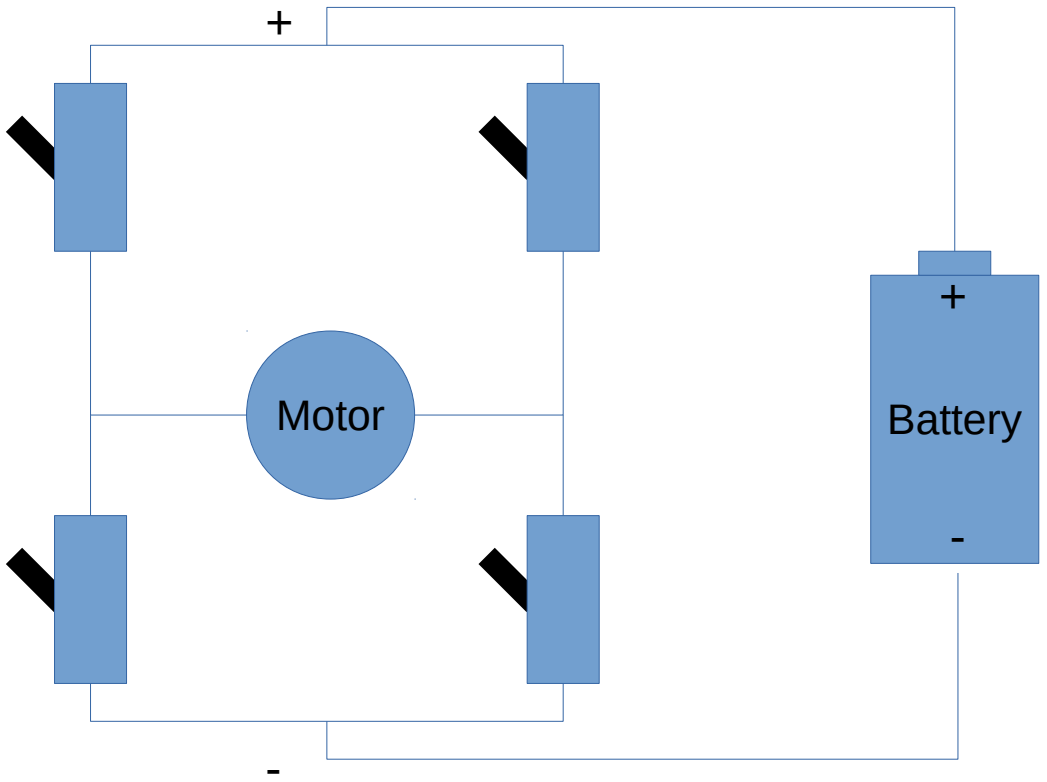
Motor Control

Motor Control

- Controlling the motors is the same as controlling the LED except two signals are needed.
- With two signals, you can control the direction of the motors and turn them on and off.
- The following pages will describe how to hook up the motors.
- A motor driver module is needed. This module allows a computer to control the motors. The motors require more power than the computer signals can provide so the module provides the power.
- The motor driver uses what is called an H-Bridge Driver.

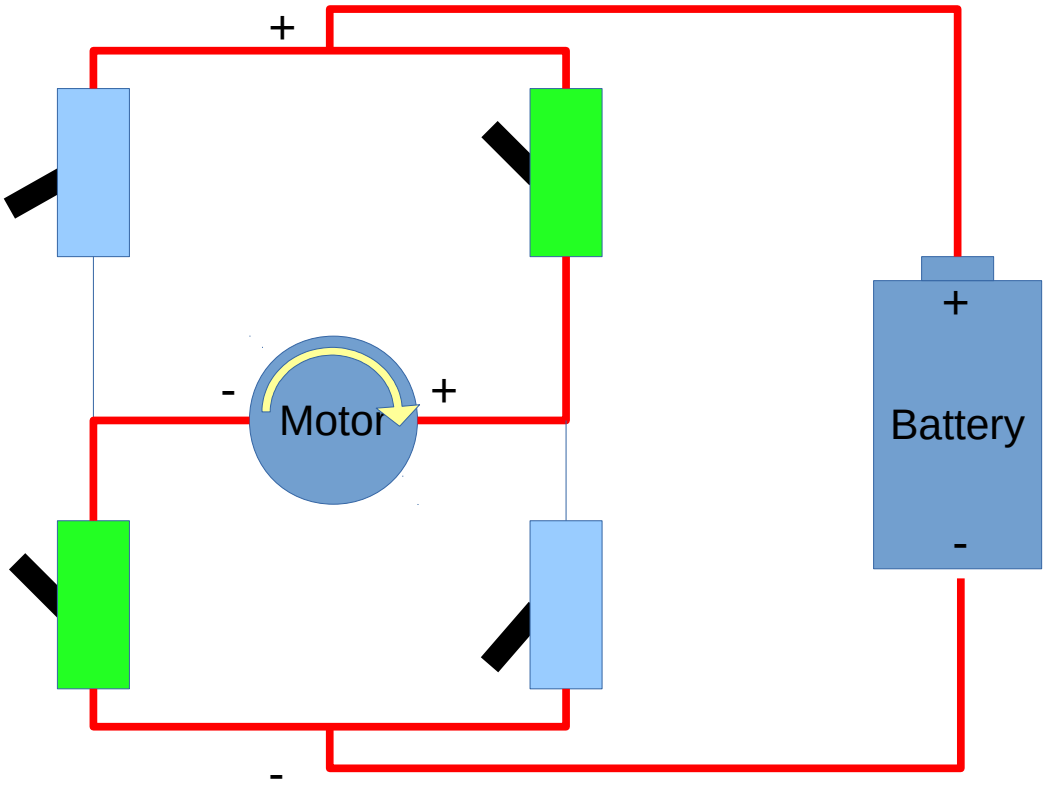
Motor Control

- Dual H-Bridge Driver is used to control the motors. It uses four transistors to control the polarity of the voltage supplied to the motor. The transistors are used as switches turning on and off. Below shows the H-bridge driver circuit and the current flows.



