Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Driving Different Motors
with Arduino

Ben Cheng

RISD ID

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Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Outline I

1 Basic AC/DC Motor
Basics of Motors
Analog Control
Digital Control

2 Stepper Motor

3 Servo Motor

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Basics of Motors

Basic Principle of Motors

Theorem (Biot-Savart Law)

$$\mathbf{B} = \frac{\mu_0}{4\pi} \oint_{C_1} \frac{I d\mathbf{l}' \times \hat{\mathbf{R}}}{R^2}$$

Theorem (Lorentz's equation)
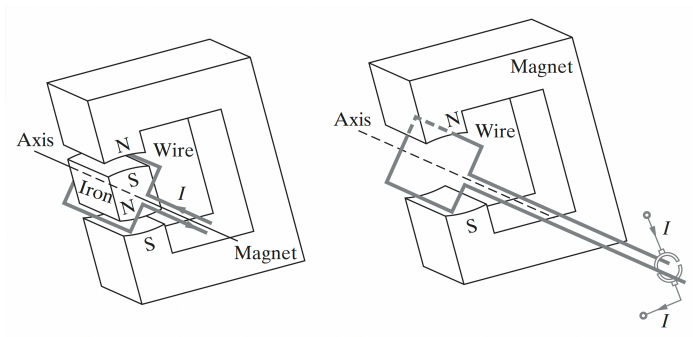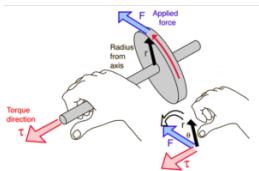
$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$$

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Basics of Motors

AC vs DC Motors

Figure: Simple dc motor. (Inan 2015)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Basics of Motors

Torque and Power

How much torque is needed to lift this?

Theorem (Torque)

$$\tau = F \times r$$

(Linear Motion Tips)

How much power do I need to drive this motor?

Theorem (Power)

$$P = I \times V$$

(Energy per unit time)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Analog Control

Analog Control

Theorem (Ohm's Law)

$$V = A \times R$$

, *or*
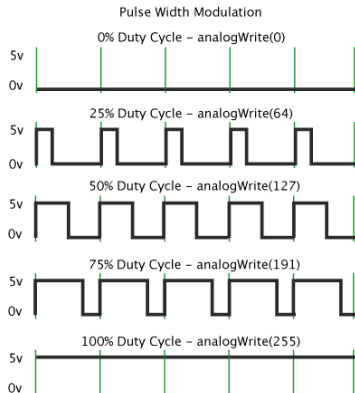
$$A = \frac{V}{R}$$

- Simple, accurate, predictable
- Power source = control unit
- Hard to implement on microcontroller

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
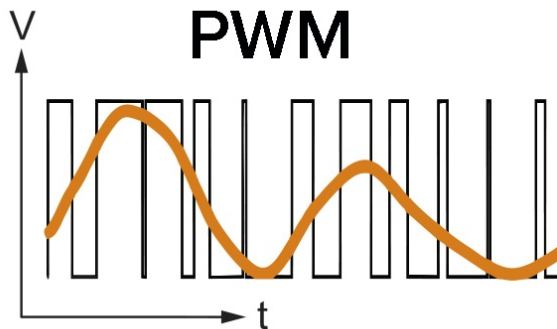○○○○○○○○○

Digital Control

Digital Control: PWM

Pulse Width Modulation

- Easy to implement on microcontroller
- Easy manipulation
- Inaccurate approximation
- Power and control unit saperated

Pulse Width Modulation

0% Duty Cycle - analogWrite(0)

25% Duty Cycle - analogWrite(64)

50% Duty Cycle - analogWrite(127)

75% Duty Cycle - analogWrite(191)

100% Duty Cycle - analogWrite(255)

(Arduino)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Digital Control

PWM Approximation

(Thomson Linear)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
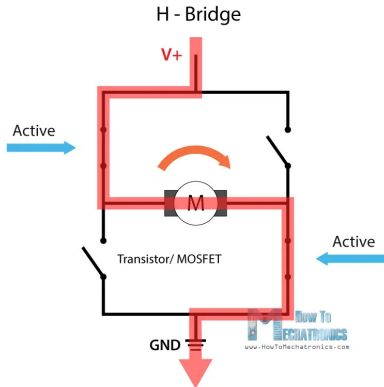○○○○○○○○○

