Introduction to Electrical Engineering Practice

Course Code: EE 113

Department: Electrical Engineering

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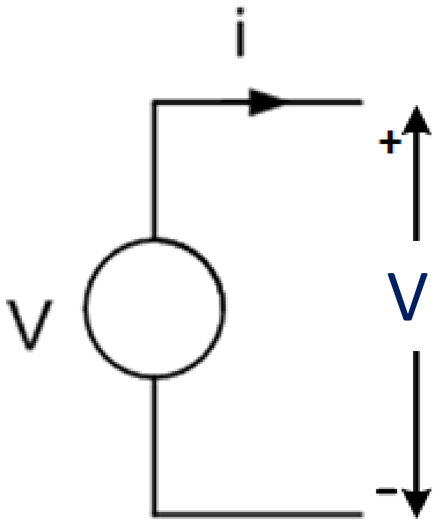
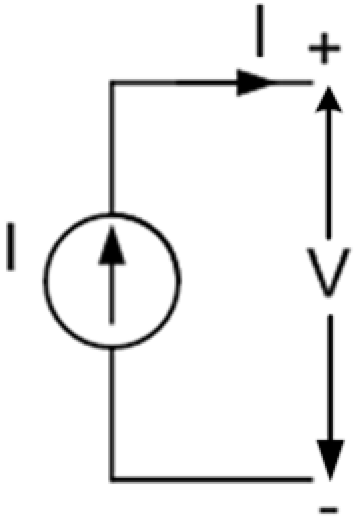
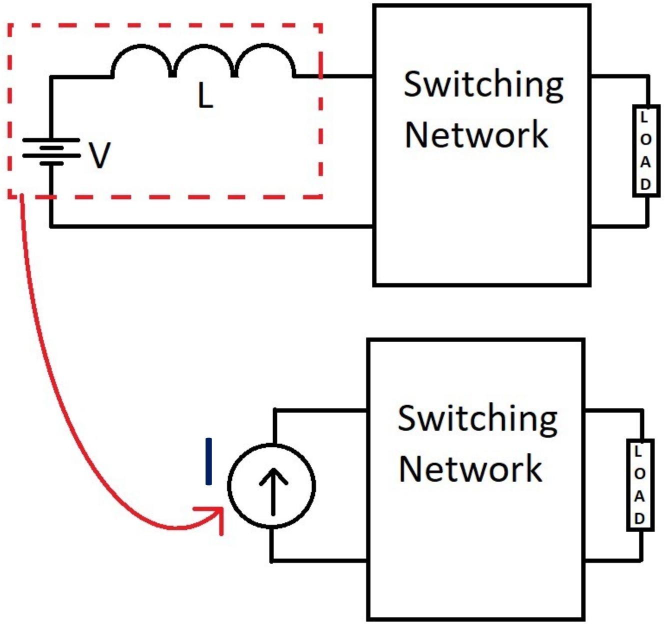
Review of Previous Lecture

Ideal voltage source :-
Terminal voltage is independent of current



Ideal current source :-
Current is independent of voltage across it.





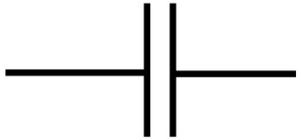
Passive Elements:

⇒ Capable of receiving power

⇒ Can not independently deliver the energy

Resistor  $V = IR$

Inductor  $v = L\dfrac{di}{dt}$

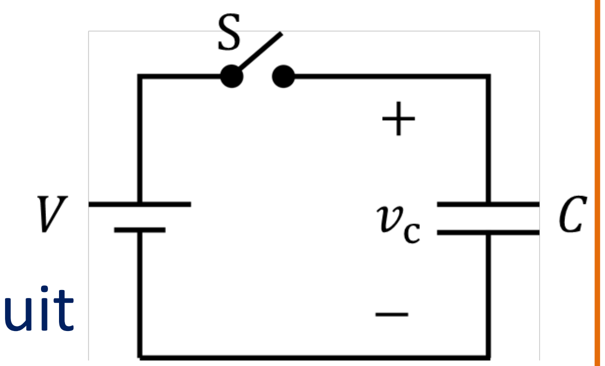
Capacitor  $v = \dfrac{1}{C}\displaystyle\int i\,dt$

