SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME: 19EEB210 / Electrical Machines and Drives

II YEAR / IV SEMESTER

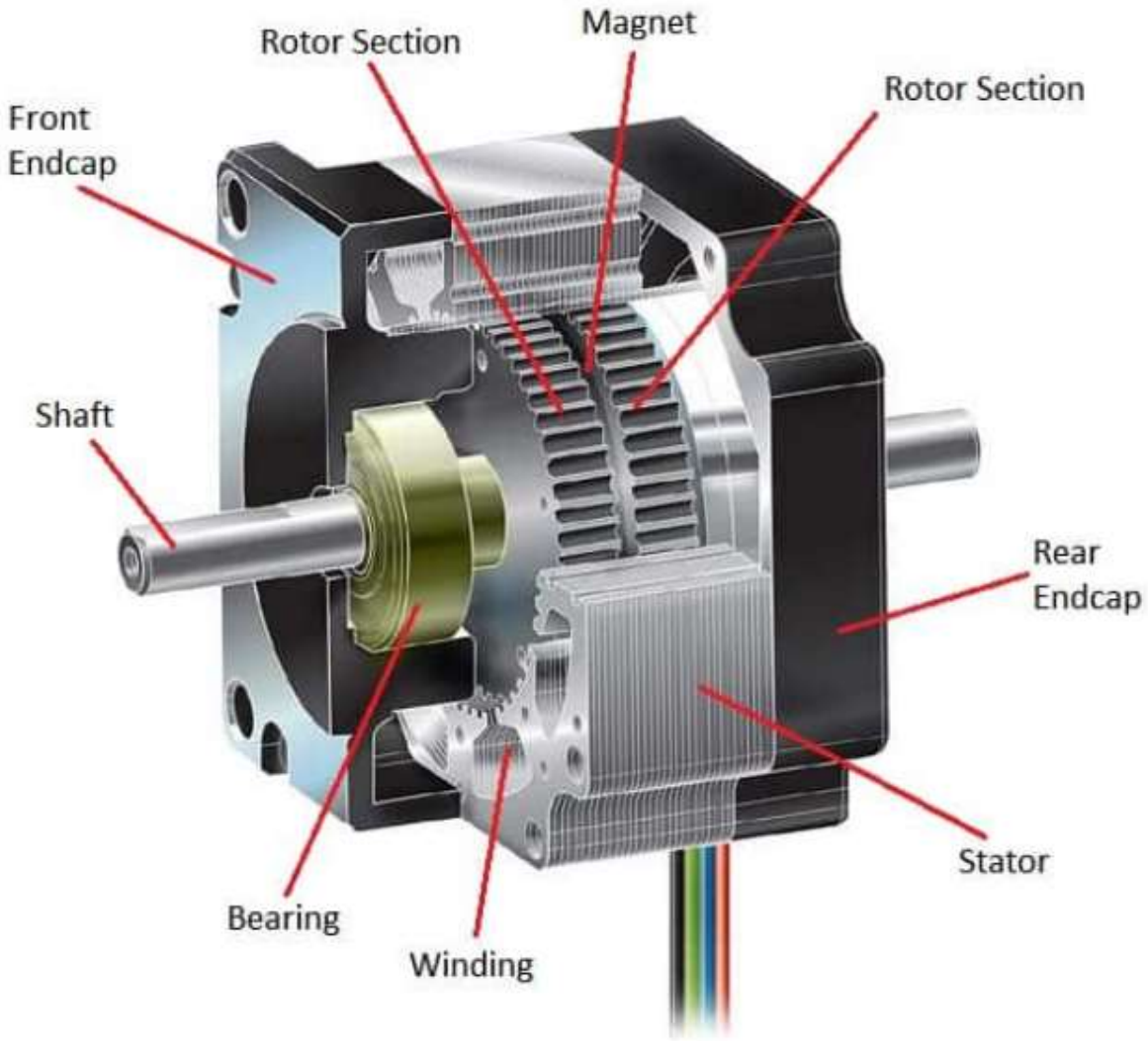
Unit II – ELECTRICAL MOTORS

Topic : Steppermotor

STEPPER MOTOR

- A Stepper Motor or a step motor is a brushless, synchronous motor which divides a full rotation into a number of steps.
- Unlike a brushless DC motor which rotates continuously when a fixed DC voltage is applied to it, a step motor rotates in discrete step angles.
- The Stepper Motors therefore are manufactured with steps per revolution of 12, 24, 72, 144, 180, and 200, resulting in stepping angles of 30, 15, 5, 2.5, 2, and 1.8 degrees per step.
- The stepper motor can be controlled with or without feedback.

