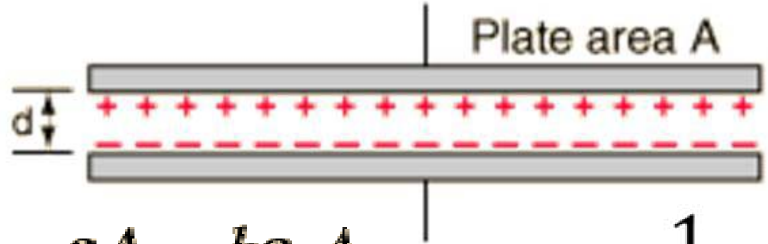
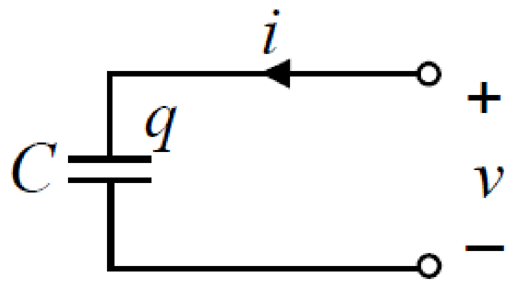
Ideal Capacitor

$$q = C\ v$$

coulombs farads volts



$$C = \frac{\varepsilon A}{d} = \frac{k\varepsilon_0 A}{d} \qquad E = \frac{1}{2} C v(t)^2$$



For dc or steady state when the voltage does not vary with time. A capacitor under dc or steady state acts like an open circuit (i=0).

$$q = C\ v$$

$$i(t) = \frac{dq(t)}{dt} = \frac{d[Cv(t)]}{dt} = C\frac{dv(t)}{dt}$$

$$v(t) = \frac{1}{C}\int_{t_o}^{t} i\,dt + v(t_o)$$

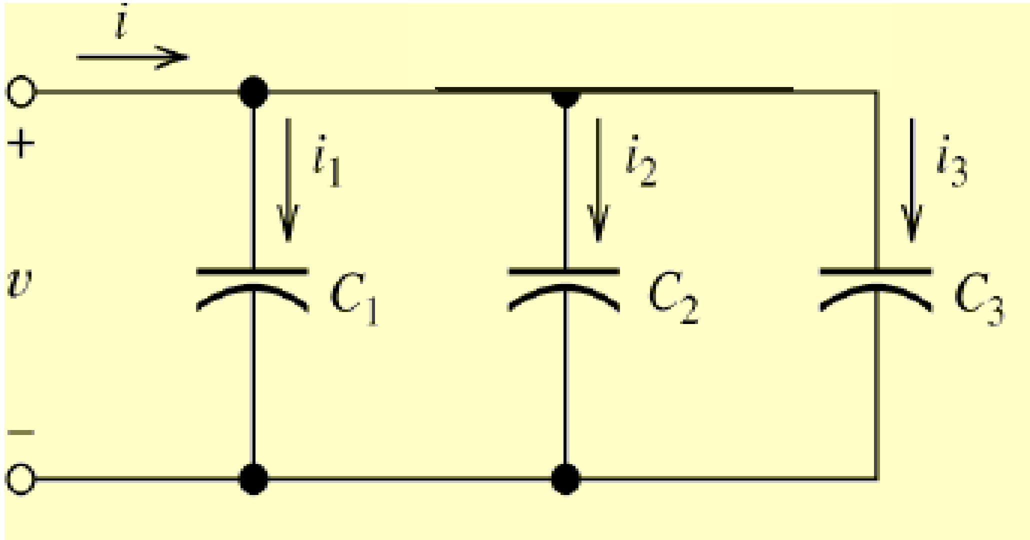
$$i_1(t) = C\frac{dv_1(t)}{dt} \qquad i_2(t) = C\frac{dv_2(t)}{dt}$$

