EE/CprE/SE 4920 Status Report 4

02/28/2025 – 03/13/2025

number: 36

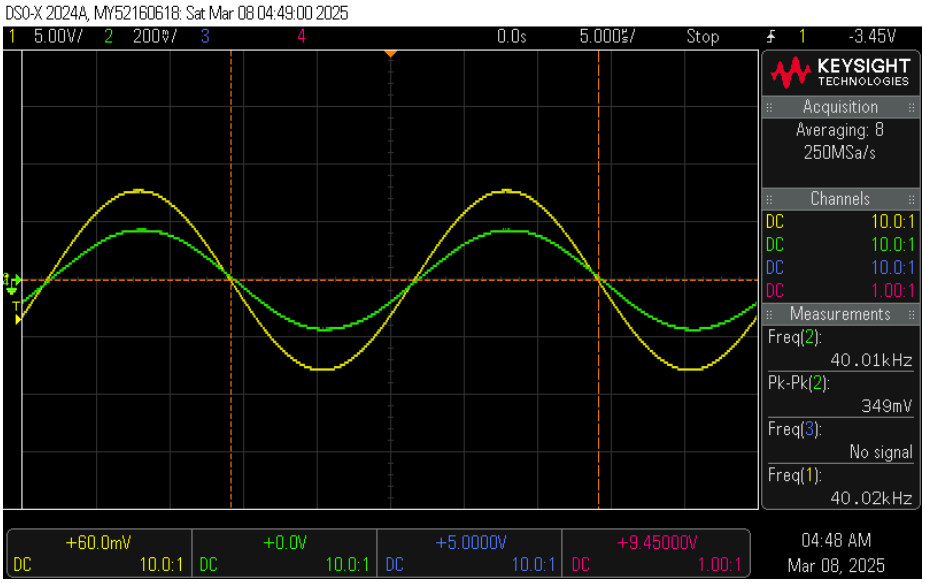
Project title: ***Ultrasonic Object Detector***

Client &/Advisor: Professor Jiming Song

Team Members/Role:
Nathaniel Clarke - Project Software Designer
Brock Dykhuis - Circuit Analysis
Nicholas Jacobs - Electronics
Jonathon Madden - UI Designer & Software Tester
Baoshan Liang - Testing and Analysis

Weekly Summary

We confirmed that the receiver properly read signals in one direction, and found that the voltage to transmitters has to be increased to allow for reflected signals to be received. The radar display was updated to allow for object grouping. The MCU code is being changed to improve concurrency (placing the receiving task, and the transmitting task on different cores).



Past week accomplishments

Brock Dykhuis -

- MCU code
    - worked on adding multiple transmitters to our existing code.
    - Theorized on ways to be able to effectively calculate the steering functions.
    - Looked into how we want to pulse the transmitters to accurately detect objects.

Nicholas Jacobs-

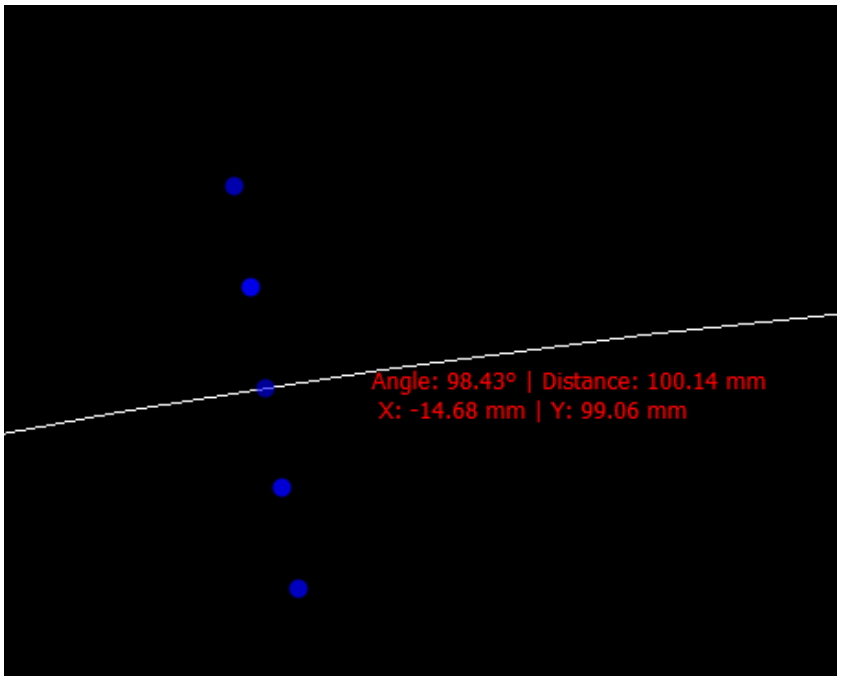
- **Transmitter Testing with Oscilloscope**
    - Verified that the transmitter is successfully sending a signal by observing waveforms on the oscilloscope.
- **Receiver Testing and Signal Detection**
    - Conducted tests on the receiver and confirmed that it is actively picking up the transmitted signal.
- **Power Requirement Analysis**
    - Calculated that additional power is needed for optimal performance and conducted research on potential power solutions.

