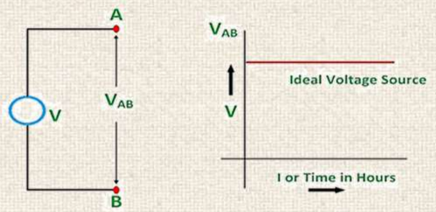
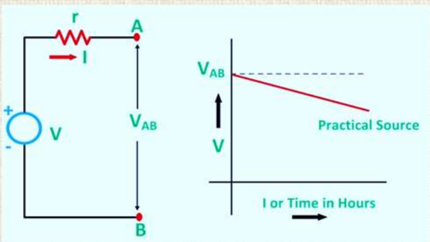
Basic Electrical Engineering

Unit 5

Ideal voltage source

- An ideal voltage source is a voltage source that supplies constant voltage to a circuit independent of the load.
- An Ideal voltage source is a two-terminal device whose voltage at any instant of time is constant and is independent of the current drawn from it.
- Ideal Voltage Source have zero internal resistance. Practically an ideal voltage source cannot be obtained.



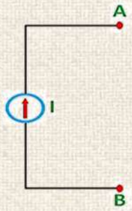


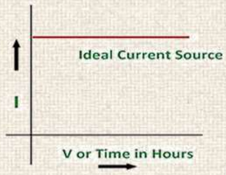
Practical voltage source

- Sources having some amount of internal resistances are known as **Practical Voltage Source**.
- Due to this internal resistance; voltage drop takes place, and it causes the terminal voltage to reduce. The smaller is the internal resistance (RS) of a voltage source, the more closer it is to an Ideal Source.

Ideal Current Source

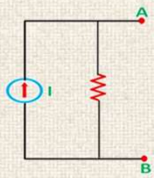
- An **Ideal current source** is a two-terminal circuit element which supplies the same current to any load resistance connected across its terminals.
- It is important to keep in mind that the current supplied by the current source is independent of the voltage of source terminals.
- It has **infinite** internal shunt resistance.

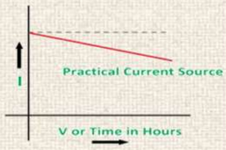




Practical Current Source

A **practical current source** is represented as an ideal current source connected with the resistance in parallel.
It has finite internal shunt resistance.





Linear Network: A network in which values of the circuit elements (resistance, inductance and capacitance) remain constant, irrespective of change in voltage or current, is known as *'linear network'*. Ohm's law is applicable to such network.
Non Linear Network: On the other hand, if values of the circuit elements change with change in voltage or current, such a network is called *'Non-linear network'*. Ohm's law is not applicable to such a network.

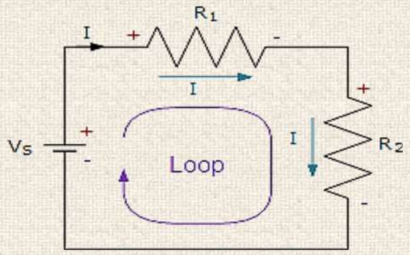
Active Network: If electric circuit contains at least single energy source, it is called *'Active network'*. It may be either voltage or current source.
Passive Network: A circuit in absence of an energy source containing only passive elements is called *'Passive network'*.

Bilateral Network: If characteristics or behavior of the circuit is independent of direction of current through various elements, such a network is called *'bilateral'*. Network comprised of pure resistance is bilateral one.
Unilateral Network: If characteristic or behavior of the circuit depends on direction of current through one or more elements it is called *'Unilateral Network'*. A diode allows flow of current only in one direction when it is forward biased, circuit consisting of diode is unilateral one.

Lumped Network: If all the network elements are physically separable, such a network is called *'lumped network'*. Most of the electrical networks are lumped in nature.
Distributed Network: A network in which elements are not physically separable is known as *'distributed network'*.

Kirchhoff's Voltage Law

- "The algebraic sum of the products of currents and resistances in each of the conductors in any closed path (or mesh) in a network plus the algebraic sum of the emfs in that path is zero".
- In any electrical network, algebraic sum of voltage drops across various elements in any closed loop or mesh is equal to algebraic sum of EMFs in that loop.

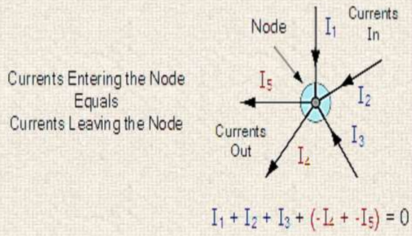


Σ IR +Σemf = 0 (round the mesh)

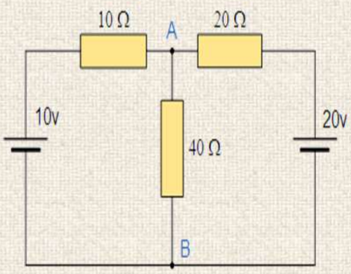
Kirchhoff's Current Law

- "In any electrical network, the algebraic sum of the currents meeting at a point is zero."

