Ultrasonic Radar

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Executive Summary

Development Standards & Practices Used

- Pulse Compression - this will be a standard to get a range of power over time
- There are not many other standards that will be used, many things will be adjusted and changed to make the radar function properly.
- The very first area of IEEE responsibility, work competence, has been very important to our project. This aspect is so important because it is very easy for us to disregard this project and put in minimal effort, but that would be ethically wrong.

Summary of Requirements

- Designing circuits to change phases to each transducer to control the scanning directions.
- Transducer, used as both transmitter and receiver.
- The mechanical wave is reflected back from any objects and detected by the transducer.
- The time delay in the pulse-echo can be used to calculate the distance of the objects.

Applicable Courses from Iowa State University Curriculum

- EE and COM S courses, none in particular, but all helped in specific ways.

New Skills/Knowledge acquired that was not taught in courses

- Working with arduino code and hardware not used in classes
- Teamwork and time managing
- Phase array and different methods of transmitting and recieving

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1 Team

1.1 Team Members

Kevin Czerwinski

Derek Thomas

Samuel Rosette

Ryan Foster

Jack Riley

Abubaker Abdelrahman

1.2 Required Skill Sets for Your Project

Some of the required skill sets for our project would be a general knowledge about coding because of the microcontroller we are using. A range of professional and communication skills are also required to make sure the team can work efficiently.

1.3 Skill Sets covered by the Team

For the most part, everyone covers the required skill sets.

1.4 Project Management Style Adopted by the team

Agile

1.5 Initial Project Management Roles

Kevin, Samuel, Ryan, Jack, Abubaker - Electrical Engineers

Derek - Computer Engineer

2 Introduction

2.1 Problem Statement

For our project, the final desired purpose is to detect insects in the air with high precision. The specific reason for detecting the insects in the air was not given to use but it could be used in many applications ranging from pest control, to monitoring the insect count in an area for environmental purposes

2.2 Intended Users and Uses

This product will be used by anyone that needs to be able to detect insects or small animals in a vicinity. As of right now, we are completing this project for our Advisor and Iowa State University with not much knowledge about who will be using it and what for. This kind of radar could be used by many different people for a range or purposes. If it works well enough with high precision it could be used by professors or students in college to learn more about ultrasonic detection systems. This user is hard-working and eager to learn. The only thing they need is to understand the material in order to teach it or learn more about it. It could also be used by scientists that study the environment and keep track of how healthy an ecosystem is by being able to count the amount of a certain type of insect present in an area. These scientists are trying to find life-changing research which gives their ideas credibility. By using our tool, they will be able to obtain quicker and trustworthy data. An ultrasonic radar could prove useful in many applications.

2.3 Requirements & Constraints

Functional requirements (specification):

- Designing circuits to change phases to each transducer to control the scanning directions.
- Transducer, used as both transmitter and receiver.
- The mechanical wave is reflected back from any objects and detected by the transducer.
- The time delay in the pulse-echo can be used to calculate the distance of the objects.

Resource requirements:

- Should be fairly affordable.
- Parts from online or ETG that are available.

Physical requirements:

- Has to mechanically rotate.
- Should be very durable because it will be used outdoors to detect insects.

Aesthetic requirements:

- Should be appealing or atleast look concise and nothing unneeded.

User experiential requirements:

- Be able to keep track of errors
- Have an idea of what is working and controlled experiments.
- Can see how far the object is at and how wide the object is.
- Other objects shouldn't affect the data. Another object shouldn't be seen as another object causing the object to have a bigger width.

Economic/market requirements:

- Should be affordable because this item will be used outdoors. There are a lot of ways this item can mess up due to environmental factors.

Environmental requirements:

- Make sure there is no harm to atmosphere
- Debris shouldn't prohibit the wave from being sent and received.
- Non-invasive detection of objects and creatures

UI requirements:

- Be able to get 3D like images out of scanning in all directions
- Make radar-like output and show where object is on map
- Return information about the object (distance and general shape)

2.4 Engineering Standards

Some engineering standards that this project will be using include:

- Pulse Compression - this will be a standard to get a range of power over time
- There are not many other standards that will be used, many things will be adjusted and changed to make the radar function properly.

3 Project Plan

3.1 Project Management/Tracking Procedures

For our procedure, we will go with an agile project management style because it would fit our project better. With our project, the requirements are much more lenient without a definite goal we need to achieve so being able to have a lot of flexibility in our management style would help the process. We could change a lot of different things throughout the testing and prototyping of our project so making sure we plan to spend extra time on this would be ideal.

