



## IPRO 344

Improving Energy-Efficiency and Offering Quality Audio in Mobile Devices and Intercoms



# Objective

- To investigate the potential improvements that Class D amplifiers offer for intercom systems
- To analyze the electro-acoustic aspects of a two-way communications channel
- To simulate and evaluate a drive-thru facility
- To develop guidelines for an acceptable drive-thru system

# Team Introduction

## Web Team

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Min Soo Kang

## Presentation Team

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Mike Carrozza  
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Alex Barnett  
Harry Lee

## Purchasing Team

Harry Lee(L)  
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## Research Team

Alex Barnett(L)  
Min Soo Kang  
Mike Carrozza



# Tasks to be Accomplished

- Investigate microphones that most accurately capture customers' voices in outdoor environment.
- Implement a pre-amplifier.
- Design a kiosk for the prototype
- Evaluate the audio quality of the system.
- Develop a prototype of improved sound quality drive-thru system.

# Progress

- **Microphone**

- MX-100 series from Shure Inc.
- High Quality Microphone Assembly
  - Built-in preamp
  - Reduction of the impact of any electromagnetic interference on the cable length
  - A higher quality element with a relatively flat frequency response from 20hz to 20kHz

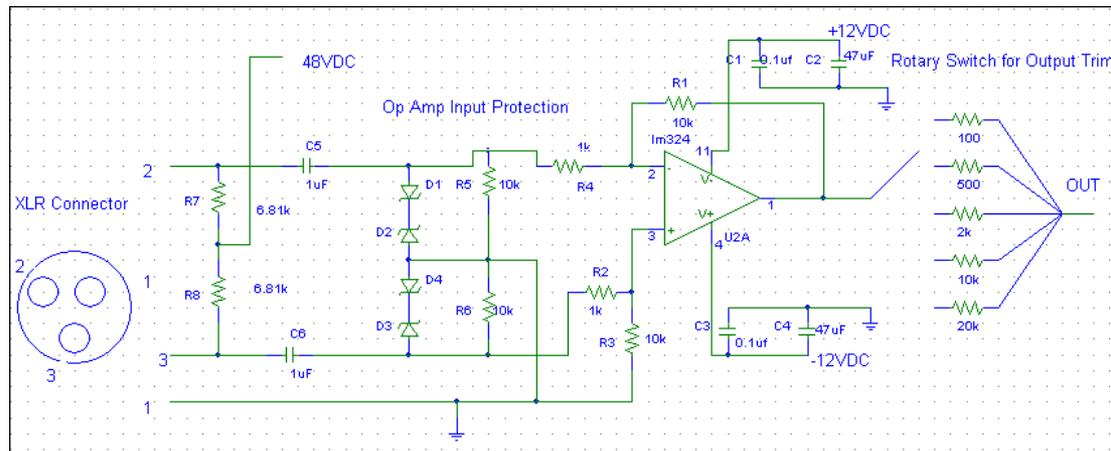


**SHURE**

<Shure MX-183>

# Progress

- **Preamplifier Design for Shure Microphone**
  - Phantom power circuit isolated with capacitors
  - Op amp protected from spikes with Zener diodes
  - Difference amplifier achieves 20dB of gain
  - Output trim allows adjustment of input levels to class D amplifier.
  - Trim comprised of stepped attenuator for precision and repeatability



Shure Micro Preamp Design

# Progress

- **Speaker**
  - Outdoor/ Weather-Proof
  - Compatibility with the class D amplifier
  - Benefits
    - Sensitivity : Above 90 dB/watt
      - Made of butyl rubber/ Withstand an outdoor environment
      - Offer more watts per speaker per dollar



