I/O Devices – Motors

EECS 388 – Fall 2022

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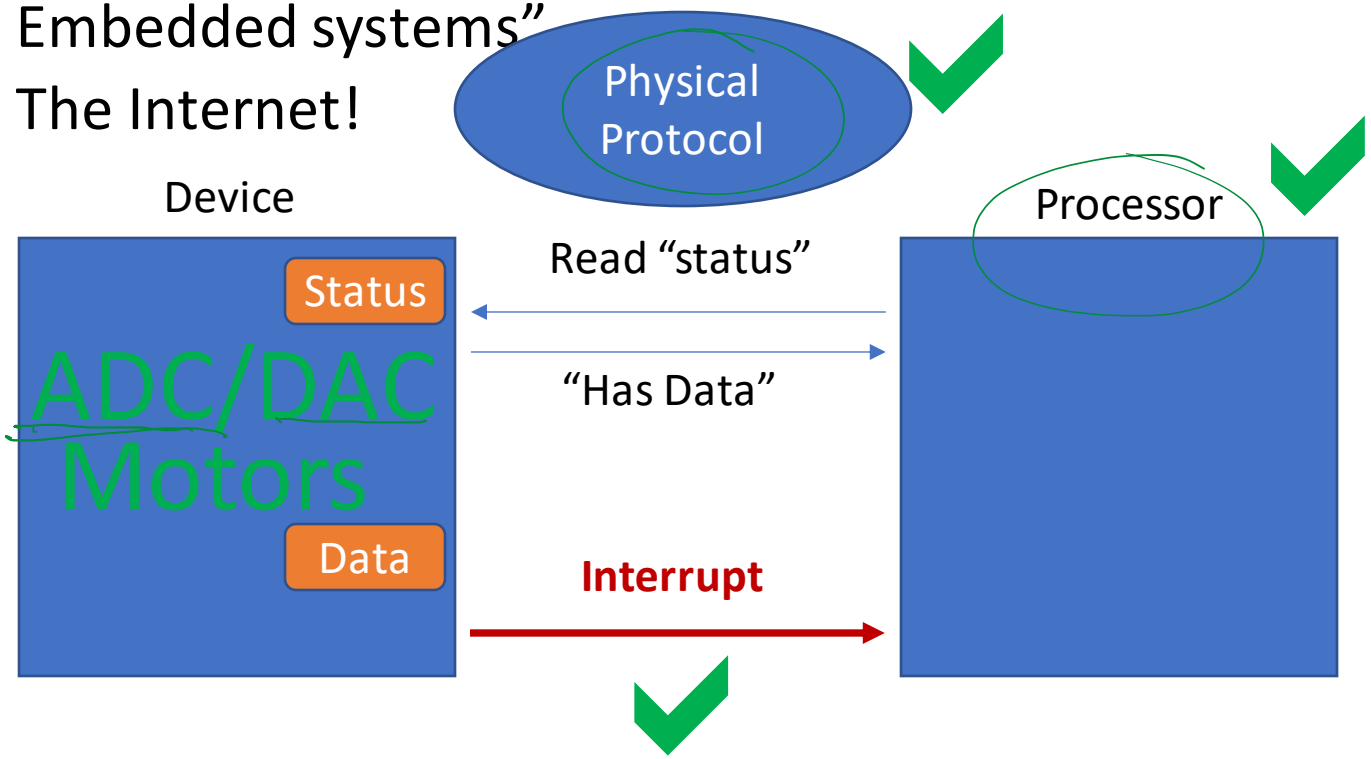
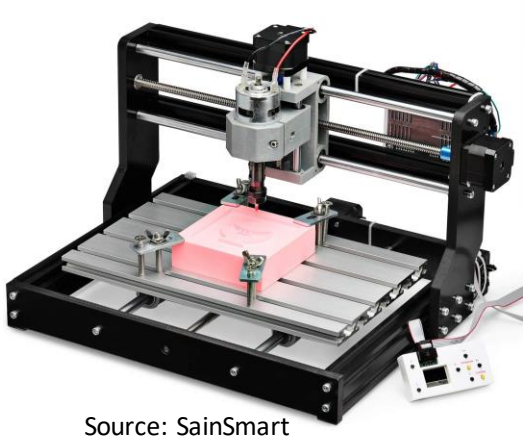
Context

- Recommended reading:
  - Datasheet of the devices
  - Chapter 14 and 16 of “AVR Microcontroller and Embedded systems”
  - The Internet!

