EE/CprE/SE 4920 Status Report 5

03/14/2025 – 04/03/2025

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 looked into ensuring we were generating the necessary frequency of power to the transmitters and found that it would be most effective to use hardware to generate the 40khz waves. We opted to use 555 timers to ensure accurate generation. We were able to establish a connection between the MCU and Raspberry and will ensure we can send data to the display in the future. Additional testing to ensure proper signal pulse timing and reception using the MCU code is necessary.

Past week accomplishments

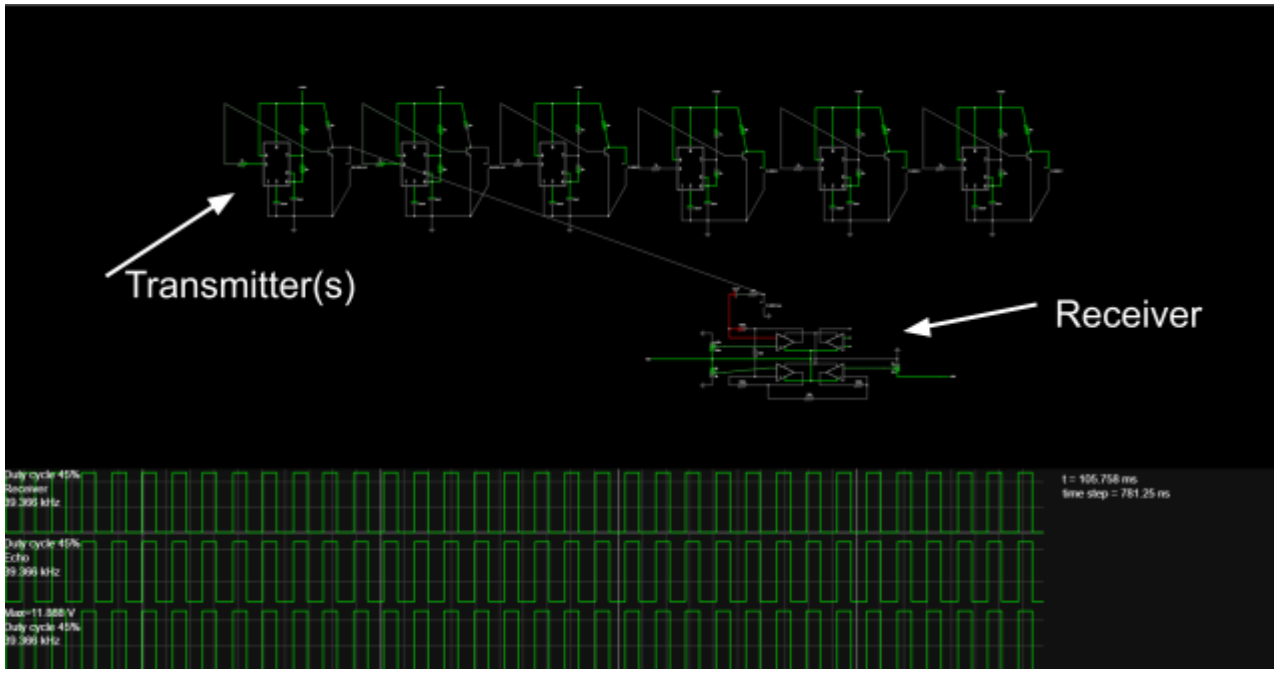
Brock Dykhuis -

- **Design Document**
  - Began updating our past semester's design document with what needs to be added for the final version
- **Code**
  - Wrote code for pulses using ledc.
  - Wrote python code that pulls from the html file and stores data in a string, this will then be used by the display.
- **Server Setup**

- Wrote instructions to get the server setup while using the ISU internet, this includes updating IP addresses, by default every device on the ISU network is assigned a dynamic 10.xxx.xxx.xxx IP.
- Also includes instructions to successfully use the server

