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ENGINEERING
TEXAS A&M UNIVERSITY

ECEN 404 Final Presentation
Team 84: Ultrasonic Radio

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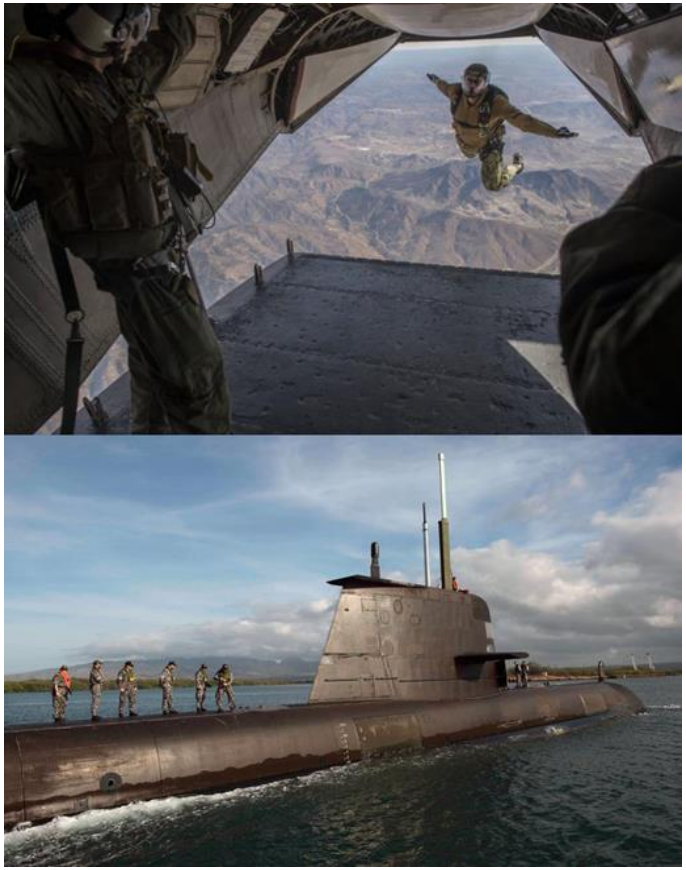
Project Summary

Problem statement:

- Communicating information is very important in almost every military operation. However, sometimes sending information through traditional methods is not feasible.

Solution proposal:

- A solution to this issue is to develop an acoustic ultrasonic radio.
  - Acoustic waves and lower frequencies will limit electromagnetic radiation
- This radio will allow for communications over relatively short distances.
- Communication will be slower than devices using electromagnetic waves



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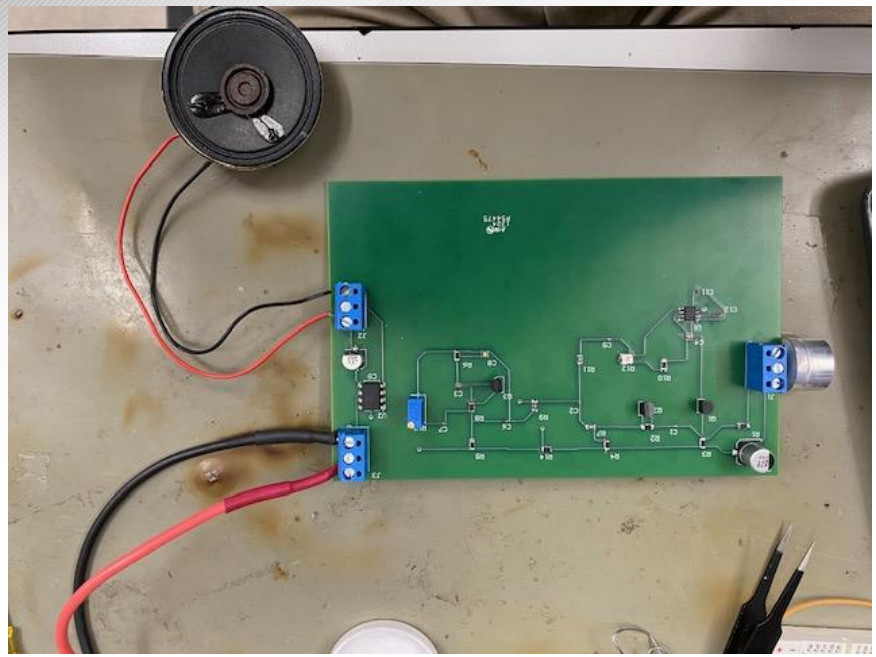
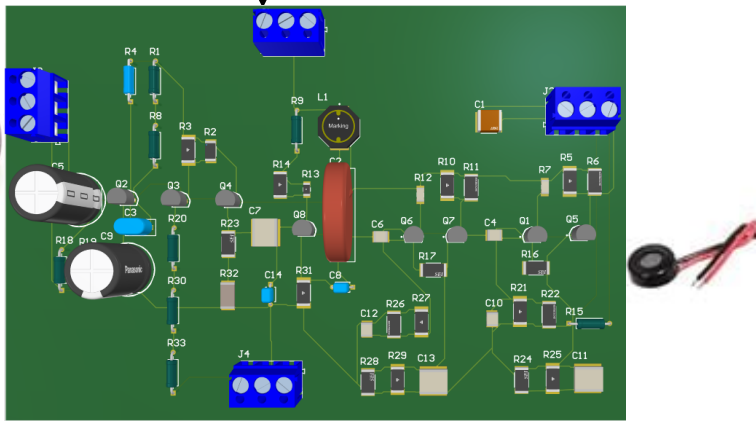
Inegrated Project Diagram

