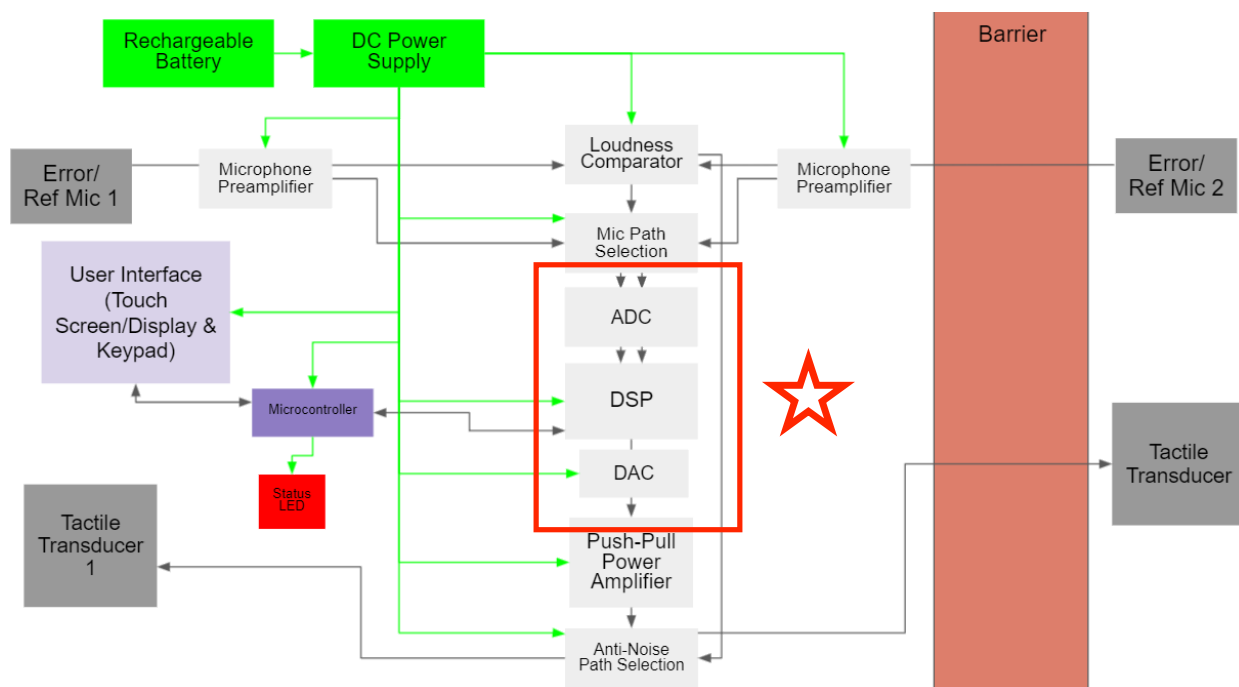


#1 Active Noise Control for Rigid Barriers

This project will seek to provide a solution for the reduction of noise transmission through rigid barriers such as household doors, drywall panels, and ceiling tiles. Utilizing the principles of Active Noise Control (ANC) the device will generate an anti-noise signal in order to counteract incoming noise as it is transmitted through the barrier. The device shall:

- Effectively attenuate transmission within a range of frequencies (20-500Hz)
- Maintain a safe operating temperature in extreme conditions
- Occupy a small footprint for easy installation on pre-existing barriers
- Be expandable via a modular platform
- Adapt to various noise sources and barrier types
- Withstand the abuse typically experienced by most barriers (Weather exposure and slamming)
- Maintain the privacy of its user

Block Diagram:



Block Diagram Specification: Development vs Purchasing:

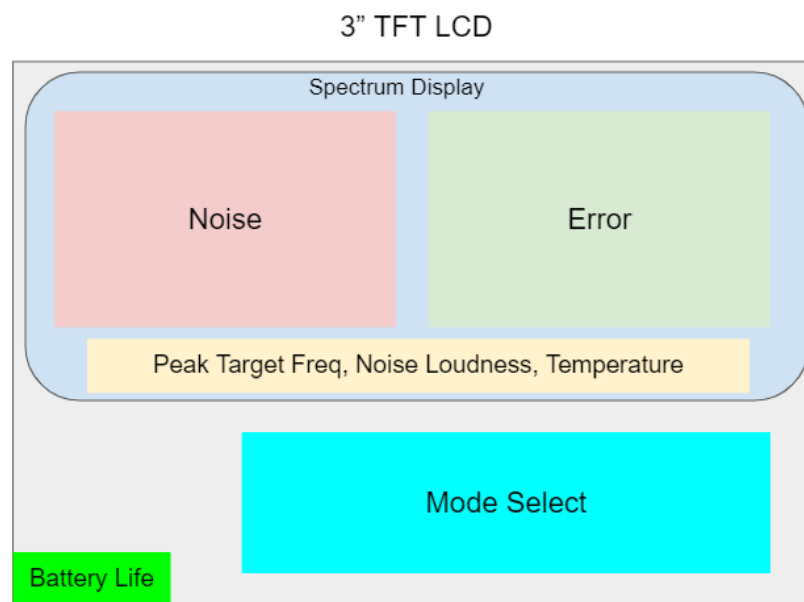
Item	Group Development	Work	Estimated Time to Complete
Rechargeable Battery	Battery should provide enough power for minimum 2Hrs of normal operation on a single charge	Purchase and test.	NA
DC Power Supply	Designed to supply correct power to all device subsystems. This will require generation and regulation of various voltages . Amplification modules will be designed to minimize the amount of different supply levels needed. The PS will also	Purchase components, Simulate, breadboard, troubleshoot, and final layout	4 weeks

	provide battery level voltage to the arduino for status indication.		
Barrier	Barrier types will be tested with both plane-wave duct and in real-world settings. ½" drywall and Hollow/Solid core doors	Purchase materials and construct	1 week
Reference Mics	Cardioid Electret Microphone will be positioned at a distance from the barrier surface to reduce the effects of Audio Codec/DSP Group Delay.	Purchase and test	Testing 1 day
Error Mics	Omnidirectional Electret Mic placed at the barrier to measure degree of error in noise/anti-noise summation	Purchase and test	Testing 1 day
Microphone Preamps	Design based on Texas Instruments (OPAx134) audio op amp. Preamp design will include a bandpass filter of mic input to target frequency range (50-150Hz) and adequate amplification for ADC interfacing without clipping.	Purchase components, Theoretical/Simulate, breadboard, troubleshoot, and final layout	5 weeks
Loudness Comparator	Designed to compare the loudness of reference microphones and set the loudest path as reference for the ANC algorithm. Although a hardware comparator (TI LMx93-N) is proposed, a better solution may be to implement path selection in DSP. This would require rearrangement of the Block diagram.	Hardware: Purchase components, Simulate, breadboard, troubleshoot, and final layout Software: Program and troubleshoot	4-5 weeks Together with path selection (pre-existing chips/package?)
Mic Path Selection	Analog Switching via CMOS IC switch. As stated above, DSP implementation may be a better option. TI TS12A4514 datasheet shows significant THD (up to 0.15%) is added. Excessive THD may compromise the quality of incoming signal.	Hardware: Simulate, breadboard, troubleshoot, and final layout Software: Program and troubleshoot	4-5 weeks
ADC/DAC (CS4271-CZZ Stereo Codec)	Although the DSP Evaluation board includes adc/dac conversion, the cs4271 is chosen for integration based on its superior latency performance.	Purchased Breadboard, troubleshoot, program, and final layout	4-6 weeks Together with DSP
DSP (ADAU1452 Evaluation Board)	Feed Forward ANC algorithm will generate an anti-noise signal based on a combination of the reference signal, estimated secondary path, and error signal. SigmaStudio is an object-based programming software that will allow for the implementation of FxLMS and necessary signal routing. Evaluation board will allow for easy calibration of the ANC algorithm	Purchased Program, testing, troubleshoot, calibration for final implementation	4-6 weeks
Microcontroller (Arduino Nano)	Programming using Arduino IDE software so that the LCD screen display's battery life, directional status of operation, and error/reference	Purchased Program and troubleshoot	6-8 weeks Together with DSP, Power supply/Battery, Touchscreen, Path selection



	frequency spectrum.		
LCD (3" TFT)	Connected to Arduino Nano which will be programmed for the functions explained above.	Purchased	Developed with Microcontroller
Push-Pull Power Amplifier	Discrete transistor design using push-pull (class AB architecture). This kind of amplifier can enhance both the load capacity, switching speed, and power consumption	Purchase components, Theory/Simulate, breadboard, troubleshoot, and final layout	5 weeks
Anti Noise Path selection	CMOS Analog switch circuit controlled by loudness comparator. Again, DSP control may be a better option	Hardware: Simulate, breadboard, troubleshoot, and final layout Software: Program and troubleshoot	4-5 weeks with loudness comparator and path selection
Tactile Transducers Dayton Audio TT25-16	Tactile Transducers will excite the barrier surface with anti-noise. 16 ohm	Purchase and test	1 day testing

