Introduction – What is a Theremin?

- Created by Léon Theremin in the 1920s
- Project idea: repurposed analog theremin
  - Two outputs as control signals
Objective

- Control Signals:
  - Frequencies from Oscillators
    *(Representing Relative Hand Placement)*

- Functions:
  - Increase/Decrease Bass, Mid, Treble, Volume

- Components:
  - Hardware: Etherwave Antennas & Oscillators, ADC (AD7352)
  - Software: Microcontroller (Teensy 3.2)
Design Model

Magnitude

Region

Function

Placement of user's hands dictate choice in function and magnitude

100% 75% 50% 25%

Bass
Treble
Mid
Volume

Function Select Antenna

Magnitude Detection Antenna

Theremin Side View

Theremin Top View
Physical Model

Front View

Side View
Overview of Requirements and Verifications

- **Power Module**
  - 14 Volt AC Transformer
  - ± 12 Voltage Regulator
  - + 3.3 Voltage Regulator
  - + 2.5 Voltage Regulator

- **Hardware Module**
  - Magnitude Detection Antenna
  - Magnitude Detection Oscillator
  - Function Select Antenna
  - Function Select Oscillator

- **H/S Integration Module**
  - Analog to Digital Converter

- **Software Module**
  - Microcontroller

- Fully Meets Requirement
- Partially Meets Requirement
Hardware: Antennas

Function Oscillator Antenna Circuit:

Magnitude Oscillator Antenna Circuit:

Antenna Capacitance

<table>
<thead>
<tr>
<th>Distance (cm)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude Oscillator Antenna Capacitance (pF)</td>
<td>87.17</td>
<td>5.33</td>
<td>4.59</td>
<td>4.14</td>
<td>3.82</td>
<td>3.6</td>
<td>3.01</td>
<td>2.59</td>
<td>2.31</td>
</tr>
<tr>
<td>Variable Oscillator Antenna Capacitance (pF)</td>
<td>120.01</td>
<td>9.06</td>
<td>7.93</td>
<td>7.62</td>
<td>7.48</td>
<td>6.75</td>
<td>6.07</td>
<td>5.67</td>
<td>5.52</td>
</tr>
</tbody>
</table>
Hardware: Function Oscillator

- Average Frequency: 431.31 kHz
- Average Peak to Peak: 3.51 V
Hardware: Magnitude Oscillator

- Average Frequency: 141.76 kHz
- Average Peak to Peak: 761.29 mV
Hardware: ADC
Hardware/Software: Integration

- AD8022 opamps
- AD7352 12-bit ADC
  - Outputs data via SPI protocol
- Teensy Microprocessor
Software: Flow Chart

START

Call function to Load WAV Audio File

Call function to Play Audio File on Speaker

Initialize Input Signals from Theremin

Determine if there is an input from function select oscillator (non-zero/valid) response

Determine which function is selected. This is based on the response from the ADC

Function 1: Bass Boosting

Amplify frequencies of 0-100 Hz and attenuate frequencies above 100 Hz

Function 2: Treble Boosting

Amplify frequencies of 400 to 600 Hz, attenuate frequencies outside of this range

Function 3: Mid Boosting

Amplify frequencies above 500 Hz, attenuate frequencies below this frequency

Function 4: Volume Boosting

Apply a 5-dB increase to the baseline volume, Apply a 3-dB decrease to the baseline volume.

Output from Function Select

Determine current Magnitude

Magnify Output Signal based on output from function select and current magnitude output

Output Audio Signal
Software: Filters

- **Function Select Input Signal**
  - Bass Boosting ➔ Low Pass Filter (100 Hz)
  - Mid Boosting ➔ Band Pass Filter (400 to 600 Hz)
  - Treble Boosting ➔ High Pass Filter (800 Hz)
  - Volume Boosting ➔ Modify Baseline Volume

- **Magnitude Input Signal**
  - Amplify output audio signal at higher frequencies
  - Attenuate output audio signal at lower frequencies
Software: Outputs of Filters

- Original Audio
- Low Pass Filter
- Band Pass Filter
- High Pass Filter
Project Successes & Challenges

Successes:
- Audio Filters
- ADC Sampling
- Oscillator Frequencies
- Antenna Sensitivity

Challenges:
- Antenna & Oscillator Integration
- FFT at high frequencies
- Buffer implementation
Hardware: Next Steps

- Enhance effect of antenna capacitance on oscillator frequency
- Design new PCB to reflect design changes and problems
  - Buffer circuits
  - Ground loops in mixed signal design
Software: Next Steps

- Implement FFT to measure control signal frequency
- Provide Additional Features:
  - Cut-Off Frequency Selection using a Potentiometer
  - Reset/Pause/Play/Skip Options using Buttons
  - Visual Display of Current Filters
  - New Mixing Effects
Conclusion: Lessons Learned

- Understanding individual modules and their role in the overall project
- Being adaptable to different circumstances and outcomes
- Teamwork and collaboration helps solve challenging problems