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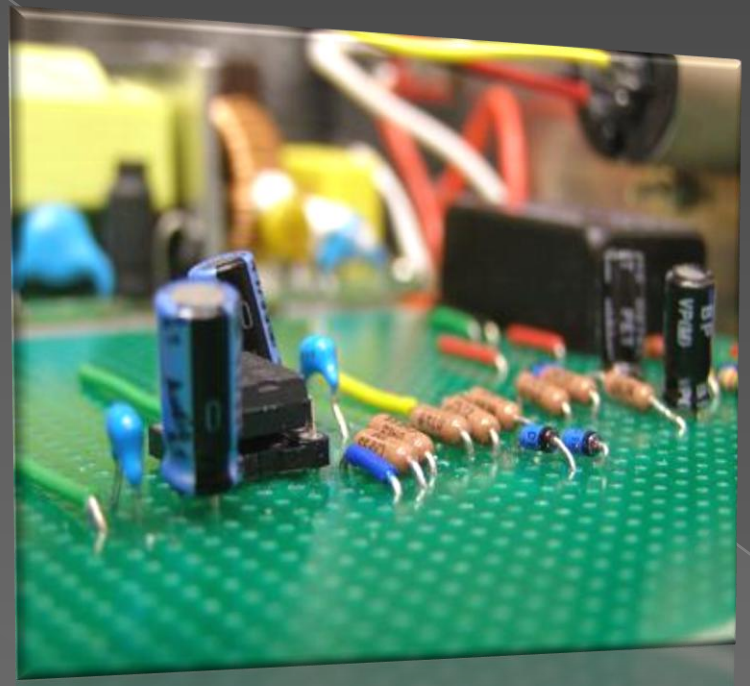


IPRO 344
Improving Energy-Efficiency & Offering Quality Audio in Mobile Devices & Intercoms

Introduction

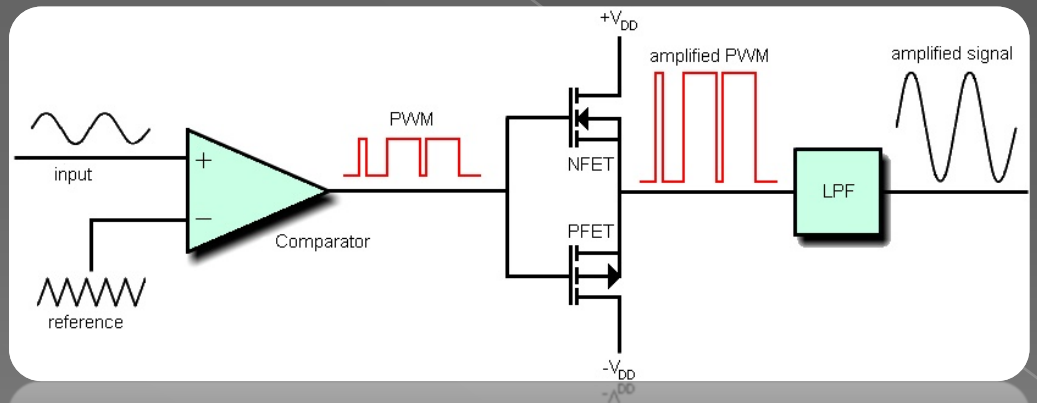
- Fall 2007
  - To study and improve technologies for low-power mobile audio
  - Compare efficiencies of Class A, B, and, AB amplifiers with Class D
- Spring 2008
  - Continued work of previous semester
  - Designed preamplifier for headset microphone
- Fall 2008
  - To improve the sound quality of drive-thru intercom system using Class D amplifier

Motivation

- Businesses seek new and innovative ways to remain competitive
- 65% of McDonald's national sales come from its drive-thru service
- Over 50% of inaccuracy in drive-thru occurs during order capture
- Class D Amplifiers able to deliver desirable sound quality

Class D Amp

- Why other classes are inefficient
  - Always have a bias current
  - Remains in active state even when not being used
- Encoding Process
  - Encode voice signals into a square waveform
  - Low-pass filter: Produce amplified version of input signal



- Efficiency of Class D
  - Uses transistors as switches ⇒ Only transitions require energy
  - Theoretical Efficiency : 100% ; Typical Efficiency : 90% ~ 95%

