Controlling Motors

OBEY ME!
On-Off Control
1. Switch control
2. Transistor control

<table>
<thead>
<tr>
<th>Type</th>
<th>Imax (mA)</th>
<th>Vce (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N3904</td>
<td>100</td>
<td>0.2</td>
</tr>
<tr>
<td>TIP120</td>
<td>1500</td>
<td>1.5</td>
</tr>
</tbody>
</table>

HIGH (+5V) and LOW (0V) pins control the transistor TIP120, which is connected to 9 or 12 V.
Pin 2

Vss
Several motors

Watch out for TIP120 overheating
Several motors, each controlled
Several batteries
MOSFET Control

PINx

GATE (G)

IRL520

DRAIN (D)

SOURCE (S)

YSS

+ \hspace{1cm} Vb
MOSFET

IRL520
I_{ds} = 10A
R_{ds\,on} = 0.18 \text{ ohm}

If I_{ds} = 2.0 \text{ A}
V_{ds} = I*R = 2.0*0.18 = 0.36V
P = IV = 2*0.36 = 0.72W

For TIP120, V_{ce} = 1.5V
P = 2*1.5 = 3W!
For high currents, bipolar wins

MOSFET
\[ P = I^2 R_{ds} \sim I^2 \]

BIPOLAR
\[ P = V_{ce} I \sim I \]
3. Relay control

- Relays great for high current motors
- Watch out for relay coil drain

![Relay Control Diagram]

TIP120 or 2N3904
Bi-directional motor control

12V DPDT RELAY

"DIRECTION" CCW

CW

PINx

1K

TIP120

"ON-OFF"

PINu

1K

TIP120

+ 12 V

TIP120 or IRL520 or RELAY
Inductive loads cause switching spikes

\[ V = L \frac{dI}{dt} \]

BIG SPIKE!
ISOLATED BI-DIRECTIONAL MOTOR CONTROL

<table>
<thead>
<tr>
<th>Pin X</th>
<th>Pin Y</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>G</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>C</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>X</td>
</tr>
</tbody>
</table>

\[= BATT (-)\]
SLOWING MOTOR

10 - 15 Ω
POWER RESISTOR
(3W+)

PINX

1K

TIP120

NEED A LOAD RESISTOR?

TRY A 2-CELL FLASHLIGHT BULB
... OR 2 IN SERIES OR PARALLEL
Speed Control by Pulse Width Modulation (PWM)

Open and close switch rapidly

- 100%
- 50%
- 25%
- 0%
PWM for Variable Speed

... while(digitalRead(6)==HIGH) {
  digitalWrite(2,HIGH);
  delay(5);
  digitalWrite(2,LOW);
  delay(35);
}
...

//run at 3 speeds
analogWrite(2,64);  //slow
delay(2000);
analogWrite(2,128); //medium
delay(2000);
analogWrite(2,255); //fast
delay(2000);
...

Duty cycle = 5/35 = 14%

Watch out for voltage spikes!