Term Project

- Invent, build, and demonstrate an exciting IoT application

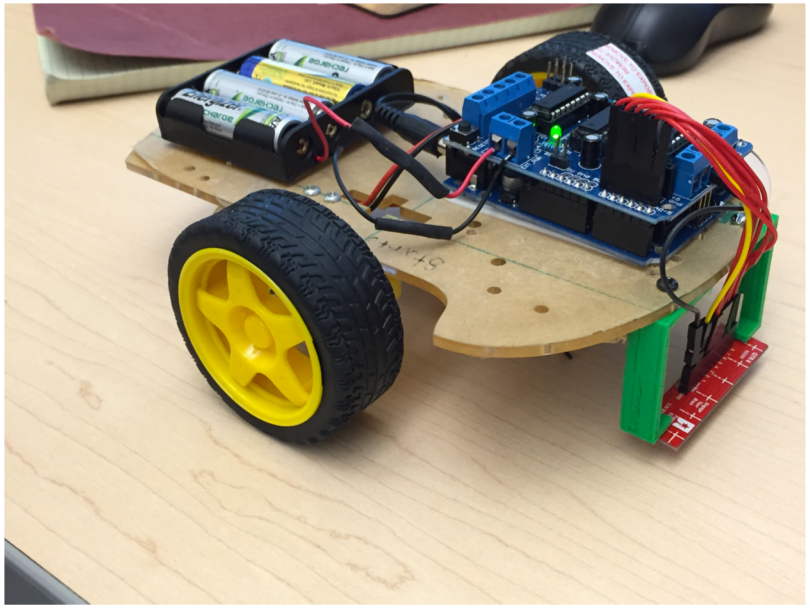
  Demo: Thursday, April 26, 5-9 PM in 430 Soda Hall

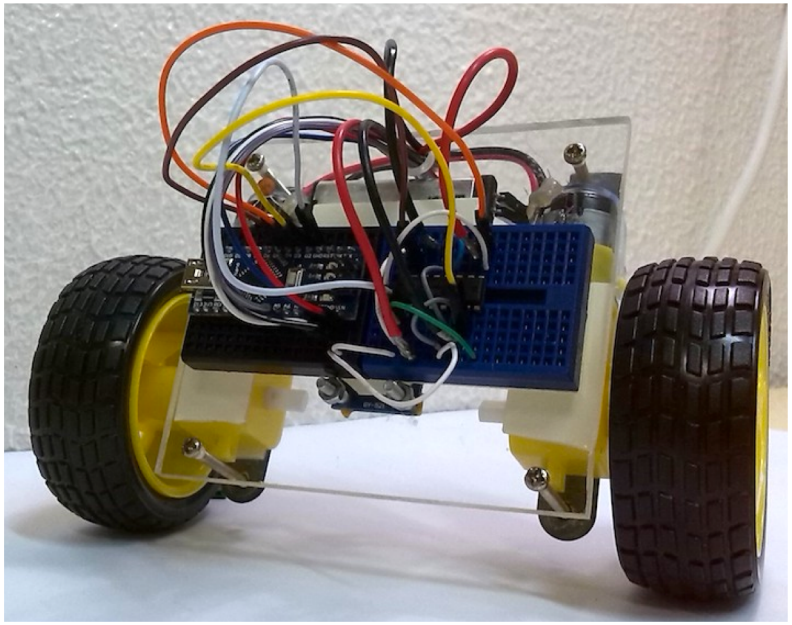
- Due Dates (see guide on course web):
  - April 5: project description
  - April 12: milestone 1
  - April 19: milestone 2
  - April 26: presentation & demo

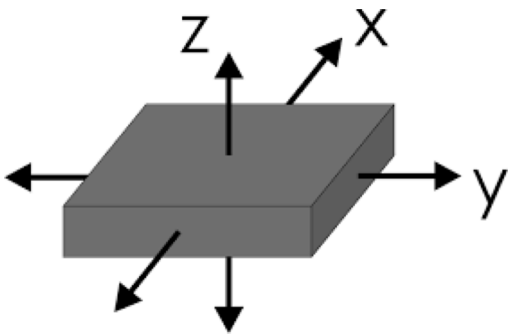
Project

- Topic
  - Up to you
  - Interesting but not impossible!
  - Some ideas in the guide (web)
- Teams of two (or one)
- Resources
  - Labs, web, Piazza, …
  - GSIs, instructors
    - Discuss your ideas
    - **Get feedback**