Current through an inductor can not change instantaneously, voltage can

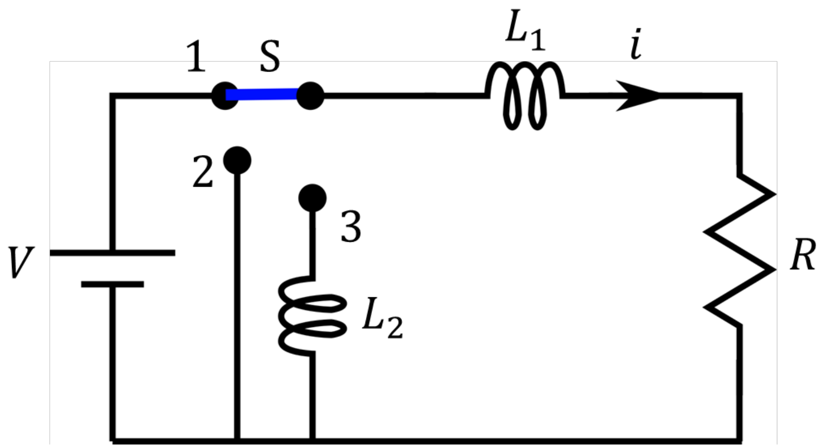
Voltage across a capacitor cannot change instantaneously, current can

Precautions:

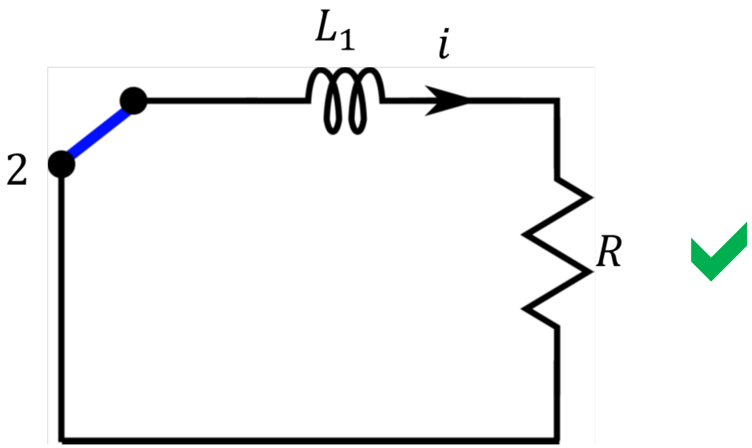
- Care should be taken while <u>energizing</u> a capacitive circuit
- Care should be taken while de-energizing an inductive circuit

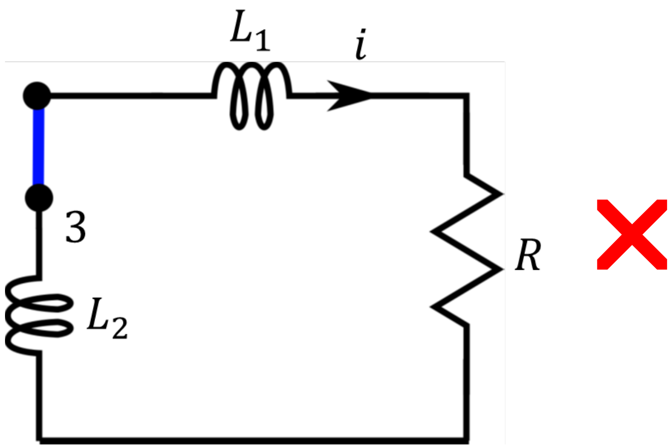


De-energizing an inductive circuits



- Can we open 'S' ?
- Can 'S' be transferred to 2 ?
- Can 'S' be transferred to 3 ?





Types of Electric circuits:

Active Network $\Rightarrow$ contains at least one active element

Passive network $\Rightarrow$ does not contain any active element

Terminologies used in Electric circuits:

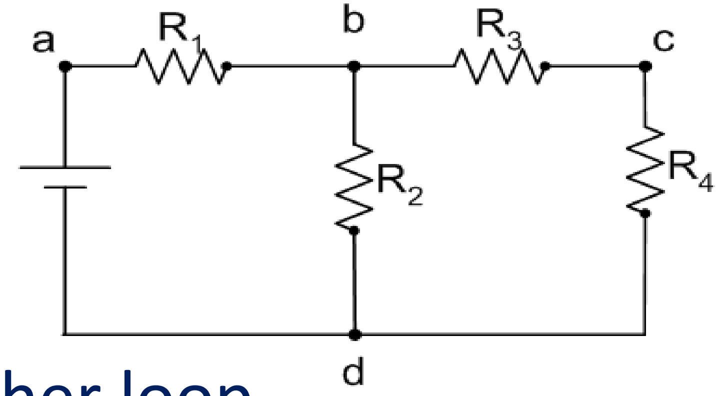
Node: Point to which two or more circuit elements are joined (a, b, c, d)

Junction: Point in a network where 3 or more circuit elements are joined (b&d)

Branch: Part of the circuit lies between two junction points (abd, bcd)

Loop: Any closed path of network
(abda, bcdb, abcda)

Mesh: Loop which does not contain another loop within it.



