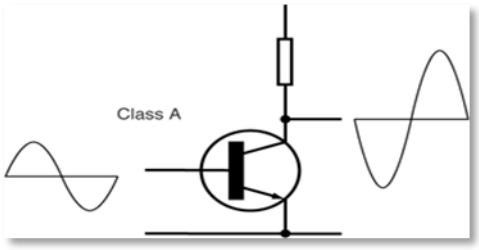
1. Abstract

IPRO 344 focuses on improving audio quality and energy efficiency for mobile devices and intercoms. Recently, a demand for faster, more reliable service increases. On the other hand, customers' satisfaction is the most important factor for any business. However, drive-thru systems don't provide high-quality service for customers. In fact, more than 50% of order accuracy problems occur at drive-thru systems, particularly, order capture. It causes several negative effects, such as repetition of Order, receiving incorrect Items, and long lines. This problem happens because of the low-sound quality between customers and order takers. Now, this is good field for IPRO 344 to improve the sound quality of drive-thru systems

2. Background

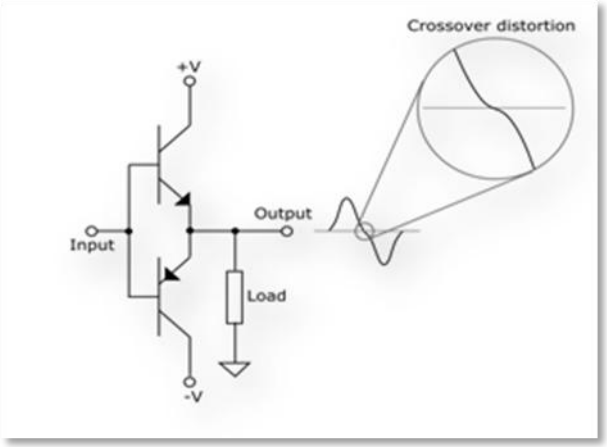
- Shure Inc. provided microphones to the project. IIT ECE department provided a laboratory to the IPRO 344 team for the development of the prototype.
- IPRO 344 began in Fall 2007. Initial objective was to study and improve technologies used for low-power mobile audio. The investigation was to include comparisons with Class A, Class B, and Class AB amplifiers as well as measure the efficiency of commercially available Class D amplifiers. Spring 2008 continued work of previous semester, which designed preamplifier for headset microphone.
- Amplifiers
  - Class A

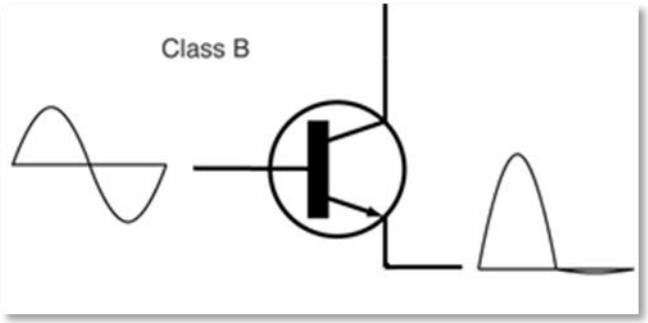


Class A amplifiers are very inefficient, with the range of 10 to 20% and 25% maximum efficiency. In many Class A amplifiers they use same transistor for both halves of the audio waveform. Class A amplifier generally runs very hot even when there is no audio output signal. Also these types of amplifiers are biased so that variations in input signal polarities occur within the limits of cutoff and saturation. Class A amplifiers operate over the whole of the input cycle such that the output signal is an exact scaled-up replica of the input with no clipping. Class A amplifiers are the usual means of implementing small-signal amplifiers.

- Class B and AB

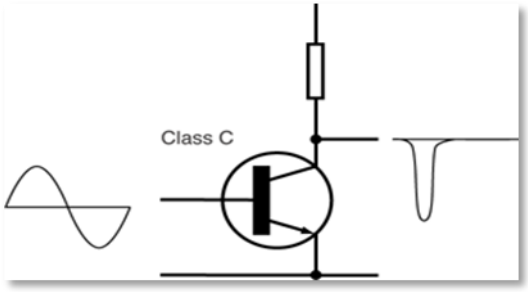
  Class B amplifiers have a very high efficiency but this class of amplifier suffers from crossover distortion. Class b amplifier has a maximum efficiency of 78%, the reason is the amplifying element will switch off half of the time and there is no dissipating power. The operation in class AB is same as class B but also conducts a small amount on the other half. The result would be the combination of output of two amplifiers; the crossover will appear much smaller.





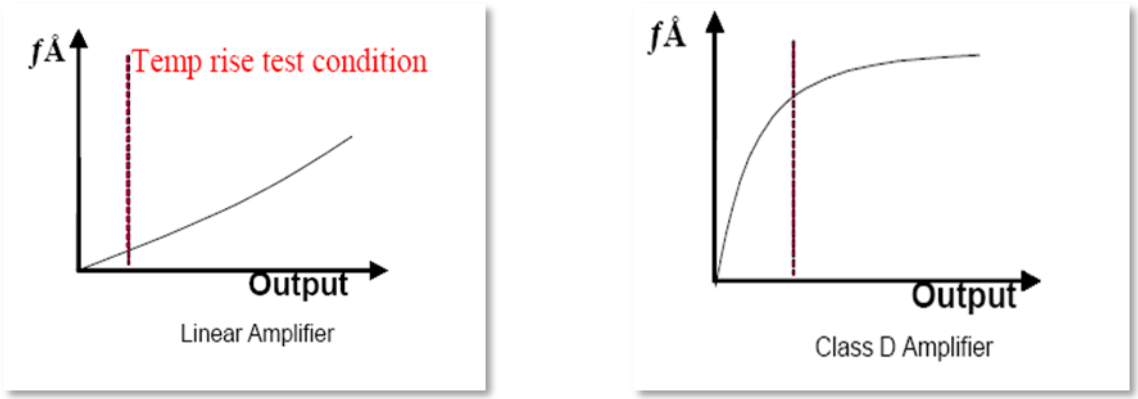
- Class C

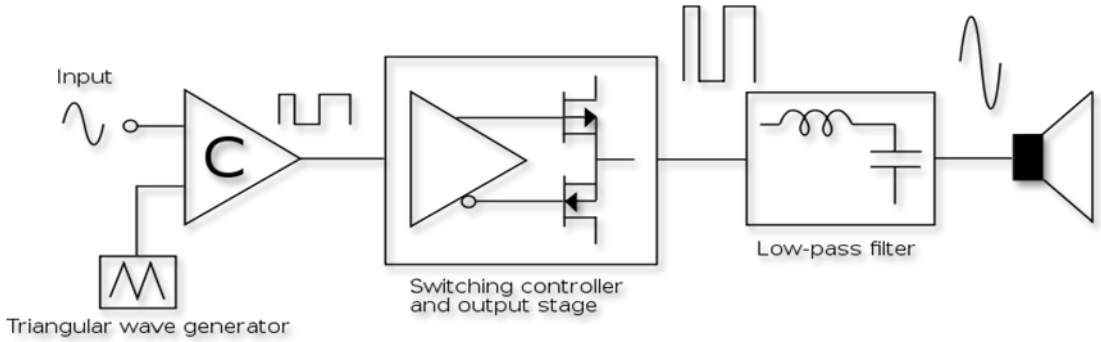
  As shown in the following figure a Class C amplifier conduct half of the input signal. Also this type of amplifier has two modes of operation: tuned, and un-tuned. They commonly used in RF circuits where a resonant circuit must be placed at the output in order to keep the sine wave going during the no conducting portion of the input cycle.



