B.Tech.

Second Semester Examination, 2009-2010

Electrical Technology (Paper-101-F)

Note : Attempt *five* questions in all Questions no. 1 is compulsory. All questions carry equal marks.

Q. 1. (a) State and explain ohm's law.

Ans. Ohm's Law : The relation between voltage current and resistance in a circuit is given by the ohm's law. It states the relation between V, I & R as

$$V = IR$$

Or

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

Ohm's law is applicable to individual components as well as the complete circuit.

If it is to be applied to only a part of the circuit then voltage and resistance corresponding to that part should be taken into consideration.

If it is to be applied to the complete circuit, then voltage across the complete circuit and effective resistance of the complete circuit should be used.

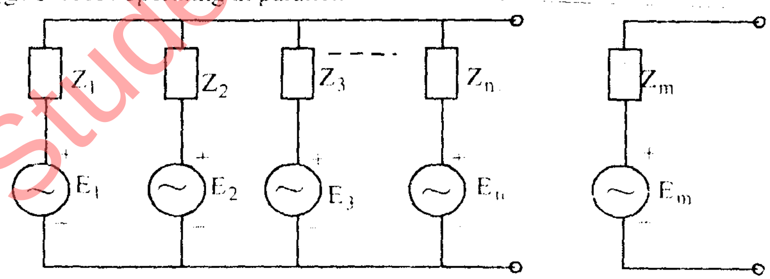
Ohm's law is not applicable to any non-linear device such as diode, transistor, zanier diodes etc. It is applicable only to the linear devices.

We can use ohm's law for AC circuits provided the circuit consists of only linear components and devices.

Q. 1. (b) State Milliman's theorem.

Ans. Milliman's Theorem : This theorem can be used either for voltage sources or current sources.

As Applicable to Voltage Sources : Using this theorem, one can determine the Thevenin's equivalent of a number of voltage sources operating in parallel.



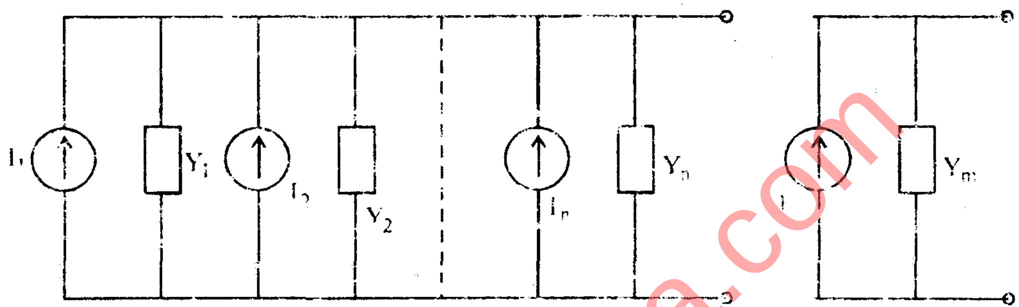
$$E_m = \frac{\sum_{i=1}^{n} E_i Y_i}{\sum_{i=1}^{n} Y_i} = \frac{E_1 Y_1 + E_2 Y_2 + \ldots\ldots + E_n Y_n}{Y_1 + Y_2 + \ldots\ldots Y_n}$$

$$Z_n = \frac{1}{\sum_{i=1}^{n} Y_i} = \frac{1}{Y_1 + Y_2 + \ldots\ldots Y_n}$$

To prove, each thevenin's voltage equivalent is transformed into Norton's current equivalent as.

$$I_i = \frac{E_i}{Z_i} = E_i Y_i; \qquad i = 1, 2, \ldots\ldots n$$

$$Y_i = \frac{1}{Z_i}$$



By KCL all current sources are added.

$$I = \sum_{i=1}^{n} I_i = \sum_{i=1}^{n} E_i Y_i = E_1 Y_1 + E_2 Y_2 + \ldots\ldots E_n Y_n$$

$$Y_m = \sum_{i=1}^{n} Y_i = Y_1 + Y_2 + \ldots Y_n$$

Then transforming back to voltage source E_m is series with impedance Z_m as shown,

$$E_m = \frac{I}{Y_m} = \frac{\sum_{i=1}^{n} E_i Y_i}{\sum_{i=1}^{n} Y_i}$$

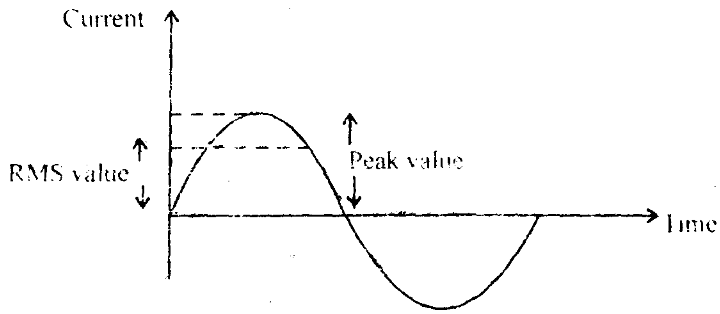
$$Z_m = \frac{1}{Y_m} = \frac{1}{\sum_{i=1}^{n} Y_i}$$

Q. 1. (c) Differentiate between rms & average value of signal.

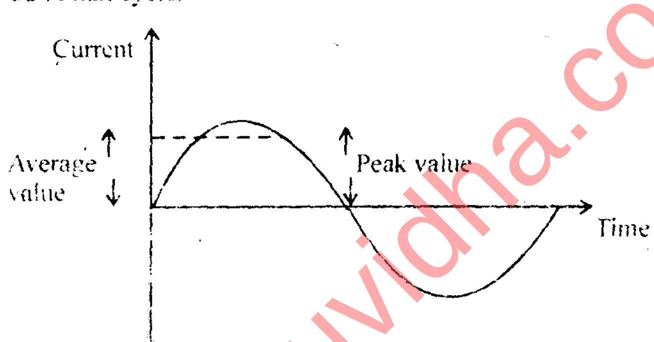
Ans. RMS Value : The RMS value of an ac current is equal to steady state or DC current that is required to produce the same amount of heat as produced by the ac current provided that resistance and time for which these currents flow are identical.

$$\text{RMS value} = 0.707 \times \text{Peak value}$$

$$I_{rms} = 0.707\, I_m$$



Average Value : The average value of an alternating quantity is equal to the average of all. the instantaneous values over a period of half cycle.



$$\text{Average value} = 0.637 \times \text{Peak value}$$

$$I_{av} = I_{dc} = 0.637\, I_p = 0.637\, I_m$$

Q. 1. (d) What is Q-factor of a circuit.

Ans. Q-Factor : The Q-factor is defined as the ratio of energy stored per cycle to the energy lost (or dissipated) per cycle

Mathematically Q can be expressed as,

$$Q = 2\pi \cdot \frac{\text{Maximum energy stored per cycle}}{\text{Energy dissipated per cycle}}$$

Q. 1. (e) Differentiate between phase & line voltages in three phase circuits.

Ans. Line voltage : If R, Y and B are called as the supply lines, then the potential difference between any two lines is known as the line voltage.

