The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur

Department of Mechanical Engineering

NAME OF COURSE: - Basic Electrical and Electronics

CODE OF COURSE: - 312020

SEMESTER: - SYME-3K

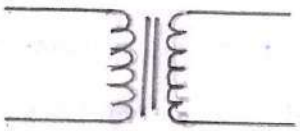
SUBJECT TEACHER: - Mr. Gitesh G. Bhagwat

Unit-II :- Transformer & Single phase Induction Motor

* Transformer :-

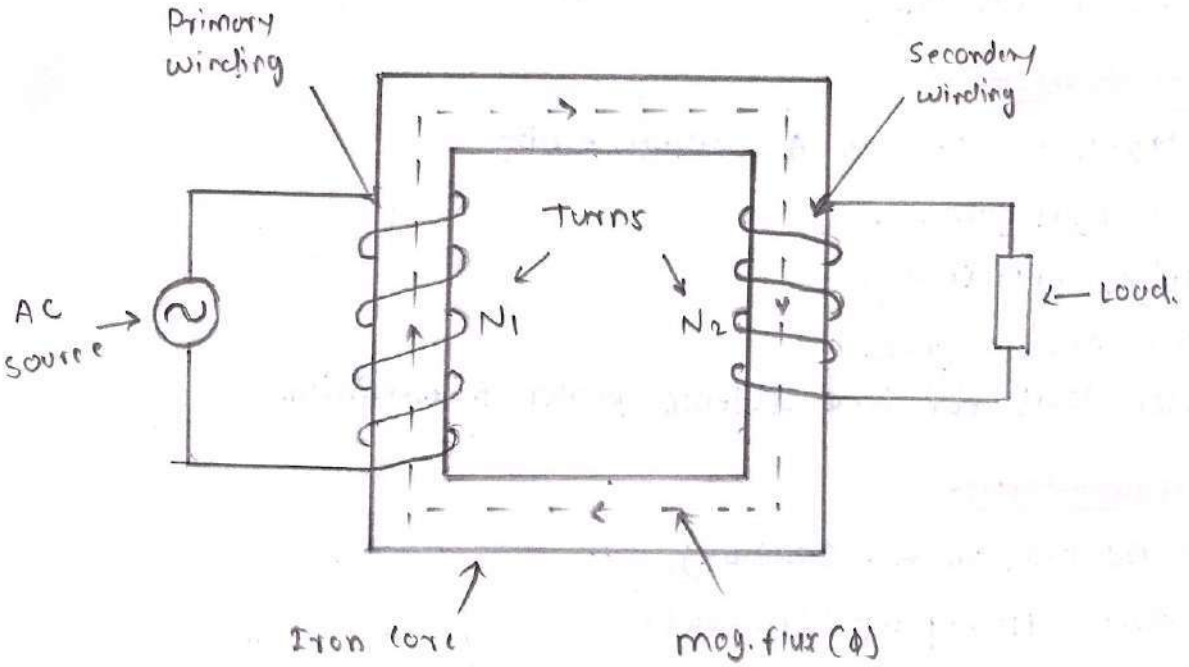
- Transformer is a static electric device which transfers electrical energy from one circuit to another circuit using principle of mutual electromagnetic induction.
- whenever transformer transfer electrical energy there is change in a voltage or current but frequency remains constant (50 Hz)

* Symbol :-



(Transformer Symbol)

* Construction of Transformer :-



- It consist of two windings on core namely primary winding with N_1 Turns. & Secondary winding with N_2 numbers of turns.
- AC supply is connected to primary winding
- Load is connected to secondary winding.
- A magnetic core is common for both primary and secondary winding.
- This is a simple construction of transformer (single phase transformer)

* Working of Transformer:-

- The working principle of transformer is based on faradays law of electromagnetic induction.
- when primary winding with N_1 turns excited by alternating voltage which circulate an alternating current which produce an alternating flux. and completes the path through common mag. core.
- Thus an alternating flux links with secondary winding as flux is also alternating.
- according to faraday's law of electromagnetic induction mutually induced emf gets developed in secondary winding.
- If load is connected to secondary winding emf drives current through it
- It means electrical energy is transfered from primary winding to secondary winding.

* Advantages:-

1) Step-up & step-down AC voltage easily.
2) low maintenance.
3) High efficiency.
4) No moving parts.
5) essential for long distance power transmission.

* Disadvantages:-

1) works only on AC (not DC)
2) Bulky & Heavy at high power.
3) It has some energy loss.
4) It can produce noise.
5) expensive to manufacture.

