EEE 1107 Solution

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(8)

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
B.Sc. Engineering 1st Year 1st Term Examination, 2018
Department of Computer Science and Engineering
EEE 1107
Basic Electrical Engineering

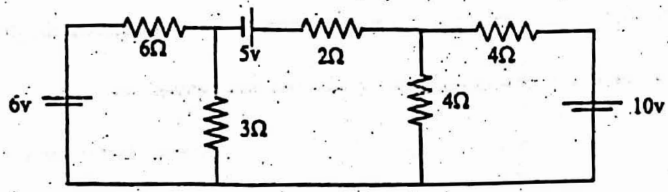
TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

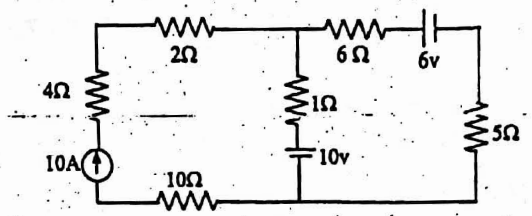
SECTION A

(Answer **ANY THREE** questions from this section in Script A)

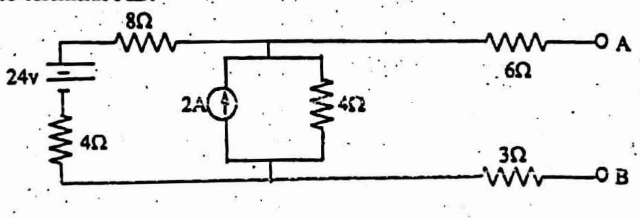
1. a) State and explain Ohm's law, KVL and KCL. (09)
   b) Deduce the condition for maximum power transmission and find the equation for maximum power. (11)
   c) Find all the branch currents using nodal analysis for the following circuit. (15)



2. a) State super position theorem. Find the current through 5ohm resistance using super position theorem for the following circuit. (13)



   b) State Thevenin's theorem and by using the theorem, replace the following network with reference to terminal AB. (13)



   c) For transmission from delta network to equivalent wye network, find each of the wye connected resistances in terms of delta resistances. (09)

3. a) Define measuring instrument and classify. What are the techniques of range extension of ammeter and voltmeter? (11)
   b) State and explain Ampere circuital law. Compare between electrical circuit and magnetic circuit. (12)
   c) Define (i) Permeability, (ii) Permitivity, (iii) Magnetic field, (iv) Electric field intensity and (v) Right hand rule. (12)

4. a) What are the factors that determine the induced voltage in a conductor? Derive the equation of generated emf of a DC generator. (12)
   b) Derive the condition for maximum efficiency of a DC motor. What is meant by back emf? (11)
   c) What are the factors that control motor speed? A 220V dc machine has an armature resistance of 0.6Ω. If full load armature current is 32A, find the induced emf when the machine acts as (i) motor (ii) generator. (12)

SECTION B

(Answer ANY THREE questions from this section in Script B)

5. a) What is phase? Find the angle of phase difference between $v = 100\cos(\omega t - 30°)$ and $i = -10\sin(\omega t - 60°)$. Which wave lags? (05)

   b) Define impedance. Find the impedance of an L branch from its dynamic equilibrium equation. (10)

   c) A voltage $v = -150\sin 377t$ is applied to a particular circuit element and it is found $i = 10\cos 377t$ amp. Make a sketch of v and i waves. Find the nature and magnitude of the circuit parameter. (10)

   d) Define phasor. Write the significance of j. Express the complex expression as a single number $\sqrt[3]{4.5 - j7.79} + \log_e 10\angle 172°$. (10)

6. a) Find the equations for energy delivered to an inductor and to a capacitor during a quarter cycle. (10)

   b) Deduce the value of crest factor and form factor of sinusoidal waves. (08)

   c) Calculate real power and reactive power employing complex form. (08)

   d) What are the differences between alternator and synchronous motor? Write the advantages of stationary armature in an alternator. Describe v-curves. (09)

7. a) Write down the principle of operation of single phase transformer. Draw the different equivalent circuits of a transformer. (11)

   b) Describe short circuit test and open circuit test of a single phase transformer. (12)

   c) Describe transformer on no load. Show that for maximum efficiency of a transformer, Cu loss must be equal to the iron loss. (12)

8. a) Mention some application of transformer. What are the main components of a transformer? (07)

   b) Deduce the expression for induced e.m.f. in a transformer and find voltage transformation ratio. (07)

   c) What are different types of $3-\phi$ transformer connections? Describe any two of them. (11)

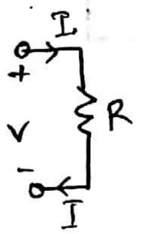
   d) Write down the principle of operation of a synchronous motor. Why synchronous motor is not self-starting? (10)

EEE 1107 (2018)

Ans. To The Question No. 1

ⓐ Ohm's Law:

Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points.



$$I \propto V$$

$$\Rightarrow I = GV$$

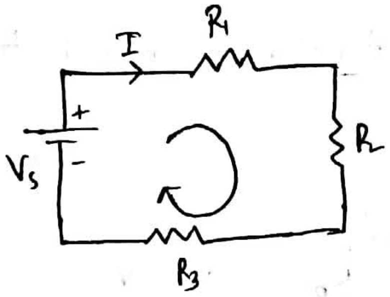
$$\Rightarrow I = \frac{V}{R} \quad [G = 1/R]$$

where I the current through the conductor, ~~to~~ V is the voltage measured across the conductors and R is the resistance where G is the conductance. Ohm's law is an empirical relation which accurately describes the conductivity of the vast majority of electrically conductive materials over many orders of magnitude of current.

(2)

Kirchoff's voltage Law:

KVL states that the algebraic sum of all the voltages around any closed loop in a series path is equal to zero;



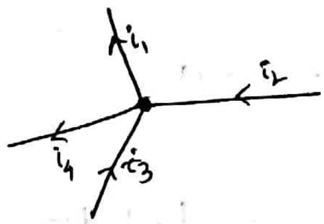
$$\Sigma V = 0$$

$$\Rightarrow \quad V_S - IR_1 - IR_2 - IR_3 = 0$$

$$\Rightarrow \quad V_s = I(R_1 + R_2 + R_3) = IR_s$$

Kirchoff's current law:

KCL states that for any node or junction in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node; or equivalently.

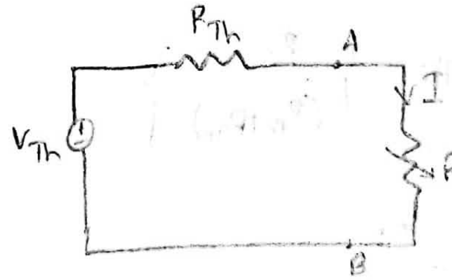


According to KCL, $i_1 + i_4 = i_2 + i_3$

So, the algebraic sum of currents in a network of conductors meeting at a point is zero.

$$\sum_{k=1}^{n} I_k = 0$$

(b) Maximum Power Transmission Theorem: "Maximum power is transferred from the source to the load when the load resistance is equal to the Thevenin's equivalent resistance."



The amount of power dissipated across the load resistor is,

$$P_L = I^2 R_L$$

Here, $I = \dfrac{V_{Th}}{R_L + R_{Th}}$

(4)

$$\therefore P_L = \left(\frac{V_{Th}}{R_{Th}+R_L}\right)^2 \times R_L \quad \cdots \cdots (1)$$

Condition for maximum power: first derivative will be zero.

$$\therefore \frac{dP_L}{dR_L} = 0$$

$$\Rightarrow V_{Th}^2 \left\{ \frac{(R_{Th}+R_L)^2 \times 1 - R_L \times 2(R_{Th}+R_L)}{(R_{Th}+R_L)^4} \right\} = 0$$

$$\Rightarrow (R_{Th}+R_L)^2 - 2R_L \times (R_{Th}+R_L) = 0$$

$$\Rightarrow (R_{Th}+R_L)(R_{Th}+R_L-2R_L) = 0$$

$$\therefore R_{Th} = R_L \Rightarrow R_L = R_{Th}$$

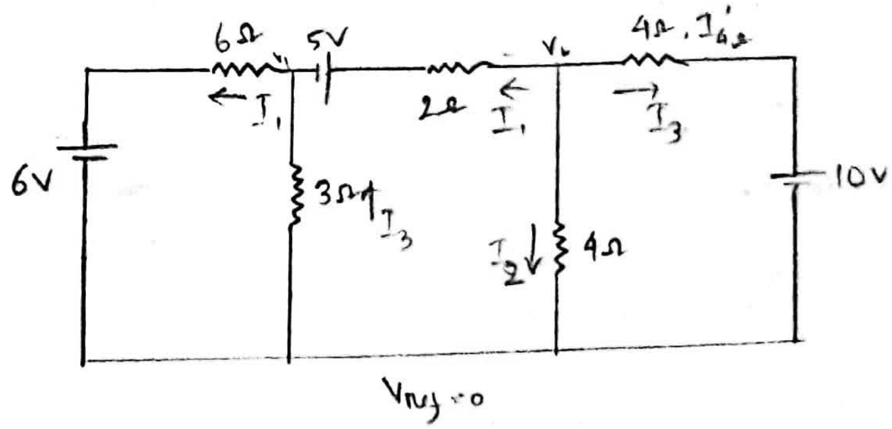
Value of maximum power:

putting $R_L = R_{Th}$ in (1),

$$P_L = V_{Th}^2 \left\{ \frac{R_{Th}}{(R_{Th}+R_{Th})^2} \right\}$$

$$= \frac{V_{Th}^2}{4R_{Th}}$$

ⓒ



Applying KCL at V_1 ⇒

$$I_1 + I_2 + I_3 = 0$$

$$\Rightarrow \frac{V_1 - 6}{6} + \frac{V_1}{3} + \frac{V_1 + 5 - V_2}{2} = 0$$

$$\Rightarrow V_1 - 6 + 2V_1 + 3V_1 + 15 - 3V_2 = 0$$

$$\Rightarrow 6V_1 - 3V_2 + 9 = 0$$

$$\Rightarrow 2V_1 - V_2 + 3 = 0 \quad \ldots \text{①}$$

applying KCL at V_2 ⇒

$$I_1 + I_2 + I_3 = 0$$

$$\Rightarrow \frac{V_2 - 5 - V_1}{2} + \frac{V_2}{4} + \frac{V_2 - 10}{4} = 0$$

$$\Rightarrow 2V_2 - 10 - 2V_1 + V_2 + V_2 - 10 = 0$$

$$\Rightarrow 4V_2 - 2V_1 - 20 = 0$$

$$\Rightarrow V_1 - 2V_2 + 10 = 0$$

⑥

using ① and ⑪ $\Rightarrow$

$V_1 = 1.33V$

$V_2 = 5.67V$

$I_{6\Omega} = \frac{1.33-6}{6} = -0.78A$

$I_{2\Omega} = \frac{V_1+5-V_2}{2} = \frac{1.33+5-5.67}{2} = 0.33\,A$

$I_{3\Omega} = \frac{1.33}{3} = 0.44\,A$

$I_{4\Omega} = \frac{V_2}{4} = \frac{5.67}{4} = 1.4175A$

$I'_{4\Omega} = \frac{5.67-10}{4} = -1.0825\,A$

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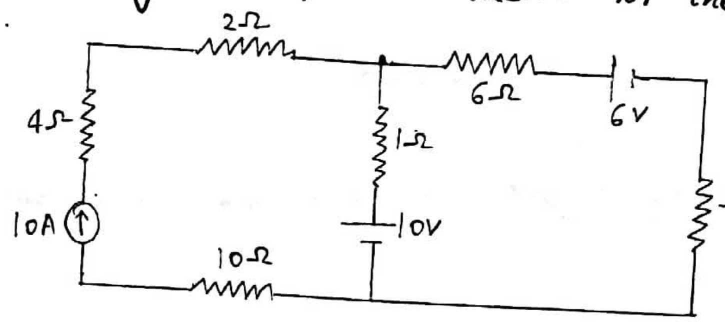
Ans to the ques No: 2

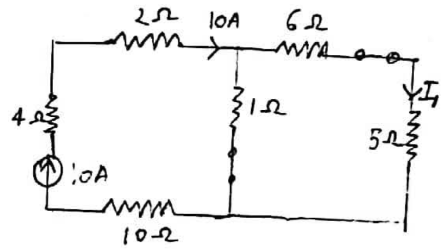
2/a

State super position theorem. Find the current through 5 ohm resistance using super position theorem for the following circuit.

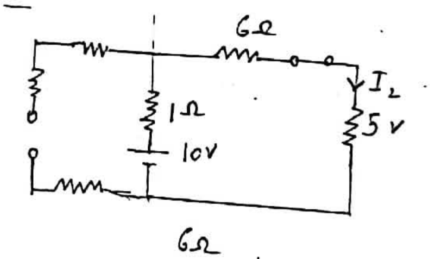


Solⁿ :

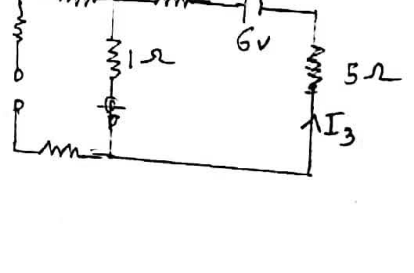
Here, $I_1 = \frac{1}{(6+5)+1} \times 10 = \frac{10}{12} = 0.83A.$



Here, $I_2 = \frac{V}{R_s} = \frac{10}{(6+5+1)} = \frac{10}{12} = 0.83A$



Here, $I_3 = \frac{V}{R_s} = \frac{6}{(6+5+1)} = \frac{6}{12} = 0.5A$



$\therefore I = I_1 + I_2 - I_3$

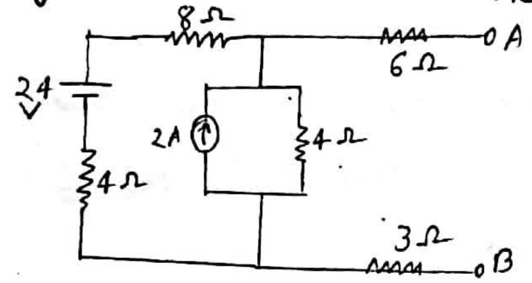
$= 0.83 + 0.83 - 0.50$

$I = 1.16A$

(Ans)

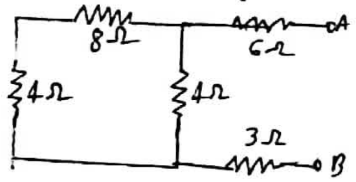
2/b

State Thevenin's theorem and by using the theorem, replace following network with reference to terminal AB.



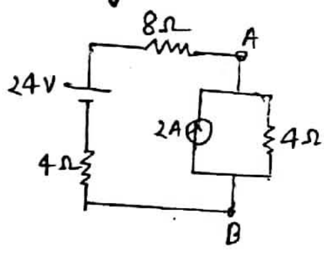
Sol^n :

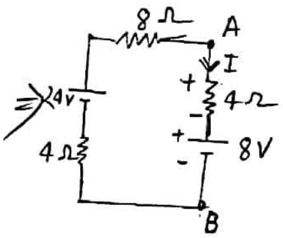
Finding R_{th} : 24 V (voltage source) shorted and 2A current source opened



$$R_{th} = 6 + \frac{(8+4)\times 4}{(8+4)+4} + 3 = 25\,\Omega$$

Finding V_{th} : As it is opened between A and B point



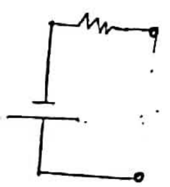


$$I = \frac{24-8}{4+4+8} = 1\,A$$

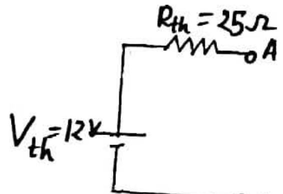
$\therefore$ $V_{AB} = -4 \cdot I - 8 = -4 \cdot 1 - 8$

$V_{th} = -12\,V$

replacing network :



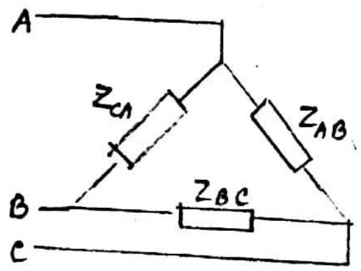
As it is a linear ~~cire~~ network, so,

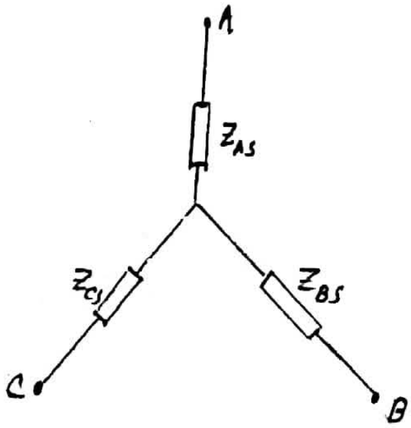


2/C

c) For transmission from delta network to equivalent . wye network, find each of wye connected resistances in terms of delta resistance

Soln : A "delta-connected" network of three impedences (or resistance)





Z_{AB}, Z_{BC} and Z_{CA} can be transformed into a "WYE-connected" network of three impedances Z_{AS}, Z_{BS} and Z_{CS} connected together at a common together at a common Node S using the following transformations.

$$Z_{AS} = \frac{Z_{AB} \cdot Z_{CA}}{Z_{AB} + Z_{BC} + Z_{CA}}$$

$$Z_{BS} = \frac{Z_{AB} \cdot Z_{BC}}{Z_{AB} + Z_{BC} + Z_{CA}}$$

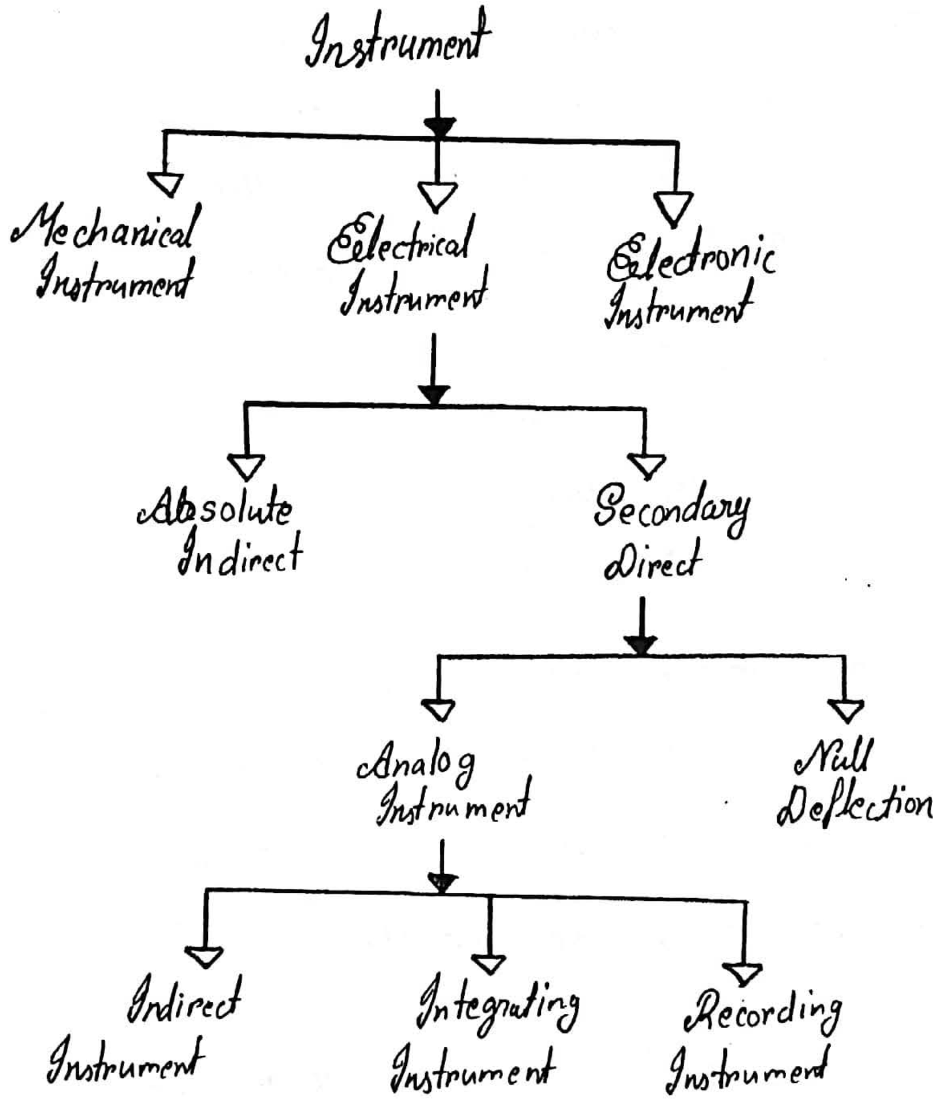
We can observe that in each of above expression. We had to multiply the two impedance values on either side of node in the WYE connection and devide by the ~~det~~ WYE of three impedances.

[The explanation all done here measured with Impedance. If we use resistance instead of impedance the properties and characteristics won't change]

Answer to the Question No. 3 (a)

Measuring Instrument: The instrument used for measuring the physical and electrical quantities is known as the measuring instrument.

Classification of Measuring instrument:



Extending the range of ammeters and voltmeters.

