California State University, Long Beach

Cecs 346

Project 2

Rodrigo Becerril Ferreyra
Student ID 017584071

A project that uses the ARM Cortex-M4 microcontroller to simulate a smart garage operation.

December 18, 2020

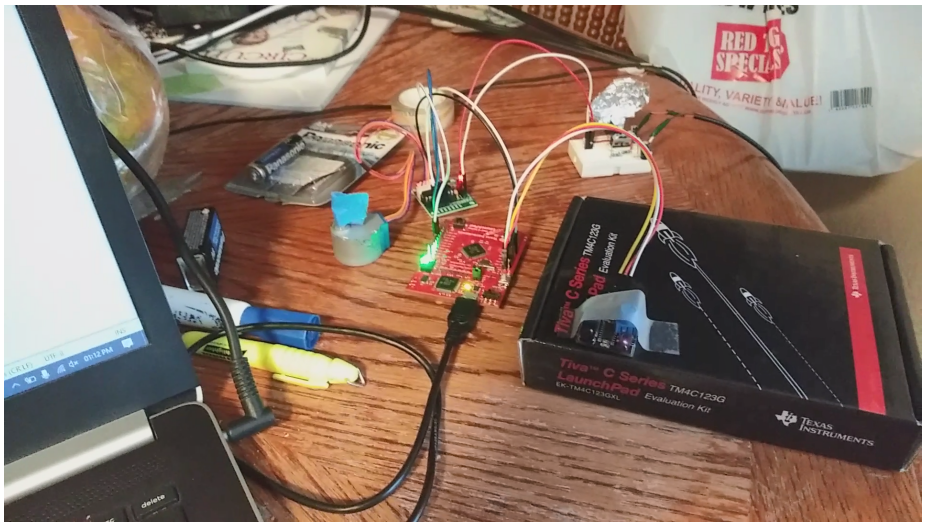

Figure 1: Picture of system running.

1 Introduction

The goal of this project is to extend the functionality of Lab 4 by adding a stepper motor and changing some functionality, such as the buttons. Specifically, the changes to Lab 4 are listed below:

- A stepper motor (28BYJ-48 driven by a ULN2003A Darlington transistor array) was added.
- `sw2` was removed and instead replaced with a toggle functionality for `sw1`.
- Timing for flashes adjusted slightly.

For more in-depth details about the rest of the functionality of this project, please refer to the Lab 4 Report.

2 Operation

As noted previously, the stepper motor used for this project is the 28BYJ-48[1], a unipolar stepper motor, which is driven by the ULN2003A(N)[2] integrated circuit. The motor/driver system takes in four signal inputs and a 5 V power input. Its four signal inputs are capable of driving the motor with only 8 mA of current from the microcontroller's GPIO ports.

[1] http://robocraft.ru/files/datasheet/28BYJ-48.pdf
[2] https://www.alldatasheet.com/datasheet-pdf/pdf/29528/TI/ULN2003AN.html

For this project, if the state transitions from green to blue, the motor will rotate a certain direction (say clockwise) to symbolize a garage door opening or closing; if the state transitions from blue to green, the motor will rotate the opposite direction (say counterclockwise).

Making the stepper motor rotate is achieved using the "wave-driving" technique; this means that only one coil is energized at a time, and the coil that is energized at any given time is situated next to the coil that was previously energized (coils 1 and 4 act as if they were next to each other).

The functionality for `sw2` was removed; instead, a toggle functionality was added to `sw1`. If the current state is green, pressing the button will make the system transition to blue; if the current state is blue, pressing the button will make the system transition to green.

The link to a video demonstration of the system can be found here: https://youtu.be/S_4pRYOBeEA.

3 Theory

Instead of using a finite state machine model for this project, I decided to go with a straightforward procedural design. By doing it this way, I was able to focus on the implementation of the stepper motor instead of taking time to completely re-write Lab 4. I was able to make a minimum number of changes in order to get this project working. Figure 2 shows a flowchart of operation.

