

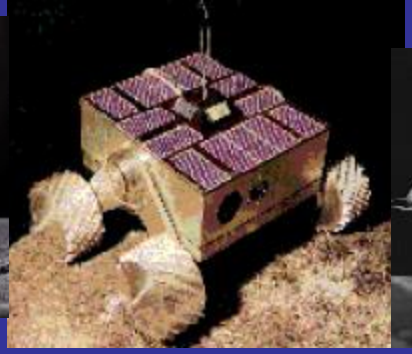
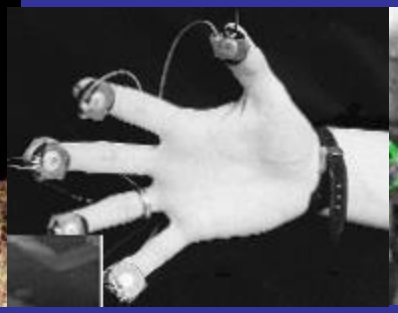


ROBOTICS ACTUATORS

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Actuators: I

- Common robotic actuators utilize combinations of different electro-mechanical devices
  - Synchronous motor
  - Stepper motor
  - AC servo motor
  - Brushless DC servo motor
  - Brushed DC servo motor

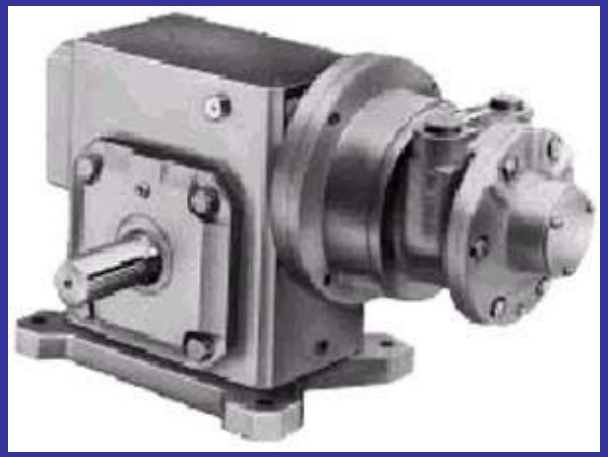
http://www.ab.com/motion/servo/fseries.html

