Shark Alert: Early Warning System

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Marc Rauschnot
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1. I agree to supervise this senior project. ______
2. The specifications are [1]-[2]:
☐ Abstract—Describes what project should do, not how.
☐ Bounded—Identify project boundaries, scope, and context
☐ Complete—Include all the requirements identified by the customer, as well as those needed to define the project.
☐ Unambiguous—Concisely state one clear meaning.
☐ Verifiable—A test can prove if system meets specification.
☐ Traceable—Each engineering specification serves at least one marketing requirement.</td></tr>
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Abstract

The Shark Alert Early Warning System is a device geared toward avid beach goers such as surfers, divers, and swimmers. The system is composed of an ultrasonic transmitter mounted on a shark's dorsal fin and a receiver worn by the user around the ankle. The receiver alerts the user to the presence of a shark upon ultrasonic signal detection.

The receiver warns the user through both visual and tactile (vibration) alerts to ensure user notification. This circuit was built and tested in the EE labs and Recreation Center pools to determine transmission range. The receiver detects the transmitted signal up to 150 feet away and fits comfortably on the user's ankle. The alert module determines receiver detection.

The transmitter remains operational over the shark's lifetime by hydraulic turbine-based AC power generation. This is accomplished by utilizing the shark's movement through the water. Testing was conducted in the Cal Poly Civil Engineering Department's Flume and in Lake Nacimiento.

Chapter 1 - Introduction

With a total of 53 shark attacks occurring in the US in 2013 [1], shark attacks are not an everyday occurrence. However, they remain a threat to beachgoers. The proposed Shark Alert Early Warning System provides an effective method for reducing the number of shark attacks. Shark Alert effectively warns people in the water - at highest risk for an attack - when a shark is nearby.

The receiver attaches to the user's ankle to provide the best transmitter signal reception. The transmitter portion attaches to the shark's dorsal fin and sends out a constant acoustic signal. The receiver detects this signal when the transmitter is within the receiver's detection range. This method of shark detection has a major advantage over current satellite shark tracking which requires shark dorsal fins above the waterline. This results in shark sightings that are few and far between, and in many cases too late to effectively warn people in danger [2]. The Shark Alert Early Warning System eliminates this issue through constant underwater signal scanning and detection.

Underwater signal detection is a much more effective method because sharks spend the majority of their lives underwater in deeper sections of the ocean [3]. Sharks also use ramjet ventilation, a method of breathing where water is forced through the gills, which requires constant swimming [4]. A major issue with current shark tag technologies is transmitter battery life [5]. Shark Alert takes advantage of the shark's constant movement and powers the transmitter with a hydraulic turbine-based AC generation system. The force of moving water against the hydraulic turbine as the shark swims creates constant rotational motion. The increased battery life helps sustain the tagged shark infrastructure for more accurate shark detection.

The Shark Alert Early Warning System improves on current shark tag system designs to give users a reliable ocean safety method.

Chapter 2 – Customer Requirements

Customer Needs Assessment

Customers require a simple, wearable device that quickly alerts the user to a shark's presence. A wearable device significantly decreases the alert time over current shark tracking technologies, currently a research-based device, using an outdated GPS system. To offer an advantage, the receiver must maintain proper operation in all weather conditions and situations. A waterproof device with a comfortable and unobtrusive shape avoids user motion restrictions. A non-restraining device implies minimal complications during use. Therefore, Shark Alert only requires battery exchange at regular intervals. An effective system must quickly alert the user to shark presence through visual cues or other human perception methods [6].

Market research and personal experience of project group members determined the basic needs for a Shark Alert user. Living in San Luis Obispo, in close proximity to the beach, yields a good understanding of the beach and ocean conditions. Group members Marc Rauschnot and Cory Peterson surf and wakeboard avidly in their free-time. Furthermore, Marc earned his diver's license and has identified potential shark dangers to divers.

Requirements and Specifications

Requirements and specifications for the Shark Alert system based on customer requirements appear in Table 1 below. The device must operate properly in ocean conditions that can adversely affect electronics and circuitry. The receiver portion must have a small overall size, approximately 3"x5"x1", for comfort. The unit must also be waterproof to 100ft below sea level. Sharks can swim in all ocean areas; the receiver's detection range extends to a 1000ft to allow the user time to reach the shore. The receiver must alert the user when a shark enters the detection radius in a clear and understandable manner. The shark-mounted transmitter portion must have a small overall size no larger than 8"x2"x2", and an aerodynamic shape to minimize swim drag. The generation subsystem [has a 2" diameter.

The main constraint in implementing Shark Alert is physically attaching a transmitter to enough sharks to create an adequate infrastructure. If a low number of sharks have installed transmitters, then device users run a higher risk of encountering sharks without warning. Shark tagging requires a large time and money investment to develop a complete infrastructure. The Shark Alert infrastructure also requires constant updates as sharks give birth or die. This results in a long delay time before the product enters circulation and constant maintenance costs. A second major constraint is verifying that the tagging process remains safe and humane for each shark, and that the tag does not hinder the shark's daily lifestyle. Building a waterproof enclosure that can withstand the high pressure of deep water poses another problem. The casing must be sturdy, water tight, and still allow for signal transmission from transmitter to receiver.

Table 1: Shark Alert Requirements and Specifications

Marketing Requirements	Engineering Specifications	Justification
[1]	Receiver dimensions less than 3”x5”x1”.	The user requires a small wearable receiver worn comfortably.
[1] [10]	Receiver mounting gear expands to a 1ft circumference.	Users without access to a wrist or ankle can wrap the mounting gear around larger body parts such as calves or quadriceps.
[9]	A receiver waterproof to 100ft below sea level.	Most users only require a waterproof depth of 10ft but a diver requires 100 ft.
[9]	Transmitter waterproof to 4,000ft below sea level.	A great white has reached a depth of 3,937ft below sea level.
[6]	Receiver has a 150ft radius transmitter detection range in standard conditions.	A reasonable detection, with debris in the water, 150ft detection range allows the user to safely reach the shore.
[8]	Receiver must alert the user when a transmitter is in range, through touch and sight.	The receiver must alert users in surface and subsurface marine environments which could impede certain human senses.
[4]	Transmitter dimensions less than 8”x2”x2”.	The transmitter must avoid adverse effects on the shark’s swimming ability.
[4] [5] [7] [11]	Power generation subsystem no larger than 4 cubic inches.	The power generation subsystem must minimize drag to avoid impeding the shark.
[2]	The transmitter must maintain continuous operation for 25 years.	Average shark life - 25 years.
[3]	The receiver uses an off-the-shelf battery.	The receiver must operate for extended time periods and use a common battery since the device life span exceeds battery life.

Marketing Requirements

1. Comfortable and wearable receiver
2. Long lasting receiver battery life
3. Receiver has easily replaceable battery
4. Small transmitter
5. Aerodynamic transmitter
6. Detection distance between transmitter and receiver allows user time reach shore
7. Long lasting transmitter battery life
8. Noticeable alert system
9. Waterproof transmitter and receiver
10. Expandable receiver mounting gear
11. Transmitter has a power generation subsystem

The requirements and specifications table format derives from [1], Chapter 3.

[20] R. Ford and C. Coulston, Design for Electrical and Computer Engineers, McGraw-Hill, 2007, p. 37
[21] IEEE Std 1233, 1998 Edition, p. 4 (10/36), DOI: 10.1109/IEEESTD.1998.88826

Block Diagrams

The level 0 block diagram shown below in Figure 1, presents the basic functionality for this senior project.

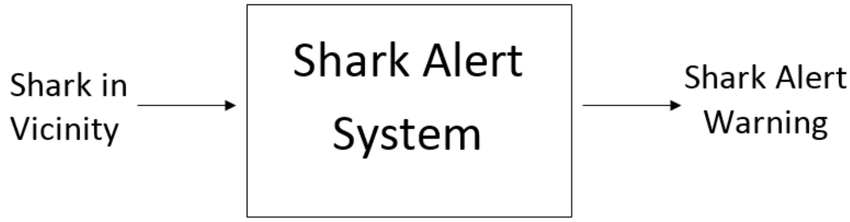

Figure 1: Level 0 Block Diagram

The level 1 block diagram in Figure 2 describes basic Shark Alert functionality as subsystem components, input to output.