Jonathon Madden -

- **Worked on the steering beam code**
    - looked into how the width of the beam will affect steering
- **Set up my own Python display**
    - Worked on creating a display with Python instead of the processing IDE

Nathaniel Clarke -

- **Updated Display Code to Allow for Object Clusters.**
    - Readings are clustered based on the proximity to a bounding box
        - If a reading is within 1 cm of a cluster it is incorporated.



- **Updating MCU code for Accuracy and Concurrency**
    - Clarified that start time should be based on the time the middle transmitter fires (in this case since the array is even it is the time between the middle transmitters firing)
    - Updated pulse length to 3 cycles for now (75 microseconds) to improve beam formation.
    - Started switching the MCU code to use FreeRTOS for concurrency where transmitting and receiving (and sending readings) are maintained on different cores to improve timing.
- **Looked into the Receiver Triangulation Method**
    - Plan to use a line of receivers leveraging the distance between receivers and the time delay between their signal reception.
    - The current plan is to use the middle transmitter time delay to find the distance, and utilize the intended steering angle and that distance as an initial guess (calculating the x and y values) to be used with fsolve from Python's SciPy library. Each transmitter will have its own distance formula.

Baoshan Liang -

I conducted tests on the receiver end of the ultrasonic detector, focusing on signal reception and analyzing the beam direction. Specifically, I studied issues related to phase and time delay, which are critical for understanding signal propagation and accurate distance measurement.

Individual contributions

NAME	Individual Contributions	Hours this week	HOURS cumulative
Nathaniel Clarke	Worked on updating the display to allow for point clustering. Began looking into receiver triangulation logic. Worked on updating MCU code to allow for proper concurrency.	12	109
Brock Dykhuis	Worked on MCU code to send pulses and be able to calculate time delay with multiple transmitters.	9	95
Jonathon Madden	Worked on the steering beam code some. Worked on setting up my own display in Python.	8	76
Nicholas Jacobs	I tested the transmitter and verified its signal using an oscilloscope, confirmed that the receiver is detecting the transmission, and researched power solutions after calculating the need for more power.	9	86
Baoshan Liang	Tested the ultrasonic detector's receiver signal, analyzed beam direction, and studied phase and time delay issues.	10	37

Comments and extended discussion

We will need to provide a new power source to the circuit to allow for more powerful signals, and better readings. We will need to test new concurrency methods to ensure the transmission time delays and pulse durations are accurate. Due to a lacking number of cores and effective non-blocking delays required for task scheduling capabilities with accuracy down to microseconds, a loop relying on cycle counts may be necessary.

Plans for the upcoming weeks

Brock Dykhuis - Over the next few weeks, I will continue to work and theorize on MCU code that will be able to calculate the steering functions and give proper readings. Also will work with Nathaniel to connect the Raspberry Pi with the display.

Nicholas Jacobs- Next week, I need to work on implementing the other radar units and integrating them into the system. I also need to get a MAX232 component for signal conversion and make sure it works properly with the setup. Along with that, I'll focus on figuring out the best power supply solution, refining signal processing, and troubleshooting any issues that come up during testing. If there's time, I'll work on optimizing the circuit layout to keep everything streamlined.

Jonathon Madden - Continue working on the display. Attempt to get correct readings from one transmitter code. Check the beam steering code logic to make sure it will work properly.

Nathaniel Clarke - Continue to work on updating the MCU code, and explore if using a loop checking Esp32 cycles(each cycle is ~4 nanoseconds) is efficient for steering functions (The number of cores is limited and each transmitter needs nonblocking delays in microseconds increments). I will need to make sure the display can properly connect to the Raspberry Pi. Additionally, I will look into potentially implementing selectable readings (displaying positional and cluster information).

Baoshan Liang -The next step is to complete the reflection test by ensuring that the ultrasonic signal is properly reflected and received. I will analyze the characteristics of the reflected signal, including its amplitude, phase shift, and time delay. Additionally, I will implement signal processing on the microcontroller to extract useful information, such as distance and object detection. This will involve configuring the microcontroller to process the received data accurately and optimize the detection algorithm for improved performance.

Summary of weekly advisor meetings

During our weekly meetings, we further clarified details about phased array steering to ensure proper understanding. We discussed that the travel timing should be based on the middle transmitter (in this case in between the two middle transmitters) since it acts as the "zero" point. We also clarified that large time delays are expected for scanning further angles. We discussed

increasing the pulse duration to allow for sufficient beam formation. Additionally, we discussed the issues with transmitter spacing potentially introducing grating lobes and we discussed how beam width may produce inaccuracies. These issues could be mitigated with the introduction of additional receivers for triangulation.