MECHTREON 3TA4 Lab 5

Control of a Stepper Motor

Introduction

In this lab you will learn how to interface the STM32L476 MCU with a stepper motor and also how to drive such a motor in full/half step mode and clockwise/counterclockwise direction, while controlling the speed of rotation.

Prelab

In addition to the class notes, you should read the following:

1. Zhu, `Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C`, Chapter 16.
2. `Overview of stepper motors`, their specifications and terminology.
3. `Stepper Motor Technology Background`.

hardware

The stepper motor used in the lab is a `26M048B1B` from Thomson Airpax Mechatronics, which is a 48 step motor. To drive this motor, any of the sequences of signals described in class can be used.

In general, a signal conditioning stage is needed for driving a stepper motor. In the lab we will use the `SN754410NE` H-bridge driver. In addition, we will use 8 diodes to protect the control circuitry from voltage spikes that would otherwise be produced by the windings (see p. 6 of the `SN754410 datasheet`).

A sequence of signals will be generated using a timer of the STM32L476 MCU to control appropriate switches in the H-bridge. The outputs of the H-bridge will be connected to the four terminals of the motor. A block diagram of the equipment arrangement is shown in Figure 1.

Figure 2 shows a schematic diagram of the connections to the H-Bridge (SN754410).

The STM32L476-Discovery board cannot handle more than 100mA when powered from the mini-USB. This means you can connect pins 1, 9 and 16 of the H-bridge to the 5V pin of the STM32L476-Discovery board, but need to connect pin 8 and the output wires (connecting to the motor) to an external power source of 5V.