Ideas







Electronics for IoT

Steppers and Servos

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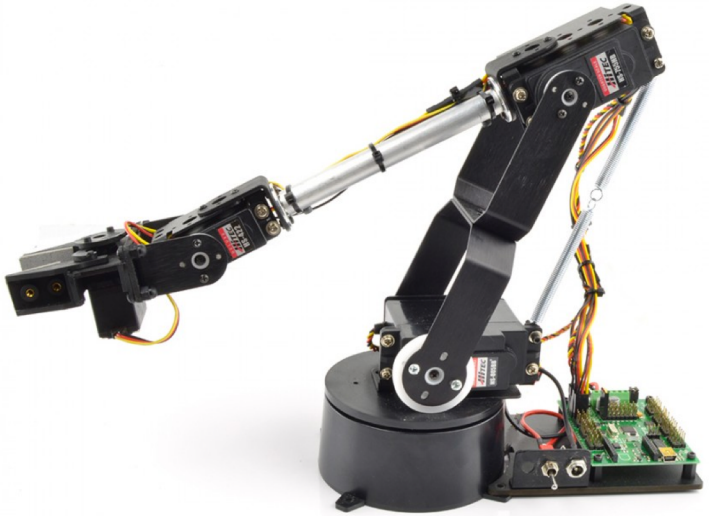
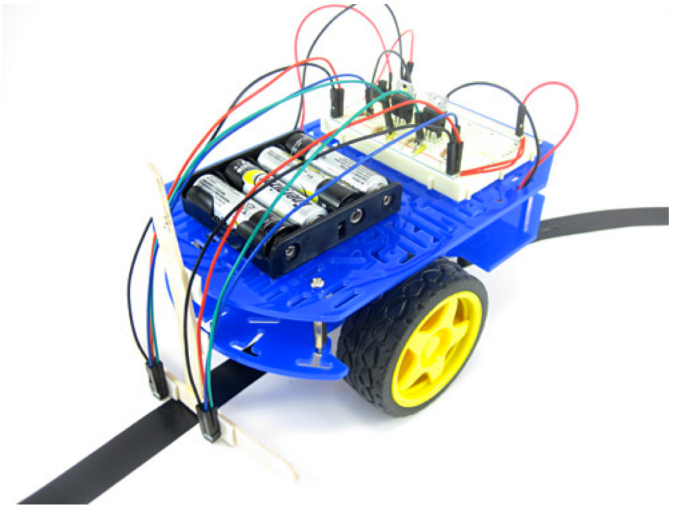
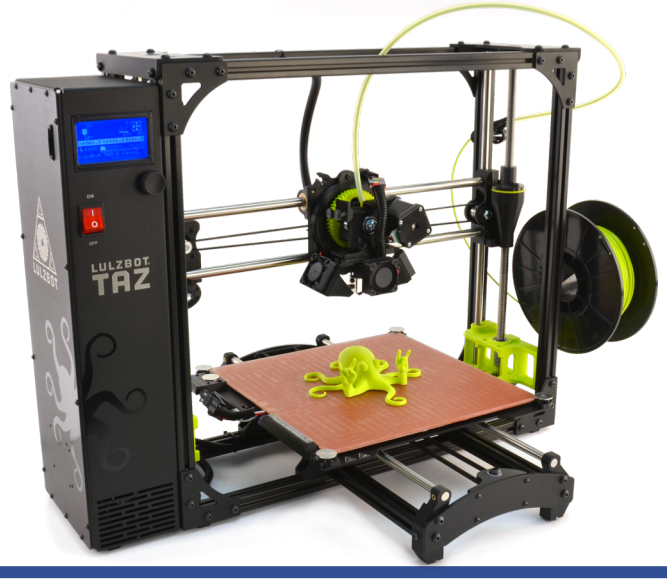
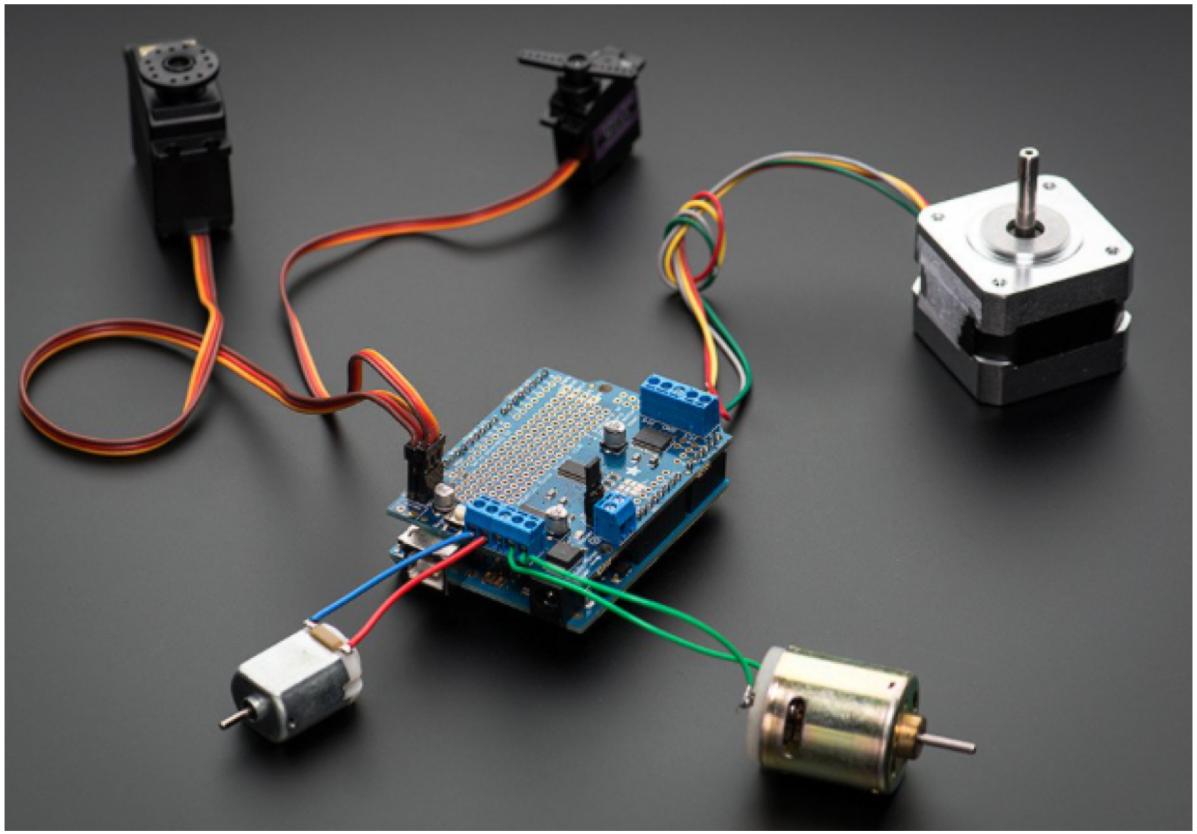
Motor Applications



