Digital Theremin with LED

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1. Introduction

1.1 Objective

The theremin is a musical instrument which a player has to use two hands to control the pitch and volume without touching the instrument. The original theremin is analog because it detects the location of a player's hands by detecting a change of charge in its antennas. The antennas work the same way as a capacitor. After its invention, another form of theremin was released, which is known as the digital theremin. Digital theremin works differently because it receives an input and converts the input to digital format by sampling the input before processes the input by using digital signal processing techniques. After that, it converts the digital output to an analog signal before it goes to speakers.

Digital theremin in the market does not produce a very good sound like the original analog theremin because of how the digital data get stored. When the digital data is converted to analog signal, the quality of the output is not as good as the original signal. However, it could produce a better sound by using a better algorithm or a better digital processing technique. This becomes a problem because the manufacturers of digital theremin are focusing on the wrong aspect. They like to add more fancy features or sounds to it rather than improving the quality of the sound itself. This is why we aim to improve the digital processing algorithm and apply some other signal processing techniques to make the sound to be the closest to the original analog theremin.

Another problem is that the original theremin requires a player to use two hands. One hand is for controlling the pitch, and the other hand is for volume controlling. Therefore, the player is limited to play one pitch at a time. We would like to modify the instrument so that the player can play it like a piano, where the player can use one hand for playing base and the other hand for playing treble. This way, the player can play a complete range of frequency. The volume control will be change to a foot pedal instead. Therefore, the player can use two hands for playing two pitches at the same time and one foot to control the volume.

Moreover, we would like to add features that have never been seen on a theremin before, such as a killswitch and LED display. In addition to adding all these extra features, our group will focus on making the instrument sound pleasing to the listeners by optimizing control over dynamics and vibrato. The result will be a unique instrument with a rich sound likes the world has ever seen before.

1.2 Background

The theremin is a classic electronic instrument made in the 1920s. It is a dynamic instrument with a unique sound and an even more unique way to play the instrument. The digital theremin needs more rich and distinct sounds with broader frequencies and dynamics. In ECE 395, one of our group members has created a working prototype digital theremin (a sensor, audio output, and programmable chip). However, it is far from sounding instrumental and lacks unique features. A company called Moog has already put a digital theremin on the market. We are not saying that our group is able to do something that this company wasn't. We are simply saying that when Moog created their digital theremin, they focused on very different aspects than our group intends to do. Their theremin focuses more on a lot of sound effects as well as automatic pitch correction.

We will revise the design of the theremin to have two distance sensors for detecting the left and right hand's distance away from the sensors. We will most likely implement a 2 input 1 output multiplexer so that both sensors don't send We will also be adding new features such as waveform generator, LED array manipulation, and incorporate smoother volume control.

1.3 High-level requirements list

Quantitative characteristics this project must exhibit the followings:

- It can produce frequencies within the range 65.41-261.63 Hz.
- It can play square, sawtooth, and sine waveforms.
- The LED array works and represents the different notes being played.

