TRANSIENT ANALYSIS

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Transient :- A transient event is a short - lived burst of energy in a system caused by a sudden change of state.

The source of transient event energy may be an internal event or nearby event. The energy then couples to other parts of the system, typically appearing as a short burst of oscillation.

In general, transients disturbances are produced whenever

i) An apparatus or circuits is connected to the or disconnected from power supply.

ii) A circuit is short circuited.

iii) There is a sudden change in the applied voltage from one finite value to the another.

Types of Transients:

i) Single energy transient

ii) Double energy transient

Single energy transients- Single energy transient are those in which only form of energy, either electromagnetic or electrostatic is involved as in RL and RC circuit.

Double energy transients- Double energy transient are those in which both electromagnetic and electrostatic form of energy are involved.

The time when transient occurs are listed below,

i) Initiation transients: This occur when a circuit is originally dead, is energised

ii) Subsidence transient: These are produced when an energised circuit rapidly de-energised and reaches eventual steady stage of 0 current or voltage. For ex, short circuiting of an RL or RC circuit.

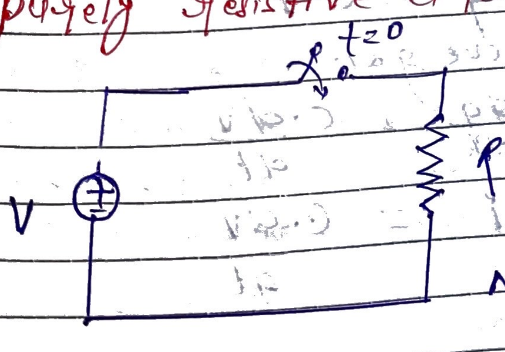
iii) Transition Transients: These are due to sudden but energetic changes from one steady state to another.

iv) Complex transients: These are produced in a circuit which is simultaneously subjected to two transients due to two independent disturbances.

v) Relaxation transients: The transient occurs cyclically towards state

Behaviour of basic components during Transient

i) purely resistive circuit:



Let the time just before t = 0 is t = 0⁻ or t(0⁻).

Now, when the switch is closed at t=0

The current I will starts flowing through the circuit, given by

$$I = \frac{V}{R}$$

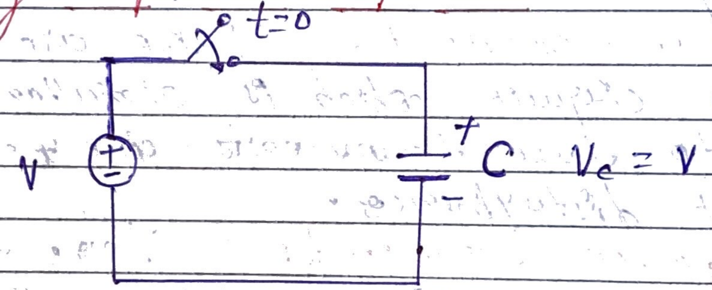
So, the current just after the switch is closed i.e at $t = 0^+$ or $t(0^+)$

$$I = \frac{V}{R}$$

Clearly, the resistor reacts instantaneously as the switch open and close.

ii) purely capacitive circuit:

Case-I



Initially there is no charge on the capacitor plate
Now, when the circuit is closed at $t=0$ then the voltage 'V' appears the capacitor
Now, If q is the charge on the capacitor plate,
Then,

$$q = C \cdot V$$

on differentiating we get

$$\frac{dq}{dt} = C \cdot \frac{dV}{dt}$$

$$i = C \cdot \frac{dV}{dt}$$

Now, i.e. $dt \rightarrow 0$
Then $\frac{dV}{dt} \rightarrow \infty$

i.e $i_c = i \rightarrow \infty$ which is not practically possible. This means capacitor oppose the instantaneous change of voltage.

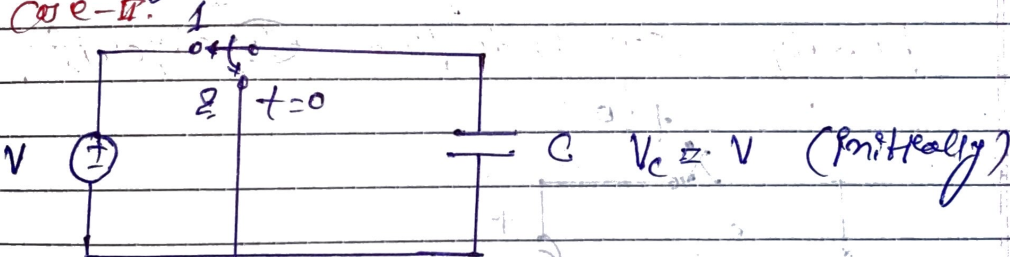
So,
The voltage across the capacitor before circuit is closed i.e at $t = 0^-$, the same voltage will appear across the capacitor at time $t = 0^+$.

So,
Voltage across the capacitor ~~before~~ at $t = 0^-$ is equal to voltage across the capacitor at $t = 0^+$.

i.e
$$\boxed{V_c(0^-) = V_c(0^+) = 0V}$$

Note: Capacitor oppose the instantaneous change of voltage

Case-II.



Suppose initially the capacitor is charged to 'V' volt by the supplied voltage V.

Now At $t = 0$ the circuit is removed from power supply.

So, ~~the~~ as the capacitor oppose the change in voltage

∴ Voltage across capacitor at $t = 0^-$ is equal to voltage across the capacitor at $t = 0^+$

i.e. $V(0^-) = V(0^+) = V$

$\Rightarrow \quad i_C = C \cdot \dfrac{dV_C}{dt} = 0$

So, At $t = \infty$ (steady state time)
The capacitor acts as open circuit.

