

Experiment #2

DC Motors and PWM



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In this experiment we are going to control the speed of a DC motor using Pulse Width Modulation (PWM). Because DC motors need high current, we can't drive the motor from a digital pin (even if the motor runs on 5 volt). Therefore, we need a driving circuit. Transistors can be used to drive motors.

We will use Arduino to generate PWM signal that to drive the DC motor with different speeds.

Components:

- 1- Arduino
- 2- Breadboard
- 3- DC-Motor
- 4- Wires
- 5- BJT, NPN Transistor (2N2222)
- 6- Diode (1N4001)
- 7- Resistors (330 Ohm)
- 8- H-Bridge L298

Pre-lab:

1-write an Arduino program that changes the state of the built-in LED every T seconds. Read T from the keyboard (use Serial Monitor).

2-Explain how a transistor (BJT and MOSFET) can be used as a switch, and explain the different operating regions of each transistor.

Background:

In this section we will provide a short introduction about the driving circuits of DC motors as well as provide a brief overview about PWM.

Driver Circuits:

Even small DC motors draw relatively high current. The toy dc motor shown below draws 70 mA and runs on 5volt DC.

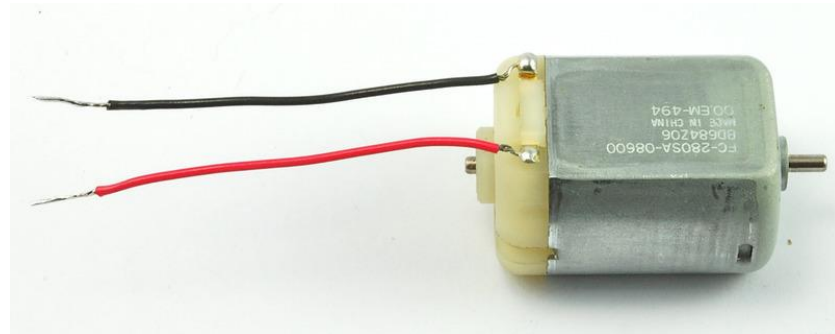


Figure 1: A small DC motor

Therefore, we need a driving circuit to run the motor. We can use a BJT transistor as a driver for the DC motor. We need a resistor on the base to limit the current from the digital pin. The diode is needed to protect the transistor.

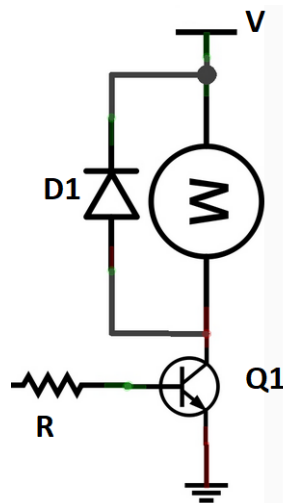


Figure 2: Using BJT to drive a motor.

Because motors usually draw large current, MOSFET transistors are usually used to drive DC Motors.

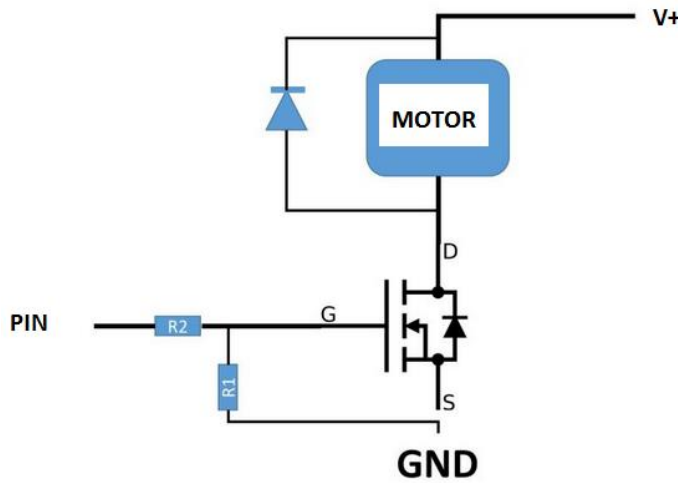


Figure 3: Using MOSFET to drive a motor

PWM:

We can pulse output on and off fast such that the connected device sees the result as a lower voltage. This way, we can control the speed of a DC-motor. We define:

$$\text{duty cycle} = \frac{\text{ON period}}{\text{ON+OFF periods}}$$

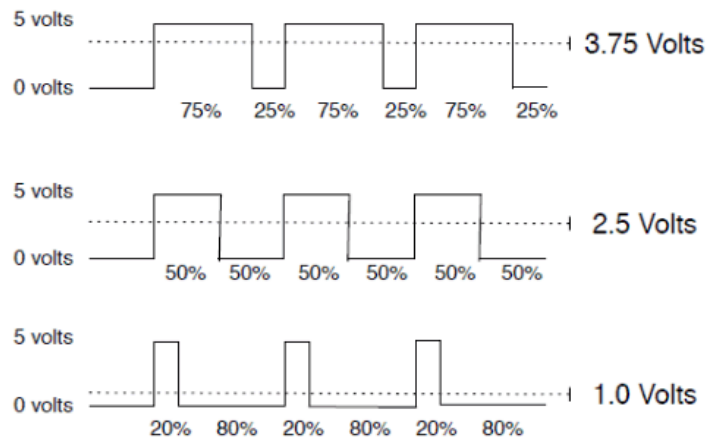


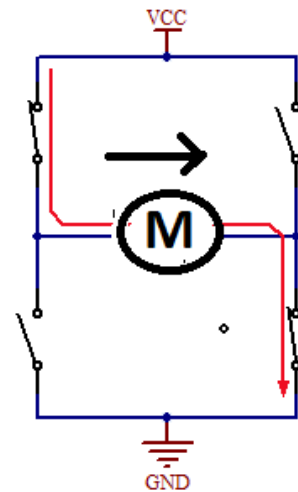
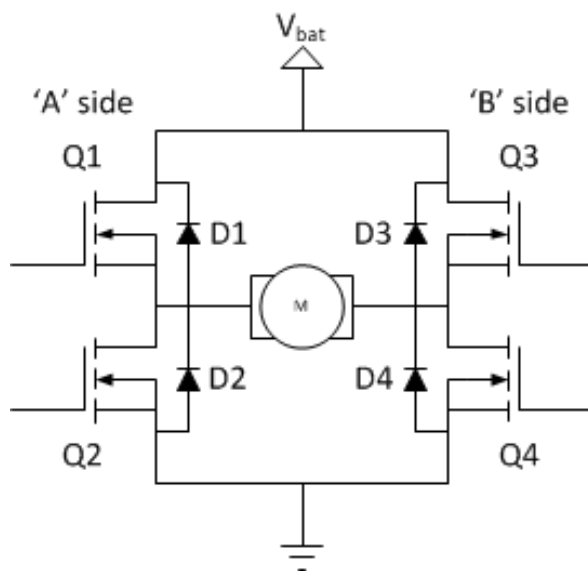
Figure 4: PWM

So, for a duty cycle of 50% and source voltage =12 volt, the load will see 6 volts.

In Arduino we can use `analogWrite(pin, value)` to generate a PWM signal with duty cycle value/255 where $0 \leq \text{value} \leq 255$

H-Bridge

To change the rotation direction of a DC-motor we need to reverse the polarity. This can be done using H-Bridge as shown in Figure 4. If Q1 and Q4 are ON while Q2 and Q3 are OFF, the motor can run clockwise, now if Q2 and Q3 are ON, while Q1 and Q4 are OFF, the motor is going to reverse the direction.



Procedure:

Part1: Use a transistor to control the speed of a DC-Motor.

Connect the circuit as shown in figure 2. Connect pin number 9 to the base on the Arduino. Now run the following code.

```
pinMode(9,OUTPUT);
```

```
digitalWrite(9,HIGH);
```

what is the result? What would be the result if we use:

```
digitalWrite(9,LOW);
```

Explain!

now use `analogWrite (9,200);`

what is the result

again try `analogWrite(9,64);`

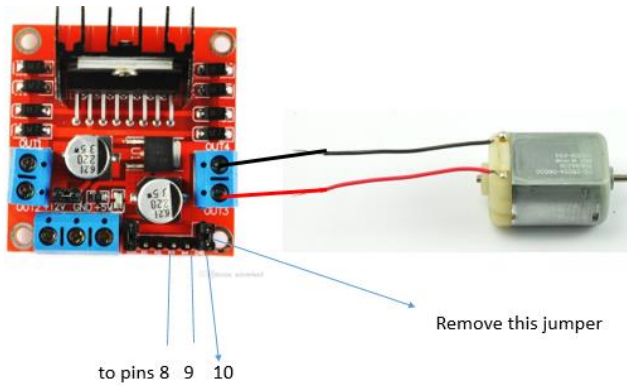
What is the result? What is the duty cycle? Try different numbers!

Task1:

Using Serial monitor, write a code to read a number from keyboard and change the speed of the motor. You have to check if the number between 0 and 255. Print an error message if the number outside this range. Show the result to the instructor.

Part2: Use H-Bridge to control the speed and direction of a DC-Motor

In this part we are going to use L298 Motor Driver Module to control the speed and direction of a DC-Motor



Connect the circuit as in Figure above. Write a code such that pin#8 is 1, pin#9 is 0 and generate a PWM signal at pin#10 with duty cycle 100%.

Now change pin#8 to 0, pin#9 is 1.

What is the result? Explain!

Now change the duty cycle at pin#10 to 50%

Explain the result

Task2:

Write code such that you can control the direction and speed of a DC-Motor from the keyboard. Show the result to the instructor.