Ultrasonic Receiver



50 kHz Ultrasonic transmission

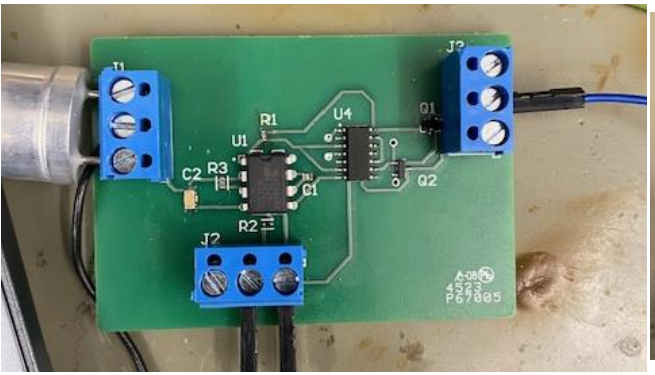
Ultrasonic Transmitter



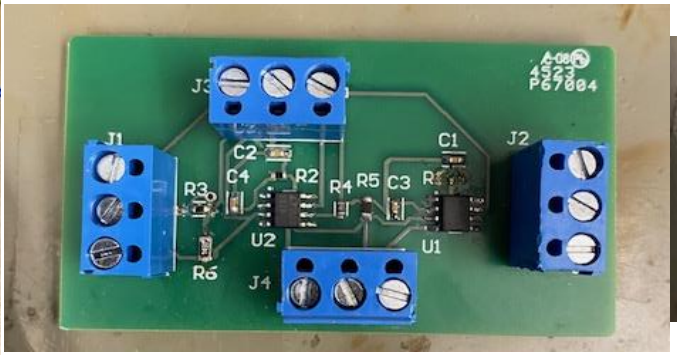
- Input microphone covers human voice frequencies (100 Hz to 3 kHz)
- Voice is translated into an electrical signal
- Signal is amplified and filtered to enhance quality and eliminate unwanted noise
- Modulated to ultrasonic frequencies for transmission, with optional additional filtering
- Modulated signal goes through a power amplifier to achieve required gain
- Signal travels to receiving microphone for filtering and amplification for demodulation
- After demodulation, signal is filtered and output through a speaker within the human hearing range
- User uses R13 potentiometer as a volume adjuster of the output
- User uses R12 potentiometer as a means to filter input frequency ranges to be demodulated

Jacob Ralls

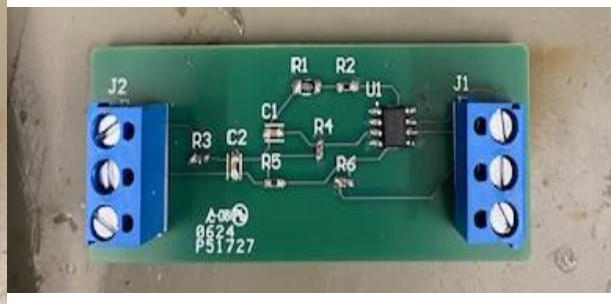
Designed, Tested, and Validated	Challenges Faced/Solutions Found
• Initially designed and tested individual working demodulator circuit • Designed and tested 4th Order Chebyshev Band Pass Filter • Designed and tested 2nd order Bessel filter design	• **Prob:** Band Pass Filter did not properly represent the gain shown in both LTSpice and Multisim simulations • **Sol:** Designed a simplified model with a focus on gain at a cost of bandwidth.



