BBM434 - Embedded Systems
Final Project Report

Homemade Drum Kit

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Abstract

This document is a detailed explanation of our project "Homemade Drum Kit" and our approachments. This project is aimed to implement midi electronic drum kit which generates several realistic drum chords of a traditional drum set.

1. Introduction

1.1. Overview of the Homemade Drum Kit

The drum kit that we have developed contains four drum pads which produce four different drum chords. Each drum pad is composed a CD that contains Piezoelectric Sensor in it (We mentioned in the proposal report what this sensor is and how it works.). Whether elderly or child, anyone can use our Homemade Drum Pad easily. In order to enjoy the drum sounds, it is enough to just hit the drums at the appropriate rhythm.

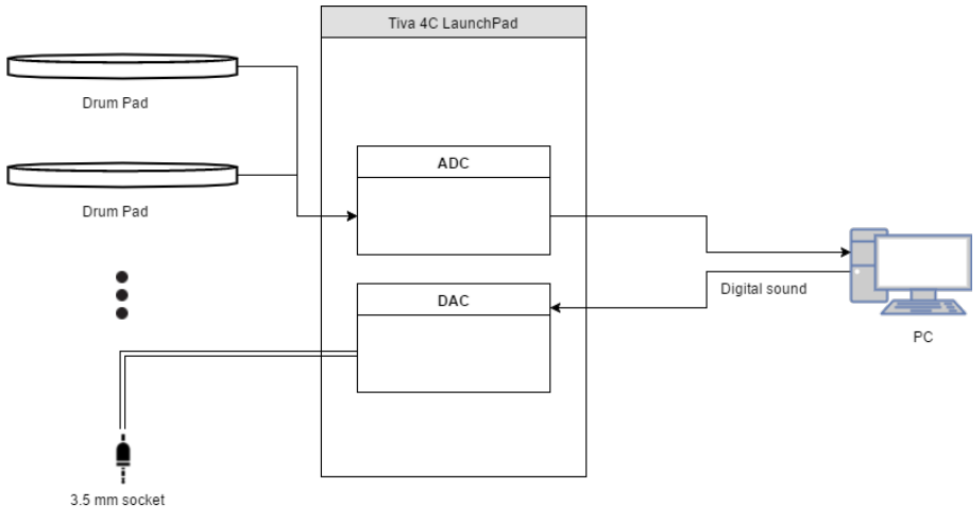

Figure 1: Hardware Layout of Homemade Drum Kit

1.2. Outline

The report shall explain features regarding the project and explain hardware design of system with some photographs and schematics.

2. Project Features

2.1. Detection of Hits

In our project, a certain pressure must be applied to the soft surface called "pad" in order for a drum voice to form. Pads measure applied pressure over the surface and generate proper parameters to obtain related sound. Inside the pads, there are sensors called **piezo sensors** which detect whether the corresponding pad is pressed or not by providing different electrical potentials according to the applied pressure.

It is necessary to transfer the different electrical potentials come from piezo sensors to the electronic environment and convert these potentials into various parametric values in that environment. For this conversion, we've used Analog to Digital Converter (ADC) circuits contained in Tiva Launchpad.

Analog to Digital Converter (ADC)

In electronics, an Analog to Digital converter is a system that converts an analog signal, such as a sound picked up by a microphone or light entering a digital camera, into a digital signal. An ADC may also provide an isolated measurement such as an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current.

Most Analog to Digital converter require processor intervention to configure each conversion when the analog input/channel is changed. These changes are captured by structures called as **sequencer**. In Tiva TM4C123GXL Launchpad, there are 4 different sequencers to detect different analog signals.

