BBM434 Embedded Systems Laboratory
Project Report

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Abstract
This document is a detailed explanation of our project "Digital Guitar". This project is aimed to implement digital guitar which have 8 buttons for each note and a proximity sensor instead of strings. It gives the impression that a user is actually hitting the string of a guitar.

Contents

1. Introduction

1.1. Overview

Purpose of this project is creating an easy to use guitar for the people who do not know how to play classical guitar. Our digital guitar have 8 buttons for each note and a proximity sensor instead of strings. Using these buttons and the proximity sensor, sound is created for the corresponding notes. Therefore, it gives the impression that a user is actually hitting the string of a guitar. It can be used by anyone, it is enough to know the notes of the song to play it.

1.2. Outline

This report contains information about project features, hardware schematics and photo documentation. In project features part, how we generate the sound, usage of DAC and proximity sensor will be explained. Then in the next section, all hardware schematics and photo documentation will be given.

2. Project Features

2.1. Generating Sound

A full cycle of a sound wave will be described which consists of initial normal conditions (no fluctuations in atmospheric pressure), an increase of air pressure, a subsequent decrease in air pressure which brings it back to normal, a decrease in air pressure (less pressure than initial conditions), and lastly, an increase which brings atmospheric pressure back to normal again. Therefore, the final conditions are the same as the initial, at-rest conditions.

Some of the features of the sound: amplitude, period, frequency. In order to generate sound, we need to be able to change these features. There are some ways to do that using digital to analog converters and implementing some algorithms. These ways will be explained in detail under the next sections.

2.2. Digital to Analog Converter(DAC)

In nature, most data are available in the form of analog and sound is just one of them. In order to generate sound, analog signal is needed. Fortunately, it is possible to convert digital signal into analog signal. By that way, we can generate sound from our computers.

Most digital music devices rely on high-speed DACs to create the analog waveforms required to produce high-quality sound.

The purpose of the Digital to Analog Converter (DAC) circuit used in our project is to produce the audio signals that will go to the speakers and provide the necessary optimizations.

The DAC that we built for this project takes 4-bit input. These inputs are come from an array which represents the sine wave and it will be explained under the next title. Output of the DAC is going to a 3 pin stereo jack which is connected to a speaker. For the DAC, we used R-2R circuit design which also will be shown later.

2.3. Creating the Sine Wave

As mentioned before, analog signal is needed for the sound. We can convert our digital signals using some tricks on hardware and software. For the hardware, we used DAC and for the software, we created the sine wave using an array. This array is generated using this [website].

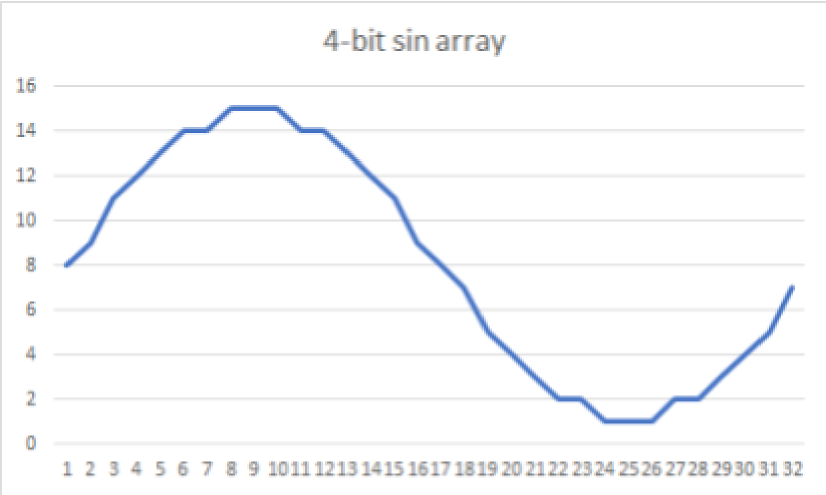

Figure-1, you can see the 4-bit sine wave array graph that we used for our DAC.

2.4. Buttons for the Notes

As we mentioned above, a sine wave array must be used in order to generate an analog signal from the digital signal. We used a timer that periodically interrupts and calls the handler function like a SysTick. Using this timer, we load this array as input for our DAC for a period of time.

Each button on the digital guitar represents a note. When the user that plays the guitar presses a button, the timer reload value is updated according to the corresponding value of the note. That means, frequency of the array is changing according to the button that is pressed, and the output is generating using DAC.

