ULTRASONIC RADAR

DESIGN DOCUMENT

Team 24
Client/Mentor: Jiming Song

Team Members:
Jacob Elliot– *Electrical Engineer*
Julia Falat– *Computer Engineer*
Logan Kinch– *Software Engineer*
Joseph Hanson– *Electrical Engineer*
Viola Newman– *Electrical Engineer*
Chris Penne– *Electrical Engineer*

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Executive Summary

Development Standards & Practices Used

- Circuit analysis
- Block Diagrams of system
- ESD safety measures
- Simulations and functional testing
- Develop software iteratively
- Model Software visually

Summary of Requirements

- Design circuit to change phases.
- Sensor to send and receive ultrasonic pulse signals.
- Calculate time signals are received for distance estimations.
- Scan all directions to generate 3D images.

Applicable Courses from Iowa State University Curriculum

Courses Taken:

CPR E 288 *Embedded Systems*

PHYS 232 *Intro to Classical Physics II*

EE 224 *Signals and Systems I*

EE 311 *Electromagnetic Fields and Waves*

EE 321 *Communication Systems I*

EE 330 *Integrated Electronics*

EE 422 *Communication Systems II*

EE 424 *Digital Signal Processing*

SE 319 *Construction of User Interfaces*

EE 333 *Electronic Systems Design*

Courses Not Taken:

EE 417 *Electromagnetic Radiation, Antennas, and Propagation*

SE 409 *Software Requirements Engineering*

SE 417 *Software Testing*

CPR E 418 *High Speed System Engineering and Testing*

EE 414 *Microwave Engineering*

New Skills/Knowledge acquired that was not taught in courses

- Interaction with client on a biweekly basis to present our progress and gather more requirements and feedback.
- Real-world circuit board design process, including brainstorming, check-ups, schematic reviews, and final documentation.
- Team collaboration with people in different areas of expertise.
- Meeting project deadlines to keep the project moving forward.

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Team

1.1 Team Members

Major	Name			
Electrical Engineering	Jacob Elliott	Joseph Hansen	Viola Newman	Chris Penne
Software Engineering	Logan Kinch			
Computer Engineering	Julia Falat			

1.2 Required Skill Sets for Your Project

1. Power supply design
2. Transducer design
3. MCU circuit design
4. Pulse/Phase control
5. PCB Layout
6. Signal Analysis
7. Embedded Systems Programming
8. Website Design
9. Circuit Analysis
10. Troubleshooting and Testing
11. PLC

1.3 Skill Sets covered by the Team

Jacob Elliot	Julia Falat	Joseph Hansen
Circuit Analysis	Embedded Systems Programming	Circuit analysis
Troubleshooting and Testing	Website Design	PCB design
PLC		Signal Analysis
		Troubleshooting/Testing

Logan Kinch	Viola Newman	Chris Penne
Website Design	Signal Analysis	Power Supply Design
Embedded Systems Programming	Transducer design	MCU Circuit Design
	Pulse/Phase Control	PCB Layout

1.4 Project Management Style Adopted by the team

Our team has adopted the Agile methodology where we will break up the milestones into issues that can be completed in a sprint. These issues will be taken up by team members and will be worked on throughout the two-week period. Every week the team will get together to talk about progress, blockers (halt in progress due to a conflict), or input from the team for future design.

1.5 Initial Project Management Roles

- Julia – Team organization, Embedded Programmer
- Viola - Client interaction, Weekly Report
- Logan - Head Programmer, Website Maintenance
- Joseph – Circuit layout expert
- Chris – Power supply expert
- Jacob – Troubleshooting, Circuit Analysis

2 Introduction

2.1 Problem Statement

The problem the ultrasonic system we are iterating on is solving is proximity detection up to a meter using radar frequencies to understand technology in everything from planes, cars, and even ships. Ultrasonics do an excellent job of detecting objects and surfaces regarding the shape, color, and surface texture.

2.2 Requirements & Constraints

Functional Requirements:

- Circuit design to change phase angles for the parallel transducer
- Transducer used as transmitter
- Receiver to obtain the signal with data
- Read a distance up to a meter
- 12V power supply
- Time delay to calculate distance of object
- GUI that displays the 3D object detected

Resource Requirements:

- Parts gathered from ETG
- Affordable, possibly use previous semesters base design

Physical Requirements:

- Phase array must be able to change angles
- Tested inside and outside for durability

Experimental Requirements:

- Error log
- Detailed document of each component
- Detailed document of each component test case

Aesthetic Requirements:

- Concise and thoughtful, no unnecessary components

Environmental Requirements:

- Ultrasonic pulse should be heard from only a small group of animals 40kHz range
- Should not affect any environmental factors (atmosphere, insects, plants, etc.)
- Be able to get precise reading through atmospheric debris

UI Requirements:

- See 3D like images

- Ability to change phase angle
- Show distance of object being detected

Time Constraint:

- Built and tested in two semesters
- Microcontroller knowledge
- Processing power of the microcontroller selected; may need to change.

