Basic Electrical Technology

RC Transient

Charging of a Capacitor through a Resistor

Applying KVL,

$$V - Ri - v_c = 0$$

where, $i = C\frac{dv_c}{dt}$

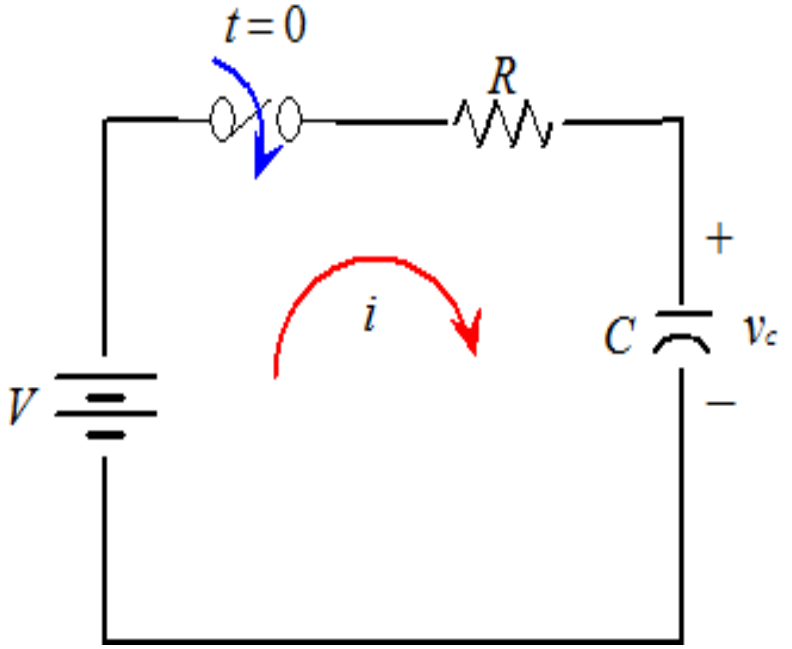
Initial Conditions,

$$At\ t = 0\ sec, V_c = 0\ V$$

Final current & voltage equation,

$$v_c = V\left(1 - e^{-\frac{1}{RC}t}\right)$$

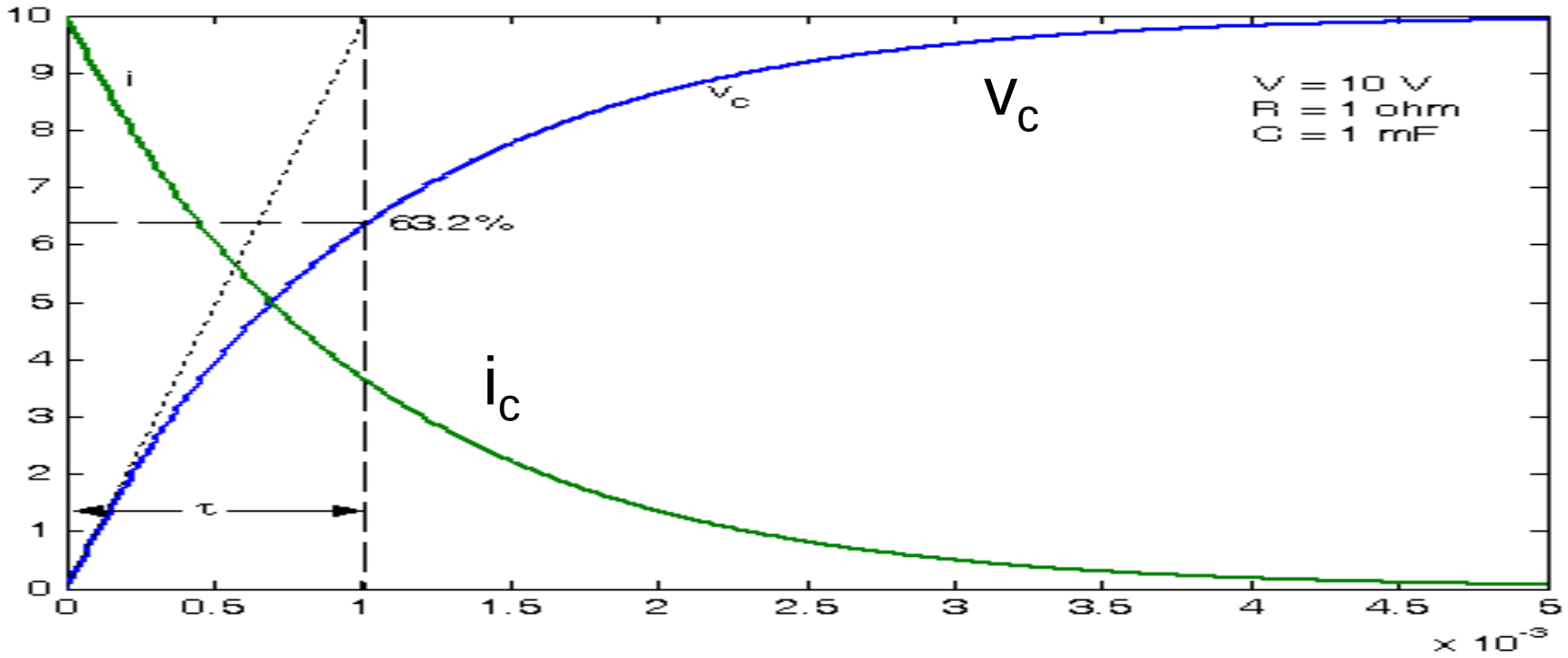
$$i_c = \left(\frac{V}{R}\right) e^{-\left(\frac{1}{RC}\right)t}$$



