

# Actuators for Mobile Robots

Actuators are used in order to produce mechanical movement in mobile robot.

# Servo System

Servo is mechanism based on feedback control. The controlled quantity is mechanical.

# Properties of Servo

- high maximum torque/force allows high (de)acceleration
- high zero speed torque/force
- high bandwidth provides accurate and fast control
- works in all four quadrants
- robustness

# Actuator Types

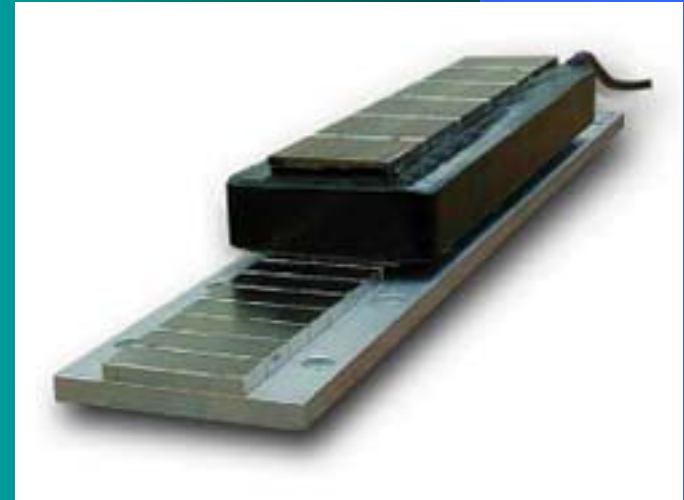
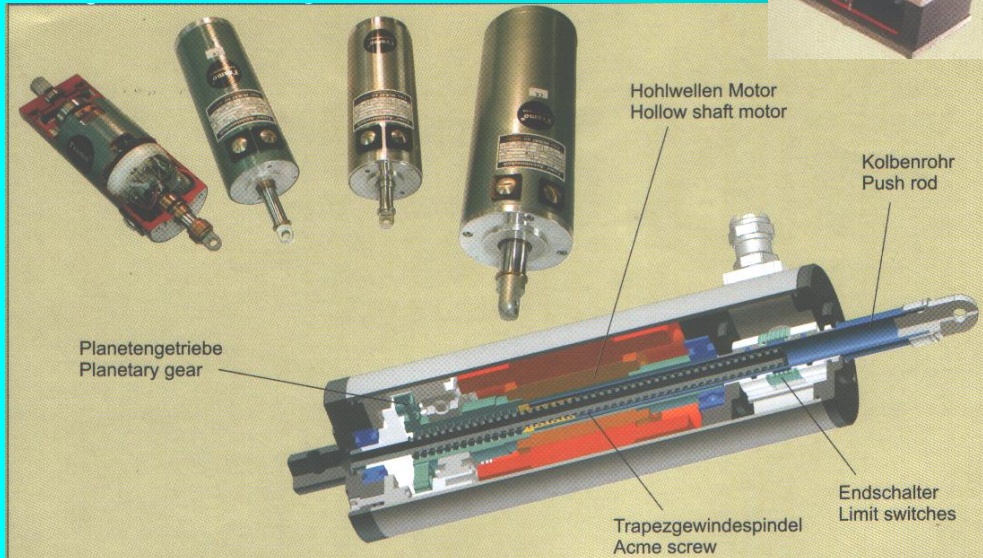
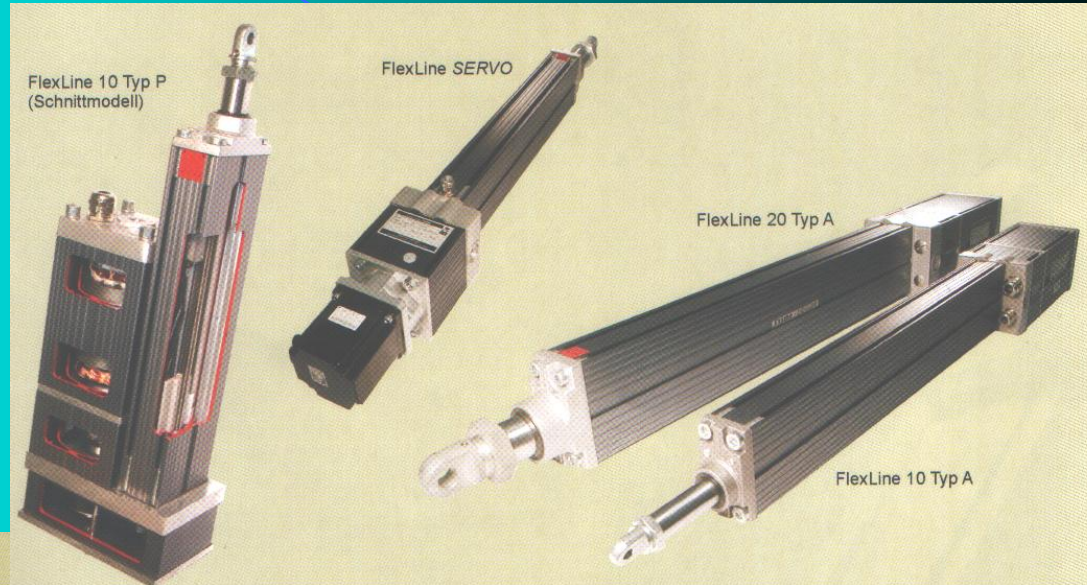
- Electrical
- Hydraulic
- Pneumatic
- Others