Proposed Touch Screen Layout:



Concerns/Probable Complications:

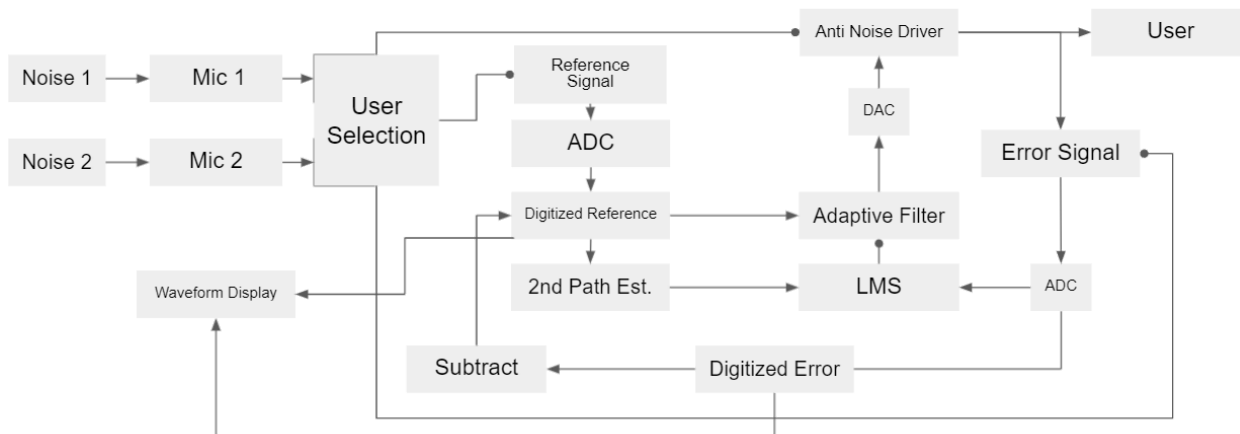
During our research into materials required for this project a few areas of probable complication came to our attention. They are listed below:

Concern	Proposed Solution
Throughput latency of the system may be compromised by the on-board audio codec included with the ADAU1452 EVAL kit. Excessive latency will diminish the effective attenuation the device can achieve.	Integration of Cirrus Logic CS4271-CZZ Stereo codec. This ADC/DAC device has far superior latency performance. Positioning the reference mic away from the barrier can also help compromise for system latency. This will effectively give the dsp