Growth of current in an inductive circuit

Time Constant (τ): Time taken by the voltage of the capacitor to reach its final steady state value, had the initial rate of rise been maintained constant

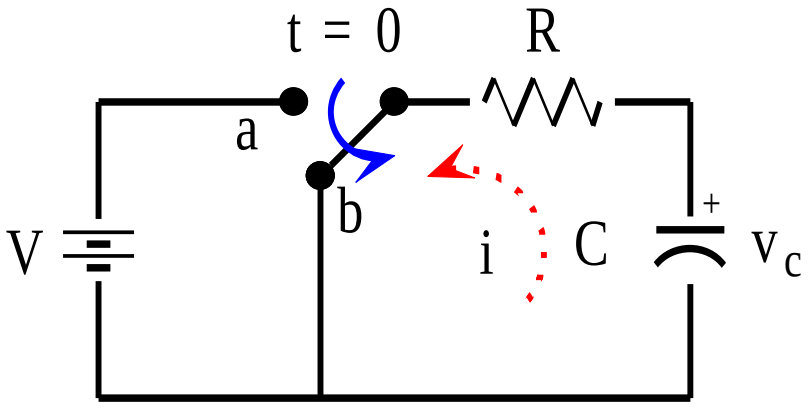
$$\tau = RC$$



Discharging of a Capacitor through a Resistor

- Capacitor is initially charged to a voltage $\boldsymbol{V}$

- At $\boldsymbol{t = 0}$, switch is moved from position $\boldsymbol{a}$ to $\boldsymbol{b}$