# Electrical Actuators

- easy to control
- from mW to MW
- normally high velocities 1000 - 10000 rpm
- several types
- accurate servo control
- ideal torque for driving
- excellent efficiency
- autonomous power system difficult

# Electric actuators

Mainly rotating but also linear ones are available  
linear movement with gear  
or with real linear motor

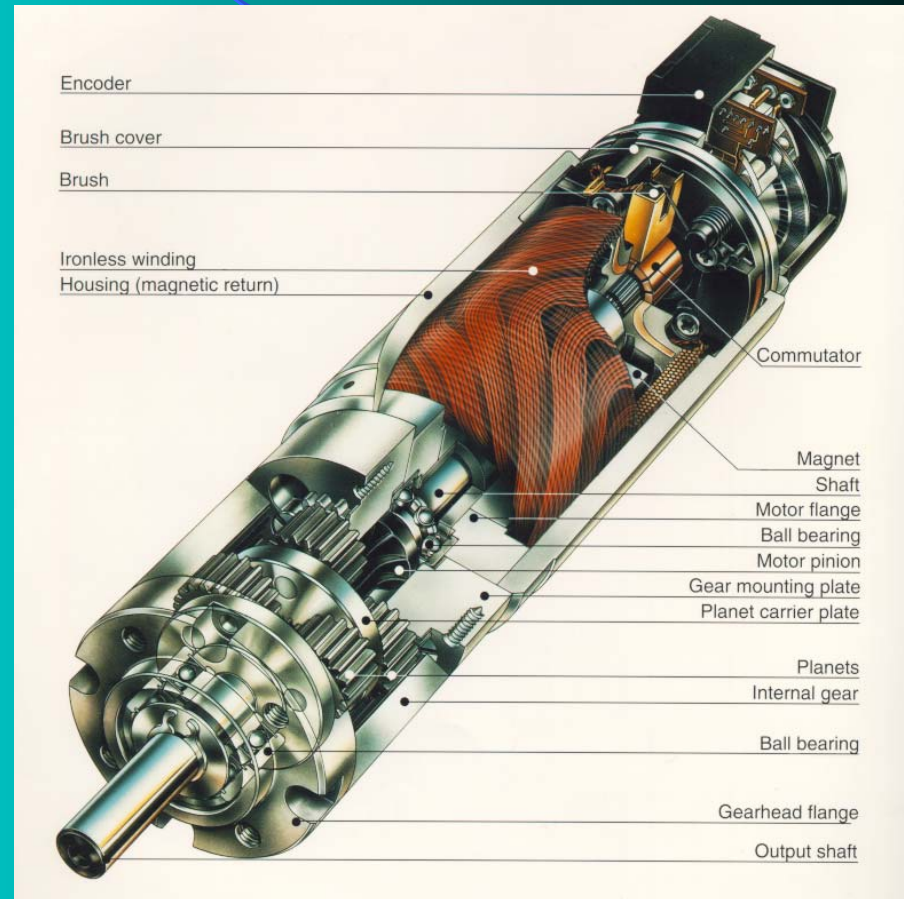


# Electrical Actuator Types

- DC-motors
- brushless DC-motors
- asynchronous motors
- synchronous motors
- reluctance motors (stepper motors)