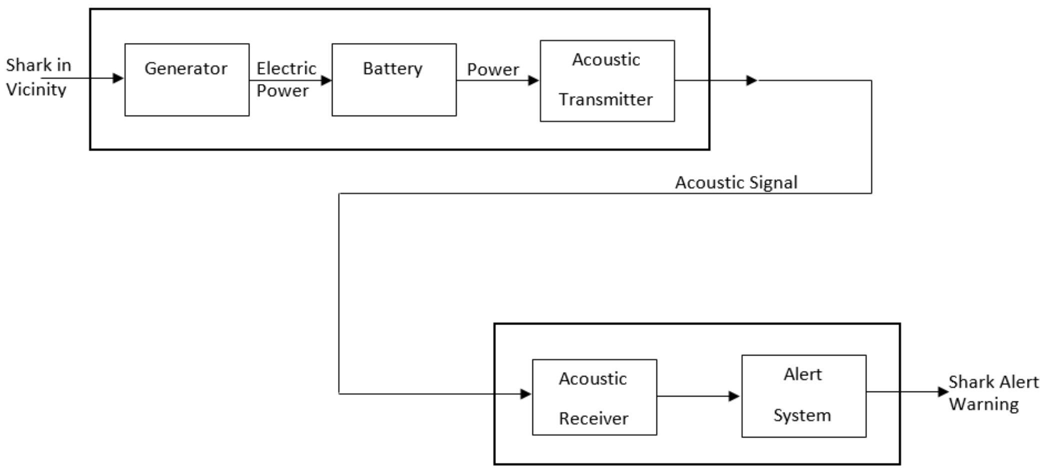

Figure 2: Level 1 Block Diagram

Chapter 3 – Final System Design

The final system design is displayed as a block diagram below in Figure 3. The hydraulic turbine-based generation system provides power for the transmitter system. Sharks must constantly swim for ramjet ventilation breathing; hence, the constant water force against the turbine maintains blade rotation and transmitter power generation. The hydraulic turbine creates an AC voltage which is converted into DC voltage by full wave rectification. The DC signal is applied to a DC to DC converter to achieve a constant 16 V. Voltage regulation is necessary because sharks travel at variable speeds and the hydraulic turbine's output voltage level is directly related to the shark's swim speed. While a shark is swimming at its average swimming speed of 3.5 to 5 mph, a much lower voltage is created compared to instances when a shark accelerates to 30 mph to catch prey. The voltage regulator maintains 16V to the crystal oscillator circuit, which creates a 200 kHz sinusoidal signal. Signal amplitude is doubled by the driver amplifier and applied to the acoustic transmitter.

The 200 kHz signal is detected through the water by the acoustic receiver and sent to a bandpass amplifier. The amplifier output is applied to a tone detector designed to output 0 V whenever a 200 kHz signal is detected and 9 V in the absence of a 200 kHz signal. The tone detector output is sent to an inverter to ensure a 9V output during signal detection. This output voltage is used to power the LED and vibrating motors to alert the user.

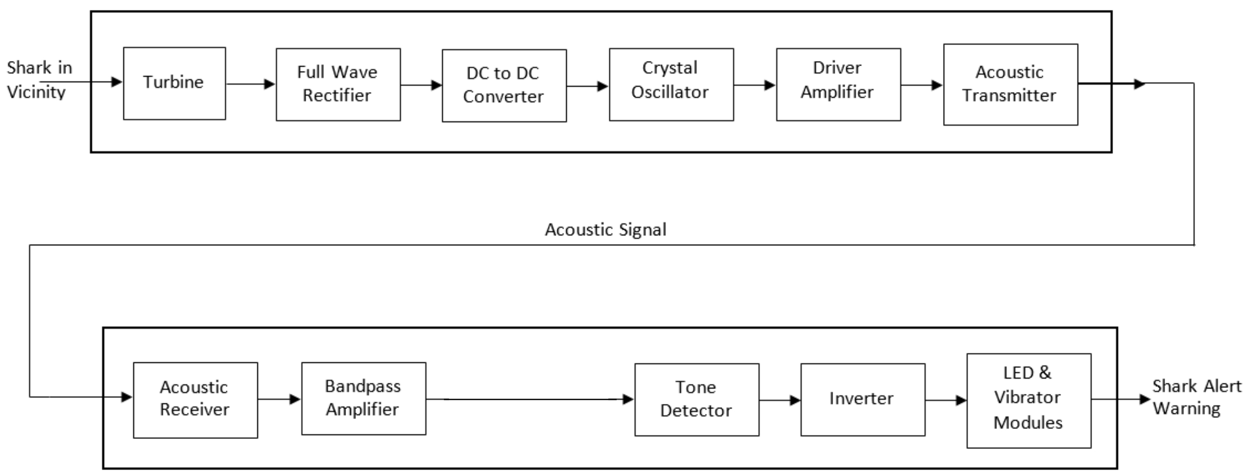

Figure 3: Final Level 2 Block Diagram

Chapter 4 – Simulations and Analysis

Hydraulic Turbine

The hydraulic turbine generation system creates an AC voltage and current when rotated by the force of flowing water. A 3D rendering of the transmitter, including the turbine, is shown below in Figure 4. A computer fan (see Figure 5) is used as the turbine. A DC voltage is normally applied to the fan, but if everything except the coil and magnets are removed, the fan can be used to create an AC voltage and current.

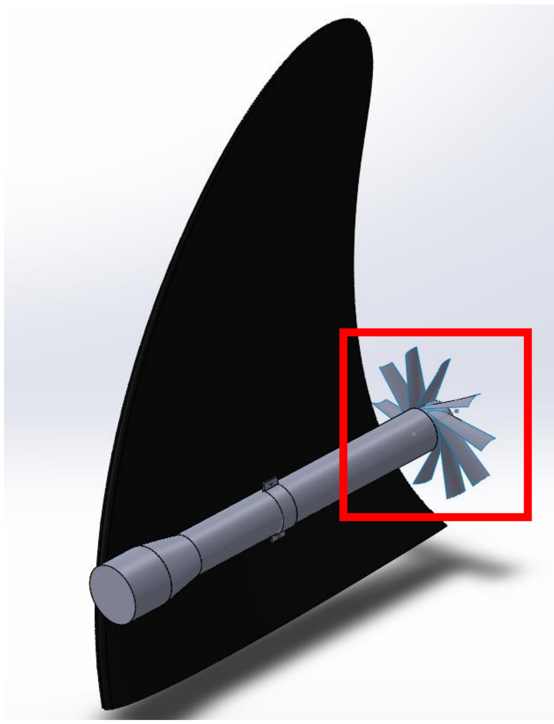

Figure 4: 3D Rendering of Shark Alert Transmitter (red box – hydraulic turbine)

Figure 5: 60mm Computer Fan

Full Wave Rectifier

The full wave rectifier accepts the AC voltage output of the hydraulic turbine-based generation system and creates DC voltage to power the transmitter. Figure 6 shows AC signal routing through a diode network that converts the AC voltage to a rectified signal applied across a resistor and capacitor. The capacitor is used to remove signal variation (AC component) to create constant DC voltage. Input and output full wave rectifier waveforms are shown in Figure 7 below. The output voltage, shown in blue, is 0.7 V below the applied voltage amplitude due to the 0.7 V forward bias diode voltage.

