

IAT 884

Alternate Output:

Motors, Movement, and Control Voltage

Motors

Types

Standard DC Motors

Speed of rotation is determined by supplied voltage

Servo

Alignment is set by a microcontroller from 0 – 180 degrees*

Stepper Motors

Precision Aligned using a microcontroller

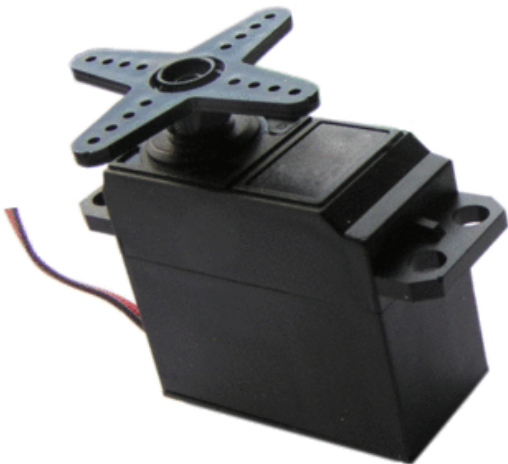
Solenoids

Motors that have a forward and backward (linear) motion

*Servos can be modified to rotate 360 degrees

Motors

Types



Motors

Standard DC Motors

Operation

Speed of rotation is determined by supplied voltage

Motors are all rated for a specific voltage.

Do not exceed this voltage or you will burn out your motor.

Motor Concerns:

Motors produce a magnetic field that can generate back voltage in a circuit which can damage a microcontroller.

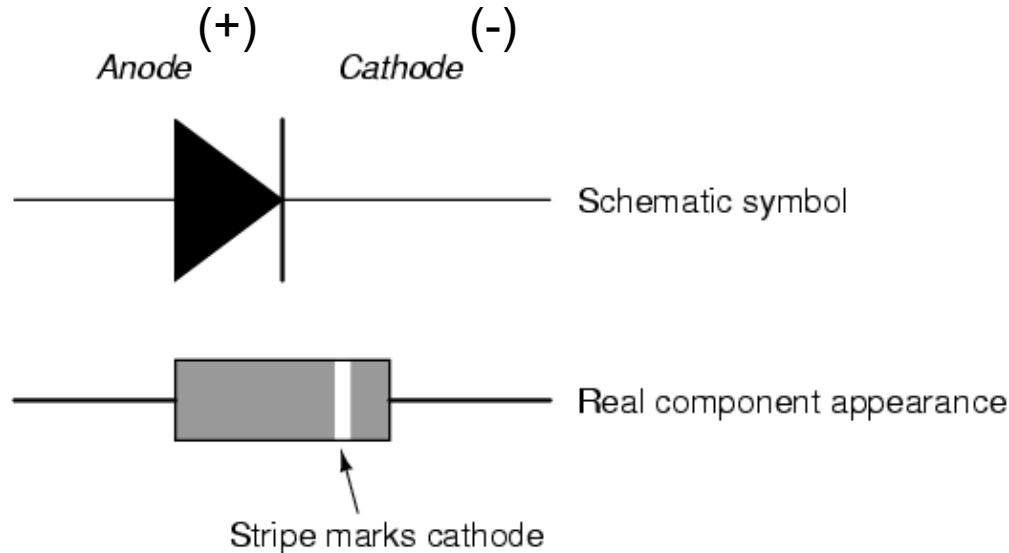
A motor may require a lot of voltage. The Arduino board can only output 5 volts.

Motors

Motors Concerns

Preventing Back Voltage

When a motor's supply voltage is removed, it can **induce** a current ("back EMF" for the keepers) the wrong way through your circuit, causing damage to sensitive components. To prevent this you put a **Snubber Diode** (aka flyback, clamp, etc.) in your circuit.