# DC-Motors

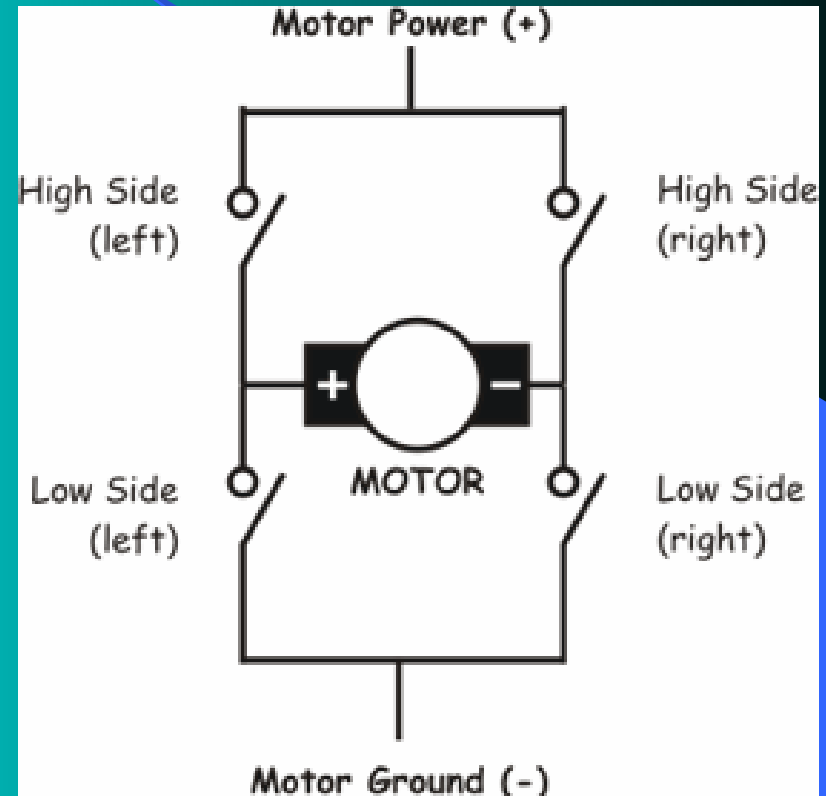
- simple, cheap
- easy to control  
( $I = T$ )
- 1W - 1kW
- can be overloaded
- brushes wear
- limited overloading  
on high speeds





# DC-motor control

- Controller + H-bridge
- PWM-control
- Speed control by controlling motor current= $\text{torque}$
- Efficient small components
- PID control

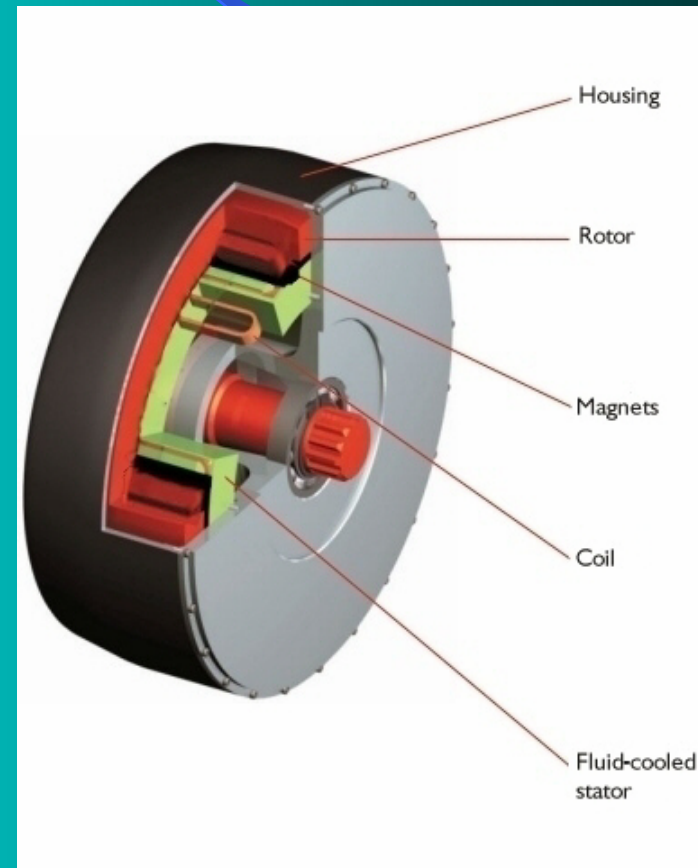


# Brushless DC-Motors (pm synchronous motor)

- no brushes → no wearing parts → high speeds
- coils on cover => better cooling
- excellent power/weight ratio
- simple
- Controller needs both speed and angle feedback
- more complicated controller
- From small to medium power (10W – 50kW)
- In hub-motors