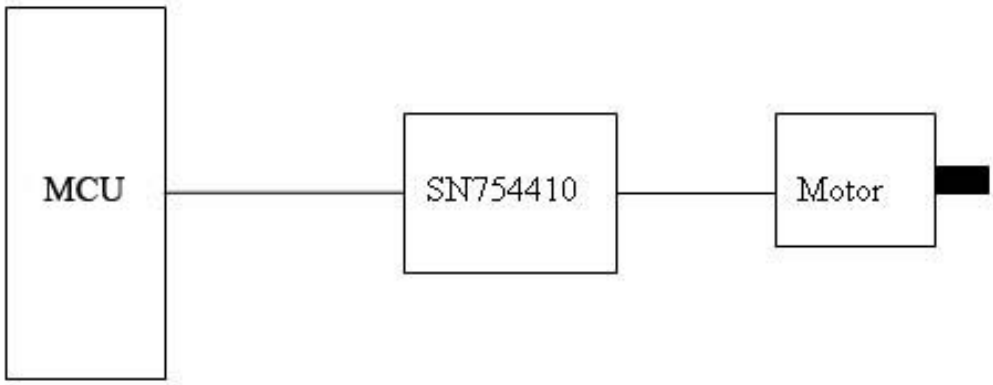

Figure 1: Block Diagram

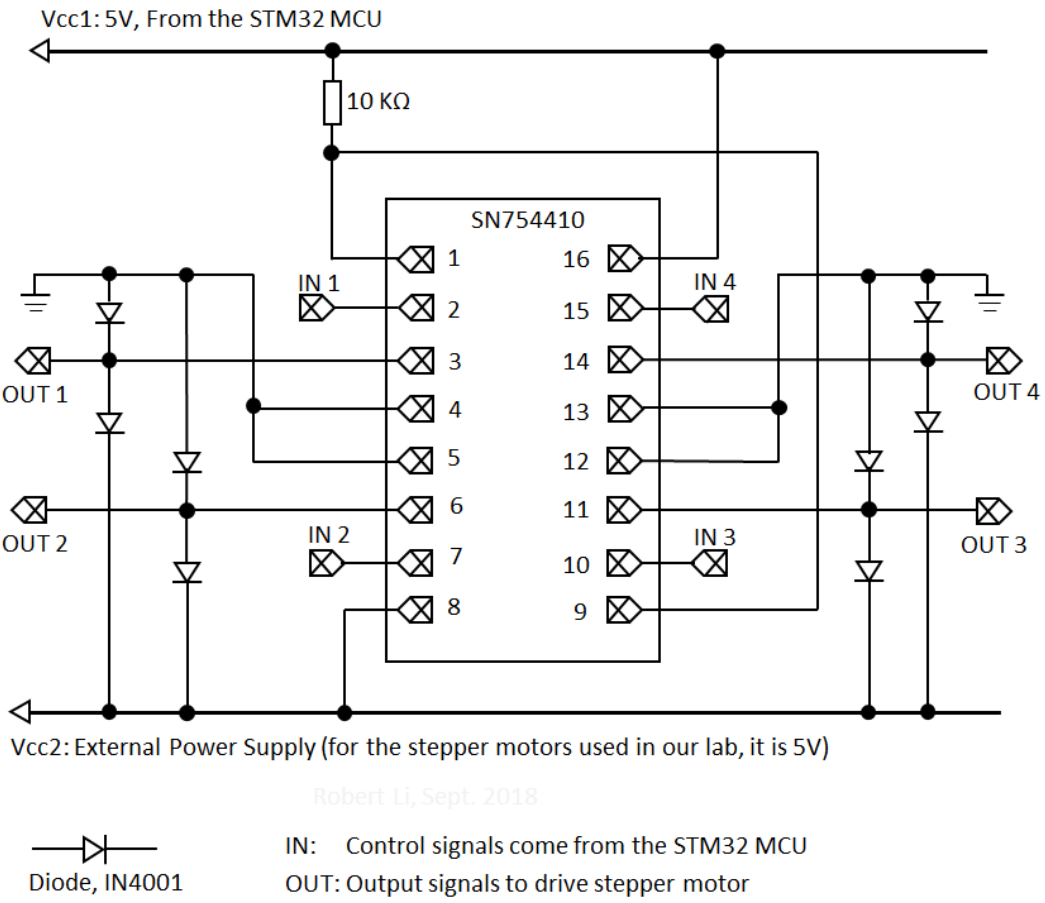

Figure 2: Schematic Diagram for Connecting H-Bridge

Individual Lab Report [40 pts.] (individual work)

The following activities should be completed and described in a report by each student **independently**. The reports must be in **PDF format (no handwriting, please)** and should be commited by each student to **dropbox folder Lab5 before deadline.** Late reports will be **penalized 10**

points for each additional 24 hours, starting from the deadline.

1. **[5 pts.]** Calculate the angular resolution of the given motor, which makes 48 steps per revolution.

2. In this lab we will use the stepper motor to implement an unusual clock. The motors shaft will be connected to a dial of the clock. Hence, we would like the motor to complete one full revolution in a very specific amount of time. The amount of time (in seconds) will be equal to the last two digits of your student number. To make the testing times reasonable and fairer across the class, you can adjust this number if it is very low or very high. Please use the following scheme to do that:

   (a) If the last two digits of your student number are less than 33, add 33 to it and use that number. E.g. if your student number is 654321, last two digits are 21, which is lower than 33. Then you add 33 to get 54 seconds, which is the period you should use.

   (b) If the last two digits are between 33 and 66 (inclusive), use the last two digits unchanged. E.g. if your student number is 123456, you should simply use 56 seconds for the period.

   (c) If the last two digits are greater than 66, subtract 33 from it and use that number. E.g. if your student number is 56789, last two digits are 89, which is greater than 66. Then you subtract 33 to get 56 seconds, which is the period you should use.

3. **[10 pts.]** Determine the time period between two steps of the stepper motor used in the lab such that the motor completes one revolution in the time interval calculated in Step 2. Do this for:

   (a) **[5 pts.]** Half-stepping sequence.

   (b) **[5 pts.]** Full-stepping sequence.

4. **[10 pts.]** In the lab you will use TIM3 of the STM32L476 to measure time periods. Assuming the clock frenquencies of both APB1 and APB2 domains of the STM32L476-Discovery board are configured as 4MHz, calculate the values for the prescaler and for the output compare register for TIM3 that will enable you to measure the time intervals calculated at steps 3a and 3b.

5. **[15 pts.]** Write C code (only the relevant parts should be included in the report) that uses TIM3 and the stepper motor to implement the clock described in Step 2. Implement this for both full-stepping and half-stepping. Make sure that the direction of the motor movement (clockwise/counter-clockwise) can be easily changed in your program. You may use the joystick buttons available on the Discovery boards.

Lab Procedure and Requirements [60 pts.] (group work)

IMPORTANT NOTE: IN ORDER TO AVOID EXPENSIVE DAMAGE, DO NOT TURN ON YOUR MOTOR WITHOUT APPROVAL FROM A TA. IF YOU DO NOT GET APPROVAL FROM A TA, YOU MAY BE ASSIGNED A ZERO FOR THE LAB.

For the lab report each student was required to perform some tasks independently, not in groups. Starting from the answers in the report of one member in your group, perform the following tasks as a group:

1. Using the equipment available in the lab, determine which wires on the motor correspond to the 2 windings.

2. Complete the breadboard circuit according to the schematic diagram given in Figure 1 and Figure 2.

3. Download the lab starter project (`lab5starter.zip`) and place it in the directory structure discussed in Lab 1.

4. Enhance the starter code so that you can drive the stepper motor in different modes of operation:

   (a) [**15 pts.**] Full or half stepping. A push button should be used to allow the user to cycle between these 2 modes.

   (b) [**15 pts.**] Clockwise or counter-clockwise rotation. A push button should be used to allow the user to cycle between these 2 modes.

   (c) [**10 pts.**] The user should be allowed to change the speed of the motor by pressing two buttons, one to increase the speed and one to decrease the speed.

5. Connect the motor, STM32L476 board, external power supply and the breadboard circuit to test your application. You may want to add some kind of marker to the motor shaft, to easily observe its movement. You can use a piece of tape wrapped around the shaft for this.

6. Perform any experiments required to answer the following questions:

   (a) [**10 pts.**] How does the behaviour of the stepper motor change when you exchange the two sides of one winding (e.g. exchange A1 and A2), without changing the program?

   (b) [**10 pts.**] How does the behaviour of the stepper motor change when you exchange the two windings (i.e. exchange A1 and A2 with B1 and B2), without changing the program?