- Class D

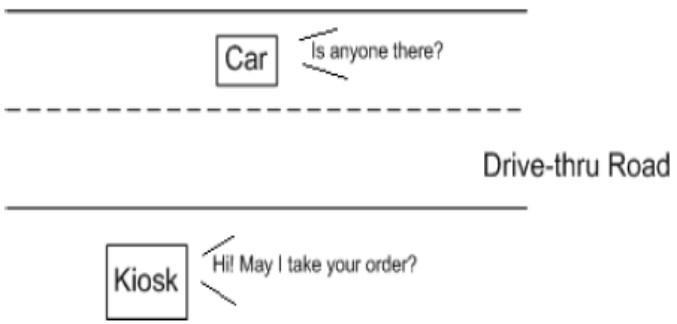
Class D amplifier or a switching amplifier is the main focus on this project. In this type of amplifier, the switches are fully off or on, these will reduce power losses. Efficiencies of 90 to 95% are possible for this amplifier. The amplifier, therefore, features the high power efficiency (low energy losses), which additionally results in lower weight by eliminating the bulky heat sinks. The whole reason of using class D is that they are more efficient than the linear amplifier. The following figures show typical efficiency curves for linear and class D amplifiers.





<Block diagram of a basic switching or PWM (Class-D) amplifier>

- Current Drive-thru Systems' Circumstance
  - Environmental interference interrupts the communication between the customer and the clerk:
    - ° Heavy rain/ wind
    - ° Car engine noises
  - Customer's position relative to kiosk makes the communication difficult:
    - ° Customer parks too far from the kiosk
    - ° Customer is not speaking into microphone



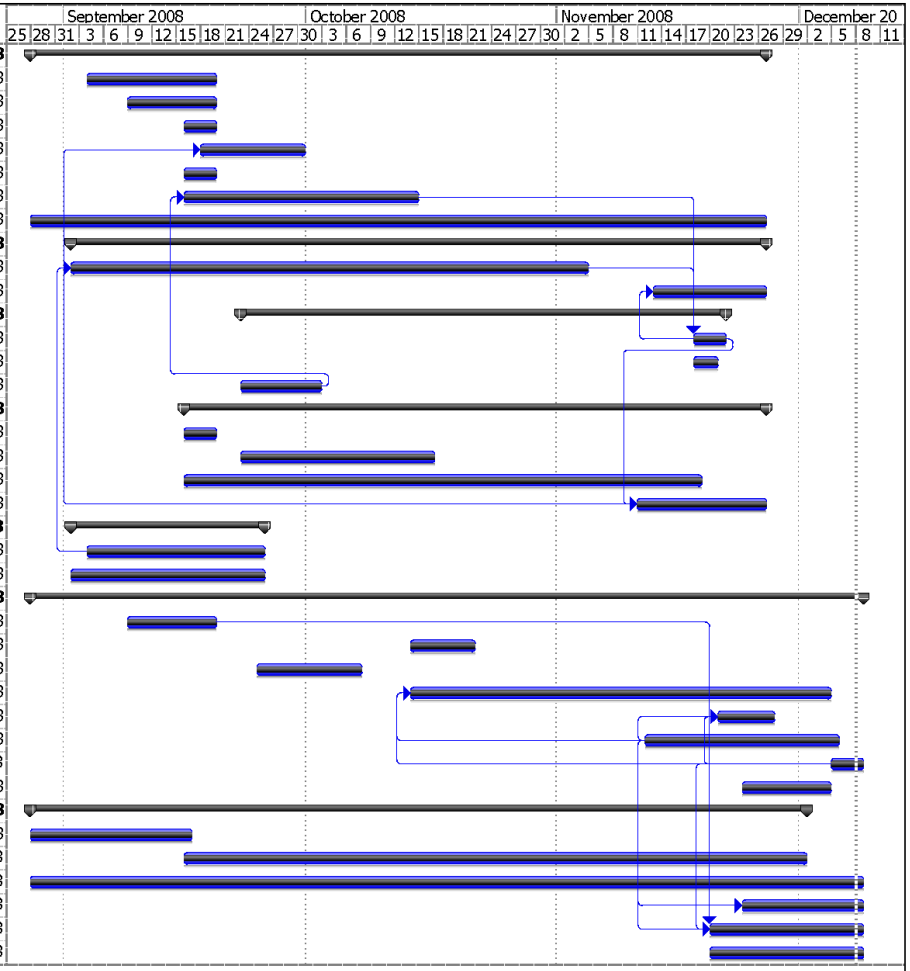
3. Objectives

The IPRO 344 team has set forth the following objectives:

- Investigate the potential improvement that Class D amplifier offer for intercom systems.
- Analyze the electro-acoustic aspects of a two-way communications channel.
- Simulate and evaluate a drive-thru facility.
- Develop guidelines for an acceptable drive-thru system.
- Investigate various microphone polar patterns, namely, omnidirectional, cardioid, and super-cardioid.
- Implement a pre-amplifier for the selected microphone.
- Design a kiosk based on the existing ones for the prototype of the drive-thru system.
- Evaluate the audio quality of the developed system.
- Develop a prototype of improved sound quality drive-thru system.

4. Methodology

ID	Task Name	Duration	Start	Finish
1	**Purchasing**	**65 days?**	**Thu 8/28/08**	**Wed 11/26/08**
2	DVD Player	12 days?	Thu 9/4/08	Fri 9/19/08
3	Procinema 600 System	9 days?	Tue 9/9/08	Fri 9/19/08
4	The Microphone Book	4 days?	Tue 9/16/08	Fri 9/19/08
5	Mic Preamp Materials	9 days?	Thu 9/18/08	Tue 9/30/08
6	Kiosk Speakers	4 days?	Tue 9/16/08	Fri 9/19/08
7	Kiosk Materials	21 days?	Tue 9/16/08	Tue 10/14/08
8	Constant updates for budget	65 days?	Thu 8/28/08	Wed 11/26/08
9	**Microphone Implementation**	**62 days?**	**Tue 9/2/08**	**Wed 11/26/08**
10	Develop pre-amp	46 days?	Tue 9/2/08	Tue 11/4/08
11	Audio quality testing	10 days?	Thu 11/13/08	Wed 11/26/08
12	**Kiosk Implementation**	**44 days?**	**Tue 9/23/08**	**Fri 11/21/08**
13	Part Assembly	4 days?	Tue 11/18/08	Fri 11/21/08
14	Painting	3 days?	Tue 11/18/08	Thu 11/20/08
15	Kiosk Drawing	8 days?	Tue 9/23/08	Thu 10/2/08
16	**Tools/Media**	**52 days?**	**Tue 9/16/08**	**Wed 11/26/08**
17	Sound Card setup	4 days?	Tue 9/16/08	Fri 9/19/08
18	Testing Software	18 days?	Tue 9/23/08	Thu 10/16/08
19	Continue searching test tools	46 days?	Tue 9/16/08	Tue 11/18/08
20	Running the Test Plan	12 days?	Tue 11/11/08	Wed 11/26/08
21	**Research**	**18 days?**	**Tue 9/2/08**	**Thu 9/25/08**
22	Determine pre-amp for Shure mic	16 days?	Thu 9/4/08	Thu 9/25/08
23	Investigate various mic/speaker	18 days?	Tue 9/2/08	Thu 9/25/08
24	**Deliverable**	**73 days?**	**Thu 8/28/08**	**Mon 12/8/08**
25	Project Plan	9 days?	Tue 9/9/08	Fri 9/19/08
26	Midterm Peer Review	6 days?	Tue 10/14/08	Tue 10/21/08
27	Midterm Review Presentation Slides	9 days?	Thu 9/25/08	Tue 10/7/08
28	Abstract/Brochure	38 days?	Tue 10/14/08	Thu 12/4/08
29	Poster	5 days?	Fri 11/21/08	Thu 11/27/08
30	Individual Reports with Ethics	18 days?	Wed 11/12/08	Fri 12/5/08
31	Subteam Report	2 days?	Fri 12/5/08	Mon 12/8/08
32	Final Presentation	9 days?	Mon 11/24/08	Thu 12/4/08
33	**Website**	**68 days?**	**Thu 8/28/08**	**Mon 12/1/08**
34	Layout of web	14 days?	Thu 8/28/08	Tue 9/16/08
35	Constant web update	55 days?	Tue 9/16/08	Mon 12/1/08
36	Meeting Minutes	73 days?	Thu 8/28/08	Mon 12/8/08
37	Code of Ethics	11 days?	Mon 11/24/08	Mon 12/8/08
38	Final Reports	13 days?	Thu 11/20/08	Mon 12/8/08
39	IPRO Deliverables CD	13 days?	Thu 11/20/08	Mon 12/8/08