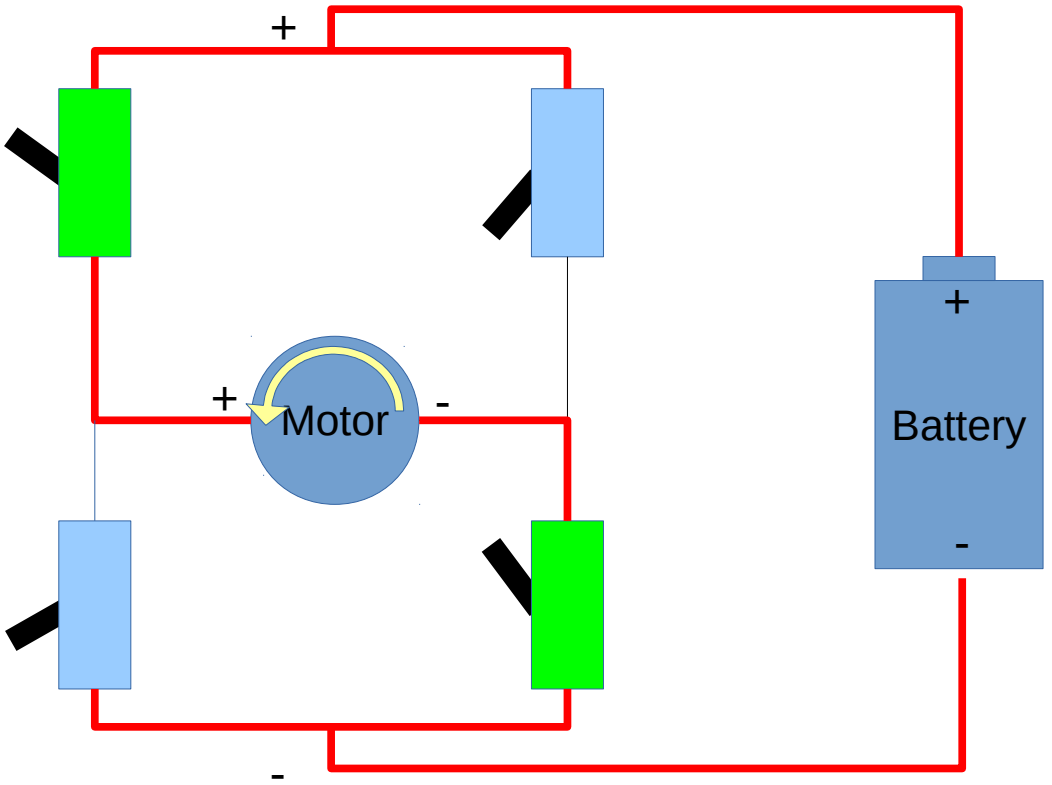
Motor Control

- To make the motor turn on one direction, two switches need to be turned on to let power get to the motor. One switch connects the positive side of the battery to to one side of the motor and another switch connects the negative side to the other side of the motor.



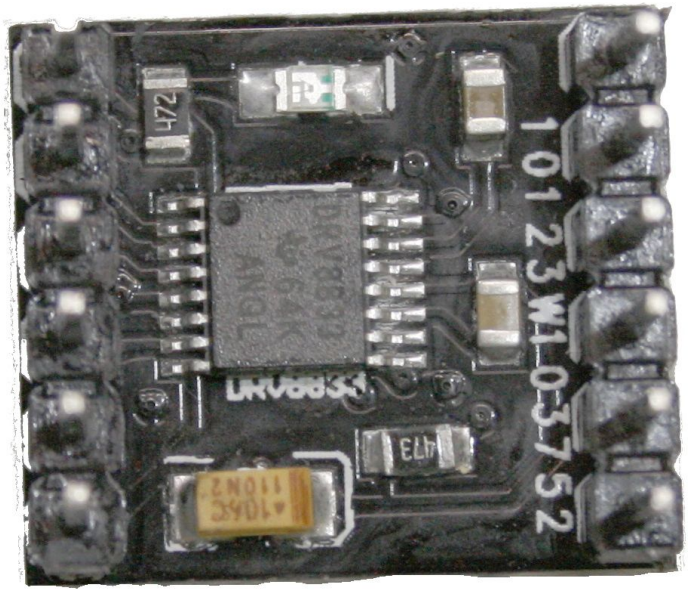
Motor Control

- Flip all the switches to the opposite position and the motor turns in reverse. Notice the polarity signs on the motor switched sides.



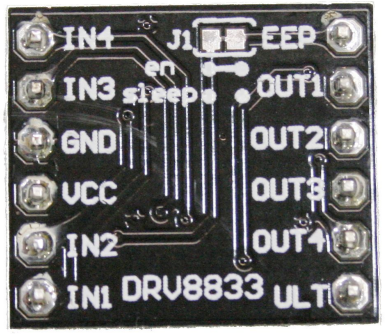
Motor Controller

- The motor controller is the interface between the motors and the processor board. It has circuitry to allow control of the motors and can handle the high currents required to operate the motors. The processor board cannot directly power the motors. The controller is capable of providing the needed current and is used as the interface.