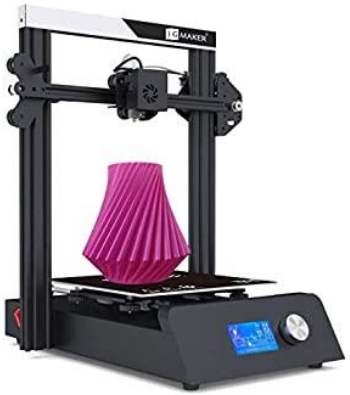


Motors are the muscles of cyber-physical systems

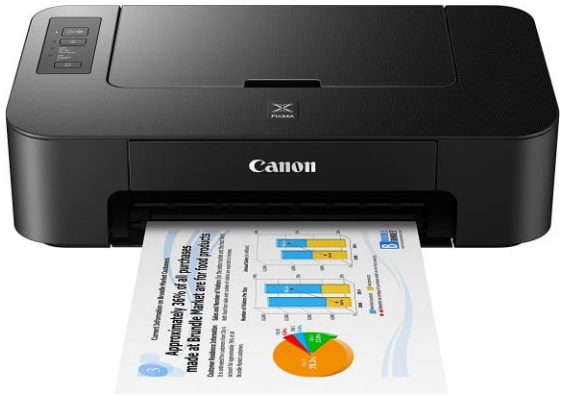


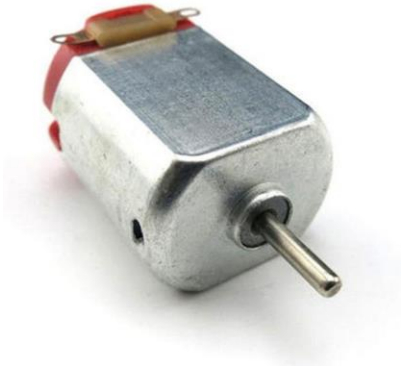
Source: SainSmart

Source: interbotix



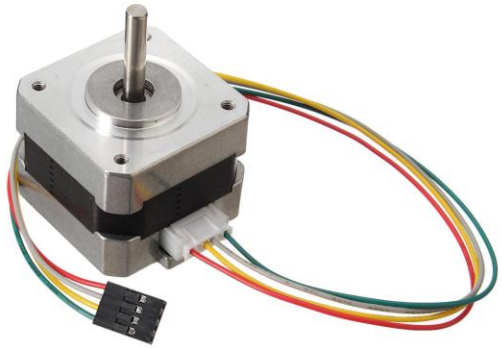
Source: JGMAKER





VS.

VS.



DC Motor

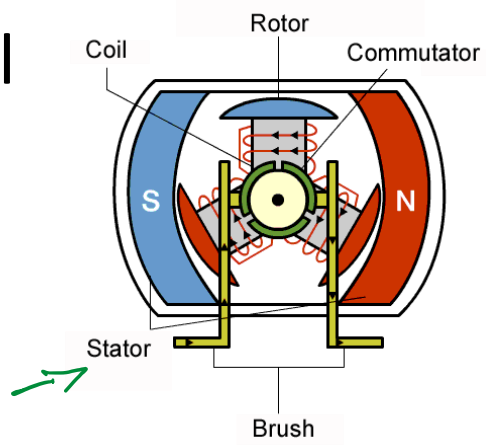
Servo Motor

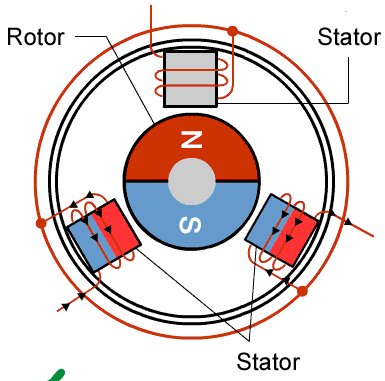
Stepper Motor

DC Motors

DC Motors

- Use magnetic fields to convert electrical energy to mechanical energy
- Brushed
  - The current is provided with two metallic brushes
  - Windings wrapped around rotator teeth
- Brushless
  - Permanent magnet rotor
  - Windings wrapped around stator polls





