Number:
Name Surname:
Department:

4. CAPACITANCE AND CAPACITORS

Purpose of Experiment:

Examination of capacitance and capacitors

Theoretical Knowledge:

The capacitance of two opposite conductors with +Q and –Q charges on them is defined by C=Q/V, where V is the potential difference between the conductors. In the SI unit system, the unit of charge is coulomb (C), the unit of potential is volt (V) and the unit of capacitance is farad (F). A structure consisting of two conductors with a thin insulator between them is called a capacitor. In practice, such made capacitors are used where capacitance is required.

Equivalent capacitance is found as when two capacitors are connected in parallel,

$$C_{eq} = C_1 + C_2$$

when connected in series,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

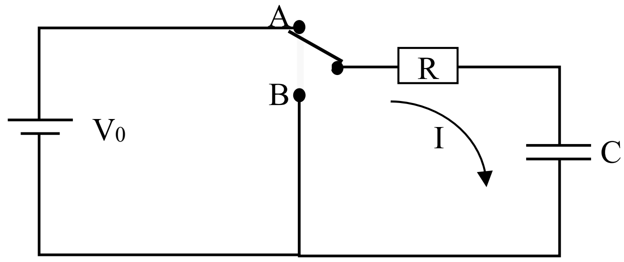

Figure 1

Since it is difficult to measure electrostatic potential, dynamic methods are mostly used to measure capacitances. Since the current is defined as the charge flowing per unit time, it is written as $I = \frac{dq}{dt}$. In Figure 1, if the switch is in the A state; since $V_0 = V_R + V_C$, $R\frac{dq}{dt} + \frac{1}{C}q = V_0$ can be written. q(t) and $\frac{1}{C}q(t) = V_C(t)$ are found as functions of time. The expression for the voltage on the capacitance is

$$V_C(t) = V_0\left(1 - e^{-\frac{t}{RC}}\right) \quad (1)$$

If the switch is in state B (discharge) it becomes $0 = V_R + V_C$. Accordingly, $R\frac{dq}{dt} + \frac{1}{C}q = 0$ can be written. The voltage across the capacitor is found as

$$V_C(t) = V_0 e^{-\frac{t}{RC}} \quad (2)$$

$V_C(\tau)$ becomes $V_C(\tau) = V_0/e$ when $t = \tau = RC$. The halving time $T_{1/2}$ which is $V_C(T_{1/2}) = V_0/2$ can be found as

$$T_{1/2} = (\ln 2).\tau \approx 0.7RC \quad (3)$$

from equation 2.

Experiment:

WARNING: The capacitors used in the experiment are directional, in case of reverse connection to the voltage, they may not hold the load suitable for their purpose and may even explode if the voltage is large. Before each test, discharge the charge by short-circuiting the terminals of the capacitor.

1. Find the internal resistance R of the multimeter you will use.
2. Set up the circuit in Figure 2 with capacitor C_1. Here R is the internal resistance of the voltmeter.

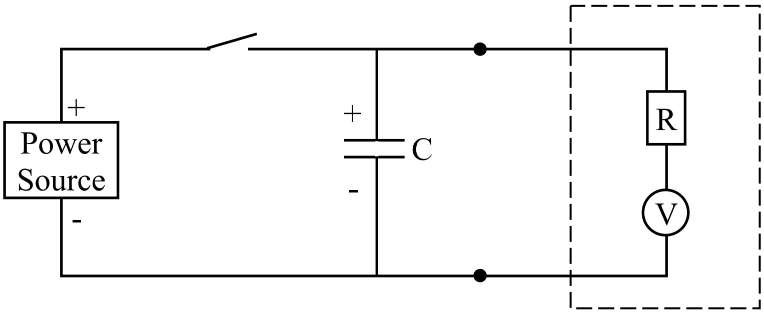

Figure 2

3. Connect the voltage source to the circuit and adjust the voltage so that the voltmeter is 10 V (V_0).
4. As soon as you disconnect one end of the voltage source, press the stopwatch and measure the time ($T_{1/2}$) when the voltage is exactly 5 V ($V_0/2$)
5. Find C_1 from the equation $T_{1/2} = 0.7RC_1$
6. Find the average C_1 value by repeating the experiment 3 times.
7. Put the capacitor C_2 instead of C_1 and measure 3 times and find the average value of C_2.
8. Find the equivalent capacitance with the same method by connecting C_1 and C_2 in parallel and compare it with the theoretical value $C_{eq}=C_1+C_2$.
9. Find the equivalent capacitance with the same method by connecting C_1 and C_2 in series and compare it with the theoretical value of $1/C_{eq} = 1/C_1 + 1/C_2$
10. Connect C_1 and C_2 in series and read the voltages V_1 and V_2 between the terminals of each capacitor for 3 times. Test the equation $C_1V_1 = C_2V_2$.

WARNING: Try to make the measurement in a very short time.

Connection Type	$T_{1/2}$ (s) Measurement 1	$T_{1/2}$ (s) Measurement 2	$T_{1/2}$ (s) Measurement 3	$T_{1/2}$ (s) Average
C_1				
C_2				
Series				
Parallel				

Comment:

Connection Type	Experimental C_{eq} (μF)	Theoretical C_{eq} (μF)
C_1		
C_2		
Series		
Parallel		