



I^{PRO} 344

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



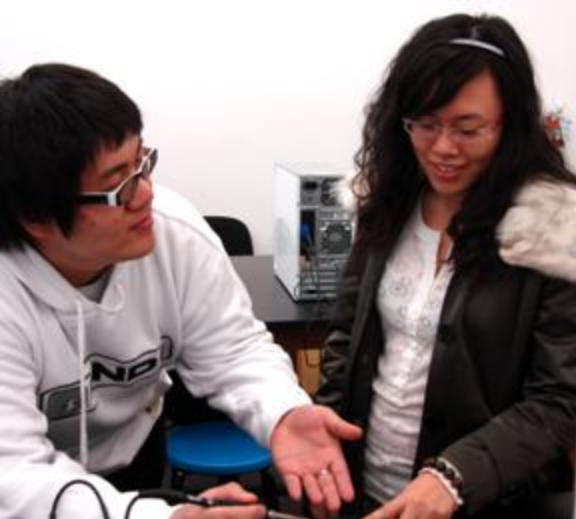
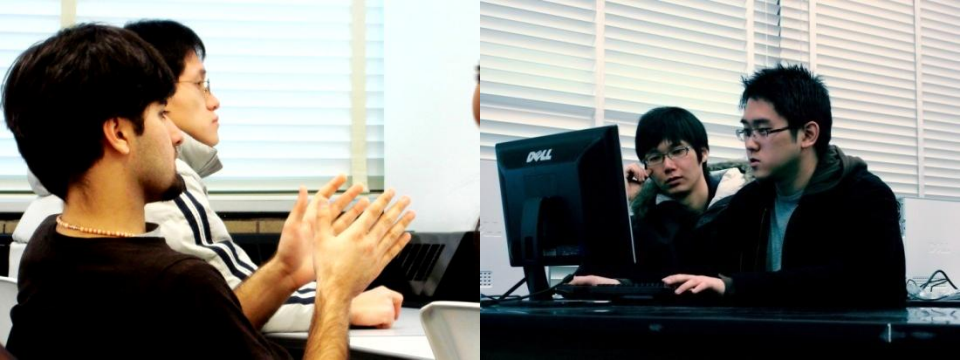
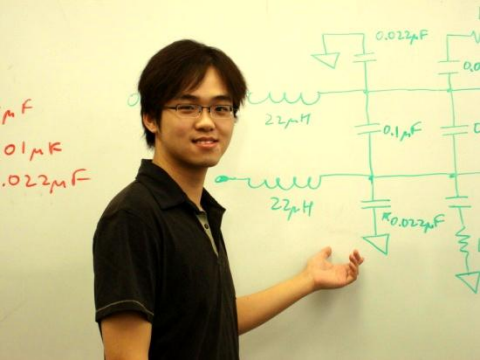
ILLINOIS INSTITUTE OF TECHNOLOGY

Objectives

- Study commercially available audio amplifiers
 - Efficiency
 - Audio Quality
- Things to focus on to improve efficiency in amplifiers
 - Voltage Regulation
 - Pre-amplifier Design
- McDonald's Drive Thru Audio System
 - Research (Field Trips, Schematics)
 - Feedback (Microphones, Class D Speaker Design)

A blurred black and white photograph of a meeting room. Several people are seated around a table, facing away from the camera towards a large screen at the front of the room. The image is out of focus, showing the silhouettes of the participants and the bright area of the screen.