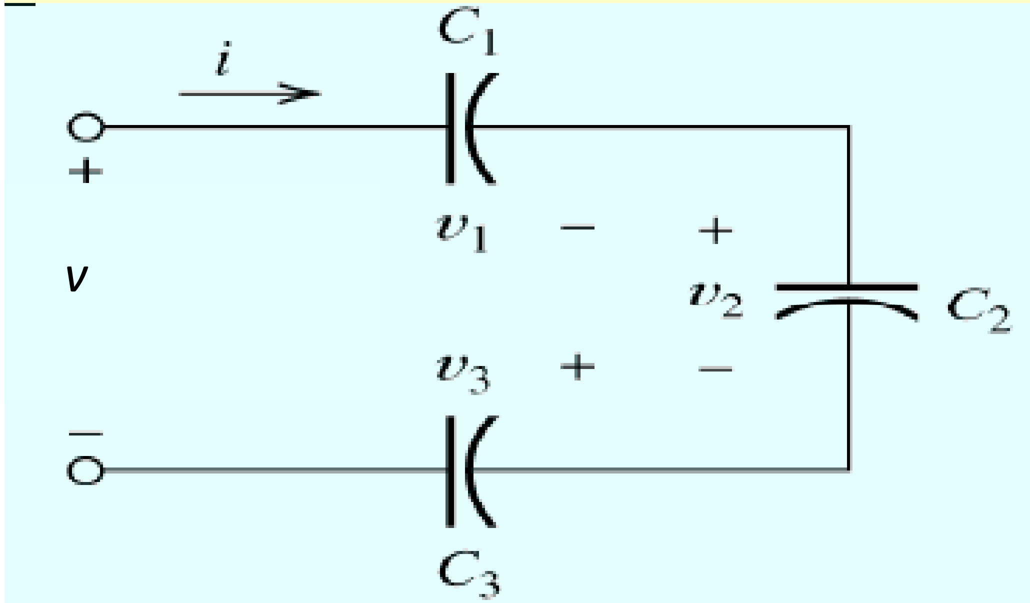
$$\alpha i_1(t) + \beta i_2(t) = C\frac{u}{dt}(\alpha v_1(t) + \beta v_2(t)) = \alpha C\frac{dv_1(t)}{dt} + \beta C\frac{dv_2(t)}{dt}$$

Therefore Capacitors linear elements. Hence Superposition, Combination rules, Thevenin/Norton are valid.

From K. Rajawat

Capacitor: series/parallel





$$i = C\,\frac{dv}{dt}$$

$$C_{eq} = C_1 + C_2 + C_3$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

ESC201 UDas Lec5 Magnetic Energy storage

Inductors

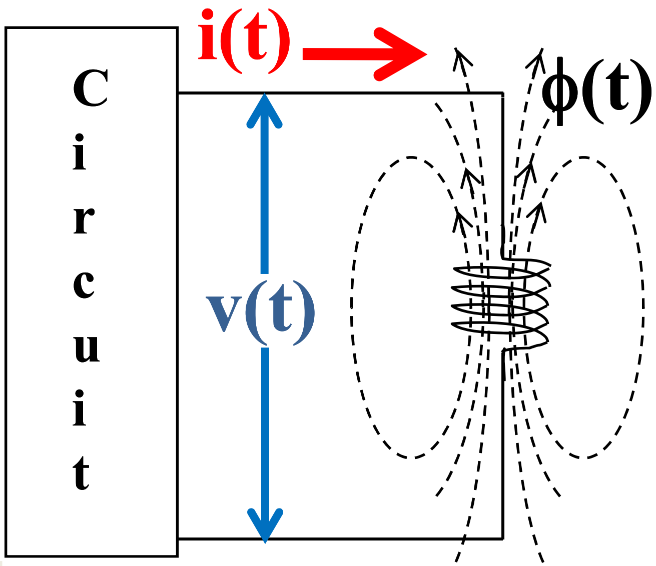
Self inductance is defined as flux linked per unit current.