2.3 Engineering Standards

I^2C or UART: Need to communicate with the MCU on the board for sensor data.

IPC-2221: PCB Layout Standards

IEEE Code of Ethics: It is vital that we follow practices with this circuit to prevent unnecessary interference with others via waves produced from the emitters.

ISO/IEC 25010:2011 Software Quality: It is important that when designing the UI, we identify software and system requirements, identify software and system design objectives, identify software and system testing objectives, and identify quality control criteria as part of quality assurance.

IEEE 1016 Software Designs Description: For this project to be used by future users, it is important to have detailed explanations of how the software of the UI works so any future changes can be made along with any future use of the project.

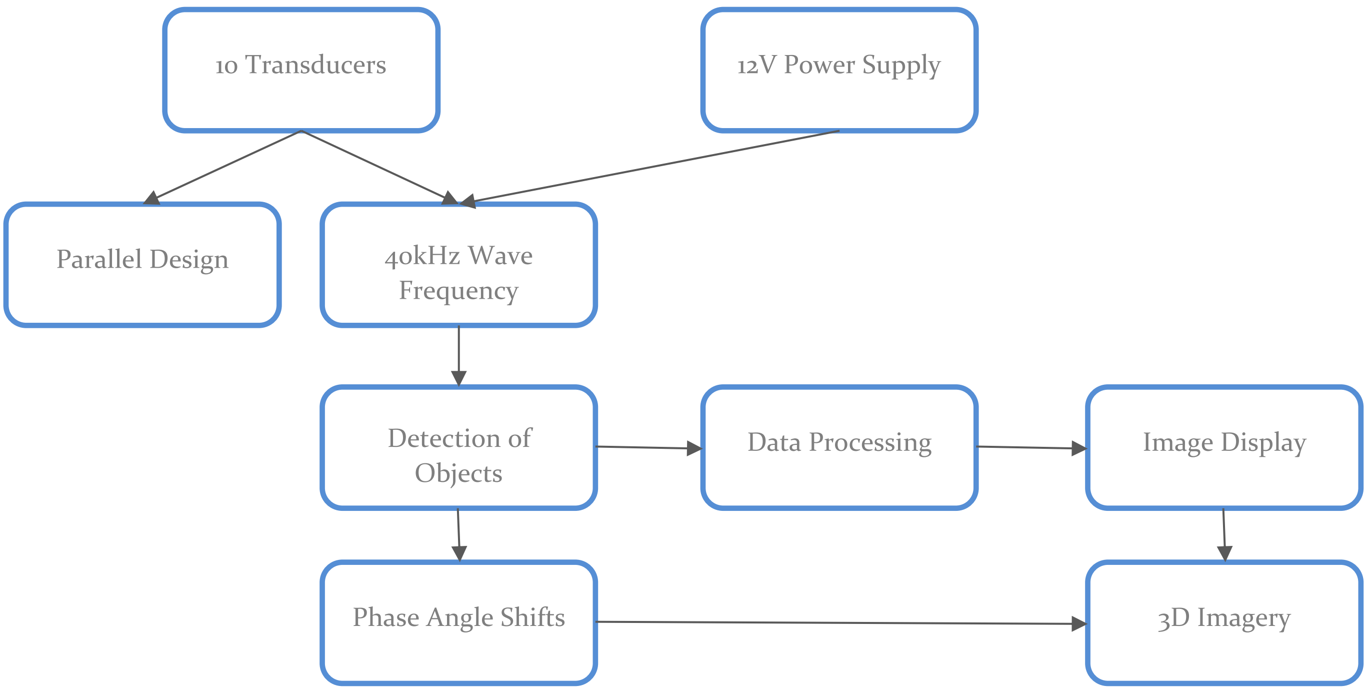
2.4 Intended Users and Uses

- Car manufacturers for anti-collision detection
- Factories for part detection and counting
- Level detection for liquids in facilities

3 Project Plan

3.1 Task Decomposition

To solve the problem at hand, it helps to decompose it into multiple tasks and subtasks and to understand interdependence among tasks. This step might be useful even if you adopt agile methodology. Utilizing agile, we can also provide a linear progression of completed requirements aligned with sprints for the entire project. At minimum, this section should have a task dependence graph, description of each task, and a justification of the tasks with respect to set requirements. You may optionally also include sub-tasks.