Team Introduction



Sub Teams

Research Team

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Presentation

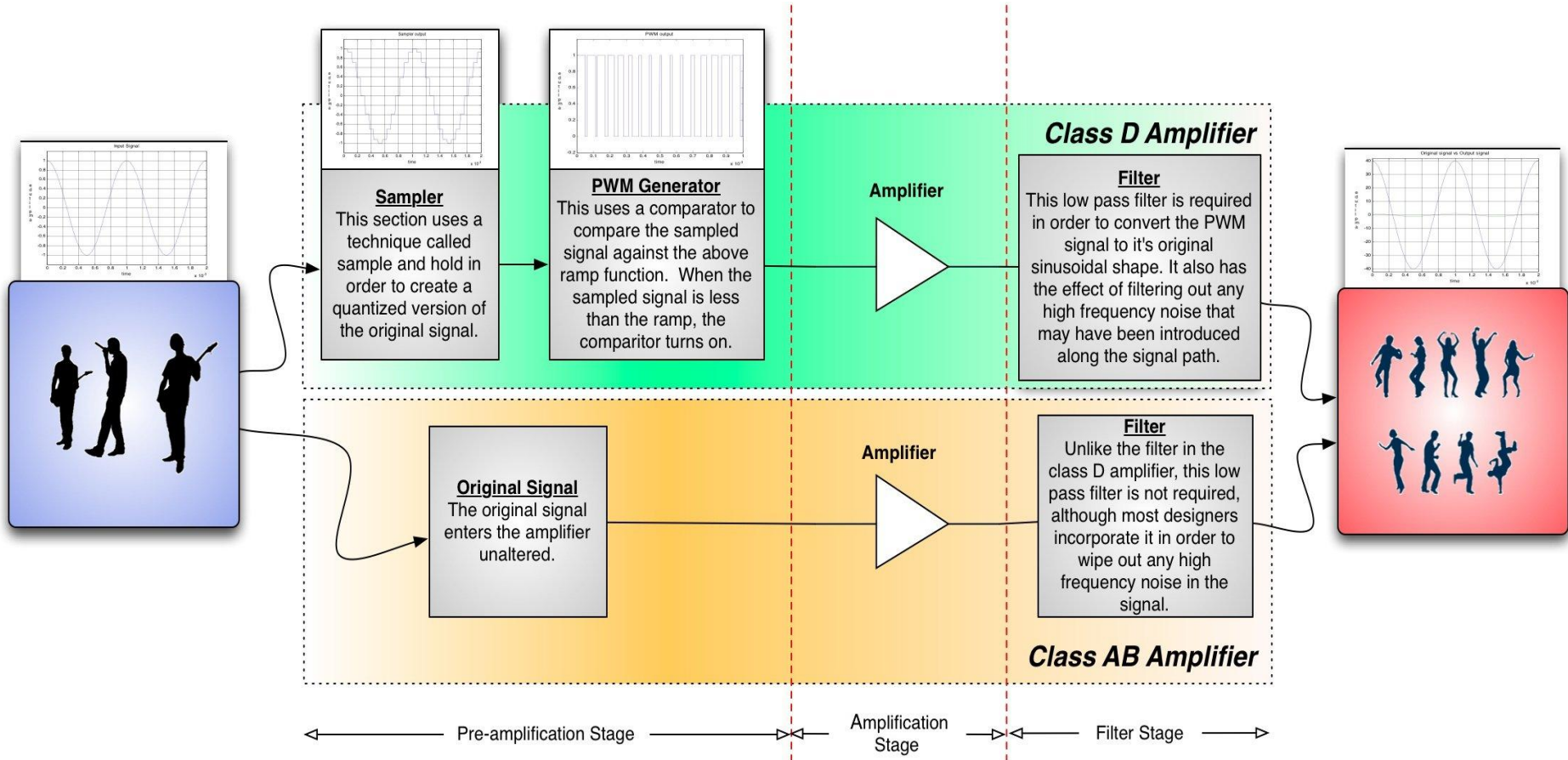
C. Song, G. Wakhlu, N. Terry



“Why worry about energy efficiency?”

- Apple reports cumulative sales of over **110 Million iPods**.
- Over **2 Billion Cell Phone** subscribers worldwide.
- US Households consumed over **1600 GWh per year** with portable rechargeable devices.
- ‘Vampire’ electronic behavior on the rise I.e. leaving electronic equipment powered up long after its usage.

