Microcontroller Programming Beginning with Arduino

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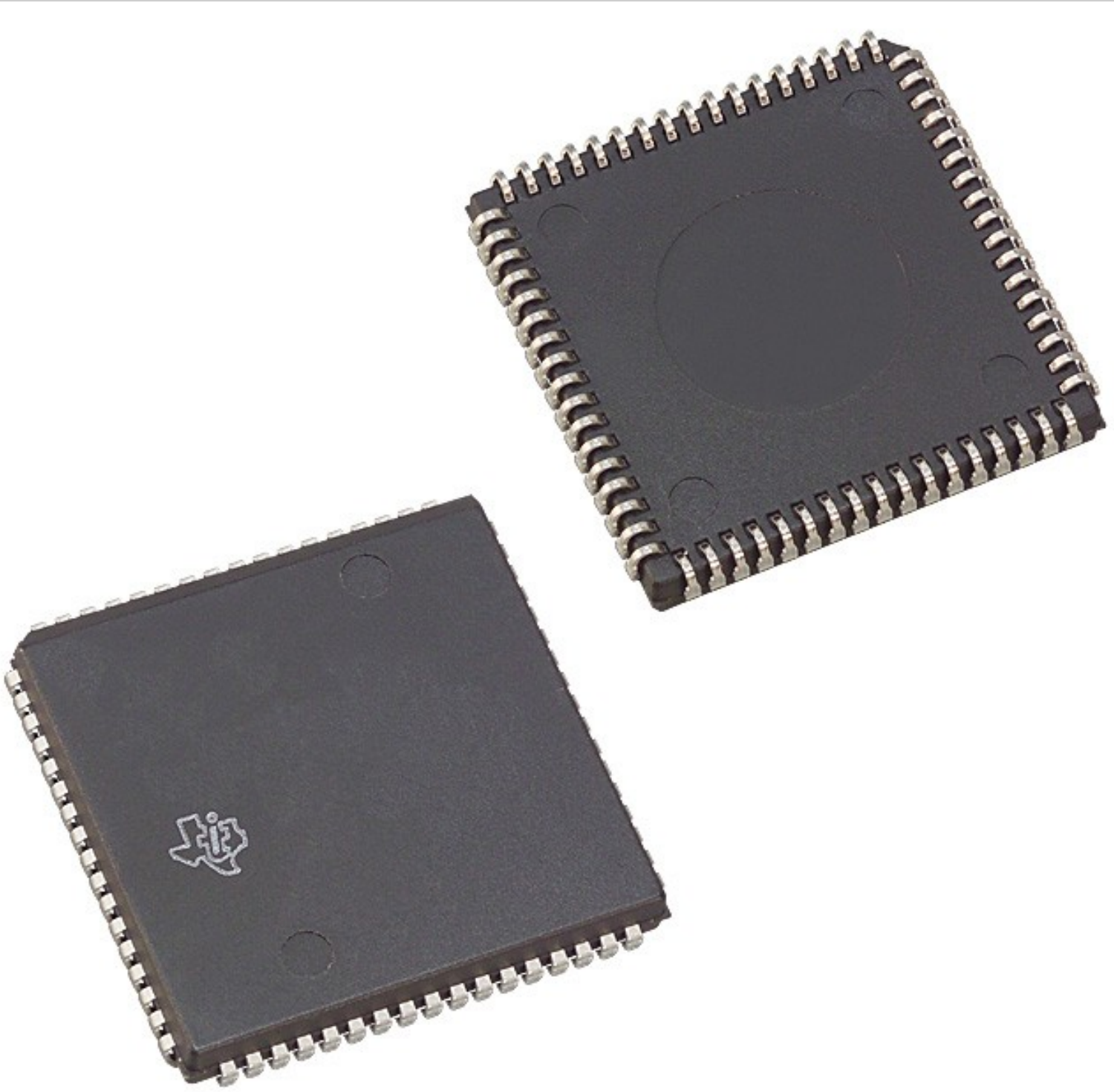
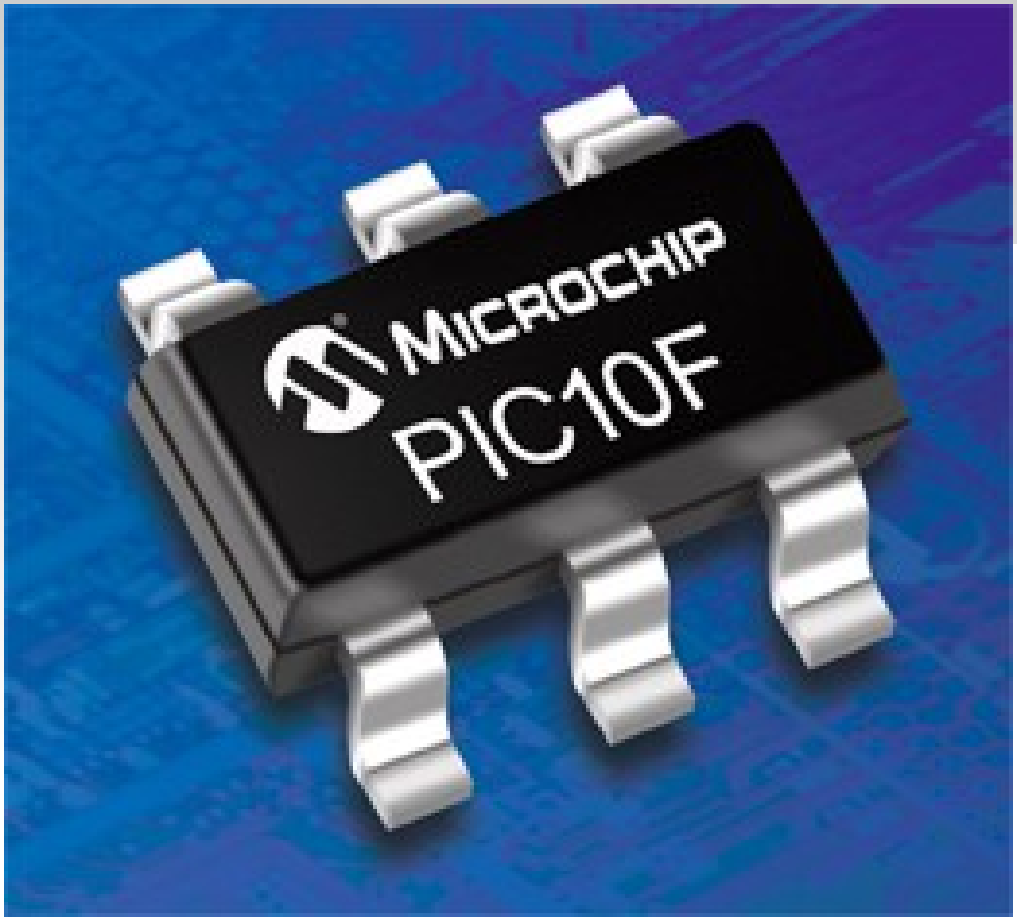
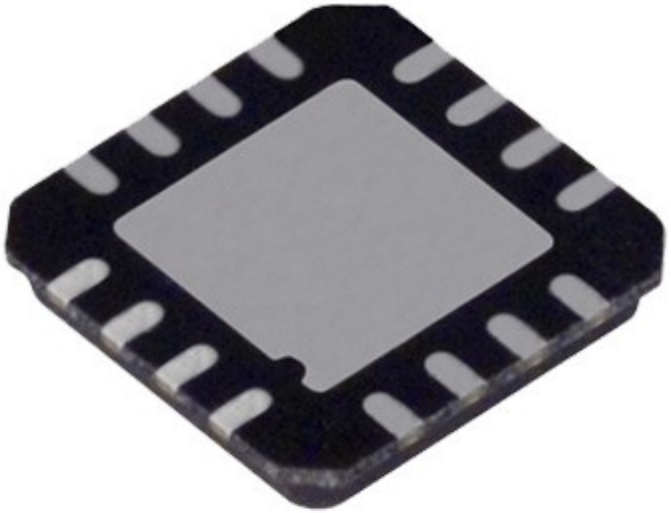
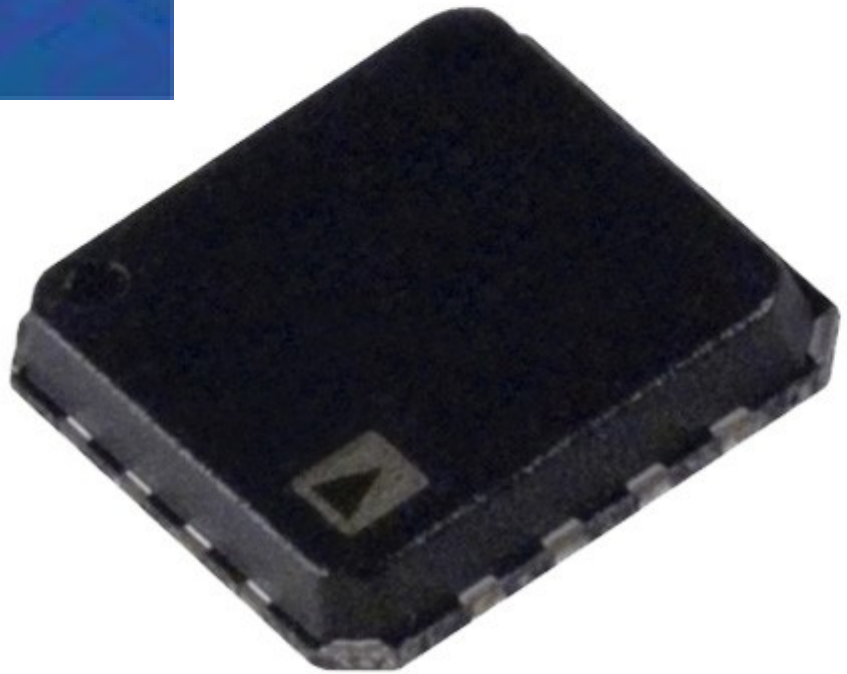
Microcontrollers