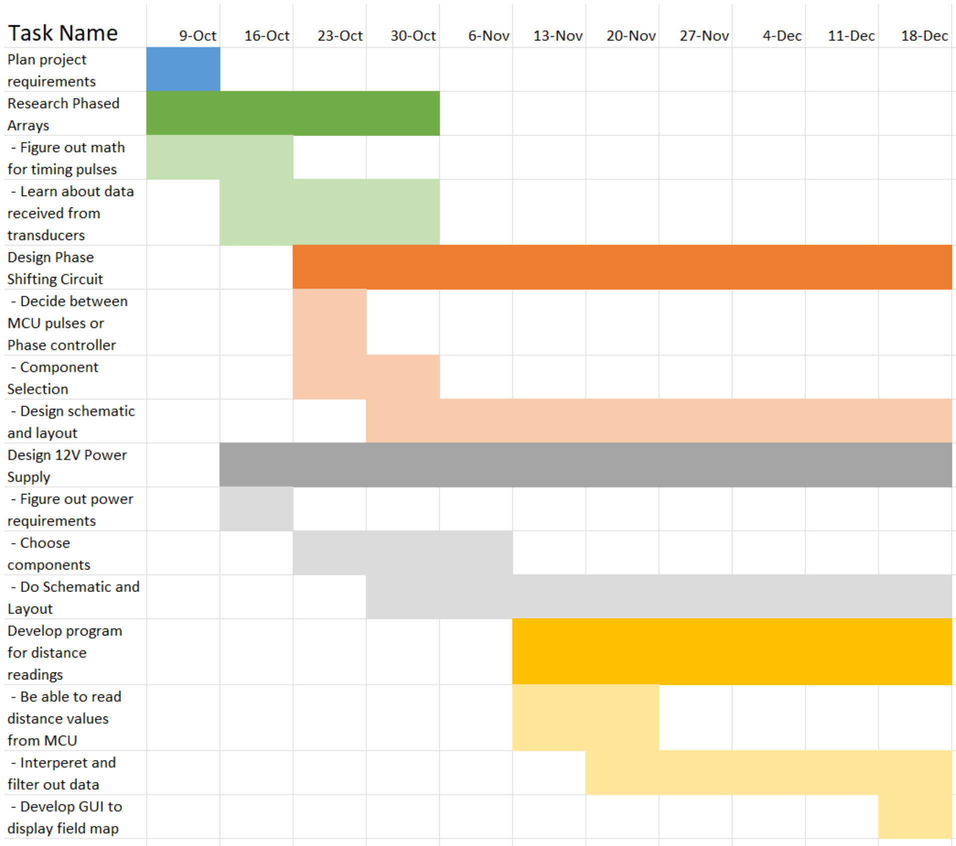
3.2 PROJECT MANAGEMENT/TRACKING PROCEDURES

For our project, we will be doing the waterfall agile methodology, because we have many dependencies that must work correctly before moving onto the next step. An example of this practice is our transducer design. If the transducers are not working correctly for reading even a few inches in front, we cannot begin receiving the signal creating a roadblock. Once the transducers begin working, then we can move on to the next part of receiving the signal to filter noise. The waterfall method pushes us to design each part the best we can before moving on to other sections. This allows us to produce a project that is at its full potential and a strong foundation for the next sections. In order to keep track of our progress, we will be using the Issue Board on our team GitLab because we can split all milestones into their own groups of subtasks towards the milestones. When we claim these subtasks, we can then document all actions, problems, and successes on the Issue comments, so no documentation is lost in the process. This also helps with tracking the progress of the milestones and talking points for any blockers that may arise.

3.3 PROJECT PROPOSED MILESTONES, METRICS, AND EVALUATION CRITERIA

Milestone	**Sub Tasks**			
Power Supply	12V Power Source	SMPS with min ripple	Input Protection	Enable/Disable and indicators
Parallel Transducers	10 Transmitters	40kHz Wave Frequency	Detection Accuracy of 70%	Phase Angle Shift
Data Processing	Pi vs Arduino	Data Processing No Longer Than 30ms		
Screen Display	Display Distances	3D Imagery		

3.4 Project Timeline/Schedule



3.5 Risks And Risk Management/Mitigation

When designing a PCB, it can lead to high risk in terms of cost and time. If it's not designed correctly, it can lead to delays because it must be redesign with the fixes needed and sent to be printed again. Printing PCBs takes time too so this would cause the entire project to be on hold for several weeks. This can be mitigated with intense reviews from all members of the final PCB Layouts and Schematics before being sent off to printing.

