CECS 447 Spring 2021

Project 1: Digital Piano

Total: 25 points

Purpose:

The purpose of this lab is to help students review ARM Cortex M4 Launchpad GPIO, hardware timer and interrupt, learn how to build a digital-to-analog conversion circuit and how to play simple songs using a speaker.

Components you may need:

A Launchpad, 4 push buttons and 4 10KΩ resistors for the push buttons, an audio amplifier and a speaker, enough resistors for 6-bit R2R DAC circuit. The push buttons are used as piano keys and a speaker is required to listen to the output.

Example projects: Music, DAC_3bit

Description:

Part I: Music Box(10 points)
You will build an embedded system that plays the following three songs:

1. Mary had a little lamb
2. Twinkle Twinkle little star
3. Happy Birthday

The onboard two push buttons will be used in the following way: Switch 1(left switch) is used to turn your music box on/off. Switch 2(right switch) is used to toggle through the three songs. The system will start with piano off. Once the piano is turned on by pressing switch 1, it will repeatedly play the first song until either one of the two onboard switches is pressed: press and release switch 1 will turn off the piano; press and release switch 2 will stop playing the current song and start playing the next song. The three songs will be played in a round-robin order until the piano is turned off.

You required to use a 16MHz system clock to generate required tones. Interrupt is required for both hardware timer and push buttons.

Part II: Digital Piano(15 points)
Build a digital piano using a 6 bit R/2R DAC and 4 push buttons for piano keys. The system requirements are given below:

1. Use GPIO PD0, PD1, PD2, PD3 to control 4 piano keys (push buttons) C, D, E, F respectively. You are required to use a 16MHz system clock to generate required tones. Interrupt is required for both hardware timer and push buttons.
2. Switch 1(left switch) is used to toggle between piano mode and auto-play mode. At start up, the system will be at piano mode.
3. Piano mode:
   Press and hold a piano key the system should play the corresponding note. The note should keep playing if the push button is pressed and stop when push button is

released. Assume at any time, no more than one key can be pressed. This mode is used for user to test and find the preferred octave for auto-play mode. Switch 2(right switch) will be used to change octave: there are three octaves to choose: lower C, middle C and upper C. The system will start from lower C. Pressing switch 2 once will move to the next octave. Pressing switch 2 multiple times will cycle through the three octaves in a round robin order.

Note	Lower C Frequency (Hz)	Middle C Frequency (Hz)	Upper C Frequency (Hz)
C	262	5233	1046
D	294	587	1174
E	330	659	1318
F	349	698	1396

4. Auto-play mode:
   The system will play one of the following three songs.
   1) Mary had a little lamb
   2) Twinkle Twinkle little star
   3) Happy Birthday

   the start of this mode, the first song will be played. Pressing switch 2 once will move to the next song. Pressing switch 2 multiple times will cycle through the three songs in a round robin order. Every time a new song is selected, it should be played from the beginning of the song. Switching a song can happen at any time a song is being played.

Extra Challenges:

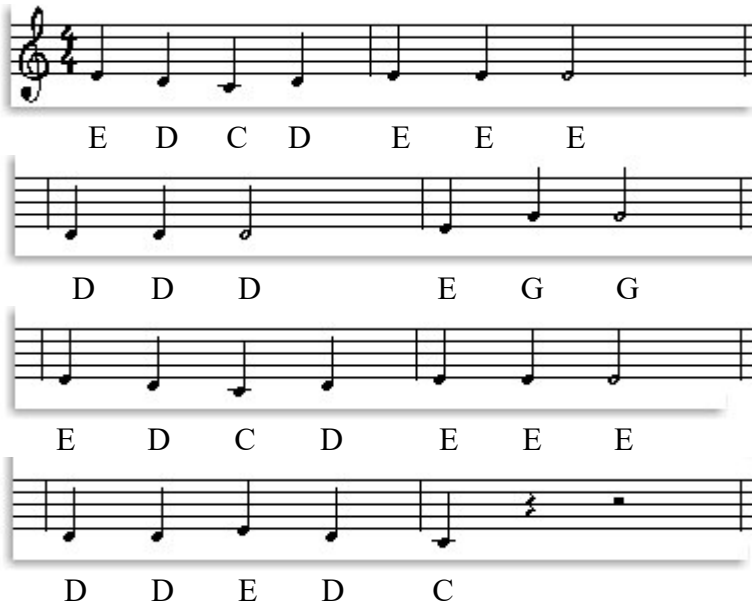
1. (5 points) Add hardware/software support for user to choose one of the three octaves for Music Box.
2. (5 points) Implement all 7 major tones for Digital Piano: ABCDEFG, and hand play one song at piano mode.
3. (5 points) Add a new song for Digital Piano with multiple tones played at the same time.