Components of an Audio System



Advantage of Class D Amplifier

Traditional Amplifiers

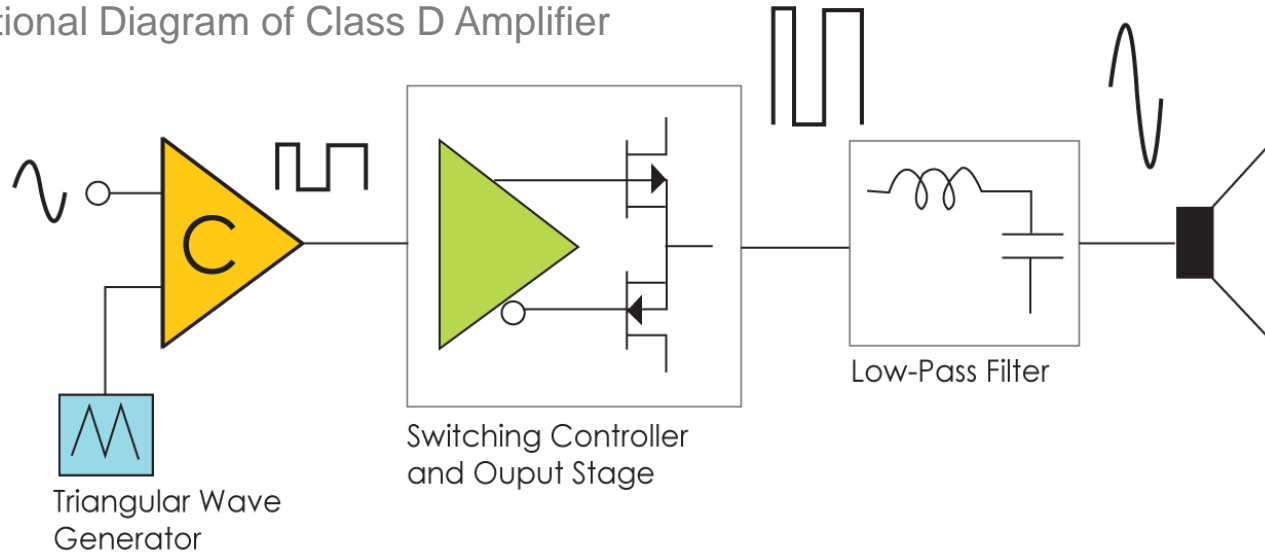
- Since the traditional amplifiers have output devices that conduct even when “off.”
- This dissipates power, which means there is zero percent efficiency during this time.
- Class A/B has efficiencies of 25% to 50%.