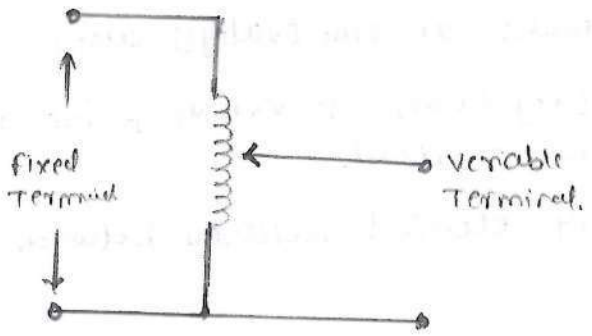
* Applications:-

1) use in power transmission 2) used in a distribution systems
3) used in a electrical appliances. 4) used for voltage regulation
5) used is audio system.

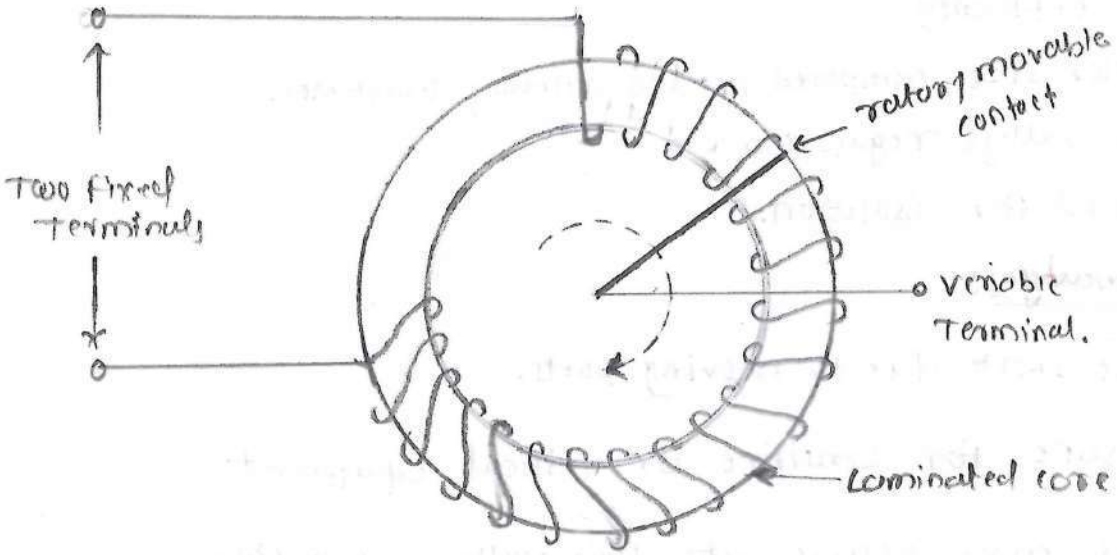
* Auto Transformer :-

- An Auto transformer is a transformer that uses only one winding for both input and output.
- It works on principle of electromagnetic induction.
- It changes the voltage level by tapping (regulating) winding at different points.

* Symbol :-



* Construction of Auto transformer :-



- An Auto transformer has single winding. This single winding is tapped at some point to provide a part of winding for input and other parts for output.
- It mainly consist of following parts.
- **Core:-** made of laminated soft iron core to reduce eddy current loss (eddy current:- leakage current through core)
- **Winding:-** A single copper winding is wound on core with taps at various points (means it can be regulated)
- **Tap Changer:-** It is changing tap or (regulator) used for allowing changing o/p voltage in auto transformer.

* Working of Auto Transformer:-

- Working principle of auto transformer is based on electromagnetic induction & voltage transformation by using single winding.
- A single winding is wound on magnetic core.
- AC voltage is applied across input terminal.
- It creats fluctuating magnetic field in the core as per faradays law of electromagnetic induction.
- Magnetic field enduce an emf (voltage) along the winding.
- By taking taps (regulator) at various point on the winding different o/p voltage can be obtained.
- There is no any electrical isolation between both sides.

* Advantages:-

1) less copper loss due to single winding.
2) High efficiency
3) Smaller size compared to two winding transformer.
4) Better voltage regulation
5) no need for isolation.

* Disadvantages:-

1) May be short due to moving parts.
2) Not safe for sensitive or critical equipment
3) Leakage may occure at low voltage side.
4) used for limited appliances.
5) not insulated from inside for core winding.

