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Internal Assessment Test -3

Introduction to Electrical Engineering Solution

1 a) Derive the emf equation of a transformer and hence obtain the voltage and current transformation ratios.

EMF Equation of a transformer :-

Let the sinusoidally varying flux be,

$$\phi = \phi_m \sin \omega t \quad — (1)$$

$$= \phi_m \sin 2\pi f t$$

where ϕ_m - peak or maximum value of flux.

f - frequency of flux.

Let e_1 and e_2 be the instantaneous emfs induced in 1 and 2 with N_1 and N_2 no turns respectively.

$$\therefore e_1 = -N_1 \frac{d\phi}{dt} \quad — (2)$$

$$= -N_1 \frac{d(\phi_m \sin \omega t)}{dt} \quad — (3)$$

$$= -N_1 \phi_m (\cos \omega t) \times \omega$$

$$= -\omega N_1 \phi_m \cos \omega t$$

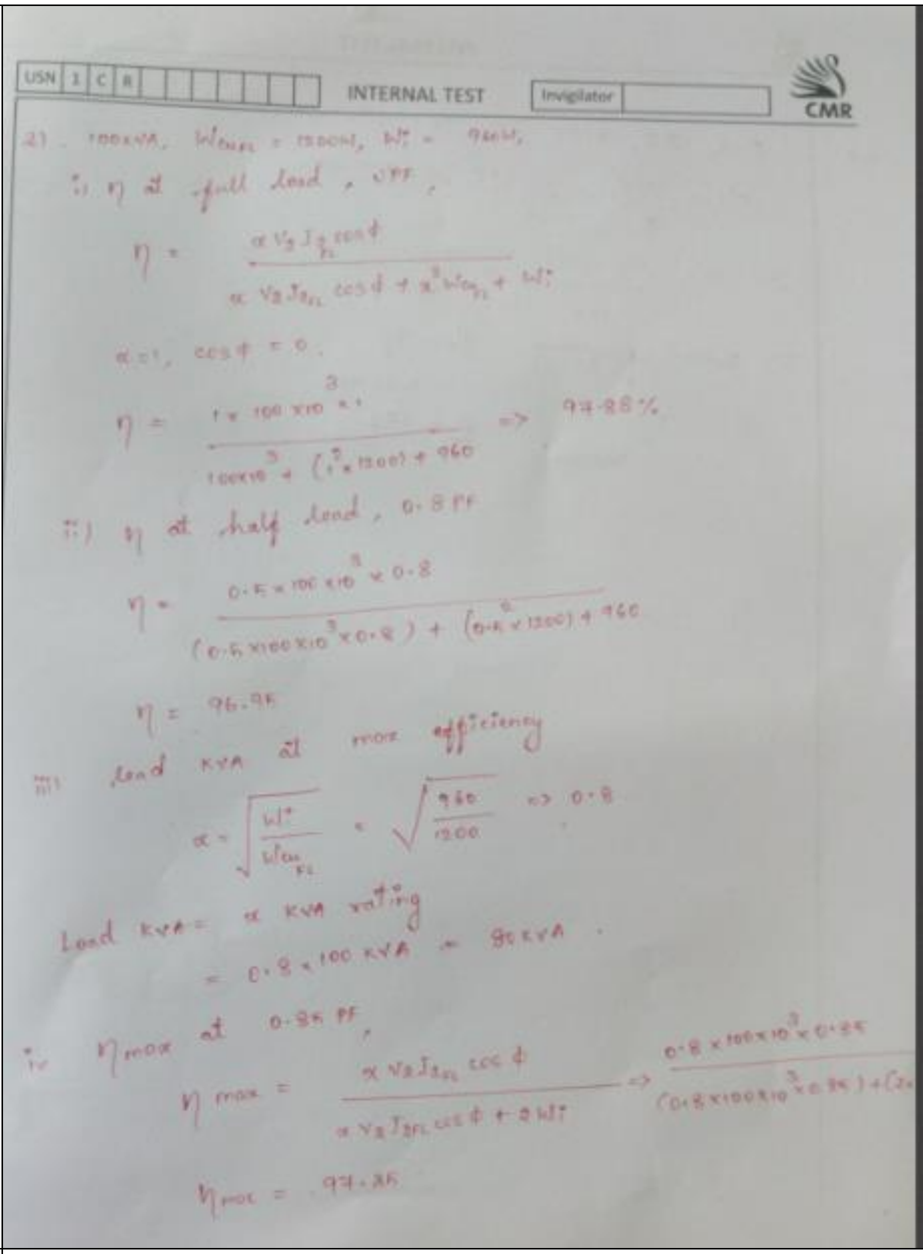
$$= \omega N_1 \phi_m \sin(\omega t - 90)$$