V_{RY}, V_{YB}, V_{RB}, V_{YR}, V_{BR} and V_{BY} are six possible line voltages. All the line voltages are sine waves of 50Hz frequency and the phase shift between the adjacent line voltages is 60°.

Phase Voltage : The voltage measured across a single winding or phase is called the phase voltage.

Q. 1. (f) What are eddy currents?

Ans. Eddy Currents : Due to the time varying flux, there is some induced emf in the transformer core. This induced emf causes some currents to flow through the core body. These currents are known as the eddy currents. The core is made of steel and has some finite resistance. Hence, due to the flow of eddy currents, heat will be produced. The power loss due to the eddy currents is given by

$$\text{Eddy current loss} = (\text{Eddy current})^2 \times r$$

Where r = Resistance of the core

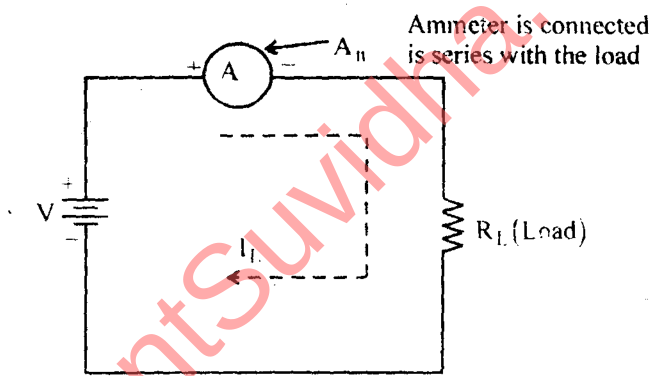
The eddy current losses are minimized by using laminations rather than a solid iron core. These laminations acts as a separate core with a small cross-sectional area, providing a large resistance to the flow of eddy currents.

Hence, laminations act as a separate core with a small cross-sectional area, providing a large resistance to the flow of eddy currents. The eddy current loss also is frequency dependent. It is directly proportional to the square of operating frequency.

$$P_e = K_e (B_{max})^2 f^2 t \cdot v$$

Q. 1. (g) What is the internal resistance of a ammeter?

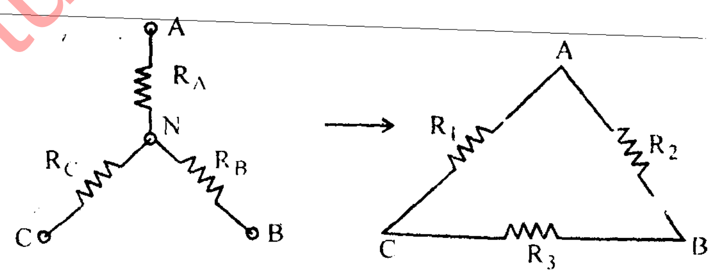
Ans. Ammeter is used for the measurement of current. The ammeter is always connected in series with the load, the current through which is to be measured as shown in figure.



Since the resistance offerend by an ammeter is very small, its introduction in series with the load does not alter the circuit conditions.

Q. 2. (a) Derive expressions for converting STAR circuit to Delta circuit.

Ans. Star to Delta Conversion :



We know that values of star are :

$$R_A = \frac{R_1 R_2}{R_1 + R_2 + R_3} \quad \text{...(i)}$$

$$R_B = \frac{R_2 R_3}{R_1 + R_2 + R_3} \quad \text{...(ii)}$$

$$R_C = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$

Multiplying equations (i) and (ii), (ii) and (iii), (iii) and (i) and adding them :

$$R_A R_B + R_B R_C + R_C R_A = \frac{R_1 R_2^2 R_3 + R_1 R_2 R_3^2 + R_1^2 R_2 R_3}{(R_1 + R_1 + R_3)^2}$$

$$= \frac{R_1 R_2 \ R_3}{(R_1 + R_2 + R_3)^2}$$

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

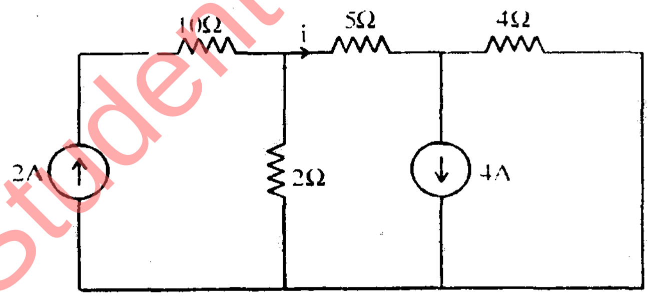
Divide equations (iv) by equations (i), (ii) and (iii) simultaneously.

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

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

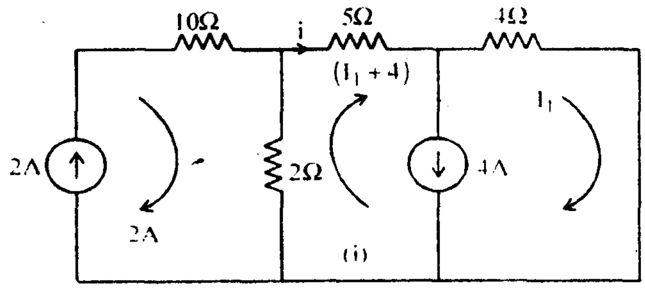
$$R_3 = R_B + R_C + \frac{R_B R_C}{R_A}.$$

Q. 2. (b) Find the current through 5Ω resistor.



Ans. Let current across 5Ω be i as shown in figure.