Working Demodulator utilizing PLL circuit



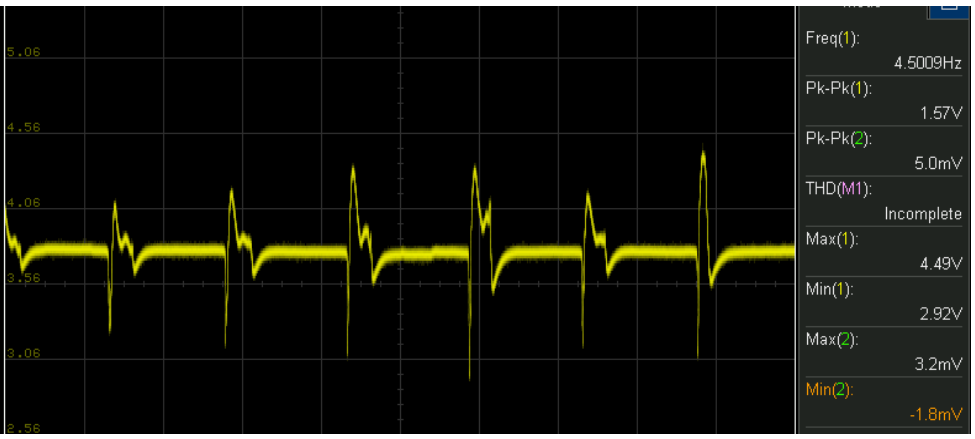
Nonoptimal 4th Order Chebyshev BPF



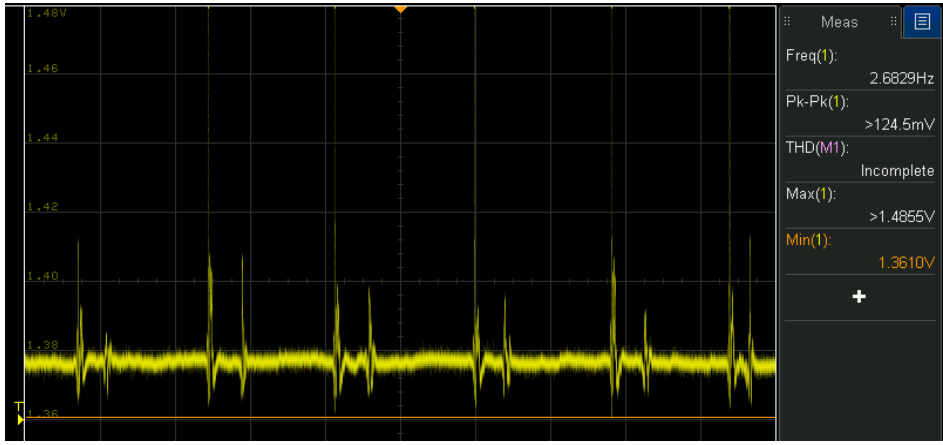
Ideal 2nd order Bessel Filter

Jacob Ralls

Designed, Tested, and Validated	Challenges Faced/Solutions Found
• Validated mass of overall system to be roughly 2.449 kg < 10 kg • Voltage input was tested to be lower than +9 VDC • Radio current level was found to be at most 0.306A validating the <0.9A requirement • Ultrasonic input mic able detect range low freq range (5Hz) and detect higher pitches (155Hz)	• **Prob:** Speaker output was unable to be heard from the required 15 meters away. • **Soln:** Designed new receiver PCB with adjustable output volume and reads wider input frequency range (Little over 500 kHz range while still being able to tune to lower ranges)



Mic Input Min Frequency



Speaker Output Min Frequency

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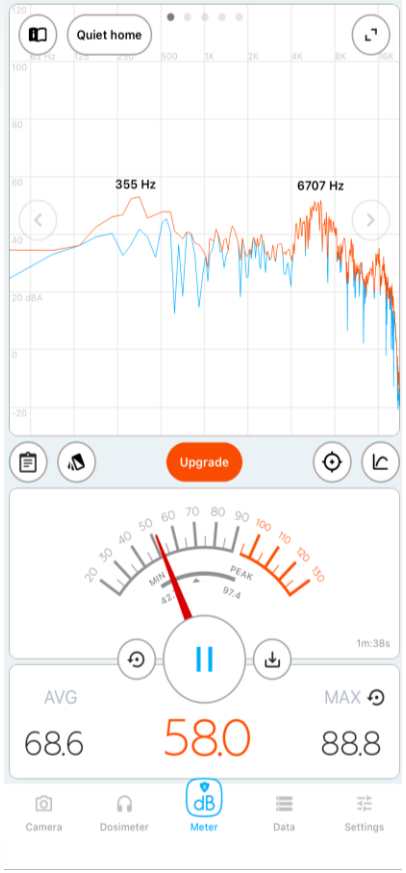
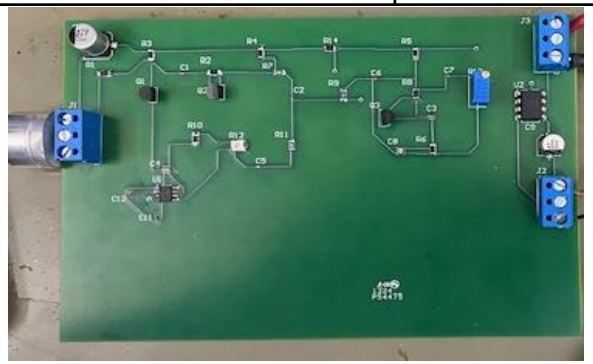
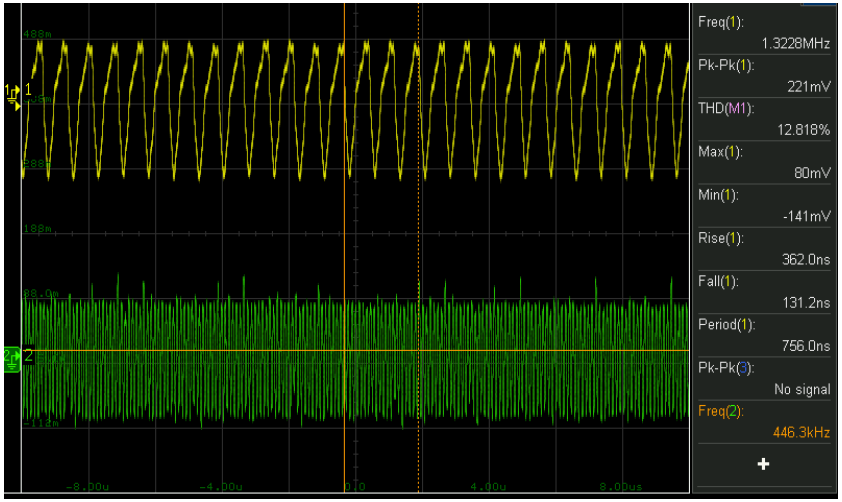
Jacob Ralls

