Chap-7 8-L (12 marks)

) Write short notes on: (Any Two) [2×4]

i) Working and application of Stepper motors
ii) Resistant start single phase motor
iii) Universal motors

b) Write short notes on: [2×4]

i) Double field revolving theory
ii) Universal motor

***

leading. ... same excitation and load current at 0.8 pf

b) Write short notes on: (Any Two) [8] [2×4]

(i) Capacitor start and run motor
(ii) Universal motor
(iii) Stepper motor

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a) Explain Double field revolving theory. How do we make single phase induction motor self starting? [8]

b) Explain the construction and working of Servo Motor. [8]

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Prove that a single-phase induction motor winding when excited by a single phase-phase supply produces two equal and opposite revolving fields. [8]

***

... Hz and the field current is 2.4 A. ... frequency is [8]

a) Explain the operating principle and characteristics of split phase induction motor with neat sketches. [8]

b) Explain construction, operation and characteristics of universal motor. Why is it called so? Give reason. [8]

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c) Using double revolving field theory, explain the working of a single phase induction motor. [6]

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b) Explain double field revolving theory refer to single phase induction motor and prove that a single phase induction motor is not self starting. [8]

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) Why single phase induction motors are not self-starting? Explain any two starting methods for single phase induction motor. [8]

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a) Explain double revolving field theory. Explain any two methods which are used for starting single phase induction motor.

b) Explain the operating principle of dc servo motor and its applications.

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a) Why single phase induction motor are not self starting? Explain any two starting methods for single phase induction motor. [8]

Single phase Induction Motor (IOE)

It consists of two main parts

(1) Stator (Stationary part)

→ It has a laminated iron core with windings placed in slots

→ The main winding is connected to the sigle-phase AC supply.

→ In some types, an auxiliary winding is used to provide the necessary starting torque.

(2) Rotor (Rotating Part)

→ rotor is short-circuited at both ends with end rings.

→ The rotor is placed inside the strator and rotates due to the magnetic field created by the strator winding.

→ Some additional components are required for starting.

Working

→ When a single-phase AC voltage is supplied, an alternating magnetic field is produced in the stator

→ This field is pulsating rather than rotating, meaning it does not automatically induce motion in the rotor.

Imp

→ Unlike a 3ϕ induction motor, a single phase induction motor does not self-start because the alternating magnetic field produces equal and opposite forces in the rotor canceling out rotation.

→ To solve this auxiliary starting methods are used (capacitors, shaded poles) etc.

→ When the rotor is started it cuts the magnetic field lines.

→ This induces a current in the rotor, which interacts with the stator's field and produce a rotating torque.

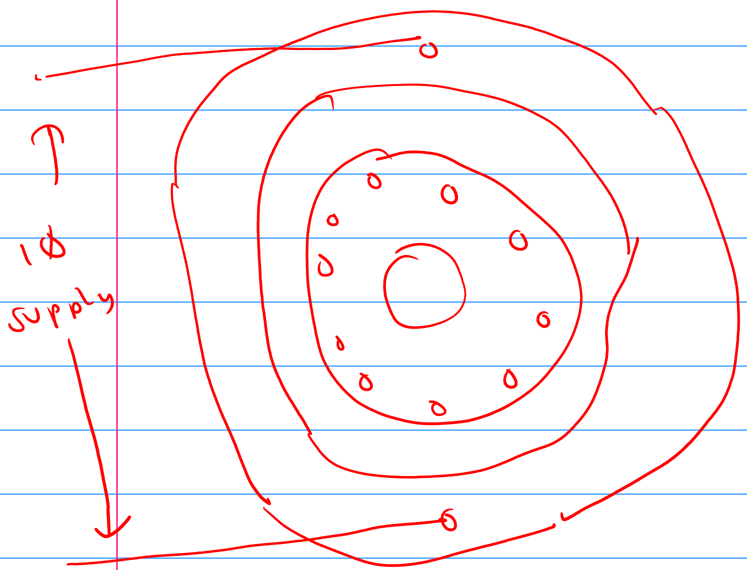
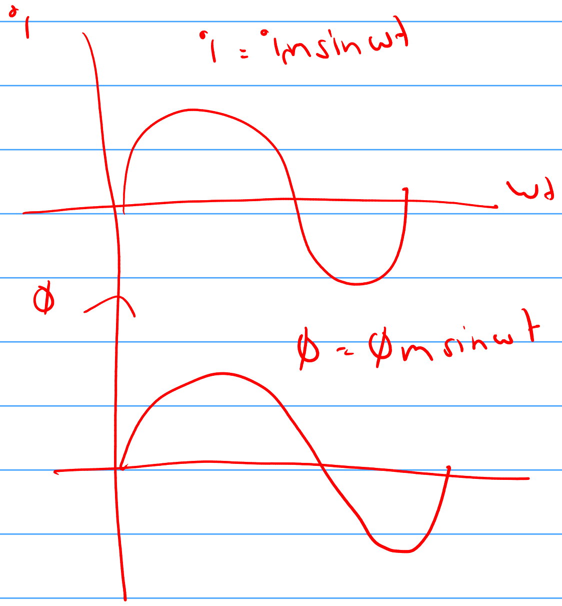


