ECET102/CPET101
Lab 12 Capacitor Lab

Required Devices and Equipment:

Resistors: 100kΩ, 1kΩ
Capacitors: 100uF
Single Pole Single Throw (SPST) switch for use with breadboard
LC measurement instrument set up to accurately measure capacitance
Stop-watch or watch with a second hand (student's)

Objectives:

1. Determine, by circuit analysis, the Thevenin equivalent circuit seen by a capacitor.
2. Calculate the time constant of an RC circuit with only one equivalent capacitor.
3. Find the equation for the voltage across a capacitor that is charging (with zero initial conditions.
4. Find the equation for the current through a capacitor that is charging (with zero initial conditions.
5. Measure capacitance
6. Measure the time and the voltage across a capacitor with a long time constant at equal time intervals.
7. Plot the voltage and current of a capacitor as it is charging.
8. Verify the equations using the measured values.

General Information:

Capacitors in parallel add to form an equivalent single capacitor. This property will be used to create a single, large capacitor that provides a long enough time constant for the circuit that students can measure time and voltage as the capacitor(s) charge.

A capacitor charges with a time constant equal to the Thevenin resistance seen by the capacitor times the value of the equivalent capacitance: $\tau = R_{Th}C$.

A capacitor in a DC network after 5 time constants is fully charged. This is called a steady-state condition. After a capacitor is fully charged, it acts like an open circuit to the DC voltage.

The energy stored in a capacitor is $W = \frac{1}{2}CV^2$

The equation for the voltage across a capacitor (in an RC circuit with only one equivalent capacitor), with zero initial conditions, as it is charging beginning at time t = 0 is:

$$v_c(t) = V_{Thev}(1 - e^{-\frac{t}{\tau}})$$

Where $v_c(t)$ is the voltage across the capacitor as a function of time (starting at time t=0, when the switch is closed). τ is the time constant of the circuit as explained above.

The equation for the current through a capacitor (in an RC circuit with only one equivalent capacitor), with zero initial conditions, as it is charging beginning at time t = 0 is:

$$i_c(t) = \frac{V_{Thev}}{R_{Thev}}(e^{-\frac{t}{\tau}})$$

Where $i_c(t)$ is the current through the capacitor as a function of time.

Procedure:

Part 1: Finding the Thevenin equivalent circuit, the time constant, the equation for the voltage across the capacitor and the current through the capacitor as it is charging.

For the circuit shown in Figure 1:

a. **Find** and **sketch** the Thevenin Equivalent Circuit seen by the Capacitor.

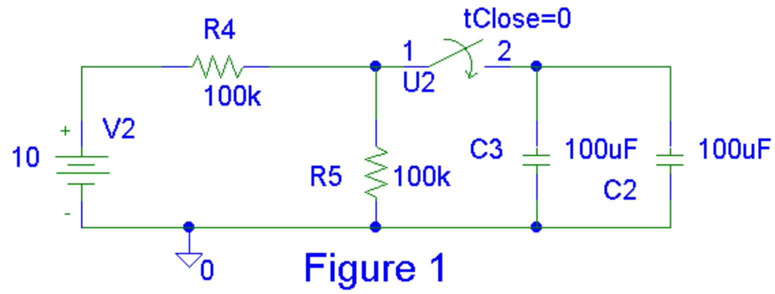


Figure 1

Sketch the Thevenin Equivalent Circuit below:

Write the values for the Thevenin equivalent resistance and voltage below:

R_{Th} = ________________ V_{Th} = ________________

b. **Find** the time constant of the circuit after the switch is closed and write the value below

τ = ________________

c. **Find** the equation for the voltage across the equivalent capacitor after the switch is closed and **write** this equation below:

$v_c(t)$ = __________________________________ Volts

d. **Find** the equation for the current through the capacitor after the switch is closed and **write** this equation below:

$i_c(t)$ = ____________________________________ milliamps

e. Using the equation in part 1c, **calculate** the value of the voltage across the capacitor at the times shown in Table 1 and write the results in Table 1.

f. Using the equation in part 1d, calculate the value of the current through the capacitor at the times shown in Table 1 and write the results in Table 1.

time (seconds)	0	5	10	15	20	25	30	35	40	45	50
$v_c(t)$ Calculated											
$v_c(t)$ Measured											
$i_c(t)$ Calculated											
$i_c(t)$ Measured											

Table 1

Part 2: Measurements

Construct the circuit shown in Figure 1.

a. **Measure** the values of the two capacitors and write these values below:

C_1 = ____________________ C_2 = ____________________

Connect the two capacitors together (+ to + and - to -) in parallel, measure the total capacitance of the two in parallel, and write the value below:

C_{total} = ____________________

b. **Measure** the voltage across the capacitor after the switch is closed using the DMM and a stopwatch or watch with a second hand and **record** the measured values at the times shown in Table 1, above (use the second hand on your watch to check the time after t=0 and record the voltages at the times specified in the table).

c. **Measure** the current through the capacitor after the switch is closed. A common method of current measurement that has little effect on the value of the current.is to measure the voltage across a small known resistance and divide by the resistance to determine the current. Use the following method to measure current.

i. Measure the resistance of a 1kΩ resistor with the DMM and write the value below.

R_{1k} = ________________

ii. Place the 1kΩ resistor in the circuit as shown in Figure 2.

iii. Measure the voltage across the 1kΩ resistor at each of the times given in Table 1 and divide by the actual resistance to obtain the current. Fill in the bottom row of Table 1 using this data.

