KLE Technological University

Creating Value
Leveraging Knowledge

ACTUATORS

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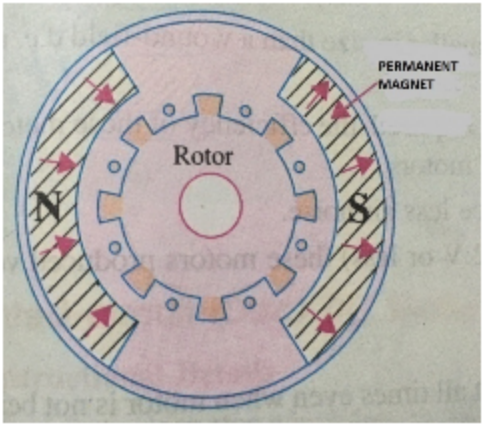
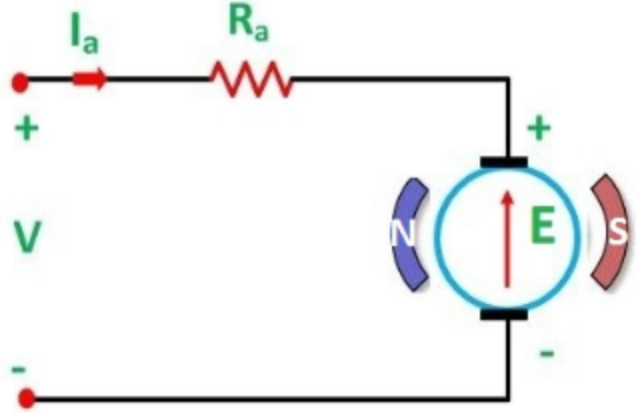
- Permanent Magnet DC (PMDC) Motor
- Stepper Motor
- Brushless DC (BLDC) Motor

PERMANENT MAGNET DC (PMDC) MOTOR

- A PMDC motor is a type of DC motor that uses a permanent magnet to create the magnetic field required for the operation of a DC motor.





- PMDC motor consists of
- Stator: It is a steel cylinder where the permanent magnets (Alnico magnets, rare earth magnets) are mounted in the inner periphery of this cylinder.

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- Rotor (armature): It consists of core, windings and commutator. Armature core is made of number of slotted circular lamination of steel sheets. These slots on the outer periphery of the armature core are used for housing armature conductors in them.
- The working principle of PMDC motor is just similar to the general working principle of DC motor i.e., when a current carrying conductor is placed inside a magnetic field, a mechanical force will be experienced by the conductor .
- As in a permanent magnet DC motor, the armature is placed inside the magnetic field of permanent magnet; the armature rotates in the direction of the generated force.
- Each conductor of the armature experiences a force and the compilation of those forces produces a torque, which tends to rotate the armature.

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- ## Advantages:

- Low cost
- Higher efficiency
- Smaller in size and portable

- ## Disadvantages:

- Permanent magnets cannot produce a high flux density as that as an externally supplied shunt field does.
- There is a risk of demagnetization of the poles which may be caused by large armature currents.

- ## Applications:

- Toys
- Windshield wipers

STEPPER MOTOR

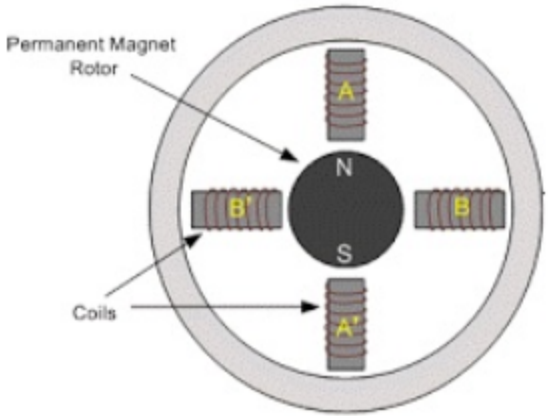
- Stepper motor is a brushless DC motor that rotates through a fixed angular step in response to each input current pulse received by its controller.
- The angle through which the motor shaft rotates for each input current pulse is called the step angle β.

$$\beta = \frac{(N_s - N_r)}{N_s . N_r} \times 360°$$

where N_S : number of stator poles

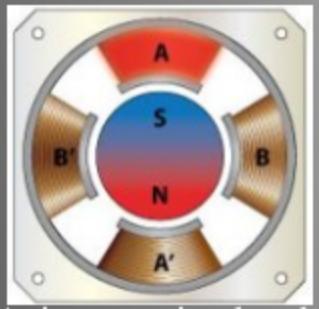
N_r : number of rotor poles

- Smaller the step angle, greater the number of steps per revolution.



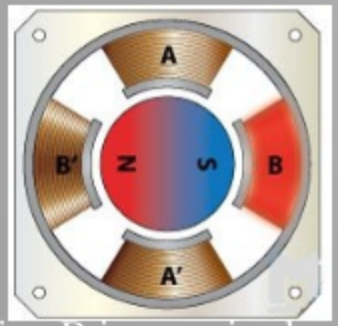
- Stepper motor consists of
- Rotor: Made of a permanent magnet (2 poles – N & S)
- Stator: Made from stack of steel laminations with projecting poles (4 poles) each wound with a stator winding (A, B, A', B')
- When a particular stator winding is energized, the rotor magnetic poles move into alignment with the excited stator poles.