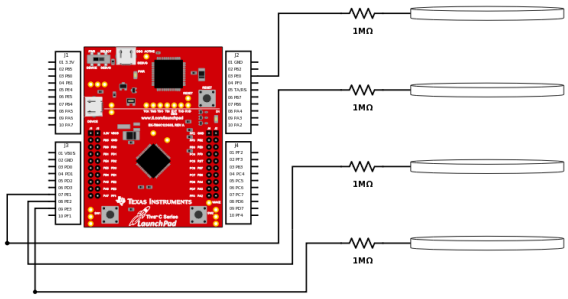

Figure 2: ADC circuit scheme

In this project, the sequencer 2 (SS2) which able to detect 4 different analog sources is used for capturing pressure signals come from pads. Sequencers have been programmed in ways to fetch data from piezo sensors and as shown in Figure2, each sensors are connected to PORTE(PE2-PE3-PE4-PE5 respectively.) with 1MΩ resistors for each sensor. Positive side of each sensor is connected to each pins through this 1MΩ resistor. And negative side of each sensor is connected to ground through this 1MΩ resistor.

2.2. Generating Sound

In order to produce a sound in electronic environment, various electrical signals must be transmitted to the device which will emit sound. This device, called "Speaker", requires the generation of relevant audio signals and the optimization of these signals in order to be able to receive electrical signals belonging to the 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.

Digital to Analog Converter (DAC)

In electronics, a digital-to-analog converter is a device that converts a digital signal into an analog signal. Whereby DAC circuits, a signal generated in the digital environment becomes detectable by the outside world with analog interfaces. Today, DAC circuits are often used for sound generation and motor control. In this project, we used the DAC circuits for the electronic characterization of traditional drum effects.

Sound exists as varying pressure waves that are created when a physical object moves, vibrating the air next to it. The sound generated by the vibration of the sound source is also provided by the vibrations of the particles in the material environment. These vibrations are called as **sound waves**. Sound wavesare often simplified to a description in terms of sinusoidal plane waves, which are characterized by these generic properties:

- Frequency
- Amplitude
- Speed of sound
- Direction

In electronics, it's possible to manipulate a sound by changing its frequency or amplitute. However, one of the most significant problem is representing sound wave in electronic environment as much realistic as possible.

Representing a Sound Wave in Bits

Sound waves have non-discrete characteristic. There is an infinite number of values between the wave value of a certain $theta$ time and the wave value of $theta + 1$ time. It is impossible to produce sound waves exactly in the electronic environment where everything is formed by 1s and 0s.However, it is possible to obtain more realistic sound with a certain resolution value.

An audio signal is represented by unsigned integer values in the digital environment. These integer values are used to determine which pin outputs the signal to generate. For example, 127 (0x7F) corresponds to 0000000001111111 in an 8-bit DAC circuit, and allows pins 1 through 7 to be high logic. The maximum and minimum values that these integer values can take are related to the resolution of the DAC circuit.

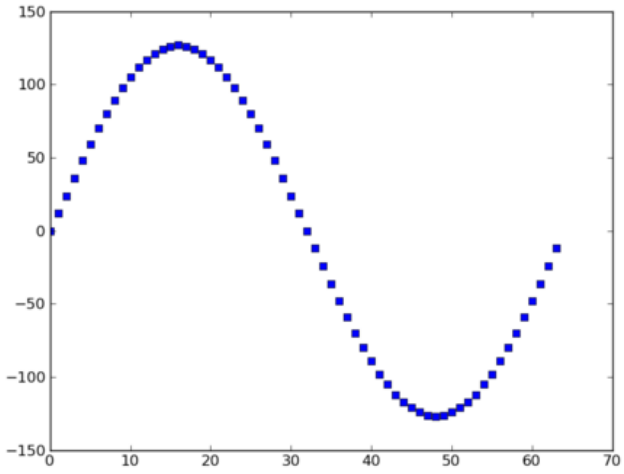

Figure 3: 8-bit representation of sine wave

DAC circuits consist of 2 types of configurations, these are Binary-Weighted and R-2R. In both configurations, the number of output signals determines the resolution of the DAC system.