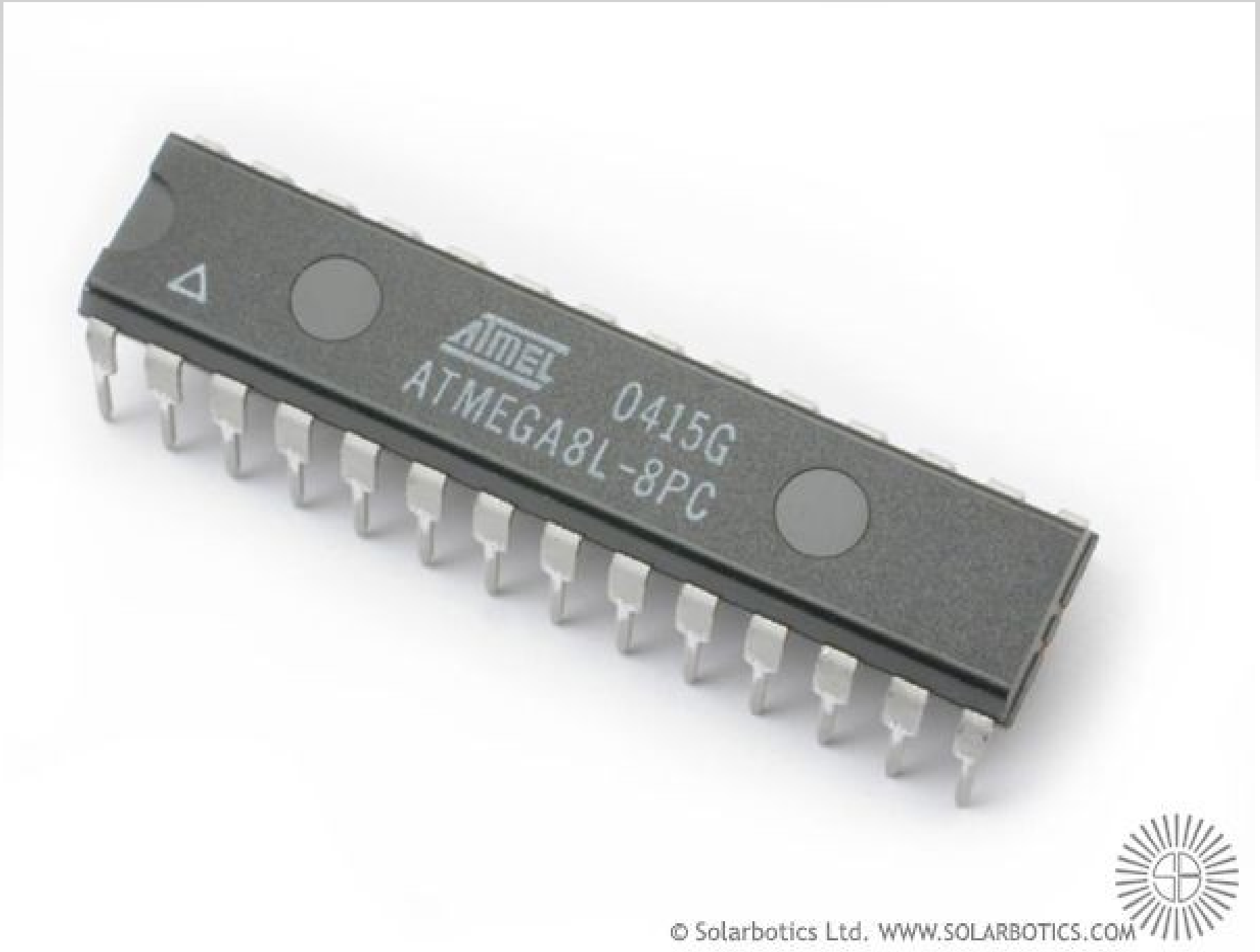
- Tiny, self-contained computers in an IC
- Often contain peripherals
- Different packages availible
- Vast array of size and power availible