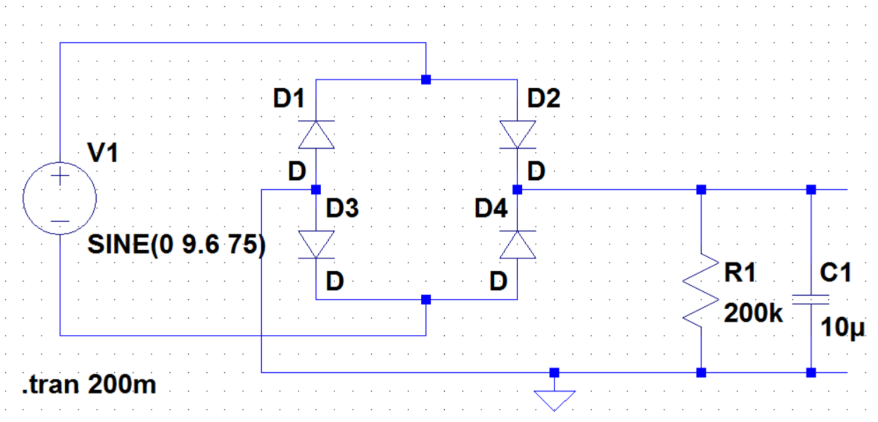

Figure 6: Full Wave Rectifier Schematic

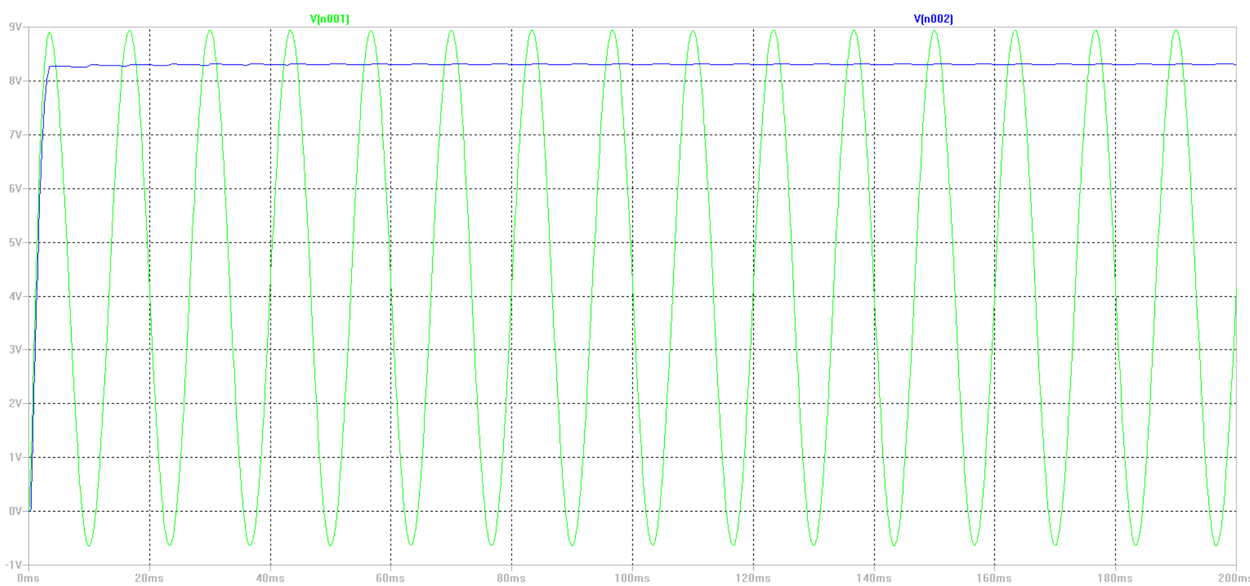

Figure 7: Full Wave Rectifier Simulation (green – input, blue – output)

DC to DC Converter

The LM2577 DC to DC converter was purchased to produce a reliable output voltage for maintaining transmitter power since Shark Alert team members have limited power electronics experience. The LM2577 DC to DC converter is shown below in Figure 8.

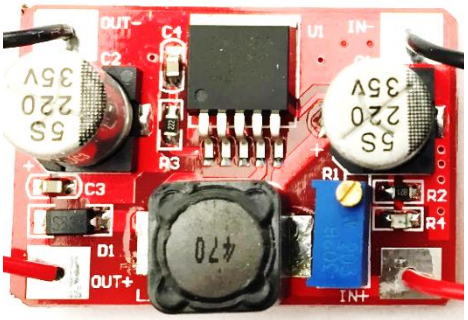

Figure 8: LM2577 DC to DC Converter

Crystal Oscillator

The selected crystal oscillator design is the MOS Fundamental Crystal Oscillator Circuit [8]. This circuit was chosen to maintain a steady 200 kHz AC voltage signal at the rated 20V amplitude. LT Spice cannot accurately simulate oscillator circuits; hence, oscillator functionality and waveforms are shown for the completed circuit, see Chapter 5– Testing and Results.

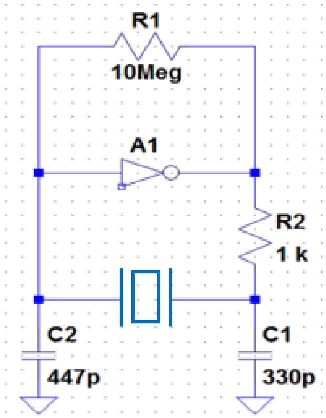

Figure 9: Crystal Oscillator Schematic

Driver Amplifier

The driver amplifier accepts the 200 kHz crystal oscillator signal and doubles the signal amplitude. This is accomplished with five inverters as shown in Figure 10 below. The first inverter, U3, inverts the signal, resulting in 180 degree phase difference between Node_1 and Node_2. Both signals are passed through a pair of parallel inverters which maintains the 180 degree phase difference and also increases the current due to the property of summing inverters. This produces outputs $V_{OUT(+)}$ and $V_{OUT(-)}$, each output is 180 degrees out of phase with respect to the other. They create an output signal twice the input signal amplitude. In Figure 11 below, $V_{OUT(+)}$, $V_{OUT(-)}$, and total signal ($V_{out(+)}$ - $V_{out(-)}$) are shown. The output signal difference creates the total signal in green.

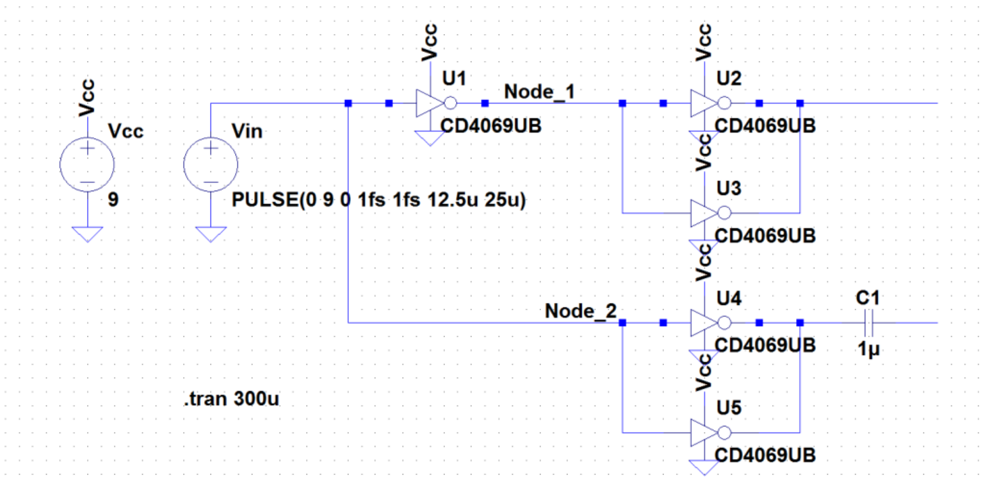

Figure 10: Driver Amplifier Schematic

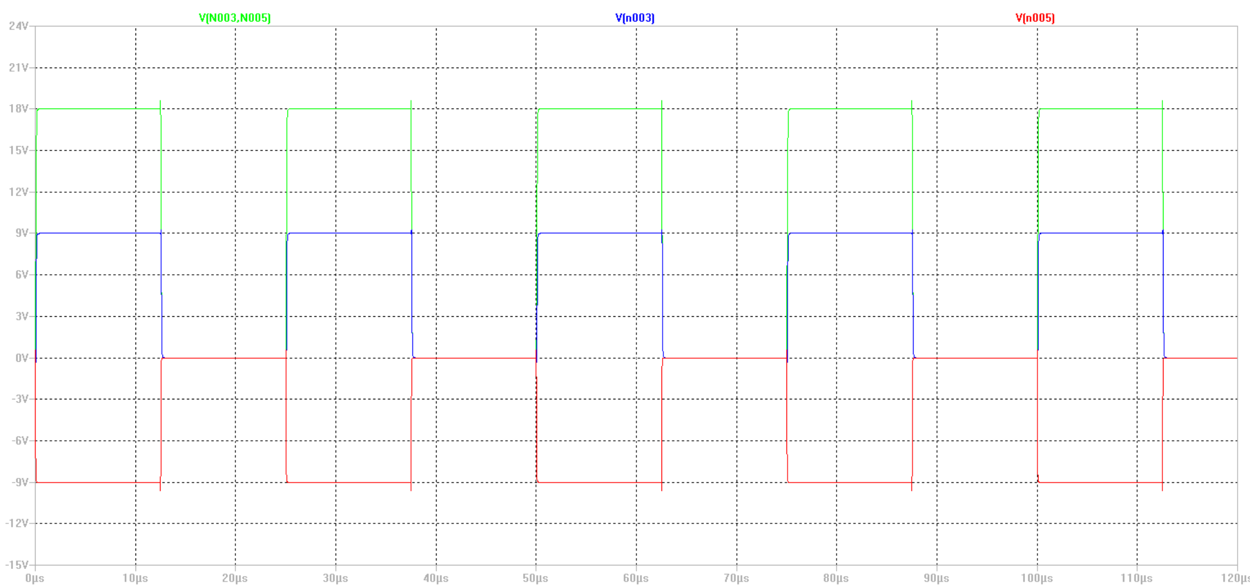

Figure 11: Driver Amplifier Output Simulation (red – $V_{OUT(-)}$, blue – $V_{OUT(+)}$, green – total)

Bandpass Amplifier

The bandpass amplifier increases received signal amplitude from the acoustic receiver and blocks signals within the 200±50 kHz band. Figure 12 below shows that each amplifier stage increases signal amplitude by a factor of 7; both stages, a factor of 49. Signals in the mV range are also sensed by the tone detector. Bandpass amplifier input and output waveforms are shown in Figure 13 below.