When using a microcontroller, such as an Arduino or Raspberry Pi, board we may have limited processing power. For Arduinos, conditional statements take much longer to process. We will need to use bitwise operators as much as possible to have our timed delay be less than 1 second when processing data. Once we determine the exact microcontroller being used, we must look at the different limitations and design the code to run efficiently.

3.6 Personnel Effort Requirements

Task	Task Length	Explanation
12 Volt power supply	10 hours	A 12 Volt power supply does not take very long to design. Input protection could take a bit more time, however.
10 Transducers	1 hour	Ordering 10 transducers will not take much time.
Parallel Design	72 hours	Properly making a design that makes these transducers work in parallel will take some design work and trouble shooting.
40KHz Sine Wave	3 hours	Creating an oscillator that oscillates at 40KHz and an amplifier to feed off this will take a couple hours to design.
Detection of Objects	48 hours	Detection of objects can take some time and troubleshooting for the circuit to be able to detect the reflected waves can add to this time.
Data Processing	168 hours (1 week)	Processing the raw data will be the largest hurdle for this project. Without the data being processed, it is meaningless.
Image Display	72 hours	Making a GUI to see the processed data can take a decent amount of time.
Phase Angle Shifts	72 hours	Phase angle shifts and the corresponding circuit design will take quite some time to make sure that our output remains strong, and that our angles are correct.
3D imaging	8 Weeks	By far the largest part of this project and would require a redesign of the circuit and code to ensure that we can collect 3D data.

3.7 Other Resource Requirements

Hardware		Software
Transducers	Resistors	Arduino
Arduino Board	SMPS	Software Libraries to display data
PCB	Inductors	
ADC	Diodes	
Op Amps	Phase Shifter	
Capacitors		

4 Design

4.1 Design Content

Software:

- Arduino board or D1 ESP32 microcontroller for processing data when signals are received.
- The board will communicate with a computer which will run the program to display the data on a UI in 3D on a computer screen.
- Control phase angle shifts of new signals to be transmitted on the parallel array from the UI on a computer screen.

Hardware:

- A power supply that allows us to work without having to connect into an outlet. This gives us the user freedom to operate the device anywhere with ease.
- Oscillator to create a 40 kHz sine wave. This will provide the necessary input to implement the radar.
- Transmitter and receiver circuits are designed from using transducers to produce our signal.
- Component that allows phase shifting implemented in the oscillator. Should allow for a delay of a given amount set by the user.

4.2 Design Complexity

- The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles.
- The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.
- Complexities for each part:

1. Power Supply
    a. Heat Dissipation
    b. Ripple Voltage/Current
    c. Power Stability
    d. Power Efficiency
2. Phased Array
    a. Pulse Timing for transducers
    b. Circuit Timings
    c. Ultrasonic waves
3. Filters
    a. Noise Reduction
    b. Frequency Response
4. Data Analysis
    a. Quantization
    b. Data filtering
    c. Data formatting
5. GUI
    a. 3D display of detected objects
    b. Process data within 30ms of receiving form transducers.
    c. Display distance and angles
    d. Change phase angle when requested.

4.3 Modern Engineering Tools

- Kicad: design our PCB and electronic schematic.
- CAD software: create housing for our finished PCB and transducer array.
- GitHub and SharePoint: share design documents with our teammates.
- Arduino: we will be using Arduino boards to process and gather data as well as creating a UI for our radar.

4.4 Design Context

Our project was developed on the ideas of Professor Jiming Song. His idea was to build the ultrasonic radar for future research purposes. The project may never be seen in public use, so we are currently designing it for private use within Iowa State University staff.

List relevant considerations related to your project in each of the following areas:

Area	Description
Public health, safety, and welfare	Our project is not meant for public use but for professional use whether it be for demonstrations, building block towards other projects, or used for future research
Global, cultural, and social	By adhering to multiple engineering standards, our project can benefit professional groups as it can help be a starting point towards future research and design. The project is part of a research and development process intended to provide experience with phased arrays, this aligns with the values of the university and students that are involved.
Environmental	Uses acoustic waves to do nondestructive distance mapping, has the benefit over certain systems in IR sensitive environments. Less environmentally conscious in acoustic sensitive environments, however, many animals can hear sound waves in the 40Khz frequency
Economic	Provides a building block for research into phased array implementations. Affordable method to experiment with phased array methods.