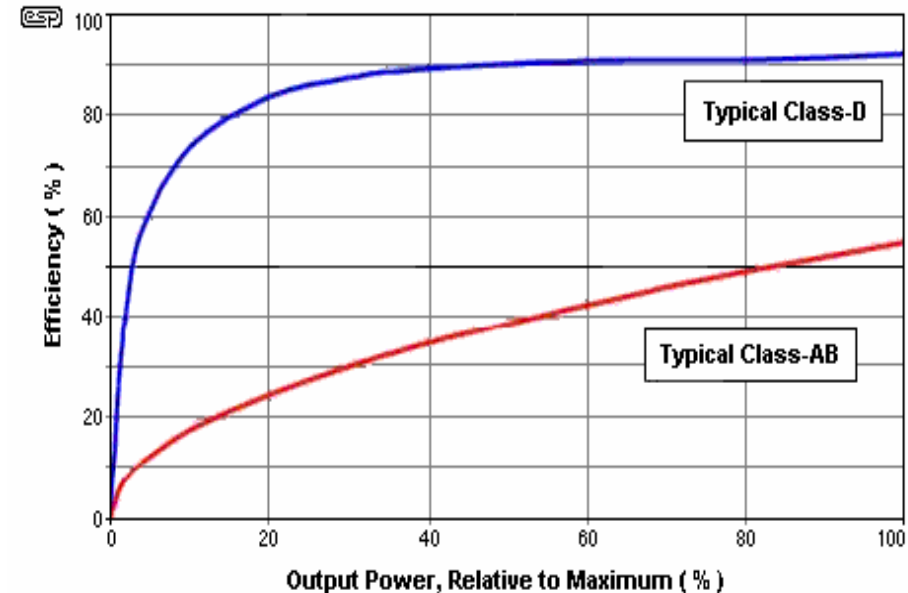
Class D Amplifiers

- Class D amplifiers operate in switching fashion.
- Power dissipation is theoretically zero. In the “off” state, current through the device is zero.
- **Less** power from the power supply, and this requires **smaller** heat sink.
- **High** power levels and **small** design.
- Efficiencies up to **97%**.

Functional Diagram of Class D Amplifier



- Reduction in size and weight of the amplifier
- Reduced power waste as heat dissipation
- Reduction in cost due to smaller heat sink and compact circuitry
- Very high power conversion efficiency, usually $\geq 90\%$.



A black and white photograph of a cluttered desk. In the background, a large computer monitor is tilted back. In the foreground, there is a keyboard, a mouse, and various electronic components, including a soldering iron, a soldering station, and several small electronic parts. A red rectangular box is overlaid on the bottom right of the image, containing the text "Semester's Achievements".

