ECE 445: Project Proposal

Drum Volume Control

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For years, I have noticed that when a band plays in a small, enclosed environment (be it a church, bar, or some other small venue), the drummer has a tendency to overpower the rest of the band. Various attempts at drum volume control have been made using passive noise control techniques, but these do not allow for adjustable volume levels. It is our group's intention to utilize active noise control (noise control requiring external power) on a single drum to provide the user with the ability to adjust the drum's volume.

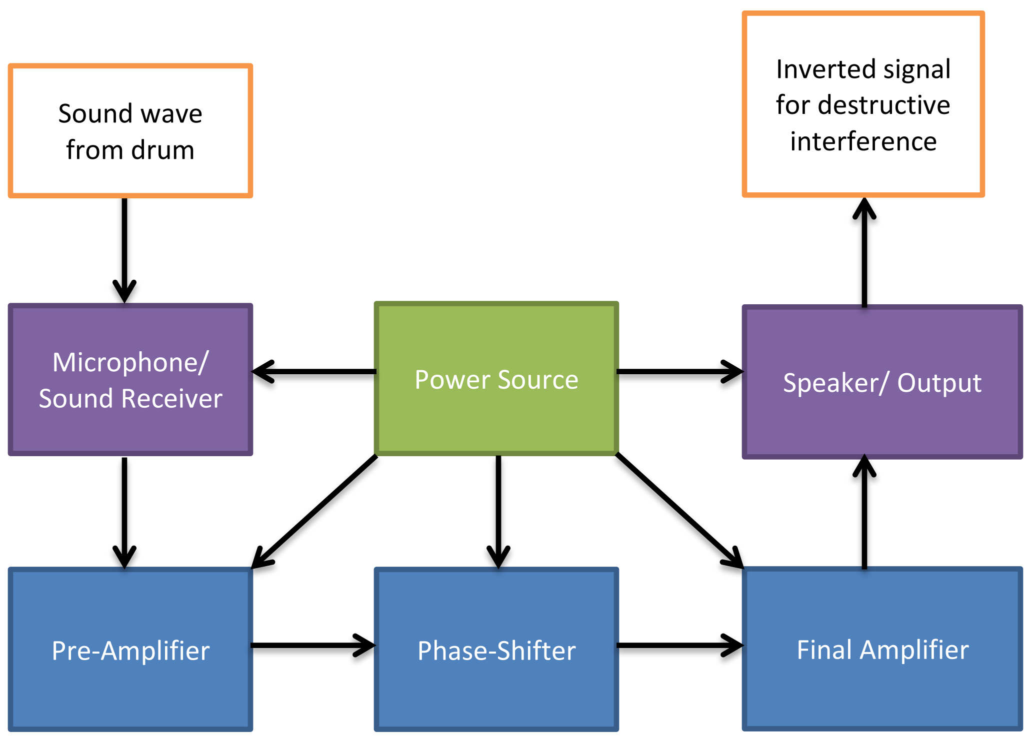
Benefits to End Customer:

- Able to attain a more balanced sound in small venues
- Volume control location conveniently placed (location of soundboard or otherwise)
- Adjustable volume -- can blend well depending on volume of rest of band

Product Features:

- Up to 6 dB attenuation of sound pressure amplitude at angles of 45º, 0º, and -45º with respect to direction drummer is facing
- Independent adjustable volume for left, right, and head-on directions

Block Diagram:



Block Descriptions:

Power: Power source for microphone, speaker, and all internal circuitry. This most likely will come from a standard wall outlet; internal circuitry will be built on a breadboard containing a voltage converter to satisfy the low-voltage requirements for op-amps and other analog circuit components.

Microphone/Sound Receiver: This is the first stage of circuit. Its purpose is to detect audio sound and frequency and convert that sound into an electrical signal to be manipulated by the rest of the circuit.

Pre-Amplifier: This will be our preliminary amplification module designed to amplify our sound signal, which will presumably be too small to effectively manipulate. The Pre-Amplifier will magnify the signal coming from the microphone to a much higher voltage level in order to process it effectively.

Phase-Shifter: This component will effectively shift frequency components of the incoming signal from the Pre-Amp by inverting the signal (inverting polarity and changing positive voltages to negative voltages and vice versa) in order to produce the sound-cancelling signal.

Final Amplifier: This component will adjust the amplitude of the signal voltage coming from the phase-shifter. This will be controlled externally (by means of a knob) to adjust the degree to which the sound from the drum will be attenuated. This signal will then be passed on to our sound-cancelling speaker to create destructive interference.

Speaker Output: Final phase in our design; this device will take the electric signal from the Final Amplifier, convert it to an acoustic signal, and send the respective sound waves in the opposite direction of the drum's original sound waves, causing constructive interference and cancelling the sound.