Or $L = \phi(t)/i(t)$.

$$\phi(t) = L \times i(t)$$

If μ is the permeability of the core of the coil, N is the number of coil turns, for ℓ(length of the coil) $\gg$ r (mean radius of coil).

$$L = \frac{\mu N^2 \pi r^2}{\ell} \quad \textbf{Henry}$$



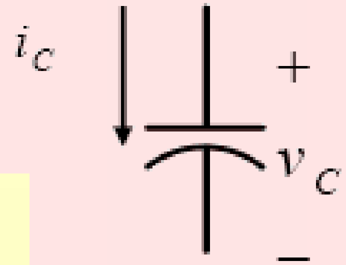
From Faraday's Law

e.m.f. generated is $-\frac{d\phi}{dt}$

$$v(t) = \frac{d\phi(t)}{dt} = L \times \frac{di(t)}{dt}$$

For dc or steady state when the current does not vary with time, an inductor acts like a short circuit (v=0)

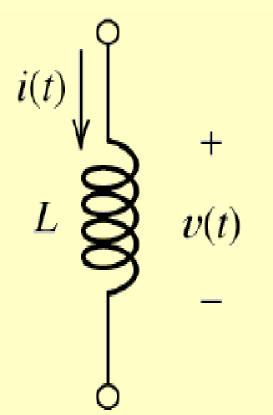
Two things to remember:



$$i_c = C\frac{dv_c}{dt}$$

Voltage across a capacitor cannot change instantaneously

Instantaneous change in voltage implies infinite current!



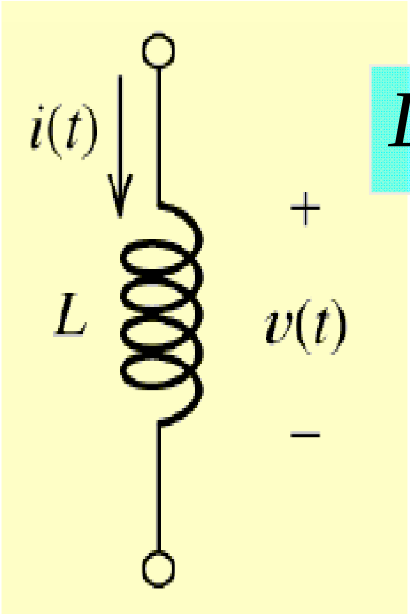
$$v = L\frac{di}{dt}$$

Current through an inductor cannot change instantaneously

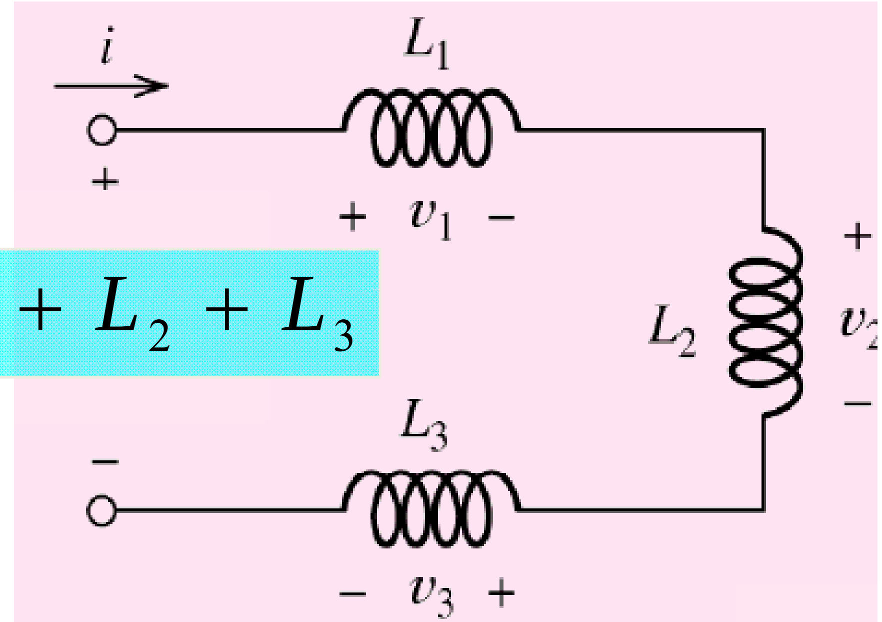
Instantaneous change in current implies infinite voltage!