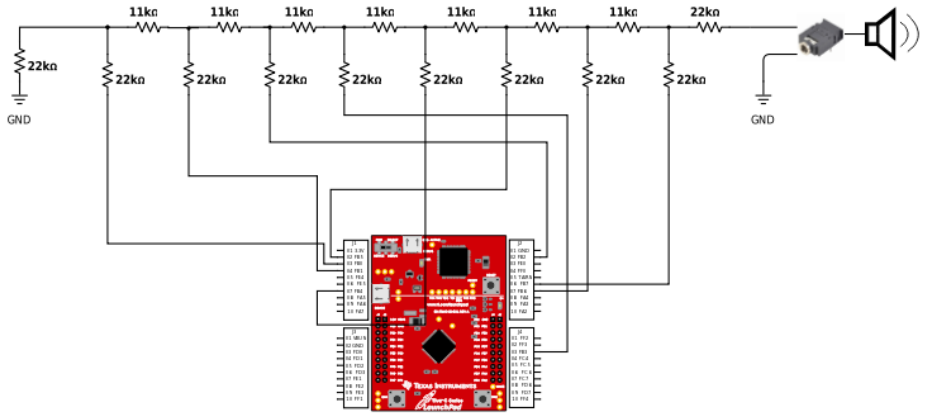

Figure 4: R-2R Ladder DAC

We created an external circuit to convert digital signal to analog signal. To describe this circuit, it is an 8-bit R-2R ladder digital to analog converter. We selected 2R as 22KΩ and to obtain R, we connected two 22KΩ resistors parallel. With this parallel connection we got a resistor that has the resistance 11KΩ. The diagram above shows the R-2R ladder Digital to Analog Converter that is used by us.

In order to transfer the drum sounds of the .wav format obtained on the internet to the launchpad, the hexadecimal values of each voice must be obtained. We used a program called as Binary Viewer (in Figure 5.) which is one of the 3rd party software we used for the project. The program outputs the hexadecimal code of any binary file (.pdf, .wav, .jpg). That program is available here.

Considering the fact that it has limited storage space, we think that we get more realistic sound by representing with 8-bit. The fact that drum sounds are represented by 8-bit integer values and that a sound file of about 1 second sometimes has tens of thousands of integer values is a challenge. However, by using an external EEPROM, it is possible to obtain more realistic sounds of 16-bit or 64-bit.

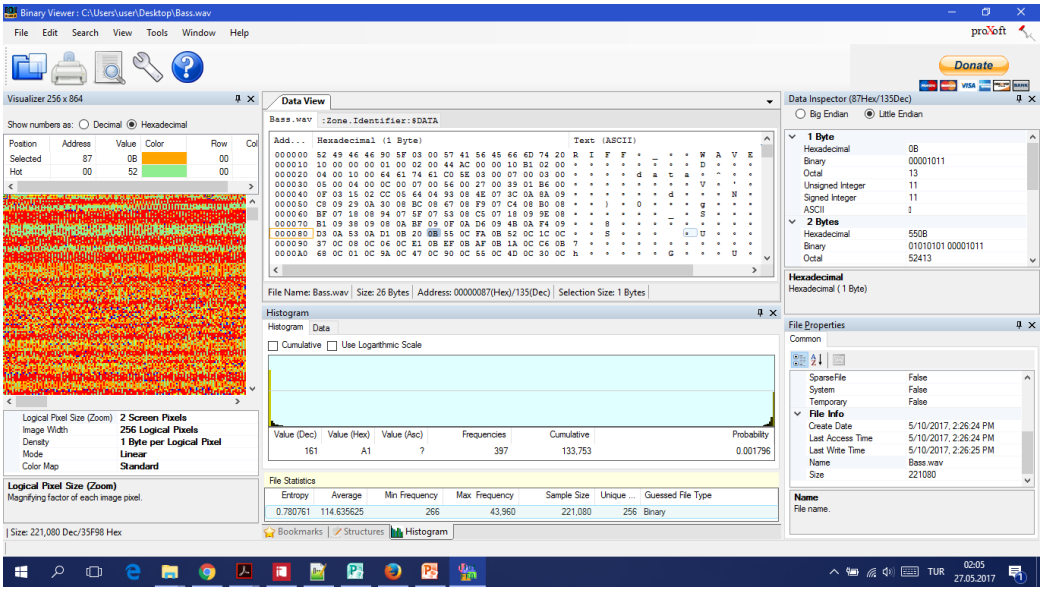

Figure 5: Binary Viewer Screenshot

2.3. Handling of Concurrent Hits

At first, we were obtaining only one sound at a time. The second sound was emerging only after the first voice was exhausted. And also if two different drums are hit at the same time, only one drum sound could be heard. For this reason, we decided to mixture drum sounds before converting them to analog signal. After that current sound is generated according to mixture of current hit drums.

