Basic Electrical Technology

RC Transient

Charging of a Capacitor through a Resistor

Applying KVL,

$$V - Ri - v_c = 0$$

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

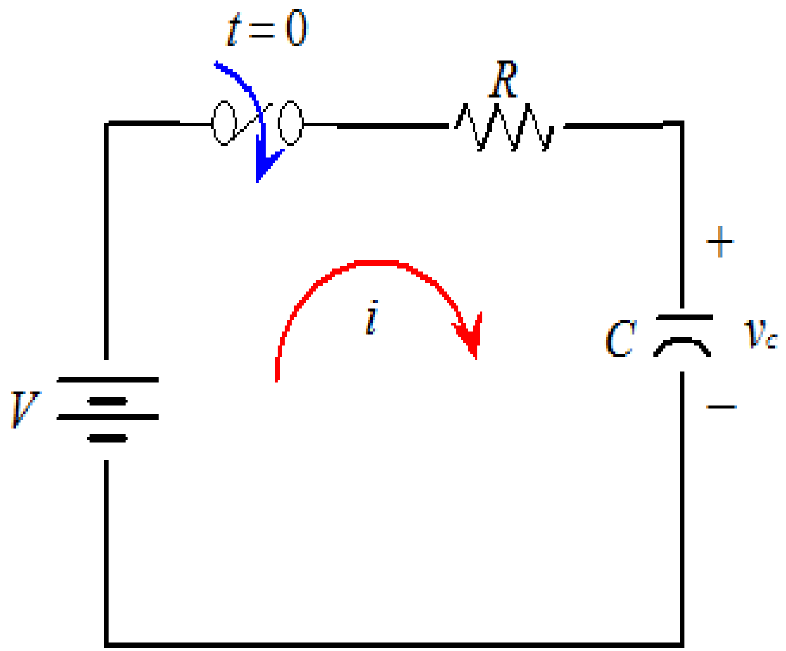
Initial Conditions,

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

Final current & voltage equation,

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

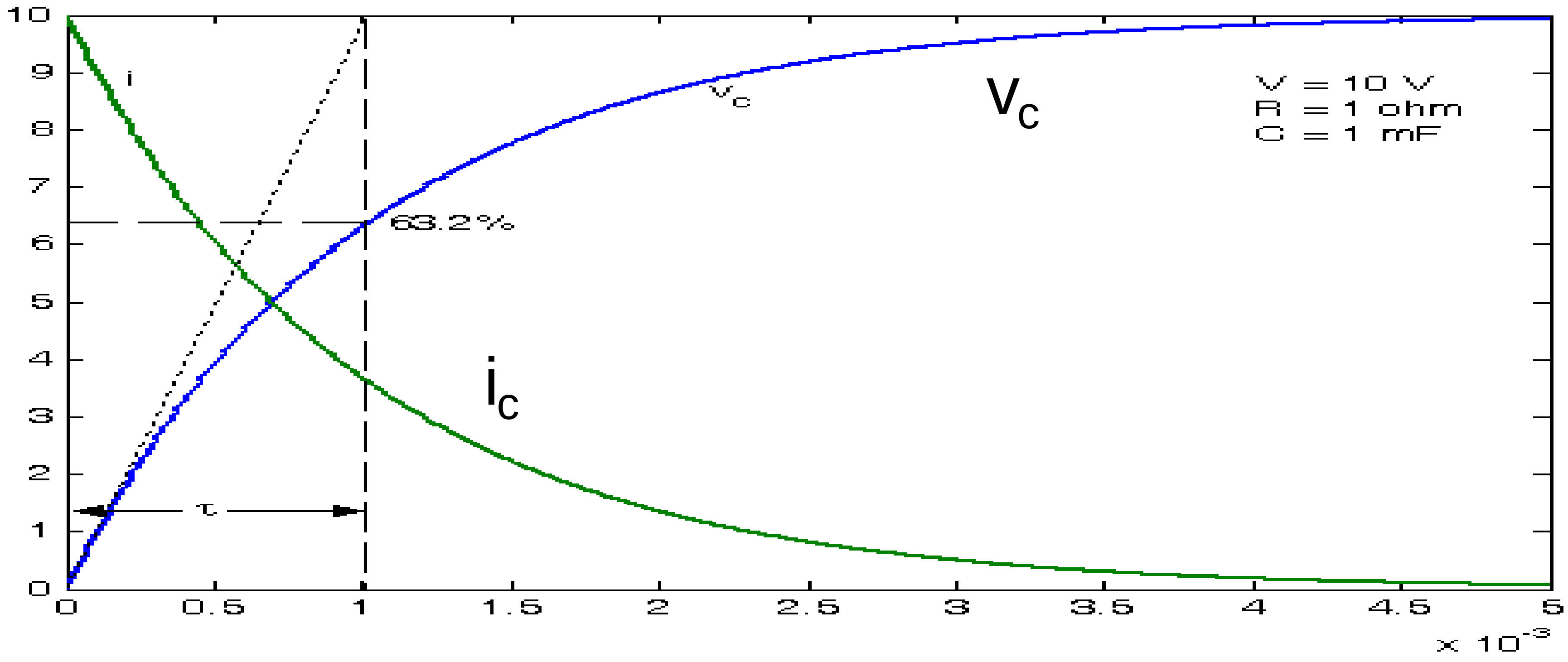
$$i_c = \left(\frac{V}{R}\right) e^{-\left(\frac{1}{RC}\right)t}$$