MICROCHIP
PIC10F



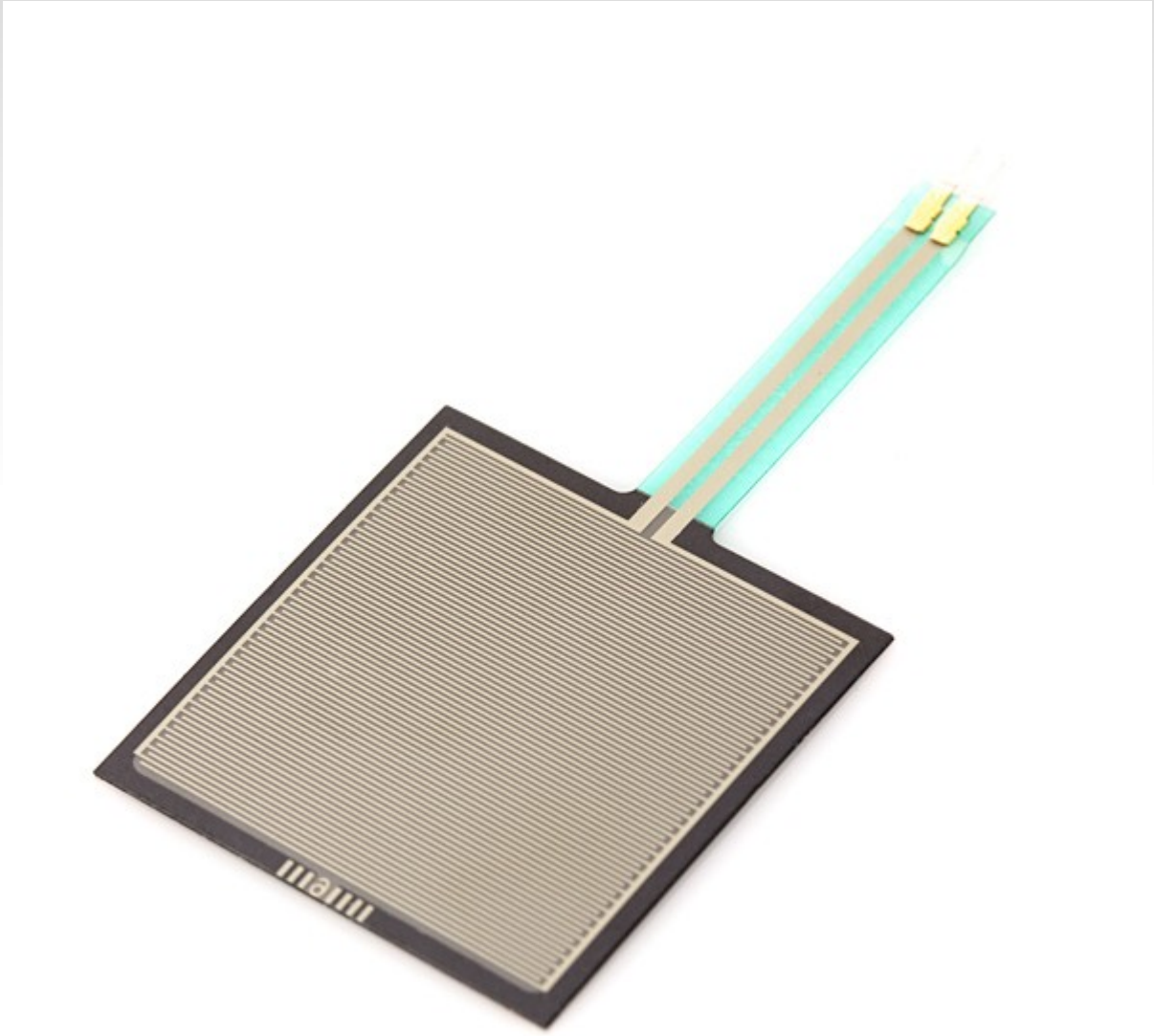




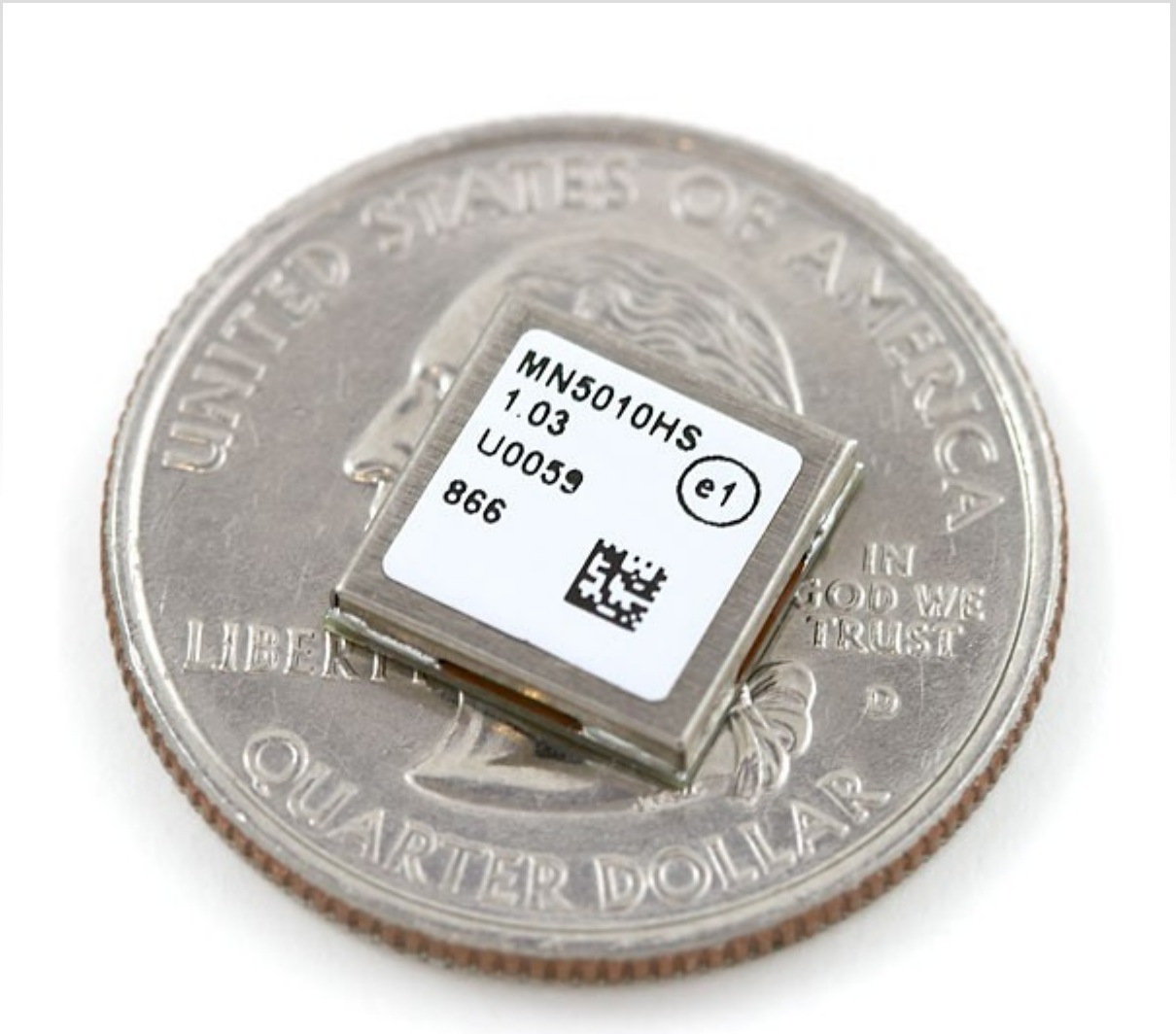
Sensory Input

- Robots need to be able to recieve input from the world in the form of sensory input.
- Microcontrollers handle this input.
- Thousands of sophisticated sensors availiable