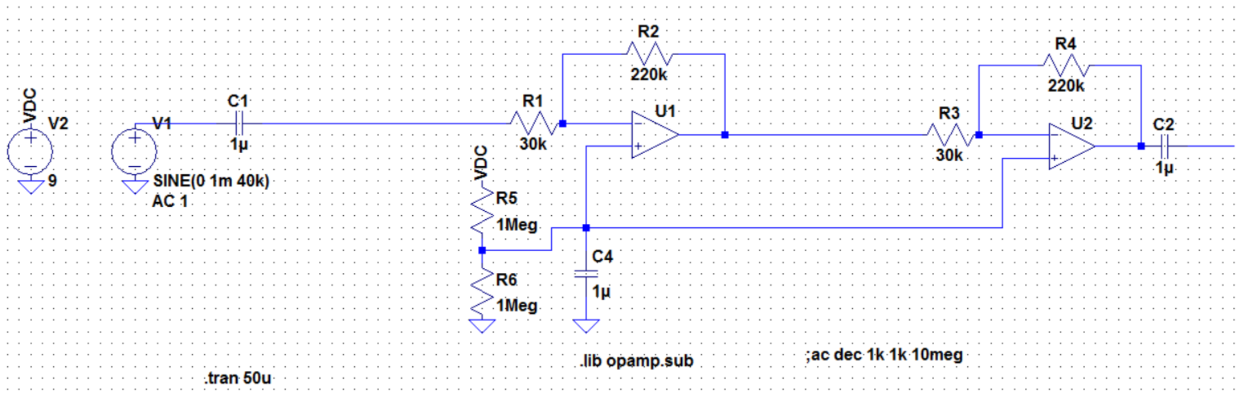

Figure 12: Bandpass Amplifier Schematic

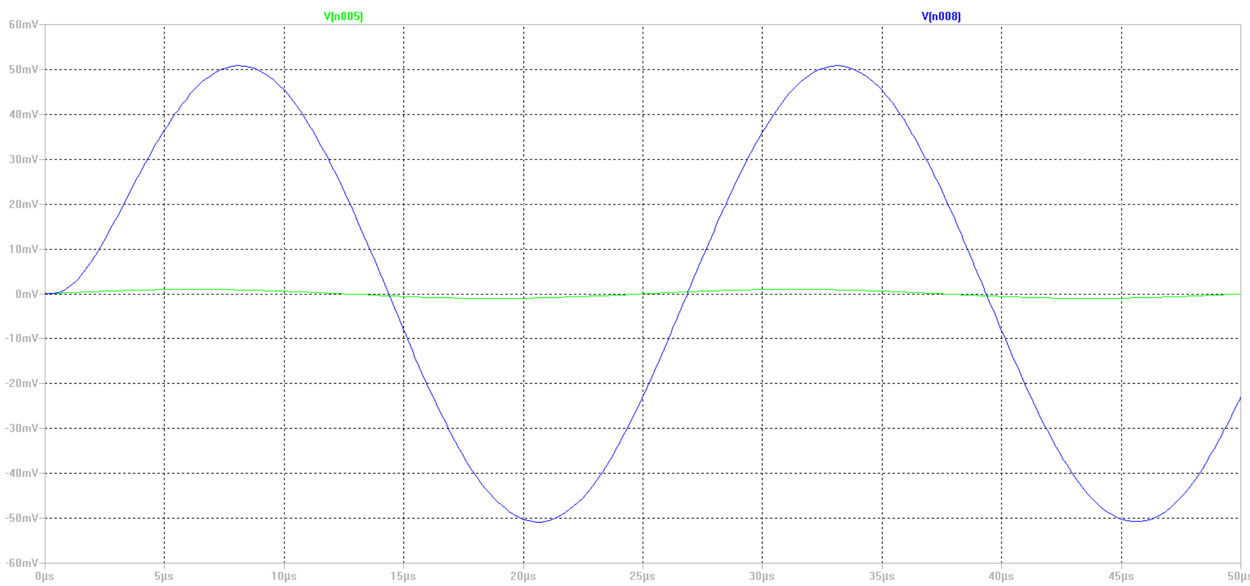

Figure 13: Band Pass Amplifier Simulation (green – input, blue – output)

Tone Detector

The tone detector creates a voltage equivalent to V_{CC} (in our case 9V) at pin 8 when a 200 kHz AC voltage signal is applied to the input. Component values chosen for a 200 kHz input signal are shown in Figure 14 below. Tone detector LT Spice simulations are not possible due to absence of the tone detector module in the LT Spice library; hence, tone detector functionality could not be verified until the circuit was completed. The waveform depicting this circuit operation confirmation is shown in Chapter 5 – Testing and Results.

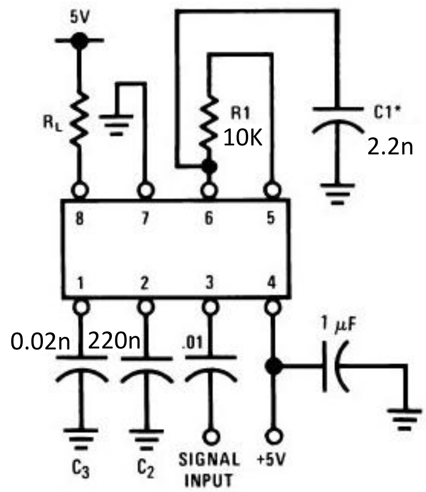

Figure 14: Tone Detector

Control MOSFET, LED and Vibrating Motors

The power MOSFET circuit in Figure 15 below is used to power the LED and vibrating motors, connected in series, and represented in Figure 15 by a single LED. This circuit is controlled by the inverted tone detector output attached to the MOSFET gate through a 10kΩ resistor. When a signal is detected and the gate input is 'high,' the MOSFET is switched on, and current flows from rail to ground illuminating the LED and vibrating the motors. When a signal is not present and the gate input is 'low,' the MOSFET is switched off; both the LED and motors are disabled.

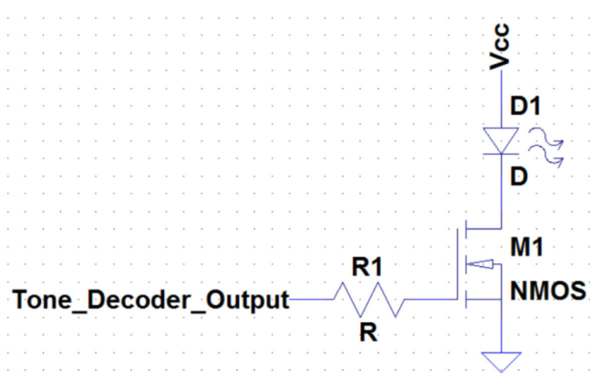

Figure 15: LED and Vibrating Motor Circuit (Motor included in LED symbol)

Chapter 5 – Testing and Results

Shark Alert testing was conducted in several locations. For small scale and individual component testing, the Shark Alert team utilized the Electric Power Institute (EPI), Student Project Lab (SPL), Motomatic Lab, and the IEEE Collaboration Lab (ICL). For large scale testing including the hydraulic turbine-based generator tests, the Shark Alert team utilized the Cal Poly REC Center pool, the CE Department's small flume, and Lake Nacimiento.

Acoustic Transmitter and Receiver (ultrasonic transducers)

Initially a set of inexpensive waterproof ultrasonic transducers were purchased. However, testing immediately proved that signal transmission is limited to 3 ft with a 20V, ½ W signal. This is does not meet the 150 ft distance requirement for the Shark Alert application. Omnidirectional ultrasonic transducers cost over $1000.00 for a single omnidirectional transducer. The most cost effective option that meets transmit distance requirements is ultrasonic fish-finders. These units were dismantled to use their ultrasonic transducers. Configuring the transducers in the setup shown in (Figure 16), the operating frequency of the fish finders was determined to be 200 kHz. The transmit signal is shown below in Figure 17.