For our project we will use a combination of our progress reports, and discord to make sure we stay on top of our project management.

3.2 Task Decomposition

For our project we have a couple different subsystems that need to be completed which can be viewed as separate tasks. For one task we need to create an array of transducers that are all simultaneously connected to the same microcontroller. We also need that microcontroller to send pulses out through each of the transducers and wait to receive data back from any returning waves. This system will need to be able to take that data and process it into useful information. The next task once we figure out how to read the data, will be to create a useful way of displaying this information. The received data could be complex so finding a way to portray this information on an LCD screen would be the final task.

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

Milestone 1:

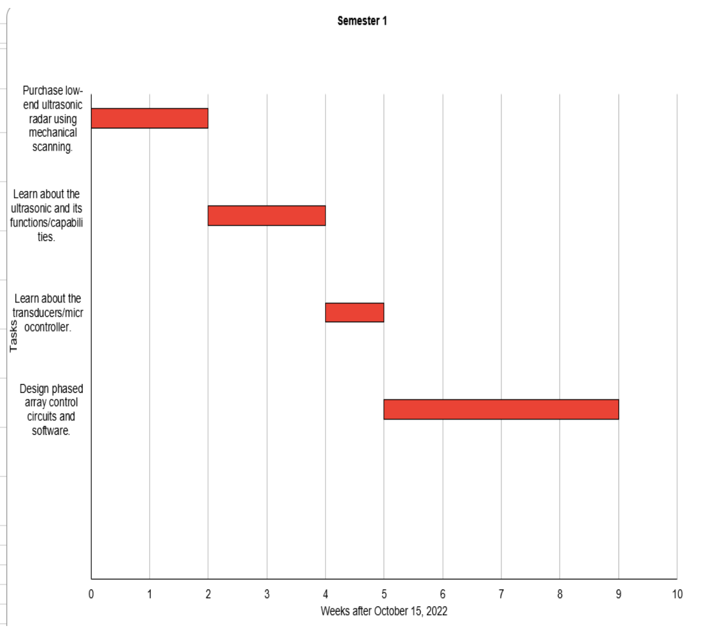
Transducer array can send pulses out and read any signals returned and use this to calculate the distance an object is away from the array with ~70% accuracy.

Milestone 2:
Data received from the array can be processed and displayed conveniently on an LCD screen with less than 20ms delay
Milestone 3:
The ultrasonic radar can function as intended without the need of a computer connection or an input source other than a power supply. It should be able to detect distances with at least 80% accuracy.
*These percentages are assumptions that could be submit to change depending on how accurate the equipment we purchase is.

3.4 Project Timeline/Schedule

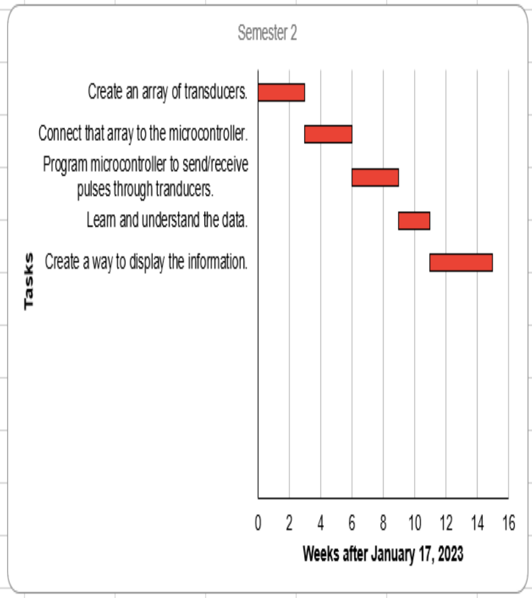
ALL DELIVARABLES WILL BE DEMOED AT ITS CORRESPONDING END WEEK

Task	Weeks after October 15, 2022	Duration
Purchase low-end ultrasonic radar using mechanical scanning.	0	2
Learn about the ultrasonic radar and its functions/capabilities.	2	2
Learn about the transducers/microcontroller.	4	1
Design phased array control circuits and software.	5	4



EACH DELIVERABLE WILL BE DEMOED AT ITS CORRESPONDING END WEEK

Task	Weeks after January 17, 2023	Duration
Create an array of transducers.	0	3
Connect that array to the microcontroller.	3	3
Program microcontroller to send/receive pulses through	6	3
Learn and understand the data.	9	2
Create a way to display the information.	11	4



3.5 Risks And Risk Management/Mitigation

In the first task, a transducer must be used to calculate the distance to the object. Therefore, the risk that can occur in this milestone is that the transducer is not working. In this case, the probability of risk occurrence is 0.5 and in case of failure, a new transducer must be replaced.