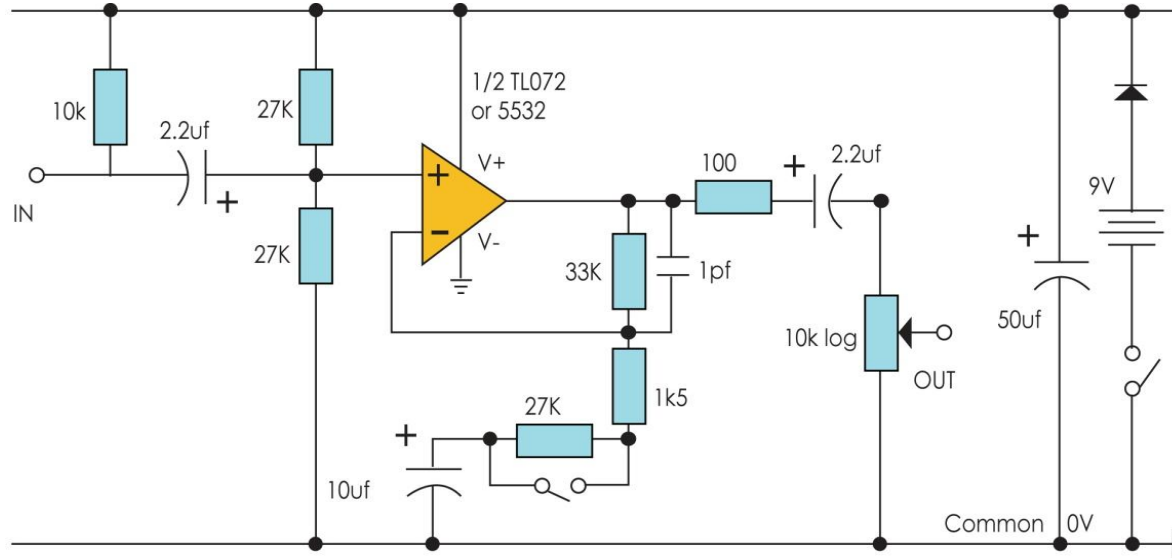
Semester's Achievements

The Components Used/Built - Microphone

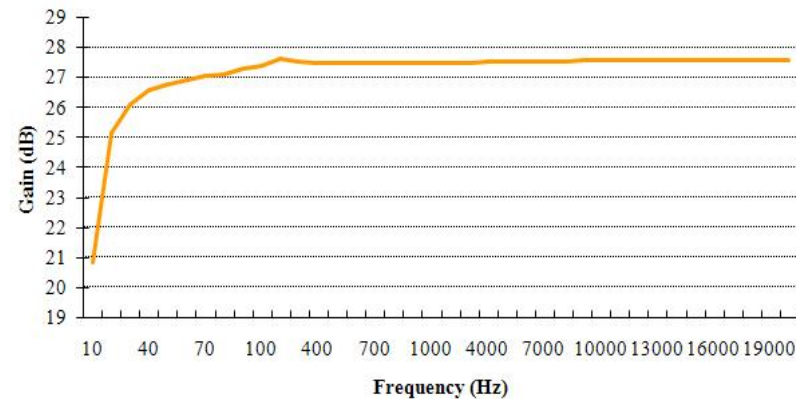
- After careful consideration, we prefer **Shure WL183** Microphone
- Omnidirectional (pick up angle is **360 degrees**)
- Low pick up noise
- Perfect for Drive Thru system where the position of the microphone is rendered unimportant.



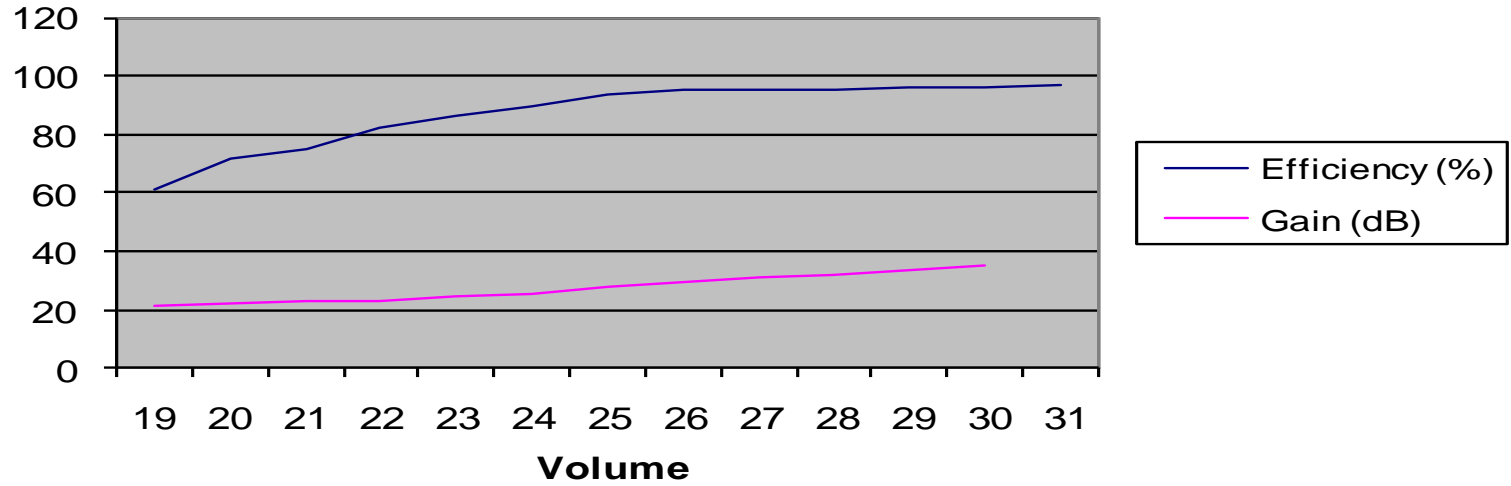
The Components We Used/Built - PreAmplifier



