Lab 0x02 - Stepper Motor Driving

This assignment is to be completed in your lab groups. You will have ~~*two*~~ *three* weeks to complete this assignment. For this lab you will implement the design you developed in HW 0x01.

Assignment

Before you begin the lab, discuss as a team what your design will be for the motor drivers. That is, come to an agreement on a design by combining or selecting from your HW 0x01 solutions. Once you have agreed upon a design, you can get started with two different aspects of the assignment: hardware setup and Python implementation.

Hardware

To complete this assignment your team will need to assemble several different electronic components. Consider the primary components as depicted in Figure 1.

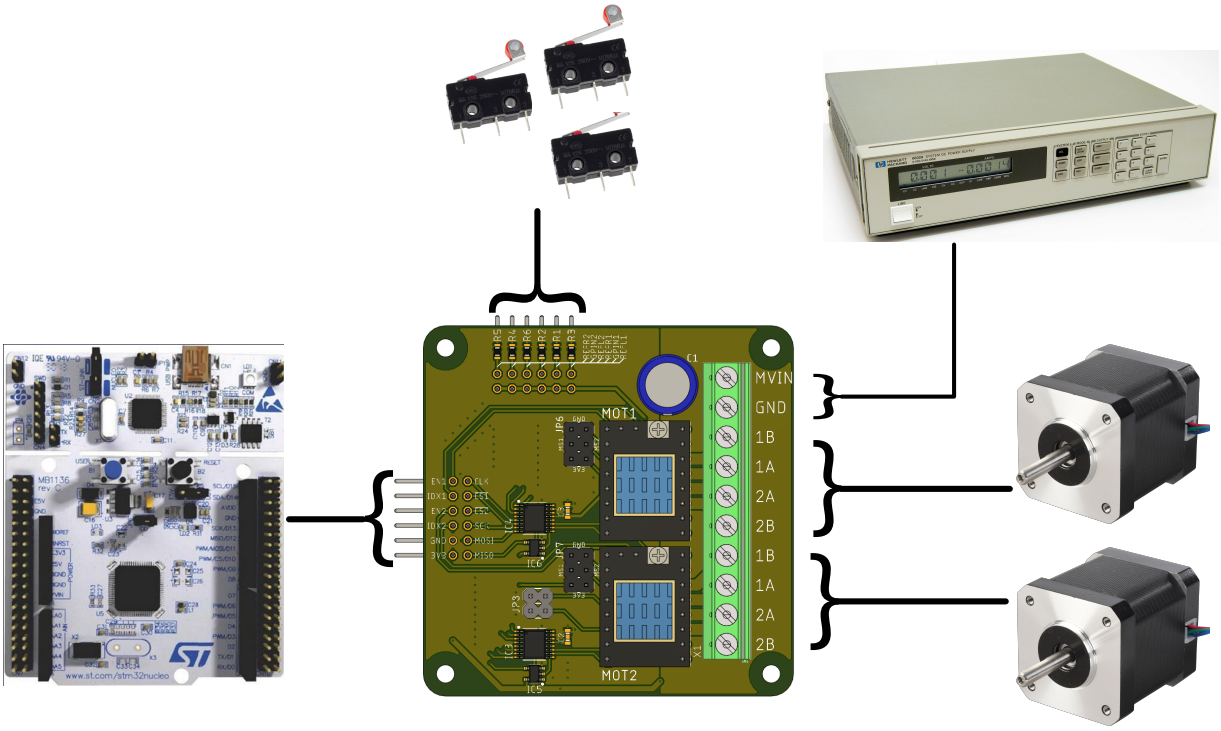

Figure 1: Connections between Nucleo (left), stepper board (center), motors (right, bottom), power supply (right, top) and limit switches (top).

Nucleo L476 and the Shoe of Brian

No assembly will be required on the Nucleo board, but your team will need to connect external wiring to the "Shoe of Brian" using the green screw terminals.

⚠It is important that these terminals are used correctly or they may be damaged!

To use the screw terminals you must have an appropriately sized screwdriver. That is, a slotted, or flat-blade style, screwdriver of the appropriate size to match the small screws on the screw terminal blocks.

Before inserting a wire it is important to unscrew the terminal *all the way* so that the cage within the terminal descends completely; if this is not done correctly the wire may end up underneath the cage instead of inside the cage. Pay attention not to jack the screw out of the terminal completely; the screw should be retained by the screw terminal at all times.

Once the cage has descended all the way, insert your properly stripped wire into the cage and then tighten the screw to raise the cage until a good grip on the wire has been secured.

The wire should be stripped such that about $\frac{3}{16}$[in] or 4.5[mm] of conductor is exposed to ensure that the cage clamps on the conductor and not the insulator without allowing any conductor exposed outside the terminal.

Dual Motor Driver Board

You will be provided a partially assembled motor driver board. The board will have all surface mount (SMD) components presoldered, but none of the through hole components. Your team will need to complete assembly of the board by populating several components. These components will include a capacitor, pins, headers, and screw terminals. There should be enough opportunity for each group member to practice a little.

An example board will be available in the lab for comparison.

