From Physical Computing at ITP

Tutorials: HighCurrentLoads

In this tutorial, you'll learn how to control a high-current DC load such as a DC motor or an incandescent light from a microcontroller.

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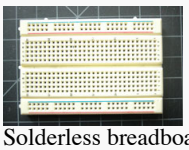
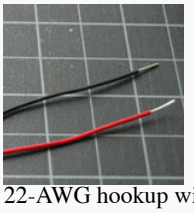
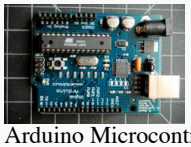
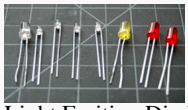
1. Parts

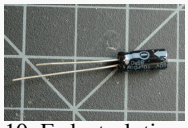
You will need the following parts for this tutorial.

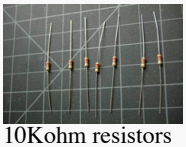

Solderless breadboard


22-AWG hookup wire

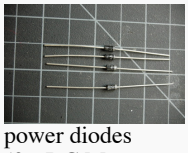

Arduino Microcontroller module


Light Emiting Diodes, LED

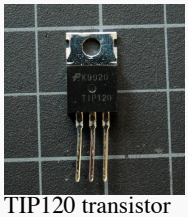

10uF electrolytic capacitor

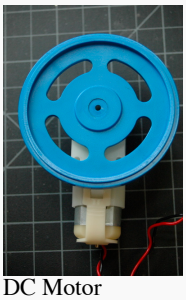

10Kohm resistors


10Kohm potentiometer

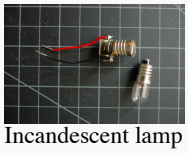

power diodes
(for DC Motor version only)


DC power supply


TIP120 transistor

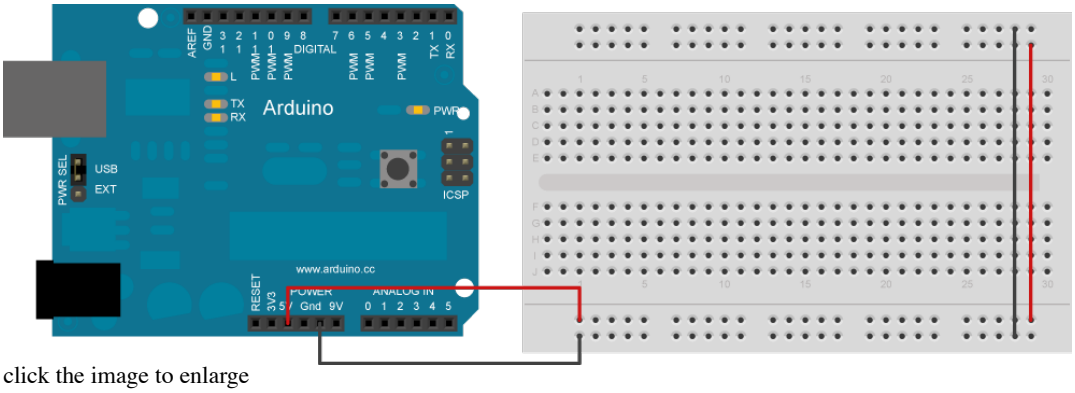

DC Motor

- or -


Incandescent lamp and socket

2. Prepare the breadboard

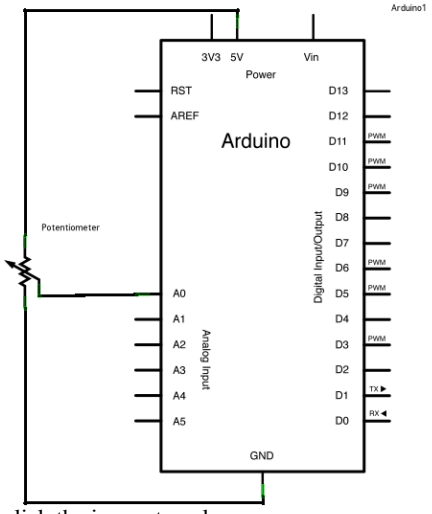
Conect power and ground on the breadboard to power and ground from the microcontroller. On the Arduino module, use the 5V and any of the ground connections:



click the image to enlarge

3. Add a potentiometer

Connect a potentiometer to analog in pin 0 of the module. You'll use this later to control the output, whether it's a motor or a light.