• 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

Figure-2, you can see the frequency values that we used to generate sound.

2.5. Proximity Sensor

A proximity sensor is a sensor that can detect the presence of nearby objects without any physical contact. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between the sensor and the sensed object.

The HC-SR04 Ultrasonic Module which we used for our project emits an ultrasound at 40 000 Hz which travels through the air and if there is an object or obstacle on its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance.

As it is known, all guitars have strings on them and they can be played using these strings. Our ultrasonic proximity sensor HC-SR04 can detect an object if the object is in the range of the sensor. Therefore, in order to use it we do not need strings. Instead of these strings, our digital guitar can be played only by using a hand without touching anything. If a user put her/his hand near to the sensor, it acts like a string. According to the pushing button, we can hear the corresponding musical note.

3. Hardware Schematics

3.1. DAC Circuit

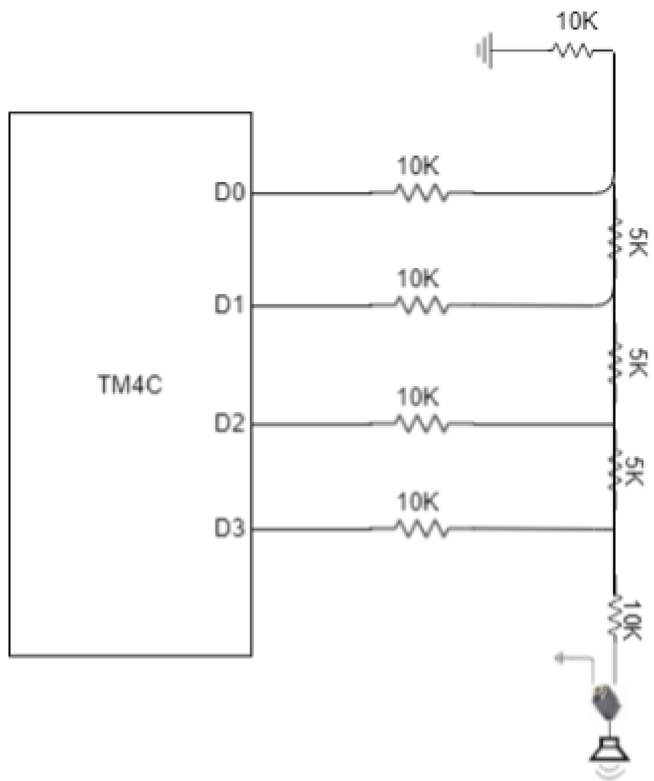

Figure-3, DAC Circuit

3.2. Sensor Circuit

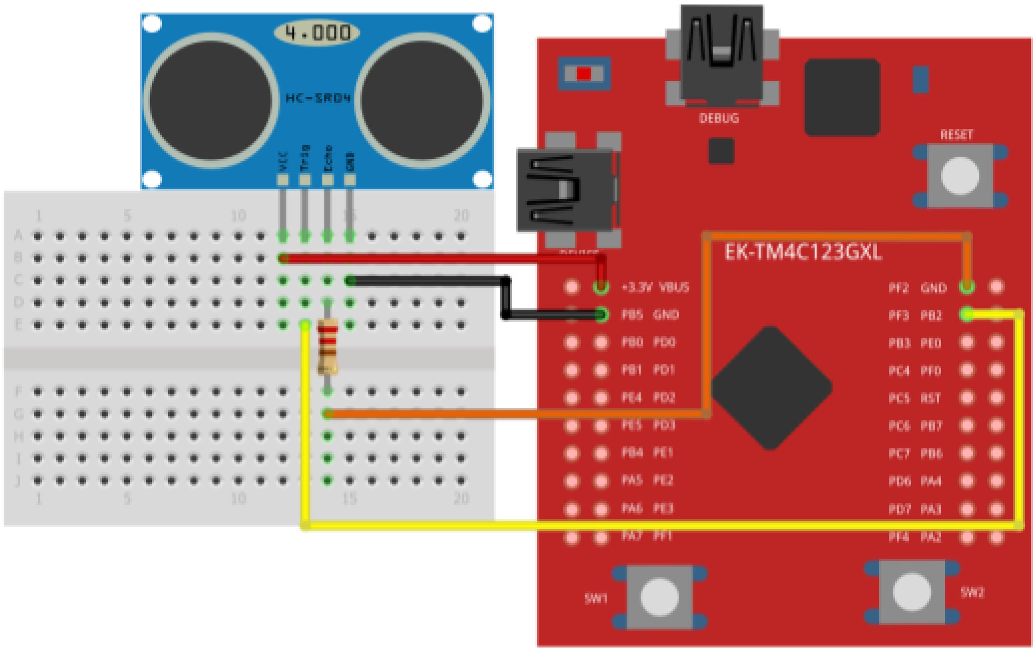

Figure-4 Sensor Circuit

3.3. Schema of the Whole System

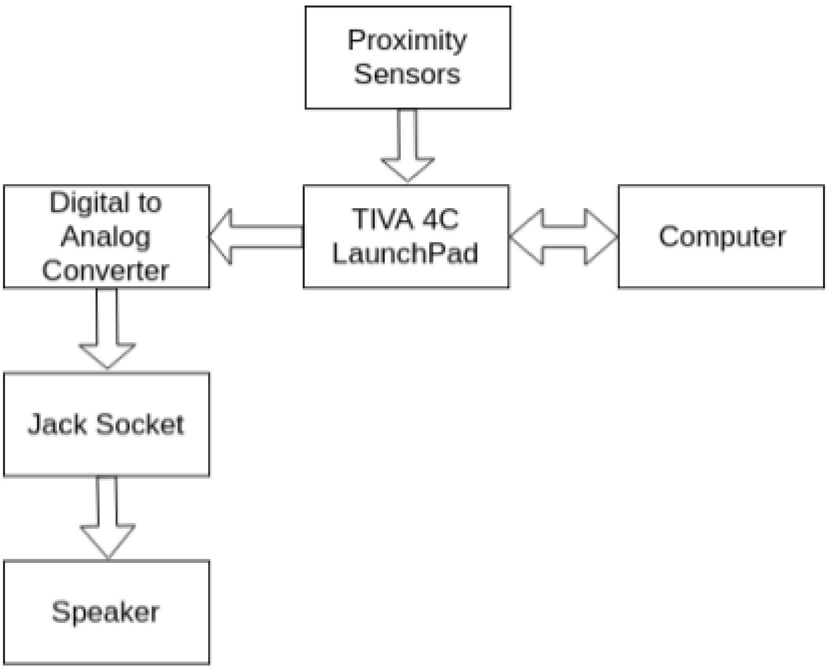

Figure-5 , the overall hardware schematic can be seen.

