Driving Different Motors
with Arduino

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Outline I

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)

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$$

AC vs DC Motors

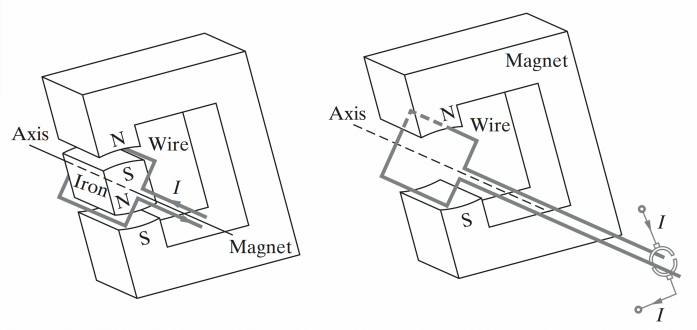


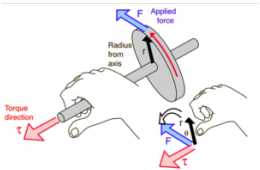
Figure: Simple dc motor. (Inan 2015)

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)

Analog Control

Theorem (Ohm's Law)

$$V = A \times R$$

, *or*

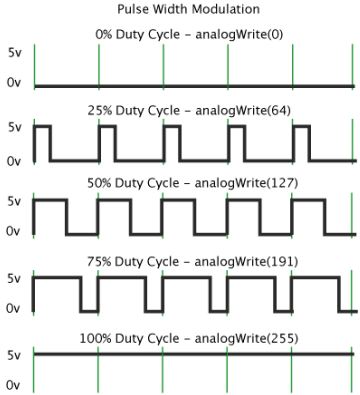
$$A = \frac{V}{R}$$

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

Digital Control: PWM

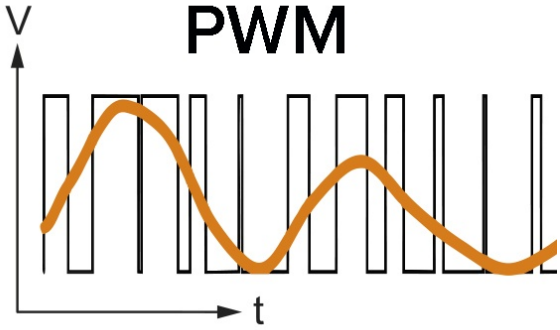
Pulse Width Modulation

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



(Arduino)

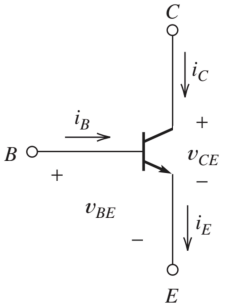
PWM Approximation



(Thomson Linear)

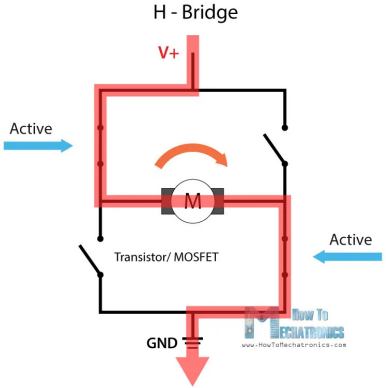
Saperated Power and Control Unit

- 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)

L298N Motor Driver



(HowToMechatronics.com)

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

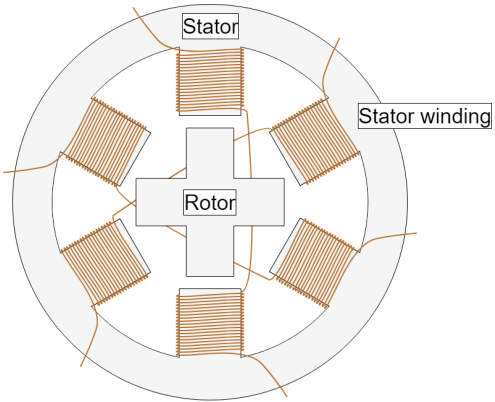
PWM Implementation

```
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 }
```