$$\therefore e_1 = 2\pi f N_1 \phi_m \sin(\omega t - 90) \quad — (4)$$

	③ From ④, the induced emf will be maximum, if $\sin(\omega t - 90) = $ unity $\therefore E_{m_1} = 2\pi f N_1 \phi_m$ — ⑤ The rms value $E_1 = \frac{E_{m_1}}{\sqrt{2}}$ — ⑥ $= \frac{2\pi f N_1 \phi_m}{\sqrt{2}}$ $E_1 = 4.44 f N_1 \phi_m$. — ⑦ Similarly, $E_2 = 4.44 f N_2 \phi_m$. * comparing eqns ① and ④, it is clear that induced emf lags the flux by 90°. **Transformation Ratio :- K** The ratio of secondary voltage to the primary voltage is known as transformation ratio or turn ratio Let N_1 - no of turns in 1° N_2 - " in 2° E_1 - rms value of induced emf in 1° E_2 - " in 2°. $K = \frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{N_2}{N_1}$ ie $K > 1$, $E_2 > E_1$ step up transformer $K < 1$, $E_2 < E_1$, step down transformer.
b)	Compare squirrel cage and slip ring types of induction motor.

Feature	Squirrel Cage Induction Motor	Slip Ring Induction Motor
Construction	Simple, robust rotor with conductive bars	Complex rotor with windings and slip rings
Starting Torque	Lower starting torque	High starting torque
Speed Control	Limited options, typically through VFDs	Easier and more precise through external resistances
Efficiency	Higher efficiency, lower losses	Lower efficiency due to additional losses
Maintenance	Low maintenance, no brushes or slip rings	Higher maintenance, brushes and slip rings require regular inspection
Applications	Fans, blowers, pumps, compressors, conveyors	Cranes, elevators, hoists, heavy-duty machinery
Cost	Lower initial and maintenance cost	Higher initial and maintenance cost
Operational Reliability	Highly reliable due to fewer moving parts	Less reliable due to wear and tear of brushes and slip rings
Heat Dissipation	Better heat dissipation	Requires additional cooling systems
Durability	More durable under harsh operating conditions	Less durable due to complex construction
Size and Weight	Generally smaller and lighter	Larger and heavier due to additional components

2 A transformer is rated at 100 kVA. At full load its copper loss is 1200W and its iron loss is 960W. Calculate: i) the efficiency at full load, UPF ii) the efficiency at half load, 0.8 p.f. iii) the load kVA at which maximum efficiency will occur iv) maximum efficiency at 0.85 p.f.