Designed, Tested, and Validated	Challenges Faced/Solutions Found
• Tunable freq and volume receiver circuit designed and tested. • Validation checks shown previously still pass. • Voice Output Validation check was then successful as an output freq. of roughly 1.2kHz was easily audible for 10 meters.	• **Prob:** Built in noise causing output buzz • **Soln:** Buzzing likely due to LM567 component. Tried disconnecting gate of JFET from junction of R11 with no little difference then eventually grounded Q1 base which mitigated issue. Also have many backup potentiometers as R12 is very brittle when adjusted





Tunable Receiver Circuit



Output of transmitter transducer (Yellow)
- 1.322MHz

Input of receiver transducer (Green)
- 446.3kHz

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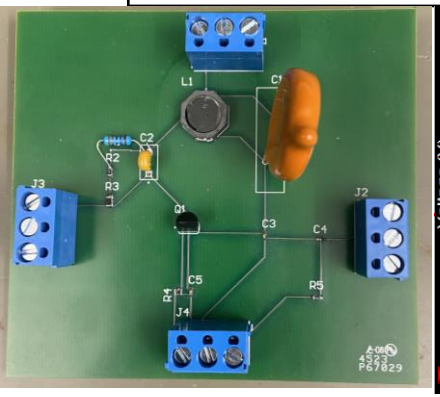
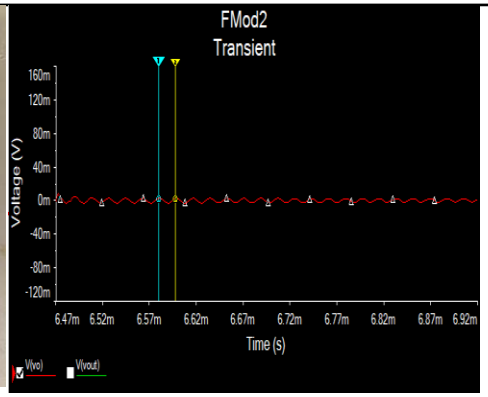
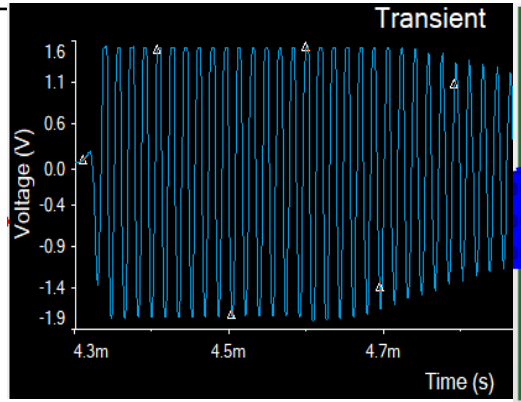
Nathan Cinocca

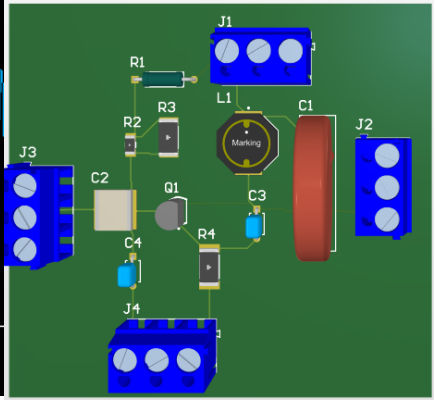
Designed, Tested, and Validated	Challenges Faced/Solutions Found
• Initially designed and tested individual frequency modulation circuit • Designed, tested, and validated low frequency filter • Designed, tested, and validated signal amplifier • Designed, tested, and validated power amplifier	• **Prob:** Frequency Modulator initially had too low of voltage to be properly tested or transmitted • **Sol:** Designed a new frequency modulator that was able to transmit at a readable frequency





Original Low Voltage Frequency Modulator





New High Voltage Frequency Modulator

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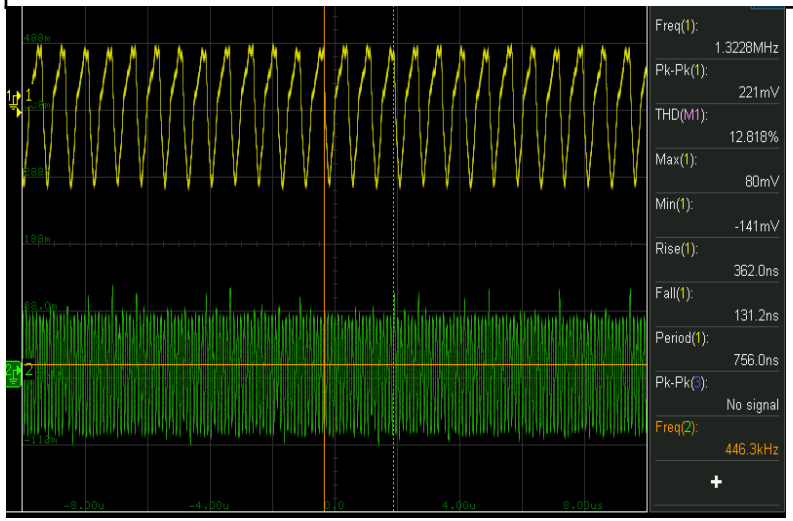
Nathan Cinocca