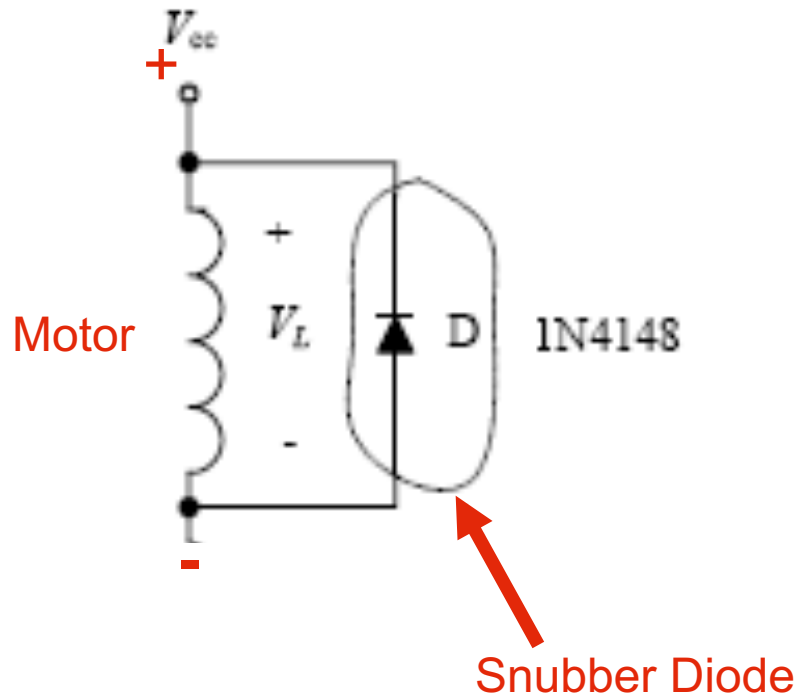


Motors

Motor Concerns

Preventing Reverse (kick) Voltage

A **Snubber Diode** is a diode placed inversely parallel to an inductive load. This provides an alternate path for the current and will protect your valuable microcontroller from surges.



Common Diodes:

1N4148

1N4001-1N4007

Motors

Motor Concerns

High Current/Voltage Loads

Sometimes a motor, light or other inductive load requires more voltage or current than a microcontroller can provide.

This requires 2 discrete power sources in a circuit.

The Microcontroller output voltage (0V-5V) can be used to proportionally change the voltage supplied to the motor (0V – 12V) by a separate power supply.

To do this we use a **transistor** (or relay).

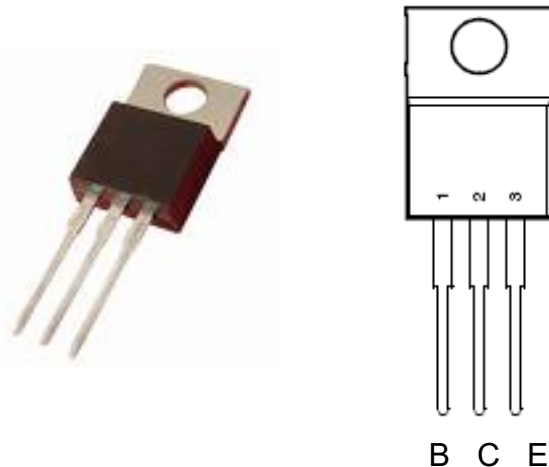
Motors

Transistors

Transistors are used to switch or amplify voltage

A basic transistor has three connections, the **base**, the **collector**, and the **emitter**.

There are many different kinds of transistors. Some look different, some act different. The two types of the most common (bipolar) transistors are **PNP** and **NPN**.



Motors

Transistors

Transistors are used to switch or amplify voltage

NPN - Switch the **negative** side of a circuit by bringing the base **HIGH**

PNP - Switch the **positive** side of a circuit by bringing the base **LOW**

NPN = “**N**ever **P**oints **iN**”

PNP = “**P**oints **iN** **P**ermanently”



PNP



NPN

Motors

Transistors

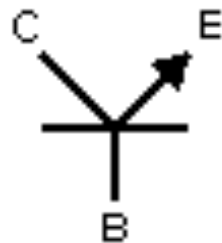
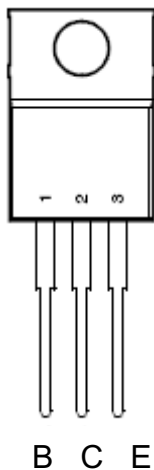
Transistors are used to switch or amplify voltage

For our circuits we will almost always use NPN transistors.

