Audio Analyzer

By: Andrew Pehrson, Henry Gillespie, Jordan Hendricks
## Agenda

Team Number: 3  
Project Title: Audio Analyzer

- Design Overview  
- Technologies Used  
- Final Schematic  
- Technical Hurdles  
- Signal Analyzation in MATLAB  
- Arduino Sampling Method  
- LED Display Implementation  
- Future Challenges

<table>
<thead>
<tr>
<th>Team Members</th>
<th>Project Task</th>
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<tbody>
<tr>
<td>Andrew Pehrson:</td>
<td>Arduino / FFT / LED Implementation</td>
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<tr>
<td>Henry Gillespie:</td>
<td>Arduino / MATLAB / FFT / Hardware</td>
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<tr>
<td>Jordan Hendricks:</td>
<td>Hardware / Schematic / Presentation</td>
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Project Requirements

- Detect 8 notes in the range C(261 Hz) to high C(523 Hz) at ±5% accuracy
- Audio must be analyzed from at least 10 ft away
- More than 20 samples must be acquired for the detected period
- At least 3 periods of data must be recorded and graphed
- The signal to noise ratio must be at least 20
Design Overview

Black Box Diagram

Audio Analyzer

Input
Frequency out

Power in

Block Diagram

Microphone
Voltage Divider
Amplifier
Microcontroller
Fast Fourier Transform

Input
Frequency out

Input

Frequencies to Analyze at ±5% Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Middle C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td>High</td>
<td>274.7</td>
<td>308.4</td>
<td>339.5</td>
<td>366.7</td>
<td>411.6</td>
<td>462.0</td>
<td>508.1</td>
<td>549.5</td>
</tr>
<tr>
<td>Middle</td>
<td>261.6</td>
<td>293.7</td>
<td>329.7</td>
<td>349.2</td>
<td>392.0</td>
<td>440.0</td>
<td>493.0</td>
<td>523.3</td>
</tr>
<tr>
<td>Low</td>
<td>248.5</td>
<td>279.0</td>
<td>313.2</td>
<td>339.5</td>
<td>372.4</td>
<td>418.0</td>
<td>468.4</td>
<td>508.1</td>
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Integrated Technologies Used

- CMC-5042PF Electret Mic
  - Captures initial sound wave and converts into electrical signal

- LMC6032 Dual OP Amp
  - Biases Voltage into amplifier to 2.5V
  - Amplifies Audio signal allowing Arduino to read with greater resolution

- Arduino Nano
  - Reads signal and turns into analog value

A single LED turns on for each identified note.
Final Schematic

Bias Voltage to 2.5 V

Sets bias current specified by microphone

Passes change in voltage

Sets the voltage gain to the Arduino

Voltage converted to ADC value
Technical Hurdles

Note Tested: A

Frequency: 460 Hz
Speaker Distance: 0in

Frequency Resolution too low

Analyzed Frequency without Approximation: 438.5 Hz
Analyzed Frequency with Approximation: 451.5 Hz
Frequency Difference: 13 Hz

Smooth Approximation to detect frequency between samples
Matlab Graphs

Note Tested: High C
Frequency: 520 Hz
Speaker Distance: 0in
Clean Signal
Biased at 2.5V
Amplitude > 1V
Fourier Transform of the input signal

Analyzed Frequency: 525.3 Hz
Signal to Noise Ratio: 30.8 dB
Arduino Sampling Method

- Sample at >10.5 kHz (once every 95 μs)
- Need at least 120 samples to graph 3 periods at 261 Hz
- More samples increase FFT resolution
LED Display

- Display[] stores mean Amplitude for note
  - Display[] sent to Arduino
  - Amplitude for later 8x8 LED matrix

- Current challenge: Data getting messed up in serial connection
Future Challenges

Note Tested: High C
Frequency: 515 Hz
Speaker Distance: 5ft
Noisy Signal
Amplitude $\ll 1V$
Fourier Transform of the input signal

Frequency Analyzed: 528 Hz
Signal to Noise Ratio: -4.5 dB
Next steps

- Multi-stage audio amplifier
- Better refine bandpass filter
- Adaptive gain
- Make pcb
- Design enclosure