2. Design

2.1 Block Diagram

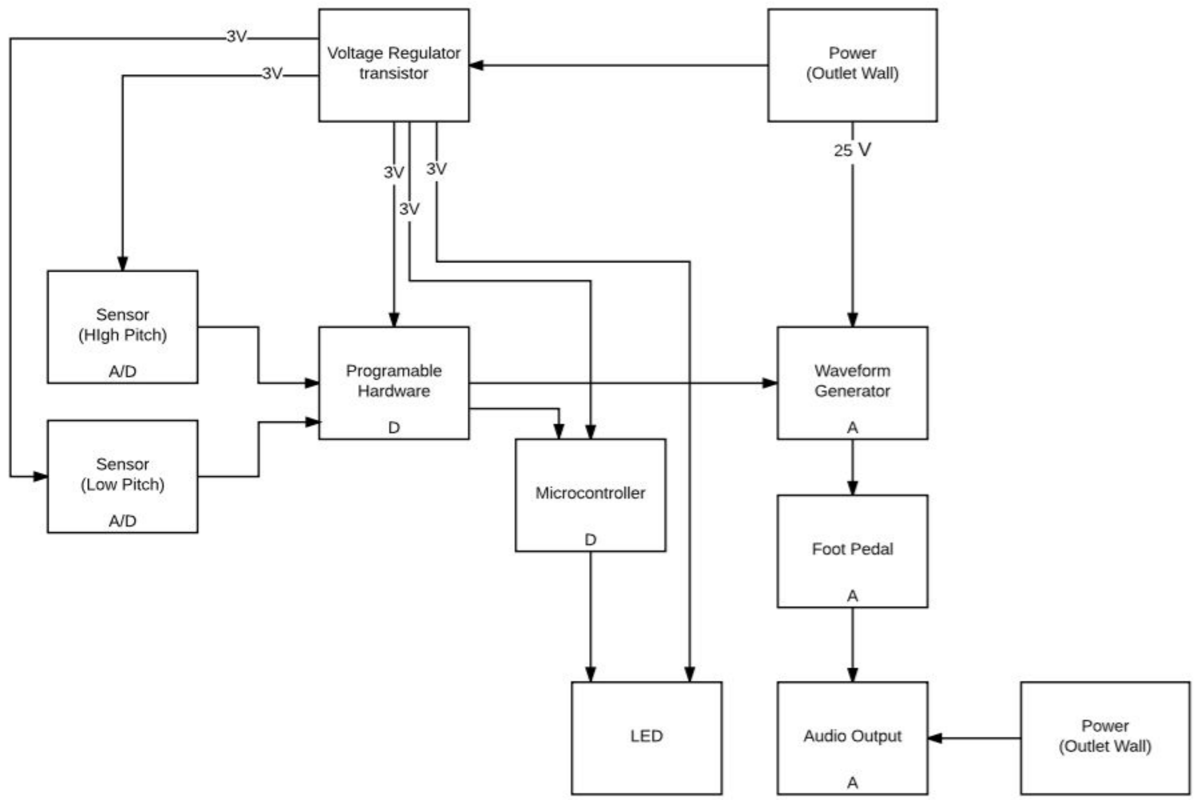

Figure 1. Block Diagram

Above is the schematic of our design for the instrument that we came up with. Each rectangle represents a general component to the circuit. Arrows are used to represent the flow of data or power from one component to the other. On the bottom of the rectangle, there is an ‘A’ to represent analog data. ‘A/D’ is used to represent analog to digital data. Finally, ‘D’ is used to represent digital data.

2.2 Physical Design

Below is a circuit of what one of our group member made in ECE 395

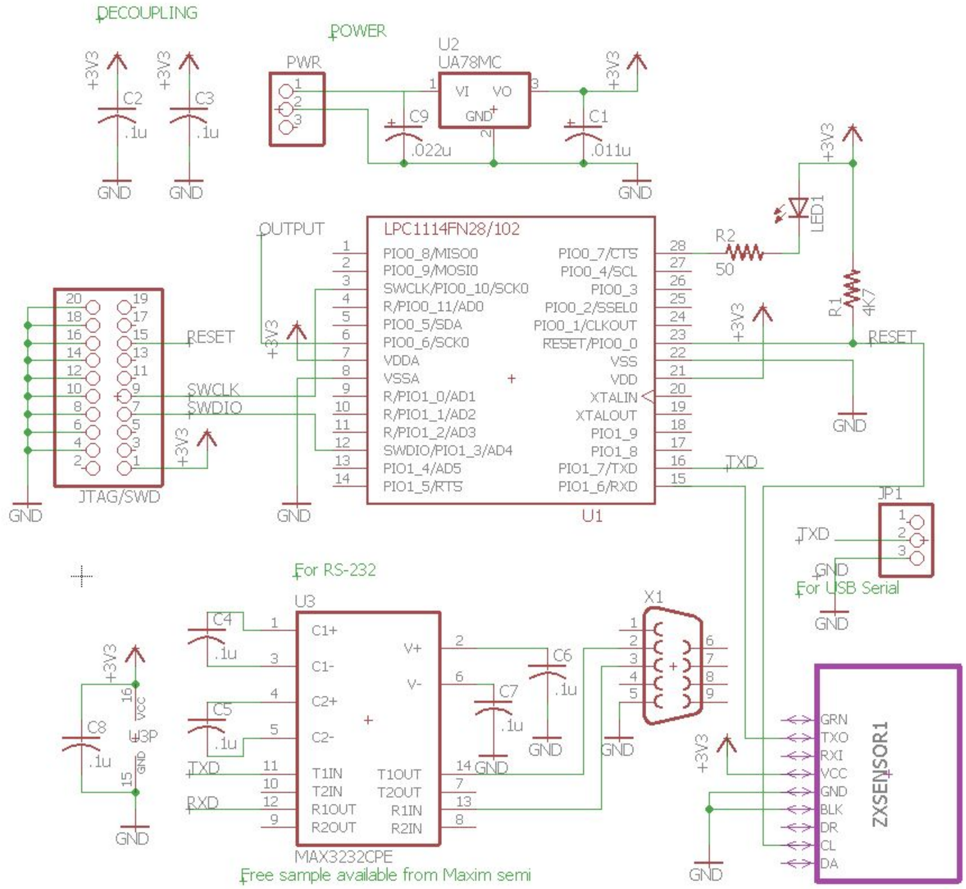

Figure 2. Circuit Diagram

What my project was able to do by the end of ECE 395:

- ➔ Generate frequencies from 104-120Hz
- ➔ Make sound
- ➔ Accurately read different distances

What it will be able to do by the end of senior design:

- ➔ Generate frequencies from 65.41-261.63 Hz
- ➔ Switch between waveforms
- ➔ Volume Control
- ➔ Show notes being played with LED display

2.3 Functional Overview

Above is a block diagram of our theremin. Every component labeled A is analog and every component labeled D is digital. The two blocks labeled sensor are the same in terms of hardware, but will be used to generate the higher and lower pitches respectively (they are represented by the zxsensor block on the circuit diagram). They are both infrared sensors that can accurately measure distances from 0 to 80cm. They take that analog information from the infrared sensors and convert it into a distinct. Both sensors will feed into programmable hardware (the LPC1114FN chip on the circuit diagram). The programmable hardware will be programmed to translate the distance readings from the sensors into specific frequencies. It will also translate those distance readings into distinct LED patterns. The microcontroller module will most likely implement a decoder that will translate binary signals into specific LEDs being lit up. The LED block is simply an array of roughly 10 standard LEDs that will light up based on what output comes from the programmable hardware. The LEDs will correlate directly with the distance readings. The waveform generator is a small ICL8038 chip that reads an analog waveform and can turn that waveform into either a square, sine, or sawtooth waveform to change the sound of the output. The foot pedal is essentially a potentiometer with a large resistance that controls volume. It requires no power and will be connected so that it is compatible with ¼ inch audio jacks. The final output will go to a speaker, which is totally separate from the circuit is building. We will most likely use an electric guitar amplifier. The power supply is 25 volts and will be supplied by a wall outlet. The waveform generator requires the most voltage at 25 volts. Everything else only requires 3 volts of electricity, which will be adjusted from the power supply with a voltage regulator transistor. The volume control requires no power supply.

2.4 Block Requirements

The requirements for each block are quite literally just the components we need. The sensor blocks require the Sparkfun ZX Gesture sensor. The Programmable Hardware block is the LPC1114FN chip. The microcontroller may include some other components, but will definitely utilize a decoder. The voltage regulator transistor is a UA78MC. The LED block is literally 10 standard LEDs and resistors. The Waveform Generator block is an ICL8038 chip. The foot pedal will require some housing mechanism with a that can allow a potentiometer to be rotated with foot motions. The audio output is a speaker. The power block is a 25 volt power supply.

2.5 Risk Analysis

There isn't a huge safety risk to our project. The most dangerous part of our project is the fact that the highest voltage will be 25 volts. We will address this safety hazard by using the one hand rule whenever the device is on and we need to make adjustments to the waveform generator chip. In addition a fuse will be added to the circuit before the power flows through the components to ensure that current does not exceed the limit the component can handle.

3 Ethics and Safety

Safety is a very important factor in our implementation of the project. Throughout the development of our project, one safety risk that we will pay close attention to is the monitoring of our power source(s). It is important that as we develop our project we keep in check what voltages are going through each component to make sure that it does not overload the capacity that could result in possibly frying it or starting a fire. Beyond the development phase, we will apply a safety measure to the circuit with a fuse to ensure that any misuse of our product like plugging into the outlet too long will prevent power from flowing past the fuse into all the components.

One possible ethical issue that could arise is that we might not be aware of our product not being able to produce all the notes/pitches that we claim. According to IEEE Code of Ethics, it is important that we are honest and realistic in stating claims based on the data that is available to us [1]. Therefore, to ensure that our design address that issue, we will be using a music tuner to test each pitch. We will check that all the range of sound that we claim can be achieved by our instrument.

We as a group envision to follow the IEEE Code of Ethics. We will accept all responsibilities in decisions that we make to ensure the well-being and safety of the public [1]. We want our product to be as safe as possible to any user by applying safety measure listed above. Furthermore, we will be seeking feedback from many different people such as friends, families, instructors, and teaching instructors. As an engineer, we will accept all the criticism of the product, acknowledge the errors, and correct them [1]. Our goal is to meet the expectation that others have for our product and to make it as flawless as possible. Although our product will initially be far from perfect, but with every mistake corrected we will be one step closer to reaching that goal.

References

[1] "IEEE IEEE Code of Ethics." IEEE - IEEE Code of Ethics. N.p., n.d. Web. 09 Feb. 2017. <http://www.ieee.org/about/corporate/governance/p7-8.html>