Inductors: series/parallel

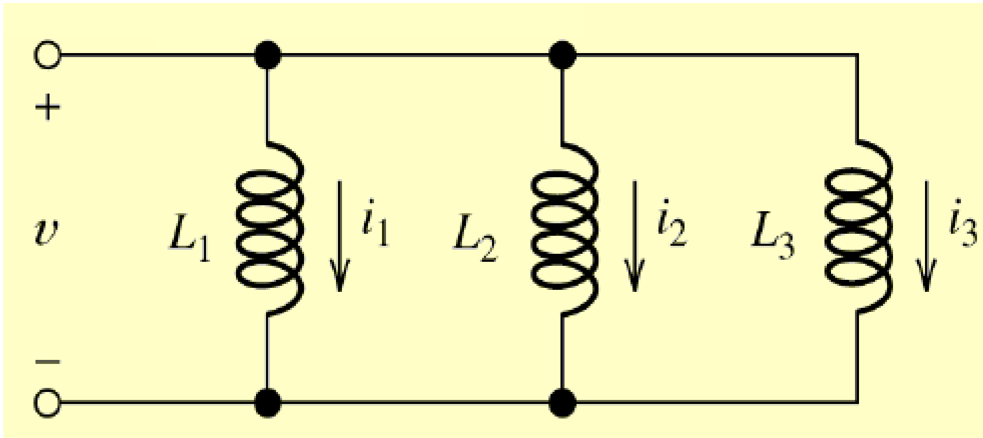
$$E = \frac{1}{2} L i(t)^2$$



$$L_{eq} = L_1 + L_2 + L_3$$



$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

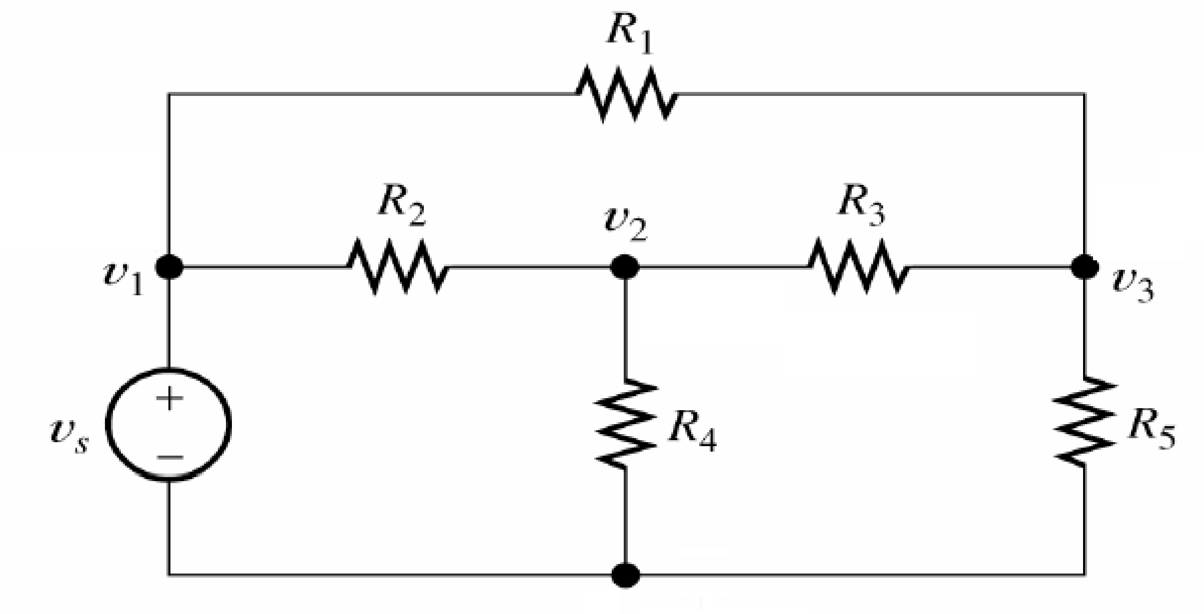


ESC201 UDas Lec5 Circuit equivalents

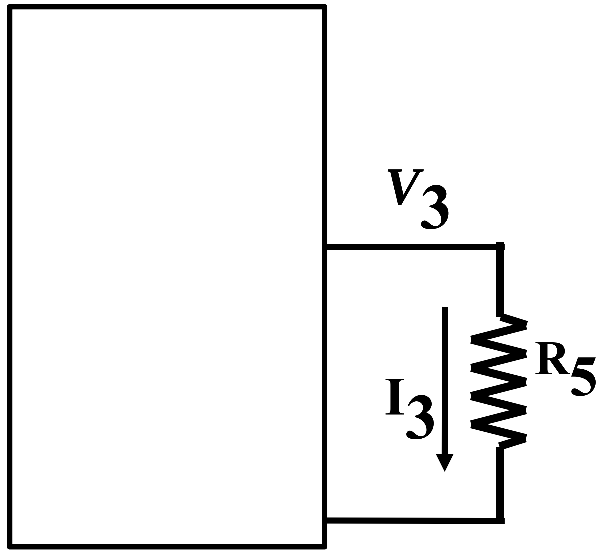
Not every circuit requires that all Node-voltages and Mesh-currents for a circuit be found, but to drive a load only those at the Load-Nodes and Load-Branch be found. Then it is unnecessary to do a full analysis on the circuit. Rather any equivalent circuit which provides the required information is sufficient.

Thevenin's Theorem: Any network containing independent and dependent sources and resistors, when viewed from the load, can be represented by an ***equivalent voltage source*** **V_T in** series with an ***equivalent resistance*** **R_{Th}**

