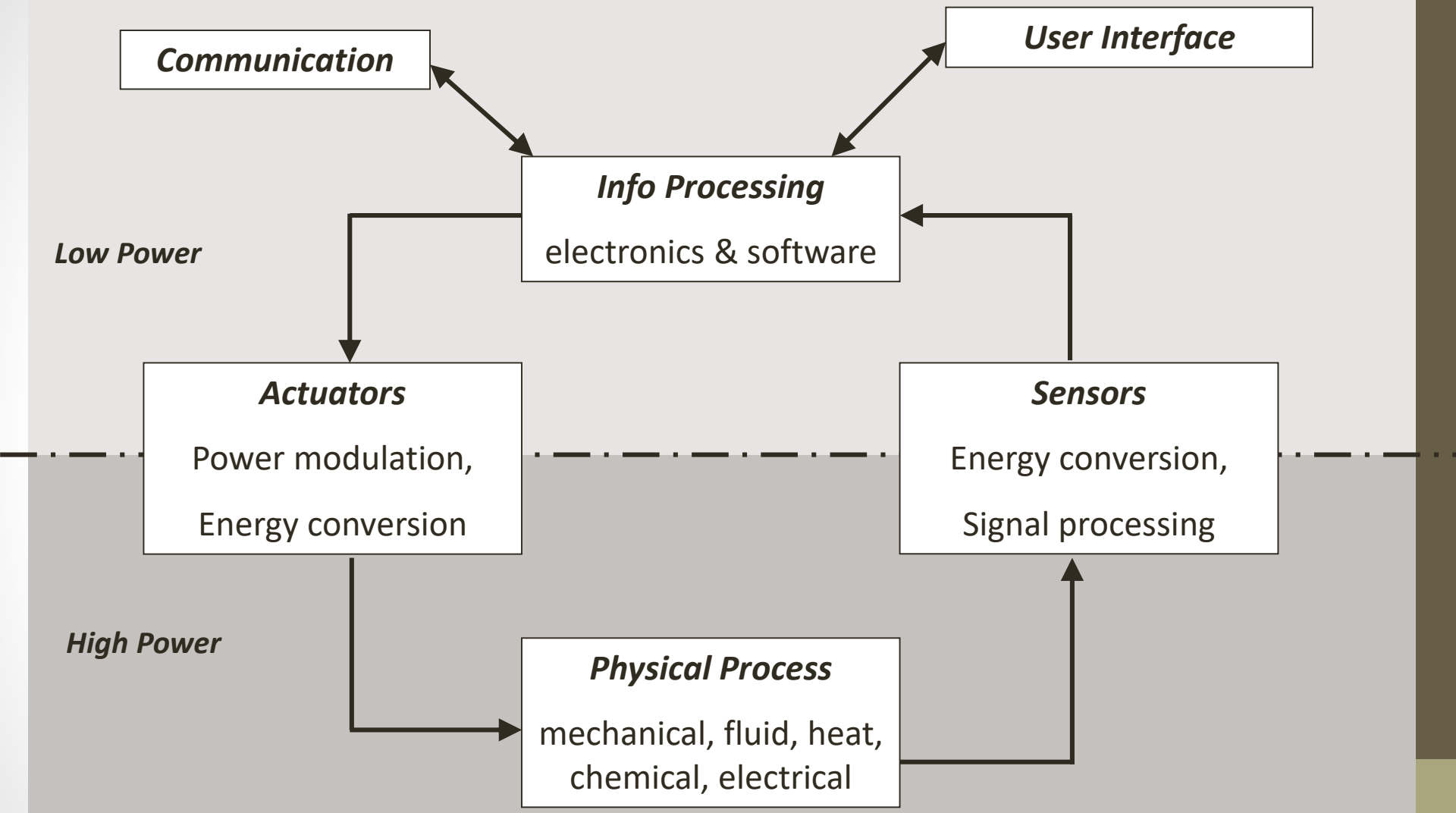
MKT 1821
Chapter-4

Mechatronics Technology: *Actuators*

Function Blocks of a Mechatronic System



Actuators

The transducers that conduct the mission.

Types:

- Hydraulic
- Pneumatic
- Electrical
- Piezoelectric
- Microelectromechanical
- Hybrid

Actuator

Actuators are generally considered to be energy conversion devices.

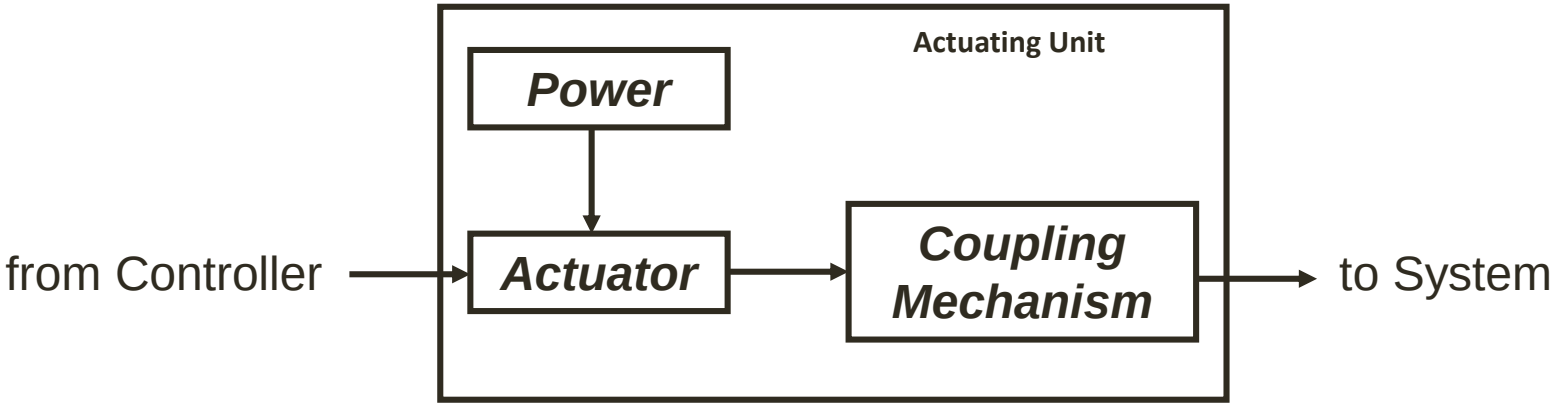
Looking at the energy perspective, a **mechatronics** system can be divided into high energy / power and low energy / power parts.

High Power Part → Physical World

Low Power Part → Data Processing

Actuator

The actuators take the control commands in electrical form and calculate the force, motion, heat, flow, etc. to produce changes in physical systems.



The power unit supplies AC - DC power at certain current and voltage values.

