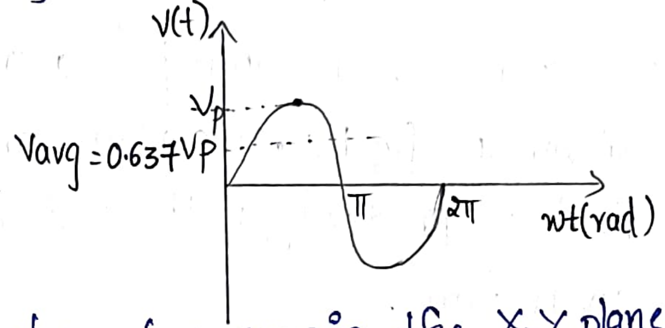
1.a. Derive the mathematical expression for average value, RMS value, peak factor and form factor of a sinusoidal voltage waveform.

Ans: Average value of a sinusoidal voltage wave form:

The average value of any function v(t) with period 'T' is given by

$$\therefore V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt$$



That means the average value of a curve in the X-Y plane is the total area under the complete curve divided by the distance of the curve.

. The average value of a sine wave over one complete cycle is always zero. So the average value of a sine wave is defined over a half cycle and not a full cycle period.

. The average value of the sine wave is the total area under the half cycle curve divided by the distance of the curve.

$$\therefore \text{Average value of sine wave} = \frac{\text{Total area under half-cycle curve}}{\text{Distance of the curve}}$$

The average value of the sine wave $v(t) = V_p \sin\omega t$ is given by

$$V_{avg} = \frac{1}{\pi}\int_0^{\pi} V_p \sin\omega t \, d(\omega t)$$

$$= \frac{V_p}{\pi}\left[-\cos\omega t\right]_0^{\pi} = \frac{V_p}{\pi}\left[-(-1-1)\right]$$

$$= \frac{2V_p}{\pi}$$

$= 0.637 V_p$

$\therefore V_{avg} = 0.637 V_p$

RMS value of a sinusoidal voltage waveform:

The root mean square (rms) value of a sine wave is a measure of the heating effect of the wave.

- When a resistor is connected accross a DC voltage source as shown in fig.1a, a certain amount of heat is produced in the resistor in a given time.

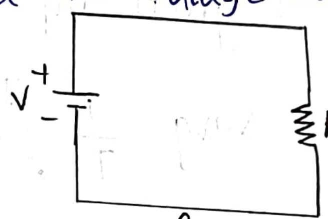


fig.1a

- A similar resistor is connected across an AC voltage source ~~for~~ on the same time as shown in fig.1b. The value of the AC voltage is adjusted such that the same amount of heat is produced in the resistor ~~as~~ in the case of the DC source. This value is called the RMS value.

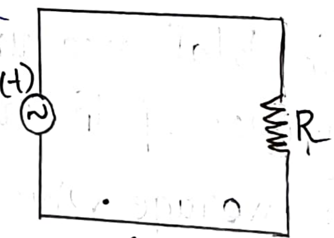


fig.1b

- That means the RMS value of a sine wave is equal to the DC voltage that produces the same heating effect.
- In general, the RMS value of any function with period 'T' has an effective value given by, $V_{rms} = \sqrt{\frac{1}{T}\int_0^T (v(t))^2 dt}$

consider a function $v(t) = V_p \sin\omega t$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T (V_p \sin\omega t)^2 d(\omega t)}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V_p^2 \left[\frac{1-\cos 2\omega t}{2}\right] d(\omega t)}$$

$$= \sqrt{\frac{V_p^2}{2\pi} \cdot \frac{1}{2}\left[\int_0^{2\pi} 1 \cdot d\omega t - \int_0^{2\pi} \cos 2\omega t \, d\omega t\right]}$$

$$= \sqrt{\frac{V_p^2}{4\pi}\left[[\omega t]_0^{2\pi} - \left[\frac{\sin 2\omega t}{2}\right]_0^{2\pi}\right]}$$

$$= \sqrt{\frac{V_p^2}{4\pi}(2\pi - 0) - \frac{1}{2}\left[\sin 2(2\pi) - \sin(0)\right]}$$

$$= \sqrt{\frac{V_p^2}{4\pi}(2\pi) - 0}$$

$$= \frac{V_p}{\sqrt{2}} = 0.707 V_p$$

$\therefore$ $V_{rms} = 0.707 \, V_p$

Peak Factor of a sinusoidal voltage wave form:

The peak factor of any waveform is defined as the ratio of the peak value of the wave to the RMS value of the wave

$$\therefore \text{Peak factor} = \frac{V_p}{V_{rms}}$$

For sinusoidal wave form, Peak factor $= \frac{V_p}{V_p/\sqrt{2}} = \sqrt{2} = 1.414$

Peak factor $= 1.414$

Form factor of a sinusoidal voltage wave form:

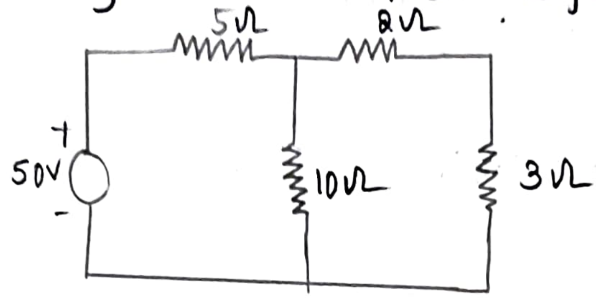
Form factor of a wave form is defined as the ratio of RMS value to the average value of the wave.

$$\therefore \text{Form factor} = \frac{V_{rms}}{V_{avg}}$$

for sinusoidal wave form, form factor $= \dfrac{V_P/\sqrt{2}}{0.637 V_P}$

$= 1.11$

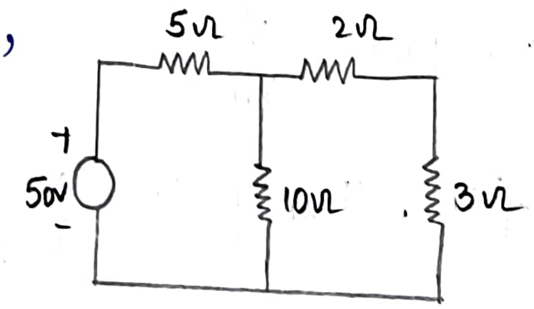
6. State Thevenin's Theorem. Determine the current in 3Ω resistor by using Thevenin's theorem for the network shown.



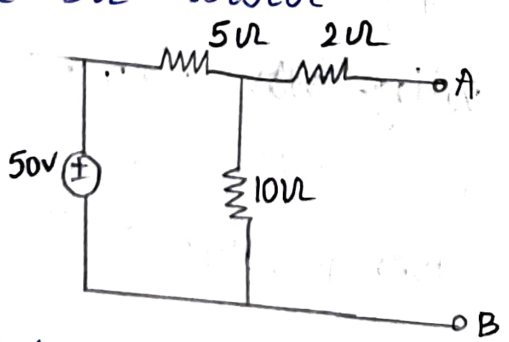
Ans:- **Statement:** Any two terminal bilateral linear DC circuits can be replaced by an equivalent circuit consisting of a voltage source and a series resistor is called Thevenin's Theorem.

Problem :-

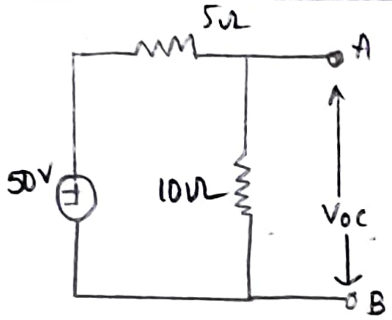
Given circuit,



Remove 3Ω resistor



To find V_{oc} :- (V_{th})

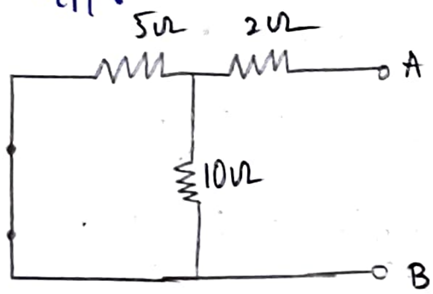


$$V_{oc} = 50 \times \frac{10}{5+10}$$

$$= 50 \times \frac{10}{15}$$

$$(V_{th}) V_{oc} = 33.33V$$

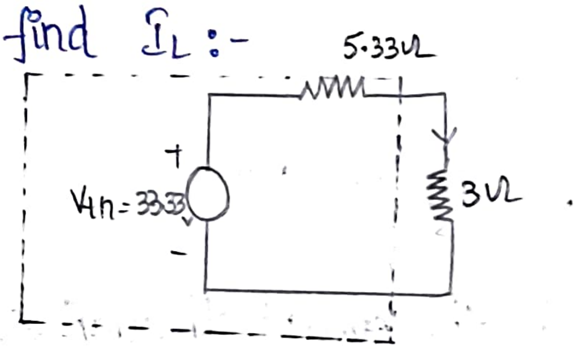
To find R_{th} :-



$$R_{AB} = \frac{5 \times 10}{5+10} + 2$$

$$R_{AB} = R_{th} = 5.33\Omega$$

To find I_L :-



$$I_L = \frac{V_{th}}{R_{th}+3}$$

$$= \frac{33.33}{5.33+3}$$

$$I_L = 4.001A$$

c. Derive the EMF equation of a DC generator.