Applying KVL,

$$\boldsymbol{v_c - Ri = 0}$$

Where, $\boldsymbol{i = -C\frac{dv_c}{dt}}$

Using initial conditions and then solving

$$\boldsymbol{v_c = V\, e^{-(\frac{1}{RC})t}}$$

$$\boldsymbol{i_c = -I\, e^{-(\frac{1}{RC})t}}$$

Discharging of a Capacitor through a Resistor

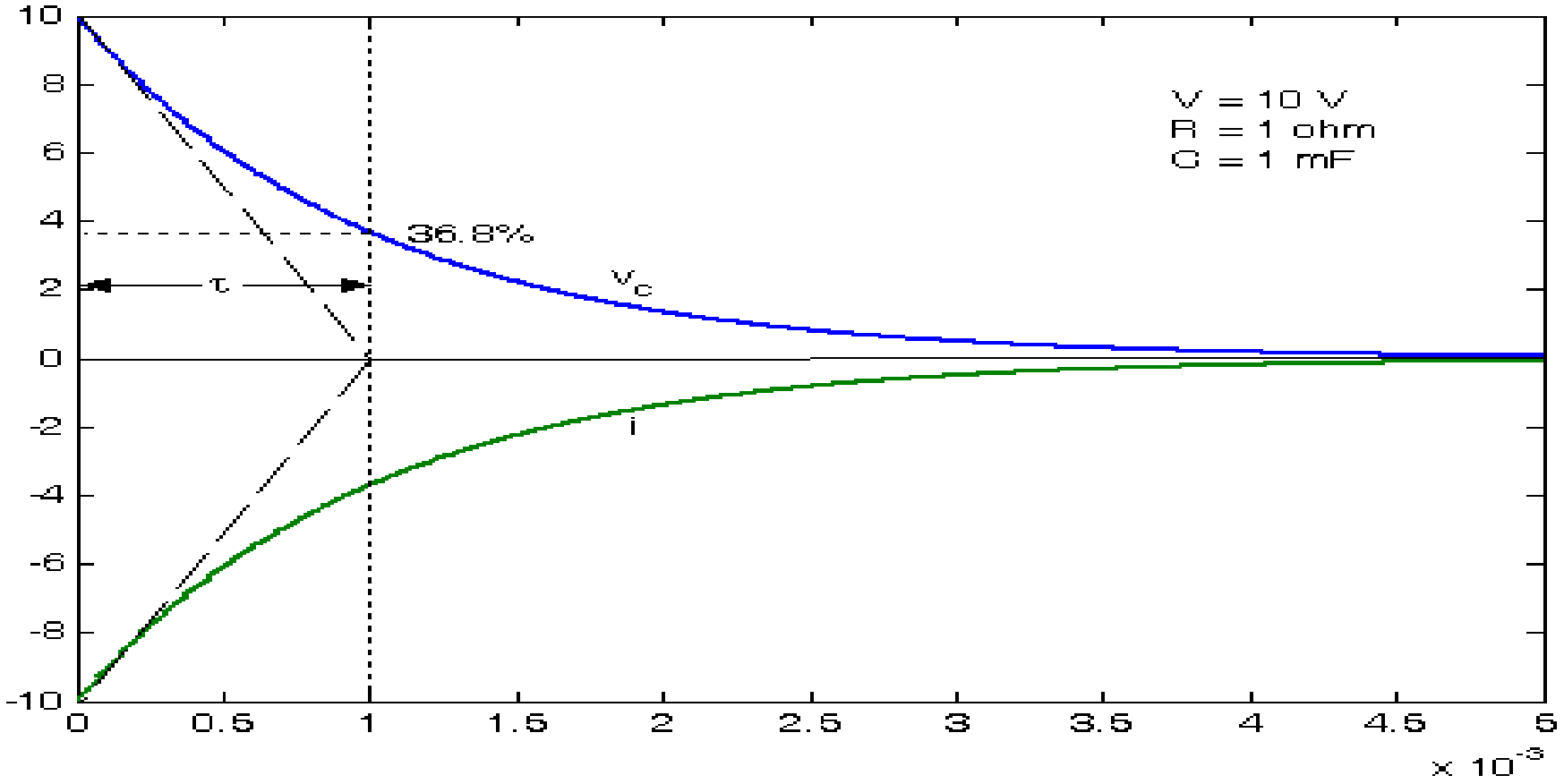
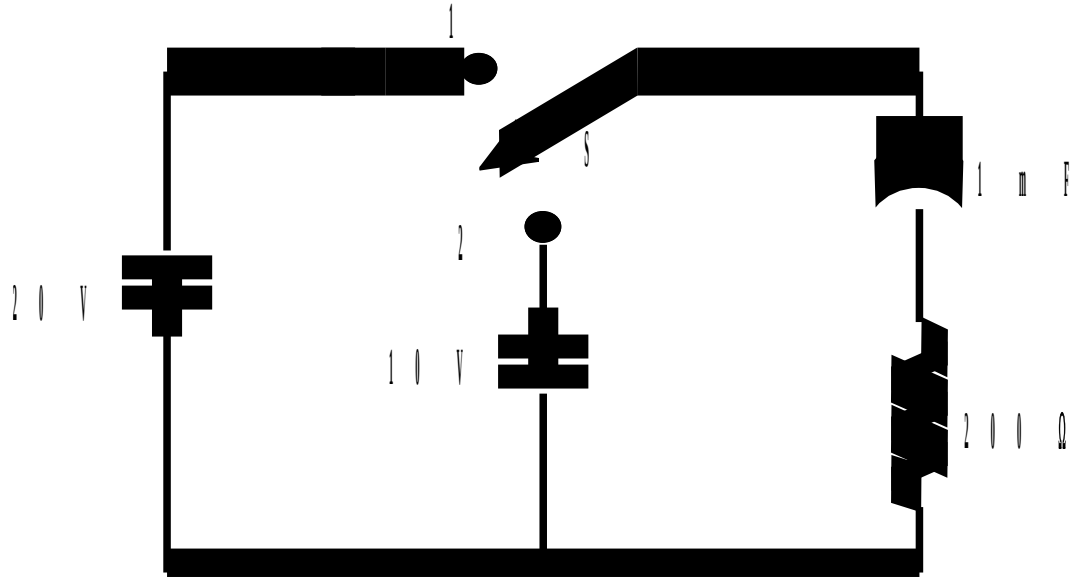


