<table>
<tr><td colspan="4">DESCRIPTIVE QUESTION BANK</td></tr>
<tr><td colspan="4">UNIT-IV</td></tr>
<tr><td colspan="4">AC MACHINES</td></tr>
<tr><td colspan="4">(1 Marks)</td></tr>
<tr><td rowspan="2">1.</td><td>Taxonomy Level: Remember</td><td>CO: C114.4</td><td>PI:2.2.3</td></tr>
<tr><td colspan="3">Define efficiency of a transformer.</td></tr>
<tr><td>Ans</td><td colspan="3">It is defined as the ratio of the output power to input power.
$$\text{Efficiency} = \frac{\text{output power}}{\text{input power}}$$</td></tr>
<tr><td rowspan="2">2.</td><td>Taxonomy Level: Remember</td><td>CO: C114.4</td><td>PI:2.2.3</td></tr>
<tr><td colspan="3">Define a transformer.</td></tr>
<tr><td>Ans</td><td colspan="3">Transformer is a electro static device. It transfers electric power from one circuit to another circuit without changing the frequency and with changing of electric current and voltage is called as transformer.</td></tr>
<tr><td rowspan="2">3.</td><td>Taxonomy Level: Remember</td><td>CO: C114.4</td><td>PI:2.2.3</td></tr>
<tr><td colspan="3">Define slip speed and slip in three phase induction motor?</td></tr>
<tr><td>Ans</td><td colspan="3">Slip speed is defined as the difference between stator speed Ns and rotor speed Nr
$$\boxed{Slip\ speed = N_s - N_r}$$
$$\boxed{Slip = \frac{N_s - N_r}{N_s}}$$
$$\boxed{Percentage\ of\ Slip = \frac{N_s - N_r}{N_s} \times 100}$$</td></tr>
<tr><td rowspan="2">4.</td><td>Taxonomy Level: Remember</td><td>CO: C114.4</td><td>PI:2.2.3</td></tr>
<tr><td colspan="3">Define self-induced E.M.F</td></tr>
<tr><td>Ans</td><td colspan="3">It is defined as the e.m.f induced in the coil due to the change of flux produced by linking it with its own turns. This phenomenon of self-induced emf</td></tr>
<tr><td rowspan="2">5.</td><td>Taxonomy Level: Remember</td><td>CO: C114.4</td><td>PI:2.2.3</td></tr>
<tr><td colspan="3">What are the main parts of synchronous generator?</td></tr>
<tr><td>Ans</td><td colspan="3">An alternator is made up of two main parts
1. Stator (Stationary part - Armature winding)
2. Rotor (Rotating part - Field). There are mainly two types of rotors used in construction of alternator:
a) Salient pole type. b) Cylindrical rotor type.</td></tr>
</table>

(3 Marks)			
1.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI:2.2.4**
	What are the losses in transformer?		

Ans

The transformer losses are two types. They are

1. Copper losses.

   These losses occur due to ohmic resistance of the transformer windings.

   $$\boxed{\text{Copper loss } (P_{cu}) = I_1^{2}R_1 + I_2^{2}R_2}$$

2. Iron (core) losses

   Iron losses are caused by the **alternating flux in the core** of the transformer.

Iron losses are again divided into two types. They are

a) Hysteresis Losses and

b) Eddy Current losses

a. Hysteresis Loss

This is due to the nonlinear behavior of B-H curve of the core. Hysteresis losses are minimizedby using Silicon Steel Core.

$$\text{Hysteresis loss } (P_h) = K_h B_0^{1.6} f v$$

Here

K_h = Hysteresis constant

B_0 = Magnetic flux density (Maximum value) in wb/m^2

f = Supply frequency (Hz)

v = Volume of the core (m^3)

b. Eddy Current Loss

This is the power loss due circulating current around the core (Eddy current).The eddy current loss is minimized by making the core with thin laminations.

$$\text{Eddy current loss } (P_e) = K_e B_0^{2} f^{2} v^{2}\tau$$

K_e = Eddy current constant

B_0 = Magnetic flux density (Maximum value) in wb/m^2

f = Supply frequency (Hz)

v = Volume of the core (m^3)

2.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI:2.2.4**
	A 500 KVA, single phase transformer has 220 v, 500 turns on the primary and 200 turns on the secondary. Find the transformation ratio and induced emf in secondary coil.		

