COMPUTER AIDED MANUFACTURING (CAM)

UNIT 3

(SYSTEM DEVICES)

DC MOTOR

The direct current (dc) machine can be used as a motor or as a generator.

DC Machine is most often used for a motor.

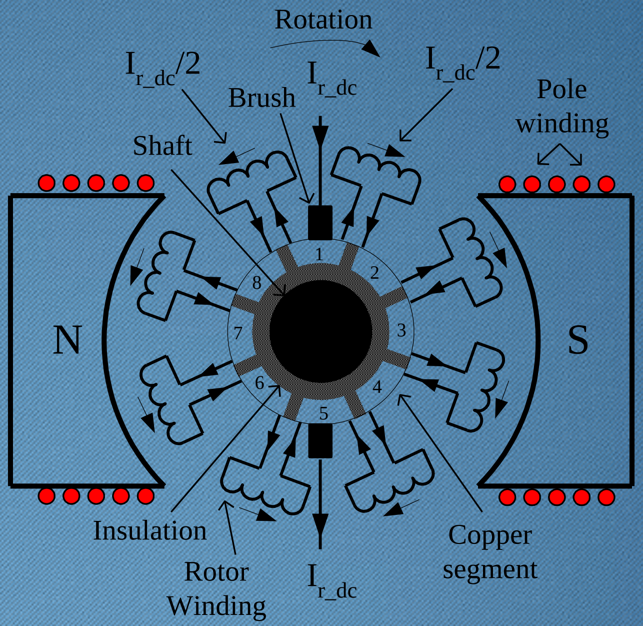
The major advantages of dc machines are the easy speed and torque regulation.

However, their application is limited to mills, mines and trains. As examples, trolleys and underground subway cars may use dc motors.

In the past, automobiles were equipped with dc dynamos to charge their batteries.

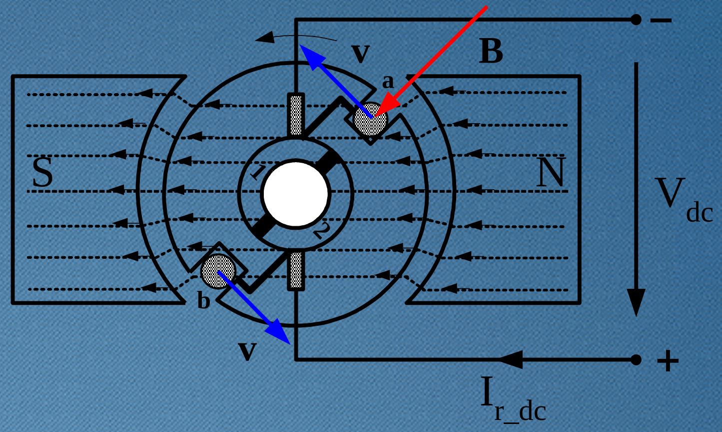
DC Motor Operation

- In a dc motor, the stator poles are supplied by dc excitation current, which produces a dc magnetic field.
- The rotor is supplied by dc current through the brushes, commutator and coils.
- The interaction of the magnetic field and rotor current generates a force that drives the motor

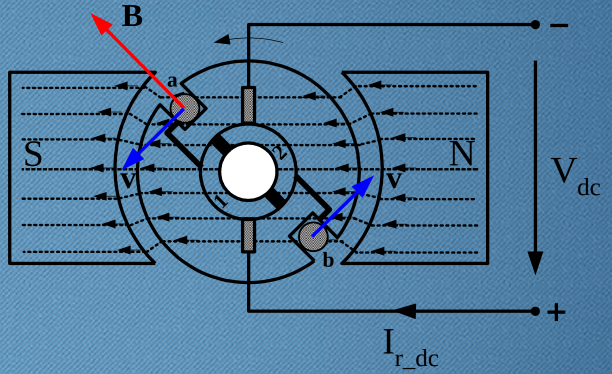


DC Motor Operation

- The magnetic field lines enter into the rotor from the north pole (N) and exit toward the south pole (S).
- The poles generate a magnetic field that is perpendicular to the current carrying conductors.
- The interaction between the field and the current produces a Lorentz force,
- The force is perpendicular to both the magnetic field and conductor