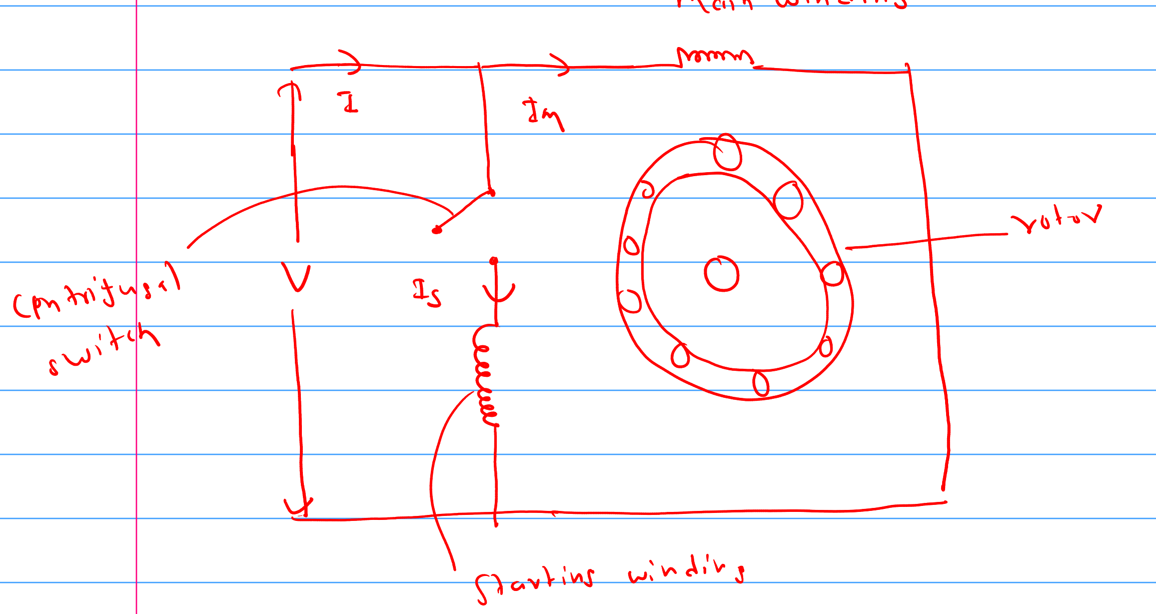
fig: 1ϕ induction motor



Starting of Single - Phase Induction motors (IOE)

① Split-phase Induction motor (Resistance Start)

to create an initial rotating magnetic field, addition windings and ckt are used



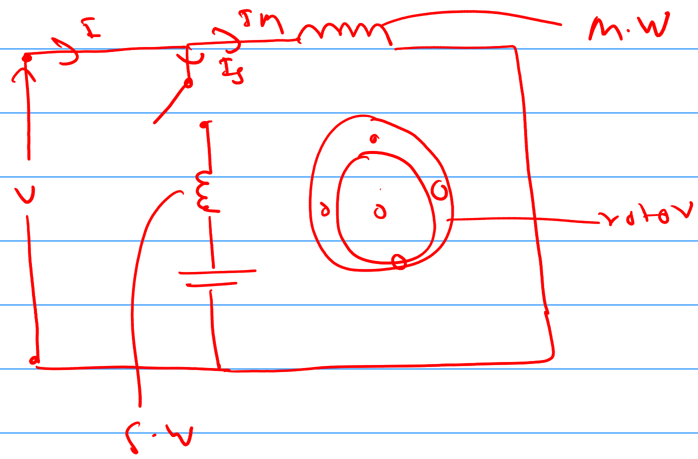
It has two windings

① main winding : runs the motor
② starting winding : creates the initial phase shift

-) A high resistance starting winding produces a phase difference between currents, generating a weak rotating field

-) once the motor reaches about 75-80 % of its rated speed, centrifugal switch disconnects the starting winding.

