Wildlife Deterrent System

The "SCARE WAVE" Audio Deterrent System

by

Ferdd Mari C. Lansang
Kevin Wong

Senior Project

ELECTRICAL ENGINEERING DEPARTMENT
California Polytechnic State University
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Thank you.

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Introduction

The purpose of this project is to protect consumers' homes from creatures that could possibly damage roofs, windows, or any parts of their home. In particular, our client, Robert E. Alberti, has a home with composite material shingles, which greatly help with heating, but tend to be more brittle. These shingles are often damaged by Acorn Woodpeckers that bury acorns under the shingling, resulting in the ceramic shingles needing replacement (a highly expensive process). Our Wildlife Deterrent System will help prevent these woodpeckers from further damaging the roof by producing sounds that will scare away the birds.

For our project, Mr. Alberti proposed financing of, ideally, $250 for parts. This was to ensure that the project had an extra measure of difficulty and a more appealing price when compared to what is currently in the market.

Due to the marketability of the final product of this project, this report will not include what can be deemed as proprietary material (i.e. detailed circuit schematics).

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Background Information

The Client's Location

In order to properly make the device, it was important to understand the location where it would be installed. Our client's house is located in a woodland area comprised of oak and pine trees; however, the immediate area surrounding the house is relatively clear/open. Essentially the place can be compared to an arena – trees encircling an open area. This worked well to our advantage as it poses little to no problems in terms of sound propagation and sound level restrictions due to noise ordinances.

Figure 1: RC Aerial Photograph of Client Location (Provided by Mr. Alberti)

Another important factor for our project was the prohibited access to the rooftop due to safety concerns caused by deterioration and damage by the woodpeckers. As a result, a roof mounted product was not recommended as it would make it hard to access and a secure installation would be difficult to achieve.

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Target Creature Information: Acorn Woodpecker

Figure 2: Acorn Woodpecker on Rooftop w/ Acorn in Mouth (http://farm4.static.flickr.com/3375/3307131423_942c0652a7.jpg)

Our client informed us that the birds that are damaging his roof are woodpeckers; although the species was not stated, it was easily identified to have a red color on its head. After some research and observation, it was clearly found to be an Acorn Woodpecker – a woodpecker species commonly found in forested areas with oaks such as those in the central coast of California [1]. They are notorious for causing damage to wooden buildings by wedging acorns between or beneath roof shakes and filling unscreened rooftop plumbing vents with acorns [2]. In worst case scenarios, if a suitable cavity is drilled it may be used for roosting or nesting [2] – leading to permanent residence and continued destruction of property.

Woodpeckers are protected by the U.S. federal government under the Federal Migratory Bird Treaty Act and therefore one cannot cause physical harm to these birds without a federal permit [2]. Essentially, this encourages the production of an alternative method of ridding these birds from the premises.

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Bird Behavior: Deterrent Factors

According to Rex E. Marsh in his handbook for management of woodpecker damage there are a number of ways to deter birds by auditory means aside from the typical predator and distress bird calls:

> Loud [sudden] noises such as handclapping, a toy cap pistol, and banging on a garbage can lid have been used to frighten woodpeckers away from houses. Such harassment, if repeated when the bird returns, may cause it to leave for good… High-frequency sound is above the normal audible hearing range of humans but, unfortunately, above the range of most birds too.

It is important to note that the hearing range of birds overlap that of humans as it limits the output audio frequency range of our device. In birds as a whole, the known hearing ranges vary from a lower limit of below 100 Hz to over 29 kHz, though not all birds have this range [3]. In the case of woodpeckers, the range is approximately 35 Hz to 18.5 kHz [4]. As a result, this renders any ultrasonic or extremely high frequency devices worthless.

Audio aside, birds have a highly developed sense of sight and are particularly alert to moving and brightly colored objects [5]. As a result, the presence of such an object can confuse and unnerve birds within its vicinity.

Although this project primarily focuses on an auditory means to deter birds, implementing a visual deterrent factor can only augment the effectiveness of the product [6]. In addition, such an addition would not hinder the original development of the product itself as it would inevitably be part of design considerations for the product's casing.

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Sound Intensity

Sound intensity is defined as the power in watts per unit area (W/m^2), where the range for human hearing is 10^{-12} to 10 - 100 W/m^2 [7]. To better understand sound intensity we use a more familiar scale which is the basis of the decibel – the logarithmic scale. By using this scale, the hearing threshold is considered to be at 0dB which makes data gathering much easier.

In terms of our project, it is necessary for us to know the decibel scale in order to have a concept of how loud our product must be.

Table of sound levels L (loudness) and corresponding sound pressure and sound intensity

Sound Sources Examples with distance	Sound Pressure Level L_p dBSPL	Sound Pressure p $N/m^2 = Pa$ sound field quantity	Sound Intensity I W/m^2 sound energy quantity
Jet aircraft, 50 m away	140	200	100
Threshold of pain	130	63.2	10
Threshold of discomfort	120	20	1
Chainsaw, 1 m distance	110	6.3	0.1
Disco, 1 m from speaker	100	2	0.01
Diesel truck, 10 m away	90	0.63	0.001
Kerbside of busy road, 5 m	80	0.2	0.0001
Vacuum cleaner, distance 1 m	70	0.063	0.00001
Conversational speech, 1 m	60	0.02	0.000001
Average home	50	0.0063	0.0000001
Quiet library	40	0.002	0.00000001
Quiet bedroom at night	30	0.00063	0.000000001
Background in TV studio	20	0.0002	0.0000000001
Rustling leaves in the distance	10	0.000063	0.00000000001
Threshold of hearing	0	0.00002	0.000000000001

Figure 3: The Decibel Scale
(http://www.sengpielaudio.com/TableOfSoundPressureLevels.htm)

According to the scale – it is desirable that our product be able to produce sound levels greater than 70 dB. Although this is a good goal to keep in mind, it is not enough due to the fact that the intensity of sound from a source diminishes as it gets farther away. In fact, this decrease follows the inverse square law [8].

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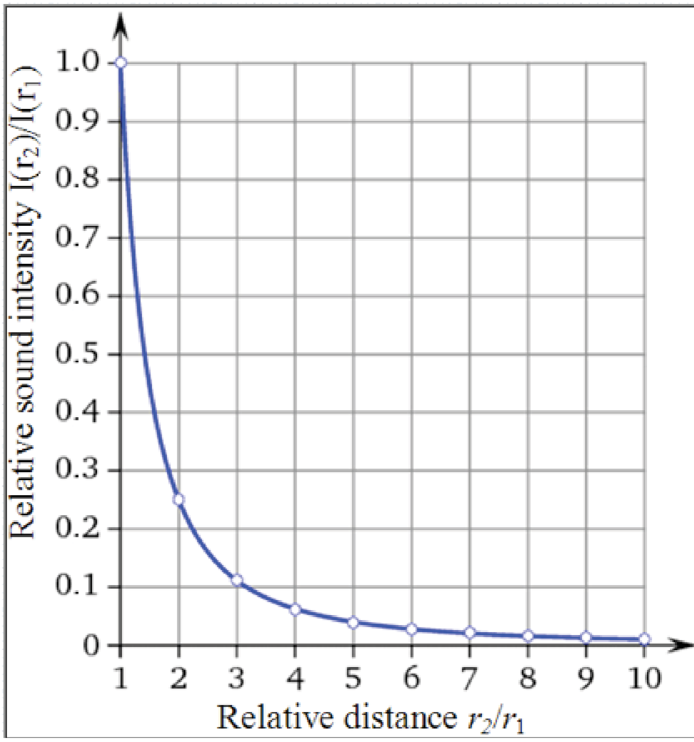

Law for Sound Energy Quantities	
Distance ratio	Sound Intensity $I \propto 1/r^2$
1	$1/1^2 = 1/1 = 1.0000$
2	$1/2^2 = 1/4 = 0.2500$
3	$1/3^2 = 1/9 = 0.1111$
4	$1/4^2 = 1/16 = 0.0625$
5	$1/5^2 = 1/25 = 0.0400$
6	$1/6^2 = 1/36 = 0.0278$
7	$1/7^2 = 1/49 = 0.0204$
8	$1/8^2 = 1/ 64 = 0.0156$
9	$1/9^2 = 1/81 = 0.0123$
10	$1/10^2 =1/100 = 0.0100$

Figure 4: Sound Intensity and Distance – The Inverse Square Law (http://www.sengpielaudio.com/calculator-squarelaw.htm)

Therefore, according to this law, if we want to maintain adequate sound levels of above 70 dB up to 30 feet it would be necessary to ensure that the product is able to produce, at minimum, 100 dB of sound. Calculations for this are as follows:

L_{p1} = sound level at epicenter (in W/m^2)

L_{p2} = sound level at distance "r" (in W/m^2)

r = distance from epicenter (in meters) ← A ratio of 1ft / 30ft is used for this case

$L_{p2} / L_{p1} = (0.3048\ m)^2 / r^2$

$(L_{p2} * r^2) / (0.3048\ m)^2 = L_{p1}$

$L_{p1} = ((10e\text{-}6\ W/m^2) * (9.144\ m)^2) / (0.3048\ m)^2 = 0.0027\ W/m^2 = \underline{100\ dB}$

Requirements

Minimum	
Audio Volume	75 dB
Audio Output Range	30 ft
Number of Generated Outputs	1
Generated Audio Output(s)	Gunshot
Trigger Type	Remote (close-range)
Number of Triggers	1
Installation Method(s)	Permanent Mount
Product Housing	Weatherproof

Table 1: Minimum Project Requirements

Ideal	
Audio Volume	75 dB+
Audio Output Range	30 ft+
Number of Generated Outputs	2-3
Generated Audio Output(s)	Gunshot Predator Animal Calls High Frequency Screeches
Trigger Type	Remote (long-range)
Number of Triggers	2-3
Installation Method(s)	Any
Product Housing	Weatherproof Visually Deterring
Additional Features	Random-timing Automatic Trigger Mode Remote or Automatic Shutdown Swappable Audio Output

Table 2: Ideal Project Requirements

Product Design

Preliminary Concept

The preliminary design concept involved the implementation of a remote controlled wireless system wherein an audio signal source was attached to a transmitter kept indoors that sends the generated audio to a wireless speaker unit directed at the roof of the house. This signal would then be converted to an analog signal, amplified, and shot straight to any woodpeckers on the roof, scaring them away. Essentially the idea was to create a centralized wireless speaker system.