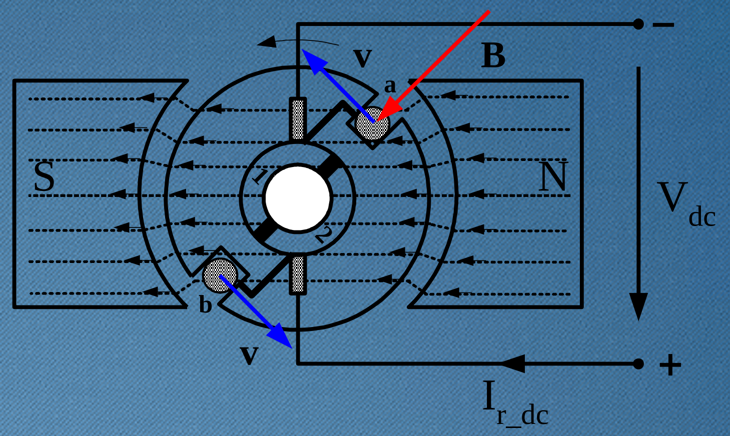
(a) Rotor current flow from segment 1 to 2 (slot **a** to **b**)



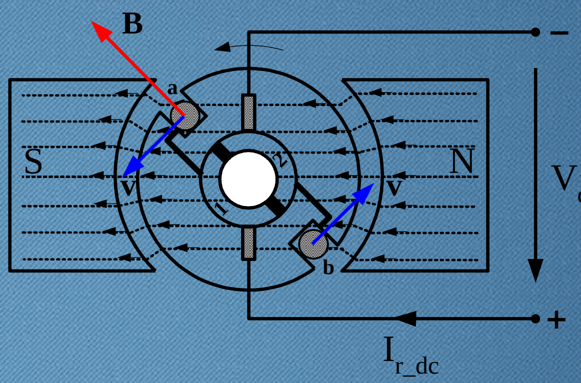
(b) Rotor current flow from segment 2 to 1 (slot **b** to **a**)

DC Motor Operation

- The generated force turns the rotor until the coil reaches the neutral point between the poles.
- At this point, the magnetic field becomes practically zero together with the force.
- However, inertia drives the motor beyond the neutral zone where the direction of the magnetic field reverses.
- To avoid the reversal of the force direction, the commutator changes the current direction, which maintains the counterclockwise rotation. .



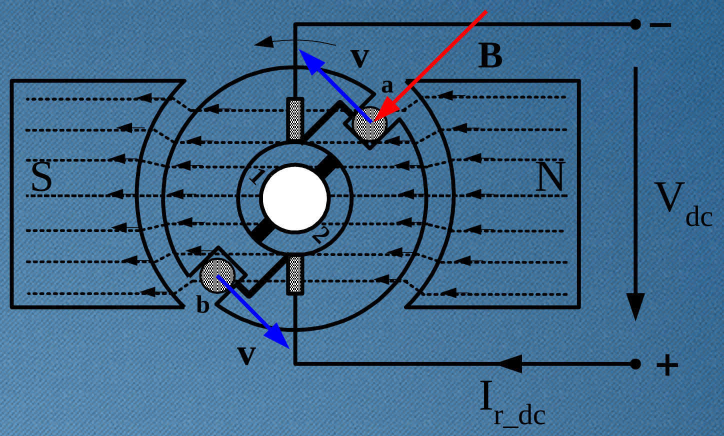
(a) Rotor current flow from segment 1 to 2 (slot **a** to **b**)



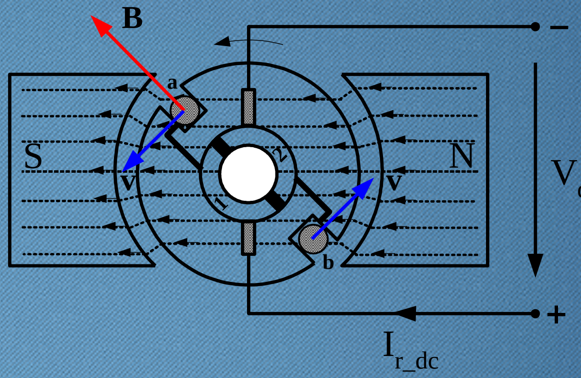
(b) Rotor current flow from segment 2 to 1 (slot **b** to **a**)

DC Motor Operation

- Before reaching the neutral zone, the current enters in segment 1 and exits from segment 2,
- Therefore, current enters the coil end at slot a and exits from slot b during this stage.
- After passing the neutral zone, the current enters segment 2 and exits from segment 1,
- This reverses the current direction through the rotor coil, when the coil passes the neutral zone.
- The result of this current reversal is the maintenance of the rotation.



