Daniel Walker Mr. Ohm LiDAR Module Project Summarization

University of Texas at San Antonio, Department of Electrical and Computer Engineering

CPE/EE 4813 ECE Capstone Design II, Spring 2024

Project: Mr Ohm Educational Robot

Project Manager: Lucas Kampe

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1.0: Introduction

Team Triple-B undertook a project to enhance the functionality of Mr. Ohm, a robot designed for educational purposes, by focusing specifically on improving its LiDAR sensor. This included concentrating on the triode mixer, which plays a critical role in the accuracy of distance measurements. By refining the triode mixer, the team aimed to significantly boost Mr. Ohm's capability to map its environment with high precision.

To achieve this, Triple-B's initiative involved meticulous efforts to optimize the conversion gain of the triode mixer. The conversion gain is a pivotal aspect of the LiDAR system that impacts the quality and reliability of the sensor's outputs. By improving this parameter, the team expected to enhance the overall sensitivity and accuracy of the distance measurements. This technical improvement was anticipated not only to bolster Mr. Ohm's performance but also to elevate the educational experience it offers. The enhanced sensor capabilities allow students to engage more deeply with the robot, facilitating a more interactive learning environment.

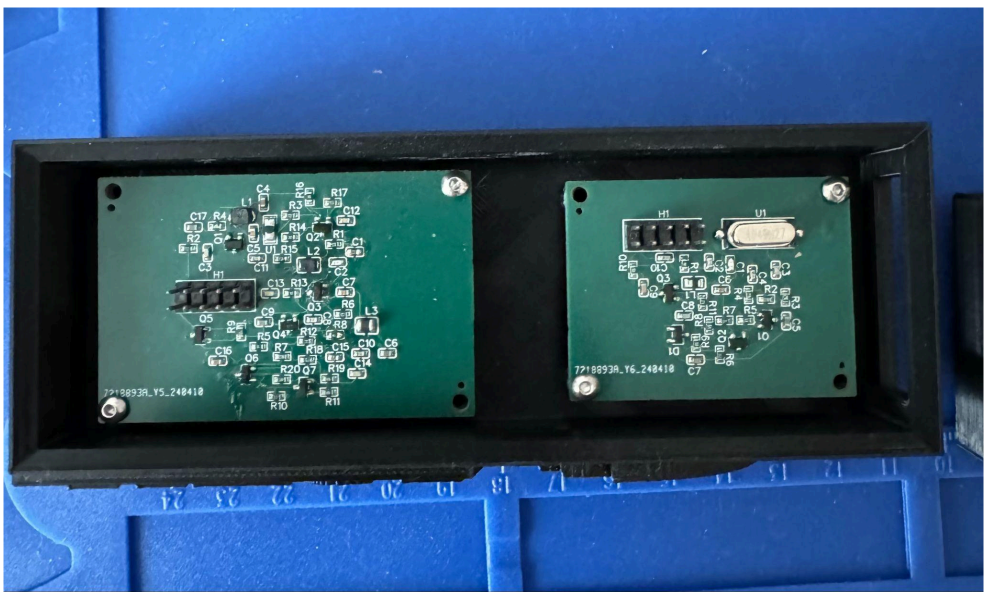

Figure 1: Final PCB Prototype

2.0: Background

Figure 2 shows the block diagram for the LiDAR sensor. The team was responsible for improving and constructing the Pulled Crystal Oscillator, the Tuned Buffer, and Triode mixer, as well as integrating these with the emitter boards from the previous year.

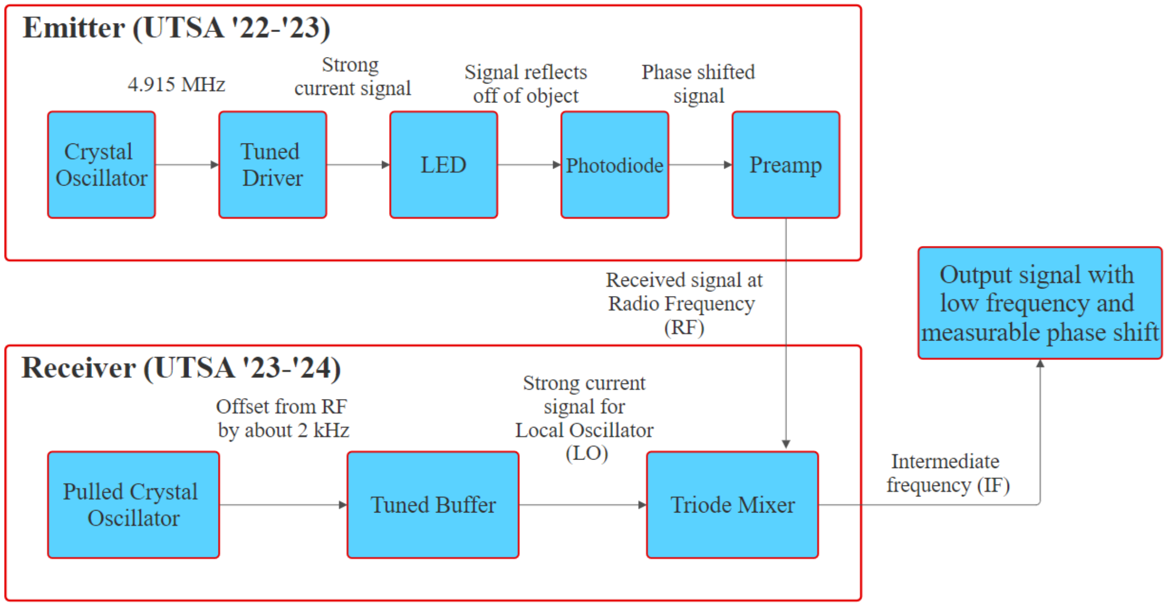

Figure 2: Block Diagram of LiDAR sensor

2.1: Equations

For the LC tank in the Tuned Buffer and Pulled Crystal Oscillator, the most important equations needed were for calculating the values of the components to ensure that the output resonates at the desired frequency, as shown in Figure 3. Equation 1 was used for calculating the inductor and capacitor values to resonate at the desired 4.915 MHz. The value of the inductor was chosen and then used in a formula in LTSpice to calculate the desired total capacitance of the capacitive tap in each stage. Then, Equation 2 was used to calculate each capacitor in the capacitive tap using the output impedance. The values of the components are very sensitive, and small changes can drastically affect the resonant frequency and gain of the amplifier.

$$f_r = \frac{1}{2\pi\sqrt{L_{tank}C_{total}}}, \qquad C_{total} = \frac{1}{(2\pi f_r)^2\, L_{tank}} \qquad (Eq.1)$$

$$R_{out} = \frac{R_{tank}}{\left({C_{top}}/{C_{bottom}}\right)^2} \qquad (Eq.2)$$

Figure 3: Formulas to calculate resonant frequency, total capacitance, and output resistance

2.2: Crystal Oscillator

This section will provide background information regarding the Crystal Oscillator, an important component to the project. When designing the real life version of this circuit, to achieve the stable and precise frequency regulation that was needed within the circuit, the team decided to use a quartz crystal as the frequency reference. The choice of quartz over other options like ceramic resonators, RC oscillators, or LC tank circuits was driven by the crystal's superior frequency precision and stability, minimal phase noise, and consistent performance across temperature variations. The crystal was specifically tuned to a frequency of 4.9152 MHz to align with the desired operation on a 5 MHz frequency band.

To deepen the team's understanding of crystal oscillator circuits and how it functioned, the team referred to "Crystal Oscillator Circuits" by Robert J. Matthys, focusing on chapters 3 and 4, as well as section 5.8. These sections provided beneficial information in regards to the Pierce oscillator—a specific type of crystal oscillator circuit –present in the current schematic provided by our sponsor– consisting of an amplifier stage, a feedback loop with the chosen crystal, and components like capacitors and inductors. This foundational knowledge was essential for both comprehending the circuit in their schematics and facilitating effective debugging.

Debugging the oscillator circuit was guided by critical insights from the book, particularly the need for a 180° phase shift in the feedback network, achieved through three low-pass filters. Each filter was expected to contribute 60° to the phase shift, crucial for stable oscillation. If a filter under examination showed inadequate or no output, the team could pinpoint issues such as faulty connections or defective components, streamlining the troubleshooting process.

2.2: Tuned Buffer

This section will provide background information regarding the Tuned Buffer, the second important component of the project. The tuned buffer within Mr. Ohm's LiDAR system plays a crucial role in managing the integrity and quality of the input signals. This component was designed to amplify the current from the crystal oscillator while preserving its original characteristics, ensuring minimal signal loss and distortion. By amplifying the signal directly derived from the crystal oscillator, the tuned buffer enhances the initial current, making it robust enough for further processing without altering its inherent frequency properties.

The tuned buffer is critical to the conversion gain of the mixer because the mixer conversion gain is proportional to the strength of the local oscillator (LO) signal. Since the tuned buffer controls the strength of the LO signal, increasing the LO strength results in higher conversion gain. The purpose of modifying the tuned buffer is to increase the strength and power of the LO signal, which could mean a higher voltage signal output (increased gain), a lower impedance output (increased current output), or both.

2.3: Triode Mixer

The purpose of the triode mixer is to make the phase difference of the reflected light easier to measure. Measuring the same phase shift at a lower frequency is simpler. However, a low-frequency light signal cannot be directly used at the photodiode because there is not enough change in phase as the reflected distance changes. The mixer allows for the conversion of the high-frequency light into an easy-to-measure low-frequency difference signal that retains the same phase shift as the high-frequency signal. The mixer takes two inputs (the photodiode output signal and the local oscillator signal) and creates an output signal with a frequency equal to the difference between the two input frequencies. The phase shift of the output signal is the same as the phase shift between the two input signals, making it much easier to measure because the output is at a low frequency.

3.0: Project Development

As the development process began, the Triple-B team first began by distributing the major components among its members to streamline the process. One team member took responsibility for constructing the crystal oscillator, while another focused on refining the triode mixer and a third on improving the tuned buffer. The tasks of PCB construction and the design and printing of the case were assigned to the remaining team members.

To facilitate effective collaboration and specialization, the team was also divided into two groups. One group concentrated on debugging and testing the emitter board from the previous UTSA design team, ensuring continuity and improvement. The other group was tasked with testing and debugging the current circuitry, addressing any new challenges that arose during development.

Throughout this process, the team also dedicated time to learning and understanding the key programs and equipment essential for their tasks. They utilized EasyEDA for electronic design automation, LTspice for simulating electronic circuits, and various lab equipment for assessing the health of the circuit.

The purpose of the project was to improve the existing circuitry, with a particular focus on enhancing the conversion gain of the mixer. One of the critical improvements being implemented was to the tuned buffer. By increasing the power of the local oscillator signal, the team aimed to achieve higher conversion gain in the mixer. If successful, this improvement would be evidenced by a higher power local oscillator signal, corresponding to increased conversion gain in the mixer.

3.1: Simulation

3.1.1: Ideal Mixer

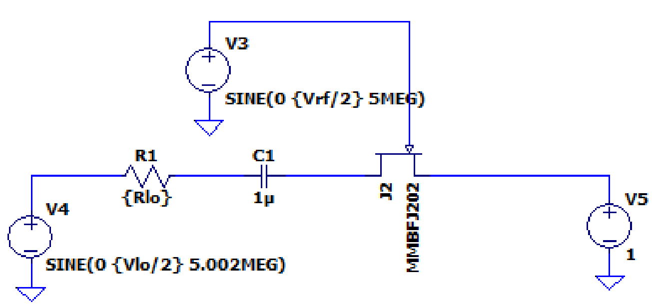

Figure 4: Ideal Mixer Circuit

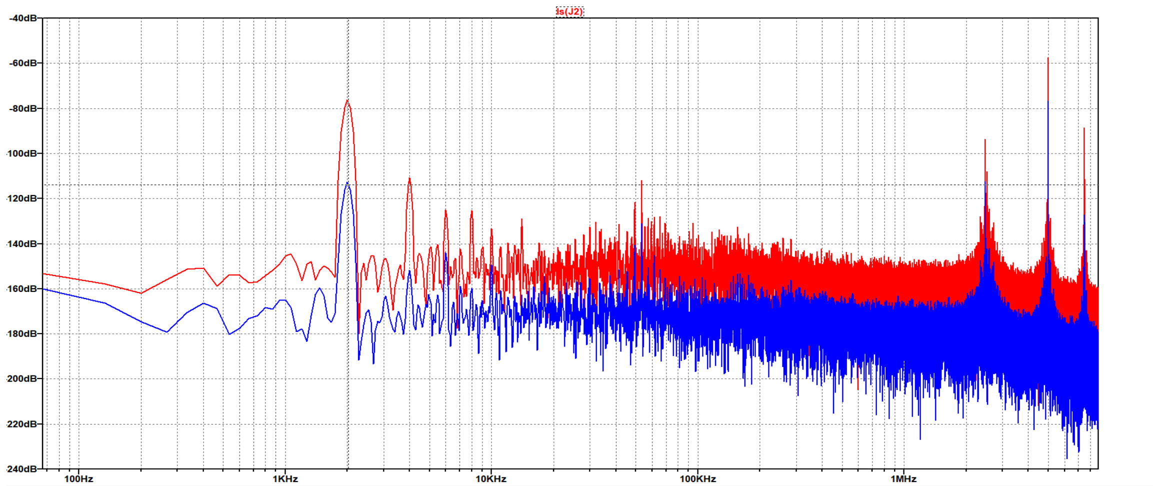

Figure 5: Ideal Mixer FFT Output

Figure 4 depicts the ideal mixer circuit which serves as a simplified model for understanding the operation of the Triode Mixer, while Figure 5 shows the FFT output for the ideal mixer circuit. The JFET has two inputs at 5 MHz and 5.002 MHz, resulting in a 2 kHz offset. The FFT output displays a spike at 2 kHz, which is the desired output. The simulation is running with two different values of the local oscillator resistance to demonstrate how it can affect the gain of the mixer. In this example, the red line represents Rlo=1Ω, and the blue line represents Rlo=1kΩ. Therefore, 1Ω provided a more desirable output. This simulation proves that reducing the output impedance of the local oscillator input signal increases the conversion gain of the mixer. Reducing the output impedance increases the output current and power of the local oscillator signal.