* Applications:-

1) Used as starter for induction motor.
2) Used in voltage regulators and stabilizers.
3) Used in audio radio equipment
4) Boosting or reducing voltage in small ranges.
5) used as power supply to labs and testing equipment.

* Transformation Ratio of Transformer:-

- Transformation ratio of transformer can be defined as "ratio of ~~transformer~~ voltage or current ~~to~~ between primary winding and secondary winding.
- also ratio of emf in secondary coil to emf in primary coil called as transformation ration.
- It is denoted by K & it is reciprocal of turns ration

$$\text{Transformation ratio } K = \frac{1}{\text{Turns ratio}}$$

$$K = \frac{1}{N_1 / N_2}$$

$$\therefore \boxed{K = \frac{N_2}{N_1}}$$

* EMF equation of transformer:-

- The EMF equation is a mathematical expression that relates the induced voltage (EMF) to the number of turns, frequency, & magnetic flux.

$$\boxed{\text{for primary coil } E_1 = 4.44 f N_1 \phi_m}$$

$$\boxed{\text{for secondary coil } E_2 = 4.44 f \cdot N_2 \phi_m}$$

where;

f = frequency

N_1 = No of primary turns

N_2 = No of secondary turns

ϕ_m = flux

E_1 & E_2 = output voltage

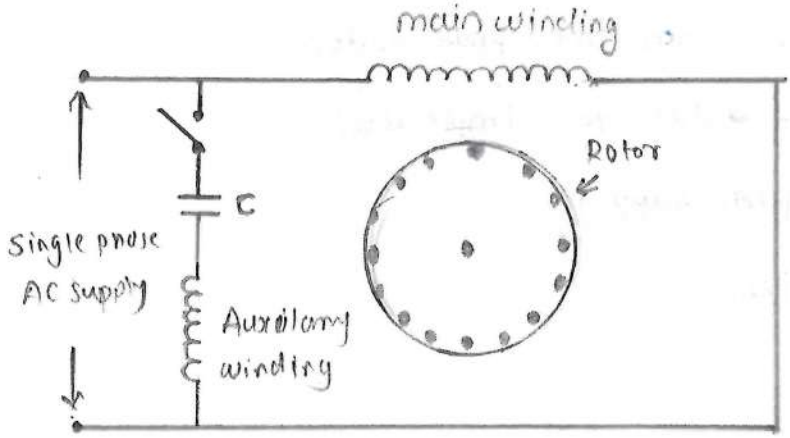
* Difference Between transformer and Autotransformer.

Sr	Parameter	Normal Transformer	Auto transformer.
1)	No of winding	It has two Seperate winding	has single winding.
2)	Electrical isolation	isolation provided between primary & secondary winding	No isolation is provided between windings.
3)	Copper requirment	more copper required due to both winding	Less copper required due to single winding.
4)	Efficiency	Low efficiency as compared to auto transformer	High efficiency due to less losses.
5)	Voltage regulation	poor voltage regulation	Better voltage regulation
6)	Resistance	High resistance	Low resistance
7)	Copper losses	More copper loss	Less copper loss
8)	Variable use	Cannot use as variable transformer	Used as variable transformer
9)	Rating	Lower KVA rating for same size	High KVA rating for same size.
10	Noise	less noisy	More noisy.

* Single phase AC Motor:-

- Single phase AC motor is an electric motor that operate on single phase AC (Alternating current).
- which converts electrical energy into mechanical energy
- Single phase supply does not produce rotating magnetic field alone.
- it required auxiliary means like starter winding or capacitor.

* Construction of single phase AC motor:-



(Single phase AC motor)

- Single phase AC motor mainly consist of following parts.
- **Stator**:
  It is stationary parts of motor.
  it has laminated iron core and slots where main winding and Starting winding (auxiliary winding) are placed.
- **Rotor**:-
  Rotor is a rotating part of the motor
  made of laminated iron and aluminium or copper bars at short circuit at both ends.
- **Capacitor or centrifugal switch**:-
  It is used to disconnect the starting winding after the motor reaches about 70-80 % of its speed.

* working of Single phase motor:-

- Single phase AC supply produces an alternating magnetic field not a rotating.
- This alternating field alone cannot start the rotor due to the absence of initial torque
- ~~term~~ is known as double revolving field theory.
- To create starting torque an auxiliary winding is added with phase shift using capacitor.
- This creats rotating magnet field.
- once the rotor start moving. it keeps runing due to magnetic interaction between the stator field and rotor.

