ECE 445

Spring 2018

Project Proposal

Real-Time Sound Visualization

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1 Introduction

1.1 Background

We plan to design a sound visualization model by using a pitch detector to detect pitch and output with musical notation on a display. Furthermore, we are going to store the melody into our designed memory chip and mimic piano sound for replaying. There will be LED effect accompanied with piano sound when it is in replay mode.

To be specific, we will make a pitch detector in hardware to detect sound in real time at 44k sampling rate. An autocorrelation analysis, center clipping, infinite peak clipping and convolution will be used inside our microcontroller. The detected pitch will be stored into memory for further replaying and displaying. Once the musical notes has been detected, it will automatically display on a Color TFT LCD display with MicroSD Card Breakout. The musical notes will flow to the right side when one note is displayed.

This goal of our project is to create a small and affordable device that listens to a musical instrument or vocal sound and recognizes the notes played with LED effect. These notes can then be sent to a synthesizer in the common MIDI format. This allows musicians to record the music that they want to store as their compositions into musical notes or for those people who do not have music score but want to play piece of music that they heard.

High-level requirements lists

- What is the power supply we are going to choose for our project?

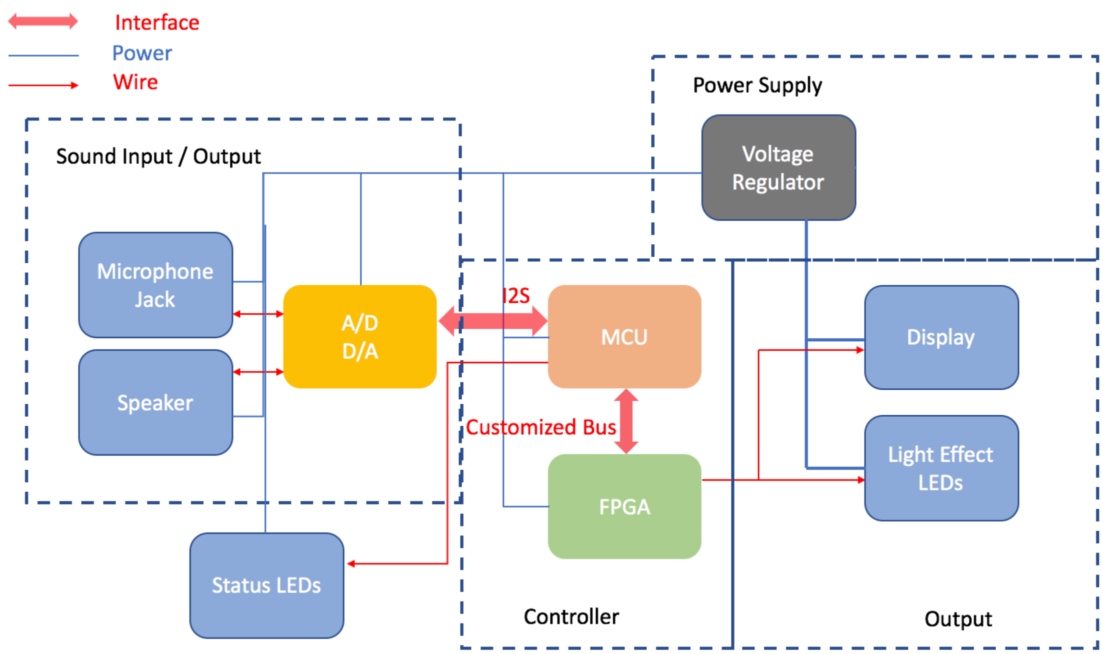
We plan to use DC/DC power supply for our project. We are going to build power supply which is a buck converter based DC-DC voltage regulator.

- How big sampling rate is to be used in the project?

Since our project is Real-Time Sound Visualization, latency cannot be too bee. As a result, our MCU might not powerful enough to do FFT over all samples. We are going to do decimation after the 44kHz sampling rate sampling.

