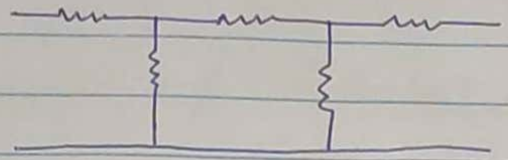
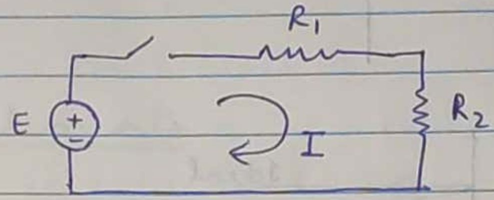
- Circuit / Network

Interconnection of various elements forms network

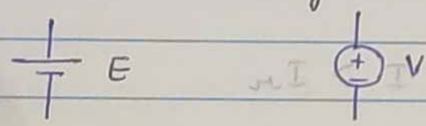




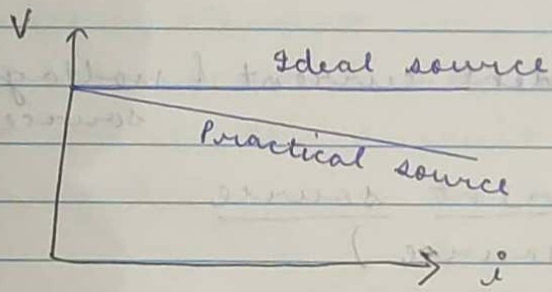
- Sources

- Voltage source
- Current source

1) Ideal voltage source

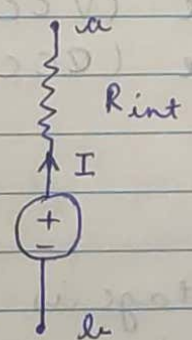


(symbols)



The voltage across an ideal voltage source remains constant irrespective of current across it.

2) Practical voltage source

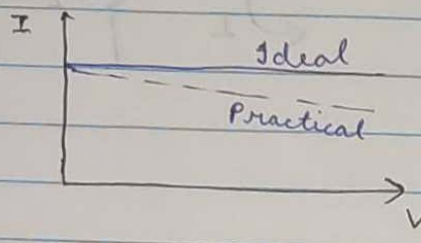


when I ↑ V_{ab} ↓

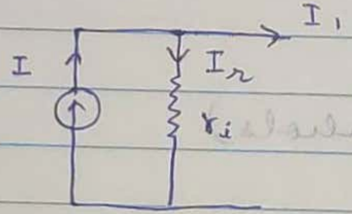
Characteristic of practical voltage source.

3) Ideal current source

symbol



4) Practical current source

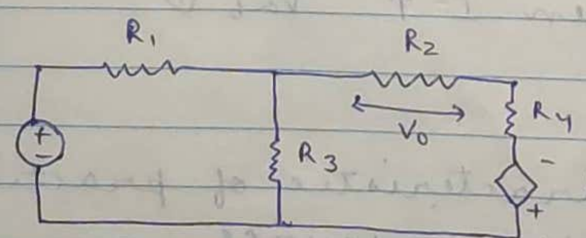


$I > I_r$

These were independent current & voltage sources

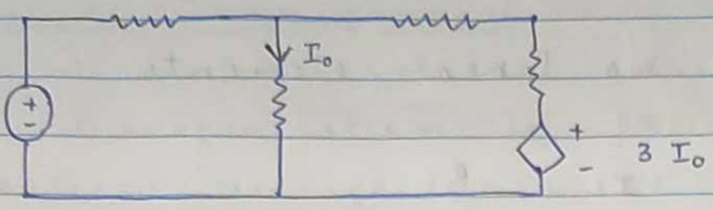
• <u>Dependent</u> <u>voltage</u> / <u>current</u> <u>source</u>
(Also called controlled source)