Norton's Theorem: Any network containing independent and dependent sources and resistors, when viewed from the load, can be represented by an ***equivalent current source*** **I_N in** shunt with an ***equivalent resistance*** **R_N**



$$R_{Th}=R_1\|\left(R_3+R_2\|R_4\right)$$



Thevenin's (Voltage Source) & Norton's (current Source) equivalent circuits:

Thevenin's Theorem:

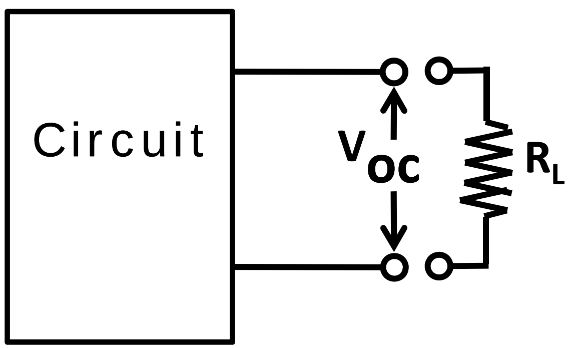
– Any network containing independent and dependent sources and resistors, when viewed from the load, can be represented by an ***equivalent voltage source*** ***V_{Th}*** in **series** with an ***equivalent resistance R_{Th}.***

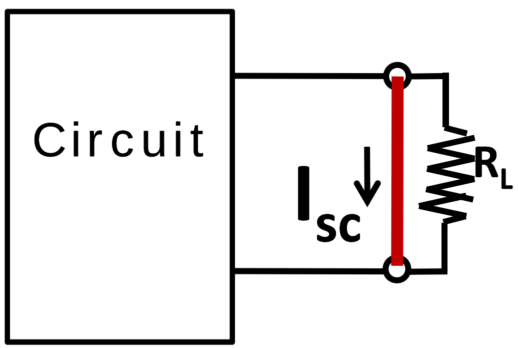
The Thevenin voltage V_{Th} is also referred to as the *Open-Circuit Voltage (V_{oc}).*

R_{Th} is defined as the ***effective resistance of the*** network, looking from the two open-circuited terminals.