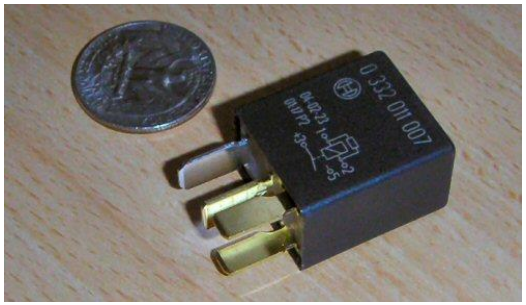
The coupling mechanism is the interface between the physical system and the actuator. The most known coupling mechanisms; pinion gear mechanism, gearbox, belt, transmission bolt, piston and kinematic chains.

Electrical Actuators

Electrical Actuator types

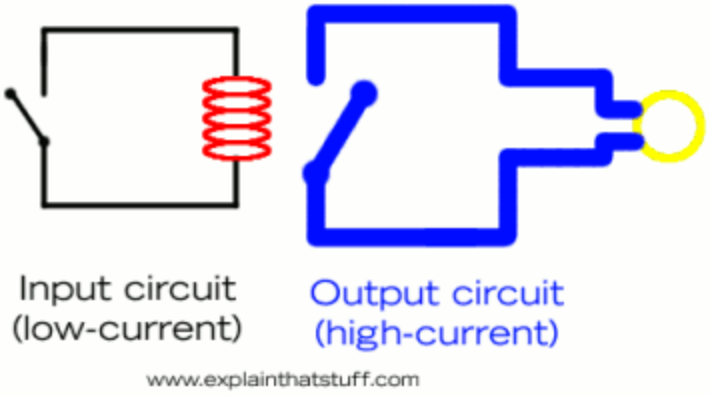
- Switching devices
  - relay, thyristor, diode, transistor,...
- Electromagnetic type devices
  - solenoid, electromagnet
- Drive systems
  - motors

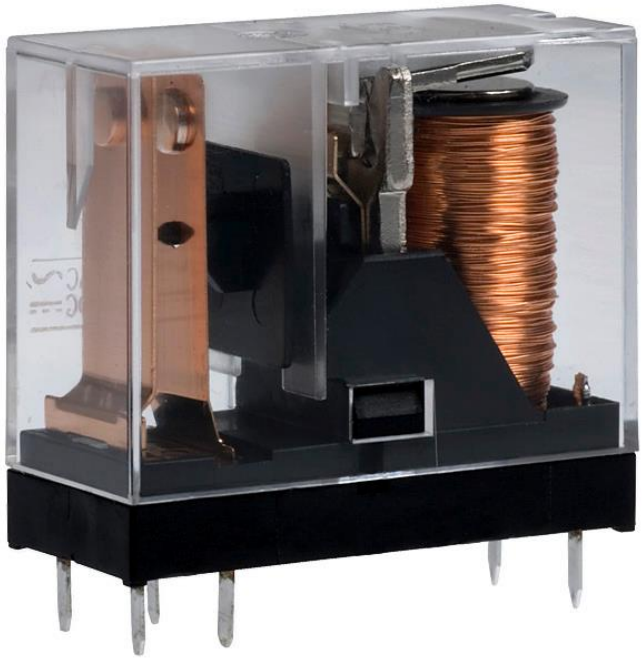
Electrical Actuators

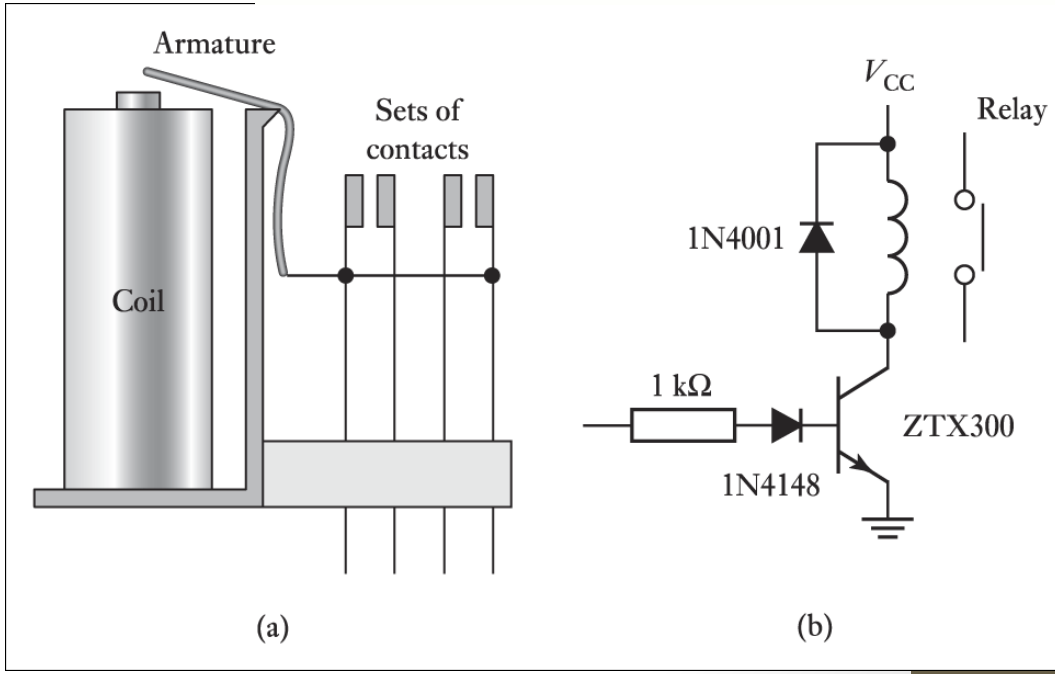


Relay:

Switching elements for switching a current from one electric circuit to another circuit.