The **Base** is connected to a control voltage (e.g. Microcontroller output)

The **Collector** is attached to the negative terminal of the motor (or light)

The **Emitter** is connected to the common ground



NPN
Schematic
Symbol

Motors

Transistors

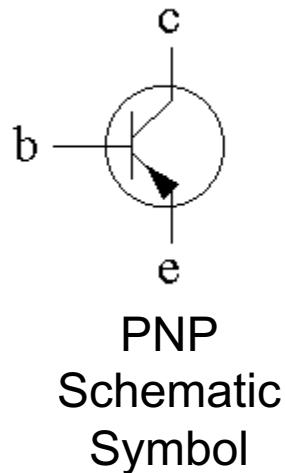
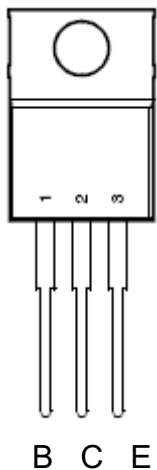
Transistors are used to switch or amplify voltage

The other type of transistor is the PNP transistor.

The **Base** is connected to a control voltage (e.g. Microcontroller output)

The **Collector** is attached to the positive terminal of the motor (or light)

The **Emitter** is connected to the power source



Motors

Transistors

Transistors are used to switch or amplify voltage

IMPORTANT NOTE:

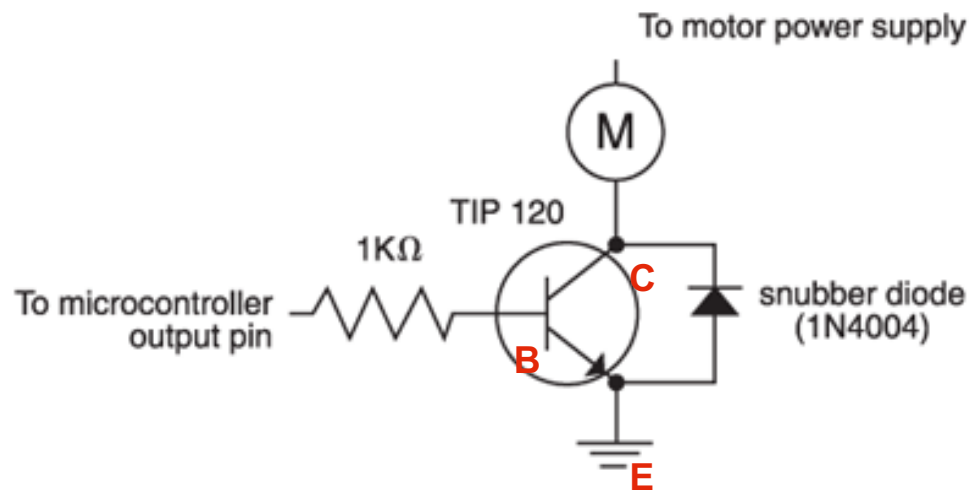
Transistors are fairly sensitive electronic components. The base can handle a limited current - typically 10-20 mA is safe and sufficient. BUT on certain types of transistors (e.g. MOSFET) it can be less than 5mA!!

Remember to use a current limiting resistor, just like with LEDs.

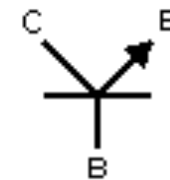
Motors

Transistors

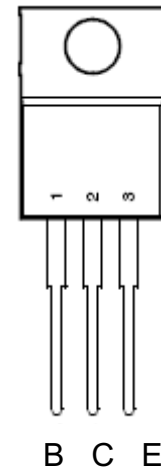
Motor Control Circuit



This diode is protecting the transistor BUT is not used correctly. Best to place the diode across the motor (switch the cathode to the positive end of the motor).



NPN Schematic Symbol

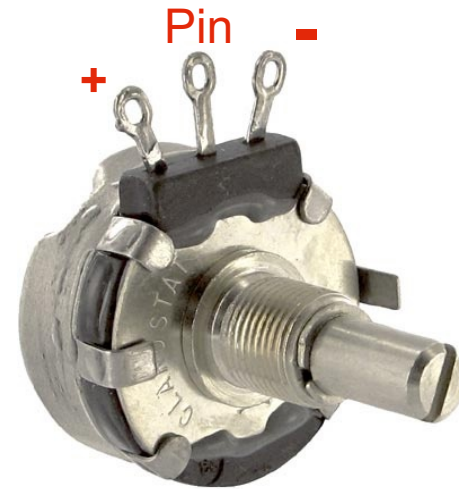
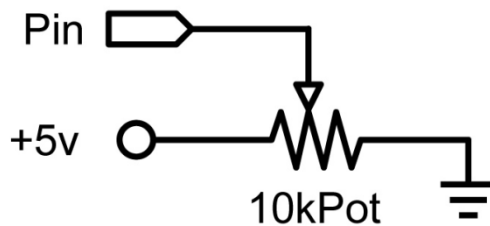


