Dual-Use Wideband Microphone Array System

E1.01 Team Sonus

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Background

Our project is a proof-of-concept dual-use wideband microphone array system that relays voice communications and alerts users if ultrasonic anomalies (leaks, failing equipment, etc.) are detected. The system detects these voice communications and anomalies with MEMS (micro-electromechanical system) microphones. If a voice (200Hz – 6kHz) is detected, then that voice gets relayed. If an anomaly is detected (>20kHz), then audio and visual alerts will go off indicating the detected intensity of that anomaly. This product is important because it can serve as early automated leak detection for pressurized vessels such as spacecraft, airplanes, industrial equipment, etc.

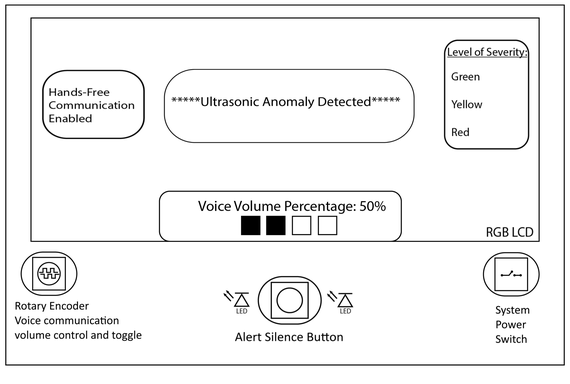
Design Requirements

- Use MEMS microphones to create the proof-of-concept system.
- Provide hands free voice communication to users.
- Detect Ultrasonic anomalies and alert users with auditory and visual warnings at a 1 Hz rate and mute when acknowledged by a user.
- A screen will display the status of all the MEMS microphones in the array.
- As a stretch goal we want to implement localization of detected ultrasonic anomalies.