4.5 Prior Work/Solutions

While many other detection devices have been designed in the past, our goal is to create one with the knowledge obtained while working towards our degrees using a parallel transducer array. By using the parallel transducer array, we can implement phase angle shifts that can allow for reading at different ranges depending on the user's needs. Using the obtained data, it can be output onto a UI. Many implemented designs already in use today can output to a UI, so this part is not unique only to our project. One of the projects we are using as a baseline is the group who conducted the same senior design last year. They were able to achieve the following:

- Ultrasonic Sensor able to detect objects.
- Usage of Arduino board to process data and display on UI.
- UI displays distance and angle of detected object in 2D radar.

The goal for us is to take these parameters already set by them and improve on them. Our goal is to do the following:

- Improve code running efficiency.
- Increase the range of transmitters and improve its accuracy.
- Improve the receiver reading accuracy.
- Increase the power to allow for simplicity in circuit components.

These were all issues with their product. Most of their issues were caused in the hardware section, like the chosen op-amp not fitting in with the parameters needed. There are many issues that can arise for us with our circuitry and code in implementing our design, but being able to hear of issues past students ran into gives us knowledge of what to look out for.

Being provided with information on the previous year is both advantageous and disadvantageous. While it gives us an idea of a way to get results, it was not a project that was working properly. We can expand on the concepts laid out for us to get a unique project to our group as well as see areas the previous year struggled with. So far, we have not followed their design other than using the same number of transducers. This is because using 10 transducers allows for an area that is an ideal size.

4.6 Design Decisions

Arduino vs. Raspberry Pi- Because our project is mainly hardware focused, using an Arduino and is cheaper than using a Raspberry Pi. We will have to be careful about how we program because the Arduino has slower processing than a Raspberry Pi. However, we can use bitwise operations to make the Arduino process data at the rate we want.

D1 ESP32 mini vs. Arduino - The difference between the ESP32 microcontroller and an Arduino board is that the D1 ESP32 comes with Wi-Fi and Bluetooth capabilities. It is also cheaper than getting an Arduino board as well. Even though we can use serial communication (i.e., through a cable) we may want to be able to control the sonar from a distance away from the device.

Transducers- Because we want this system to be high power and more accurate than the last system built, we will need to choose the appropriate sensors for the job.

Amplifiers and filters- We will need to choose amplifiers that have a fast enough slew rate to account for the pulses we are sending the transmitters.

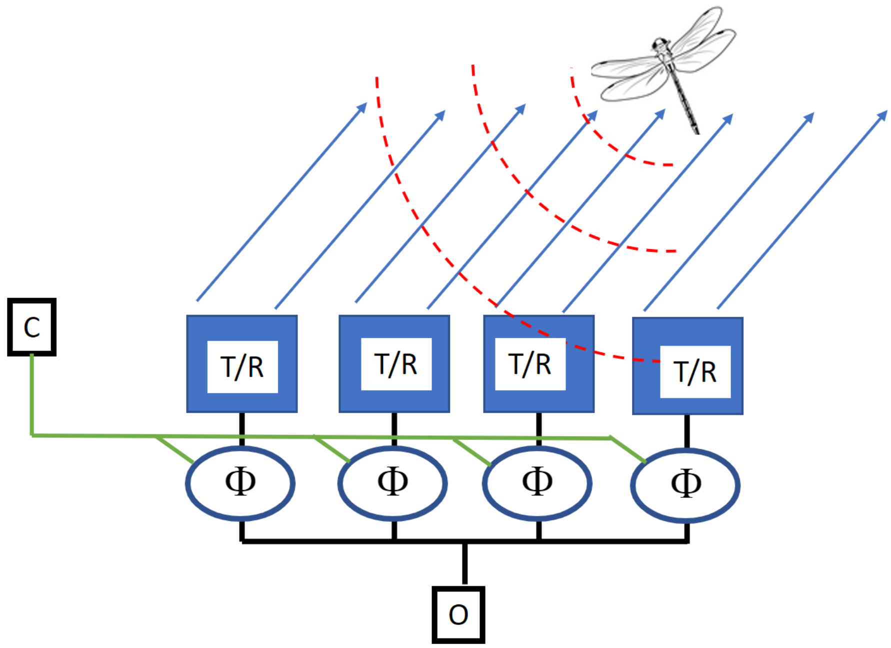
4.7 Proposed Design

What we have done so far is research the different types of ultrasonic sensors and agreed on the direction to go which was also confirmed by our mentor/client. A phase array ultrasonic radar is what we will be designing. This started last year but the phase array implementation was not finished.

4.7.1 Design 0 (Initial Design)

Concepts used when coming up with our initial design ideas. Using these concepts, we analyzed the functionality of the system to determine if another solution needed to take place.

Design Visual and Description



Taken from Jiming Song client presentation slides.