Remote ~ Receiver ➡ Processor ➡ *Audio Signal Source* ➡ A/D ➡ Transmitter ~ Receiver ➡ D/A ➡ Amplifier ➡ Speaker

Figure 5: Preliminary Design Concept Flowchart

At first glance, this idea was very appealing as it does not involve wires being threaded through walls, insulated with PVC piping outdoors, hidden underground for aesthetics, and so forth. However, it was realized after some research that the components necessary for implementing such a system were expensive and too complex to construct from scratch. In addition, it was found that attenuation and noise become more prevalent when transmitting data from long distances wirelessly, which presents the high risk of the transmitted audio either being distorted or undetected. In other words, the designs were deemed impractical for use especially in this application.

Although the preliminary concept was unusable, it proved to be useful in generating a similar but more practical design that involved a simple rearrangement of the components.

Remote ~ Receiver ➡ Processor ➡ *Audio Signal Source* ➡ Amplifier ➡ Speaker

Figure 6: Improved Design Concept Flowchart

By simply hardwiring the audio signal source to the speaker, the amount of components required to create the product was significantly reduced. At the same time the wireless aspect of the system is retained as it is still remotely triggered and all of the parts are localized.

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Final Product Design

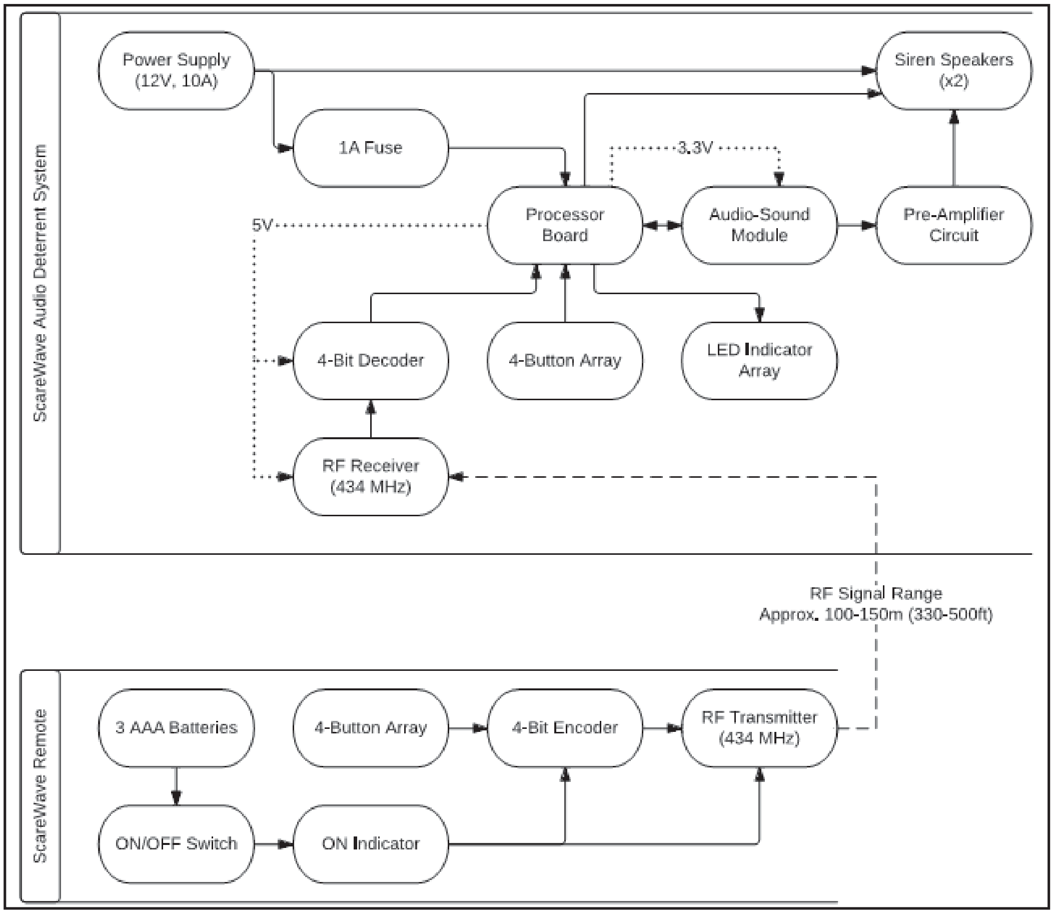

Figure 7: Final Product Design - Black Box Diagram

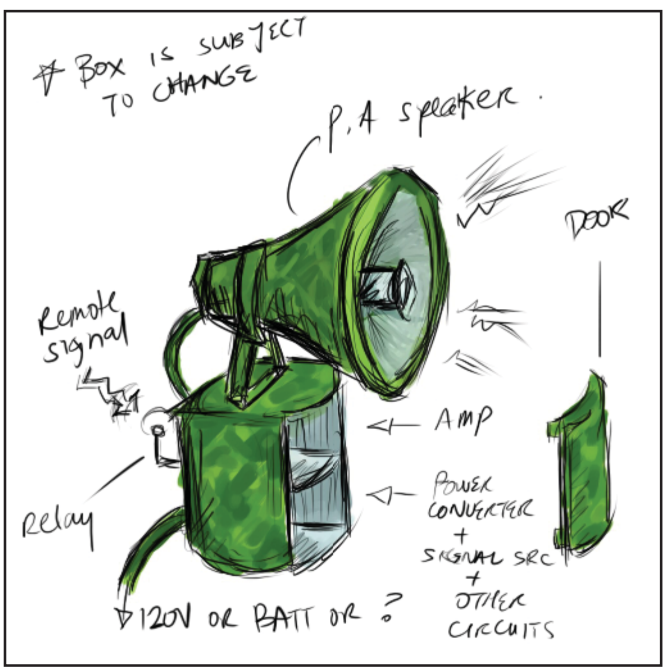

Figure 8: Final Product Design - Concept Sketch

The final product design is modular and focuses on portability and speedy production while meeting more than the minimum requirements.

Unlike the preliminary concept, this design allows all of the system components to be located and housed in one enclosure. As a result, the user can freely position the device anywhere. This also allows for many possibilities in the design of the enclosure – for example, a door/hatch can be incorporated to allow easy component access for maintenance or user customization.

In addition, external components such as the speaker can easily be mounted on the enclosure itself.

The final design incorporates the following benefits:

Benefits	Concept Details
Cost Effective	❖ Simplified component interfacing ❖ Reduced number of components ❖ Reduced overall size of system housing/case
Localized Components	❖ Easier to repair, upgrade, and customize - Ports and connectors can be added easily to accommodate new devices and different types of Audio Signal Sources - An extra speaker can be added easily if the need arises ❖ Portable and compact ❖ Replaces wireless transmission of audio signal with a more reliable, direct wire implementation resulting in undistorted audio ❖ Different methods of power distribution can be easily implemented - Solar - Battery - 120VAC Outlet Plug
Remote Operated	❖ Allows wireless triggering of the device from anywhere ❖ Grants the user freedom to position the system wherever desired

Table 3: Final Design Features

The design is, in essence, modular and components can be broken down into two main categories: System components and Remote components. Of course, each component requires hardware and software interfacing in order for the actual system to run. Therefore, it is important to understand how each component works and how they will communicate with other devices.

Product Component Details

The table below outlines main components used for the product and/or how they meet the required product features. It was our goal to create a product that met as many ideal requirements as possible.

Main System Components	Details
12V 35WRMS/100WPMPO Police Siren Speaker	Generates sound levels of approx. 100dB+
Audio Processing Sound Module	Processes audio files for playback stored in a microSD card Allows user the ability to swap out audio files as desired
Microcontroller Board	Used to control the audio processing module and process incoming RF signal data from remote control
350W CPU Power Supply	Cheaper means of generating a large amount of power and multiple voltage outputs (3.3V, 5V, +/-12V)
434MHz RF Link 2400bps Receiver	Receives RF signal data for processing
Decoder IC	Decodes transmitted RF serial data into original data
Main Remote Components	
434MHz RF Link Amplitude-shift Keying Transmitter	Transmits serial data from the encoder IC
Encoder IC	Converts switch inputs into transmittable serial data

Table 4: Component Details

Component Analysis and Experimentation

Reverse Engineering the Police Speaker/Siren Handset

In order to properly interface our audio signal source to our speaker/siren, it was necessary to understand how the handset (the default audio signal source) was wired to the speaker. The handset was disassembled and the enclosed PCB was analyzed.