3.1.2: Original tuned buffer

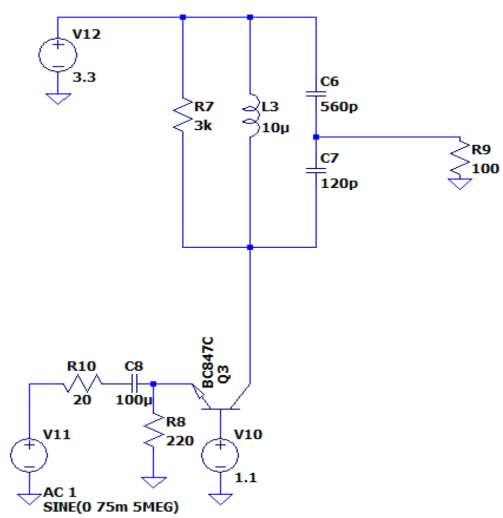

Figure 6: Original Tuned Buffer Circuit

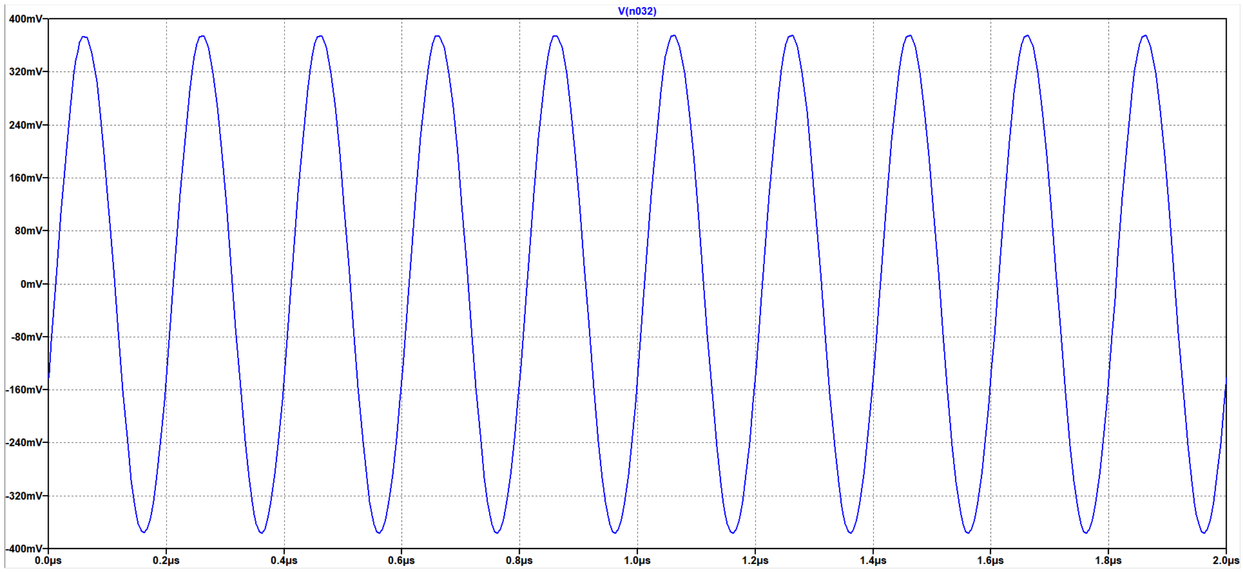

Figure 7: Original Tuned Buffer Output

Figure 6 shows the original circuit provided to the team by the sponsor, using pre-established values from the Betterbots website, before any changes were made, while Figure 7 displays the output of the circuit. The results shown in Figure 7 were obtained using a 100Ω resistor load, which resulted in an output voltage of around 750 mVpp and a current of 7.5 mA.

<u>3.1.3: Two-Stage Tuned Buffer</u>

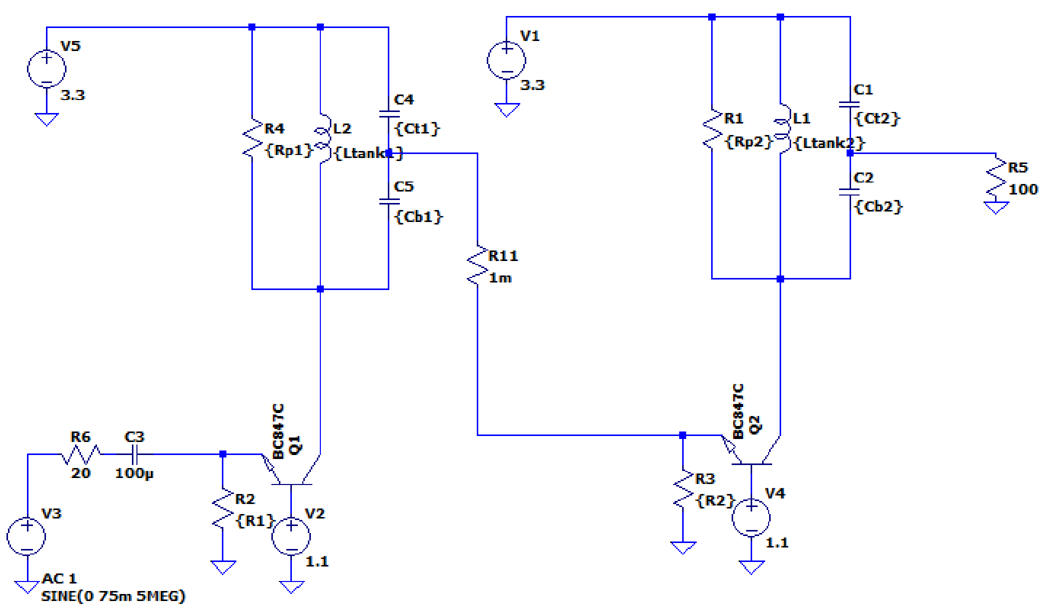

Figure 8: Tuned Buffer with Second Stage

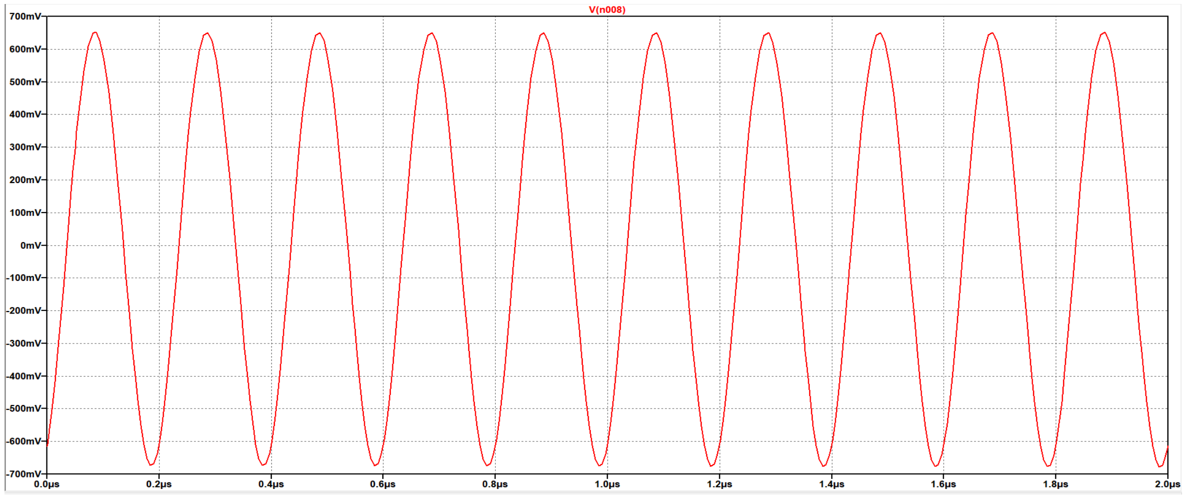

Figure 9: 2-stage Tuned Buffer Output

Figure 8 shows the Tuned Buffer with the second stage implemented, with values chosen using the equations depicted in Figure 3 for the LC tank of the second stage, while Figure 9 displays the output of the circuit. With the second stage added to the tuned buffer, the voltage was able to be increased to 1.3 Vpp, and the current to 13 mA. The increased voltage and output current means that the signal has more power than the original circuit when used as the local oscillator input to a mixer, which should result in increased conversion gain. There were other iterations with the second stage that used larger bias currents that could create a higher output; however, it was better to use lower bias currents for better efficiency. Once this circuit was finalized, real inductors needed to be chosen to simulate the internal resistance and capacitance.

3.1.4: Real Inductors

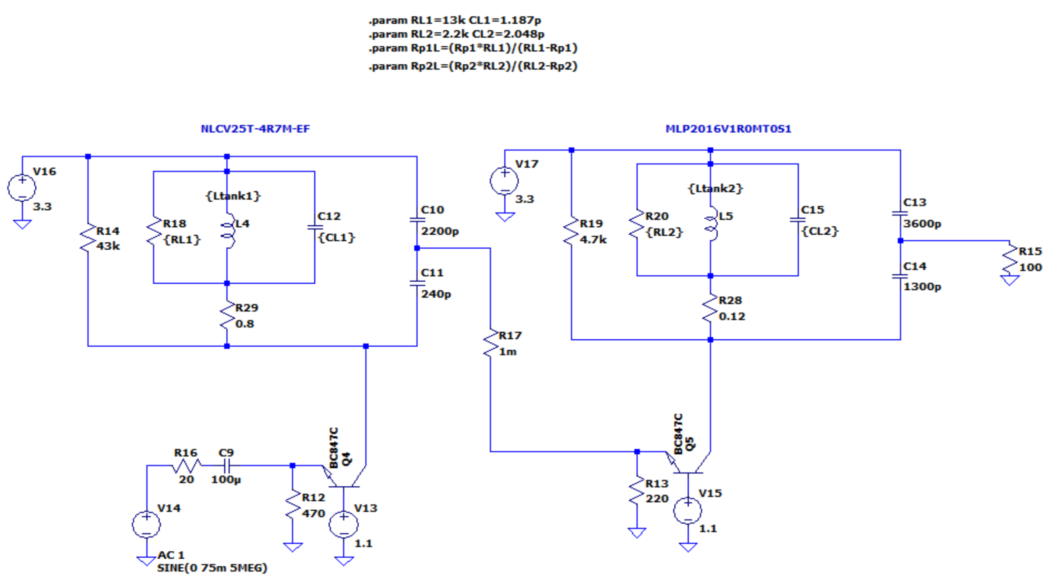

Figure 10: Tuned Buffer with Real Inductors

Real inductors needed to be chosen to simulate the internal resistances and capacitance of the inductor, so the part numbers listed in Figure 10 were selected. Using the equations in the figure, new parallel resistances were chosen to compensate for the parallel resistance in the inductor. However, due to issues in testing that will be discussed later, the following circuit was used as the final tuned buffer.