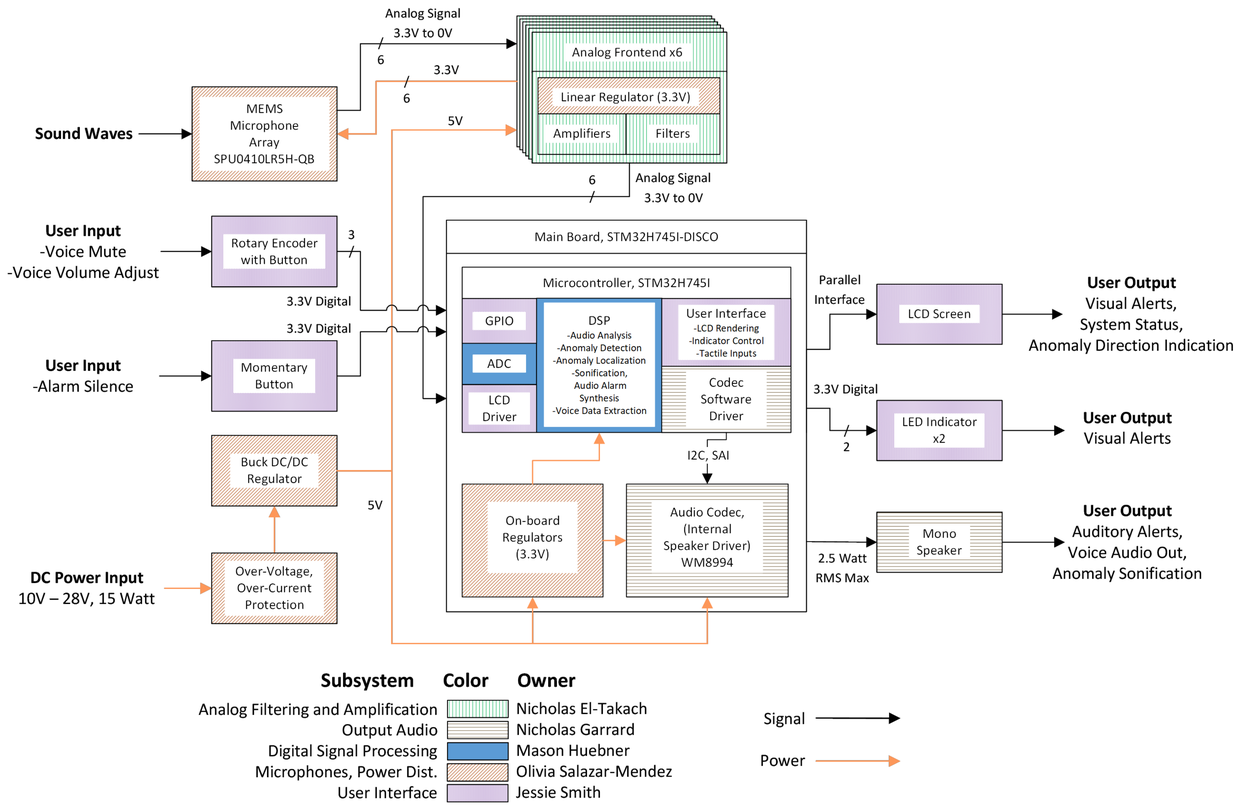
Design Considerations

- Redundancy
- Size and weight
- Power draw & heat
- Anomaly localization
- Universal UI

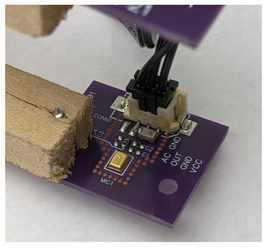
User Interface Design Concept



System Block Diagram

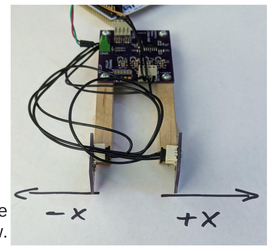


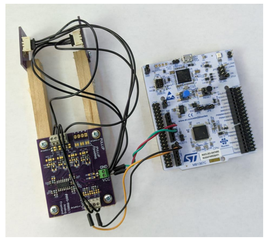
Design Concept



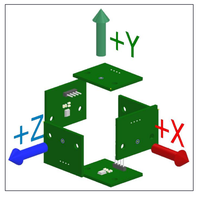
Closeup of an assembled microphone breakout board.

Axis labels used for the spectrum plots shown below.



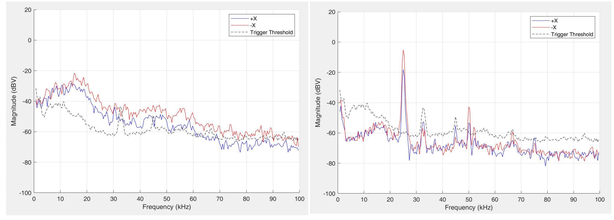


Proof of concept hardware for detecting ultrasonic sound using digital signal processing.



Initial layout plan for the microphone array, using 6 channels for 3D localization.

Detected emissions from airflow through a large orifice. The larger signal magnitude across the –X plot implies the source lies in that hemisphere.



Detected emissions from a transducer fed by a square wave, with fundamental frequency at 25 kHz and harmonic at 50 kHz.

Design Features

Feature:	Description:
Omnidirectional Anomaly Detection	Detect wideband signals (Ultrasonic, Voice) in all directions.
Hands-Free Voice Communications	Voice (200 Hz - 6kHz) is passed and annnounced through the local speaker.
Auditory and Visual Alerts	Alert users if an anomaly is detected with lights and an alert tone. Sonification of the anamoly will alert users of the intensity.
User Interface	Alarm toggle switch with voice communication toggle and volume control.
Directional Indication for a detected Anomaly **(Stretch Goal)**	A vector arrow produced on the GUI will indicate the direction of the anomaly.

Design Risks

- Potential delays due to ongoing COVID-19 pandemic.
- Potential delays due to ongoing part shortages.
- Learning curves for any subsystem/implementation
- Undiscovered design flaws
- Delays caused by acts of God (eg. Another Texas snowpocalypse).

Future Plans

Next semester, we plan to construct and begin testing our product with regards to the design considerations above. If a suitable amount of time remains after testing, we plan to attempt to add localization capabilities to anomaly detection, showing users where an anomaly is coming from.

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