Performance Requirement:

Up to 6 dB sound pressure amplitude attenuation at a distance of 10 ft in directions at angles of 45º, 0º, and -45º with respect to axis perpendicular to plane of playing area (in other words, 6 dB of attenuation if the drum or drummer is looking at you straight on, or at angles of 45º in either direction).

Testing Procedures:

Our first task will be to build and verify the functionality of our phase-shifter. Once we build this device, we will test it by inputting a waveform produced by the function generator and measuring the input voltage alongside the output voltage. We will display both signals on an oscilloscope and verify its functionality by observing that the output waveform will be identical to the input waveform in all respects except that it will be reflected about the horizontal axis. We will make measurements of ten distinct points along the time axis and show that the voltage values will opposite on each graph.

Our next task will be to build our pre-amplifier and final amplifier. These components will be measured in similar ways; we will input a waveform from the function generator and display both the input and output on an oscilloscope. We will then verify, first by observation and then by displaying voltage values at ten distinct points along the time axis, the functionality of these components by showing the output values are amplified by whatever factor we choose when designing the circuit. These primary tests will be conducted with our variable resistance set to its maximum value; after the primary tests, we will adjust the variable resistance to verify that as we decrease the resistance, attenuation will decrease as well. In all future tests with the final amplifying circuitry, tests will be performed at first with the variable resistance set to its maximum value, followed by testing of the varying resistance to verify the decrease in attenuation.

After this, we will combine all three components and perform the same test; inputting a waveform from the function generator and verifying that the output is amplified and negated. Once again, we will display values at ten distinct points along the time axis to verify its functionality.

Our next task will be signal detection of a single frequency. We will generate a single frequency sine wave using a function generator and run it through a speaker, and we will place our primary microphone at some close proximity to the speaker. We expect the signal picked up by the microphone to be an extremely attenuated version of what the function generator is producing, so determining an optimal distance from the speaker will be challenging. Our best bet will probably be to toggle the distance of the microphone from 0-3 feet away from the speaker (with the microphone and speaker facing each other) and carefully observe the oscilloscope to determine when voltage readings are the highest. After we have determined this optimal distance, we will run the signal obtained from the microphone through our three-component circuit to test the phase-shifting and amplifying functionality once again (using identical methods from before; displaying input and output waveforms on the oscilloscope and measuring ten distinct values on the time axis. In this case we will run two separate tests; one using the signal from the microphone as the input to test the functionality of the circuit once again, and one using the function generator as the input to test the circuit and microphone simultaneously.)

Finally, once this has been sufficiently tested, we will add our final component to the circuit and run the amplified, phase-shifted signal through another speaker. This speaker will be placed directly in front of our initial speaker (facing the opposite direction), and we will then determine the optimal distance from the initial speaker it is to be placed. We will begin by placing it either directly behind or directly beside our microphone, and then adjusting the distance from there. Though I suspect the time delay for our signal to be processed to be negligible, obviously this is one factor we will not be sure of until testing. We will test the distance between the two speakers in two ways: first, we will conduct a hearing test. This will be rather crude, but after all, the point of this project is for the human ear to detect an audible difference in volume. We will stand directly in front of our initial speaker at a distance of 10 feet, then toggle the distance of our secondary speaker within ±1 foot of our microphone. This test will essentially consist of listening to the sound to determine where to place the speaker to get optimal attenuation.

Our second test, which will not be quite as crude, will be to place a secondary microphone at a distance of ten feet in front of our initial speaker and display its inherited signal on an oscilloscope. We will measure the signal detected by the microphone while just playing the sine wave through the speaker (without attempting to attenuate it at all), then take an additional measurement with the sound-cancellation. We will then toggle the location of our second speaker until we determine, by observing the graph on the oscilloscope, the location which will produce the most attenuation (6 dB of attenuation, to be specific). We will then repeat this experiment using additional microphone and speaker set-ups, placing the new microphones and speakers at angles of 45º to the right and left with respect to axis perpendicular to the face of the initial speaker. In this way, we will be able to test the attenuation in those directions as well as directly in front of the speaker. After testing each microphone/speaker set-up individually, we will test them all at the same time to verify that our speakers are not causing unwanted interference with each other.

We will then repeat this test for multiple frequencies. To ensure that we are testing our set-up for frequencies most similar to that of the drum we are going to test, we will use a microphone to detect the sound of our drum and, using the oscilloscope, view the Fourier Transform of that signal to determine what frequency components contain the most energy. Once we have determined this, we will conduct our previous test with those particular frequencies to gain a better understanding for how close our microphones and speakers should be placed with respect to the actual drum.