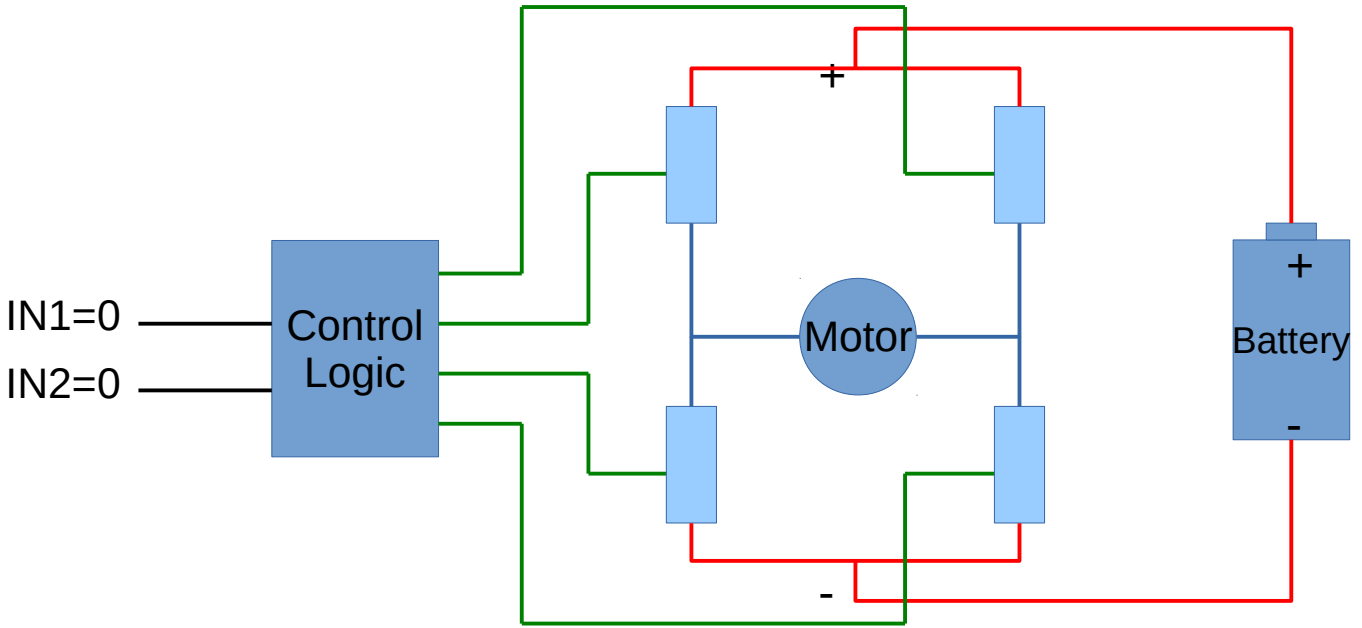
Motor Controller

- The motor controller module consists of two H-bridge drivers to control two motors.
- The circuit side is shown at the top right. The square block in the center contains the two motor drivers.
- The bottom picture shows the signal names next to the pins.
- Power is supplied at pins GND and VCC.
- Control signals for each motor is IN1, IN2, and IN3, IN4.
- The motors connect to the pins marked OUT.
- The other pins are not used.



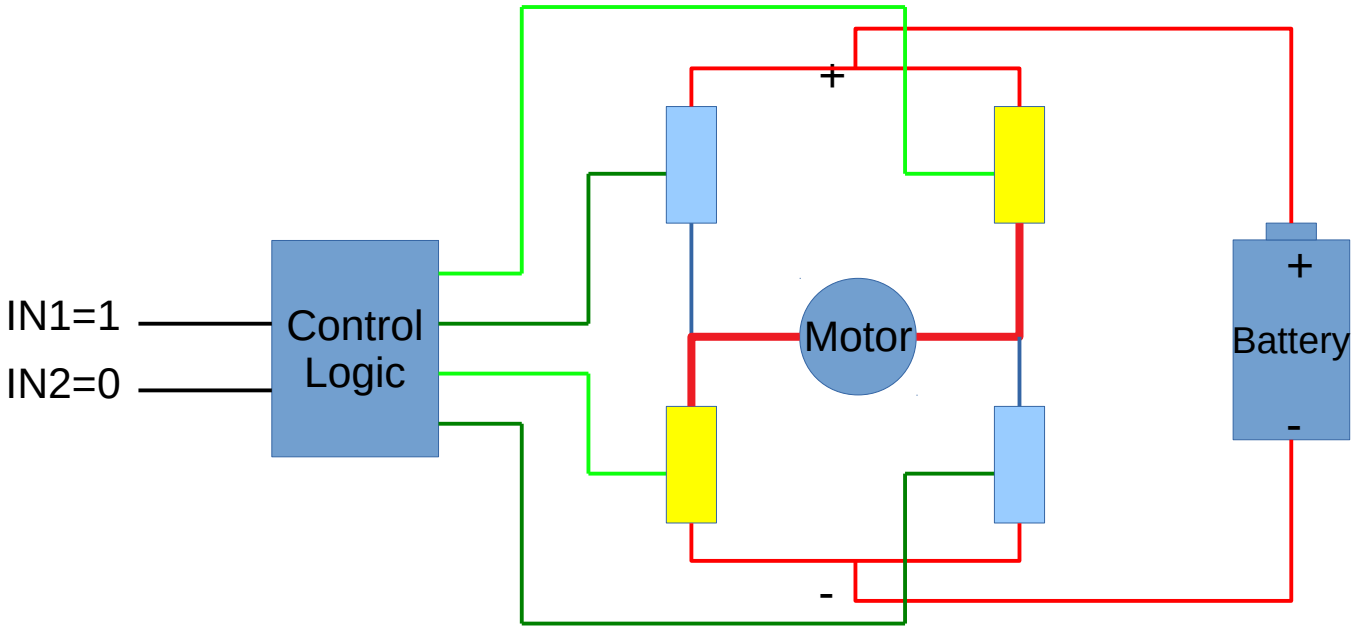
Motor Controller

- There are two signals that control the direction and operation. Control logic decodes the two signals and turns on the appropriate switches to control the motor. The drawing shows the condition of IN1 and IN2 set to logic low.