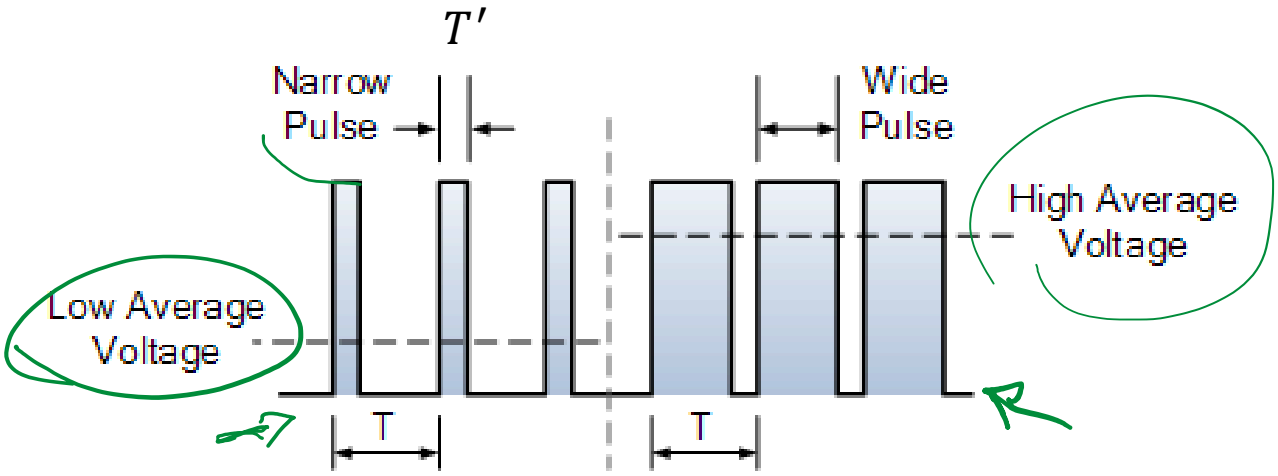
Source: Renesas

How to Control the Speed of a DC Motor?

- Speed of the motor is directly proportional to supply voltage.

Pulse-Width Modulation (PWM)

- Controlling average power delivery by switching the power on and off at a fast rate
- Duty cycle: the portion of "on" time: $\frac{T'}{T} * 100\ (\%)$
- Average Voltage = $Duty\ Cycle\ * V$



Source: https://www.electronics-tutorials.ws/blog/pulse-width-modulation.html

DAC VS. PWM?

- Depends on the application
- Overhead?

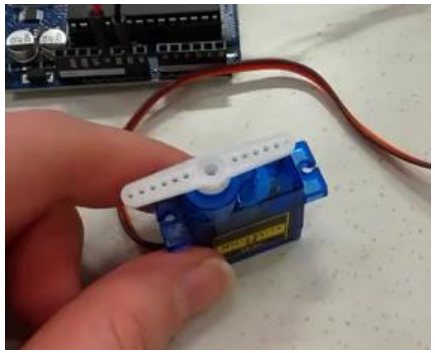
➢ Example: Driving an LED?
  - PWM: switching is faster than the eye's response

➢ Example: Small DC motors?
  - PWM: mechanical inertia smoothens the movement

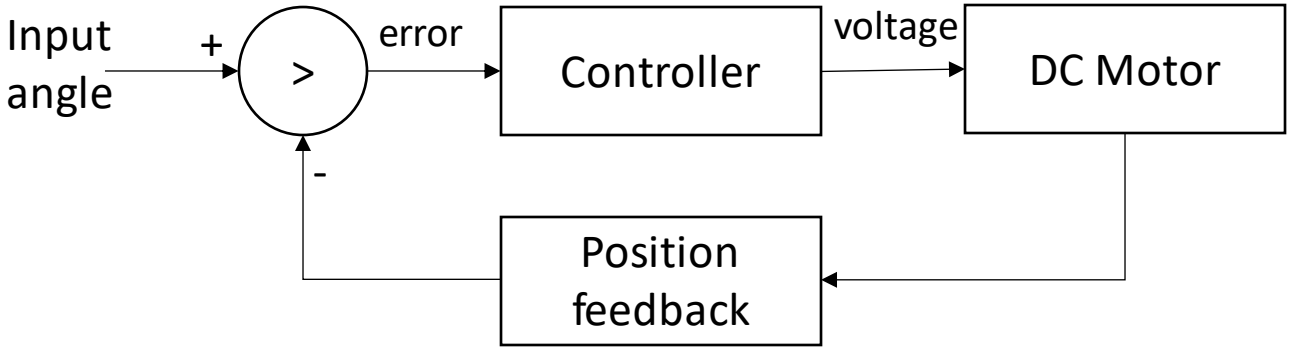
➢ Example: Generating sound?
  - DAC: we need a continuous, noise free analog signal