2 Design

Block diagram



Functional Overview

To achieve our goal of performing pitch detection, a frequency spectrum analyzation is mandatory. Our method is to perform Fast Fourier Transform(FFT) on the sound data collected. To do FFT, we need to sample sound and digitize all the data and store in memory. As a result, we chose an ARM based MCU to do all the calculation. The MCU we chose, has built-in DSP module and capable of utilizing those DSP module with DSP library provided by supplier.

All the components will be mounted on a PCB (printed circuit board) except display and light effect LEDs.

Power Supply:

We have a lot of component, so we need to build a robust power supply circuit. Power supply consists of several buck converter DC-DC voltage regulators, which will provide different voltage needed by different component. The power supply takes 12 volt DC as input. The LCD screen and LEDs are going to be more power-hungry the other component. The power supply circuit is separated from the rest. FPGA has a Maximum input voltage of 1.43V. MCU requires 1.7 to 3.5V

Requirement: The power supply need to have output of 1.2v +/- 5%. 3.3V +/- 5%, 5V +/- 5%.

MCU:

We are plan to use a STM32 ARM MCU. The current MCU we doing research on is STM32F756, which is Cortex M7 based, and capable of doing DSP instruction. Based on our research an even a smaller M4 based MCU can perform FFT. Our MCU is responsible to read data from A/D convertor, store data in memory and perform FFT.

Before FFT decimation is required to reduce the amount of data. As learned from ECE310, decimation will cause aliasing. Thus a Low-Pass-Filter is needed before performing FFT. A simple averaging should be sufficient.

Requirement: The delay of result is less than 1s, and the rate of sample possessed is more than 10k/s.

FPGA:

Another important module in our control unit is FPGA. One of the important roles FPGA played in our system is to work as a VGA display driver. The MCU is dedicated on performing FFT algorithm, therefore, FPGA is responsible to display result on a LCD screen, similar to what we did in ECE 385. Moreover, FPGA will also responsible to control LEDs. The FGPA we are going to use is Altera Cyclone V.

Requirement: Video signal output with VGA at resolution 640 * 480.

A/D D/A converter:

We are going to use a ADC to collect sound data. The one on DE2 board used in ECE 385 is perfectly fine. One of our team member has used that ADC/DCA in his 385 final project. Our MCU and ADC communicate with I2S interface.
The melody store in memory of MCU will be played back by the same chip we used for ADC.
Requirement: working sampling rate 44KHz.

IDE:

The IDE we are going to use is Eclipse.
Requirement: Successfully upload program.

3 Ethics and Safety

Since we plan to do sound visualization model, we might use some music pieces and even an entire song to test the functionality. We will follow the IEEE Code of Ethics, #6: “to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others” [3]. Because we respect musician’s work, we will not spread the music that has copyright and we will not save the music for commercial purpose neither.

In order to test human sound as input, we plan to invite people with different voice to help. We will record them sing and talk. Therefore, according to ACM code of Ethics and Professional Conduct, #1.7: “Respect the privacy of others.” [4], we will always ask if they are willing to share their recording with us, and if it’s good to use their recording during our demo. If any one of them says that it’s not good to use his/her voice, we will remove his/her recording from the memory.

The main safety concern of our project is the DC power supply. It’s mentioned in the DC Power Electrical Safety Guidelines: “Ensure that the polarity of the DC input wiring is correct. Under certain conditions, connections with reversed polarity might trip the primary circuit breaker or damage the equipment.” [5] We will carefully mark the polarity before turning on the switch. Furthermore, according to the article, What's the Difference Between AC and DC Electric Shocks: “DC current will make a single continuous contraction of the muscles, and can cause fibrillation of the heart at high enough levels.” [6] We will always check if the switch is turned off before we debug our circuit. So that we won’t get injured by the power.

References

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[5] DC Power Electrical Safety Guidelines
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