1) Voltage controlled voltage source (VCVS)
2) Current controlled voltage source (CCVS)
3) Voltage controlled current source (VCCS)
4) Current controlled current source (CCCS)



(voltage is dependent on R_2's voltage)

(VCVS)



(CCVS)

• Unilateral / Bilateral elements

1) Unilateral elements: Current flows in only one direction (diodes) (Bipolar junction transmitter)

2) Bilateral elements: Current flows in both the directions (Resistance, Inductor, Capacitor)

• Active / Passive elements

1) Active element
If an element has an internal energy source to drive the circuit then it is an active element. Ex - voltage sources, semiconductor devices.

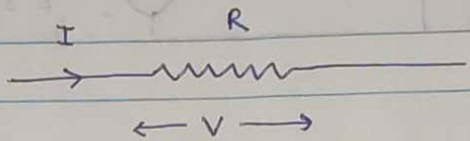
2) Passive element in transition state
They store internal energy, and then drive current. Ex - R, L and C.

• Linearity property of network
If a network is linear, then it should follow:

a) Homogeneity $f(ax) = af(x)$
b) Superposition $f(x_1 + x_2) = f(x_1) + f(x_2)$

Elements R, L & C as linear elements

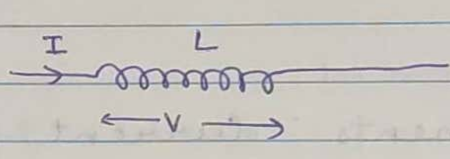
1) Resistors



$$\boxed{V = iR}$$

This equation follows homogeniety and superposition, thus it is a linear element

2) Inductor

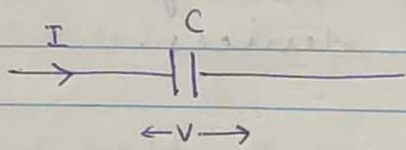


$V = L\dfrac{dI}{dt}$ (this eq^n is not used)

This equation can not be used to prove linearity

$\boxed{\phi = LI}$ (This equation follows homogeniety and superposition thus it is a linear element)

3) Capacitor



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

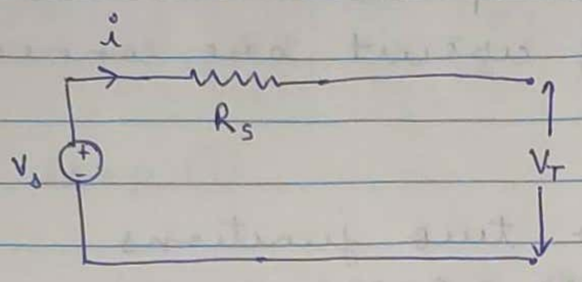
$$V = \frac{1}{C}\int I \cdot dt$$

Again this equation is unable to prove linearity thus, instead this is used :

$$\boxed{Q = CV}$$

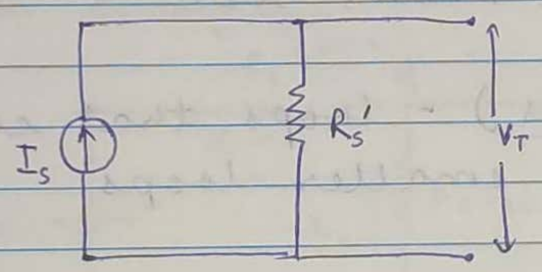
Source Transformation

This transformation is applicable in case of practical voltage / current source.

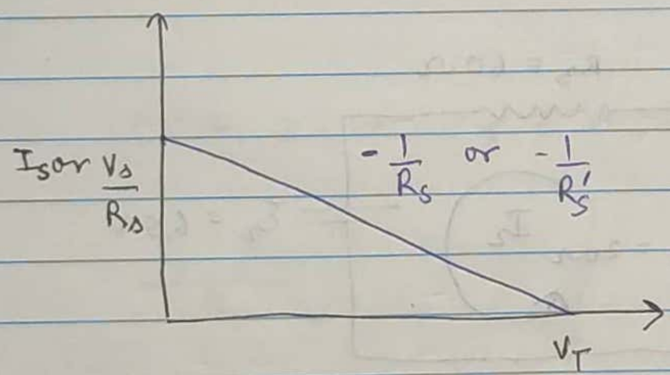


a voltage source which is a part of a bigger circuit.