	
3	With diagrams explain the concept of rotating magnetic field.

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2) 100kVA, $W_{cu,FL} = 1200W$, $W_i = 960W$,

i) η at full load, UPF,

$$\eta = \frac{x V_2 I_{2FL} \cos\phi}{x V_2 I_{2FL} \cos\phi + x^2 W_{cu,FL} + W_i}$$

$x = 1$, $\cos\phi = 0$.

$$\eta = \frac{1 \times 100 \times 10^3 \times 1}{100 \times 10^3 + (1^2 \times 1200) + 960} \Rightarrow 97.88\%$$

ii) η at half load, 0.8 PF

$$\eta = \frac{0.5 \times 100 \times 10^3 \times 0.8}{(0.5 \times 100 \times 10^3 \times 0.8) + (0.5^2 \times 1200) + 960}$$

$\eta = 96.95$

iii) load kVA at max efficiency

$$x = \sqrt{\frac{W_i}{W_{cu,FL}}} = \sqrt{\frac{960}{1200}} \Rightarrow 0.8$$

Load kVA = x kVA rating

= 0.8 × 100 kVA = 80 kVA.

iv) η_{max} at 0.85 PF,

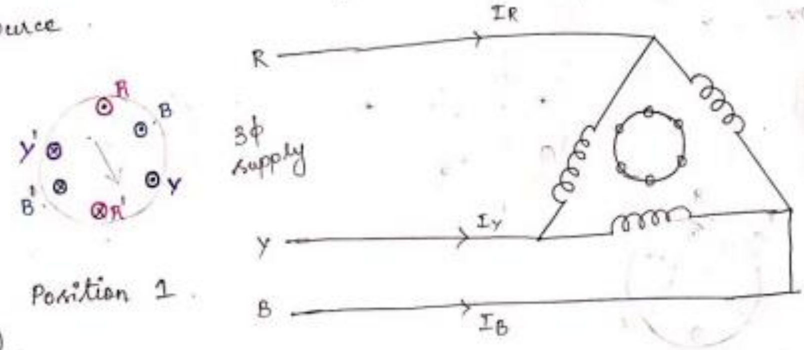
$$\eta_{max} = \frac{x V_2 I_{2FL} \cos\phi}{x V_2 I_{2FL} \cos\phi + 2W_i} \Rightarrow \frac{0.8 \times 100 \times 10^3 \times 0.85}{(0.8 \times 100 \times 10^3 \times 0.85) + (2 \times}$$

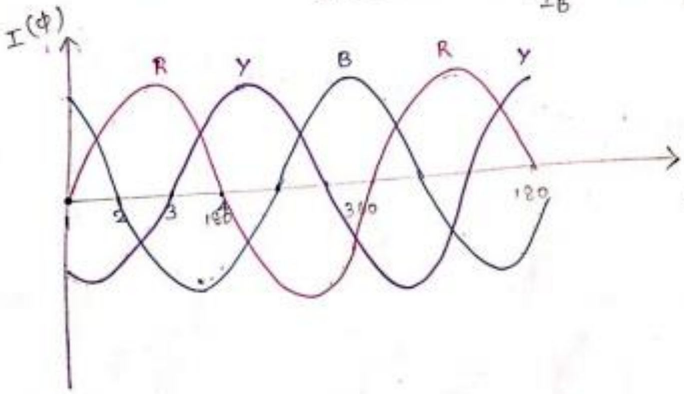
$\eta_{max} = 97.25$

Concept of "rotating magnetic field":-

* A rotating magnetic field is produced when 3ϕ winding is energised from 3ϕ supply.
* The produced magnetic field is such that, the poles do not remain in fixed position hence the name, rotating magnetic field.

Consider a 3ϕ winding energized from 3ϕ source.



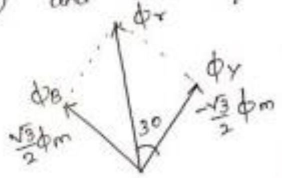


Let ϕ_m be the maximum flux due to any phase,

$$\left.\begin{aligned} \phi_R &= \phi_m \sin \omega t \\ \phi_Y &= \phi_m \sin(\omega t - 120) \\ \phi_B &= \phi_m \sin(\omega t + 120) \end{aligned}\right\} \quad (1)$$