Deliverables:

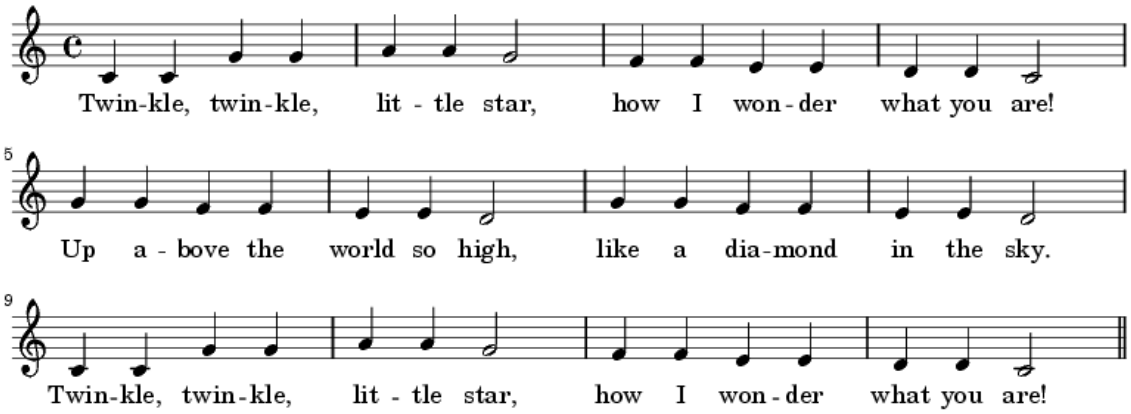
1) Demonstrate the two embedded systems separately.
2) Submit to beachboard dropbox a project report.
3) A short video or link to the video showing your demonstration for both parts.

The rest of this lab description provides score tables for the specified three songs.

Mary Had A Little Lamb



Twinkle Twinkle Little Star



|C C G G|A A G- |F F E E |D D C - |

|G G F F |E E D - |G G F F |E E D - |

|C C G G |A A G - |F F E E |D D C - |

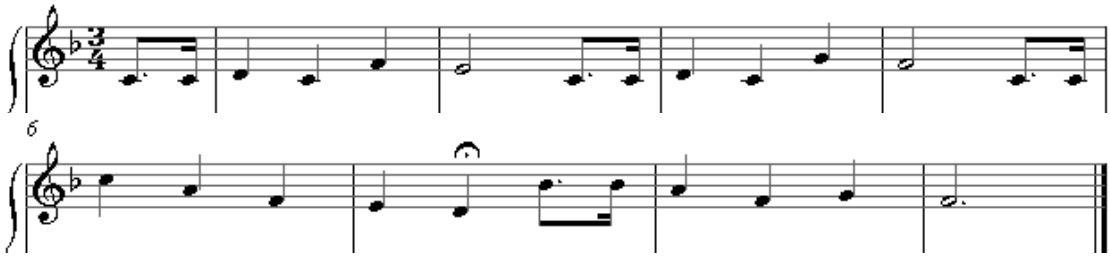
Note Table

|4,4,4,4|4,4,8|4,4,4,4|4,4,8|
|4,4,4,4|4,4,8|4,4,4,4|4,4,8|
|4,4,4,4|4,4,8|4,4,4,4|4,4,8|

Duration Table: 4 for a quarter note

Happy Birthday

trad.



|C C |D C F |E C C |D C G |F C C|

Note Table

|C’ A F|E D B B |A F G |F|

|3,1|4,4,4|8,3,1|4,4,4|8,3,1|
|4,4,4|4,4,3,1|4,4,4|12|

Duration Table