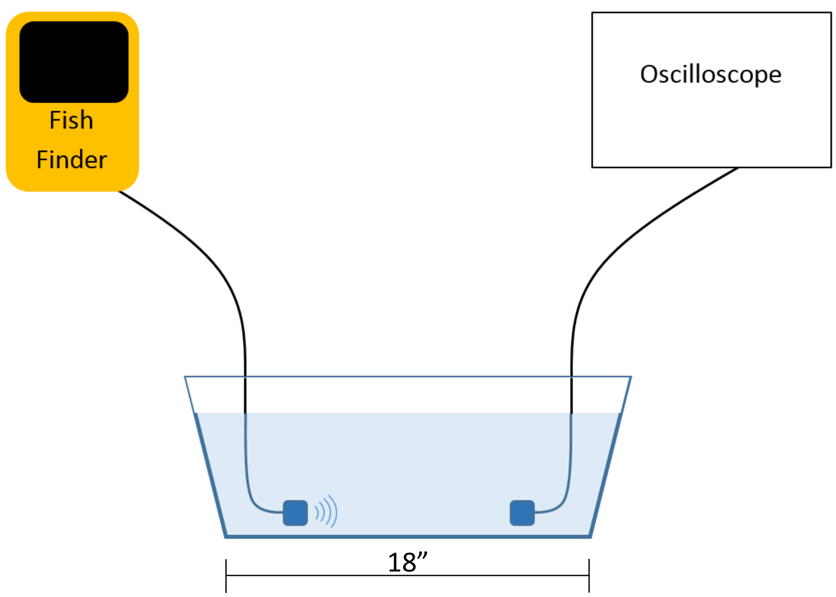

Figure 16: Test Configuration using Fish-Finders as Signal Source

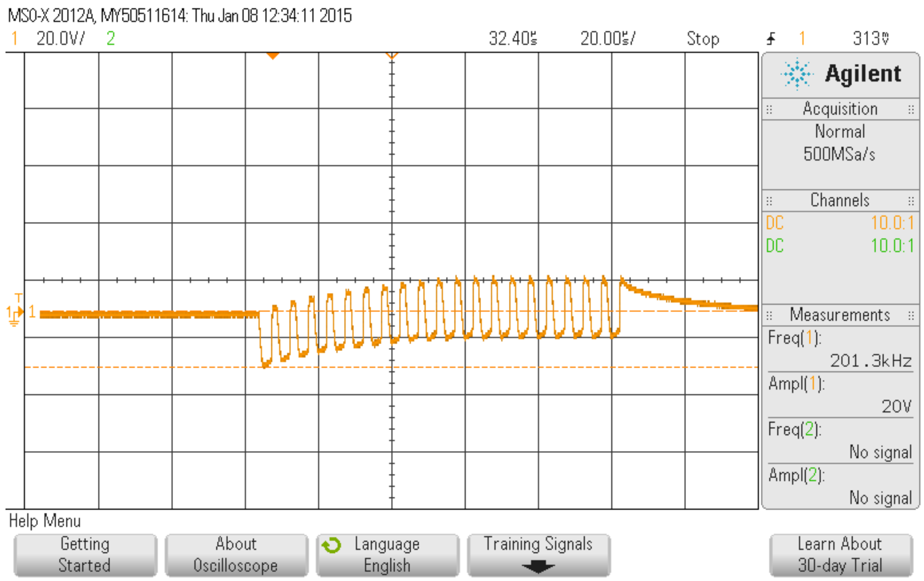

Figure 17: Fish-Finder Transmit Signal

The transducers were tested to determine the frequency with maximum signal strength. Testing through 18 inches of water using a function generator in place of the fish-finder (Figure 14) revealed that a 206 kHz signal produced the strongest response. However, 206 kHz oscillator crystals are unavailable. To realize the oscillator design in Figure 7, the best option is to use a 200 kHz signal. Transducer signal strength exhibited decreased intensity when using 200 kHz instead of 206 kHz, but was suitable for the application. A 200 kHz, 5V signal sent and received through 18 inches of water is shown below in Figure 18. It was determined that the receivers' minimum detectable signal amplitude is 300 mV.

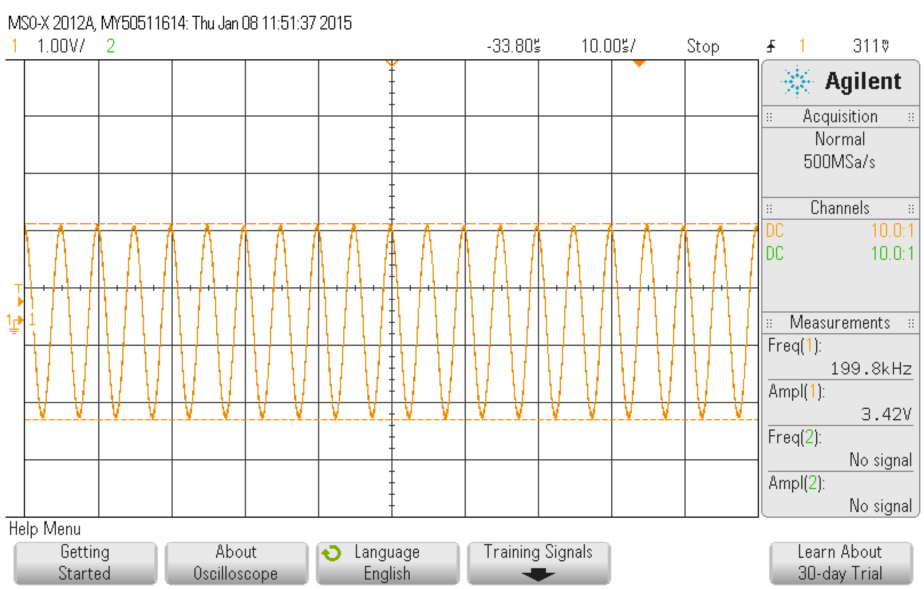

Figure 18: 5V, 200 kHz Signal Read by the Receiver Transducer; Function Generator used as Transmitter Power Source

Crystal Oscillator

The DC power source was used to provide 18V rails to the crystal oscillator. The oscillator circuit output was probed with the oscilloscope; results are shown below in Figure 19. This oscillator was operated for 30 minutes while maintaining the 200 kHz 18V sine wave.

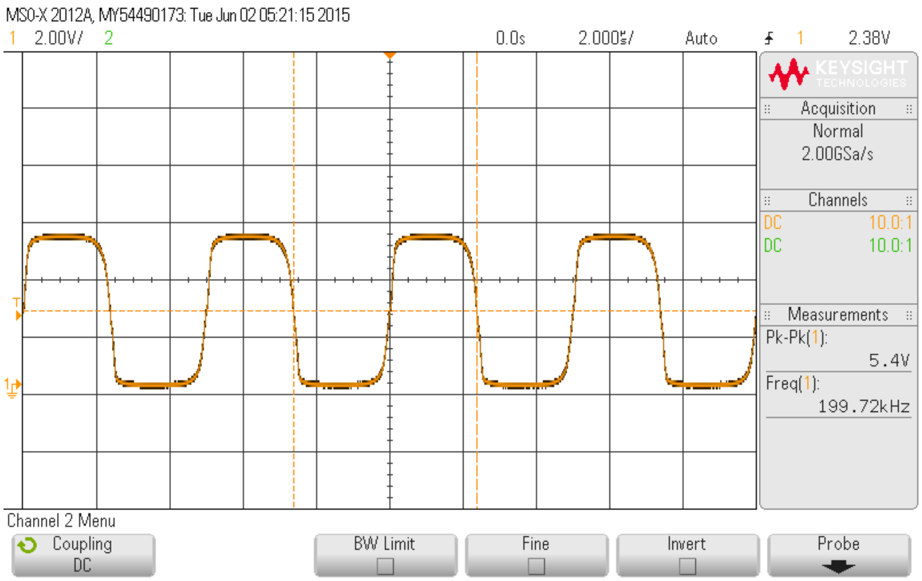

Figure 19: 200 kHz Crystal Oscillator Output

Driver Amplifier

The driver amplifier was connected to an 18V peak-peak AC voltage signal. The two driver amplifier output waveforms are shown in Figure 20. Outputs are 180 degrees out of phase as expected which is key to doubling the signal strength. The oscilloscope was then connected across two outputs as shown in Figure 21. Since the signals are out of phase, the output amplitude is $36V_{pp}$, the difference between the +18V and -18V outputs.

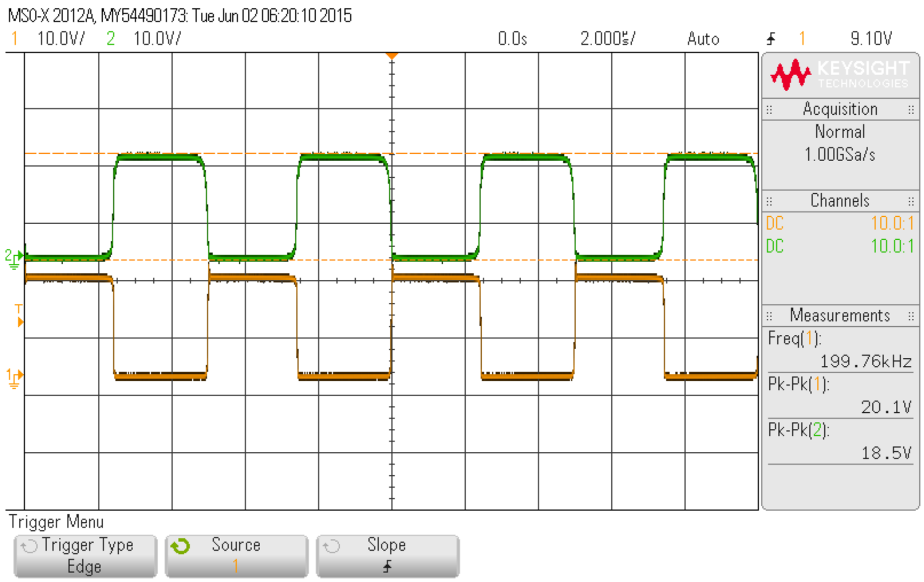

Figure 20: Driver Amplifier Individual Outputs, Ch. 1 – $V_{OUT(+)}$,Ch. 2 – $V_{OUT(-)}$