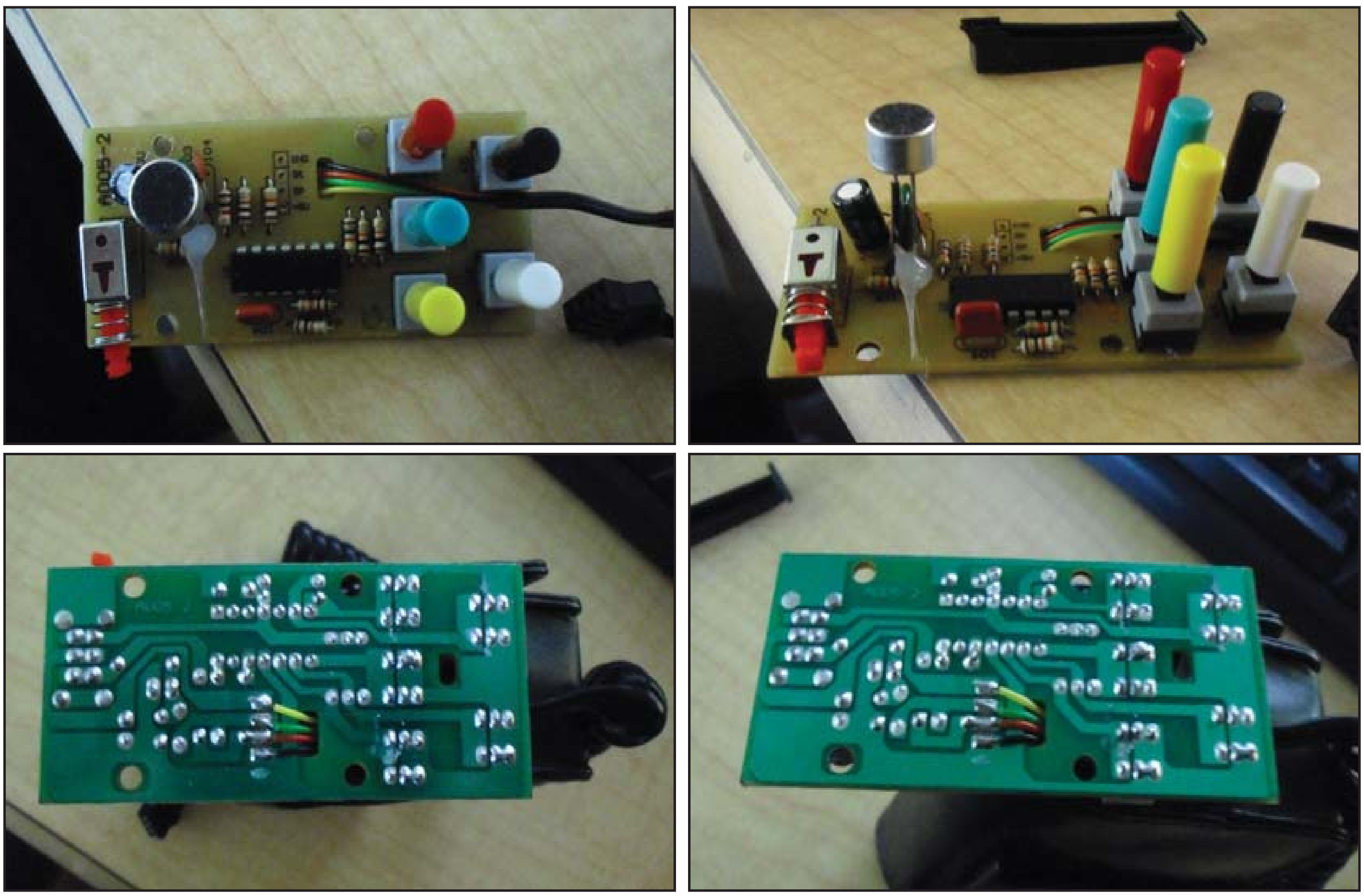

Figure 9: Police Siren/Speaker Handset PCB

The black, red, green, and yellow wires were of key importance as they were what connected to the siren/speaker itself. A circuit schematic of the PCB was produced to easily identify the function of each wire.

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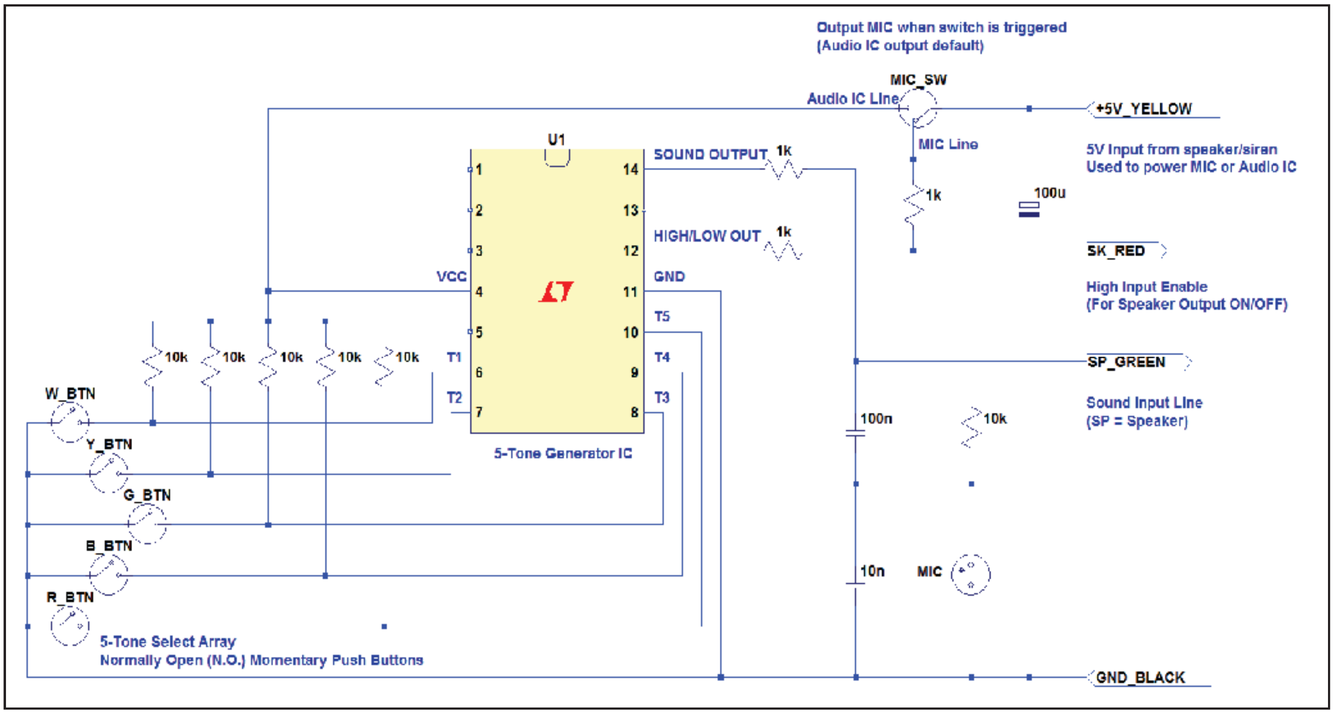

Figure 10: Reproduced Schematic Diagram of Police Siren/Speaker Handset PCB

The analysis resulted in the following wiring details:

Wire Color	PCB Label	Function
BLACK	GND	Ground
RED	SK	Active High Switch
GREEN	SP	Speaker Audio Input
YELLOW	+5V	+5V Rail

Table 5: Police Speaker/Siren Handset Wiring Details

After the analysis was completed, the SK wire was soldered to the 5V rail in order to keep the audio input line ON for speaker output. An audio source could then be connected to the SP line to make use of the speaker/siren for audio playback.

Speaker Range Experiment

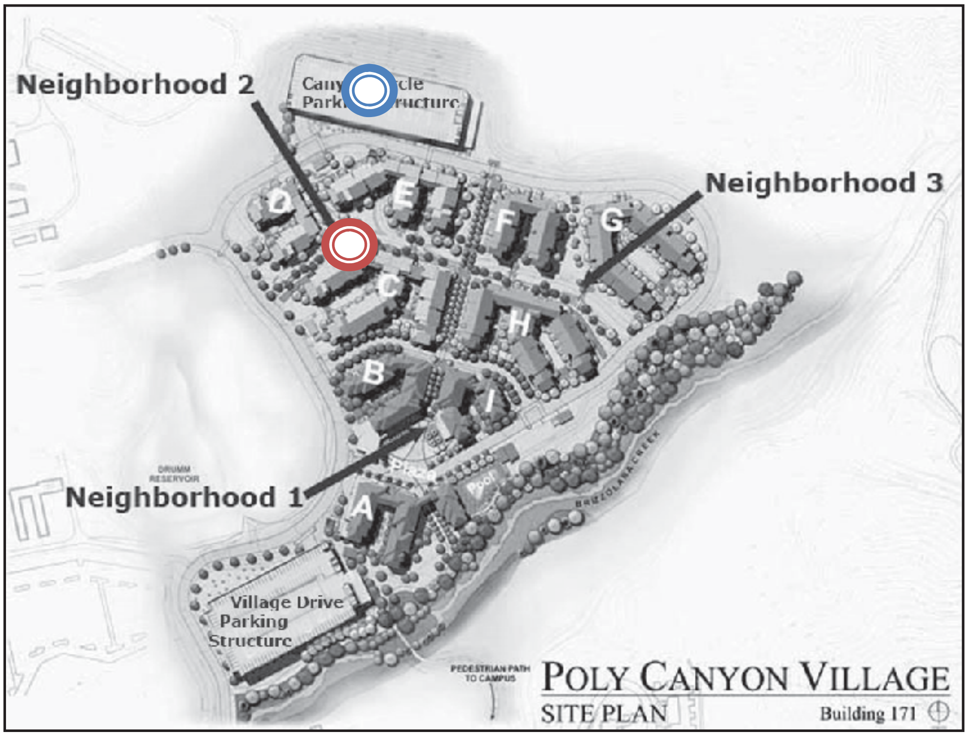

Figure 11: Sound Range Experiment at Poly Canyon Village (http://housing.calpoly.edu/images/jpg/pcvsiteplannames1.jpg)

An experiment to test the range of the siren/speaker was conducted at Poly Canyon Village. The speaker was connected to a laptop and the audio file used was a high frequency (13-16 kHz) tone, to avoid violating noise ordinance, at maximum volume. Figure 9 outlines the experiment – The red circle denotes the position of the signal source while the blue circle denotes the final destination of an observer. This distance is well beyond that of our client's location and does not have the same ideal conditions, but it served as a way to measure the speaker's capabilities.