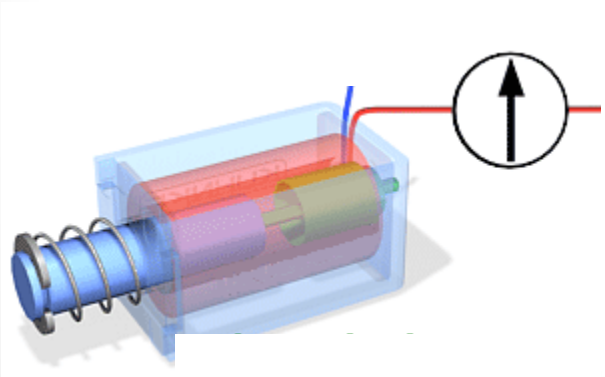


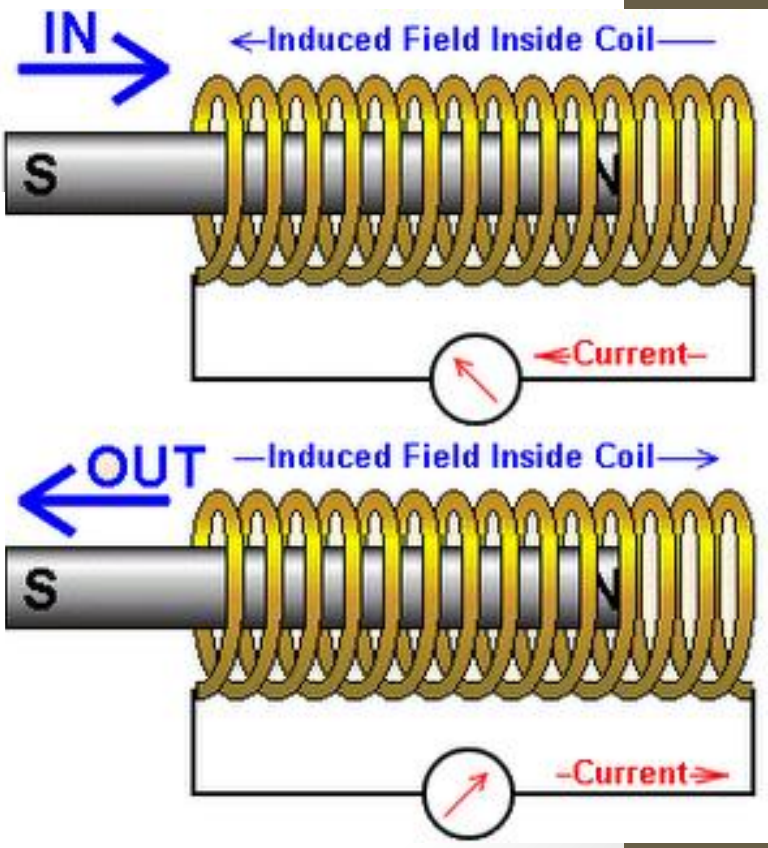


Electrical Actuators

Selenoid:

They are elements that translate energy into linear motion. They are operated by controlling the magnetic field.





Electrical Actuators (Motors)

Devices that convert electrical energy into mechanical energy (circular motion) are called electric motors.
Each electric motor consists of two main parts, one fixed (Stator) and the other rotating around (Rotor or Stator).

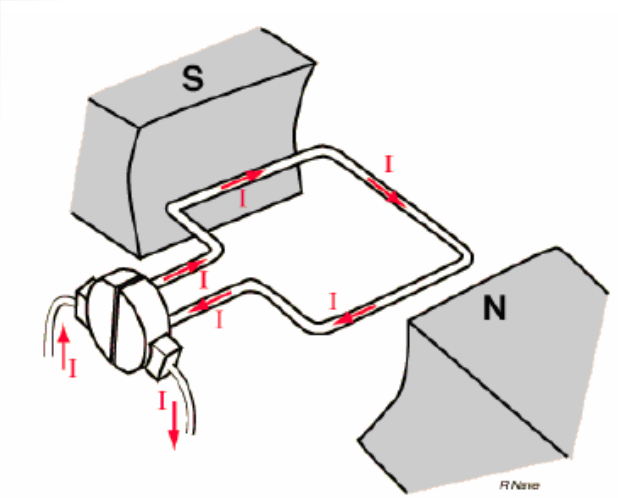
These main parts are divided into parts, including electric current carrying parts (for example: windings), magnetic conducting parts and construction parts (eg screws, bearings).

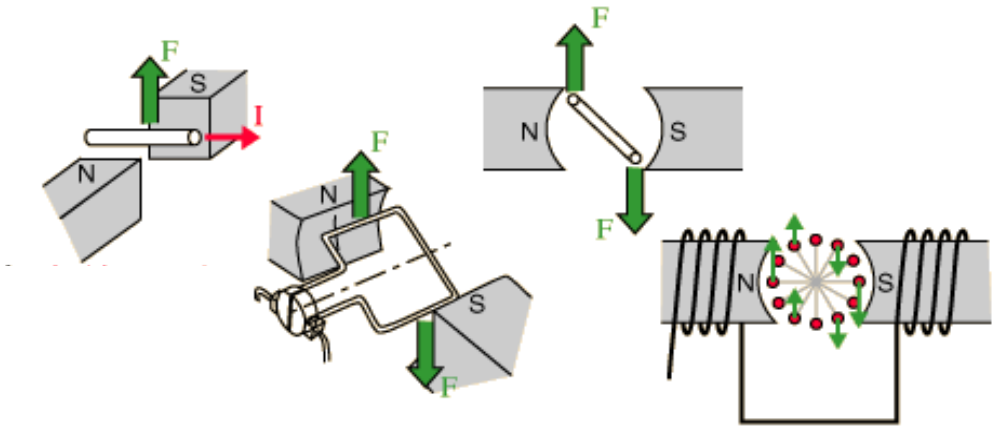
Electric Motor types

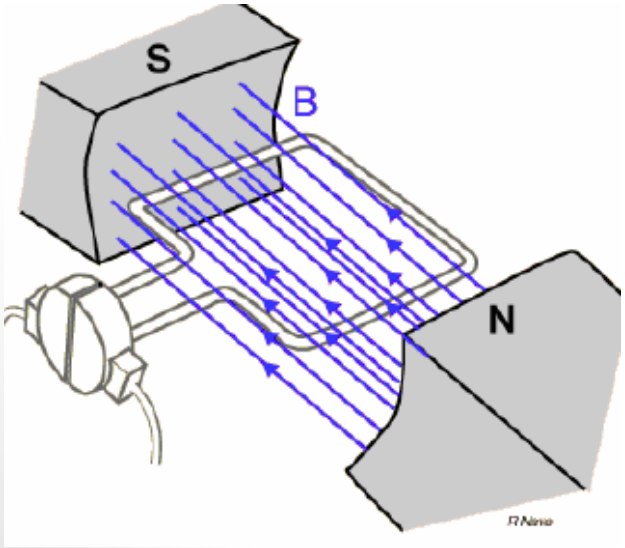
- AC motors
- DC motors
  - a) Permanent magnet (brushless)
  - b) DC Shunt motor
  - c) DC series motor
- Step(per) motors
- Gearhead motors