Designed, Tested, and Validated

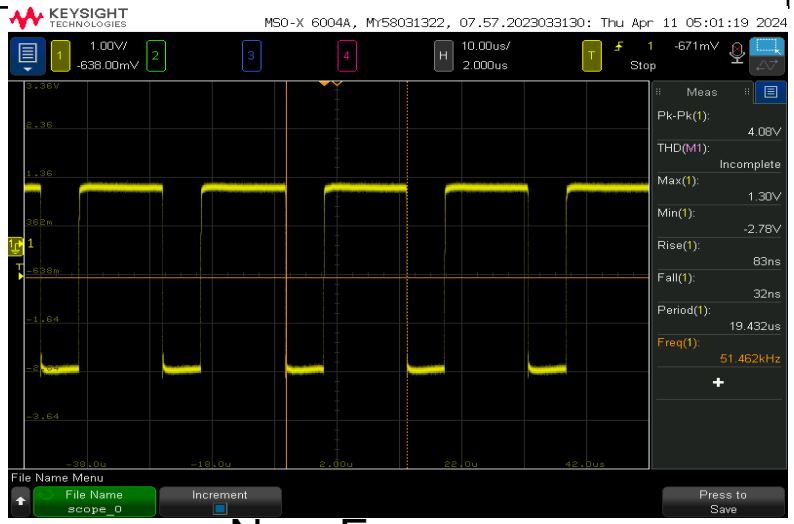
- Voltage input was tested to be lower than +5 VDC
- Current level was found to be at most 0.306A validating the <0.9A requirement
- Ultrasonic input mic able detect range low frequencie range (5Hz) and detect higher pitches (155Hz)
- When Transmitter side was tested with output transducer the transmission frequency was around 1.3 MHz

Challenges Faced/Solutions Found

- **Prob:** The Transmission frequency was far too high upon original testing
- **Soln:** Edited Modulator parameters and improved circuit connections to change transmission frequency back to 50kHz



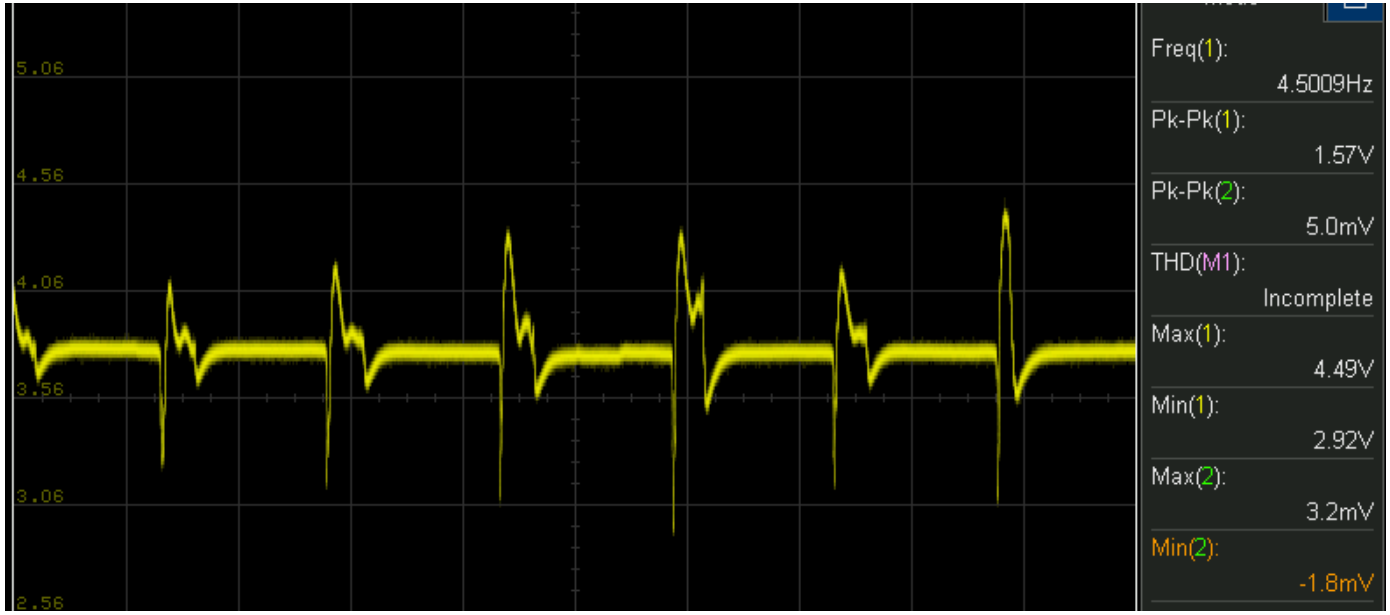
Original Frequency Modulator Transmission