i) at $\omega t = 0$,

Substituting the value of ωt in (1) and also refering the wave form,



$$\phi_R = 0$$

$$\phi_Y = \phi_m \sin(-120)$$

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

$$\phi_B = \phi_m \sin(120)$$

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

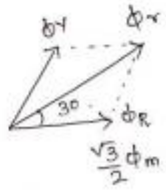
$$\therefore \phi_r = 2 \cos \frac{\sqrt{3}}{2}\phi_m \cos 30$$

$$\boxed{\phi_r = 1.5\phi_m}$$

ii) at $\omega t = 60$,

$$\phi_R = \phi_m \sin 60$$

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



$$\phi_Y = \phi_m \sin -60$$

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

$$\phi_B = \phi_m \sin 180$$

$$= 0$$

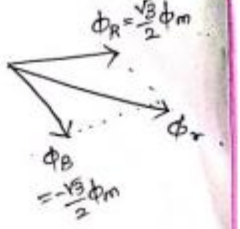
$$\boxed{\phi_r = 1.5\phi_m}$$

iii) at $\omega t = 120$,

$$\phi_R = \phi_m \sin 120 = \frac{\sqrt{3}}{2}\phi_m$$

$$\phi_Y = \phi_m \sin 0 = 0$$

$$\phi_B = \phi_m \sin 240 = -\frac{\sqrt{3}}{2}\phi_m$$



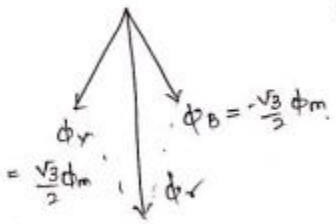
$$\boxed{\phi_r = 1.5\phi_m}$$

iv) at $\omega t = 180$,

$$\phi_R = \phi_m \sin 180 = 0$$

$$\phi_Y = \phi_m \sin(180-120) = \phi_m \sin 60 = \frac{\sqrt{3}}{2}\phi_m$$

$$\phi_B = \phi_m \sin(180+120) = \phi_m \sin 300 = -\frac{\sqrt{3}}{2}\phi_m$$