3. Hardware Schematics

In this section we will provide some images to describe the circuit schematics of our Drum Pad. In the first figure below, you can see the visual circuit of our system.

3.1. Visual Circuit of Whole System

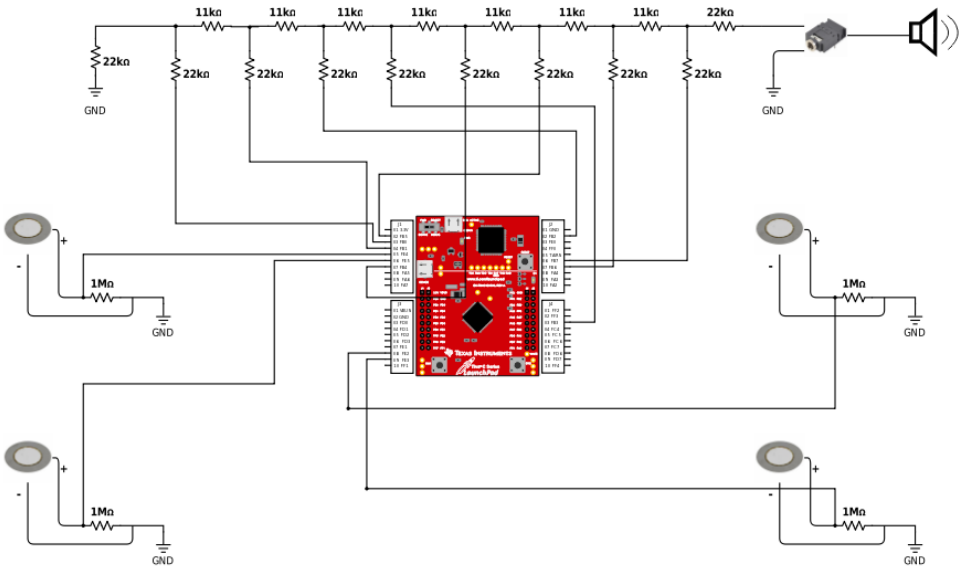

Figure 6: Hardware Schematic of Our Homemade Drum Pad