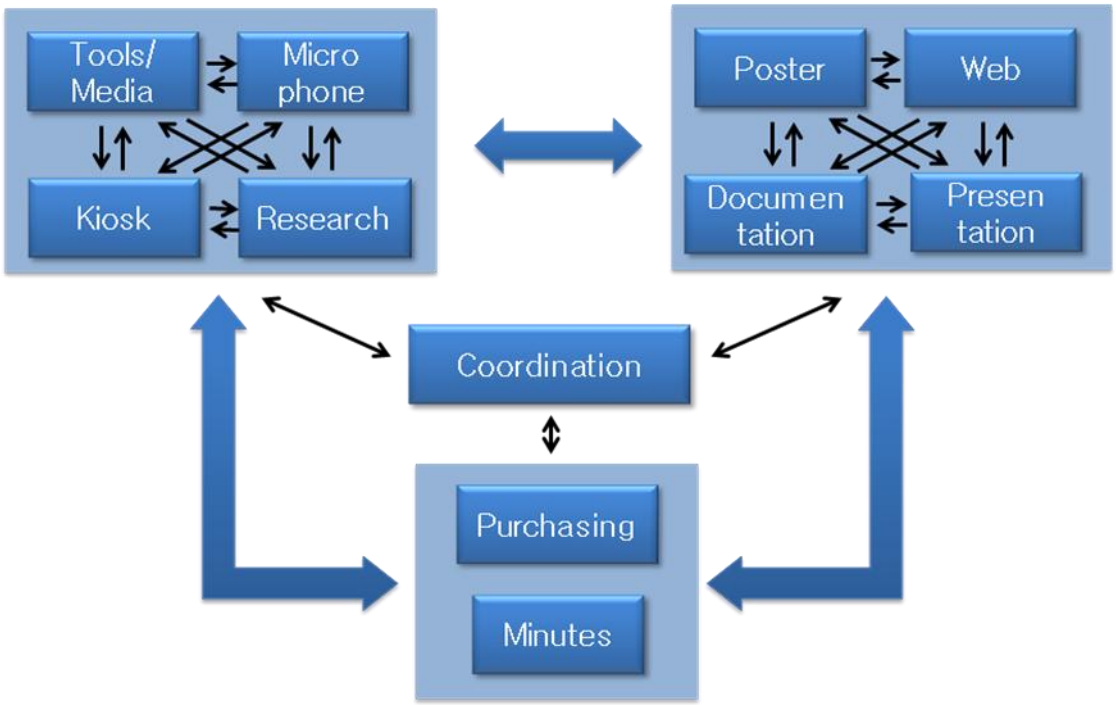
Project: IRPO344 F08
Date: Thu 12/4/08

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Tasks shown on the final time line is not differed from the one shown in the Project Plan. If compared the current time line with the one in Project Plan, one could see the due date for some tasks had been delayed. Time estimates for some tasks, mainly deliverables, were changed over the semester to fit team members' working progress and school schedule. The delays were caused by unexpected malfunctioning in project components as well as the effort on debugging them. Also, new tasks such as Individual Reports with Ethics were required deliverables to our team leader, Dr. Wong, for team members to show their contributions throughout the semester as well as awareness of the ethical aspect of the project.

5. Team Structure and Assignments

IPRO 344 maintains the first team structure and assignments. The picture below shows the entire team structure and co-relationship between teams.



Sub-Team 1: Web Team

Purpose: The objective of the web team is to design and implement an attractive and user friendly website. Information conveyed through the website includes the team's background, goals, current research, prototypical progress, and links to previous IPRO websites. The intended audience for the website is existing and future sponsors, students and faculty of IIT, and IPRO judges.

Team Members:

- Mike Carrozza – Team Leader
- Alex Barnett
- Min Soo Kang

Tasks:

- Develop an overall visual look for the website that is simple and appealing
- Convey important and non-proprietary information regarding our product
- Introduce the viewer to the team members and their background
- Use cascading styles sheets and HTML to develop static HTML pages
- Communicate with IIT's Web Server to manage files
- Continually update website with current progress and research

Sub-Team 2: Purchasing Team

Purpose: The Objective of this team is to purchase and deliver all necessary equipments and parts needed to conduct our project.

Team Members:

- Henry Lee – Team Leader
- Roozbeh Shegarifi

Tasks:

- Come up with the budget for the project
- Communicating with IPRO office on having the money available if needed
- Check different supplier for the cheapest price if possible
- Ordering the equipments and part
- Make sure that the items we order comes in on time

Sub-Team 3: Documentation Team

Purpose: The objective of Documentation team is to create and maintain all documents related to IPRO 344 through official channels. The collected document help next IPRO team understand the purpose of IPRO 344 and identify the progress of it.

Team Members:

- Ming Soo Kang– Team Leader
- Harry Lee
- Roozbeh Shegarfi

Tasks:

- Collect and maintain all documents
- Support Poster team for offering information to make a poster
- Support Presentation team for preparation of presentation

Sub-Team 4: Microphone Team

Purpose: Microphone team is responsible for assembly of microphone pre-amplifiers and improvement of audio sound quality.

Team Members:

- Mohammad Raza– Team Leader
- Li Li

- AlexBarnett
- Chia-Hao Tu
- Michael Carrozza

Tasks:

- Communicate closely with research team on the design of microphone pre-amplifiers
- Work with Tools/Media team to investigate the sound quality captured by microphone with the specified pre-amplifier design

Sub-Team 5: Kiosk Team

Purpose: Kiosk Team is in charge of taking all the equipment gathered and constructing the actual kiosk. Find a good way to mount the speaker and microphone so we can get optimal quality from it.

Team Members:

- Roozbeh Shegarifi – Team Leader
- Nastasja Terry
- Kevin Gullikson
- Alex Barnett
- Harry Lee

Tasks:

- Build the actual kiosk
- Correctly mounting the speakers and microphone
- Mimic the acoustic properties of an actual drive through kiosk

Sub-Team 6: Tools/Media Team

Purpose: The tools and media team is responsible for proposing and installing tools/instruments for the team.

Team Members:

- Li Li – Team Leader
- Mohammad Raza

Tasks:

- Work closely with implementation and research teams to determine instruments needed for the project
- Setup of instruments

Sub-Team 7: Poster Team

Purpose: The objective of the poster team is to create a poster to display on IPRO day. This poster should clearly show what the goals of this IPRO were and what we accomplished. The poster should stand out so as to attract attention.

Team Members:

- Kevin Gullikson – Team Leader
- Li Li
- Min Soo Kang
- Chia-Hao Tu

Tasks:

- Work with the documentation team to compile any technical information we may want to display
- Work with the Presentation team to decide what information we want to present on their slideshow and our poster
- Submit a budget to the purchasing team for the poster board, as well as any markers, etc. we may need to decorate it
- Create the poster, set up for IPRO day and be there to present it

Sub-Team 8: Research Team

Purpose: The research team provides information for other teams to utilize in the project implementation. The research team will utilize datasheets, web tutorials, and published research to collect and convey data to the Microphone Preamplifier and Kiosk teams.