Ans	Given data P = 500KVA E1=220V N1 = 500 turns and N2 = 200 turns The transformation ratio $$K = \frac{N_2}{N_1} = \frac{E_2}{E_1}$$ $$K = \frac{200}{500}$$ $$K = 0.4$$ $$E2 = \frac{N_2}{N_1} E1 = 220\,\frac{200}{500}$$ $$=88V$$		
3.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI:2.2.4**
	Write down the formulas for rotor frequency, slip, slip speed and synchronous speed. A 10 pole, 3-phase induction motor runs at a speed of 485 rpm at 50 Hz supply. Find i)synchronous speed and ii) slip iii) percentage of slip		
Ans	**Given data** $P = 10$ $N = 485 rpm$ $f = 50\ Hz$ $N_s = ?$ $S = ?$ $$N_s = \frac{120f}{P} = \frac{120 \times 50}{10} = 600\ rpm$$ $$S = \frac{N_s - N_r}{N_s} = \frac{600 - 485}{600} = 0.1916$$ $$\%S = \frac{N_s - N_r}{N_s} \times 100 = 19.16$$		
4.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI:2.2.4**
	Write down the applications of three phase induction motors.		
Ans	**Applications of Slip Ring Induction Motor** In this type of motor, the rotor has slip-rings and brushes to generate high torque and provide maximum speed control. The applications of slip ring induction motors are given here. • **Lifting industries** • **Chemical industry** • **Rolling mills** • **Medical equipment** **Electrical equipment:** These motors allow external resistance with a high PF rating; thus, used ingenerators, turbines, winders, and dynamos.		

Applications of Squirrel Cage Induction Motor:

These motors have low-load carrying capacity; thus, used for low load applications;

- **Lathe and turning machinery**
- **Blowers and pumps**
- **Home appliances:** Home appliances are another major application of three phase induction motor. Squirrel cage motors are a reliable option for home appliances and domestic uses because of their robust construction, cheap cost, and easy maintenance. These motors are implemented inrefrigerators, compressors, and mixers.

5.	Taxonomy Level: Understand	CO: C114.4	PI:2.2.4
	Write down the applications of synchronous generator.		

Ans

- **Marine alternators** – these types are used for generating power in marine applications.
- **Brushless alternators** –these types are the main source of power in electrical power plants.
- **Diesel-electric locomotive alternators** – locomotives need electric and mechanical power simultaneously, and the source of power is AC generators.
- **Automotive alternators** – modern automobiles use generators for satisfying electric power. All the electric power in the vehicles and charging battery is generated in AC generators.
- **Radio alternators** – these types are used for transmission of radiofrequency in low bands.

(5 Marks)

1.	Taxonomy Level: Create	CO: C114.4	PI:1.3.1

A 500 KVA, single phase transformer has 500 turns on the primary and 200 turns on the secondary. The primary is connected to 2000 V, 50 Hz supply. Determine the Secondary voltage and the maximum value of flux.

Given data

$P = 500\ kVA, f = 50\ Hz$

$N_1 = 500, N_2 = 200$

$V_1 = 2000V$

$V_2 = ?, \phi_m = ?$

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

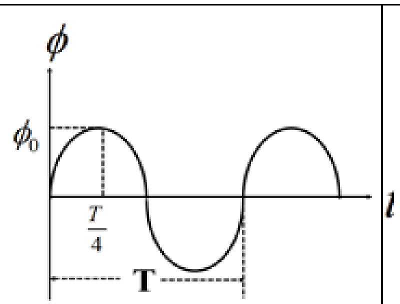
$$\boxed{E_2 = E_1 \frac{N_2}{N_1} = 2000 \times \frac{200}{500} = 800\ V}$$