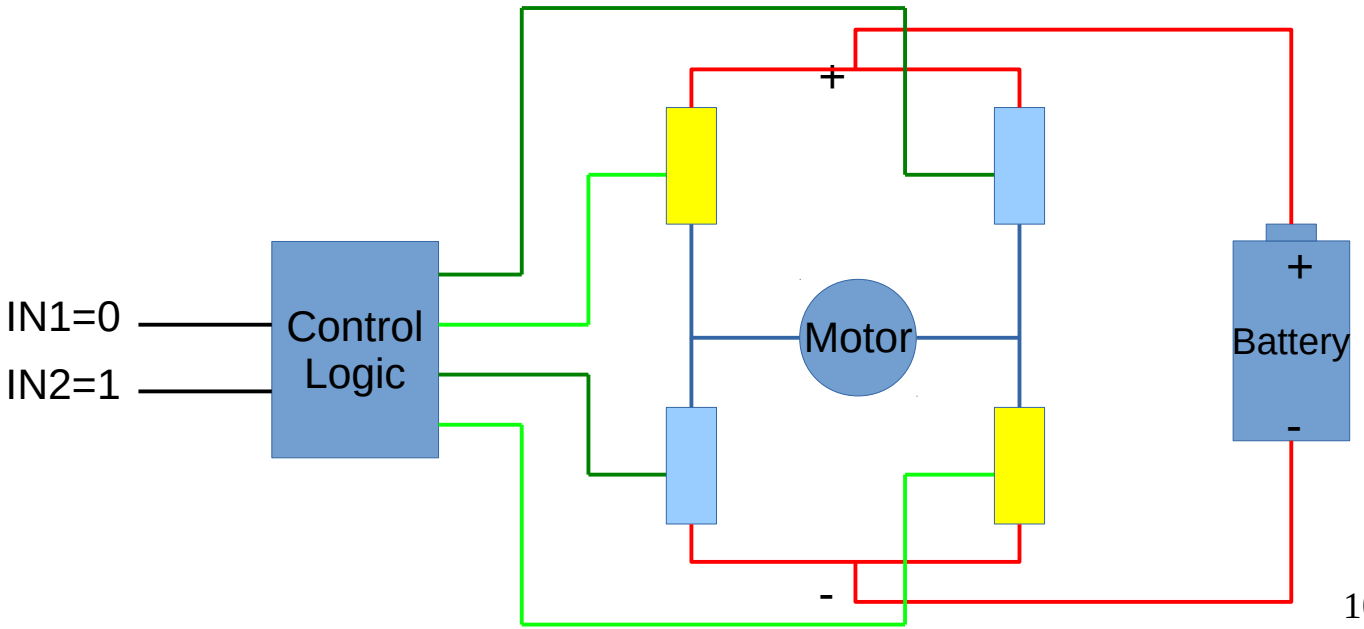
Motor Controller

- When IN1 is set to logic 1 and IN2 is set to logic 0, the motor drives in the forward direction.
- You will notice that setting IN1 = 1, and IN2=0 turns on two signals that turn on the two switches.



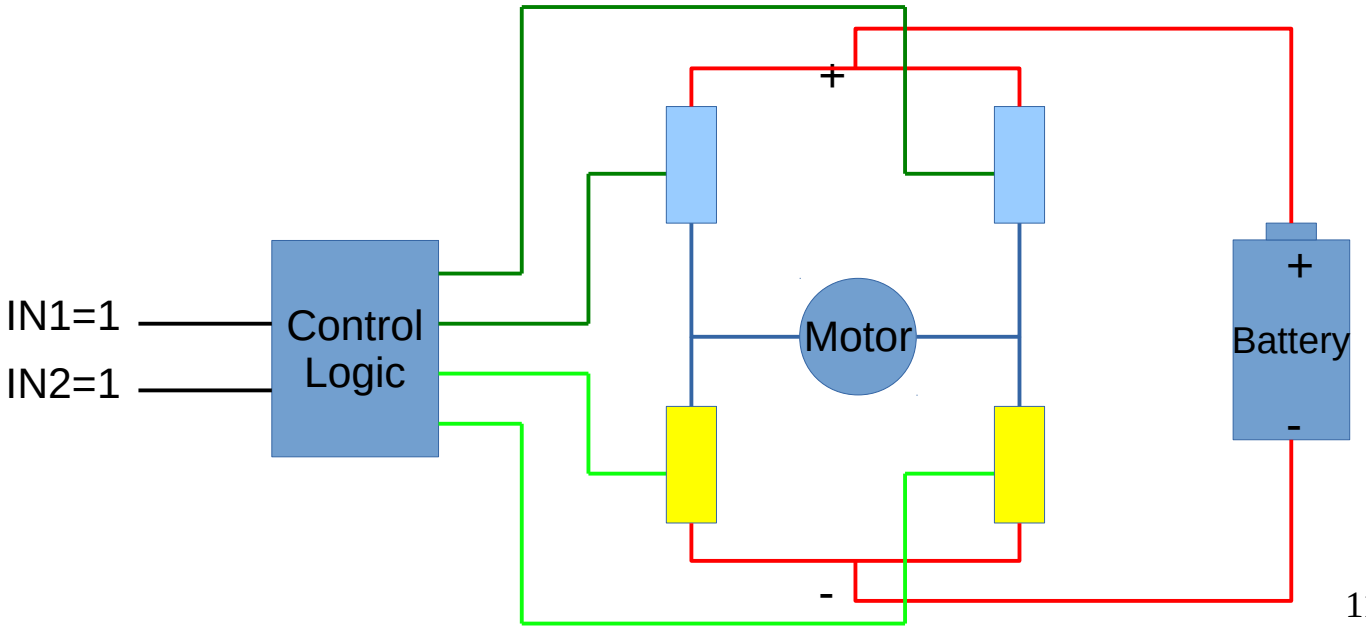
Motor Controller

- When IN2 is set to logic 1 and IN1 is set to logic 0, the motor drives in the reverse direction.
- You will notice that setting IN1 = 0, and IN2=1 turns on two signals that turn on the two switches.