In the second task, the data received must be processed and displayed by the microcontroller. The failure in this task will occur if the microcontroller fails to function. The risk probability also in this task is 0.5. In case of failure, the microcontroller should be replaced.
The last task requires a power supply source that helps the ultrasonic radar to function. In this project, batteries are used and there is almost no risk. In case batteries get empty they are recharged or replaced with other ones for a low cost.

3.6 Personnel Effort Requirements

Member	Task 1 - The first task is to create an array of transducers. This will require 3-5 hours.	Task 2 - Now we have to connect the array to the microcontroller. This will require	Task 3 - Need that microcontroller to send pulses out through each of the transducer	Task 4 - Learning and understanding the data is a key point because this is what	Task 5 - Display the output. This will require 3-5 hours.	Task 6 - Whatever else that needs to be done. (5 hours)

		2-5 hours.	s and wait to receive data back from any returning waves. This will require 3-5 hours.	we will output. This will require 3 - 5 hours.		
Jack	1 hour	1.5 hour	.5 hour	1 hour	1.5 hour	.5 hour
Riley	1.5 hour	.5 hour	1 hour	1.5 hour	.5 hour	1 hour
Ryan	1.5 hour	.5 hour	1 hour	1.5 hour	.5 hour	1 hour
Sam	.5 hour	1.5 hour	1 hour	.5 hour	1.5 hour	1 hour
Derek	.5 hour	1 hour	1.5 hour	.5 hour	1 hour	1.5 hour

3.7 Other Resource Requirements

We will need to purchase transducers to use for the array (amount not decided on yet) as well as a microcontroller to interact with each of the transducers. We will also need an LCD screen to be able to display the recorded information.

4 Design

4.1 Design Context

4.1.1 Broader Context

Area	Examples
Public health, safety, and welfare	Though our radar uses a range outside the range of audible frequencies, this radar could still potentially lead to hearing loss depending on the distance and power of our device.

Global, cultural, and social	- Ultrasonic radars are used in various military applications. - Often used in robotics when sensing walls or incoming objects - Can be used to track and log movements and actions of living organisms
Environmental	Since some animals are capable of hearing ultrasonic frequencies, our radar could affect the behaviors of said animals and potentially harm them if proper consideration is not taken.
Economic	- Can be used for research to save money - Could be used in commercial products; increasing civilian spending

4.1.2 Prior Work/Solutions

Some prior work that we have seen with regards to this project uses basic Arduino ultrasonic sensors to send out and receive data that bounces off of an object. In a previous course, most of us had to use one of these sensors on a Roomba to scan an environment. It's a common sensor that is even posted on the Arduino website as a project (LINK). This can be used to create an ultrasonic radar but only contains a single transmitter and receiver. This differs from our project as we need to use an array of sensors to make it much more accurate. Another project we found was a youtube video of a guy that created an array of ultrasonic sensors to view the effect of the interference of all of the emitters (LINK). This is much closer to what we want to achieve, although he is not using it as a radar. He is simply observing the phase shift effect. We also want to use a 2 dimensional array of ultrasonic transmitters, not just a single row of them.

4.1.3 Technical Complexity

Our project becomes quite complex once broken down into the principles required to have it work successfully. Being able to transmit an ultrasonic wave is not a very complicated task, trying to bounce it off of an object and receive that signal to read the distance of the object is much more complicated. Applying that to an array makes it even more difficult. Signal processing will be a huge aspect of our project and could be quite challenging. Making this array work properly would require accurate spacing of the array elements and precise differences in the timing between each ultrasonic pulse that is sent out. Another part of this project that could prove challenging is reading in the data and displaying it on an LCD screen as none of us has had much experience using these types of screens.

4.2 Design Exploration

4.2.1 Design Decisions

Some of the design decisions that we have had to make have a much larger impact on the project than others. One decision that we made regarded the way that we were going to display the information from the radar. We decided that we wanted the radar to work without the need of a laptop being connected to it, so we will use an implemented LCD to show what the radar scans. Another design decision that we will have to make is whether we will use a matrix arrangement of the ultrasonic emitters or if it benefits us to align them in a different orientation. Different patterns could create a more accurate radar. We also need to choose the type of controller we will use for the radar. An arduino microcontroller would be cheaper and easier to interface with, but a raspberry pi would be faster and would allow for more complexity in the design with a higher cost to it. This is another important decision that could greatly change the amount of time we need to spend on the project.