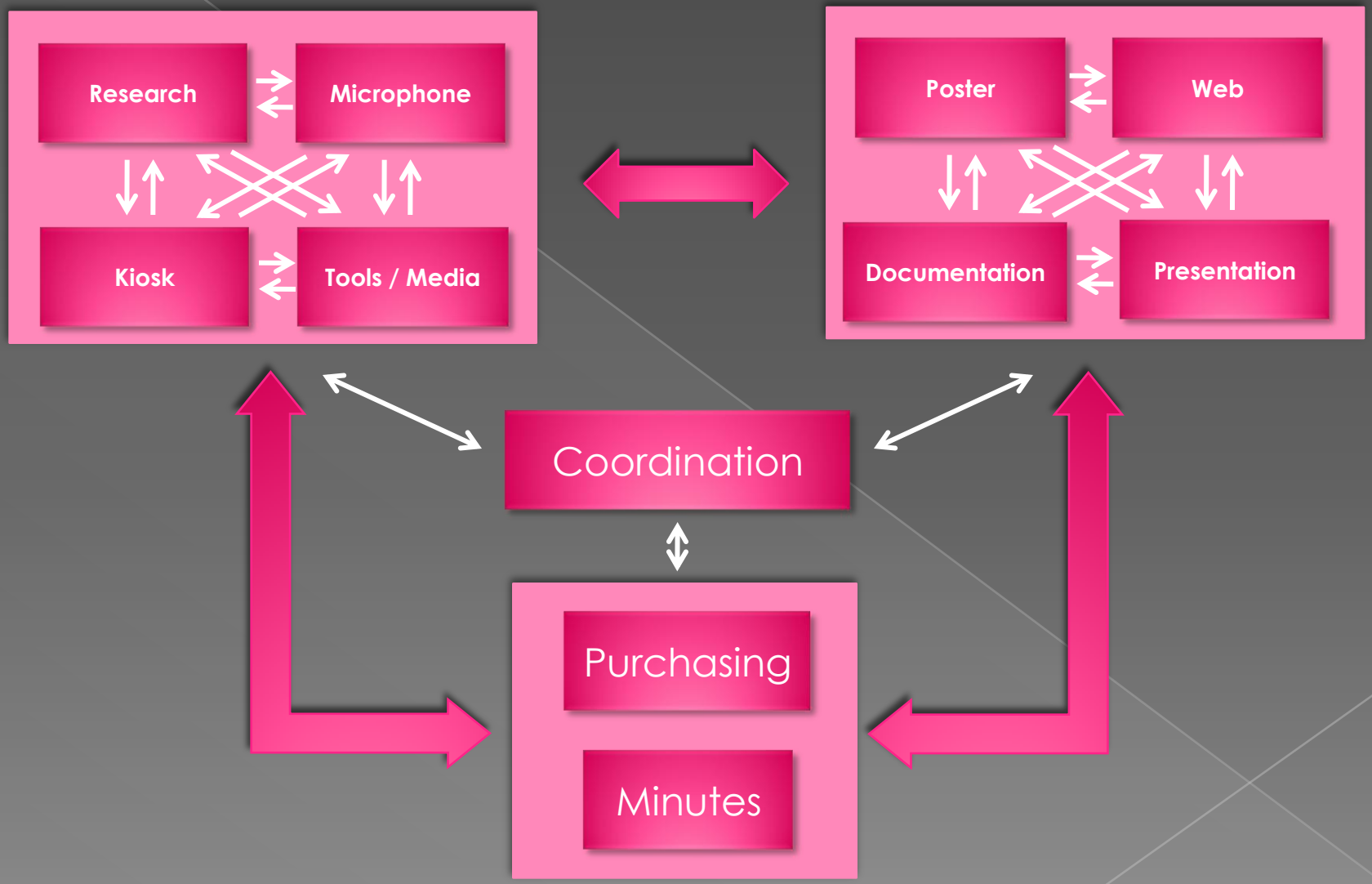
Project Approach

- Phase I: Constructing Phase (Present)
  - Design and construction of kiosk
  - Implementation of a two-way communications system using Class D amplifiers
- Phase II: Testing Phase
  - Simulate communication constraints
  - Compare various microphone response patterns
  - Analyze the quality of communication
- Phase III: Refinement Phase
  - Use Phase II results for system improvement
  - Develop metrics for an acceptable drive-thru facility