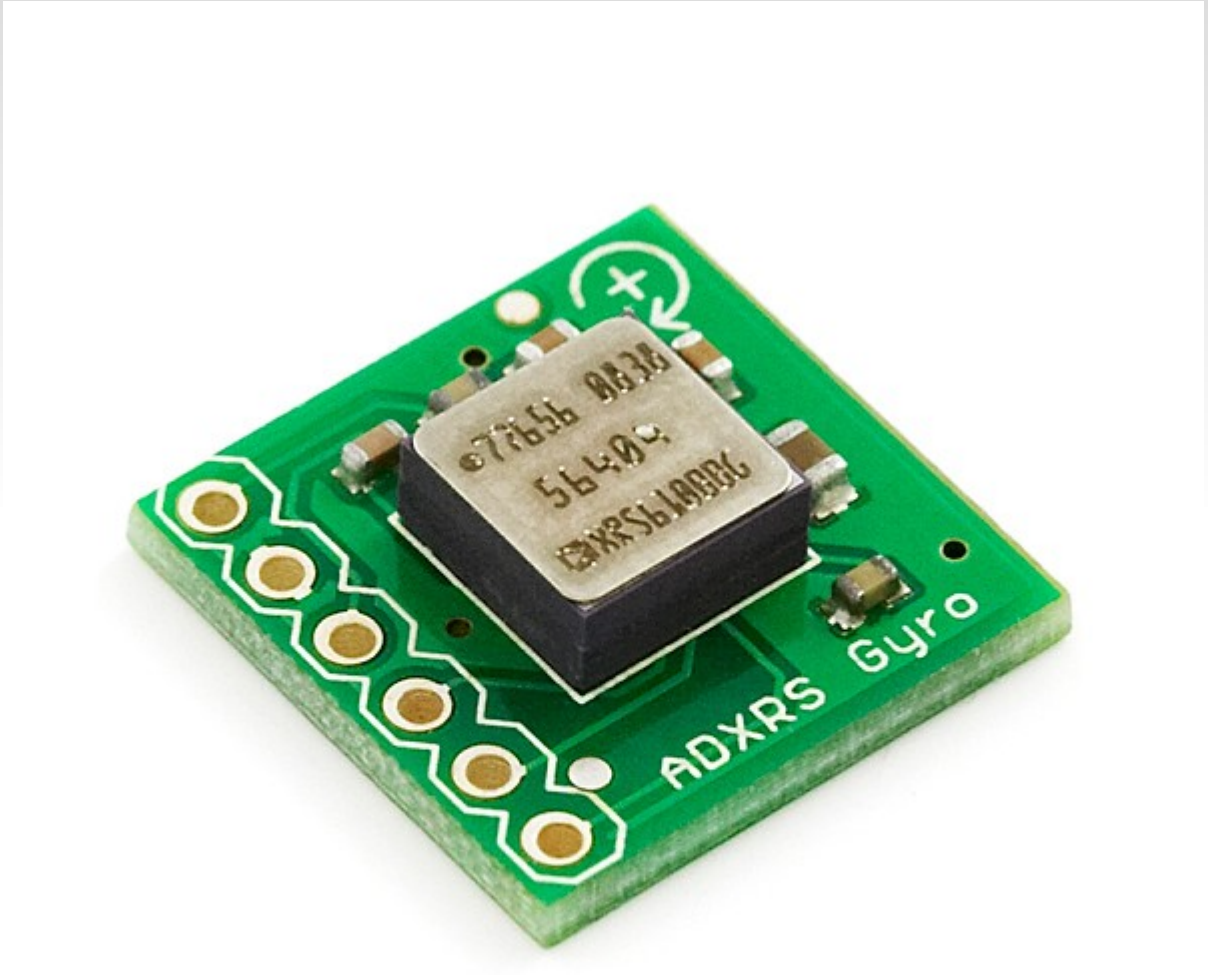
Pressure/Force Sensors



GPS Locators



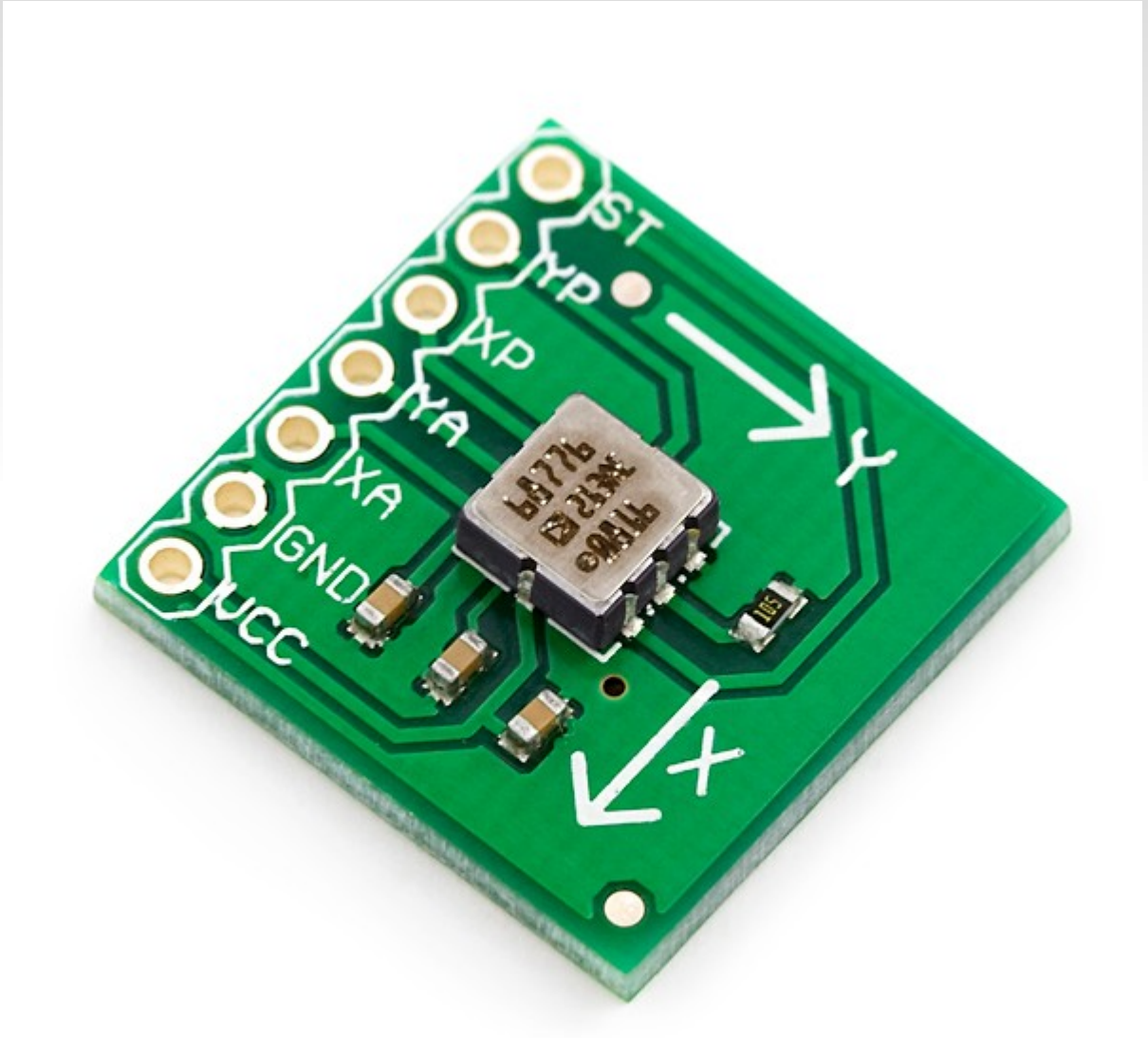
Gyroscopes



Wheel Encoders

Infared Proximity Detectors

Accelerometers

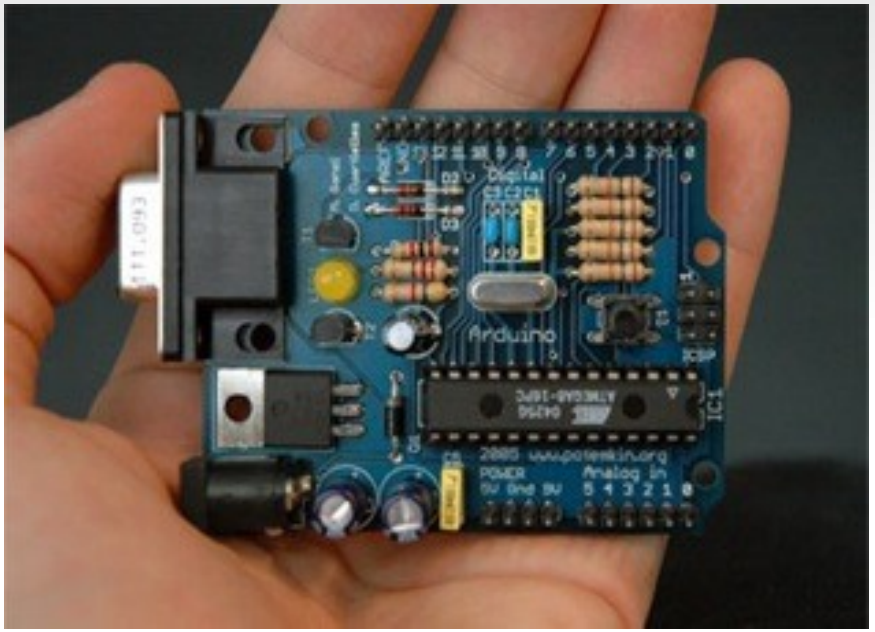


Ultrasonic Rangefinders

Alcohol Vapor Density Detectors

Arduino

- Development board for the ATMega328
- Inludes
  - Programmer,
  - Voltage Regulators
  - Seral to USB Converter



- CHEAP -- $30! Has everything you need!

Arduino C Template

```
void setup() {
  // Setup stuff to only run once at the beginning
}


void loop()
{
  // This function gets called indefinatly
}
```

Peripherals

- Analog to Digital Converters (ADC)
- Counters/Timers (TMRx)
- PWM Modules (CCP/PWM)
- Serial Ports (UART)
- Many, many more....

Digital I/O

- Only HIGH and LOW values
- Each pin configurable to do input or output
  - pinMode(pinNumber, pinState)

  - pinMode(13, INPUT)
  - pinMode(13, OUTPUT)

Digital I/O (Part II)

- Output
  - digitalWrite(pinNumber, HIGH/LOW)
- Input
  - int val = digitalRead(pinNumber)

Arduino Digital I/O Example

```
int ledPin =  13;
void setup() {
  // Set the digital pin as output:
  pinMode(ledPin, OUTPUT);
}
void loop()
{
  // Bring the pin high (1)
  digitalWrite(ledPin, HIGH);
}
```

Serial Interface (UART)

- Communicate with other microcontrollers or PC's
- Asynch. communication
- Arduino libraries make it extremely easy
  - Serial.begin(baudRate)
  - Serial.println(”String To Send”)
  - int bytesWaiting = Serial.Availible()
  - Char incomingData = Serial.read()