Ans: Let ϕ = flux/pole in Wb

Z = total number of armature conductors

P = number of poles

A = number of parallel paths = 2 for wave winding

= P for lap winding

N = speed of armature in r.p.m

E_g = e.m.f of the generator

= emf / parallel path

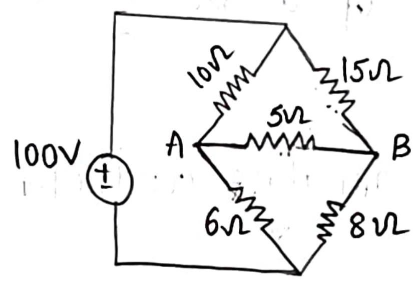
- Flux by one conductor in one revolution of the armature $= d\phi = P\phi$ webers
- Time taken to complete one revolution $= dt = 60/N$ second
- emf generated / conductor $= \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60}$ volts
- emf of generator, E_g = emf per parallel path

= (emf / conductor) × No. of conductors in series per parallel path $= \frac{P\phi N}{60} \times \frac{Z}{A}$ volts

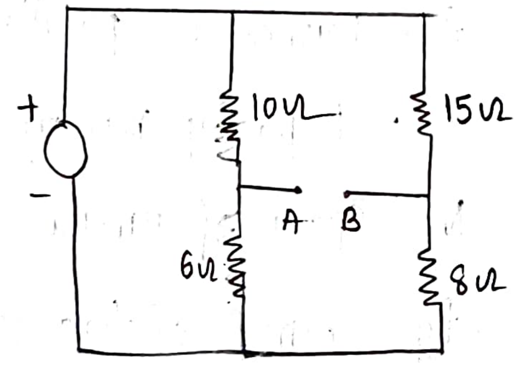
$$\therefore \boxed{E_g = \frac{\phi Z N P}{60A}} \text{ Volts}$$

where $A = 2$ for wave winding, P for lap winding

2.a Use Thevenin's theorem to find the current through 5Ω resistor for the network shown.



