ECE 445: Senior Design

Project Proposal

Theremixer - Theremin DJ Controller

Team 15

Shiv Kapur | skapur5

Akhil Reddy | akhil3

Karthik Achar | kpachar2

I. Introduction

A. Objective

The Theremin is an extremely unique musical instrument first patented in 1928. By using relative positioning to control oscillators, users are able to operate the theremin by simply waving their hands. After learning more about the instrument, we wanted to bring a classical instrument into a modern light, creating the Theremixer DJ Theremin. Our proposed solution brings new avenues to express musical creativity. The Thermixer will be a stand alone DJ controller fully capable of altering music settings such as: bass, treble, pitch and volume. Users will be able to modify these settings through their perceived hand movements by the theremin antennae. Users will also be able to visualize these audio levels and the waveform on a connected monitor. The primary objective of our project is to provide users a novel way to mix music. In today's day and age, DJ mixers have consisted of robust systems that have a high cost and a large learning curve. But, we hope to create a simplistic mixer that can actually allow users to mix music with ease.

B. Background

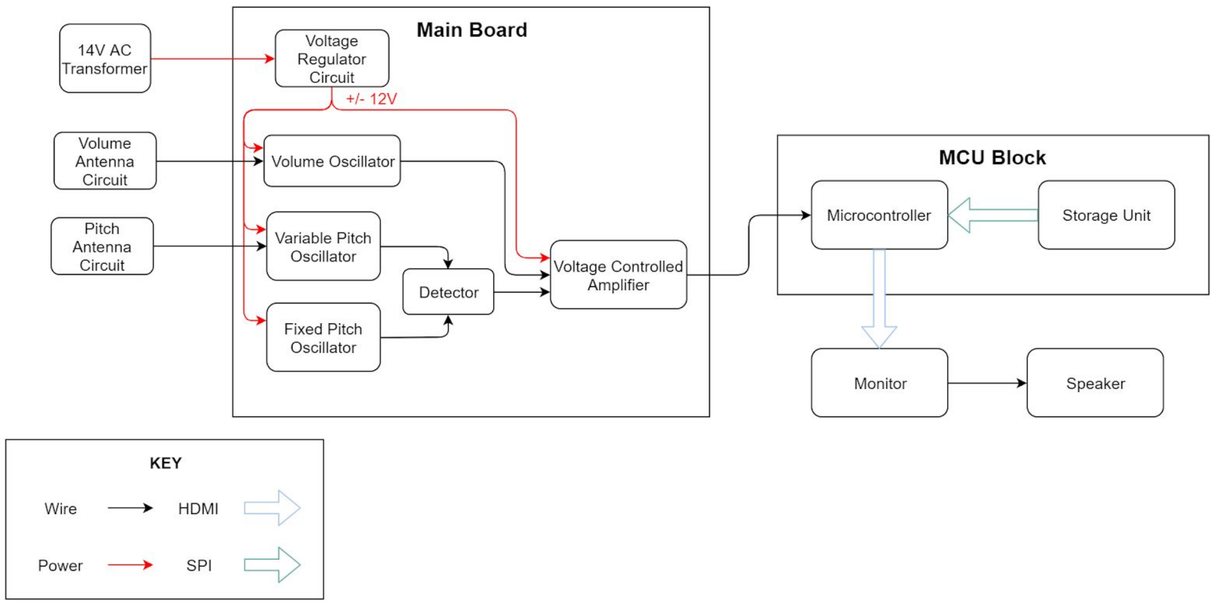
For thousands of years, music has been the foundation of helping people reach new heights. Music has allowed people to break boundaries, smash ceilings, and set records. There are hundreds of different music instruments across various cultures and regions. One such instrument is the theremin, known for its ingenuity in utilizing gestures between two antennas to control the output music. The theremin is named after its inventor Leon Theremin who received a patent for the device in 1928. The theremin has been recreated multiple times over the last 90 years in order to adapt to more modern technical abilities. Some recent adaptations of the theremin include digital theremins, including MIDI controller theremins which output MIDI signals rather than line level audio in order to provide easy use for live music playing and production. The theremixer is an effort to utilize a traditional instrument with mixing capabilities found in modern DJ hardware using hand gestures.

