ME4405 - Fundamentals of Mechatronics (Spring 2020)

Lab Assignment Eight (revised)
DC Motor Speed Control Using the MSP432

Due Thursday, April 9th, 2020

Objective: The objective of this lab is to learn how to interface and control a brushed DC motor with the MSP432 using PWM. You will control both the speed and direction of the motor using the microcontroller.

Deliverables and Grading:

To get credit for this lab assignment you must:

1. Submit a video demonstration by 5 pm on Thursday, April 2nd 2020. Show your Buzzcard in the video. **(50 points)**
2. Submit the commented final version of your code on Canvas. **(Pass/Fail)**
3. Lab quiz will be held Friday, April 10th **(10 pts)**

Setup:

This lab requires Code Composer Studio, the MSP432, and a driver circuit for brushed DC motor control. The lab uses onboard features of the device such as GPIO, ADC14 and Timer A.

Problem Statement:

Build a driver circuit for a brushed DC motor. This circuit will be used to control the speed and direction of the motor. The direction and speed control signals are generated by a software program. Speed control will be based on analog input from a voltage divider circuit using a potentiometer. The main component used in the driver circuit is an H-bridge IC.

Your software control program should operate as follows. Initiate S1 and S2 as inputs. S1 and S2 should be used as toggle switches. The motor should start spinning in one direction when S1 is pressed and stop spinning when S1 is pressed again. Same for S2, but in the opposite direction if S2 is pressed. LEDs can be used to indicate and differentiate the motor in ON condition vs OFF condition for the 2 spin directions. Based on the analog input voltage received from the voltage divider circuit, the duty cycle of the PWM signal should be varied to control motor speed while the motor is spinning in either direction. Motor speed control should be accomplished using PWM.

Background:

Brushed DC Motor:

The brushed DC motor is a type of motor that operates on DC voltage and current. It is bidirectional, meaning if the supply terminals are swapped the motor turns in the opposite direction. An H-bridge helps in achieving this functionality without physically having to swap the terminals.

The motor we are using, model number M1N10FB11G, is manufactured by NMB Technologies. Specifications for this motor can be found in the datasheet at:

http://www.nmbtc.com/pdf/motors/M1N10.pdf

This motor is capable of high speeds, with a rated output speed of 13850 rpm. The input voltage for the motor is 5V.

H-bridge IC:

The H-bridge IC that we are using for this lab is the TI L293DNE. This is a quadruple half H-bridge driver IC. It has four half H-bridges that can be used either independently for motors with unidirectional applications, or in pairs for motors with bidirectional applications. The datasheet for the H-bridge driver IC can be found at: http://www.ti.com/lit/ds/symlink/l293.pdf.

We will be using ports 1 and 2 of the H-bridge as a pair. This forms a full H-bridge which enables bidirectional operation of the motor.

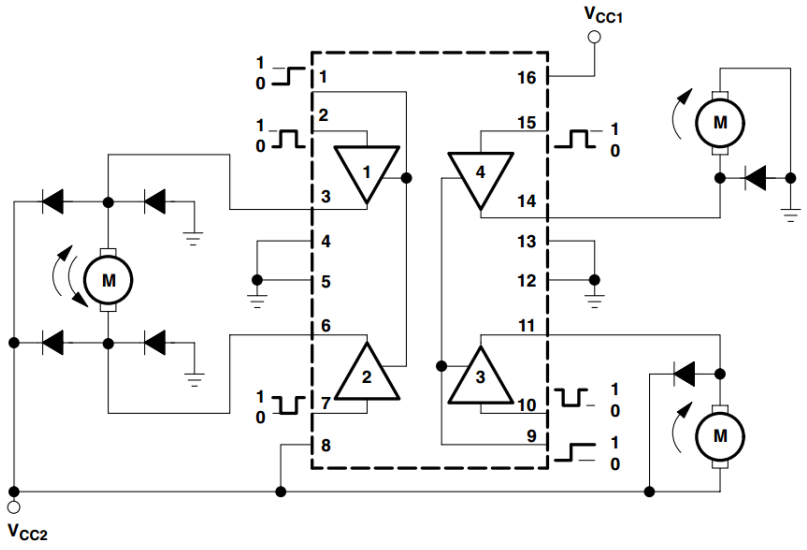

Figure 1. L293DNE connection diagram

Figure 1 shows the possible wiring configurations that can be used with this H-bridge IC. The interfaces at ports 3 and 4 port are used for unidirectional operation of a motor only. The left side of the diagram (showing ports 1 and 2) show the wiring schematic for bidirectional operation of the motor. We will be using this configuration.

The pins on the H-bridge IC are as follows.

Pin Number	Pin Name	Pin Function
1	1,2EN	Enable drivers 1 and 2 (Set to high)
2	1A	Input control signal from MSP for driver 1
3	1Y	Output signal to motor for driver 1
4	Heat Sink/GND	Connect to Ground
5	Heat Sink/GND	Connect to Ground
6	2Y	Output signal to motor for driver 2
7	2A	Input control signal from MSP for driver 1
8	Vcc2	Power supply for motor (Connect to = +5V)
9	3,4EN	Enable drivers 3 and 4
10	3A	Input control signal from MSP for driver 3
11	3Y	Output signal to motor for driver 3
12	Heat Sink/GND	Connect to Ground
13	Heat Sink/GND	Connect to Ground
14	4Y	Output signal to motor for driver 4
15	4A	Input control signal from MSP for driver 4
16	Vcc1	Power supply for control logic (Connect to = +5V)

The MSP432 should be connected to the H-bridge IC as shown in the figure below.