Apply KVL :



By seeing from the figure,

$$i = I_1 + 4 \qquad \text{...(i)}$$

By KVL in loop (i)

$$2[(I_1 + 4) - 2] + 5[I_1 + 4] + 4I_1 = 0$$

$$2(I_1 + 4) - 4 + 5[I_1 + 4] + 4I_1 = 0$$

$$7I_1 + 28 + 4I_1 - 4 = 0$$

$$11I_1 = -24$$

$$I_1 = -\frac{24}{11}$$

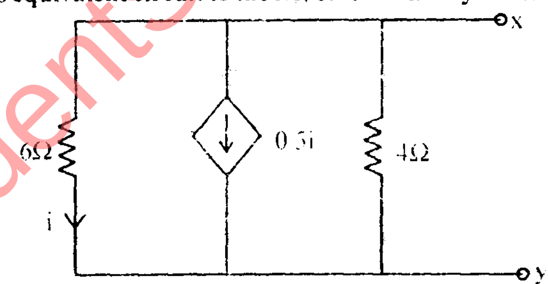
From equation (i)

$$i = I_1 + 4 = -\frac{24}{11} + 4$$

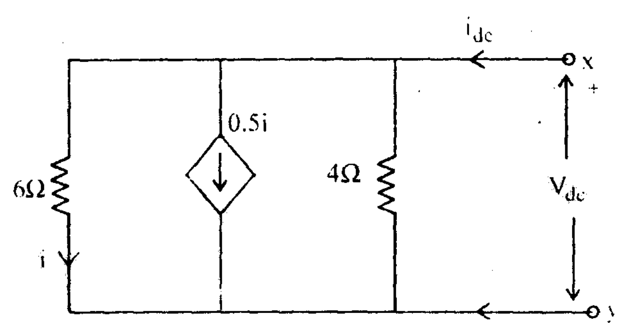
$$i = \frac{20}{11} \text{ Amp.}$$

Current across $5\Omega = i = \frac{20}{11}$ Amp. **Ans.**

Q. 3. (a) Find Norton's equivalent circuit to the left of terminal x-y in the Fig. show.



Ans. As the circuit to the left of x-y in fig. does not have any independent source hence $I_{sc}(= I_N) = 0$.



To find R_{int} through x-y, but x-y be kept open circuited and a dc voltage V_{dc} is applied, input current being i_{dc}.

Here,
$$i_{dc} = \frac{V_{dc}}{4} + 0.5i + \frac{V_{dc}}{6}$$

But
$$i = \frac{V_{dc}}{6}$$

$$i_{dc} = \frac{V_{dc}}{4} + 0.5 \times \frac{V_{dc}}{6} + \frac{V_{dc}}{6}$$

$$= \frac{V_{dc}}{4} + \frac{1}{12}V_{dc} + \frac{V_{dc}}{6}$$

$$= \frac{V_{dc}}{2}$$

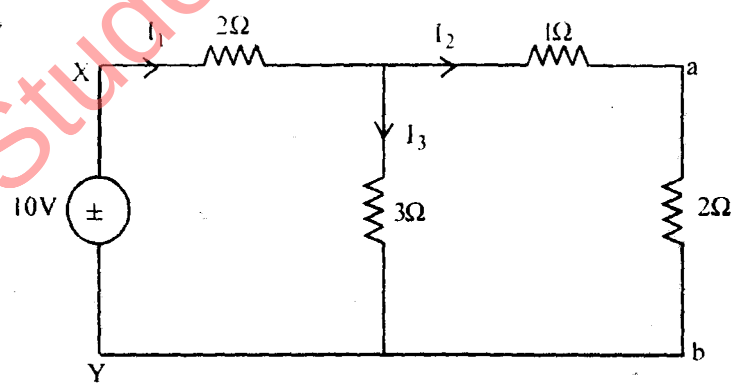
$$R_{int} = \frac{V_{dc}}{i_{dc}}$$

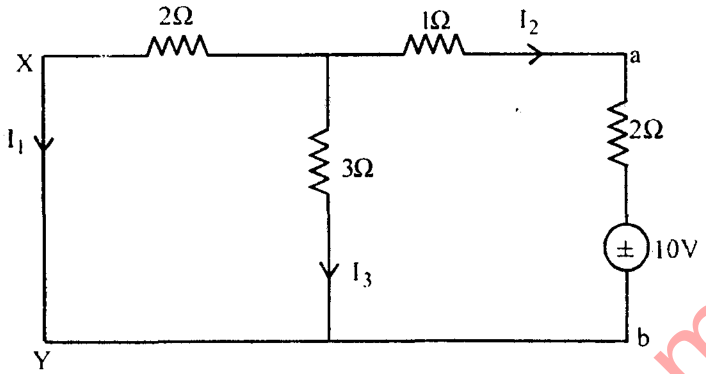
$$= 2\Omega$$ **Ans.**

Q. 3. (b) State and explain reciprocity theorem. Derive results for it.

Ans. Reciprocity Theorem : In any branch of a network, the current (I) due to a single source of voltage (V) else where is the network is equal to the current through the branch in which the source was originally placed when the source is placed in the branch in which the current (I) the branch in which the current (I) was originally obtained.

Example:





With reference to fig., the equivalent resistance across XY is given by,

$$R_{eq} = [(2+1) \| 3] + 2 = 3.5\Omega$$

$$I_1 = \frac{10}{3.5} = 2.86\,A$$

$$I_2 = 2.86 \times \frac{3}{3+3} = 1.43\,A$$

$$I_3 = 2.86 - 1.43 = 1.43\,A$$

With reference to fig. (ii)

$$R_{eq} = (2 \| 3) + 1 + 2 = \frac{6}{5} + 3 = \frac{21}{5} = 4.2\Omega$$

$$I_2 = \frac{10}{4.2} = 2.381\,A$$

$$I_1 = I_2 \frac{3}{3+2} = 2.831 \times \frac{3}{5} = 1.43A$$

Hence we observe that when the source was in branch x-y, as in fig. (i), the a-b branch current is 1.43A; again when the source is in branch a–b, fig. (ii) the x-y branch current becomes 1.43A. This process the reciprocity theorem.

Q. 4. (a) A direct voltage of 200V is suddenly applied to a series LR circuit having $R = 20\Omega$ and inductance 0.2H. Determine the voltage drop across the inductor at the instant of switching on and at 0.02 sec later.

Ans. As soon as the voltage is applied.

$$R_i + L\frac{di}{dt} = V$$

Or $$20i + 0.2\frac{di}{dt} = 200$$

Due to the presence of the inductor at $t = 0^+$, $i = 0$

Hence, the drop across the resistor being zero, 200V drop will appear across the inductor.