The ranges of electrical measuring instruments (whether ammeter or voltmeter) are limited by currents, which may be carried by the coils of the instruments safely. For example, the moving coils of the instruments can carry maximum current of about 50 mA safely and the potential drop across the moving coil is about 50 mV. Hence, it becomes necessary that the current and voltage being measured be reduced and brought within the range of instrument.

Common devices used for extending the range of ammeters and voltmeters are

a) Shunts

b) Multipliers

Answer to the Question No. 3(b)

Ampere's Circuital Law:

Ampere's circuital law states the relationship between the circuit and magnetic field created by it. This law says, the integral of magnetic field density (B) along an imaginary closed path is equal to the product of current enclosed by the path and permeability of the medium

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

It alternatively says, the integral of magnetic field intensity (H) along an imaginary ~~en~~ closed path is equal to the current enclosed by the path.

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

$$\Rightarrow \oint \frac{\vec{B}}{\mu_0} \cdot \vec{dl} = I$$

$$\Rightarrow \left[\because \vec{H} = \frac{\vec{B}}{\mu_0} \right]$$

Comparison of Electrical and Magnetic circuit:

There are similarities and dissimilarities between the electrical c circuit and magnetic circuit. This comparison will give us a clear idea of electrical, magnetic circuit.

Similarities between electrical and magnetic circuit

Electric Circuit	Magnetic Circuit
(i) Path traced by the current is know as electric current.	(i) Path traced by the magnetic flux is called as magnetic circuit.
(ii) EMF is the driving force in the electric circuit. The unit is volt.	(ii) MMF is the driving force in the magnetic circuit. The unit is ampere turns.
(iii) The flow of the electrons decides the current in conductor	(iii) The number of magnetic lines of force decides the flux.

Dissimilarities between electrical and magnetic circuit

Electric Circuit	Magnetic Circuit.
(i) In the electric circuit, the circuit is actually flows. ie there is movement of electrons.	(i) Due to mmf flux gets established and does not flow in the sense in which current flows.
(ii) Energy must be supplied to the electric circuit to maintain the flow of current.	(ii) Energy is required to create the magnetic flux, but is not required to maintain it
(iii) There is continuous consumption of electrical energy.	(iii) Energy is required to create the magnetic flux and not to maintain it.

Answer to the Question No. 3(c)

(i) Permeability: In electromagnetism, permeability is the measure of the ability of a material to support the formation of a magnetic field with itself otherwise known as distributed inductance in Transmission Line theory. Hence, it is the degree of magnetization that a material obtains in response to an applied magnetic field. It is represented by μ.

(ii) Permitivity: In electromagnetism, absolute permittivity, often simply called permittivity, usually denoted by the Greek letter ϵ, is the measure of capacitance that is encounted when forming an electric field in a particular medium. More specifically, permittivity describes the amount of charge needed to generated one unit of electric flux in a particular medium

(iii) Magnetic field: The magnetic field is the area around a magnetic in which there is magnetic force. Moving electric charges can make magnetic fields. Magnetic fields can usually be seen by magnetic flux lines. The closer the flux lines are to eachother the stonger the magnet is.

(iv) Electric field intensity: Electric intensity is the strength of electric field at a point. Electric intensity at a point is defined as the ~~po~~ force experienced per unit positive charge at a point placed in the electric field.

(v) Right ~~had~~ hand rule: Right hand Rule shows the direction of induced current when a conductor attached to a circuit moves in a magnetic field. It can be used to determine the direction of current in a generator's windings.

4) ⓐ What are the factors that determine the induced voltage in a conductor? Derive the equation of generated emf of a DC generator?

Ans: 1st part: In the early 19th century, a scientist by the name Michael Faraday published several papers on electro magnetic induction, which is the ability of a changing magnetic field to induce a voltage in conductor. To better understand this phenomenon, Faraday conducted a number of experiment. One of these experiments used a coil of wire, a ~~vol~~ permanent magnet and a device to detect voltage in the wire. When the magnet was passed through the coil of wire, a voltage was induced in the wire, but it disappeared when the magnet stopped moving. Faraday found that there were two factors

that affected how much voltage w
induced in the conductor.

(i) The first factor was the number of turns of wire in the coil, which increased the amount of wire exposed to the magnetic field. The results of faraday's experiments show that the induced voltage increased direct proportion to the number of turns in the electrical coil. In ot words, doubling the number of turn resulted in a doubling of the induce voltage.

(ii) The second factor was how quick the magnetic field was changing. There are a couple of different way that we can make a magnetic fi change. One way is to change the stre of the field produced by the magne

If we use an electromagnet to create the magnetic field, we can turn the magnet on and off or simply vary the current to change the strength of the field. The second way is to move the ~~el~~ field relative to the conductor. We could do this by moving the coil around in the field or by moving the magnet around the coil - it doesn't matter which, as long as there is ~~a~~ relative motion.

2nd Part:

The derivation of emf equation for DC generator has two parts:

(i) Induced emf of one conductor.
(ii) Induced emf of the generator.

(i) Derivation for induced emf of one Armature Conductor:

For one revolution of the conductor

Let, φ = Flux produced by each pole in weber (Wb)

and P = number of poles in the DC generator.

Total ~~pta~~ flux produced by all the poles $= \phi \times p$

Time taken to complete one revolution

$$= \frac{60}{N}$$

where, N = speed of the armature conductor in rpm.

Now, according to Faraday's law of induction, the induced emf of the armature conductor is denoted by "e" which is equal to the rate of cutting the flux.

Therefore, $e' = \frac{d\varphi}{dt} = \frac{\text{total flux}}{\text{time taken}}$

∴ Induced emf of one conductor is,

$$e' = \frac{\phi P}{\frac{60}{N}} = \phi P \frac{N}{60}$$

(ii) Derivation for induced emf for DC generator: Let us suppose there Z total numbers of conductor in a generator and arranged in such a manner that all parallel paths are always in series.

Here, Z = total numbers of conductor

A = number of parallel paths.

Then, Z/A = number of conductor connected in series

We know that induced emf in each path is same ~~acco~~ across the line.

Therefore,

Induced emf of DC generator,

e = emf of one conductor × number of conductor connected in series.

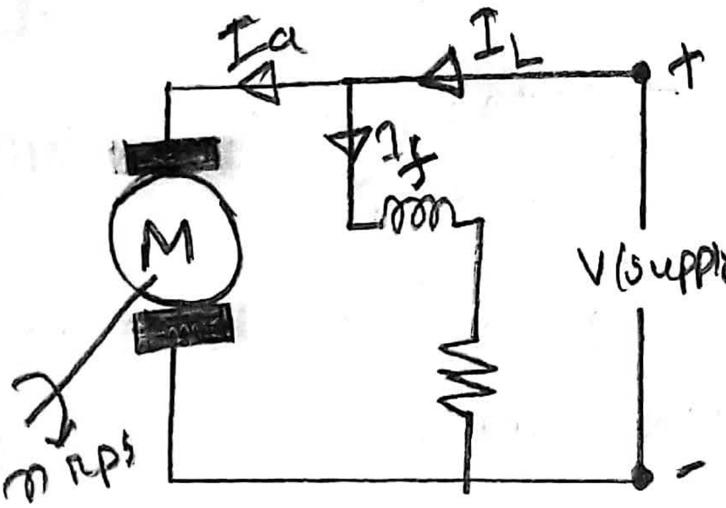
∴ Induced emf of DC generator is,

$$e = \phi P \frac{N}{60} \times \frac{Z}{A} \text{ volts.}$$

(b) Derive the condition for maximu efficiency of DC motor? What is mean by back emf?

<u>Ans: 1st part:</u>

Let us consider a loaded shunt mo as shown in figure-(i). The vario currents along with their direct are also shown in the figure.



<u>Fig-(i)</u>: Machine operates as motor

We assume that field current I_f remains constant during change of load

Let, P_{rot} = Constant rotational loss.

VI_f = Constant field copper loss.

Constant loss, $P_{const} = P_{rot} + VI_f$

Constant loss, $P_{const} = P_{rot} + VI_f$

Now, input power drawn from supply $= VI_L$

power loss in the armature $= I_a^2 r_a$

Net mechanical output power $=$

$$VI_L - I_a^2 r_a - (VI_f + P_{rot})$$

$$= VI_L - I_a^2 r_a - P_{const}.$$

So, efficiency at this load current,

$$\eta_m = \frac{VI_L - I_a^2 r_a - P_{const}}{VI_L}$$

Now, the armature copper loss $I_a^2 r_a$ can be approximated to $I_L^2 r_a$ as $I_a \simeq I_L$. This is because the order of field current may be 3 to 5% of the rated current. Expect for very lightly loaded motor, this assumption is reasonably fair. Theorefore replacing I_a by I_f in the above expression for efficiency η_m, we get,

$$\eta_m = \frac{VI_L - I_L^2 r_a - P_{const}}{VI_L}$$

$$= 1 - \frac{I_L r_a}{V} - \frac{P_{const}}{VI_L}$$

Thus, we get a simplified expressi[on] for motor efficiency η_m in terms of the variable current (which depen[ds] ~~on~~ on degree of loading) I_L, current drawn from the supply. So, to find out the condition for maximum efficiency, we have to differentiate η_m with respect to I_L and set it to zero as shown below,

$$\frac{d\eta_m}{dI_L} = 0$$

or, $\frac{d}{dI_L}\left(\frac{I_L r_a}{V} - \frac{P_{const}}{VI_L}\right) = 0$

or, $\frac{r_a}{V} + \frac{P_{const}}{VI_L^2} = 0$

or, $\frac{P_{const}}{VI_L^2} = -\frac{r_a}{V}$

∴ condition for maximum efficiency is $I_L^2 r_a \approx I_a^2 r_a = P_{const}$

~~∴ the a~~

∴ The armature current at which efficiency becomes maximum is

$$I_a = \sqrt{\frac{P_{const}}{r_a}}$$

2nd part:

When the armature of a DC motor rotates under the influence of the driving torque, the armature conductors move through the magnetic field and hence e.m.f is induced in them as in a generator. The induced e.m.f. acts in opposite direction to the applied voltage (Lenz's law) and is known as back or counter e.m.f (Eb).

$E_b = P\phi ZN/60A$ ~~Eb = PφZN60A~~

~~or Eb = PφZN60A~~

The back emf, $E_b (= P\phi ZN/60A)$ is always less than the applied voltage V, although this difference is small when the motor is running under normal conditions.

(c) What are the factors that control motor speed? A 220 V dc machine has an armature resistance of 0.6Ω. If full load armature current is 3 find induced emf when the machine acts as (i) motor.

Ans: The factors that control motor speed are –

(i) Flux (φ): The speed is inversely proportional to flux φ.

(ii) Armature voltage drop: The speed is directly proportional to armature voltage drop ($I_a R_a$)

(iii) Applied voltage: The speed is directly proportional to ~~armature~~ applied voltage (V).

Ans to the Q. NO: 5

(a) What is phase? Find the angle of phase difference between $v = 100\cos(\omega t - 30^\circ)$ and $i = -10\sin(\omega t - 60^\circ)$. Which lags?

Soln:

Phase is the fractional part of a period through which time or the associated time angle ωt has advanced from an arbitary reference.

Given,

$$v = 100\cos(\omega t - 30^\circ)$$

$$i = -10\sin(\omega t - 60^\circ)$$

$$= 10\sin(180^\circ + \omega t - 60^\circ)$$

$\therefore$ phase difference $= \omega t - 30^\circ - 180^\circ - \omega t + 60^\circ$

$$= -150^\circ$$

The current lags and voltage leads.

(b) Define impedance. Find the impedance of an L branch from its dynamic equilibrium equation.

Soln:

Impedance is the ratio of maximum voltage and the maximum current and the angle between them. It is donated by

$$Z = \frac{V_m}{I_m} \angle \theta .$$

the equilibrium equation of L branch is,

$$v = L\frac{di}{dt} = V_m \sin\omega t$$

$$di = \frac{V_m}{L} \sin\omega t$$

$$i = -\frac{V_m}{\omega L} \cos\omega t + C_1 \quad \text{(both side are integrated)}$$

$$\Rightarrow i = \frac{V_m}{\omega L}(\sin(\omega t - 90^\circ)) = I_m \sin(\omega t - 9$$

so, $I_m = \frac{V_m}{\omega L} \Rightarrow \frac{V_m}{I_m} = \omega L$

$$\therefore Z = \omega L$$

$$\therefore Z_L = \omega L \angle 90^\circ$$

$$X_L = \omega L = 2\pi f L$$

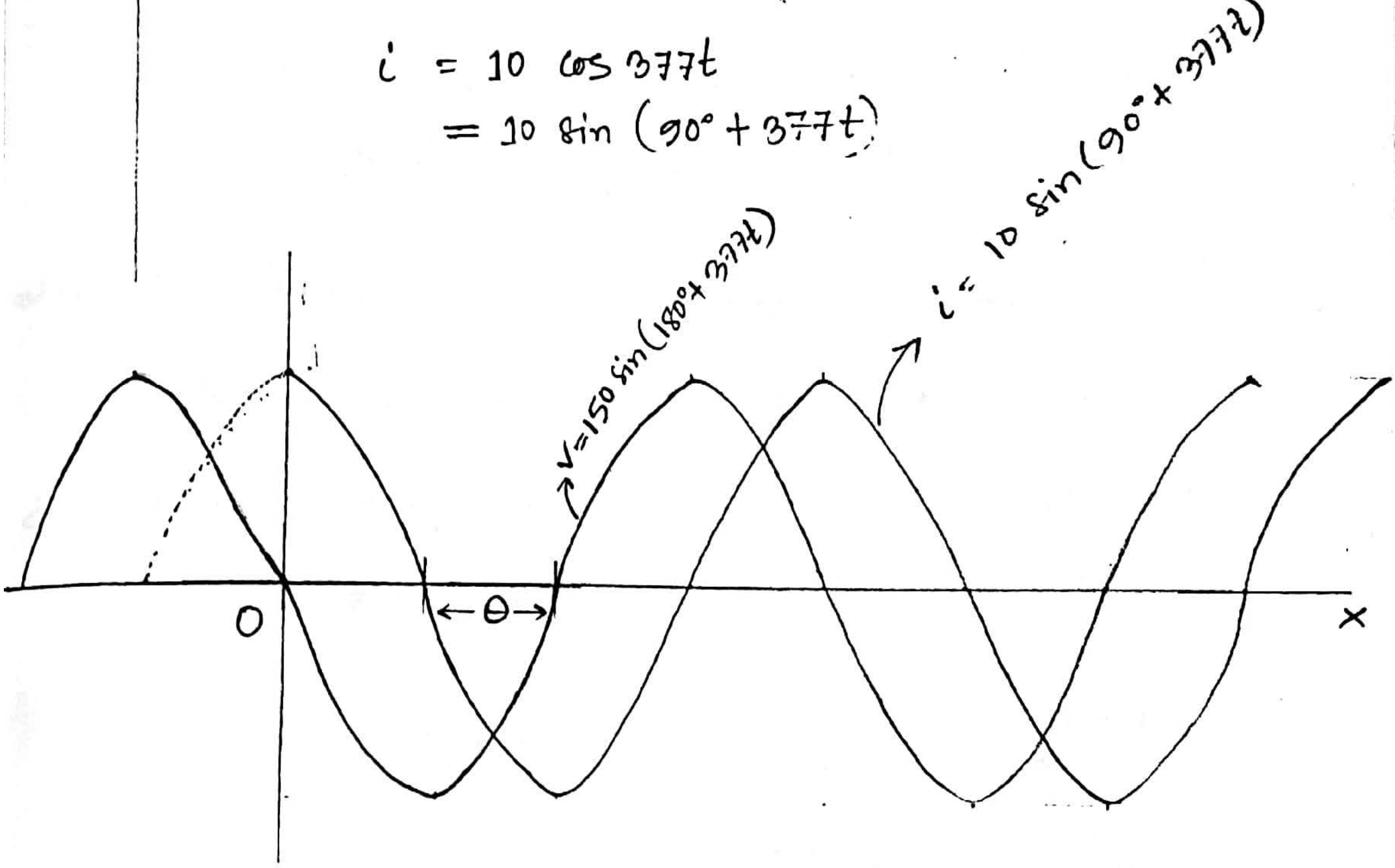
(c) A voltage $v = -150 \sin 377t$ is applied to a particular circuit element and it is found $i = 10 \cos 377t$ amp. Make a sketch of v and i waves. Find the nature and magnitude of the circuit parameter.

Solⁿ:

Given,

$$v = 150 \sin(180° + 377t)$$

$$i = 10 \cos 377t$$
$$= 10 \sin(90° + 377t)$$



path difference, $\theta = 180° + 377t - 90° - 377t = 90°$

$$Z = \frac{V_m}{I_m} = \frac{150}{10} = 15 \angle 90°$$

i leads v by $90°$ or v lags i by $90°$.

6. (a) Find the equation for energy delivered to an inductor and to a capacitor during a quarter cycle.

→ For inductor:

$$p = -\frac{V_m I_m}{2} \sin 2\omega t$$

$$W_L = -\int_{T/4}^{T/2} \frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= \frac{V_m I_m}{2 \times 2\omega} \Big[\cos 2\omega t\Big]_{T/4}^{T/2}$$

$$= \frac{V_m I_m}{4\omega} \Big[\cos 2\pi - \cos \pi\Big]$$

$$= \frac{V_m I_m}{4\omega} \times 2$$

$$= \frac{1}{2} \times \frac{V_m}{\omega} I_m$$

Here, $\frac{V_m}{I_m} = \omega L$

$I_m L = \frac{V_m}{\omega}$

$$= \frac{1}{2} L I_m^2$$

For Capacitor:

$$p = \frac{V_m I_m}{2} \sin 2\omega t$$

$$W_C = \int_0^{T/4} \frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= -\frac{V_m I_m}{2 \times 2\omega} \Big[\cos \left(2 \times \frac{2\pi}{T}\right)\Big]_0^{T/4}$$

$$= \frac{V_m I_m}{2\omega} = \frac{1}{2} C V_m^2$$

(32) b) Deduce the value of Crest factor and form factor of sinusoidal wave.

→ (b) Form factor: Ratio ~~between~~ of effective value to average value

for a sinusoidal waves $F.F. = \frac{1/\sqrt{2}\, I_m}{0.656 I_m}$

$= 1.11$

Crest factor: Ratio of maximum value to effective value

For a sinusoidal waves $C.F. = \frac{I_m}{0.707 I_m}$

$= 1.41$

c) Calculate real power and reactive power employing complex form

(c) $P_{real} = VI\cos\theta$

$P_{reactive} = VI\sin\theta$

For real Power,

$P = VI\cos(\theta_v - \theta_i)$

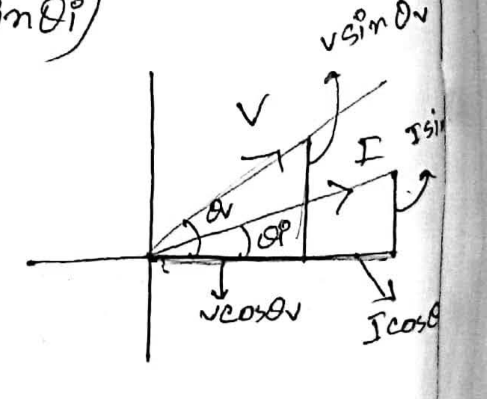
$= VI(\cos\theta_v \cos\theta_i + \sin\theta_v \sin\theta_i)$

$= (V\cos\theta_v)(I\cos\theta_i) + (V\sin\theta_v)(I\sin\theta_i)$

Here,

$V = V\cos\theta_v + jV\sin\theta_v$

$= v + jv'$



$I = I\cos\theta_i + jI\sin\theta_i$

$= i + ji'$

$\therefore P = vi + v'i'$

For reactive power,

$$P_x = VI\sin(\theta_v - \theta_i)$$

$$= (V\sin\theta_v)(I\cos\theta_i) - (V\cos\theta_v)(I\sin\theta_i)$$

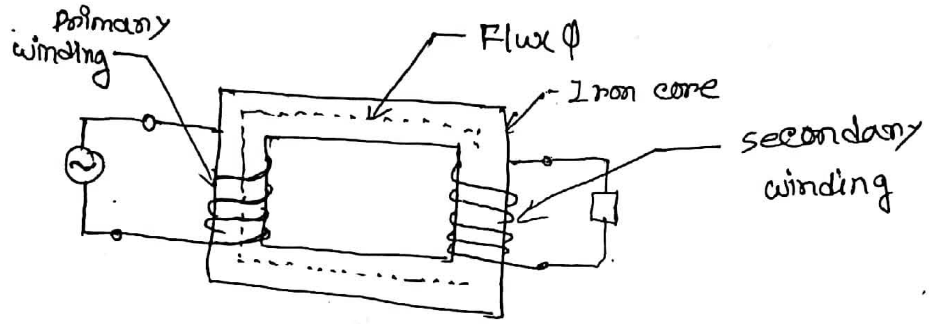
$$= v'i - vi'$$

$$\therefore P_x = v'i - vi'$$

NO. 7:

a) Write down the principle of operation of single phase transformer. Draw the different equivalent circuits of a transformer.

Ans:



Single Phase Transformer Schematic

The principle of operation:

The working principle of the single phase transformer is based on the Faraday's law of electromagnetic induction.

Faraday's Law: "Rate of change of flux linkage with respect to time is directly proportional to the induced EMF in a conductor or coil".