Actuators: II

Hydraulic Motor

Pneumatic Cylinder

Stepper Motor



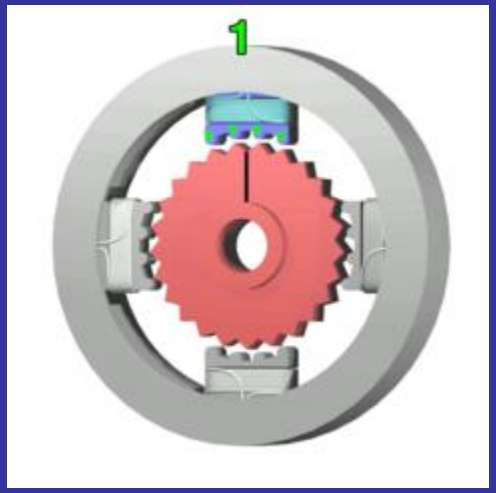
Pneumatic Motor

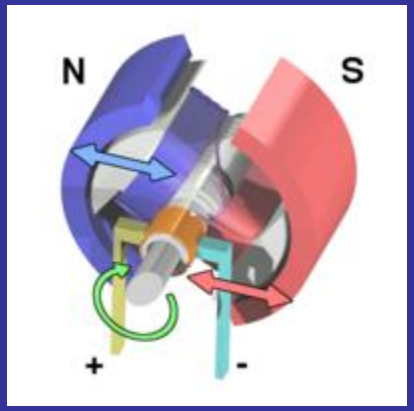
DC Motor

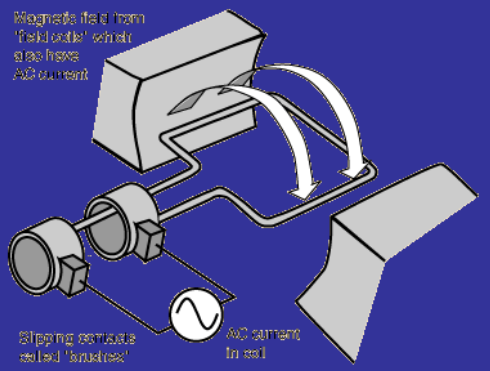
Servo Motor

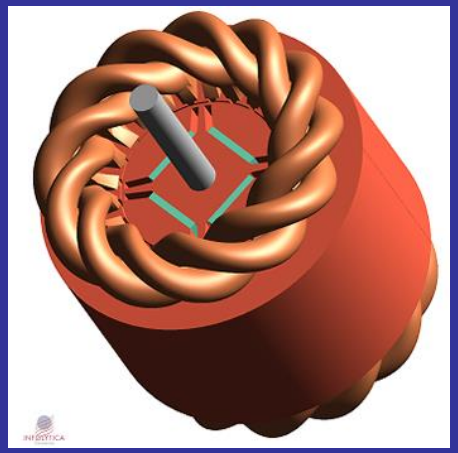
Actuators

- Actuators are mechanisms for getting things (in particular, robots) to move.
- An actuator is the actual mechanism that enables the effector (device that affects the environment) to execute an action.
- It is the device that provides the motive power to the process.
- Actuators typically include
  - electric motors (current) ,
  - hydraulic cylinders (fluid pressure), or
  - pneumatic cylinders (air pressure).









Stepper, AC and DC Motors

DC Motors

- **The *direct current (DC) motor* is the** most common actuator.
- **DC motors convert electrical into mechanical energy.**

DC Motors

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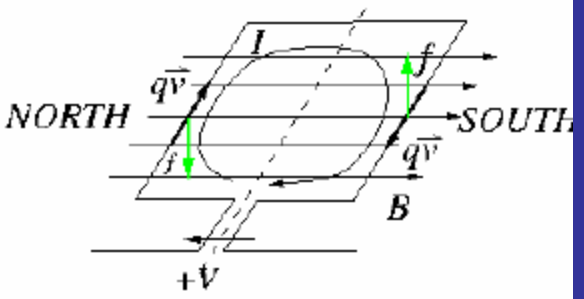
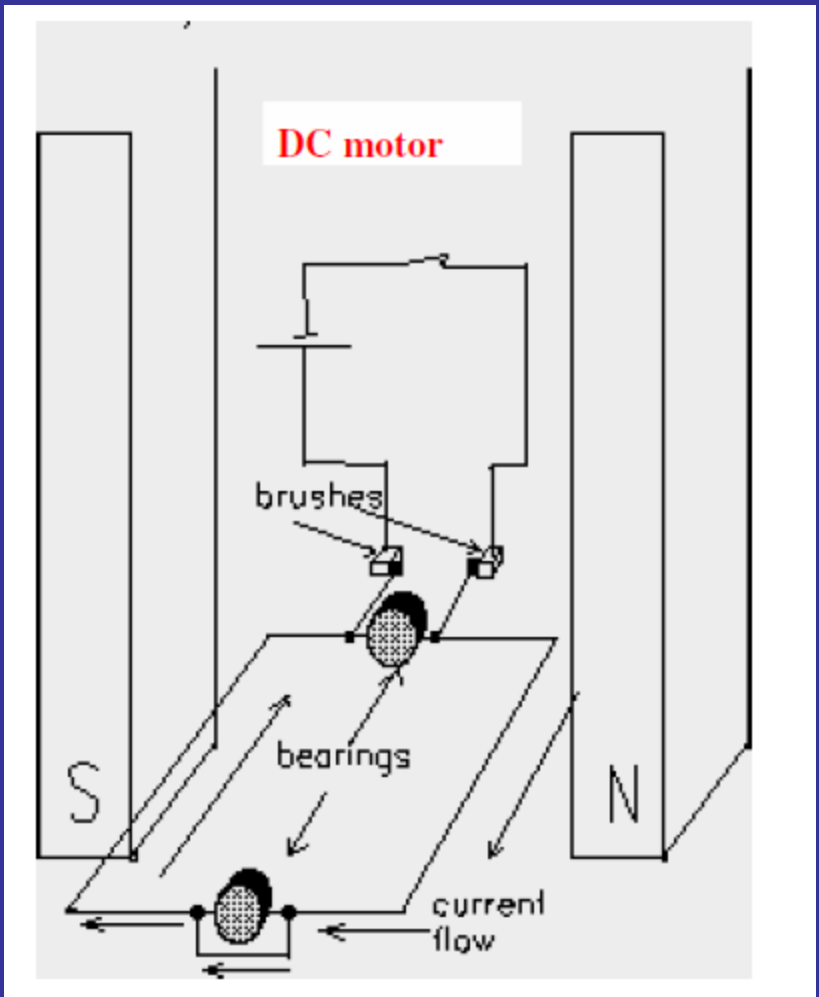