# PM Brushless Hub motor

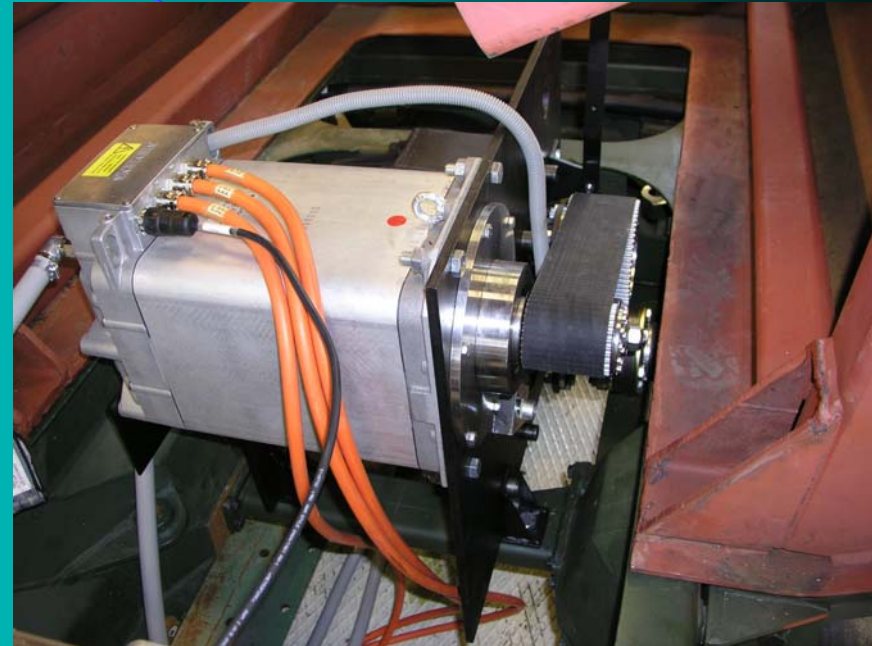
- Characteristics:
- Outer rotor with permanent magnets
- Inner stator with fluid-cooled single coils
- Simple mechanical and electrical design
  - no rotating electrical parts (no brushes or sliding contacts)
  - no complicated windings
  - large air gap
- Power supply by current inverters using most recent IGBT technology
- Microprocessor control with diagnostics of all propulsion data
- Advantages:
- Extremely high torque and power ratings: 4 to 10 times better torque and power values compared to conventional electrical machines
- Easy to integrate due to the small volume
- Highest efficiency values under all operating conditions
- Maintenance-free
- Simple and accurate control of all operational conditions
- Typical Applications:
- Road vehicles
- Rail vehicles
- Industrial drives which require maximum torque with lowest possible dimensions



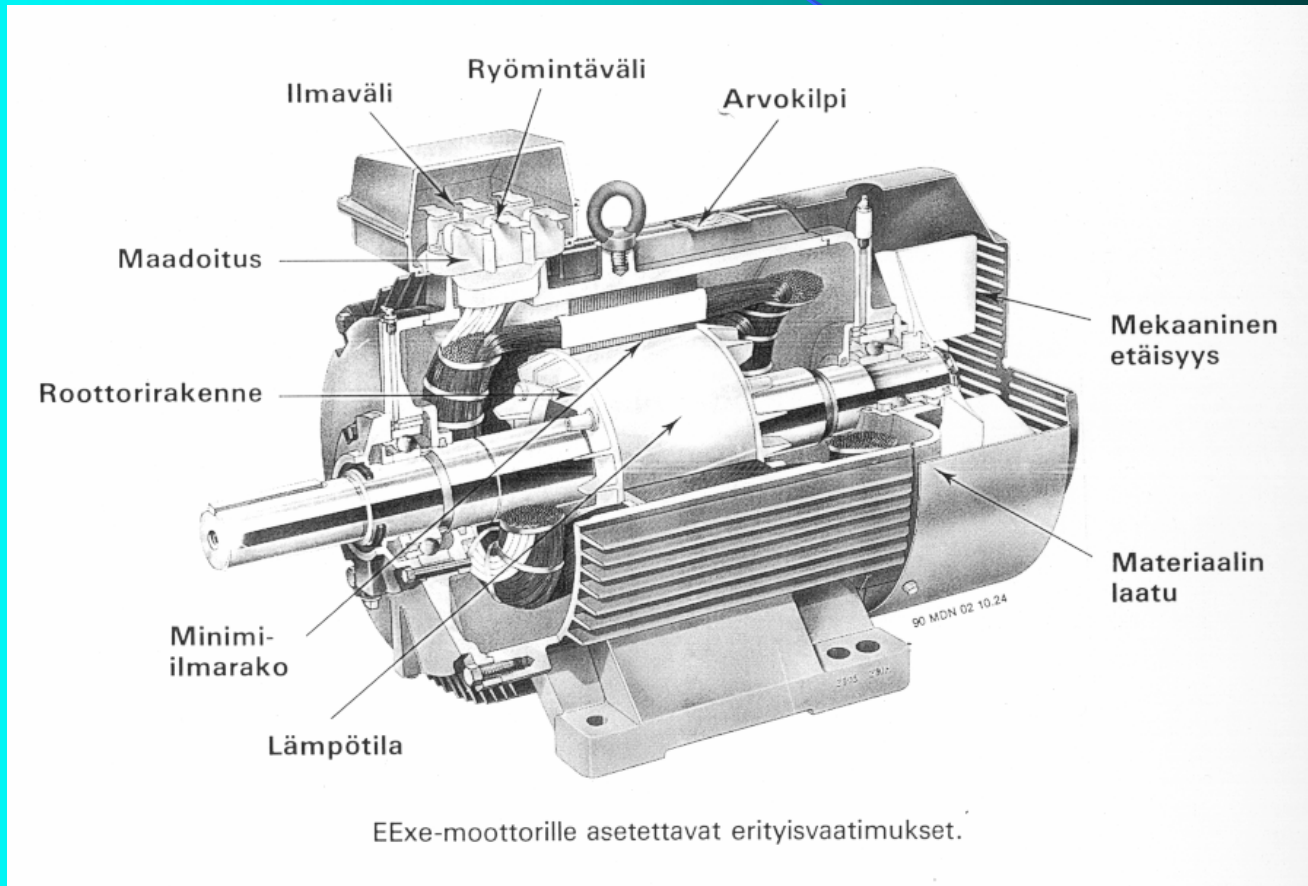
Adopted from: <http://www.magnetmotor.de/>