The induced emf in the primary is given by,

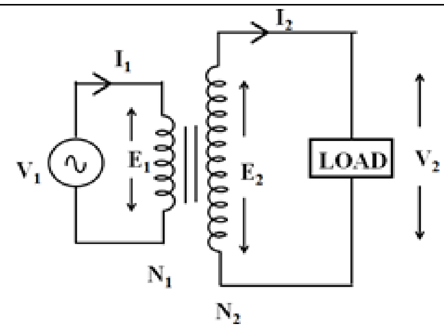
$$\boxed{E_1 = 4.44 N_1 \phi_0 f}$$

$$\boxed{\phi_0 = \frac{E_1}{4.44 N_1 f} = \frac{2000}{4.44 \times 500 \times 50} = 0.0180\ wb}$$

2.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI:1.3.1**
	Derive the emf equation of a transformer.		



Flux waveform



Transformer

As, shown in the Figure a, the flux rises sinusoidally to its maximum value Φ_0 from 0.

It reaches to the maximum value in T/4 sec (T= 1/f). Therefore,

$$\text{The Avg Value of } \frac{d\phi}{dt} = \frac{\phi_0}{\left(\frac{T}{4}\right)} = \frac{4\phi_0}{T} = 4\phi_0 f$$

$$\boxed{Form\ Factor = \frac{RMS\ value}{Avg\ value} = 1.11}$$

$$\text{The RMS Value of } \frac{d\phi}{dt} = 1.11 \times 4\phi_0 f = 4.44\phi_0 f$$

$$E = N \times \frac{d\phi}{dt}$$

$$E = N \times 4.44\phi_0 f$$

$$E = 4.44 N\phi_0 f$$

The induced emf in the primary is given by,

$$\boxed{E_1 = 4.44 N_1 \phi_0 f}$$

The induced emf in the primary is given by,

$$\boxed{E_2 = 4.44 N_2 \phi_0 f}$$

3.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI:1.3.1**
	Explain the necessity of rotating magnetic field in 3 phase induction motor.		

When 3-phase supply is fed to the stator winding of the 3-phase induction motor, a rotating magnetic field (RMF) is produced. This magnetic field is such that its poles do not remain in a fixed position on the stator but go on shifting their positions around the stator. For this reason, it is known as rotating magnetic field (RMF) or RMF.

The speed of the rotating magnetic field is known as synchronous speed (NS). The value of synchronous speed depends upon the number poles (P) on the stator and the supply frequency (f).

Therefore, Synchronous speed is

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

N_s =Speed of Rotating magnetic field (rpm)

It is also called Synchronous speed or Stator speed.

f = Stator supply frequency (Hz)

P=Stator Poles

The magnetic flux produced by the current in each phase. The resultant of these fluxes at that instant (φr) is having a constant magnitude $1.5\varphi_m$ and resultant flux vector is rotated 30° further clockwise without changing its value.

4.	**Taxonomy Level: Analyze**	**CO: C114.4**	**PI:1.3.1**
	Comparison between squirrel cage induction motor and slip ring induction motor.		

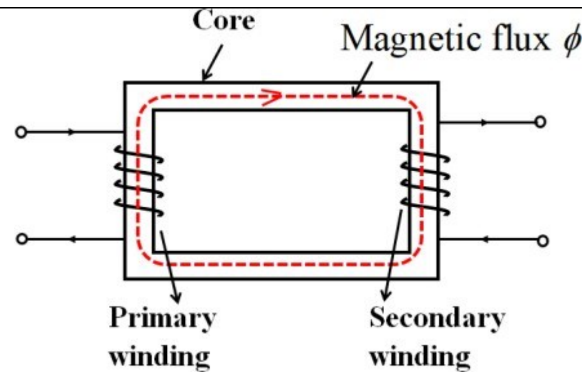
SL.NO	SQUIRREL CAGE INDUCTION MOTOR	SLIP RING INDUCTION MOTOR
1.	Low starting torque	Much higher starting torque(by inserting resistances in rotor circuit)
2.	No slip rings, brush gears, etc.	Extra slip rings, brush gears,etc.
3.	Cheaper	Higher cost
4.	Minimum maintenance	Higher degree of maintenance
5.	Comparatively higher efficiency	Comparatively lower efficiency
6.	No speed control	Speed control(by varying resistance in the rotor circuit)
7.	Cannot be used for loads demanding high starting torque	Capable of starting with load demanding high starting torque
8.	Higher starting current(5 to 6 times the full load current)	Comparatively lesser starting current (2 to 3 times the full load current
9.	Needs a starter	Can be started directly on line (resistance in the rotor circuit acts like a starter and reduces the starting current)
10.	Rugged in construction.	Construction somewhat different from squirrel cage induction motor.

