C • H • A • P • T • E • R

1

Basics of Electrical Circuits and Kirchoff's Laws

1.1 ACTIVE AND PASSIVE ELEMENTS

OCT/NOV. 2017

Active Element : An active element is one which supplies energy to a circuit is called as an ***active element.***

Voltage sources and current sources are the examples for active elements.

Passive Elements : A passive element is one which can dissipate or store energy is called as a ***passive element.***

Resistors, inductors and capacitros are the examples for passive elements.

- The resistor dissipates energy in the form of heat. Hence resistor is called **energy dissipative element.**
- Inductors and capacitors stores energy within them. Hence inductors and capacitors are called **energy storage elements.**

1.2 RESISTANCE, CAPACITANCE AND INDUCTANCE PARAMETERS

1.2.1 Resistance (R)

Resistance is the physical property of a circuit element which opposes the flow of electric current.

- Resistance restricts the flow of electric current through the material.
- Resistor is a device which opposes the flow of current.
- The unit of resitance (R) is ohm and represented by the symbol Ω. The symbol of resistor is shown below.

Symbol

- Quantitatively the value of resitance is obtained from ohm's law.

The resistance offered by a material when a current of I ampere flows through it with V volt potential difference across the material is obtained as,

$$R = \frac{V}{I} \text{ ohm}$$

- When an electric current flows through any conductor, heat is generated due to collision of three electrons with atoms. The power absorbed by the resistor is given by

$$P = VI = (IR)\,I = I^2 R \text{ watts}$$

- The energy lost in the resitance in the form of heat is expressed as

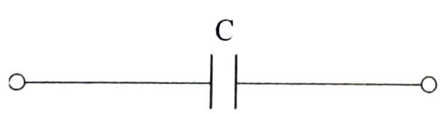
$$W = \int_0^t P \cdot dt = P \cdot t = I^2 R \cdot t = \frac{V^2}{R} \cdot t \text{ Joules}$$

1.2.2 Capacitance (C)

It is the capability of an element to store electric charge within it.

A capacitor is a device consisting of two conducting plates separated by a dielectric material, which stores electric energy in the form of electric field.

- The unit of capacitance is Farad (F). The symbol of capacitor is shown below.



Symbol

- Quantitatively capacitance is a measure of charge per unit voltage that can be stored in an element.

$$\therefore \text{ Capacitance, } C = \frac{Q}{V}$$

- The current through the capacitor is given by,

$$i = \frac{dq}{dt} = C\frac{dV}{dt}$$

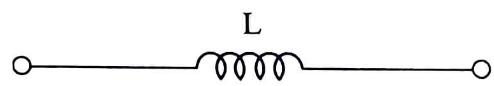
- The energy stored in a capacitor is given by,

$$W = \frac{1}{2} CV^2 \text{ Joules}$$

1.2.3 Inductacne (L)

Inductance is the property of a material by which it opposes any change of current passing through the conductor.

- A wire of finite length, when twisted into a coil, it becomes a simple inductor.
- An inductor is a coil which posses the property of inductance.
- The unit of inductance is henry (H). The symbol for an inductor is shown below.



Symbol

- When a coil carries a varying current an e.m.f is induced in it due to the change of flux linkages. The induced e.m.f is given as

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

where L = Inductance and $\frac{di}{dt}$ = time rate of change of current.

- The energy stored in an inductor is given as

$$W = \frac{1}{2} L\, i^2 \text{ joules}$$

1.3 ENERGY SOURCE

Energy source is a device which supplies electric energy to a circuit.

1.3.1 Classification of Energy Sources

There are basically two types of energy sources. They are :

1. Voltage sources
2. Current sources.

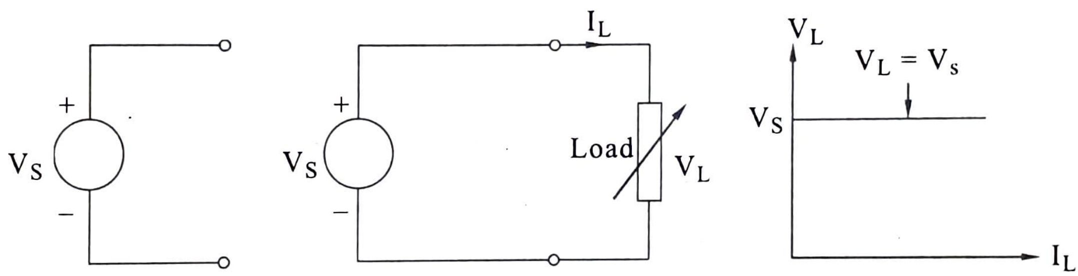
- Batteries and generators are normally used as voltage sources.
- Most of the semiconductor devices like transistor etc are treated as current sources.

1.4 IDEAL VOLTAGE SOURCE AND IDEAL CURRENT SOURCE

1.4.1 Ideal Voltage Source

An ideal voltage source is defined as the energy source which delivers a constant voltage to the load connected across its terminals, irrespective of the load current (I_L) variations.

The symbol of ideal voltage source and its V – I characteristics are shown in Fig. 1.1.

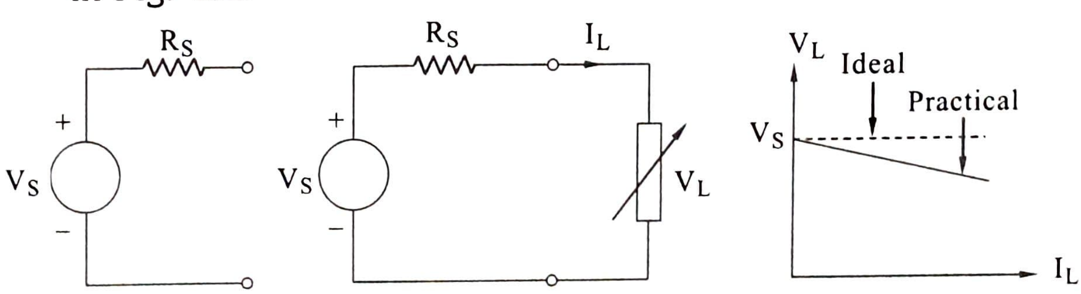


(a) Symbol **(b)** Circuit **(c)** V-I Characteristics

FIG 1.1 :

1.4.2 Practical Voltage Source

Ideal voltage source does not have internal resistance. But practically, every voltage source has small internal resistance in series with voltage source and represented by R_S as shown in Fig. 1.2.



(a) Symbol **(b)** Circuit **(c)** V-I Characteristics

FIG 1.2 :

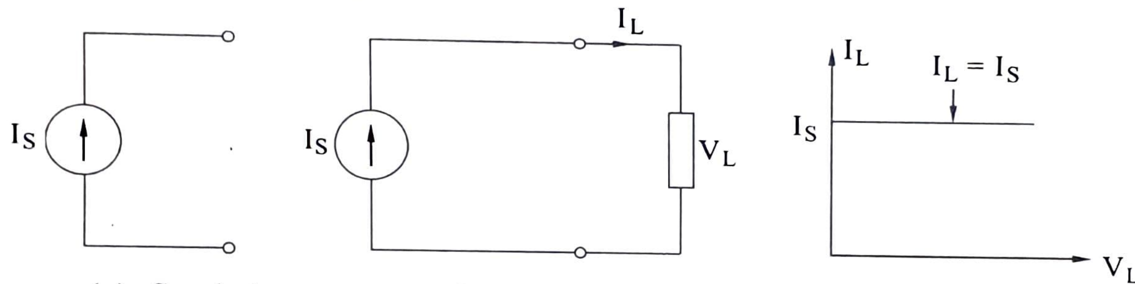
Fig. 1.2, shows the symbol of practical voltage source, and its V-I characteristics.

Because of internal resistance R_S, the voltage across the load terminals decreases slightly with increase in load current, as shown in Fig. 1.2 (c).

1.4.3 Ideal Current Source

An ideal current source is defined as the energy source which delivers a constant current to the load connected to its terminals, irrespective of the load voltage variations (V_L).

The symbol of ideal current source and its V – I characteristics are shown in Fig. 1.3.

