BBM 432 – Embedded Systems
Lab 8
-Homemade electronic piano-

Preparation

You will need a Launchpad, a headphone jack, three 1.5K resistors, three 12K resistors, four switches (optionally eight) and a breadboard.

Purpose

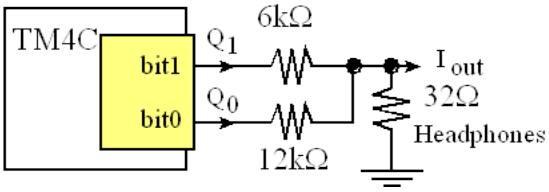
You will generate sound using a DAC over the headphone and build a simple electronic piano.

Implementation

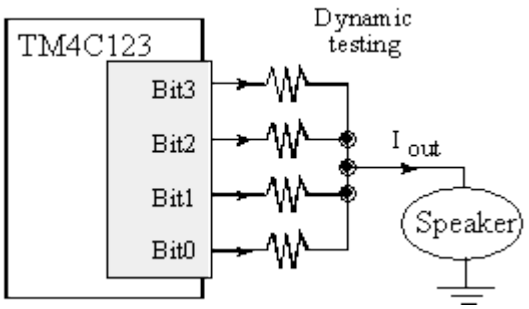
The binary weighted DAC.

The first step is to design and test a 4-bit binary-weighted DAC, which converts 4 bits of digital output from the TM4C123 to an analog signal. You will convert the digital output signals to an analog output using a simple resistor network. If you connect the DAC to headphones, you will be able to hear the sounds created by your software.

A two-bit binary DAC is what we have covered in the lecture:



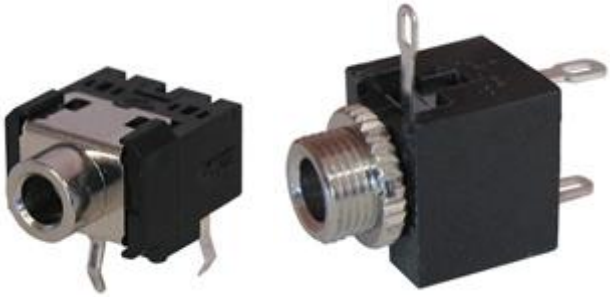
In this lab you will implement a four bit DAC by using a 1.5K resistor, a 3K resistor (two 1.5K resistors in series), a 6K resistor (two 12K resistors in parallel) and a 12K resistor.



The headphone interface

Next, build the external circuit on the breadboard. Connect one side of the headphone jack to ground and the other to the DAC. Since the sound is caused by the oscillations, it doesn't

matter which side of the headphones go to the microcontroller and which side goes to ground. Figure below shows four stereo jacks. The jack is used to connect the headphones to the circuit. Most jacks have three pins. Luckily for us, sound will be created if we connect any two of these three pins to the circuit, in either direction.



The music generation code

You can use the sine generator we covered in the class as the base code. That code, however, was for a three-bit DAC. Since you will develop a 4-bit DAC in this lab, you need to change the array that represents the sine wave. That code also was to generate a 100 Hz note. In this lab, you will change the frequency to output multiple notes. You can change the frequency by adapting the SysTick reload value.

If you have eight switches, implement the following notes with the frequencies given in the table. If you have a less number of switches choose 4 of them.

• Do	• 도	• 262 Hz
• Re	• 레	• 294 Hz
• Mi	• 미	• 330 Hz
• Fa	• 파	• 349 Hz
• Sol (So)	• 솔	• 392 Hz
• La	• 라	• 440 Hz
• Si (Ti)	• 시	• 494 Hz
• Do	• 도	• 523 Hz

If the first switch is kept pressed, the piano should output the note Do, if the second switch is pressed the output should be note Re, etc. The output should continue as long as the switch is pressed.

Find a software like this, and check your output tone:

https://play.google.com/store/apps/details?id=org.cohortor.gstrings&hl=en

BONUS (%50): If multiple keys are pressed at the same time, you should output a superposition of the musical tones. You have to find a way to sum the signals with different frequencies. Have a look at the following site how it looks, you can also listen to the waves.

https://academo.org/demos/wave-interference-beat-frequency/

You can check your output with a spectrum analyzer:

https://play.google.com/store/apps/details?id=com.raspw.SpectrumAnalyze&hl=en