C is the controller which is an Arduino board/ESP32 mini that will be in charge of changing the phase angle shifts of the transducers

Φ is the current phase angle that the transducers are sending their signals at

O is the data processor which is again the Arduino board that will take all processing data received from the transducers and display back to the UI

T/R is the transducers that transmit and receive the ultrasonic wave.

The design of the circuitry is where each transducer is in parallel with one another, so each transducer emits and receives the mechanical wave at the same.

Functionality

The current design was created by a team from a previous senior design project. This design is what this design will be based on from the start, and it meets a fair number of the basic functional requirements. The current design can send out pulses in a directed beam forward using an array of 10 transducers. It is then able to plot the distance to an object on a 2D GUI. It unfortunately does not have the capability to direct the beam in any direction other than straightforward as no phased array designs were implemented in this iteration. It also falls short in some of the circuit design requirements such as the power supply not being able to supply enough power for the circuit to work at its full capacity.

4.7.2 Design 1 (Design Iteration)

Include another most matured design iteration details. Describe what led to this iteration and what are the major changes that were needed in Design 0.

Will update this design when we begin implementing next semester.

Design Visual and Description

Include a visual depiction of this design as well highlighting changes from Design 0. Describe these changes in detail. Justify them with respect to requirements.

4.8 Technology Considerations

Highlight the strengths, weaknesses, and trade-offs made in technology available.

Discuss possible solutions and design alternatives.

4.9 Design Analysis

- Did your proposed design from 4.7 work? Why or why not?
- What are your observations, thoughts, and ideas to modify or iterate further over the design?

5 Testing

5.1 Unit Testing

The display of objects will be tested individually by running fake data to initially set up how the screen will look when an object is detected. This will then be modified to include real-time data. To test the real data, we will use a few transducers and a receiver to see what sort of voltage values we will be getting from the receiver. This will tell us how much adjustment we must make to the signal to make use of the full-scale data range within the ADC of the microcontroller. We will then make sure that we can read these voltage values with our microcontroller.

5.2 Interface Testing

With our project, we have our hardware design that sends data to our UI. This process will have to be tested both on the hardware side with being able to send and receive data to then be used for the display on the software side. We can also test the waveform with an oscilloscope to ensure that what we are receiving is what we are reading from the microcontroller.

5.3 Integration Testing

For our testing we have a few critical components that must work together. Our voltage supply must work correctly alongside our transducer set up and our receiver set up. We will also need to ensure that it all works at the voltage level that our microcontroller operates at. To accurately test each part, we will have to take it step by step. First, we will test our voltage regulator and figure out what voltage exactly it will output. Then we will use this voltage output as the source for our transducer and receiver circuit. Since we will be testing them separately, we will set our waveform generator output to be the same as the output of our voltage regulator.

5.4 System Testing

After integration testing, we will need to do test the whole system all together. We will have to physically feed the regulator circuit into the transducer circuit to ensure that everything functioned properly as when we did our integration testing. Simultaneously we will need to have the receiver circuit working and prepared to capture all data that is returned to the receiver. After we have all these things, we can assume that our system as a whole works properly.

5.5 Regression Testing

Since this will be baseline testing for the ideas of how a transducer and receiver work, there will be no critical features that are currently implemented that work correctly. We generally do not want to break the transducers or receiver however, so before we plug any of those things into a circuit, we need to make sure that we will not go over the voltage or current limit. We will have to reference the data sheet and add a series resistor according to the specifications of the transducer/receiver.

5.6 Acceptance Testing

Since this first semester is focused on research and planning, we are spending most of our time understanding each component needed to make the system work effectively. We have created a list of milestones and issues that follow along with our project requirements so we can account for all requirements being met. We will then test the system with our client and make sure that it is to their standards or make any changes they deem necessary.

5.7 Results

Though we have not gotten to testing yet, we do have access to the data from last year's senior design team and are confident that our design will work in the same way that theirs did. We do not expect to have to change the gain, the type of transducers, or the type of receiver that we will be using in our design. The fundamental ideas behind how things work will not change from our design to theirs.

6 Implementation

This next semester will be the start of our implementation. Many goals will need to be accomplished in this time frame to ensure the project is working and to the standards laid out by us in the fall 2023 semester. The goals we look to accomplish this semester are as follows:

- Create a power supply capable of producing 12 volts.
- Figure out the best way to create a 40 kHz wave, either with the MCU or an oscillator.
- Successfully emit and receive a signal using the transducers and receiver.
- Create filters that get rid of unwanted frequencies while maintaining the information we are looking for.
- Interpret the data into a graphical user interface with clear imagery.
- Create a phase input on the GUI that the user can use to change the phase angle.

As we go through our actual implementation next semester, we will we update this portion to include the processes needed to implement our testing.