Hence, at instant of switching, the voltage drop across the inductor is 200V. The charging current is given by

$$i = \frac{V}{R}\left(1 - e^{-t/T}\right)$$

$$i = \frac{200}{20}\left(1 - e^{-t/(L/R)}\right)$$

$$= 10\left(1 - e^{-100t}\right)$$

$$t = 0.02\text{sec}, \quad i = 10\left(1 - e^{-100 \times 0.02}\right)$$

$$i = 8.646\,A\,.$$

The voltage across the inductor after lapse of 0.02 sec from switching is

$$L\frac{di}{dt} = 200 - iR = 200 - 8.646 \times 20$$

$$= 27V$$

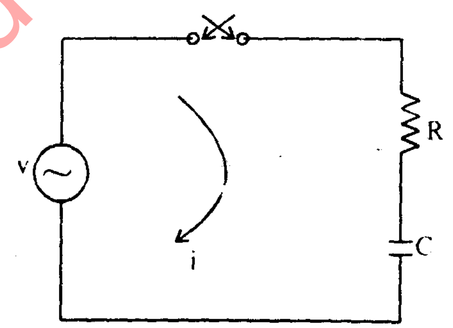
The rate of change of current at $t = 0.01$ sec, is then

$$\frac{di}{dt} = \frac{27V}{L} = \frac{27}{0.2}$$

$$= 135A/\text{sec}.$$

Q. 4. (b) Derive an expression for transient response in series R.C. circuit with sinusoidal excitation.

Ans.



$$V = V_m \sin(\omega t + \phi)$$

Application of KVL in the series RL circuit of fig. yields.

$$R_i + \frac{1}{C}\int i dt = V_m \sin(\omega t + \phi)$$

Differentiation of equation gives,

$$\left(P + \frac{1}{R_c}\right) i = \frac{\omega V_m}{R} \cos(\omega t + \phi)$$

The complementary function being i_c the current solutions of the differential equation is given by

$$i = i_c + i_p$$

$$i_c = c' e^{-t/RC} \text{, i being a constant}$$

$$i_p = \frac{V_m}{\sqrt{R^2 + (1/\omega c)^2}} \sin\left(\omega t + \phi + \tan^{-1} \frac{1}{\omega CR}\right)$$

$\therefore$
$$i = c' e^{-t/2c} + \frac{V_m}{\sqrt{R^2 + (1/\omega c)^2}} \sin\left(\omega t + \phi + \tan^{-1} \frac{1}{\omega CR}\right)$$

In order to determine the constant c' the circuit condition at t = 0 is considered. At t = 0, the capacitor acts as a short circuit.

$\therefore$
$$i_0 \text{ (initial current)} = \frac{V_m}{R} \sin\phi$$

Hence, setting t = 0, the complete solution becomes,

$$i_0 \left(= \frac{V_m}{R} \sin\phi\right) = c' + \frac{V_m}{\sqrt{R^2 + (1/\omega c)^2}} \sin\left(\phi + \tan^{-1}\left[\frac{1}{\omega CR}\right]\right)$$

Or
$$c' = \frac{V_m}{R} \sin\phi - \frac{V_m}{\sqrt{R^2 + \left(\frac{1}{\omega c}\right)^2}} \sin\left(\phi + \tan^{-1} \frac{1}{\omega CR}\right)$$

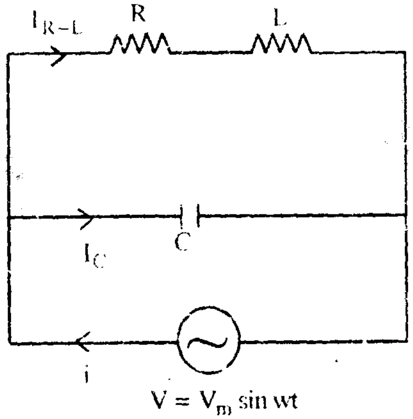
Substituting of c' value,

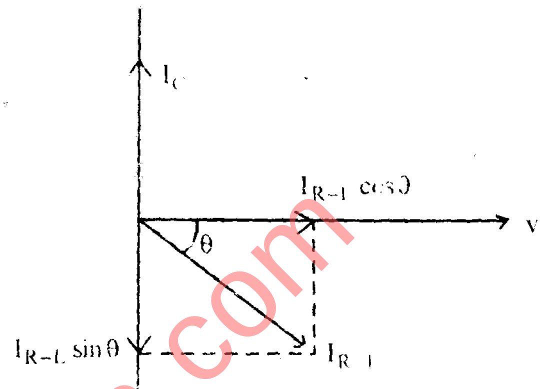
$$i = e^{-t/RC} \left[\frac{V_{in}}{R} \sin\phi - \frac{V_m}{\sqrt{R^2 + \left(\frac{1}{\omega c}\right)^2}} \times \sin\left(\phi + \tan^{-1}\left[\frac{2}{\omega cR}\right]\right)\right.$$

$$\left. + \frac{V_m}{\sqrt{R^2 + \left(\frac{1}{\omega c}\right)^2}} \sin\left(\omega t + \phi + \tan^{-1}\left(\frac{1}{\omega cR}\right)\right)\right]$$ **Ans.**

Q. 5. (a) Derive the expression of resonance frequency and impedance in case of parallel RLC circuit.

Ans. Resonance in Parallel AC Circuit :





At steady state

$$I_C = I_{R-L} \sin\theta$$

$$\frac{v}{X_C} = \frac{v}{\sqrt{R^2 + X_L^2}} \cdot \frac{X_L}{\sqrt{R^2 + X_L^2}}$$

$$X_L . X_C = R^2 + X_L^2$$

$$R^2 + (\omega L)^2 = \omega L . \frac{1}{\omega C}$$

$$\omega^2 L^2 = \frac{L}{C} - R^2$$

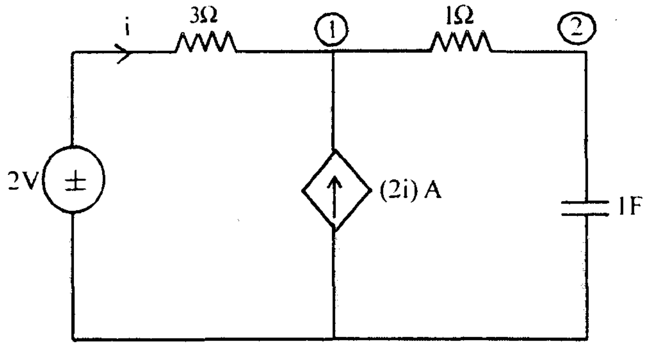
$$\omega^2 = \frac{1}{LC} - \left(\frac{R}{L}\right)^2$$

$$\omega = \sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2}$$

$$2\pi f_C = \sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2}$$

$$f_C = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2} \quad \textbf{Ans.}$$

Q. 5. (b) Find the voltage of the capacitor at $t = 0+$ assuming no charge stored in the capacitor at $t = 0$.



Ans. Let the voltage at node (1) be v_1 and that at (2) be v_2.