Digital Control

Saperated Power and Control Unit

- Scale of current:
    - $2A$: Fry a human
    - $0.35A$: DC Motor
    - $20mA$: Arduino Pinout
- Saperate power and signal circuit
    - MOSFET
    - Bipolar Junction Transistor
    - Relay
    - H-Bridge

BJT. (Hambly 2018)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Digital Control
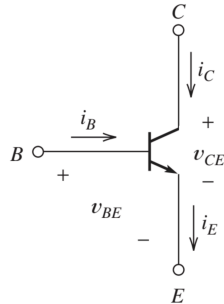
L298N Motor Driver

H - Bridge

Active

Transistor/ MOSFET

Active

- ENA to pin 9 (PWM)
- IN1, IN2 to pin 5, 6
- GND and 12V to pwr supply
- OUT1, OUT2 to motor

(HowToMechatronics.com)

Digital Control

PWM Implementation

```
1   int speed = 255;
2   String inputStr = "";
3   bool clean = false;
4
5   void setup() {
6       inputStr.reserve(200);
7       Serial.begin(9600);
8       // put your setup code here, to run once:
9       pinMode(5, OUTPUT);
10      pinMode(6, OUTPUT);
11      pinMode(9, OUTPUT);
12
13      digitalWrite(5, 1);
14      digitalWrite(6, 0);
15  }
```

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Digital Control

analogWrite()

```
1   void loop() {
2       // put your main code here, to run repeatedly:
3       if (clean) {
4           analogWrite(9, inputStr.toInt());
5           Serial.println(inputStr.toInt());
6           // clear the string:
7           inputStr = "";
8           clean = false;
9       }
10
11      }
```
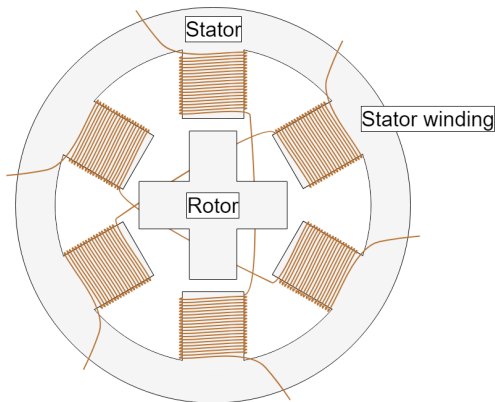
Basic AC/DC Motor
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Stepper Motor
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Servo Motor
ooooooooo

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Stepper Motor

Stator

Stator winding

Rotor

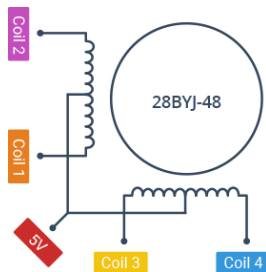(monolithicpower.com)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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28BYJ-48 Stepper Motor

- 4 coils
- 32 steps per revolution
- plus 64:1 gear ratio
- 2048 steps per revolution
- 5 pins

(lastminuteengineering.com)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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## Stepper vs DC Motor

- Stepper is very accurate
- More difficult to control
- More power draw, more heat generation
- Stepper is suitable for short period, precise application.
- DC motor is for continuous, powerful application.

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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ULN2003

- 7 Darlington pair (BJT)
- 500*mA* emitter current

(Texas Instrument)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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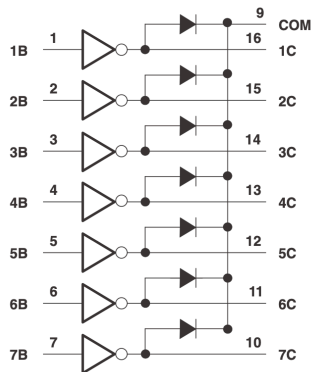
Stepper Library

```
1  #include <Stepper.h>
2
3  // initialize the stepper library on pins 8 through 11:
4  Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);
5
6  void setup() {
7      // set the speed at 6 rpm:
8      myStepper.setSpeed(6);
9      // initialize the serial port:
10     Serial.begin(9600);
11 }
12
13 void loop() {
14     // step one revolution  in one direction:
15     Serial.println("clockwise");
16     myStepper.step(2048);
17     delay(500);
18 }
```
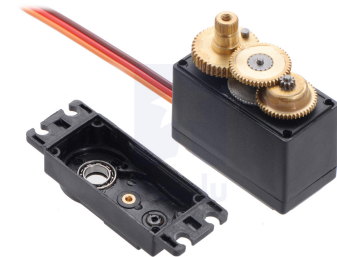
Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Inside Servo Motor

