RC Circuit

Date: 01/07/2020

Experiment No.: 08

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

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

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

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 $\log_e(V - V_C) = \frac{-t}{CR} + \log_e V$

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

(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.

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

) From capacitor charging graph, calculate the time corresponding to the capacitor voltage .632 V_{max} which is time constant (λ) of the RC circuit.

ischarging:

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

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

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

Observation:

R = 470KΩ C = 100 μF RC = 47.

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	0	21	200	
2	10	4.84	22	210	
3	20	8.32	23	220	
4	30	10.91	24	230	
5	40	12.84	25	240	
6	50	14.36	26	250	
7	60	15.54	27	260	
8	70	16.56	28	270	
9	80	17.39	29	280	
10	90	18.03	30	290	
11	100	18.55	31	300	
12	110	18.99	32	310	
13	120	19.36	33	320	
14	130	19.72	34	330	
15	140	19.94	35	340	

16	150	19.99		36	350	
17	160	19.99		37	360	
18	170	19.99		38	370	
19	180	19.99		39	380	
20	190	19.99		40	390	

Circuit Diagram:

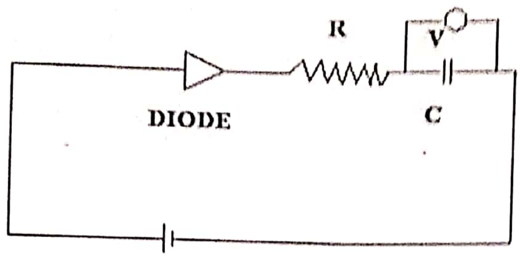


Table – 2: (Discharging of Capacitor)

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	19.99		21	200	
2	10	17.03		22	210	
3	20	13.59		23	220	
4	30	11.24		24	230	
5	40	9.27		25	240	
6	50	7.52		26	250	
7	60	6.09		27	260	
8	70	4.92		28	270	
9	80	3.87		29	280	
10	90	3.84		30	290	
11	100	2.62		31	300	
12	110	2.15		32	310	
13	120	1.74		33	320	
14	130	1.43		34	330	
15	140	1.15		35	340	
16	150	0.94		36	350	
17	160	0.54		37	360	

18	170	0.44		38	370	
19	180	0.31		39	380	
20	190	0.25		40	390	

Calculation:

$R =$ 470 KΩ, $C =$ 100 μF,

$RC =$ 47 sec, $\lambda =$ 52 (From graph)

Percentage of Error: $= \frac{52-47}{47} \times 100 = 10.6\%$.

Conclusion: From the above experiment I have learnt how to make connections of the capacitor for charging and discharging purposes. I have also learnt about the function generator and its uses.

Marks Awarded

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

Signature of the student: Altamash Firdous.

Regd. No: 190410400

Group: B1 (29)

Branch: ECE.