Ans: Given circuit can be drawn as

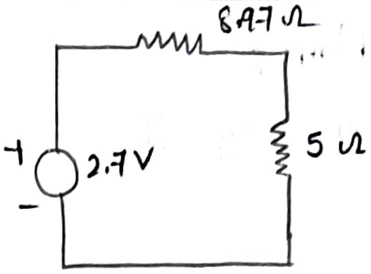


Current in 6Ω resistor is

$$I_{6\Omega} = \frac{100}{10+6} = \frac{100}{16}$$

$$I_{6\Omega} = 6.25A$$

Voltage across 6Ω resistor is



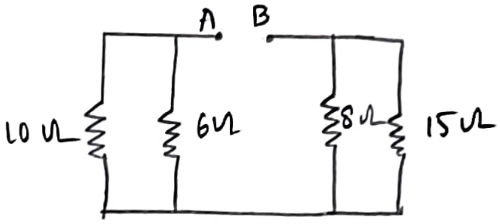
$V_{6\Omega} = 6.25 \times 6 = 37.V$

$I_{8\Omega} = \frac{100}{8+15} = 4.35A$

$V_{8\Omega} = 4.35 \times 8 = 34.8V$

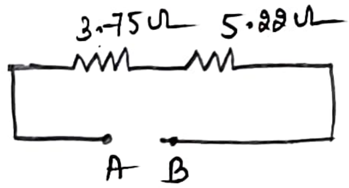
$\therefore V_{AB} = 37.5 - 34.8$

$= 2.7V$



$(R_{th})\ R_{AB} = 6 \| 10 + 8 \| 15$

$= \frac{6 \times 10}{6+10} + \frac{8 \times 15}{8+15}$



$= 3.37 + 5.22 = 8.97\Omega$

$\therefore$ Current in 5Ω resistor is $I_{5\Omega} = \frac{8.7}{8.97+5}$

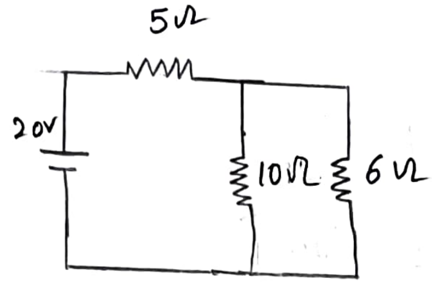
$= 0.193A$

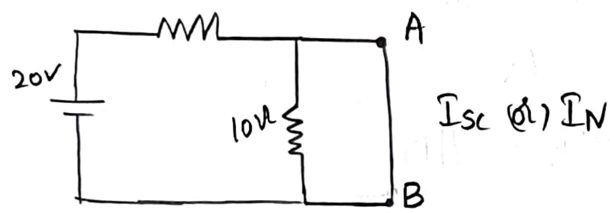
6. State Norton's Theorem. Determine the current through 6Ω resistor using Norton's theorem for the network shown.

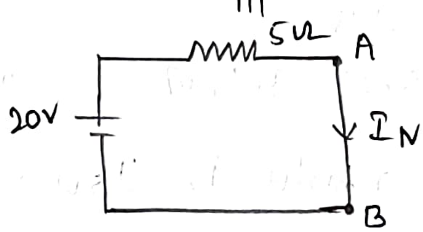
Ans: Statement: A linear circuit active network consisting of independent and or dependent voltage & current sources and linear bilateral network elements can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance the current source being the short circuited current across the load terminal and the resistance being the internal resistance of the source network looking through the open circuited load terminals is called the Norton's theorem.

Problem:

Given circuit

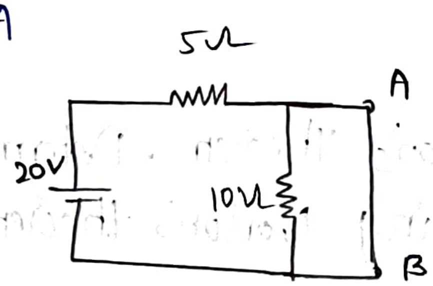


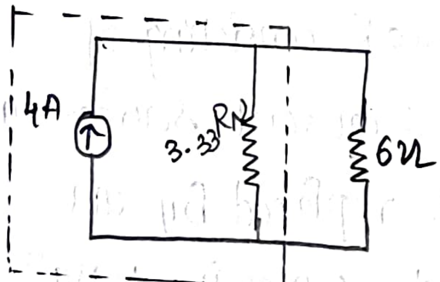




$$I_N = \frac{20}{5} = 4A$$

$$R_N = \frac{5 \times 10}{5+10} = 3.33\Omega$$



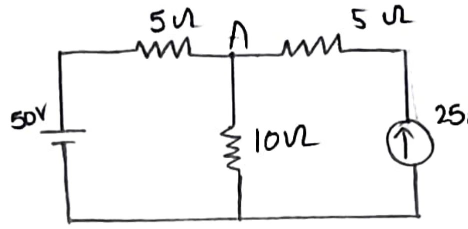


Norton's equivalent circuit

$$I_L = 4 \times \frac{3.33}{3.33+6}$$

$$\boxed{I_L = 1.427A}$$

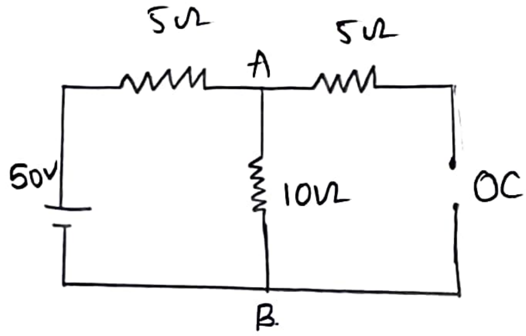
C. State Superposition Theorem. Find the voltage across 10Ω resistor using superposition theorem for the network shown.



Ans: Statement:- Any linear, bilateral two terminal network consisting of more than one sources, the total amount current or voltage in any part of a network is equal to the algebraic sum of the currents or voltages in the required branch with each source acting individually while other sources are replaced by their ideal internal resistance is called Super position theorem.