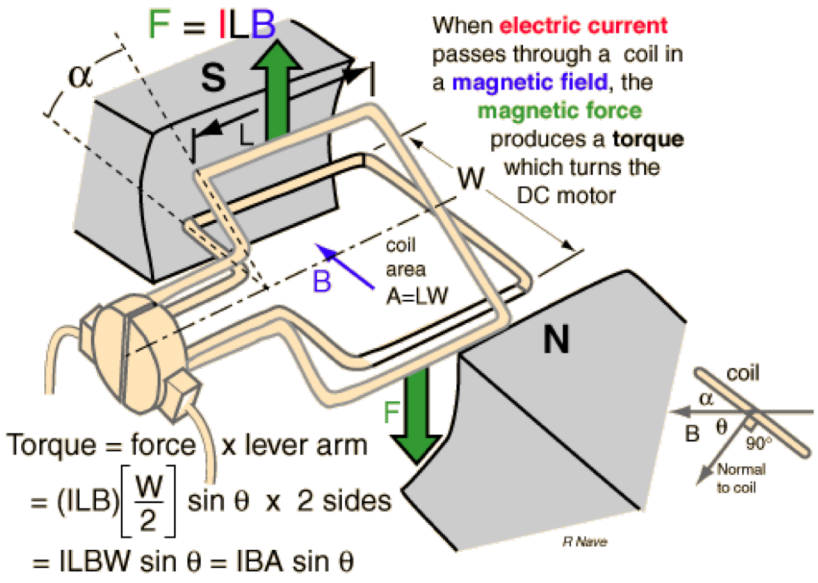


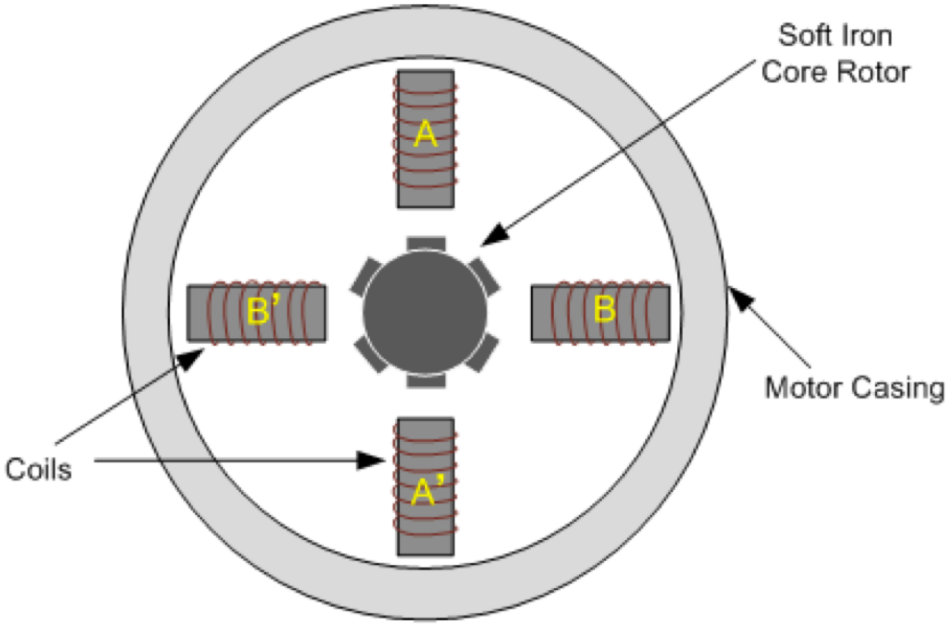


Motor Types

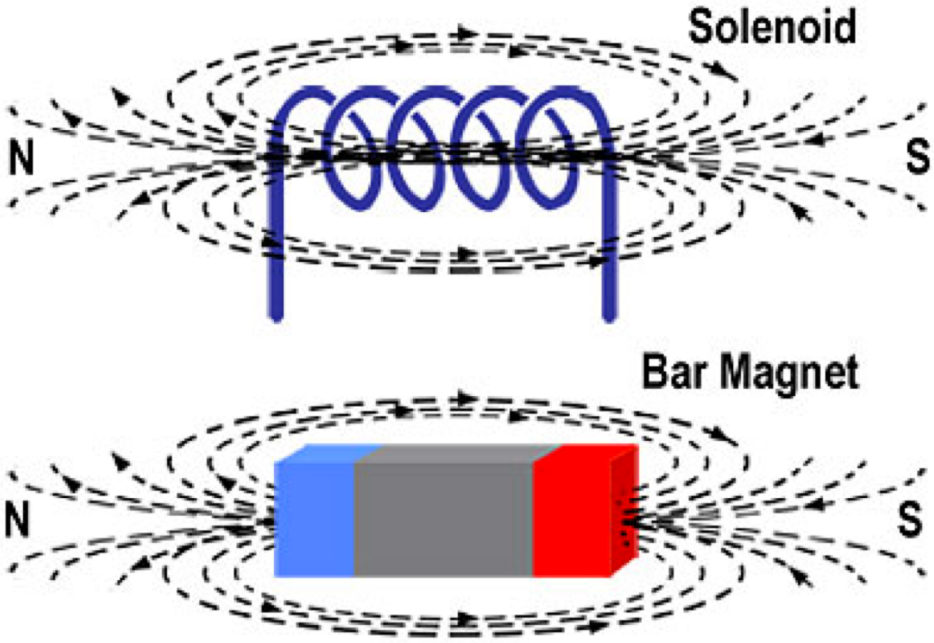


Stepper Motor

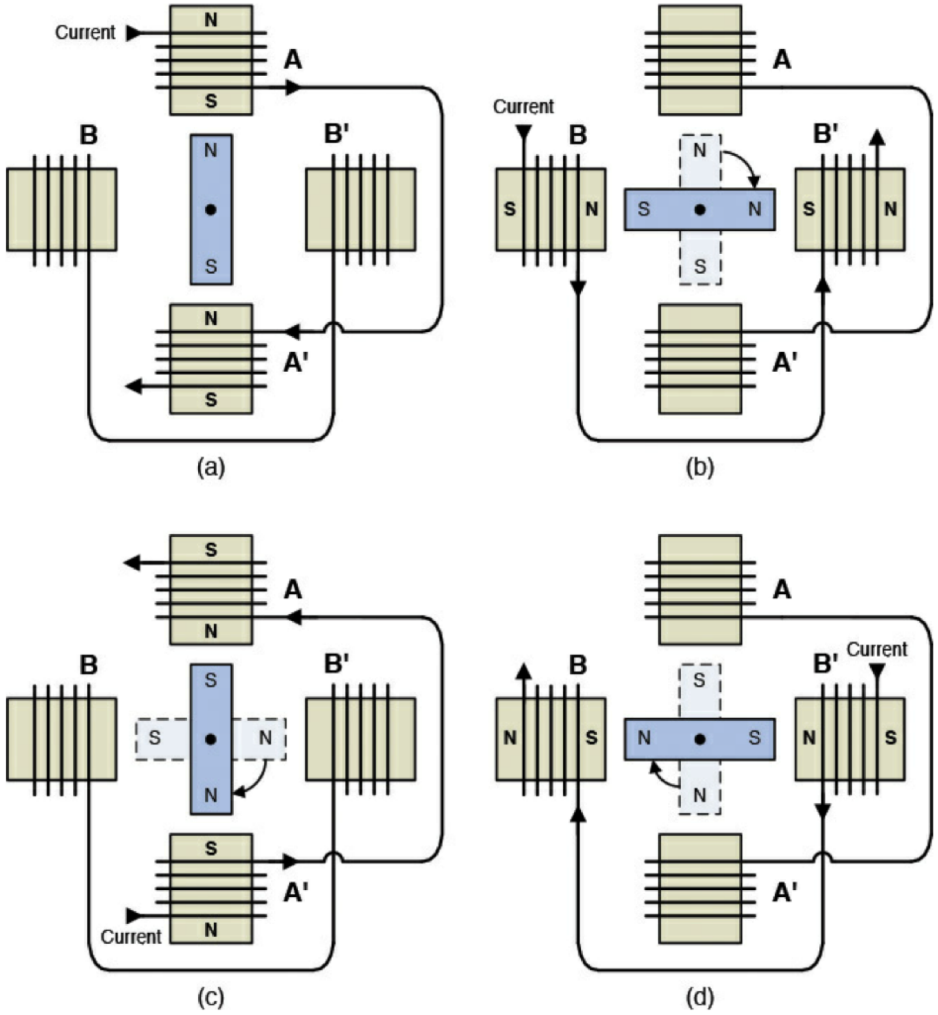




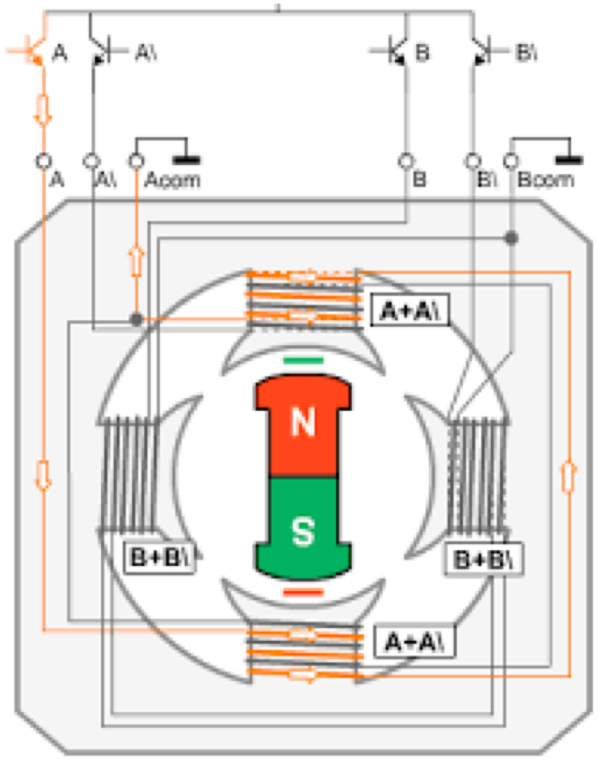
Electromagnet

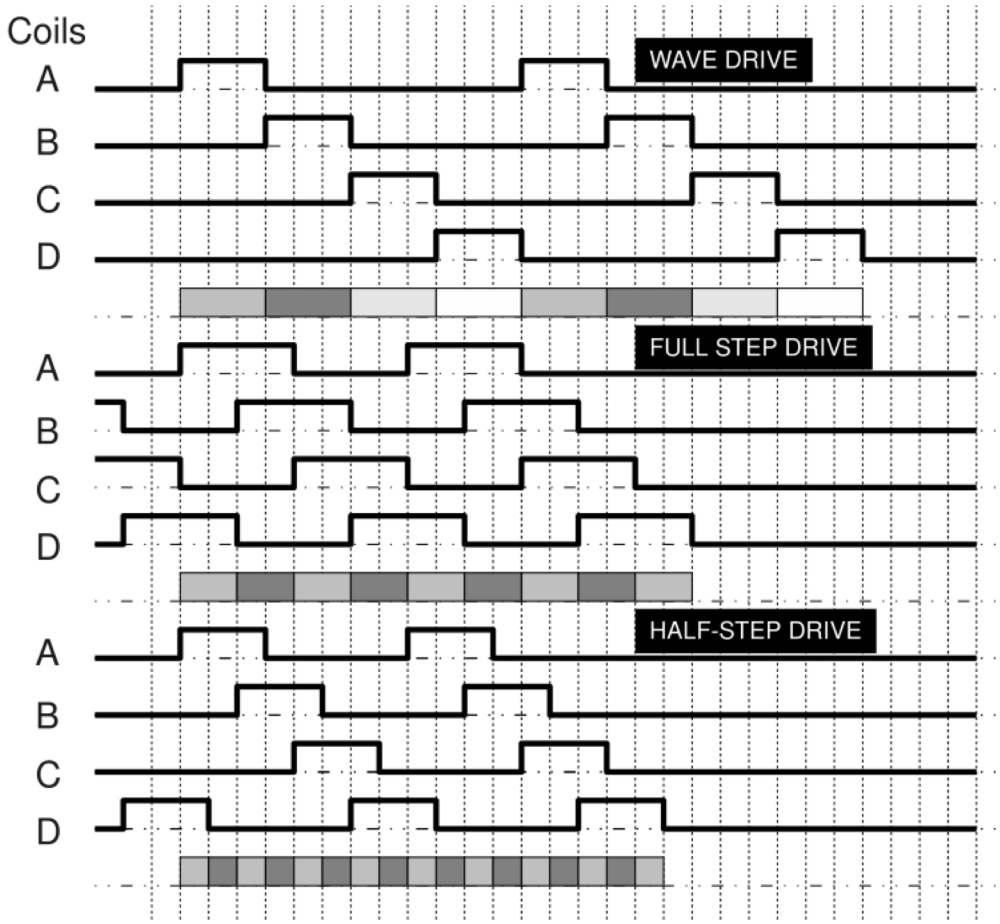


