NETWORK THEORY

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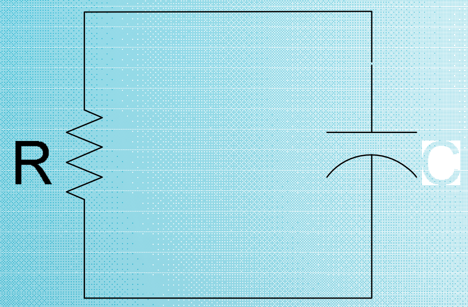
SECTION A

TOPIC COVERED: TRANSIENT RESPONSE OF RL TO VARIOUS EXCITATION SIGNALS

SECTION A : **TRANSIENT RESPONSE**

- Transient Response of RC, RL, and RLC Circuits to various excitation signals such as step, ramp, impulse and sinusoidal excitations using Laplace transform

RC CIRCUIT



Power dissipation in the resistor is:

$$p_R = V^2/R = (V_o^2/R)\, e^{-2t/RC}$$

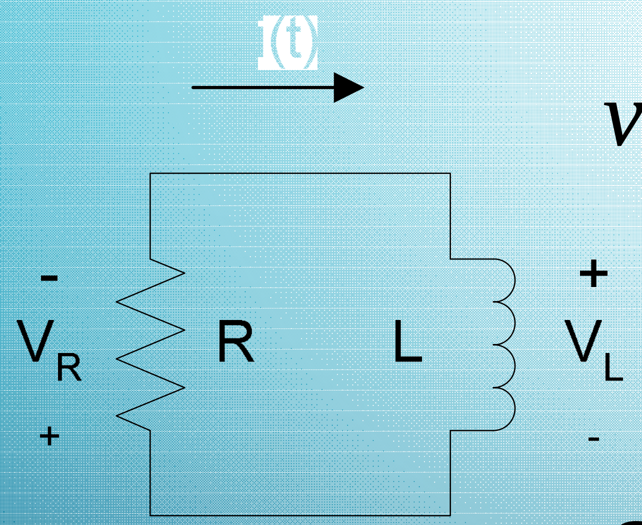
Total energy turned into heat in the resistor

$$W_R = \int_0^\infty p_R dt = \frac{V_o^2 \int_0^\infty e^{-2t/RC} dt}{R}$$

$$= V_o^2 R\left(-\frac{1}{2RC}\right) e^{-2t/RC} \Big|_0^\infty$$

$$= \frac{1}{2} C V_o^2$$

RL CIRCUITS



Initial condition

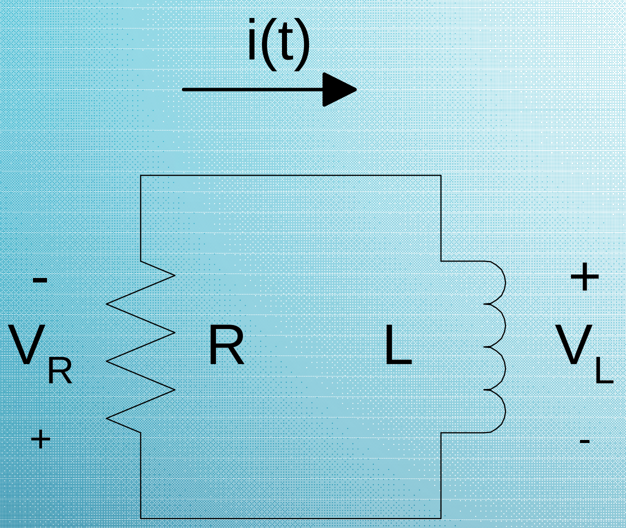
$i(t=0) = I_o$

$$v_R + v_L = 0 = Ri + L\frac{di}{dt}$$

$$\frac{L}{R}\frac{di}{dt} + i = 0$$

Solving the differential equation

RL CIRCUITS



Initial condition
$i(t = 0) = I_o$

$$\frac{di}{dt} + \frac{R}{L} i = 0$$

$$\frac{di}{i} = -\frac{R}{L} dt, \quad \int_{I_o}^{i(t)} \frac{di}{i} = \int_o^t -\frac{R}{L} dt$$

$$\ln i \Big|_{I_o}^{i} = -\frac{R}{L} t \Big|_o^t$$

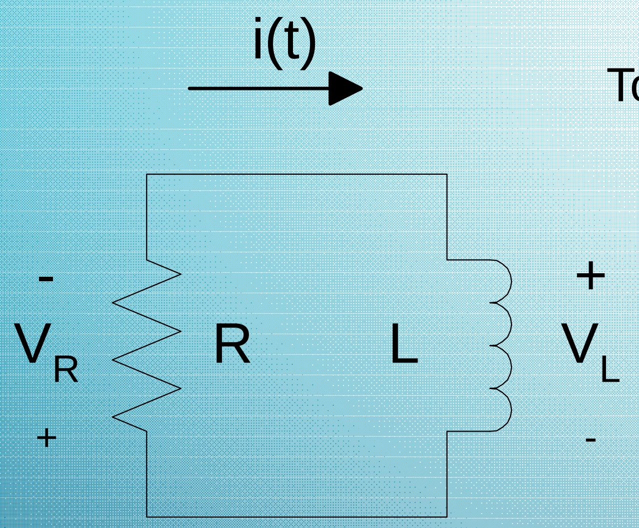
$$\ln i - \ln I_o = -\frac{R}{L} t$$

$$i(t) = I_o e^{-Rt/L}$$

RL CIRCUIT

Power dissipation in the resistor is:

$p_R = i^2R = I_o^2 e^{-2Rt/L} R$



Total energy turned into heat in the resistor

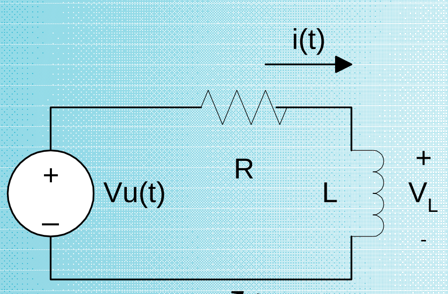
$$W_R = \int_0^\infty p_R dt = I_o^2 R \int_0^\infty e^{-2Rt/L} dt$$

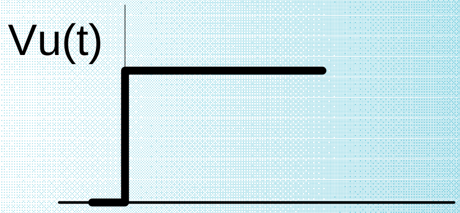
$$= I_o^2 R\left(-\frac{L}{2R}\right) e^{-2Rt/L} \Big|_0^\infty$$

$$= \frac{1}{2} L I_o^2$$

It is expected as the energy stored in the inductor is $\frac{1}{2} L I_o^2$

RL CIRCUIT





$$Ri + L\frac{di}{dt} = V$$

$$\frac{Ldi}{V - Ri} = dt$$

Integrating both sides,

$$-\frac{L}{R}\ln(V - Ri) = t + k$$

$$i(0^+) = 0, thus \;\; k = -\frac{L}{R}\ln V$$

$$-\frac{L}{R}[\ln(V - Ri) - \ln V] = t$$

$$\frac{V - Ri}{V} = e^{-Rt/L} \qquad or$$

$$i = \frac{V}{R} - \frac{V}{R}e^{-Rt/L}, \;\; for\, t > 0$$

where *L/R* is the time constant

DC STEADY STATE

The steps in determining the forced response for *RL or RC* circuits with dc sources are:

1. Replace capacitances with open circuits.

2. Replace inductances with short circuits.

3. Solve the remaining circuit.