Team Members:

- Alex Barnett – Team Leader
- Min Soo Kang
- Mike Carrozza

Tasks:

- Determine the requirements of current Shure microphone
- Propose potential designs to the microphone preamplifier team
- Investigate logistics of speaker connection and cabinet requirements
- Investigate potential Kiosk microphone
- If time permits, investigate solutions to wind and Diesel interference

Sub-Team 9: Presentation Team

Purpose: The presentation team compiles all the results from the microphone, kiosk and tools / media teams. The team also works with minutes, documentation and poster team to report the progress that the IPRO has made over the semester. Utilizing Powerpoint as a main tool, the members are able to convey all of the technical information to IPRO judges in an attractive and professional manner.

Team Members:

- Nastasja Terry – Team Leader
- Mike Carrozza
- Alex Barnett
- Mohammad Raza

Tasks:

- Gather pertinent information regarding the background, progress and future of IPRO 344
- Explain semester objectives and results
- Dissect technical analysis data into analogies for the “non-engineer”

- Communicate future prospects of the IPRO and how businesses / consumers can benefit
- Disclose the ethical implications of the project, as well as ethical obstacles that occurred during the semester

Agenda Maker- Chia-Hao Tu

Meeting Minute Taker- Terry Nastasja and Kevin Gullikson

Time Keeper- Chia-Hao Tu

Filing and Organizing Weekly Timesheets- Terry Nastasja

Weekly Task Lists- Kevin Gullikson

iGroups Coordination- Chia-Hao Tu

Master Schedule Maker- Chia-Hao Tu

IPRO344 Representative/Presenter- Nastasja Terry, Michael Carrozza, and Mohammad Raza

6. Budget

The main is the main duty of the purchasing team. Just like any other team, the purchasing sub-team is vital on producing the final outcome of the project. The Objective of this team is to purchase and deliver all necessary equipments and parts needed to conduct our project. With the effort and collaboration from other sub-team, the purchasing team has to come up with the budget for the project. The team is responsible for communicating with IPRO office on having the money available when needed. Often times, the team has to check different supplier for the cheapest price if possible. Most important of all, making sure that the ordered equipments will arrive on time. The following is the complete list of expenditures for IPRO-344.

Microphone/Pre-amp

Part	Description	Price	Quantity	P*Q	Supplier
71-CMF551K0000BHEB	1/8W .1% 1k resistor	$0.36	4	$1.44	Mouser
71-CMF5510K000BEEB	1/8W .1% 10k resistor	$0.52	6	$3.12	Mouser
660-MF1/4DCT52R1500F	1/4 1% 150 resistor	$0.05	6	$0.30	Mouser
594-5073NW200R0J	200 ohm 5%	$0.16	2	$0.32	Mouser
594-5073NW820R0J	820 ohm 5%	$0.16	2	$0.32	Mouser
660-MF1/4LCT52R222J	2.2k 5%	$0.05	2	$0.10	Mouser
71-CMF075K0000JNEK	5k 5%	$0.18	1	$0.18	Mouser
594-5073NW20K00J	20k 5%	$0.16	2	$0.32	Mouser
71-CCF02100KJKE36	100k 5%	$0.19	2	$0.38	Mouser
105-14572	6X2 rotary switch	$4.76	1	$4.76	Mouser
863-LM833NG	dual LM833 opamp	$0.91	2	$1.82	Mouser
523-AC3FDZ	xlr female connector	$3.96	1	$3.96	Mouser
502-BPJF02X	rca female connector	$1.70	1	$1.70	Mouser
71-CPF3-D-6.81	6.81k .5% phantom resistor	$0.69	4	$2.77	Mouser
594-2222-021-90545	68uF 63v Polar Electrolytic Capacitor	$0.71	1	$0.71	Mouser

108-0038-EVX	spst switch toggle 5a	$2.83	2	$5.66	Mouser
546-1411RU	8inX6inX3.5in case Al	$15.89	1	$15.89	Mouser
575-343308	IC socket 8P dip	$1.03	1	$1.03	Mouser
728-FM2106-3005-SS	11mm PCB Standoff	$1.00	8	$8.00	Mouser
647-UKT1V470MDD	35 V, 47 uF, Audio Electrolytic Cap	$0.15	2	$0.30	Mouser
81-RPER71H104K2P1A03	Monolithic Multilayer 0.1uF	$0.13	3	$0.39	Mouser
647-UVP1H010MDD	Bi-Polar Electrolytic Capcitors	$0.19	2	$0.38	Mouser
610-1N4627	0.25 W 5% Zener Diodes	$0.23	4	$0.92	Mouser
			Subtotal	**$54.77**	
			Shipping	**$7.77**	
			Total	**$62.54**	
ASL40-48A	"+48V" PSU open Frame	$40.00	1	$40.00	Astrodyne
ASD03-48D12H	36-72 V to 15 V DC-DC converter	$19.00	1	$19.00	Astrodyne
			Subtotal	**$59.00**	
			Shipping	**$11.14**	
			Total	**$70.14**	
#275560	Nady CM100 Measurement condenser microphone	$44.45	1	$44.45	Guitar Center

			Subtotal	**$44.45**	
			Shipping	**$4.98**	
			Total	**$49.43**	
#2701063	PK4 1A 5x20 Slow Blow Fuse	$2.99	1	$2.99	Radio Shack
#2701065	PK4 3.15A 5x20 Slow Blow Fuse	$2.99	1	$2.99	Radio Shack
#2701046	PK4 .315A 5x20 Slow Blow Fuse	$2.99	1	$2.99	Radio Shack
#2701238	5x20 mm Fuse Holder	$2.69	2	$5.38	Radio Shack
#6102847	9 ft BLK/RA extension cord	$4.99	1	$4.99	Radio Shack
			Subtotal	**$19.34**	
			Tax	**$1.98**	
			Total	**$21.32**	
CON-242	2-PIN Connector w/header .10"	$0.70	8	$5.60	All Electronics
CON-243	3-PIN Connector w/header .1"	$1.00	3	$3.00	All Electronics
ECS-4	Solderable Perf Board, line pattern	$6.25	1	$6.25	All Electronics
			Subtotal	**$14.85**	
			Shipping	**$7.00**	

			Total	**21.85**	
#22141	Bit Drill 3/32" Cobalt CD	$4.49	1	$4.49	Ace Hardware
			Subtotal	**$4.49**	
			Tax	**$0.46**	
			Total	**$4.95**	
#5575077	Flat Black Spray Paint	$3.12	4	$12.48	Menards
			Subtotal	**$12.48**	
			Tax	**$1.25**	
			Total	**$13.73**	
			Grand Total	**$239.01**	

Kiosk Speakers

Part	Description	Price	Quantity	P*Q	Supplier
Polk Atrium 55	8 ohm, 10-80 Watts, 4.5" woofer, 0.75" tweeter, outdoor speakers with	$149.99	1	$149.99	Crutchfield

	enclosure				
Polk Audio db521	4 ohm, 4-45 Watts, 5.25" woofer, 0.75" tweeter, marine certified, 2-way coaxial speakers, NO enclosure	$89.99	1	$89.99	Crutchfield
			Sub-Total	**$239.98**	
			Shipping	**$10.99**	
			Total	**$250.97**	

Connection / Mounting materials

Description	**Price**	**Quantity**	**P*Q**	**Supplier**
Heat Shrink Microphone cable adaptor	$4.99	1	$4.99	Radio Shack
Banana Plug	$3	2	$6.00	Radio Shack
Speaker cable	$10	1	$9.99	Radio Shack
Heat Shrink	*$4.99*	*1*	*$4.99*	*Radio Shack*
			Total=$39.62	
Velcro Fastener	$2.99	4	$11.96	ACE

Mounting Rubber Vacuum Belt	$2.79		$2.79	ACE
Screws	$0.23	2	$0.46	ACE
			Total=$16.77	
			Grand Total=$56.39	