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     }
```

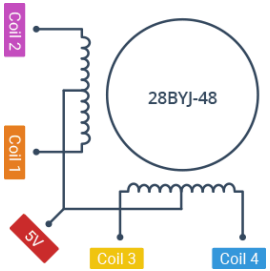
Stepper Motor



(monolithicpower.com)

28BYJ-48 Stepper Motor

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



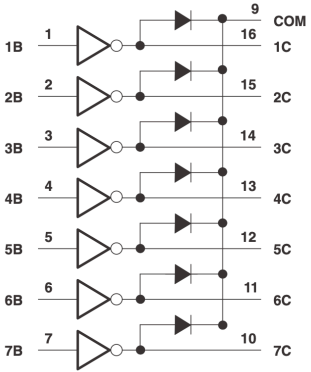
(lastminuteengineering.com)

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.

ULN2003

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



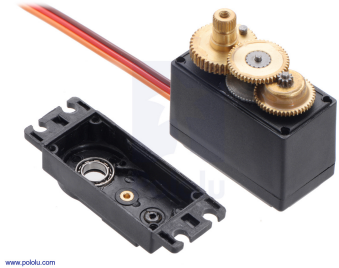
(Texas Instrument)

Stepper Library

```
#include <Stepper.h>

// initialize the stepper library on pins 8 through 11:
Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);

void setup() {
    // set the speed at 6 rpm:
    myStepper.setSpeed(6);
    // initialize the serial port:
    Serial.begin(9600);
}

void loop() {
    // step one revolution  in one direction:
    Serial.println("clockwise");
    myStepper.step(2048);
    delay(500);
}
```

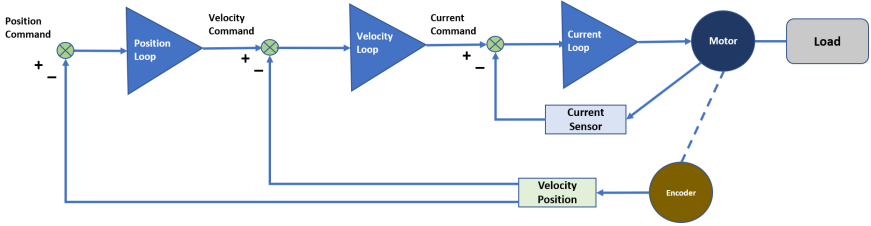
Inside Servo Motor

- DC Motor
- Gearbox
- Encoder
- Controller IC



(popolu.com)

Increasing Precision of DC Motor



(Kollmorgan)

File>Examples>Servo>Sweep

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

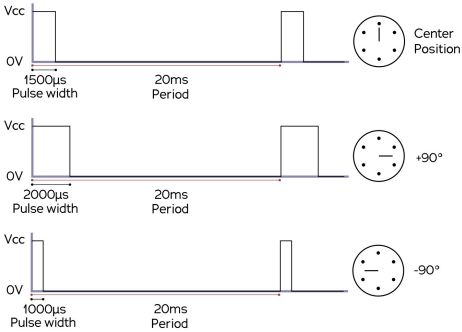
```
1  #include <Servo.h>
2  Servo myservo;
3  void setup() {
4      myservo.attach(9);
5  }
6  void loop() {
7      int pos = 0;
8      for (pos = 0; pos <= 180; pos += 1) {
9          myservo.write(pos);
10         delay(30);
11     }
12     for (pos = 180; pos >= 0; pos -= 1) {
13         myservo.write(pos);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

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);
}
```

Servo Pulse



(Wikipedia user Hforesti)

Servo vs Stepper vs DC Motor

Servo

- precise
- digital
- for less than 1 rev

Stepper

- precise
- digital
- for short period

DC Motor

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

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
```

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  }
```