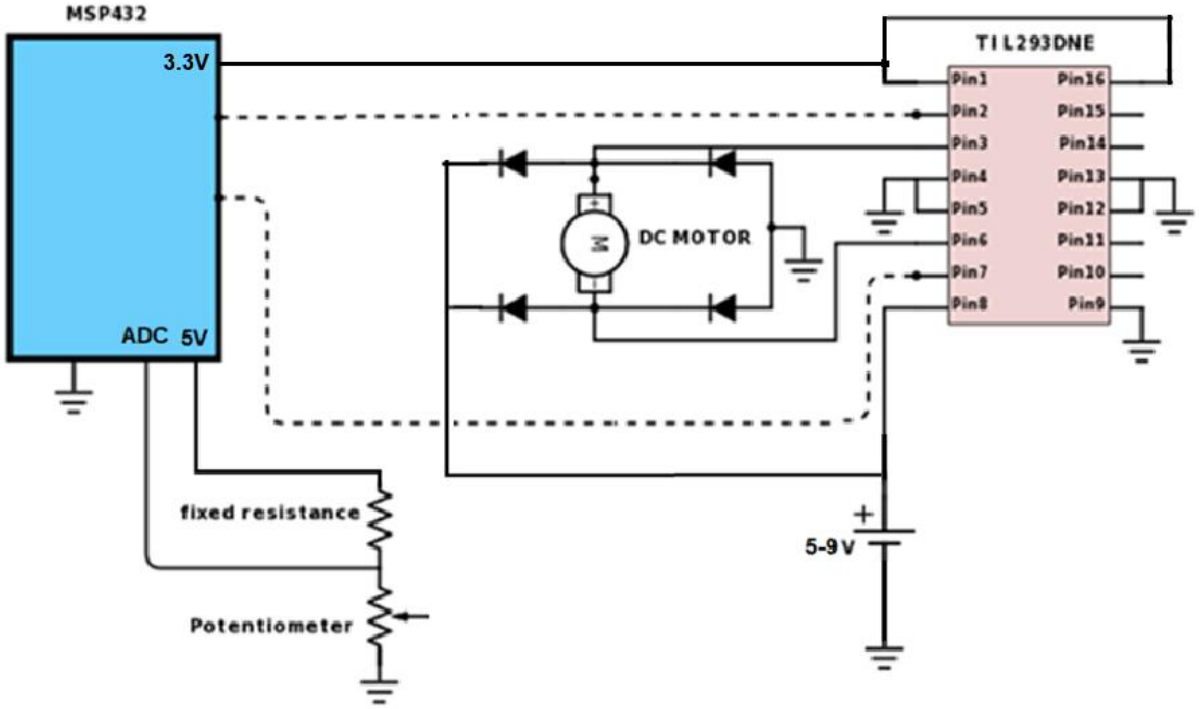

Figure 2. Circuit diagram for the H bridge interface with motor

To understand exactly what the input control signals do, refer to Figure 1. The power supply on the right side of the figure will be provided by your battery pack, which should be 5V, 6V, or 9V (the motor and the H-bridge can handle any of those voltage settings). Setting pin 2 of L293DNE high and simultaneously setting pin 7 of L293DNE low will turn the motor in one direction. To turn the motor in the other direction, pin 2 should be low and pin 7 of L293DNE should be high. **Note that these pins can also accept PWM signals from the MSP432**. In order to operate the motor in either direction, a PWM signal should be applied to one of these two pins while maintaining the other pin low.

Hardware:

Figure 2 shows the circuit used to interface the brushed DC motor with the MSP432. The motor needs a +5V (or higher) supply which is provided by the L293DNE via pins 3 and 6. The flyback diodes provide paths for current to flow when the drivers are switched off. Assemble the circuit on your breadboard as shown. Before connecting the motor, test the output of pins 3 and 6 of the L293DNE after applying the required PWM input signals. If the outputs are acceptable, connect the circuit to the motor. Please continue to check the temperature of the MSP432. If it is getting hot, disconnect the MCU immediately and debug the circuit. **Remember to connect a common ground between the MCU and driver circuit.** The batteries power the H-bridge, the DC motor (through H-bridge), and provide the voltage drop across the potentiometer for Lab 8. Make sure to power the voltage divider circuit from the MSP432 so that ADC pins are not damaged.

Software:

Press S1 to start spinning the motor in one direction. Turning the knob of the potentiometer should change the speed of the DC motor (Zero to maximum speed). Then press S1 to stop spinning the motor. Now, press S2 to start spinning the motor in the opposite direction. Once again, turning the potentiometer knob should allow you to vary the motor speed throughout it speed range from 0 to maximum. Then press S2 to stop spinning the motor. **The DC motor should never receive PWM signals of opposite spin directions at the same time. This could potentially cause the motor to burn out.** Therefore, before you connect the motor terminals to the circuit, verify the functionality of using S1 and S2 as ON/OFF switches to ensure that the motor receives only 1 PWM signal at a time. Only when you are confident of the functionality of your code should you connect the terminals of the DC motor.

To turn the motor in one direction, start one Timer A module and stop the other. Never have both Timer A modules started (enabled) at the same time, as putting two simultaneous PWM signals through the motor in opposite directions may damage it.