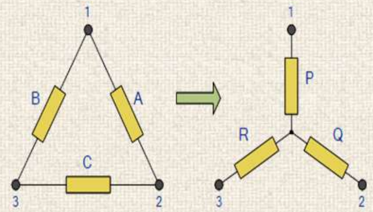
  Or
- "The algebraic sum of all currents entering and exiting a node must equal zero."



Σ I = 0 ……at a junction or node



Delta to Star



Compare the resistances between terminals 1 and 2.

$$P + Q = A \text{ in parallel with } (B + C)$$

$$P + Q = \frac{A(B + C)}{A + B + C} \quad \text{...EQ1}$$

Compare the resistances between terminals 2 and 3.

$$Q + R = C \text{ in parallel with } (A + B)$$

$$Q + R = \frac{C(A + B)}{A + B + C} \quad \text{...EQ2}$$

Compare the resistances between terminals 3 and 1

$$P + R = B \text{ in parallel with } (A + C)$$

$$P + R = \frac{B(A + C)}{A + B + C} \quad \text{...EQ3}$$

$$EQ3 - EQ2 = (P + R) - (Q + R)$$

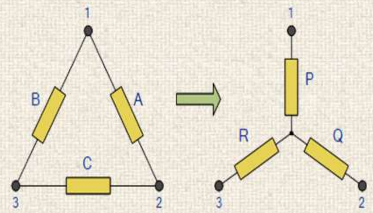
$$P + R = \frac{B(A+C)}{A+B+C} - Q + R = \frac{C(A+B)}{A+B+C}$$

$$\therefore P - Q = \frac{BA + CB}{A+B+C} - \frac{CA + CB}{A+B+C}$$

$$\therefore P - Q = \frac{BA - CA}{A+B+C} \quad \text{....EQ4}$$

Adding equation 1 and 4

Delta to Star



Adding equation 1 and 4

$$(P - Q) + (P + Q)$$

$$= \frac{BA - CA}{A + B + C} + \frac{AB + AC}{A + B + C}$$

$$= 2P = \frac{2AB}{A + B + C}$$

Which gives us the final equation for resistor P as:

$$\boxed{P = \frac{AB}{A+B+C}}$$

Similarly:

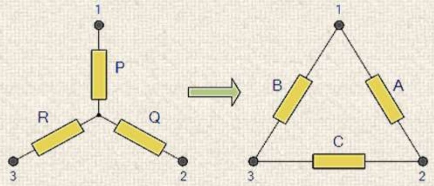
$$\boxed{Q = \frac{AC}{A+B+C}} \quad \boxed{R = \frac{BC}{A+B+C}}$$

Star to Delta

$$P = \frac{AB}{A+B+C} \quad \text{Eq………..1}$$

$$Q = \frac{AC}{A+B+C} \quad \text{Eq………..2}$$

$$R = \frac{BC}{A+B+C} \quad \text{Eq………..3}$$



Multiply eq 1*2, 2*3 and 3*1, then

$$PQ = \frac{A^2BC}{(A+B+C)^2} \; eq \ldots\ldots 4$$

$$QR = \frac{ABC^2}{(A+B+C)^2} \; eq \ldots\ldots 5$$

$$RP = \frac{AB^2C}{(A+B+C)^2} \; eq \ldots\ldots 6$$

add eq 4,5,& 6 , then

$$PQ + QR + RP = \frac{ABC(A+B+C)}{(A+B+C)^2}$$

$$PQ + QR + RP = \frac{ABC}{(A+B+C)} \quad ..\text{Eq7}$$

Divide eq 7 to 1 , then

$$C = \frac{PQ+QR+RP}{P}$$

Divide Eq 7 to 2 , then

$$B = \frac{PQ+QR+RP}{Q}$$

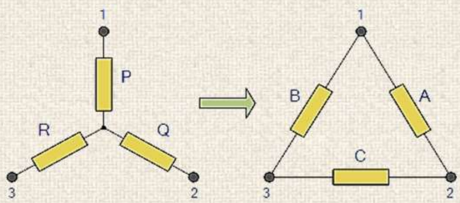
Divide Eq 7 to 3 , then

$$A = \frac{PQ+QR+RP}{R}$$

$$P = \frac{AB}{A+B+C}$$

$$Q = \frac{AC}{A+B+C}$$

$$R = \frac{BC}{A+B+C}$$



$$A = \frac{PQ}{R} + Q + P$$

$$B = \frac{RP}{Q} + P + R$$

$$C = \frac{QR}{P} + Q + R$$

Delta to Star

$$X \rightarrow X/3$$

If all resistance are same:

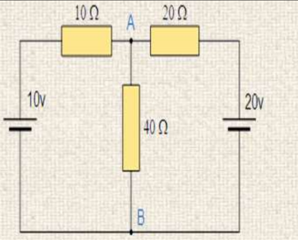
Star to Delta

$$Y \rightarrow 3Y$$

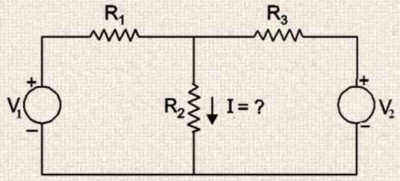
$$P = \frac{X * X}{X + X + X} = \frac{X^2}{3X} = X/3$$

$$A = \frac{Y * Y}{Y} + Y + Y = \frac{Y^2}{Y} + 2Y = 3Y$$

Superposition Theorem

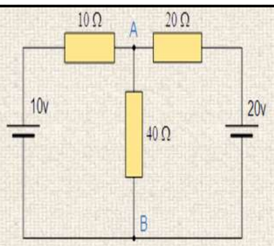


Superposition Theorem states that “In any linear, bilateral network containing at least two energy sources, the current flowing through a particular branch is the algebraic sum of the currents flowing through that branch when each independent source is considered separately and all other independent sources are replaced by their respective internal resistances.”



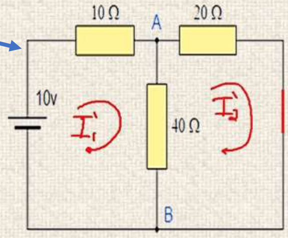
Note: Voltage source – Short circuit
Current Source – Open Circuit

Explanation



Consider the ckt shown in fig. and we have to find current Through AB Terminal by superposition theorem.

Step 1:- Consider 10 V w.r.t 20V short circuit then find current AB terminal



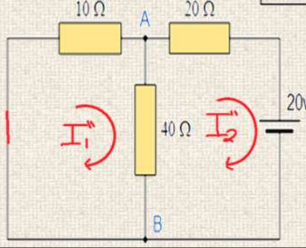
Step 2:- Consider 20 V w.r.t 10 shot circuit then find current AB terminal

Step 3 As per superposition

$I_1 = I_1' + I_1''$

$I_2 = I_2' + I_2''$

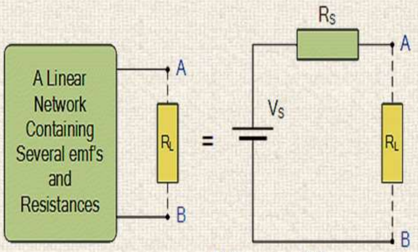
$I_{AB} = I_1 - I_2$



I’ and I” can be calculated by using KVL or branch current method.

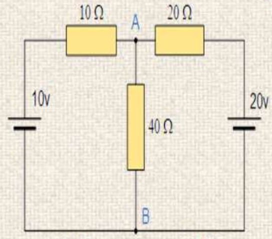
Thevenin's Theorem

Thevenin's Theorem states that "Any linear active bilateral circuit containing several voltages/current source and resistances can be replaced by just one single voltage in series with a single resistance connected across the load".



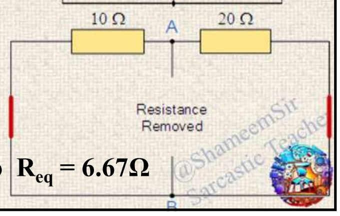
Explanation

Consider the ckt shown in fig. and we have to find current Through AB Terminal by Thevenin's theorem.



Step 1: Identify Load branch (Always Given)
Step 2: Find Thevenin's equivalent resistance

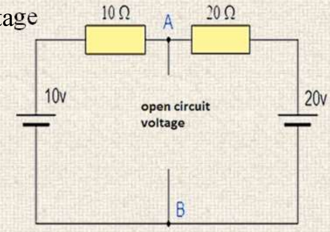
1. All independent voltage source short circuit
2. All independent current source open circuit
3. Remove Load branch and find equivalent resistance across load terminal.



10 and 20 ohm resistance are parallel to each other so R_{eq} = 6.67Ω

Step 3: Find Thevenin's voltage

1. All independent voltage and current source as it is
2. All passive element as it is except load branch
3. Remove Load branch and find Thevenin's voltage (open circuit voltage)



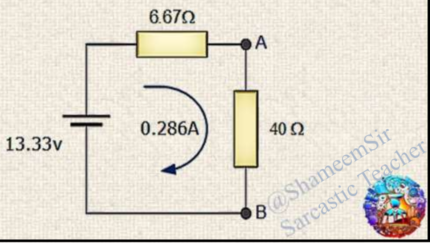
$$I = \frac{V}{R} = \frac{20v - 10v}{20\Omega + 10\Omega} = 0.33\ amps$$

This current of 0.33 amperes (330mA) is common to both resistors so the voltage drop across the 20Ω resistor or the 10Ω resistor can be calculated as:

V_{AB} = 20 – (20Ω x 0.33amps) = 13.33 volts.

Step 4: Draw Thevenin's voltage equivalent circuit:

Then the Thevenin's Equivalent circuit would consist or a series resistance of 6.67Ω and a voltage source of 13.33v. With the 40Ω resistor connected back into the circuit we get:



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