* Advantages:-

1) simple in construction
2) low cost :- cheaper than three phase motor
3) Easy to repair :- due to simple design
4) Runs on single phase supply.
5) Compact in size.

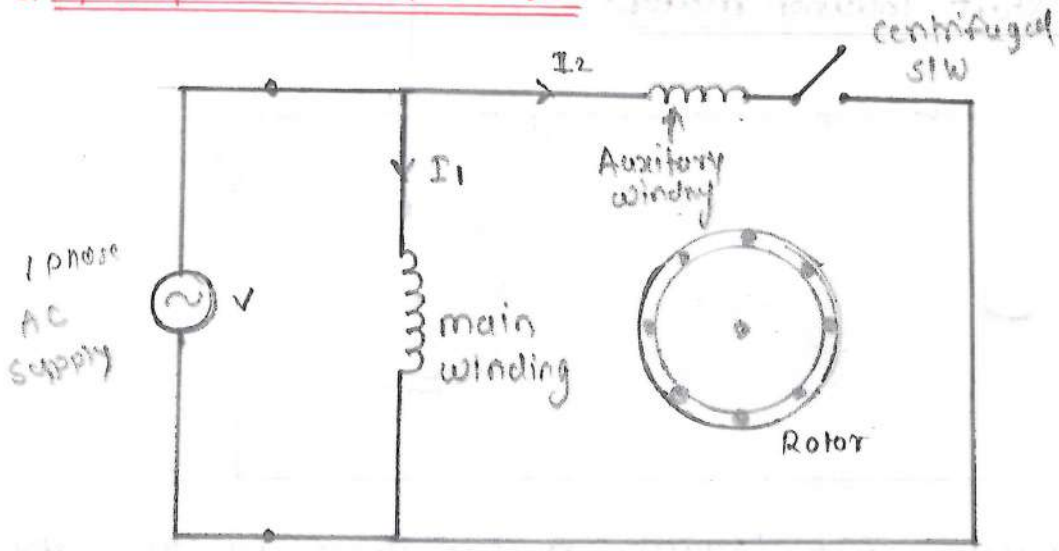
* Disadvantages:-

1) No self starting need extra mechanism.
2) Lower efficiency :- consume more power.
3) Low starting torque :- not suitable for heavy loads
4) has more noise and vibration.
5) Limited power output hence suitable for small loads.

* Applications :-

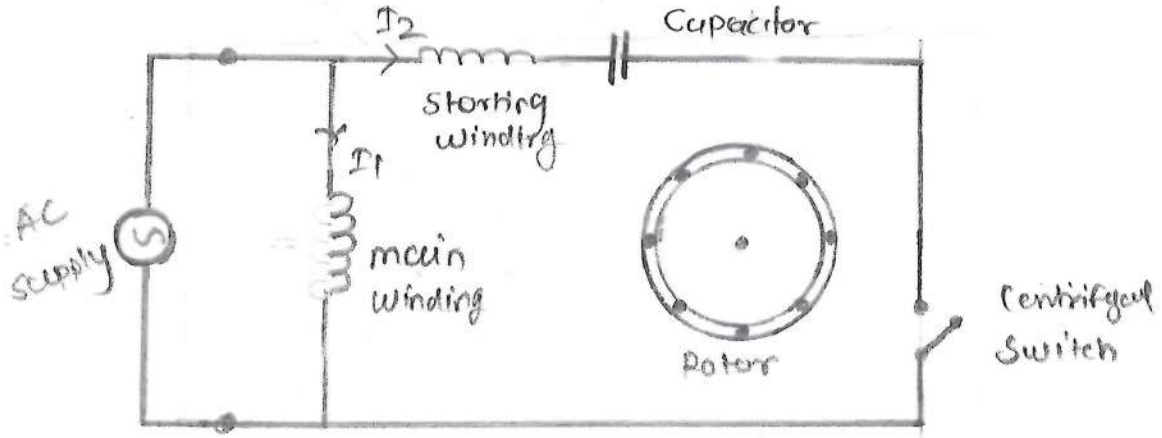
1) Used in ceiling fans for rotating blades.
2) Used in mixer and Grinders.
3) rotating motor of Drum at washing machine.
4) Used in Domestic water pumps.
5) Used in Air conditioners for blower and compressor motor.
6) Used in small fans and heating operations
7) Used in vacuume cleaner. as suction mechanism.