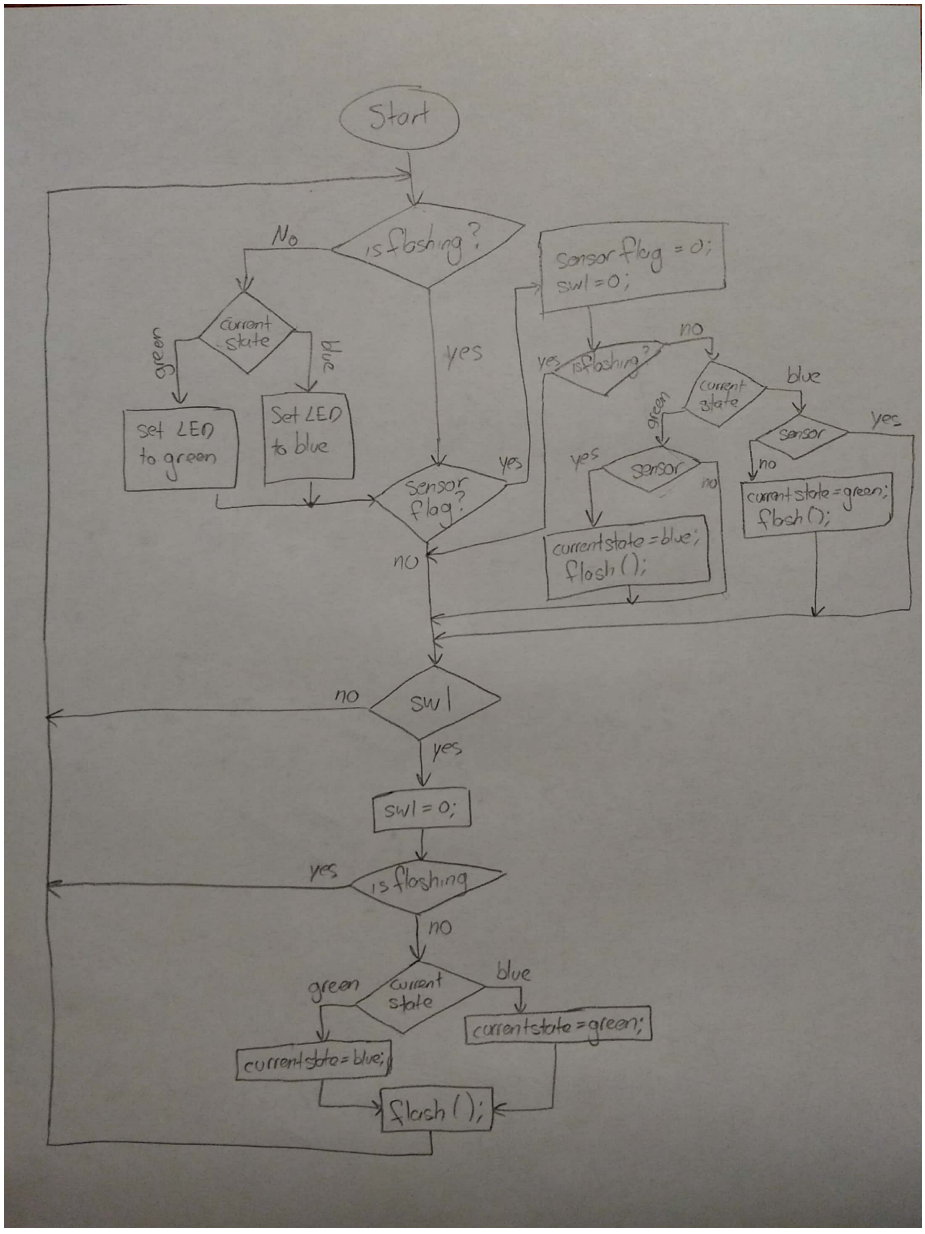

Figure 2: Flowchart of main operation.

What is not shown in this flowchart are the `flash();` function and how the flags get set. This is all implemented using interrupts, so it does not happen in

the main function, and are implemented separately.

4 Hardware Design

Just as before, the IR sensor is connected to the same pins on the microcontroller. The difference between Lab 4 and Project 2, however, is the addition of a motor/driver combo. Four MCU outputs are dedicated to connecting to the driver's inputs, and its outputs are connected to the four stepper motor inputs. The motor/driver combo is externally powered, to reduce the power of the microcontroller board. It is necessary to output 8 mA of current through the pins connected to the driver in order for the driver to be effective.

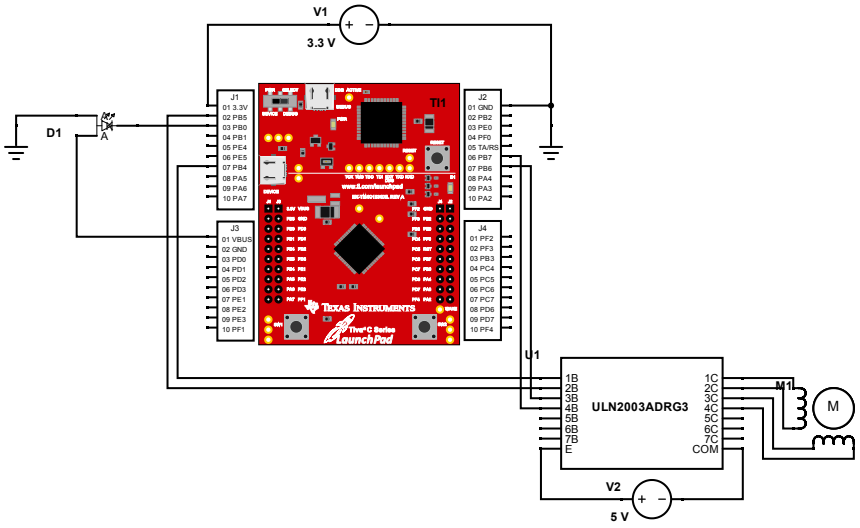

Figure 3: Schematic diagram of external connections.

5 Software Design

The flowchart for the software design is presented in Figure 2. The basics are copied over from Lab 4: using the SysTick timer, the red light flashes at a frequency of 4 Hz while the output for the motor changes every 200 Hz. The total amount of time spent flashing and rotating the motor is 5 s.

6 Conclusion

This project, built from Lab 4, has helped me learn about how a stepper motor is implemented, and how you can get both precise angles and moderate speed

using one. I learned about the various ways one can drive the motor, and their advantages and disadvantages.