Kiosk Materials

Part	Description	Price	Quantity	P*Q	Supplier
1.85E+11	5/8” Wood used for exterior walls, 4x8	$21.97	4	$87.88	Home Depot
Screws	Fasteners (screws)	$2.19	2	$4.38	Home Depot
Elmer's Carpenter's Glue	Wood Glue for all joints, 3.25 oz.	$1.97	1	$1.97	Home Depot
Alex Fast Dry White Caulk	Caulk for interior joints	$2.24	1	$2.24	Home Depot
Access Panels		$11.95	3	$35.85	Home Depot
Sand Paper	120 HP	$3.69	1	$3.69	Home Depot
				Sub-total=$136.01	
				Tax	**$13.94**
				Total	**$149.95**

Headset

Life chat Lx-2000	Headset	29.99	1	29.99	Best Buy
				Sub-total=	**$29.99**
				Tax	**$3.07**
				Total	**$33.06**

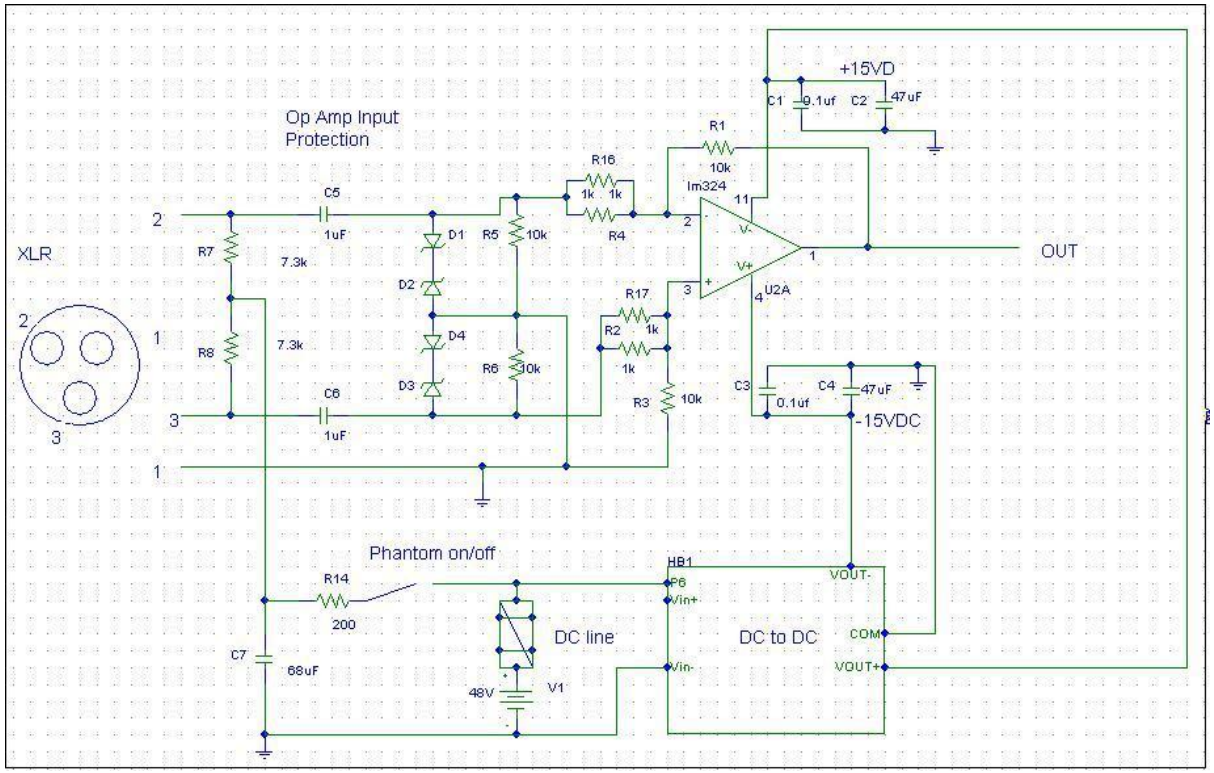
OverallTotal = $729.38

7. Results

- IPRO 344 investigated microphones and speakers to implement a prototype of a kiosk. Polk Audio speakers were chosen, because of three main reasons:
  - Butyl rubber composite cone can withstand outdoor environment
  - Sensitivity greater than 90 dB/w
  - Lowest price for greatest audio quality

- MX180 series microphone is donated by Shure Inc. It has high fidelity microphone, which is enough to capture a good sound quality for a prototype of a kiosk.

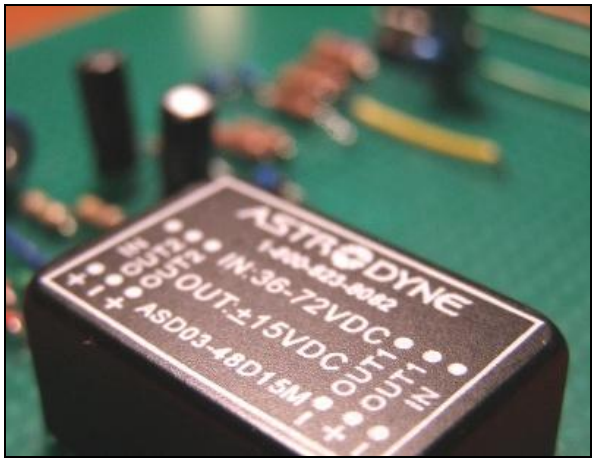
- IPRO 344 concentrates on implementing a preamplifier to amplify the signals which captured by the Shure microphone. The picture below shows the schematic design of the preamplifier.



<Preamplifier Schematic>

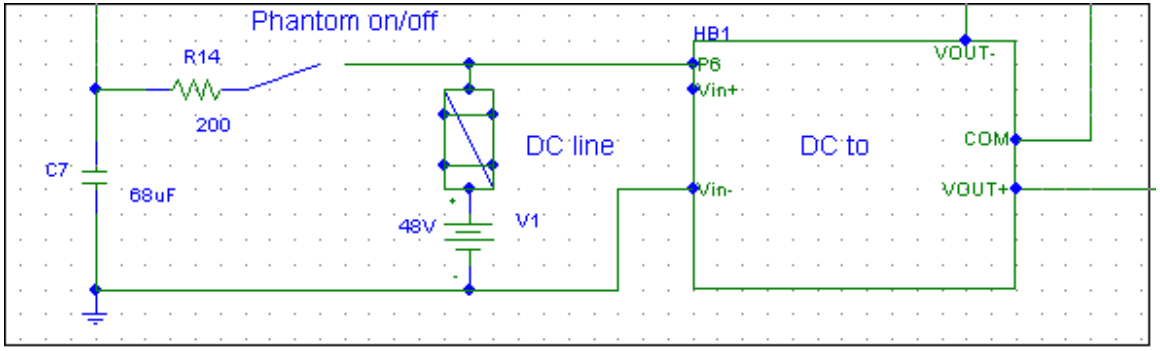
- The preamplifier consists of three major sections; Power supply management, Operational amplifier configuration, and Preamplifier input protection
    - Power supply management

        The 48V DC source seen is provided by the Astrodyne ASL40-48 Open Frame Power Supply. The 48V is supplied through a 315mA line fuse to the DC to DC converter.