7 Professionalism

This discussion is with respect to the paper titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 Areas of Responsibility

Area of Responsibility	**Definition**	**NSPE Canon**	**IEEE Code of Ethics**	**Difference from NSPE**
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence. Avoid deceptive acts.	To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations	The NSPE is more hard set on not undertaking anything outside of your expertise. The IEEE code of ethics maintains that it's alright to take on task as long as they have the qualifications OR after being informed of pertinent limitations

Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	To avoid unlawful conduct in professional activities, and to reject bribery in all its forms	The IEEE code of ethics doesn't focus much on the employer as much as it does personal morals. Aside from avoiding bribery there isn't much to be said for the IEEE Code of ethics in the realm of Financial Responsibility.
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	To improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems	NSPE states to provide information in an objective and truthful manner so that people can see only the facts. IEEE differs by stating that people should not only be aware of the information but also understand it so that they are truly aware of what is going on.
Health, Safety, and Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public.	To hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment	These two are actually very similar to each other and both hold the safety, health, and welfare of the public paramount. The IEEE Code of ethics goes a bit more into promptly disclosing factors that might endanger the public.
Property Ownership	Respect property,	Act for each employer or	To avoid injuring others, their	The only real difference between

	ideas, and information of clients and others.	client as faithful agents or trustees.	property, reputation, or employment by false or malicious actions, rumors or any other verbal or physical abuses	the NSPE and IEEE Code of ethics here is that the IEEE states not damaging the property of others while the NSPE only focuses on clients and employers.
Sustainability	Protect environment and natural resources locally and globally.	N/A	To strive to comply with ethical design and sustainable development practices	There isn't anything to say for the NSPE in terms of sustainability whereas the IEEE has a statement for complying with sustainable development practices.
Social Responsibility	Produce products and services that benefit society and communities .	Conduct themselves honorably, responsibly, ethically, and lawfully to enhance the honor, reputation, and usefulness of the profession.	To improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems	The IEEE code of ethics states responsibility for having the public understand new and emerging technologies. The NSPE however focuses on the honor, reputation, and usefulness of the profession rather than the public.

7.2 Project Specific Professional Responsibility Areas

Area of Responsibility	**Project Correlation**
Work Competence	High: Our team is striving to make sure that our work is complete and well thought out. We don't plan on skipping any corners and expect the final design to not only work but also be reliable.
Financial Responsibility	Medium: This responsibility doesn't really coincide with our project a lot, however; we are making sure that the cost doesn't exceed reasonable limits in order to not waste funds. We are making sure that our product is able to work as intended without going well over what is necessary financially.
Communication Honesty	Medium: Whenever there is communication needed with our client and TA, we are making certain that they are well informed of our progress. We've been able to turn to them for help when we needed it before and plan on continuing this as we make more developments in our project.
Health, Safety, and Well-Being	Low: Our project poses virtually no safety or environmental hazards that need to be acknowledged.
Property Ownership	Medium: We have made sure to cite others work when referenced in our project as well as learn from the work of the group preceding ours. By respecting the work that they have done we have been able to learn a lot to be able to improve upon their design without outright copying it.
Sustainability	N/A
Social Responsibility	Low: Our work on this project doesn't have much to tie into social responsibility. Most of what we are doing doesn't further research in a particular field and is something that has been done before in different ways. We also don't hold much responsibility with the reputation of others outside of the team and those related to it.

8 Closing Material

8.1 Discussion

Not available until final design is completed next semester.

8.2 Conclusion

So far for our project, we have generated a deep understanding of how an ultrasonic sensor works, how to change the phase angle, and the circuitry and power supply to support an array of 12 transducers and 12V of power. Once we have our parts delivered, we will immediately begin working on the issues we have split up in our Git Lab, so no time is further wasted. Once a task is completed, we will continue to have meetings to demonstrate how it works and its success. Because there was a lot of research and documentation to do this semester, we fell behind in making a decision to order the parts sooner. For future reference, it is recommended that we order the parts earlier as we did not expect the delivery of products to take 6 weeks. We ordered our products Nov 29, 2023.

8.3 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

[1] N_Tech, “Radar using Ultrasonic Sensor and Arduino,” YouTube. Jun. 20, 2021. Accessed: Nov 20, 2023. [Online]. Available: https://www.youtube.com/watch?v=NwmcNCvUcDc

[2] “DIY sonar scanner (practical experiments),” YouTube. Feb 19, 2022. Accessed: Nov 20, 2023. [Online]. Available: https://www.youtube.com/watch?app=desktop&v=z4uxC7ISd-c

8.4 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.