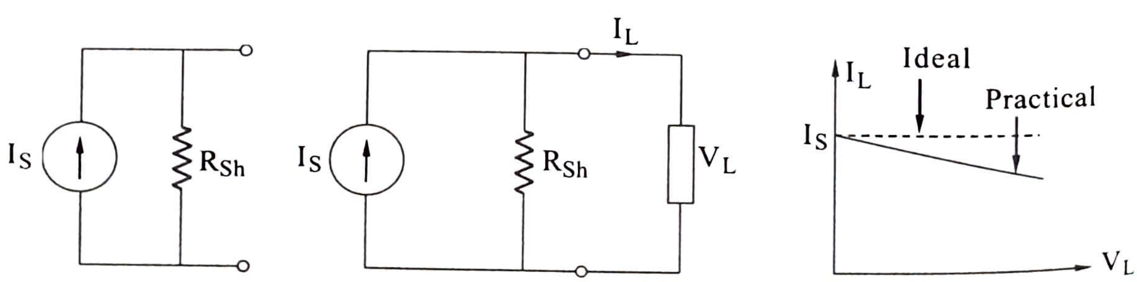


(a) Symbol **(b)** Circuit **(c)** V-I Characteristics

FIG 1.3 :

1.4.4 Practical Current Source

Ideal current source does not have internal resistance, but practically, every current source has high internal resistance, in parallel with current source and is represented by R_{sh} as shown in Fig. 1.4.



(a) Symbol **(b)** Circuit **(c)** V-I Characteristics

FIG 1.4 :

Because of internal resistance R_{sh}, the current through its terminal decreases slightly with increase in load voltage, as shown in Fig. 1.4 (c).

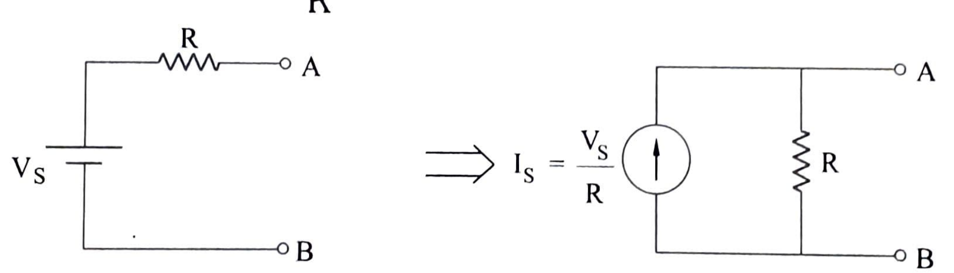
1.5 SOURCE TRANSFORMATION TECHNIQUE

It is often necessary or convenient to convert voltage source to current source and vice versa in solving complex networks. Replacing one source by an equivalent source is called **source conversion.** This conversion serves as powerful tool to simplify the analysis of circuit specially with mixed sources.

1.5.1 Conversion of Voltage Source to Current Source

Any voltage source V_S in series with a resistance **'R'** can be represented by a current source **"I_S"** in parallel with the resistance, R as shown and the magnitude of the current source,

$$I_S = \frac{V_S}{R}$$



Voltage Source

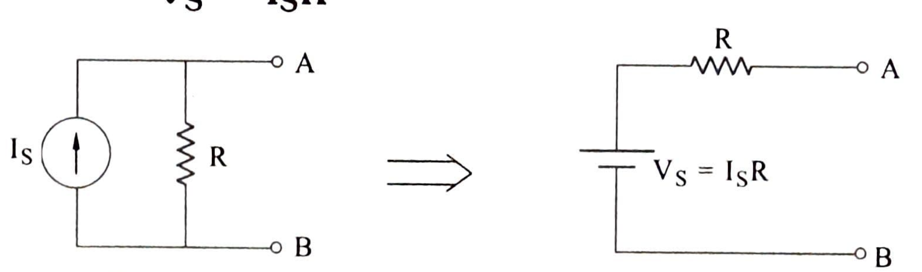
Equivalent Current Source

FIG 1.5 :

1.5.2 Conversion of Current Source to Voltage Source

Any current source **'I_S'** in parallel with a resistance **'R'** can be represented by a voltage source in series with resistance **'R'** as shown and the magnitude of the voltage source,

$$V_S = I_S R$$



Current Source

Equivalent Voltage Source

FIG 1.6 :

PROBLEM – 1

Convert the following voltage sources to an equivalent current sources.

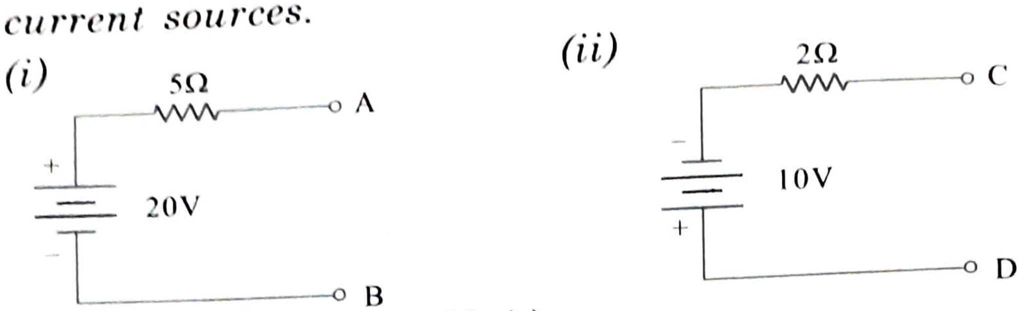


Fig (a) :

Solution :

(i) Given $V_S = 20$ V,

$R = 5\,\Omega$, then

$$I_S = \frac{V_S}{R} = \frac{20}{5} = 4\text{ A.}$$

∴ The equivalent current source is shown in Fig (b).

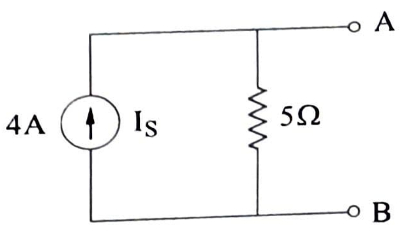


Fig (b) :

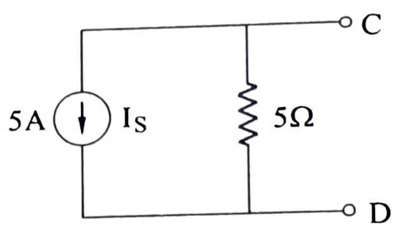


Fig (c) :

(ii) $$I_S = \frac{V_S}{R} = \frac{-10}{2} = -5\text{ A}$$

(minus indicates current 5 A circulates in anticlock wise)

∴ The equivalent current source is shown in Fig (c).

PROBLEM – 2

Convert the following current source to an equivalent voltage source.

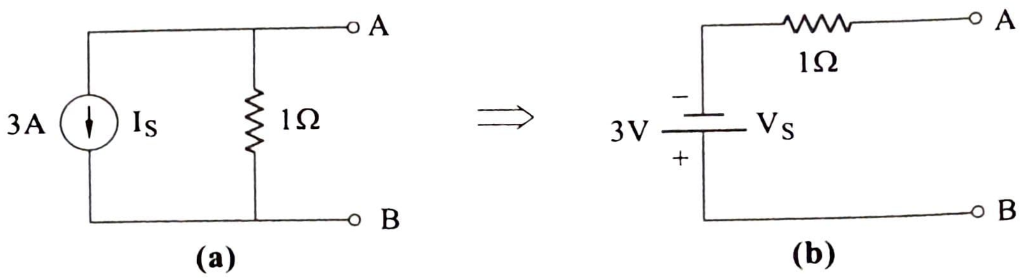


FIG :

Solution :

Given : $I_S = -3\text{ A}, \quad R = 1\,\Omega$, then

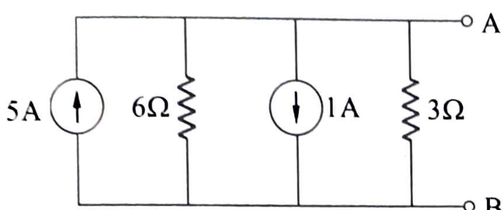
$$V_S = I_S R = -3 \times 1 = -3\text{ V}$$

$\therefore$ The equivalent voltage source is shown in Fig (b).

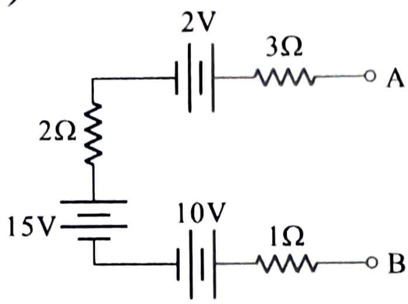
PROBLEM – 3

Find a single source equivalent at terminals AB of the circuits shown below.

(i)



(ii)



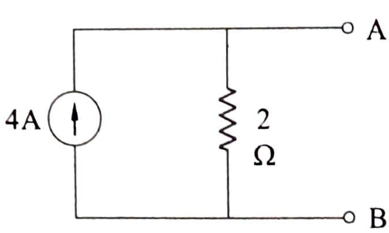
Solution :

Note :

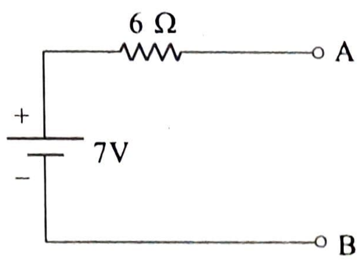
1. Current sources in parallel can be added or substracted depending on the direction of current.
2. Voltage sources in series can be added or subtracted depending on their polarities.