4.2.2 Ideation

One design decision that ideation played a big role in was the orientation of the ultrasonic sound transmitter array. There are many different ways that we could align these emitters that would all create different constructive interference patterns. We could have a single transmitter, a row of them close to each other, a two by two matrix filled with emitters, we could arrange them in a circular pattern, or we could even try an eccentric design like a star or ellipse created out of ultrasonic emitters. Each different shape would have a different effect on the radar, some being more effective than others.

4.2.3 Decision-Making and Trade-Off

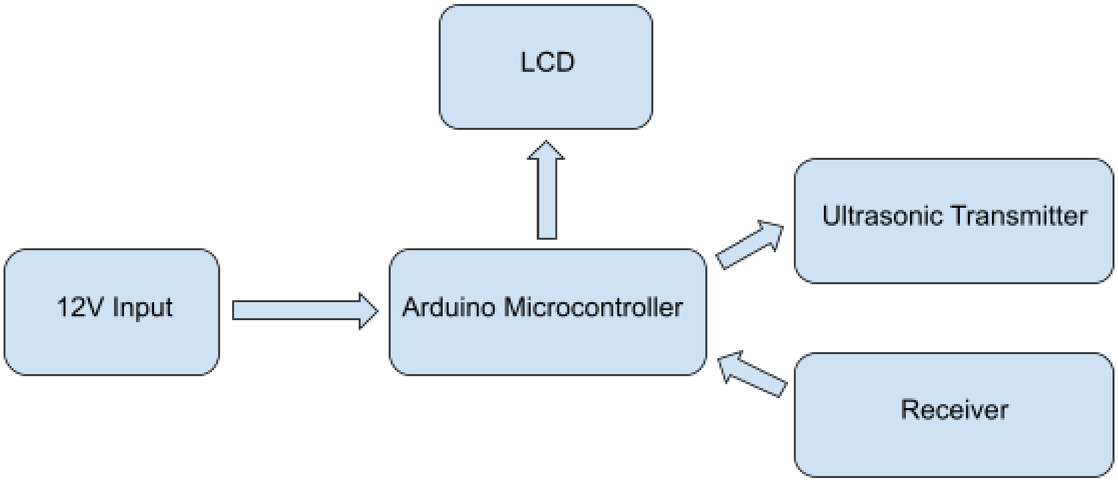
The following decision matrix uses a scale of 1-5 with 5 being the highest score.

		Single Transmitter		Row of Transmitters		Matrix of Transmitters		Circular Pattern		Star Pattern		Ellipse Pattern	
Criteria	Weight	Score	Total	Score	Total	Score	Total	Score	Total	Score	Total	Score	Total
Cost	0.5	5	2.5	2	1	4	2	3	1.5	4	2	5	2.5
Complexity	0.6	1	0.6	3	1.8	4	2.4	4	2.4	5	3	4	2.4
Ability to Scan in Different Directions	0.8	1	0.6	4	3.2	5	4	4	3.2	3	2.4	3	2.4
Ease of Production	0.3	5	1.5	4	1.2	3	0.9	3	0.9	2	0.6	2	0.6
Accuracy	0.7	1	0.7	3	2.1	5	3.5	4	2.8	3	2.1	3	2.1
Total			5.9		9.3		12.8		10.8		10.1		10.1

In the end we decided to move forward with the matrix array of each ultrasonic transmitter. This one would allow for the highest accuracy without being as complex as some of the other choices.