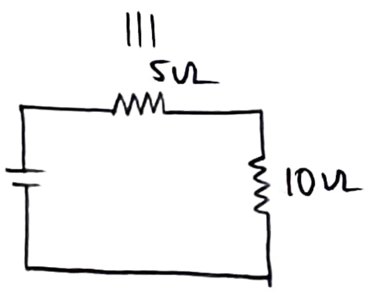
Problem:

Case-1: when 50V is acting

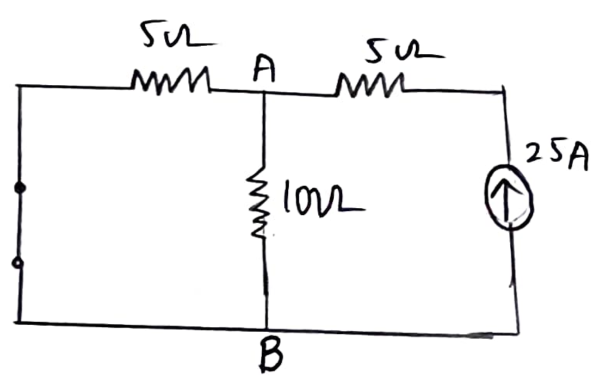


$$V_{10\Omega} = 50 \times \frac{10}{5+10}$$

$$V_{10\Omega} = 33.33V$$



Case-2 :- when 25A is acting



$$I_{10\Omega} = 25 \times \frac{5}{5+10}$$

$$= 8.33A$$

$$V_{10\Omega} = I \times R$$

$$= 8.33 \times 10$$

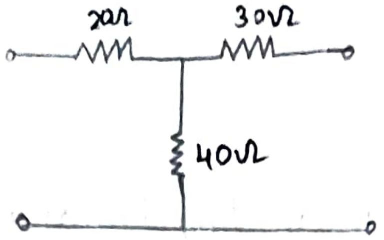
$$= 83.3V$$

$$\therefore V_{total} = V_{10\Omega}① + V_{10\Omega}②$$

$$= 33.33 + 83.3$$

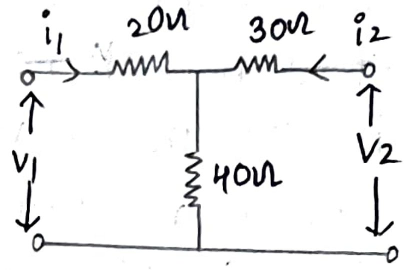
$$\boxed{V_{total} = 116.63}$$

3. a.i. Find z parameters for the given circuit.