Servo Motors

Servo Motor

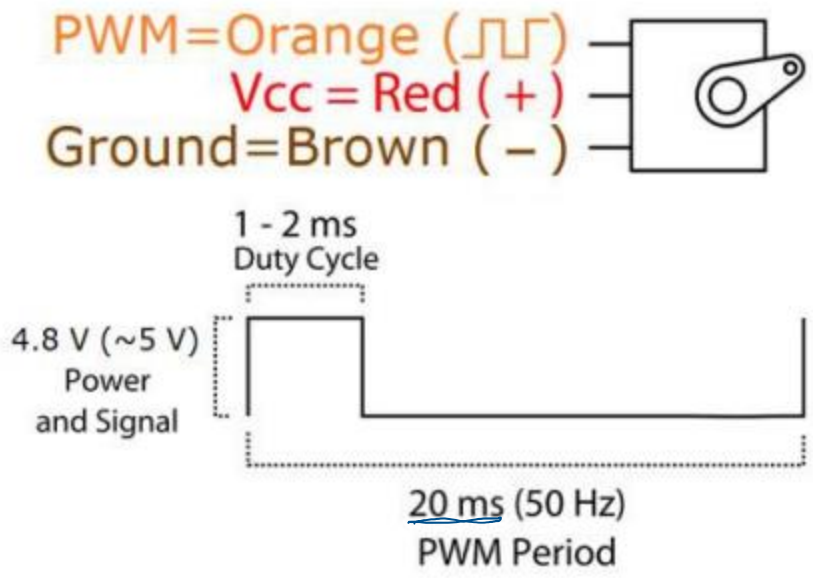


- A self-contained electrical device for precise control of linear or angular position or velocity



Servo Motor Control Using PWM

- Angle = Function(PWM duty cycle)
  - E.g., 1ms = 0 degree, 1.5ms = 90 deg., 2ms = 180 deg.



Source: servo motor SG90 datasheet

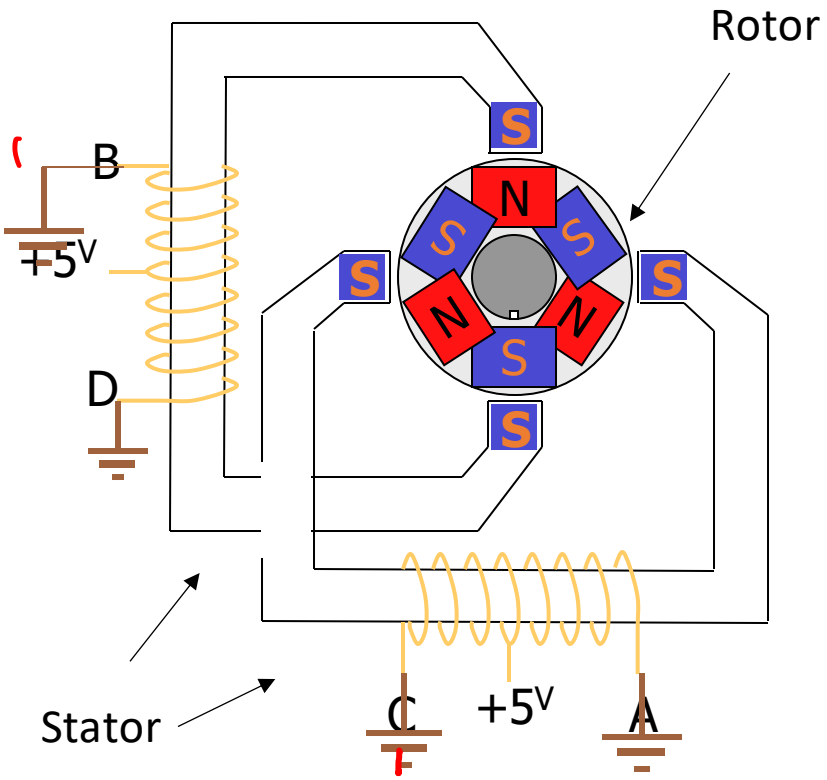
Stepper Motors

Stepper Motors

- More accurately controlled than a normal motor allowing fractional turns or n revolutions to be easily done
- Low speed, and lower torque than a comparable D.C. motor
- Useful for precise positioning for robotics

Stepper motor

- Stepper motor is a motor, whose rotation angle is proportional to its input pulse.
- 4-step switching sequence
  - One tooth pitch per 4 seq



Step #	Winding A	Winding B	Winding C	Winding D
1	1	0	0	1
2	1	1	0	0
3	0	1	1	0
4	0	0	1	1

Clockwise

Counter Clockwise

Stepper Motor Step Angles

- Minimum step angle is a function of number of teeth on the rotor

Step Angle	Steps Per Revolution
(360/500) = 0.72	500
1.8	200
2	180
2.5	144
5	72
7.5	48
15	24

Vector Generation

- Write C code to generate the bit stream on the GPIO pins