8.4.1 Team Contract

Team Members:

1)	Logan Kinch	2)	Jacob Elliott
3)	Joseph Hansen	4)	Viola Newman
5)	Christopher Penne	6)	Julia Falat

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:

   Wednesday from 10 – 11 am at the TLA in person. If someone is home because they are sick, we will have one person go into the discord so they can join and be part of the group as the rest of us are face-to-face.

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):

   Discord for when we are not in person to make day to day updates and communication. For reminders, we will put in our meeting times on a shared calendar. To catch up with the client, we will use email as our main source, but will use our monthly in person meeting as our main source of updates.

3. Decision-making policy (e.g., consensus, majority vote):

   For all decisions that affect the team, we will state our cases for either side and make a majority vote on the matter and whichever side has the most votes will be the decision.

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):

   Julia Falat will be our record keeper as she is taking on the role of being the team organizer. She will be sharing the meeting notes to a designated Discord channel for meeting notes so everyone can have access to these notes and look back at them when needed.

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:

   We expect everyone to show up to the team meetings as this will be our time to get most of our collaborative work done. It is okay if a person is to show up late, as long as they give a heads up that they will be running late. Participation will be required as well as we all need to work together to complete the project.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines: Everyone is responsible for finishing the task that was given to them at level that will move the project forward. It should also be done in a timely manner to keep the project moving smoothly.
3. Expected level of communication with other team members:

Since we are using Discord as our main level of communication, it will be required that our level of communication will be higher because Discord relies on the receiver to contact the sender back in a timely manner. We expect that this process to answer the sender back takes no longer than a day or two.

4. Expected level of commitment to team decisions and tasks:

   The level of commitment to team decisions will be 100% as we will ask everyone their opinion on the matter before we vote. This vote will include all members and therefore all members must be committed to the decision at hand.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):
   a. Julia – team organization, embedded programmer
   b. Viola - Client interaction, Weekly Report
   c. Logan - Head Programmer, Website Maintenance
   d. Joey – Circuit layout expert
   e. Chris – Power supply expert
   f. Jacob – Troubleshooting
2. Strategies for supporting and guiding the work of all team members:

   Communicate with them through discord and in person if anyone needs help. Use the Git Lab Issue board to monitor work progress and have the issue owner talk about what they are working on or stuck on.

3. Strategies for recognizing the contributions of all team members:

   We will use the website to individually record which things each team member has contributed to the project.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.
   a. Julia - Agile, project management, embedded systems, C, Verilog, VHDL
   b. Viola - Circuit analysis skill along with basic signal understanding. Efficient communication skills and detail oriented. Can create documentation that is easy to follow.
   c. Logan – C, C++, Python, JavaScript, Java, Groovy, HTML, Team projects, Agile methodology
   d. Joey- PCB design, soldering, and communications systems experience.
   e. Chris – Power supply circuit design, high speed data circuit design, PCB layout. Previous experience with schematic reviews and technical design presentations/documentation
   f. Jacob- PLC, Circuit design and testing, communication skills, PCB layout
2. Strategies for encouraging and support contributions and ideas from all team members:

   At them in discord to encourage them to give their ideas on the topic. When meeting in person asking everyone’s opinion so more ideas flow giving an overall better project. Look at our Issues board and if any are in the blocked section, we will have the Issue owner give a reason for why it is blocked.

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)

   Monitoring the different tasks on our board and messaging people when the task is hindering others from moving forward.

Goal Setting, Planning, and Execution

1. Team goals for this semester:
   a. Deep understanding of requirements
   b. Organized communication channel for storing notes and group work.
   c. Create Milestones in Git and Issues under each Milestone.
   d. Detailed Design document
   e. List of what we want on our team website.
2. Strategies for planning and assigning individual and teamwork:

   Create Git Milestones and Issues under those Milestones so that we can pick and choose which task we will want to work on for the sprint.

3. Strategies for keeping on task:

   Review sprint tasks every meeting and discuss progress. Assign issues that need to be completed. Keep up good communication when running into issues that block progress.

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?

   We will discuss the issue as a group and see if we can come up with a resolution to the issue.

2. What will your team do if the infractions continue?

   If the issue cannot be solved by group intervention, we will consult one of our TA's or our professor to see if they have any remedies to the situation.

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a) I participated in formulating the standards, roles, and procedures as stated in this contract.
b) I understand that I am obligated to abide by these terms and conditions.
c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) Joseph Hansen DATE 9/6/23
2) Viola Newman DATE 9/6/23
3) Christopher Penne DATE 9/6/23
4) Jacob Elliott DATE 9/6/23

5) Logan Kinch DATE 9/6/23
6) Julia Falat DATE 9/6/23