Illustration 1

In the network shown in the figure, the switch is closed to position 1 at t = 0 & is moved to position 2 at t = 0.4 sec. Determine the voltage across the capacitor vc(t) & sketch it for 0 ≤ t ≤1 second

Also find the value of ‘t’ for which vc(t) = 0



Solution

$v_c = 20(1 - e^{-t/0.2})$

$At\ t = 0.4\ sec, v_c = 17.29\ V$

$After\ 0.4\ second, the\ switch\ is\ in\ postion\ 2$

$v_c = -10 + 27.29e^{-(t-0.4)/0.2}$

$At\ t = 1\ sec, v_c = -8.64\ V$

$\boldsymbol{Ans: At\ t = 0.6\ sec, v_c = 0\ V}$

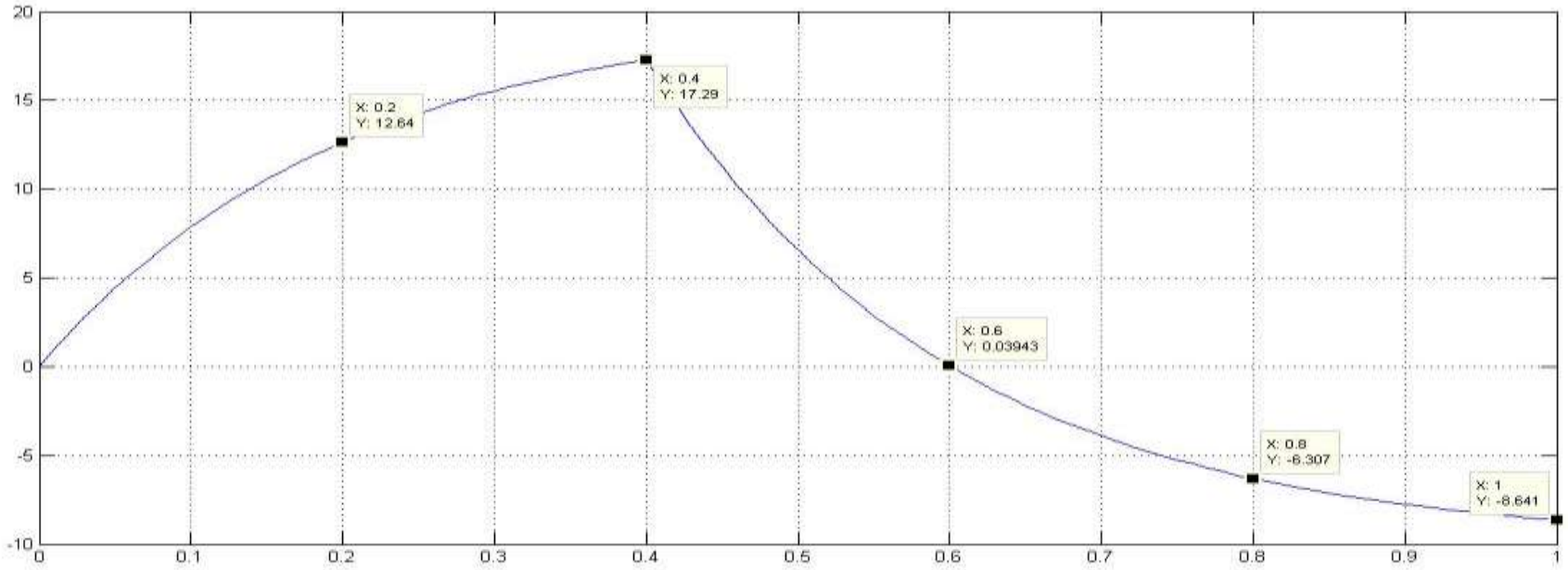


Illustration 2

An 8uF capacitor is connected in series with a 0.5MΩ resistor, across a 200 V d.c. supply through a switch. At t=0 seconds, the switched is turned on, Calculate

i. Time constant of the circuit

ii. Initial charging current.

iii. Time taken for the potential difference across the capacitor to grow to 160V.

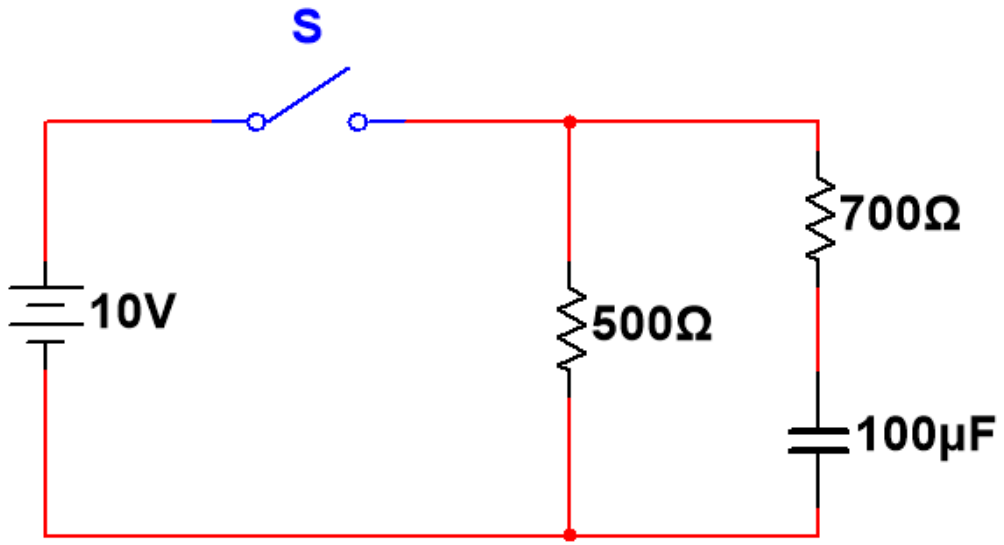
iv. Current & potential difference across the capacitor 4.0 seconds after the switch is turned on.

v. Derive the expressions used

Ans:
(i) 4 seconds, (ii) 400 µA , (iii) 6.44 seconds
(iv) 126.424 V & (v) 147.15 µA

Illustration 3

For the circuit shown in the figure, the switch ‘S’ is closed at t = 0 seconds. Determine how long it takes after the switch is closed for the total current drawn from the supply reaches 25mA



Ans:

t = 0.0735 s