- **They consist of permanent magnets and loops of wire inside. When current is applied, the wire loops generate a magnetic field, which reacts against the outside field of the static magnets. The interaction of the fields produces the movement of the shaft/armature.**
- **The Lorenz force $\vec{f} = q\vec{v}x\vec{B}$ generates a torque on the rotor proportional to the current (qv - velocity times charge) and the magnetic field B.**

DC Motors

- When constant voltage is applied, *a DC motor draws current in the amount proportional to the work it is doing*. For example, if a robot is pushing against a wall, it is drawing more current than when it is moving freely in open space.
- The *stall current* of the motor: the most current it can draw at its specified voltage.
- Within a motor's *operating current* range, the more current is used, the more *torque* or *rotational force* is produced at the shaft.

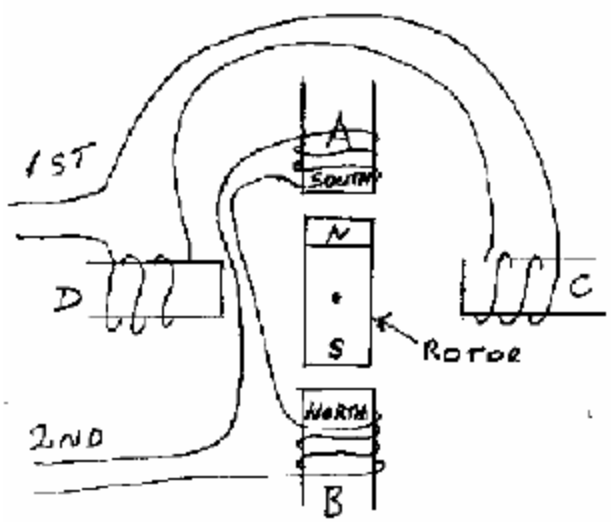
- **Motors require more battery power (i.e., more current) than electronics**
  - e.g., 5 milliamps for the 68HC11 processor vs. 100 milliamps - 1amp for a small DC motor.


DC motor
brushes
bearings
S
N
current
flow

Servo Motors

- It is sometimes necessary to be able to move a motor to a specific position.
- Motors that can turn to a specific position are called *servo motors* and are in fact constructed out of basic DC motors, by adding:
  - a position sensor for the motor shaft.
  - an electronic circuit that controls the motor's operation.
- Since positioning of the shaft is what servo motors are all about, most have their movement reduced to 180 degrees.

Basic Stepper Motor Concepts



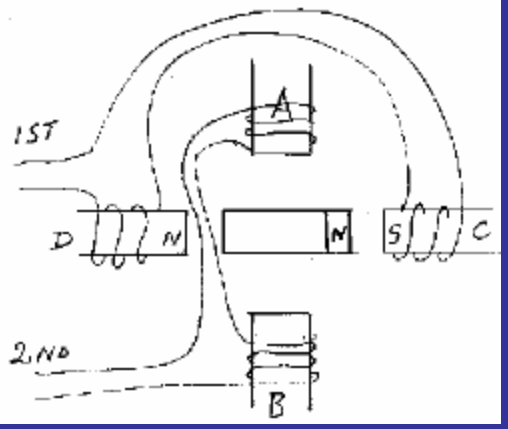
4 wires

- a stepper motor has more than two wires leading into it.
- The rotor in this case is a bar magnet that pivots about its center.
- You see two loops of wire, each loop forming its own electromagnet and each end having a different polarity.