(a) Rotor current flow from segment 1 to 2 (slot **a** to **b**)



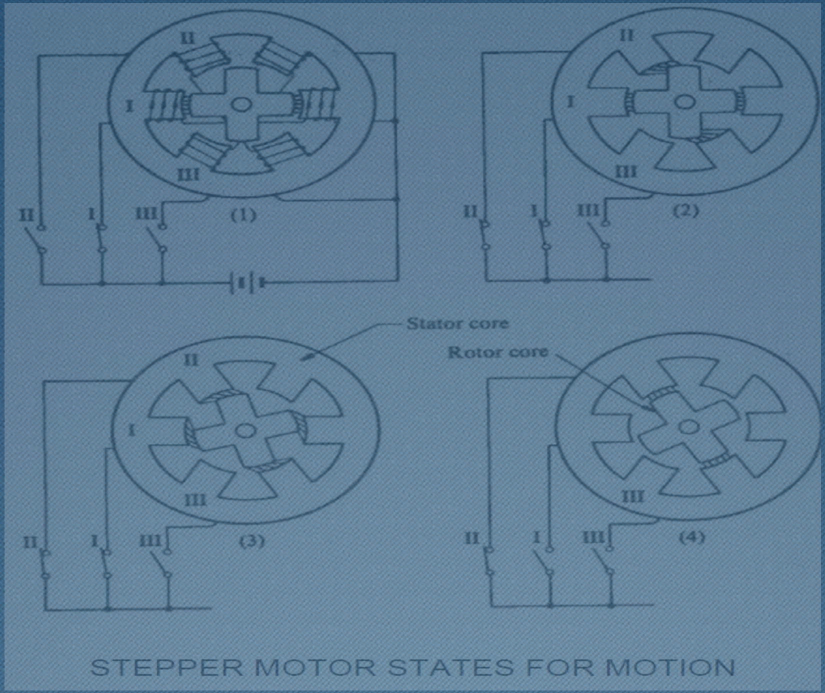
(b) Rotor current flow from segment 2 to 1 (slot **b** to **a**)

STEPPER MOTORS

STEPPER MOTOR – an electromagnetic actuator. It is an incremental drive (digital) actuator and is driven in fixed angular steps.
This mean that a digital signal is used to drive the motor and every time it receives a digital pulse it rotates a specific number of degrees in rotation.

- Each step of rotation is the response of the motor to an input pulse (or digital command).
- Step-wise rotation of the rotor can be synchronized with pulses in a command-pulse train, assuming that no steps are missed, thereby making the motor respond faithfully to the pulse signal in an open-loop manner.
- Stepper motors have emerged as cost-effective alternatives for DC servomotors in high-speed, motion-control applications (except the high torque-speed range) with the improvements in permanent magnets and the incorporation of solid-state circuitry and logic devices in their drive systems.
- Today stepper motors can be found in computer peripherals, machine tools, medical equipment, automotive devices, and small business machines, to name a few applications.

Stepper motors are usually operated in open loop mode.



The above figure is the cross-section view of a single-stack variable-reluctance motor. The stator core is the outer structure and has six poles or teeth. The inner device is called the rotor and has four poles. Both the stator and rotor are made of soft steel. The stator has three sets of windings as shown in the figure. Each set has two coils connected in series. A set of windings is called a “phase”. The motor above, using this designation, is a three-phase motor. Current is supplied from the DC power source to the windings via the switches I, II, and, III.

Starting with state (1) in the upper left diagram, note that in state (1), the winding of Phase I is supplied with current through switch I. This is called in technical terms, “phase I is excited”. Arrows on the coil windings indicate the magnetic flux, which occurs in the air-gap due to the excitation. In state I, the two stator

poles on phase I being excited are in alignment with two of the four rotor teeth. This is an equilibrium state.