<Astrodyne ASD03-48D15H) DC-DC converter>

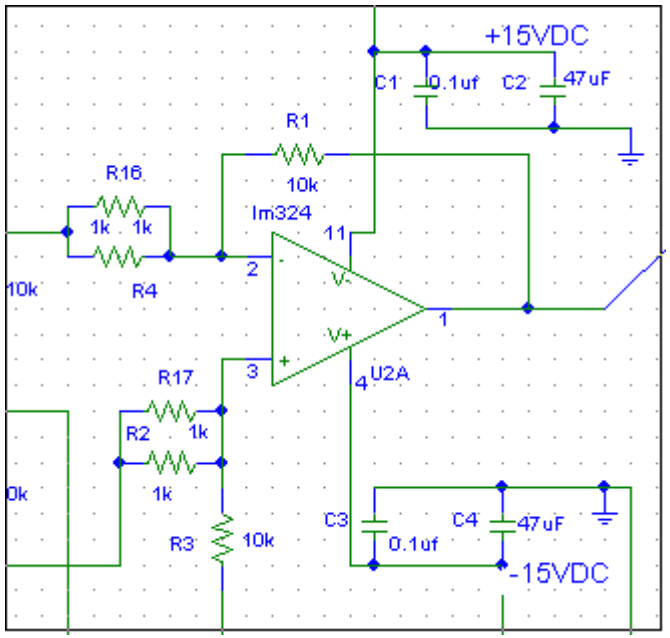
The 48V supply ground and the DC to DC converter COM terminal are both connected to chassis ground. The 48V is also delivered to the phantom power section of the circuit. The phantom power circuit is isolated from the DC to DC converter by a single pole single throw switch. This feature is to provide compatibility with other microphones which do not require phantom power. The C7 and R14 pair forms a low pass filter with a cutoff frequency of 11.7 Hz. The filter was designed to reduce the effect of any 60Hz ripple remaining in the DC 48V.



<Power supply management section of preamp>

- Operational amplifier configuration

  The LM833 was chosen for its low-noise and large bandwidth performance characteristics. In order to achieve good common mode rejection, R1, R2, R3, R4, R16, and R17 are all 0.1% tolerance metal film resistors. The op-amp and resistor configuration produces 26dB of voltage gain. C2 and C4 are 47uF electrolytic capacitors for low frequency power supply filtration, while C1 and C3 are 0.1uF ceramic capacitors for high frequency power supply filtration. Together, the set of power rail capacitors provide an AC ground for the op amp.

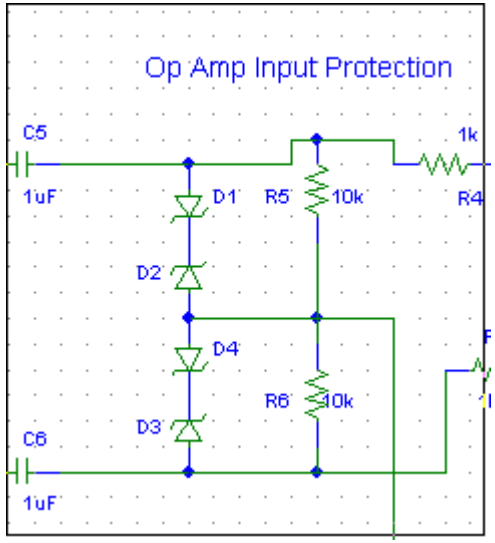


<Differential amplifier configuration>

- Preamplifier input protection

  The op amp input protection seen in figure 5 serves to separate the circuit from the DC 48V phantom power and any associated transients as well as any possible overloading input signals. C5 and C6 serve to block DC and thus prevent the phantom power from affecting the op amp. D1 through D4 are 6.8V Zener diodes. They provide a

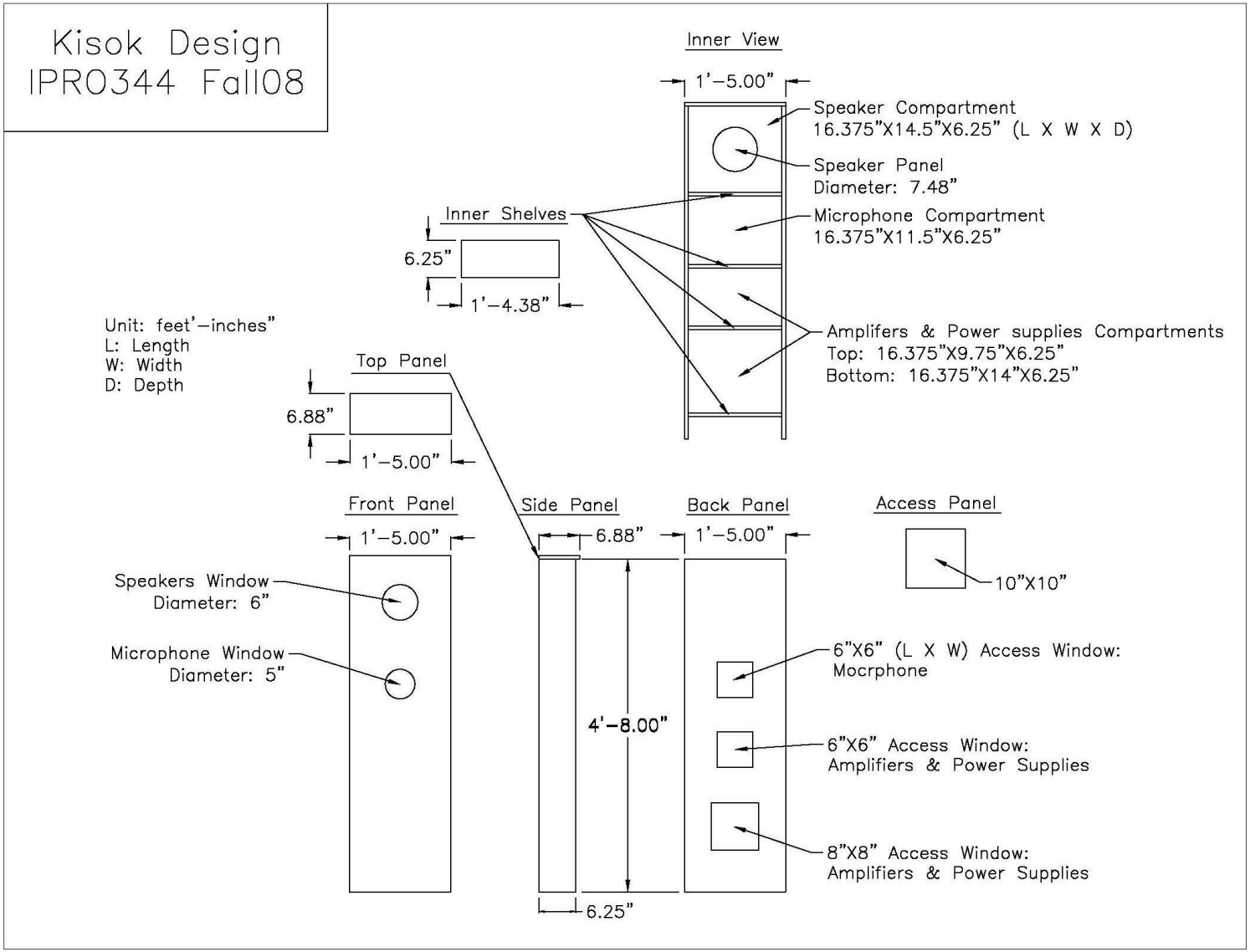
ceiling of +/-6.8V for each op amp input terminal. R5 and R6 serve to provide high input impedance and dominate over the output impedance of connected microphones.



<Op amp input protection>

- In the beginning of the semester, IPRO 344 decided to build a prototype of the drive trough kiosk to simulate and to experience an actual drive-through facility. To establish our goals, team determined to use same dimensions of the most abundant existing kiosk design which is easier to construct compared to the others. Team chooses to use wood because it was easy to cut and construct the kiosk. As for the design of the kiosk, team builds two separate chambers for speaker and microphone. The team used sound deadening material in the two chambers to prevent sound distortion and improve the sound quality. Also making additional shelves for electronic components. The following diagram is the blue print of the IPRO344 kiosk design.