A volunteer who could hear the high frequency tone was asked to walk from the signal source to the parking structure (blue circle) while constantly updating us to whether or not the signal could be heard. The tone was found to be audible the entire distance with little attenuation in audio level. At the same time, others who could hear the high frequency tone were rather deterred or annoyed. Qualitatively, this experiment appeared to be a very good indication that the speaker can indeed produce the ideal volume and range required for the product.

Jury-Rigging the CPU Power Supply

A CPU power supply provides a great amount of power and multiple voltage outputs at a much cheaper price than a standalone switching power supply. However, in order to make use of a CPU power supply as a standalone device it is important to know the type – ours is a 24-pin ATX power supply.

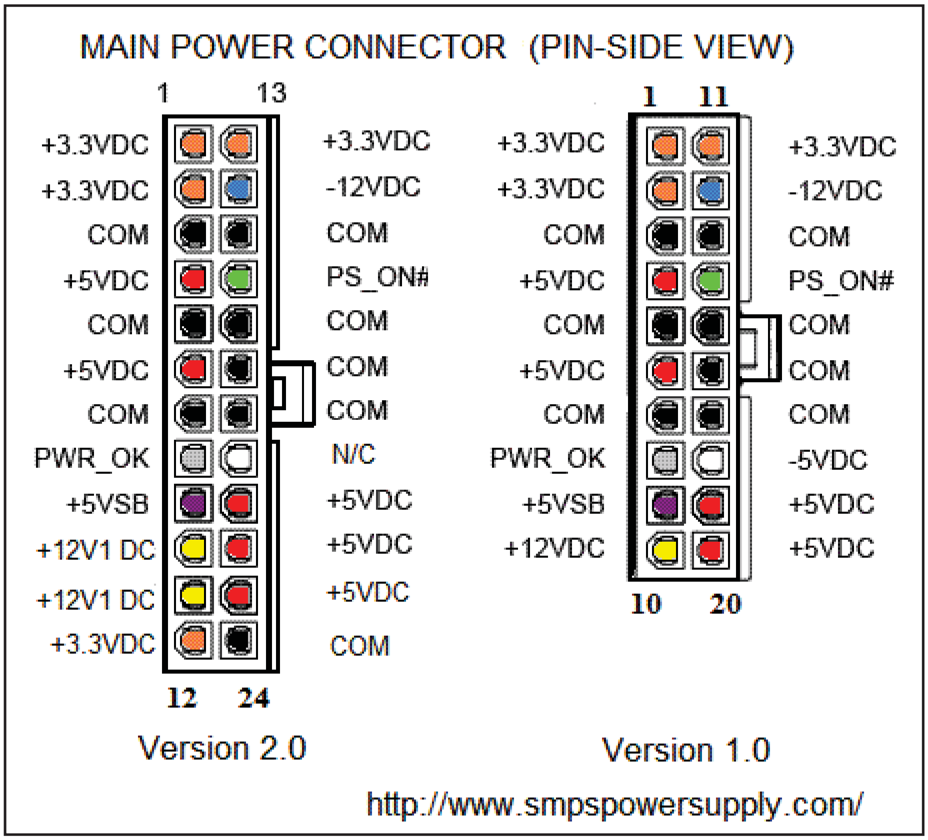

Figure 12: ATX Power Supply – Main Power Connector Pin-Out

Power supplies follow a general standard so it was not hard to find the ATX power connector pin-out. The procedure is relatively simple – the PS_ON (green) pin needs to be shorted to a COM (black) pin. This is because the PS_ON pin is normally activated when a computer power button is pressed and released while in standby mode [7]. Therefore, by shorting the PS_ON pin, it causes the CPU power supply to constantly provide voltage as long as it remains on. As a general precaution, it is required that the power supply be connected to an adequate load in order to prevent damage [8].

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Microcontroller Audio Test

A second experiment with the speaker was conducted at a local open field. However, in this experiment the sound files used were not high frequency – rather a series of different audio files of varying frequencies was used (i.e. hawk calls and other animal sounds). In addition, the speaker was connected to the microcontroller board, configured with a simple program that plays a single audio file on start-up, instead of a laptop.

The results of the experiment are as follows:

Distance from Epicenter (ft)	Sound Intensity (dB)
Epicenter	~90-92
10-20	~40-50
20-30	~30-35

Table 6: Sound Intensity of Speaker Connected to Microcontroller Board (no pre-amp)

The results of this experiment were not at all what we expected considering our first speaker test. In response, we connected the speakers to a laptop and gathered data using the same audio files:

Distance from Epicenter (ft)	Sound Intensity (dB)
Epicenter	~110
10-20	~80-90
20-30	~60-70

Table 7: Sound Intensity of Speaker Connected to Laptop

These results implied that the magnitude of the output signal from the microcontroller was too low – this was reinforced by the fact that the resulting sound intensity was adjustable by using the volume control on the laptop. From this, it was deemed necessary to include a simple pre-amplifier circuit in our design to help boost the incoming signal to the speaker.

Pre-Amplifier Design

In order to successfully design and construct a pre-amplifier for our project it was necessary to find out the actual value of the magnitude of the incoming signal and the gain value of the internal amplifier in the speaker. This was accomplished by connecting the speaker to the microcontroller board and using an oscilloscope to determine the maximum voltage it is able to output. The gain value of the internal amplifier in the speaker was determined by measuring the magnitude of the signal on the output of the amplifier and dividing that value by the input signal magnitude which was measured previously.

Microcontroller Output	Speaker Output	Internal Amplifier Gain	Speaker Peak Power	Speaker Impedance
0.013 V_p	1.3 V_p	100 V/V	100 W	8 Ω

Table 8: Gathered Values for Pre-Amplifier Design

These values were then used to calculate (using the equation $P = V^2/R$) possible pre-amplifier gain values that would boost the microcontroller output as much as possible without exceeding the peak power rating of the speaker.

Microcontroller Output (mV)	Pre-Amplifier Gain	Pre-Amplifier Output (mV)	Speaker Output (V)	Output Power (W)
13	13.32	173.2	17.32	50
13	14.6	189.7	18.97	60
13	15.76	204.9	20.49	70
13	16.85	219.1	21.91	80
13	17.87	232.4	23.24	90
13	18.36	238.7	23.87	95
13	18.84	244.9	24.49	100

Table 9: Pre-Amplifier Design Calculations

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After gathering the data, we designed a simple audio pre-amplifier incorporating BJT's and simulated the circuit on LTSPICE – a potentiometer was incorporated into the circuit in order to adjust the gain.

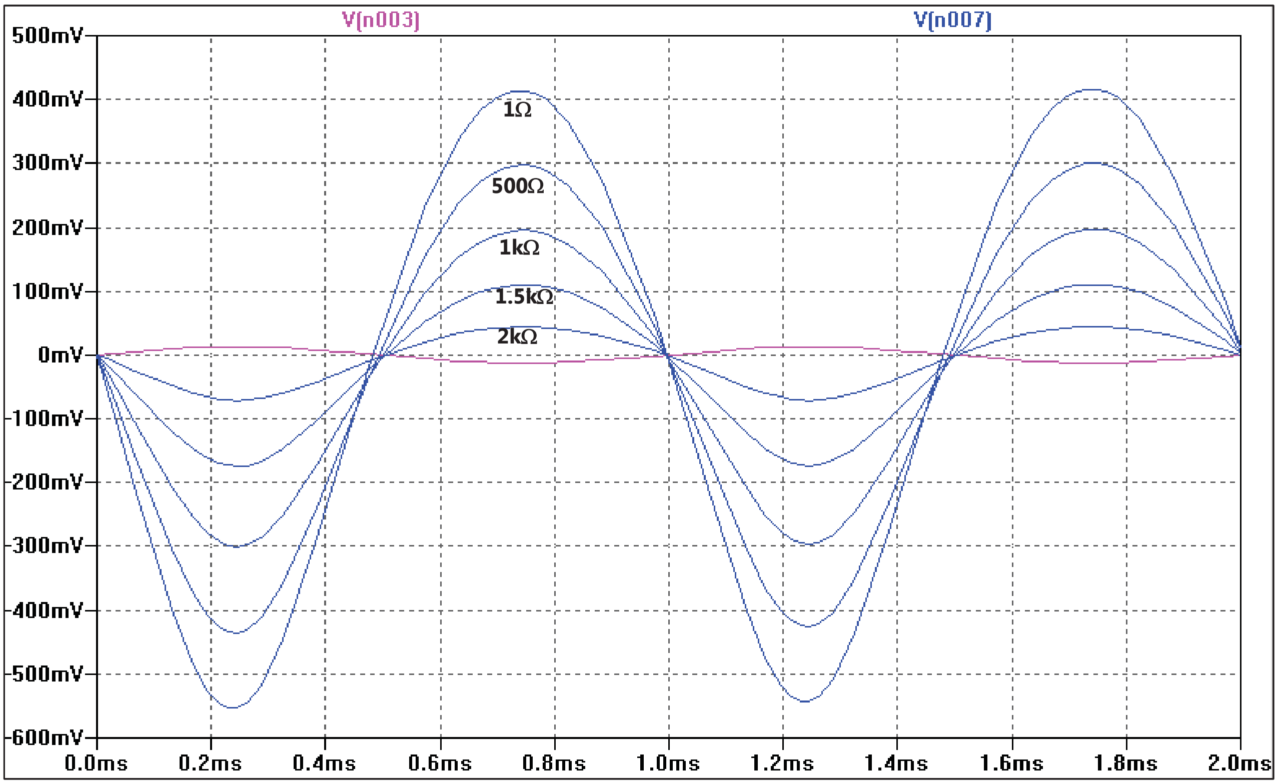

Figure 13: Simulated Results of Pre-Amplifier Output (blue) at Various Gain Settings

The simulation results confirmed that our pre-amplifier circuit is more than able to provide the amplification we desire and so we proceeded with construction of the pre-amplifier. A potentiometer was installed as in the simulated circuit for testing purposes and also to allow us to be able to reduce the sound intensity and work with the product without suffering hearing loss. After construction, the pre-amplifier was connected to the output of the microcontroller board and the output was measured and captured via oscilloscope.