② Capacitor - Start Induction Motor

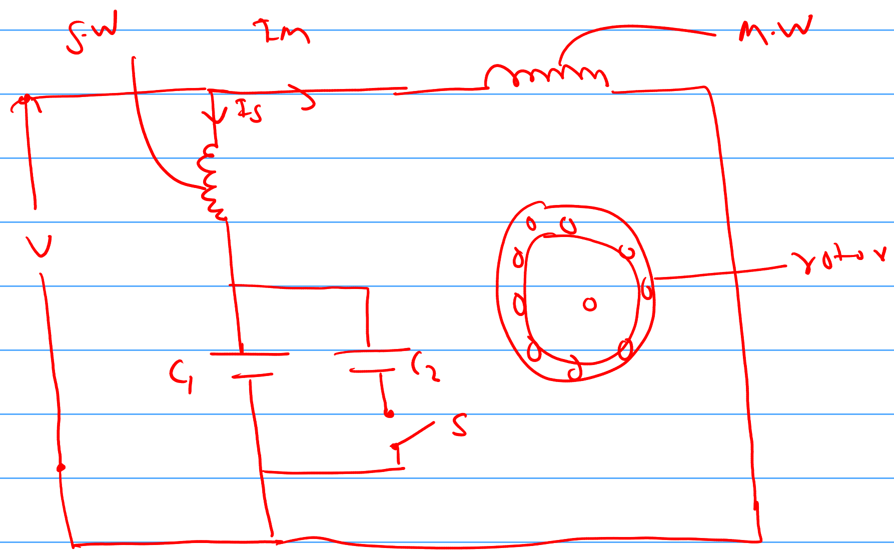


→ Similar to split-phase motor but with a capacitor in the starting circuit.

→ The capacitor improves the phase shift, generating a stronger starting torque

→ The starting winding is disconnected once the motor reaches a certain speed.

③ Capacitor - Star Capacitor - Run Induction Motor



Uses two capacitors

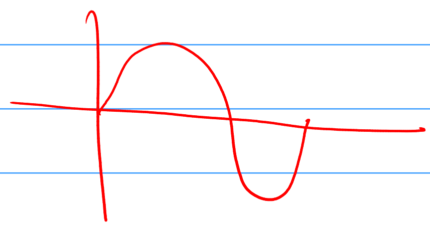
→ A starting capacitor (C_2) (high value) for strong initial torque

→ A running capacitor (C_1) (lower value) to maintain better efficiency

→ The starting capacitor is disconnected after reaching but the running capacitor remains in the ckt.

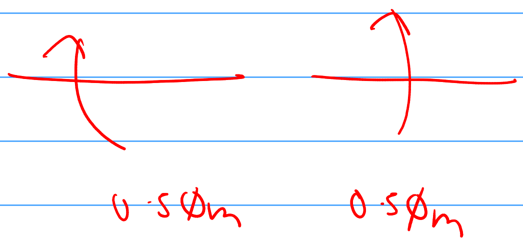
Double Field Revolving Theory (DFR) (most imp)

→ The pulsating magnetic flux produced by 1ϕ winding is equivalent to phasor sum of two oppositely rotating mag flux, each having magnitude of $0.5\phi_m$ having a synchronous speed of $N_s = \frac{120f}{P}$



Analytic proof:

Fig below shows two rotating vector OF and OB having magnitude of $0.5\phi_m$ and rotating in opposite direction.