The principle of operation of a transformer has been explained in the following simple steps:

- As soon as the primary winding is connected to a single-phase supply, an AC current starts following through it.

- An alternating flux is produced in the core by the AC primary current.
- The alternating flux gets linked with the secondary winding through the core.
- Now, according to Faraday's law of electro-magnetic induction this varying flux will induce voltage into the secondary winding.

Equivalent circuits of a transformer:

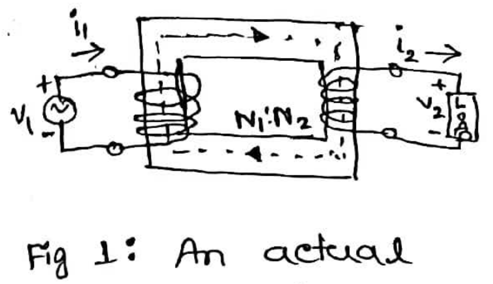


Fig 1: An actual transformer

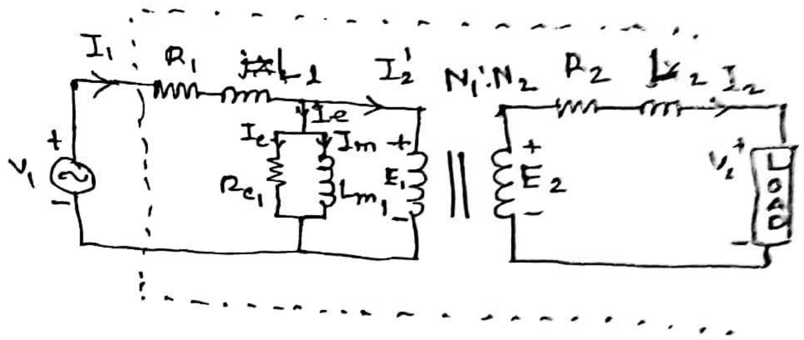


Fig2: Equivalent Transformer circuit.

EEE-1107 (2018)

Answer NO: 08

a) There are four principal applications of transformers:

i) Power transformer: They are designed to operate with an almost constant load which is equal to their rating

ii) Distribution transformer: These transformers have variable load which is usually considerably less than the full-load rating

iii) Autotransformers: An autotransformer has only one winding and is used in cases where the ratio of transformation (k), either step-up or step-down, differs little from 1.

iv) Instrument transformers: current & voltage transformers are used to extend the range of a.c. instrument.

The main components of a transformer are:-

i) Magnetic Core.

ii) Primary & Secondary windings.

iii) Insulation of windings.

iv) Lead & tappings for coils with their supports, terminals & terminal insulators.

v) Tank, Oil, cooling arrengment, conservators dryers etc

b) E.M.F. Equation of a Transformer:

consider that an alternating voltage V_1 of frequency f is applied to the primary as shown in Fig 1. The sinusoidal flux ϕ produced by the primary can be represented as:

$$\phi = \phi_m \sin\omega t$$

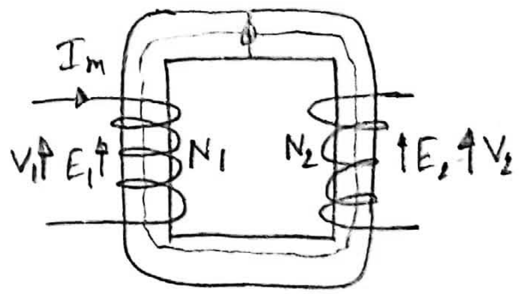
The instantaneous e.m.f. e_1 induced in the primary is,

$$e_1 = -N_1 \frac{d\phi}{dt}$$

$$\text{or, } e_1 = -N_1 \frac{d}{dt}(\phi_m \sin\omega t)$$

$$\text{or, } e_1 = -\omega N_1 \phi_m \cos\omega t$$

$$\text{or, } e_1 = -2\pi f N_1 \phi_m \cos\omega t$$



(i)

Fig: 1.1

$\therefore e_1 = 2\pi f N_1 \phi_m \sin(\omega t - 90^\circ)$ —————— (i)

It is clear from the above equation that maximum value of induced e.m.f in the primary is,

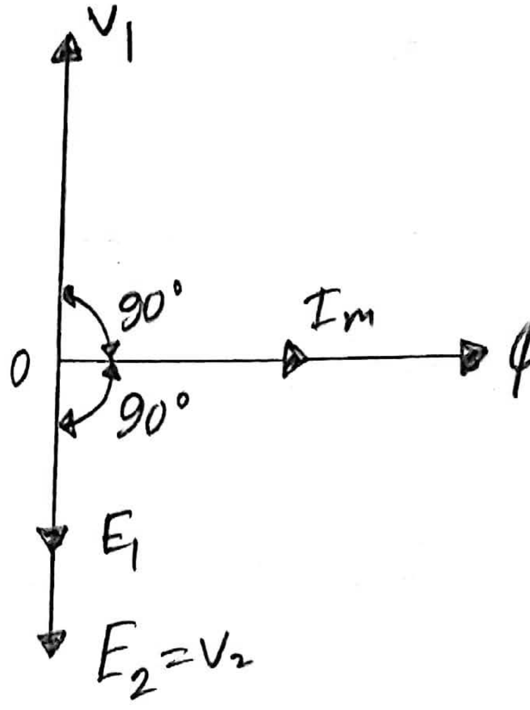


Fig: 1.2.

$E_{m_1} = 2\pi f N_1 \phi_m$

The r.m.s. value E_1 of the primary e.m.f is,

$$E_1 = \frac{E_{m_1}}{\sqrt{2}} = \frac{2\pi f N_1 \phi_m}{\sqrt{2}}$$

$$= 4.44 f N_1 \phi_m$$

Similarly, $E_2 = 4.44 f N_2 \phi_m$

In an ideal transformer $E_1 = V_1$ & $E_2 = V_2$.

Voltage Transformation Ratio (K):

From the above equations of induced e.m.f we have (fig. 2),

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

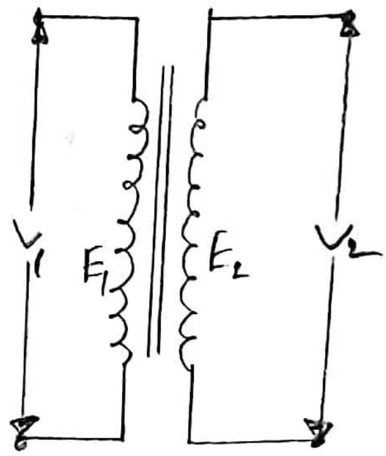


Fig. 2

The constant K is called voltage transformation ratio:

Thus if $K = 5$ (i.e. $N_2/N_1 = 5$), then $E_2 = 5E_1$

For an ideal transformer :

(i) $E_1 = V_1$ and $E_2 = V_2$ as there is no voltage drop in the windings,

$$\therefore \frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = K$$

(ii) There are no losses. Therefore, volt-amperes input to the poimary are equal to the output volt-amperes i.e. $V_1 I_1 = V_2 I_2$

or, $\frac{I_2}{I_1} = \frac{V_1}{V_2} = \frac{1}{K}$

Hence, currents are in the inverse ratio of voltage transformation ratio.

(c) A three-phase transformer can be built by suitably connecting a bank of three single-phase transformers or by one three-phase transformer. The primary or secondary windings may be connected in either star (Y) or delta (Δ) arrangement. The six common connections are:

(i) Y–Y (ii) Δ–Δ (iii) Y–Δ (iv) Δ–Y (v) V–V

& (vi) T–T.

The first two 3-ϕ transformer connections are described below:

(i) Y-Y Connection: In the Y-Y connection shown in Fig 3, 57.7% (or $1/\sqrt{3}$) of the line voltage is impressed upon each winding but full line current flows in each winding.

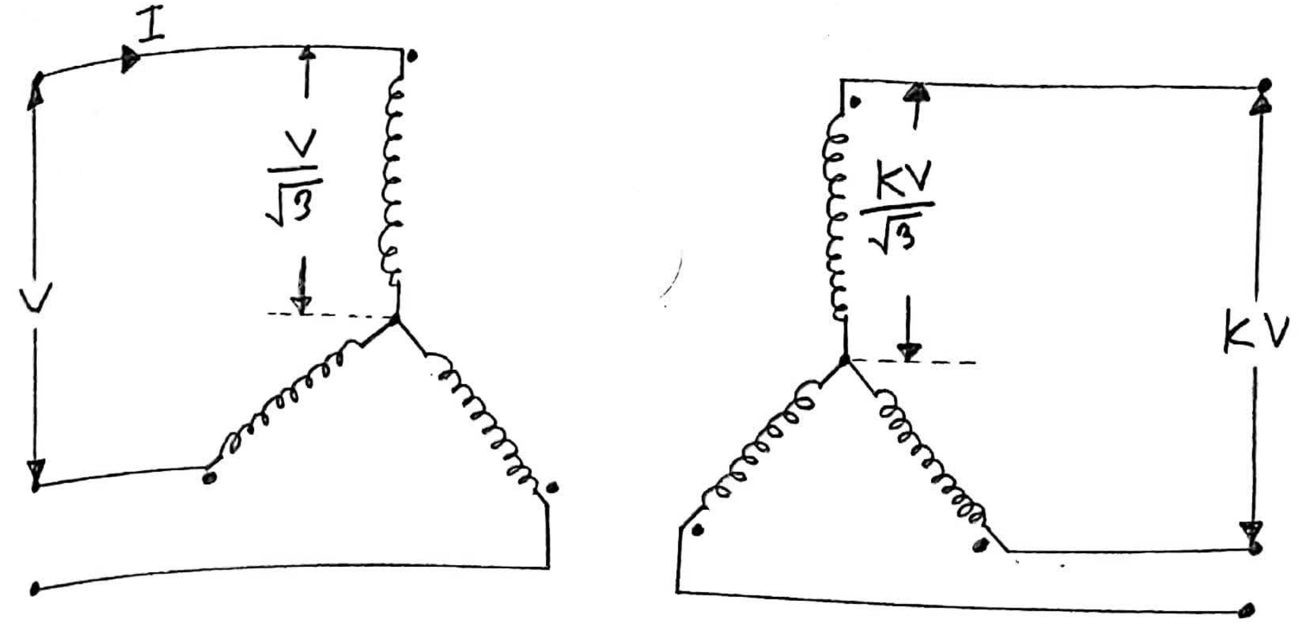


Fig.3: Y-Y connection

Power circuits supplied from a Y-Y bank often create serious disturbances in communication circuits in their immediate vicinity. Because of this and other disadvantages, the Y-Y connection is seldom used.

(ii) Δ-Δ connection: The Δ-Δ connection shown in Fig.4 is often used for moderate voltage. An advantage of this connection is that if

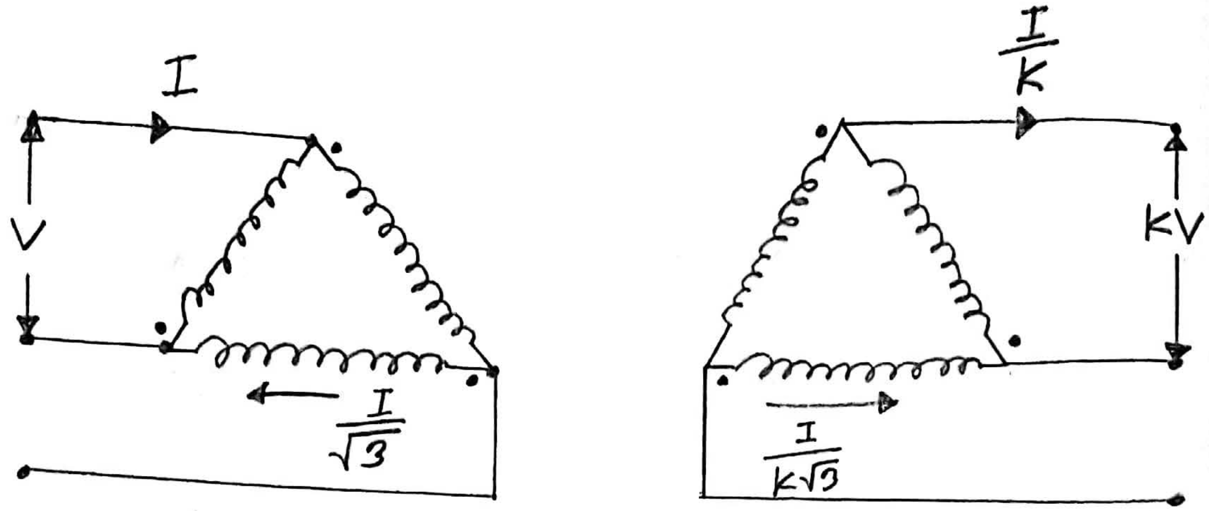


Fig: 4

one transformer gets damaged or is removed from service, the remaining two transformers can be operated in what is known as the open - delta or V-V connection. By being operated in this way, the bank still delivers three-phase currents and voltages in their ~~correct~~ correct phase relationships but the capacity of the bank is reduced to 57.7 % of what it was with all three transformers in service.

d) Principle of Operation of synchronous motor:

Synchronous motors are a doubly excited machine, i.e., two electrical inputs are provided to it ~~Its stator winding which consists of a~~

(i) When single-phase stator having an auxiliary winding is energized, a synchronously revolving field is produced. The motor starts as a standard squirrel-cage induction motor and will accelerate to near its synchronous speed.

(ii) As the rotor approaches synchronous speed, the rotating stator flux will exert reluctance torque on the rotor poles tending to align the salient-pole axis with the axis of the rotating field. The rotor assumes a position where its salient poles lock with the poles of the revolving field. Consequently, the motor will continue to run at the speed of revolving flux i.e., at the synchronous speed.

iii) When we apply a mechanical load, the rotor poles fall slightly behind the stator poles, while continuing to turn at synchronous speed. As the load on the motor is increased, the mechanical angel between the poles increases progressively. Nevertheless, magnetic attraction keeps the rotor locked to the rotating flux. If the load is increased beyond the amount under which the reluctance torque can maintain synchronous speed, the rotor drops out of step with the revolving field. The speed then drops to some value at which the slip is sufficient to develop the necessary torque to drive the load by induction-motor action

Synchronous motor is not self sorting. This is because the speed with which rotating magnetic field is rotating is so high that it is unable to rotate the rotor from its initial position, due to the inertia of the rotor. So under any cases

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12

whatever may be the starting position of the rotor, synchronous motor is not self starting.

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
B.Sc. Engineering 1st Year 1st Term Examination, 2017
Department of Computer Science and Engineering
EEE 1107
Basic Electrical Engineering

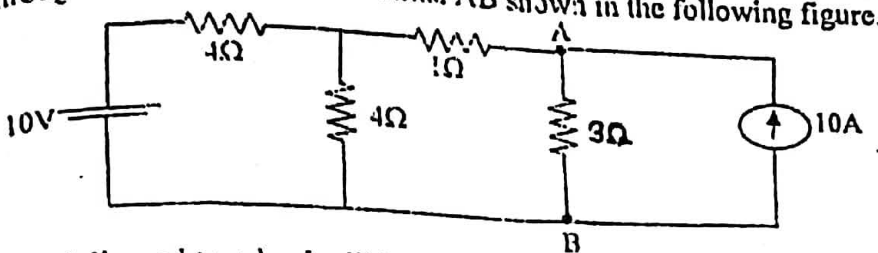
TIME: 3 hours FULL MARKS: 210

N.B. i) Answer ANY THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

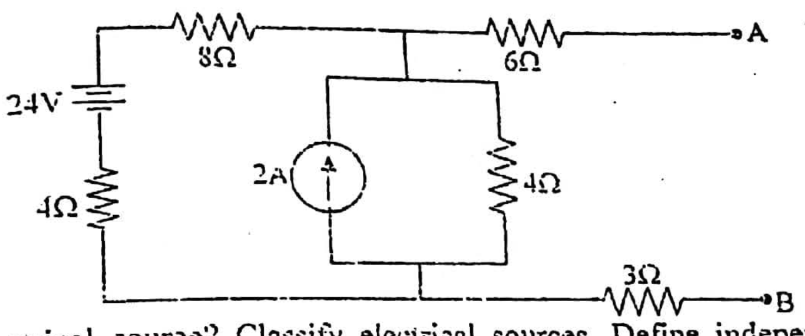
(Answer ANY THREE questions from this section in Script A)

1. a) Write short notes on KVL, KCL and Ohm's law. (06)
b) State the conditions for applying superposition theorem to a circuit. Use the theorem to find current through 3Ω resistor of the terminal AB shown in the following figure. (12)



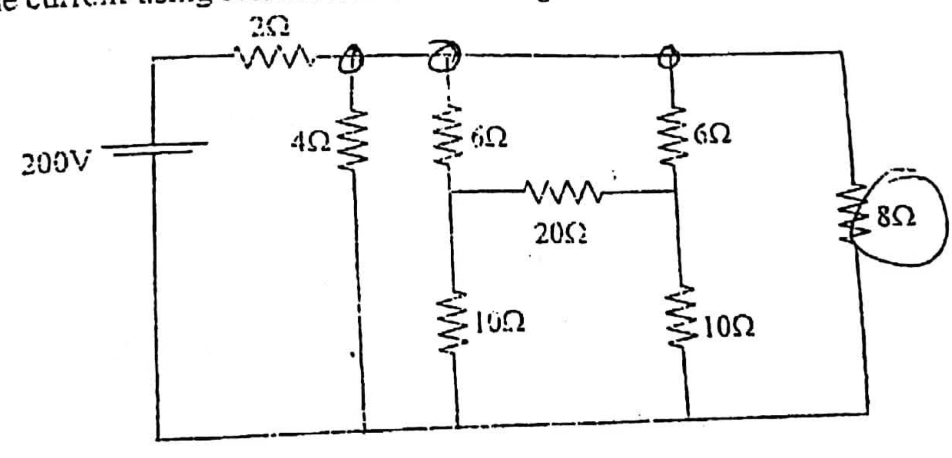
c) "The power delivered to a load will be maximum when the load resistance is equal to the line resistance"-prove it. Also show that at maximum power the efficiency is 50%. (09)
d) An electrical heater takes 1 KW from main supply with certain voltage. If the voltage is increased by 20%, the current through the heater is 8 Amp. (i) What is the original voltage? (ii) What is the resistance of the coil? (08)

2. a) For transformation from delta network to equivalent wye network, find each of the wye connected resistances in terms of delta resistances. (10)
b) State Thevenin's theorem and by using the theorem, replace the network shown in the following figure with reference to the terminals AB. (15)

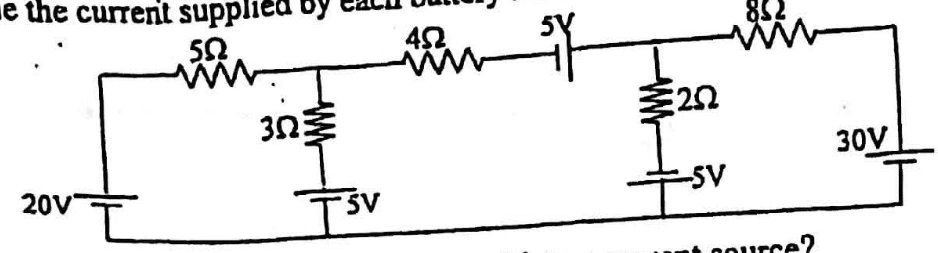


c) What is electrical source? Classify electrical sources. Define independent and dependent sources. (10)

3. a) Find the current using Norton's theorem through a load of 8 Ω in the following circuit. (15)



b) Determine the current supplied by each battery in the following circuit.



c) How can a voltage source should be converted into a current source? (05)

4. a) Write down the working principle of a DC generator. (15)
b) Describe different parts of a DC motor. (15)
c) Prove that speed of motor depends on applied voltage, flux and armature resistor. (05)

SECTION B

(Answer ANY THREE questions from this section in Script B)

5. a) Define with necessary diagrams (i) Oscillating current (ii) Periodic current (iii) Alternating current (iv) Period and (v) Cycle. (10)
b) Define impedance. Derive the equation of impedance of ~~R and~~ L branch. Show graphical representation of voltage, current and power variation in that branch. (15)
c) Find the amount of energy stored by a capacitor during a quarter cycle. (10)

6. a) Show that the crest factor of a sine wave is $\sqrt{2}$ and the form factor of the wave is 1.11. (10)
b) A voltage $v = 200\sin 377t$ is applied to an inductive branch and the maximum current is 10 A. (i) Find the voltage of L in millihenrys and (ii) If it is known that this inductive coil actually possesses 1.0 Ω resistance, what is the true value of L? (12)
c) What is phasor? Write the significance of operator j. Find all possible roots of the expression (13)

$$\sqrt[4]{\frac{10\angle 45^\circ 5e^{j60}(-4.047 - j2.94)}{1 - j1.732}}$$

7. a) Write the working principle of a transformer. Mention some applications of it. What are the main components of a transformer? (10)
b) Explain the transformer on no load and on load. Draw the necessary vector diagrams. (08)
c) Deduce the expression for induced voltage in a transformer and find out voltage transformation ratio. (07)
d) Draw the equivalent circuit of a transformer and find out the total impedance between input terminals. (10)

8. a) Describe the working principle of a synchronous motor. Write down the method of starting. (15)
b) What are the main four parameters of a transformer? How can they be determined? Describe transformer tests briefly. (10)
c) A single phase transformer has 400 primary and 1000 secondary turns. The net cross-sectioned area of the core is 60 cm². If the primary winding be connected to a 50 Hz supply at 520 V; calculate (i) peak value of the flux density in the core (ii) the voltage induced in secondary winding. (10)

$\frac{E_P}{E_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$

(ii) $\frac{V_2}{520} = \frac{1000}{400}$ $\therefore V_2 = 1300V$

(i) max flux, voltage const. freq flux turn

$520 = 4.44 \times f \times \Phi_m \times 250$

$E = 4.44 f \Phi N$

$\Phi = 9.36 \times 10^{-3}$

EEE-2017

Q-1

a) write short notes on KVL, KCL and Ohm's Law.