3.2. Actual View of Our System

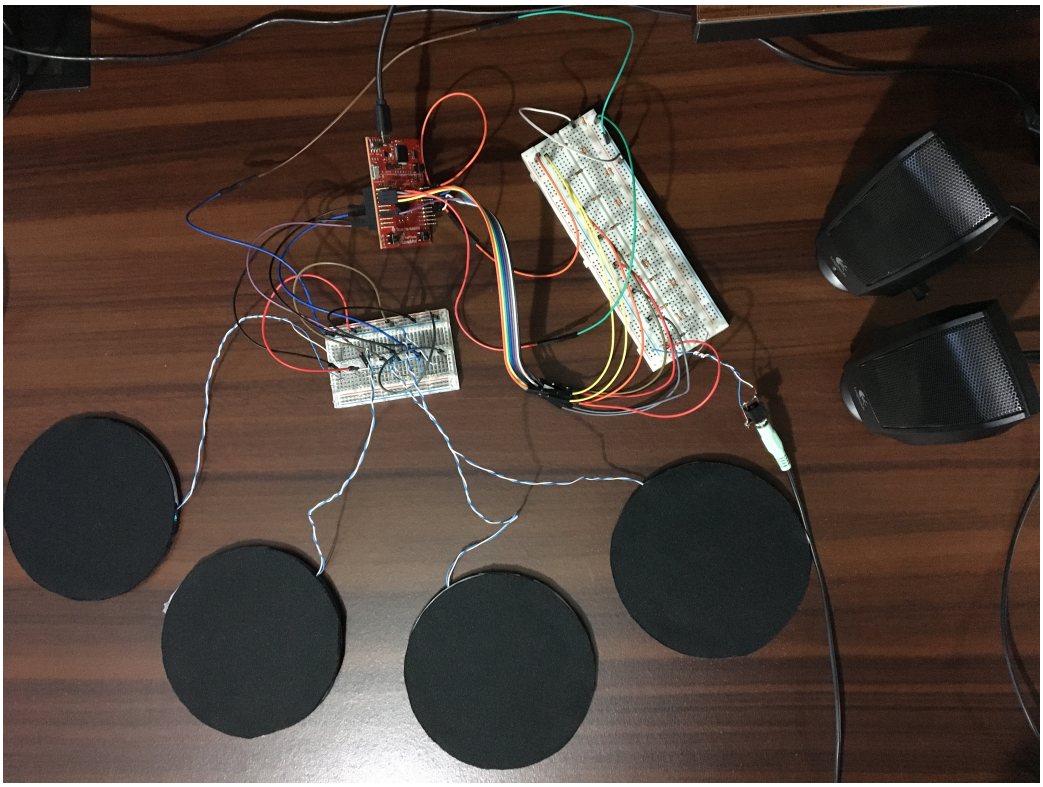

Figure 7: Actual Image of Our Drum Pad

3.3. Actual View of Digital to Analog Converter

Here you can see the real view of 8-bit digital to analog converter that is our own design.

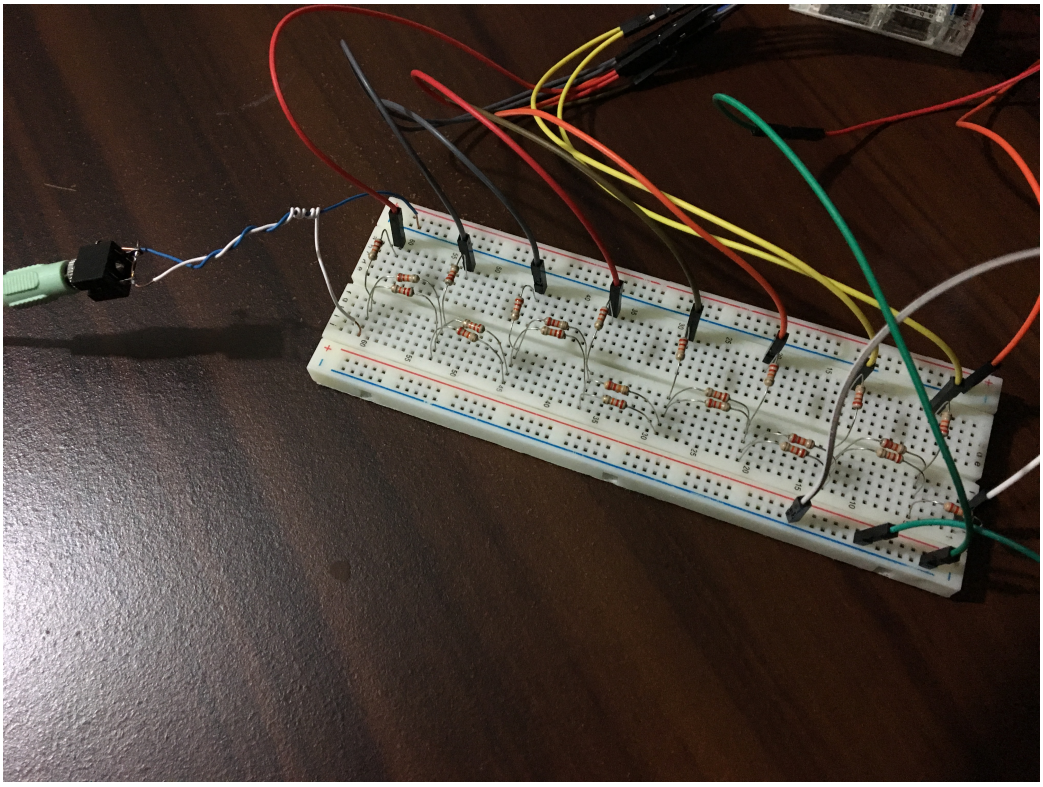

Figure 8: Actual Image of 8-Bit Digital to Analog Converter