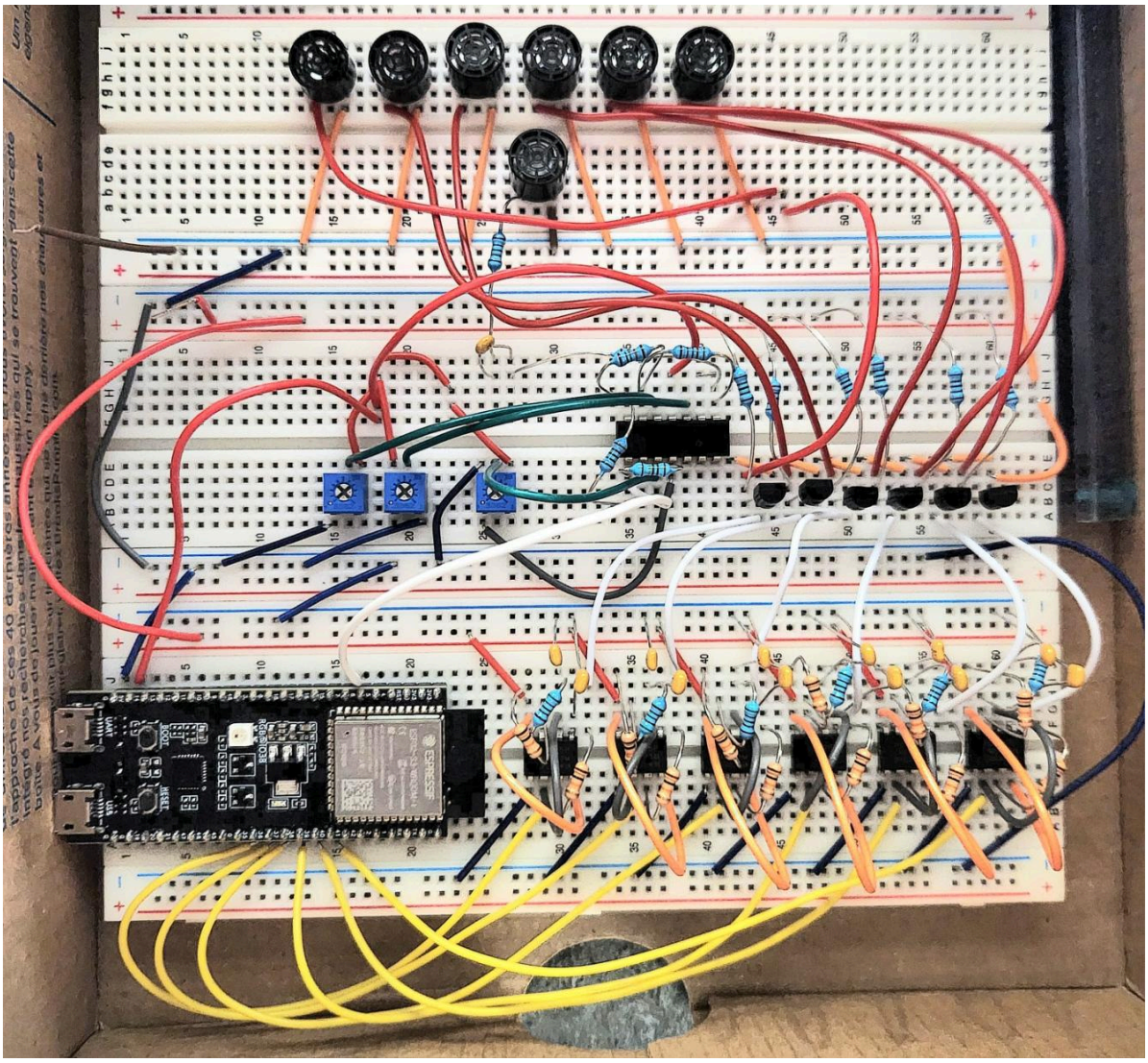
Nicholas Jacobs-

- **Receiver Circuit Simulation and Testing**
  - The receiver circuit was successfully simulated using the newly selected components. After confirming the design in the simulation, the circuit was physically built and tested. Real-world testing validated the simulation results, demonstrating that the receiver was functioning as expected.
- **Transmitter and MAX232 IC Simulation and Testing**
  - The transmitter and MAX232 IC were simulated, showing promising results in theory. However, when the MAX232 IC was physically tested, it proved to be inefficient for the intended application. Further investigation is needed to determine the cause of inefficiency and whether an alternative approach is necessary.
- **Alternative Simulation with 555 Timers**
  - Due to issues with the MAX232 IC, an alternative simulation was conducted using 555 timers. The new simulation was able to achieve a stable 40kHz operating frequency, which is essential for proper ultrasonic transmission. This alternative design may provide a more efficient solution.



- **Circuit Construction**

- The circuit was physically built over a period of approximately six hours. The process involved assembling and wiring the necessary components while ensuring proper connections to avoid faults or inefficiencies in the system.



- **Circuit Testing and Signal Transmission**
  - Initial functionality tests confirmed that the circuit was capable of sending signals. The transmitted signal was successfully detected, indicating that the fundamental design is working as intended. Further testing and refinements will be needed to optimize performance and address any remaining inefficiencies.

