Sound Isolation System

UTDesign II: Fall 2016
Mentor: Professor Marco Tacca

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Background
Audio media sources are as common and numerous today as cars on a city highway, however we don’t always want to hear our neighbor’s audio playback, nor do we always want to share our own content that comes in audio form. This project is focused on the creation of a system that can control or confine an audio signal within a desired output area, extending the concept of noise cancellation to remove sounds outside set audible ranges.

Problem
Noise-cancelling headphones are not a practical solution for multi-user audio experiences.
In venues where interaction among attendees is crucial, a solution is needed for an acceptable and effective containment of audio sources; isolating the sound media output to only the intended audience.

Objectives
- Quality: User enjoyment of audio content within the listening area
- Effectiveness: A significant perception of reduced volume outside the listening area
- Ease of Implementation: Setup should be of equal or less difficulty as compared to any other consumer audio system

System Overview
- The system functions by distributed real-time control that detects incoming sounds at one or more points and generates the corresponding sound cancellation signal.
- Initial system design concentrates on the cancellation of a unidirectional sound source at a user-specified distance for demonstration of the effectiveness of this sound cancellation method.

Hardware Design
- Design is based on a high-fidelity audio amplifier circuit using Texas Instruments’ LM6172 and LME49710 audio amplifiers, which were selected for their ultra-low distortion and low noise, as well as their ample gain-bandwidth products.
- For enhanced stability over the feedback loop a pair of diodes reduce op-amp output swing when the corresponding transistor switches off.
- A pair of BJTs are used in the class B portion of the amplifier circuit to provide the current necessary to drive the speakers used for sound cancellation.

Conclusion
The level of sound cancellation from the one-dimensional sound cancellation system is consistent with what can be achieved with standard noise cancelling headphones, but more importantly shows that sound cancellation is possible over slightly longer distances. The MATLAB models also show how proper combination of phase offsets is crucial to enable the realization of two-dimensional systems, and may even suggest the possibility of systems operating in physical 3D space.

Results

Sound Environment for Testing
- For enhanced visibility and measurability of the system operation, a sound duct was constructed to simulate a one-dimensional vector.
- Using one speaker to act as the originating audio signal, a second speaker was placed mid-way across the length of the duct to act as the sound cancellation speaker
- To test the degree of sound cancellation, an additional microphone was placed at the end of the duct for comparison to the signal detected by the first microphone

Simulations and Modeling using MATLAB
- At the point where sound cancellation is intended to occur, the sum of the phase differences must be 360°, or one full cycle.
- In one dimension this is easily implemented with the original sound as a reference to 0°, and the cancellation audio set to 180°.
- In two dimensions, the overlap from adjacent cancellation signals must be taken into account; as in the case three signals: the original sound is 0°, the first cancellation sound is offset 120°, and a second cancellation signal is 240°

Organization
Danniel Perez: Sound environment design and construction; Procurement
Andreu Chung: Circuit troubleshooting and repair; Research support
Ashwin Nadkarni: Background information research; Circuit design support
Michael Siep: Circuit design and final assembly; Mathematical modeling

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Ethics Statement: Overall system design is a collective work of the organization defined below. Circuit elements are based on team decisions for performance parameters in addition to well known general amplifier topologies. Use of MATLAB software was in full compliance with the university license terms and all MATLAB code is the original work of the team.