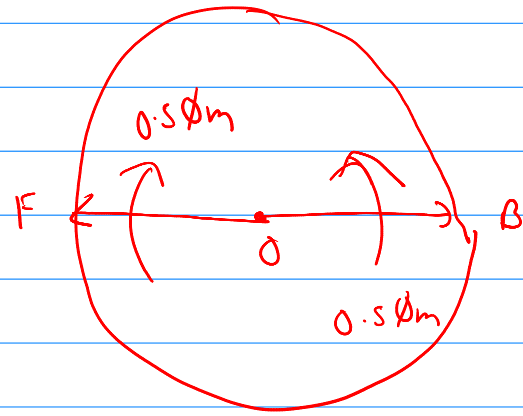


fig:

at $\omega t = 0$

→ angle btwn two vector $= 180^\circ$

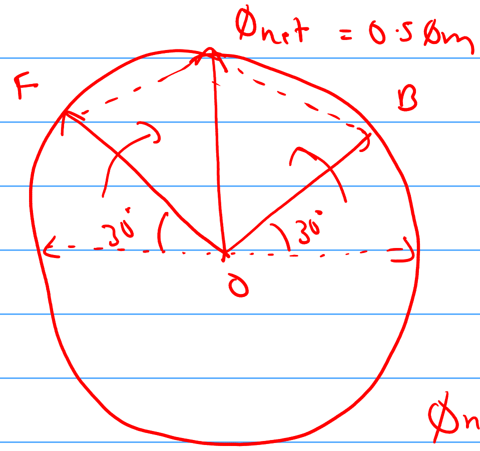
$$\phi_{net} = \sqrt{(0.5\phi_m)^2 + (0.5\phi_m)^2 + 2(0.5\phi_m)(0.5\phi_m).\cos 180^\circ}$$

$$\phi_{net} = \sqrt{2(0.5\phi_m)^2 - 2(0.5\phi_m)^2}$$

$$\phi_{net} = 0$$

every step by 30°

now rotate forward and backward vector by 30°



at $\omega t = 30^\circ$

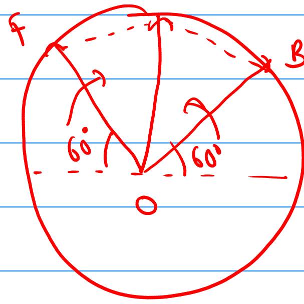
$$\phi_{net} = \sqrt{(0.5\phi_m)^2 + (0.5\phi_m)^2 + 2 \times 0.5\phi_m \times 0.5\phi_m \cos(180 - 60^\circ)}$$

$$\phi_{net} = \sqrt{2(0.5\phi_m)^2 - \frac{1}{2} \times 2(0.5\phi_m)^2}$$

$$= 0.5\phi_m$$

Again

$\phi_{net} = 0{\cdot}86\, \phi_m$



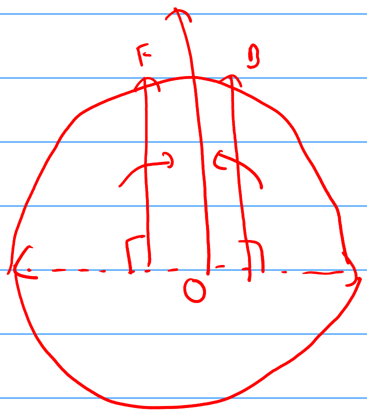
at $\omega t = 60^\circ$

$$\phi_{net} = \sqrt{2 \times (0{\cdot}5\phi_m)^2 + 2 \times (0{\cdot}5\phi_m)^2 \times \cos(180-120)}$$

$$= 0{\cdot}5\, \phi_m \times \sqrt{3}$$

$$= 0{\cdot}86\, \phi_m$$

$\phi_{net} = \phi_m$

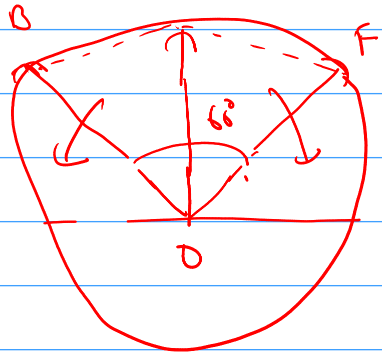


at $\omega t = 90^\circ$

$$\phi_{net} = \sqrt{2 \times (0{\cdot}5\phi_m)^2 + 2 \times (0{\cdot}5\phi_m)^2 \times \cos 60^\circ}$$

$$= 2 \times 0{\cdot}5\, \phi_m = \phi_m$$

ϕ_{net}



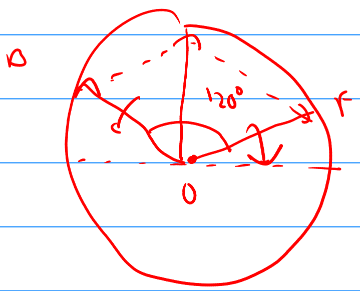
at $\omega t = 120^\circ$, $\theta = 60^\circ$