Jonathon Madden -

- **Test MCU code with one transmitter being controlled by two separate pins**
  - Same result as with it being controlled by one pin. This did not give us an accurate reading
- **Tried to build MCU using led control**
  - To better control the output of the pins, we tried to used ledcwrite to better control the PWM signal that the pins used. This solution might not be needed as

the hardware might be able to control the 40 kHz output. Might just be able to use Analogwrite instead.

Nathaniel Clarke -

- **Worked on formulating String on MCU to send to Raspberry PI**
  - We decided to send the full sweep at a time; otherwise data may be replaced before it is used.
- **Looked into 40Khz wave generation from MCU pins**
  - Found sine waves are not feasible and would have to be generated in hardware, due to insufficient clock speed.
  - Found that square waves could be generated with ledc, but the esp32 S3 development module only has 8 low-speed channels. This would prevent the usage of 10 transmitters.
  - Found that manually setting pins to high/low could be viable, but would require precise timing utilizing clock cycles, and direction pin register manipulation.
  - Ultimately we decided it would be best to implement the wave generation through hardware caused by a consistent high signal for a number of cycles (setting a pin to high).
  - Formulated a few methods for wave generation before
- **Updated Display Code**
  - Resolved issue with two or more exactly equivalent readings (originally removing one of these points would delete cluster information for multiple readings)
  - Began troubleshooting serial reading, values could be read using Python with test scripts, but they were not properly displaying.

Baoshan Liang -

- I explored how square waves can be used to drive ultrasonic transmitters and studied the relationship between square and sine wave signals. I used the ESP32's LEDC module to generate a 40 kHz square wave for signal transmission.
- I implemented Wi-Fi connectivity, allowing the user to control the signal remotely—such as starting or stopping transmission and adjusting waveform parameters. This integration lays the groundwork for a basic wireless ultrasonic control system.

Individual contributions

NAME	Individual Contributions	Hours this week	HOURS cumulative
Nathaniel Clarke	Worked on sweep readings string in MCU code to be sent to the Raspberry PI. Looked in 40Khz wave generation, and formulated backup options. Worked on Display code.	14	123
Brock Dykhuis	Began working on the final design document and updating code after we started to change our design after more thorough testing.	8	103

Jonathon Madden	Test code that had the transmitters controlled by two separate pins. Wrote code that used the ledcwrite function instead of analog write, thinking we could better control the output frequency of the pins.	12	88
Nicholas Jacobs	I successfully simulated and tested the receiver circuit, confirming its functionality in both simulation and real-world testing. While simulations for the transmitter and MAX232 IC were promising, physical testing of the MAX232 proved inefficient, leading to an alternative simulation using 555 timers, which operated at 40kHz. I then spent approximately six hours constructing the circuit, ensuring proper assembly and wiring. Initial tests showed that the circuit successfully transmitted signals, confirming basic functionality. Further refinements will focus on optimizing performance and addressing any remaining inefficiencies.	18	104
Baoshan Liang	Generated a 40 kHz square wave with ESP32 LEDC and enabled remote control via Wi-Fi.	10	60

Comments and extended discussion

We are still encountering issues with unexpected electrical signals when pins were manually set to low, and we encountered unexpected behavior from the MCU's serial port utilizing Aurdino's serial monitor. Additional testing is needed to ensure there are no issues with the MCU causing this unexpected behavior.

Plans for the upcoming weeks

Brock Dykhuis - Continue to work on the design document and assist with further code changes as needed.

Nicholas Jacobs- I will replace the existing capacitors with the newly ordered 3nF capacitors to ensure the circuit operates at 40kHz. After installing the new components, I will run simulations to verify the frequency adjustment and confirm proper functionality. If necessary, I will make additional adjustments to optimize performance based on the simulation results.

Jonathon Madden - Continue working on trying to get the MCU to work. Update the final design document.

Nathaniel Clarke - Continue working on the display, and integrate the option to read from the Raspberry PI server. Determine necessary pin registers for direct manipulation to provide more accurate timing. Formulate alternative phased pulse styles if time allows (i.e., starting with an

effective middle transmitter [between the middle two transmitters], using modulo of time delays to fall within one cycle [25 microseconds]).

Baoshan Liang -Future work includes integrating ADC signal reception, performing distance calculations, and building a complete ultrasonic sensing system.

Summary of weekly advisor meetings

During our weekly advisor meetings, we discussed the addition of 555 timers to the circuit and other updates to the detector circuitry. We also discussed additional cases to test to ensure detector functionality. Additionally, we discussed our progress with establishing the connection from the circuit to the Raspberry Pi to the display. We made sure to address future goals to ensure sufficient progress in the coming weeks.