ECE437: Sensors and Instrumentation

Lab 11: H-Bridge Motor Controller

Introduction

In this lab you will learn how to use an H-Bridge circuit to control a stepper motor. You will use PMOD sensor from Digilent to interface the FPGA with the motor. In particular, you will use PMOD_DHB1 sensor to control the speed and directionality of the motor. The PMOD sensor interfaces with the custom sensor board that you have been using this semester. The PMOD ports are at the periphery of the sensors board and you will need to use the schematic of the sensor board to locate the necessary pins you will need to communicate. The PMOD extension board contains an H-bridge circuit from Texas Instrument. The datasheet for the sensor and PMOD extension board are located on the course website.

Relevant Documents for this Lab

Required reading material for this lab:

1. The datasheet for PMOD DHB1 extension board is located on the course website.
2. The datasheet for the H-bridge integrated circuit (Texas Instrument DRV8833) is located on the course website.

Additional reference material for this lab:

1. None.

The Goals of This Lab Are:

1. The objective of this lab is to control the directionality and step size of the motor using custom built FPGA code. You will also acquire the acceleration and magnetic information from the LSM303 sensor on the board. This will enable you to automatically test the SLM303 sensor using the motor.

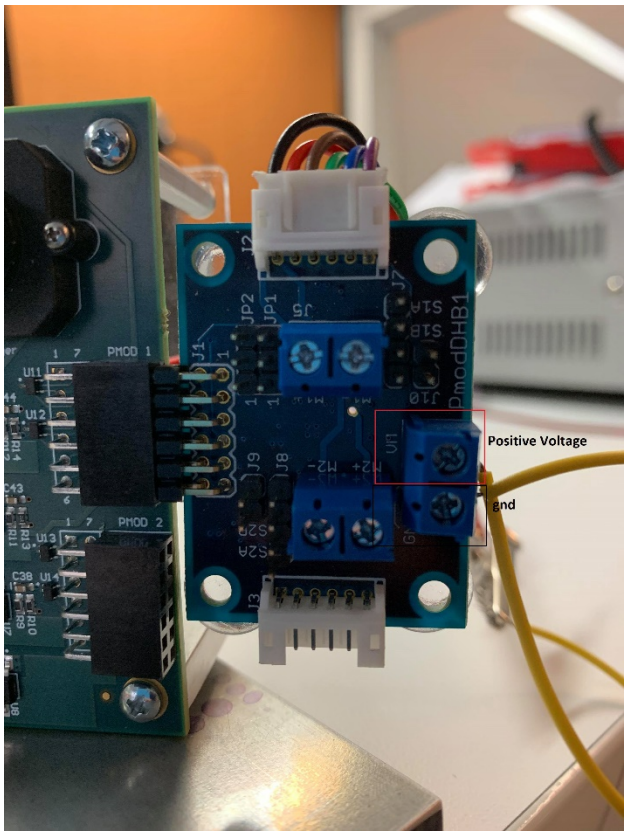
Prelab Questions (25 pts):

1. Look over the online documentation for the PMOD DHB1 board. What kind of motors can you control with this PMOD? (5 pts)
2. What is the maximum number of motors that you can independently control with the PMOD DHB1 board? (5 pts)
3. What is the on resistance of the left and right output branch of the H-bridge? (5 pts)
4. The PMOD board will be connected to the sensor board where the OpalKelly FPGA board is connected. What are the pins on the OpalKelly FPGA that you will use to control the motor? (10 pts)

Checkpoint 1 (100 points)

The goal of this lab is to write the necessary firmware (Verilog code) and software (Python) that will enable you to control the rotation of the motor via the PMOD DHB1 board while simultaneously acquiring acceleration and magnetic information from the LSM303 sensor. You will use the framework that you developed in the previous lab where you were able to read acceleration and magnetic data from the LSM303 sensor. You will build on top of this frame work and add the necessary firmware and software to control a motor.

Connect the PMOD DHB1 sensor to the sensor board as shown in the figure bellow. Connect two wires on jumper J4 of the PMOD board to the power supply. Make sure that the positive voltage and ground are correctly connected to the power supply and PMOD as shown in the figure bellow.



The FPGA Verilog code will control directly the directionality and number of step pulses to the motor. Your FPGA code will have to communicate also with the PC, where a user will enter the directionality of the motor spin and the number of pulses that the FPGA will send to the motor. Here are the detailed specifications:

1. An end user will specify the number of pulses and directionality of the motor spin. This information will bed sent to the FPGA via the USB interface.
2. The FPGA will receive this information from the PC and generate a clock signal with 200 Hz frequency. The FPGA will send exactly the number of clock cycles specified by the end user.

3. While the motor is spinning, the FPGA will read the acceleration and magnetic information from the sensor board and send this information to the PC. Your code will send at least 5 times more data readings (acceleration and magnetic information from all three axis) then the number of pulses sent to the motor. The sensor readings should be independent of the pulses sent to the motor and should capture number of readings while the motor is rotating.
4. Once the FPGA sends the required number of pulses, the motor will stop spinning.
5. Continuously display acceleration and magnetic information on the screen

Checkpoint 2 (20 points)

You will test the acceleration of the motor as a function of different voltages applied to the H-bridge circuit. At this stage, you will just demonstrate a working code prototype and you will test it in the next labs. Since we will only have two boards that are mounted on a motor, you will have to record this data over the next several labs and demonstrate your results in the final report for this class. Write a Python code that will allow you to the following:

1. Set the voltage that powers the motor to 3V.
2. Continuously record acceleration and magnetic information from the sensor.
3. Rotate the motor for 100 clock cycles.
4. Increment the voltage on the power supply by 0.5 volts until 5V maximum output and repeat steps 2 and 3.
5. Plot the mean and maximum acceleration vs. applied power voltage.