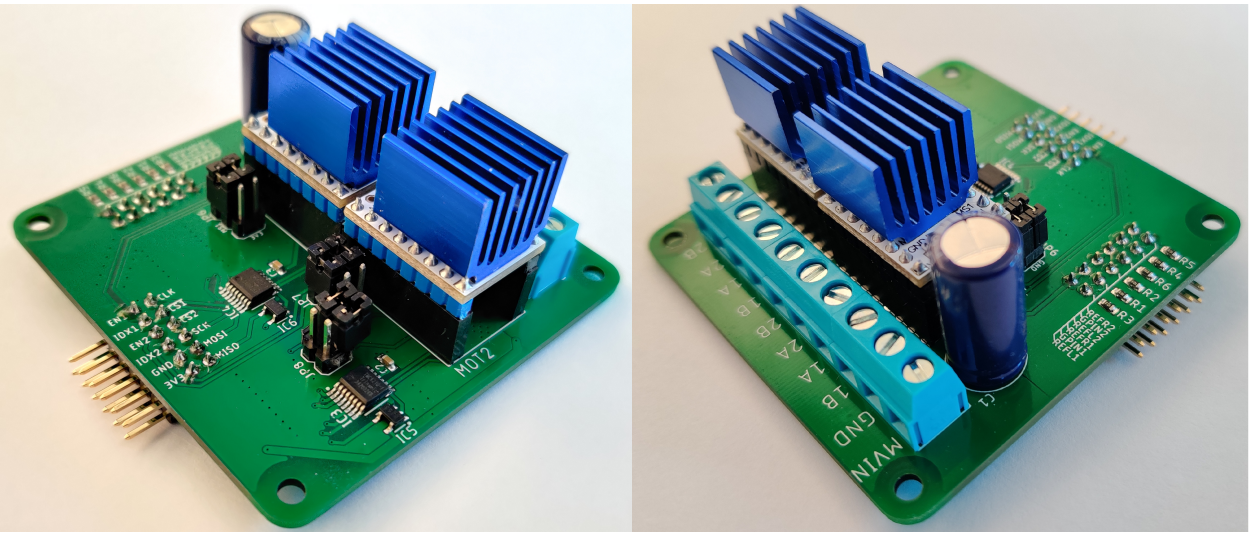

Figure 2: Fully assembled stepper driver board.

Cable Assembly

The motor driver board must connect to the Shoe of Brian with some kind of cable assembly. You will be responsible for constructing a cable assembly to transmit the necessary signals such as SPI and enable signals. To help facilitate creating neat cable assemblies you will be provided ten pre-crimped wires in a variety of colors which you can place into a rectangular connector housing to match the connector on the motor driver board. Table 1 shows the ten connections that you will need to interface the Shoe of Brian with the two TMC4210 and two TMC2208 ICs. The IDX pins are not needed in normal operation.

Table 1: Microcontroller connection to motor driver breakout. Room is included to write in wire colors and the selected pins on the Shoe of Brian.

Notes	**Motor Driver Board Pin**				**Notes**
	EN1	•	•	CLK	
	IDX1	×	•	nCS1	
	EN2	•	•	nCS2	
	IDX2	×	•	SCK	
	GND	•	•	MOSI	
	3V3	•	•	MISO	

2x Stepper Motors

For whatever motors you select, you will need to be able to connect the terminals of the motors to the motor driver board. You may need to make some custom cable assemblies for this depending on which motors your team has selected for the term project.

Firmware

Once your hardware setup is sorted, or in parallel with the hardware setup, you will need to write and test a Python driver for your stepper driver board. That is, you will need to implement the class that you designed during HW 0x01.

Preliminary Milestones

For the beginning of work on your lab assignment you should prioritize hardware setup and initial firmware testing; ideally you should have completed the following before the second work period for this lab:

- Completely assemble the motor driver board. When you are finished, have all teammates inspect the solder joints on the driver board; when your team agrees on the quality of assembly have your instructor inspect things before you begin connecting wires.
- Generate a clock signal for the CLK input to the TMC4210 using a timer on the STM32 microcontroller. Confirm on an oscilloscope that you are generating a clock signal with the appropriate frequency before you connect the signal to your motor driver board.
- Complete assembly of the cable that will connect the motor driver board to your Nucleo board. As with the soldering, have each member of your team independently inspect the completed cable assembly before you power on your system. Your instructor can also help inspect the cable harness. Once your team is *confident* that the wiring is connected properly you may power on the board and begin testing.

  ⚠Use caution when you finally commit to testing the hardware. The hardware is likely to be damaged if connected improperly.
- Begin preliminary development of your driver class by writing a single function that allows you to read or write data from an arbitrary register on the TMC4210 over SPI. Confirm that SPI is working properly by querying the TYPE_VERSION register. If you read back the correct default value from this register you can be confident that the SPI portion of your hardware setup is working correctly.

Requirements and Deliverables

To receive full credit on this assignment you will submit a PDF to Canvas in memo format; *note:* if you are unsure about proper memo formatting please review before submitting. Many groups did not follow the memo format on previous submissions.

Your memorandum must include several paragraphs describing the scope of the lab assignment, the methods and techniques you used to assemble the board, and details about your driver design and implementation; additionally mention any particular struggles (hardware or software) that your team faced and how you overcame those struggles.

Also include the following content as attachments, or where appropriate, in the body of the memo:

1. Include a finalized version of the class design that your team started in HW 0x01.
2. Include a wiring diagram showing the connections between the Nucleo/Shoe of Brian and the motor driver board. Also include a description or diagram showing any modifications made to the motors or the wiring harness used to interface with the motors.
3. Include several oscilloscope captures showing the following:
    - The CLK line operating at 20 MHz as made evident using the measurement tools on the scope.
    - The entire SPI bus during one datagram transfer reading from the TYPE_VERSION register. That is, a capture from all four scope channels showing the value of nCS1, SCK, MOSI, and MISO. You may also want to use the serial decoding features on the scope to show the values of the data on the SPI bus.

    Be sure to fit the scope captures to use the full screen so that the produced images are clear and scaled nicely.
4. A screenshot from a PuTTY or Thonny console window showing the received datagram from reading the TYPE_VERSION register.
5. A link to a web-hosted video showing the motor move in a specific pattern. A suitable pattern would be anything that illustrates the correct behavior of your setup; an example would be making the motors spin exactly one revolution at a time with a short pause in between each revolution.