Lab 4. H-Bridge IC and Direction Control of DC Brushed Motors

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In this lab, we will learn and practice how to use an H-bridge IC (e.g., L293/293D) to control the direction of a regular DC brushed motor. In the next lab, we will practice both direction and speed control of a motor by using a H-bridge IC.

As we learned in the lecture, there are many different ways to obtain an H-bridge, either in a circuit or a single IC. As explained in the class, you can build a full H-bridge circuit by using four transistors, and combine it with PWM to control a regular DC brushed motor's direction and speed. However, customization of an H-bridge for different application can be quite time-consuming and costly. Since H-bridges are widely used in many applications for providing voltage with adjustable polarities and driving up current, many semiconductor manufacturers have made it into mass-produced solid-state ICs. Some popular H-bridges are L293/293D/298 series from STMicroelectronics and SN75446/75447/754410 series from Texas Instruments.

Most commercial H-bridge ICs are built to provide as much functionalities as possible. Thus, it is somehow a bit more complicated to use than building your own customized H-bridge circuit, particularly for a beginner. You need to carefully read the IC's datasheet and fully understand the user guide, in particular, the operation of the IC. Once you figure out it works, it will become very easy to use H-bridge IC.

In this lab, we will use an H-bridge IC (e.g., L293 or L293D) to control the direction of a DC brush motor. Arduino will be used to generate the control signals.

Note: since we do not control the motor speed, PWM signal is not needed in this lab.

Devices and Materials Needed:

An Arduino I/O Board (Uno is recommended)
A DC brushed motor; a battery (or power supply) for the motor
An H-bridge IC (e.g., L293/293D or SN754410)
Jumper cables and various passive components

2 Oscilloscope signal cables

Optional: Indicator LED, filtering capacitor, flyback Diodes (1N4001 can be used) if you use L293.

Arduino Keywords and Functions Used in this lab:

const
pinMode( )
digitalWrite( );
Serial.begin( )
Serial.print( ) ; Serial.println( )
Serial.available( ); Serial.read( )
delay( )

Procedure:

1. Before you start the lab, search and download from the Internet the datasheets of your motor and H-bridge IC (e.g., L293/293D or SN754410).
2. Read the datasheets carefully, be aware how many volts your motor takes, and make sure that the maximum output current of H-bridge IC is larger than what your motor needs.
3. Read the user guide of your H-bridge IC, fully understand how it operates. In your lab report, show the diagram and briefly explain the pin definition of your H-bridge IC.
4. Draw a circuitry schematic for direction control of a DC brushed motor by using H-bridge IC. In the lab report, present the schematic and clearly explain how the circuit operates to run the motor along two directions. ***Hint:*** Draw a truth-table to help explain.

   Note: No any hand-drawn diagram or clip from the lecture slide is allowed for the circuitry schematic. Use a software (e.g., *MultiSim, ProE, SmartDraw or MS Visio*) to draw the circuitry schematic. You can also use *Fritzing* to draw the wiring schematic (see details about Fritzing on the course website). Include either circuitry or wiring schematic in your lab report.
5. Select output ports on Arduino I/O board for the H-bridge’s enable pin and two input pins. Write down the port numbers. Indicate port number assignment in lab report.

   Note: Uno PWM ports are 3, 5, 6, 9, 10 and 11, which, by default, are output pins.
6. Build your circuit on breadboard. Connect the battery (or power supply) to the circuit.

   Note: Do NOT forget to connect Arduino’s ground and motor power supply’s ground together to form a common ground.
7. Write a complete Arduino sketch to make the motor rotate at a direction

and with any speed. Do NOT forget to use pinMode( ) to set the port as output at first.

Note: Be aware of the difference between analogWrite( ) and digitalWrite( ).

8. Connect the two control signals that are fed to H-bridge input pins to oscilloscope. Display their waveforms on the oscilloscope. Include the waveforms in lab report. Explain why the waveforms are different.
9. In your sketch, add code to brake the motor for 6 seconds, then run the motor at the opposite direction for 10 seconds then brake for 6 seconds again.

   Note: "delay( )" function needs to be used to let the motor run and brake for a few seconds. For example: delay(3000); //To last for 3000ms=3sec.
10. Run the new complete sketch, pay close attention to how the control signals change their waveforms when the motor rotates at different directions. Record the new waveforms when the motor spins at the opposite direction and brakes. Include all the waveforms in lab report.

    Warning: Do **NOT** just list the waveforms in the lab report. You must include a description or brief caption to explain what scenario each waveform is for.
11. Include the complete and correct sketch in your lab report.

Due Date of Lab Report: To be announced on the Blackboard.
Please submit your lab report ONLY via the Blackboard.

Do not make any figure too large in your lab report. Half page is the max size for any figure. Regarding to the lab report, a "Lab Report Requirements" has been posted on the Blackboard. Please read it carefully!