STEPPER MOTOR

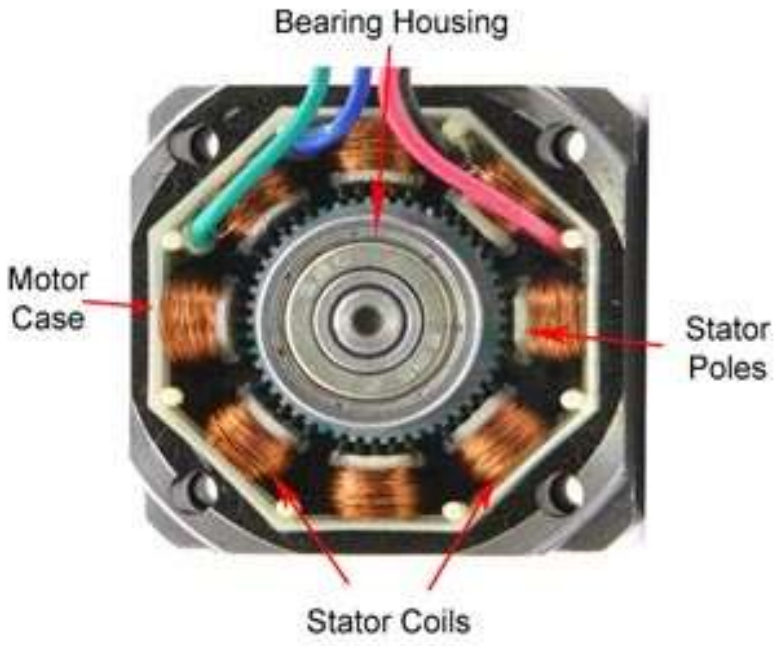


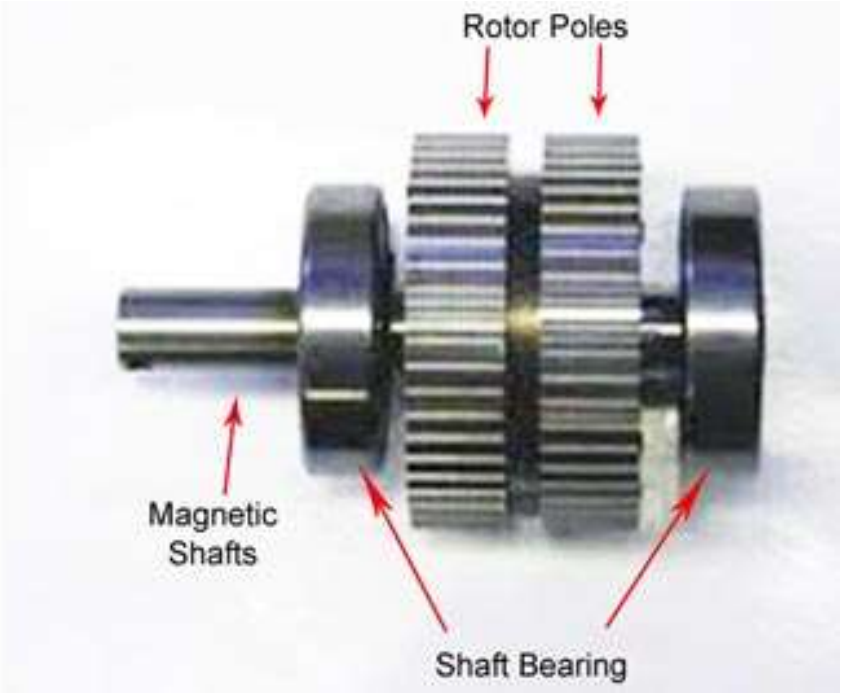
Stepper Motor Construction

WORKING

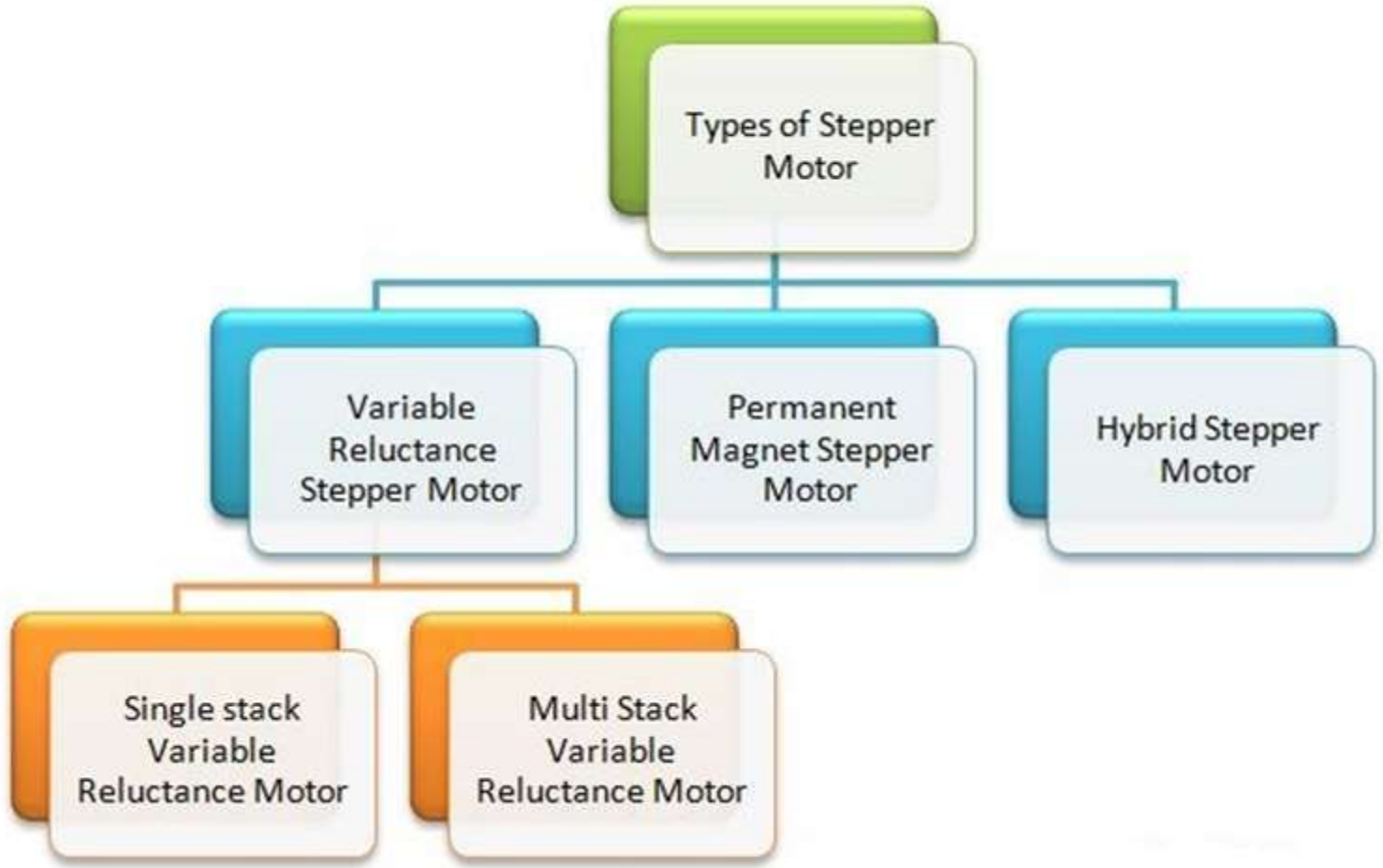
- Stepper motors work on the principle of electromagnetism.
- There is a soft iron or magnetic rotor shaft surrounded by the electromagnetic stators.
- The rotor and stator have poles which may be teethed or not depending upon the type of stepper.
- When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of a variable reluctance stepper).
- This way the stators are energized in a sequence to rotate the stepper motor.

OVERVIEW


Bearing Housing
Motor Case
Stator Poles
Stator Coils


Rotor Poles
Magnetic Shafts
Shaft Bearing

TYPES


Types of Stepper Motor
Variable Reluctance Stepper Motor
Permanent Magnet Stepper Motor
Hybrid Stepper Motor
Single stack Variable Reluctance Motor
Multi Stack Variable Reluctance Motor

TYPES

• **Permanent Magnet Stepper**. PM steppers have rotors that are constructed with permanent magnets, which interact with the electromagnets of the stator to create rotation and torque. PM steppers usually have comparatively low power requirements and can produce more torque per unit of input power.

•**Variable Reluctance Stepper**. VR stepper rotors are not built with permanent magnets. Rather, they are constructed with plain iron and resemble a gear, with protrusions or “teeth” around the circumference of the rotor. The teeth lead to VR steppers that have a very high degree of angular resolution; however, this accuracy usually comes at the expense of torque.

•**Hybrid Synchronous Stepper**. HS stepper rotors use the best features of both PM and VR steppers. The rotor in an HS motor has a permanent magnet core, while the circumference is built from plain iron and has teeth. A hybrid synchronous motor, therefore, has both high angular resolution and high torque

STEP ANGLE

- Step angle is defined as the angle at which the rotor of a stepper motor moves when one pulse is applied to the input of the stator.
- The positioning of a motor is decided by the step angle and is expressed in degrees.
- The resolution or the step number of a motor is the number of steps it makes in one revolution of the rotor.
- The smaller the step angle, the higher the resolution of the positioning of the stepper motor.
- The accuracy of positioning of the objects by the motor depends on the resolution. The higher the resolution greater will be the accuracy.
- A standard motor will have a step angle of 1.8 degrees with 200 steps per revolution. The various step angles like 90, 45, and 15 degrees are common in simple motors.