- DC Motor
- Gearbox
- Encoder
- Controller IC

www.pololu.com

(popolu.com)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Increasing Precision of DC Motor

Position
Command

Velocity
Command

Current
Command

Position
Loop

Velocity
Loop

Current
Loop

Motor

Load

Current
Sensor

Velocity
Position

Encoder

(Kollmorgan)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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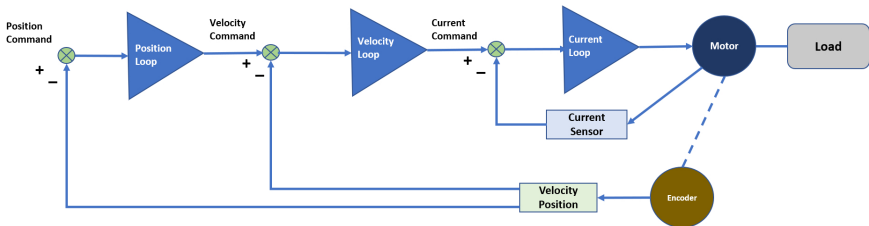
File>Examples>Servo>Sweep

Orange to pin 9, red to 3V3, brown to GND

```
1   #include <Servo.h>
2   Servo myservo;
3   void setup() {
4       myservo.attach(9);
5   }
6   void loop() {
7       int pos = 0;
8       for (pos = 0; pos <= 180; pos += 1) {
9           myservo.write(pos);
10          delay(30);
11      }
12      for (pos = 180; pos >= 0; pos -= 1) {
13          myservo.write(pos);
14          delay(30);
15      }
16  }
```

Basic AC/DC Motor
ооооооооооо

Stepper Motor
оооооо

Servo Motor
оооооооооо

File>Examples>Servo>Knob

Potentiometer: middle pin to A0, side pins to GND/5V

```
int potpin = A0;  // analog pin used to connect the potentiometer
int val;
void loop() {
    val = analogRead(potpin);
    val = map(val, 0, 1023, 0, 180);
    myservo.write(val);
    delay(15);
}
```

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Servo Pulse
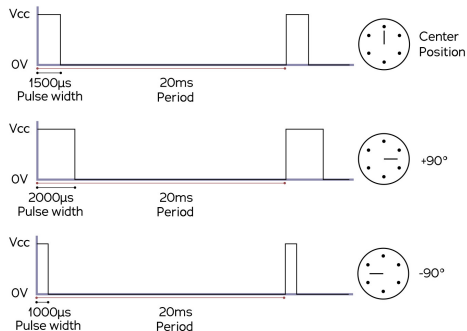
(Wikipedia user Hforesti)

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Servo vs Stepper vs DC Motor

Servo

- precise
- digital
- for less than 1 rev

Stepper

- precise
- digital
- for short period

Servo

- not for angular precision
- digital/analog
- for continuous rev

Basic AC/DC Motor
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Stepper Motor
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Servo Motor
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Bonus: IoT Servo

- Tools>Board>ESP8266>NodeMCU 1.0
- File>Examples>ESP8266HTTPClient>BasicHttpsClient

```
19  #define STASSID "RISD-MiscDevices"
20  #define STAPSK "T3chn0l0gy"
```

```
48  // client->setFingerprint(fingerprint_sni_cloudflaressl_com);
49  // Or, if you happy to ignore the SSL certificate, then use the
        following line instead:
50  client->setInsecure();
```

```
55      if (https.begin(*client, "https://idsb-motors.onrender.com/angle
            ")) { // HTTPS
```

Basic AC/DC Motor
ооооооооооо

Stepper Motor
оооооо

Servo Motor
оооооооо●

Bonus: IoT Servo

```
25  Servo myservo;
26
27  void setup() {
28      myservo.attach(2); //GPIO2=D4
```

```
67  if (httpCode == HTTP_CODE_OK || httpCode ==
        HTTP_CODE_MOVED_PERMANENTLY) {
68      String payload = https.getString();
69      Serial.println(payload);
70      myservo.write(payload.toInt());
71
72  }
```