Norton's Theorem:

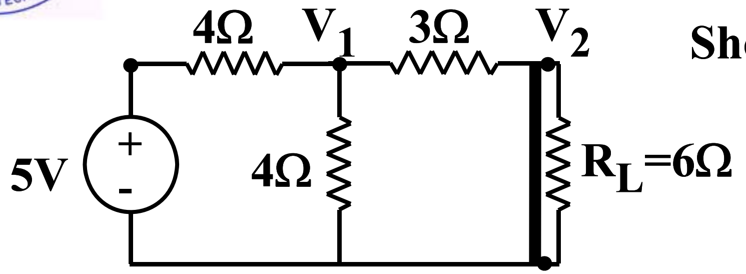
– Any network containing independent and dependent sources and resistors, when viewed from the load, can be represented by an ***equivalent current source*** ***I_N in* shunt** with an ***equivalent resistance R_N. But value of R_N = R_{Th} and I_N*** is referred to as the ***Short circuit Current (I_{sc})***.





R_{Th}= 3+4||4 = 5Ω, V_{oc}= (5/8)x4 = 2.5V

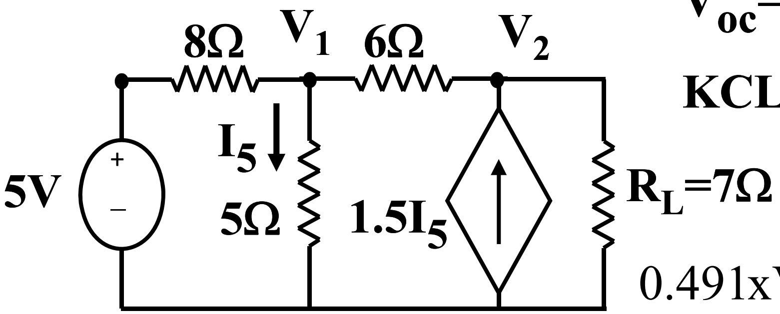
Short R_L : $I_{sc} = I_{3\Omega}\big|_{V2=0}$ and apply KCL at node 1.



$$\frac{V_1-5}{4}+\frac{V_1}{4}+\frac{V_1}{3}=0$$

$$0.833xV_1=1.25, I_3{=}I_{sc}=\frac{V_1}{3}=\frac{1.5}{3}=0.5A$$

Sure ,V_{oc}/I_{sc} give the same value of R_{Th}=5Ω



$V_{oc}=V_2$ when R_L is taken out.