Kirchhoff's voltage law: The algebric sum of the potential drops in one direction is equal to the algebric sum of the electronegative across acting in the same direction.

$\sum E = \sum IR$

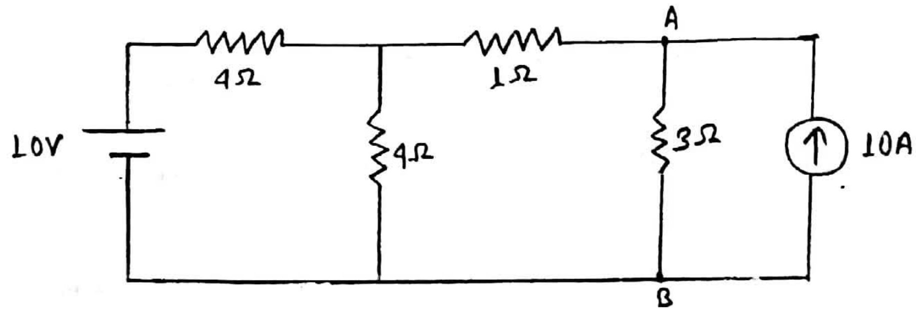
Kirchhoff's current law:- The algebric sum of the currents entering and leaving a junction (or region) of a network is zero.

$\sum I_i = \sum I_o$

Ohm's law: In constant temperature the current through a resistance between two points is directly proportional to the voltage across two points.

$I \propto V$

b) State the conditions for applying superposition theorem to a circuit. Use the theorem to find current through 3Ω resistor of the terminal AB shown in the flowing figure.



~~Case 1:~~

~~Removing the current source~~

Ans:

In order to apply the superposition theorem to a network, certain conditions must be met:

1. All the components must be linear, for e.g. - the current is proportional to the applied voltage (for resistors), flux linkage is proportional to current (in inductors), etc.

2. All the components must be linear, ~~for e.g. the current~~ meaning that the current is the same amount for opposite polarities of the source voltage.

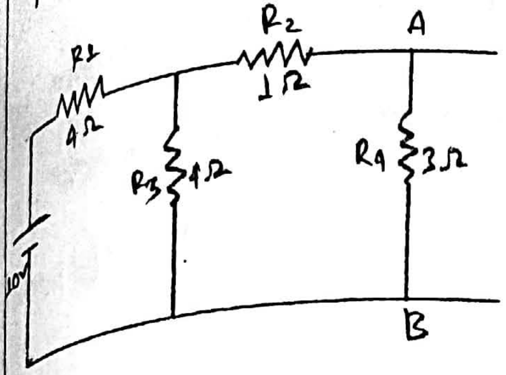
3. Passive components may be used. e.g. resistors, capacitors. that do not amplify or rectify.

4. Active components may not be used. Active components include transistors, semiconductor diodes, and electron tubes.

Such components are never bilateral and seldom linear.

Case 1:

Removing current source,



$R_{S1} = R_2 + R_4$

$= 1 + 3$

$= 4\ \Omega$

$R_{P1} = R_3 \| R_{S1}$

$\therefore \frac{1}{R_{P1}} = \frac{1}{R_3} + \frac{1}{R_{S1}}$

$= \frac{1}{4} + \frac{1}{4}$

$\therefore R_{P1} = 2\ \Omega$; $R_s = R_1 + R_{P1}$

$= 6\Omega$

$I = \frac{V}{R_{P1}} = \frac{10}{\cancel{2}6} = \cancel{5A}\ 1.67A$

$\cancel{\therefore I_4 = \frac{4}{4+4}}$

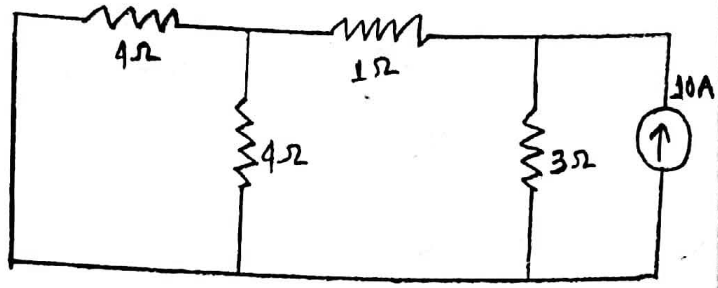
$\therefore I_4 = \frac{R_3}{R_3 + (R_2 + R_4)} \times \cancel{5}\ 1.67$

$= \frac{4}{4+3+1} \times \cancel{5}\ 1.67$

$= \cancel{2.5A}\ 0.835A$

Case 2:

Shorting voltage sorce,



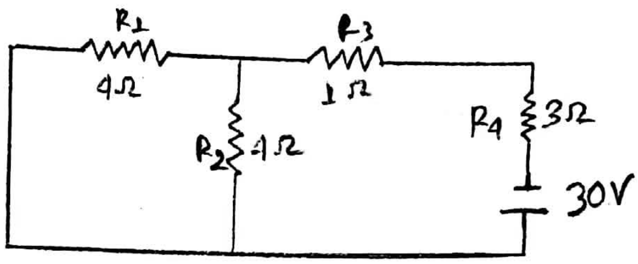


Fig: equivalence circuit

$R_{P1} = R_1 \| R_2$

$\frac{1}{R_{P1}} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{4} + \frac{1}{4}$

$\Rightarrow \frac{1}{R_{P1}} = \frac{1+1}{4}$

$\Rightarrow R_{P1} = \frac{4}{2} = 2\Omega$

$R_S = R_4 + R_3 + R_{P1}$

$= 3 + 1 + 2$

6Ω

$I_4 = \frac{V}{R_S} = \frac{30}{6} = 5A$

∴ Current through 3Ω resistor of the terminal AB

$I_S = 5 - 0.835 = 4.165A$

Ans.

Q "The power delivered to a load will be maximum when the load resistance is equal to the line resistance" - Prove it. Also show that at maximum power the efficiency is 50%.

Ans:

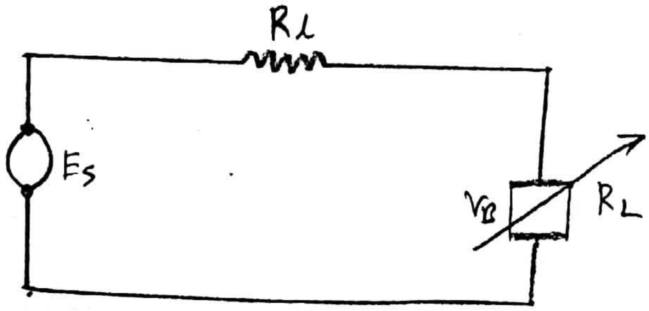


Fig: 1.1

From fig 1.1 $\quad I = \dfrac{E_S}{R_L + R_l}$

$$P_L = I^2 R_L$$

$$= \frac{E_S^2}{(R_L+R_l)^2} \times R_L$$

$$= \frac{E_S^2 \cdot R_L}{\cancel{(R_L+R_l)^2}\ R_L^2 + 2R_L \cdot R_l + R_l^2}$$

load will receive maximum power,

$$\frac{dP_L}{dR_L} = 0$$

$$\Rightarrow \frac{(R_L^2+2R_L \cdot R_l+R_l^2) \cdot E_s^2 \cdot 1 - E_s^2 \cdot R_L(2R_L+2R_l)}{(R_L^2+2R_L \cdot R_l+R_l^2)^2} = 0$$

$$\Rightarrow R_L^2 + 2R_L \cdot R_l + R_l^2 - 2R_L^2 - 2R_L \cdot R_l = 0$$

$$\Rightarrow R_l^2 - R_L^2 = 0$$

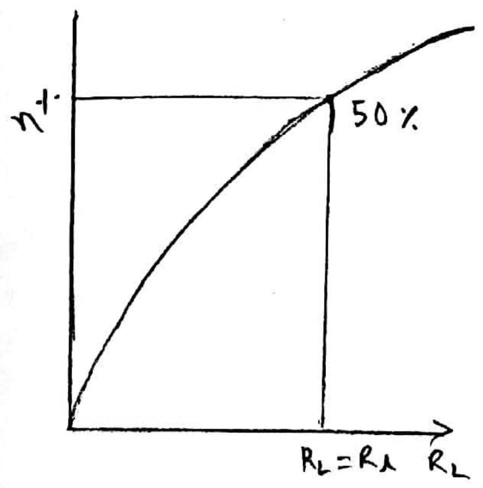
$$\Rightarrow R_L = R_l$$

∴ The power delivered to a load will be maximum when the load resistance is equal to the line resistance.

Another,

$$\text{Efficiency } (\eta) = \frac{P_L}{P_S} \times 100\%$$

$$= \frac{I^2 R_L}{I^2(R_L+R_l)} \times 100\%$$



At maximum power,

$$\eta = \frac{I^2 R_L}{I^2(R_L+R_L)} \times 100\% \quad [\because R_L = R_l]$$

$$= \frac{1}{2} \times 100\%$$

$$= 50\%$$

Showed.

d) An electrical heater takes 1kW from main supply with certain voltage. If the voltage is increased by 20%. the current through the heater is 8 Amp (i) What is the original voltage? (ii) what is the resistance of the coil?

Ans:

i)

Let, original voltage is V

$\therefore 1000 = (V + 0.2V) \times 8$

$\Rightarrow 1000 = 9.6V$

$\Rightarrow V = 104.167$ Volts.

$\therefore$ The original voltage is 104.167 volts.

Ans.

ii) We know,

$P = \frac{V^2}{R}$

$\Rightarrow R = \frac{(104.167)^2}{1000}$

$= 10.85\ \Omega$

Here

$V = 104.167$ Volts

$P = 1000$ W

$R = ?$

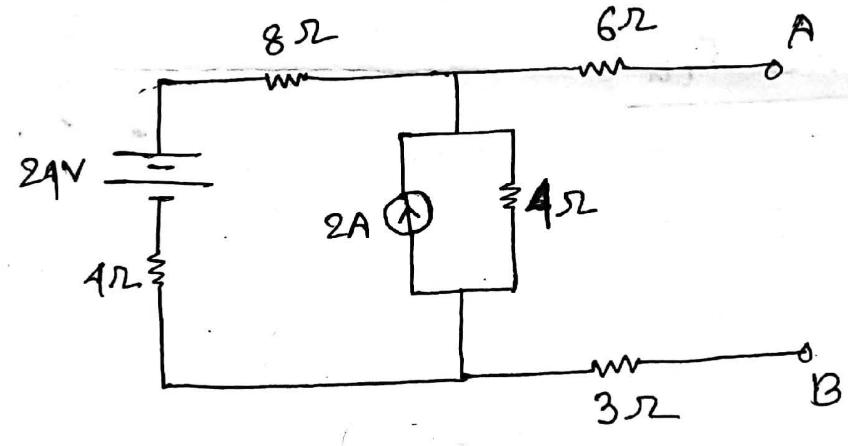
The resistance of the coil is 10.85Ω.

Ans.

EEE-1107 (Exam - 2017)

2. a) For transformation from delta network to equivalent wye network, find each of the wye connected resistances.

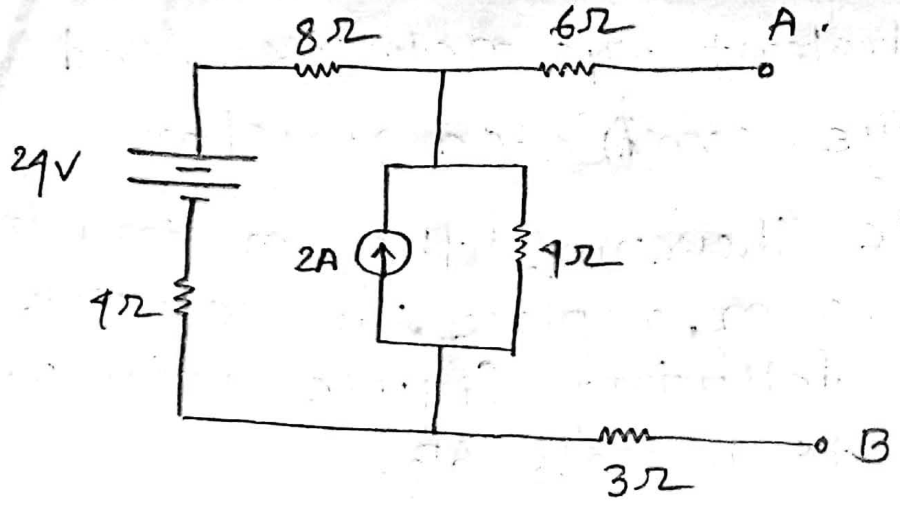
b) State Thevenin's theorm and by using the theorm, replace the network shown in the following figure with reference to the terminals AB.



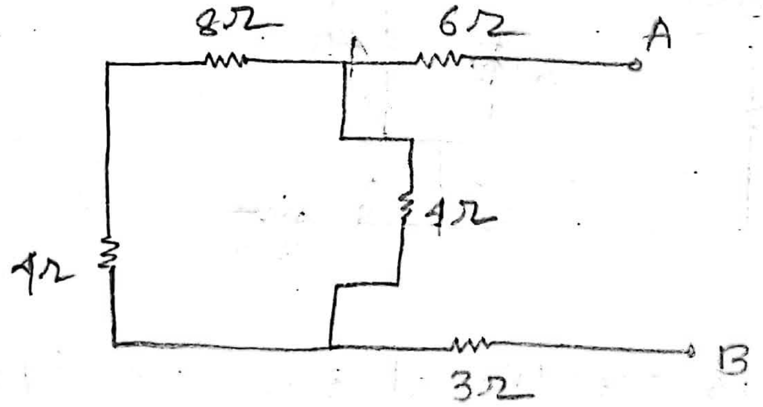
c) What is electrical source? Classify electrical sources. Define independent and dependent sources.

Answer

b)

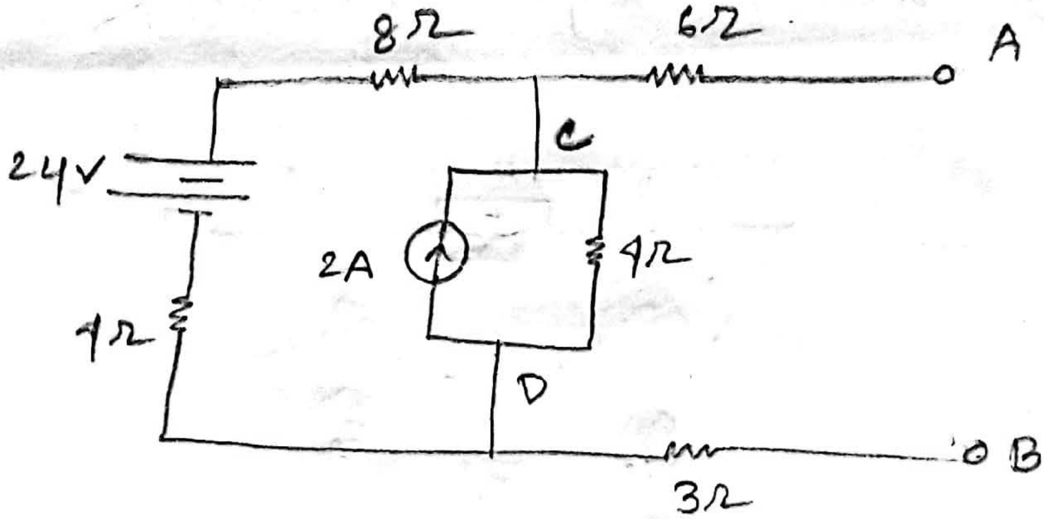


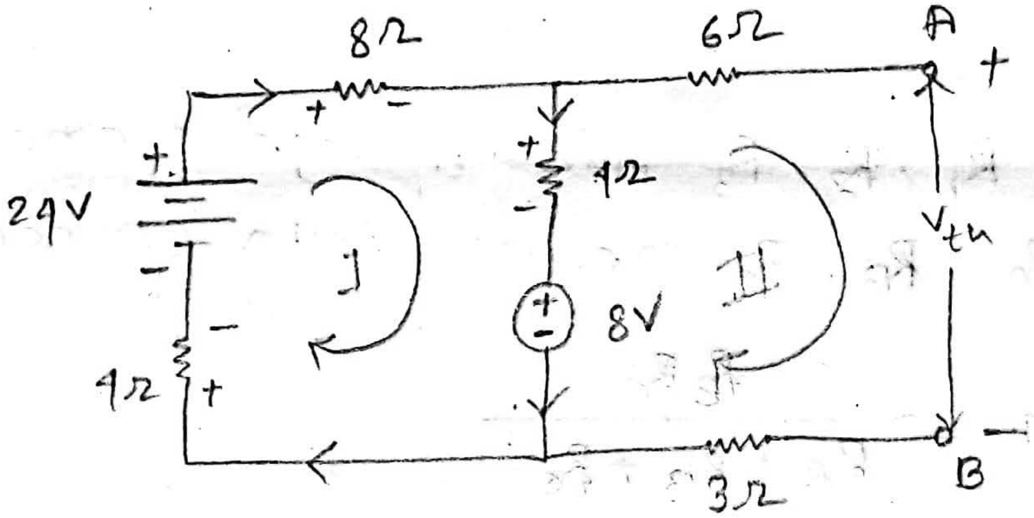
To find R_{th}:



$$R_{th} = \{(8+4) \parallel 4\} + 6 + 3$$
$$= 12\Omega$$

To find V_{th}:





apply KVL at loop-I

$$+24 - 8I - 4I - 8 - 4I = 0$$

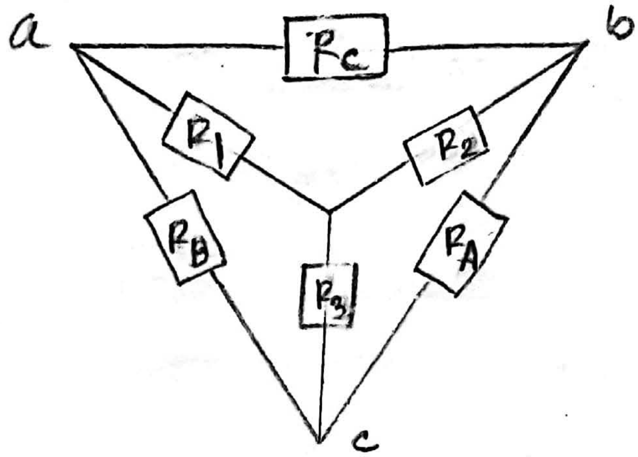
$$\Rightarrow I = 1\,A.$$

apply KVL at Loop-II,

$$V_{th} - 4I - 8 - 6.0 - 3.0 = 0.$$

$$\Rightarrow V_{th} = 12V.$$

a) Transformation from delta network to equivalent wye network:



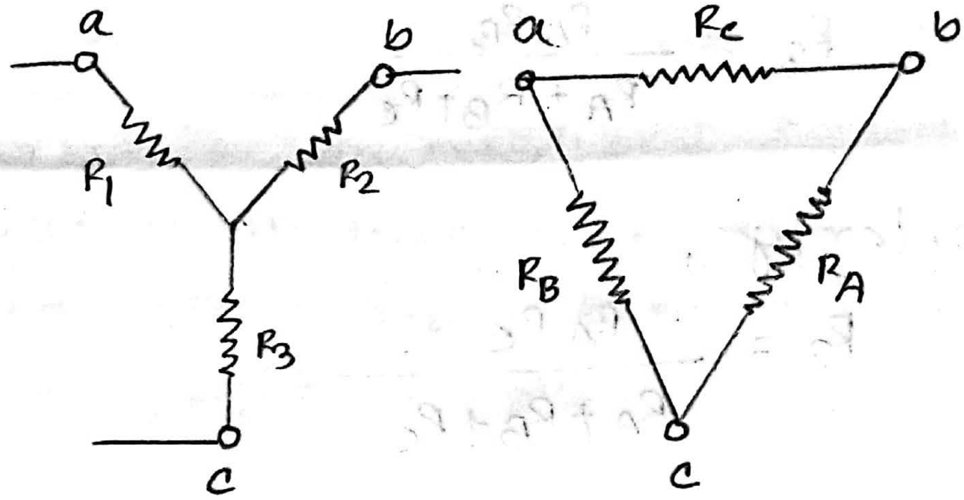
Here, R_1, R_2, R_3 are in wye connection and R_A, R_B, R_C are in delta connection.