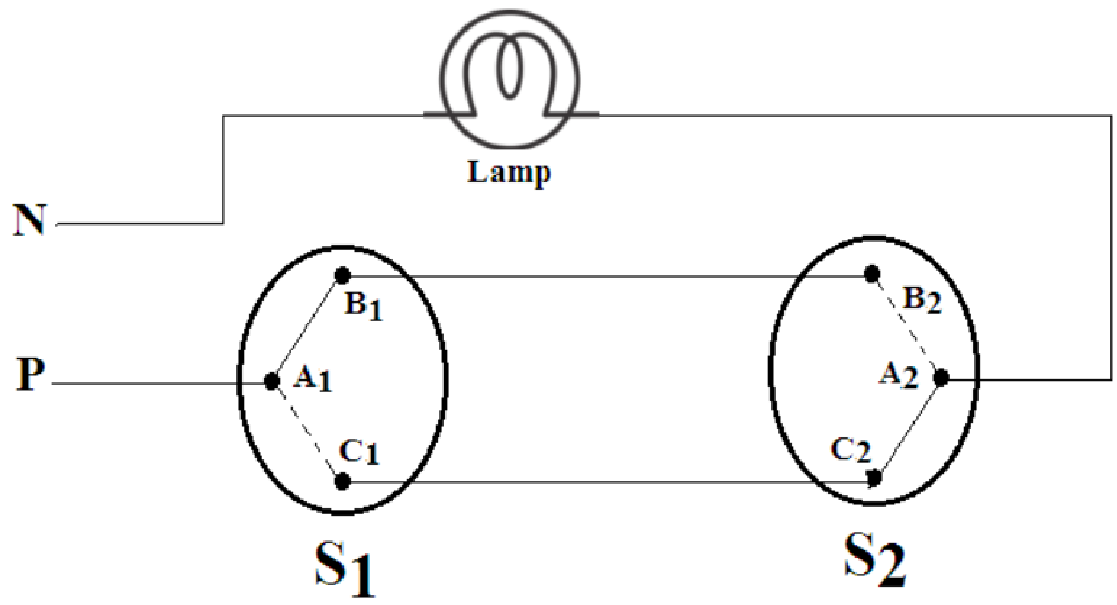


$$\boxed{\phi_r = 1.5\phi_m}$$

Thus from above discussion, it is clear that a 3ϕ supply produces a rotating field of const value $1.5\,\phi_m$ rotating at synchronous speed $N_S = \frac{120f}{P}$ - speed of rotating magnetic field

4	With neat circuit diagram and switching table explain about the two way and three way control of load lamp.

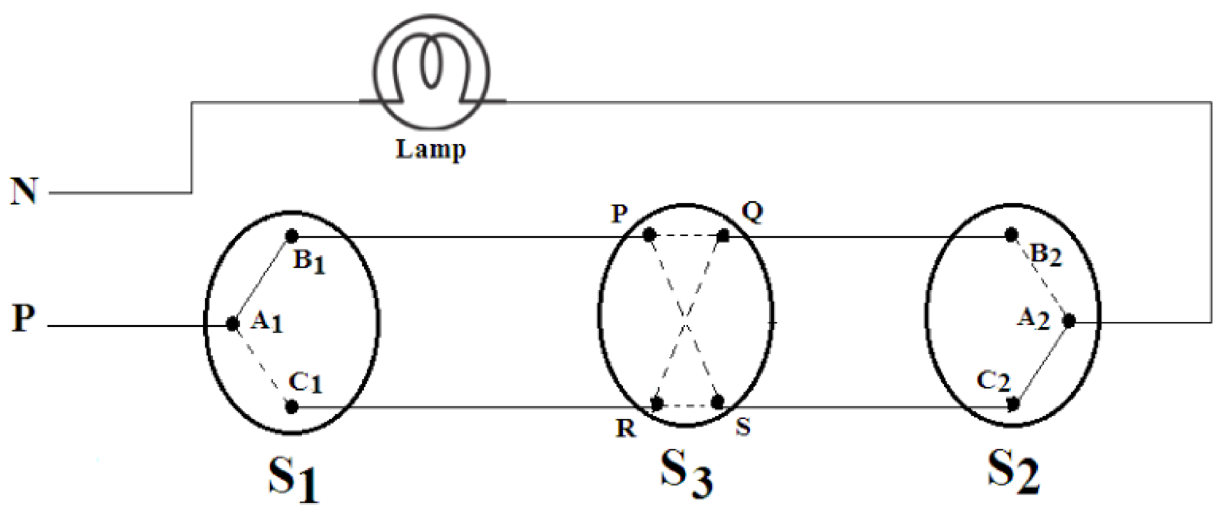
Two way Control of Lamp



Truth Table

Sl. No.	Switch S1	Switch S2	Lamp
1	$A_1 - B_1$	$A_2 - B_2$	ON
2	$A_1 - B_1$	$A_2 - C_2$	OFF
3	$A_1 - C_1$	$A_2 - B_2$	OFF
4	$A_1 - C_1$	$A_2 - C_2$	ON

Three way Control of Lamp



Truth Table

Sl. No.	Switch S1	Intermediate Switch S3	Position of S3	Switch S2	Lamp
1	$A_1 - B_1$	P – S & Q – R	Cross Connection	$A_2 - B_2$	OFF
2	$A_1 - B_1$	P – S & Q – R		$A_2 - C_2$	ON
3	$A_1 - C_1$	P – S & Q – R		$A_2 - B_2$	ON
4	$A_1 - C_1$	P – S & Q – R		$A_2 - C_2$	OFF
5	$A_1 - B_1$	P – Q & R – S	Straight Connection	$A_2 - B_2$	ON
6	$A_1 - B_1$	P – Q & R – S		$A_2 - C_2$	OFF
7	$A_1 - C_1$	P – Q & R – S		$A_2 - B_2$	OFF
8	$A_1 - C_1$	P – Q & R – S		$A_2 - C_2$	ON