Step 1:



- Stator winding A is energized , the rotor magnetic poles move into alignment with the excited stator pole. ($\theta = 0°$)

Step 2:

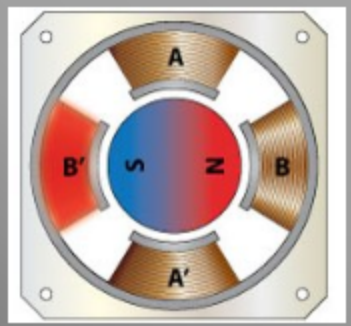


- Stator winding B is energized
- Rotor rotates by a full step of 90° in clockwise (CW) direction

Step 3:

- Stator winding A' is energized
- Rotor rotates by a full step of another 90° in CW direction

Step 4:



- Stator winding B' is energized
- Rotor rotates by a full step of another 90° in CW direction

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- ## Advantages:

- Low cost
- High reliability
- A simple, rugged construction
- Low maintenance

- ## Disadvantages:

- Require a dedicated control circuit
- High torque output achieved at low speed

- ## Applications:

- Robotic arm
- Paper feeder on printers
- Tape drives, floppy disc drives

BRUSHLESS DC (BLDC) MOTOR

- BLDC motor is a kind of permanent magnet synchronous motor.
- Commutation of a BLDC motor is controlled electronically (no brushes, no commutator).
- A BLDC motor consists of
- Rotor : Incorporates the permanent magnets
- Stator: Contains the coils. By applying DC power to the coil, the coil will energize and become an electromagnet.
- The operation of BLDC motor is based on simple force of attraction between permanent magnet and an electromagnet.

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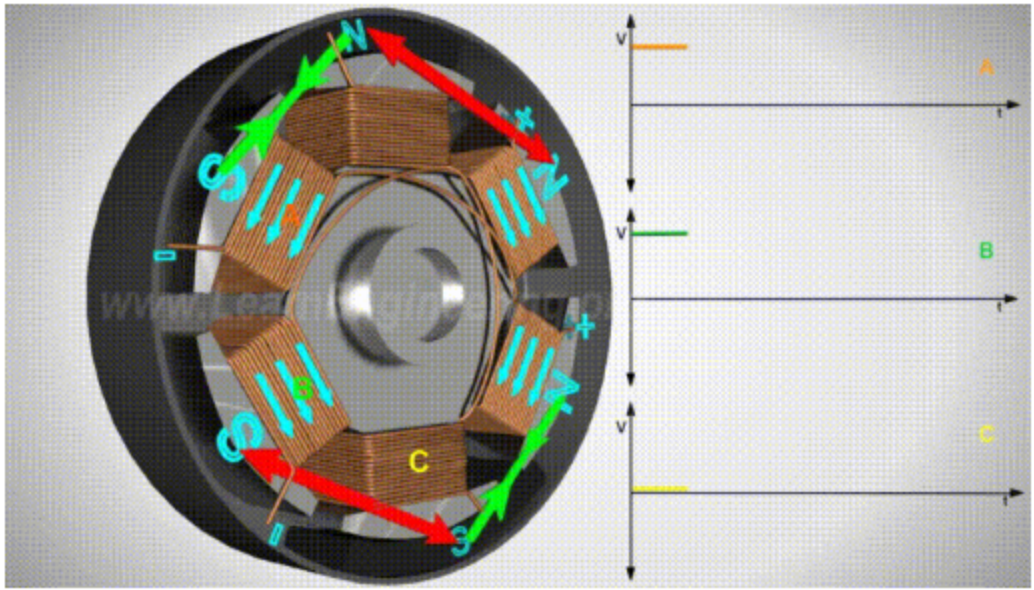

- When coil A is energized, the opposite poles of rotor and stator are attracted to each other.
- As the rotor nears coil A, coil B is energized and as the rotor nears coil B, coil C is energized.
- As the rotor nears coil C, coil A is energized with opposite polarity.
- This process is repeated and the rotor continues to rotate.

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- BLDC motors often incorporate either internal or external position sensors to sense the actual rotor (Hall Effect sensor).
- To rotate the BLDC motor, the stator windings should be energized in a sequence.
- Rotor position is sensed using Hall effect sensors embedded into the stator.
- Whenever the rotor magnetic poles pass near the Hall effect sensors, they give a high or low signal, indicating the N or S pole is passing near the sensors.
- Based on the combination of these three Hall sensor signals, the exact sequence of commutation can be determined.

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- ## Advantages of BLDC Motor

- Better speed versus torque characteristics
- High efficiency
- Long operating life due to a lack of electrical and friction losses
- Noiseless operation
- Higher speed ranges

- ## Disadvantages of BLDC Motor

- These motors are costly
- Electronic controller required control this motor is expensive
- Not much availability of many integrated electronic control solutions, especially for tiny BLDC motors
- Requires complex drive circuitry
- Need of additional sensors

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- Applications of BLDC Motors

- Computer hard drives and DVD/CD players
- Electric vehicles, hybrid vehicles, and electric bicycles
- Industrial robots, CNC machine tools, and simple belt driven systems
- Washing machines, compressors and dryers
- Fans, pumps and blowers