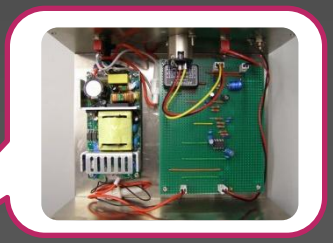
Objective

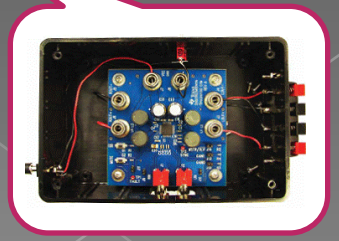
- To investigate the potential improvement that Class D amplifiers offer for intercom systems
- To analyze the electro-acoustic aspects of a two-way communications channel
- To simulate and evaluate a drive-thru facility
- To develop guidelines for an acceptable drive-thru system

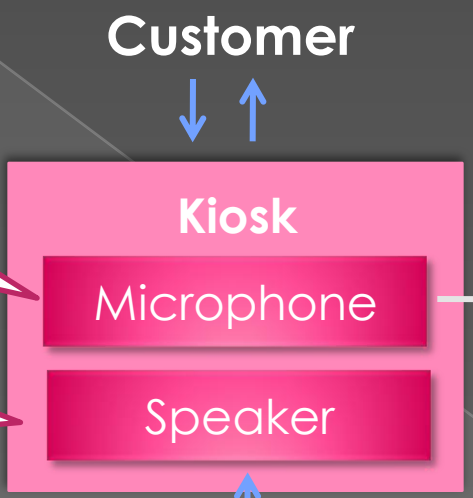
Team Introduction

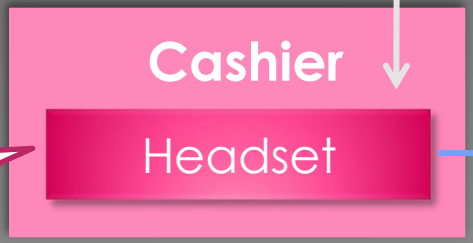


Audio System Diagram



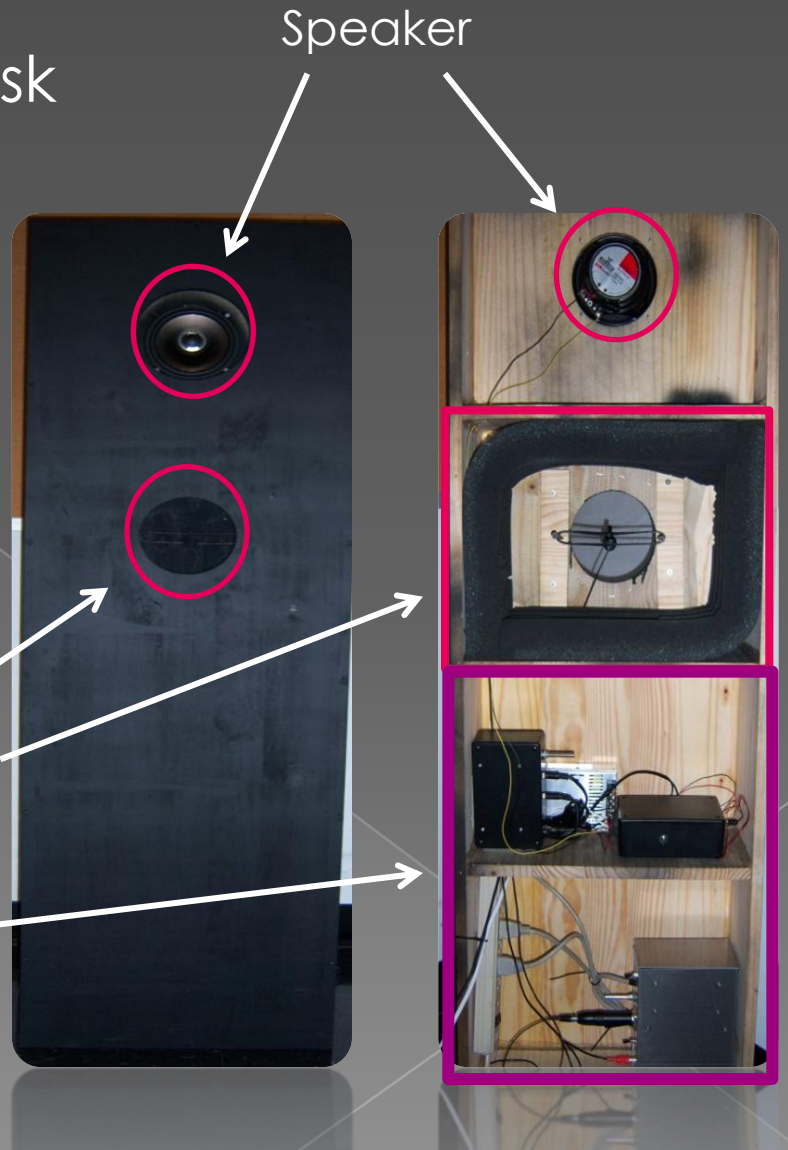






Kiosk

- Replicated size of typical kiosk
- Constructed of wood
- Microphone and speaker chamber acoustically conditioned
- Access to interior achieved through access panels