(i) Total current $\quad I_S = 5 - 1 = 4\,A$ and $R = \dfrac{6 \times 3}{6+3} = 2\Omega$

$\therefore$ The equivalent single current source is shown in Fig (a).



(a)



(b)

FIG :

(ii) Total voltage $\quad V_{AB} = 2 + 15 - 10 = 7\,V = V_S$

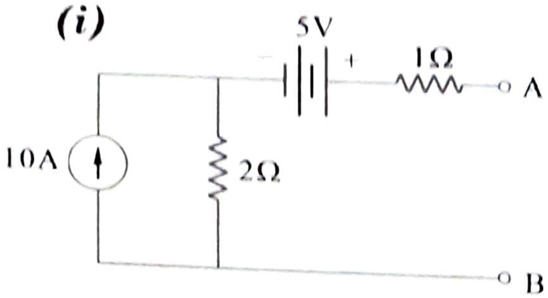
$$R = 3 + 2 + 1 = 6\Omega$$

$\therefore$ The equivalent voltage source is shown in Fig (b).

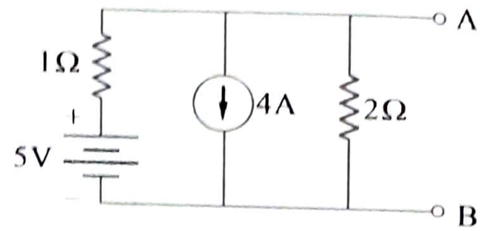
PROBLEM – 4

Find a single source equivalent at terminals AB of the circuits shown below.

(i)



(ii)



Solution :

(i) Converting 10 A source in parallel with $2\,\Omega$ to an equivalent voltage source, we get

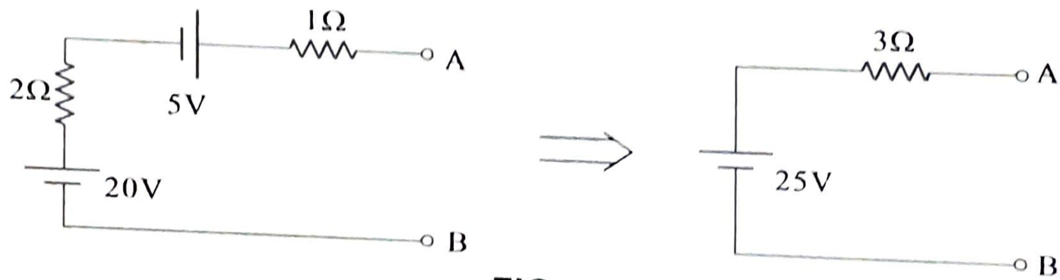


FIG :

(ii) Converting the 5 V source in series with $1\,\Omega$ to an equivalent current source we get.

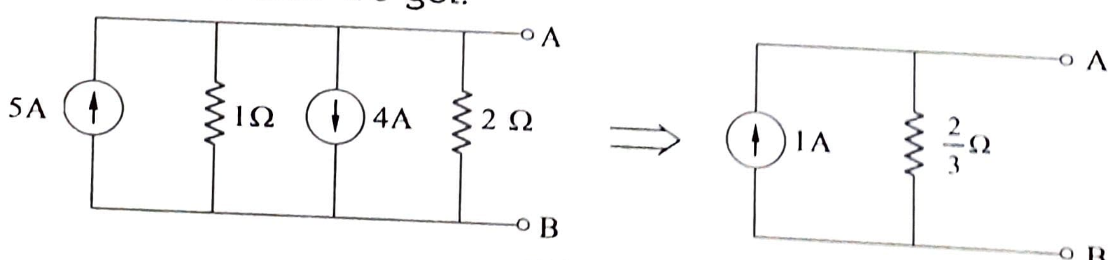
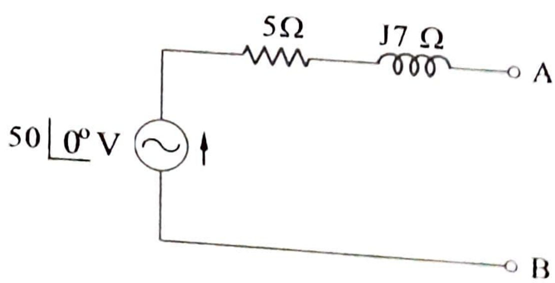


FIG :

PROBLEM – 5

Convert the following voltage source into a equivalent current source ?

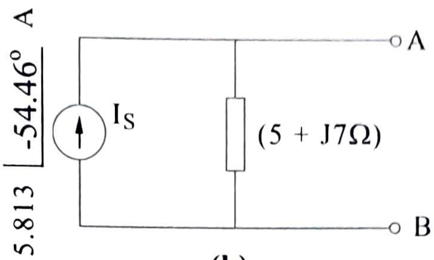


(b)

Solution :

$$I_S = \frac{V_S}{Z} = \frac{50\angle 0^\circ}{(5+J7)} = \frac{50\angle 0^\circ}{8.6\angle 54.46}$$

$$I_S = 5.813\angle -54.46^\circ \text{ A}$$



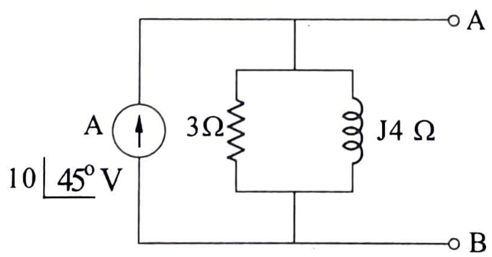
(b)

∴ The equivalent current source is shown in Fig (b) above

PROBLEM – 6

Convert the following current source into equivalent voltage source.

APRIL. 2004

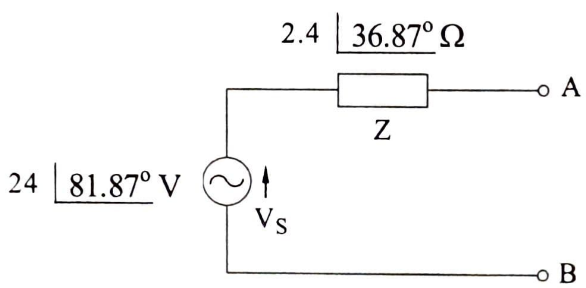


Solution :

$$V_s = I_S Z = 10\angle 45^\circ \times \frac{3 \times J4}{3 + J4} = 10\angle 45^\circ \times 2.4\angle 36.87^\circ$$

$$V_s = 24\angle 81.87^\circ \text{ volts.}$$

∴ The equivalent voltage source is shown in figure below.



OCT/NOV. 2017

1.6 OHM'S LAW

Statement : *"Ohm's Law states that, at constant temperature, the current flowing through the conductor is directly proportional to the applied voltage and inversely proportional to the resistance of that conductor."*

Mathematically $I = \frac{V}{R}$ (or) $V = IR$

Where V = Applied voltage in volts,

I = Resulting current in amperes,

R = Resistance in ohms.

Ohm's Law for a.c. Circuit : The ohm's law can be applied to *d.c.* as well as ac circuits. However, in case of *a.c.* circuits impedance Z, is used in place of resistance.

Thus ohm's law for *a.c.* circuit is given by

$$I = \frac{V}{Z} \text{ (or) } V = IZ$$

OCT/NOV. 2017

1.6.1 Limitations of Ohm's Law

Ohm's law is not applicable under the following conditions :

1. For non linear devices such as diode, transistor etc.
2. For metals which get heated up due to flow of current through them.
3. For electrolytes where enormous gases are produced on electrodes.
4. For semi conductors.
5. For vaccum tubes.
6. For gas filled tubes.
7. For arc lamps.

1.7 KIRCHOFF'S LAWS

OCT/NOV. 2017

In 1847, a German physicist, **Kirchoff**, formulated two fundamental laws of electricity. These laws are of tremendous importance from network simplication point of view.

1.7.1 Kirchoff's Current Law (KCL)

"Kirchoff's Current law states that, the sum of the currents entering a junction is equal to the sum of the currents leaving the junction".

(or)

"It states that the algebraic sum of all the currents meeting at a common junction is zero".

Mathematically ΣI at Junction = 0.

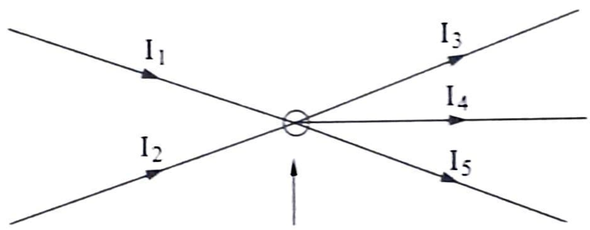


FIG 1.7 :

Σ currents entering = Σ currents leaving

$$I_1 + I_2 = I_3 + I_4 + I_5$$

(or) $$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

Note : is very much useful in node voltage analysis.