New Frequency Modulator Transmission

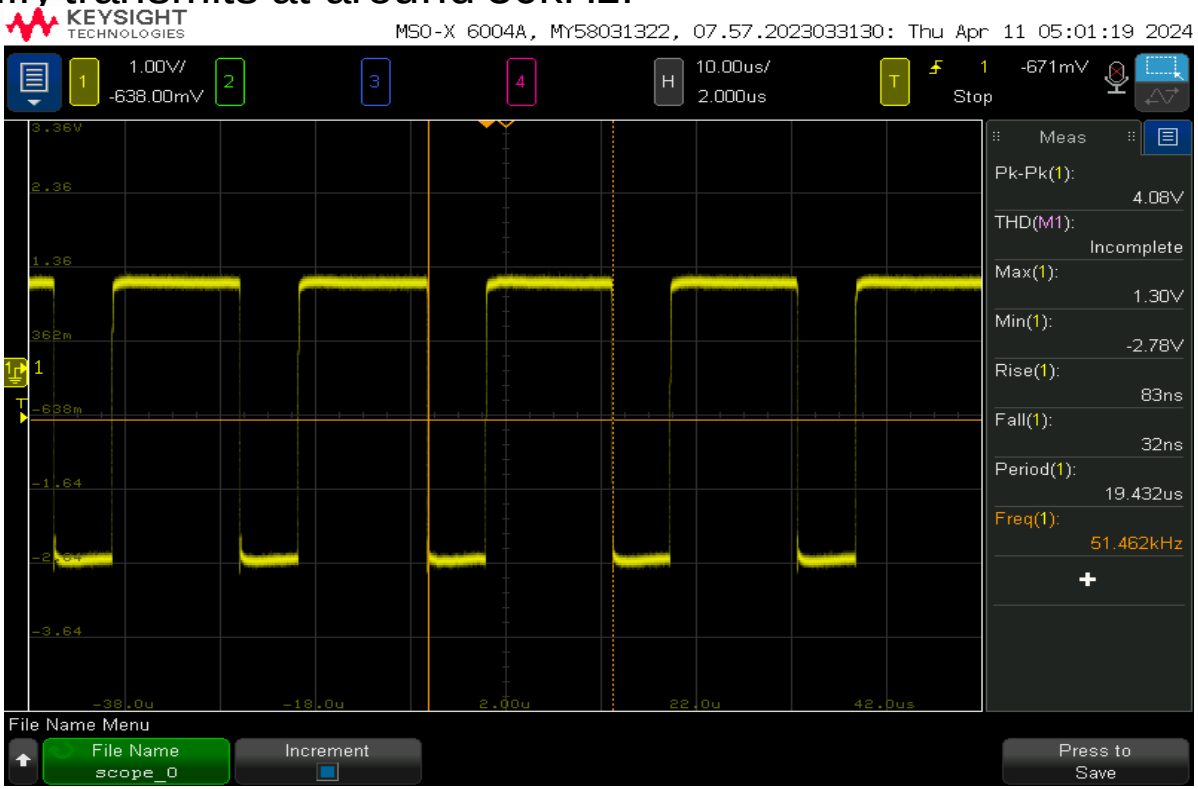
Integrated System Results

Task 1: User provides input through the mic. Successfully able to detect range of frequencies as low as 4.5 Hz