C. High-Level Requirements List

1. Our theremin will have an audio output maximum voltage of 0.5-1 VAC with a frequency range of 0-3 kHz.
2. Our microcontroller will perform DSP operations on the analog input and .wav file to output through HDMI with low latency.

II. Design

A. Block Diagram



B. Physical Design

We aim to make the Theremixer look very similar to a traditional Theremin. All of our hardware and interface components will be in a compact housing. The housing will be designed to provide a user interface through switches, and dials. Two antennas will be extruding from our housing to allow user control of pitch and volume. A wire will also connect the theremin housing to a monitor that will display audio levels and a visualization of the waveform produced. Our design is subject to constraints based on our hardware and spacing decisions.

C. Functional Overview & Block Requirements

1. Theremin (Hardware Block)

The theremin block is the hardware portion of our design. To ensure this block works would be to ensure the output voltages and frequencies are at the desired range described in the high level requirement.

a) 14 Volt AC Transformer - We will use a premade AC transformer to connect to our power supply. The transformer will provide 14 Volts AC at 60 Hz.

b) Voltage Regulator Circuit - This circuit will use a full-wave rectifier with LM7912 and LM7812 3-Terminal Negative Regulators to power the main board components through voltage rails.

Requirement: The voltage regulator circuit will provide +12V and -12V voltage rails from the 14V AC input source.

c) Pitch Antenna Circuit - We will create an antenna by soldering a wire to a ⅜ inch plated copper tubes connected to four 10 mH inductors in series.
Requirement: The pitch antenna circuit will be responsive to hand movements to alter the effective impedance of the antenna circuit.

d) Variable Pitch Oscillator - The pitch antenna circuit will feed into this oscillator to create the sinusoidal pitch waveform. This waveform will be sensitive to hand positioning near the pitch antenna.
Requirement: The variable pitch oscillator will maintain a variable frequency within the range of 257-263 kHz +/- 5% based on hand movements near the pitch antenna.

e) Fixed Pitch Oscillator - The fixed pitch oscillator will create a steady sinusoidal waveform of a resonant frequency 260 kHz. Its waveform will be used to compare with the variable pitch oscillator by the detector.
Requirement: The fixed pitch oscillator will create a sinusoidal waveform with a resonant frequency of 260 kHz +/- 5%.

f) Volume Oscillator - The volume oscillator will create a sinusoidal waveform with varying frequencies based on hand positioning near the volume antenna.
Requirement: The volume oscillator will create a sinusoidal waveform with a resonant frequency of 450 kHz.

g) Detector - Using a 1N4148 diode, the detector circuit will use the modulated input from the pitch oscillators and output the two waveforms' difference frequency. This signal will then be sent to the voltage connected amplifier.
Requirement: The detector will extrapolate a sinusoidal waveform with a frequency of 0-3 khz and a nominal amplitude.

h) Voltage Connected Amplifier (VCA) - The VCA amplifies the detector's output to a nominal line level audio signal to be used for processing by the microcontroller.
Requirement: The Voltage Connected Amplifier will produce an audible signal with a frequency range of 0-3kHz.

2. MCU Block

a) Microcontroller - The microcontroller will be essential to transform the input audio signal based on the theremin input to produce the output of the mixed music. It will take an analog input from the theremin and an audio signal from a WAV file from a flash drive/SD card. The essential software operation is to alter the audio signal from the WAV file to “mix” the music. The “mix” will include a changes in pitch, volume, bass, and treble. These parameters will be set based on the amplitude and frequency of the analog voltage output from the theremin.

Requirements:

(1) The microcontroller must communicate with analog inputs from the theremin and WAV files from a USB/SD card.