KCL at node 1 gives : $\frac{V_1-5}{8}+\frac{V_1}{5}+\frac{V_1-V_{oc}}{6}=0$

$$0.491xV_1=(1/6)V_{oc}+(5/8)$$

$$0.491xV_1=(1/6)V_{oc}+(5/8)$$

$$V_1=0.34V_{oc}+1.27, \therefore V_{oc}=0.467x6x0.34V_{oc}+1.27x0.467x6$$

$$V_{oc}=\frac{1.27x0.467x6}{0.0473}=75.2V$$

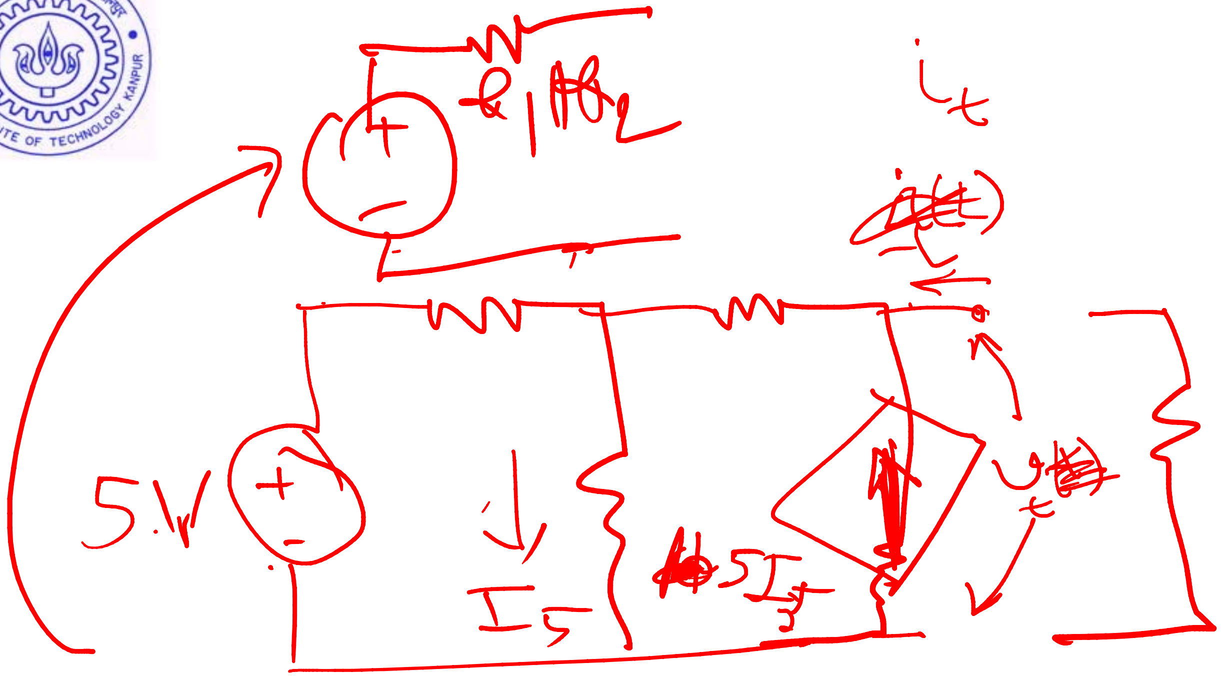
KCL at node 2 gives :

$$\frac{V_1-V_{oc}}{6}+1.5I_5=0$$

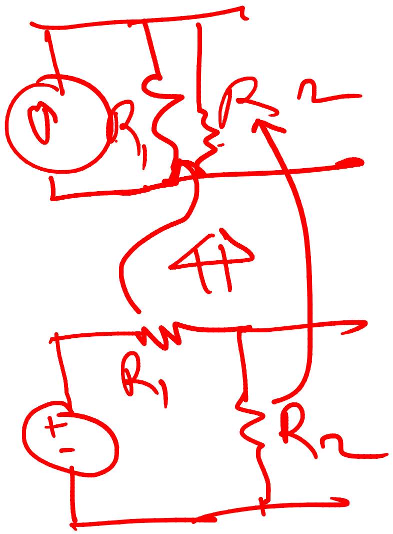
$$\frac{V_1-V_{oc}}{6}+1.5\frac{V_1}{5}=0$$

$$0.467x6V_1=V_{oc}$$

when R_L is shorted V_2=0,
and $I_{sc}=1.5I_5+V_1/6=1.5(V_1/5)+V_1/6=0.467V_1$
KCL at node1 gives: $(V_1-5)/8+V_1/5+V_1/6=0$
V_1= (1/0.492)x(5/8)=1.27V or I_{sc}=0.59A, R_{Th}=126.7Ω

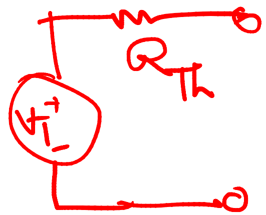


$V_T = I_N R_{Th}$



$v_t \longrightarrow i_t$

$$\frac{v_t}{i_t} = R_{Th}.$$



$R_N = R_{Th}$