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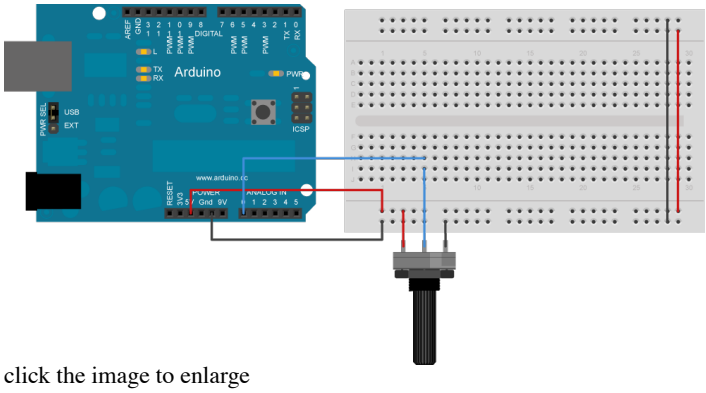
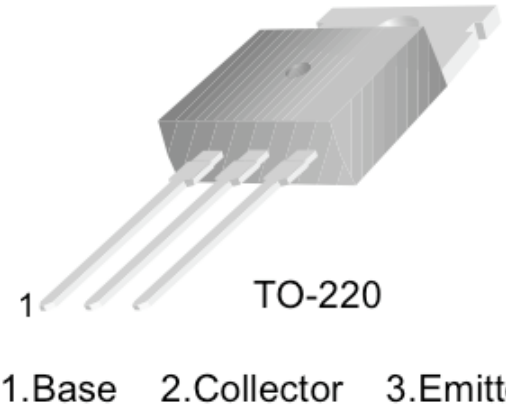


click the image to enlarge

4. Connect a transistor to the microcontroller

The transistor allows you to control a circuit that's carrying higher current and voltage from the microcontroller. It acts as an electronic switch. The one you're using for this lab is an NPN-type transistor called a TIP120. The datasheet for it can be found **here**. It's designed for switching high-current loads. It has three connections, the base, the collector, and the emitter. The base is connected to the microcontroller's output. The high-current load (i.e. the motor or light) is attached to its power source, and then to the collector of the transistor. The emitter of the transistor is connected to ground.

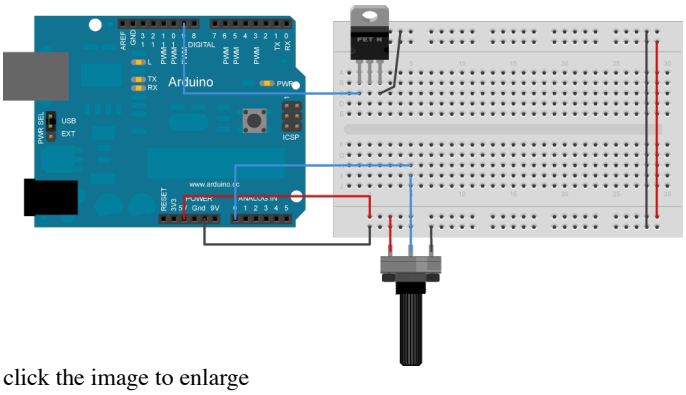


Pinout of a TIP-120 transistor, from left to right: base, collector, emitter.

Note: you can also use an IRF510 or IRF520 MOSFET transistor for this. They have the same pin configuration as the TIP120, and perform similarly. They can handle more amperage and voltage, but are more sensitive to static electricity damage.

The schematic symbol of an NPN transistor where B is the base, C is the collector, and E is the emitter.

Connect the base to an output pin of the microcontroller, and the emitter to ground like so:



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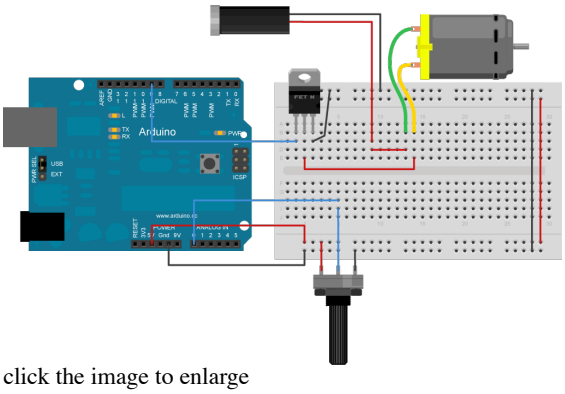
4.1 Connect a motor and power supply

Attach a DC motor to the collector of the transistor. Most motors will require more amperage than the microcontroller can supply, so you will need to add a separate power supply as well. If your motor runs on around 9V, you could use a 9V battery. A 5V motor might run on 4 AA batteries. a 12V battery may need a 12V wall wart, or a 12V battery. The ground of the motor power supply should connect to the ground of the microcontroller, on the breadboard.



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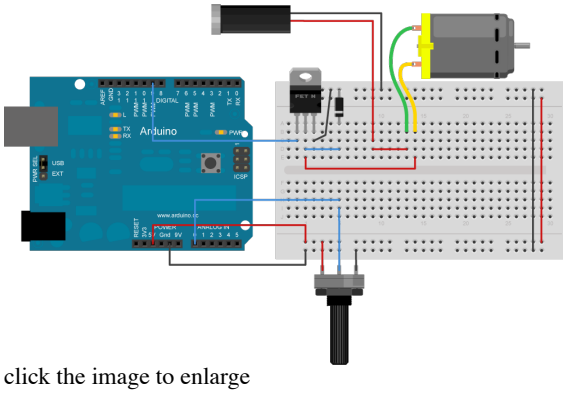
FInally, add diode in parallel with the collector and emitter of the transistor, pointing away from ground. The diode to protects the transistor from back voltage generated when the motor shuts off, or if the motor is turned in the reverse direction.