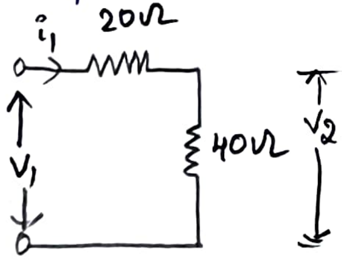


Sol: Given,

circuit



Case-I:- open the output port i.e $i_2 = 0$



$$Z_{11} = \frac{V_1}{i_1}$$

$V_1 = i_1 R \qquad R = 20+40$

$V_1 = i_1 60 \qquad R = 60\Omega$

$V_1 = 60 i_1$

$$= \frac{60\cancel{i_1}}{\cancel{i_1}}$$

$$\boxed{Z_{11} = 60\Omega}$$

$$V_2 = V_1 * \frac{40}{40+20}$$

$$= 60 i_1 \times \frac{40}{60}$$

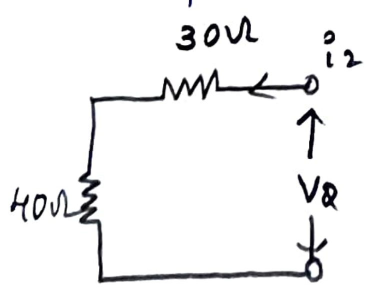
$$= 40 i_1$$

$$Z_{21} = \frac{V_2}{i_1}$$

$$= \frac{40\cancel{i_1}}{\cancel{i_1}}$$

$$\boxed{Z_{21} = 40\Omega}$$

Case-II :- Open the input port i.e $i_1 = 0$



$V_2 = R i_2 \qquad R = 30+40$

$\qquad\qquad\qquad = 70\Omega$

$V_2 = 70 i_2$

$$Z_{22} = \frac{V_2}{i_2}$$

$$= \frac{70\cancel{i_2}}{\cancel{i_2}}$$

$$\boxed{Z_{22} = 70\Omega}$$

$$V_1 = V_2 \times \frac{40\Omega}{40+30}$$

$$= 70 i_2 \times \frac{40}{40+30}$$

$$= \cancel{70} i_2 \times \frac{40}{\cancel{70}}$$

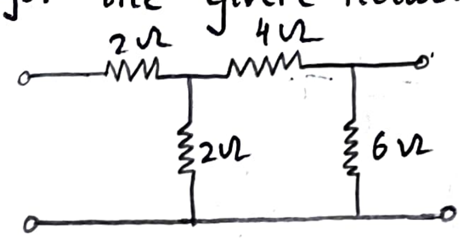
$$V_1 = 40 i_2$$

$$Z_{12} = \frac{V_1}{i_2}$$

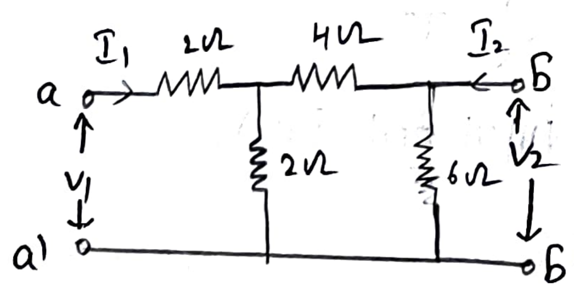
$$= \frac{40 \cancel{i_2}}{\cancel{i_2}}$$

$$\boxed{Z_{12} = 40\Omega}$$

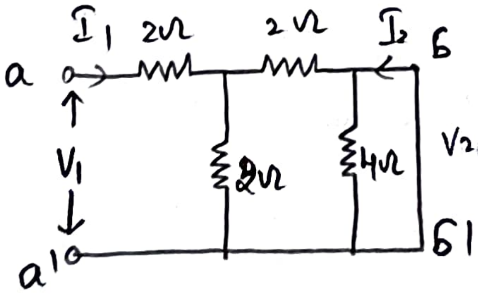
ii. Y-parameters for the given network shown below.



Sol:- Given circuit



Case-I:- Short circuit output port i.e $V_2 = 0$



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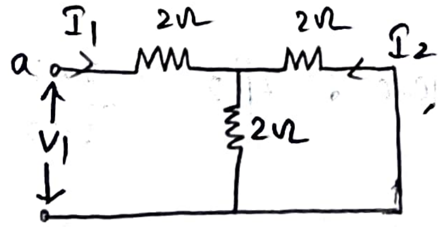


$$I_2 = I_1 \times \frac{2}{2+2}$$

$$= I_1 \times \frac{\cancel{2}}{\cancel{4}\,2}$$

$$I_2 = \frac{I_1}{2}$$

$$V_1 = I_1 R_{eq}$$

$$= I_1 \times \frac{2\times 2}{2+2} + 2$$

$$= I_1 \times \frac{4}{4} + 2$$

$$= I_1 \times 3$$

$$V_1 = 3I_1$$

$$Y_{21} = \frac{I_2}{V_1}$$

$$= \frac{\frac{I_1}{2}}{3I_1}$$

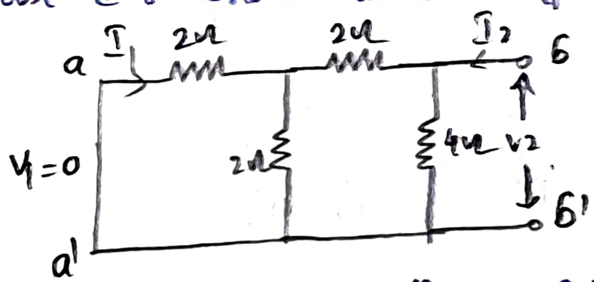
$$= \frac{\cancel{I_1}}{2} \times \frac{1}{3\cancel{I_1}} = \frac{1}{6}$$

$$\boxed{Y_{21} = -\frac{1}{6}\,℧}$$

$$Y_{11} = \frac{I_1}{V_1} = \frac{I_1}{3I_1} = \frac{1}{2}$$

$$\boxed{Y_{11} = \frac{1}{2}\,℧}$$

Case-II :- Short circuit input port i.e $V_1 = 0$



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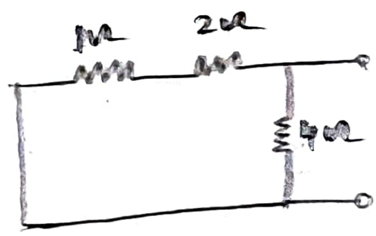
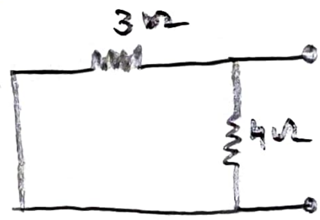