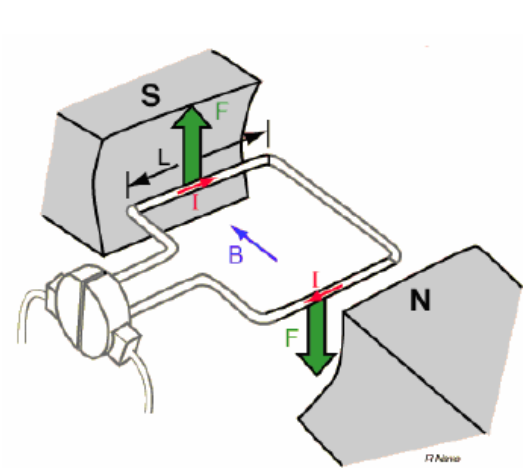
Electrical Actuators

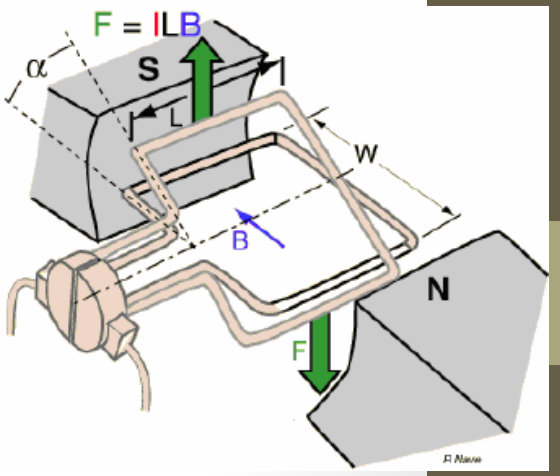
Motors



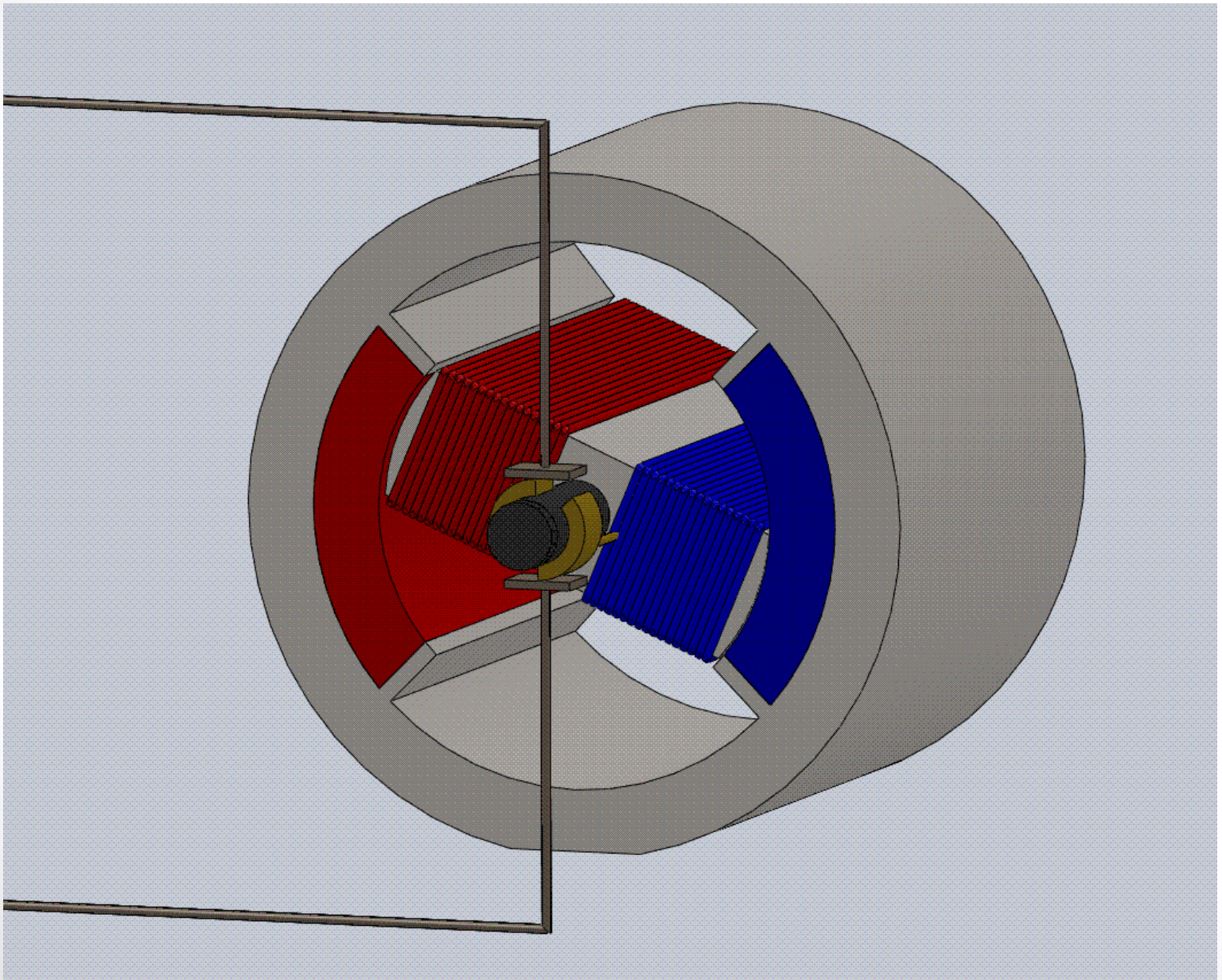






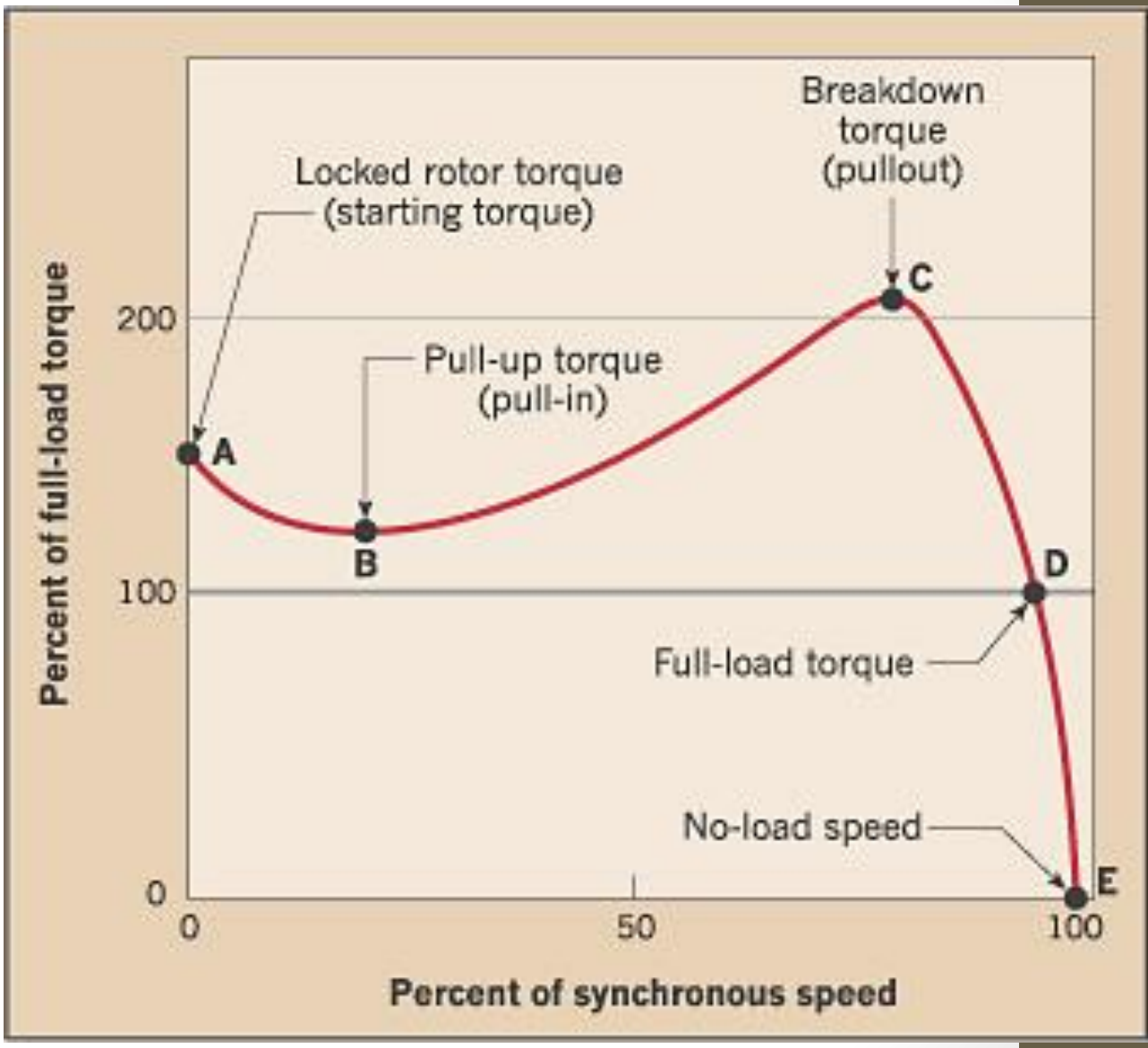


Electrical Actuators



Electric motors

They must be chosen to meet the dynamic needs of the machines. The most important selection criterion is to determine the load characteristic (torque-speed relationship). Other criteria; purpose of use, available electrical power and price.



Torque–speed graph

Motor Selection Factors

When selecting a motor consider these issues:

- Speed range
- Torque-speed variations
- Reversibility
- Required power
- Load inertia
- Starting torque
- Size and weight restrictions
- Price
- Maintenance

Selection factors

Consider these questions when selecting a motor:

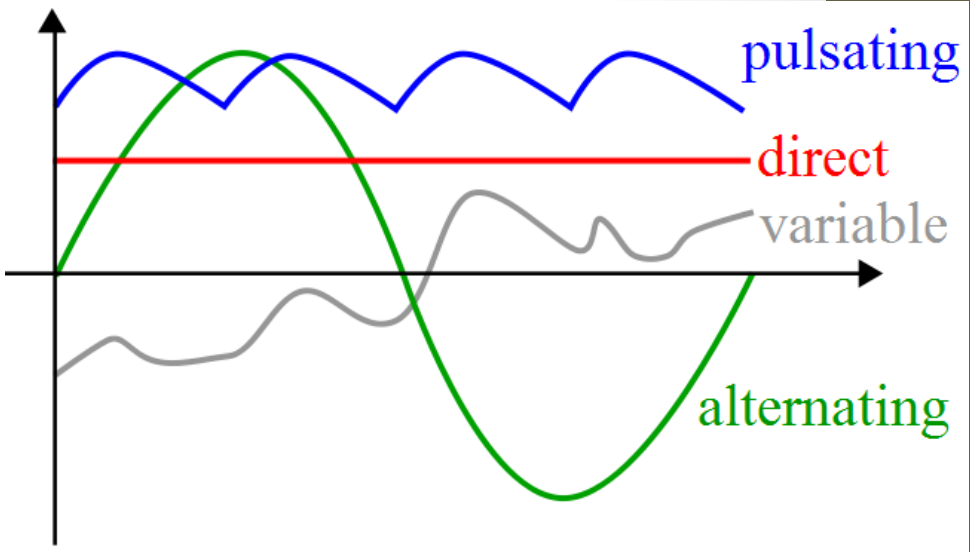
1. Will the motor start under load?
2. What is the maximum speed the motor can produce?
3. How much power does the load require?
4. Is the load to be driven at constant speed?
5. Is transmission gearbox required?

Useful information sources

- Experts
- Manufacturer specification sheets