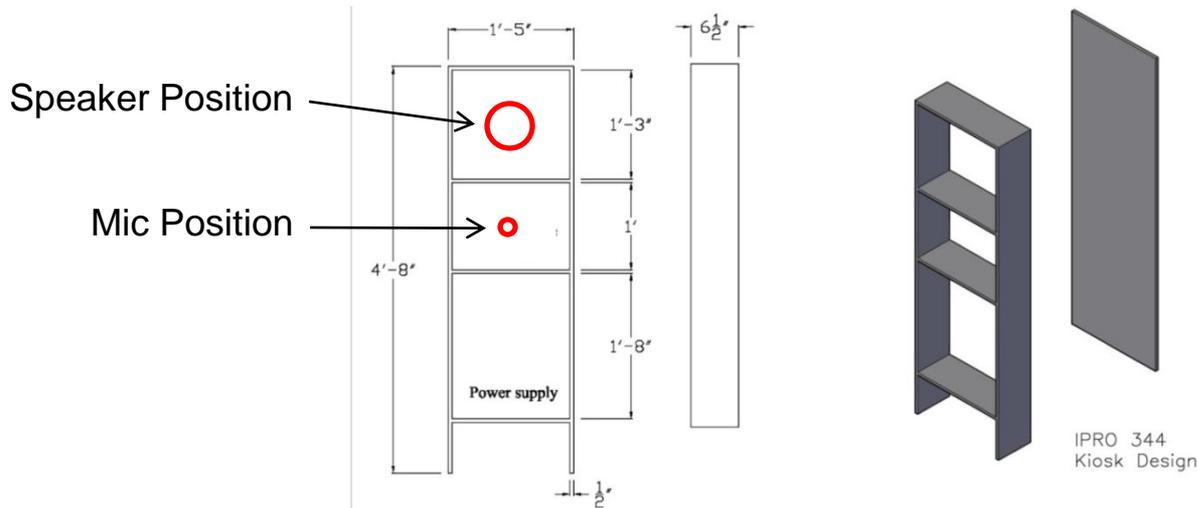
<Polk Atrium 45>



<Polk Audio db 401>

# Progress

- **Kiosk**
  - Material & Shape : Wood & Cubic
  - Design : - Isolating the Interior of the Kiosk in order to Prevent Sound Feed Back from Speaker to Microphone
    - Mimic the acoustic properties of an actual drive through kiosk.
    - Careful positioning of speaker and microphone to prevent from tipping over



# Progress

- **IPRO 344 Web Page**
  - Topics : Overall Purpose, Products, Prototypical results and progress, Research and Background, Members

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*It takes a team!*

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## IPRO 344: Audio Quality & Energy Efficiency for Mobile Devices and Intercoms

*We are dedicated to making a difference!*

Supported by the Illinois Institute of Technology and sponsored by McDonald's corporation, IPRO 344 seeks to improve the sound quality of existing McDonald's drive-thru restaurants. What began as an exploration into Class D audio amplifiers has paved the way for a new and vastly improved intercom system for drive-thru restaurants. Class D amplifiers offer a low-power, high efficiency solution for mobile devices and intercoms.



Class D audio amplifiers are highly efficient due to their rapidly switching states. At any given moment, a class D amplifier is switched either fully on or fully off. In these states, the amplifier does not drain energy from the source. Energy is used only during the transition periods, thus reducing the total power consumption. This has allowed high power amplifiers to be constructed without the need for a heat sink as well as reduced size. IPRO 344 first began investigating the use of Class D amplifiers in the Spring of 2007. They are desirable to be used within our improved intercom system because they reproduce excellent sound quality, are low-cost, and energy efficient. Lower power consumption is the goal of most electronic devices as well as friendly to the environment.

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## Why are Class D amplifiers so Efficient?

To understand why class D amplifiers operate with such great energy efficiency, a brief introduction to other amplifiers is in order.

Amplifiers are active devices, which by definition, require external power sources. An amplifier uses energy from these sources to amplify an input signal. What differentiates classes of amplifiers is the method of how the energy is used and how amplification is achieved. Class A amplifiers, shown to the left, are the simplest configurations as well as the least efficient. Class A amplifiers continuously conduct and are said to operate in a linear mode. The output of a class A amplifier is simply an amplified version of the input and uses the external power supplies to achieve this. But what if there is no input signal? Well, the power sources continue to supply current to the amplifier and thus gets wasted. The reason that class A is so inefficient should now be apparent. Enter class B. Class B amplifiers, shown to the right, use a clever trick to prevent the amplifier from wasting the power supply's energy. Rather than be in a continuous conduction state, a class B amplifier uses 2 different branches. One branch will conduct only when the input signal is above 0 Volts. When the input signal falls below this line, the second branch begins to conduct while the first is shut off. In this way, the class B amplifier conducts only when an input signal is present. A variation that corrects distortion in a class B amplifier is a class AB amplifier. Both operate with this "pull/pull" method, in which the amplifier conducts only part of the time. This leads to much greater efficiency, with a theoretical limit of 78.5%.

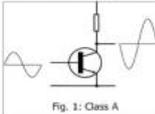


Fig. 1: Class A

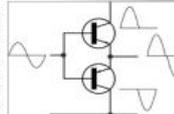


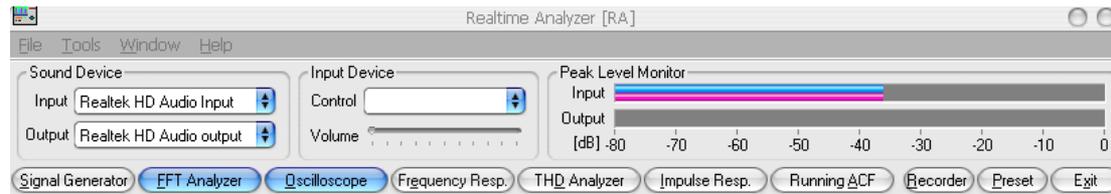
Fig. 2: Class B

**So how does class D work?**

Class D amplifiers first modify an input signal before amplification takes place. The input signal is compared with a triangular waveform that serves as a reference signal.