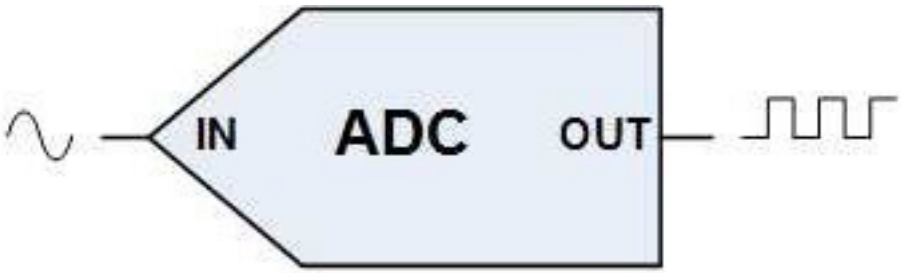
Arduino Serial Example

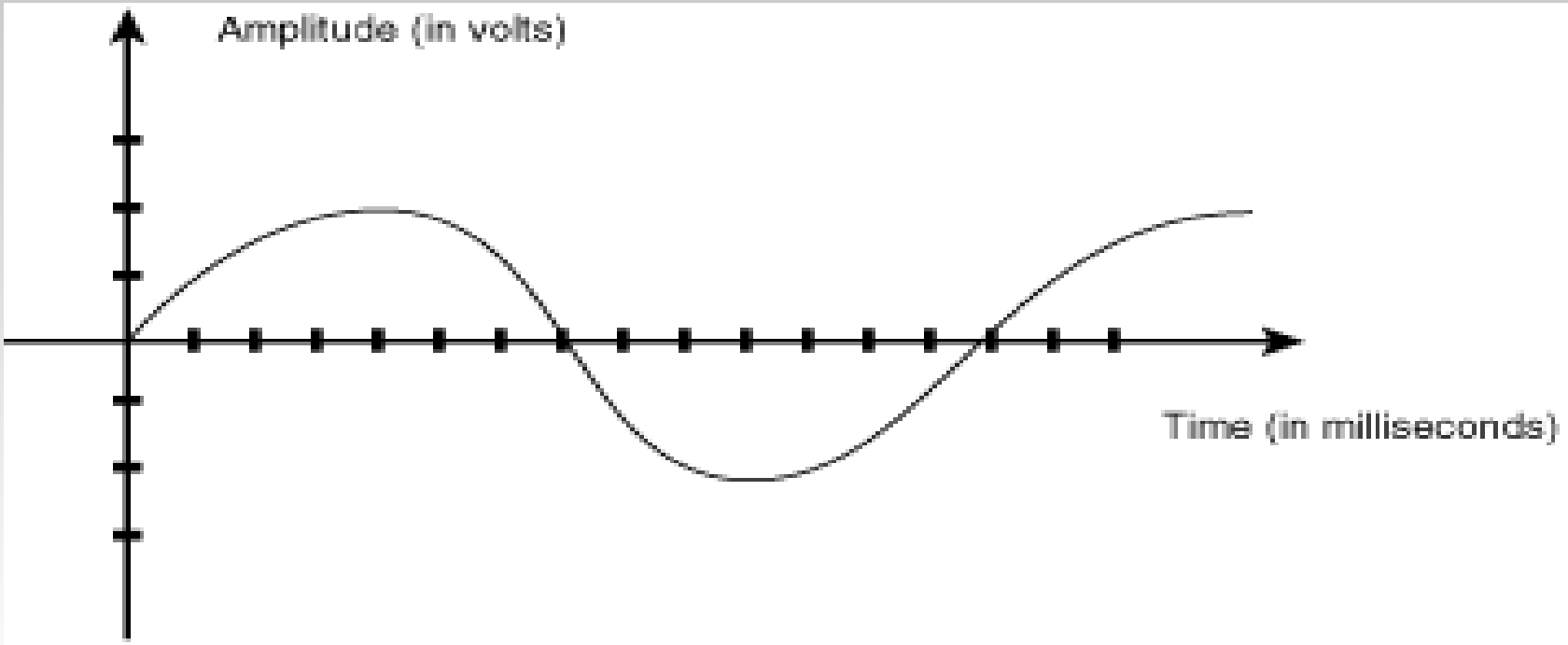
```
void setup() {
        Serial.begin(9600);  // Setup baud rate
    }

void loop() {
        Serial.println(”Give me input”);  // output data
        while(Serial.availible() < 1) {     // if there's data waiting
            char input = Serial.read();     // get a byte of data
        }

}
```

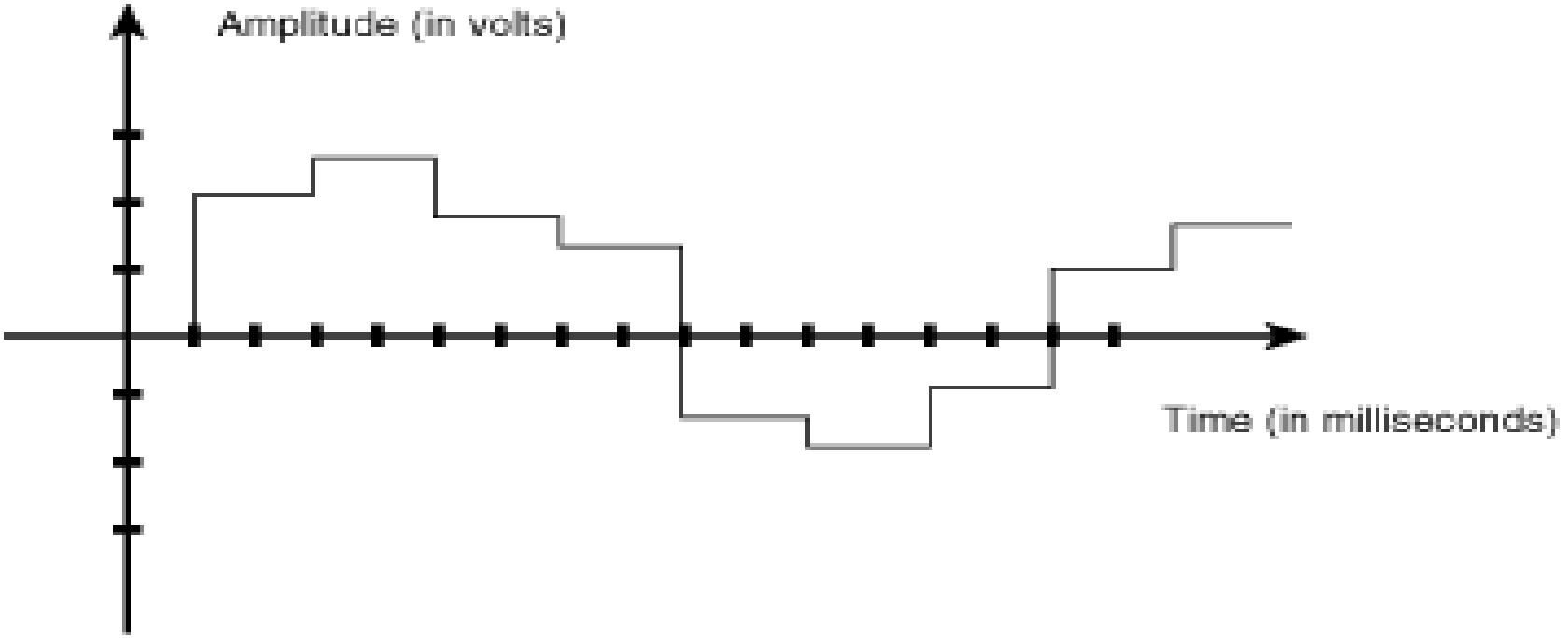
Analog to Digital Converter (ADC)