Next, switch II is closed to excite phase II in addition to phase I. Magnetic flux is built up at the stator poles of phase II in the manner shown in state (2), the upper right diagram. A counter-clockwise torque is created due to the “tension” in the inclined magnetic flux lines. The rotor will begin to move and achieve state (3), the lower left diagram. In state (3) the rotor has moved 15°.

When switch I is opened to de-energize phase I, the rotor will travel another 15° and reach state (4). The angular position of the rotor can thus be controlled in units of the step angle by a switching process. If the switching is carried out in sequence, the rotor will rotate with a stepped motion; the switching process can also control the average speed.

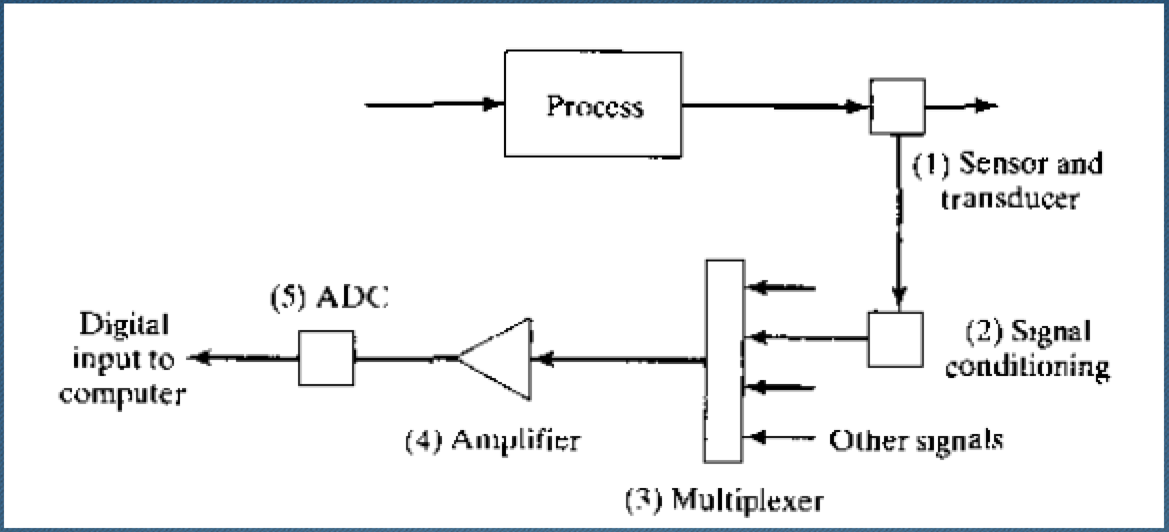
ANALOG TO DIGITAL

Continuous analog signals from the process must be converted into digital values to be used by the computer. and digital data generated by the computer must be converted to analog signals to be used by analog actuators. We discuss analog-la-digital conversion in this section and digital-to-analog conversion in the following section. The procedure for converting an analog signal from the process into digital forn typically consists of the following steps and hardware devices.

1. Sensor and transducer. This is the measuring device that generates the analog signal

2. Signal conditioning. The continuous analog signal from the transducer may require conditioning to render it into more suitable form. Common signal conditioning steps include: (1) filtering to remove random noise and (2) conversion from one signal form to another, for example, converting a current into a voltage.

3. Multiplexer. The multiplexer is a switching device connected in series with each input channel from the process; it is used to time-share the analog-to-digital converter (ADC) among the input channels. The alternative is to have a separate ADC for each input channel. which would he costly for a large application with many input channels. Since the process variables need only be sampled periodically, using a multiplexer provides a cost-effective alternative to dedicated ADCs for each channel.



4. Amplifier. Amplifiers arc used to scale the incoming signal up or down to be compatible
with the range of the analog-to-digital converter.

5. Analog-to-digital converter. As its name indicates, the function of the ADC is to convert the incoming analog signal into its digital counterpart.

DIGITAL TO ANALOG

The process performed by a digital-to-analog converter (DAC) is the reverse of the ADC process. The DAC transforms the digital output of the computer into a continuous signal to drive an analog actuator or other analog device. Digital-to-analog conversion consists of two steps: (1) *decoding*, in which the digital output of the computer is converted into a series of analog values at discrete moments in time, and (2) *data holding*, in which each successive value is changed into a continuous signal (usually electrical voltage) used to drive the analog actuator during the sampling interval.