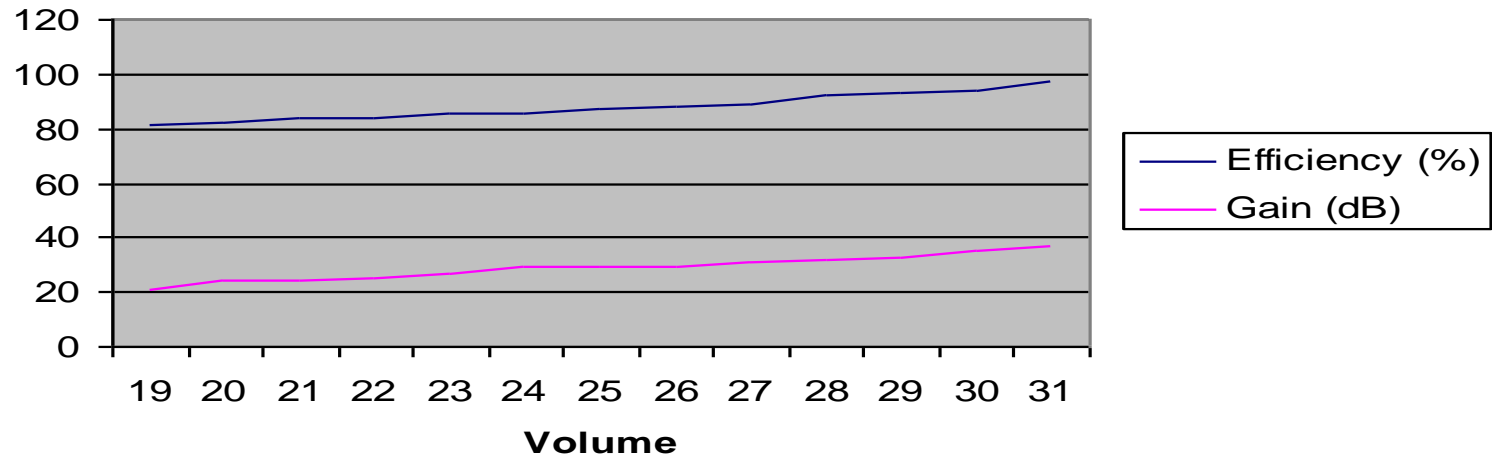
- Used to amplify weak input electrical signals
- Active device
- Provide relatively significant voltage gain of ~ 27dB (23mv)
- Quality of sound retained; volume increased