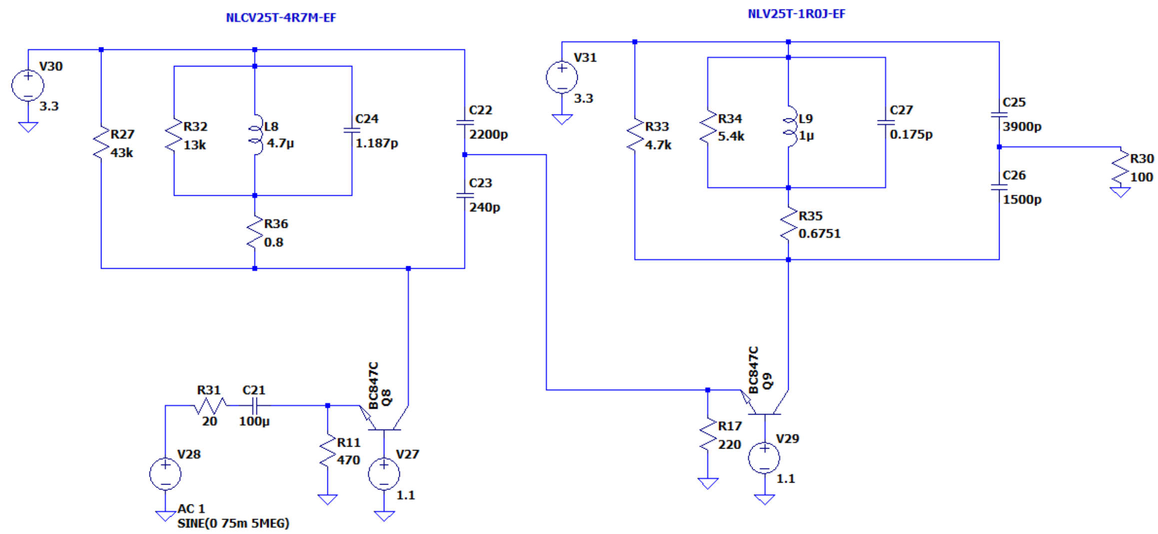

Figure 11: Final Tuned Buffer

After testing, the final schematic for the tuned buffer with the real inductors chosen can be seen in Figure 11.

3.1.5: Testing emitter follower

Another version of the tuned buffer was simulated using an emitter follower for one of the stages instead of a common base amplifier as shown in Figure 12. The emitter follower configuration was chosen for its potential advantages in providing high input impedance and stable voltage gain. However, during simulation, it was observed that this configuration did not output a high enough current compared to the common base configuration, despite using the same bias current for the transistors.

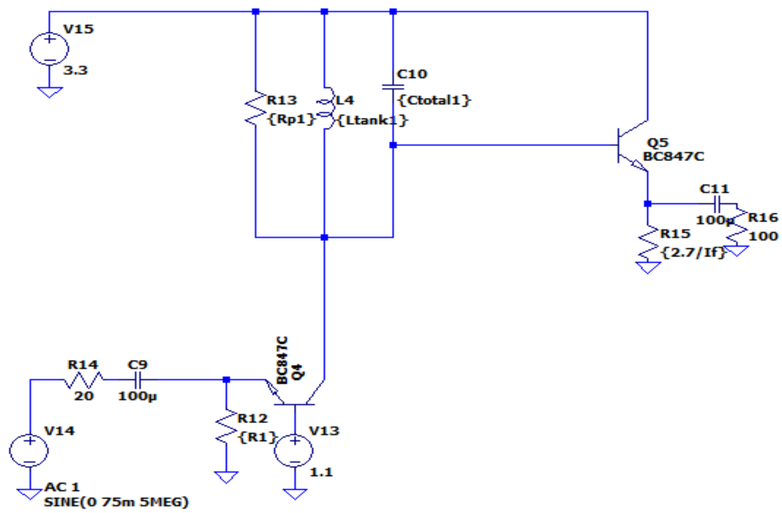

Figure 12: Emitter Follower Circuit for Tuned Buffer

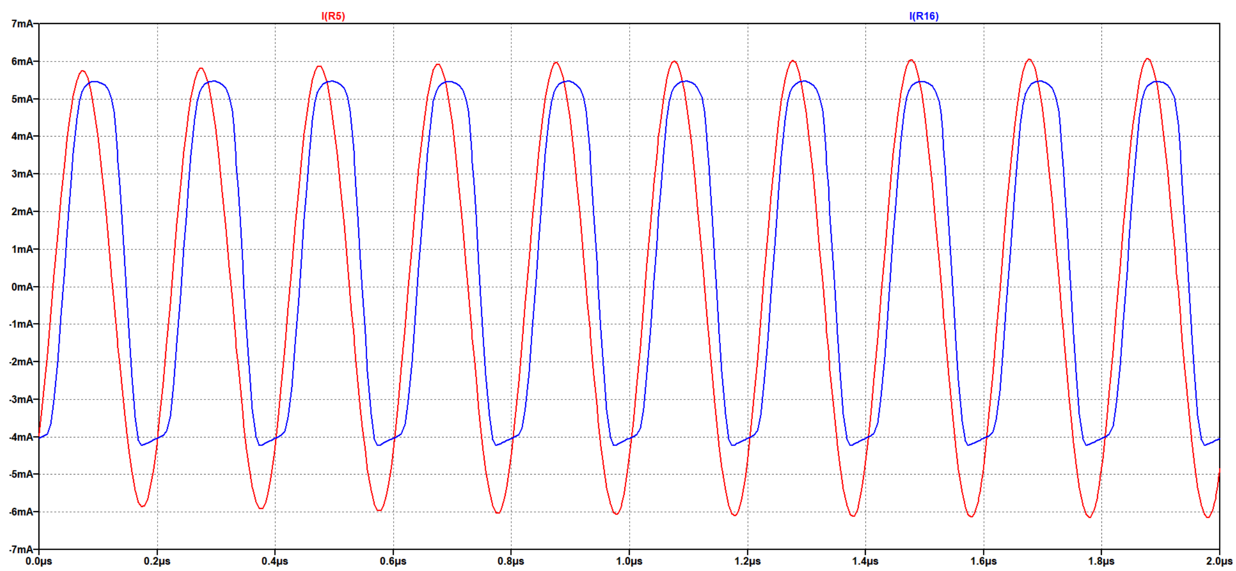

Figure 13: Output of Emitter Follower and Two-stage amplifier

As shown in Figure 13, the output of the emitter follower (blue) was lower than that of the two-stage common base amplifier (red). This was due to the transistors in the emitter follower saturating with less gain compared to the common base amplifier circuit.

3.2: Prototypes

3.2.1: Crystal Oscillator:

The initial version of the prototype, starting with the crystal oscillator, did not perform as expected. The construction issues are apparent in Figure 14; it reveals a messy arrangement where components were soldered too closely together, and unnecessarily long, disorganized wires were used for short connections. This clutter not only compromised the aesthetic but also made troubleshooting challenging. With everything so clustered, it was difficult to access specific areas to measure critical parameters like the voltage at a particular collector of a transistor or the current drawn from a component.

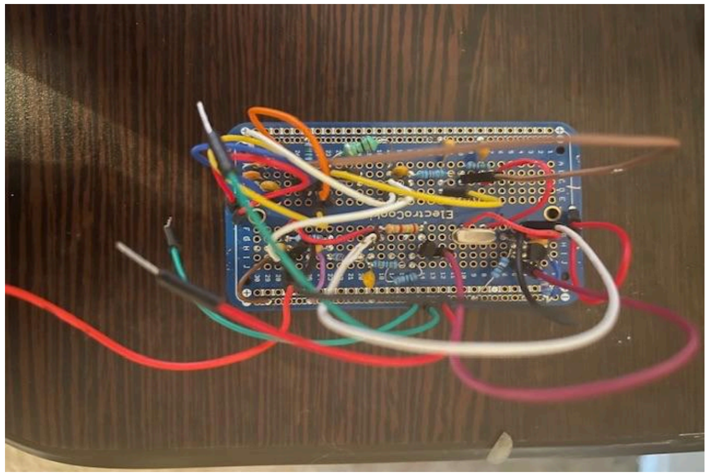

Figure 14: 1st version of Crystal Oscillator

During the troubleshooting process, it was discovered that two crucial connections in the feedback loop of the crystal oscillator were missing, as depicted in Figure 15 below, marked with a red circle. These connections are vital because they are responsible for delivering feedback signals that help regulate and stabilize the oscillator's frequency. Without these feedback signals, the circuit cannot maintain the precise oscillation needed for proper functionality, leading to a lack of power delivery to specific sections and ultimately resulting in circuit failure.

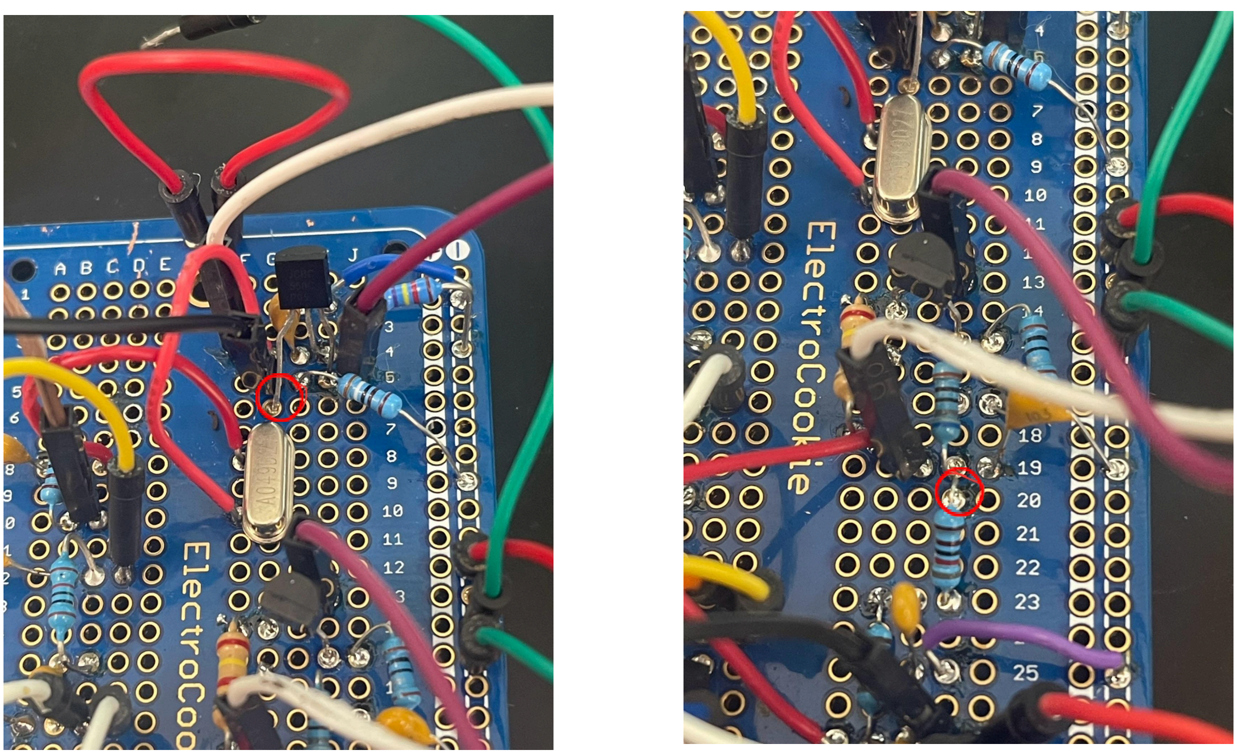

Figure 15: Incomplete connections of Crystal oscillator circuit

Taking these findings into consideration, the team constructed another prototype, incorporating the necessary corrections to the feedback loop connections. After the minor adjustments, this revised prototype yielded the expected results. As evident from Figure 16 below, this prototype features a cleaner layout, utilizing short wires appropriately for short connections and soldering component leads directly to their required destinations to ensure robust connectivity. Additionally, the use of long wires was minimized, employed only where necessary to reach other connections.

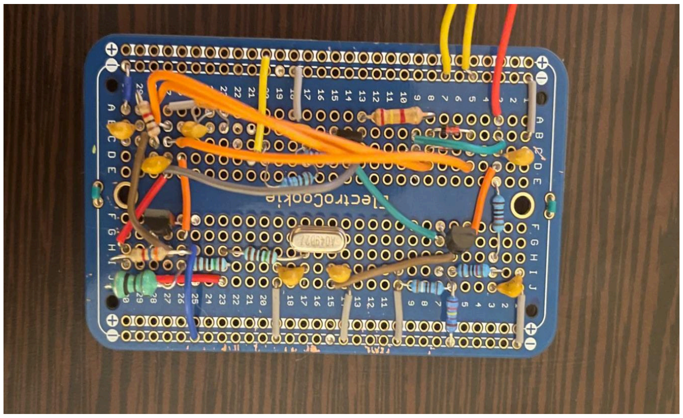

Figure 16: 2nd version of Crystal Oscillator

3.2.2: Tuned Buffer:

Moving on to the tuned buffer, the first prototype constructed, as shown in Figure 17, provided a promising output. Although the resonant frequency was slightly off from the target, the prototype demonstrated that the circuit could operate correctly. The prototype's ability to function correctly, despite the slight frequency deviation, was a positive indication that the tuned buffer could be fine-tuned and optimized in subsequent iterations.