$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C}$$

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C}$$

Now, show in below,



$$R_{a-c}(Y) = R_{a-c}(\Delta)$$

$$R_{a-c} = R_1 + R_3 = \frac{R_B(R_A + R_C)}{R_B + (R_A + R_C)}$$

$$R_{a-b} = R_1 + R_2 = \frac{R_C(R_A + R_B)}{R_C + (R_A + R_B)}$$

$$R_{b-c} = R_2 + R_3 = \frac{R_A(R_B + R_C)}{R_A + (R_B + R_C)}$$

$$(R_1 + R_2) - (R_1 + R_3) = \frac{R_C R_A + R_C R_B}{R_A + R_B + R_C} - \frac{R_B R_A + R_B R_C}{R_A + R_B + R_C}$$

$$\Rightarrow R_2 - R_3 = \frac{R_A R_C - R_B R_A}{R_A + R_B + R_C}$$

$$(R_2 + R_3) - (R_2 - R_3) = \frac{R_A R_B + R_A R_C}{R_A + R_B + R_C} - \frac{R_A R_C - R_B R_A}{R_A + R_B + R_C}$$

$$\Rightarrow 2R_3 = \frac{2 R_B R_A}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C}$$

similarly,

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_B R_C}{R_A + R_B + R_C}$$

c) Electrical source is defined as the resources for electric power and it also provides energy in electrical from. Coal, nuclear, natuaral gas, water, oil, biomas, wint etc.
They are two types of electrical sources:

1) independent or ideal

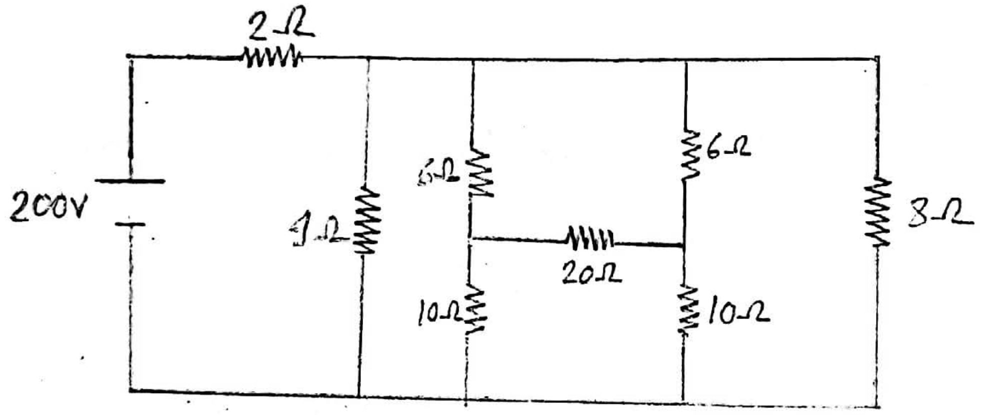
2) dependent or controlled.

Independent Sources: An independent source is an idealized circuit component that fixes the circuit parameters in a branch, respectively, to a specified value.

dependent Sources: A dependent source is a circuit component whose value depends on circuit parameter ~~ta~~ ~~eles~~ elsewhere in the network. It is more useful. Sometimes it also depend upon time-varying. ~~Biop~~ Bipolar junction transistor, operational amplifier and so on.

Ques no. 3

Q.(a): Find the current using Norrors theorem through a load of 8 Ω in the following circuit.



Ans to the Q.(a):

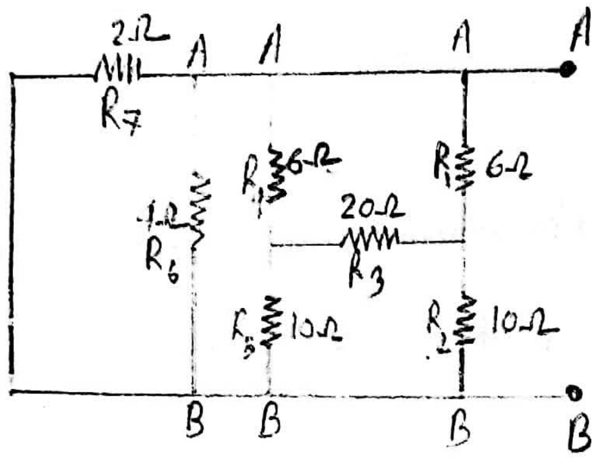
From the circuit load resistance, $R_L = 8\Omega$

Let

The current following through R_L is I.

To get the value of I we have know the value of R_N and I_N.

For R_N: To calculate R_N we have to short the voltage sources and open the load resistance. Then the equivalent



$\therefore R_N$

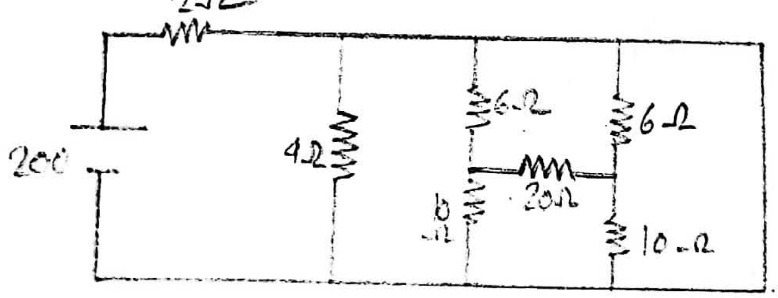
According to whitstone-brige law :- No current will flow through R_3. Because $\frac{R}{R_2} = \frac{R_4}{R_5}$

So $R_N = (R_1+R_2) \parallel (R_4+R_5) \parallel R_6 \parallel R_7$

$= (16 \parallel 16 \parallel 4 \parallel 2)$

$= \frac{8}{7}\ \Omega$

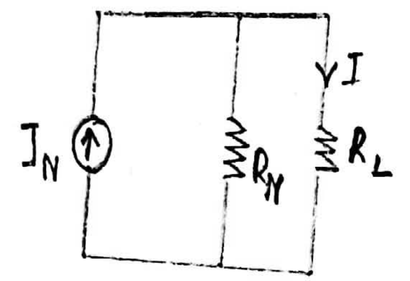
For I_N: We have short R_L. Then equivalent circuit



$I_N = \frac{200}{2}$

$= 100\ A$

So Norton's equivalent circuit

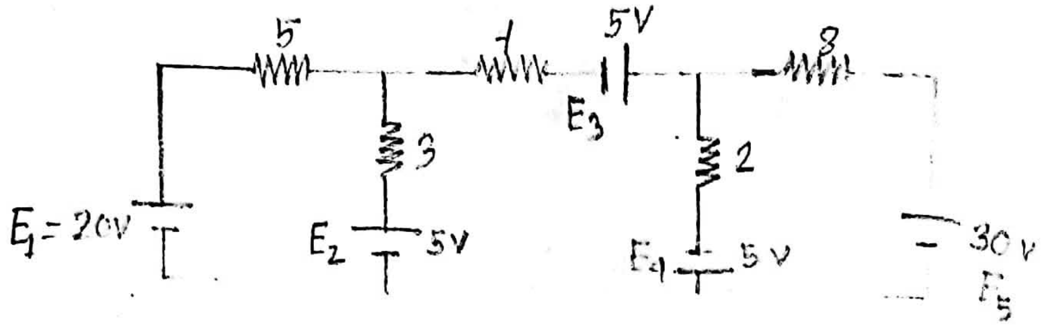


$$\therefore I = I_N\left(\frac{R_N}{R_N+R_L}\right)$$

$$= \frac{100 \times 8/7}{(8/7)+8}$$

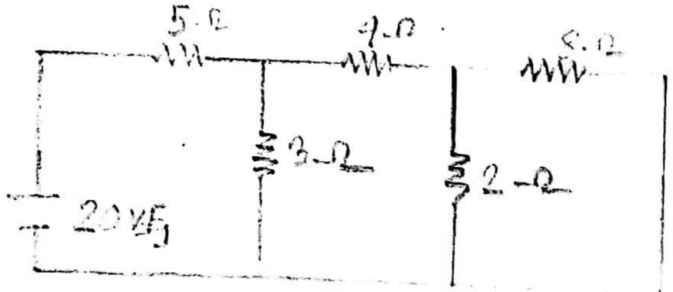
$$= 12.5\,A$$

Q.no 3 (b) : Determine the current supplied by each battery in the following circuit.



Ans to the Q.(b):

The current supply by E_1: To measure the current supply by E_1, all battery sources will be short except E_1. Then the equivalent circuit will be

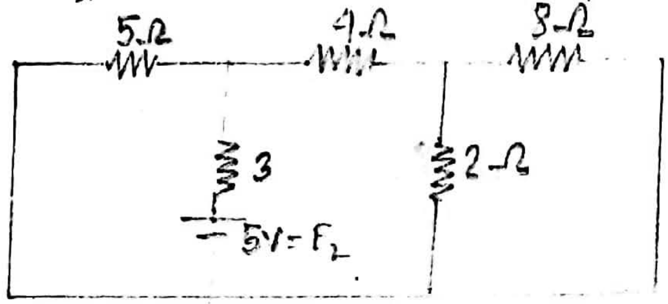


$\therefore$ ~~I_1 =~~ $R_{eq} = 5+[3\,||\{4+(8||2)\}]$

$= \cancel{5+}\ 11.72\ \Omega$

$\therefore I_1 = \frac{E_1}{R_{eq}} = \frac{20}{11.72} = 1.706\ A$

For E_2: Equivalent ~~ckt~~ circuit -

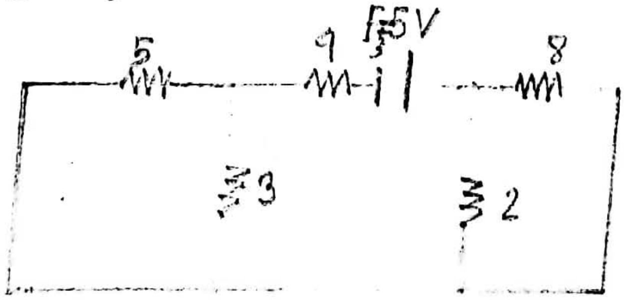


$$R_{eq} = 3 + \{5 \| 4 + (8 \| 2)\}$$

$$= 5.64\ \Omega$$

$$\therefore I_2 = \frac{E_2}{R_{eq}} = \frac{5}{5.64} = 0.89\ A$$

For E_3: Equivalent circuit



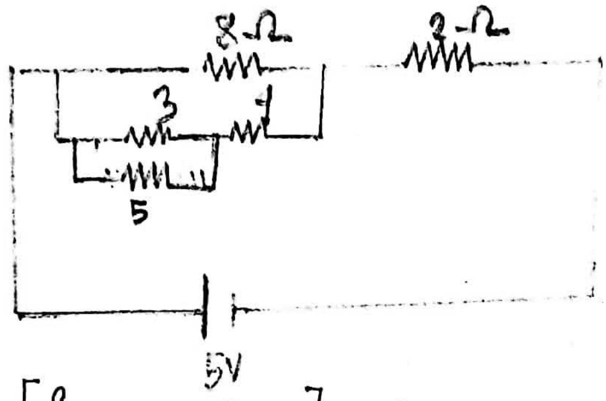
$$R_{eq} = (5 \| 3) + 4 + (8 \| 2)$$

$$\doteq 7.475\ \Omega$$

$$I_3 = \frac{E_3}{R_{eq}} = \frac{5}{7.475}\ A$$

$$= 0.6689\ A$$

For E_4: Equivalent resistance will be



$$R_{eq} = [\{(5 \parallel 3) + 4\} \parallel 8] + 2$$

$$= 5.387\ \Omega$$

$$\therefore I_4 = \frac{E_4}{R_{eq}} = \frac{5}{5.387}\ A$$

$$= 0.928\ A$$

For E_5:

Equvalent resistance

$$R_{eq} = [\{(5 \parallel 3) + 4\} \parallel 2] + 8$$

$$= 9.49\ \Omega$$

$$I_5 = \frac{E_5}{R_{eq}} = \frac{30}{9.49} = 3.16\ A$$

Q. no 3(c) : How can a voltage source should be converted into current source?

Ans: In a voltage source there will be a resistor connected in series and in a current source there will be a resistor connected with parallel. To convert from voltage source to current source we ~~ha~~ will have connect the resistance with~~an~~ an ammeter of current

$I = V/R$

After calculating we have just connect the ~~so~~ current source which produce the current equal to I and R resistance will be in parallel

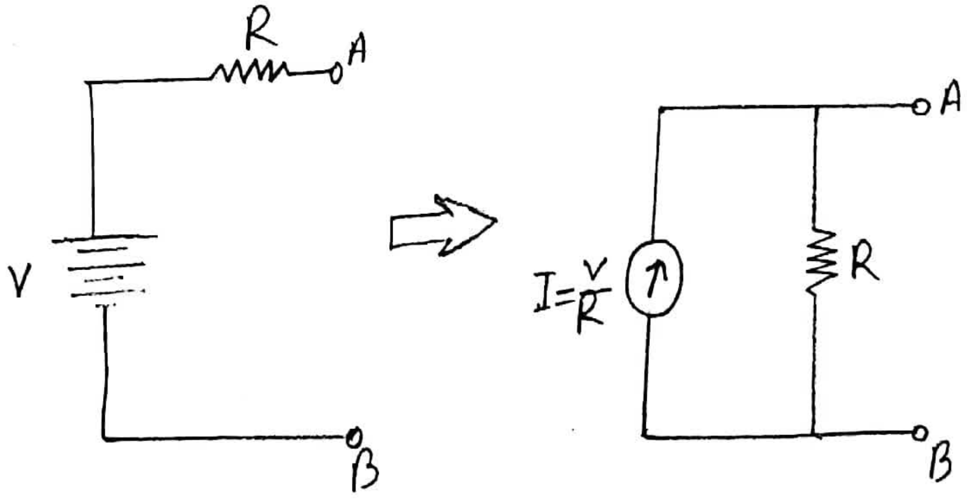
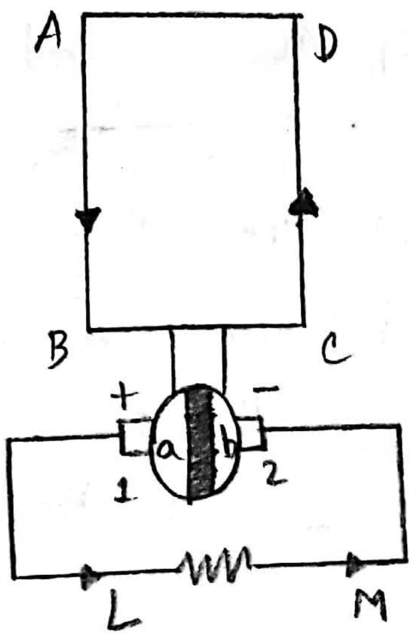


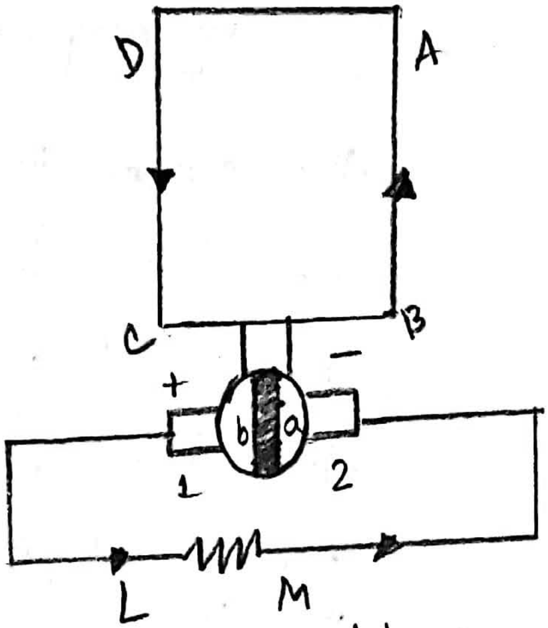
Fig: Convertion voltage source to current source

4 (a) Write down the working principal of a DC generator.

⇒ A DC generator is an electrical machine which converts mechanical energy into direct current electricity. This energy conversion is based on the principle of Faraday's law of electromagnetic induction. This law states that when a conductor moves in a magnetic field, it cuts magnetic lines of force, which induces an electro-magnetic force in the conductor. The magnitude of this induced EMF depends upon the rate of change of flux. This EMF will cause a current to flow if the conductor circuit is closed.

In a dc motor, a conductor of rectangular shape is placed between two opposite poles of magnet. The rectangular loop of the conductor is which rotates inside the magnetic field about its axis. When the loop rotates from its vertical position to its horizontal position, it cuts the flux lines of the field. Therefore, an EMF induced in both of the sides of the loop. As the loop gets closed there will a current circulating through the loop. The direction of the current can be determi by Flemming's right hand Rule. This rule says th if you stretch thumb, index finger and middle finger of your right, perpendicular to each othe then thumbs indicates the direction of motion of the conductor, index finger indicates the direction of magnetic field i.e, N-pole to S-pole and middle finger indicates the direction of flow of current through conductor. As a result, the direc of current on any side of the loop will keep changing as the loop keeps rotating due to the magnetic force across it. However, when the tangential motion of the sides of the loop is parallel to the flux lines of field, there will be no flux cutting and consequently there will be no current in the loop.



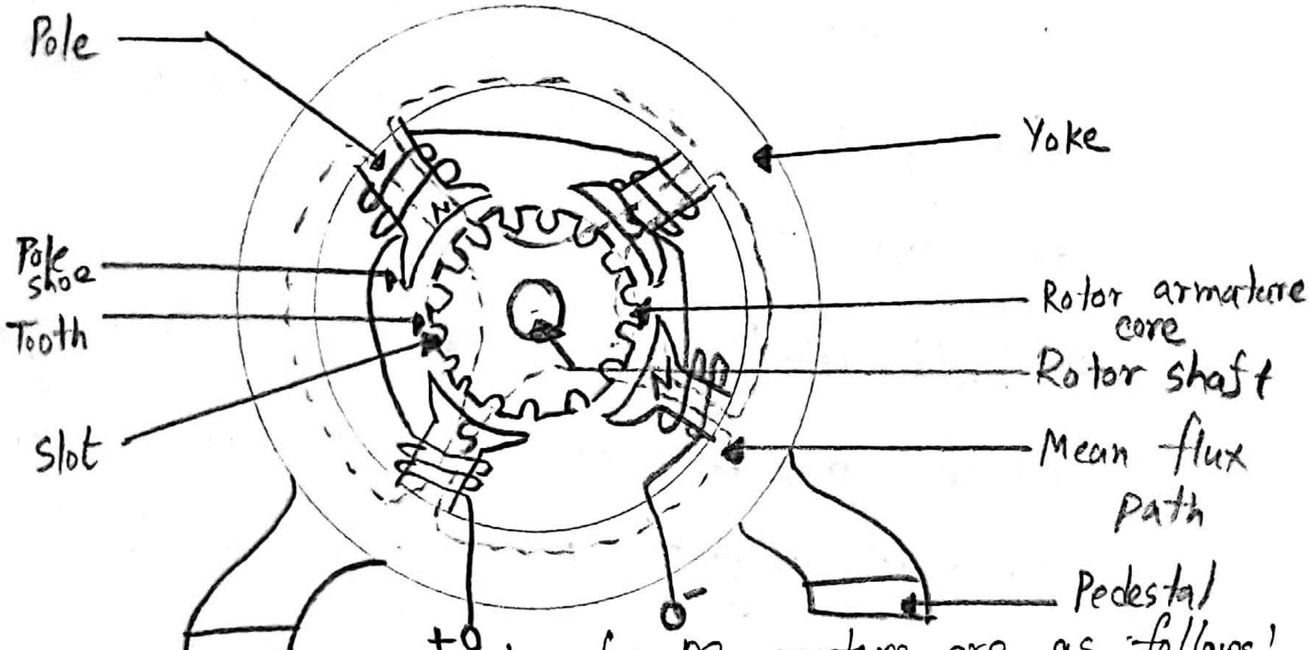


The loop is connected with a split ring as shown in the figure. Split rings, made of a conducting cylinder, get cut into two halves or segments insulated from each other. We connect the external load terminals with two carbon brushes which rest on these split slip ring segments.

In the first half of the revolution current always flows along ABLMCD i.e. brush no 1 in contact with segment a. In the next half revolution, the direction of the induced current in the coil is reversed. But at the same time the position of the segments a and b are also reversed which results that brush no 1 comes in touch with the segment b. Hence the current in the load resistance again flow from L to M. The change over of the segments a and b from one brush to other takes place when the plane of rotating coil is at a right angle to the plane of the lines of force.

Define different parts of a DC motor.

⇒ A DC motor is any of a class of rotary electrical machine that converts direct current electrical energy into mechanical energy.



The basic parts for DC motors are as follows:

① **Stator:** The stator carries the field winding and Poles. The stator together with the rotor constitutes the magnetic circuit or core of the machine. It is a hollow cylinder.

2. **Rotor:** It carries the armature winding. The armature is the load carrying member. The rotor is cylindrical in shape.

3. Armature winding: The winding rotates in the magnetic field set up at the stationary winding (Field winding). It is the load carrying member mounted on the rotor. An armature winding is a continuous winding; that is, it has no begining or end. It is composed of a number of coils in series.

4. Field winding: This is an exciting system which may be an electrical winding or a permanent magnet and which is located on the stator.

5. ~~Commutator~~ Brushes: These are conducting carbon graphite spring loaded to ride on the commutator and acts as interface between the external circuit and the armature winding.

~~6. Brushes: These ar~~

6. Commutator: The coils on the armature are terminated and interconnected through the commutator which compromised of a number of bars or commutator segments which are insulat

from each other. The commutator rotates with the rotor and serves to rectify the induced voltage and the current in the armature both of which are A.C.