Here , $2 \| 2 = \frac{2\times 2}{2+2} = \frac{4}{4} = 1\Omega$

≡



$$V_2 = I_2 R_{eq}$$

$$= I_2 \frac{3\times 4}{3+4}$$

$$= I_2 \frac{12}{7}$$

$$Y_{22} = \frac{\cancel{I_2}}{\frac{12}{7}\cancel{I_2}} = \frac{7}{12}$$

$$\boxed{Y_{22} = \frac{7}{12}\ \mho}$$

$$I_1 = I_2 \times \frac{2}{2+2}$$

$$= I_2 \times \frac{2}{4}$$

$$I_1 = \frac{2}{4} I_2$$

$$Y_{12} = \frac{I_1}{V_2}$$

$$= \frac{\frac{2}{4}\cancel{I_2}}{\frac{12}{7}\cancel{I_2}}$$

$$= \frac{\cancel{2}}{4} \times \frac{7}{\cancel{12}\,6}$$

$$= \frac{7}{24}\ \mho$$

$$\boxed{Y_{12} = -\frac{7}{24}\ \mho}$$

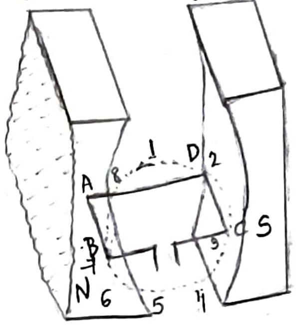
Explain the principle of operation of DC generator with neat diagram

D.C Generator Principle :-

An electric generator is a machine that converts mechanical energy into electrical energy. An electric generator is based on the priple that whenever flux is cut by a conductor, an emf is induced which will cause a current to flow if the conductor circuit is closed. The direction of induced emf (and hence current) is given by Fleming's right hand rule, Therefore, the essential components of a generator are :(a) a magnetic field (b) conductor or a group of conductor

(c) motion of conductor w.r.t magnetic field.

Consider a single turn loop ABCD rotating clockwise in a uniform magnetic field with a constant speed as shown in fig(1.1). As the loop rotates, the flux linking the coil sides AB and CD changes continuously. Hence the emf induced in these coils sides also changes but the emf induced in one coil side adds to that in other.



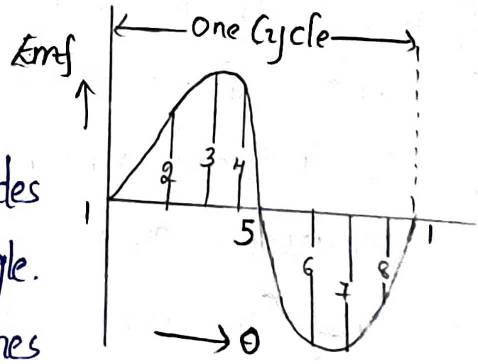
fig(1.1)

i) When the loop is in position no.1 see fig(1.1), the generated emf is zero because the coil sides (AB and CD) and cutting no flux but are moving parallel to it.

ii) When the loop is in position no.2, the coil sides are moving at an angle to the flux and therefore, a low emf is generated as indicated by point 2 in fig (1.2).

iii) When the loop is in position no.3, the coil sides (AB and CD) are at right angle to the flux and are, therefore, cutting the flux at a maximum rate. Hence at this instant, the generated emf is maximum as indicated by point 3 in fig(1.2)

iv) At position 4, the generated emf is less because the coil sides are cutting the flux at an angle.



fig(1.2)

v) At position 5, no magnetic lines are cut and hence induced emf is zero as indicated by point 5 in fig (1.2)

there are two ... the other
is in series

vi) At position 6, the coil sides move under a pole of opposite polarity and hence the direction of generated emf is reversed. The maximum emf in this direction (i.e reverse direction, see fig 1.2) will be when the loop is at position 7 and zero when at position 1. This cycle repeats with each revolution of the coil.

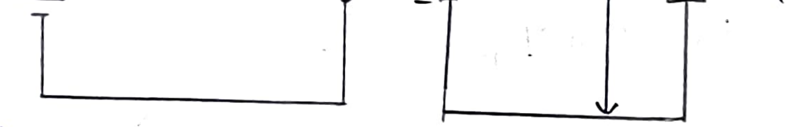
How the DC generators are classified and explain in detail about the types of DC generators with a neat sketch.