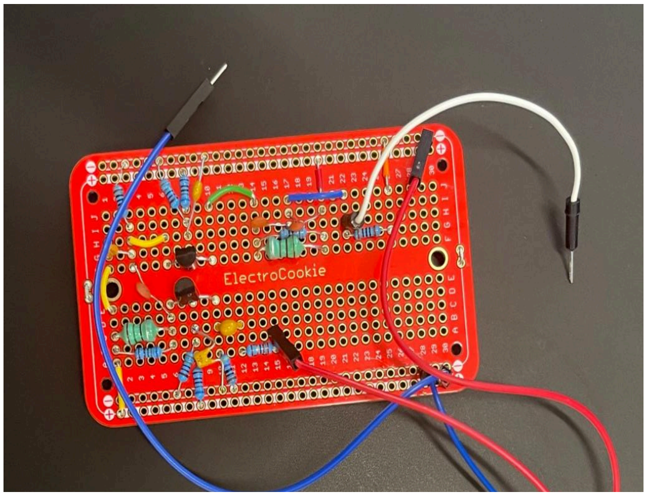

Figure 17: 1st version of Tuned Buffer

3.2.3: Triode Mixer:

Regarding the triode mixer, the primary issue with the first prototype, as shown in Figure 18, was the lack of access to the proper header needed to mount an SMD JFET onto the protoboard. To attempt to achieve functionality while awaiting the arrival of the appropriate header, the team decided to carefully solder the JFET to wires, as shown below. Unfortunately, this workaround proved unsuccessful. The makeshift connections likely introduced instability and poor contact, which are critical issues for the sensitive nature of JFET operation, ultimately preventing the circuit from working as intended.

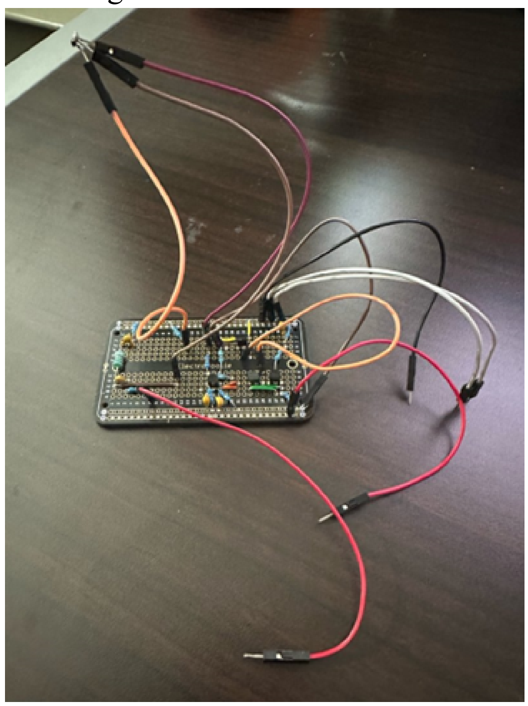

Figure 18: 1st version of Triode mixer

Once the team obtained the appropriate header, a second prototype was built, as shown in Figure 19. This version successfully incorporated the SMD JFET on the protoboard, resulting in the correct operation of the triode mixer. This allowed the triode mixer to function as intended, effectively combining the input signals from the tuned buffer and receiver module and generating the desired intermediate frequency (IF) output.

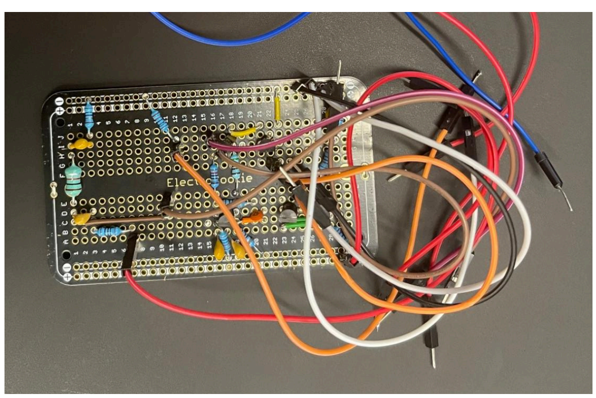

Figure 19: 2nd version of Triode Mixer

3.3: PCB Design

When moving into PCB design, the site EasyEDA was the go-to software that allowed the team to build and design their circuits. EasyEDA is a software platform used for PCB design, simulation, and ordering. It offers two key services: JLCPCB, which manages PCB orders, and LSCS, which provides an extensive parts library accessible to EasyEDA users. Josh was responsible for learning how to use the EasyEDA software to create a new PCB design for the crystal oscillator and a new PCB for the improvements made to the Tuned Buffer and Triode Mixer. Both PCBs were 4-layer designs, consisting of a Top Layer, Inner 1 (GND plane), Inner 2, and Bottom Layer.

3.3.1: Tuned Buffer & Triode-Mixer V1

For the first revision, the Tuned Buffer was the only component included in the schematic. At this stage, Josh, who was responsible for this task, was still learning how to use EasyEDA. This initial phase involved not only familiarizing himself with the software's interface and functionalities but also understanding the best practices for PCB layout. One specific challenge he faced was properly labeling redundant pins on the header, ensuring that all connections were accurately represented.

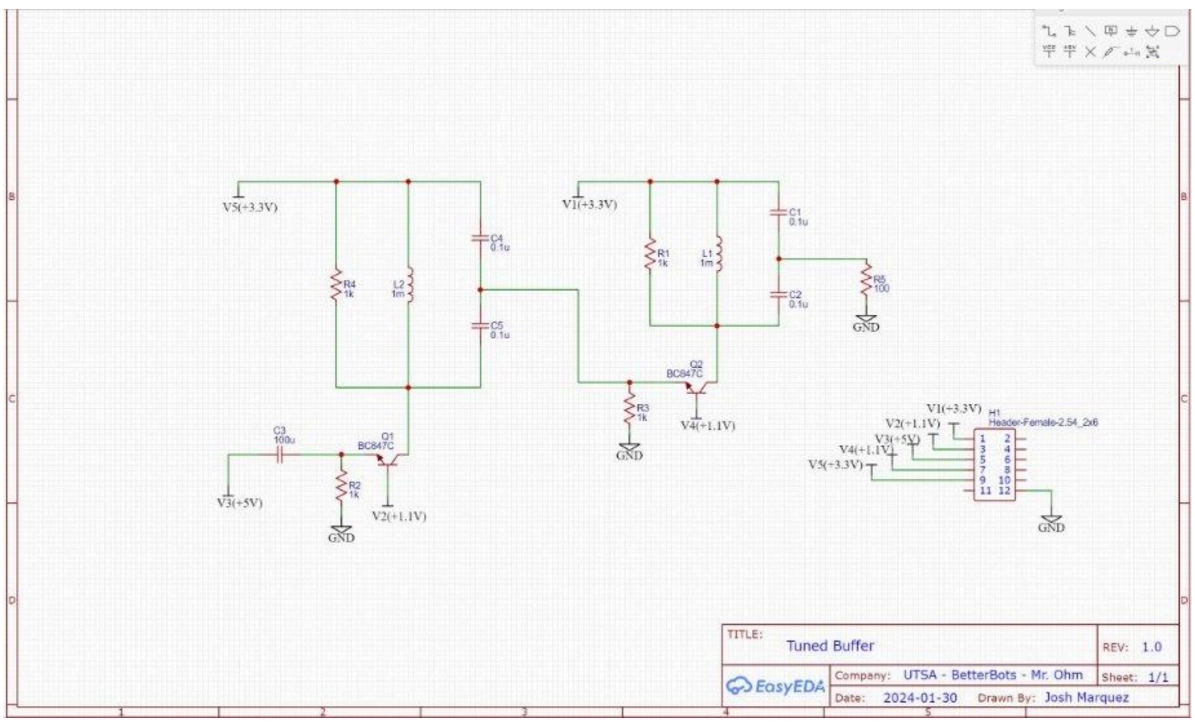

Figure 20: Original Wiring Diagram

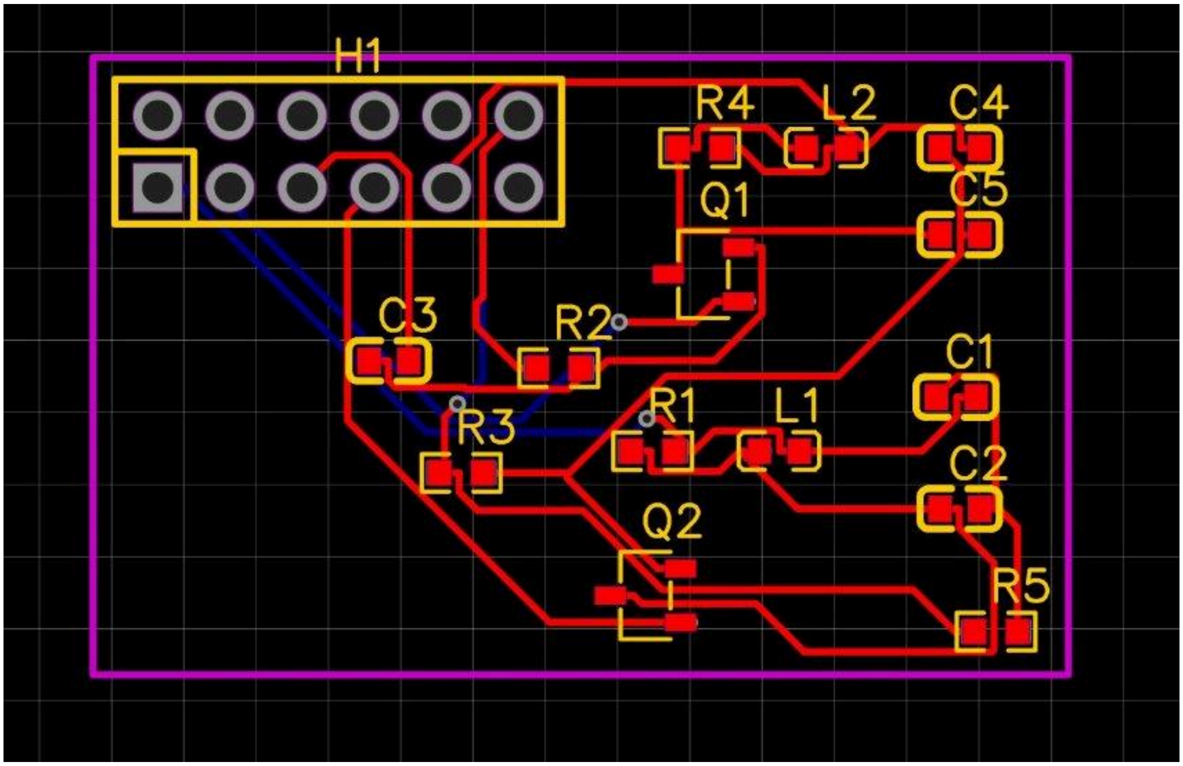

Figure 21: Tuned Buffer PCB (Learning stage)

3.3.2: Tuned Buffer & Triode-Mixer V2

For the second revision, the Triode Mixer was added to the schematic. However, the PCB design for this version was not created because Josh was still receiving feedback on improvements that could be made to the schematic, such as re-routing connections, fixing traces, and optimizing component placement. During this phase, Josh focused on incorporating the suggested changes and refining the design to ensure all components were correctly represented and interconnected. This involved carefully adjusting the layout to minimize potential interference, improving the signal integrity, and ensuring that all test points were clearly labeled for easier troubleshooting.

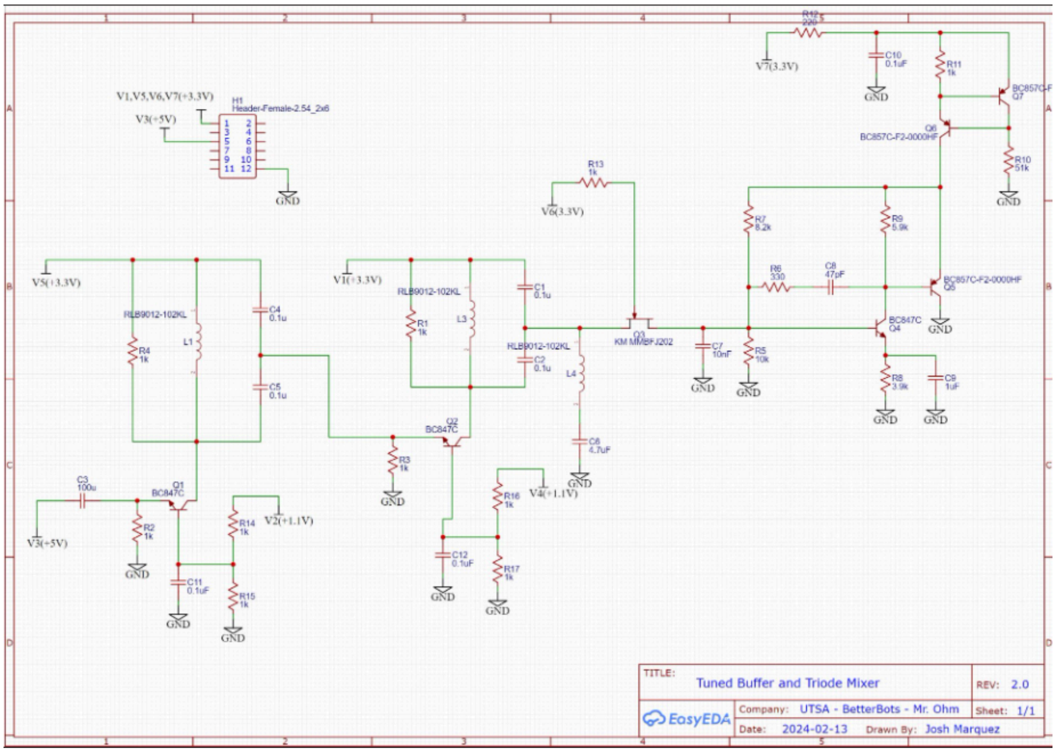

Figure 22: Tuned Buffer & Triode-Mixer schematic V2

3.3.3: Tuned Buffer & Triode Mixer V3

For the third revision, the overall schematic shell was perfected. However, many mistakes were made and valuable lessons were learned regarding the PCB design in this iteration. One major issue was the inadequate spacing of components, which led to difficulties in assembly and potential interference between parts. Additionally, having a routed ground instead of a dedicated ground plane caused significant problems with signal integrity and noise reduction. Josh realized that these design flaws could compromise the performance and reliability of the circuit. To address these issues, future revisions would need to ensure adequate spacing between components and the implementation of a proper ground plane to enhance the stability and functionality of the PCB.

