4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

The first key decision is that we are using the STM32 microcontroller app to analog our ultrasonic sensor coding and connect to the main board to deal with the high frequency distribution. And Second key decision is that we used C code to run the system in Arduino for ADC channel explorers. The third key decision is that our high frequency ultrasound signal systems are sensitive to noise and interference, which will improve our receiver positions with more accuracy and consistency.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish to include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

For 4.2.2 and 4.2.3, we were handed a design and were told to develop it. Because of this much of our design was already set in stone and we have minimal room for modifications. The design we were provided does seem to be well thought out and makes logical sense.

4.3 Proposed Design

4.3.1 Overview

Our proposed design is separated into 3 large parts. The first part is the data gathering part, the next is the data transmission and finally ending with the receiver and display. The data gathering portion of the project is what is connected to the testing equipment, the part of the project that is reading the information and gathering the data. The next section of the project is the data transmission, which is cleaned up by an amplifier and sent through microchips to be changed from analog data to digital data to then be transmitted over the wifi or bluetooth. The final subset of the project is the receiving end and the way the data is shown on the receiving device. That device is connected to the transmitter through the same wifi or bluetooth and the display is going to show in the form of a graph that one can interact with.

4.3.2 Detailed Design and Visual(s)

Provide a detailed, technical description of your design, aided by visualizations. This description should be understandable to peer engineers. In other words, it should be clearly written and sufficiently detail such that another senior design team can look through it and implement it.

The description should include a high-level overview written for peer engineers. This should list all sub-systems or components, their role in the whole system, and how they will be integrated or interconnected. A visual should accompany this description. Typically, a detailed block diagram will suffice, but other visual forms can be acceptable.

The description should also include more specific descriptions of sub-systems and components (e.g., their internal operations). Once again, a good rule of thumb is: could another engineer with similar expertise build the component/sub-system based on your description? Use visualizations to support your descriptions. Different visual types may be relevant to different types of projects, components, or subsystems. You may include, but are not limited to: block diagrams, circuit diagrams, sketches/pictures of physical components and their operation, wireframes, etc.

Each of these subparts of the project break into even smaller parts. The parts in which our group is focusing on are the later two, the transmission and the receiver.

The transmission breaks into 2 separate parts, the ADC with the upgraded clock and the wifi transmitter. The ADC microcontroller will be the STM blue pill for testing purposes so that we can get the code accurate and ready for transmission. We then change to the STM 32H750 for the upgraded clock speed for the final product. This upgraded clock speed will allow for more data samples to be collected and allow for the client request to be met.
The digital data will be sent into the Esp32 microchip so it can be used as an antenna to transmit said data in real time over the wifi. This chip will only be used to transmit the data and will not cause any of the information to be corrupted or changed as it will not change the data in any way. These two will work together, with a simple cable connection, to make it so the data gathered can be seen at a different point in the room. The power for both of these products will be supplied with the power for the amplifier and the main system.

The third subpart of the project, the receive. This part of the project is just a display of the data that is transferred over the wifi using a GUI. The GUI will be programmed by us with a focus on user-friendliness and ease of use in lab settings. A large part of this will be already programmed in the systems and we will be utilizing STM IDE for help with the programming process. This will utilize a few different products in order to work and function, although this is not our main focus.

4.3.3 Functionality

Describe how your design is intended to operate in its user and/or real-world context. What would a user do? How would the device/system/etc. respond? This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

Our wDAQ product will be used within a biomedical laboratory, with a machine that outputs ultrasonic frequencies while spinning at high speeds. Users would attach the wDAQ to this machine to measure these frequencies. Normal oscilloscopes would not be usable in this scenario because of the rotating machine which prevents the use of cables. Our wDAQ will operate the same as a normal oscilloscope otherwise, providing a visual graph of its measurements over wi-fi to a display on a separate device.

4.3.4 Areas of Concern and Development

How well does/will the current design satisfy requirements and meet user needs?

The design will be optimized to most satisfy the wireless and portability needs of the users. Using a wi-fi microcontroller to connect to a display wirelessly, there will be no cables necessary to use the wDAQ. The design has also been made very simple so that hardware components are minimized, creating a small and very mobile device.

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

Our current design may fall short of other products in terms of accuracy of signal readings, which may require more powerful microcontrollers to get better readings.

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

For now, we will proceed with our current design. Since the potential issue outlined above won't be observable until user testing is complete (since our current design is likely to be accurate enough to satisfy users), no hardware upgrades will be made for this version of our product.

4.4 Technology Considerations

On the hardware side of things, we are utilizing the STM microcontroller. The main appeal of these microcontrollers is that they have a 20 Mhz clock, so our data's shape can be maintained and the data presented will be more accurate. We will also utilize another microcontroller to transmit the data to the final display, this microcontroller will also utilize the STM's clock speed to avoid any data being cut off. The STM likely could be swapped out for any microcontroller that also has a 20 Mhz clock speed.

On the software side of things, we will utilize the STM IDE which is necessary to interface with the microcontroller. Within the IDE, C is the programming language that is used. This is a very accessible programming language and all group members are familiar with it.

While our group has not specifically worked on it, an amplifier is also an essential part of this project.

4.5 Design Analysis

So far, we have managed to code the STM to perform a conventional ADC conversion using UART. We also have coded it to perform an ADC using direct memory access (DMA). We know for sure that our STM microcontroller can take an analog signal and convert it to a digital one. Previous groups have also worked on the amplifier, so significant progress has been made on that end.