- Product catalog
- Design handbooks
- Motor nameplate
- Web

Electrical Actuators

- AC Motors
- DC Motors



The flow that changes direction and intensity periodically depending on the time is called "alternating current". The abbreviation of the words "Alternative Current" in English is indicated by "AC".

In time, the direction and the flow of which the intensity does not change are called direct current. Abbreviation of the words "Direct Current" in English is indicated by "DC".

Electrical Actuators

AC Motors

- Synchronous
- Asynchronous (induction motors)

The difference between them, roughly; the rotation speed of the shaft and magnetic velocity in synchronous motors are equal to each other.

Those are different in induction motors.

Synchronous motors have complex structure and control.

It is more expensive than asynchronous motors.

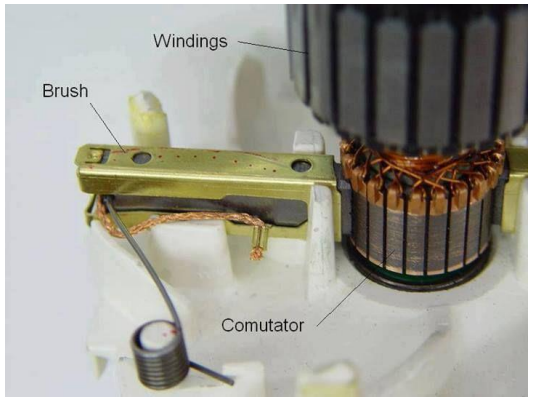
Electrical Actuators

DC Motors

The angular speed of the motor is directly proportional to the applied voltage. Rotates in the direction of the current supplied to the motor, reverses when reversed polarized.

