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ECE 315 Lab Section H41

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1 Abstract

The purpose 😌 of this lab 😐 was to

• gain experience susing a microcontroller, running the FreeRTOS real-time kernel, to control the operation of a small stepper motor

- to enhance step the user interface of a stepper motor control application on the Zybo Z7.
- gain experience swith measuring experimentally the speed and acceleration limits of a small stepper motor.

We will be using the $\begin{tabular}{l} \end{tabular} \end{tabular} Zybo Z7 development board by <math>\begin{tabular}{l} \end{tabular} \end{tabular} Digilent.$ The board is built around the $\begin{tabular}{l} \end{tabular} \end{tabular} \end{tabular} Zynq-7010$ System-on-Chip silicon chip and contains two 667 MHz ARM Cortex A9 32-bit CPUs. For this lab, we will be using CPU0 to run the FreeRTOS real-time kernel. We will also be using one 28BYJ-48 stepper motor with unipolar drive windings, one 5-V DV power supply, one ULN2003-based driver module, one breadboard, one LTV-847 opto-isolator transistor array, four 220-ohm resistors, four $\begin{tabular}{l} \end{tabular} \end{tabular} \end{tabular}$ resistors, and various wires.

In this lab, we will be completing two exercises. In exercise 1, we will be completing the FreeRTOS task _Task_Motor() to rotate the stepper motor. This task is responsible for calling the necessary stepper functions to move the motor.

In exercise 2, we will be providing an emergency stop command for the stepper motor. We are implementing this functionality using one of the Zybo Z7 board's pushbuttons (BTN0) as an emergency stop button.

2 Design

2.1 Hardware Design

We first got the hardware set up. We first set up the wire connections from the ② Zybo to our breadboard according to the schematics in the lab handout. We connected the appropriate wires and resistors to the slots of the chip. We then connected the motor/motor control to the breadboard

as well. It is important to note that the motor is powered by an external 5V connection, not by the Zybo. We verified that 5V was running through the system using a voltmeter.

2.2 Exercise 1 Design

We first completed the z^{ZZ} _Task_Motor function in z^{ZZ} lab4_main.c . Inside of the while loop, we wait until we read some motor parameters from FIFO1. We read this into a struct containing various motor parameters such as current position, rotational speed, acceleration, and deceleration. After reading these parameters from FIFO1, we call the appropriate stepper functions in the driver files:

- Stepper_setCurrentPositionInSteps to set the current position of the stepper motor,
- Stepper_setSpeedInStepsPerSecond to set the speed in steps per second of the stepper motor,
- Stepper_setAccelerationInStepsPerSecondPerSecond to set the acceleration in steps per second of the stepper motor, and
- Stepper_setDecelerationInStepsPerSecondPerSecond to set the deceleration in steps per second of the stepper motor.

After setting the parameters, we begin actually moving the motor. Recall that the user input results in a list of destination/delay pairs. We begin iterating through each of these starting at the first one. We first set the target variable to be the position of the first destination/delay pair. We then call the stepper function provided in the driver file to move the motor to the desired destination. We then disable the motor, again using the function provided in the driver file. Lastly, we call vTaskDelay using a delay provided in the destination/delay pair. After this, we repeat with the next destination/delay pair until there are no more destination/delay pairs.

2.3 Exercise 2 Design

To implement the emergency stop, we first read the button value using XGpio_DiscreteRead. If the button is indeed pressed, then we initiate the emergency stop sequence. How the emergency stop is implemented is discussed below.

To implement the emergency stop, we first set the position of the motor to the current target. We then set sequenceIndex to 0 and disable the stepper motor (using the methods provided in the driver file). We then delete the xMotortask and xUarttask to terminate those tasks so that the entire system is stopped and so that the emergency stop cannot be overridden by another task. The motor is now off and no other tasks exist that can restart the movement of the motor.

We next want to flash a red LED at 2Hz. In order to do this, we simply create an infinite loop. Similarly to a previous lab, we turn the LED on for half the delay time, turn it off for half the delay time, and repeat this forever. At this point, the emergency sequence is complete and only resetting the system can stop the emergency state.

3 Testing

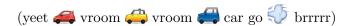


Table 1: Tests for exercise 1 and 2.

| Description | Expected | Pass |
|--|--|------|
| Enter nothing | Motor should not move | Yes |
| Enter default motor position, speed, | Motor turns clockwise, then after an | Yes |
| acceleration, and deceleration. Then | observable delay, begins to turn coun- | |
| enter destination/delay pairs of | terclockwise. At the end, the motor | |
| 2048/1000 and -2048/1000 | stops moving | |
| Repeat the above steps, but press | Motor should stop and red LED should | Yes |
| BTN0 while the motor is turning clock- | flash at 2Hz | |
| wise | | |
| Repeat the above steps, but press | Motor should stop and red LED should | Yes |
| BTN0 while the motor is turning coun- | flash at 2Hz | |
| terclockwise | | |
| Enter default motor position, speed, | Motor turns clockwise, counterclock- | Yes |
| acceleration, and deceleration. Then | wise and then clockwise again before | |
| enter destination/delay pairs of | stopping | |
| 2048/1000, -2048/1000, and 2048/1000 | | |

Conclusion

The purpose of this lab was to

• gain experience wusing a microcontroller, running the FreeRTOS real-time kernel, to control the operation of a small stepper motor

- to enhance the user interface of a stepper motor control application on the Zybo Z7.
- gain experience with measuring experimentally the speed and acceleration limits of a small stepper motor.

We believe we have fully completed the objectives of this lab.



In exercise 1 and 2, we gained experience using a microcontroller, running the FreeRTOS real-time kernel, and controlling the operation of a small stepper motor. We did this through setting up the microcontroller and stepper motor. We also wrote the _Task_motor() task which was responsible for calling the necessary stepper functions to move the motor. We also gained experience enhancing the user interface of a stepper motor control application on the Zybo Z7. We also gained experience in exercise 2 with measuring experimentally the speed and acceleration limits of a small stepper motor. We also set BTN0 on the Zybo Z7 board's pushbuttons to initiate an emergency stop.

Appendix 5

5.1Exercise 1 Source Code

The source code is in the file lab4_main.c that was submitted along with this report.



Exercise 2 Source Code

The source code is in the file lab4_main.c that was submitted along with this report.