$$\phi_{net} = \sqrt{2 \times (0{\cdot}5\phi_m)^2 + 2 \times (0{\cdot}5\phi_m)^2 \cos 60^\circ}$$

$$= \sqrt{3 \times (0{\cdot}5\phi_m)^2}$$

$$= 0{\cdot}86\, \phi_m$$

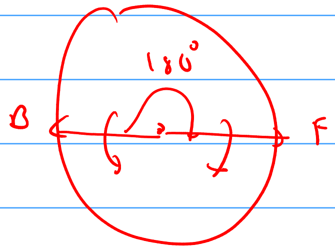
ϕ_{net}



at $\omega t = 150^\circ$, $\theta = 120^\circ$

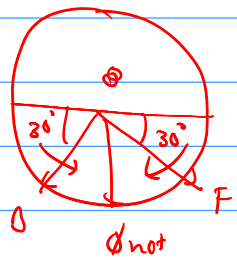
$\phi_{net} = 0{\cdot}5\, \phi_m$

At $\omega t = 180^\circ$



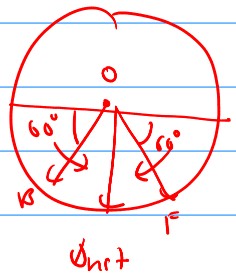
$\phi_{net} = 0$

at $\omega t = 210^\circ$



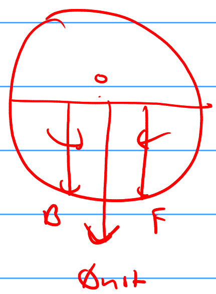
$\phi_{net} = -0.5\,\phi_m$

at $\omega t = 240^\circ$



$\phi_{net} = -0.86\,\phi_m$

at $\omega t = 270^\circ$



$\phi_{net} = -\phi_m$

at $\omega t = 300^\circ$, $\phi_{net} = -0.86\,\phi_m$

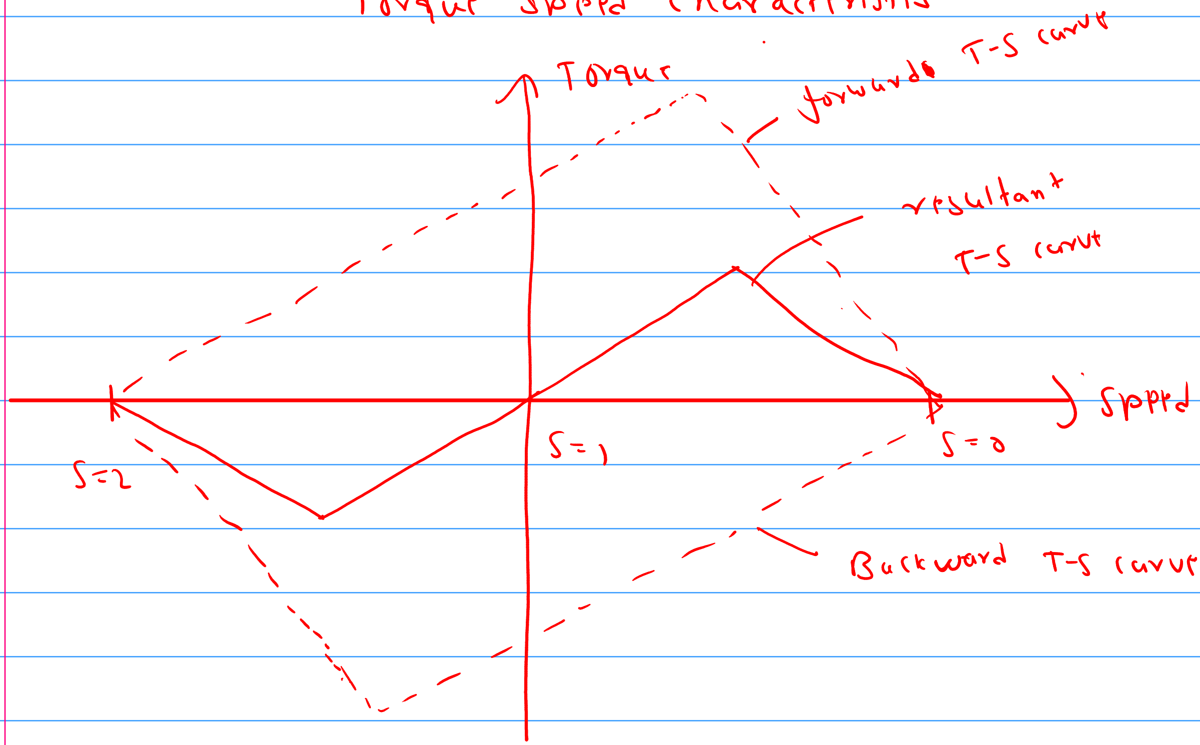
$\omega t = 330^\circ$, $\phi_{net} = -0.5\,\phi_m$