Stepper Motor Principle

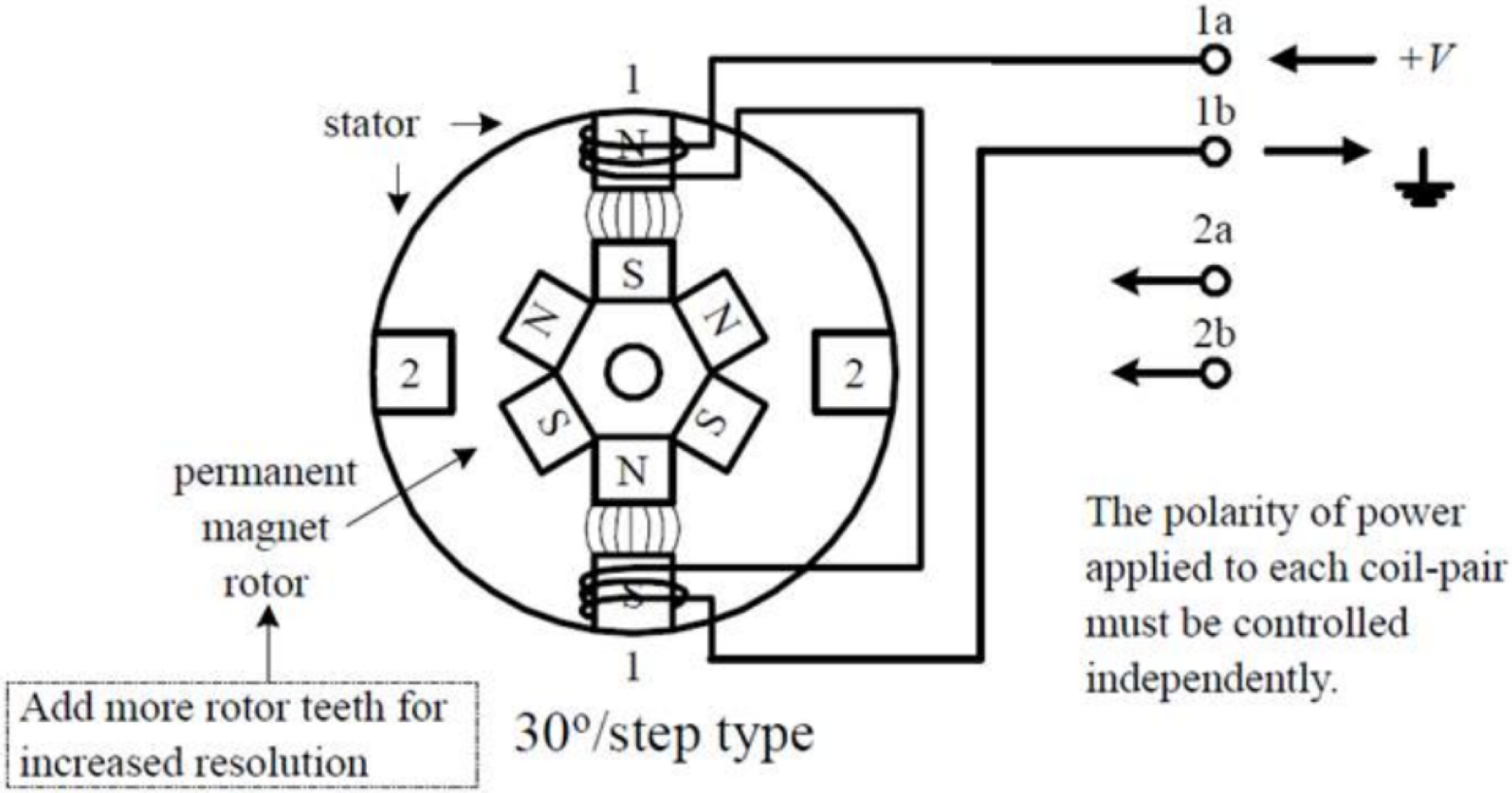


Stepper Motor Control

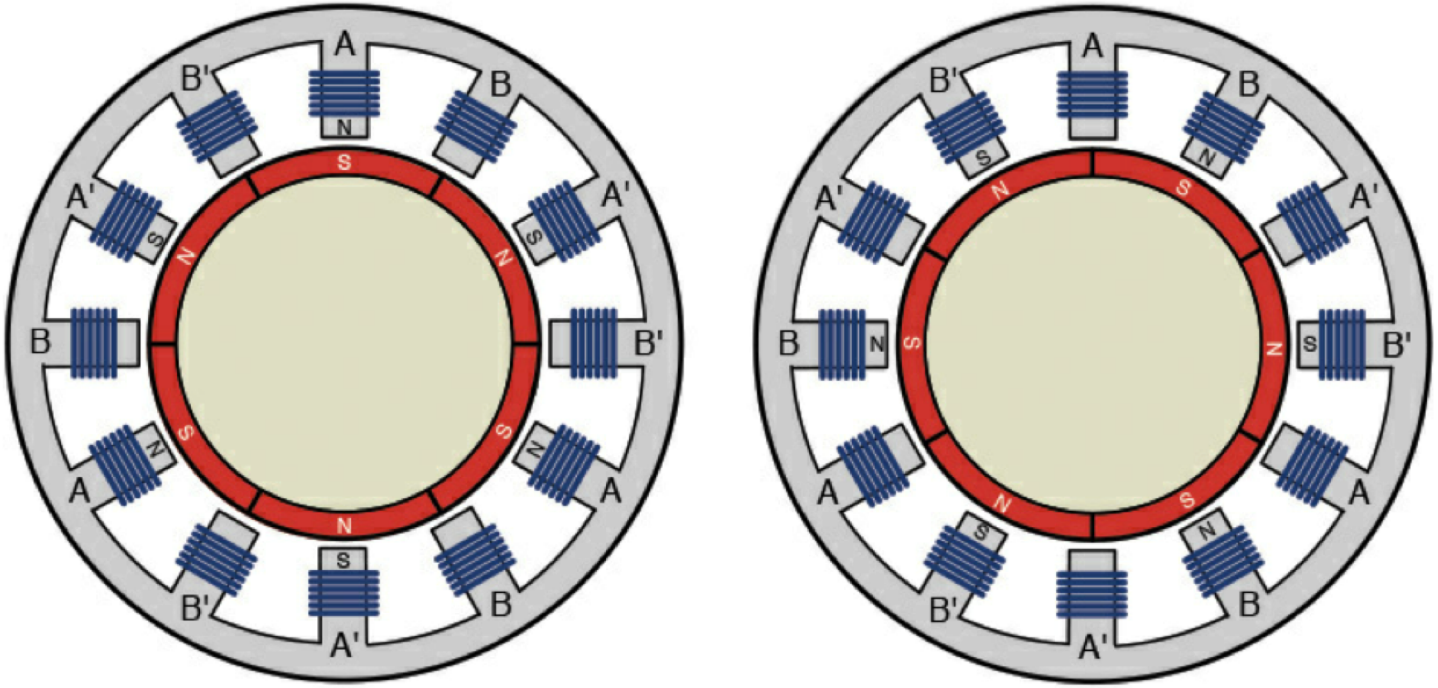




Improving Angular Resolution

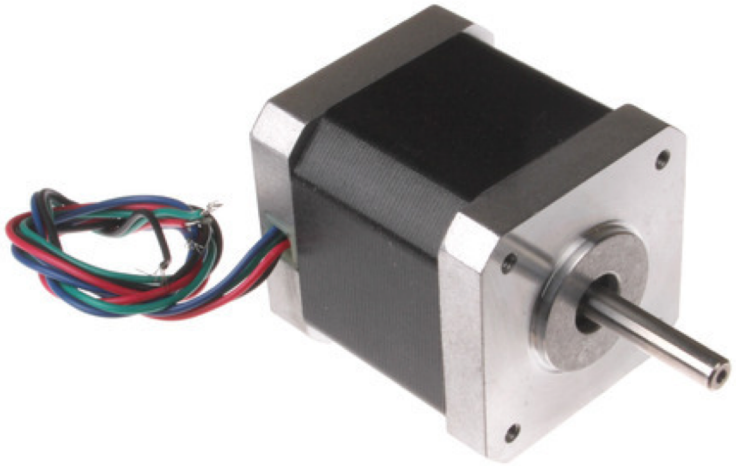


Angular Resolution



Stepper Motor Specifications

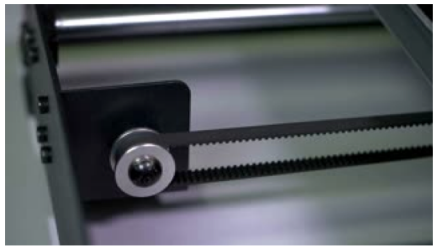
Example:



NEMA 17 1.8 degree 200 steps-per-revolution four-phase unipolar permanent-magnet stepper-motor

Step angle:	1.8° full step 0.9° half-step
Phase/Windings:	4/2
Voltage & Current:	12V at 400 mA
Resistance per Phase:	30 ohms
Inductance per Phase:	23 mH
Holding Torque:	2000 g-cm
Detent Torque:	220 g-cm max
Weight:	0.24 kg (0.5 lbs.)
Max continuous power:	5 W

Stepper Linear Drive



Stepper Characteristics

- Precise angle control
  - E.g. 1.8 deg/step (200)
- But: no absolute position information
  - End of track sensors
  - Missed steps