4.3 Proposed Design

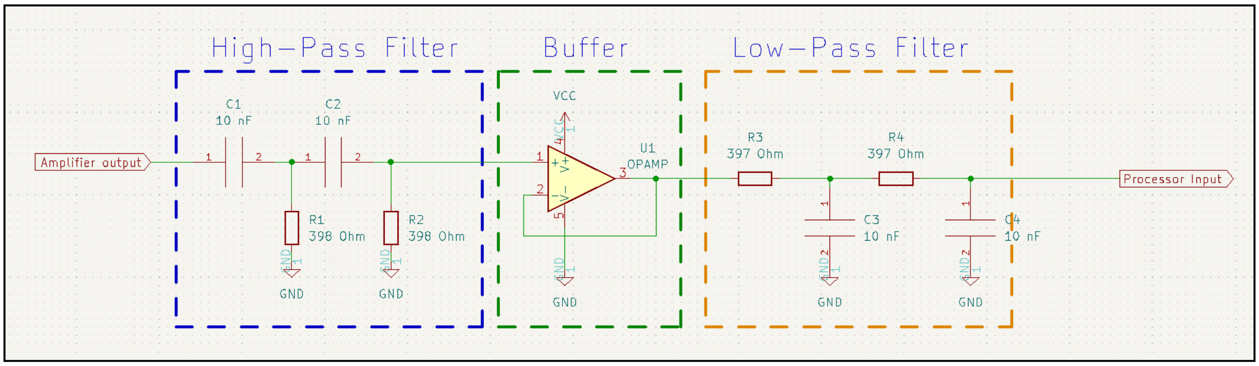
4.3.1 Overview



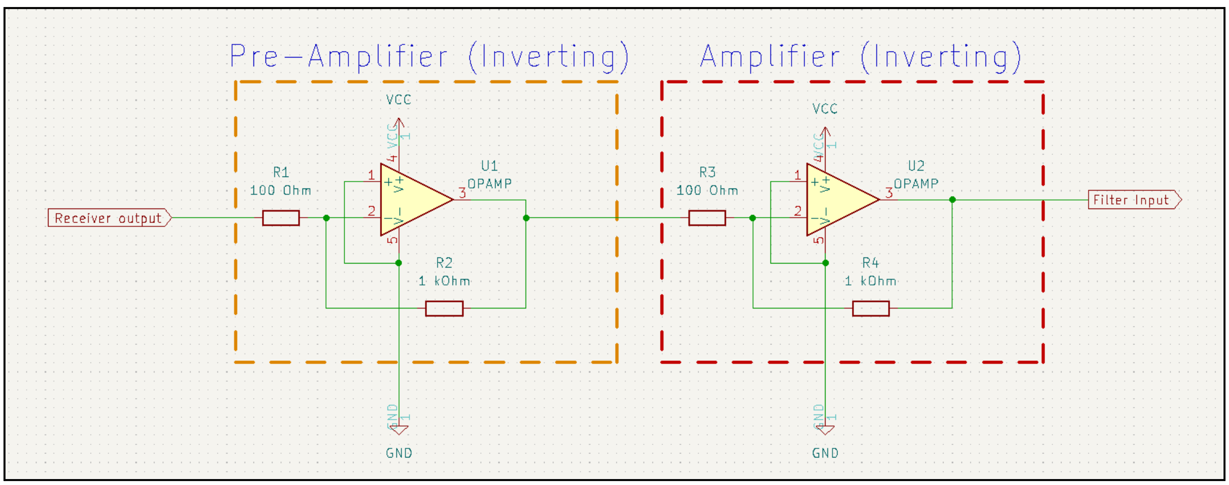
The design will be composed of a microcontroller connected to the transmitters and receivers with code written for sending and receiving the signals as well as the data processing. Once the information is properly calculated, it will display the objects detected on the LCD display and show their distances as well. All of this will be powered by a 12V input.

4.3.2 Detailed Design and Visual(s)

Our design will require a 12V input from a DC plug which will power an arduino microcontroller. Using this microcontroller we will be able to send out ultrasonic pulses that will reflect off of objects in front of the array of transmitters. This reflected signal will be picked up by the receiver. By using the speed of sound and the time taken for the signal to be picked up, the microcontroller can calculate the distance of the objects. The angle will be determined by the phase shift in the transmitted signals. With this data processed, an LCD will be included to display the data which would make the device easier to use without requiring any extra equipment. A button will be used to begin the scanning process.



The above pictured stages of filters will be used to filter out any unwanted noise in the signals and the amplifier circuit pictured below will be used to amplify the power going into the transmitters. Amplifying the power allows the radar to have a further effective range.



4.3.3 Functionality

Our design is intended to be used to detect small insects. If there is a field in which insects would need to be detected either in farming or whatever situation, this radar can be used. It is meant so that proper pesticide can then be sprayed and humans do not have to constantly monitor the field.

4.3.4 Areas of Concern and Development

The current design is only our first rough design. We are in the process of getting the right transmitters and receivers we need. Once we get that done, we can worry more about the phase array aspect and then how to output the data. Our primary concerns would include if this idea is actually needed and if companies would invest in such a thing. Is it too hard to operate and maintain? Is it too finicky and will it break fast? Immediate plans include to create a sturdy hardware setting for it and also test it fully so it can be reliable.

4.4 Technology Considerations

We are currently using propagating sound waves to gather spatial information. More specifically, we are arranging a series of transducers in a grid to send sound "rays" whose direction is determined by the constructive and destructive interferences within the sound wave. This arrangement is called a *phased array.* Many alternatives exist; one of the most popular being electromagnetic (EM) rangefinding. EM rangefinding uses a similar principle, however, the molecular compressions and rarefactions are replaced with fluctuations in the electric and magnetic field. There are a number of benefits and drawbacks involved with using this technology in opposition to other alternatives such as electromagnetic-based range finding.