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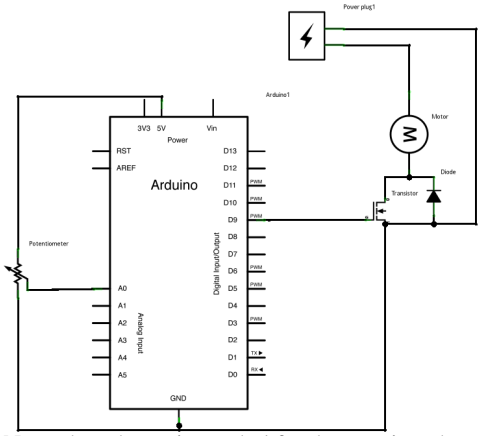
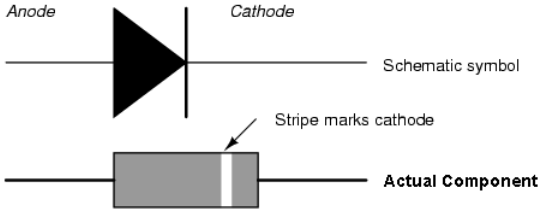


Note: the schematic symbol for the transistor here is actually for an IRF510 MOSFET. But it can be replaced with a TIP120 click the image to enlarge

Be sure to add the diode to your circuit correctly. The silver band on the diode denotes the cathode which is the tip of the arrow in the schematic, like so:

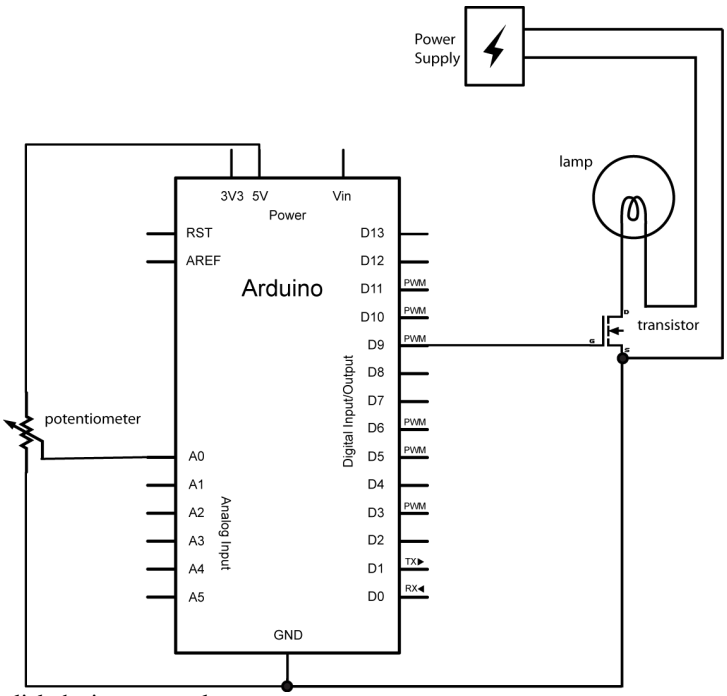


click the image to enlarge.

This circuit assumes you're using a 12V motor. If your motor requires a different voltage, make sure to use a power supply that's appropriate. Connect the ground of the motor's supply to the ground of your microcontroller circuit, though, or the circuit won't work properly.

4.2 Connect a lamp instead

You could also attach a lamp using a transistor. Like the motor, the lamp circuit below assumes a 12V lamp. Change your power supply accordingly if you're using a different lamp. In the lamp circuit, the protection diode is not needed, since there's no way for the polarity to get reversed in this circuit:



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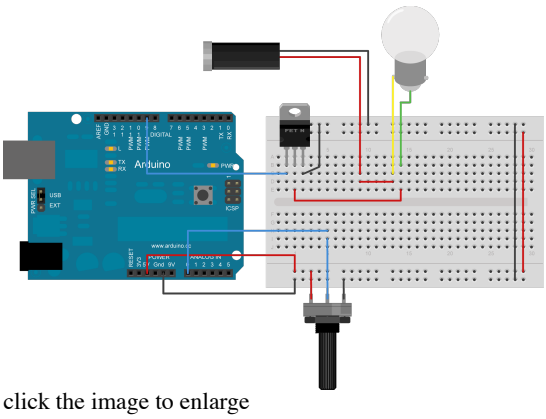

click the image to enlarge

5. Program the microcontroller

Here's a quick program to test the circuit:

```
const int transistorPin = 9;    // connected to the base of the transistor

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

void loop() {
  digitalWrite(transistorPin, HIGH);
  delay(1000);
  digitalWrite(transistorPin, LOW);
  delay(1000);
}
```

Now that you see it working, try changing the speed of the motor or the intensity of the lamp using the potentiometer. Try this code:

```
const int potPin = 0;            // Analog in 0 connected to the potentiometer
const 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);
}

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

6. Notes

For the motor users:
A motor controlled like this can only be turned in one direction. To be able to reverse the direction of the motor, an H-bridge circuit is required. For more on controlling DC motors with H-bridges, see the **DC Motor Control lab**