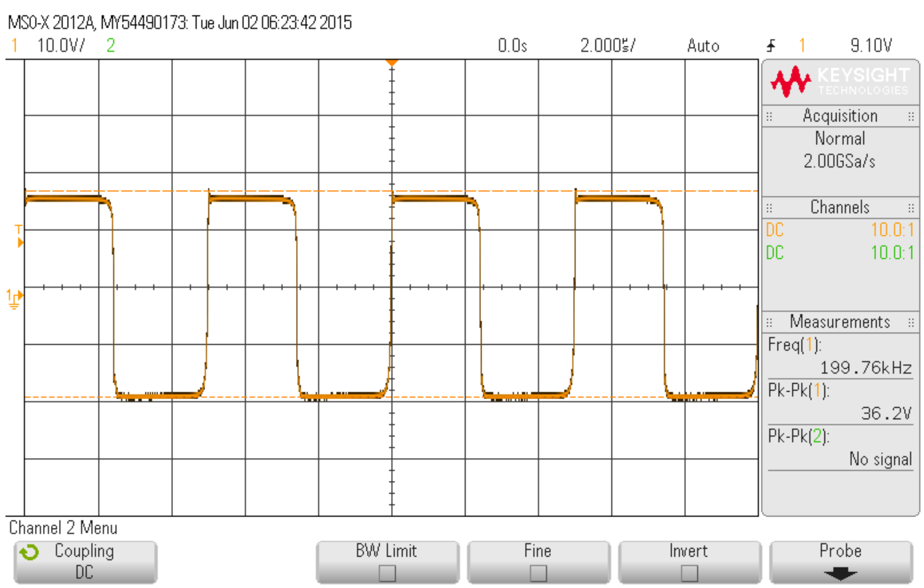

Figure 21: Total Driver Amplifier Output: $V_{OUT(+)} – V_{OUT(-)}$

Bandpass Amplifier

The bandpass amplifier from Figure 12 was constructed and Figure 22 shows test results at 202 kHz, input vs. output. The amplifier was designed for a gain of 50; however, testing indicates a gain closer to 10. Since the smallest signal amplitude received by transducers is 300 mV, a gain of 10 is sufficient for system operation. The rails are set to 9 V, the maximum output voltage. This results in output voltage clipping as seen in Figure 22. Tone detector testing (see Figure 23) revealed that the clipped signal can be used.

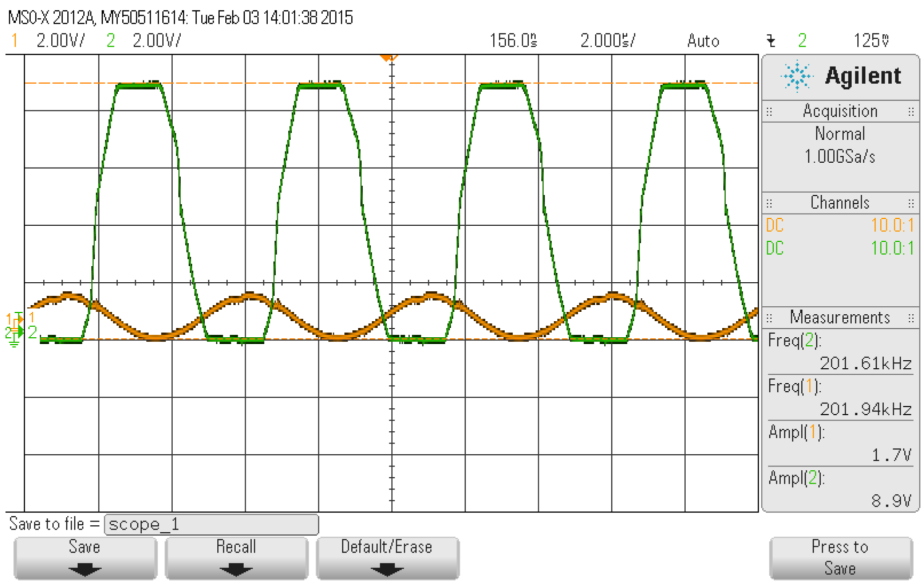

Figure 22: Ch. 1 – Bandpass Amplifier Input, Ch. 2 – Bandpass Amplifier Output

Tone Detector

The tone detector was tested using the Bandpass Amplifier output's 200 kHz signal. This caused the tone detector to lock the output signal at 0V (as seen in Figure 23). If a different frequency is received, the tone detector output is 9V. This was tested by grounding the input port and noting 9V at the tone detector output. Since the inverter input is the output of the tone detector, a 9V output will become a 0V output and fits the system requirements.

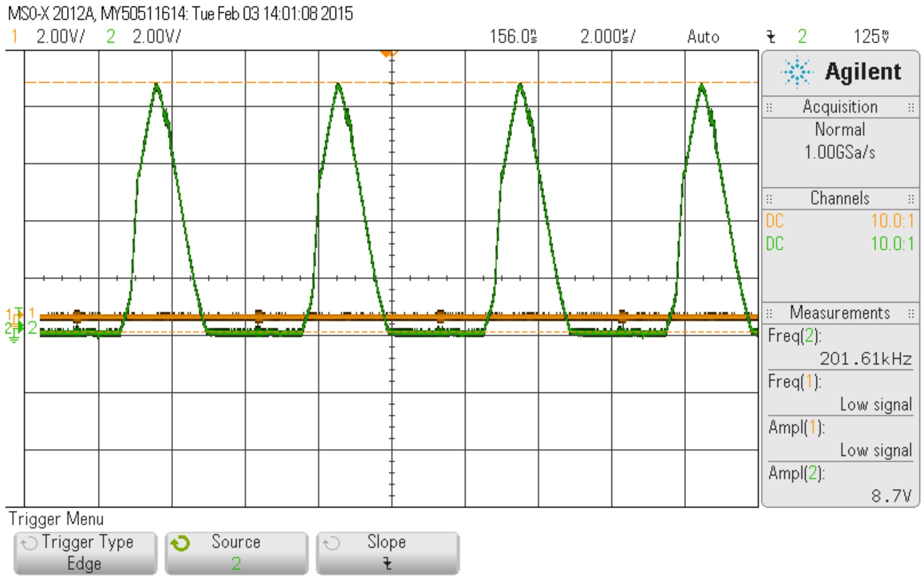

Figure 23: Ch. 1 – Tone Decoder Output, Ch. 2 – Tone Decoder Input

Hydraulic Turbine

The flume used for testing the generator turbine is pictured below in Figure 24 and an RPM measurement video method is shown in Figure 25. A GoPro video camera in a waterproof case recorded flowing water induced fan blade rotation video. Screenshots were used to determine pink tape travel between frames. Overall flume testing was inconclusive; the fan enclosures disrupted water flow. In a larger cross sectional flow area, the water would reestablish equilibrium speed as expected. Due to the small flume width, frictional forces, and boundary layers at the water-plastic side contact prevented consistent water speeds and fan RPMs. The low speed allowed large boundary layers to form causing turbulence and inconsistent measurements. We used a FLO-MATE Model 2000 portable flow meter to record measurements. The initial flume test results are shown below in Table 2; the data followed an inconsistent pattern.

Table 2: Initial Flume Test Results

Fan/Flume Configuration	Water Speed (ft/s)	Fan blade speed (RPM)
60 mm / No Tilt	4.0	400
60 mm / 10° tilt	4.5	533
60 mm / 30° tilt	4.5	900
60 mm / 45° tilt	4.6	2700
60 mm / Flow restricted**	4.0	515
50 mm / No tilt	4.0	2160
50 mm / 30° tilt	4.5	960
50 mm / 45° tilt	4.6	1800
** Flow was restricted by metal plates on both sides of the fan forcing all water flow through the fan enclosure		

Figure 24: Fan Blade Speed Test Flume

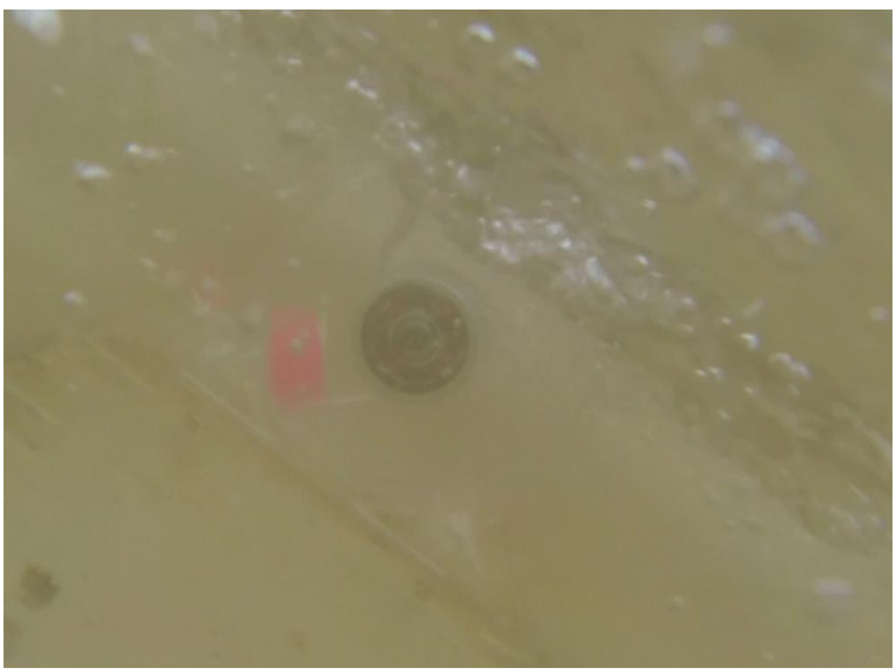

Figure 25: GoPro Screen Capture; Underwater Fan RPM Measurements

With flume testing resulting in inconsistent data, motors in the Motomatic Lab were explored to rotate the fan at set speeds to generate voltage and current. Computer fan output voltage testing results are shown in Figure 26 below while Motomatic test results are shown in Table 3.