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

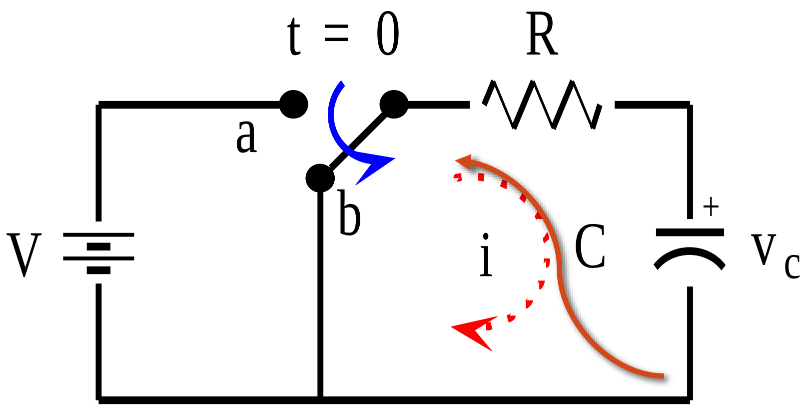
$$\tau = RC$$



Discharging of a Capacitor through a Resistor

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

- At $\boldsymbol{t} = \boldsymbol{0}$, 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

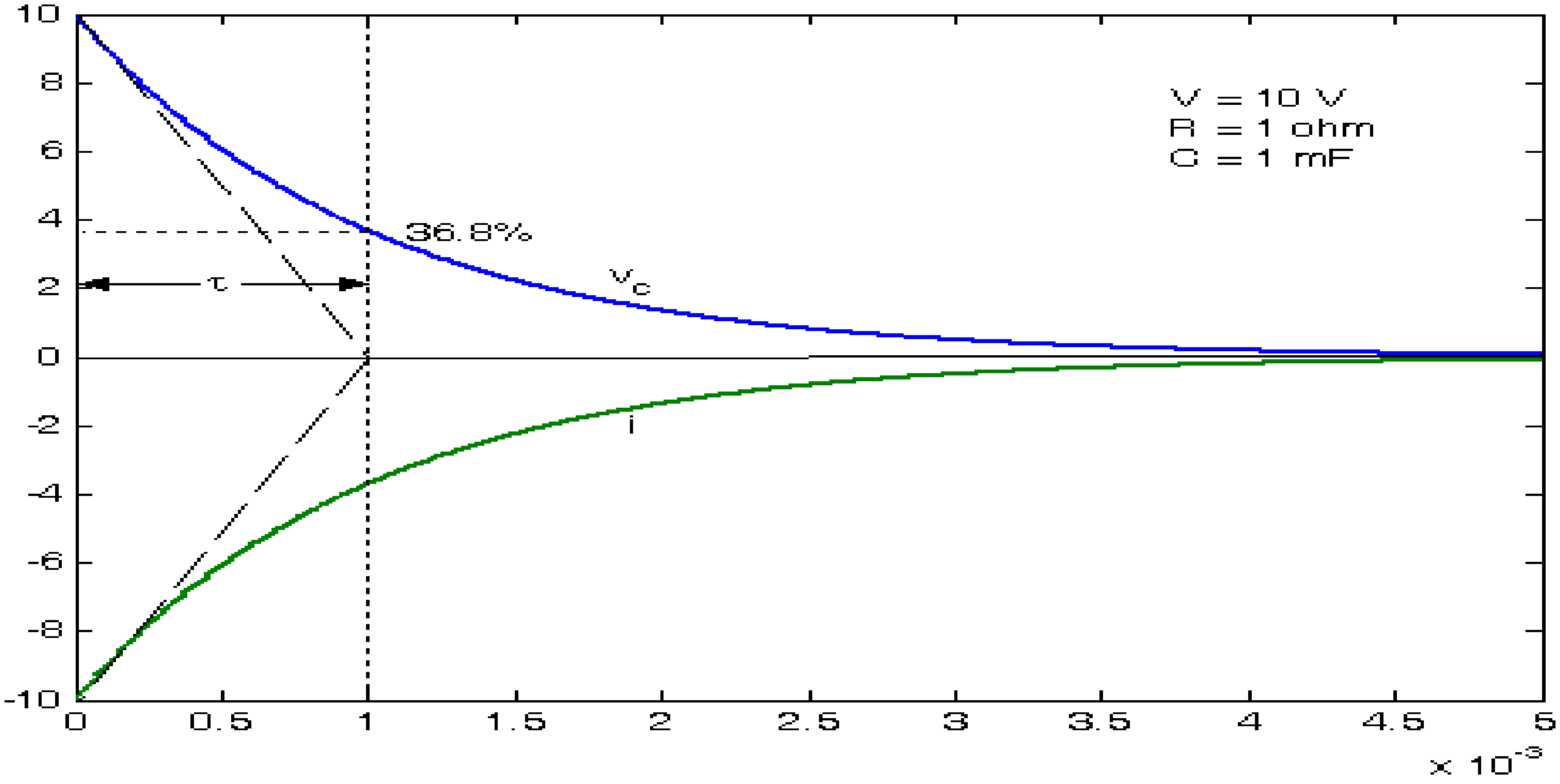


Illustration 1

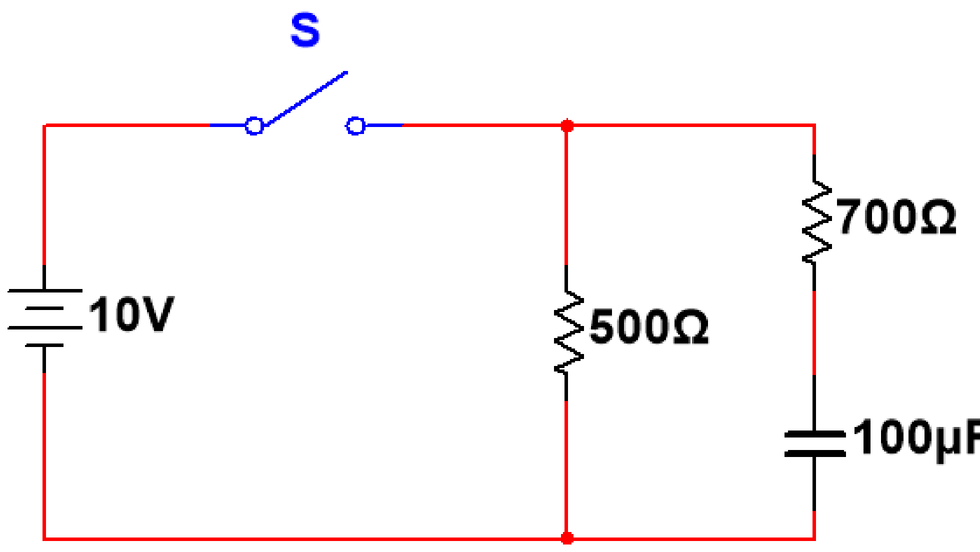
An 8 μF capacitor is connected in series with a 0.5 MΩ resistor, across a 200 V dc supply through a switch. At t=0 sec, the switch is turned on. Calculate