Applying KCL at node (i)

$$\frac{v_1 - v_2}{1} = 2i + i = 3i = 3\left(\frac{E - v_1}{3}\right)$$

$$v_1 - v_2 = E - v_1$$

$$2v_1 = E + v_2$$

$$v_1 = \frac{E + v_2}{2}$$

Using KCL at node (2)

$$\frac{v_1 - v_2}{1} + c\frac{dv_2}{dt} = 0$$

Or $$v_2 - v_1 + \frac{dv_2}{dt} = 0$$

$$v_2 - \frac{E + v_2}{2} + \frac{dv_2}{dt} = 0$$

Or $$\frac{v_2}{2} + \frac{dv_2}{dt} = \frac{E}{2}$$

$$v_2(P + 0.5) = \frac{E}{2}$$

This differential equation would have a complementary as well as particular solution.
The complementary solution is,

$$v_2(t)_{comp} = c_1 e^{-0.5t}$$

While the particular solution is,

$$v_2(t)_{part} = \frac{E/2}{0.5} = 2v \quad (\because E = 2v)$$

$\therefore$ Complete solution is $v_2(t) = 2 + c_1 e^{-0.5t}$

Application of initial condition.

$$(v_2 = 0) \text{ yields}$$

$$c_1 = -2$$

$$v_2(t) = 2 - 2c_1 e^{-0.5t} \text{ v} \qquad \textbf{Ans.}$$

Q. 6. (a) A rms voltage in a three phase star circuit is given by 231V (ph-N). Write the instantaneous voltage expression. If the current in each phase lag the corresponding phase voltages by 30°, what are the expressions of instantaneous currents.

Ans. In Y-connection

$$V_{L-L} = \sqrt{3} V_{ph}$$

$$= 1.732 \times 231$$

$$V_{L-L} = 400V$$

$$V_{R(L-L)} = \sqrt{2}(400)\sin wt = 566 \sin wt \text{ V}$$

$$V_{Y(L-L)} = 556 \sin(wt - 240°) \text{ V}$$

$$V_{B(L-L)} = 556 \sin(wt - 240°)$$

$$= 556 \sin(wt + 120°) \text{ V}$$

As the phase currents would lag the corresponding phase voltages by 30°.

Hence,
$$IR_{(ph)} = \left(\frac{231}{z}\right) \times \sqrt{2} \sin(wt - 30°)$$

$$= 327 \sin(wt - 30°) \text{ A} \qquad [\because z = 1\Omega]$$

$$I_{Y(ph)} = 327 \sin(\omega t - 120 - 30)$$

$$= 327 \sin(wt - 150°) \text{ A}$$

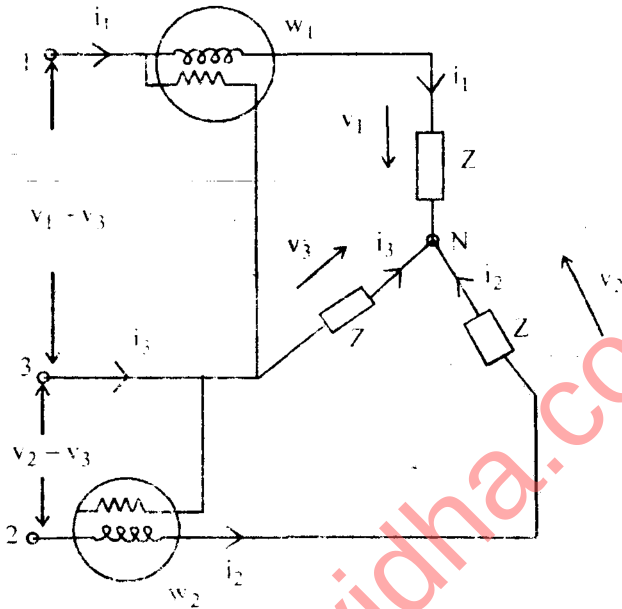
$$I_{B(ph)} = 327 \sin(wt + 120 - 30)$$

$$= 327 \sin(wt + 90°) \text{ A} \qquad \textbf{Ans.}$$

Q. 6. (b) Explain the circuit used for the measurement of three phase power by two wattmeter method. Derive expressions for it.

Ans. Three phase power measurement by two wattmeter method are :

(i) By Star-Connection.



Total instantaneous power

$$P = v_1 i_1 + v_2 i_2 + v_3 i_3 \quad \text{...(i)}$$

By KCL at node N.

$$i_1 + i_2 + i_3 = 0$$

$$i_3 = -(i_1 + i_2)$$

Put value of, i_3 in equation (i)

$$P = v_1 i_1 + v_2 i_2 - v_3 i_1 - v_3 i_2$$

$$= i_1(v_1 - v_3) + i_3(v_2 - v_3)$$

$$P = W_1 + W_2$$

(ii) By Delta Connection :

Total instantaneous power

$$P = v_1 i_1 + v_2 i_2 + v_3 i_3 \quad \text{...(i)}$$

By KVL, $v_1 + v_2 + v_3 = 0$

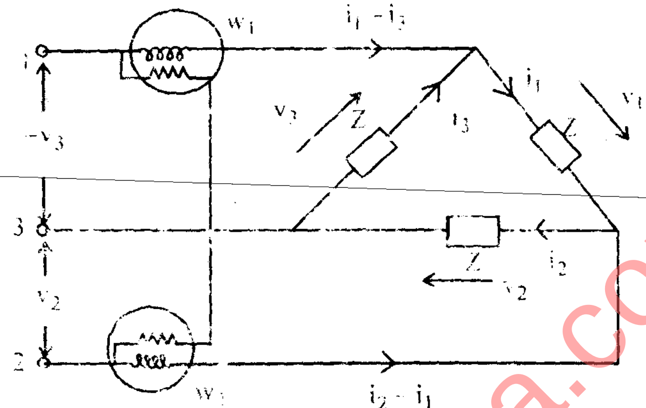
$$v_1 = -(v_2 + v_3)$$

Put v_1 in equation (1)