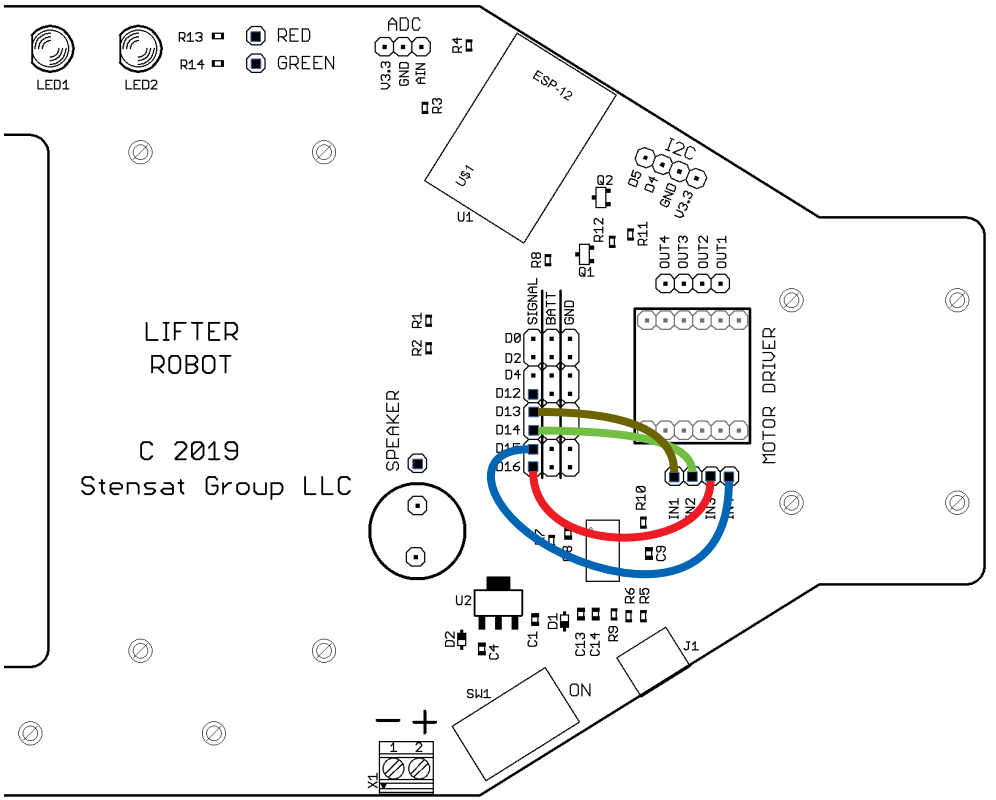
Motor Controller

- When you set both IN1 and IN2 to logic 1, you get a breaking action.
- This turns on the two bottom switches which shorts the motor connections together. The inductance created by the motor turning in one direction will power the motor to turn in the opposite direction. It causes the motor to slow down quickly.