Motors

Potentiometer

Variable Resistor

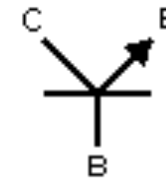
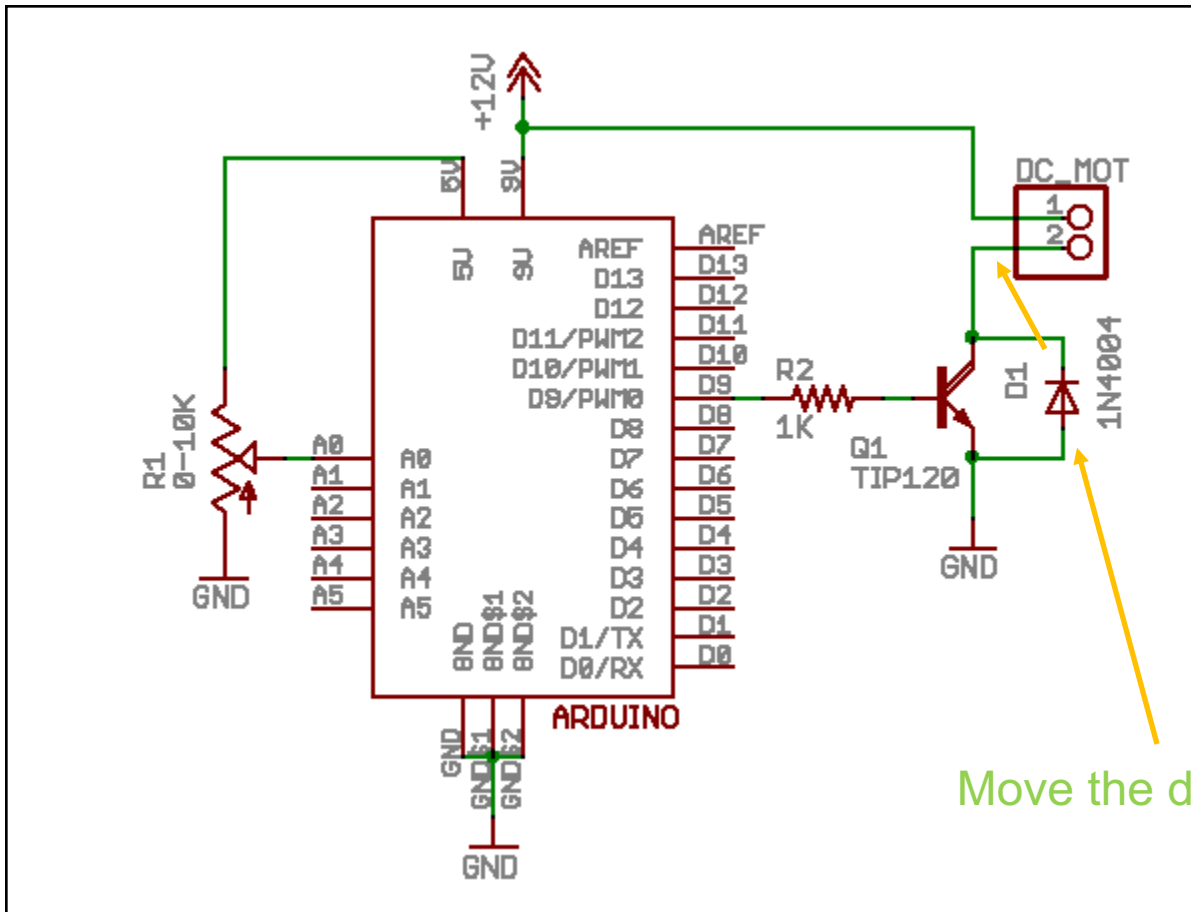
A potentiometer is a rotary voltage divider. It functions like a variable resistor changing the output voltage when the knob is turned.