1.7.2 Kirchoff's Voltage Law (KVL)

"Kirchoff's voltage law states that, the sum of the potential rises around any closed circuit is equal to the sum of the potential drops in that circuit".

Mathematically,

Σ potential rises = Σ potential drops

Σ e.m.fs = Σ IR drops.

(or)

" It states that, the algebraic sum of potential rises and potential drops around a closed circuit is zero".

Mathematically, $\sum V = 0$

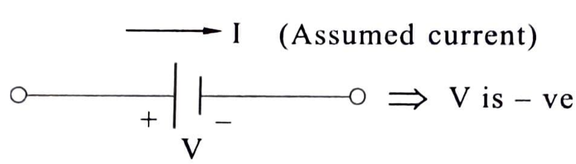
NOTE : KVL is very much useful in mesh current analysis.

1.7.3 Sign Convention

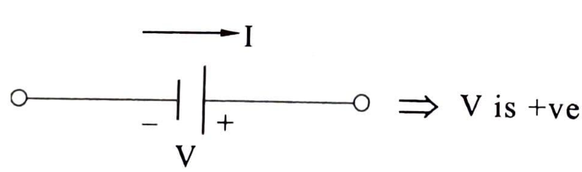
While applying KVL to a closed path, we have to assign polarities, i.e., + or – to voltage rises and voltage drops.

1. **Sign Convention for Voltage Sources :** The polarity of the voltage sources purely depends on the direction of the assumed mesh currents.

   (i) ***Sign Convention for DC Source :*** If the assumed mesh current passes from + to – terminal of the source, then it is considered as potential drop and assigned negative sign for that voltage.

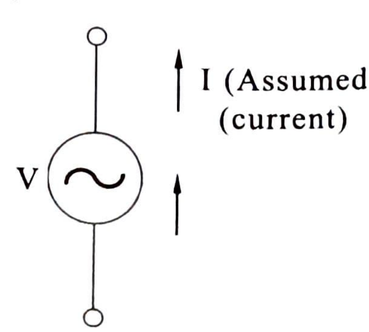


   - If the assumed mesh current passes from – to + terminal of the source, then it is considered as potential rise and positive sign is assigned for that voltage.

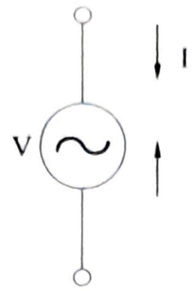


   (ii) **Sign Convention for a.c. Source :**

   - The voltage of the ac source is taken as positive if it is in the same direction of the assumed current.



- The voltage of the ac source is taken as negative if it is in the opposite direction of the assumed current.



2. **Sign Convecation for Passive Elements :** We can assign a positive (+) sign for the voltage to the terminal of the element where the current enters and a negative sign to the terminal of the element where the current leaves it.

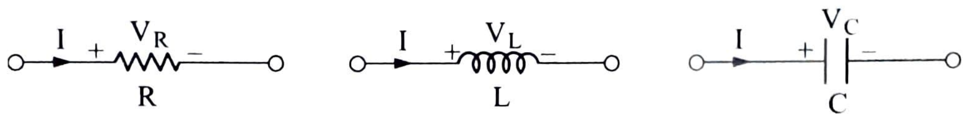


FIG 1.8 :

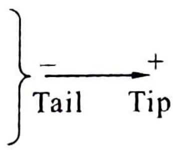
From the above figure, we observed that in all passive elements , the current I is passing from + to – terminal. Hence all passive elements are considered as potential drops.

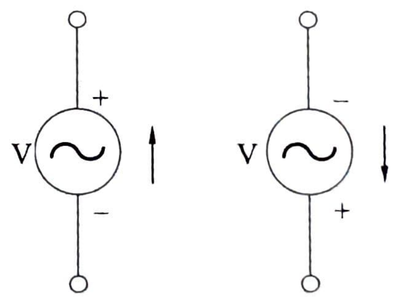
Note : While applying KVL to the circuit, polarities of voltage sources are very important. To avoid confusion, We can assign polarities for a.c. source also.

For example :

Tip → Positive

Tail → Negative





1.7.4 *Steps to Apply KVL to get Network Equations*

Step-1 : *Assume the direction of mesh currents for each loop.*

- We can assume the direction of mesh currents arbitrarily i.e., either clock wise or anti clock wise direction.

  But to avoid negative currents, it is better to choose the direction of mesh current from + to – terminal of a battery.

Step-2 : *Apply KVL for various loops.*

- To apply KVL in a closed path, start any point in the path and proceed round the path in the direction of assumed current.
- While traversing a closed path if we move from positive terminal to negative terminal, there is a potential drop, which is assigned a negative sign.
- if we move from – to + terminal, there is a potential rise, Which is assigned a positive sign.
- Add all the voltages across the elements algebraically till the starting point is reached.
- The resulting equation is called KVL equation.
- The final KVL equation is the same wheather the closed path is traversed in clock wise or anti clock wise direction.

Step-3 : Solve the KVL equations and obtain the values of the assumed currents

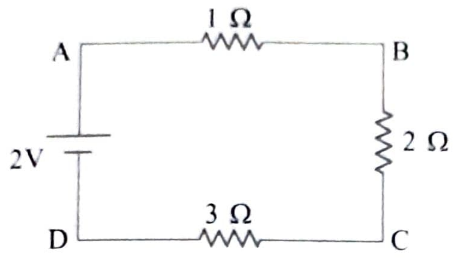
Setp-4 : If the calculated value of a particular current has positive sign, it means that its assumed direction is correct.

If it has a negative value then the actual direction is opposite to that of assumed current.

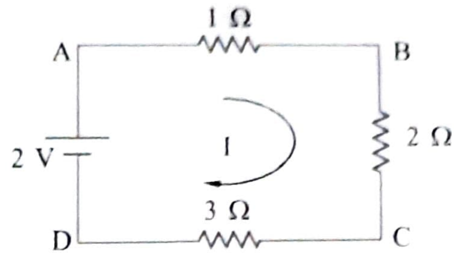
1.8 SOLVED PROBLEMS ON KCL AND KVL

EXAMPLE - 1

Find the current flowing through, voltage drop and power dissipation across the 2-Ω resistor for the circuit shown in Fig. (a) below.



(a)



(b)

Solution :

Step-1 : Assume clock wise current as shown in Fig (b) for the given closed circuit.

NOTE : If we choose anti clock wise direction for this circuit, we get negative current, because 2V source delivers clock wise current through the circuit.

Step-2 : Applying KVL for the closed path, ABCDA we get KVL equation.

KVL : $\sum IR$ drop $= \sum$ e.m.fs

[∵ 2 V source is considered as potential rise, because, the assumed mesh current is passing from – to + terminal of the source. Hence positive sign is assigned.]

$$1\,I + 2\,I + 3\,I = 2$$

$$6\,I = 2$$

$$I = \frac{2}{6} = 0.33\ A$$

(a) The Current flowing through $2\,\Omega$ resistor is

$$I_{2\Omega} = I = 0.33\ A$$

(b) The voltage drop across the $2\,\Omega$ resistor is

$$V_{2\Omega} = I\,R = 0.33 \times 2 = 0.66\ V$$

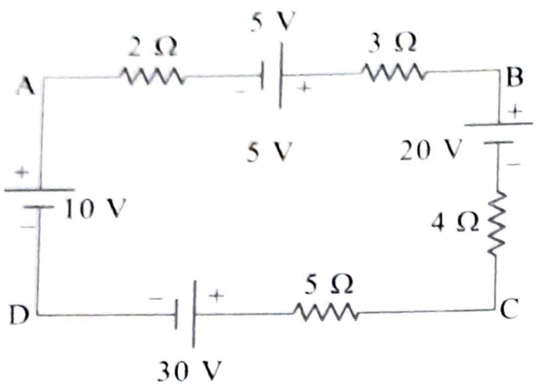
[according to ohms law $V = IR$]

(c) Power dissipated across the $2\,\Omega$ resistor is

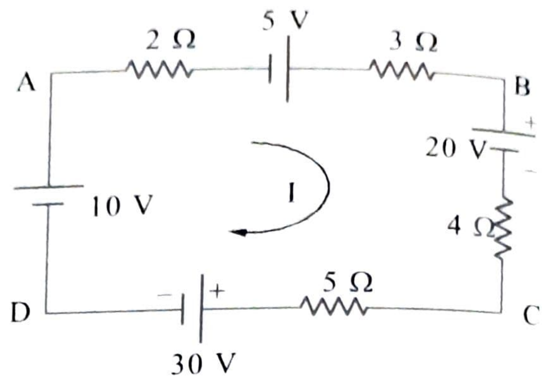
$$P_{2\Omega} = I^2 R = (0.33)^2 \times 2 = 0.2178\ watts$$

EXAMPLE – 2

Find the current following through 3Ω resister for the circuit shown in Fig. (a) below.