* Split phase induction motor :-



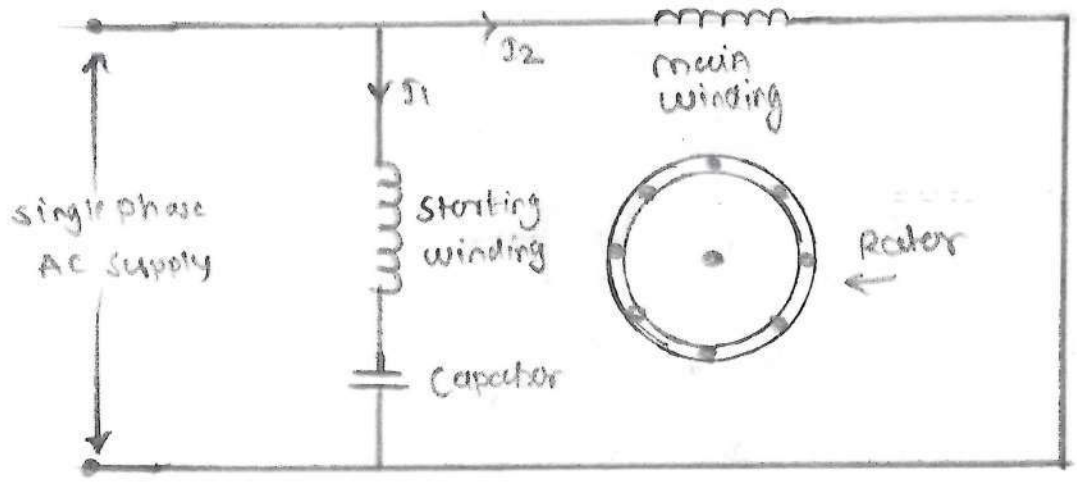
- In split phase induction motor the stator has two windings
  1) main winding has more inductance & less resistance
  2) Auxiliary winding has less inductance & more resistance.
- when we supply single phase AC power both winding get current because of their different resistance and capacitance value.
- Current in each winding is not in phase
- There is phase different is created about 30°.
- This phases difference caues stator to produce rotating magnetic field.
- The rotating field ~~induced~~ induces Emf in rator & it starts rotating.
- when motor reaches about 75-80% of it's full speed
- A Centrifugal switch disconnect the starting winding.
- Then afterwards motor starts running using only on the main winding.
- In that manner the split phase induction motors works.

* Capacitor start Induction motor:-



- In a capacitor start induction motor there are two capacitors are used.
- 1) Start capacitor:- for high capacitance used only for during startup.
  2) Run Capacitor:- low capacitance to remains circuit continously.
- Centrifugal switch:- used to disconnect start capacitor after startup.
- Both capacitor start capacitor and run capacitor are connected in parallel with the auxiliary winding.
- which provides strong phase shift as well as very high starting torque.
- due to which a rotating magnetic field is created which is responsible for rotate the rotor.
- once the motor reaches at full speed a centrifugal switch opens by disconnecting the start capacitor.
- Then afterwards The run capacitor remains in the circuit improving efficiency, power factor, and torque during normal operations