Table 3: Motomatic Driven Computer Fan Test Results

RPM	AC Voltage (V)	AC Current (A)	Generated Power (W)
450	7.45	0.065	0.24
500	8.60	0.072	0.31
600	9.34	0.083	0.39
700	10.35	0.093	0.48
800	12.90	0.104	0.67
900	13.60	0.114	0.78
1000	15.90	0.125	0.99
1100	18.00	0.140	1.26
1200	20.00	0.147	1.47
1300	21.50	0.151	1.62

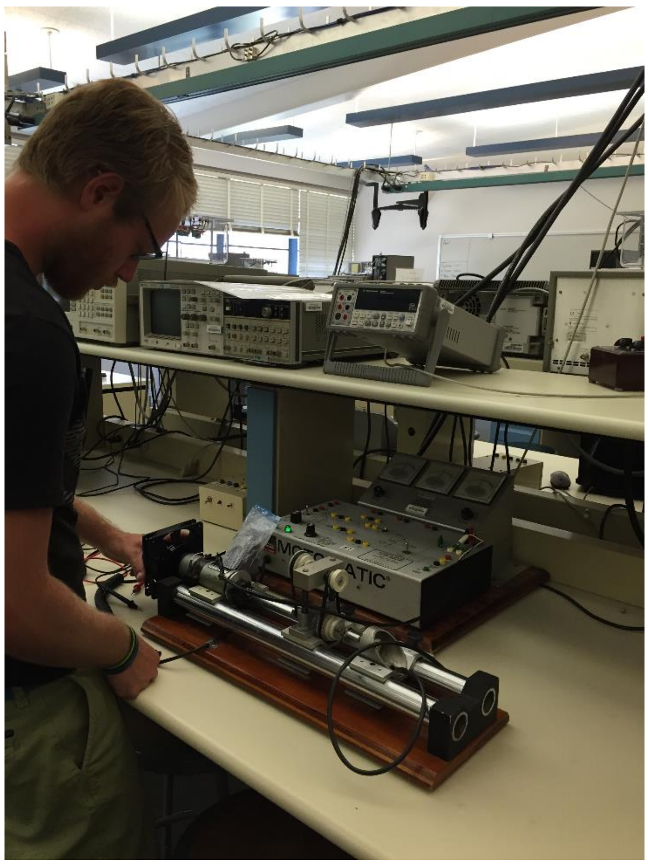

Figure 26: Cory Peterson Testing Computer Fan on the Motomatic

Tests were performed in Lake Nacimiento to avoid flume test difficulties. Results show that the secondary flume tests were more accurate than initial lake testing. Lake test accuracy is supported by consistent results and water flow restriction problems experienced in the flume test. Using the boat for testing in the lake test allowed for a better simulation of open-water fluid dynamics experienced by the tag if attached to a great white shark.

On April 26th, 2015, Team Shark Tag went to Lake Nacimiento to test generator spin rates at different boat speeds. Team member Marc was pulled by rope behind the boat while holding the generator (see Figure 27). Team member Cory controlled boat speed. Cory used Perfect Pass Wakeboard Pro [9], a speed controller with a paddlewheel system to accurately achieve the desired 5 MPH speed. This was verified using a GPS smart-phone application. A volunteer held a GoPro camera to capture generator blade rotation. Multiple tests were completed at 5 MPH; all returned consistent results (see Table 4 below). The results strongly indicate sufficient power generation to drive the transmitter circuit. These RPM values, when tested on the Motomatic, produced 0.48 W (see Table 4). Based on pool testing, this is sufficient power to transmit approximately 300 ft.

Figure 27: Marc Holding the Computer Fan and a GoPro Camera to Measure Fan RPM Values at Different Boat Speeds

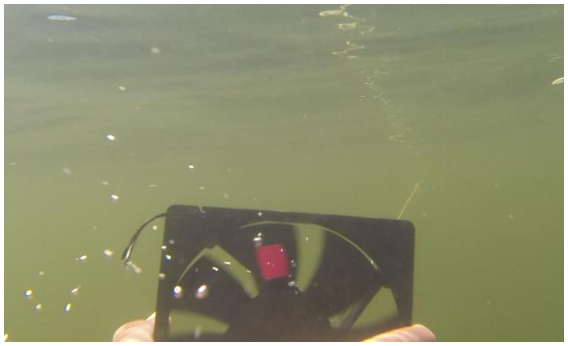

Figure 28: Lake Nacimiento Fan Blade RPM Measurements

Table 4: Lake Test Results

Test Number	Speed MPH	RPM
1	5.0	720
2	4.7	685
3	5.4	765
4	5.7	805

A second round of lake testing was conducted to measure the voltage produced by underwater fan blade rotation. These tests resulted in approximately 0 V readings. We concluded that the copper coils short-circuited in the water. Insulation was added to the coils, which should solve the problem, but time did not allow for additional lake testing. In Chapter 6 – Suggestions for Improvement, a new concept for a watertight hydraulic turbine-based generation system is discussed.

Table 5: Secondary Flume Test Results, 120 mm diameter Fan

Water Speed (mph)	Voltage (V)	Current (mA)	RPMs
2.40	1.94	17.98	277
2.37	2.65	23.78	320

Transmitter and Receiver Housings

The transmitter housing is composed of 1.5” schedule 40 PVC. The ultrasonic transducer was glued onto the top of the PVC. The original design requires generator installation onto the transmitter backside on a PVC end-cap. Due to testing constraints at the Senior Project Expo, the generator and remaining transmitter components were built on two separate PVC sections. These pieces thread together, male to female end caps, as seen in Figure 29. This transmitter assembly allows end-cap separation for battery insertion for transmitter power. The transmitter housing, with installed end cap, was left underwater for a period of 24 hours. No leaks were observed.

Figure 29: Transmitter Housing

In building the receiver, a waterproof enclosure, Plano Guide Series 3449 Size Polycarbonate Field Box, was acquired, see Fig. 30. A small hole was drilled in the box top-side to attach the ultrasonic transducer using PVC glue to retain waterproof characteristics. Two additional holes were drilled in the box bottom-side to place the vibrating modules closer to the user's skin. The modules were glued into place and waterproofed using Mighty Sealer, a flexible rubber coating sealant. A small hole was also drilled into the side of the box for "warning LED" installation – protrudes outside the case. This improves LED visibility to the user. The box was painted black for aesthetic reasons, and a Velcro strap was added for receiver housing attachment to the user's ankle. This box was placed underwater for 24 hours; no water leaks were observed.

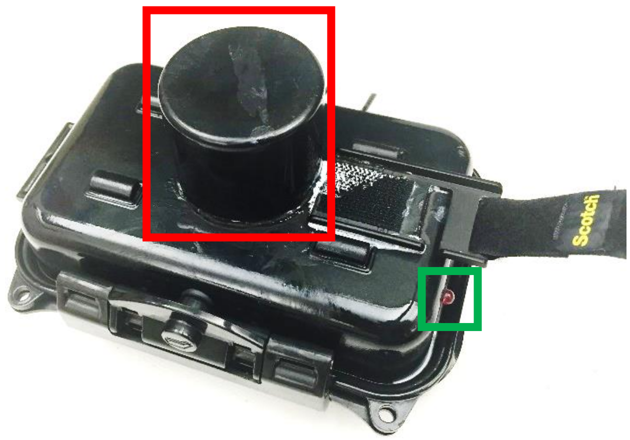

Figure 30: Receiver Housing, Plano Guide Series 3449 Size Polycarbonate Field Box (the Ultrasonic Transducer is in Red, and the "warning LED" is in Green)

Chapter 6 – Suggestions for Improvement

This project proved that a wearable shark alert is a completely viable solution to shark attacks on surfers, divers, and beach-goers alike. Still there are project improvements that would enhance system performance. The main improvement is to incorporate omnidirectional ultrasonic transducers to eliminate signal directional issues and improve signal reception. PCB layouts for all circuits would also improve system performance. Circuits soldered onto proto-boards requires excessive volume. PCB's reduce transmitter and receiver housing size to enhance wearing comfort. The last major improvement is to waterproof the hydraulic turbine-based generation system. Lake testing showed problems when the wire coil is in contact with water. To completely eliminate this issue, a new design involving two computer fans is suggested. Blades on one fan would be removed for placement inside the PVC piping instead of outside. This avoids coil contact with water. The second fan would utilize only the blades, not the generator portion; connect directly to the inside fan by metal shaft. This maintains generator functionality while avoiding coil water contact.