Efficiency and Gain when R Load = 8 Ohms

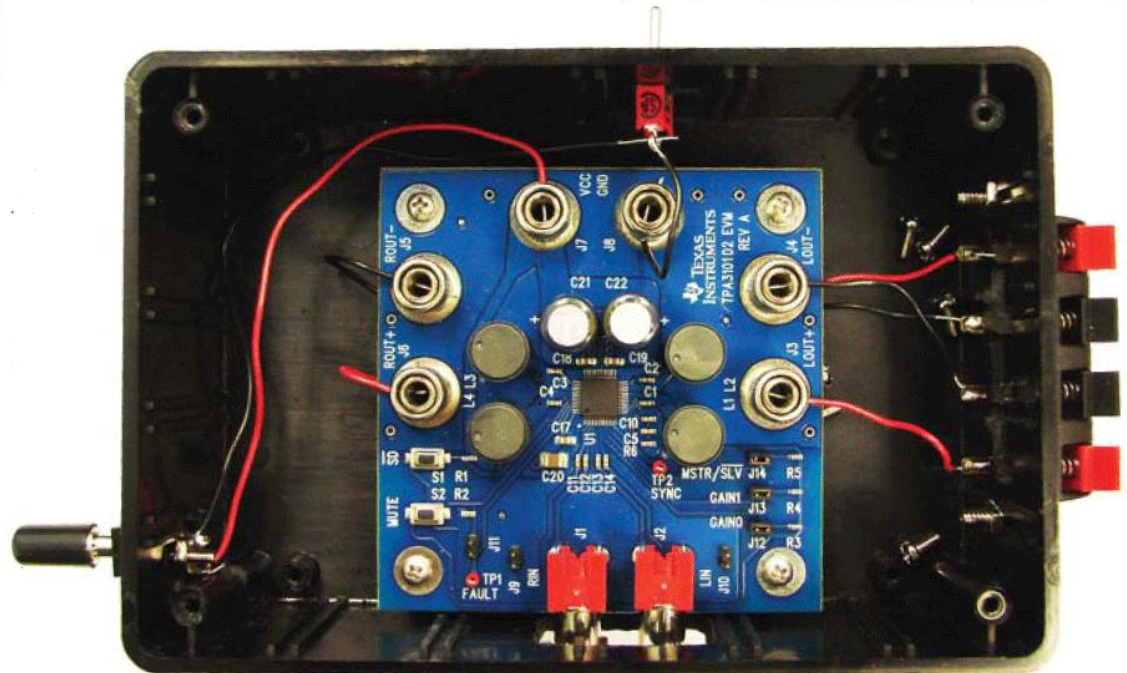
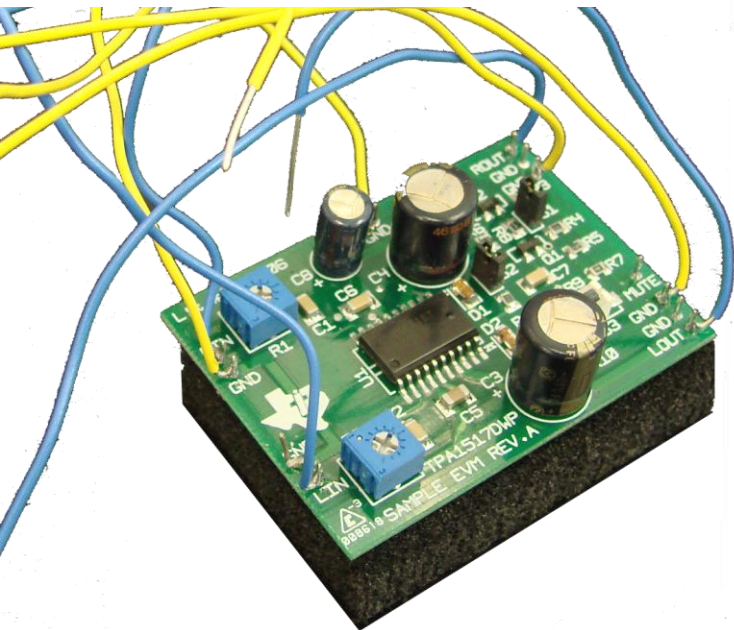


Efficiency and Gain when R Load = 4 Ohms



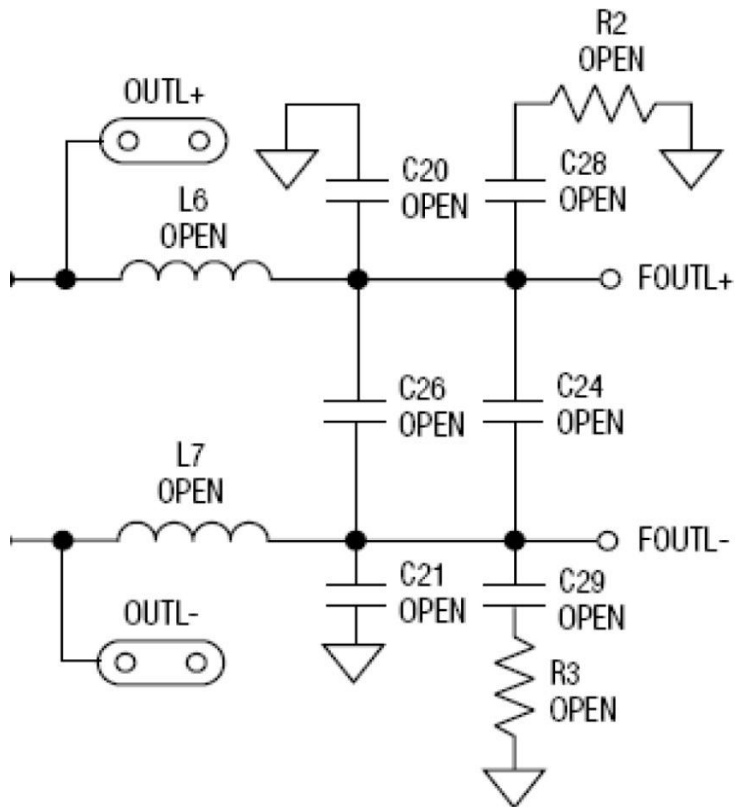
The Components We Used/Built - Amplifiers