# Asynchronous Motors

- very simple, very popular in industry
- 0,5kW - 500kW
- More difficult to control (frequency)
- nowadays as accurate control as DC-motors
- In mobile machines also (5kW →)



# Structure of an As-motor



# Synchronous Motors

- usually big 100 kW - XXMW
- also small ones ~ brushless DC-motors from 50W to 100 kW
- controlled like as-motors (frequency)
- ships
- industry
- Mobile machines

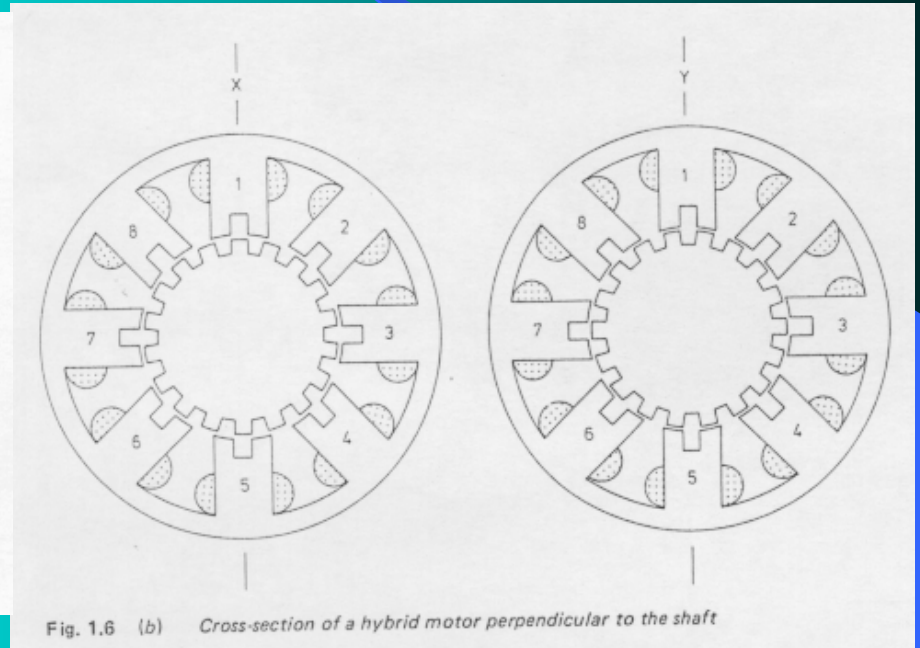
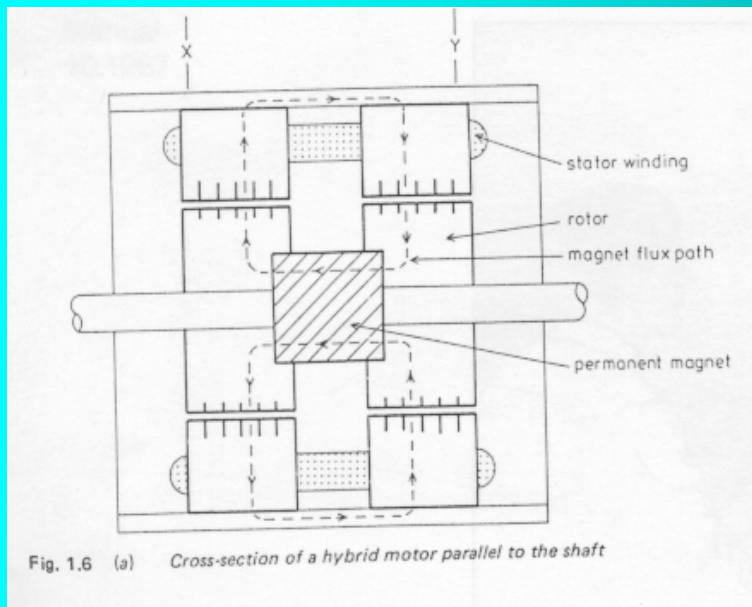