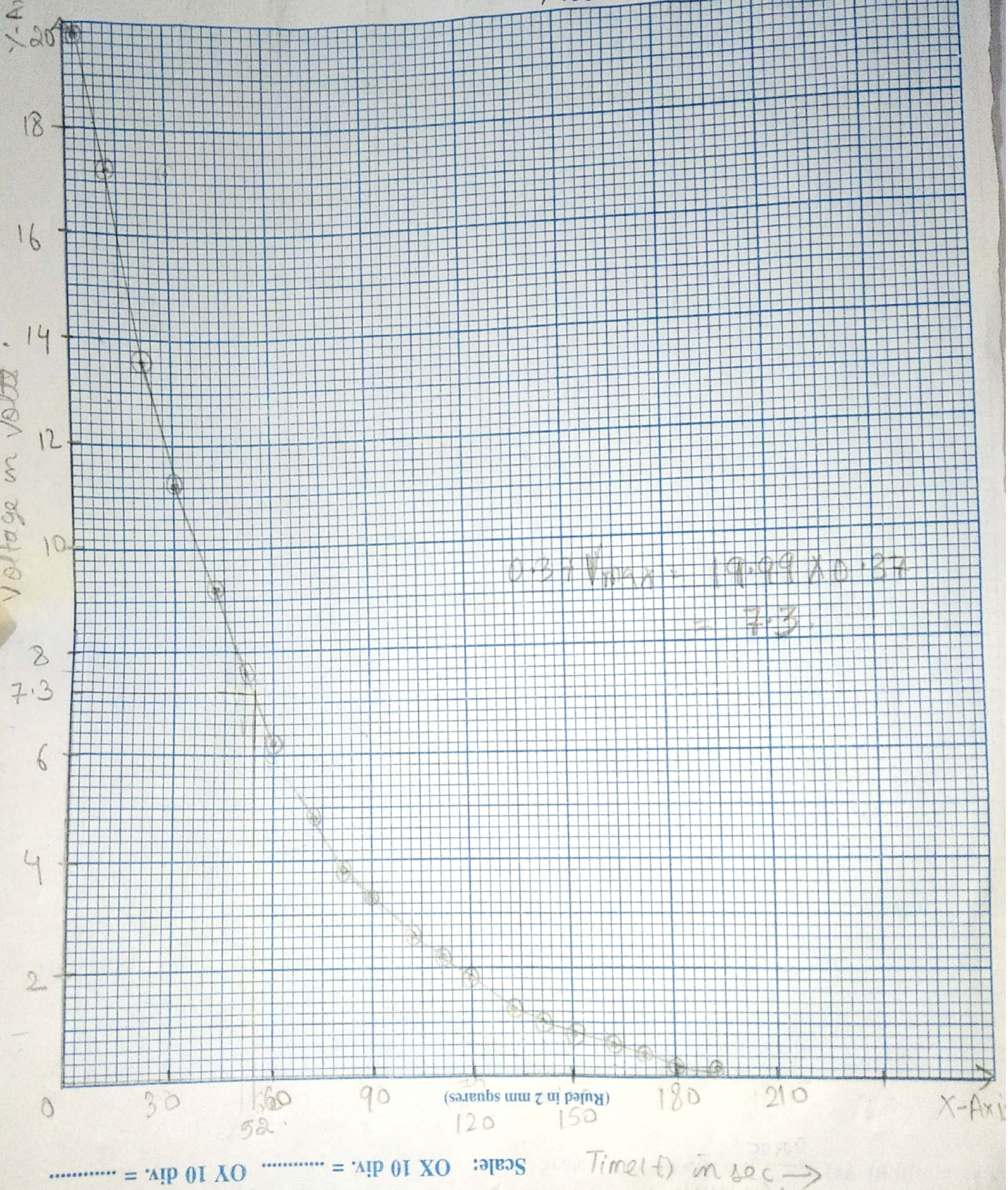
Signature of the Faculty

RC CIRCUIT (DISCHARGING)

Scale: 10 div = 30 sec (X-Axis)
; 10 div = 2 Volt (Y-Axis)

Teacher's Signature : ....

Date : ....



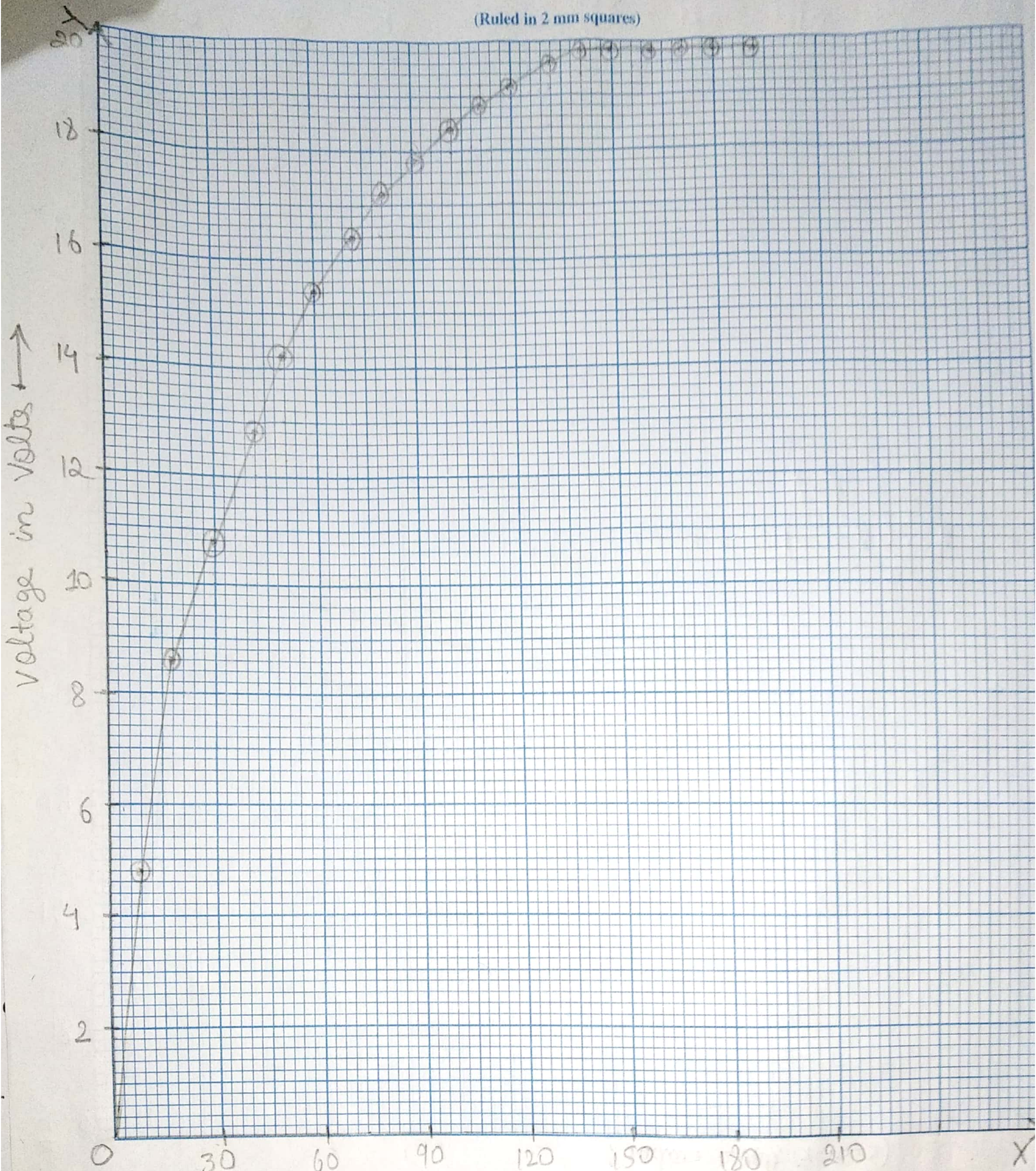
Scale: OX 10 div. = ... OY 10 div. = ...

DATE → 01.07.2020

R C CIRCUIT. (CHARGING GRAPH).

Scale: OX 10 div. = 30 sec OY 10 div. = 2 V

(Ruled in 2 mm squares)



Date : 01.07.2020

Time (t) in sec →

Teacher's Signature : ....