The above segment can be substituted by



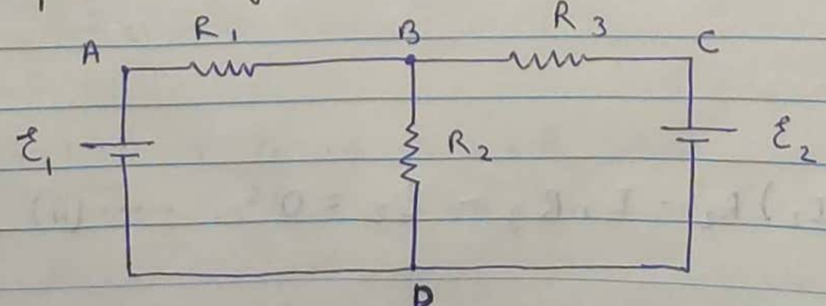
The load resistance is in parallel connection



graph is same in both cases.

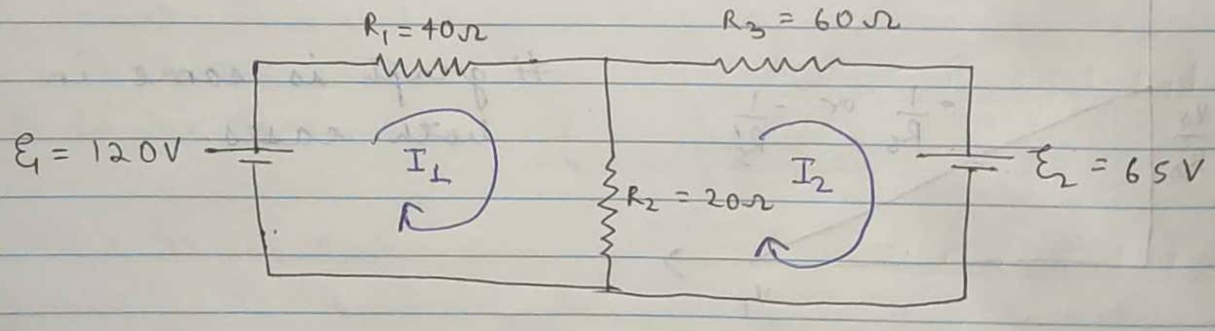
Loop / Mesh analysis

1) Loop analysis



- Node - an equipotential point at which two or more elements of circuit are connected
  Ex - A, B, C, D
- Junction - an equipotential point at which three or more elements of circuit are connected.
  Ex - B, D
- Branch - part lying b/w two junctions
  Ex - BD, BAD, BCD
- Loop - Any closed path in the circuit is a loop. Ex - ABCDA, ABDA, BCDB
- Mesh - (elementary loops) - loops that can't be separated into smaller loops

Mesh analysis



In loop ①

$$\mathcal{E}_1 - I_1 R_1 - (I_1 - I_2) R_2 = 0 \quad \cdots\cdots (i)$$

In loop ②

$$(I_1 - I_2) R_2 - I_2 R_3 - \mathcal{E}_2 = 0 \quad \cdots\cdots (ii)$$

(i) - (ii)