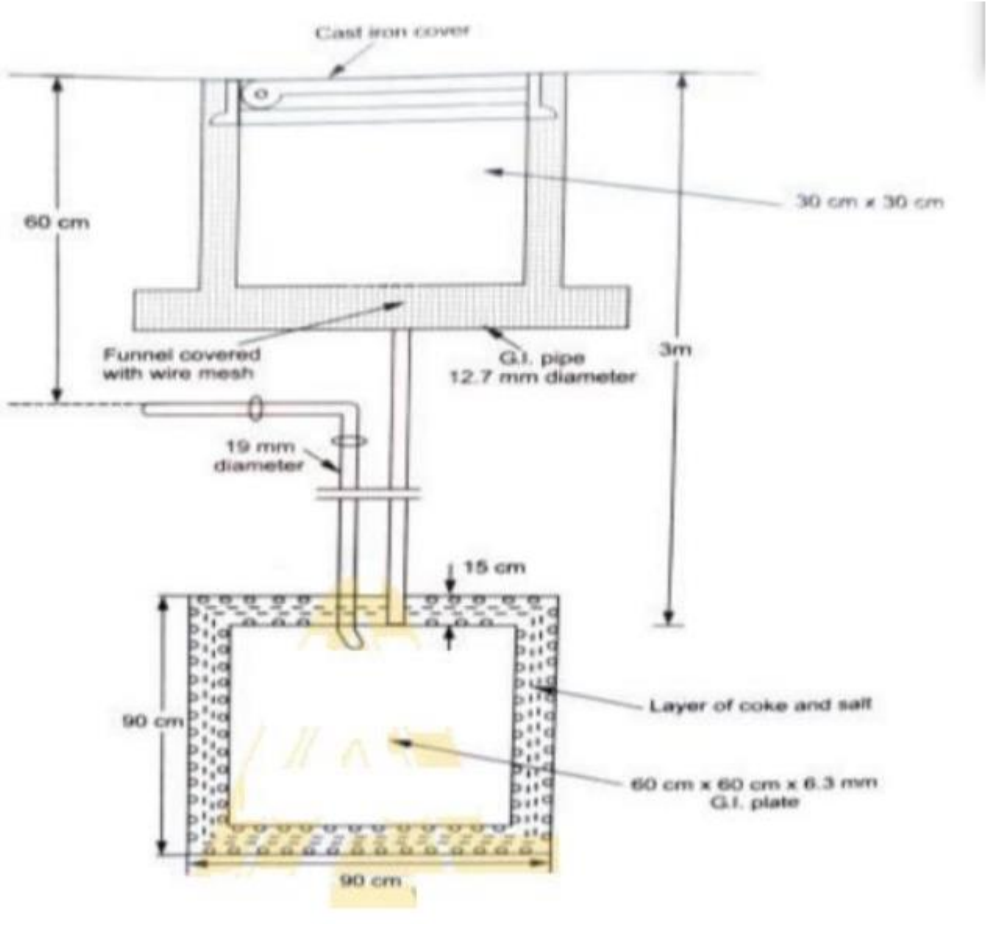
5 a)	Explain the term ‘earthing’. Why earthing is earthing required?. With a neat diagram, explain the operation of plate earthing. Earthing: Connection of the body of electric equipment to the general mass of the earth by wire of negligible resistance is called Earthing. It brings the body of the equipment to the zero potential during electric shock. Necessity of Earthing: 1. To protect the human beings from danger of shock in case they come in contact

with the charged frame due to defective insulation.