(a)



(b)

Solution :

Step-1 : Assume the direction of the mesh current for the closed mesh ABCDA, as shown in Fig (b).

Note : When multi-sources are given in a circuit, assume clock wise direction.

Step-3 : Applying *KVL* for the closed loop, we get *KVL* equation.

KVL : $\sum IR$ drops = $\sum$ e.m.fs

$$2I + 3I + 4I + 5I = 5 - 20 - 30 + 10$$

$$14I = -35$$

$$I = \frac{-35}{14} = -2.5\ A$$

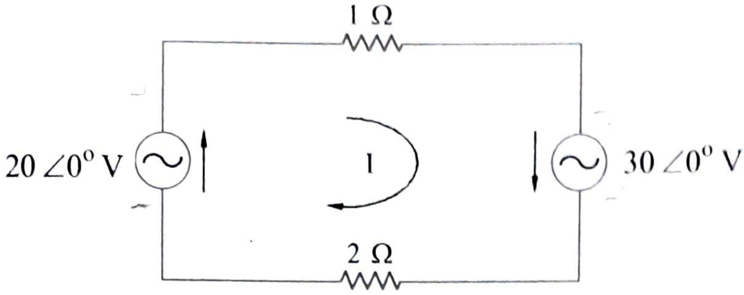
Here the current *I* is negative, hence the actual direction of *I* is opposite to that of assumed clock wise direction, i.e., *I* flows through the circuit is in anti clock wise direction.

∴ The current following through 3Ω resistor is

$$I_{3\Omega} = I = 2.5\ \text{A (anti clock wise)}$$

EXAMPLE – 3

Find I in the circuit shown in figure below.



Solution :

Applying KVL for the closed circuit, we get

KVL equation.

KVL :

$$\sum IR \text{ drops} = \sum \text{e.m.f's}$$

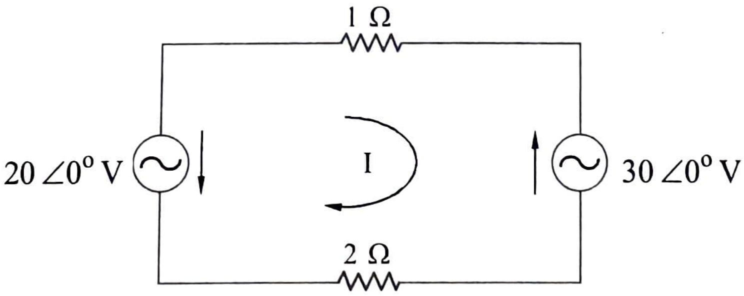
$$1\,I + 2\,I = 30\angle 0^\circ + 20\angle 0^\circ$$

$$3\,I = 50\angle 0^\circ$$

$$I = \frac{50\angle 0^\circ}{3} = \mathbf{16.66\ A}$$

EXAMPLE – 4

Find I in the circuit shown in figure below.



Solution :

Applying KVL for the closed circuit,

We get,

$$1\,I + 2\,I = -\,30\angle 0^\circ - 20\angle 0^\circ$$

$$3\,I = -\,50\angle 0^\circ$$

$$\text{I} = \frac{-50\angle 0^\circ}{3} = -\,\mathbf{16.66\ A}$$

EXAMPLE – 5

Write KVL equation for the circuit shown in figure below.

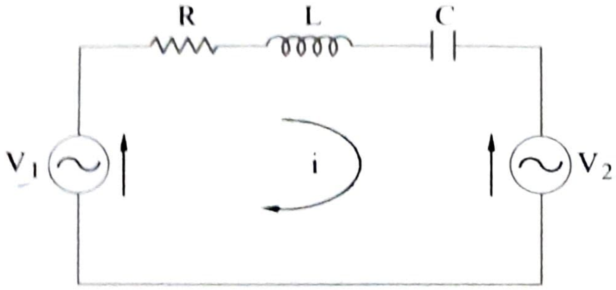


FIG :

Solution :

Apply KVL for the closed circuit, we get

$$R\,i + L\frac{di}{dt} + \frac{1}{C}\int i\,dt = V_1 - V_2$$

EXAMPLE – 6

Determine the current through resistance R_3 in the circuit shown in figure below.

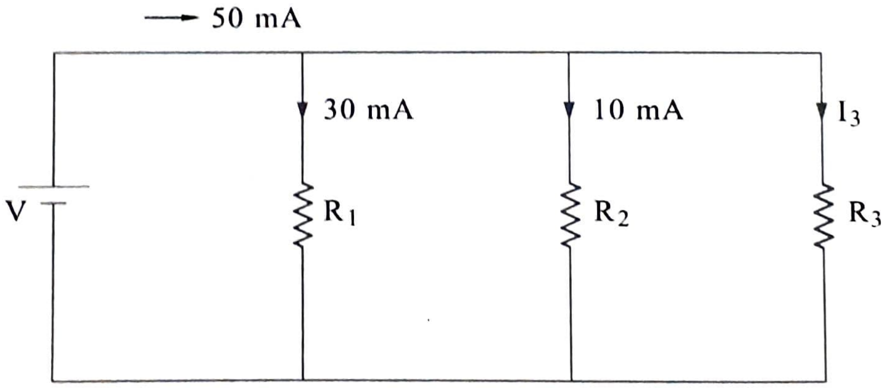


FIG :

Solution :

According to KCL,

$$I_T = I_1 + I_2 + I_3$$

Where I_T is the total current and I_1 , I_2 and I_3 are the currents in resistances R_1, R_2 and R_3 respectively.

$$50 = 30 + 10 + I_3 \quad \text{(or)}$$

$$I_3 = 50 - 40 = 10 \text{ mA}$$

EXAMPLE – 7

Determine the current in all resistors in the circuit shown in figure below.

MAR/APR. 2016

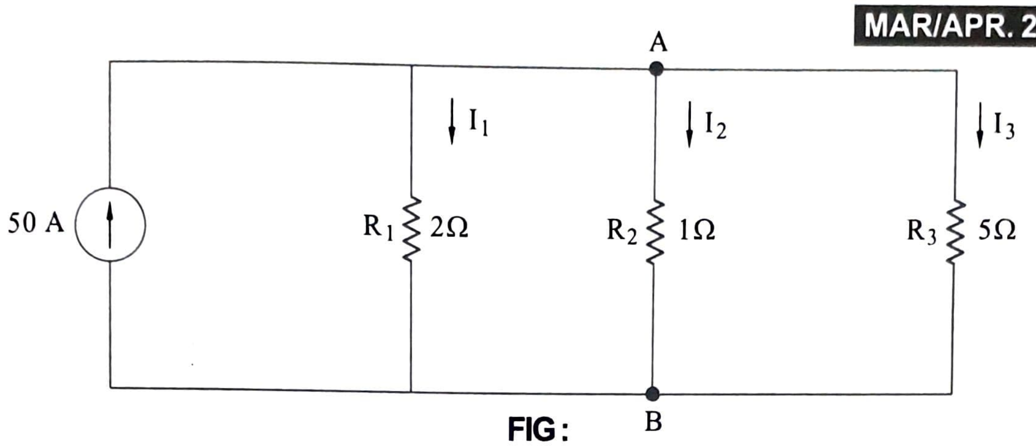


FIG :

Solution :

The above circuit contains a single node 'A' with reference node 'B'. Our first step is to assume the voltage V at node A. In a parallel circuit the same voltage is applied across each element. According to ohm's law, the current passing through each element are

$$I_1 = \frac{V}{2},\ I_2 = \frac{V}{1},\ I_3 = \frac{V}{5}$$

By applying Kirchoff's current law, we have

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{2} + \frac{V}{1} + \frac{V}{5}$$

$$50 = V\left[\frac{1}{2} + \frac{1}{1} + \frac{1}{5}\right] = V\,[0.5 + 1 + 0.2]$$

$$V = \frac{50}{1.7} = 29.41V$$

Once We know the voltage V at node A, We can find the current in any element by using ohm's law.

The current in the 2Ω resistor is

$$I_1 = \frac{V}{R_1} = \frac{29.41}{2} = 14.705\ A$$

$$I_2 = \frac{V}{R_2} = \frac{29.41}{1} = 29.41\ A$$

$$I_3 = \frac{V}{R_3} = \frac{29.41}{5} = 5.882\ A$$

EXAMPLE – 8

For the circuit shown in fig (a) below, find the voltage across the 10 Ω resistor and the current passing through it.