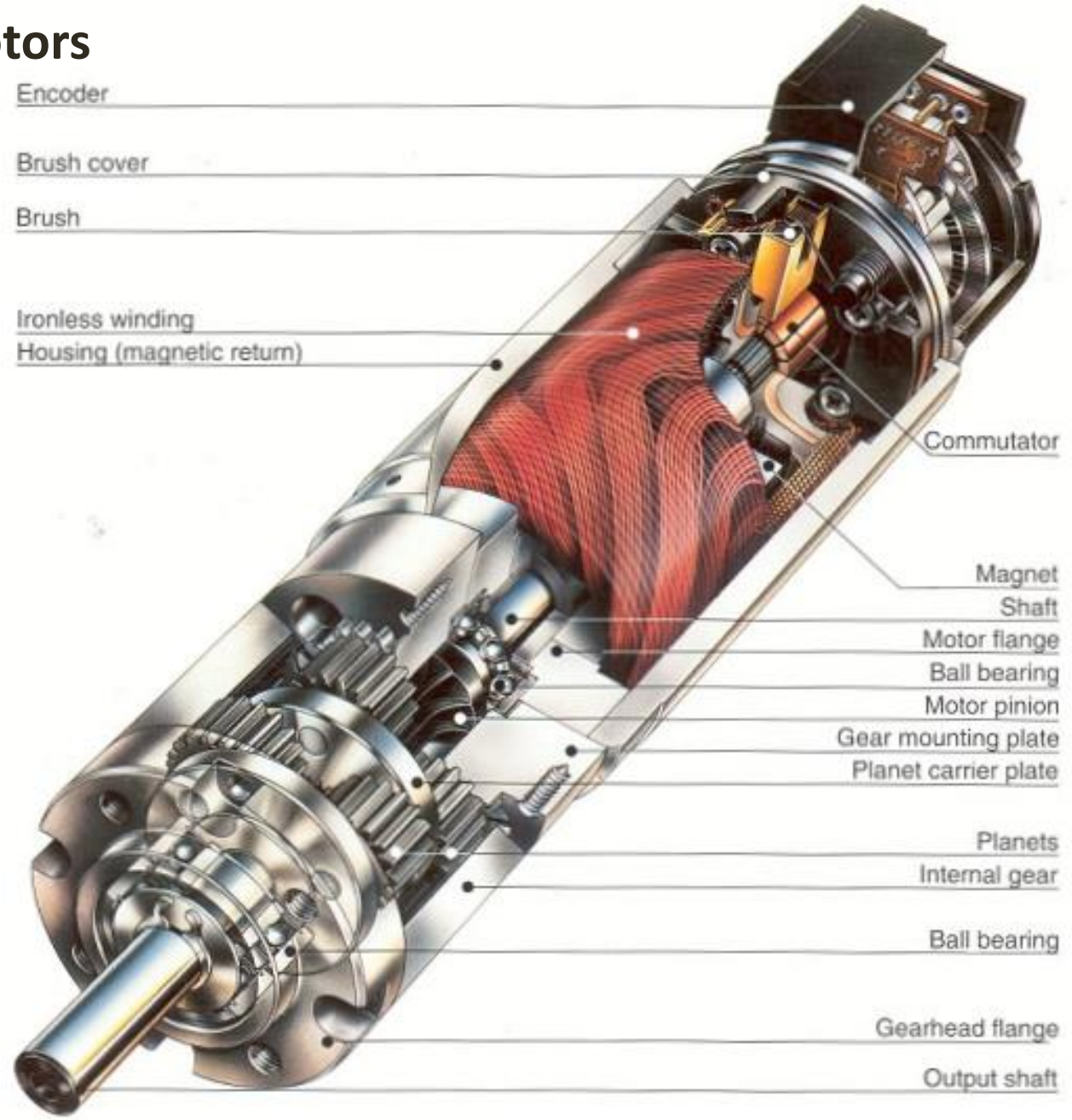
Brush (Fırçalı) DC Motors

In DC motors with brushes, electrical conduction to rotatable windings is provided by brush-collector structure. In brush motors, conductive metal or coal type conductors are used to conduct the stator, that is, the middle coiled current, and when the motor is turned, the rotation of the motor continues for a different polarity. Brush is usually worn after long time.



Brush (Fırçalı) DC Motors

Brush type motors are generally used when low cost is required. They are not preferred in areas of use where the spark may cause explosion. They need occasional maintenance due to brush wear.



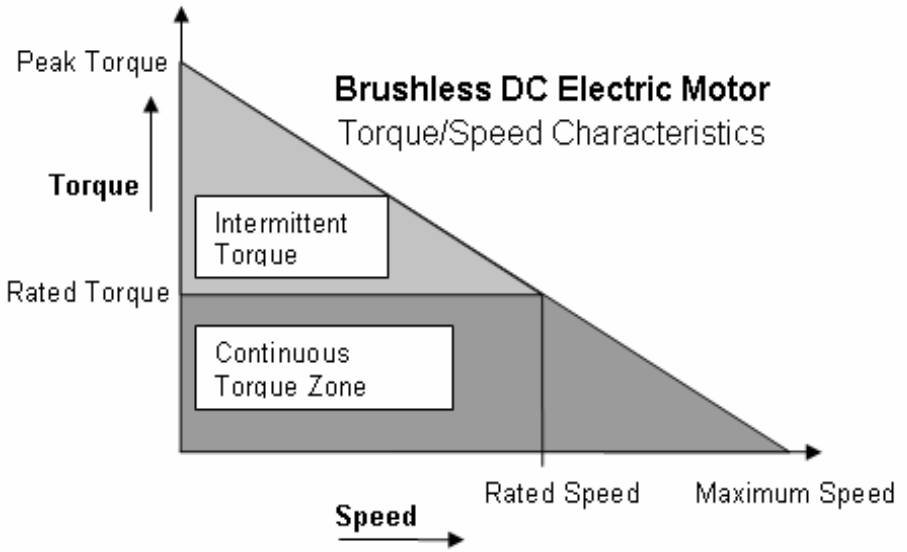
Maxon motor

Electrical Actuators

Brushless (Fırçasız) DC Motors

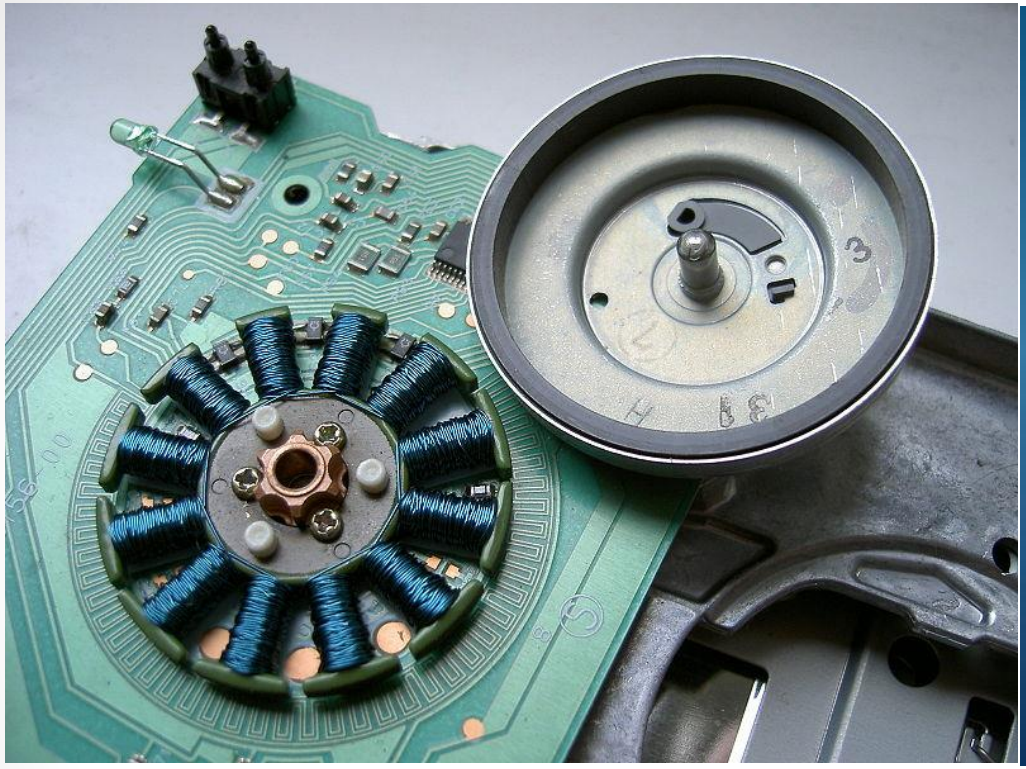
They provide high efficiency and reliability. It also has the advantages of low noise, long life (no brush wear), no sparking, and low electromagnetic interference (EMI) values. The disadvantage is that they are expensive.