One of the main benefits of this technology is simplicity. With methods such as EM rangefinding, we must take into consideration transmission line effects. At frequencies in the RF range, simple wires begin to exhibit overwhelming parasitic behaviors. As a result, the designers must design multiple complementary circuits, along with ensuring that the length of every intermediate wire does not exhibit detrimental parasitic effects. Ultrasonic sensing does not share these drawbacks, as signals in the kilo-Hertz range do not cause high impedance in basic, small-scale wiring. Another benefit is the lower precision threshold. The velocity of a sound wave through any medium will be orders of magnitude slower than light. This means that the equipment needed to realize a traveling sound wave is accessible to developers at a much more affordable price.

One of the major drawbacks for ultrasonic sensing is the reduced applicable range. Ultrasonic sensing is often impractical at distances greater than a few meters unless adequate power is provided. This is due to the fact that this sort of detection naturally comes with a much lower signal-to-noise ratio. While EM also suffers from noise disturbances, sound waves are considerably more susceptible to noise than EM. Due to the rapid oscillation and propagation speed of EM communication, these noise effects can be mitigated using codes and many propagation cycles. Ultrasonic sensing however does not share this luxury. Not only do sound waves suffer from somewhat unpredictable dispersion patterns, heavy temperature dependance, and molecular drift (wind) dependance, but the oscillation frequency and velocity of large particle-based wave propagations will always be orders of magnitude slower than that of light.

4.5 Design Analysis

So far we have made a simple prototype of an ultrasonic radar. This has allowed us to familiarize ourselves with a lot of the basic functions that we will need to use when we make the final phase array ultrasonic radar. Something that we need to change is using more transceivers. Moving forward we plan on using an array of transducers. This will allow us to have a wider range that we can scan. Our next step is to build a prototype phase array and start to work on being able to change the direction of the output signal to give a scanning effect of a large area.

5 Testing

For our project, testing will be heavily focused on the accuracy of the scanning capabilities of our radar. Since our ultrasonic radar will need to be able to scan a range, we will also need to test its accuracy on objects that are not placed directly in front of the array. So for our testing we will accurately measure out distances in front of the radar and place objects that can be noticeable detected by it. We will then run the scan and see how well the radar works with picking up an object in front of it vs at an angle. A test will also be completed using smaller and smaller objects to see how small of an object can be detected by our radar.

5.1 Unit Testing

The specific ultrasonic transmitters and receivers are being tested. These components are the most important part of the project, the more accurate they are the better the radar works. We will test them throughout the implementation of the radar, with upgrades most likely needing to be done in the future.

5.2 Interface Testing

There are a few interfaces in our design. Primarily we have the mechanical radar and then we have the software that is separate, but reliant on the radar. I think these two interfaces will need to both work fully for the overall project to succeed and for us to reach our goals. In order to test both, we will have input and output comparisons. So, we will see the mechanical output from the radar, and when connecting it to the software, we will cross-check to see that the input going into the software is the same, to make sure there are no discrepancies in the passage of I/O. Some tools we will use include measurement tools that are functional without mechanical pieces, and then a display and perhaps a code script to run on the software.

5.3 Integration Testing

There are some key critical integration paths, some smaller than others, but all important. We know that the transmitters, whether transmitting or receiving, have to integrate with each other flawlessly for us to get the feedback we desire. In order to test this, we will have to generate sound waves in specific patterns. When we visualize the output, we should see a trend given the sound waves we generate and then we can see how far off or how close we are to the expected results. Another critical integration path is then when translating what the radar detects to an LCD screen or computer software. In order to get this translated and tested, we will create a testing software script to check our integration of software alone and the software communicating with the hardware.

5.4 System Testing

In order to test our device, we must take into consideration a few parameters. We must define accuracy, precision, range, and additional capabilities. An example of an additional capability is the ability to detect objects behind other objects; which has been emphasized that this is a rather difficult task. The tools that can be used to determine the accuracy and range could involve a testing rig. This rig could use a set of objects to be detected in a field. These objects must have known dimensions and would be placed a known distance from our sensor. Precision in our case would be defined by the smallest spatial resolution that our device can detect. We could use the previously mentioned range rig for this test as well. Using objects of incrementally decreasing length and width, we can determine the resolution of our sensor at different distances; which corresponds to the precision of our device. Finally the additional capabilities can be measured by simply placing two small objects (such as two pens) in front of one another. If we can detect the more distant object, we can confirm the additional capability parameter of our project.