$$P = -v_2 i_1 - v_3 i_1 + v_2 i_2 + v_3 i_3$$

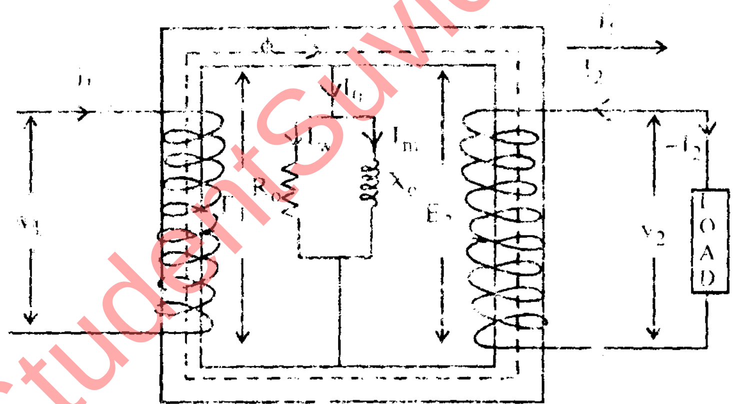
$$= -v_3(i_1 - i_3) + v_2(i_2 - i_1)$$

$$P = w_1 + w_2.$$



Q. 7. (a) Draw the phasor diagram for the transformer at resistive, inductive and capacitive loads.

Ans. Phasor Diagram :



Flux $\phi = \phi_m \sin wt$ ...(i)

By lenz law,

$$e = \frac{-Nd\phi}{dt}$$

$$e = -N\frac{d}{dt}\phi_m \sin wt$$

$$= -N\phi_m w \cos wt$$

$$e = N\phi_m w \sin(wt - 90^\circ)$$

For primary, $E_1 = N_1 \phi_m w \sin(wt - 90^\circ)$ ...(ii)

For secondary $E_2 = N_2 \phi_m w \sin(wt - 90^\circ)$ ...(iii)

$-E_1 v_1$ ...(iv)

$E_2 = V_2$ ...(v)

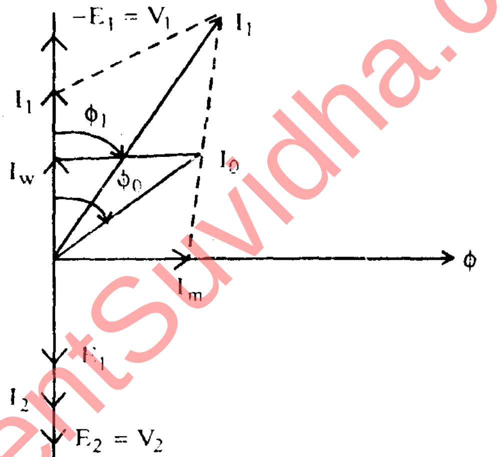
$I_w = I_0 \cos\phi_0$ ..(vi)

$I_m = I_0 \sin\phi_0$ ...(vii)

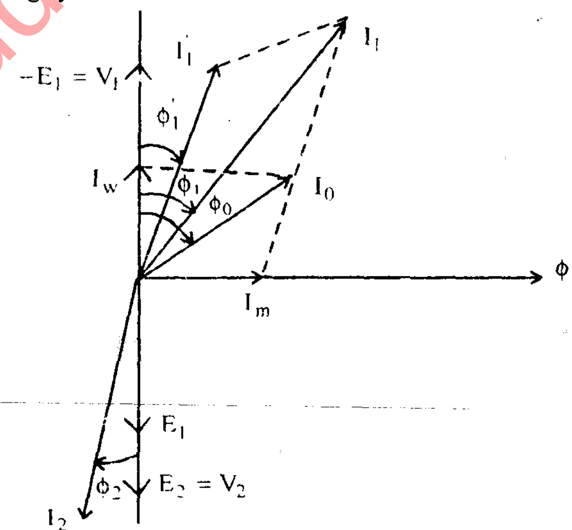
Or $I_0^2 = I_0^2 + I_m^2$ ...(viii)

$I_1 = I_0 + I_1'$ ...(ix)

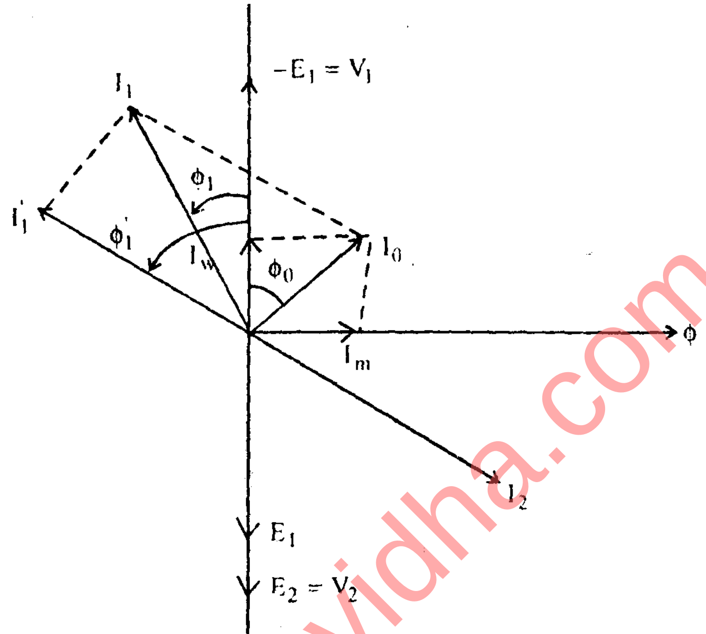
(i) Resistive Load : v, i are in same phase.



(ii) Inductive Load : i lag by v.

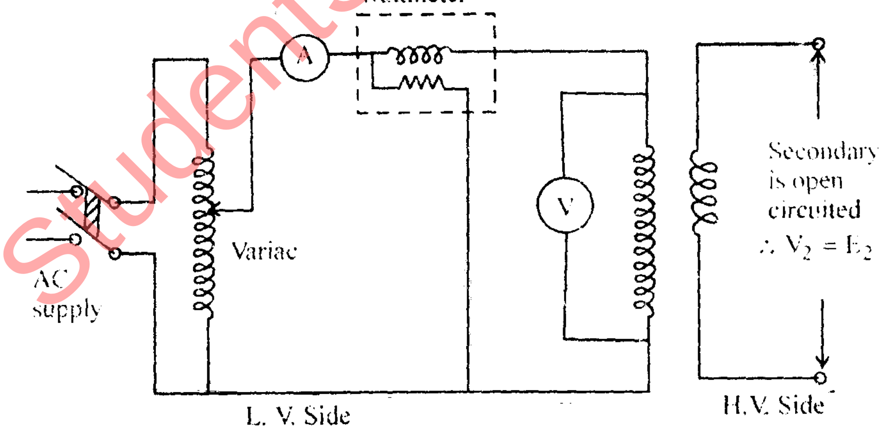


(iii) Capacitive Load : i lead by v.