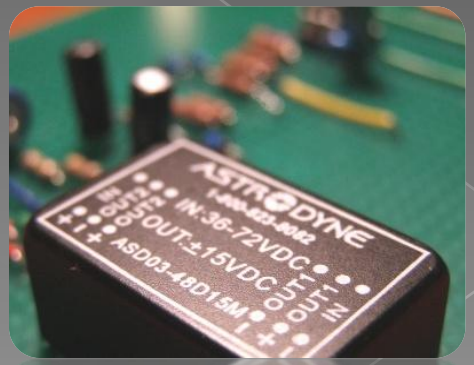


Microphone

- MX 180 Series
  - Donated by Shure Inc.
  - High fidelity
  - Inherent 12 dB of gain
  - Requires preamplifier

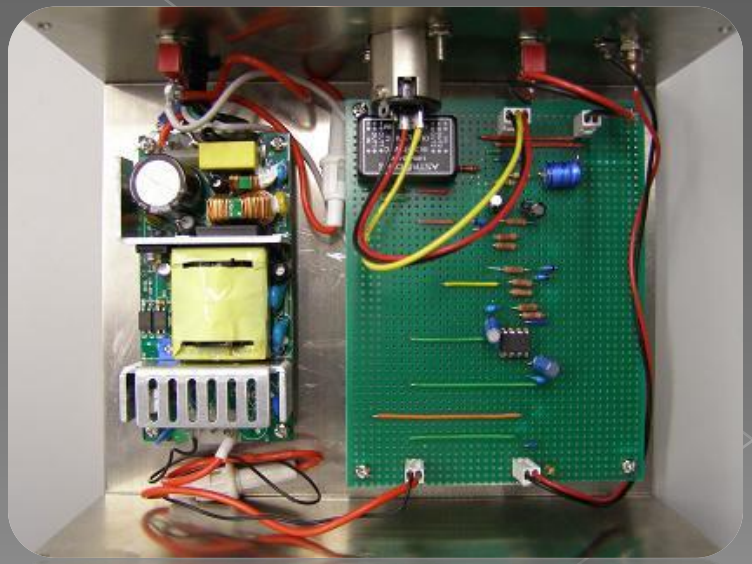
Preamplifier

- Purpose
  - Provide a 48V DC external phantom power supply and an electronically balanced signal
- Power Supply Management
  - Astrodyne ASL 40-48 Open Frame Power Supply
    : Supply 48V DC through 315mA line fuse to the DC to DC converter
  - Transform 48 Volts to ±15 Volts for op-amp power supplies
  - Eliminate the need for a second power supply
  - Minimize board space



Preamplifier (cont.)

- Operational Amplifier Configuration
  - LM833: low-noise and large bandwidth
  - 0.1% tolerance resistors ⇒ Maximize common mode rejection
- Preamplifier Input Protection
  - Separates circuit from the 48 VDC power supply
  - Protects against transients and overloading input signals



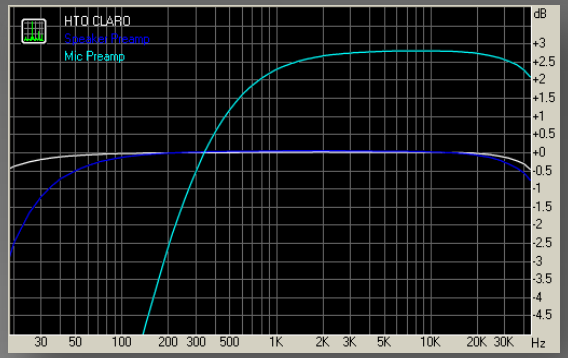
Speaker

- Polk Audio Speakers
  - Butyl rubber composite cone
    ⇒ Withstand outdoor environment
  - Sensitivity greater than 90 dB/W
  - Lowest price for greatest audio quality