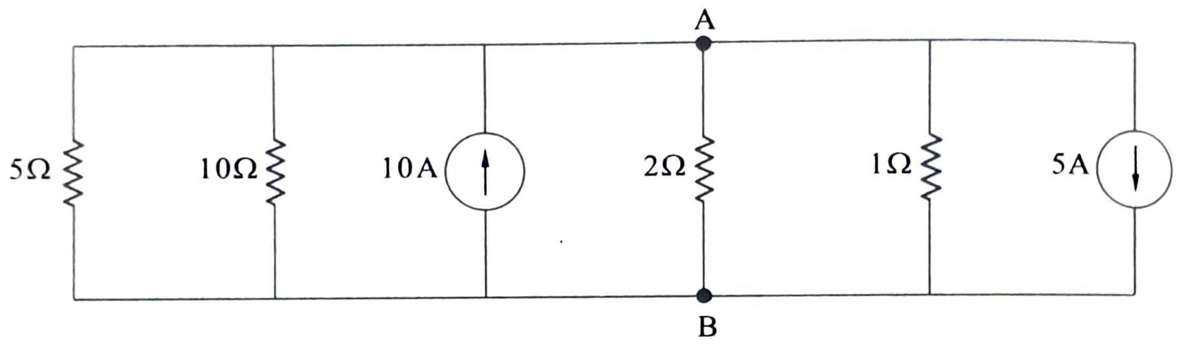


FIG (A) :

Solution :

The circuit shown above is a parallel circuit, and consists of a single node A. By assuming voltage V at the node A w.r.t B, we can find out the current in the 10 Ω branch.

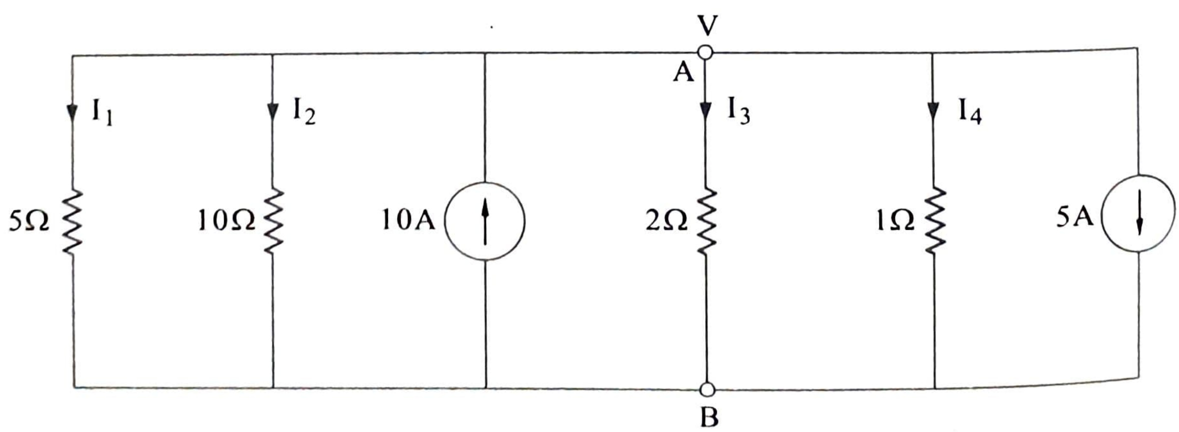


FIG (B) :

According to K.C.L

$$I_1 + I_2 + I_3 + I_4 + 5 = 10$$

By using ohm's law we have

$$I_1 = \frac{V}{5};\ I_2 = \frac{V}{10};\ I_3 = \frac{V}{2};\ I_4 = \frac{V}{1}$$

$$\frac{V}{5} + \frac{V}{10} + \frac{V}{2} + \frac{V}{1} + 5 = 10$$

$$V\left[\frac{1}{5} + \frac{1}{10} + \frac{1}{2} + 1\right] = 5$$

$$V\,[0.2 + 0.1 + 0.5 + 1] = 5$$

$$V = \frac{5}{1.8} = 2.78\text{ V}$$

$\therefore$ The voltage across the $10\,\Omega$ resistor is 2.78 V and current passing through it is.

$$I_2 = \frac{V}{10} = \frac{2.78}{10} = 0.278\text{ A}$$

EXAMPLE – 9

Determine the total current in the circuit shown in figure below.

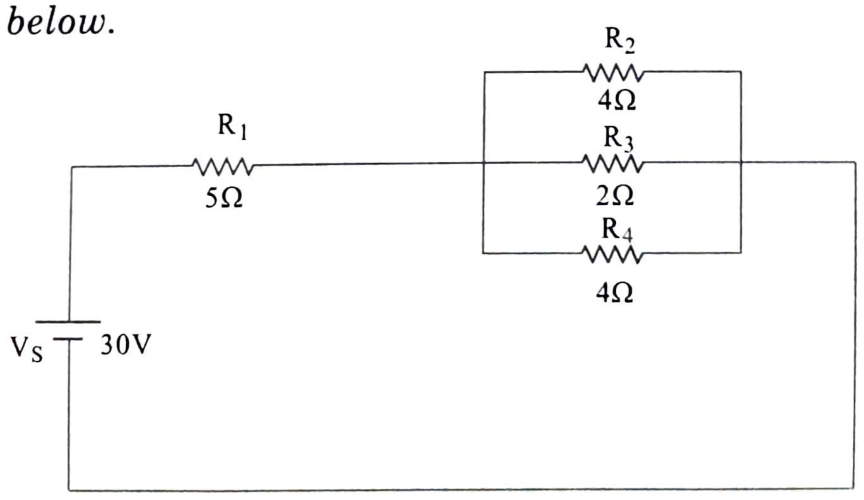


FIG :

Solution :

Resistances, R_2, R_3 and R_4 are in parallel.

∴ Equivalent resistance,

$$R_{eq} = R_2 \| R_3 \| R_4$$

$$R_{eq} = \frac{1}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}} = \frac{1}{\frac{1}{4} + \frac{1}{2} + \frac{1}{4}} = 1\,\Omega$$

Now, R_1 and R_{eq} are inseries.

∴ Total resistance,

$$R_T = R_1 + R_{eq}$$

$$R_T = 5 + 1 = 6\Omega$$

The total current, $I_T = \frac{V_S}{R_T} = \frac{30}{6} = 5A$

EXAMPLE – 10

For the circuit shown in fig (a) below, find the current through resistor R_3. Given that the voltage source supplies a current of 3A.

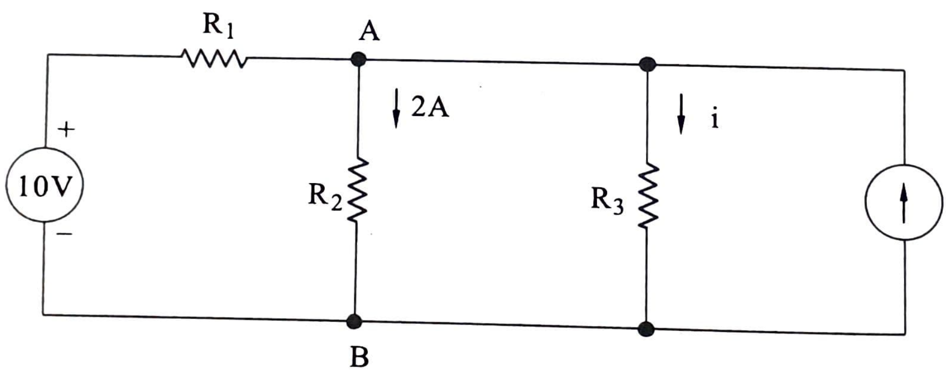


FIG (A) :

Solution :

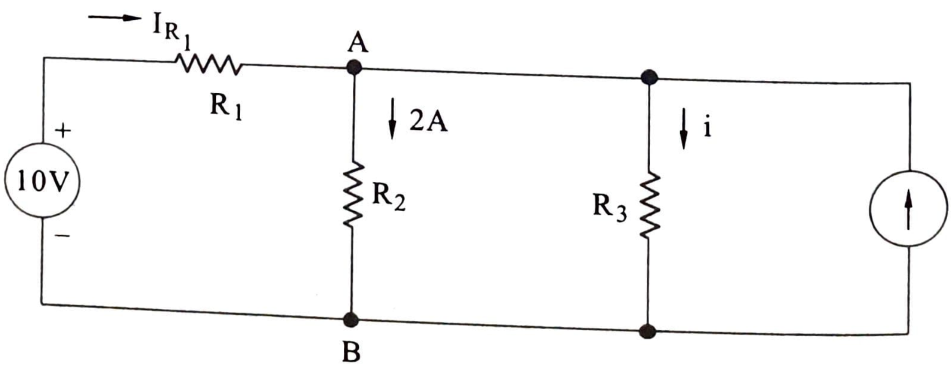


FIG (B) :

Applying KCL at node 'A', we get

$$I_{R1} - 2 - i + 5 = 0$$

The voltage source supplies a current of 3A. This is equal to I_{R1}.