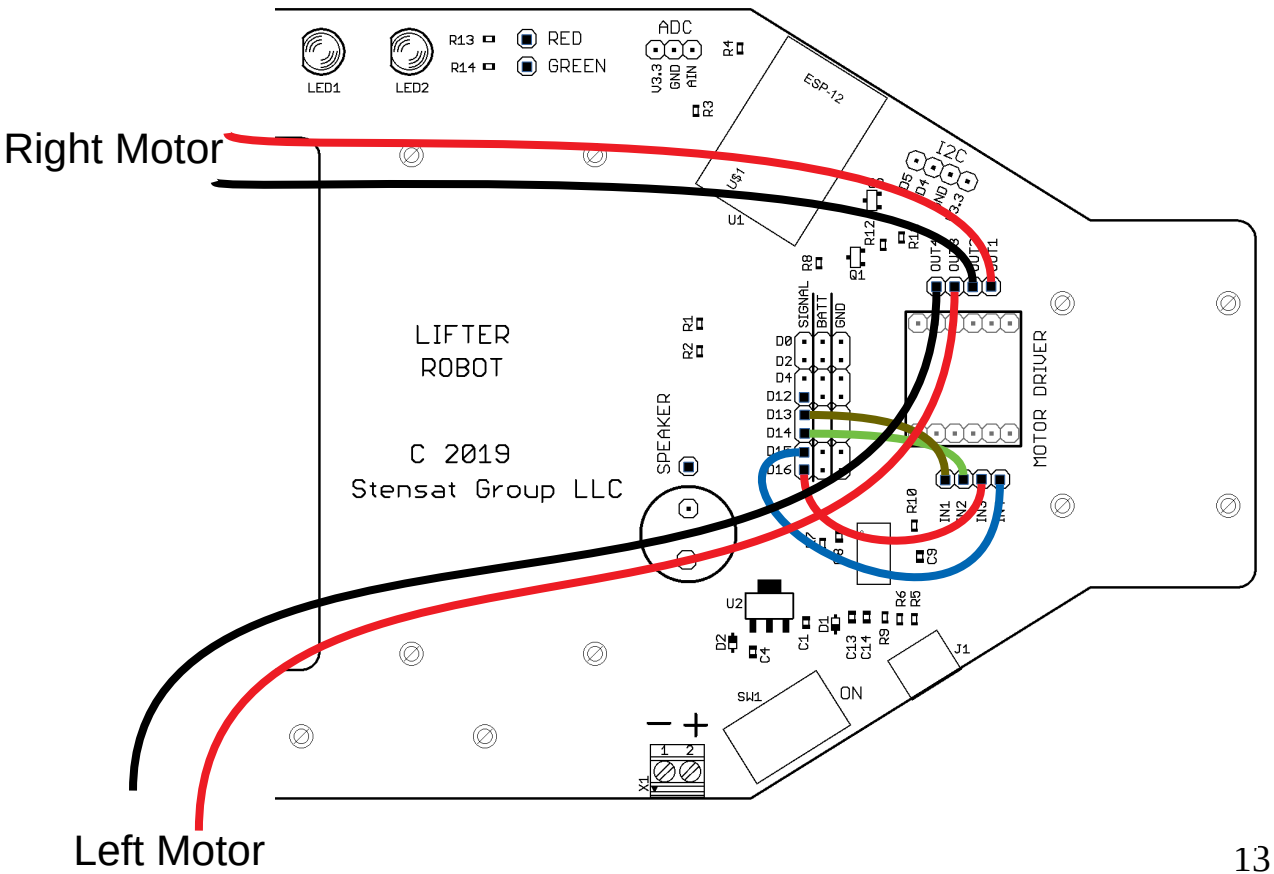
Motor Controller

- Remove all jumper wires that may still be installed.
- Connect the motor driver as shown.
- Connect digital port 16 to IN3.
- Connect digital port 15 to IN4.
- Connect digital port 14 to IN2.
- Connect digital port 13 to IN1.



Motor Controller

- Connect the motors to the motor driver.
- The left motor connects to OUT3 and OUT4.
- The right motor connects to OUT1 and OUT2.



Motor Control

- Make sure the power switch is in the off position.
- Insert 4 AA batteries into the battery holder.
- Enter the code to the right. The code will turn on the motors to spin the wheels in the forward direction.
- If any of the wheels are spinning in reverse, swap the two wires in the corresponding OUT plug on the base plate.

```
void setup()
{
     pinMode(13,OUTPUT);
     pinMode(14,OUTPUT);
     pinMode(15,OUTPUT);
     pinMode(16,OUTPUT);
}

void loop()
{
     digitalWrite(13,HIGH);
     digitalWrite(14,LOW);
     digitalWrite(15,HIGH);
     digitalWrite(16,LOW);
     delay(5000);
     digitalWrite(13,LOW);
     digitalWrite(15,LOW);
     delay(2000);
}
```

Direction Control

- The digital pins D13 and D14 control the right motors.
  - Setting D13 high and D14 low makes the right wheels spin forward.
  - Setting D13 low and D14 high makes the right wheels spin reverse.
  - Setting D13 low and D14 low turns off the motors.
- The digital pins D15 and D16 control the left motors.
  - Setting D15 high and D16 low makes the left wheels spin forward.
  - Setting D15 low and D16 high makes the left wheels spin reverse.
  - Setting D15 low and D16 low turns off the motors.
- The next page shows the combination of digital pin settings for the direction of motions.

Direction Control

Forward Motion

```
digitalWrite(13,HIGH);
digitalWrite(14,LOW);
digitalWrite(15,HIGH);
digitalWrite(16,LOW);
```

Reverse Motion

```
digitalWrite(13,LOW);
digitalWrite(14,HIGH);
digitalWrite(15,LOW);
digitalWrite(16,HIGH);
```

Halt

```
digitalWrite(13,LOW);
digitalWrite(14,LOW);
digitalWrite(15,LOW);
digitalWrite(16,LOW);
```

Right Turn

```
digitalWrite(13,LOW);
digitalWrite(4,HIGH);
digitalWrite(15,HIGH);
digitalWrite(16,LOW);
```

Left Turn

```
digitalWrite(13,HIGH);
digitalWrite(14,LOW);
digitalWrite(15,LOW);
digitalWrite(16,HIGH);
```

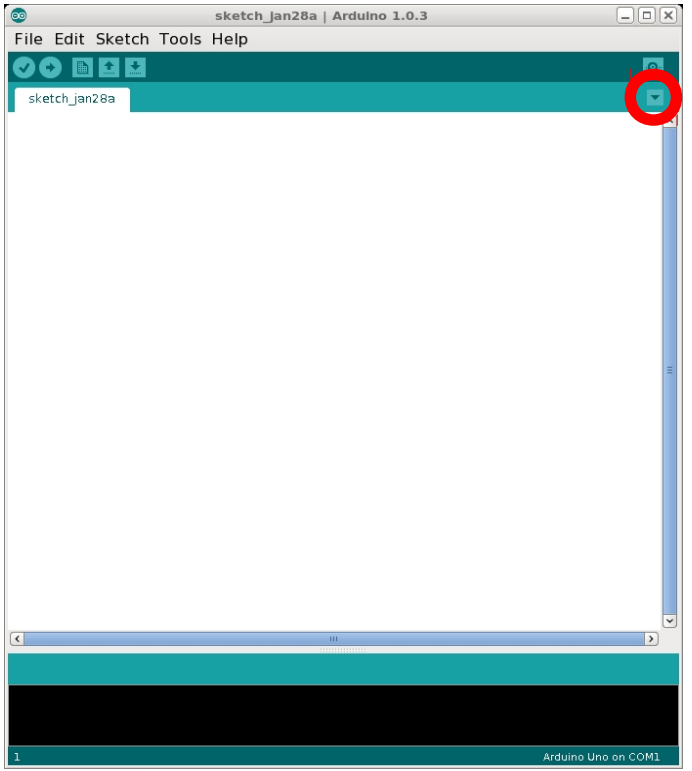
Direction Functions

- To make programming easier, functions will be created to specify the motions of the robot.
- A **function** is a collection of instructions that are grouped by braces **{ }** and given a name.
- The format is shown to the right with one of the motions.
- The code in the loop function can call the forward function eliminating the need to rewrite the **`digitalWrite()`** functions every time.
- The motion functions should be inserted at the top of all programs.

```
void forward()
{
  digitalWrite(13,HIGH);
  digitalWrite(14,LOW);
  digitalWrite(15,HIGH);
  digitalWrite(16,LOW);
}
```