$\omega t = 360^\circ$, $\phi_{net} = 0$

Hence it is clear from the above graphical analysis as stated by double revolving field theory, the pulsating magnetic field produced by the single phase winding is equivalent to the phase sum of two oppositely rotating magnetic fields each having magnitude of $0.5\phi_m$ with a synchronous speed of $N_s = \frac{120f}{P}$

forward mag field → clockwise
backward mag field → anticlockwise

Torque speed characteristics



Universal Motors (IOE) (SN)

→ A universal motor is a type of electric motor that can operate on both AC and DC power.

→ It is a series-wound motor, meaning stator and rotor are connected in series.

Key features	Application
→ works on AC and DC	① Power tools (drills, grinders)
→ high speed	② Household appliances (vaccum, blender)
→ compact and lightweight	③ hairdryers.
→ high starting torque	
→ noisy operation	

Special Purpose Machine (IOE)

→ designed for specific task that cannot be performed efficiently by standard machines.

- stepper motors
- servo motors
- schrage motor

① Stepper motor

→ A stepper motor is a type of DC motor that moves in discrete steps, meaning it rotates in fixed angles (steps) instead of continuous motion. It is widely used for precise control in various applications.

Working

→ It works on the principle of electromagnetic induction and are controlled by applying electrical pulses to their coils. The motor consists of a rotor (permanent magnet or iron core) and a stator (coils or windings)

→ When a specific coil is energized, the rotor aligns with its mag field.

→ By sequentially energizing different coils in a specific pattern, the rotor moves in discrete steps.

→ The step angle depends on the motor type and no of coils.

Types

① Permanent magnet stepper motor : uses a permanent magnet rotor, providing good torque at low speeds

② Variable Reluctance stepper motor : uses a soft iron rotor that moves towards the least magnetic reluctance path.

③ Hybrid stepper motor : combines features of both

Applications

① Robotics → robotics arms for precise positioning
② 3D printers
③ Hard drives
④ medical Equipments
⑤ Speedometers

Servo motors (IoT)

→ A servo motor is a rotary or linear actuator that provides precise control of angular or linear position, velocity, and acceleration. It consists of a motor coupled with a sensor for position feedback and a controller that adjust its movement.

Working

→

→ A servo motor operates on the principle of closed-loop control which means it continuously monitors its position and adjusts accordingly.

→ A control signal (PWM - Pulse width modulation) is given to the servo.

→ The built-in controller interprets the signal and compares it with the current position.

→ The motor rotates accordingly.

→ The position sensor continuously checks if the desired position is reached.

→ If there is a difference between the desired and actual position, the controller corrects it.

→ This closed-loop feedback system ensures high precision and accuracy.

Applications

1. Robotics
2. Drones
3. Medical Equipment
4. automobile
5. Consumer electronics
6. aerospace

Schrage Motor (IOE)

→ special type of ac commutator motor that provides variable speed operation with high efficiency. It is an asynchronous motor with a wound rotor and a commutator arrangement used where precise speed control is required.

Working

→ The motor starts as wound-rotor induction motor

→ The slip rings and commutator adjust the phase relationship between rotor and stator currents.

→ The brush shifting mechanism changes the effective speed by modifying the rotor voltage.

→ Speed can be controlled without external resistor, making it more efficient than other wound rotor motors.

→ By adjusting the brush position, the speed can be increased, decreased or even reversed.

→ The speed range typically varies from sub-synchronous to super-synchronous speeds.

Applications

1. Textile machines
2. Paper Industry
3. Steel Rolling mills
4. Elevators and cranes