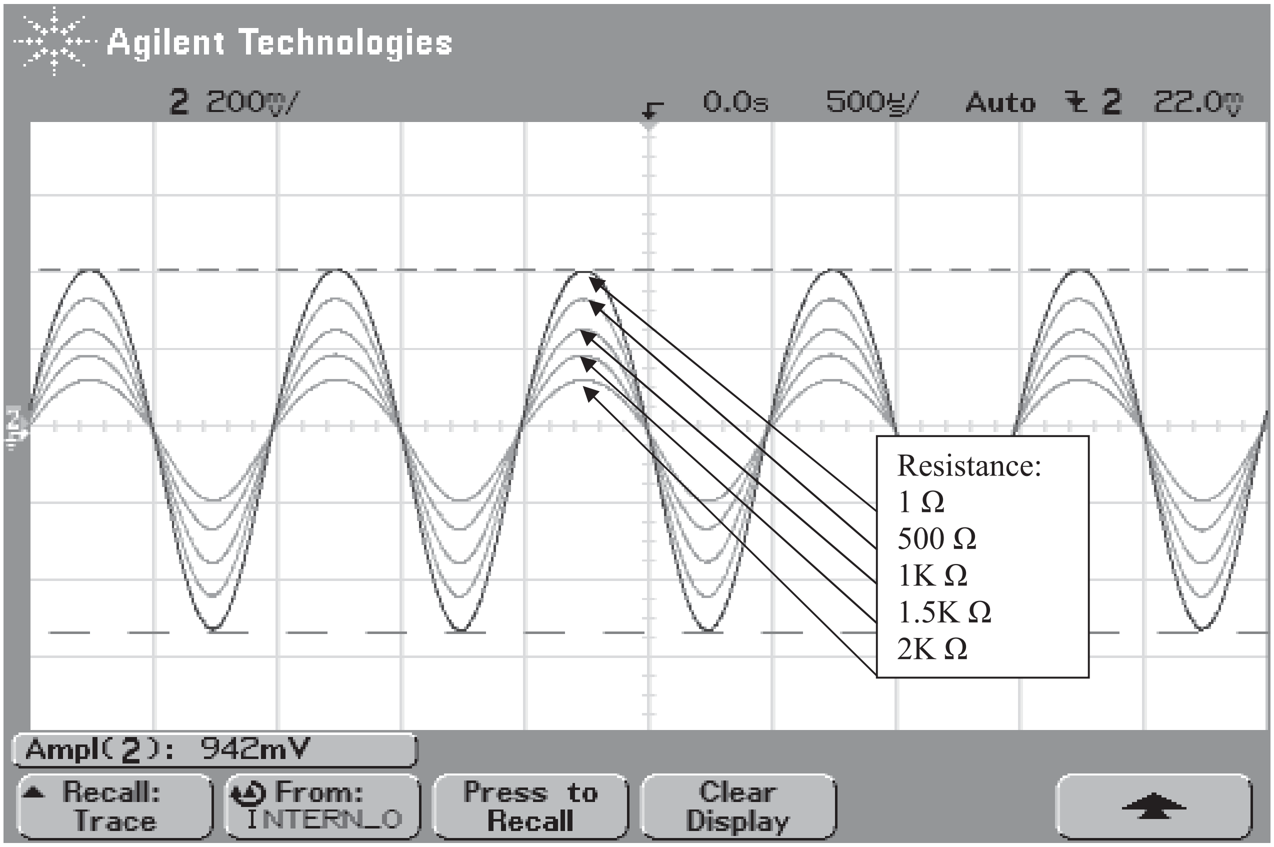

Figure 14: Pre-Amplifier Circuit Voltage Output at Various Gain Settings

Comparing the gathered data to the simulations, it can be concluded that the pre-amplifier design achieves its goal and is fully capable of providing the desired output voltage plus more. The pre-amplifier was connected to the speaker and another speaker test was conducted to see if the sound intensity increased as desired:

Distance from Epicenter (ft)	Sound Intensity (dB)
Epicenter	~125
10-20	~100-110
20-30	~80-100
30-40	~60-80

Table 10: Sound Intensity of Speaker Connected to Microcontroller Board (w/ pre-amp)

Given the results, the pre-amplifier was a success and incorporated into the overall product design which included a revision of the block diagram.

Chassis Design and Construction

When it came time to design the chassis for the electronics used for the product we found it to be much more efficient and cost-effective to obtain already constructed enclosures rather than making them from scratch. These enclosures would provide us with a basic frame to work with that could be modified to fit the electronic components.

The base frame of enclosure for the electronics used for the main control unit of the deterrent system was obtained from an electronics junk warehouse. From observation, the enclosure itself appeared to have been used for a server hard drive. This was advantageous to us as it meant that the enclosure itself is designed to withstand a great amount of heat and stress. In terms of modification, little was necessary as space was already allotted for both the power supply and the electronics. Only the front and back panels were modified to accommodate for chassis mounts, ports, and other interfacing components.

The remote control enclosure was a much easier feat – a small project enclosure box was bought from a local electronics store. Modification was a bit more demanding as the box did not accommodate much space for the electronic components and the front panel was nothing more than a clean flat surface. In effect, the inside of the box was ground down and a design for the front panel that allowed for mounting of buttons, switches, and LED’s was made.

Modifications for both the remote and the main control unit were designed by us and handed to Jason Brummel who drafted the designs onto SolidWorks and performed the machining process with a laser cutter and other tools in Cal Poly’s Machining Workstation in the Bonderson Building.

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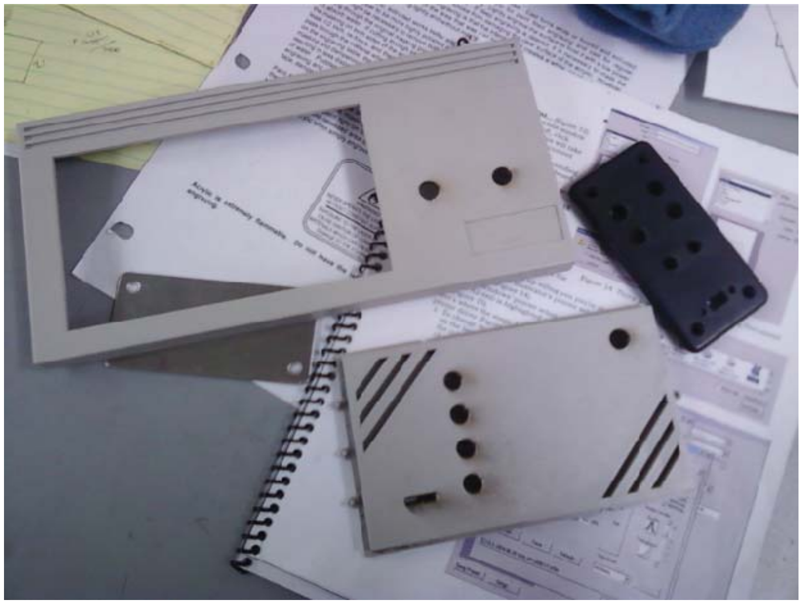

