RC Circuit

Experiment No.:_________ **Date: __________________**

Aim:

To study the charging and discharging of a capacitor with different pulses of width much less than the time constant.

Apparatus:

a) RC Circuit KIT
b) Function generator

Theory:

a) Let V_C =Potential difference across capacitor

C = Capacitance of the capacitor

I = The charging current

q = The charge on the capacitor plates

V = The applied voltage

V_R = The voltage across the resistor

$$V = V_R + V_C = IR + V_C \text{ --- (1)}$$

Now $I = \frac{dq}{dt} = \frac{d}{dt}(CV_C) = C\frac{dV_C}{dt}$

$$\therefore \; V = CR\frac{\boldsymbol{dVc}}{dt} + V_C \text{ --- (2)}$$

$$-\frac{dV_C}{V-V_C} = -\frac{dt}{CR}$$

Integrating the above we get,

$$\int -\frac{dV_C}{V-V_C} = -\frac{1}{CR}\int dt$$

$$\therefore \log_e(V - V_C) = -\frac{1}{CR} + K \text{ -- (3)}$$

K is constant of integration, whose value can be found from initial known conditions. We know that when charging begins, i.e. $t = 0, V_C = 0$

Substituting these values in equation (3)

We get $\log_e V_C = K$

Hence, equation (3) becomes $\log_e(V - V_C) = \frac{-t}{CR} + \log_e \boldsymbol{V}$

$$\Rightarrow \log_e \frac{V - V_C}{V} = \frac{-t}{CR} = \frac{-t}{\lambda}$$

(Where $\lambda = CR =$ Time constant)

$$\Rightarrow \frac{V - V_C}{V} = e^{\frac{-t}{CR}} = e^{\frac{-t}{\lambda}}$$

$$\Rightarrow V_C = V\left(1 - e^{\frac{-t}{\lambda}}\right)$$

When $t = \lambda$; $V_C = V\left(1 - e^{-\frac{\lambda}{\lambda}}\right) = V(1 - e^{-1}) = V\left(1 - \frac{1}{e}\right) = V\left(1 - \frac{1}{2.718}\right) = 0.632V$

This is equation of charging.

b) While discharging, $V = 0$ (Applied potential difference is zero.)

$$\Rightarrow 0 = V_R + V_C$$

$$\Rightarrow 0 = IR + V_C$$

$$\Rightarrow 0 = IR + \frac{Q}{C} \Rightarrow IR = -\frac{Q}{C}$$

$$\Rightarrow I = -\frac{Q}{RC} \Rightarrow I = -\frac{Q}{\lambda}$$

$$\Rightarrow \frac{dQ}{dt} = -\frac{Q}{\lambda}$$

Integrating both the sides

$$Q(t) = Q_{max}\, e^{-\frac{t}{\lambda}}$$

$$\Rightarrow I(t) = \frac{dQ(t)}{dt} = \frac{d\left(Q_{max} e^{-\frac{t}{\lambda}}\right)}{dt}$$

$$I(t) = -I_{max} e^{-\frac{t}{\lambda}}$$

Taking absolute value of above

$$V_R(t) = I(t)R$$

$$= RI_{max} e^{-\frac{t}{\lambda}} = V_{max} e^{-\frac{\lambda}{\lambda}} = V_{max} e^{-1}$$

$$\Rightarrow V_R = \frac{V_{max}}{e} = \frac{V_{max}}{2.718} = 0.37V_{max}$$

Procedure:

Charging:

a) Connect the circuit of the supplied RC KIT as per the circuit diagram.

b) Supply the desired pulse on the function generator, keeping the voltage range at 20 volt.

c) Note the charging voltages of the capacitor in the pulse time interval.

d) Plot the graph between V_C (Capacitor Voltage) versus time.

e) From capacitor charging graph, calculate the time corresponding to the capacitor voltage 0.632 V_{max} which is time constant (λ) of the RC circuit.

Discharging:

a) Disconnect the supplied voltage from the function generator and not the discharging capacitor voltage from the voltmeter in pulse time interval.

b) Plot the graph between VC (discharge) versus time and calculate the time corresponding to 0.37 of the V_{max}. This is the time constant (λ) of the circuit.

c) Compare the calculated time constant (λ) value from the graph with the RC product value of the used circuit.

Observation:

$R =$ ____________ $C =$ ____________ $RC =$ ____________

Table – 1: (Charging of Capacitor)

Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)		Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)
1	0			21	200	
2	10			22	210	
3	20			23	220	
4	30			24	230	
5	40			25	240	
6	50			26	250	
7	60			27	260	
8	70			28	270	
9	80			29	280	
10	90			30	290	
11	100			31	300	
12	110			32	310	
13	120			33	320	
14	130			34	330	
15	140			35	340	

16	150			36	350	
17	160			37	360	
18	170			38	370	
19	180			39	380	
20	190			40	390	

Circuit Diagram:

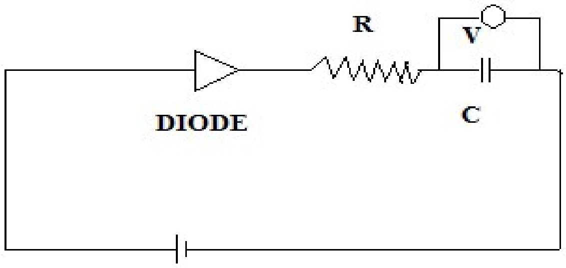

Table – 2: (Discharging of Capacitor)

Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)		Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)
1	0			21	200	
2	10			22	210	
3	20			23	220	
4	30			24	230	
5	40			25	240	
6	50			26	250	
7	60			27	260	
8	70			28	270	
9	80			29	280	
10	90			30	290	
11	100			31	300	
12	110			32	310	
13	120			33	320	
14	130			34	330	
15	140			35	340	
16	150			36	350	
17	160			37	360	

18	170			38	370	
19	180			39	380	
20	190			40	390	

Calculation:

$R =$ ___________, $C =$ ____________,

$RC =$ _______________, $\lambda =$ _______________ (From graph)

Percentage of Error:

Conclusion:

Marks Awarded

Planning and Execution (2)	Result and Report (6)	Viva (2)	Total (10)

Signature of the student:

Regd. No:

Group:

Branch:

Signature of the Faculty