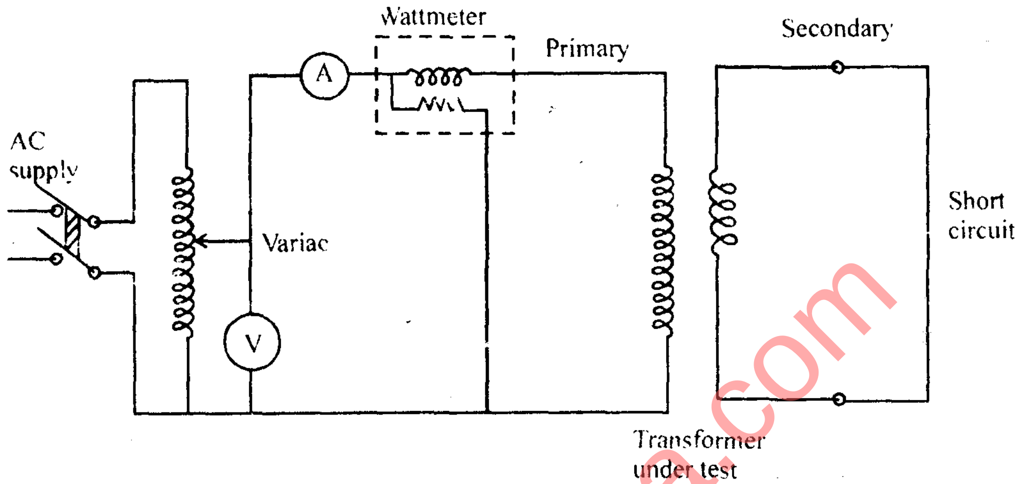
Q. 7. (b) Explain the open and short circuit test of transformer.

Ans. Open Circuit Test : The setup for O.C. test of a transformer is shown in figure.



The primary winding of the transformer is connected to the rated ac voltages by means of using a variance. A voltmeter is connected across the primary winding to measure the primary voltage. An ammeter is used for measuring the primary current & the wattmeter is connected to measure the input power. The secondary is open circuited because it is Open Circuit (O.C.) test sometimes a voltmeter is connected across the secondary to measure $V_2 = E_2$. Note that the ac supply voltage is applied generally to the low voltage side and the higher voltage side is used as secondary.

Short Circuit Test : The setup for carrying out the short circuit test on a transformer is shown in figure.



(i) Variable is used to adjust input voltage precisely to the rated voltage.

(ii) The voltmeter is connected to measure the primary voltage. The ammeter measure the short circuited rated primary current I_{sc} & the wattmeter measures the short circuit input power.

(iii) The secondary is short circuited with the help of thick copper wire.

(iv) Generally the high voltage side is connected to ac supply & the low voltage high current side is shorted.

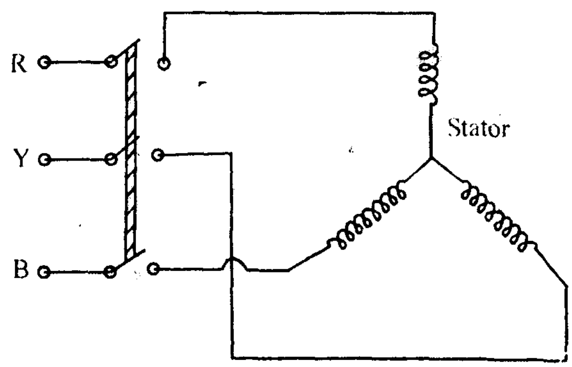
Q. 8. (a) Draw and explain the construction and working of induction motor.

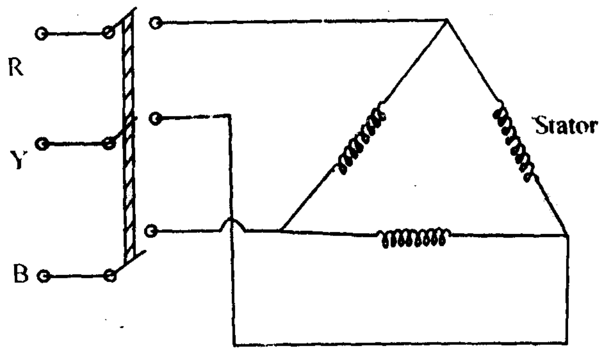
Ans. Construction & working of induction motor.

(i) Basically induction motor consists of two main parts :

- (i) The stationary frame called stator.
- (ii) The rotating armature called rotor.
- (iii) Similar to stator, the rotor drum is provided with slots.

(ii) The stator is a stationary winding which can be a star connected or delta. Connected and connected to be 3-phase ac supply through a switch.





Stator Winding Connections

(iii) The function of stator winding is to produce a rotating magnetic field in the air gap between the stator & rotor.

(iv) Rotor is the rotating winding.

(v) The rotor is not connected to any external supply. The current flows through the rotor due to the principle of induction. Hence, the name induction motor.

(vi) Rotor can be of two types namely squirrel cage rotor and wound rotor.

Q. 8. (b) What are synchronous machines? Draw their block diagram and explain their working.

Ans. Synchronous Machines :

(i) A synchronous machine is electrically identical with a alternate or are ac generator.

(ii) However when used as synchronous machine, the three phase ac supply is connected to the stator & external excitation is connected to rotor field.

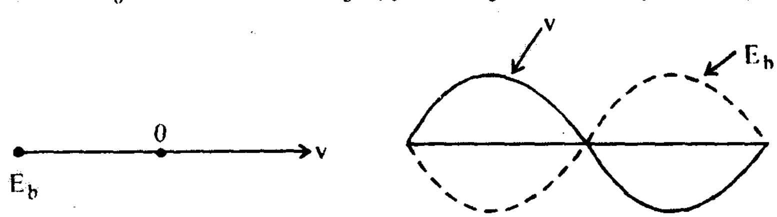
(iii) The synchronous machine will the operated as a motor to deliver rotational mechanical energy to the load.

(iv) The speed of rotation is called as synchronous speed N_s which is directly proportional to supply frequency because,

$$N_s = \frac{120f}{P}$$

(v) The ideal synchronous motor does not have any losses. Because there are no losses, the motor will draw zero armature current.

(vi) The magnitude of E_b and V is same & E_b opposes E_b as shown in phase diagram.