Summary:

	$t=0$	$t=0^+$	$t=\infty$
Case-I		S.C	O.C
Case-II	+ V_0	V_0	V_0 O.C

Note: The condition of component at $t=0^+$ is known as initial condition and at $t=\infty$ is known as final condition.

III, Purely inductive circuit

Case-I

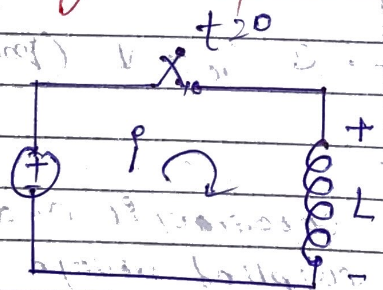
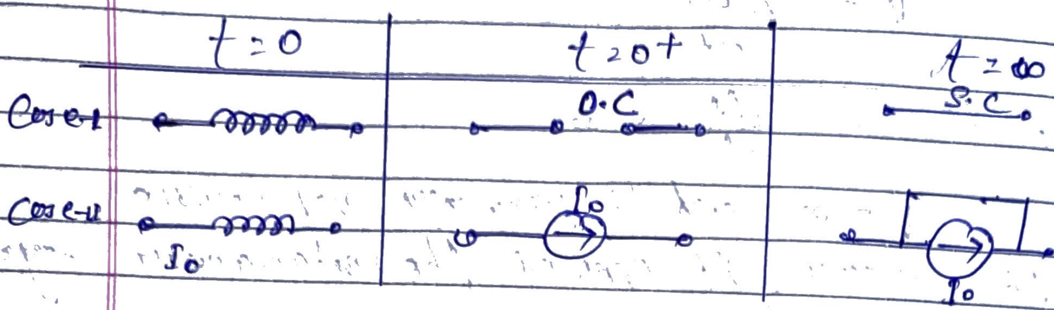


Fig (a)

Initially, the inductor is uncharged.
Now, when the switch is ON, the current starts to flow in the circuit.
Then

or, At $t = \infty$, it acts as a short circuit



SOURCE FREE RESPONSE OF RC CIRCUIT

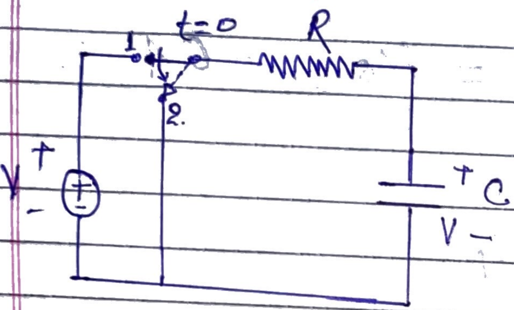


Fig: (a)

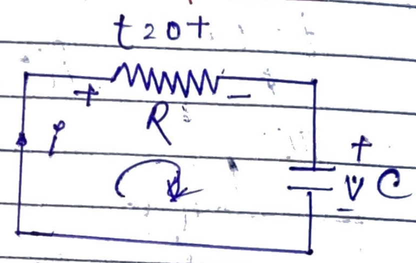


Fig (b)

Let us consider a RC circuit which is initially energised by the power supply V. Now, At $t = 0$, the switch position is moved to position 2 from 1, the equivalent circuits is shown in fig (b).

The potential across capacitor at $t = 0^-$, $V_c = V$

" " " " $t = 0^+$, $V_c = V$

Now the capacitor starts to discharge through the resistor R.

Now, applying K.V.L in the loop

$$iR + V_c = 0$$

∴ ~~the same current flowing through the~~

capacitor and resistor.

$$i = C \cdot \frac{dV_c}{dt}$$

put the value of i we get

$$R \cdot C \frac{dV_c}{dt} + V_c = 0$$

$\because V_c = V$, $\quad R \cdot C \frac{dV}{dt} + V = 0$

$$\frac{dV}{dt} + \frac{V}{RC} = 0 \quad \text{——— (II)}$$

The equation (II) represents linear differential equation of I^{st} order.

So, the solution of equation consists of only complementary function which is given by

$$V(t) = A \cdot e^{-\frac{1}{RC}t} \quad \text{——— (III)}$$

Now, applying initial condition at $t = 0^+$

$\because$ At $t = 0^+$

$$V_c(0^+) = V(0^+) = A \cdot e^{-\frac{1}{RC} \times 0}$$
$$= A = V$$

$\therefore V_c(0^+) = V$

$\therefore V = A$

On putting the value of $A = V$ in equation (III) we get

$$\boxed{V(t) = V \cdot e^{-\frac{1}{RC}t}}$$

RC is know as time constant of RC circuit and it is denoted by τ.

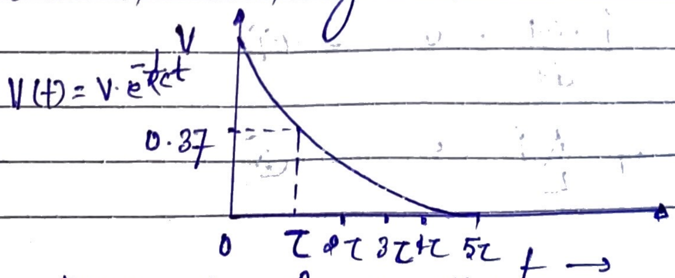


Fig: Variation of V(t) with t