3.4. Flowchart of the System

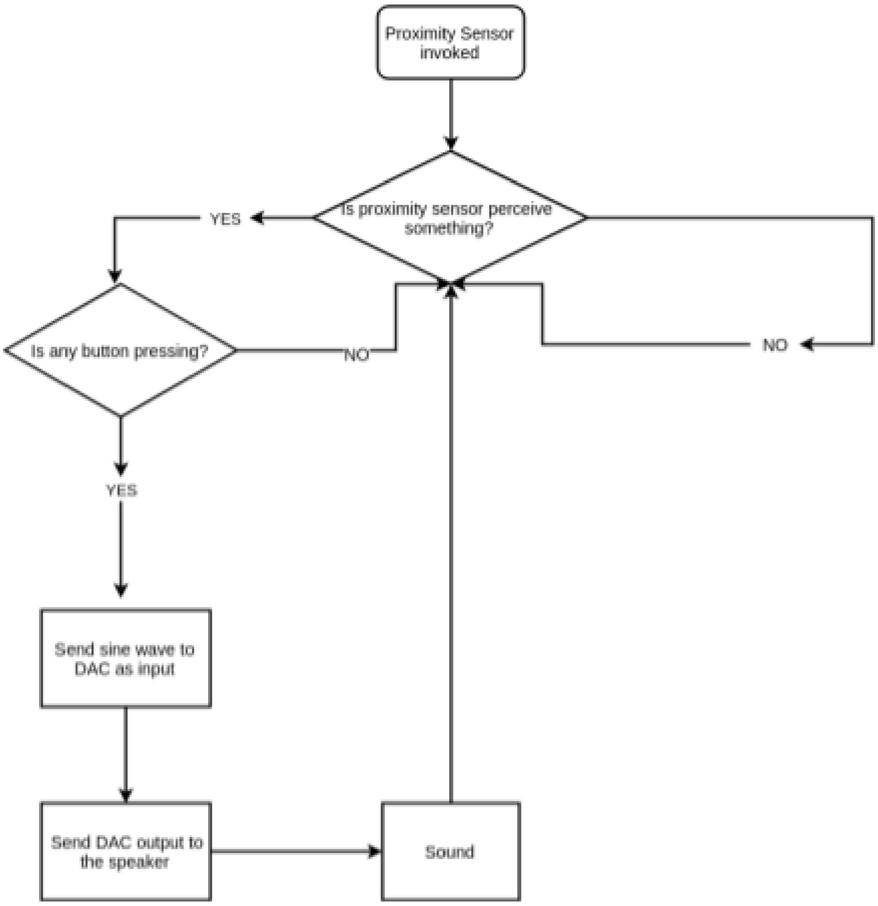

Figure-6, Flowchart of the system

4. Photo Documentation

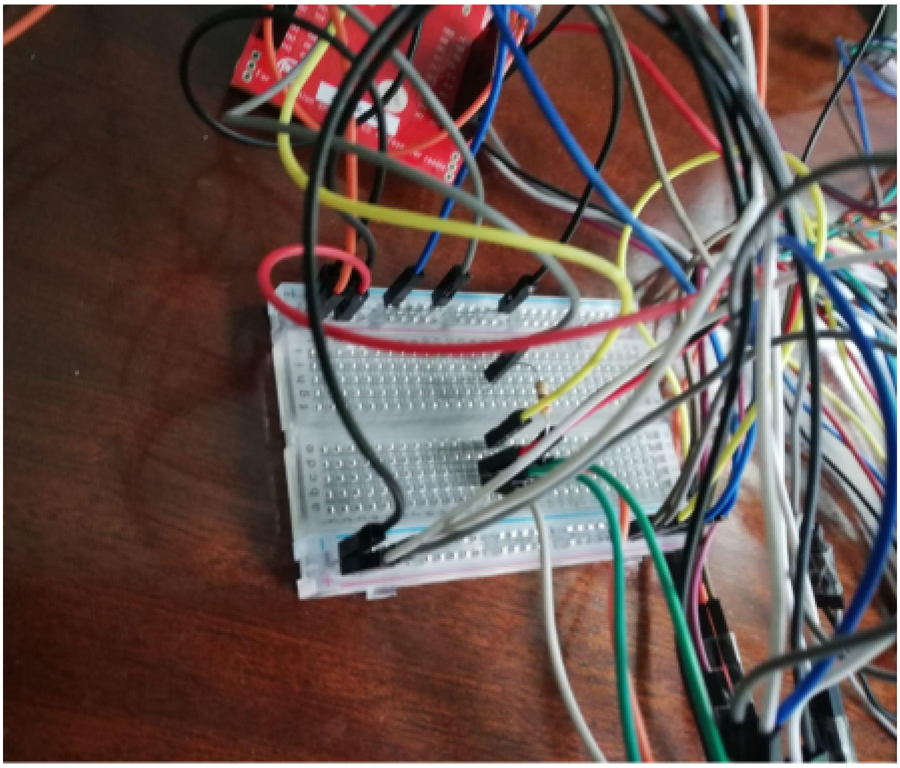