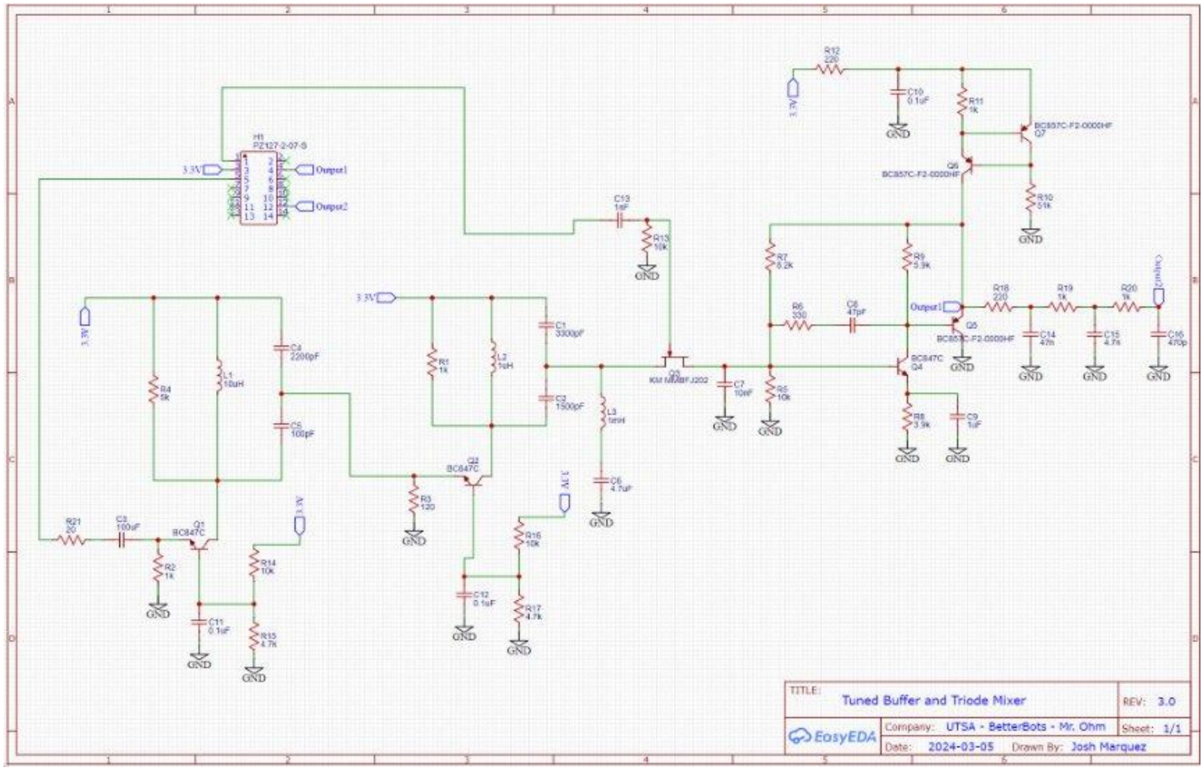

Figure 23: Tuned Buffer & Triode-Mixer schematic V3

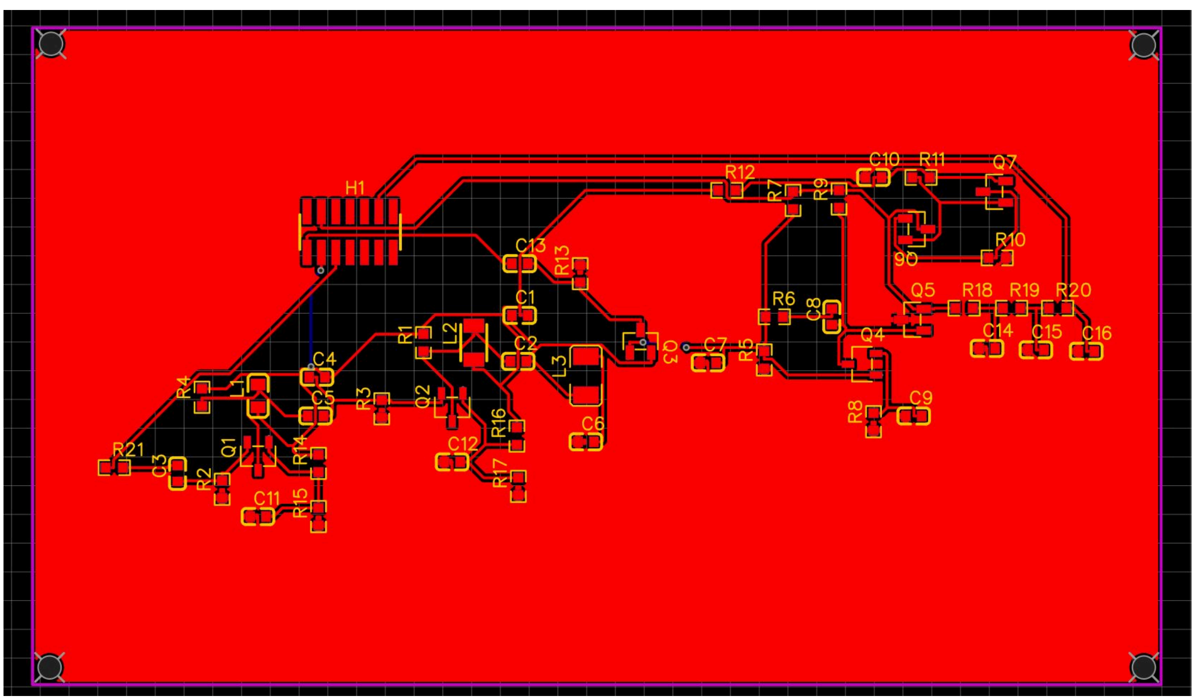

Figure 24: Tuned Buffer & Triode-Mixer PCB V3

3.3.4: Tuned Buffer & Triode Mixer V4

The main issues with this schematic were the spacing of components and the use of a routed ground trace. Although a ground plane was added to address the grounding issue, Josh did not yet know how to implement the GND vias correctly in the EasyEDA software, which led to insufficient grounding throughout the PCB. This oversight affected the overall performance and stability of the circuit. Despite these challenges, the schematic itself did not undergo any further changes.

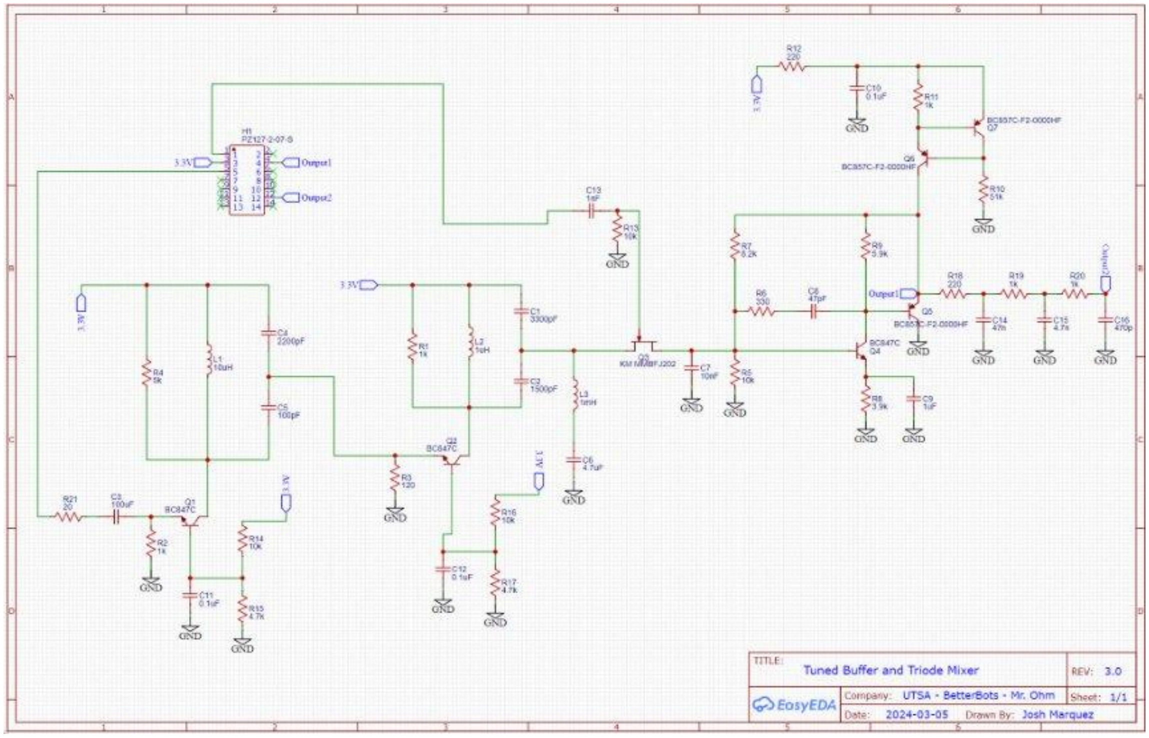

Figure 25: Tuned Buffer & Triode-Mixer schematic V4

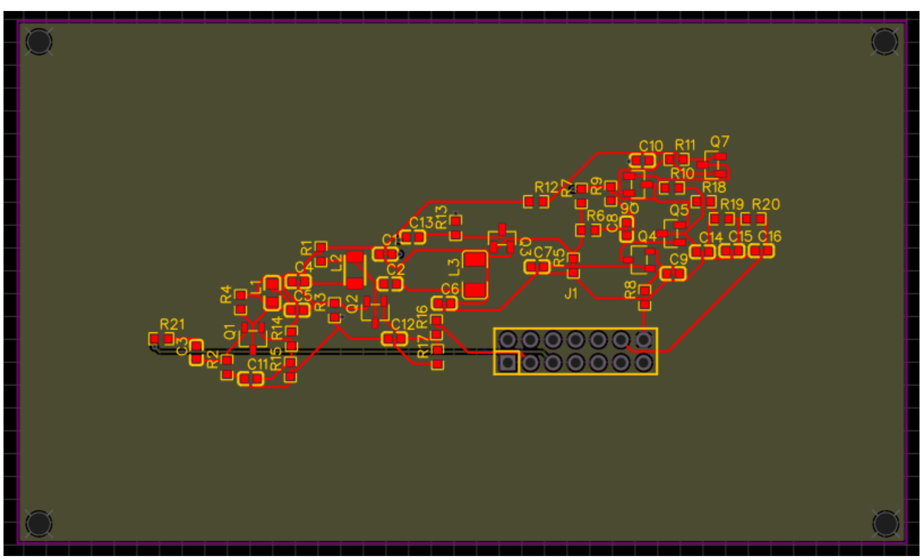

Figure 26: Tuned Buffer & Triode-Mixer PCB V4

3.3.5: Tuned Buffer & Triode Mixer V5

This was the final version for the Tuned Buffer and Triode Mixer. In the schematic, the design was updated to replace a 14-pin header with a 10-pin header to match the UTSA 2022-2023 boards. Additionally, specific inductor manufacturer parts were added: L1 (NLCV25T-4R7M-EF), L2 (MLP2016V1R0MT0S1), and L3 (LB2518T102K).

The most significant changes occurred in the PCB design. Spacing between components was greatly improved, reducing the risk of interference and making the assembly process easier and more reliable. Furthermore, GND vias connecting to a dedicated GND plane were implemented, which enhanced the overall grounding of the circuit and improved signal integrity. These improvements addressed previous issues and resulted in a more efficient final PCB design.