- Amplifiers increase the loudness of the sound
The gain of an amplifier is measured by $G(\text{dB})=10 \log(P_{out}/P_{in})$
- Efficiency is the amount of input power that is useful to the power output.
- In more efficient amplifiers there is less loss of energy so in turn less heat
- Noise is also increased (linearly) with amplification, so more gain means more noise

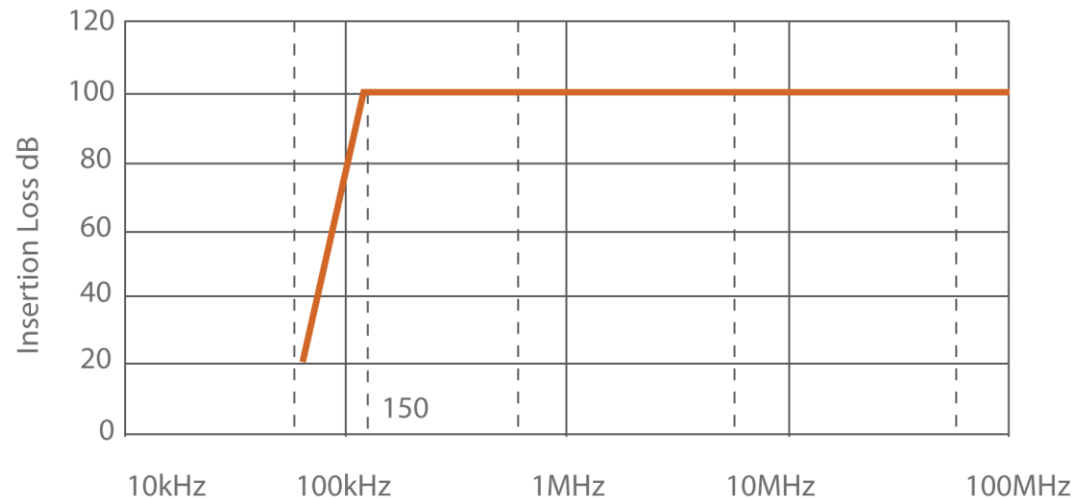


The Components We Used/Built - Filter

- A filter 'allows' sound at certain frequency to pass while restricting others.
- This restricts noise that is usually found at certain frequencies
- It also modulates the sound attenuating frequencies that might have had a large signal level.



- Insertion Loss is defined as the ratio between the signal level entering the filter to the signal level leaving the filter



Accomplishments

- Procurement of essential amplifiers and circuitry
- Building Pre-Amp
- Building filter for amplifier
- Touring SHURE Labs to select appropriate microphone
- Modular design for components
 - Protected circuits
 - Interchangeable
- Code of Ethics established
 - Focusing in efficiency with low price for the community
 - Reporting all transactions
 - Putting Safety first at all times
 - Working with respect of others and putting effort



Future Opportunities

- Dynamic power source
- Speech recognition
- Filter/Preamplifier Optimization
- McDonald's as possible sponsor
 - Improving Drive-Thru Experience
 - Increasing order efficiency



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Thank You