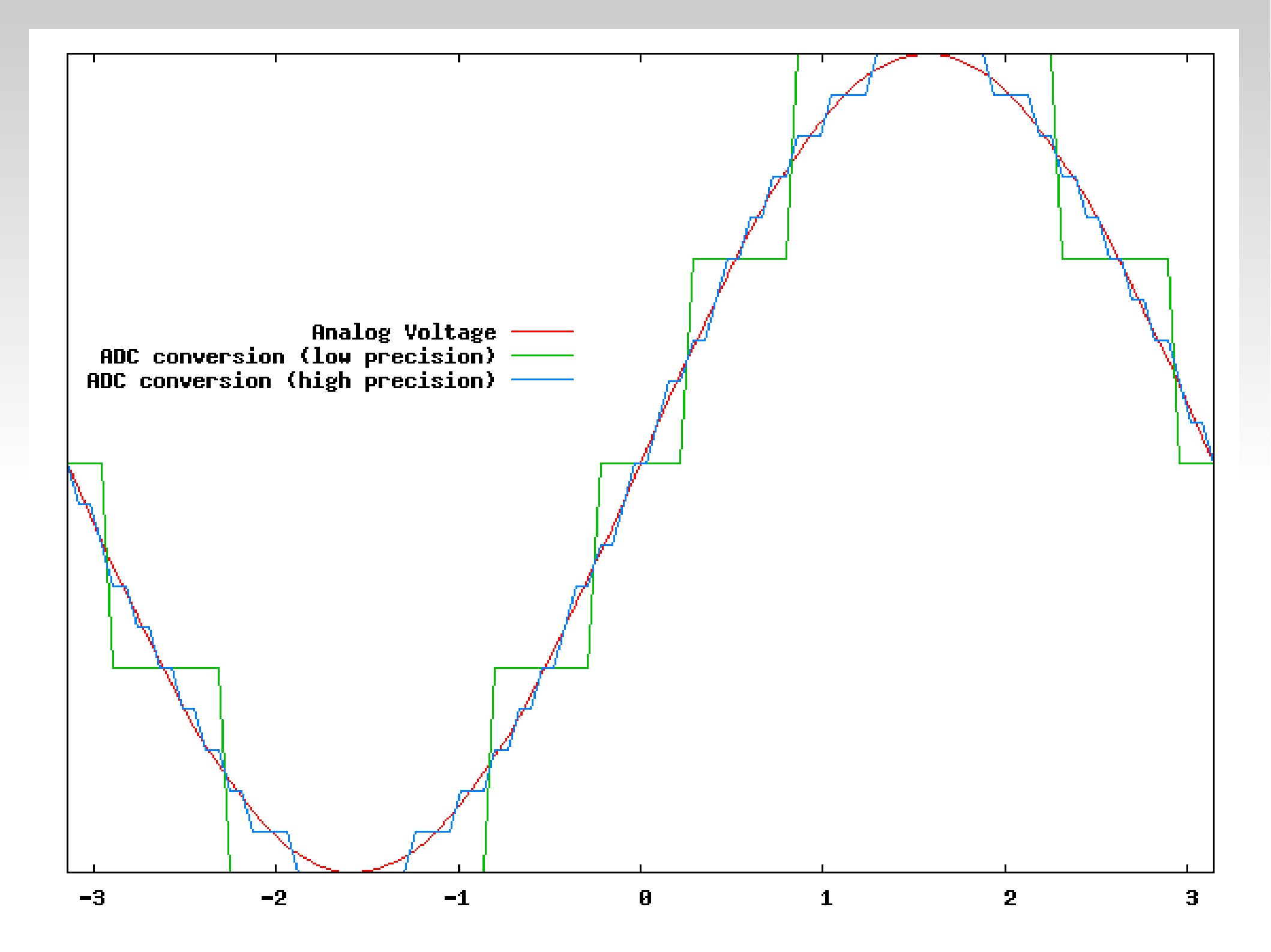
- Take **analog** voltage as input on one of the pins
- Return **digital** representation to program

- Different numbers of bits change precision.




Amplitude (in volts)
Time (in milliseconds)


Amplitude (in volts)
Time (in milliseconds)


Analog Voltage
ADC conversion (low precision)
ADC conversion (high precision)
-3
-2
-1
0
1
2
3

Light Sensors

- Photoresistors
- Extremely Simple to Use
- Resistance changes with light
- Measure voltage over the sensor with an ADC, and you're done

- Many more complicated sensors simulate this behavior for simplicity

Arduino ADC Example

```
int sensorPin = 0;

void setup() {
  Serial.begin(9600); // Turn on Serial Connection
}
void loop() {
  // read the value from the sensor:
  sensorValue = analogRead(sensorPin);

  // Print sensor value to the Serial
  Serial.println(sensorValue);
}
```

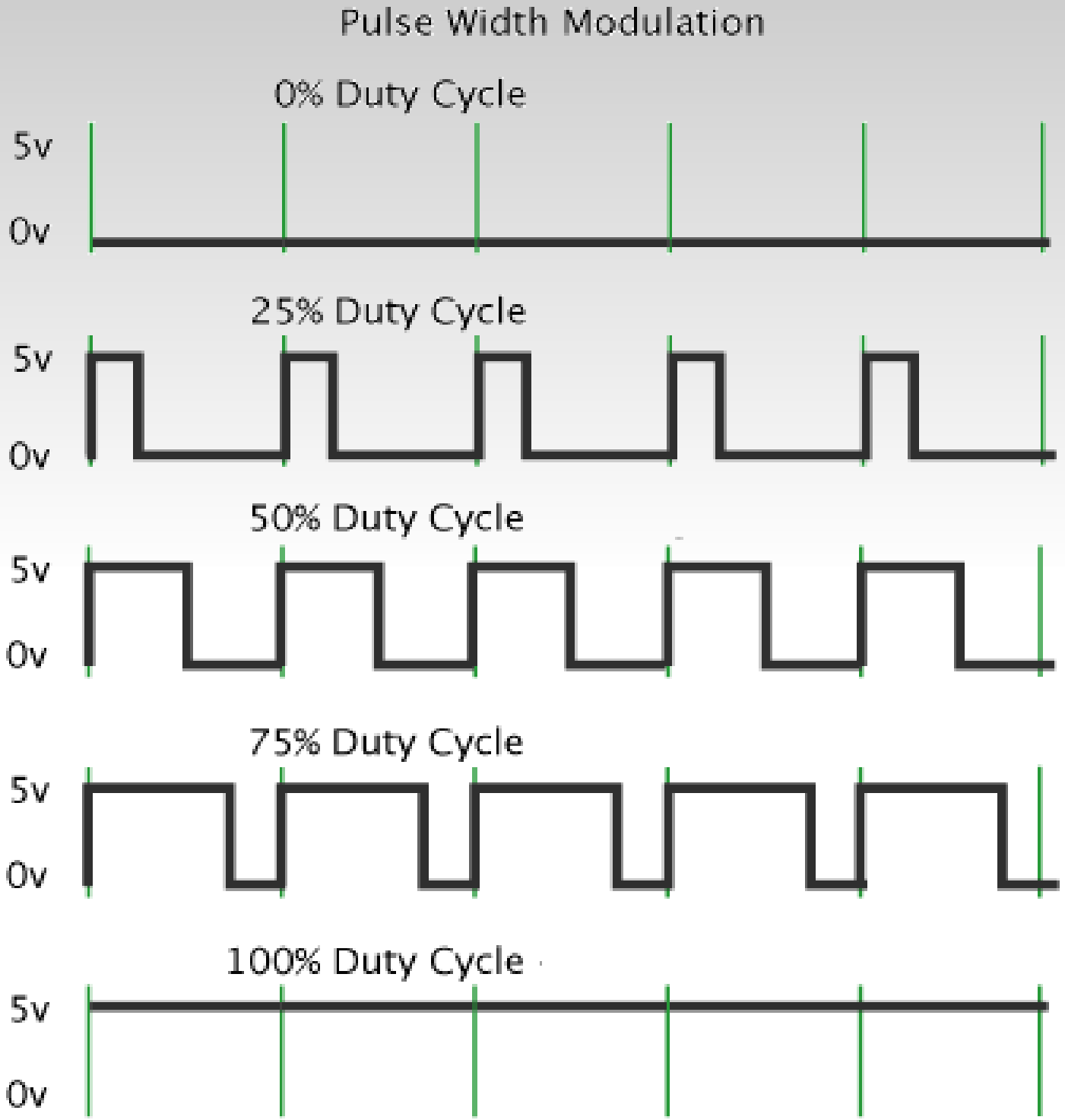
PWM Modules (CCP)