ABB synchronous motor  
1-60 MW

# Reluctance (Stepper) Motors

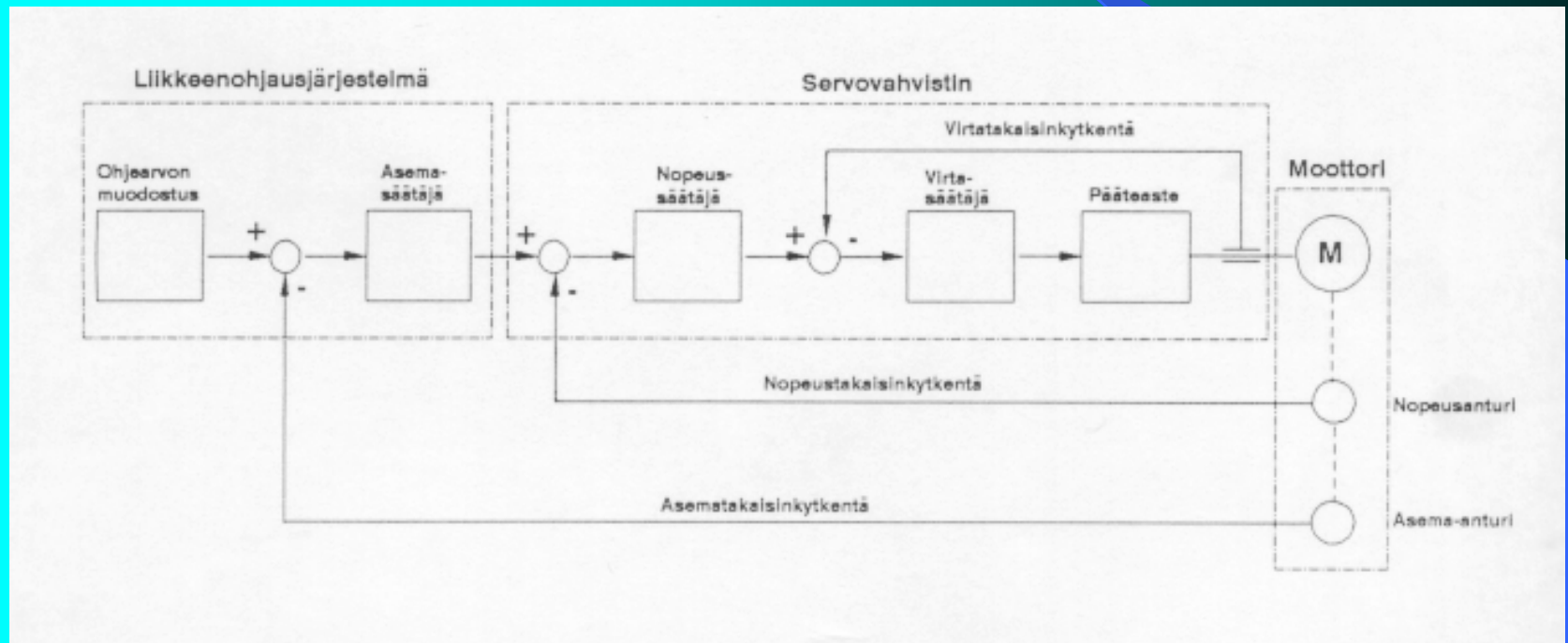
- angle control
- slow
- usually no feedback used
- accurate positioning
- with out feedback not servos
- easy to control