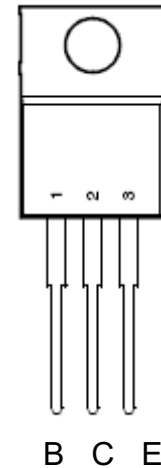
Motors

Transistors

Example: Use a potentiometer to control motor speed



NPN Schematic Symbol

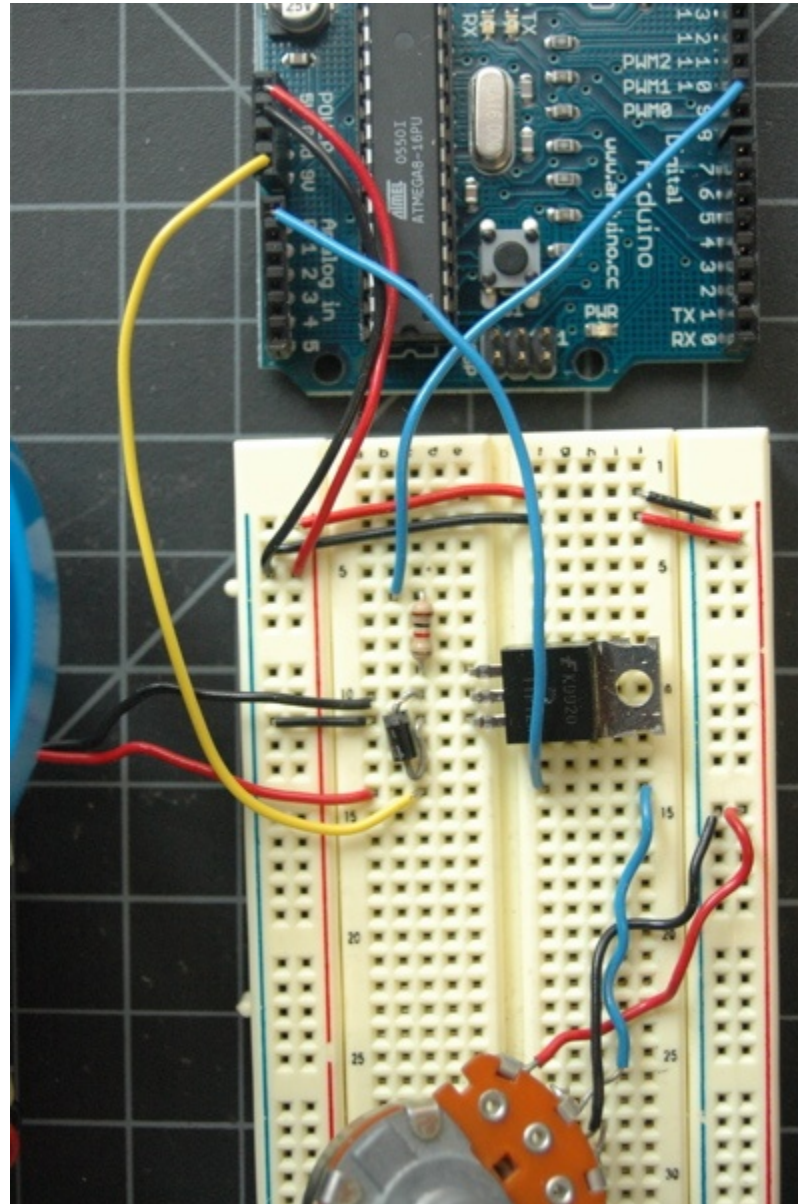


Move the diode to the motor!

Motors

Transistors

Arduino Circuit (Diode is incorrect)



Source: <http://ip.nyu.edu/physcomp/Tutorials/HighCurrentLoads>

Motors

Transistors

Example: Use a potentiometer to control motor speed

```
int potPin = 0;           // Analog in 0 connected to the potentiometer
int transistorPin = 9;    // connected to the base of the transistor
int potValue = 0;        // value returned from the potentiometer

void setup() {
  // set the transistor pin as output:
  pinMode(transistorPin, OUTPUT);
  Serial.begin(9600);
}

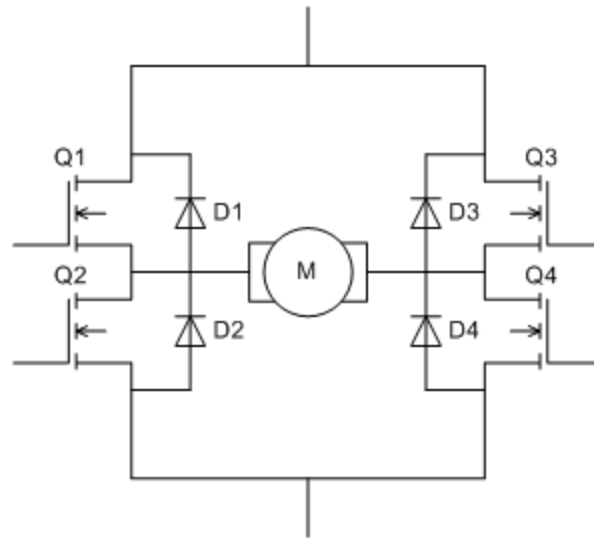
void loop() {
  // read the potentiometer, convert it to 0 - 255:
  potValue = analogRead(potPin) / 4;
  Serial.println(potValue, DEC);
  // use that to control the transistor:
  analogWrite(9, potValue);
}
```