A tutorial on basic electromagnetism and how it applies to stepper motors can be found at: http://home.mira.net/~tonymerc/steptheo/steptheo.htm

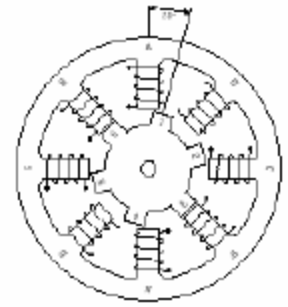
Basic Stepper Motor Concepts

- If we apply a voltage such that pole piece A is South and B is North (it must be because of the way they are wound) the rotor magnet will line up as shown.
- the rotor lined up in this position but that it will stay in this position as long as there is voltage applied to the coil.
- This holding position will stay as long as there is not unreasonable force applied against it and the voltage is sufficient to provide a large enough current through the coil and consequent magnetic attraction.
- If we remove the voltage from the second loop and apply it to the first loop, pole pieces A and B will have no magnetic attraction and pole pieces C and D will have.
- The rotor will turn, so the magnet will take up a new position and be rotated 90 degrees clock wise.

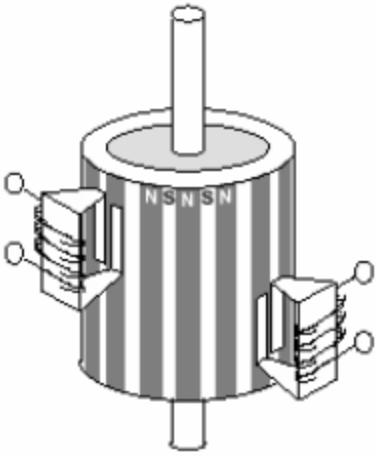


"Stepper Motor Basics"
http://www.ericsson.se/microe/pdf/industri/app/motorbas.pdf or

http://home.mira.net/~tonymerc/steptheo/steptheo.htm

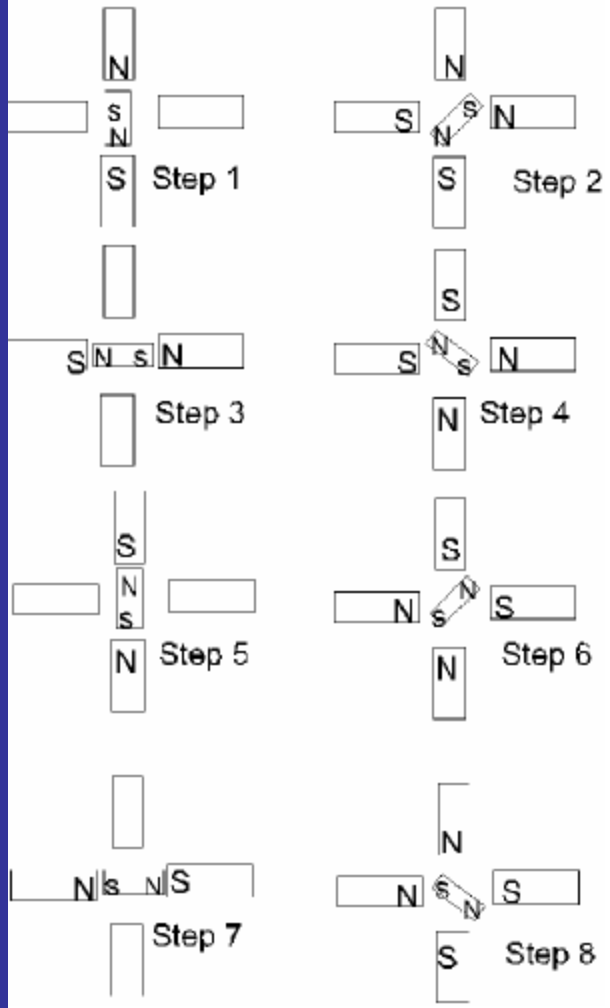


- Variable Reluctance (VR) type consists of a soft iron multi-toothed rotor and a wound stator.
  - When the stator windings are energized with DC current the poles become magnetized.
  - Rotation occurs when the rotor teeth are attracted to the energized stator poles.

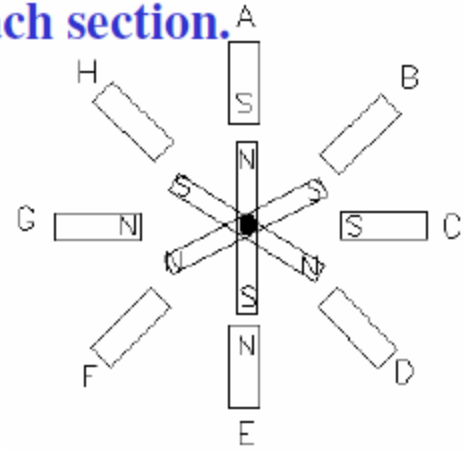


- Permanent Magnet motor.
  - Permanent magnets added to the motor structure.
  - The rotor is magnetized with alternating north and south poles situated in a straight line parallel to the rotor shaft.
  - PM motor exhibits improved torque characteristics.