Figure-7, Sensor Circuit

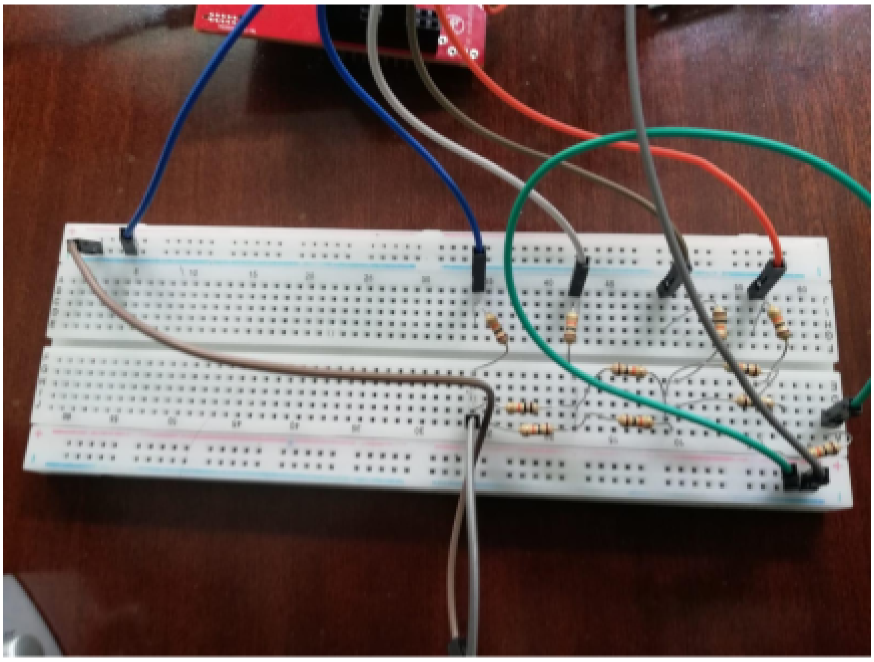

Figure-8, DAC Circuit

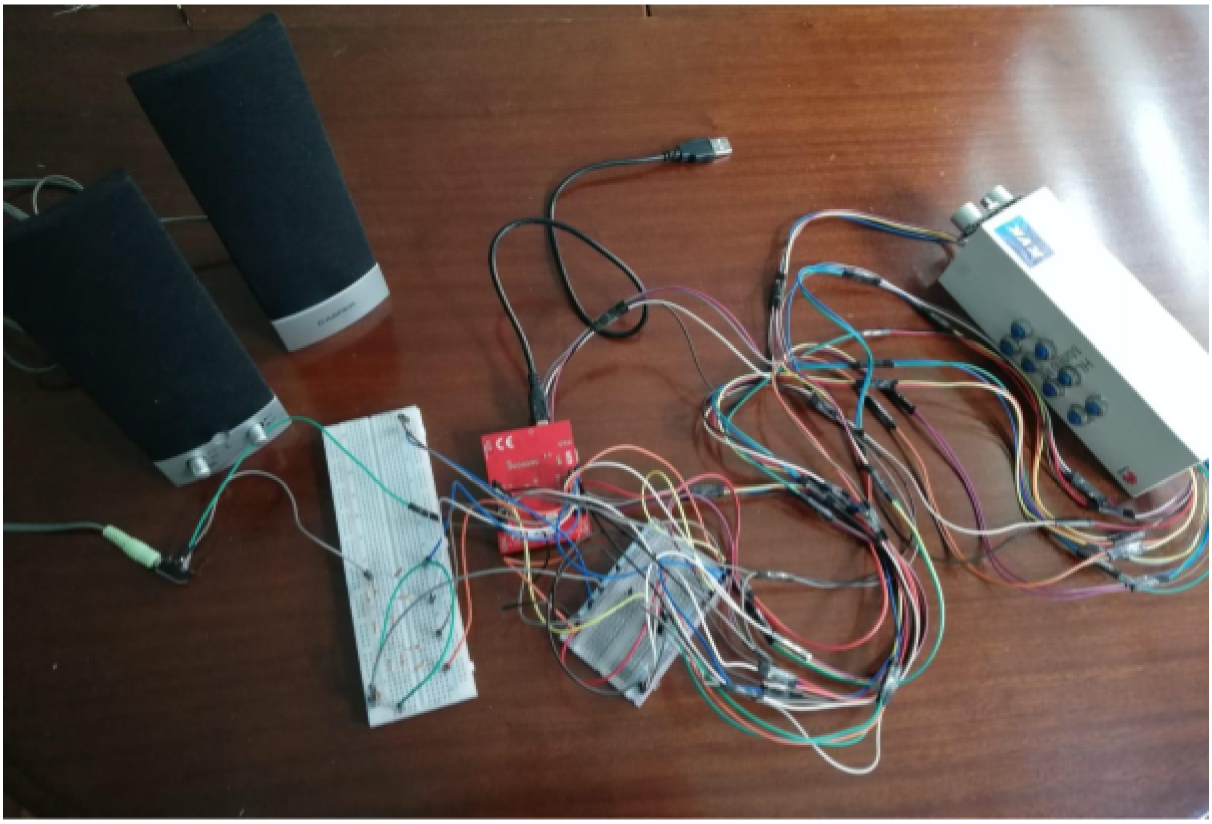

Figure-9, Whole System

Figure-10, Digital Guitar