Figure 16: Machined Enclosure Front Panels

Figure 15: Jason Brummel Operating the Laser Cutter

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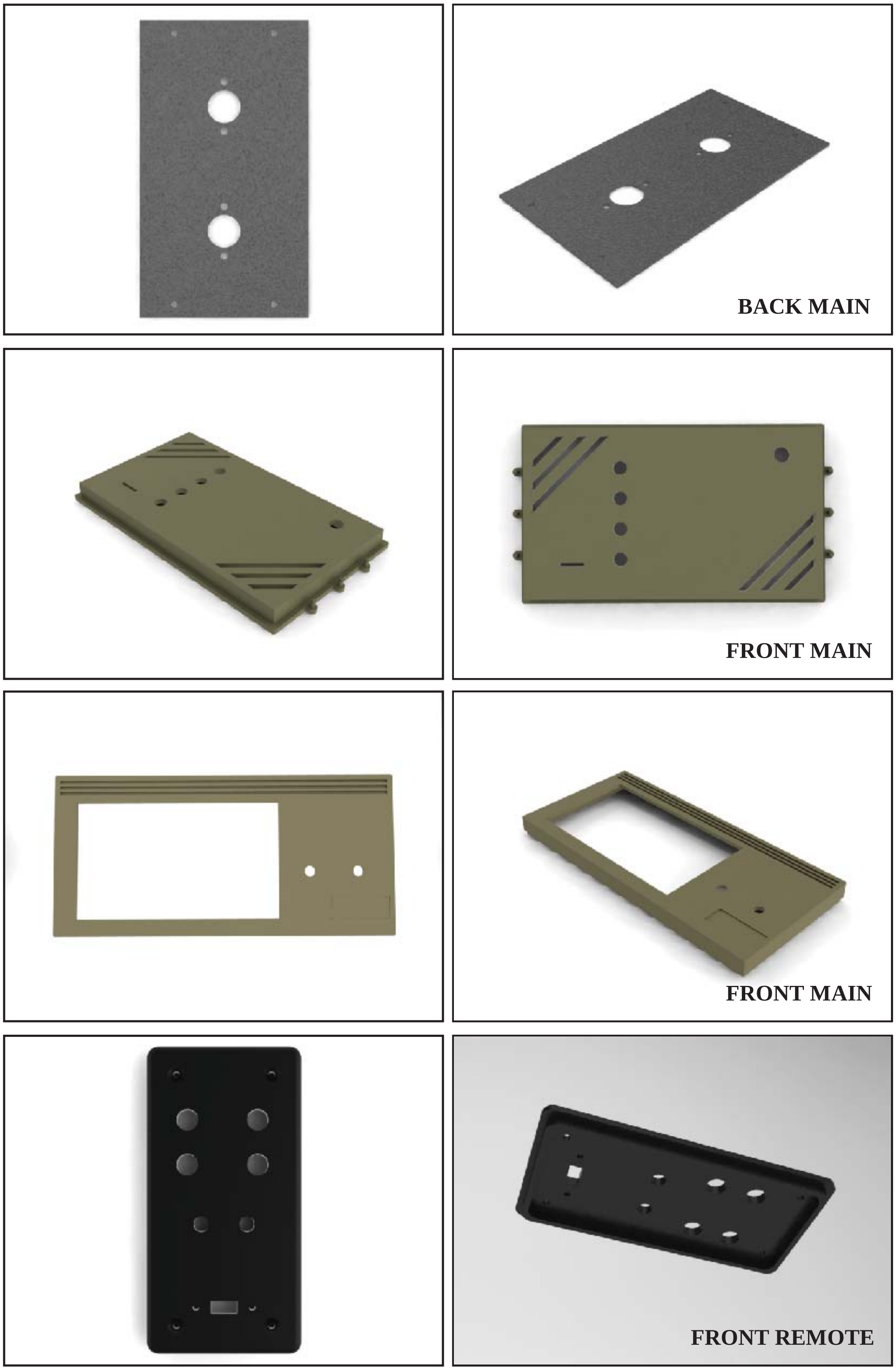

Figure 17: Main Control Unit and Remote Chassis SolidWorks Drafts (courtesy of Jason Brummel)

Final Construction and Testing

Overview

Final construction of the product was modular and involved the finalization and interconnection of the various circuits involved. Our modular approach at the project helped greatly in this process as it allowed for quick troubleshooting and improvements – the former occurring most frequently in our case. This is because each major electronic component can be isolated and tested as its own standalone device – for example, if output sound is not functioning as desired we could easily isolate the pre-amplifier and the microcontroller board and check to see which component is producing the problem.

A second, identical, speaker was added to the system in order to increase the area it could cover since the area directly behind one speaker does not observe the same sound level as the area in front. This does not necessarily double the sound intensity as one would expect and in fact it only produces, at most, a 3 dB increase [11]. The reason for this is simply because sound intensity is based on a logarithmic scale wherein increases in speaker power to increase sound intensity grant diminishing returns.

Our construction process also required that we keep in mind that the product is for a client as it requires an instruction manual outlining how to operate it as well as its major features. Thus, as each component was interfaced notes were made on what it provided in terms of function and how the client will make use of it.

The final touches to the product were creating the logo and product name. We chose the name "SCARE WAVE" as it describes the purpose and function of the product in a straight-forward manner: It produces sound waves that have the ability to scare away desired target pests. The logo itself incorporates the scare factor by resembling a grim looking face with glowing eyes.

Please refer to Appendix D for photographs of the final product and Appendix B for the product manual.

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Microcontroller Board Programming

The programming for the product was an entire project on its own that went in parallel with the final construction and interfacing of the hardware. The task was taken up by Ferdd Lansang who, similar to the hardware, took a modular approach was taken to quickly complete and incorporate all the functionalities needed to make the product operate as desired. These functions include controlling the audio processing module, processing RF data and responding to it by executing the corresponding command (i.e. if the automatic button is pressed, the system should enter automatic operation mode), and ensuring minimum power usage by automatically shutting off power to peripheral devices, such as the speaker, whenever it is not in use.

The modular approach described was achieved by creating multiple standalone functions that would be called by a main function that continually runs as long as the system is powered on. Each function included debugging code that allowed for quick maintenance in the event of a runtime error. There was actually one particular instance in which we observed runtime errors wherein the automatic operation mode continually output audio and any output audio produced unwanted clicking noises before the actual audio file playback. Thankfully, because of the coding style and approach used, it only took a matter of seconds to fix both errors completely – proving the worth of good coding style and documentation. Aside from maintenance, this debugging code also allowed for easy modification and addition of other features that would improve the system itself. For example, the device can readily accept and implement a strobe light given its already existing blink function.

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Field Testing

Testing at Poly Canyon Village was conducted wherein the system was left on automatic operation mode for two hours nearby an area with a dense population of nesting birds. The audio file being automatically played after every random number of minutes, between 1-15min, has passed was a hawk call. A couple birds scattered away after the initial playback and several followed after the next two. Returning to the system after the allotted time passed, only a couple birds remained. This signified that the system definitely has the ability to scare off birds in general.

Following this test, the product was brought to Mr. Alberti's home where it was mounted on the roof and tested for sound intensity.

Figure 18: View of Speakers Mounted on Rooftop

Results of the test at Mr. Alberti's home were similar to those recorded in Table 10 with a slight increase of 3 dB as expected. Again, the addition of a second, identical, speaker does not translate to a doubling in sound intensity as expected due to the diminishing returns of speaker power increases [11]. To actually be able to obtain a significant 10 dB increase, the speaker power would have to be multiplied 10 times or increase the number of identical speakers by 10 – obviously this is not the best approach financially so for future implementations it would be better to use higher power speakers.

As we demonstrated the use of the system to our client Mr. Alberti, we observed a couple interesting things. For one, the use of the hawk call actually attracted hawks to the area and caused them to circle around above the roof of his house. In addition, the noise level produced by the birds began to diminish which gave us a sign that the system is definitely scaring off some of the other birds. We, however, were not fortunate enough to have woodpeckers around except for one that perched at a nearby tree that we managed to scare off using the hawk call. Of course, this was not enough to actually prove whether or not the system works against the target creature; however, our client is very satisfied and has stated that he will keep us updated and informed on the success of our product.

Figure 19: Testing Station – Laptop Used to Demonstrate Audio Customization

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Conclusion

The project "Wildlife Deterrent System – The "SCARE WAVE" Audio Deterrent System" was definitely one we, or others, did not expect to be a very comprehensive project in terms of Electrical Engineering (EE) knowledge among others. The project involved use of knowledge in power, amplifier circuits and circuits in general, signals, hardware/software (microcontroller) interfacing, programming, and many others not limited to the EE profession such as physics and biology. In addition, the project definitely called for research skills to understand the behavior and hearing biology of birds as well as a sense of economics and industrial manufacturing engineering (IME) – knowing when it is best to manufacture a component vs. buying one already built. After all, we only had $250 in funds to complete the project and very limited time in which having the best approach to the project, in our case a modular one, was necessary to fully complete it by the deadline. Finally, the project also practiced our ability to communicate not only with our client and each other, but others whose expertise lies outside of the EE realm in order to complete tasks that we do not necessarily have the proper training or experience to accomplish such as machining.

Therefore, our main piece of advice to other students working or preparing for their Senior Project is to keep an open mind and not judge a project by the simplicity of its idea. For although the idea may have been simplistic, actually carrying out and completing the task is a lot, as they say, "easier said than done".

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Future Work

Due to the financial and time constraints set on our project, we were unable to add many of the proposed ideas to us by students, faculty, and visitors during the EE Senior Project Exhibition. Some of these ideas were: Target sensing and/or motion tracking, a strobe light fixture add-on, remote power on/off, shaped enclosures (system shaped like an owl or etc), and fully automatic operation.

These are all valid and interesting ideas that could have been executed if there were more funds and time allotted. As we have stated in the beginning of this report – we have plans and hopes for being able to patent and market our device. So perhaps, when manufacturing of our device for the market is carried out – some of these improvements may be incorporated. Of course, these improvements may be worked on our own free time as well for our own personal versions of the device.

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Appendix A: Product Manual

SCARE WAVE
Audio Deterrent System
Product Manual

WARNING

- This device produces sound intensities that reach beyond 100 decibels (entering the threshold of pain). As a result, do not operate this device when you or other people are within 10 feet of the speakers.

- Although the SCARE WAVE Main Control Unit is weatherproofed, it is advised that it be positioned at a location where it will not be exposed to extreme amounts of water or other liquid as it will cause severe damage to the system.

- Do not attempt to modify the hardware or software of the device as it may cause damage to the system or render it non-operational.

- Use only the speakers provided with the system as the ports on the controller box and the connectors on the speakers are specially designed to interface with each other. Do not attempt to connect other speakers or devices to the system as it may cause damage to the system and/or the connected device.

- Use only with 120V power outlets.

By using this device you acknowledge the above statements and hold yourself liable for any harm or injury that may be caused from operation of the device as well as any damage to the system due to improper use.