7. Poles: The field winding is placed in poles, the number of which is determined by the voltage and current ratings of the machine.

8. Slot/Teeth: For mechanical support, protection from abrasion and further electrical insulation, non-conducting slot liners are often ~~wid~~ wedged between the coils and the slot walls. The magnetic material between the slots is called teeth.

9. Motor Housing: The motor housing supports the iron-core, the brushes and the bearings.

EEE - 2017

1107

Question: 5. (a) Define with necessary diagrams (i) Oscillating current (ii) Alternating current (iii) period and (iv) cycle

Section - B

5 (a) (i) Oscillating current: Oscillating current is current which alternately increases and decreases magnitude with respect to time at some definite law.

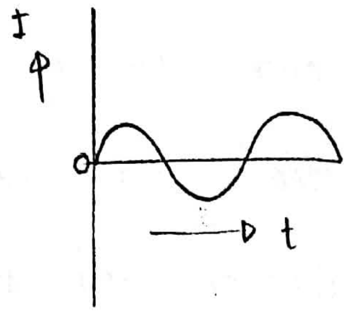


Fig: Diagram of oscillating current

(ii) Alternating current: Alternating current is a periodic current which average value within a period is zero.

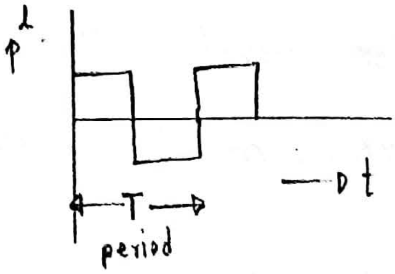
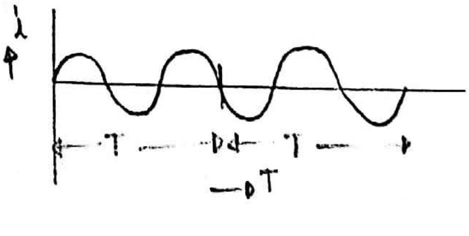


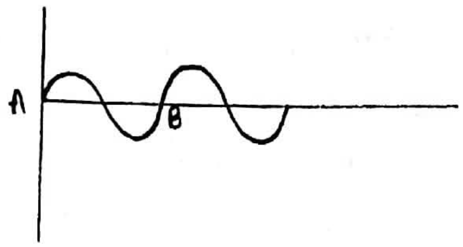
Fig: Diagram of alternating current.

(iii) period: Smallest way of time that recurs.



Here T is period.

cycle: complete set of positive and negetive values.



Here AB is a cycle.

Question

(6) Define Impedence. Derive the equation of impedance of L Branch. show graphical representation of voltage current and power of that Branch.

Impedance: Ration between maximum voltage and maximum current with angle between voltage and current combindly called impedance.

Derivation of the equation of impedance of L branch:

In pure inductance circuit, the equation of dynamic equilibrium:

$$v = L\frac{di}{dt} = V_m \sin wt$$

$$di = \frac{V_m}{L} \sin wt\, dt \quad \ldots (1)$$

After both sides of both equation are integrated it follows that

$$i = -\frac{V_m}{wL} \cos wt$$

$$i = \frac{V_m}{\omega L}\sin(\omega t - 90^\circ) = I_m \sin(\omega t - 90^\circ)$$

$$\therefore Z_L = \frac{V_m}{I_m} \angle \theta_v - \theta_1$$

$$= \frac{V_m}{\frac{V_m}{\omega L}} \angle 90^\circ$$

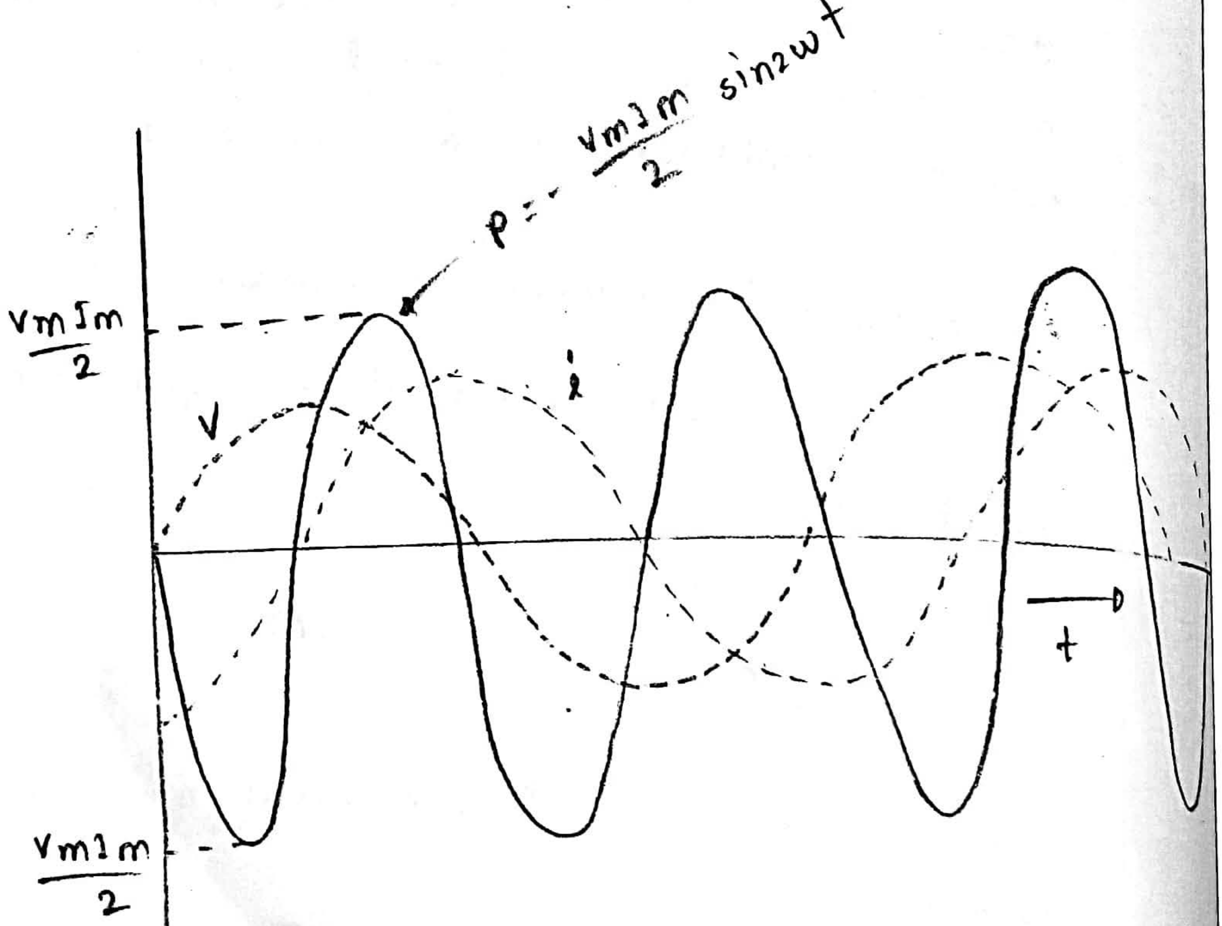
$$\boxed{Z_L = \omega L \angle 90^\circ}$$

This denotes the impedance of pure L branch.

$$p = vi = [V_m \sin\omega t][I_m \sin(\omega t - 90^\circ)]$$

$$= V_m I_m (-\sin\omega t \cos\omega t)$$

$$= -\frac{V_m I_m}{2}\sin 2\omega t$$



(c) Find the amount of energy stored by a capacitor during a quater cycle.

Sol^n: The amount of energy stored by a capacitor during one quater cycle can be determind by integrating the power equation over any positive loop

$$P = \frac{V_m I_m}{2} \sin 2\omega t$$

$$W_c = \int_0^{T/4} \frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= \frac{V_m I_m}{2\left(\frac{4\pi}{T}\right)} \times \left[- \cos \frac{4\pi}{T} \times t\right]_0^{T/4}$$

$$= \frac{V_m I_m}{\left(\frac{4\pi}{T}\right)} = \frac{V_m I_m}{2\omega}$$

Since $I_m = \omega C V_m$

$$W_c = \frac{V_m(\omega C V_m)}{2\omega} = \frac{1}{2} V_m^2 C \quad \text{(Ans)}.$$

8. a) Describe the working principle of a synchronous motor.

Ans: Synchronous motor is a doubly excited machine i.e. two electrical inputs are provided to it. It's stator winding which consists of a 3 phase winding is provided with 3 phase supply and rotor is provided with DC supply.

A synchronous motor works on the principle of magnetic interlocking. Working principles are described below:

1. The 3 phase stator winding in connected with 3 phase supply.
2. It create the stator RMF (rotating magnetic field) when rotate at synchronous speed in the air gap.
3. Now rotate the motor by some external means at about synchronous speed.
4. Excite the rotor winding with D.C. supply.
5. It create the poles at the rotor.
6. When flux in a magnetic locking between stator and Rotor magnetic field.
7. Rotor also start rotating at synchronous speed.

Write down the method of starting of synchronous motor.

Ans: The methods are given below:

1. By DC motor:

The synchronous motor's rotor is coupled with DC motor and it's made to run at synchronous speed with help of field ckt of dc motor, then ac supply to stator and dc supply to rotor is given and the motor gets started.

2. By AC motor:

Above same procedure is repeated, but in this use AC motor (pony) a induction motor having at least 2 poles less than that of syn. motor, so that it can run the syn. motor at synchronous speed

3. Damper winding:

In this method the synchronous is initially allowed to run as induction motor with the help of damper winding and then it's allowed to run as synchronous motor when it catches near synchronous speed.

Synchronous motors are nowadays stated as self-starting because they are provided with damper windings.

6) What are the main four parameters of a transformer

Ans: 1. VA rating.

2. Input voltage range.

3. Weight or mass

4. Short-circuit or fault current rating.

How can they be determined?

The parameters of a transformer can be determined by performing two tests: the open-circuit test and the short-circuit test.

The open-circuit test:

As the name implies, one winding of the transformer is left open while the other is excited by applying the rated voltage. The frequency of the applied voltage must be the rated frequency of the transformer. Although it does not matter which side of the transformer is excited, it is safer to conduct the test on the low-voltage side. Another justification for performing the test on the low-voltage side is the availability of the low-voltage source in any test facility.

Short-circuit test:

1. Isolate the power transformer from service
2. Remove HV/LV jumps and disconnect neutral from earth/ground.
3. Short LV phases and connect these short circuited terminals to neutral.
4. Energise HV side by LV supply.

Describe transformer tests briefly.

Ans: Some transformer tests are:

1. Open-circuit test.
2. Short-circuit test.
3. Sumpner or back to back test: This test is conducted simultaneously on two identical transformers and provides data for finding the efficiency, regulation and temperature rise. The main advantage of this test is that the transformers are tested

(84) under full-load conditions without much expenditure of power. The power required to conduct this test is equal to the losses of the two transformers. It may be noted that two identical transformers are needed to carry out this test.

(c) A single phase transformer has 400 primary and 1000 secondary turns. The net cross-sectioned area of the core is 60 cm². If the primary winding be connected to a 50 Hz supply at 520 V; calculate (i) peak value of flux density in the core, (ii) the voltage induced in secondary winding.

Ans: (ii) $\frac{E_s}{E_p} = \frac{n_s}{n_p}$

$$\Rightarrow E_s = \frac{n_s}{n_p} \times E_p = \frac{1000 \times 520}{400} = 1300\,V \text{ (Ans.)}$$

(i) $\cancel{B_{max}} = \frac{\cancel{V_{rms}}}{\cancel{4.44 \times f N} A}$ ~~testa~~.

(i) $E_{rms} = \frac{N\omega}{\sqrt{2}} \phi_{max}$

∴ max flux density in the core,

$$\phi_{max}' = \frac{E_{rms} \times \sqrt{2}}{N\omega} = \frac{E_{rms} \times \sqrt{2}}{N \times 2\pi f}$$

$$= \frac{520\,V \times \sqrt{2}}{400 \times 2\pi \times 50\,Hz}$$

$$= 5.852 \times 10^{-3}\ Wb \text{ (Ans.)}$$

CSE-1

20

64\F

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
B.Sc. Engineering 1st Year 1st Term Examination, 2016
Department of Computer Science and Engineering
EEE 1107
Basic Electrical Engineering

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) B-H curve may be supplied if necessary.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) Define: (i) node (ii) mesh (iii) linear circuit. (06)
b) Using mesh analysis, determine the currents for the network in Fig. 1(b). (12)

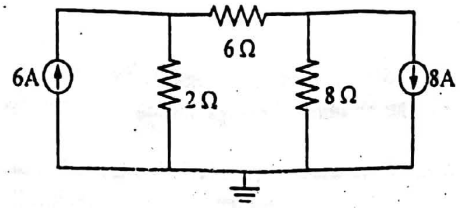


Fig. 1(b).

c) Deduce the condition for maximum power transfer. Under maximum power transfer conditions, show that the power transfer efficiency is 50%. (11)
d) Arrange seven resistors each having a magnitude of 4 ohm in such a way so that the equivalent circuit resistance will be 7 ohm. (06)

2. a) Mention three conditions for applying superposition theorem in a circuit. Using superposition theorem, find the current through 10Ω resistor of Fig. 2(a). (13)

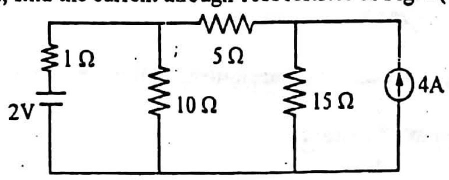


Fig. 2(a).

b) Find the Thevenin's equivalent circuit for the network shown in Fig. 2(b) across the R_L. (12)

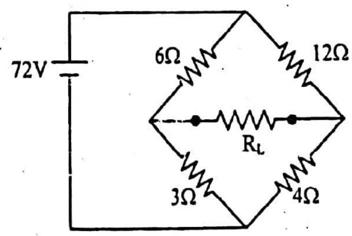


Fig. 2(b).

c) For transformation from 'delta network' to equivalent 'wye network' find each of the 'wye' connected resistance in terms of three 'delta' connected resistances. (10)

3. a) Define magnetic field, flux density and permeability. State Ampere's circuital law for magnetic circuit and give an example. (10)
b) Write the principle of generator and motor. Describe a practical dc generator. (12)
c) Classify dc generators according to their excitation with necessary diagrams. Describe the three important characteristic curves of dc generator. (13)

4. a) Describe armature reaction and its effects. (06)
b) Define critical resistance and explain voltage build up of a shunt generator. (10)
c) Define counter e.m.f. and write its significance. (07)
d) Mention the methods of speed control of a dc motor. Describe any one of them. (12)

SECTION B

(Answer ANY THREE questions from this section in Script B)

5. a) What is phase? Find the angle of phase difference between $v = 100\cos(\omega t - 30°)$ and $i = -10\sin(\omega t - 60°)$. Which wave lags? (05)
   b) Define impedance. Show that at no time the power in a pure resistance reach negative values. (06)
   c) Find the impedance of an L branch from its dynamic equilibrium equation. (12)
   d) A voltage $v = -150 \sin 377t$ is applied to a particular circuit element and it is found that $i = 10\cos 377t$ amp. Make a sketch of the v and i waves. Find the nature and magnitude of the circuit parameter. (12)

6. a) Show that the crest factor of sine wave is $\sqrt{2}$ and the form factor is 1.11. (10)
   b) Find the equations for the amount of energy during a quarter cycle of an inductor and a capacitor. (15)
   c) Find the equation of instantaneous power delivered to the R-L branch and from the equation define real and reactive power. Also represent the power graphically. (10)

7. a) What is phasor? Write the significance of operator j. (04)
   b) Calculate real power and reactive power employing complex forms. The voltage of a circuit is $v = 200\sin(\omega t + 30°)$ and the current is $i = 50\sin(\omega t + 60°)$. What are the p.f., reactive factor and volt-amp? (12)
   c) Why is transformer rating in KVA? Describe the open circuit test and short circuit test of a single phase transformer. (13)
   d) What are the differences between alternator and synchronous motor? Write the advantages of stationary armature in an alternator. (06)

8. a) Write the working principle of a transformer. Define step up and step down transformer. Write some applications of them. (12)
   b) What are the losses in a transformer? Define efficiency and find the condition for maximum efficiency of a transformer. (08)
   c) Describe transformer on (i) no-load and on (ii) load conditions. Draw necessary vector diagrams. Give constructional details of a transformer and write also the methods of cooling of it. (15)

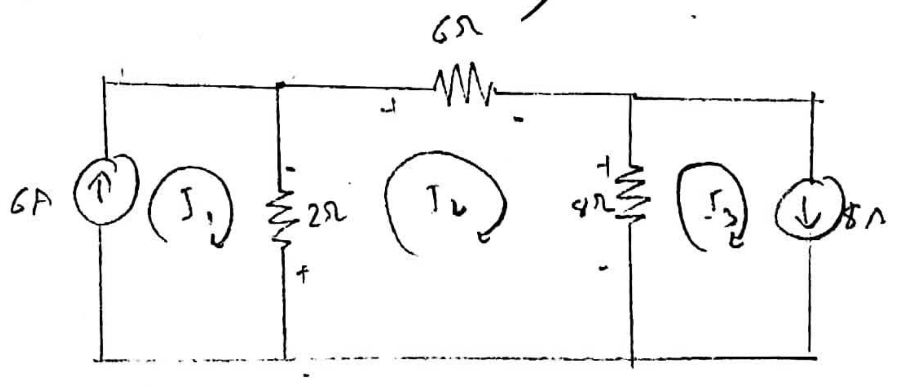
Ans. no. 1

a) i) Node : Node is a point in a network or diagram at which lines or pathways intersect.

ii) Mesh : A mesh is a closed path in a circuit with no other paths inside it.

iii) Linear circuit : A linear circuit is an electronic circuit which obeys the superposition principle.

(b)



Using supermesh and applying KVL,

$$-(I_2-I_1)2 - 6I_2 - (I_2-I_3)8 = 0$$

$$\Rightarrow -2I_2 + 2I_1 - 6I_2 - 8I_2 + 8I_3 = 0$$

$$\Rightarrow 2I_1 - 16I_2 + 8I_3 = 0 \quad \text{—(i)}$$

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$I_1 = 6\ A,$

$I_3 = 8\ A$

From (1) ⇒

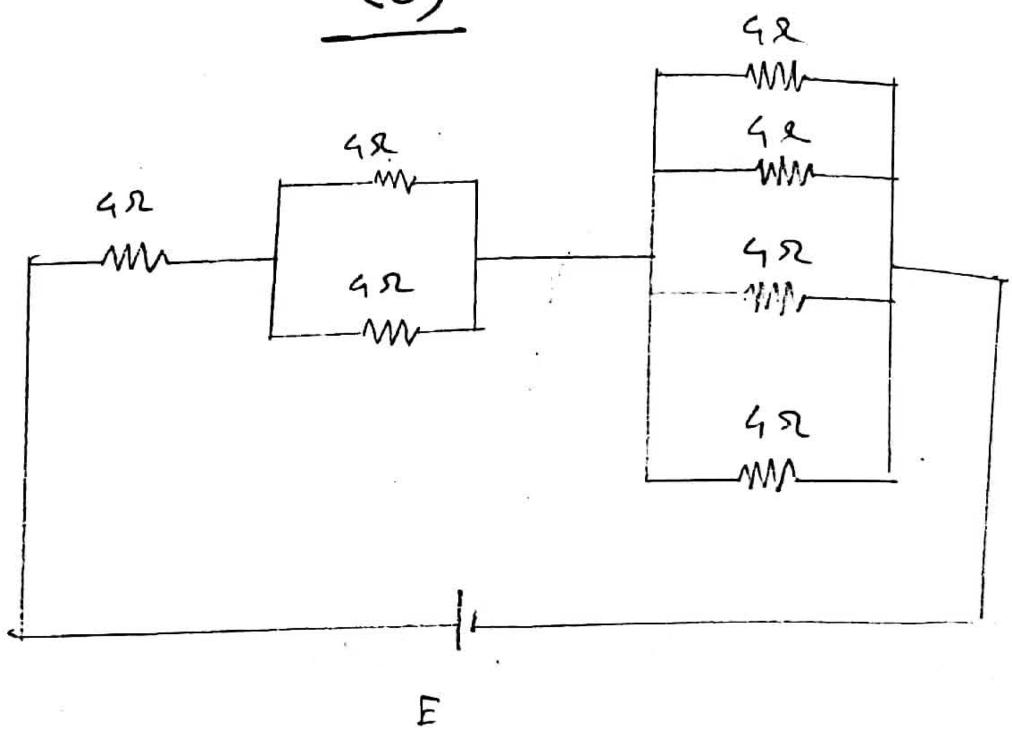
$2 \times 6 - 16 I_2 + 8 \times 8 = 0$

$\therefore I_2 = 4.75\ A$

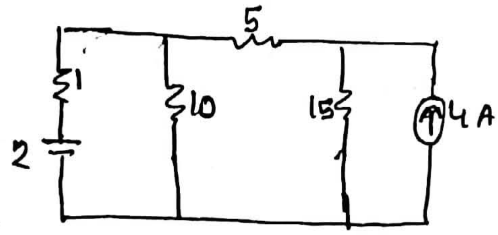
$\therefore I_{2\Omega} = I_1 - I_2 = 6A - 4.75A = 1.25\ A$ *

$I_{8\Omega} \uparrow = I_3 - I_2 = 8 - 4.75 = 3.25\ A$

(d)



2.(a) Mention three condition for applying supperposition theorem in a circuit. Using superposition theorem, find the current through 10 Ω resistor. of Fig. 2(a).