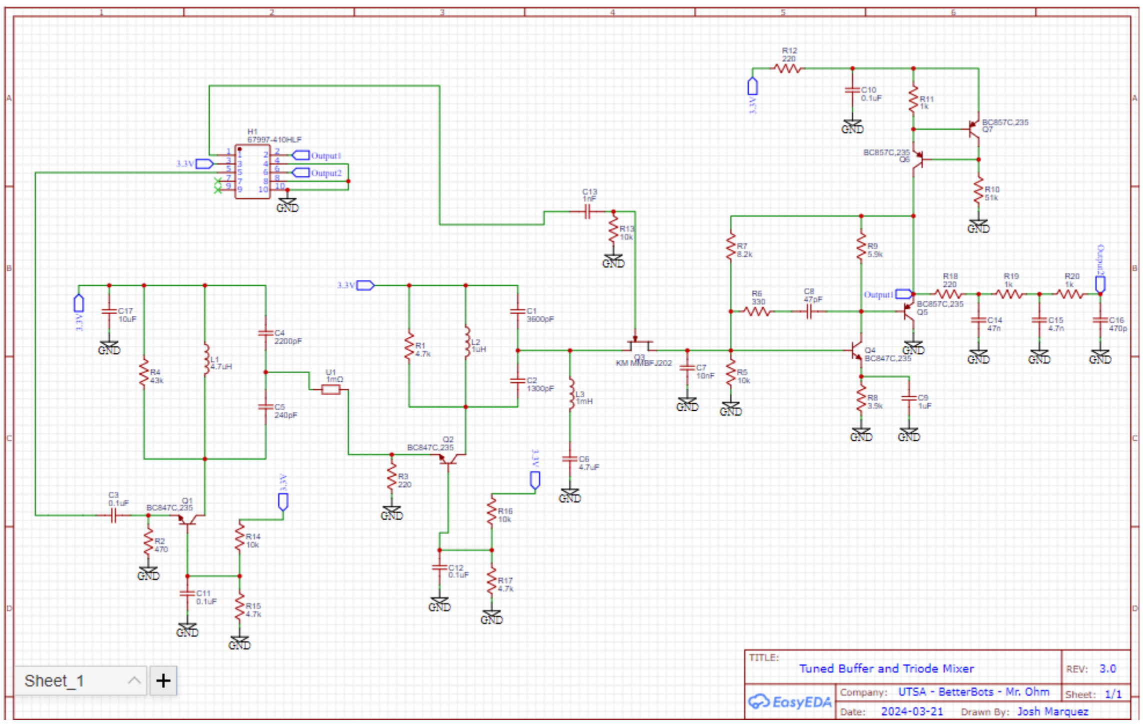

Figure 27: Tuned Buffer & Triode-Mixer schematic V5

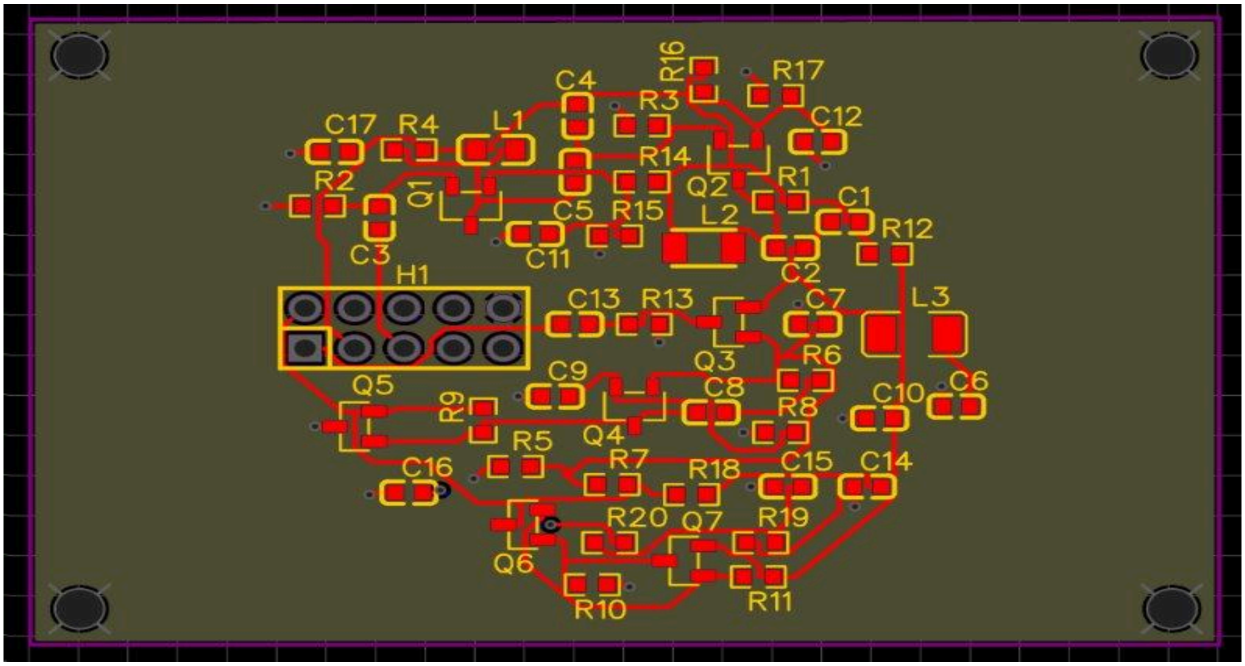

Figure 28: Tuned Buffer & Triode-Mixer PCB V5

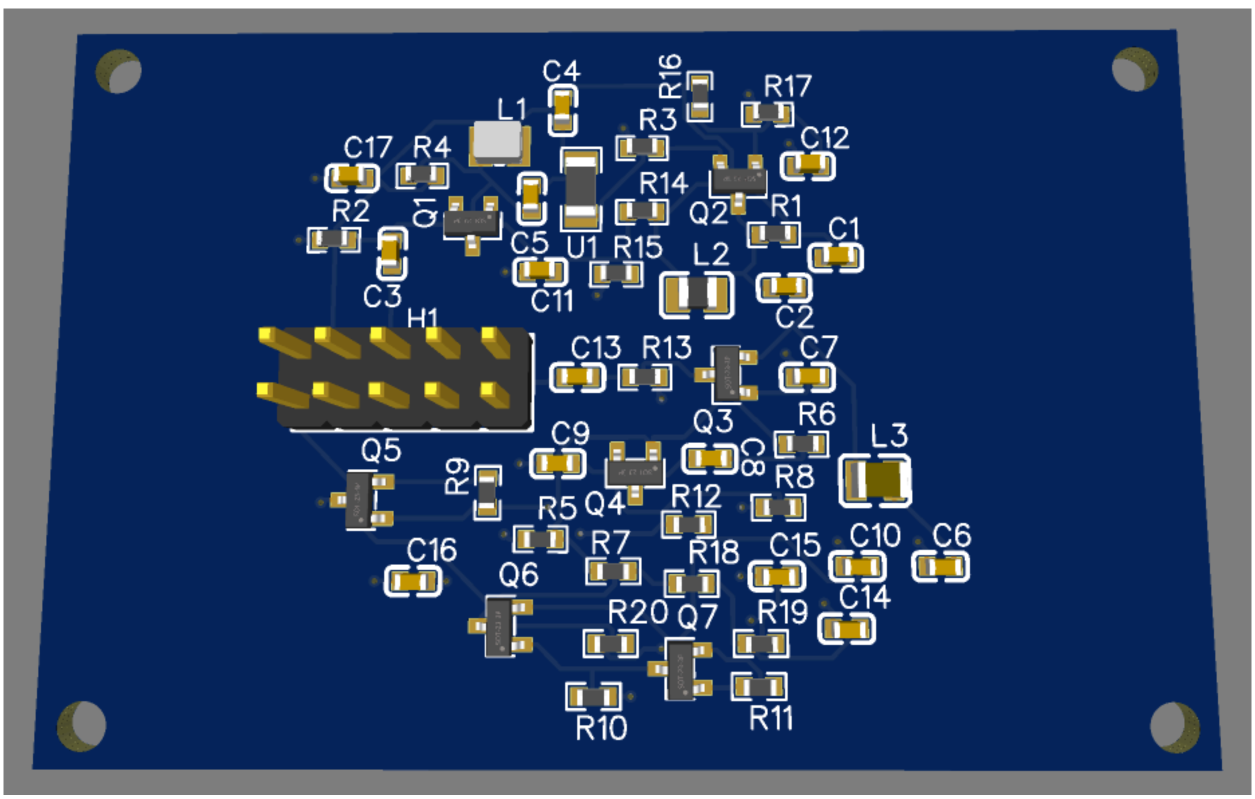

Figure 29: Tuned Buffer & Triode-Mixer PCB 3D V5

3.3.6: Crystal Oscillator V1

This was the only revision for the Crystal Oscillator. The lessons learned from designing the Tuned Buffer and Triode Mixer PCB in EasyEDA proved to be very valuable and were applied to the Crystal Oscillator design. These insights included better component spacing, proper implementation of GND vias, and overall PCB layout optimization. As a result, the design process was more efficient, and only one revision was necessary to achieve the desired functionality and performance.