Please contact Ferdd Mari C. Lansang or Kevin Wong for any issues that may need to be addressed

PRODUCT OVERVIEW

Package Contents

- “SCARE WAVE” Main Control Unit
- Remote Control Unit (requires 3 AAA batteries)
- Set of two speakers (each has an allotted 50 ft of cable)
- Power Cable

Installation:

1) Make sure the MicroSD card is plugged into the SCARE WAVE Main Control Unit
   - Ensure that the MicroSD card is loaded with desired audio files
   - Refer to “Custom Audio” section for more details

2) Make note of what audio file each button is associated with on the provided labels on the SCARE WAVE Main Control Unit

3) Plug in provided speakers to speaker ports before positioning speakers to desired locations

4) Make sure the SCARE WAVE Main Control Unit is off before connecting the power cord to the system

5) Mount the SCARE WAVE Main Control Unit on an open and easily accessible area
   - Ensure the area will not expose the system to extreme amounts of water and other liquids
   - Ensure the area will not block off the cooling fan

6) Connect the power cord to a 120V power outlet and turn the system ON

7) Turn the remote control ON and press the button corresponding to desired audio file to play

8) Enjoy! Please scare responsibly.

FRONT PANEL AND REMOTE

1) <u>Manual Operation Buttons and Wet Erase Labels</u>
   - Buttons correspond to label numbers
   - Use only dry erase markers on laminated labels
   - Erase writing by **gently** rubbing small wet cloth on laminated area only

2) <u>Automatic Operation Mode Indicator</u>
   - Turns ON if the system is in automatic operation mode

3) <u>MicroSD Card Slot</u>
   - The safety cover can only be opened from the bottom lip using the left tab

     <u>NOTE:</u> Opening the cover in any other manner will damage it

   - Please refer to the "Custom Audio" section for more details on the MicroSD functionality

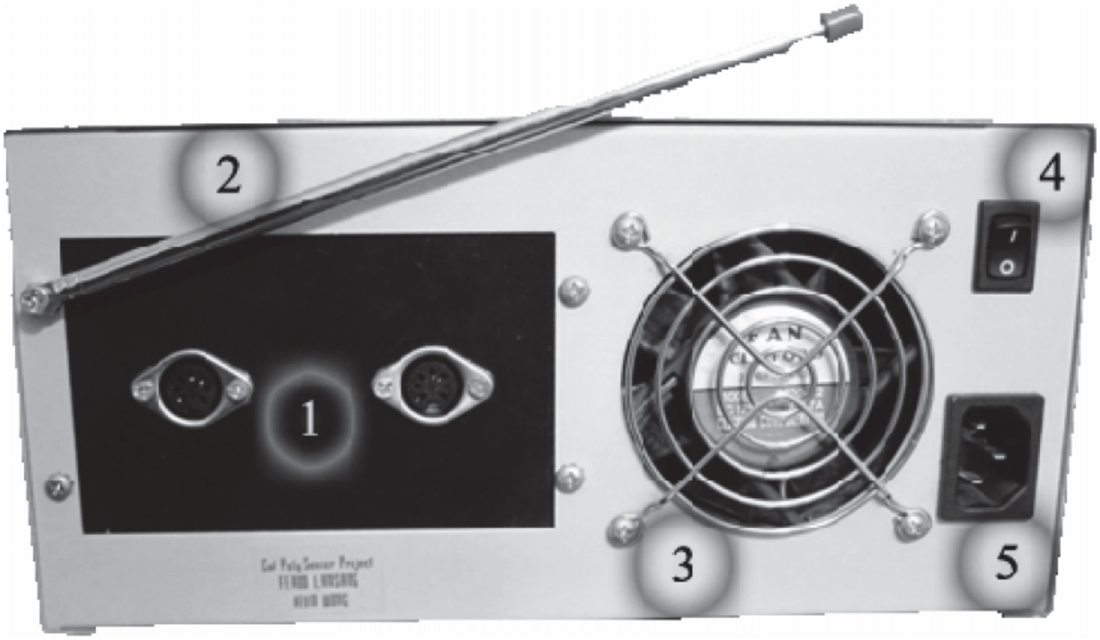
4) <u>System ON Indicator</u>
   - Turns ON if the system is ready and operational

5) <u>Remote Operation Buttons</u>
   - Buttons correspond to label numbers
   - Button labeled "A" triggers Automatic Operation Mode (plays associated audio file periodically after a random number of minutes, between 1 and 15 min, has passed)

6) <u>Remote ON Indicator</u>
   - Turns ON if the remote is ready and operational
   - Most visible indoors as sunlight may drown out the color

7) <u>Remote ON/OFF Switch</u>
   - Remote is OFF when the switch is set left
   - Remote is ON when the switch is set right

BACK PANEL



1) <u>Speaker Ports</u>
   - Specialized one-way ports for use with provided speakers

2) <u>Extendable Antenna</u>
   - Freely rotatable on center point
   - Extend to increase remote control range by up to 100 ft under ideal conditions

3) <u>Cooling Fan</u>
   - Provides internal system cooling
   - Avoid positioning the device in a manner that blocks or exposes the cooling fan to extreme amounts of water/liquids

4) <u>System ON/OFF Switch</u>

5) <u>System Power Cord Input Port</u>

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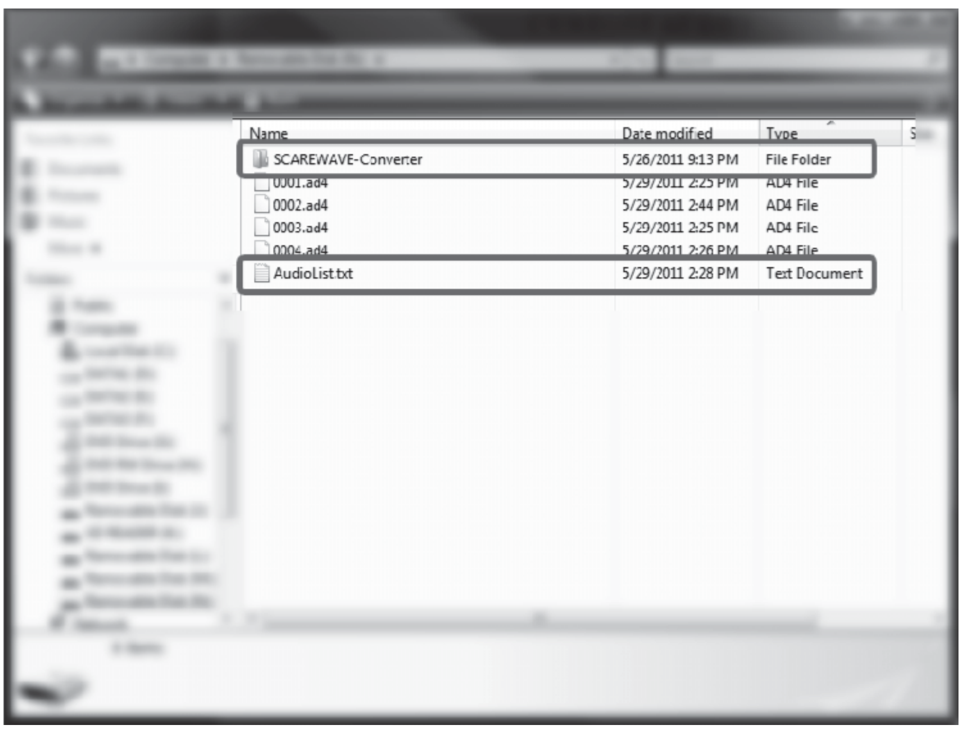
CUSTOM AUDIO

The SCARE WAVE Audio Deterrent System comes loaded with a set of default audio files. To swap the defaults with your own custom audio files, do the following:

1) Flip open the safety cover on the SCARE WAVE Main Control Unit
2) Gently push on the MicroSD card – this will cause it to pop out
3) Carefully pull the MicroSD card out of the slot
4) Load the MicroSD card on your personal computer
5) Open the folder titled “SCAREWAVE-Converter”

   (Note: A text file named “AudioList” is provided to help you keep track of which audio file each button is associated to)



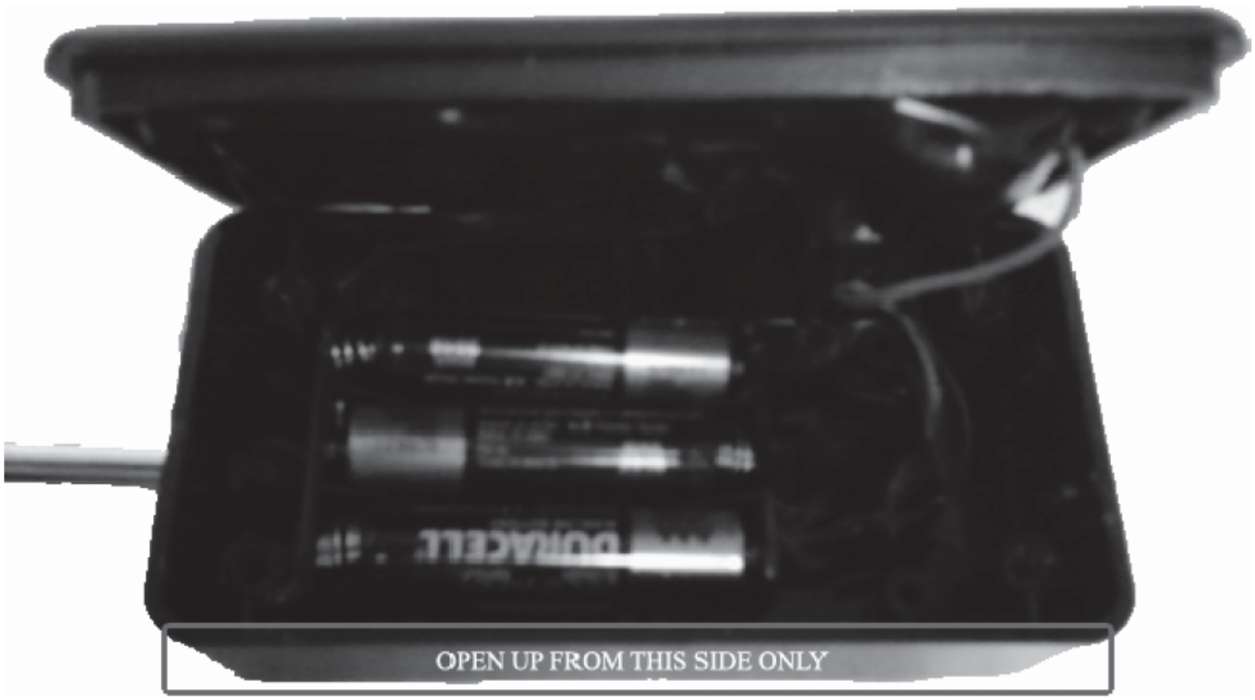
6) Open the text file entitled “ReadMe” and follow the provided instructions