Substituting, $I_{R1} = 3$ A,

We get $3 - 2 - i + 5 = 0$ (or)

$$i = 6 \text{ A}$$

$\therefore$ The current flowing through the resistor R_3 = 6A

EXAMPLE – 11

In the circuit shown in figure, find V_x and i_x.

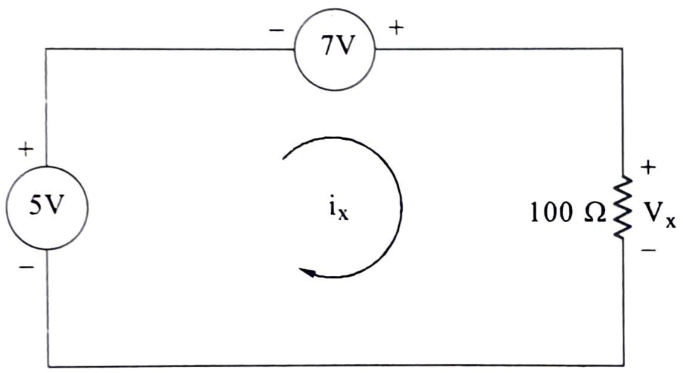


FIG :

Solution :

Applying KVL around the loop to get V_x.

$$-5 - 7 + V_x = 0 \quad \text{(or)}$$

$$V_x = 12 \text{ V}$$

By Ohm's law,

$$i_x = \frac{V_x}{100} = \frac{12}{100}$$

$$i_x = 120 \text{ mA}$$

EXAMPLE – 12

Determine i_x and V_x in the circuit shown in figure below.

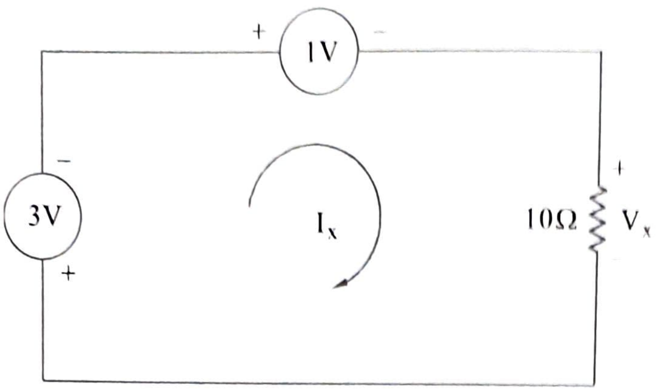


FIG :

Solution :

Applying KVL for a closed loop to get V_x

$$+3+1+V_x = 0 \text{ (or)}$$

$$V_x = -4V$$

By Ohm's law,

$$i_x = \frac{V_x}{10} = \frac{-4}{10}$$

$$\therefore \quad I_x = -400 \text{ mA.}$$

EXAMPLE – 13

Determine the current i also find the power delivered by the 80V source.

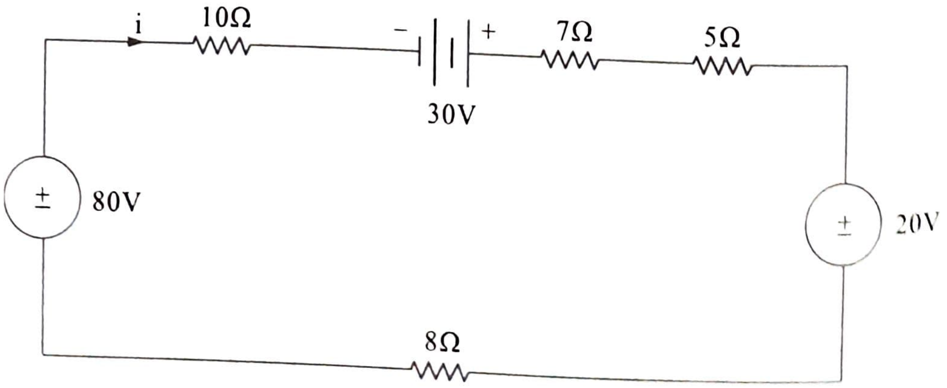


FIG :

Solution :

Applying KVL, we get

$$-80 + 10i - 30 + 7i + 5i + 20 + 8i = 0$$

$$-90 + 30i = 0 \text{ (or)}$$

$$i = \frac{90}{30} = 3A$$

The power delivered by the 80 V source

$$P_S = V_S \times i = 80 \times 3 = 240W$$

EXAMPLE – 14

Obtain a single current source for the network shown in Fig. (a) below.

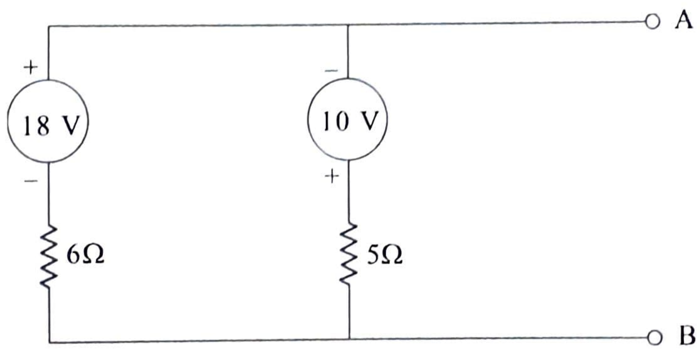


FIG (A) :

Solution :

Let us first convert the voltage sources to equivalent current source.

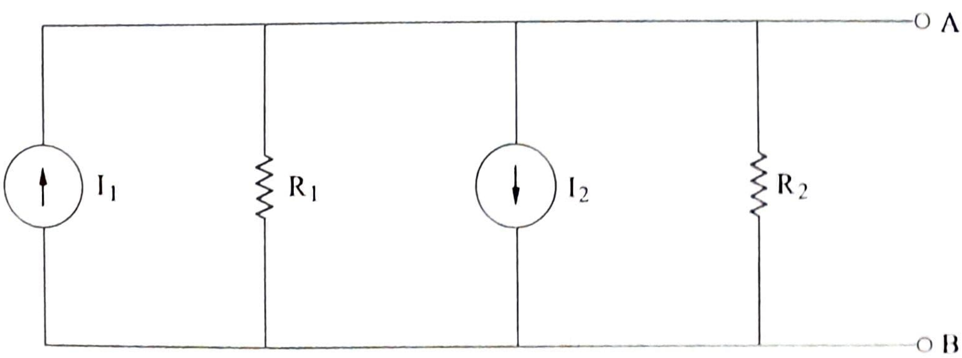


FIG (B) :

Here $I_1 = \frac{18}{6} = 3A,$

$$I_2 = \frac{10}{5} = 2A$$

$$R_1 = 6\Omega \text{ and } R_2 = 5\Omega$$

The equivalent current source is obtained as

$$I_{eq} = I_1 - I_2 = 3 - 2 = 1A$$

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{6 \times 5}{6 + 5} = 2.73 \ \Omega$$

∴ The equivalent single current source is shown in figure below.

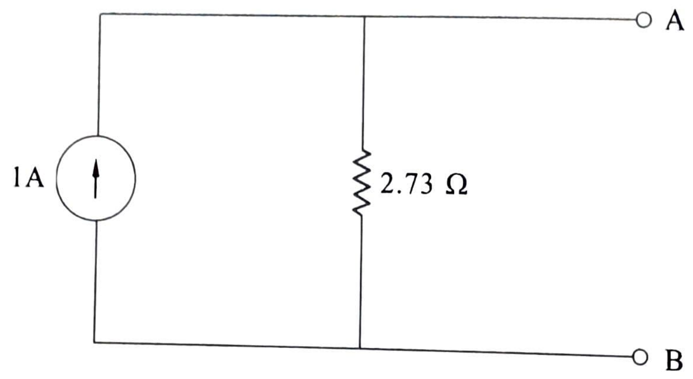


FIG :

EXAMPLE – 15

Convert the following circuit shown in Fig. (a) below into a single voltage source.