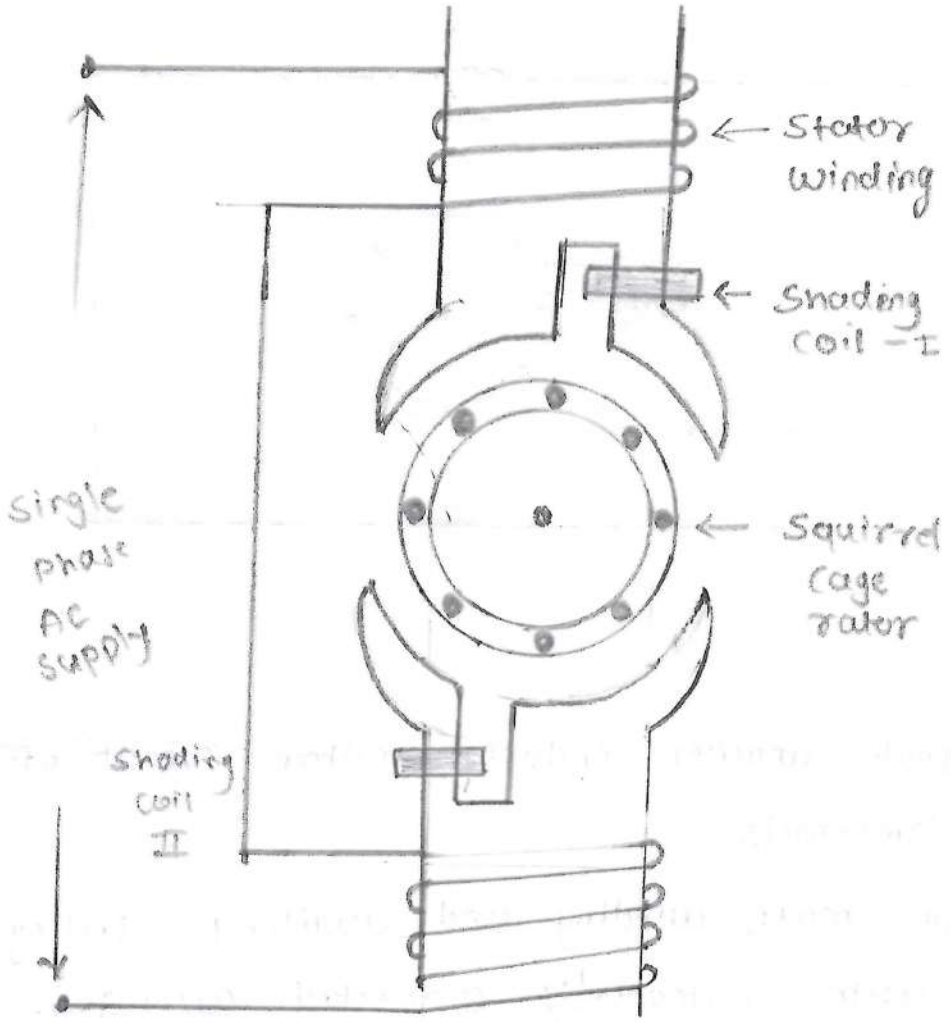
* Permanent split capacitor Induction motor:-



(Permanent split capacitor induction motor)

- permanent split capacitor induction motor consist of following components.
- Stator:- has main winding and auxiliary winding connected in series with permanently connected capacitor.
- Rotor is the rotating part of the motor.
- It dont have centrifugal switch.
- when AC power is applied due to capacitor the Capacitance remains in the circuit always
- which produces a constant phase difference between main and auxiliary winding.
- which is responcible for rotating magnetic field. it is generated from starting and continous during operation.
- motor starts and runs using both windings and and with some capacitor.

* Shaded pole induction motor:-



- **Construction:-**
- Stator has projecting poles made of laminated steel.
- each stator pole is devided into two parts.
- Shaded and unshaded part
- which has thicker copper ring (shading coil) placed around it
- has rotor (rotating part)

* working:-

- When single phase AC voltage is applied to stator winding an alternating magnetic flux is produced at poles.
- flux changes direction with each half cycle.
- flux from stator poles split into two parts.
  one part passes trough unshaded poles and one pass trough shaded part with copper ring.

- when magnetic flux increases, current induced in shading coil (by faradays law)
- This current oppose the change and delays flux in the shaded part (by lenz's law)
- flux in unshaded part comes first then in shaded part
- This time difference make magnetic field move from the unshaded to shaded part side.
- which creats weak rotating magnetic field.
- The rotating field cut the rotor, inducing current
- which creats torque & rotor start rotating from unshaded part to shaded part.

* Applications of single phase induction motor.

- Single phase induction motor are commonly used in household appliances as well as commercial settings.
- **Household Appliances:-**
  fans, refrigerator, washing machine, vaccume cleaners, air conditioners. and other smaller appiances.
- **Commercial Applications:-**
  water pumps, blowers, small commercial refrigerator, and many other lower power equipments.
- **Light industrial applications:-**
  small pumps, compressors, and other light industrial settings.
- **Agriculture Applications:-**
  Threshing machine, waterpumps, and other forming equipments

* Applications of induction motor:-

Induction motor have wide range of applications in divers sector due to there robustness, efficiency, and costeffectiveness.

- **Industrial Applications:-**

Induction motors are essential for powering machinery in manufacturing, driving conveyors, pumps, compressors, & milling machines.

- **HVAC System (Heating Ventilation & Air conditioning)**

They are used in systems such as where. includes heating, ventilations, air conditioning is involve, eg. fan, blowers, AC unit.

- **Mining Industry:-**

Induction motor used for powering conveyors and compressors in many mining operations.

- **In Electric vehicles:-**

Induction motors are used in EV's due to there high torque. and efficiency.

- **Medical Equipments:-**

mostly used in MRI machine, ~~surgical~~ surgical robots, and many other diagnostic medical instruments.