Function File

- Start a new program with the Arduino program.
- Click on the down arrow to the right where circled in red.
- A menu will open. Select “New Tab”
- Below, it will ask for a name. Enter **motion**
- Click 'OK'
- A new tab is created called 'motion'
- You will enter all the movement functions here.
- Enter the functions listed in the next page.



Motion Functions

```
void forward()
{
  digitalWrite(13,HIGH);
  digitalWrite(14,LOW);
  digitalWrite(15,HIGH);
  digitalWrite(16,LOW);
}

void reverse()
{
  digitalWrite(13,LOW);
  digitalWrite(14,HIGH);
  digitalWrite(15,LOW);
  digitalWrite(16,HIGH);
}
void halt()
{
  digitalWrite(13,LOW);
  digitalWrite(14,LOW);
  digitalWrite(15,LOW);
  digitalWrite(16,LOW);
}
```

```
void right()
{
  digitalWrite(13,LOW);
  digitalWrite(14,HIGH);
  digitalWrite(15,HIGH);
  digitalWrite(16,LOW);
}

void left()
{
  digitalWrite(13,HIGH);
  digitalWrite(14,LOW);
  digitalWrite(15,LOW);
  digitalWrite(16,HIGH);
}
```

Test Drive

- Click on the tab to the left of **motion** tab. Enter the code to the right.
- The code to the right is a start.
- Notice the **`delay()`** function is included after each motion function. This give the robot time to perform that motion. The value included in the delay function is time in milliseconds.
- Add directions to the program and change up the delays. Come up with a complex set of motions. Always remember to include a delay after the function to move the robot.
- When complete save the sketch as “move”. Remember this sketch. The motion file will be reused.

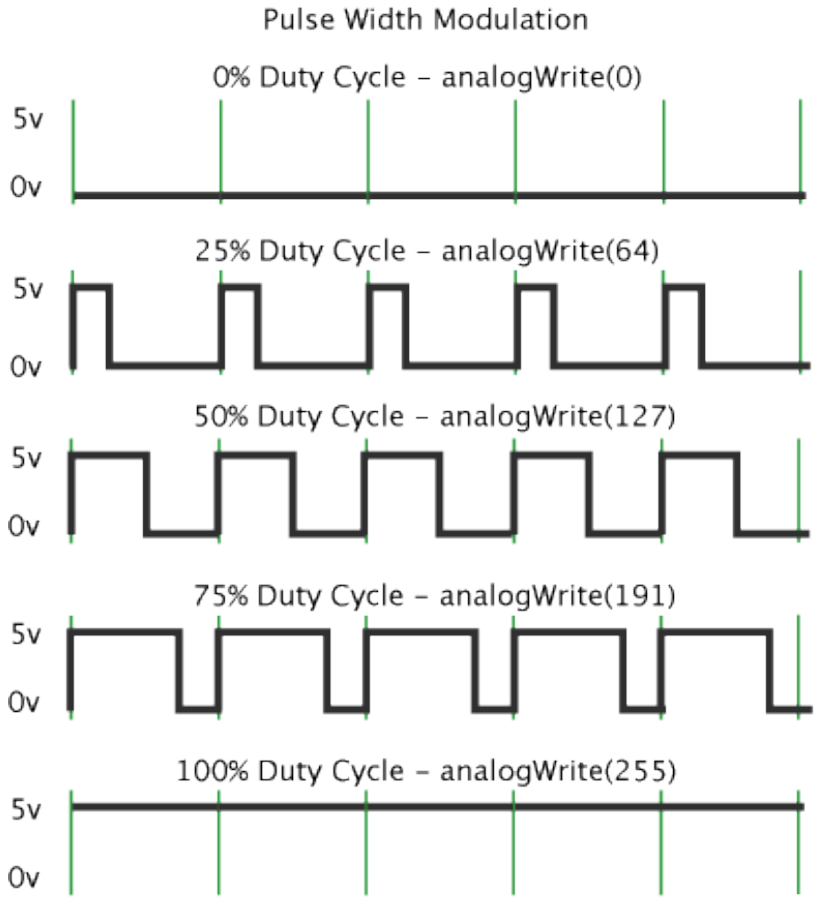
```
void setup()
{
     pinMode(13,OUTPUT);
     pinMode(14,OUTPUT);
     pinMode(15,OUTPUT);
     pinMode(16,OUTPUT);
}

void loop()
{
     forward();
     delay(1000);
     left();
     delay(400);
     reverse();
     delay(1000);
}
```

Experiment Time

- Now that you know the basics. Write a program to make the robot move in a square pattern.
- Use the **delay()** function to control how long the robot turns and moves in a straight direction.