Motors

H-Bridge Circuits

Bidirectional Motor Control

Transistors are great if we only need to move a motor in one direction. H-Bridge Circuits allow us to change a motor's direction on demand. An H-Bridge is just 4 transistors wired together.

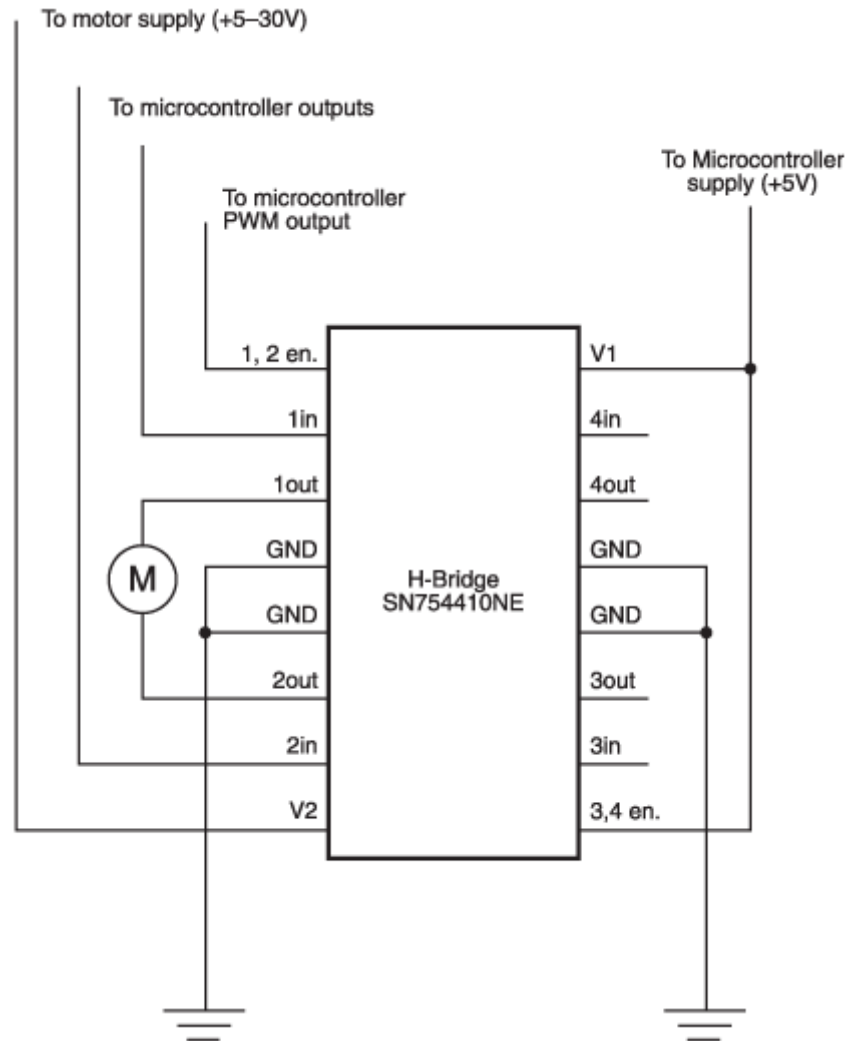


H-Bridge Circuit

Motors

H-Bridge Circuits