:- Classification of DC generators :-

Two types of DC generators

1. Separately Excited DC generators
2. Self Excited DC generator

1. Separately excited DC generators: This DC generator has a field magnet winding which is excited using a separate DC voltage source (ex: Battery)



Armature Current, $I_a = I_L$

Terminal voltage, $V = E_g - I_a R_a$

Electric power developed $= E_g I_a - V_{brush}$

Power delivered to load $= E_g I_a - I_a^2 R_a$

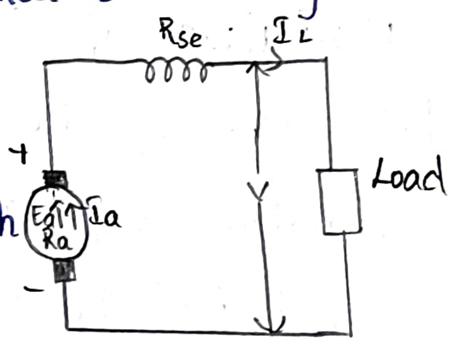
$= I_a(E_g - I_a R_a)$

$= V I_a$

Self-excited DC generator: These are the generator in which the field winding is excited by the output generator of itself

These are of 3 types :- 1. Series
2. Shunt
3. Compound

1. Series generator :- If a field winding is connected in series with armature winding then it is called a Series generator



Armature current $I_a = I_{se} = I_L = I$

Terminal voltage, $V = E_g - I(R_a + R_{se}) - V_{brush}$

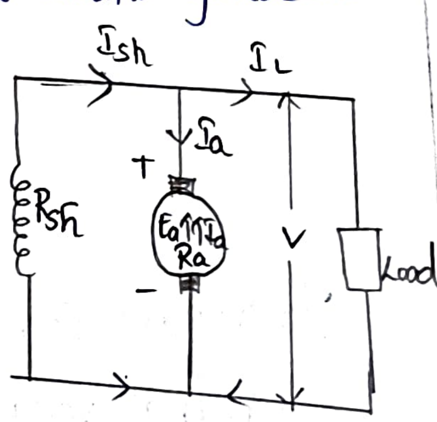
Power developed in armature $= E_g I_a$

Power deylivered to load $= E_g I_a - I_a^2 (R_a + R_{se})$

$= I_a [E_g - I_a (R_a + R_{se})]$

$= V I_a$ (or) $V I_L$

2. Shunt generator: If a field winding is connected in parallel with armature winding then it is called Shunt generator



Shunt field current, $I_{sh} = V / R_{sh}$

Armature current $I_a = I_L + I_{sh}$

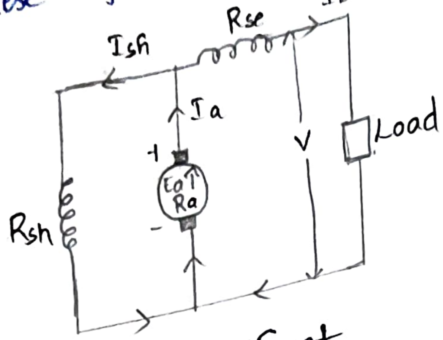
Terminal voltage, $V = E_g - I_a R_a - V_{brush}$

Power developed in armature $= E_g . I_a$

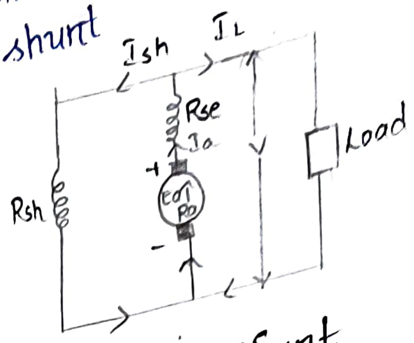
Power delivered to load $= V . I_L$

3. Compound Generator :- In a compound-wound generator there are two sets of field windings on each pole - one is in series and the other in parallel with armature

These of two types :- 1. Short shunt
2. Long shunt



Short Shunt



Long Shunt

Short Shunt

Series field current $I_{se} = I_L$

Shunt field current $I_{sh} = \frac{V + I_{se} R_{se}}{R_{sh}}$

Terminal Voltage $V = E_g - I_a R_a - I_{se} R_{se} - V_{brush}$

Power developed in armature $= E_g I_a$

Power delivered to load $= V I_L$

Long Shunt

Series field current $I_{se} = I_a$
$= I_L + I_{sh}$

Shunt field current $I_{sh} = \frac{V}{R_{sh}}$

Terminal Voltage
$V = E_g - I_a(R_a + R_{se}) - V_{brush}$

Power developed armature
$= E_g I_a$

Power delivered to load $= VI$