2. It guarantees the safety of electrical appliances and devices from the excessive amount of electric current.
3. It protects the appliances from high voltage surges and lightning discharge.
4. It provides an alternative path for leakage of current hence protects the equipment.
5. It keeps the voltage constant in the healthy phase.
6. It protects the Electric system and buildings from lightning.
7. It avoids the risk of fire in the electrical installation system.
8. To maintain the line voltage constant under unbalanced load condition.

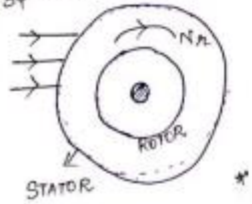
Plate Earthing :

In this method a copper plate or GI plate of 60cmX60cmX3.18cm is placed vertically down inside the ground at a depth of 3m. The plate is surrounded by the alternate layers of salt and coal with a minimum thickness of about 15cm. The earth wires drawn through the GI pipe are bolted through the earth plate. The GI pipe is fitted with the funnel on a top in order to have an effective earthing by pouring the salt water periodically. The schematic arrangement is as shown below.



The earthing efficiency increases with the increase of the plate area and depth of the pit. The depth of the pit depends upon the resistivity of the soil. The only disadvantage of this method is that discontinuity of earth wires from the earthing plate which is placed below the ground as it cannot be observed physically this may cause miss leading and result into heavy losses under fault condition.

6 a) Explain the principle of operation of Induction motor.

	Principle of operation: (3) 3φ ac supply → RMF $N_S = \frac{120f}{P}$  * Consider the rotor of IM is at standstill. $N_r = N_{ro} = 0$. When 3φ ac supply is given to stator, RMF is produced in air gap whose speed is given by $N_S = \frac{120f}{P}$ * This RMF passes thro air gap and cut the rotor conductors (stationary), due to relative speed b/w rotating flux and stationary rotor, e.m.f s are induced in the rotor conductors, since they are short-circuited current start flowing in the rotor conductors. * Now the current carrying conductor placed in mag field experiences the force and produces a torque which tends to move the rotor in same direction as that of the rotating magnetic field. (b'coz of Lenz's law – the direction of rotor currents will be such that they tend to oppose the cause producing them) i.e the relative speed b/w rotating field and stationary conductors. ... and slip:
b)	A 4 pole, 3phase, 50 Hz induction motor runs at a speed of 1470 rpm. Find the synchronous speed , the slip and frequency of the induced EMF in the rotor under this condition CMR INTERNAL TEST 6 b) $P = 4$, 3φ, 50Hz IM, $N_r = 1470$ rpm. i) $N_S = \frac{120f}{P} = \frac{120 \times 50}{4} \Rightarrow 1500$ rpm. ii) $S = \frac{N_S - N_r}{N_S} = \frac{1500 - 1470}{1500} = 0.02$ iii) Rotor frequency $f_r = sf$ $= 0.02 \times 50$ $f_r = 1Hz$
7	Define unit and Tariff . Explain the two part tariff with its merits and demerits? UNIT: The unit of electrical energy consumed is kWh. One kilowatt-hour is the electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour. Therefore 1kwh =1 unit. Two Part Tariff When the rate of electricity energy is charged on the maximum demand of the consumer and the units consumed is

	called two part tariff. In this tariff scheme, the total costs charged to the consumers consist of two components: Fixed charges and variable charges . It can be expressed as: Total Cost = [A (kW) + B (kWh)] in Rs. Where, Fixed charges - A = charge per kW of max demand Variable charges - B = charge per kWh of energy consumed. The fixed charges will depend upon maximum demand of the consumer and the variable charge will depend upon the energy (units) consumed. The fixed charges are due to generation, transmission and maintenance. Advantages : If a consumer does not consume any energy in a particular month, the supplier will get the return equal to the fixed charges. Disadvantages: If a consumer does not use any electricity, he has to pay the fixed charges regularly. The maximum demand of the consumer is not determined. Hence, there is error of assessment of max demand.