i. Time constant of the circuit
ii. Initial charging current.
iii. Time taken for the potential difference across the capacitor to grow to 160 V.
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 2

For the circuit shown in the figure below, the switch ‘S’ is closed at t = 0 sec. Determine how long will it take, after the switch is closed, for the total current drawn from the supply to reach 25mA.

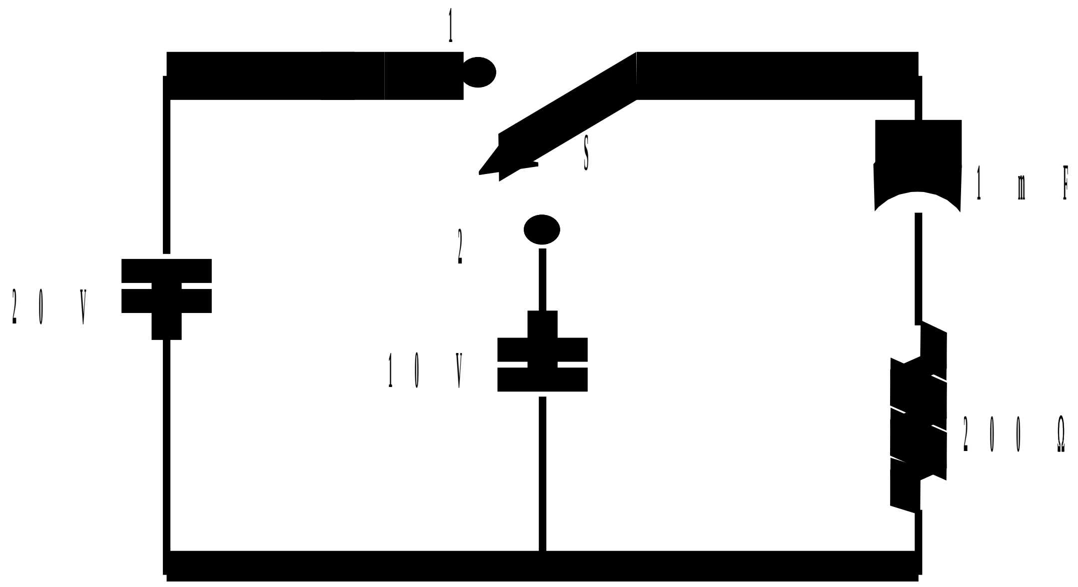


Ans: t = 73.5 ms

Illustration 3

In the network shown below, 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 $v_c(t)$ & sketch it for $0 \le t \le 1$ sec

Also find the value of 't' for which $v_c(t) = 0$



Solution

$v_c = 20(1 - e^{-t/0.2})$
$At\ t = 0.4\ sec, v_c = 17.29\ V$

$After\ 0.4\ second, the\ switch\ is\ in\ postion\ 2$
$v_c = -10 + 27.29e^{-(t-0.4)/0.2}$
$At\ t = 1\ sec, v_c = -8.64\ V$
$\boldsymbol{Ans:\ At\ t = 0.6\ sec, v_c = 0\ V}$