# Principle of Stepper Motor





# Servo Control of an Electrical Motor



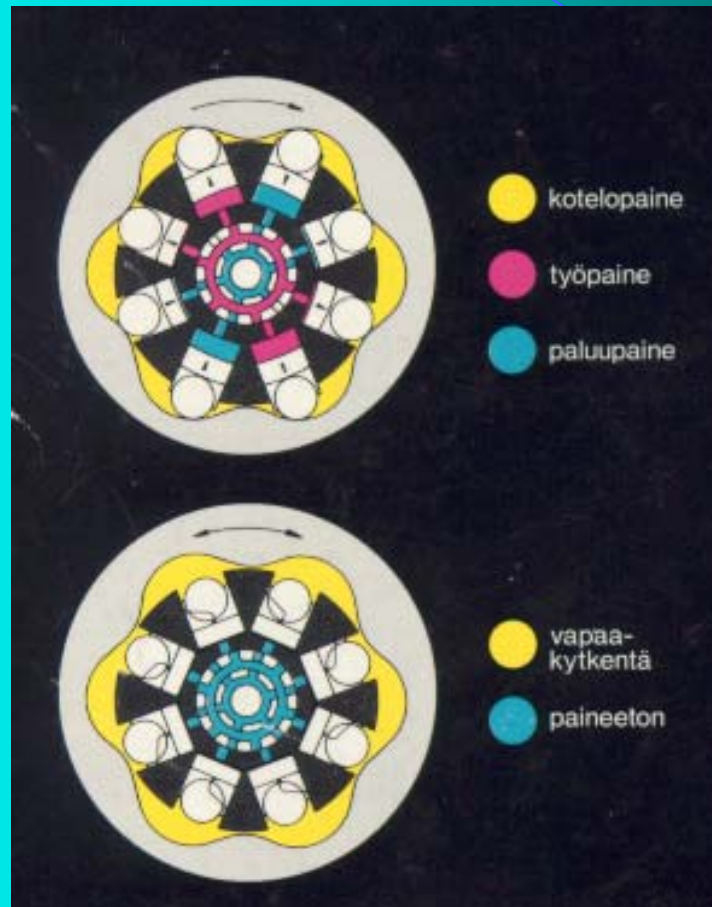
# Hydraulic Actuators

- linear movement
- big forces without gears
- actuators are simple
- in mobile machines
- Bad efficiency
- motor, pump, actuator combination is lighter than motor, generator, battery, motor & gear combination