$$\mathcal{E}_1 - I_1 R_1 + I_2 R_3 + \mathcal{E}_2 = 0$$

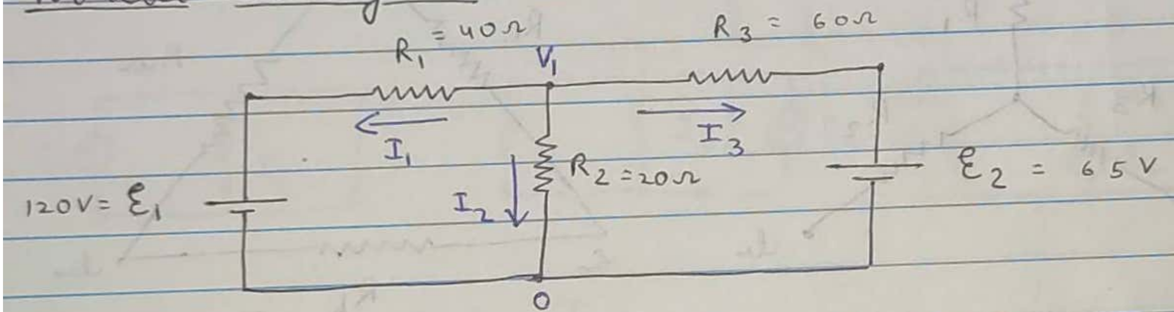
$$120 - 40 I_1 + 60 I_2 + 65 = 0$$

$$8 I_1 - 12 I_2 =$$

In loop ③,

$$(I_2 - I_3) R_4 - I_3 R_5 - \mathcal{E}_2 = 0$$ and so on.

<u>Nodal Analysis</u>



$$I_1 + I_2 + I_3 = 0 \quad \dots (i)$$

$$\left.\begin{array}{l} \dfrac{V_1 - \mathcal{E}_1}{R_1} = I_1 \\[2ex] \dfrac{V_1 - \mathcal{E}_2}{R_3} = I_3 \\[2ex] \dfrac{V_1 - 0}{R_2} = I_2 \end{array}\right\}$$ Put, values as $I_1 + I_2 + I_3 = 0$

$$\Rightarrow \frac{V_1 - 120}{40} + \frac{V_1}{20} + \frac{V_1 - 65}{60} = 0$$

$$\therefore V_1 = \frac{490}{11} = 44.54 \text{ V}$$

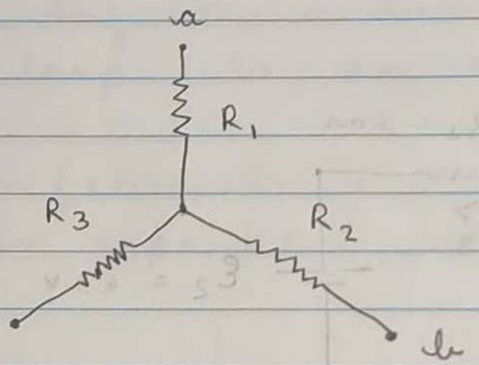
$I_1 = \frac{-83}{44}$, $I_2 = \frac{49}{22}$, $I_3 = \cancel{\frac{-15}{11}}$ $\frac{-3}{22}$

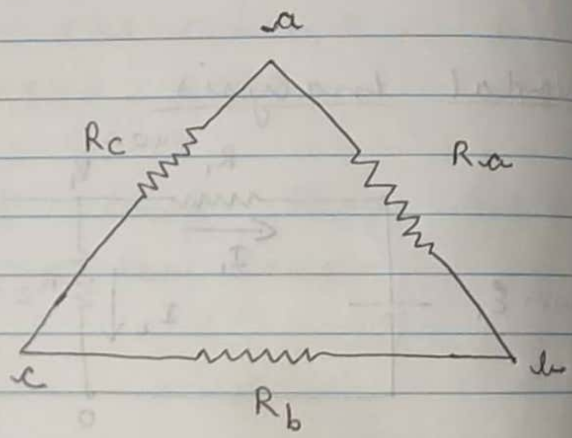
Power delivered for $\mathcal{E}_1$

$$P = \mathcal{E}_1 \times I_1 \quad \left(\begin{array}{ll} I_1 \text{ +ive} & \text{absorbing power} \\ \text{-ive} & \text{dissipating power} \end{array} \right)$$