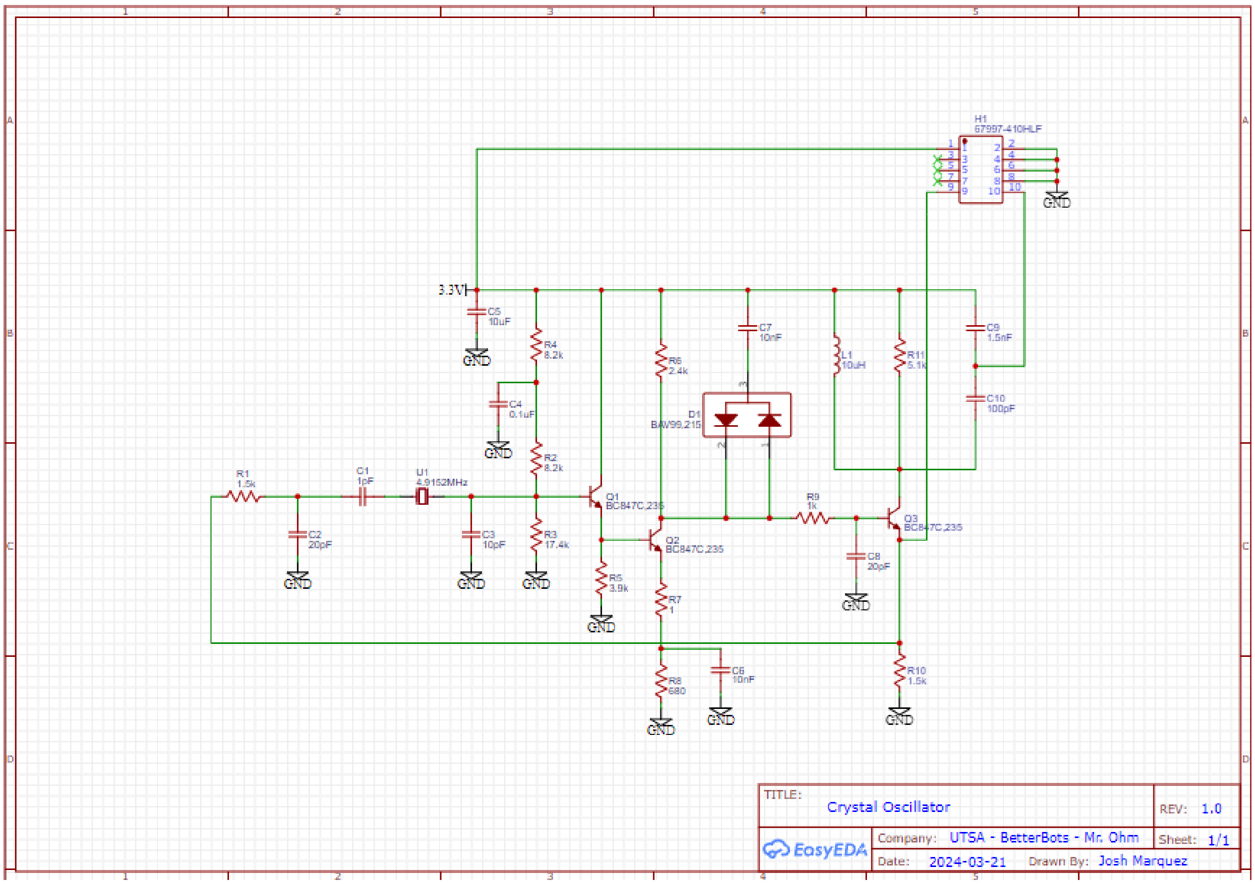

Figure 30: Crystal Oscillator schematic V1

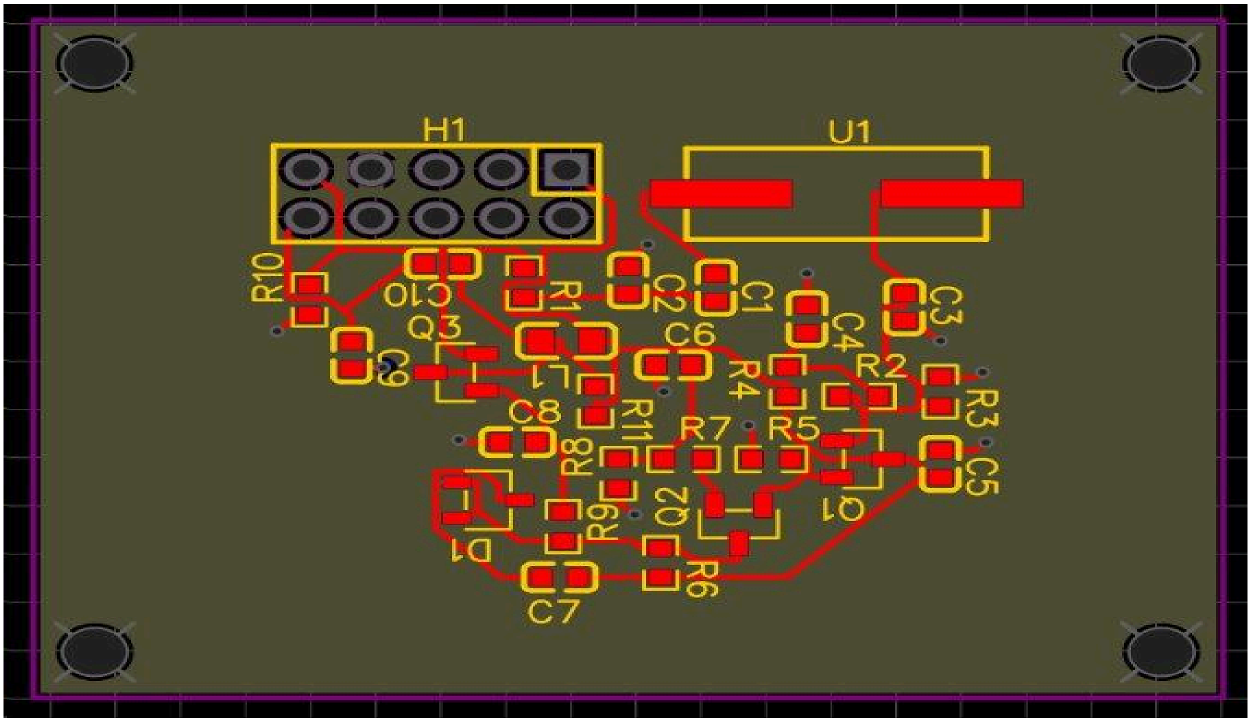

Figure 31: Crystal Oscillator PCB V1

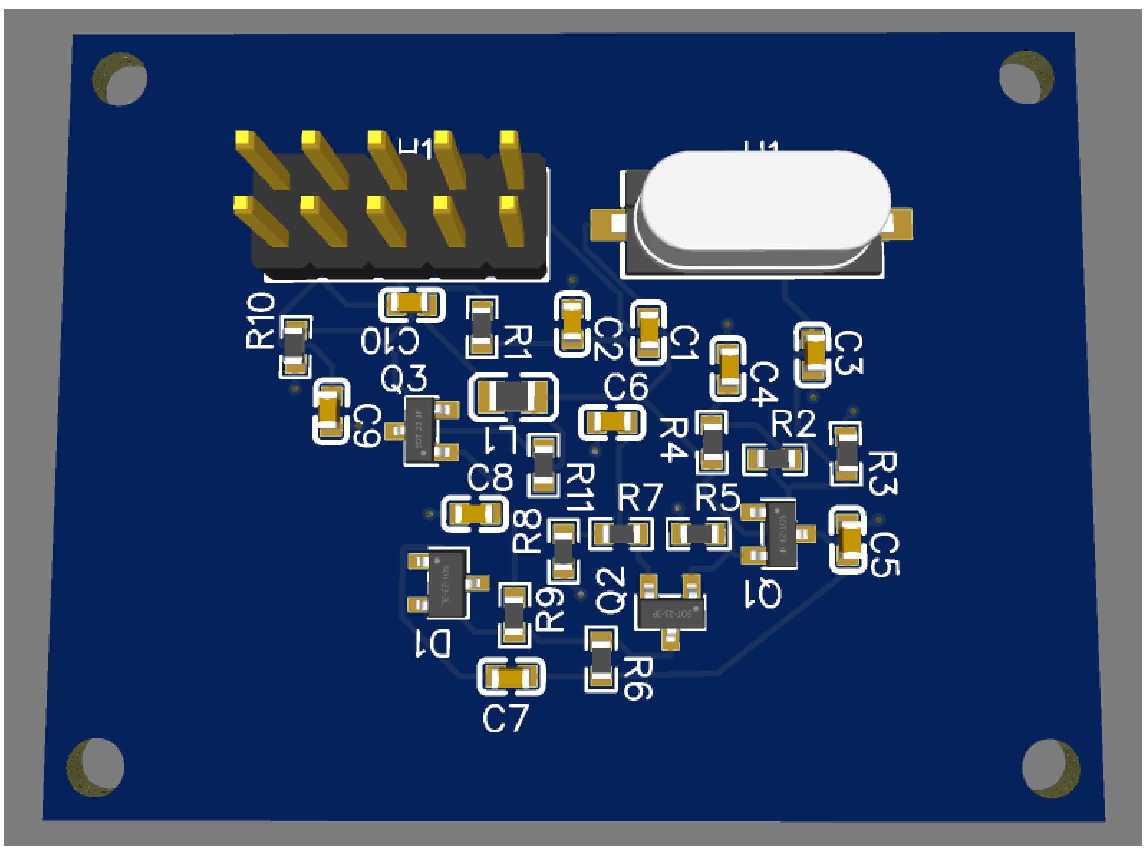

Figure 32: Crystal Oscillator PCB 3D V1

4.0: Testing

After simulating the circuits, the next step was testing the prototypes and PCBs. For the prototypes, protoboards were used with leaded components. Each circuit was constructed on separate boards to test each one individually. The simulations were then used to compare to the prototypes. These prototypes allowed the team to get an understanding of the circuits and to find common errors that might be found when testing the PCBs. These prototypes were done while the PCBs were being designed and shipped. Once the PCBs arrived, testing began for them, similar to the protoboards.

In addition, the team worked to improve the emitter boards from the previous year. The team was able to find some errors and improve them. However, the boards were not able to properly function. This section documents the process of testing all of the PCBs.

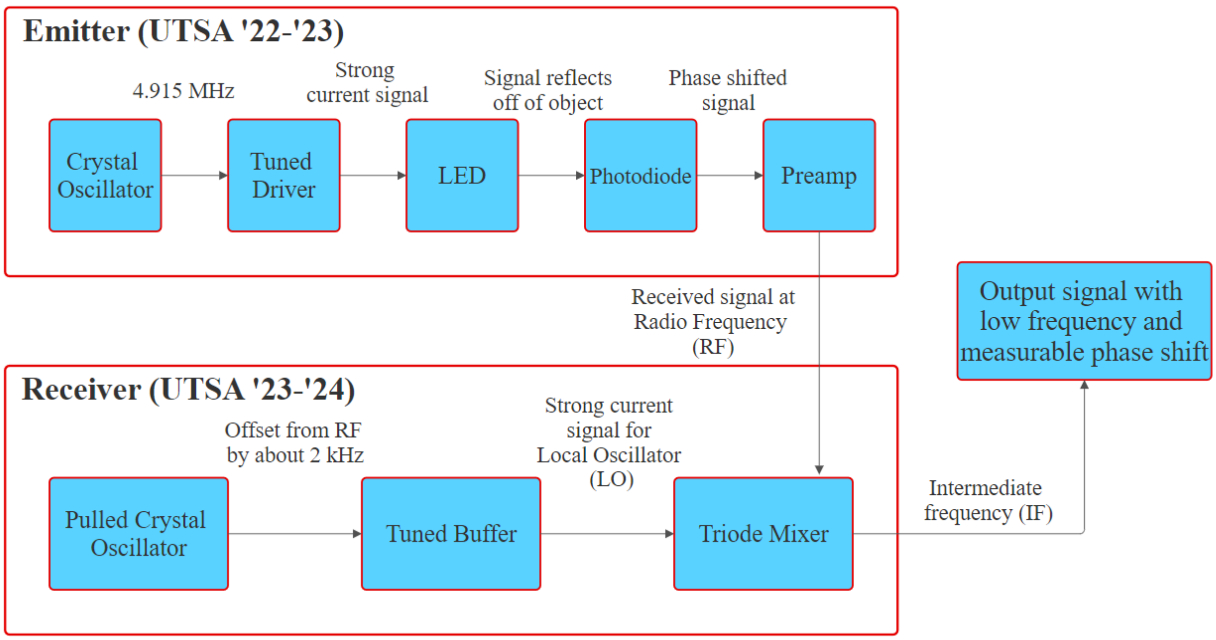

Figure 33: Block Diagram of LiDAR sensor

4.1: Emitter Boards (UTSA ‘22-’23)

The previous team was responsible for constructing PCBs for the five blocks in the emitter of the LiDAR sensor, as shown in Figure 33. The crystal oscillator, tuned driver, and LED were on the first board, and the photodiode and preamp were on the second board. The team first tested the crystal oscillator, and found that it the output reference signal at the emitter of Q2 was around 1 Vpp at about 4.9 MHz, which meant that it was working properly.

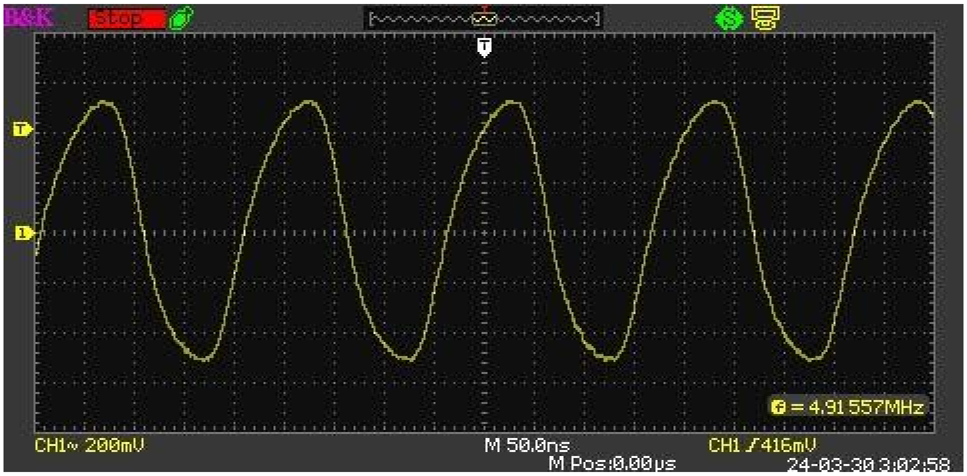

Figure 34: Output of Emitter Crystal Oscillator at Emitter of Q2

However, issues were found when checking how much voltage was going to the LED. When measuring the voltage at the LED, there was almost no signal being read, so the team checked each stage of their tuned driver. The first stage of the tuned driver seemed to match the simulation files, however, the second stage had less gain, and then the output of the third stage had almost no signal on the scope. The team tried to input a signal with different frequencies, but there were no peaks other than around 4.9 MHz.

The team also found that one of the resistors that was supposed to be 723 ohms was a different value. However, swapping it out with the correct value had no impact on the output signal.

Due to time, no testing was able to be conducted on the receiver board. However, it still output a signal when connected to the triode mixer.

4.2: Pulled Crystal Oscillator

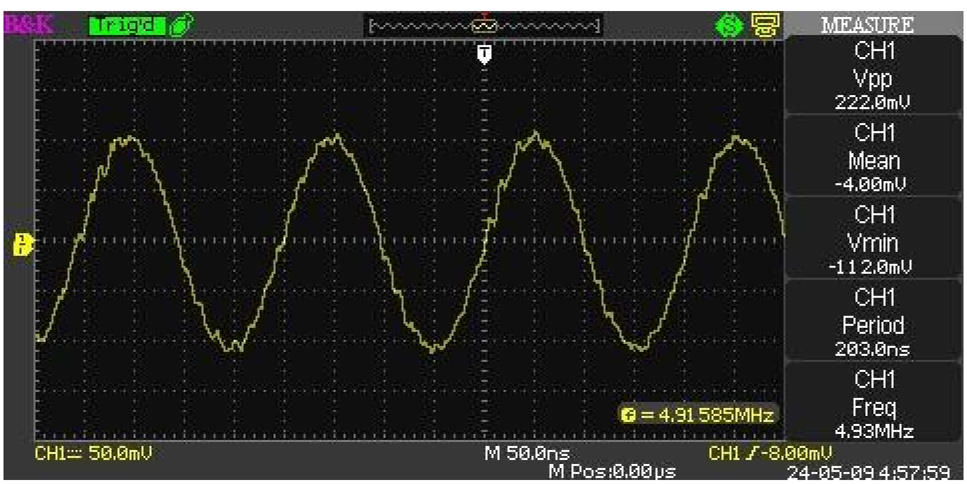

Figure 35: Output of Pulled Crystal Oscillator at Capacitive Tap

The crystal oscillator board was first tested with a 1pF capacitor in series with the crystal.