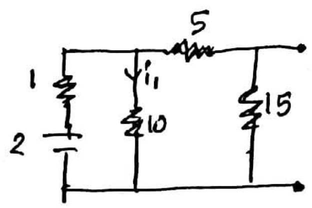


→ Conditions:

(i) Find the current of a particular branch for each voltage and current source.

(ii) Applicable to linear bilateral network.

(iii) While finding the branch current for one voltage or current source the rest of the voltage source will be shorted and the current source will be opened.



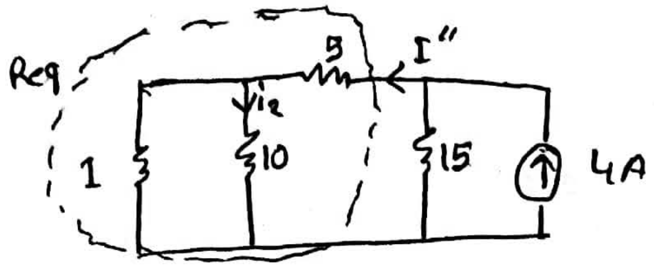
$R_{eq} = 1 + 10 \parallel 20$

$= 1 + \frac{10 \times 20}{20+10} = 7.67$

$I = \frac{2}{7.67} = 0.26A$

$i_1 = \frac{20}{10+20} \times 0.26$

$= 0.174\ A$



$R_{eq} = 1 \parallel 10 + 5$

$= \frac{10}{11} + 5$

$= 5.9$

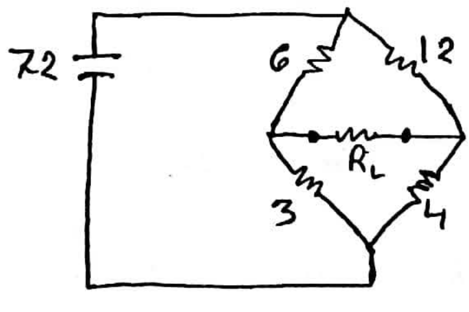
$I'' = \frac{15}{15+5.9} \times 4$

$= 2.87\ A$

$i_2 = \frac{1}{1+10} \times 2.87 = 0.261$

$\therefore I_{(10\Omega)} = i_1 + i_2 = 0.174 + 0.261 = 0.435\ A.$

(b) Find the Thevenin's equivalent circuit for the network shown in Fig. 2(b) across the R_L.

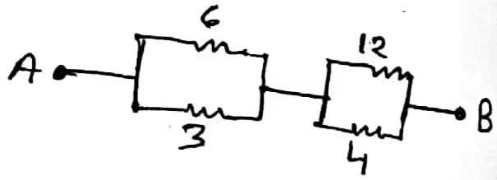


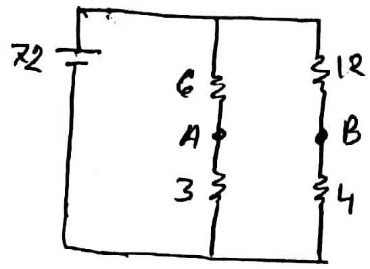
=) By shorting voltage source

$R_{th} = 6 \parallel 3 + 12 \parallel 4$

$= \frac{6 \times 3}{6+3} + \frac{12 \times 4}{12+4}$

$= 5\ \Omega$





$E_A = E \times \frac{3}{6+3}$

$= 72 \times \frac{3}{9}$

$= 24V$

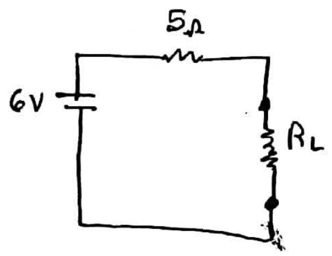
$E_B = E \times \frac{4}{12+4}$

$= 72 \times \frac{4}{16}$

$= 18V$

$V_{th} = E_A - E_B = 24 - 18 = 6V.$

Thevenin's equivalen circuit:



ⓒ For transformation from 'delta network' to equivalent 'wye network' find each of the 'wye' connected resistance in terms of three 'delta' connected resistances.

Ans: 2018 এর 2C এর অনুরূপ

90 ①

3. (a) magnetic field: ~~B~~ The magnetic field is the area around a magnet where there is a magnetic force.

flux density: Flux density is the number of ~~of~~ magnetic lines of flux that pass through a certain point on a surface.

magnetic permeability: It means the ability of a magnetic material to support magnetic field devlopment. In other ~~o~~ words magnetic permeability is the constant in the proportionality between magnetic induction and magnetic field intensity.

Ampere's circuital law:

The integral of ~~o~~ magnetic field density (B) along an imaginary closed path is equal to the product of current and closed by the path and permeability of medium genanator:

(b) There are two types of genarator (1) AC genarator and (2) DC genarator. Both of ~~them~~ these two convert the mechanical power to electrical power.

Both of these genarator produce electric power based the principle of Faraday's law of electromagnetic induction. This law states that when a conductor moves in a magnetic field it cuts magnetic ~~lie~~ lines of force, which induces an electromagnetic force (EMF) in the conductor.

principale of motor:

An electric motor is an electric machin which converts electrical power to mechanical power. The basic work principle of a motor is whenever a current carring conductor is placed ~~to~~ in a magnetic field it experiences a mechanical force. The direction of this force is given by ~~f~~ Flemming's left hand rule. And its magnitide is given by $F = Bil$.

Describe a practical DC Generator:

⇒ construction of DC generator

There are some parts of DC generator these are —

~~yoke the outer frame~~

① yoke – the outer frame of a dc machine is called as yoke. It is made up of cast iron or steel.

② poles and pole shoes: poles are joined to the yoke with the helps of bolts or welding. The pole shoes serve two purposes.

(a) they support field coils

(b) spread out the flux in air gaps.

~~③ Field welding:~~

③ Armature:

Armature core is the rotor of dc generator. It is ~~a~~ cylindrical in shape. The armature is build up of thin laminated circular steel disk. Armature is keyed to the ~~shap~~ shaft.

④ Armature winding:

It is usually a former wound copper coil which run in armature slot. Armature winding can be wound two methods (i) lap winding ② wave winding.

⑤ Commutator: & Brush

physical connection to the armature winding is made through a commutator brush arrangement. The function of a commutator is to collect the current generated in armature conductor. A commutator consist of a set of copper segment which are insulated from each other. Brushes are usually made from carbon or graphite. The rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

(4) (a) Descrilbe armature reaction & effect.

Armature reaction is effect of armature flux on main field flux. Basically there are two windings in a dc motor - Armature winding and field winding. When we excite field winding, it produces a flux which links with the armature. The current in armature produces another flux which lags the main flux.

This is referred to armature reaction. It has two effects:

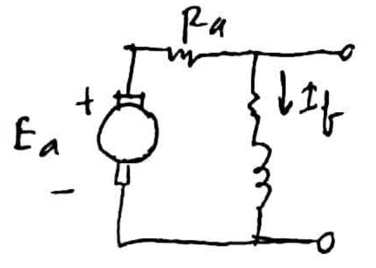
(1) Demagnetising effect: It reduces the strength of main flux.

(2) crossmagnetising effect: It's effect is that it bends/ distortes the main flux line along the conductor.

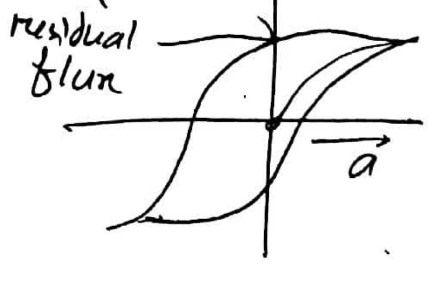
(b) Critical field resistant & voltage build up of a shunt generator.

In a DC shunt generator, the voltage include accross the armature, V_a, is directly proportional to the flux accross ~~the~~ it. The flux is directly proportional to the field current, I_f. The critical field resistance is defined as the maximum field circuit resistance with which the shunt generator would excite.

Voltage Buildup : ~~(1) Open circuit~~



Initially $I_f = 0$, though voltage is generated because of a residual flux in the pole of the machine.



$E_{a\,\text{residual}} = K \phi_{res} \omega$ ($\simeq 1V$ or $2V$)

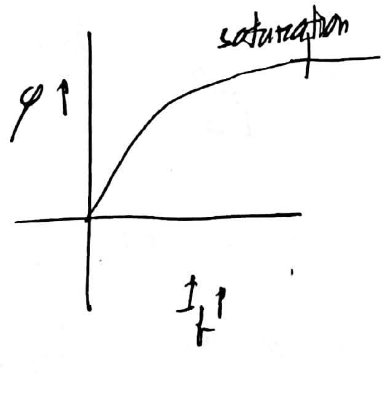
$I_f = \dfrac{E_{a\,\text{residual}}}{R_f}$; because of E_a residual flux

ϕ will increase. $\phi > \phi_{residual}$. For this E_a will also increase. and V_T will increase. $I_f = \dfrac{V_T}{R_f} \uparrow$. and this I_f also increase. For that ϕ again increase.

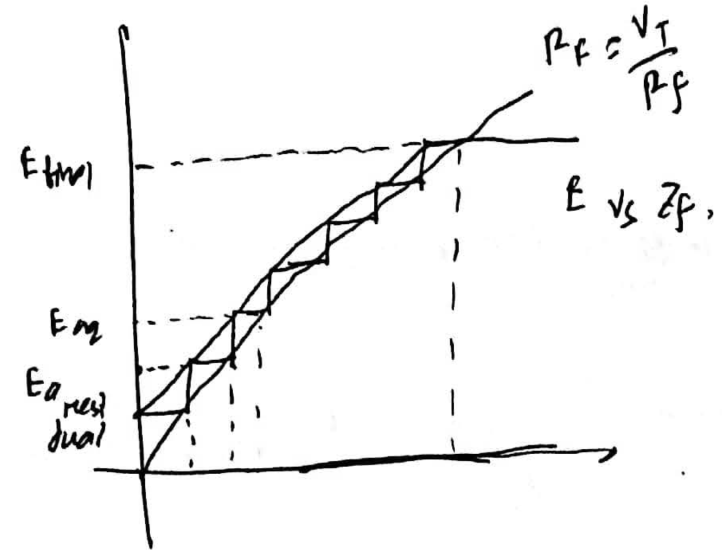
$$\uparrow I_f = \frac{E_{a\,res}}{R_f} \to \phi \uparrow \to E_a \uparrow \to V_t \uparrow \to I_f \uparrow$$

এইভাবে loop টা কাজ করে।

When the ϕ reach to maximum this procedure is stopped.



Graph :



4) c)

Define counter e.mf & significance.

E.m.f : c.e.m.f is the electromotive force or voltage that oppose the change in current which induced it.

Its significance : It helps a DC motor to draw as much as armature which is sufficient to develop torque

$$I_a = \frac{V - E_b}{R_a}.$$

When the motor is running on no load, small torque is required to overcome the friction and windage losses. Armature current I_a is small and counter e.m.f = applied voltage.

The counter e.m.f allows a larger current to flow through the armature and larger current means increased driving torque. Thus, driving torque increases as the motor turns down. As the armature speed increases the back e.m.f also increas and causes the armature current I_a to decrease. The motor will stop accelarating when armature current is just sufficient to produce the reduced torque.

speed control of Shunt : (1) Flux control Method
(2) Armature " "
(3) Voltage " "

" " of series motor : (1) flux control
(2) Variable Resistance in series with Armature
(3) series parallel control.

Flux control Method.

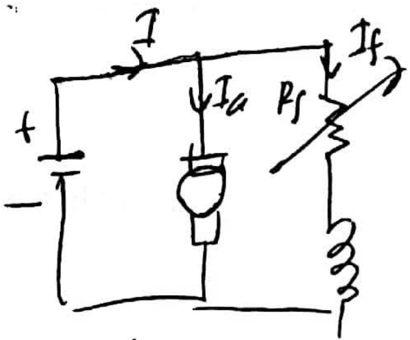


fig 1.

Speed of a DC motor is inversely proportional to the flux per pole. Thus by decreasing the flux, speed can be increased. to control the flux, a rheostate is added in series with the field winding, as shown in fig 1. Adding more resistance will increase the speed as it decrease the flux. In shunt motor, as field current is relatively very small,

$I_{sh}^2 R$ is very small. Therefore, this method is quite efficient.

Though speed ~~of~~ can be decreased above the rated value by reducing flux with this method, it puts a limit to maximum speed as weakening of field flux beyond a limit adversely affect the commutation.

Answer of Question Number 5:

a) Question: What is phase? Find the angle of phase difference between $V = 100\cos(\omega t - 30^\circ)$ and $i = -10\sin(\omega t - 60^\circ)$. Which wave lags?

Answer: Phase is the fractional part of a period through which time or the associated time angle ωt has advanced from an arbitrary reference.

Given equations: $V = 100\cos(\omega t - 30^\circ)$

$$= 100 \sin(90 + \omega t - 30^\circ)$$

$$= 100\sin(\omega t + 60^\circ)$$

$$i = -10\sin(\omega t - 60^\circ)$$

$$= 10\sin(180^\circ + \omega t - 60^\circ)$$

$$= 10\sin(\omega t + 120^\circ)$$

$\therefore$ angle of phase difference $= 60^\circ - 120^\circ$

$$= -60^\circ$$

$\therefore$ The current wave leads. Hence the voltage wave lags.

b) **Question:** Define impedence. Show that at no time the power in a pure resistance reach negative values.

Answer: **Impedence:** Impedence, in electrical devices, refers to the amount of opposition faced by direct or alternating current when it passes through a circuit or system. Its magnitude defines the ratio of V_m to I_m. and its angle represents the difference the phase angle of voltage and current or viceversa.

2nd part: We know,

$$v = V_m \sin \omega t \longrightarrow (1)$$
$$i = I_m \sin \omega t \longrightarrow (2)$$

The power in a pure resistence is given by the product of (1) & (2)

$$p = vi = V_m I_m \sin^2 \omega t$$
$$= V_m I_m \frac{1}{2}(1 - \cos 2\omega t)$$
$$= \frac{V_m I_m}{2} - \frac{V_m I_m}{2} \cos \omega t \longrightarrow (3)$$

Here, power will be minimum if $\cos \omega t$ becomes maximum. The maximum value of $\cos \omega t$ is 1. Putting $\cos \omega t = 1$ we get,

$$P_{min} = \cancel{\frac{V_m I_m}{}} \; 0 \rightarrow (4)$$

It is clear that equation (4) is non-negative. ∴ Hence, the power in a pure resistance cannot reach negative values at any given time.

c) **Question:** Find the impedence of an L branch from its dynamic ~~equation~~ equilibrium equation.

Answer: If a circuit element of pure inductance is considered, then the equation for dynamic equilibrium is:

$$v = L\frac{di}{dt} = V_m \sin\omega t$$

$$\Rightarrow di = \frac{V_m}{L}\sin\omega t\, dt \rightarrow (1)$$

By integrating both side of the equation (1) we get,

$$i = -\frac{V_m}{\omega L}\cos\omega t + C_1 \rightarrow (2)$$

The constant of integration C_1 will be considered to be equal to zero since only the steady-state current symmetrical about the zero axis is to be considered.

Under the above conditions equation (2) reduces to

$$i = \frac{V_m}{\omega L}\sin(\omega t - 90^\circ) = I_m \sin(\omega t - 90^\circ) \rightarrow (3)$$

It will be observed from equation (3) that $\frac{V_m}{I_m} = \omega L$ and that i lags v by one quarter of a cycle or 90°.

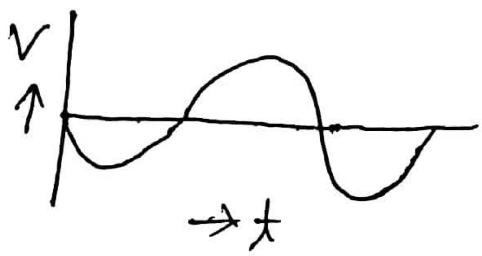
Hence the impedence of a pure L branch is:

$$Z_L = \omega L \angle 90^\circ$$

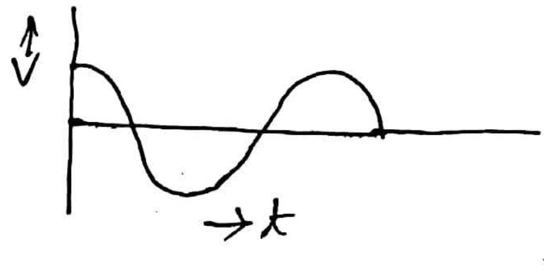
d) Question: A voltage $v = -150 \sin 377t$ is applied to a particular circuit element and it is found that $i = 10 \cos 377t$ amp. Make a sketch of the v and i waves. Find the nature and magnitude of the circuit parameter.

Answer:

Sketch of v:



Sketch of i:



nature: Both waves are sinusoidal

Magnitude: Observinge the equations we get,

$$V_m = -150$$

$$I_m = 10$$

6(a). **Question:** Show that the creast factor of sine wave is $\sqrt{2}$ and the form factor is 1.11.

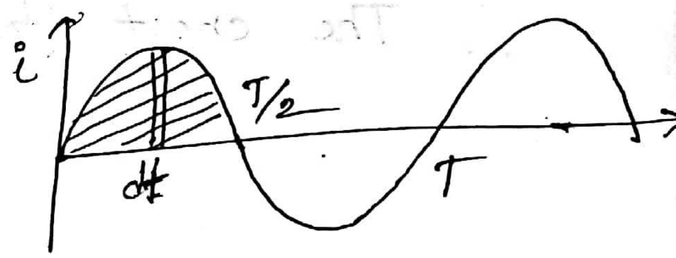
Answer:

We know,

$$P_{av} = \frac{V_m I_m}{2} \cos\theta \qquad R\angle 0^\circ;\ \omega L \angle 90^\circ;\ \frac{1}{\omega C}\angle -90^\circ$$

$$I_{rms}^2 R = \frac{1}{T}\int_0^T i^2 R\, dt$$

Here, $i = I_m \sin\omega t$



$$\Rightarrow I_{rms}^2 = \frac{1}{T}\int_0^T I_m^2 \sin^2\omega t\, dt$$

$$= \frac{I_m^2}{2}\int_0^T (1 - \cos 2\omega t)\, dt$$

$$= \frac{I_m^2}{2}\left[t - \frac{\sin 2\omega t}{2\omega}\right]_0^T$$

$$\Rightarrow I_{rms}^2 = \frac{I_m^2}{2}$$

$$\therefore I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707\, I_m$$

$$I_{av} = \frac{2}{T}\int_0^{T/2} I_m \sin \omega t \, dt$$

$$= \frac{2 I_m}{T}\left[\frac{-\cos \omega t}{\omega}\right]_0^{T/2}$$

$$= \frac{2\, I_m}{T} \times \frac{T}{\pi}$$

$$\Rightarrow I_{av} = \frac{2\, I_m}{\pi} = 0.636\, I_m$$

$\therefore$ The crest factor $= \dfrac{\text{maximum value}}{\text{effective value}}$

$$= \frac{I_m}{0.707\, I_m}$$

$$= 1.414$$

$$= \sqrt{2}$$ (showed)

The form factor $= \dfrac{\text{effective value}}{\text{average value}}$

$$= \frac{0.707\, I_m}{0.636\, I_m}$$

$$= 1.11$$ (showed)

Question 6(b): Find the equations for the amount of energy during a quarter cycle of an inductor and a capacitor.

Soln:

For Inductor:

$$p = Vi = -\frac{V_m I_m}{2} \times \sin 2\omega t$$

$$W_L = \int_{T/4}^{T/2} -\frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= -\frac{V_m I_m}{2} \int_{T/4}^{T/2} \sin 2\omega t \, dt$$

$$= -\frac{V_m I_m}{2} \left[\frac{\cos 2\omega t}{2\omega} \right]_{T/4}^{T/2}$$

$$= \frac{V_m I_m}{2} \left\{ \cos\left(2 \times \frac{2\pi}{T} \times \frac{T}{2}\right) - \cos\left(2 \times \frac{2\pi}{T} \times \frac{T}{4}\right) \right\}$$

$$= \frac{V_m I_m}{4\omega} (\cos 2\pi - \cos \pi)$$

$$= \frac{V_m I_m}{4\omega} \{1 - (-1)\} = \frac{V_m I_m}{4\omega} \times 2$$

$$= \frac{\omega L \times I_m^2}{2\omega}$$

$$\boxed{W_L = \frac{1}{2} L I_m^2}$$

This is the required equation.

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For capacitor:

$$W = \int_0^{T/4} \frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= -\frac{V_m I_m}{2} \left[\frac{\cos 2\omega t}{2\omega}\right]_0^{T/4}$$

$$= \frac{V_m I_m}{4\omega} \left[\cos 0 - \cos 2\omega \times \frac{T}{4}\right]$$

$$= \frac{V_m I_m}{4\omega} \left\{1 - \cos\left(\frac{2\times 2\pi}{T} \times \frac{T}{4}\right)\right\}$$

$$= \frac{V_m I_m}{4\omega} \left\{1 - (-1)\right\}$$

$$= \frac{V_m I_m}{2\omega}$$

$$\left[\frac{V_m}{I_m} = \frac{1}{\omega C}\right]$$

$$I_m = V_m . \omega C$$

$$= \frac{V_m \times V_m \, \omega C}{2\omega}$$

$$\boxed{W = \frac{1}{2} C V_m^2}$$

↳ Required equation.