Speed Control

- It may be noticed that the robot may tend to drift to the left or right. This is due to the motors not being equally powerful.
- There is a way to attempt to equalize them by controlling their speed.
- A simple way to control the speed is to pulse power to the motors. This technique is called pulse width modulation.
- On the arduino, the **`analogWrite()`** function performs this. It generates a repeating pulse at about 490 Hz.
- The size of each pulse is the duty cycle. The higher the duty cycle the more power the motor gets.
- Adjusting the duty cycle will adjust the motor speed.



analogWrite()

- The function **`analogWrite()`** function takes two values.
- First is the pin number.
- Second is the duty cycle represented as a value from 0 to 1023.
- 0 is 0% duty cycle.
- 1023 is 100% duty cycle.
- 511 is 50% duty cycle.
- The function is written as
- **`analogWrite(pin,duty)`**;

Motor Speed Control

- Enter the program to the right. This program generates a PWM signal to the motor. Only one side needs a PWM signal. The other is set to 0 so no PWM signal is present.
- The code sets the PWM signal to 1023 which is 100% duty cycle meaning it is on all the time. This is the same as **`digitalWrite()`** function.
- Run the code and see which direction the robot drifts.
- Reduce the value for the opposite direction by 10 and try again. Keep adjusting until the robot drives relatively straight. It won't be perfect.
- The **`analogWrite()`** functions can replace the **`digitalWrite()`** functions in the motion functions.

```
void setup()
{
     pinMode(13,OUTPUT);
     pinMode(14,OUTPUT);
     pinMode(15,OUTPUT);
     pinMode(16,OUTPUT);
}

void loop()
{
     analogWrite(13,1023);
     analogWrite(14,0);
     analogWrite(15,1023);
     analogWrite(16,0);
     delay(5000);
     analogWrite(13,0);
     analogWrite(15,0);
     delay(2000);
}
```

Motor Speed Control Function

- Add this function to the motion tab after all the other functions. This function allows the rover to move forward and gently curve left or right instead of rotating in place with the right and left commands.
- This function has two argument or parameters that get passed to it, **`left`** and **`right`**. These variables are set to the values passed and used inside the function only. They have a range of 0 to 1023.
- Create a function for reverse.

```
void sforward(int left, int right)
{
     analogWrite(13,left);
     analogWrite(14,0);
     analogWrite(15,right);
     analogWrite(16,0);
}
```

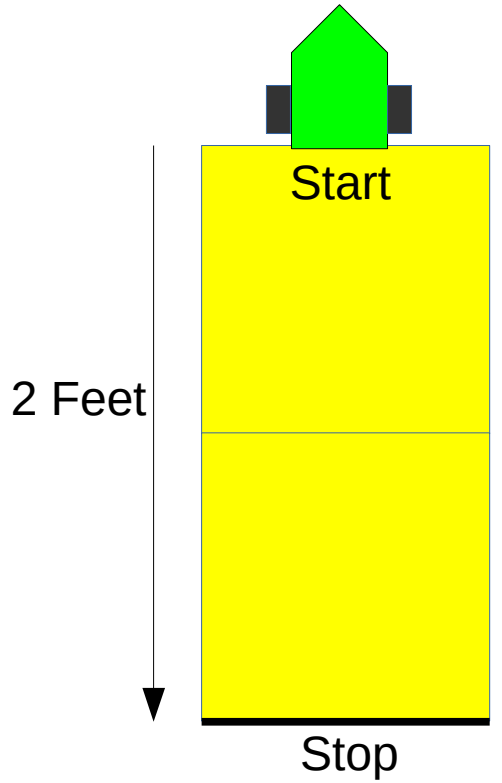
Motor Speed Control Function

- Back in the first tab, change the program in the loop() function to what is in the right.
- Upload the code and see what it does.
- Modify the program to make the robot move in large curves and small curves.
- Modify the program to make the robot move in a S pattern and then in a circle.

```
void loop()
{
    sforward(1000,1000);
    delay(1000);
    sforward(1000,600);
    delay(1000);
}
```

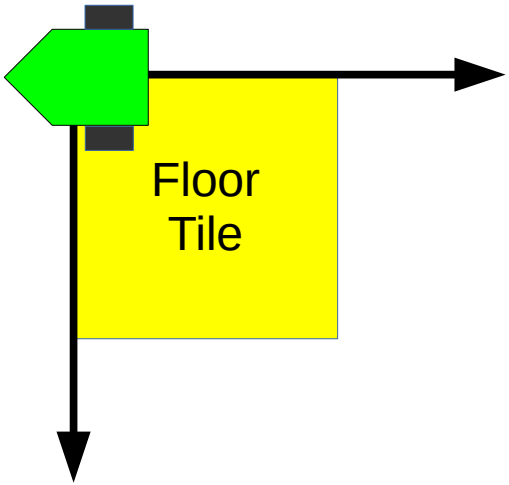
Calibrating Travel

- Since there is no feedback on the motors to detect distance or wheel rotation, time will be used to specify the distance and the amount of turning.
- Mark off two feet on the floor. Floor tile is usually 1 foot square.
- Write a program to move forward two feet and stop. Start with a delay of 1000 ms.
- Adjust the delay until the robot travels two feet. Keep this value.
- If necessary, adjust the PWM values to keep the robot as straight as possible.



Calibrating Turns

- Now mark on the floor a right angle. If the floor has tiles, use the corner of a tile for your right angle.
- Program the robot to turn right and set the delay to 400 ms and turn off.
- Place the robot on the corner of the right angle facing the left line.
- See how much the robot turns and adjust the delay until it turns 90 degrees.
- Verify the value turning left and adjust if necessary.



Course Travel

- Now for the fun part. Modify and expand the program to go through the obstacle course shown below. The large square represent 2 foot grids.
- This attempt through the course is called dead reckoning. Write a program to go through a sequence of motions to reach the end of the course. Adjust the delays between each motion so the robot travels to the finish line without going on off the squares.
- Change the course and make it more complex if you want.