The sequence for half stepping works like this:



- If we have a situation such that the stator has eight individual sections on it there is 45 degrees between each section or pole piece.
- If the rotor has six sections on it as shown there is 60 degrees between each section.



POWER SOURCES

- **THE THREE POWER SOURCES USED IN CURRENT ROBOTS ARE:**
  - **ELECTRIC: ALL ROBOTS USE ELECTRICITY AS THE PRIMARY SOURCE OF ENERGY.**
    - **ELECTRICITY TURNS THE PUMPS THAT PROVIDE HYDRAULLIC AND PNEUMATIC PRESSURE.**
    - **IT ALSO POWERS THE ROBOT CONTROLLER AND ALL THE ELECTRONIC COMPONENTS AND PERIPHERAL DEVICES.**
    - **IN ALL ELECTRIC ROBOTS, THE DRIVE ACTUATORS, AS WELL AS THE CONTROLLER, ARE ELECTRICALLY POWERED.**
    - **BECAUSE ELECTRIC ROBOT DO NOT REQUIRE A HYDRAULIC POWER UNIT, THEY CONSERVE FLOOR SPACE AND DECREASE FACTORY NOISE.**
    - **NO ENERGY CONVERSION IS REQUIRED.**
  - **PNEUMATIC: THESE ARE GENERALLY FOUND IN RELATIVELY LOW-COST MANIPULATORS WITH LOW LOAD CARRYING CAPACITY.**
    - **PNEUMATIC DRIVES HAVE BEEN USED FOR MANY YEARS FOR POWERING SIMPLE STOP-TO-STOP MOTIONS.**
    - **IT IS INHERENTLY LIGHT WEIGHT, PARTICULARLY WHEN OPERATING PRESSURES ARE MODERATE.**

- **HYDRAULIC: ARE EITHER LINEAR POSITION ACTUATORS OR A ROTARY VANE CONFIGURATION.**
  - **HYDRAULIC ACTUATORS PROVIDE A LARGE AMOUNT OF POWER FOR A GIVEN ACTUATOR.**
  - **THE HIGH POWER-TO-WEIGHT RATIO MAKES THE HYDRAULIC ACTUATOR AN ATTRACTIVE CHOICE FOR MOVING MODERATE TO HIGH LOADS AT REASONABLE SPEEDS AND MODERATE NOISE LEVEL.**
  - **HYDRAULIC MOTORS USUALLY PROVIDE A MORE EFFICIENT WAY OF ENERGY TO ACHIEVE A BETTER PERFORMANCE, BUT THEY ARE EXPENSIVE AND GENERALLY LESS ACCURATE.**

ROBOT ACTUATORS

Hydraulic	Electric	Pneumatic
More Suitable for large robots & heavy pay load	For all size of robots	More suitable for medium pay loads
Highest power/Weight ratio	Medium Power/Weight ratio	Lowest power to weight ratio + Reliable components
Stiff System, High accuracy, better response	Low stiffness	Very low stiffness, Inaccurate response
No reduction gear needed	Reduction gears used reduce inertia on the motor	No reduction gear needed
Operating Pressure is high compared to pneumatics	No need to consider the operating pressure	Low pressure compared to hydraulics
May leak. Not fit for clean room application	Does not Leak, good for clean room. Can be spark – free good for explosive environment	It may leak. But suited for clean room application
Reliable & High maintenance	Reliable, low maintenance	Reliable & low maintenance
Requires Pump, reservoir, motor, hose, etc.,	Requires motor only	Requires compressor, reservoir, motor, hoses, etc.,
It is less noisy compared to Pneumatics	It is smooth in operation	It is a noisy system compared to hydraulic
Very susceptible to dirt and other foreign material in oil	Better control good for high precision robots	Moderate control and good for high precision robots
Viscosity of oil changes with temp.	Motor needs braking device when not powered. Otherwise the arm will fail	Difficult to control their linear position
It is an expensive system	It is an moderate cost system	It is an cheaper system
Operating medium is oil	It produce an rotational force when current carrying conductor is placed in the magnetic field	Operating Medium is air

THANK U VERY MUCH

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