Stepper Characteristics

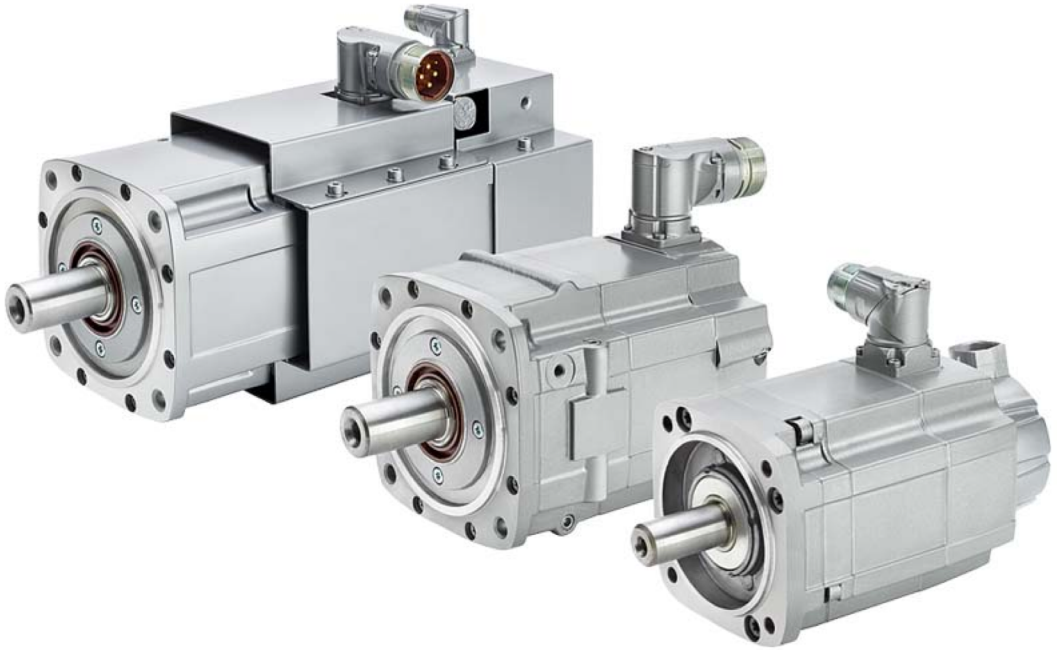
Benefits

- Precise angular control
- Excellent low-speed torque
- Simple
  - Needs no feedback
- Overload save
  - Not damaged by mechanical overload
- Inexpensive

Limitations

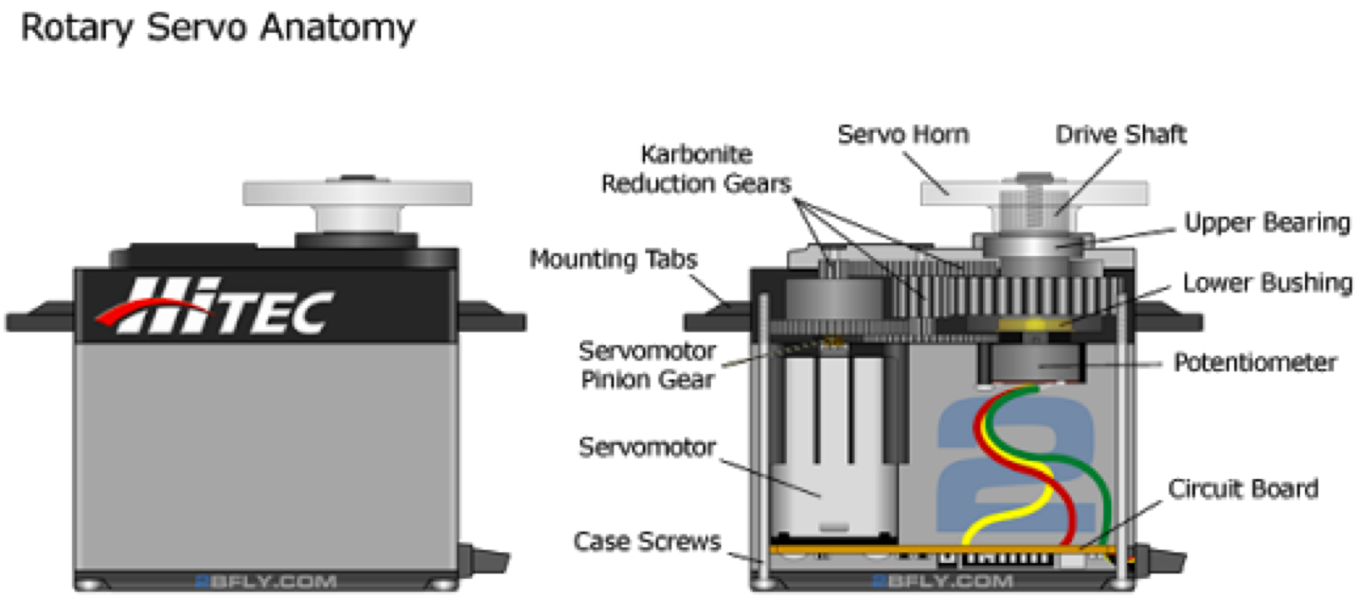
- Only relative control
- Low efficiency: DC power
  - Gets hot
- Torque drops at high speed
  - Missing steps
- Heavy
  - Low torque to weight ratio