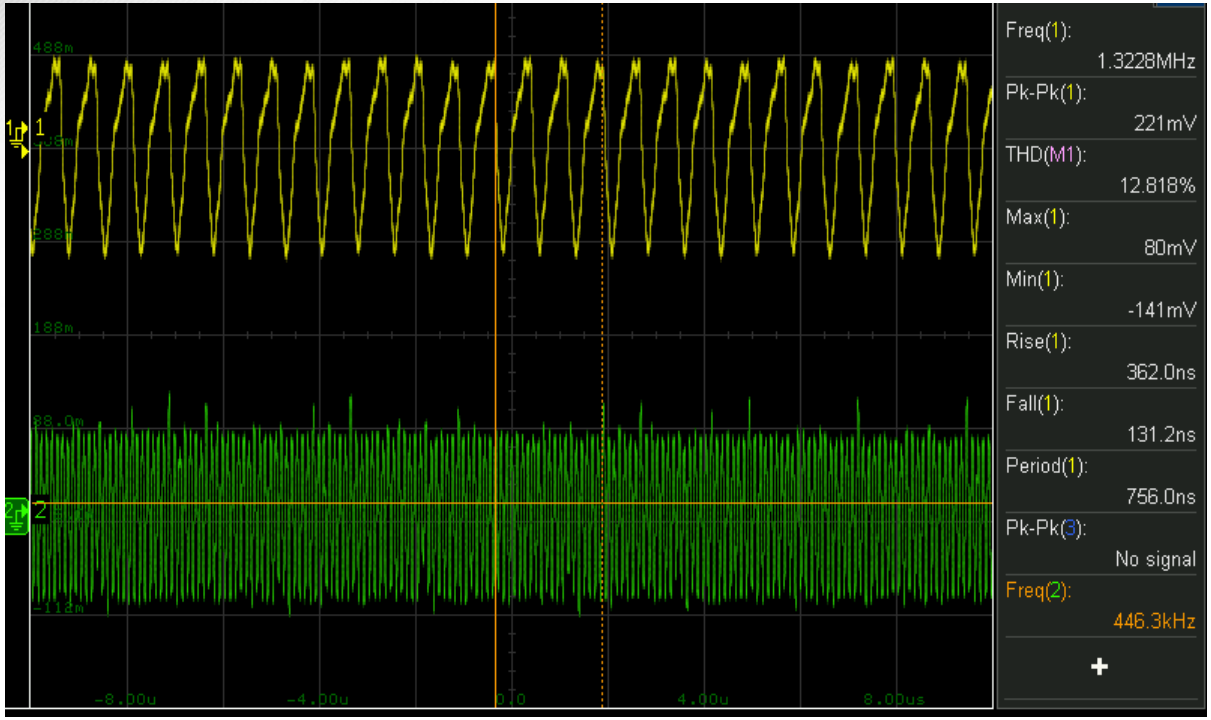


Integrated System Results

Task 2: Signal then gets sent through the transmitter half of the circuit. Successfully transmits at around 50kHz.



Integrated System Results



Task 3: Signal then gets transmitted and received by the receiver. Not quite accurate as we are looking for a match between the two frequencies for a passed test and to effectively perform a proper transmission across the signals.

This process is the most notable failure within our system and is being heavily tested.

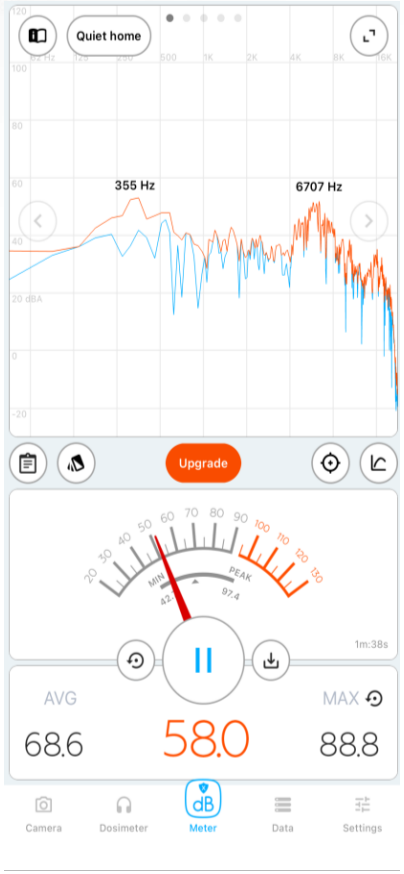
Integrated System Results

Task 4: Received signal goes through the receiver process

- Due to the high amount of noise projected in the output of the circuit, it is difficult to deduce if proper demodulation is occurring.
- This process is currently deemed as an unknown due to these noise levels.

Integrated System Results

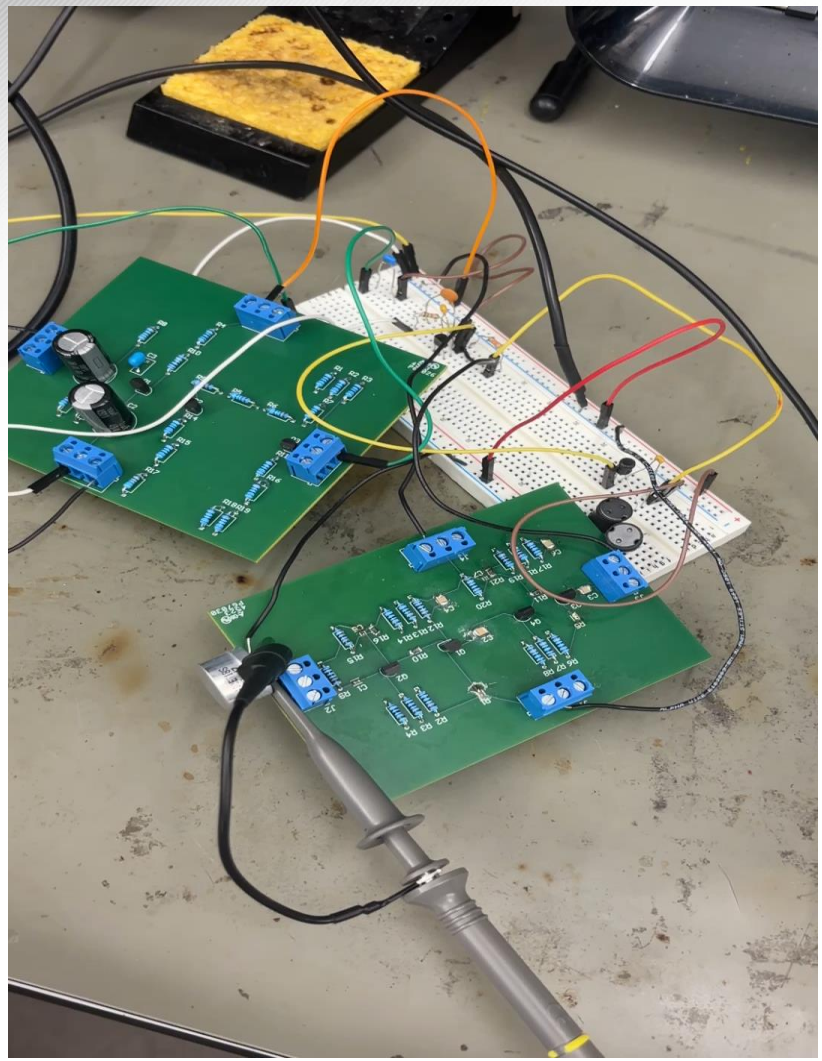
Task 5: Output of the signal gets projected through the speaker.