5.5 Regression Testing

In order to avoid going backwards and breaking anything that we knew were working from testing, we will have checkpoints. Just like a video game has checkpoints, when our code fails or the test fails, we will have it saved to the last point as to which all tests were passing or majority was. This way we will not lose any work done and we will be able to see how far we have gotten without errors and we can move up from there. In order so it will not break, we have to make sure our system is rigorous and the testing is multifaceted. The requirements will be specific and based on what the software and hardware needs and we are still figuring out what specific tools will be used, but we have the overall idea.

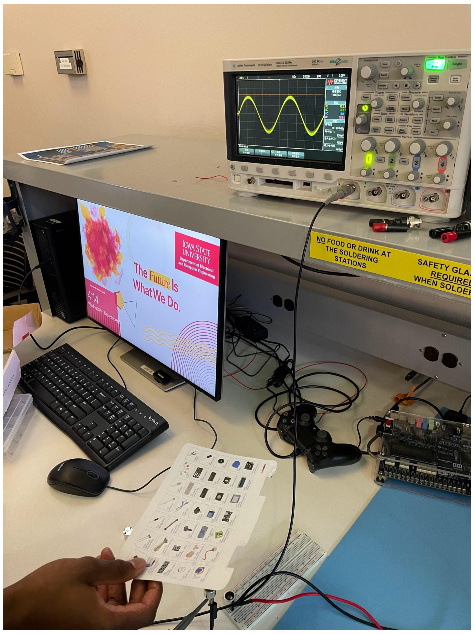
5.6 Acceptance Testing

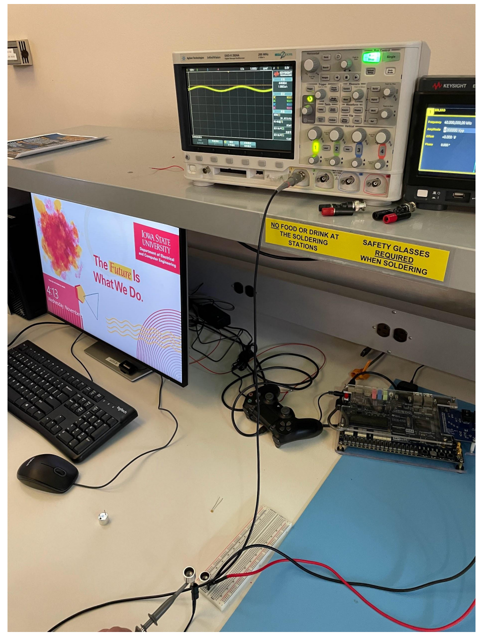
The purpose of the first semester is to understand every single component of our project. That being said, we're experimenting with the transducers, and circuitry to accomplish the goals of the project. Once we find what works best for our project, we will incorporate it into our ultrasonic radar next semester. Every two weeks, we will show our advisor that the desirable results are being obtained. This will keep our group accountable and on track to meet all the functional and non-functional requirements. Once we complete everything, we will give our advisor directions on how to use the ultrasonic radar. He should then test the ultrasonic radar by himself to detect moving objects. We will have no control of the ultrasonic radar which will show us if a typical user might run into any problems that we didn't see. This will show us if we need to do any last minute fixes to the ultrasonic radar and software.

5.8 Results

Tested a single ultrasonic transmitter and receiver to see how accurately a wave can be received after bouncing off of an object. The initial test looks promising, we connected a 3V peak to peak wave at 40kHz to the transmitter and the receiver was able to accurately pick it up after reflecting off an object with minimal distortion. With an amplification circuit, the transmitted wave would have more power and would be able to travel further which would allow for higher accuracy. We are waiting for parts for an amplifier circuit before we can test a full array. This document will be updated with further testing results.

The images below show the testing of the transmitter and receiver. The transmitter is hooked up to a function generator that's set up to output a 3 V peak to peak 40 kHz wave and the receiver is connected to the oscilloscope. On the left it shows that when an object is placed in front of the receiver/transmitter setup, there is a reflected wave picked up on the oscilloscope. The right image shows the setup without any object.





6 Implementation

For the next semester, our team plans on getting much more in depth with our project. We used this semester more as a planning process to be able to figure out just what we need to do to accomplish our goal.

7 Professional Responsibility

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

IEEE talks about work competency in its I part. Financial responsibility is mentioned in I4. They say to not fall into bribery. So it is different from the NSPE because NSPE talks about reasonable price and cost, but IEEE doesn't mention that. It does say to treat people with respect though, so it could be related.