Servo Motors

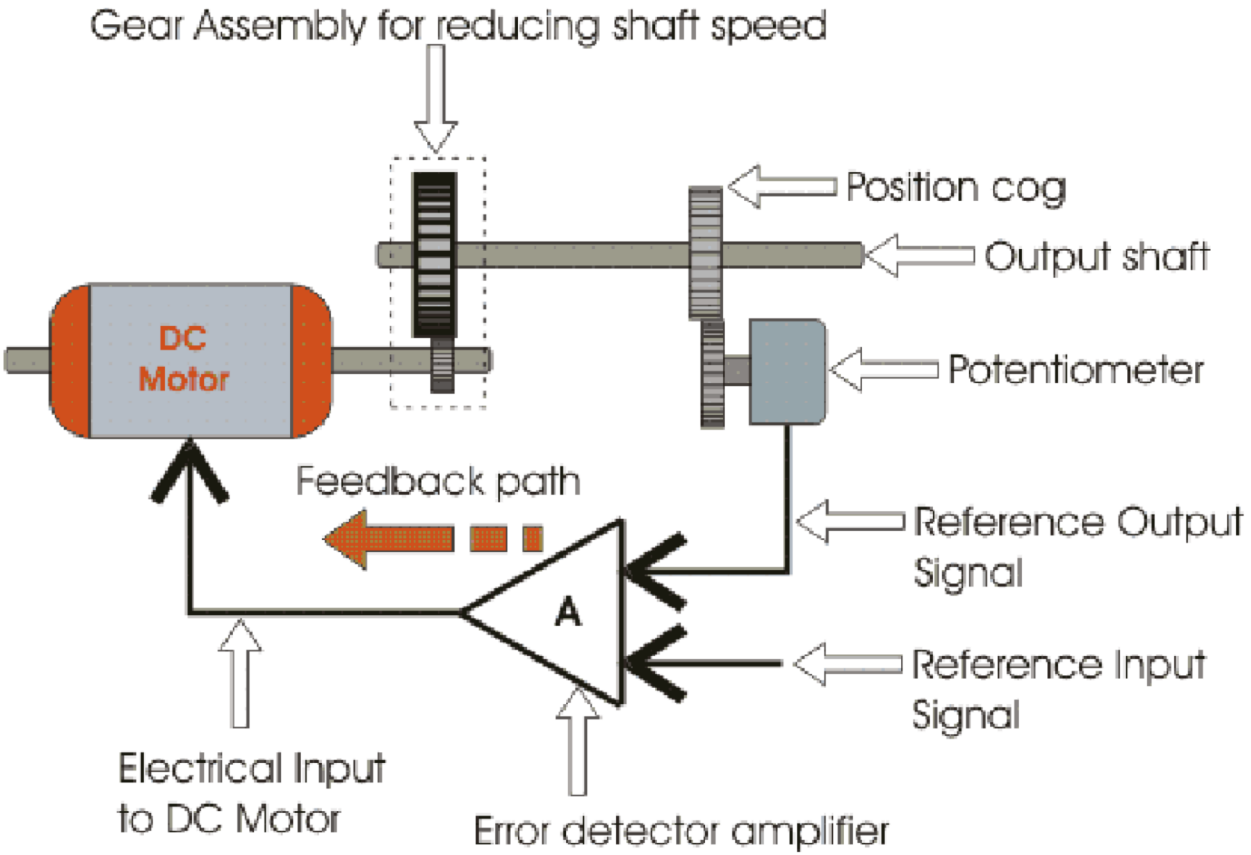


Servo Motor Function

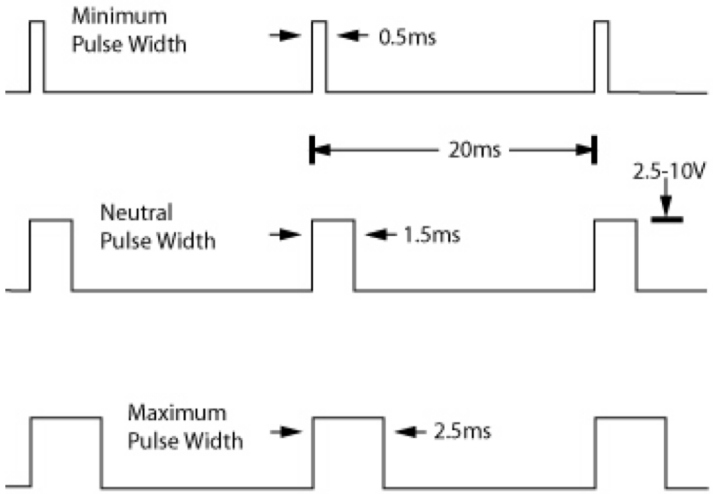
Servo Example

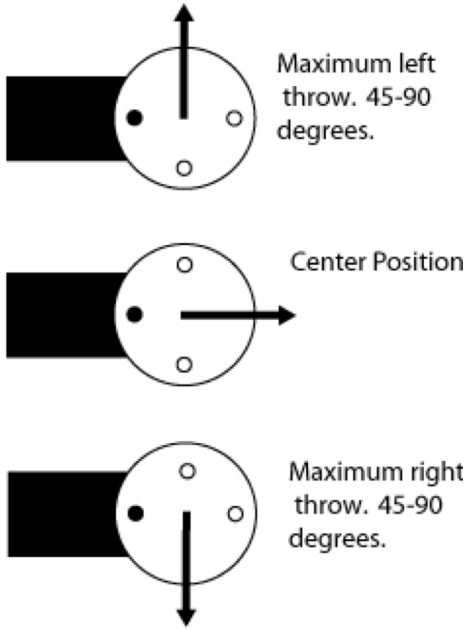


Feedback Control



Servo PWM Control





Servo Motor Characteristics

Servo Motor Characterisitcs

Benefits

- Absolute angle/position control
- Encoder determines accuracy / resolution
- High efficiency, stays cool
- High torque / weight ratio
- Reserve “torque”
  - High torque for short time

Limitations

- Complex
  - Encoder, feedback circuit
- Not fail save
  - Damaged by continuous overload
  - “runs away” if something breaks
- “Jitter”, overshoot
  - Overcome with sophisticated feedback circuits

Summary

- DC (brushed, brushless)
  - Simple PWM speed/torque control
  - No position control (without encoder / feedback → servo)
- Stepper
  - (Relative) angle control
  - Simple, fail save
  - High power dissipation
- Servo
  - Absolute angle control
  - Efficient (low power)
  - Complex, not fail save

EE49 Outlook

- Sensors
  - "Smart" … I2C:
    - All electronics inside
    - Just connect to microcontroller
    - Increasing choices
  - Conventional:
    - Separate interface electronics
- Cloud interaction, e.g.
  - Send text / email alert
  - Inquire weather, traffic, … data