5.	Taxonomy Level: Analyze	CO: C114.4	PI:1.3.1
	Comparison between salient pole rotor and smooth cylindrical rotor of synchronous generator.		

Sr. No.	Salient Pole Type	Smooth Cylindrical Type
1.	Poles are projecting out from the surface.	Unslotted portion of the cylinder acts as poles hence poles are non-projecting.
2.	Air gap is non-uniform.	Air gap is uniform due to smooth cylindrical periphery.
3.	Diameter is high and axial length is small.	Small diameter and large axial length is the feature.
4.	Mechanically weak.	Mechanically robust.
5.	Preferred for low speed alternators.	Preferred for high speed alternators i.e. for turboalternators.
6.	Prime mover used are water turbines, I.C. engines.	Prime movers used are steam turbines, electric motors.
7.	For same size, the rating is smaller than cylindrical type.	For same size, rating is higher than salient pole type.
8.	Separate damper winding is provided.	Separate damper winding is not necessary.

(10 Marks)

1.	Taxonomy Level:Understand	CO: C114.4	PI: 2.2.4
	Explain the construction and working principle of a transformer.		



The essential parts of Transformer are one magnetic material (core) and two winding (primary and secondary).

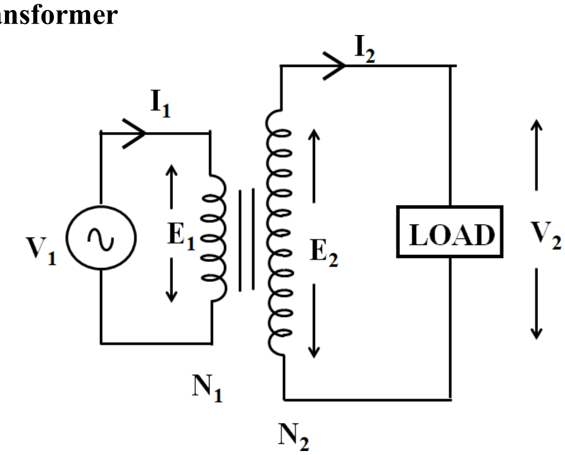
1. Core

- The Magnetic material or Core is made of Iron/Silicon Steel.
- Core is generally laminated to reduce Eddy current losses.
- There are two types of Cores used in Transformer. Namely, Core type and Shell type.
- Core carries both primary and secondary windings.
- Magnetic flux is produced in the core, when AC source is given to the primary winding.
- The flux produced in the core is alternating in nature.

2. Windings

- It mainly consists of two windings namely, Primary winding and secondary winding.
- The winding which is connected to supply is called Primary winding. The windingwhich is connected to load is called secondary winding.
- Windings are made up of copper. And carries current.
- The heat released from the windings is called copper loss.

Working Principle of Transformer



Transformer works on **Faraday's Laws of Electromagnetic induction** principle.

- An AC voltage is applied to the Primary. This voltage drives a current in the Primary (called magnetizing current).
- Magnetizing current energizes the magnetic core and produces an **alternating flux** inthe core.
- Alternating flux gets linked with the both primary and secondary windings; an emf gets induced in the primary and secondary windings.
- The induced emf in the Primary is by the Conduction Principle.