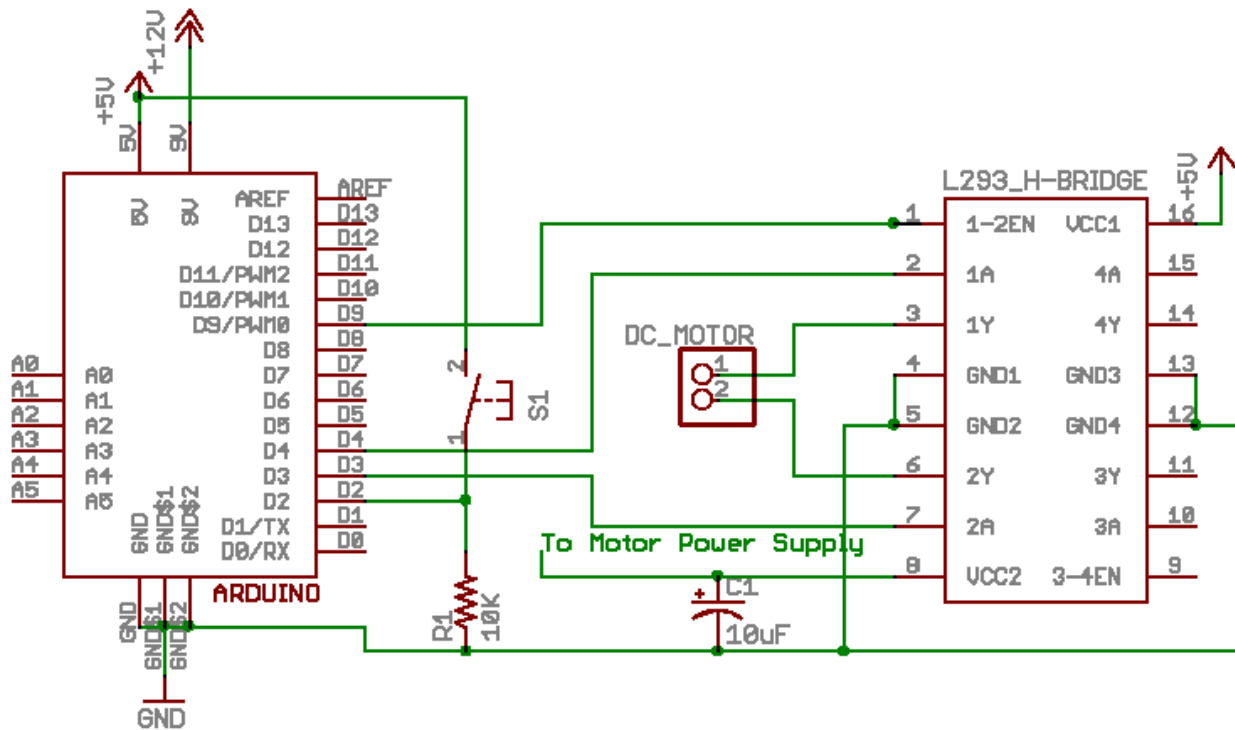
Wiring Scheme



Motors

H-Bridge Circuits

Connecting to an Arduino



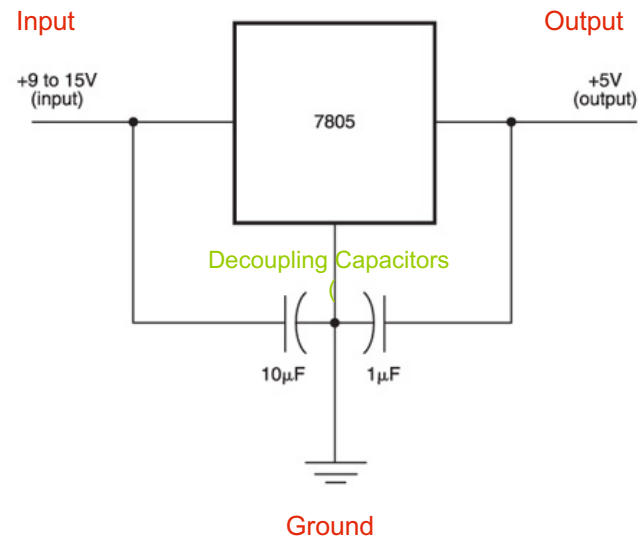
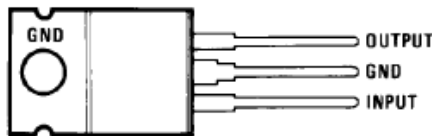
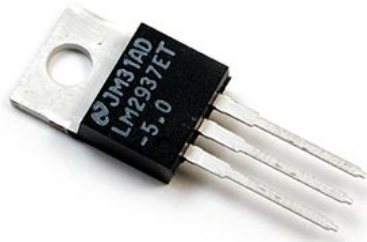
Motors

Voltage Regulators

Voltage regulators convert a higher voltage to a lower voltage.

