Charge and Discharge of a Capacitor

Introduction

Capacitors are devices that can store electric charge and energy. Capacitors have several uses, such as _lters in DC power supplies and as energy storage banks for pulsed lasers. Capacitors pass AC current, but not DC current, so they are used to block the DC component of a signal so that the AC component can be measured. A capacitor can be slowly charged to the necessary voltage and then discharged quickly to provide the energy needed. It is even possible to charge several capacitors to a certain voltage and then discharge them in such a way as to get more voltage (but not more energy) out of the system than was put in. This experiment features an RC circuit, which is one of the simplest circuits that uses a capacitor.

Objective of the experiment:

1- Learn about capacitor charging and discharging.
2- Calculate the time constant for the capacitor discharge.
3- Calculate the voltmeter resistance.

Theory:

The capacitance is given by:

$$\mathbf{C = \frac{Q}{V}} \qquad \text{.......... (1)}$$

Where the capacitance C measured in farad, the charge Q measured in coulomb, and the voltage in volte. From above relation (1) we can see that the voltage is proportional to the charge:

$$\mathbf{V = \left(\frac{1}{C}\right) Q} \qquad \text{.......... (2)}$$

Where $\frac{1}{C}$ is proportionality constant. The time constant Ʈ (tau) is the time in seconds required to charge or discharge the capacitor to certain percentage from the final voltage. And it can be calculated from:

$$\mathbf{Ʈ = R\,C} \qquad \text{.......... (3)}$$

Where **Ʈ** in seconds, **R** resistance in Ohm and **C** is the capacitance in farad (not microfarad).

The exponential relation for capacitor discharge is:

$$V=V_o\,e^{-t/RC} \qquad \dots\dots\dots\dots (4)$$

R: is the resistance that the capacitor charge split-up through it.
C: capacitor capacitance.
V_o: the initial voltage of the capacitor after charging.
V: the instantaneous voltage at time (Ʈ).

When discharge start at time (Ʈ):

$$Ʈ = R\,C \qquad \dots\dots\dots\dots (5)$$

And by substitution of equation (5) in (4) we get:

$$V = V_O / e \qquad \dots\dots\dots (6)$$

If we draw a graph between **V** and **Ʈ** we get a curve as shown in figure (2), from it we can find the time constant **Ʈ** and the resistance value **R** of the voltmeter. **Ʈ** in seconds (sec) **R** in ohm (Ω) **C** in Farad (F)

Instruments:

- DC power supply.
- Capacitor.
- Voltmeter.
- Timer.
- Connection wires.

Methods:

1. Connect the circuit as shown in figure (1).
2. Charge the capacitor until it reach V_o which is the highest value reached by voltmeter, record V_o value.
3. Disconnect one of wires from source for discharge, record the time.

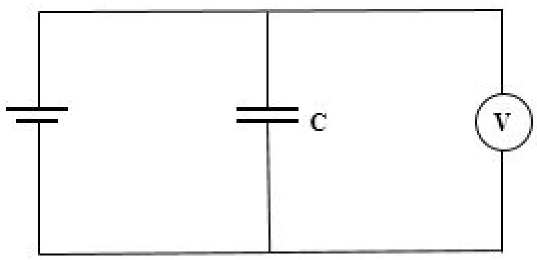

Figure 1. Experiment circuit.

4. required for the voltmeter reading to reach (V_o-1) volte using timer.
5. Repeat step (2, 3) for different voltage with recording the time for each.
6. Write down your reading in below table:

V (volt)	V_o	V_o-1	V_o-2	V_o-3	V_o-4	V_o-5	V_o-6
t (sec)							

7. Draw a graph between voltage (V) on y-axis and t (sec) on x-axis as shown in figure (2).
8. Calculate the value (**V_o/e**), where **V_o** is the highest value for voltage, and **e** is function **e = exp(1) = 2.718**.
9. Put the value of (**V_o/e**) on y-axis, and find **Ʈ** correspondence to it on x-axis as shown in figure (2).
10. Calculate time constant **Ʈ**.
11. Calculate the resistance of the voltmeter **R** from **R = Ʈ / C**

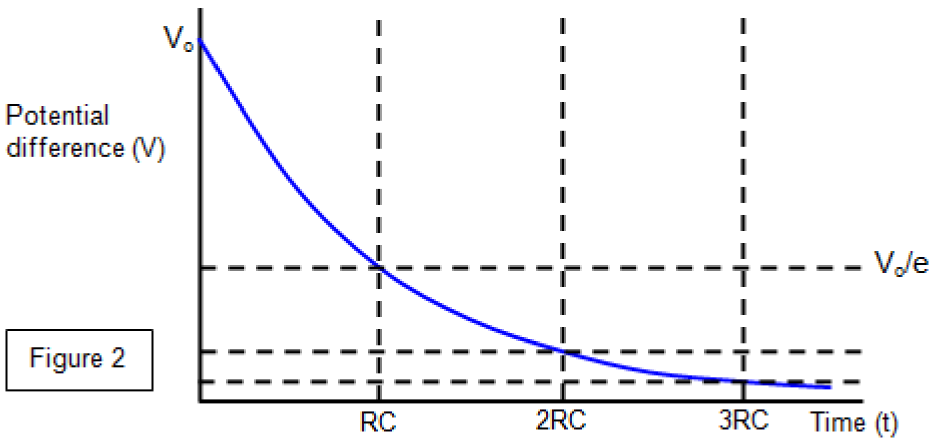

Figure 2. Graph used to calculate time constant Ʈ and voltmeter resistance R.

Discussion:

Q1) Define capacitor!

Q2) What affect the discharge time of a capacitor?

Q3) Does the discharge time affected by the voltmeter resistance?

Q4) Why the voltmeter is always connected in parallel in electrical circuit?