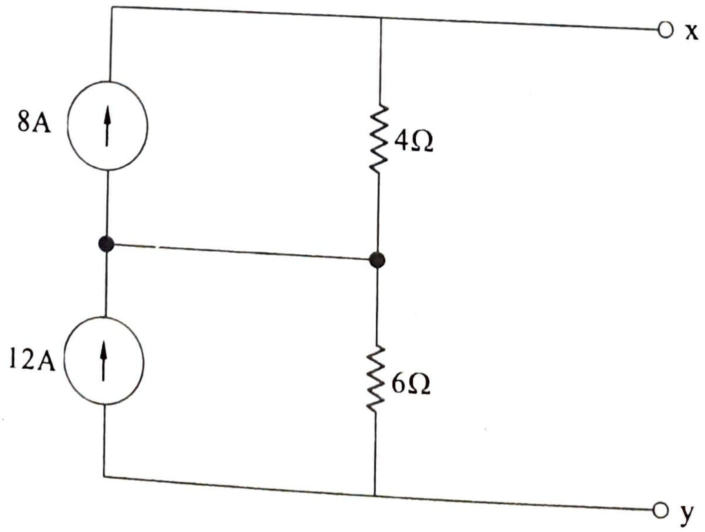
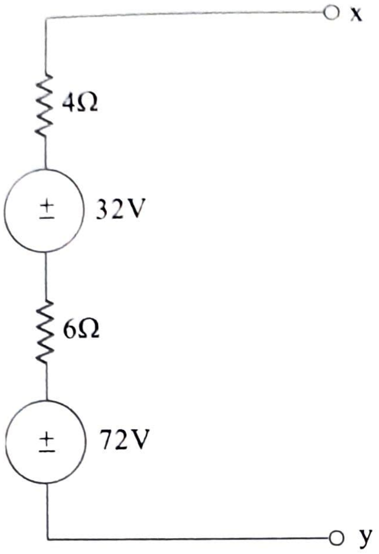


FIG (A) :

Solution :

Let us first convert the multiple current sources into equivalent voltage sources as shown in Fig. (b). These voltage sources



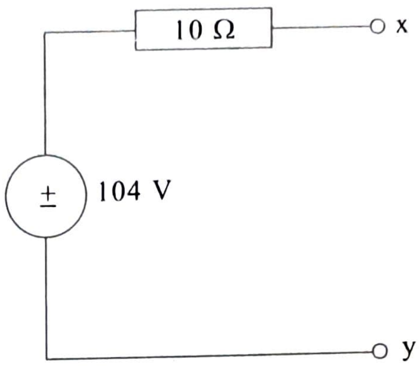


FIG (C) :

FIG (B) :

are transformed into single voltage source, where

$$V_{eq} = 32 + 72 = 104 \text{ V}$$

$$R_{eq} = 4 + 6 = 10\,\Omega$$

EXAMPLE – 16

Three resistors $R_1 = 5\Omega$, $R_2 = 10\Omega$ and $R_3 = 15\Omega$ are joined in series and a 10 V, voltage source is connected across them. Find the voltage drops across R_1, R_2, R_3 using voltage division.

Solution :

As per given data the circuit can be drawn as

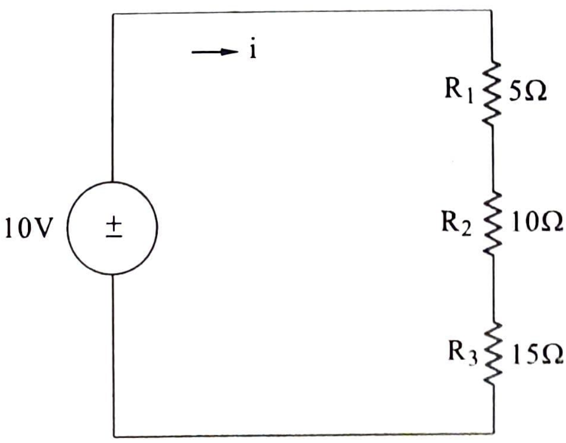


FIG :

∴

Total resistance $R_{eq} = R_1 + R_2 + R_3$

$$R_{eq} = 5 + 10 + 15 = 30\,\Omega$$

Also voltage drops across the resistors

$$R_1 \text{ is } V_1 = \frac{V \times R_1}{R_{eq}} = \frac{10 \times 5}{30} = \frac{50}{30}\,V$$

$$R_2 \text{ is } V_2 = \frac{V \times R_2}{R_{eq}} = \frac{10 \times 10}{30} = \frac{10}{3}\,V \text{ and}$$

$$R_3 \text{ is } V_3 = \frac{V \times R_3}{R_{eq}} = \frac{10 \times 15}{30} = \frac{150}{30} = 5\,\Omega$$

EXAMPLE – 17

In the circuit shown in figure below, find the currents I_1 and I_2 by the current division method.

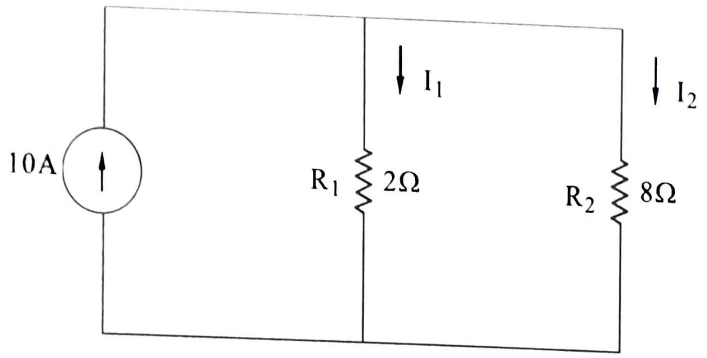


FIG :

Solution :

By current division rule

$$I_1 = I \times \frac{R_2}{R_1 + R_2} = \frac{10 \times 8}{2+8} = 8\text{ A}$$

$$I_2 = I \times \frac{R_1}{R_1 + R_2} = 10 \times \frac{2}{2+8} = 2\text{ A}$$

EXAMPLE – 18

In the circuit shown in Fig. (a) below, find the current I and the voltage across the 30Ω resistor.

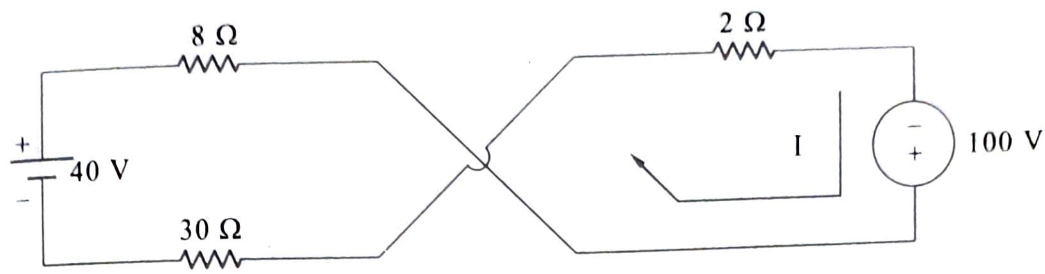


FIG (A) :

Solution :

We redraw the circuit and assume current direction as shown in Fig. (b) below.

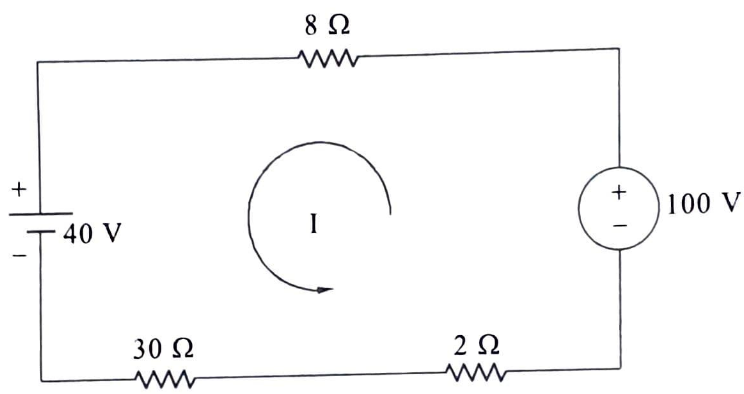


FIG (B) :

By applying KVL for the closed loop, we get

$$8\,I + 40 + 30\,I + 2\,I - 100 = 0$$

$$40\,I - 60 = 0$$

(or) $$I = \frac{60}{40} = 1.5 \text{ A}$$

$\therefore$ Voltage drop across $30\,\Omega$ resistor is

$$V_{30} = IR = 1.5 \times 30 = 45 \text{ V}$$

REVIEW QUESTIONS

Short Answer Questions :

1. Define active and passive elements.
2. Define active elements and write any three examples. **(Oct/Nov. 2017)**
3. Define energy source.
4. Classify the energy sources.
5. State Ohm's law and mention any three limitations. **(Oct/Nov. 2017)**
6. State the limitations of ohm's law.
7. State KCL and KVL.

Essay Type Questions :

1. Explain ideal voltage source and ideal current source. **(Oct/Nov. 2012, 2008 ; April/May. 2010 ; March. 2008)**
2. State Kirchoff's current law and Kirchoff's voltage law. **(Oct/Nov. 2017)**
3. Explain resistance, capacitance and inductance paramenters.
4. Convert ideal voltage source to ideal current source and vice versa. **(Oct/Nov. 2017)**