(2) The microcontroller must perform DSP operations with low latency.

(3) The microcontroller must output video and audio samples through the HDMI port.

D. Risk Analysis

The volume and pitch antennae are significant risks to the successful completion of this project. Circuit calibration to ensure a variable output voltage of 0.5-1 VAC under a range of 0-3 kHz is is vital for a functioning theremin. We will need to include volume and pitch tuning circuits to guarantee proper audio output from the theremin. Another potential risk to the successful completion of our project is output latency from the theremin to the mixing program. There must be low latency for users to have full control of the mixer so that gestures on the theremin will have immediate reactions to the music output to the speakers. The volume antenna will include a volume oscillator and volume tuning circuit. The pitch antenna will include a variable pitch oscillator, a fixed pitch oscillator, and a pitch tuning circuit. For successful completion, it will be necessary that these circuits are calibrated to produce a desirable output. Proper calibration will ensure that substantial hand movements from the user will create varying output voltages from 0.5-1 VAC with a frequency range of 0-3 kHz. Another significant risk of our project is the proper design of the microcontroller. This is because the microcontroller is vital for the extension of the traditional theremin to a theremin that can mix music. It is essential that we build a microcontroller that can an analog input from the theremin, read a WAV file from a USB or SD card, and output a video signal to a monitor and audio signal to a speaker.

III. Ethics and Safety

There are several ethical and safety matters to consider throughout the development of our project. Firstly, the IEEE Code of Ethics #5 states that the goal is "to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems" [1]. Our project encompasses replicating a traditional theremin design to develop an alternative operation of mixing music using output from the theremin. This aligns closely with the IEEE Code of Ethics #5 because we want to help individuals understand alternative uses of traditional technologies in the modern day. We also hope to accept honest criticism of our work throughout the semester to help guide our project and make fixes where necessary in accordance with IEEE of Ethics #7[1]. Another critical foundation of our project is to work closely with each other to develop professionally, and always uphold the IEEE Code of Ethics. The Code of Ethics is not only a statement of what to do on paper, but also the framework for an engineer's mindset to always be solution oriented while upholding certain principles.

The theremin we hope to construct would be a modern replication of the traditional theremin. We are going to be building a theremin that is an adaption of an Etherwave Theremin that has been developed my Moog Music previously [2]. Fortunately, Moog Music has published various open-source information to help guide the design of the theremin [3]. We hope to use this design as a foundation for further developing a modern theremin and provide an alternative use with music mixing. Additionally, another ethical point to concern is developing a platform to alter precreated music. Although the music is the property of artists, we will follow similar practices as those DJs in today's day and age who mix music at clubs. We hope to access the music we play legally through a streaming service or through purchase of music albums. Overall, our project does not pose any significant ethical concerns that might impact its success. This is primarily due to the fact that we are taking a traditional design and making a modern use of it.

There are very little safety concerns in relation to our project . Our project has power component that has a very low probability of being hazardous since it is only being used to power our theremin and circuit. In order to prevent any problems with power, we will always build stable connections in our circuit and ensure that connections are made properly. Another safety concern we might face will be during the design of the housing. This is because we need to properly construct a wooden housing with knobs, power inlet, and other components with proper spacing to allow for a fully functional theremin music mixer. In order to be safe, we will always use best practices in the lab and verify our design before constructing it.

IV. References

[1] IEEE, 'IEEE Code of Ethics', 2014. [Online.] Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 01 - Feb - 2019].

[2] Robert Moog, Electronic Musician, 'Build the EM Theremin', 1996. [Online.] Available: https://www.cs.nmsu.edu/~rth/EMTheremin.pdf. [Accessed: 01 - Feb - 2019].

[3] Moog Music Inc, 'Understanding, Customizing, and Hot-Rodding Your Etherwave Theremin', 2003. [Online.] Available: http://www.suonoelettronico.com/downloads/HotRodEtherwav.pdf. [Accessed: 01 - Feb - 2019].