Mesh I $\longrightarrow$ That I which flows around the perimeter.

$\Rightarrow$ Clockwise is +ve

Circuit Laws:

Kirchhoff's Voltage law: In any closed path

$$\sum V \text{ rise} = \sum V \text{ fall}$$

V drop $\Rightarrow$ +ve

V rise $\Rightarrow$ -ve

Kirchhoff's Current law: At any node

$$\sum I \text{ Entering} = \sum I \text{ Leaving}$$

Circuit Analysis

Broadly classified into

Steady state analysis → DC circuit / AC circuit

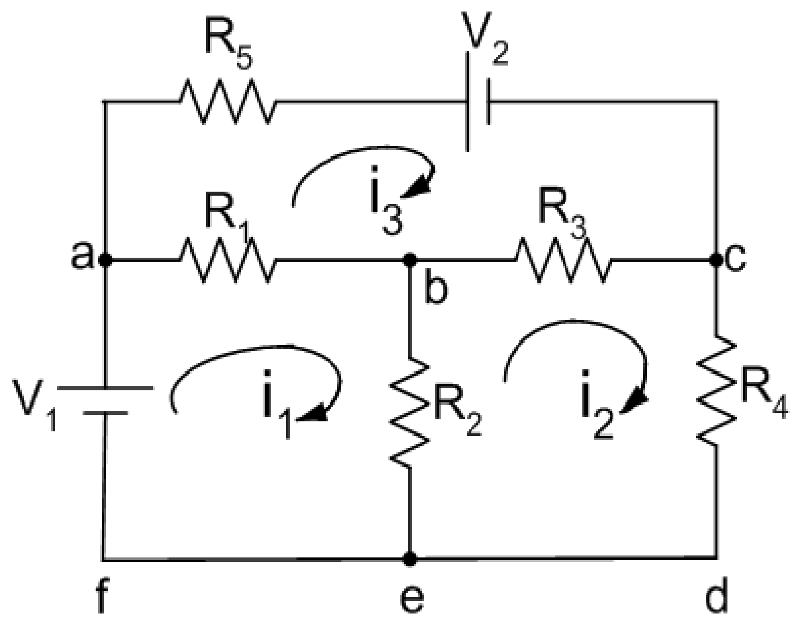
Transient analysis ⟶ behavior during transient state

<u>Mesh I method</u>: KVL is used

If b ⟶ No. of branches = 6

n ⟶ No. of Junctions = 4

⇒ Mesh equations = b - (n-1) = 3



Mesh1:

$$R_1(i_1 - i_3) + (i_1 - i_2)R_2 = V_1$$

$$(R_1 + R_2)i_1 - R_2 i_2 - R_1 i_3 = V_1$$

Mesh2:

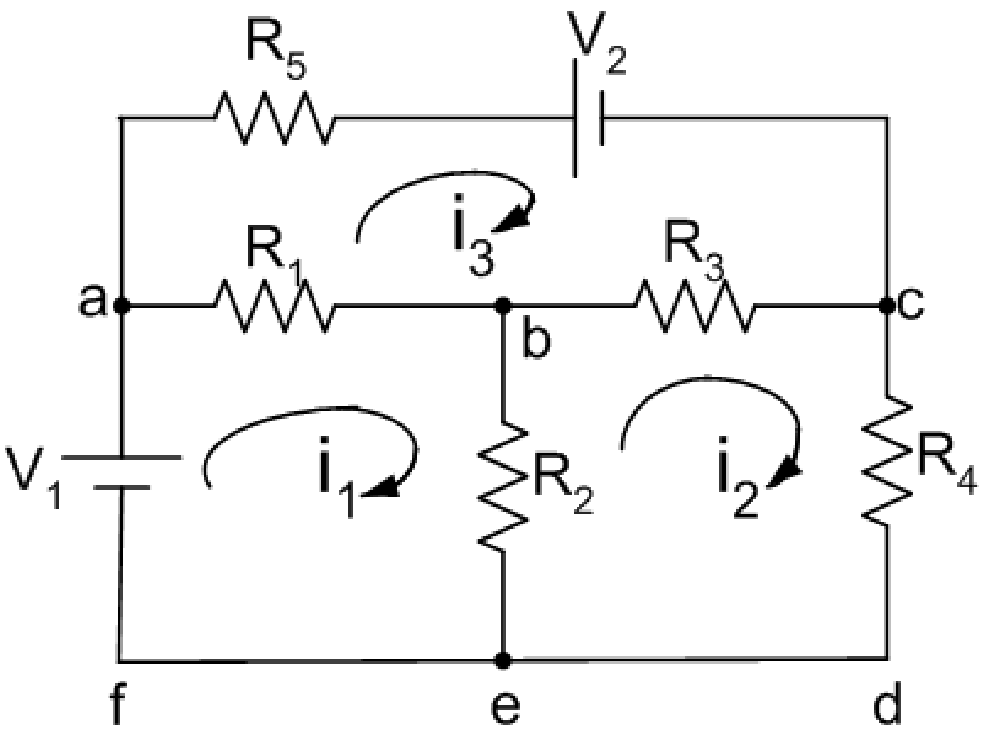
$$(i_2 - i_3)R_3 + i_2 R_4 + (i_2 - i_1)R_2 = 0$$

$$-R_2 i_1 + \left(R_2 + R_3 + R_4\right)i_2 - R_3 i_3 = 0$$

Mesh3:

$$(i_3 - i_1)R_1 + (i_3 - i_2)R_3 + i_3 R_5 = -V_2$$

$$-R_1 i_1 - R_3 i_2 + \left(R_1 + R_3 + R_5\right)i_3 = -V_2$$

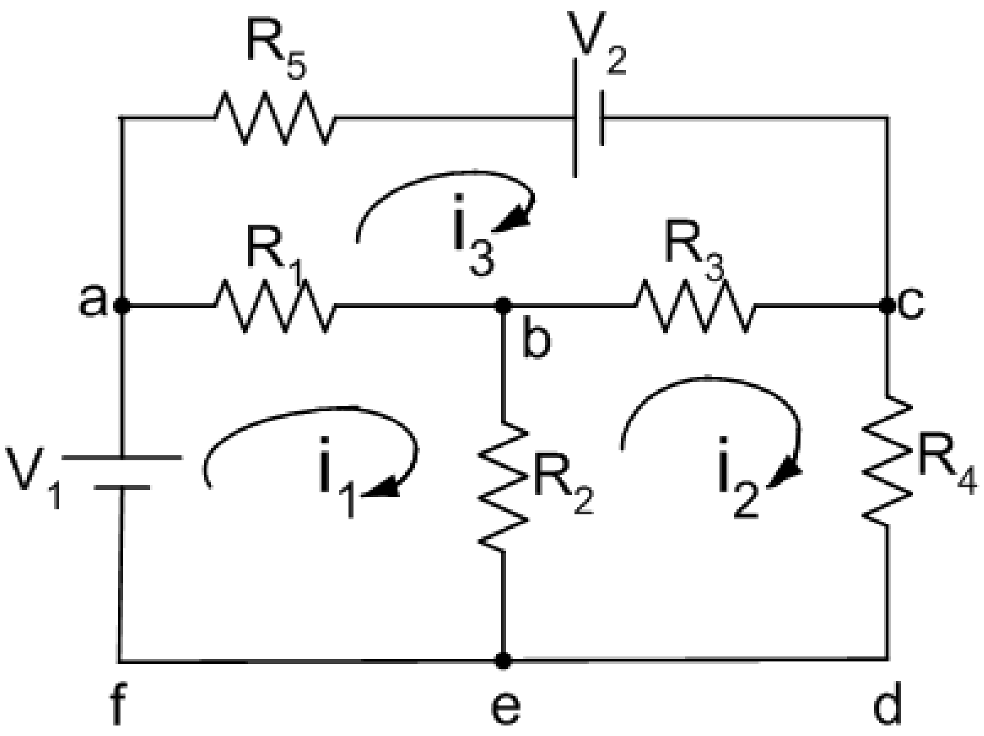


Steps:

⇒ Identify meshes

⇒ Assign clockwise I

⇒ Use KVL & write mesh equations

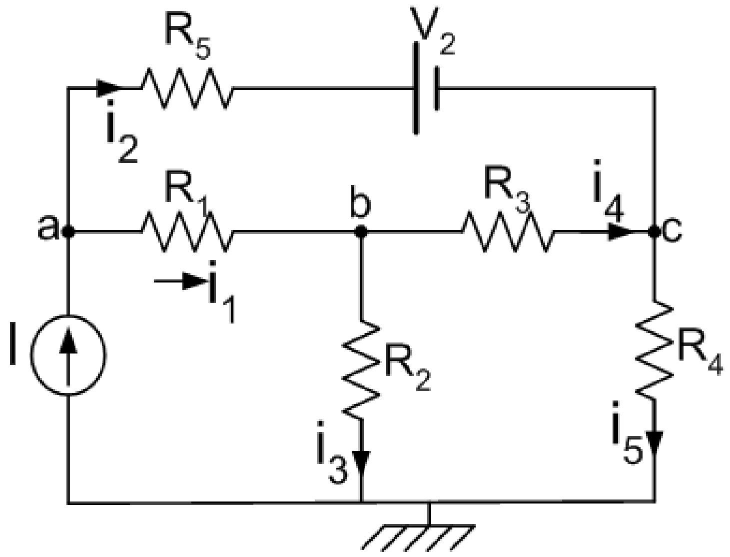


Circuit analysis by Node voltage method:

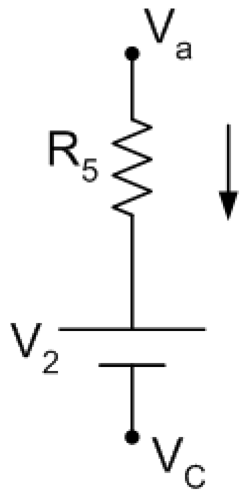
KCL is used

$\Rightarrow$ Take one reference node.