Our final test will consist of running all of our previous tests with the actual drum itself. This will require a way to consistently strike the drum with equal intensity. Our preliminary plan will be to build an apparatus consisting of a long tube hanging directly over the drumhead, through which we will drop an object (say, a bouncing ball) that, in this way, will conceivably replicate a drumhead strike with consistent intensity each time. This will be tested by way of a microphone and oscilloscope to verify that the signal produced by this falling object will be identical each time. Once we have verified that, we are free to conduct all previous tests on the drum; first testing with one microphone/speaker set-up with maximum variable resistance, then with varying resistance, then testing with multiple microphone/speaker set-ups facing in different directions (with varying resistance). At each step along the way, we will conduct our tests by inheriting a signal from a microphone placed ten feet from the source without sound cancellation, then inherit the same signal with sound cancellation and verify that at our maximum variable resistance we attain an attenuation factor of 6 dB (at -6 dB, the voltage will drop to approximately half of its original value.)

<u>Tolerance Analysis</u>:

For our circuit, the main point of concern lies within the final amplifier component, or more specifically, the variable resistor within this component. This amplifying circuitry (and thus, the variable resistor) needs to accomplish two tasks: first, to be able to provide enough power to the speaker for it to be able to cause 6 dB of attenuation at its maximum value; and second, to limit the power provided to the speaker so as to not damage the speaker itself. Since we do not as of yet know exactly what model speaker we are going to be using, we will estimate that providing the speaker with 80-90% of its maximum rated input power will be sufficient to account for 6 dB of sound attenuation, and at the same time will provide a large enough safety buffer to keep from harming the speaker. Unfortunately, however, we will not know what this means exactly in terms of resistor values until we obtain our speakers.

COST ANALYSIS

NON-STANDARD PARTS	UNIT COST ($)	QUANTITY	TOTAL COST ($)
SPEAKERS	7-15	6	42-90
MICROPHONES	5-10	3	15-30
PHASE-SHIFTER CKT		3	
Resistors	0.10	6	0.60
Op-amp	0.70	3	2.10
PRE-AMP CKT		3	
Resistors	0.10	9	0.90
Op-amp	0.70	3	2.10
AMPLIFIER CKT		3	
Resistors	0.10	9	0.90
Op-amp	0.70	3	2.10
LABOR			12,000.00
GRAND TOTAL			12,051.15 – 12,114,15

LABOR CALCULATION

The labor costs for the project are calculated according to the following formula:

($/hour) * (2.5) * (hours to complete) = (total labor cost)

We will estimate that each person will spend about 40 hours on the research, design, implementation and writing the final report. There are 3 people working on this project so we estimate that about 120 total hours will be spent on labor. We will further estimate our future salary to be $40 per hour. This brings the total cost for labor to about $12,000.

$40/hour * 2.5 * 120 = $12,000.00

Timetable:

Week of 2/8/2012	Turn in proposal for the project.
2/10/2012	Order all parts for circuitry. All group members must check the parts to be ordered are correct.
Week of 2/13/2012	Sign up for Design Review. Begin detailed theoretical construction of the circuitry. Victor Salov: design phase shifter. Udara Cabraal: design pre-amplifier. Aaron Gipp: design amplifier.
Week of 2/20/2012	Have a paper ready for design review. Individual progress reports. Talk with TA about the design as a group.
Week of 2/27/2012	Receive parts and begin soldering circuits. Victor Salov: solder phase-shifter. Udara Cabraal: solder pre-amp. Aaron Gipp: solder amplifier.
Week of 3/5/2012	Begin testing of pre-amplifier circuit, phase shifter, final amplifier.
Week of 3/12/2012	Turn in individual progress reports. Present slides and charts of each circuit and function. Each team-member is responsible for presenting their circuit in a slide and including a statistic of what has been measured during testing.
Week of 3/19/2012	Spring Break For those who are here, test circuit as a single component w/ function generator signal not as input into a speaker.
Week of 3/26/2012	Test with single frequency w/ function generator input into speaker, determine optimal location for mics/speakers, verify 6 dB attenuation in three directions.
Week of 4/2/2012	Build apparatus for striking drum, test circuit with drum, determine optimal locations for mics/speakers.
Week of 4/9/2012	Order PCB from machine shop. Each student is responsible for revision of their individual circuitry. Testing of speaker + circuit combination.
Week of 4/16/2012	Sign up for a demo time slot. Optimization of speaker location must be completed this week in order for drum volume control to be possible. Begin writing final report.
Week of 4/23/2012	Optimization of drum + speaker + circuit based on distances between drum and speaker. Complete final report and prepare presentations.
Week of 4/30/2012	Presentations must be completed. Victor Salov: Introduction/Objective/Review Original Design. Udara Cabraal: Describe project build and functional tests/ Discuss successes and challenges. Aaron Gipp: Other tests/ Recommendations . This week is Checkout Day.