

Lab Assignment #3

The purpose of this lab is to predict and observe the transient response of an RC circuit to step changes in voltage. You will need a watch to measure time in seconds.

Do the following calculations before you come to lab.

1. Suppose you have a $1\text{ K}\Omega$ resistor and a $1\mu\text{F}$ capacitor connected in series across a 5V DC source (5 VDC). What is the capacitor voltage after a long time in this configuration? Suppose you replace the DC source by a short circuit at time $t=0$. Calculate the capacitor voltage for $t>0$. Graph the capacitor voltage for $-1\text{ms}<t<4\text{ms}$. How long does it take the capacitor voltage to reach the value of $5e^{-1} = 5/e$? This length of time is called the time constant. What value does the capacitor voltage approach a long time after $t=0$?
2. Suppose you have a $1\text{ K}\Omega$ resistor and a $1\mu\text{F}$ capacitor connected in series across a 5 VDC. Suppose you replace the 5 VDC with a -5 VDC at $t=0$. Calculate the capacitor voltage for $t>0$. Graph the capacitor voltage for $-1\text{ms}<t<4\text{ms}$. How long does it take the capacitor voltage to reach $-5+10/e$ V? What value does the capacitor voltage approach a long time after $t=0$?

Do the following in lab

3. Get a capacitor around $20\text{-}50\mu\text{F}$ and check its capacitance as you did in Lab 1. Use a series resistor greater than 100Ω , a source frequency greater than 10 Hz, and a source voltage around 5V. Use an adjustable resistor box to provide resistance, but verify its value with a meter before you calculate the capacitor value.
4. Using the same RC circuit as in part 3, set the source to about 5 VDC, set the meter to measure DC voltage and connect the meter across the capacitor. Disconnect the source from the resistor-capacitor-meter combination and measure the time it takes the capacitor voltage to reach $1/e$ times its original values. The voltmeter is like a very large resistor; how large is its resistance? Do you get the same result with the voltmeter set on 20 V versus 200 V?
5. Get the same capacitor and resistor you used in Lab 2. Suppose you connected them in series across a 0 V source and the initial capacitor voltage was 5 V, how long will it take the capacitor voltage to reach $5/e$ V? This length of time is called the time constant. Let f_0 be the reciprocal of the time constant. If you connected the same resistor and capacitor in series across a -5V source and the initial capacitor voltage was 5 V, how long would it take the capacitor voltage to reach $-5 + 10/e$ V? Connect the capacitor and resistor in series across the voltage source, and set the voltage source to produce a square wave. Set the frequency to around $0.1 f_0$. Use an oscilloscope to observe the source voltage on one channel, and the capacitor voltage on another channel. Make an accurate drawing of the capacitor voltage in transition as the source switches from positive to negative voltage or vice versa. The width of your drawing should be around 5 time constants. Your drawing should show the grid lines on the scope display and should indicate how many volts there

are between grid lines in the vertical direction and how many seconds there are between grid lines in the horizontal direction. You can turn off the channel that shows the source voltage when you make your drawing.

After the lab is finished lab

6. Explain why the resistor, which was connected in series between the source and capacitor in part 4, doesn't affect the experiment once the source is disconnected. Why was this resistor used?
7. Explain whether your drawing of the capacitor voltage in part 5 is consistent with your calculation of the time constant for that circuit.

Write the requested calculations, measurements, observations, and analyses in sequence in your lab report.