SYSTEM SPECIFICATIONS

Maximum Effective Range for Remote Control System Operation	
Local Conditions (Presence of radio interference and etc.)	**Range (ft)**
Ideal (No radio interference)	~450-500
Typical	~300-400
Bad	~150-200

Speaker Sound Intensity by Distance from Epicenter	
Distance from Epicenter (ft)	**Sound Intensity (dB)**
Epicenter	~125
10-20	~100-110
20-30	~80-100
30-40	~60-80

REMOTE BATTERY REPLACEMENT



The remote control requires three AAA batteries for operation.

1) Remove the four front panel screws with a screwdriver
2) Carefully lift the front panel from the left side as indicated by the white arrow on the side of the remote.

   <u>NOTE:</u> Do not lift the front panel upward or attempt to remove the panel completely as this will cause damage to the remote and render it non-operational.
3) Replace the batteries
4) Close and screw the front panel back on securely – do not over tighten

Appendix B: Components Inventory

Components	Quantity	Unit Price (US$)
12V 35WRMS/100WPMPO Police Siren Speaker	2	25.99
434 MHz RF (Amplitude-shift Keying) Transmitter/Receiver Pair	1	11.90
Audio Processing Sound Module	1	26.95
Microcontroller Board	1	22.00
Encoder and Decoder IC Pair	2	2.34
350W CPU Power Supply	1	14.99
RG-59/U Siamese Cable, RG-59 20AWG + 1 Pair 18AWG	100 ft.	27.12
Various Small Circuit and Chassis Components*	1	55.02

Total Cost for Parts	214.64
Shipping Costs	37.69

* Includes capacitors, resistors, wires, connector ports, mounting hardware, machine screws, and etc used for circuit construction and chassis mounting/interfacing.

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Appendix C: Analysis of Senior Project Design

The "Wildlife Deterrent System – The "SCARE WAVE" Audio Deterrent System" project involved working with a client, Mr. Robert Alberti, who requested the production of a device that would be used to scare away wildlife around his property, namely the Acorn Woodpecker. It was specified that this device be weatherproof and able to produce a 75 dB gunshot sound, when remotely triggered, which would cover a 30 ft radius circle of area. However, we have taken these specifications and went above and beyond with the final product. Our final product is weatherproofed and able to produce four user-specifiable, via provided MicroSD card and software, sound files that, when remotely triggered up to 300-400 ft, is emitted by the device at a maximum sound level of 125 dB within a 30 ft radius circle of area. In addition, due to the versatility of our design, the product can be used for other purposes. The device was pre-loaded with the client's desired gunshot sound, sonar, hawk screech, and hawk call.

Project Title: Wildlife Deterrent System – The "SCARE WAVE" Audio Deterrent System

Students' Names:

Kevin Wong: ______________________________ Date: _______________

Ferdd Lansang: ______________________________ Date: _______________

Advisor Name

Dennis Derickson: ____________________________ Date: _______________

Summary of Functional Requirements:

Minimum	
Audio Volume	75 dB
Audio Output Range	30 ft
Number of Generated Outputs	1
Generated Audio Output(s)	Gunshot
Trigger Type	Remote (close-range)
Number of Triggers	1
Installation Method(s)	Permanent Mount
Product Housing	Weatherproof

Ideal	
Audio Volume	75 dB+
Audio Output Range	30 ft+
Number of Generated Outputs	2-3
Generated Audio Output(s)	Gunshot Predator Animal Calls High Frequency Screeches
Trigger Type	Remote (long-range)
Number of Triggers	2-3
Installation Method(s)	Any
Product Housing	Weatherproof Visually Deterring
Additional Features	Random-timing Automatic Trigger Mode Remote or Automatic Shutdown Swappable Audio Output

Primary Constraints:

- $250 project budget and two quarter time constraint – called for careful research and scrutiny of component market prices as well as important buy vs. build decisions. This also determined the type of power source used for the project – considering the costs the device was made to work off of a 120VAC outlet port rather than a standalone source. In addition, these factors are what pushed us to use a modular approach in completing the project as it saved time both in construction and troubleshooting.

- Very comprehensive project that demanded research and review of multiple EE topics as well as topics outside the EE major such as bird biology and sound intensity.

- Balancing senior project work and class work – this was a major constraint as it pushed us to not only schedule work well, but to make important choices (grade points in class vs. several useful project work hours) to ensure the completion of the product.

Economic:

- The original budget of the project was $250 as proposed by Mr. Alberti. The final cost for parts came out to be $214.64, with $37.69 in shipping costs of which were considered separate from the total. Please refer to Appendix B for a chart of these costs.

- Development time encompasses the majority of the allotted two quarters, Winter 2011 and Spring 2011, to complete the Project. The total number of hours has been difficult to log as the project became more involved and logging hours occurred daily and frequently that the act became more burdensome than beneficial.

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If Manufactured on a Commercial Base:

- If this product were to be manufactured on a commercial base it would probably sell the most in areas frequented by birds and other wildlife pests. Additionally, it would sell to people for general use such as home protection due to the fact that it allows for customization of the audio files allowing it to mimic the presence of a dog to protect a backyard or the presence of people to give the illusion that a house is occupied when in fact its residents are away. In particular, this device would sell the most, in terms of general use, during the Halloween season. So, due to its versatility, a multitude of these devices would be sold per year.

- The manufacturing costs of this product would be a lot less than what we have spent in constructing the device over the life time of our project. This is even truer considering the fact that real world manufacturing gives the opportunity of reducing the size and development time of the device by incorporating all the electronics into a system-on-a-chip design. With the overall size and development time reduced, it opens up more possibilities for improvement of the system as more money is saved in its manufacturing.

- The cost and profit ratio for this device would probably lean toward a small profit focusing on the likely high demand for the product that would yield a larger sum in the long run. In terms of cost of operation – since the device automatically shuts off power to peripheral devices, such as the speaker, the cost of operation is kept at a very minimum during idling periods.

Environmental:

One environmental impact this device may have is the permanent evacuation of specific wildlife species in an area where it is being used for that purpose. This could cause a dramatic change in the surrounding ecosystem because if one species leaves the area it could let another die out due to lack of food or let another flourish due to lack of predators.

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Manufacturability:

Due to the modular approach taken in designing and constructing the device, a key standard in manufacturing, there are most likely little to no challenges in manufacturing it. One of the issues that barely stand out as a problem would be the modification of any speakers that will be used for the device. This is because the speakers we used had to be modified to interface correctly with the device. Additionally, a change in the microcontroller board used may call for a translation of the code into one that is understood by the new one, which, again, is not a tremendous feat due to the modular approach taken.

Sustainability:

Upgrading the device will be an easy task as it is set up to be scalable; in other words, it allows for the addition of peripheral devices with little to no change in the system itself. Some examples of good upgrades would be a targeting and motion sensing feature and a simple strobe light attachment to add to its deterring effect towards wildlife.
Maintenance is not an issue as it is weatherproof and can withstand a good amount of stress – it can be treated like a personal computer tower unit; it'll collect dust but it'll remain functional.

Ethical:

One major ethical implication for this product would come from extreme misuse. The ability to customize the audio playback of the system grants the user the ability to use the device to mimic gunshots or human distress. This is definitely an ethical concern where the device is used in an abusive, disruptive, and terrorizing manner.

Health and Safety:

One main safety issue with this project would be damage to peoples' hearing that can be caused by improper use such as placing the speakers directly against the human ear or being too close to the speakers in general when using the device. Another safety issue that may come up deals with the device's function to scare and startle – it is not recommended for use by or against those with heart problems. In addition, it may lead to the inhibition of safety were the system be used to mimic human distress. In general, **responsible use** is encouraged to prevent injury to one's self or others.

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Social and Political:

One major sociopolitical concern that can be associated with the manufacture and sale of this device, aside from possible noise ordinance violation increases, is the improper/irresponsible use of the device leading to a regulation of its use. The customizability of the device allows for users to have it mimic gunfire or even human distress – valid reasons for the regulation of its use. Again, it is important to emphasize **responsible use** of the device and this statement may become a stronger statement if the device happens to become a successful product.

Development:

Tools and techniques independently learned during the course of the project are as follows:

- Coding language for the microcontroller board and how it is interfaced with other devices
- Reverse engineering
- Efficient use of circuit board real estate
- Modular system design and construction

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Appendix D: Finished Product Photo Collage