Overview

- Use a capacitive touch enabled grid to generate x-y touch position
- Feed the information into a tone generator with multiple frequencies
- Output the sound using a Class AB amplifier
Block Diagram

Oscillator \( \omega_c = 1 \text{ KHz} \) → Capacitive Grid → Differentiator and Bandpass \( \omega_c = 1 \text{ KHz} \) → Reference Comparison

Op-amp Adder (50 KHz BW) → Note Selector → VCOs \( \omega_c = 3, 9, 1.5, 2 \text{ KHz} \) → DAC

LPF \( \omega_{c0} = 5 \text{ KHz} \) → Amplifier (10 KHz BW)
Block Diagram

Oscillator ($\omega_0=1$ KHz) → Capacitive Grid → Differentiator and Bandpass ($\omega_0=1$ KHz) → Reference Comparison

Op-amp Adder (50 KHz BW) → Note Selector → VCOs ($\omega_0=3, 9, 1.5, 2$ KHz) → DAC

LPF ($\omega_{sc}=5$ KHz) → Amplifier (10 KHz BW)
Capacitive Touch Sensor (Physical Construction)

- Single sided copper clad board
- Rows and columns formed by copper tape
- Geometry minimizes capacitance between rows and columns
- Test pad measured a capacitance of ~3pF with human touch roughly doubling the capacitance
Block Diagram

- Oscillator ($\omega = 1$ KHz)
- Capacitive Grid
- Differentiator and Bandpass ($\omega = 1$ KHz)
- Reference Comparison
- Op-amp Adder (50 KHz BW)
- Note Selector
- VCOs ($\omega = 3, 9, 1.5, 2$ KHz)
- DAC
- LPF ($\omega_{pe} = 5$ KHz)
- Amplifier (10 KHz BW)
Capacitive Touch Sensor (Sensing Circuitry)

- Signal passes through differentiator with transfer function $H(j\omega) = R_1C_1j\omega$
- Output passed through bandpass filter ($\omega=\sim1$ KHz) and notch filter (60Hz) to eliminate coupled noise.
- Peak detector measures output peak and compares with reference voltage using LM311
Block Diagram

- Oscillator \( \omega_c = 1 \text{ KHz} \)
- Capacitive Grid
- Differentiator and Bandpass \( \omega_c = 1 \text{ KHz} \)
- Reference Comparison
- Op-amp Adder \( 50 \text{ KHz BW} \)
- Note Selector
- VCOs \( \omega_c = 3, 9, 1.5, 2 \text{ KHz} \)
- DAC
- LPF \( \omega_{zc} = 5 \text{ KHz} \)
- Amplifier \( 10 \text{ KHz BW} \)
Capacitive Sense Input Oscillator

- Phase shift oscillator at ~1 kHz

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DAC

- Capacitive Sensor produces on-off signal for each row and column
- R-2R ladder combines signals to create analog voltage centered at VCO bias

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Voltage Controlled Oscillator

- Output from the DAC controls the output frequency.
- Schmitt trigger uses capacitor voltage to switch mosfet and cause a drain/charge cycle.
- Bandwidth of 500Hz.
- Low pass filtering of output triangle wave.
Note Selector

- Turn off signal from VCOs that are not activated
- Uses digital signal from reference comparison
Low Pass Filter and Op Amp Adder

- Low Pass Filter to reduce distortion
- AB amplifier to power speaker
## Timeline

<table>
<thead>
<tr>
<th>Week of</th>
<th>Task</th>
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</thead>
<tbody>
<tr>
<td>April 11</td>
<td>Test Single Capacitive Pad (Eric)</td>
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<tr>
<td></td>
<td>Design and Test VCOs (Corey)</td>
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<td>April 18</td>
<td>Build and Test Capacitive Grid (Eric)</td>
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<td>Build Note Selector and all VCOs (Corey)</td>
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<td>April 25</td>
<td>Integrate and Debug (Both)</td>
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<tr>
<td></td>
<td>Stretch Goals (Both)</td>
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<tr>
<td>May 2</td>
<td>Stretch Goals and Present</td>
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Challenges

- Measuring small capacitance changes
- Grid construction (row/column asymmetry)
- Cross talk between grid lines
- Sensitivity of Voltage Controlled Oscillator
Stretch Goals

- Adding optional distortion/amplitude control to output audio signal
- Adding “light show” in addition to tone generation
- PCB design