They come in a variety of types including 3.3V, 5V and 9V.

They can get HOT under normal operation, but this might also indicate that you have wired something incorrectly!



Motors

Servo Motors

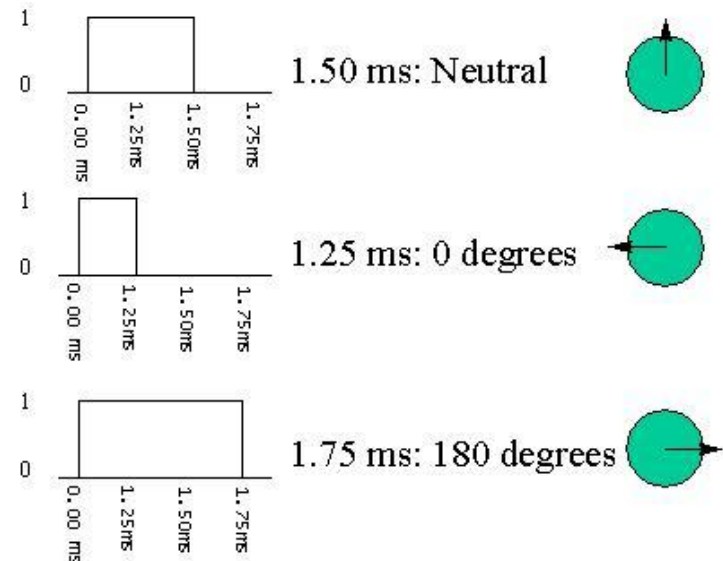
Servo Motors Use Pulse coded modulation to change a motor's position from 0 -180. When a motor receives a specific pulse it will move to the corresponding angle and maintain that position as long as it continues to receive the same signal. The signal must be resent at least every 20 ms.

Pulse Length

1.5 ms 90 Degrees (Neutral)

> 1.5 = closer to 180 degrees

< 1.5 = closer to 0 degrees.



Motors

Servo Motors

Arduino

The Arduino programming language has two methods for controlling servos.

- 1. Manually set the pulse lengths, min pulse, max pulse, etc.**
- 2. Use the Software Servo library `<servo.h>` by Arduino Playground.**

Motors

Servo Motors

Servo.h – Main Functions

attach(int)

Turn a pin into a servo controller. Calls pinMode.

detach()

Release a pin from servo control.

write(int)

Set the angle of the servo in degrees, 0 to 180.

read()

return that value set with the last write().

attached()

return 1 if the servo is currently attached.

Motors

Servo Motors

Example: Control the position of a motor using a potentiometer

```
#include <Servo.h>
Servo servol;

int potValue = 0;                                //Value of signal coming from Potentiometer

void setup() {
  pinMode(2, OUTPUT);
  servol.attach(2);
}

void loop() {

  potValue = analogRead(0);                      // Get value of potentiomete
  potValue = map(potValue, 0,687,0,180);        //scale the value to fit between 0-180, the range of the servo
  servol.write(potValue);                       //Set the servo's new position
  servol.refresh();
  delay(1);
}
```

Activities

Design a circuit that uses a potentiometer to control a DC Motor. You should use a 12 volt adapter as a separate power source for the motor and an NPN transistor to switch the current. You will need to use a voltage regulator to bring the voltage supplied to the motor down to 5v.

Step 1: Attach Potentiometer (and test functionality using serial window)

Step 2: Build Voltage Regulator circuit to power motor (test with multi-meter)

Step 3: Finish circuit by adding transistor and motor elements.

Design a circuit to control a servo motor. Use the potentiometer from your previous circuit to control the position of the servo. Use the AC adapter to power the Arduino board to ensure that you have enough power for the system and to make it more portable. *You can use the software servo library from Arduino Playground.*

Step 1: Attach AC adapter to Arduino Board and adjust pin for external power.

Step 2: Make sure potentiometer is working and check output range.

Step 3: Convert incoming value from the potentiometer to a value between 0 – 180 to correspond to the angle of the servo

Step 4: Attach servo