STEP ANGLE CALCULATION

Step angle calculation :

$$\varphi = \left(\frac{N_s - N_r}{N_s * N_r}\right) * 360^\circ$$

φ = Step Angle
N_s = Number of teeth on stator
N_r = Number of teeth on rotor

Steps per second = rpm * φ * 60

STEPPING MODES

FULL STEP

- Standard hybrid stepping motors have 200 rotor teeth, or 200 full steps per revolution of the motor shaft.
- Dividing the 200 steps into the 360° of rotation equals a 1.8° full step angle.
- Normally, full step mode is achieved by energizing both windings while reversing the current alternately.

HALF STEP

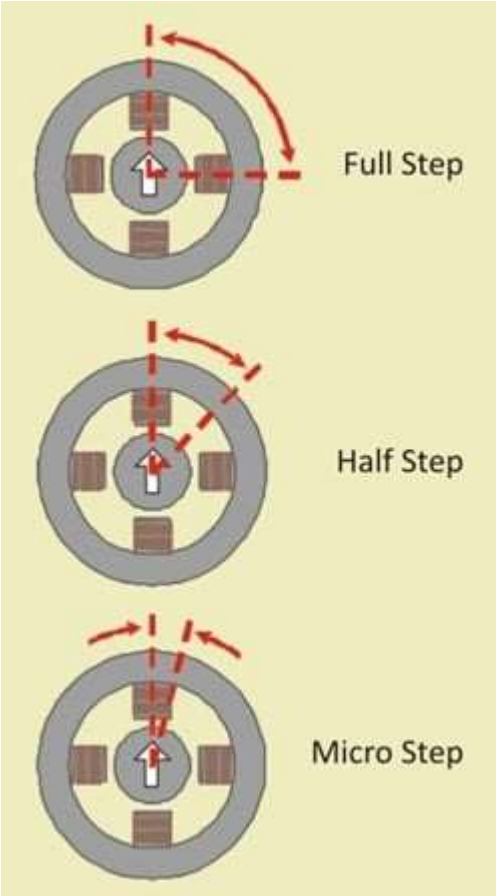
Half step simply means that the step motor is rotating at 400 steps per revolution.

- In this mode, one winding is energized and then two windings are energized alternately, causing the rotor to rotate at half the distance, or 0.9°.
- Although it provides approximately 30% less torque, half-step mode produces a smoother motion than full-step mode.

STEPPING MODES

MICROSTEP

- Microstepping is a relatively new stepper motor technology that controls the current in the motor winding to a degree that further subdivides the number of positions between poles.
- It is typically used in applications that require accurate positioning and smoother motion over a wide range of speeds.
- Like the half-step mode, microstepping provides approximately 30% less torque than full-step mode.



APPLICATIONS

- As the stepper motor is digitally controlled using an input pulse, they are suitable for use with computer-controlled systems.
- They are used in numeric control of machine tools.
- Used in tape drives, floppy disc drives, printers, and electric watches.
- The stepper motor also uses in X-Y plotter and robotics.
- It has wide application in textile industries and integrated circuit fabrications.
- The other applications of the Stepper Motor are in spacecraft launched for scientific explorations of the planets etc.
- These motors also find a variety of commercial, medical, and military applications and are also used in the production of science fiction movies.
- Stepper motors of microwatts are used in wristwatches.
- In the machine tool, the stepper motors with ratings of several tens of kilowatts are used.

ADVANTAGE & DISADVANTAGE

Advantages of Stepper Motor

- Excellent start-stop and reverse response.
- Rotation angle is proportional to the number of pulses.
- Broad speed range as speed is proportional to pulse frequency.
- Maximum torque when the motor is stationary (when windings are energized).
- Precise positioning and repetitive motion due to low error accumulation between steps (3-5% per step).
- Response is determined solely by digital input pulses, allowing for open-loop control, simplifying the motor structure and control costs.
- High reliability due to the absence of brushes, and motor lifespan depends only on bearing lifespan.

Disadvantages of StepperMotor

- Challenging to operate at high speeds.
- Obtaining large torque is difficult.
- Risk of resonance if not controlled properly.
- Prone to losing steps when overloaded, causing vibration and noise at high speeds.
- No advantages in terms of volume and weight, with low energy efficiency.

KEEP
LEARNING.

Thank u

SEE YOU IN NEXT CLASS