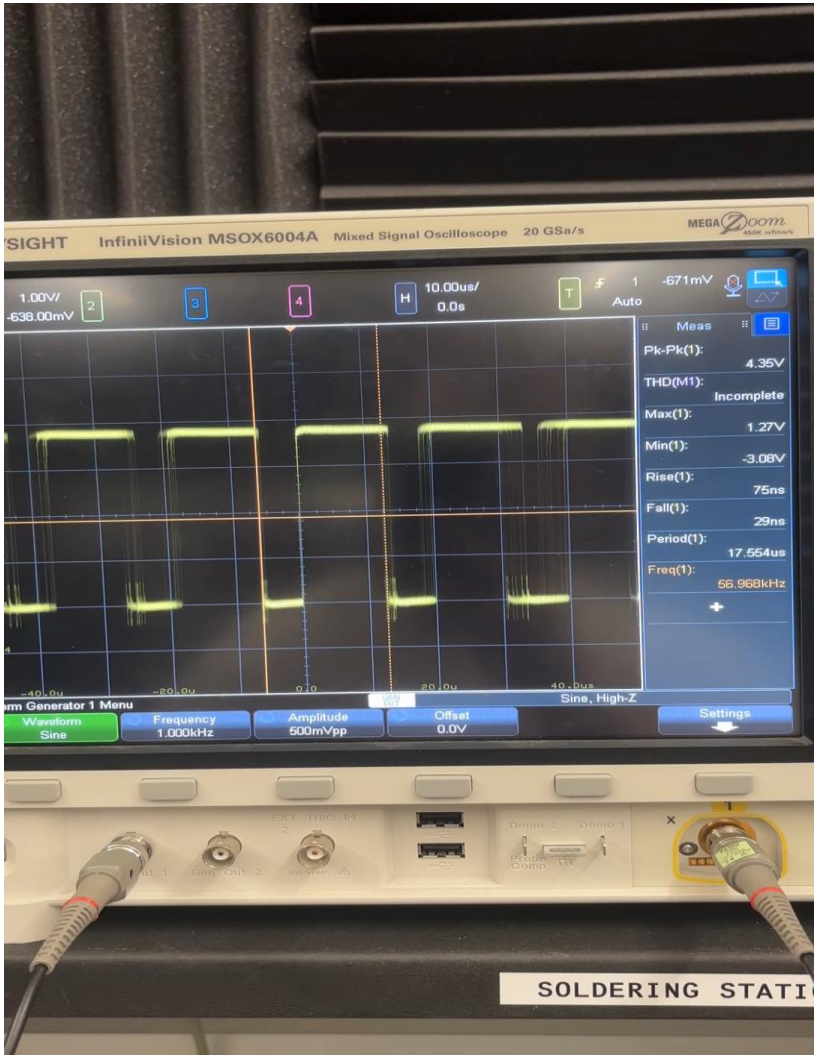


- Successfully able to output at a high enough volume at a recorded max of 88.8 decibels to be detectable at an acceptable range.

- This process is deemed as a success due to the output being audible from our selected 15 meters of distance while also being adjustable.

Videos




InfiniiVision MSOX6004A
Mixed Signal Oscilloscope
20 GSa/s
Meas
Pk-Pk(1):
4.35V
THD(M1):
Incomplete
Max(1):
1.27V
Min(1):
-3.08V
Rise(1):
75ns
Fall(1):
29ns
Period(1):
17.554us
Freq(1):
56.968kHz
Waveform
Sine
Frequency
1.000kHz
Amplitude
500mVpp
Offset
0.0V
Settings
Sine, High-Z

Conclusions

- As a result of challenges with model compatibility and complications regarding our sponsor's preferences, which have led to divergent deliverables and objectives, the design has been modified from the original specifications to operate as a one-way communication system, rather than the initially planned full-duplex bidirectional communication system.
- Some of our tests within our validation plan could be proven theoretically but the equipment used to test these, to our knowledge, were not readily available. I.e. a "container with high pressure" and "container with controlled humidity" for both the "Pressure (Altitude)" and "Humidity" tests respectively.

- Current status: Integration complete, however transmission process not fully validated, continued testing and debugging of pot rec circuit to cut noise to read input, integration/validation to be completed in 1 week

Thank you for your attention.
Any questions?