# Hydraulic actuators



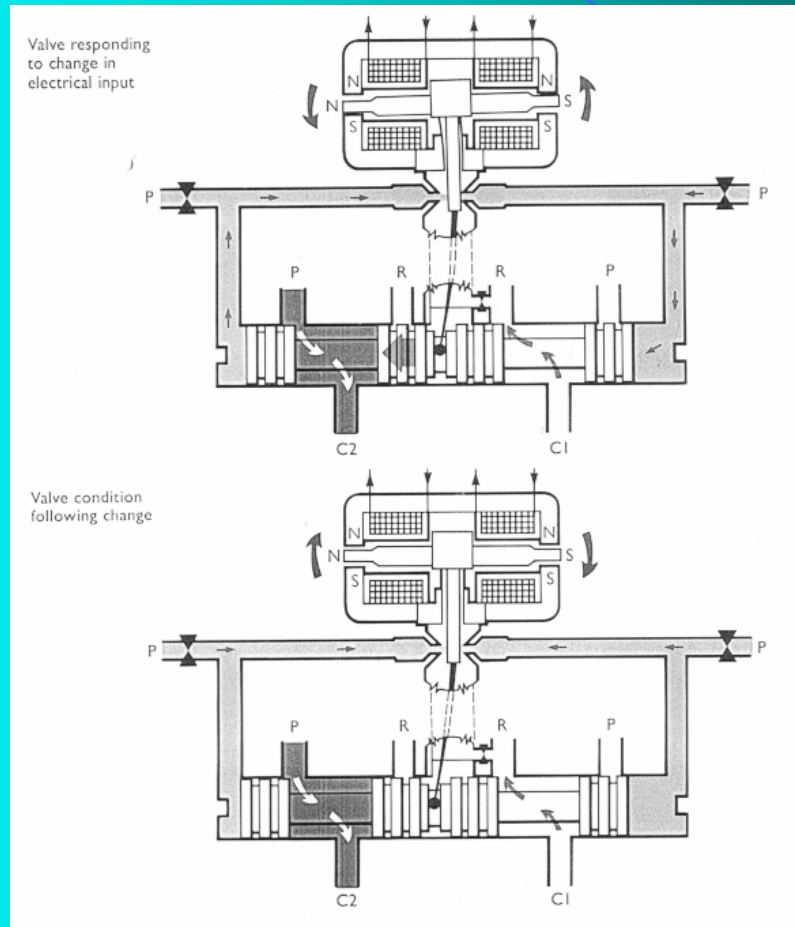
# Hydraulic motor



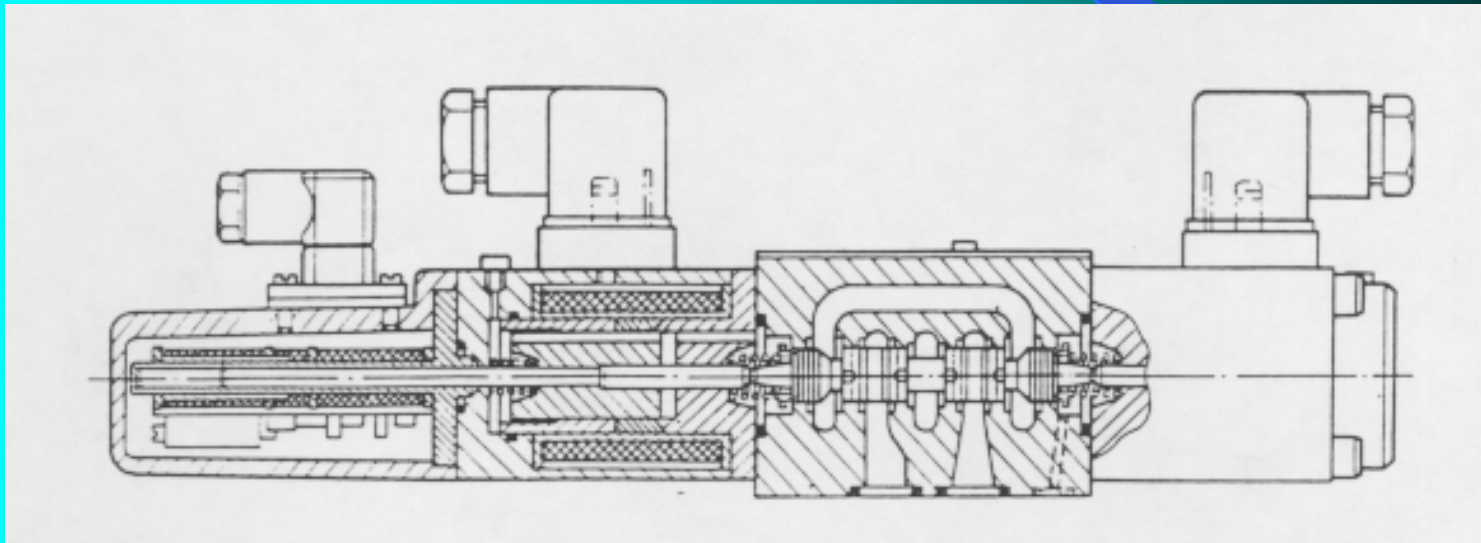
# Hydraulic Valves

- servo valves
  - complicated structure, expensive
  - good control
- proportional valves
  - simple, cheap
  - robust
  - more difficult to control
- Digital hydraulics, new!
  - several fast on/off valves ( $2^n$ )
  - digital control of the flow

# Servo Valve



# Proportional Valve



# Pneumatic Actuators

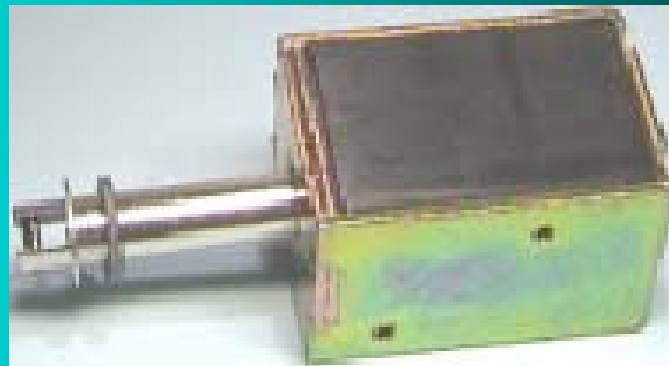
- ◆ like hydraulic except power from compressed air
- ◆ fast on/off type tasks
- ◆ big forces with elasticity
- ◆ no leak problems



# Other Actuators

- piezoelectric
- magnetic
- ultra sound
- SMA
- inertial

# Examples



# Arska



# Workpartner



# Shape Memory Alloy Robot