The induced emf in the secondary is by the Mutual Induction Principle.

2.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI: 2.2.4**
	Explain the construction and working principle of three phase induction motor.		

Construction of three phase induction motor

The essential parts of three phase induction motor are Stator and Rotor.

1. Stator

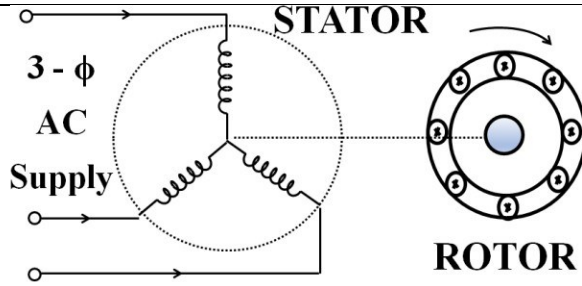
The stator is cylindrical core with slots in its inner periphery. The stator having three phasewinding. And it is connected to three phase supply.

2. Rotor

There are two types of rotor constructions in three phase induction motor. Squirrel cage and slipring

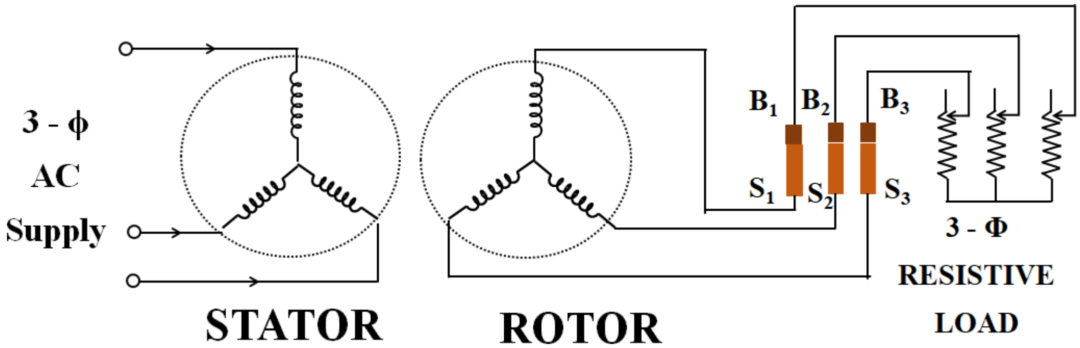
i. Squirrel cage rotor

In this type, the rotor core is cylindrical in shape with slots to carry copper bars. These copperbars are shorted with the help of two copper rings.

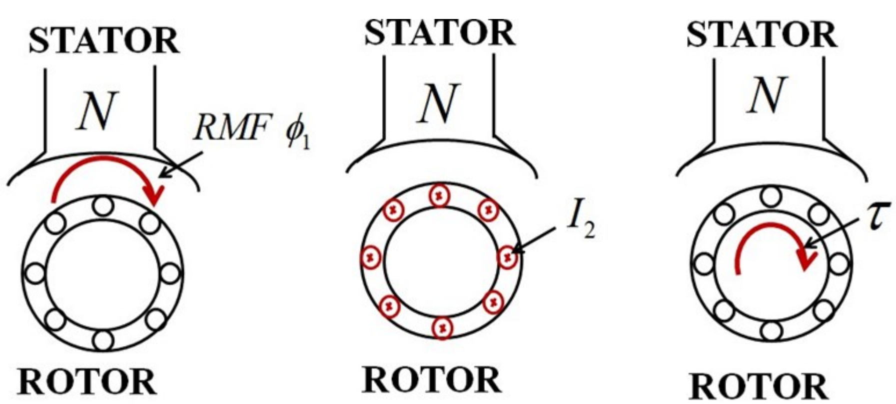


ii. **Slip ring rotor**

In this type, the rotor conductors are placed in the rotor slots to form a balanced three phase winding. These rotor windings are connected to three phase load through slip rings and brushes.