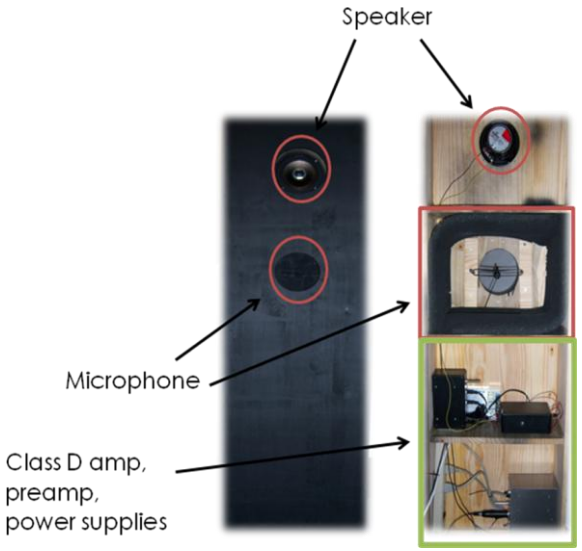
Kisok Design
IPRO344 Fall08



Building the kiosk itself is very tricky, because team should be extremely accurate and precise in cutting the wood panels into desired pieces. After team got the parts and tools, start engaging the building process. With the proper position of the speaker and microphone determined by the team, we are able to mount the Polk speaker and microphone inside the kiosk.

The next step is to organize the entire electronic components such as the preamplifier, power supplies and the class D amplifier inside the kiosk to prepare for preliminary testing. During testing the team realized that all components must be accessible for future modifications. With great thoughts and suggestions, the team settled on using access panels.

To finalize the kiosk, team beautified the exterior of kiosk by using black spray paints. The painting itself took several days to complete. We have to apply several layers and each layer take about 24-hours to dry. With the effort and perseverance, the team had successful finish the kiosk.

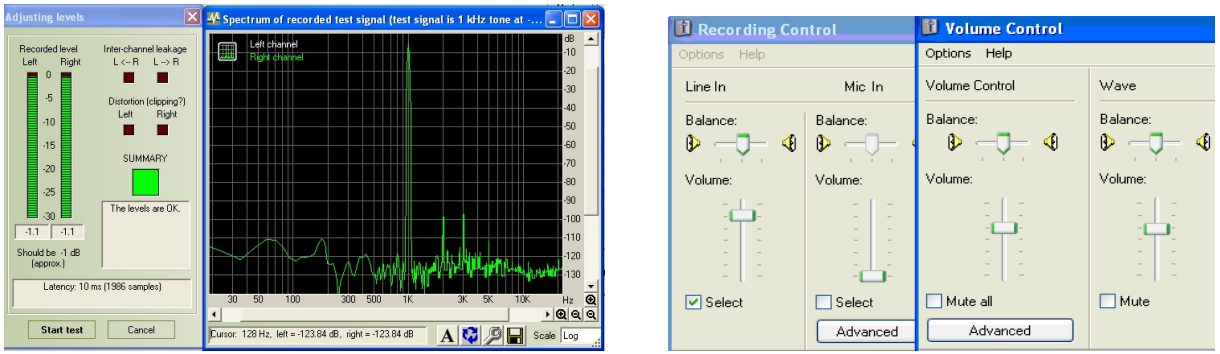


- In the first half of the semester, IPRO 344 focused on looking for professional software based tools to test the sound quality of our audio system. Several test software are conducted such as Multi-Instrument 3.0, Acoustic Analyzing System 5E and RightMark Audio Analyzer 6.1.2. For detail test report please see the files “Mid-term Report” and “RMAA” in Tool and Media sub-team folder. A table for the functions of each tool can be summarized in the following table:

Tools	Functions and Advantages	Disadvantages	Cost
Multi- Instrument 3.0	real time oscilloscope and real time spectrum analyzer with parameter measurement: THD, THD+N, SINAD, SNR, Noise Level Useful tutorial which provide us a lots of background in acoustics measurement	Limited of function No text file export function (need to purchase)	30 days Free trial
Acoustic Analyzing System 5E	Real time FFT analyzer including Power Spectrum, Octave band and etc. Convenient text and image export functions	Much detail setting, hard to manipulate	30 days Free trial
RightMark Audio Analyzer 6.1.2	Professional test for sound card And MP3 player with parameter as frequency response, noise level and THD	The adjusting is Hard to handle. Only available for Electronic noise	Free

Therefore, when we need to test the electronic noise produce by our amplifier system, we can use RightMark Audio Analyzer 6.1.2. When we need to measure the SNR outside the circuit part, Acoustic Analyzing System 5E can help.

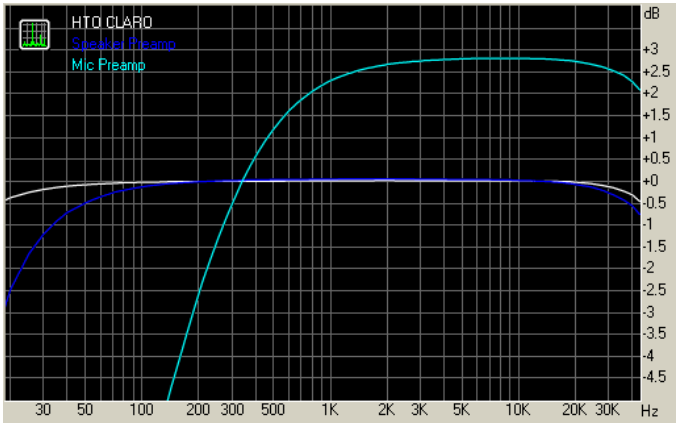
For the electronic circuit evaluation, the both the preamps designed by Spring 08 team (the preamp for speaker) and current team (the preamp for microphone) are tested by RMAA software and CTO CLARO soundcard. The test method and tutorial for RMAA has been already posted in Tools and Media sub-team folder. A useful article regarding RMAA Testing of Audio IC Op Amps written by Dr. Michel I. Gallant can be found at the following link: http://www.jensign.com/RMAA/RMAAOpAmpTests.html.



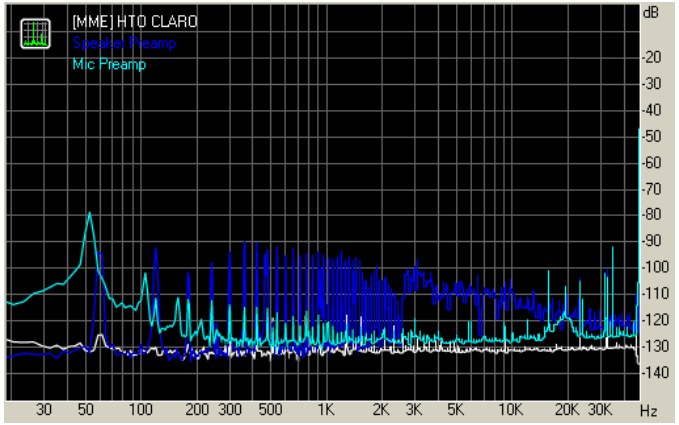
< RMAA level adjustment and value setting>

The basic Testing Method is: Line Out --> Preamp-Under-Test --> Attenuator--> Line In. RMAA was run in mono-mode using a 24 bit/96 kHz sampling rate in the loop-back configuration. For the op-amp tests, the output of Preamp was connected to an attenuator box with the settings -26 dB attenuation for the 26 dB gain amp. The attenuator output was connected to Line In of the CTO CLARO card. The result is shown in the following table.