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Appendix A

Table 6: Analysis of Senior Project Design

Project Title: Shark Alert

Students' Names: Cory Peterson .
Signature

Taylor McClain .
Signature

Marc Rauschnot .
Signature

Advisor's Name: Dean Arakaki .
Initials Date

1. Summary of Functional Requirements

In a world filled with danger, the thrill seekers of the world run an even higher risk of finding themselves in a dangerous position. Yet this does not stop them from finding that rush and risking their lives. Out of the many extreme sports, surfing, diving, and other ocean sports place participants in additional danger due to creatures that live in the ocean. Sharks in particular threaten the lives of many ocean-goers and surfers alike. This senior project involves shark tag transmitter and wearable receiver system development to warn the user when a tagged shark is swimming nearby.

A transmitter tagged to the dorsal fin of a shark sends out a constant acoustic telemetry signal that travels through the water to the surfer's bracelet receiver when in range. The receiver is attached to the user's ankle with an expandable strap for users of all sizes and ages. The bracelet has an adjustable band secured by a sturdy clip. The receiver is equipped with vibrator modules as well as an LED to clearly warn the user when the transmitter signal is received.

2. Primary Constraints

A main constraint in implementing Shark Alert is physically attaching transmitters to enough sharks to effectively warn users of a shark's presence. If a relatively low number of sharks have an installed transmitter, shark attacks without warning may occur more frequently. Individually tagging sharks is essential for detection; however tagging requires a large time commitment to build up a database of tagged sharks. This system also requires constant additions/deletions when sharks give birth or die. This delays product circulation and requires constant maintenance.

A second major constraint is verifying that the tagging process is safe and humane for each shark, and that the tag does not hinder the shark's daily lifestyle. This constraint can be overcome with a sleek and aerodynamic transmitter housing design and an efficient hydraulic turbine. Building a waterproof enclosure that can withstand the high pressure of deep water also poses a problem. The casing must be sturdy and water tight and also allow for signal transmission from transmitter to receiver. Proper housing material selection and configuration design overcome this issue.

3. Economic

The Economic Impacts:

- Human Capital –
  - Directly affects people who:
    - Tag the sharks
    - Contribute to design and manufacturing

        - Contribute to receiver marketing and sales
    - Indirectly affects people who:
        - Work for delivery companies
        - Work for retail businesses
- Financial Capital –
    - Investor capital
- Manufactured/Real Capital –
    - Prototypes
        - Electronic Circuits
        - Enclosures
    - Shark tagging boat
    - Final product production
- Natural Capital –
    - Sharks
    - The ocean

Shark Alert benefits only accrue when sufficient sharks have been tagged with transmitters and receivers enter the market. As discussed in the constraints section, this results in a long time period where costs exceed profits. Initial high costs originate from research and development, testing, production and creating the tagged shark infrastructure. Costs continue to accrue after the initial product launch; however at a decreased rate compared to initial costs.

The project will not realize gross profits until the infrastructure is created. At this point, over $600,000 must be returned to primary investors. Profits are split among company owners according to ownership share.

Products are released to the public after building a sufficient infrastructure; estimated to require between 8 and 12 months. Shark tag transmitters should last the entire shark life span while the receiver side can last 5 years, with proper maintenance and care. The only maintenance cost is receiver battery replacement.

Post project completion, the Shark Tag Team pursues investors and begins the tagging process to build the Shark Alert infrastructure.

4. If manufactured on a commercial basis:

- Estimated number of receivers sold per year – 20,000
- Estimated manufacturing cost for each receiver– $20.00
- Estimated manufacturing cost for each transmitter - $30.00
- Estimated purchase price for each device receiver– $69.99
- Estimated profit per year – $500,000
- Estimated cost for user to operate device - $50.00/5yrs (battery replacement)

5. Environmental

Prominent environmental impacts from Shark Alert are manufacturing and product shipping pollution, disturbance to ocean life when using boats to tag sharks, and the sharks' physical stress from the tagging process. Less prominent environmental impacts occur when a shark tag comes loose and pollutes the ocean or is ingested by another ocean creature.

Natural Resource and Ecosystem Services

- Directly
    - Sharks
    - The ocean
- Indirectly
    - Resources used to create the casing
    - Gasoline used for product shipping and boat fuel

- Boats driving through coral reefs and disturbing the ecosystem

Direct impact to ocean life occurs from boats and shark tagger crews; noise and waste. Indirect effects are caused by gas to operate the boat, and boat and device construction. The project may raise shark awareness and helps diminish sharks' image as cold-blooded killers by decreasing shark attack frequency. This in turn creates a more positive beach environment.

6. Manufacturability

The most difficult part foreseen in the manufacturing process is outer casing design to both accommodate electronics and avoid seawater contact. Other issues include case strength to protect sensitive electronics yet permeable to allow for signal output. Case manufacturing processes involve injection molding to enhance process efficiency and maximize final product durability.

7. Sustainability

One challenge with shark tag effectiveness is continual shark tagging to maintain infrastructure. The transmitter must also withstand corrosive salt-water properties and sudden shark movements.

The transmitter uses a generator system for complete self-sufficiency – eliminating batteries and greatly reducing its carbon footprint. Boat fuel for shark tagging is essential for the process.

Upgrades to improve project design include an app to synchronize the receiver with a smartphone for information transfer. This app would improve communications with beach observers as well as improved tracking knowledge.

8. Ethical

The main ethical dilemma is minimizing adverse effects on sharks during the tagging process and to verify the transmitter does not hinder the sharks' daily lifestyle. Certain advocacy groups consider it unethical to force an animal to wear a device; however, studies have shown that shark tag devices do not harm the shark.

Tagging a shark through the dorsal fin does not cause the shark pain, and humans look out for their own self-interest. Keeping other people safe is a high priority for most humans; therefore a product that can potentially save lives is considered an ethical product.

Using the Utilitarianism framework [21], tagging sharks is ethical as the greatest good is for the greatest number of people. The tagging process helps both sharks and users through reducing unnecessary conflicts. Less humans are lost to shark attacks and less sharks are lost when people have a reduced fear of sharks.

With respect to the golden rule, tagging sharks offers an ethical solution to shark attacks because it diminishes the stigma that sharks are killers. Sharks do not intend to harm humans; hence, they do not deserve adverse publicity. If humans were considered killers [in a miscommunicated situation], then humanity would appreciate help in clarifying the issue.

This project abides by the IEEE code of ethics by creating a product that potentially saves lives and helps create a safer beach environment. Shark Alert Co. operates on the basic human fundamentals of trust and respect to create a product that enables the user to have a positive experience.

9. Health and Safety

Concerns

- Going out to sea in questionable weather conditions
- Luring great white sharks (one of the most dangerous predators in the world)
- Making contact with these sharks in order to attach the tag
- Using electronic equipment around water

The major health and safety concerns arise from the shark tagging process. This requires a team to navigate a boat on the ocean and lure sharks. If the weather is poor, there is a potential for boat damage or sinking. When luring in the shark, the shark tag team comes in close contact with hungry and aggravated sharks. Another area of potential danger comes from testing electronic circuitry in the water. The teams run the risk of electrical shock injuries.

10. Social and Political

This project has potential for political and social issues from animal rights activists. Product use involves direct contact with sharks and attaching the transmitter without the true consent of the shark.

- Stakeholders
    - Direct
        - Sharks
        - Users
        - Researchers/Scientists
        - Shark Experts
        - Senior Project Advisor
        - EE Department
    - Indirect
        - Animal Rights Activists
        - Coast Guard
        - Observers

Direct stakeholders see the product first hand and directly utilize the product. The sharks, researchers/scientists, and shark experts experience a direct effect during the shark tagging process. The sharks wear the transmitter and researchers and experts mount the transmitter. Users have a direct impact from using the project. Our senior project advisor directly helps with each project step. The EE department has a direct impact in helping to fund the project and supply certain resources.

Indirect stakeholders see a secondary product effect. Animal rights activists might have issues with shark tagging and may try to stop product installation. Coast Guard observers receive extra input from device users that enhances Coast Guards job functions and improves the safety of beach observers.

The only harm that can come to the stakeholders comes from the physical harm to the shark and the emotional harm to animal rights activists. Benefits greatly out-weigh negative effects by creating a safer beach environment and giving researchers valuable research information. Additionally, studies show that tagging sharks does not harm them.

11. Development

Project members completed tasks individually, and then combined efforts. This utilized each group member's unique thinking process. In addition, cited works illustrates the extensive literature search. Each member gave our group insights toward project completion.

A new tool to be used for this project is an injection mold to form the casing. This allows for a sturdy, custom-built case.