Working principle of three phase induction motor



a) RMF is produced in the Stator *b*) Rotor Current I_2 *c*) Torque developed in Rotor

1. Whenever 3-phase AC supply is given to the 3-phase stator windings of an induction motor, a rotating magnetic field (RMF), Φ_1 is produced as shown in Figure a.
2. This RMF cuts the stationary rotor conductors; hence an emf will be induced in the rotor conductors, according to Faraday's laws of electromagnetic induction principle. Thisemf causes a current to flow in the rotor conductors I_2 as shown in Figure b.
3. Now, the rotor is a current carrying conductor and it is in the rotating magnetic field produced by the stator. Whenever a current carrying conductor placed in a magnetic

field, torque will be developed in the conductor. So torque will be developed in the rotoras shown in Figure c.

The torque developed in the rotor i.e. in the motor is given by,

$$\boxed{\tau \propto \phi_1 I_2 \cos\theta_2}$$

$$\boxed{\tau = K\phi_1 I_2 \cos\theta_2}$$

τ = Torque developed in the motor (N.m)

ϕ_1 = RMF from the Stator (wb)

I_2 = Rotor current (A)

$\cos\theta_2$ = Rotor Power factor

K = Constant

3.	**Taxonomy Level: Understand**	**CO: C114.4**	**PI: 2.2.4**
	Explain working principle of synchronous generator and give its applications.		

As alternator consists of two main parts viz.

1. **Stator** – The stator is the stationary part of the alternator. It carries the armature winding in which the voltage is generated. The output of the alternator is taken form the stator.
2. **Rotor** – The rotor is the rotating part of the alternator. The rotor produces the main field flux.

Salient Pole Rotor:

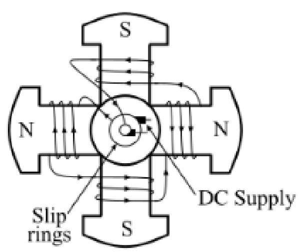


Fig. - Salient Pole Rotor

Cylindrical Rotor:

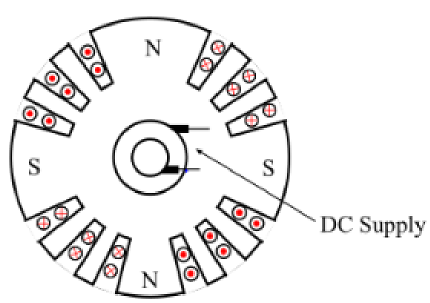


Fig. - Cylindrical Rotor

Working principle:

- An alternator or synchronous generator works on the principle of electromagnetic induction, i.e., when the flux linking a conductor changes, an EMF is induced in the conductor. When the armature winding of alternator subjected to the rotating magnetic field, the voltage will be generated in the armature winding.
- When the rotor field winding of the alternator is energised from the DC exciter, the alternate N and S poles are developed on the rotor. When the rotor is rotated in the anticlockwise direction by a prime mover, the armature conductors placed on the stator are cut by the magnetic field of the rotor poles. As a result, the EMF is induced in the armature conductors due to electromagnetic induction. This induced EMF is alternating one because the N and S poles of the rotor pass the armature conductors alternatively.
- The direction of the generated EMF can be determined by the Fleming's right rule and the frequency of it is given by,

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

Where,

N_s is the synchronous speed

P is the number of rotor poles.

The magnitude of the generated voltage depends upon the speed of rotation of the rotor and the DC field excitation current. For the balanced condition, the generated voltage in each phase of the winding is the same but differ in phase by 120° electrical.

Applications:

1. **Marine alternators** – these types are used for generating power in marine applications.
2. **Brushless alternators** –these types are the main source of power in electrical power plants.
3. **Diesel-electric locomotive alternators** – locomotives need electric and mechanical power simultaneously, and the source of power is AC generators.
4. **Automotive alternators** – modern automobiles use generators for satisfying electric power. All the electric power in the vehicles and charging battery is generated in AC generators.
5. **Radio alternators** – these types are used for transmission of radiofrequency in low bands.