The phase difference between V and E_b is zero. Hence,

$$\bar{I}_a = \frac{\bar{V} - \bar{E_b}}{Z_s} = 0$$

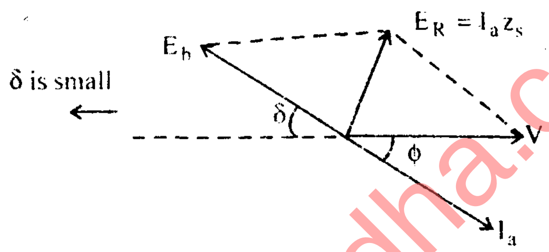
(vii) However practically it is not possible because there are losses taking place even at no load. In order to overcome these losses & keep rotor rotating some power has to be drawn from supply. For this purpose, some armature current should be drawn.

(viii) Due to various losses present on no load, the rotor slips back behind the stator poles by a small angle called as load angle or torque angle or power angle δ.

(ix) The rotor however keeps on rotating at synchronous speed due to magnetic locking.

(x) The phasor diagram on no load condition with losses is shown. Note that magnitude of E_b is same as that of v but E_b is not exactly opposite to V.

(xi) Instead E_b makes an angle d "δ" with respect to its initial position.



(xii) Hence the vector difference between V and E_b is not zero. Instead the vector difference between V and E_b is equal to $I_a Z_s$.

$$\therefore \qquad \overline{V} - \overline{E}_b = \overline{I_a Z_s}$$

(xiii) Thus the armature current I_a is dependent on the phasor difference between V and E_b.

(xiv) If δ is small on & no load. The armature current I_a is also small. Under no loads conditions the load angle δ is small.

Q. 9. Write short notes on :

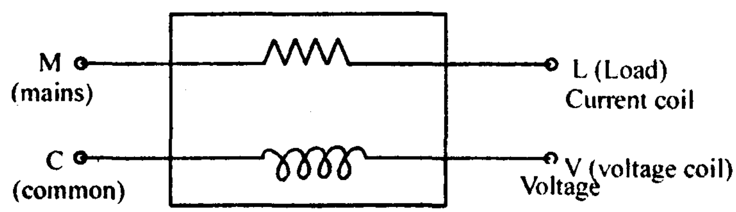
(i) Watt meter

(ii) Energy meter.

Ans. (i) Watt Meter :

(i) The wattmeter is an instrument which can measure that power in single or three phase ac circuits. It gives its reading directly in watts.

(iii) The wattmeter has two different coils namely voltage coil and current coil. The voltage coil is also called as pressure coil. It is the moving coil.



Current Coil :

(i) The coil shown between the terminals M(mains) & L (Load) is current coil. It is fixed coil.

(ii) It is to be connected in series with load.

(iii) The resistance of this coil is small due to its large cross sectional area and small number of turns.

Voltage Coil or Pressure Coil :

(i) The coil shown between the terminal C (common) & V (Voltage) is called as voltage or pressure coil.

(ii) It is always connected across the supply to measure the voltage.

(iii) The resistance of voltage coil is large. It is made of thin wire with a large number of turns.

Wattmeter Reading :

(i) Let the current flowing through the current coil be I_c and let the voltage across the pressure coil be V_{pc}.

(ii) Then the wattmeter reading is given by,

$$\underbrace{W}_{\substack{\downarrow \\ \text{Wattmeter} \\ \text{reading}}} = \underbrace{V_{pc}}_{\substack{\downarrow \\ \text{Voltage} \\ \text{across} \\ \text{pressure} \\ \text{coil}}} \times \underbrace{I_c}_{\substack{\downarrow \\ \text{Voltage} \\ \text{across} \\ \text{pressure} \\ \text{coil}}} \times \underbrace{\cos\left(V_{pc} \wedge I_c\right)}_{\substack{\downarrow \\ \text{Angle between} \\ V_{pc}\ \&\ I_c}}$$

The wattmeter reading is proportional to the cosine of the angle between V_{pc} & I_c i.e., $\cos\left(V_{pc} \wedge I_c\right)$.

(ii) Energy Meter : Energy is defined as the product of power & time. It is measured in watt-hour or kilowatt-hour (kWh).

(i) The meter used to measure the energy consumption is known as energy meter.

(ii) Therefore an energy meter must consist of a current coil & a voltage coil (similar) to a wattmeter) & an additional device which will count the time.

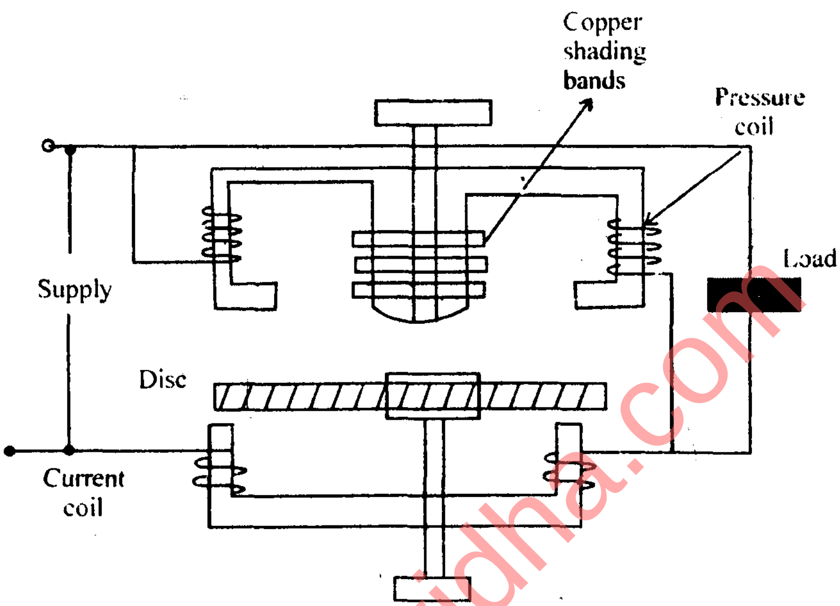
Induction Type Energy Meter :

(i) The induction instrument described above is very commonly used as an energy meter construction of energy meter.

(ii) The two exciting coil act as current coil and voltage coil and disc acts as a time counting device.

(iii) The disc is kept free to rotate continuously, speed of disc depends on the power supplied to the load. More the load, higher is the disc speed.

(iv) In this instrument a gear train is provided to count the revolutions of the disc. Number of revolutions of disc are directly recorded in terms of energy consumed.


Copper
shading
bands
Pressure
coil
Load
Supply
Disc
Current
coil