It looks like a brush DC motor. The commutation is made electronically. The magnets are on the rotor and the coils are on stator. At light loads, they are more efficient than brushes. Mostly on computer harddisks, CD / DVD players, PC cooling fans, etc. used for.



Electrical Actuators

Brushless (Fırçasız) DC Motors



Floppy disk motor

Electrical Actuators

Brushless (Fırçasız) DC Motors

- Electric and hybrid vehicles use high-powered brushless motors.
- Ventilation, air conditioning and refrigerators are starting to be preferred because they provide very low electricity consumption compared to AC motors.
- Another advantage is that the microcomputers and the control systems that are used in these devices and the brushless motors can be controlled.
- The most preferred motive in the construction of a model vehicle such as model aircraft, helicopters etc.

Characteristics

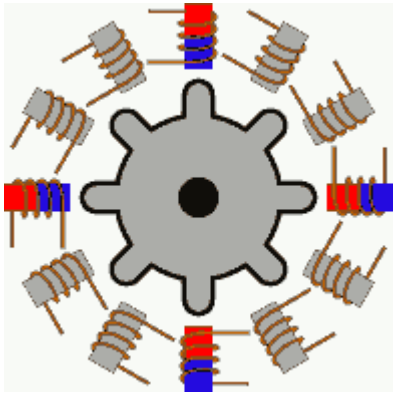
Stepper motor

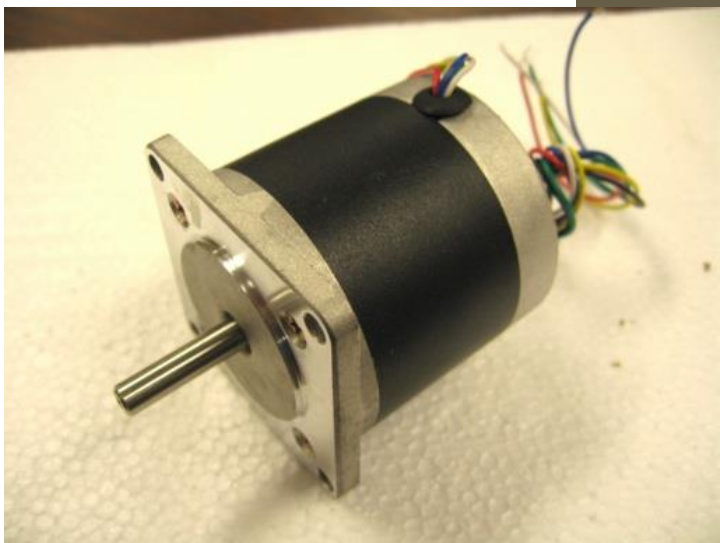
- Can rotate in both directions
- Moves in precise angular increments (steps)
- Sustain a holding torque at zero speed
- Easy to control

Electrical Actuators

Stepper Motors

Synchronous type brushless electric motors. The engine is designed so that a revolution takes place in many steps. There is no feedback.
As long as the steps are not skipped, it is possible to know which position the engine shaft is in. When the electromagnetic coil is energized, the rotor moves to the nearest equilibrium point. The motor is moved step by step through the appropriate magnetizing sequence. If the load on the motor shaft is too great or the motor is to be rotated at excessive speeds, the motor may skip.





Electrical Actuators

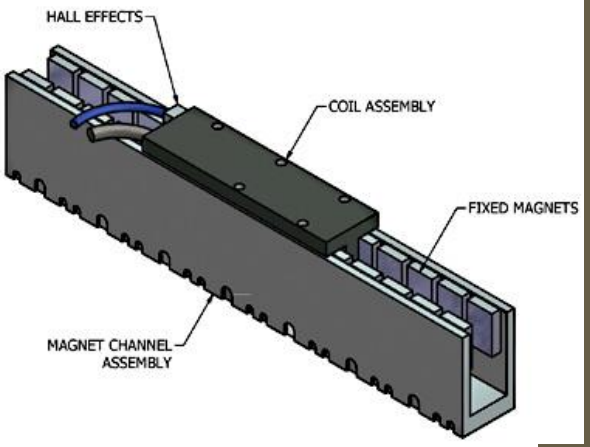
Servo Motors

They are the motors used for position, speed or torque control. Continuous position and / or speed feedback is sent to the motor control system. System performance is corrected by comparing the actual command value with the actual value and attempting to reset the error.

Electrical Actuators: **Servo Motors**

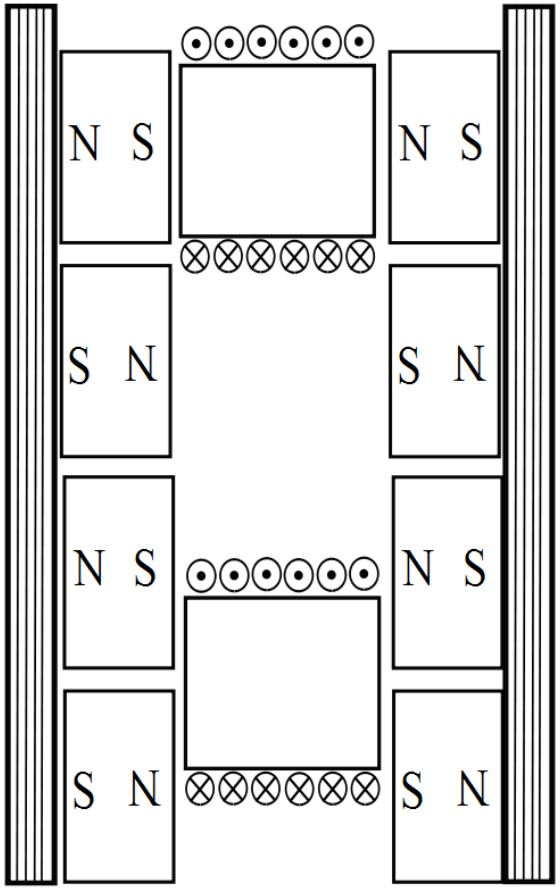
Position and / or torque control is performed in servo motors. **When high acceleration or deceleration is required, servo motors are used**. The transmitted signal moves depending on the strength and duration.

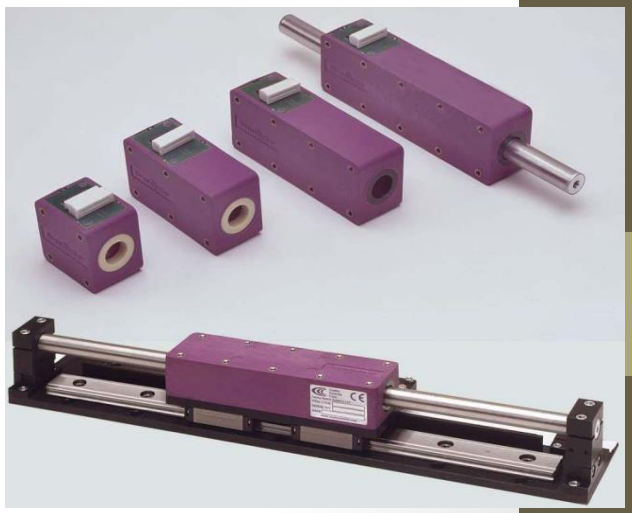
Linear Motors



In normal electric motors, the stator and rotor, which are circular, operate by being opened. Produces force instead of torque.