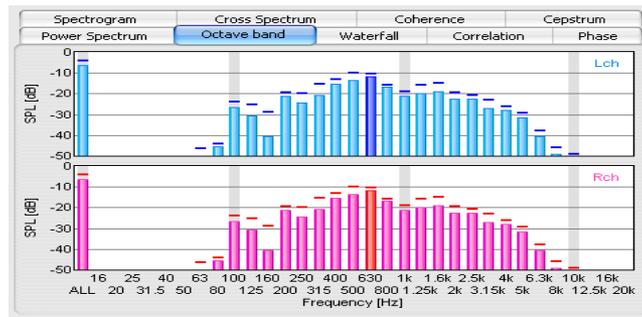
# Progress

- **Sound Analysis Tools**
  - Acoustic Analyzing System 5E
    - Offer the FFT analyzer with 9 options
    - Using the real time spectrum analyzer, environmental noise and human voice can be analyzed

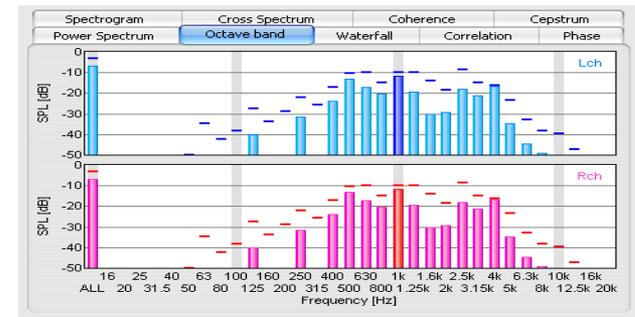


## <FFT Analyzer>

- When speaking in front of the Microphone,



<Human Speech without Music>



<Human Speech with Music>

# Progress

- **Sound Analysis Tools**
  - RightMark Audio Analyzer 6.1.2
    - Test the electronic noise produced by the amplifier system
    - Self-test of the soundcard and audio signal

Device:	[MME] HTO CLARO	Music source from iTouch	[Empty]	[Empty]	
Sampling mode:	16-bit, 44 kHz	16-bit, 44 kHz			
Frequency response (multitone), dB	+0.01, -0.02	+0.02, -0.11			
Noise level, dBA	-97.4	-95.2			
Dynamic range, dBA	96.2	94.5			
Total harmonic distortion (THD), %	0.0006	0.0040			
Intermodulation distortion + noise, %	0.0043	0.0077			
Stereo crosstalk, dB	-98.4	-93.6			
Intermodulation distortion + noise (swept freqs), %	0.016	0.039			
Frequency response (swept sine), dB	+0.0, -0.0	+41.7, -56.0			
Total harmonic distortion (swept freqs), dB	-88.28, -89.23				
	<input checked="" type="checkbox"/> Select	<input checked="" type="checkbox"/> Select	<input type="checkbox"/> Select	<input type="checkbox"/> Select	
					
HINT: Right-click on result boxes to view the detailed reports...					

<the Result of Self-Test >

# Challenges

- **Microphone**
  - Encounter unexpected problem as we go along the implementing process
- **Speaker**
  - Search for durable high quality outdoor speakers to produce sounds like actual human voice
- **Kiosk**
  - Exact location of microphone and speaker, best distance between microphone and speaker is not known
  - Feedback noise from the microphone can not be eliminated
- **Tools/ Media**
  - Outdoor noise is variant and complicated to analyze
  - Difficult to represent sound quality using numerical data
- **Web Page**
  - Making website cross browser compatible

# To Do

- **Microphone**
  - Build high quality preamplifier to drive the power amplifier
- **Kiosk**
  - Build the kiosk
  - Test the microphone in different places to find the best place for the microphone
- **Tools/ Media**
  - Continue searching for software tools to measure the outdoor noise
  - Try to write a MATLAB program to do above
- **Web Page**
  - Complete content for any unfinished pages
  - Continually update with progress of prototype and testing
- **Poster**
  - Find a creative and eye-catching way to display information

# To Do

- **Purchasing**
  - collect all required equipments
- **Documentation**
  - Prepare for the final report and presentation
  - Support post team and web team
- **Research**
  - Gather journal articles & publications that can assist others in designing the project
- **Coordination**
  - Make Gantt chart and manage the flow of tasks
- **Minutes**
  - Make a record of everyday progress
- **Presentation**
  - Present the midterm and final presentation



THANK YOU