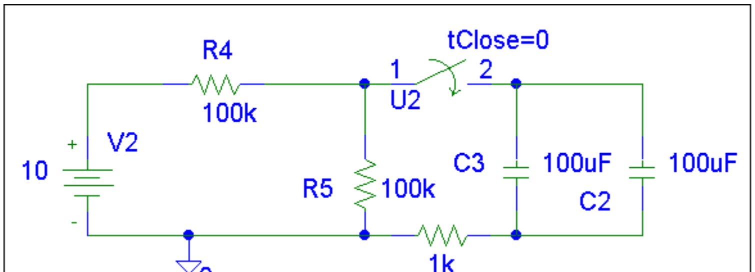
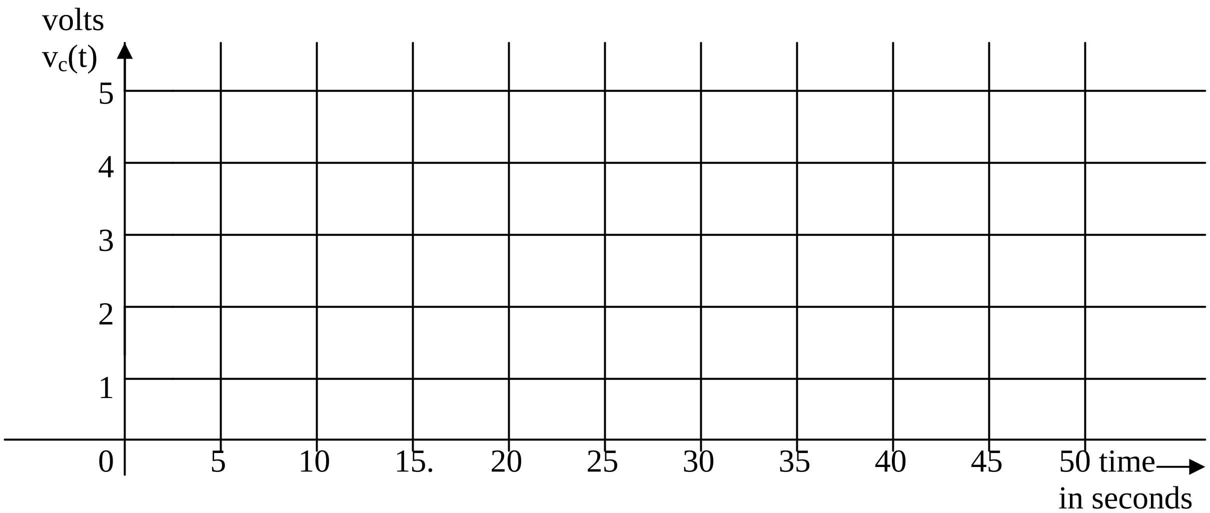


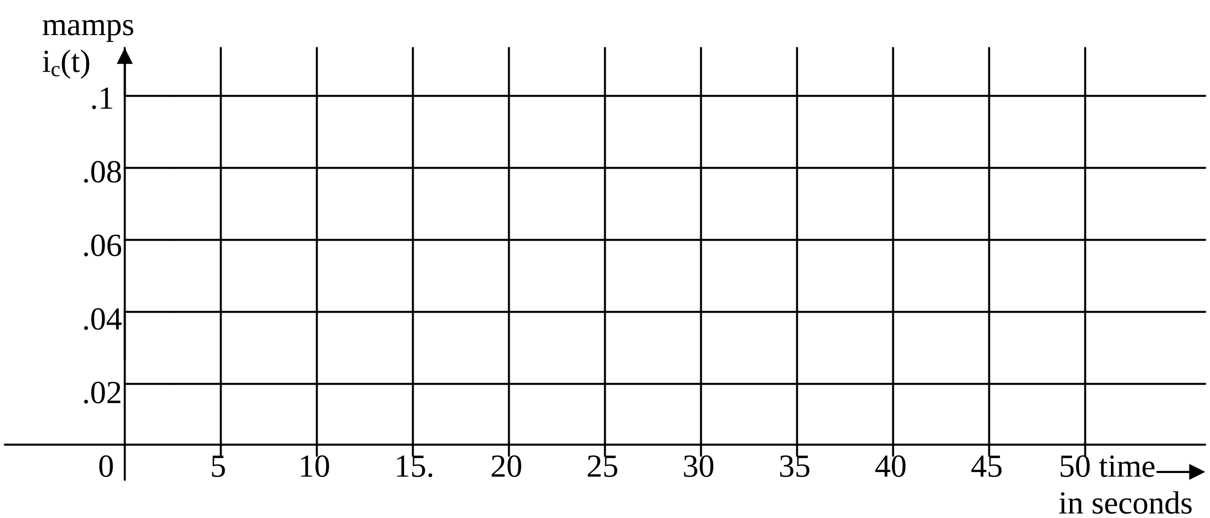
Figure 2

d. **Explain** below why adding the 1kΩ resistor into the circuit has almost no effect on currents and voltages in the circuit.

e. For both the **Calculated** and the **Measured** values of voltage (from Table 1): **Sketch**, on the graph below, the Voltage across the capacitors after the switch is closed at t = 0 seconds.



f. For both the **Calculated** and the **Measured** values of current (from Table 1): **Sketch**, on the graph below, the current through the equivalent single capacitor after the switch is closed at t = 0 seconds.



g. **Comment** below on differences between the calculated and measured curves of voltage and current.