- Create PWM signals on output pins
- Measure PWM signals on input pins
- CCP stands for Capture/Compare

- What is PWM, anyway?

Pulse Width Modulation (PWM)

- Transmit analog values using a single digital input/ output pin through careful timing.
- A PWM signal consists of two values
  - Period: how long before the signal repeats
  - Pulse Width: how long the signal is HIGH before it goes LOW.
- Duty Cycle: % of time the signal is HIGH, or (Pulse Width / Period)

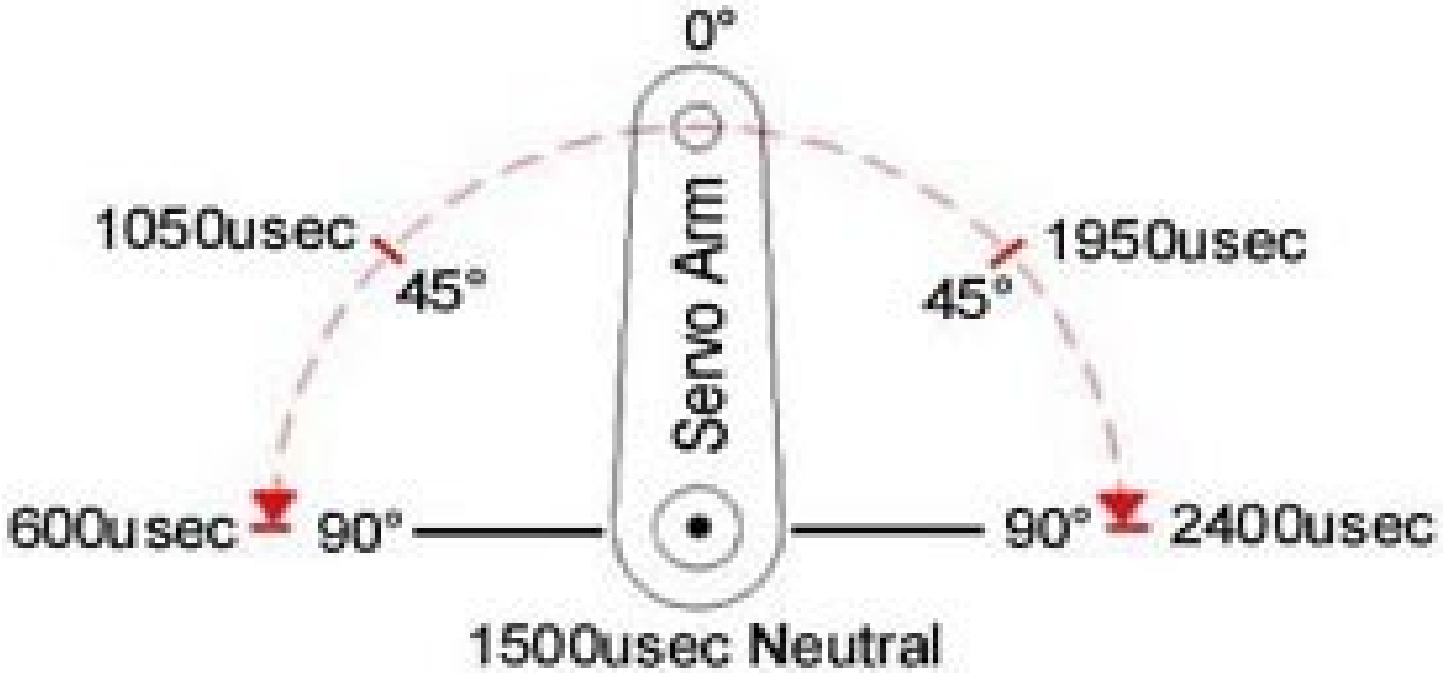

Pulse Width Modulation
0% Duty Cycle
5v
0v
25% Duty Cycle
5v
0v
50% Duty Cycle
5v
0v
75% Duty Cycle
5v
0v
100% Duty Cycle
5v
0v

PWM In Robotics

- The average voltage (Duty Cycle * Voltage) can be used to control the speed of DC motors.
  - Innaccurate, poor strength, braking, and other problems exist.
- Servo Motors and Speed Controllers.

Servo Motors

- DC Motor with gears allow for high torque
- Embedded microcontroller monitors PWM input and motor position.
- Vary pulse width to change **position** of motor



Speed Controllers

- Embedded microcontroller varies voltage on output lines based on PWM input.
- Results in constant voltage to motors rather than intermittent.
- Allow a second, more powerful, power supply to drive large motors.
- Alter pusle width to change the **speed** of the motor

Arduino PWM Command

- AnalogWrite(Pin, DutyCycle)
  - DutyCycle = 0 → 0%, 127 → 50%, 255 → 100%
  - Pin can be 3, 5, 6, 9, 10, or 11
- Frequency of about 490Htz
  - Other periods are possible, but not with AnalogWrite

Arduino PWM Example

```
int Pin = 9;

void setup()

{

  pinMode(Pin, OUTPUT);

}

void loop()

{

  analogWrite(Pin, 127);  // Generate 50% duty cycle on ”Pin”

}
```

Useful Resources

- Robot Parts and Excellent Forums
  www.TrossenRobotics.com
- Electrical parts, sensors, and microcontrollers
  www.Sparkfun.com
- Arduino Development Platform
  www.ardiono.cc