ECE 5780/6780 Final Project – Spring 2024

Due Date: Monday, April 29

Objectives

The purpose of this final project is to use concepts learned throughout the semester to build and demonstrate a working digital theremin.

Overview

In this final project you will create a digital theremin using FreeRTOS running on the STM32L476 Nucleo-64 board with working pitch and volume controls.

Preparation

You will need your STM32L476 Nucleo-64 Board and ECE 5780/6780 lab kit.

Requirements

1. Interface two Adafruit US-100 proximity sensors, an audio amplifier circuit, and a serial connection to the STM32L476 to produce a digital theremin.

2. One of the proximity sensors controls pitch. While a true theremin has infinite pitch resolution, the digital theremin should produce frequencies in discrete half-steps over at least a 2-octave range. Table 1 shows the required frequencies.

Note	Frequency	Note	Frequency
C3	130.813 Hz	C4	261.626 Hz
C#3	138.591 Hz	C#4	277.183 Hz
D3	146.832 Hz	D4	293.665 Hz
D#3	155.563 Hz	D#4	311.127 Hz
E3	164.814 Hz	E4	329.628 Hz
F3	174.614 Hz	F4	349.228 Hz
F#3	184.997 Hz	F#4	369.994 Hz
G3	195.998 Hz	G4	391.995 Hz
G#3	207.652 Hz	G#4	415.305 Hz
A3	220.000 Hz	A4	440.000 Hz
A#3	233.082 Hz	A#4	466.164 Hz
B3	246.942 Hz	B4	493.883 Hz
		C5	523.251 Hz

Table 1: Two octaves of musical notes

3. The other proximity sensor controls volume. While a true theremin has infinite volume resolution, the digital theremin should produce 8 discrete volumes that can be distinguished by ear. Volume level 0 indicates no sound.

4. The digital theremin should be interfaced to a PC via serial UART. Any time the pitch or volume of the tone changes, an appropriate message should be sent to the PC. Each message must be either an entry from the Note column of Table 1 or a volume message. Only one message should appear per line on the terminal. Employ one of the methods discussed in class to treat the UART transmitter as a shared resource to prevent garbled messages. Message display should not affect the musical output. Here is an example of a message stream:

   E4
   Vol 5
   Vol 4
   Vol 0
   Vol 5
   Vol 0
   Vol 5
   G4
   Vol 6
   G#4

5. Submit a typical lab report.

Pass-off

Demonstrate the working system to the instructor in-person. Show you can play a recognizable song such as “Mary Had a Little Lamb” or “Twinkle, Twinkle Little Star”. 5 points of extra credit will be awarded for successfully playing “The Scotsman”.

Grading

You can get partial credit on the project even if it is not 100% functional. Here is the breakdown:

Feature	Points
Proximity Sensor controls pitch	20
Proximity Sensor controls volume	20
Serial Terminal displays pitch and volume info	20
Song Demonstration	20 (+5 extra credit)
Lab Report	20
TOTAL	**100**

Table 2: Grading Rubric