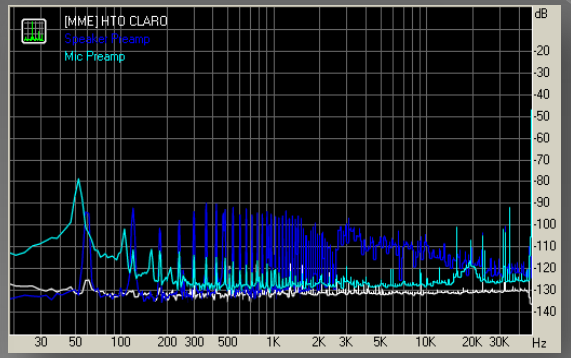
Analysis

- Testing of Preamp Performances

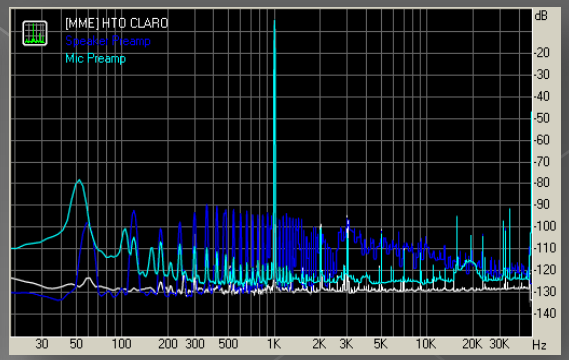
Test	[MME]HTO CLARO	Speaker Preamp	Mic Preamp
Frequency Response(dB)	0.01 ~ 0.12	0.05 ~ 0.72	2.81 ~ 14.80
Noise Level	-98.5	-94.1	-85.1
Dynamic Range	98.6	93.9	85.2
THD(%)	0.0034	0.0043	0.0041
IMD + Noise(%)	0.0073	0.078	0.030
Stereo crosswalk(dB)	-51.0	-43.4	-49.4



<Frequency Response>



<Noise Level>



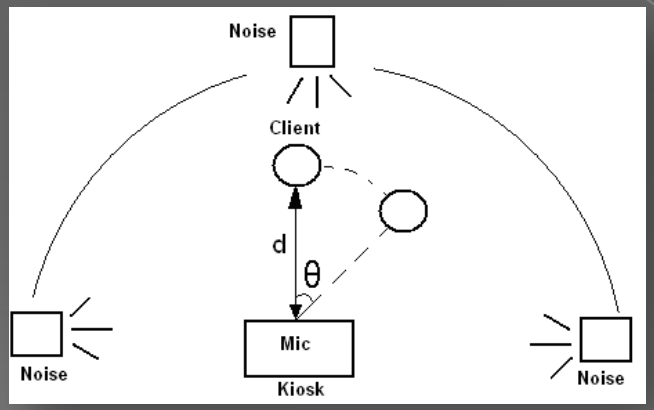
<THD + Noise at -3dB FS>

Qualitative Conclusions

- IRPO 344's amplifier can accurately represent the complex human voice-band
- Initial Testing shows that the distance between microphone and customer produces large variations in quality
- A high fidelity communications system aids comprehension by replicating the voice with familiar nuances

Future Test Plan

- Signal – to – Noise Ratio of Preamp
  - Purpose: find out the optimal position for clients in order to develop guidelines for an acceptable drive-thru system



<Acoustic Test Diagram>

d / Θ	1m	2m	3m
0	X dB	X dB	X dB
30	X dB	X dB	X dB
60	X dB	X dB	X dB
90	X dB	X dB	X dB

<Possible SNR measurement Table>

Obstacles & Solutions

- Least noticeable means to access interior of kiosk
  - Used flush mounted access panels
- Not enough shelf space for components
  - Transferred existing preamp to smaller enclosure
  - Modified interior to add an extra shelf
- Crucial shipment never arrived
  - New order placed with different supplier and expedited
- Some components failed to work
  - Analytically determine reason for breakdown, and replace and fix components as necessary

Ethical Considerations

- Current global energy production and usage is considered
  - Class D amplifiers are near perfectly efficient
- ROHS compliance where available
  - The ROHS Directive stands for "the restriction of the use of certain hazardous substances in electrical and electronic equipment
  - Law in the EU, ethical option for our IPRO

Continuing the Project

- Continue with Phase II and Phase III
  - Consume one semester for each
- Reviewing the website
  - Will reduce the time it takes for proceeding groups to start work
  - Serves as a framework for future groups to add their contributions
- Suggestion for most immediate attention
  - Automatic gain control to equalize all communications
  - Noise cancellation to improve perception
  - Confirm expectations of microphone polar response

Expansion

- Applications of Intercom System

<Banks>

<Train Stations>

<Intercom System>

<Airports>

<Public Buildings>

THANK YOU