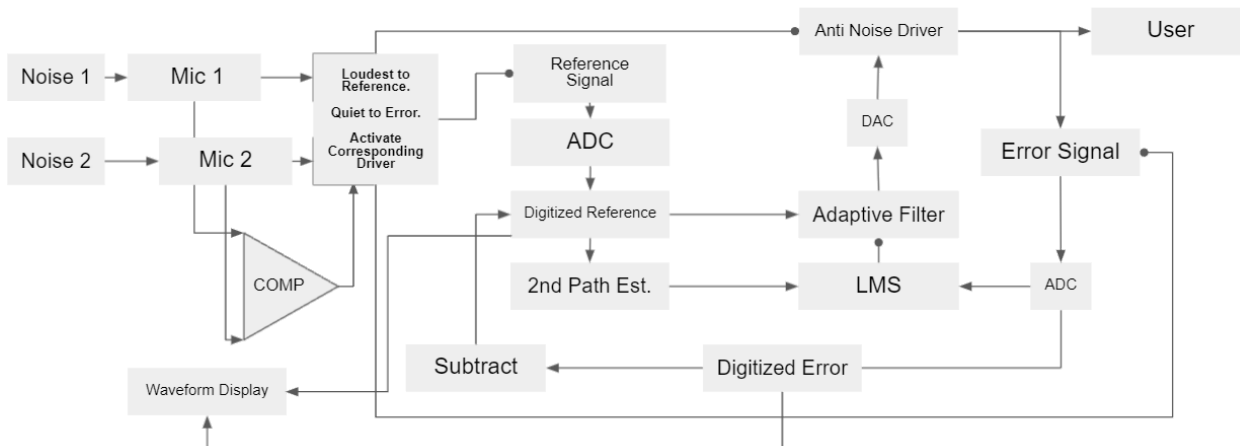
	more time to process incoming signals.
<p>System Latency requires positioning of the reference microphone at a suitable distance away from the barrier surface for group delay compensation.</p> <p>Reference mic will require directional polar pattern to minimise the effect of surface reflections on reference signal.</p> <p>This positioning/polar pattern is not optimal for error mic. Separate signal paths/preamp circuits will be needed for both reference and error. This effectively doubles the amount of necessary circuitry.</p>	<p>Elimination of bi-directional operation would allow for optimal device configuration without the addition of excessive circuitry.</p> <p>The design, construction, and implementation of the multi-power supply, microphone preamplifiers, filter circuitry, and power amplification will pose an adequate challenge to the combined electrical engineering abilities of our group.</p> <p>Elimination of the switching function of our design will allow for more focus on the core operation of the amplification, ANC signal processing, and user interface aspects of our design.</p>
<p>Although our research has shown the ADAU1452 to be the most appropriate DSP solution for our project. The price of an evaluation board is quite high and has brought the total project cost to high level</p>	<p>Lower cost 3rd party options of the ADAU1452 eval board do exist but are not supported by Analog Devices documentation. The risk of such a device malfunctioning is too high.</p> <p>The above mentioned elimination of the bi-directional operation will help to mitigate the cost of our project.</p>

Flow Chart:

User Selection Mode



Auto Detection Mode



Design Engineering Requirements (DER):

Level	Requirements "The Device Shall Include"	Verifications and Success Criteria Tests/Trials
High	<ol style="list-style-type: none"> 1. Successfully attenuate transmission of periodic noise signals (50 - 150 Hz) using Feed-Forward ANC. 2. Effective operation on both hollow/solid core doors and ½" Gypsum Board. 3. Switch directional operation based on loudness detection. 4. A safe external temperature (<50°C) maintained during operation. 5. Touchscreen display of battery life, directional status, and error/reference frequency spectrum. 	☐ Plane-Wave duct calibration of FF ANC algorithm. ☐ Plane-Wave duct/real world transmission attenuation tests on materials using sinusoidal and bandpassed gaussian signals (minimum 10 trials/material) ☐ Calibration of loudness detection circuit ☐ Measure system temperature at max output (>5 minutes) ☐ Subsystem status displayed to user
Mid	<ol style="list-style-type: none"> 1. Device throughput group delay <1ms 2. The device's construction shall allow for optimal coupling to different surfaces. 3. Touchscreen allows for user control/monitoring of the device without errors. 4. Analog amplification and filter circuitry operates with flat frequency response (±0.1dB from 20-150Hz) and minimal THD/Noise. 	☐ Select component configuration for lowest possible latency ☐ Construct device for secure attachment/reattachment ☐ Coding is successfully compiled ☐ Design and test all circuits for optimal frequency, noise, and THD performance
Low	<ol style="list-style-type: none"> 1. A rechargeable battery shall power the device for a minimum of 2 hrs 2. Analog circuitry provides appropriate signal conditioning/level for respective device stages. 3. Power supply maintains power within component tolerances 	☐ Determine components/design to minimize power consumption ☐ Determine optimal signal parameters for all device stages ☐ Measure PS Outputs

Estimated Cost of Materials:

Item	Unit Price	Number	Subtotal
16 ohm Tactile Transducer	\$17	3	\$51
ADAU1452 Evaluation Board	\$190	1	\$190
Arduino Nano	\$10	1	\$10
Rechargeable Battery	\$10	2	\$20
3" TFT LCD	\$27	1	\$27
Audio Op-Amp	\$7	4	\$28
Cardioid Electret Mic	\$1	4	\$4
Omnidirectional Electret Mic	\$1	4	\$4
CS4271-CZZ Stereo Codec	\$8.75	2	\$17.50