6(c)

Question: Find the equation of instantaneous power delivered to the R-L branch and from the equation define real and reactive power. Also represent the power graphically.

Answer:

The instantinuous power delivered to R-L branch may be obtained from

$$p = vi = \left[V_m \sin(\omega t + \theta)\right]\left[I_m \sin \omega t\right]$$

After the $\sin(\omega t + \theta)$ term is expanded, the above equation can be written in the following forms:

$$P = V_m I_m \sin \omega t \left[\sin \omega t \cos\theta + \cos \omega t \sin\theta\right]$$

$$= V_m I_m \sin^2 \omega t \cos\theta + V_m I_m (\sin \omega t \cos \omega t) \sin\theta$$

$$= \frac{V_m I_m}{2} \cos\theta - \frac{V_m I_m}{2}\left[\cos 2\omega t\right] \cos\theta + \frac{V_m I_m}{2}\left[\sin 2\omega t\right] \sin\theta \quad (1)$$

This is the equation of Instantinuous power delivered to R-L branch.

Real power: Instantaneous real power refers to $\left[\frac{V_m I_m}{2}\cos\theta - \frac{V_m I_m}{2}(\cos 2\omega t)\cos\theta\right]$, the first two terms on the right hand side of equation (1). Reference to fig. 1 will show that these two terms combine to form an instantaneous power variation which contains no negative values; hence this portion of equation (1) is called the instantaneous real power.

Unless qualified to mean instantaneous real power, the expression real power refers only to $\frac{V_m I_m}{2}\cos\theta$

Reactive power:

The third term on the right hand side of equation (1) $\frac{V_m I_m}{2}(\sin 2\omega t)\sin\theta$ is called instanteneous reactive power, for the reason that the area under the $\left[\frac{V_m I_m}{2}(\sin 2\omega t)\sin\theta\right]$ curve represents the energy which occillates between the driving source and the reactive elements of the receiving circuit.

Unless qualified to mean instantaneous reactive power, the expression reactive power refers only to $\frac{V_m I_m}{2} \sin\theta$

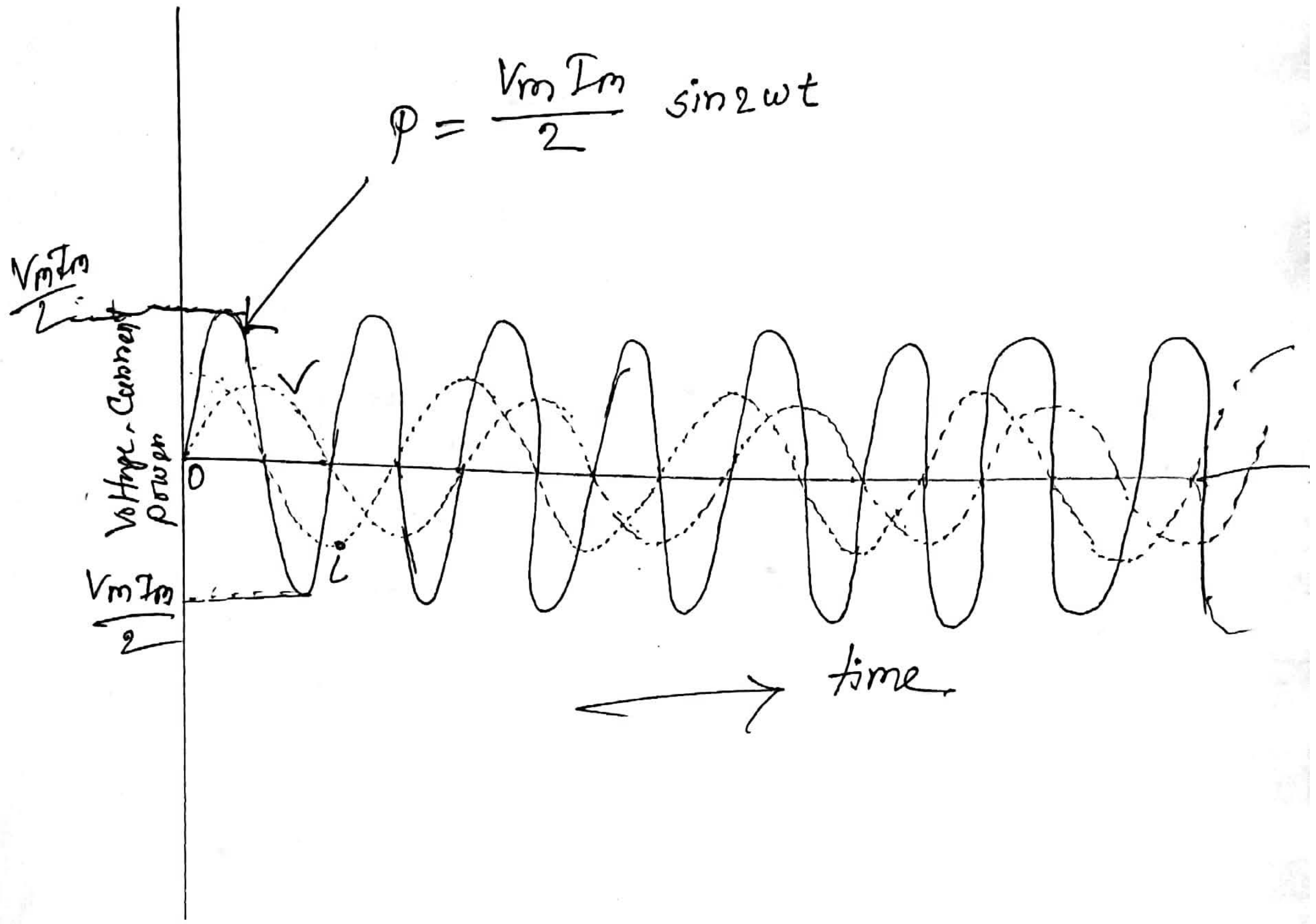


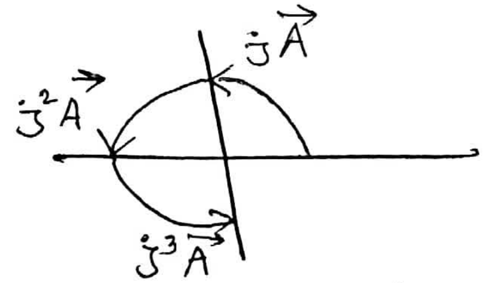
Fig. 1 Voltage, current and power in a purely capacitive branch.

Answer to the question no. 7(a)

A phasor is a complex number that represents a sinusoidal function whose amplitude,.. angular frequency and initial phase are time invariant. In other words, the coplanar vectors which represent sinusoidally-time varying quantities are called phasors.

Significance of operator j:

The symbolic notation for a phasor is $\vec{A} = x_A + j y_A$. The letter j used in this expression is the symbol of an operation. It is used to indicate the counter clockwise rotation of a vector through 90°. It is assigned a value of $\sqrt{-1}$. The double operation of j on a vector rotates it counter clockwise through 180°.



we can see from the figure above that,

$j = \sqrt{-1}$

$j^2 = (\sqrt{-1})^2 = 1$

$j^3 = (\sqrt{-1})^3 = -\sqrt{-1} = -j$

Answer to the question no. 7(b)

$v = 200 \sin(\omega t + 30^\circ)$

$i = 50 \sin(\omega t + 60^\circ)$

$P.f = \cos(\theta_v - \theta_i)$

$= \cos(30^\circ - 60^\circ)$

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

Reactive factor $= \sin(\theta_v - \theta_i)$

$= \sin(30^\circ - 60^\circ)$

$= -0.5$

Now,

$V_m = 200$	$I_m = 50$
$V_{rms} = \frac{200}{\sqrt{2}}$	$I_{Rms} = \frac{50}{\sqrt{2}}$

Volt-ampere $= VI = \frac{200}{\sqrt{2}} \times \frac{50}{\sqrt{2}}$

$= \frac{10000}{2}$

$= 5000$ W

(3)

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Answer to the question no. 7(c)

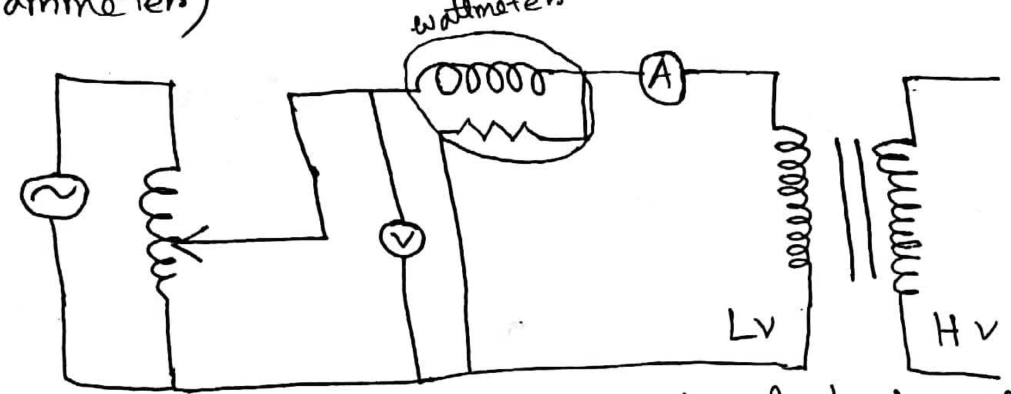
The ~~outop~~ output of a transformer is simply an electrical quantity. In cases where the manufacturers do not know the pf ratings the the transformer will be used - the power factor is a variable that is dependent on the load connected to source of power. So manufacturers make use of KVA rating for transformers. ~~alone~~ In a similar way, the output in motors is mechanical energy so pf is not ~~available~~ variable, which is why kW rating is used in cases involving motors. Manufacturers don't take any decision regarding the type of load the transformer will carry (capacitive or inductive) so they can only consider voltage and capacity.

Open circuit test:

The connection diagram for open circuit test on transformer is shown in the figure. A voltmeter, wattmeter and an ammeter are connected in Low voltage with the help of a variac of variable ratio auto transformer. The high voltage side is

(9)

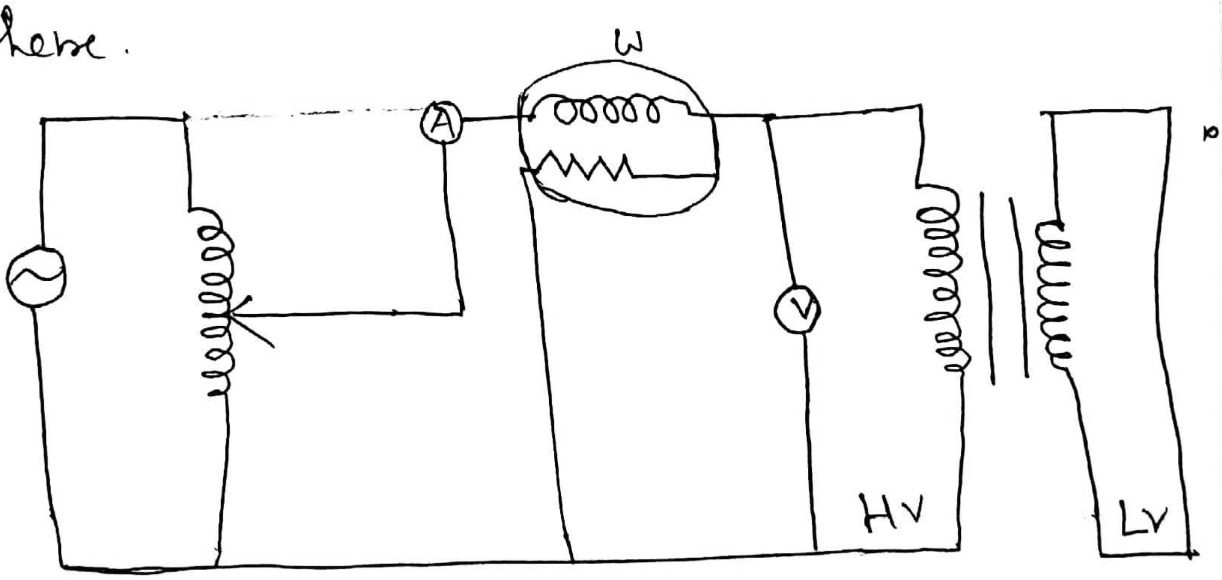
kept open. Now with the help of a variac, applied voltage gets slowly increased until the voltmeter gives readings equal to the rated voltage of the low voltage side. After reaching rated low voltage side voltage, we record all the three instruments' readings. (voltmeter, wattmeter, ammeter)



The input power is indicated by the wattmeter. And the output power is zero as the other side of the transformer is open circuited.

Short circuit test: ~~#~~ The connection diagram for short circuit test on transformer is shown below. A voltmeter, wattmeter and an ammeter are ~~is~~ connected in HV side as shown in the diagram. The voltage at rated frequency is applied to that HV side with the help of a variac of variable ratio auto transformer. We have to short circuit the LV side of the transformer. Now, with the help of a variac of variable ratio, applied voltage is slowly increased until the wattmeter, and an ammeter gives reading equal to the rated current of the HV side.

After reaching ~~rea~~ rated current of HV side, we record all three instruments reading. The ammeter gives the primary equivalent of full load current I_L. As the voltage applied for full load current in short circuit test on transformer is quite small compared to the rated primary voltage of the transformer, the core losses in transformer can be neglible here.



Answer to the question no. 7 (d)

⇒ TRY IT YOURSELF.

Ans to the question no 8

(a)
Transformer is a ~~vevi~~ device which transform voltage and ~~un~~ current keeping the total power constant.

Basically, it works on the principle of Farady's law of induction. When AC current is flow through the primary coil, that means, when the current ~~flow~~ ~~thr~~ in primayry coil is changed, the flux linked to the secondary coil also changes. Hance an EMF is produced in secondary coil.

Step up transformer:

The trunsformer that ~~converts~~ transforms low ~~less~~ voltage into high voltage ~~in seconda~~ is called ~~te~~ step-up transformer. ~~The~~ The voltage increases, in the same way current decreases in secondary coil.

Application: ~~trans~~ transmission of ~~te~~ electricity.

Step down transformer:

The transformer that transforms high voltage into low Voltage is called step down transformer The voltage decreases and in the same way current increases in secondary coil.

Application: phone charger, adapter.

(b)

The loses of transformer are of two types.

Those are:

① Core loss

⑪ Copper loss

Copre loss has two types also. There are,

- ~~Histe~~ Hysteriesis loss
- Eddy Current loss,

Efficiency of transformer:

The ratio of output and input power is called the efficiency of a transformer.

$$\text{efficiency} = \frac{\text{Power output}}{\text{Power input}}$$

There are four condition to increase the efficiency of transformer.

1. Loop area: If the nomber of loop increased, the flux ~~is~~ will be induced more. ~~Son the~~

2. Insulation: The insulation between sheets of core should be perfect to stop eddy current loss.

3. Resistance of primary and secondary coil: The materials of primary and secondary coils must be such that their electrical resistance is very small.

4. Flux cupling: The primary and secondary coil should be wound in such a way that flux

coupling between them is maximum because power transfer from primary to secondary coil takes place though flux linkages.

(c)

~~The~~ Transformer on no-load condition:

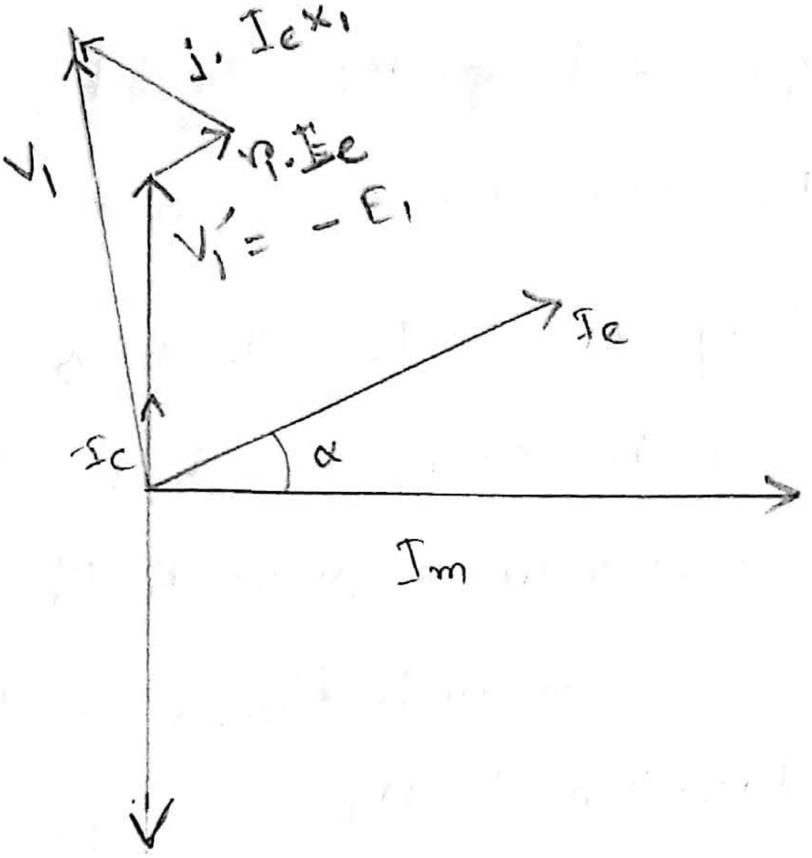
When the transformer is operating in no load the secondary winding is open circuited. Which means there is no load on secondary circuit. Hence, secondary current will be zero. While primary winding carries a small current I_0. (no load current). This current is responsible for iron loses. and a very small amount of cupper loses.

Transformer on-load condition:

When an electrical is connected to the secondary winding of a transformer an the transformer loading is therefore zero, a current flows in the secondary winding and out of the load. The secondary current is due to the induced secondary voltage, set up by magnetic flux created in the core from primary current.

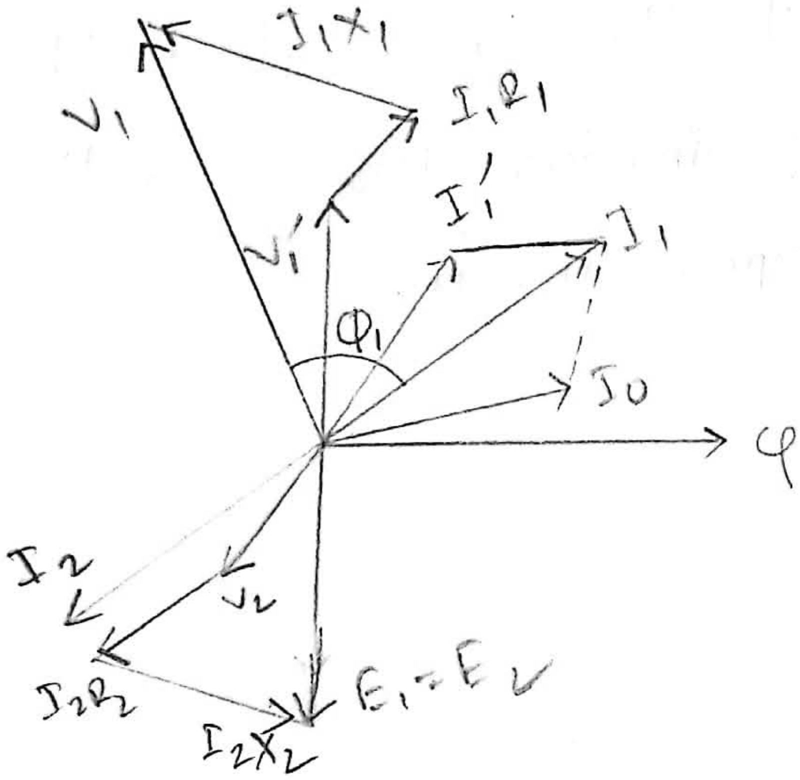
The secondary current I_s which is determined determined by the characteristics of the load, creates a secondary magnetic field. ϕ_s in the transformer core with flows in the exact opposite direction to the main primary field ϕ_p. These two magnetic field oppose each other resulting in a combined magnetic field of less magnetic strength than the single field produced by the primary windings alone when the secondary circuit was open circuit.

Vector diagram for no load condition:



Source voltage · $V_1 = V_1' + r_1 I_c + j I_c X_1$

Vector diagram for on load condition:



Constructional Details of transformer.

The main parts of transformer are:

1. Laminated core
2. Windings
3. Insulating materials.
4. Transformer oil.
5. Cooling tubes.

There are two windings in a transformer. Those are primary winding and secondary windings. Some insulated wires and winded in a core, that named as primary windings. ~~We provided~~ Primary winding works as input winding of transformer. The ~~sec~~ secondary winding ~~are~~ is also ~~made~~ some wires winded on the other side of core. Transformer oil ~~are~~ is used to make the transformer cool.

There are some method for cooling the ~~materi~~ transformer:

1. Natural Air
2. Air blast
3. ~~Natu~~ Oil Natural

4. Oil blust
5. Waterr and oil
6. water and oil circulation
7. Waterr and forced oil.

These are the main methods used to make the transformer cool.