However, this did not output any signal. The next step was to replace it with a 10pF capacitor which did work, and the frequency was similar to the other crystal oscillator board. A 3pF and 5 pF capacitor were both tested, and the 3pF did not output a signal, but the 5 pF did. With the 5 pF, the oscillator was connected to the mixer, and the other input of the mixer was a function generator set at 4.917 MHz, the output was 1.55 kHz. This would mean that the crystal oscillator was outputting a signal at about 4.9155 MHz. This however is only a small offset from the emitter's crystal by a few hundred hertz. Ideally, this is supposed to be about 2 kHz. The team was unable to further test other capacitor values.

4.3: Tuned Buffer

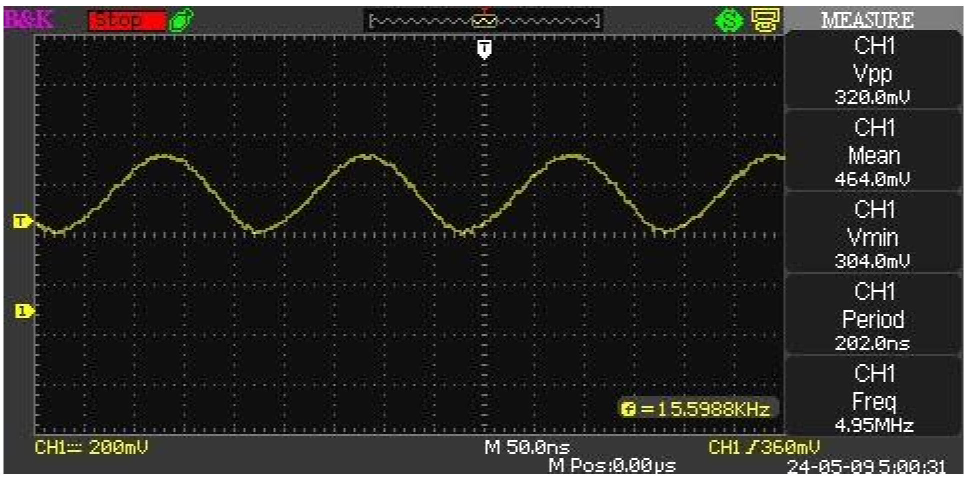

Figure 36 : Output of First Stage of Tuned Buffer

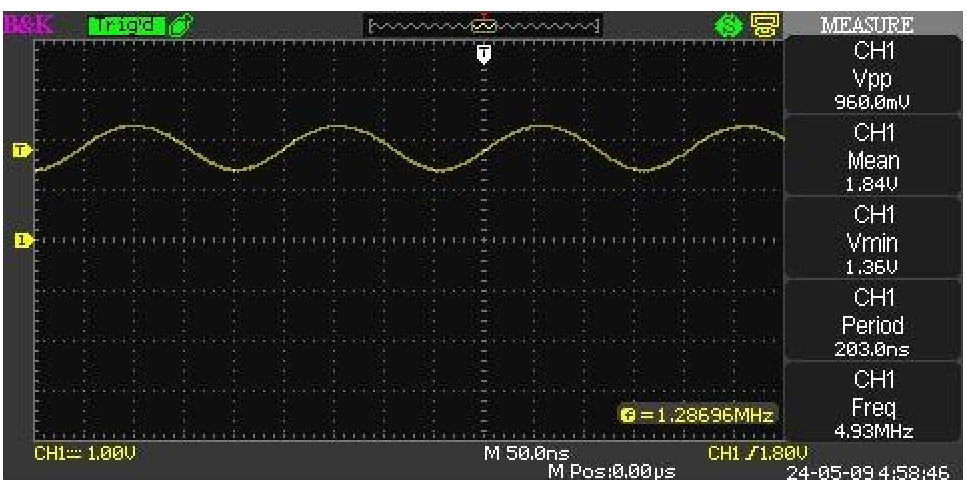

Figure 37: Output of Tuned Buffer

The final output of the tuned buffer was able to amplify the signal using the two-stage amplifier simulated in LTspice. However, there were issues with the circuit previously. After measuring the output of both stages, the second stage seemed to have no output signal. The next step was to test the circuit with different input frequencies using the function generator. It was found that the circuit was amplifying the signal at around 4.7 - 4.8 MHz. The inductor value was the issue with it, because the inductor that was chosen had a 20% tolerance, which threw off the resonant frequency. This was proved by changing the inductor value in the simulation, which matched the result of the circuit. When a new inductor was chosen with a 5% tolerance, the issue was solved. After this, the capacitor values in the capacitive taps were slightly altered to compensate for the changes.

4.4: Triode Mixer

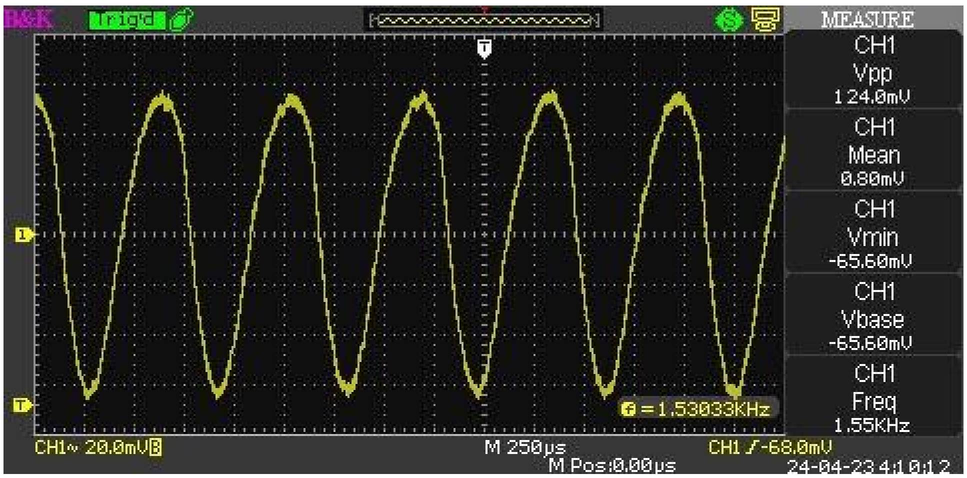

Figure 38: Output of Triode Mixer

The triode mixer portion of the PCB did not have any major issues once the tuned buffer circuit was working. This circuit was used to test the input frequency of the crystal oscillator. As stated previously, a function generator was used to represent the received signal to be mixed with the local oscillator. Using an input at 4.917 MHz, the above output was achieved, representing the difference between the signals. When using the emitter and receiver boards, the received signal had an offset of about 400 Hz, but the signal to the LED was very weak, so the phase shift was unable to be seen.

5.0: Conclusion and Comments

Our journey with the LiDAR sensor for the BetterBots Mr. Ohm project proved to be quite the adventure. At the outset, our primary goal was to enhance the LiDAR system, building upon the groundwork laid by the previous UTSA design team. We began by immersing ourselves in understanding how the LiDAR system worked, seeking to comprehend its intricacies. Then, we moved on to testing their ideas through simulations to ensure their viability.

The real challenge arose as we transitioned from the simulations built in LTspice to tangible prototypes on protoboards. While we originally thought we had everything figured out and working, it later showed that putting our ideas into practice would reveal unexpected hurdles. Some components didn't perform as anticipated despite yielding promising results via simulations, prompting us to delve deeper into understanding how the circuits truly operated in order to troubleshoot correctly.

Crafting the PCBs was also another challenge; none of the team members had any prior experience when it came to soldering such small and fragile components. We encountered numerous problems during testing that stemmed from incorrectly soldered components, components not touching the PCB pads to establish a connection, or simply soldering on the wrong valued component. Working with SMD components, they tend to look very similar, making it easy to mistake one for another. However, the team adapted quickly to learning this new skill, and as testing and resoldering commenced, efficiency improved.

Throughout the project, collaboration among team members played a crucial role in overcoming challenges. Each member of the team brought unique skills and perspectives to the table, allowing us to approach problems from different angles and come up with innovative solutions. Regular communication and sharing of ideas ensured that everyone was on the same page, facilitating smooth progress and effective problem-solving.

Working together also fostered a sense of camaraderie and mutual support within the team. During times of frustration or setback, we were able to lean on one another for encouragement and assistance, reinforcing the importance of teamwork in achieving our goals. This collaborative spirit not only strengthened our bonds but also contributed to a positive and motivating work environment.

Furthermore, working on this project provided numerous benefits to each of us individually. Beyond gaining technical skills, we developed valuable soft skills such as communication, teamwork, and adaptability. The experience of overcoming challenges and persevering through setbacks instilled a sense of resilience and determination in each team member. Moreover, seeing our collective efforts culminate in progress and eventually leading to a successful final project and presentation instilled a sense of pride and accomplishment, motivating us to continue pushing boundaries and striving for excellence in future endeavors.

As we reflect on our journey, it's clear that there is still room for improvement. One area that requires further attention is the gain of the output signal. The output signal of the mixer was not of high enough voltage to reliably determine the phase shift for reflectors more than a few feet away from the emitter. To address this, future work should focus on increasing the gain. This additional gain could be achieved by either adding an extra stage to the preamp before the mixer or incorporating an additional amplifier after the mixer.

In conclusion, the LiDAR project was not only a technical endeavor but also a journey of personal and professional growth for each team member. Through collaboration, perseverance, and shared determination, they navigated challenges and emerged stronger and more capable than before.

6.0: Team Member Roles

Lucas Kampe - Project Manager & Hardware Engineer

As the project manager, Lucas was responsible for planning and scheduling project tasks, keeping the team on schedule, and scheduling and leading team meetings. Lucas made many of the decisions for planning on the next steps of the project and created the work breakdown structure. Lucas delegated the critical tasks of the project to all of the team members and made sure that all tasks were being completed.

For the hardware, Lucas was responsible for improving the simulation of the tuned buffer, and was able to improve the current output by about 50%. Once this was approved by the sponsor, Josh was able to implement it into the PCB design. Lucas was then responsible for constructing prototypes of the tuned buffer on protoboards. Once the PCBs arrived, he took the lead when testing them. He assisted in soldering them together and debugging them. In addition, he assisted with the testing of the emitter boards from the previous year whenever needed.

Kyndal Gardner - Secretary & Hardware Engineer

As Triple-B's secretary, Kyndal played a crucial role in ensuring the team's organization and cohesion. Collaborating closely with Lucas, our team lead, Kyndal took charge of arranging meetings with our sponsor, ensuring they proceeded seamlessly. Alongside Lucas, she crafted meeting agendas, ensuring everyone was aware of the topics to be discussed.

When it came to hardware, Kyndal undertook the significant task of constructing the crystal oscillator, one of the three major components of the project. Devoting ample time, she meticulously worked on transforming the schematic available on the BetterBots website and turning it into a functioning prototype. This involved constructing several prototypes, troubleshooting them when the desired results were not reached with available lab equipment provided by the Makerspace, and putting in the time to research the best way to solve any errors faced and respond accordingly, which included replacing components with a higher tolerance, resoldering components, and ensuring an electrical connection was present.

In addition to her hardware responsibilities, Kyndal took charge of identifying encountered issues. She documented our successes and failures, sharing them with the team before sponsor meetings or team discussions. This facilitated informed decision-making and kept the team on the right track.

Anthony Rodriguez - Hardware Engineer

As a Hardware Engineer, Anthony assumed primary responsibility for the execution of the triode mixer. His initial tasks involved affecting modifications in simulation using LTSpice. This process entailed close collaboration with the sponsor, Daniel Walker, and the entire team to ascertain that the outcomes met the requisite standards and integrated seamlessly with other circuitry systems. Subsequently, Anthony undertook the translation of the simulated circuit into a physical prototype. He further contributed to the final prototype by furnishing the circuitry he had meticulously developed, facilitating its integration into a printed circuit board (PCB). Additionally, Anthony contributed to testing the emitter board and integration with the triode mixer and the portions that each member worked on.

Stephanie Del Castillo - 3D Printing Specialist & Test Engineer

As the 3D Printing Specialist, Stephanie was responsible for designing a case to hold two PCBs inside Mr. Ohm, ensuring proper measurements, and considering aesthetics. As a Test Engineer, Stephanie ensured that everything in the design worked as planned and met the required standards. Stephanie collaborated with Josh and Lucas in testing the functionality of the emitter PCB to ensure that it generated the desired signals.

Josh Marquez - Design Engineer & Test Engineer

As the Design Engineer, Josh was responsible for implementing the improvements made to the Tuned Buffer and Triode Mixer to PCB through the EasyEDA software. Josh was responsible for learning the basics on how to use the EasyEDA software and the Do’s and Don'ts of creating a PCB. Such as, the importance of minimizing trace lengths and component placement, while keeping signal integrity in mind.

As the test engineer, Josh assisted with testing and debugging UTSA 2022-2023 emitter and receiver PCB’s along with UTSA 2023-2024 Tuned Buffer, Triode Mixer, and Crystal Oscillator PCB’s. Josh also performed continuity checks and visual inspection of all boards. Additionally, Josh contributed to any other testing or debugging that needed to be done throughout the project.