7.2 Project Specific Professional Responsibility Areas

The very first area of responsibility, work competence, has been very important to our project. This aspect is so important because it is very easy for us to disregard this project and put in minimal effort, but that would be ethically wrong. This is a professional activity that we should be, and have been, highly involved in. We all make sure to put in the highest standard of work possible to ensure this is a project that we can all be proud of.

8 Closing Material

8.1 Discussion

As of right now we have made a large amount of progress on our project. We currently have plans for hardware and software and have a good understanding on how we want to accomplish our goal. We have done testing on parts we would like to use as well. Overall we are still a bit behind with the stage that we were planning to be at by now due to issues with software but we plan on catching up next semester.

8.2 Conclusion

Our goal for this semester was to get some plans going for our ultrasonic radar project as well as to begin ordering parts. We were able to get most of this achieved. We have been having issues lately with software, but other than that, our project has been moving along as planned.

8.4.1 Team Contract

Team Members:

1) ____Kevin Czerwinski_____________ 2) _____Derek Thomas____ _

3) ____Samuel Rosette______________ 4) _Abubaker Abdelrahman_________

5) __________Ryan Foster__________ 6) ___________Jack Riley____________

7) _______________________________ 8) _______________________________

Team Procedures

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

Meetings every Wednesday from 3-4 pm, face to face or virtual depending on what we need to achieve.

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

Preferred method of communication for all important updates is Discord

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

For decision making we will try to have unanimous decisions that everyone is in favor of, in the case of a disagreement we will proceed in a majority vote. We have an even number of people so if split evenly we will ask for outside opinions from either our advisor or our professor to come to an agreement.

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

We will decide on a note taker for each meeting. We will probably have a rotation going and we will have a shared document to keep record of our meetings and work we got done.

Participation Expectations

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

Everyone is expected to come to every meeting they are able to attend, if not able to then they are expected to let the rest of the group know beforehand that they cannot make it. Participation from everyone is expected as well.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

Everyone in the team is expected to share responsibility equally and stay on top of deadlines and timelines. Each member should be aware of upcoming assignments and be able to complete their share of work. If someone is unsure on how to complete their task, then they should let the rest of the group know in advance. This can help avoid a situation where a deadline is missed.

3. Expected level of communication with other team members:

Everyone should let it be known if they got something done, if they are late on something, or if there is anything they feel the need to communicate. We prioritize communicating over not getting work done cause we are all here to help each other.

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

Everyone should have an equal amount of commitment to this project. We should all aim to put the same amount of time per week into this project. For all the decisions and tasks, everyone should give an opinion so we can get the best results.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):

As a team we will decide on the leadership roles as time comes. Throughout the first few weeks of actually working, we will get an idea on who is being more of a leader in which category, so we'll come back to update as needed.

2. Strategies for supporting and guiding the work of all team members:

We can have a checklist on our meeting notes and that way people can initial when they complete work and also for other team members to keep track of progress.

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

To recognize contributions, we can at the meetings go through and recognize people who completed most tasks. Also, people should go around and say what they have completed.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

Each person on the team comes from a different background and specializes in a different aspect of each of our majors. This variation of skills and knowledge creates an atmosphere in which everyone is able to provide their own unique perspective on our project. Some of the fields in our group are power, electronics, signals, electromagnetics, and software.

2. Strategies for encouraging and supporting contributions and ideas from all team members:

Keeping an open mind and assessing the pros and cons of each idea should be a priority to keep all members of the group engaged

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?)

Speaking up is really the only way to stay involved. We are all adults and that's how the world works.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

Obtain an A in the class.

Everyone will develop a new skill (This can be from the programming or hardware aspect of the project).

2. Strategies for planning and assigning individual and team work:

Individual work will be assigned to each individual based on their preferences and strengths.

3. Strategies for keeping on task:

All members of the group are aware that a grade is dependent on staying productive. To help the group is to help the individual.

Consequences for Not Adhering to Team Contract

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

We will reach out to that team member and ask them what is wrong. We will try to be understanding if they have a reasonable explanation. However, we won't allow it to be a continuous behavior. A warning will be given.

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

If the issues continue, we will have to notify our professor, client, and advisor.

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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) ___________________Ryan Foster____________________ DATE ___12/07/2022_______

2) ___________________Kevin Czerwinski________________ DATE ___12/07/2022______

3) ___________________Samuel Rosette_______________ DATE ______12/07/2022____

4) ___________________Abubaker Abdelrahman_________ DATE _____12/07/2022_________

5) ______________Derek Thomas___________ DATE _______12/07/2022___________

6) ______________________Jack Riley_______________ DATE ___12/07/2020________