Let $v_a, v_b, v_c \Rightarrow$ 'V' at a,b,& C respectively



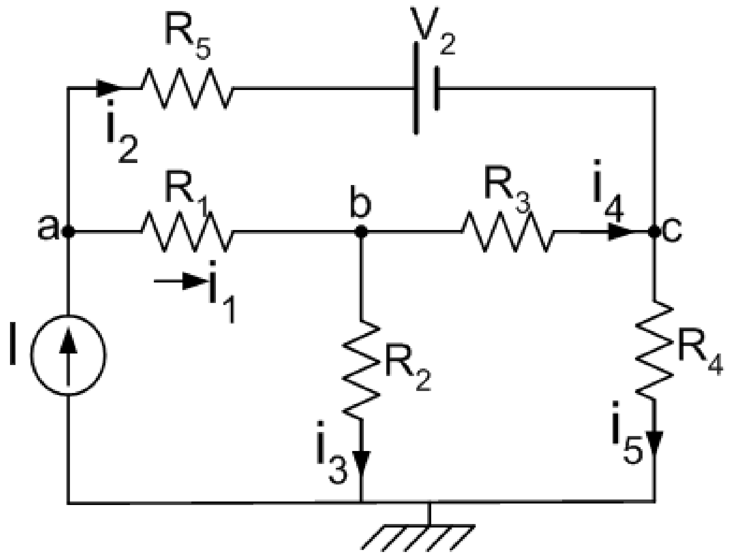
$$i_1 = \frac{v_a - v_b}{R_1}$$



$$i_3 = \frac{v_b}{R_2} \qquad i_4 = \frac{v_b - v_c}{R_3}$$

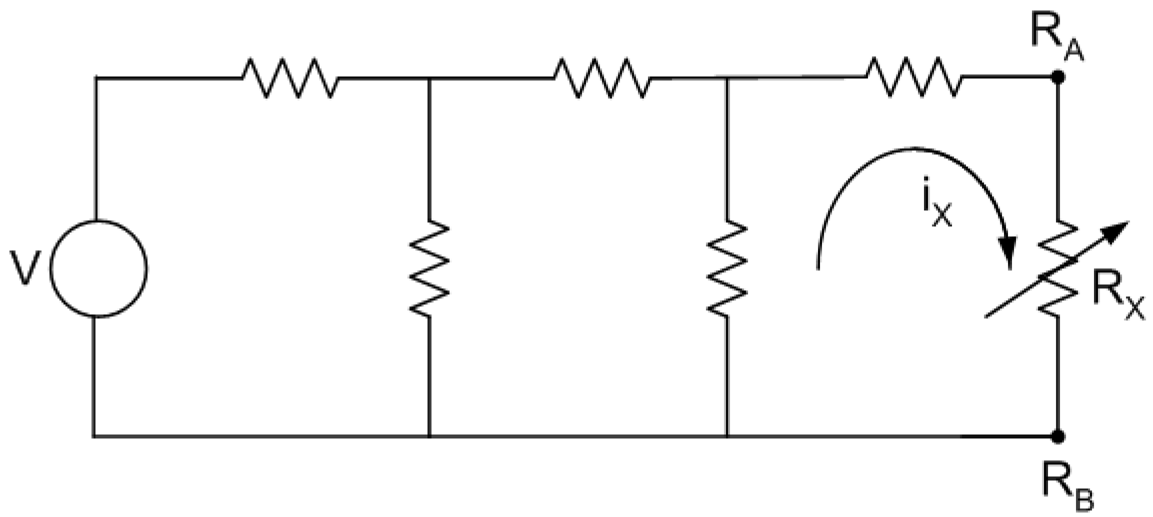
$$i_5 = \frac{v_c}{R_4} \qquad i_2 = \frac{v_a - (v_c + v_2)}{R_5}$$

Steps:



- $\Rightarrow$ Choose a reference node
- $\Rightarrow$ Write junction V_1………V_{n-1} at their respective junctions
- $\Rightarrow$ Assign the direction of I in each branch
- $\Rightarrow$ Write branch currents in terms of junction voltages
- $\Rightarrow$ Use KCL

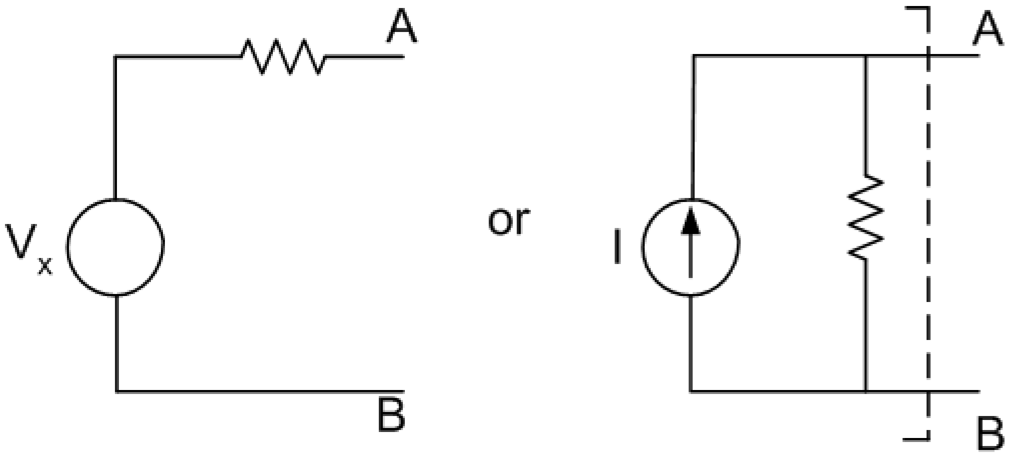
Suppose the value of one element is varying



⇒ Assume that only i_X to be determined

⇒ Using the mesh equation, solving for i_X will be tedious

⇒ Instead replace the network with two terminals A & B by an Equivalent circuit



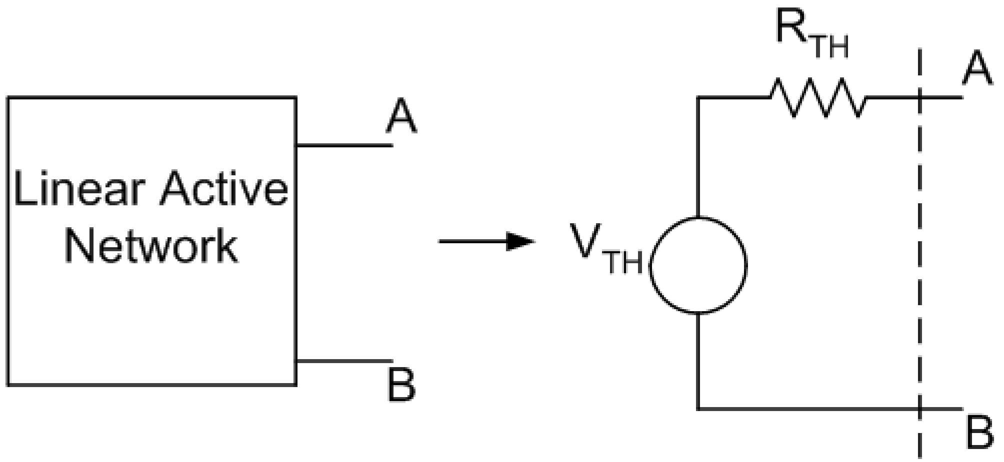
Thevenin (French engineer) OR Norton's Theorem (Bell lab)