$$= R_1 I_1^2$$

<u>Star Delta Transformation</u>





$$R_1 = \frac{R_a R_c}{R_a + R_b + R_c} \qquad R_a = \frac{R_1 R_3 + R_2 R_3 + R_1 R_2}{R_3}$$

$$R_2 = \frac{R_a R_b}{R_a + R_b + R_c} \qquad R_b = \frac{R_1 R_3 + R_2 R_3 + R_1 R_2}{R_1}$$

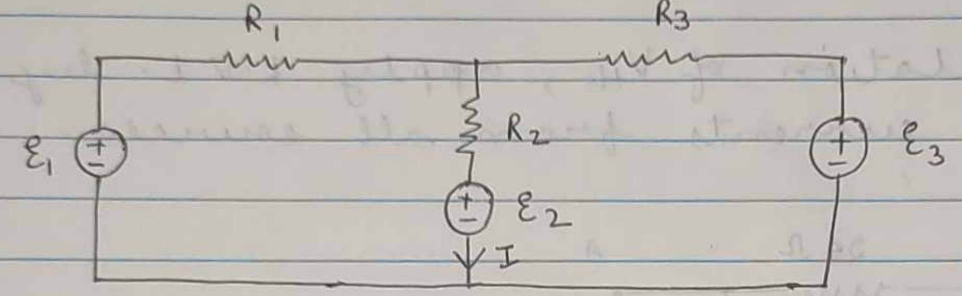
$$R_3 = \frac{R_b R_c}{R_a + R_b + R_c} \qquad R_c = \frac{R_1 R_3 + R_2 R_3 + R_1 R_2}{R_2}$$

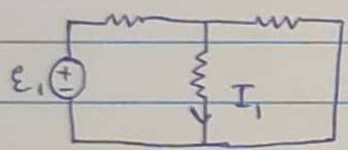
Network Theorems

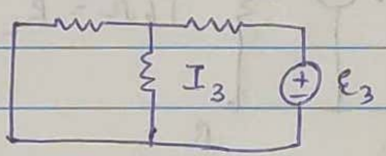
1) Superposition theorem
2) Thevenin's theorem
3) Norton's theorem
4) Maximum Power Transfer theorem.

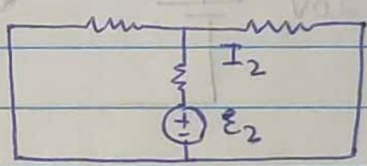
Superposition theorem

In any active linear bilateral network, if we have two or more sources then the combined effect of both sources is summation of effect of both cases, where one of the sources was inactive.





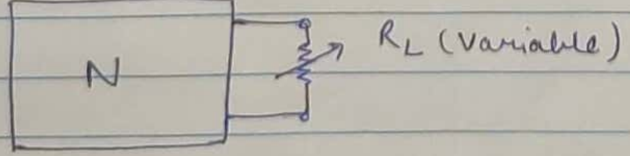




$$I = I_1 + I_2 + I_3$$

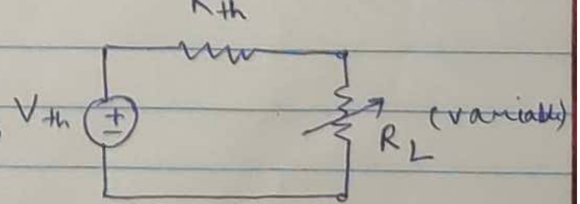
Thevenins theorem

These theorems reduce a complex network into a simple circuit.



complex network

$\Rightarrow$



Steps

1) For calculation of R_{th}, we inactive all the sources by converting →

voltage source - short circuit
current source - open circuit

2) for calculation of V_{th}, apply K.V.L. by including currents from all sources.