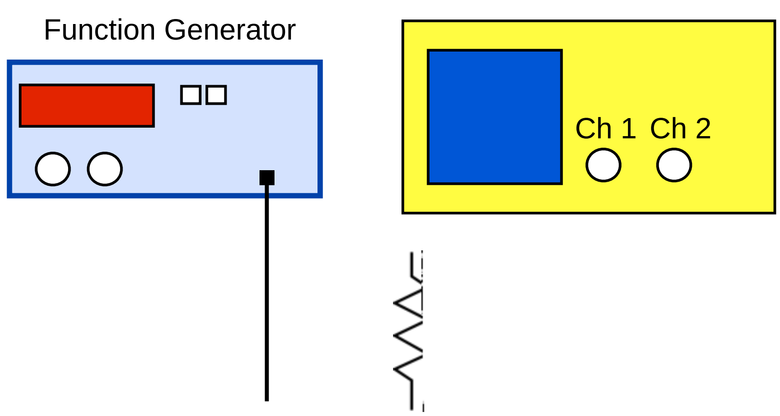

Figure 5: Setup for measurement of fast time constant.

Answer the following questions in your lab report:

1. Compare your measured value with the product of RC obtained from the individual values of R and C measured earlier and equation $= RC$.