The elevator mechanism in mines, sliding doors in the side, X-Y movement of the cutter in the laser cutting, weapons in need of high kinetic energy, trains in amusement parks, etc.





Hydraulic and Pneumatic Actuators

Most popular types:

- Rotary hydraulic motors
- Linear pistons/cylinders
- Control valves

With great forces, they are often used to produce large movements.

1. **Pneumatic actuators** are used in applications where low-to medium-severity forces, short movements and high speeds are needed, as they often use pressurized air.

Hydraulic and Pneumatic Actuators

***2.* Hydraulic actuators** operate by transmitting pressure with incompressible oils. They produce very large movements with very large forces at low cost. Their main disadvantages are complexity and need for much attention.

Hydraulic motors transform high pressure and flow into rotational motion. They are used in applications where low speed and high torque are needed.

Pneumatic motors are similar to hydraulic motors, but they can not reach high torques like them.

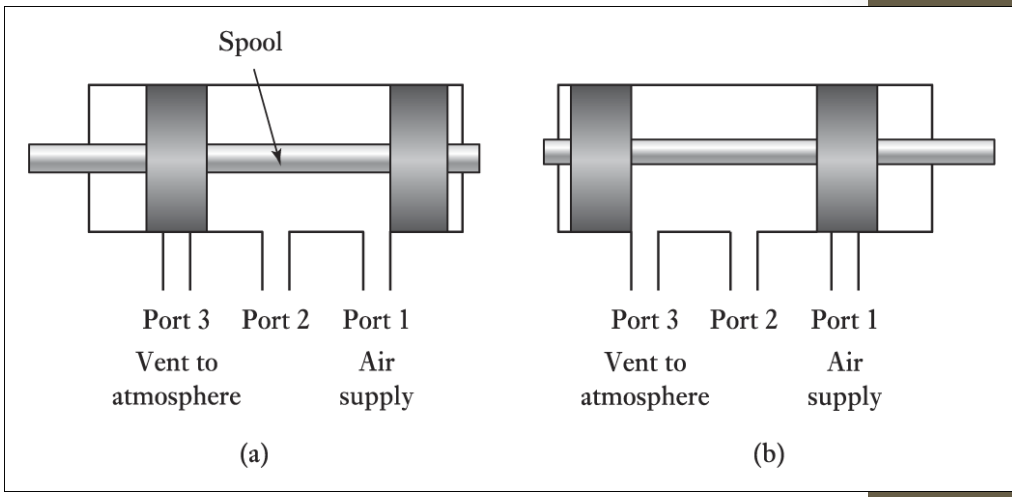
Hydraulic and Pneumatic Actuators

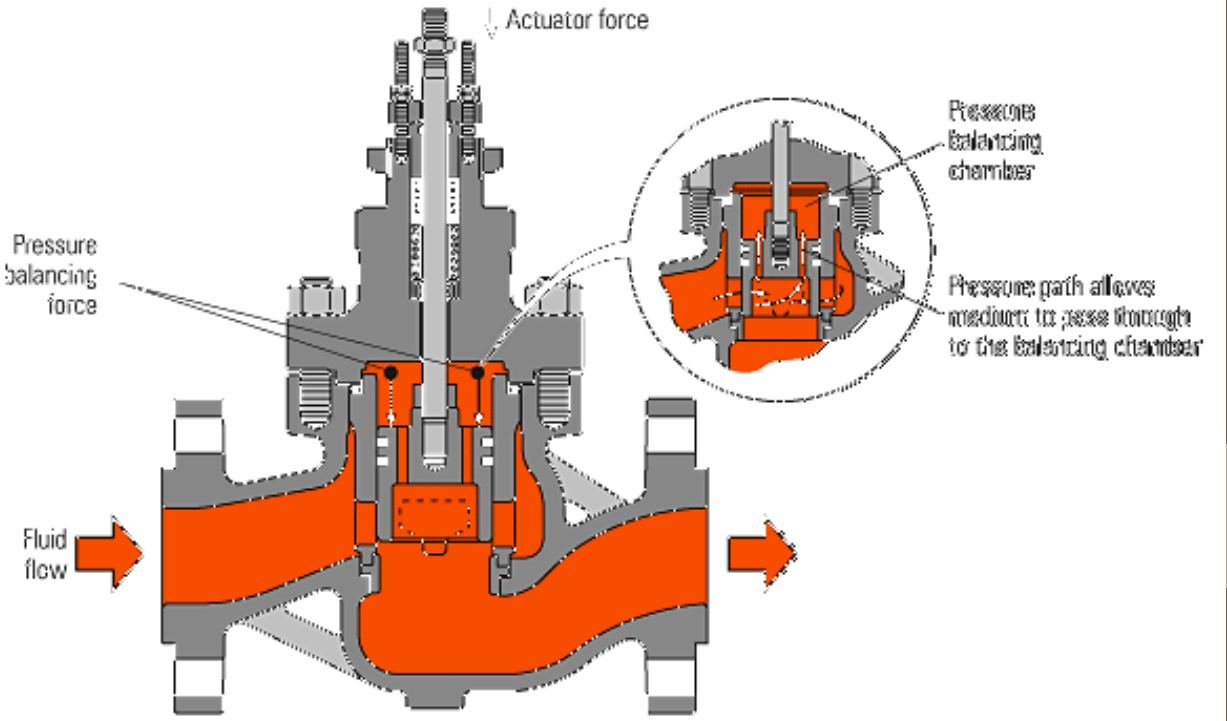
Cylinders and pistons are suitable for obtaining linear motion.

The control valves, together with the rotary motors and pistons, are used to change the flow (direction, rate).

Hydraulic and Pneumatic Actuators

Control valves are used to change quantities such as flow, pressure, temperature. They are mostly used with hydraulic motors or cylinders.





COMPARISON
HYDRAULIC & PNEUMATIC SYSTEMS

S. No.	Hydraulic System	Pneumatic System
1.	It employs a pressurized liquid as a fluid	It employs a compressed gas, usually air, as a fluid
2.	An oil hydraulic system operates at pressures up to 700 bar	A pneumatic system usually operates at 5–10 bar
3.	Generally designed as closed system	Usually designed as open system
4.	The system slows down when leakage occurs	Leakage does not affect the system much
5.	Valve operations are difficult	Valve operations are easy
6.	Heavier in weight	Lighter in weight
7.	Pumps are used to provide pressurized liquids	Compressors are used to provide compressed gases
8.	Automatic lubrication is provided	Special arrangements for lubrication are needed

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