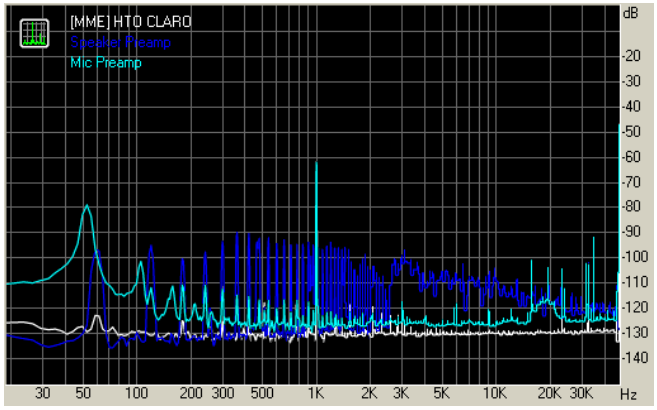
Test	[MME] HTO CLARO	Head-Set Preamp	Mic Preamp
Frequency response (from 40 Hz to 15 kHz), dB:	+0.01, -0.12	+0.05, -0.72	+2.81, -14.80
Noise level, dB (A):	-98.5	-94.1	-85.1
Dynamic range, dB (A):	98.6	93.9	85.2
THD, %:	0.0034	0.0043	0.0041
IMD + Noise, %:	0.0073	0.078	0.030
Stereo crosstalk, dB:	-51.0	-43.4	-49.4



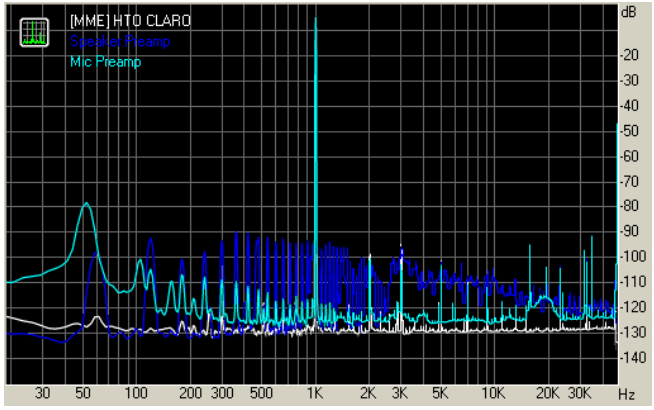
<Frequency Response>



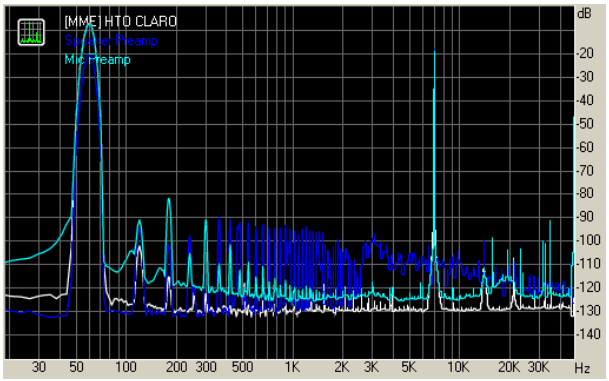
<Noise Level>



<Dynamic Range>



<THD + Noise (at -3 dB FS)>



< Intermodulation distortion>

From the table and plots above, we can see the lower cutoff frequency for mic-preamp is higher that of the speaker-preamp, at approximately 100 Hz which matches the PSpice simulation. However, in the real world performance the mic-preamp has better sound quality than speaker-preamp. In the other parameters, noise level, Total Harmonic Distortion and Intermodulation distortion, the mic-preamp all has better results, especially for IMD + Noise which is a very important Stanford for audio quality.

8. Obstacles

While working on the kiosk, the team didn't realize that all installed components must be accessible to maintain sound adjustments. In order to solve this problem, kiosk team decided to use access panels because the cost of access panels is low and it is easy to install them on the back panel of the kiosk.

In addition, team recognized that there is not enough shelf space for components. To attack the problem, team added one more shelf to the interior of the kiosk. Also, small adjustment were made to the internal components. We consolidated the power supplies and transferred the existing preamplifier to a smaller enclosure.

Midway through the semester, a crucial shipment was holding up the microphone preamp construction. Although the items were ordered at the beginning of the semester, it was discovered the supplier ships from Thailand and often takes 3 months to deliver. A new order was placed with different supplier and expedited. Luckily, the new order arrived on time for completing the project.

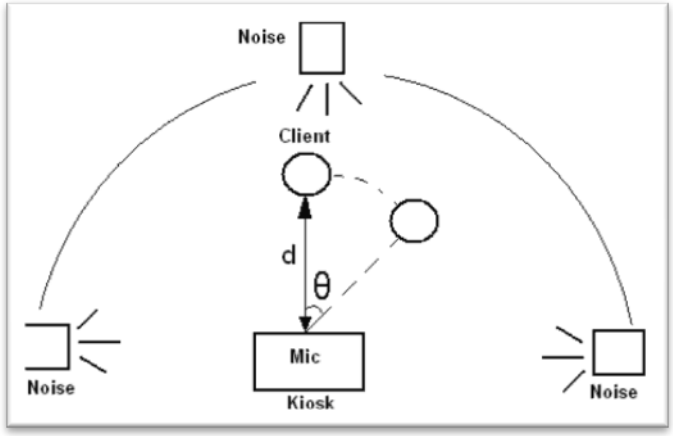
Late in the semester, IPRO344 team experienced some equipment malfunctions. IRPO344 team members were able to diagnose the issues closely along with the help and explanation from the instructor. All of the malfunctions were the result of improper levels and connections during testing. Signal levels much greater than the expected 40mVpp microphone signals caused the DC fuse to blow in the microphone preamplifier power supply. The headset microphone was accidentally plugged into the output of computer sound card; inflicting damage to the headset microphone. One of the two channels in the class D amplifier was destroyed by connecting the negative terminal to a DC ground through the Oscilloscope. To solve these issues, the team isolated troubled components with meters and oscilloscope, recreated the scenarios that caused the breakdowns, analytically determined the reasons for breakdown, and replaced and fixed components as necessary.

One of the major barriers that current IPRO344 encountered was finding solutions to solving the low-frequency "popping" sound generated from the speaker of the kiosk. The team members did manage to solve this problem by putting two separate class D amplifiers for each direction of communication. Although it is suspected that the noises were caused by some internal crosstalk, the causes of such problem were still undefined, and it is up to the next IPRO344 team to unravel.

9. Recommendation

In order to achieve the overall goal of the IPRO344, this semester's IPRO344 constructed a 3-phase plan and completed phase 1. IPRO344 team recommends that phase 2 and 3 will be executed in at least a semester for each phase.

- Phase I: Construction Phase – in this phase, IPRO344 constructed a kiosk and a pre-amplifier to implement a 2-way communication system along with available Class D amplifier and high fidelity microphone provided by Shure Inc.
- Phase II: Testing Phase – in this phase, next IPRO344 would simulate communication constraints, such as surrounding noise and various positions of the clients ordering to the kiosk, which is illustrated on the figure on the right. Also, the team would compare various microphone response patterns and analyze the quality of the communication. In addition, the team should determine the best location for the microphone and the speaker placement. Furthermore, the team will have more opportunity to collaborate with IRPO



343 to accomplish these objectives.

- Phase III: Refinement Phase – this phase is the final phase of IPRO344. The team will utilize the test results and findings from Phase II to improve components such as automatic gain control and noise cancellation, develop metrics for an acceptable drive-thru facility, and create low-cost solutions for immediate implementation.

10. References

Sergio Sánchez Moreno “Class D Amplifiers: Theory and Design” ColdAmp © June 2005 http://sound.westhost.com/articles/pwm.htm#2

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Andrew, Rachel & Schafer, Dan. *HTML Utopia: Designing Without Tables Using CSS*, Sitepoint Publishing© 2003

Guide of how to use RMAA: http://igroups.iit.edu/download.php?id=45169

Test and conclusion of the tested software tools: http://igroups.iit.edu/download.php?id=45299

RMAA Testing of Audio IC Op Amps: http://www.jensign.com/RMAA/RMAAOpAmpTests.html

RMAA official website with download link: http://audio.rightmark.org/index_new.shtml

Acoustic Analyzing System 5E: http://www.ymec.com/hp/signal2/thd.htm

Multi- Instrument 3.0: http://www.fivesign.com/downloads/program/MultiInstrument-Lite_1599_1_download.html

11. Acknowledgements

Dr. Thomas Wong’s, professor in the ECE Department, input was essential to the success of IPRO 344. His expertise in amplifiers and low-power mobile audio applications helped the team significantly. Tao Shen, T.A. in the ECE Department, helped in lab and testing of evaluation boards