ECE 206: H-Bridge and Direction Control

Introduction

In previous labs, you have learned about controlling and measuring the speed of a (DC) motor. For this lab, we will introduce the H-bridge circuit, which is made up of four transistors (shaped as an H, as the name would imply). For this lab, we will use two pairs of complementary power MOSFETs, but an H-bridge may also be built out of BJTs or other transistors. What is important is to
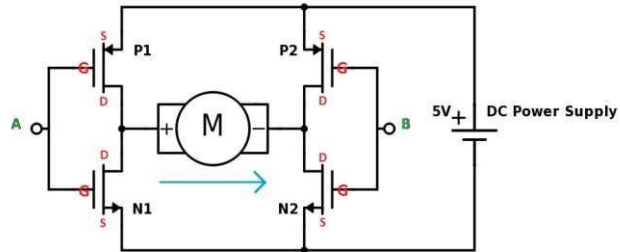

Figure 1: Experimental Setup

have a combination of both N and P type devices (hence, complementary pair). The N-type device (in this case, N channel MOSFETs) will conduct when the gate voltage is ~1.5V (or more) higher than the source voltage. The P-type device will conduct when the gate voltage is ~1.5V (or more) lower than the source voltage. You should note that with the circuit in Figure 1, the two top transistors (P1 & P2) are PMOS devices (arrow points into source), while the two bottom transistors (N1 & N2) are NMOS devices (arrow points out of source). The small arrows also denote which direction the current should flow in our circuit if that transistor is in the ON-state.

In the simple case where we are not concerned about speed control, the H-bridge is controlled by inputs A and B, which will come from your Arduino. P1 and N1 share the same gate input A. P2 and N2 share the same gate input B. As part of the prelab, you will fill in a truth table to understand how to control the motor.

Prelab Deliverables:

Fill out the following truth table.
For each row:
1. The circuit state describes which state each of the 4 transistors are in.
2. You need to find the A and B inputs (HIGH/5V or LOW/0V) necessary to produce that desired state. Note: Not all the combinations of 4-states are possible given only 2 inputs A and B. With only A and B, we can produce 4 different input combinations, but there are 16 different possible circuit states. Our limiting factor will be how we connect the MOSFETS in the circuit.
3. Assume the motor will spin clockwise if the current is in the direction indicated by the blue arrow and counterclockwise if the current is reverse of the blue arrow, and no spin if there is no current.

Circuit State					Inputs Needed to Produce Circuit State		Motor Result
P1	P2	N1	N2	Possibility	A-Input	B-Input	
OFF	OFF	OFF	OFF	Not Possible	N/A	N/A	N/A

OFF	OFF	OFF	ON				
OFF	OFF	ON	OFF				
OFF	OFF	ON	ON				
OFF	ON	OFF	OFF				
OFF	ON	OFF	ON				
OFF	ON	ON	OFF				
OFF	ON	ON	ON				
ON	OFF	OFF	OFF				
ON	OFF	OFF	ON				
ON	OFF	ON	OFF				
ON	OFF	ON	ON				
ON	ON	OFF	OFF	Possible	0V	0V	Motor does not spin
ON	ON	OFF	ON				
ON	ON	ON	OFF				
ON	ON	ON	ON				

1. To have the motor spinning clockwise
   a. A-input has to be   HIGH/5V   LOW/0V   (Circle One)
   b. B-input has to be   HIGH/5V   LOW/0V   (Circle One)
2. To have the motor spinning counterclockwise
   a. A-input has to be   HIGH/5V   LOW/0V   (Circle One)
   b. B-input has to be   HIGH/5V   LOW/0V   (Circle One)

References:
- H-bridge https://en.wikipedia.org/wiki/H_bridge
- Also see references (linked on website) for 2SJ652 P-MOS and 2SK3703 N-MOS

Challenges:
- Build a circuit which can control the motor direction. Motor should be able to change speeds according to user input (using either serial terminal, potentiometer, and/or the encoder knob) and directions depending on which way the potentiometer/encoder knob is turned.

Procedure:

- Set up the circuit as shown in Figure 1. For each of the 4 transistors, make sure you connect the 3 legs properly. If you mix up matching the 3 legs to Gate/Drain/Source, you could create a short and damage the circuit components. The DC power supply should not be giving more than 100mA.

- Demonstrate to your TA a working H-Bridge.

Report Deliverables:

- Provide descriptions with accompanying diagrams of your circuit and experimental setup. Include annotated photographs of your experimental setups if you wish, but you must have circuit schematics made from Fritzing. Circuit schematics are preferred over breadboard schematics, as breadboard schematics tend to be less clear. Points will be taken off for incorrect/misleading/unclear schematics.

- Have your TA check verify your H-bridge. The motor should be able to spin in both directions, and the speed of the motor should change depending on user input.

Report Element	Value
Documentation of Lab Completion	40
Circuit Diagrams	30
Report Quality and all other elements	30
Total Possible Score	100/100