Thevenin's Theorem:

Any linear active network with output terminals AB can be replaced by an ideal voltage source V_{TH} in series with a single resistor(?) R_{TH},

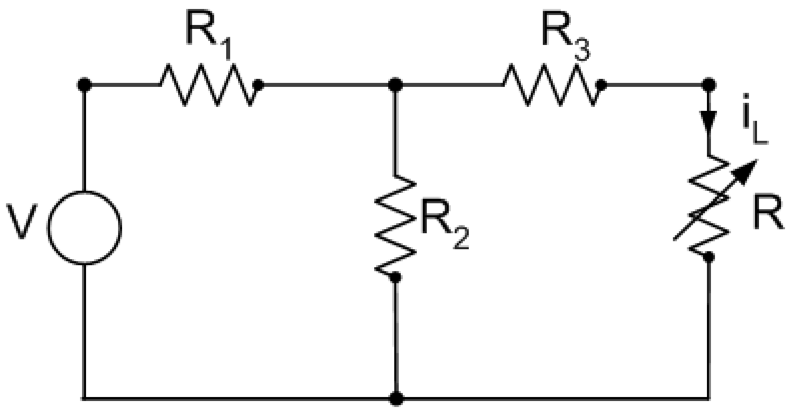
Where $V_{TH} \longrightarrow$ Open circuit voltage measured across the terminals AB

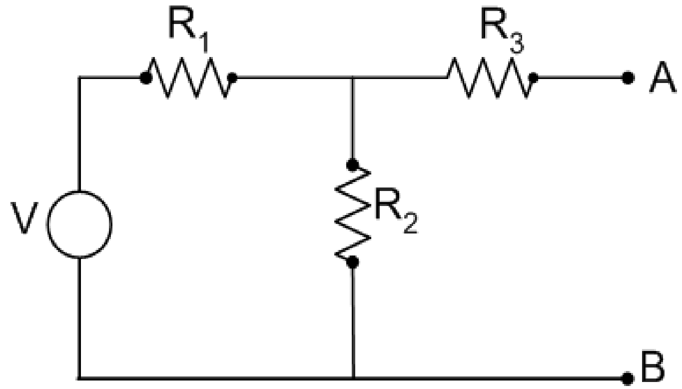
$R_{TH} \longrightarrow$ Equivalent resistance of the network at the terminals AB when all internal sources are set equal to zero.



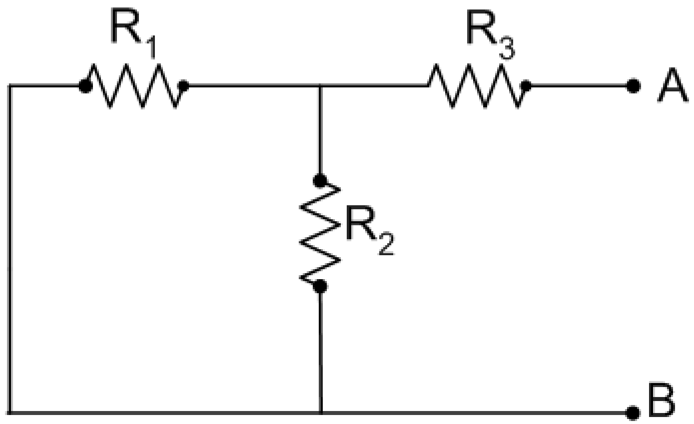
Short circuit the 'V' source & open circuit the I source

e.g.:





$\Rightarrow$ Network to be replaced by Thevenin's equivalent



V_{TH} = 'V' across R_2 = $\left(\dfrac{V}{R_1 + R_2}\right)R_2$

$$R_{TH} = R_3 + \frac{R_1 R_2}{R_1 + R_2} \qquad i_L = \frac{V_{TH}}{R_{TH} + R}$$