Pet Pest Protector

By
Madison Hedlund
Kyle Schildgen
Zuriel Tronco

Design Document for ECE 445, Senior Design, Fall 2019
TA: Mengze Sha
3 October 2019
Project No. 8

Table Of Contents

1 Introduction

1.1 Problem and Solution Overview

Approximately 60.2 million homes own a dog and their safety is a concern of owners around the country [1]. Unfortunately, when working with animals you don't know when they will be calm and when they will be triggered to attack going from harmless to harmful. This leads to many attacks between dogs and humans and other animals. Every year about 4.5 million dog bites occur which leads humans to approximately 866 emergency department visits and 26 hospital stays each day [2]. Similarly to humans, skunks can also appear in your backyard and will be seen as a friendly creature to the dog, but upon approaching the skunk may spray the dog leading them to potential blindness, vomiting and nausea [3]. If a skunk bites your dog they may be infected with diseases including Tularemia, Canine hepatitis, or Listeriosis. Skunks aren't the only animal that can appear in a backyard to harm a dog. Some other animals include coyotes and snakes [4]. When a coyote is provoked its first instinct is to kill the pet and not just injure them so quick intervention is important. Over one-million animals are reported to have been bitten by a snake in one year with dogs enduring the most bites [5]. These bites lead to a twenty percent fatality rate. Our goal is to provide a safety system for the owner and their pet giving the owner a chance to intervene before a situation gets harmful and gives them an extra sense of security when their dog is in the backyard. The safety system consists of passive infrared sensors and lights on the pets collar. The sensors will detect people and creatures in the yard. When something is detected a light flashes to stun the intruder and an alert is sent to the owner through bluetooth transmission.

Other companies have tried to come up with systems to alert of intruders in their yard, but none of them took the same approach as us. Google took one approach with their Nest Cam Outdoor [6]. This system consists of an outdoor camera that sends an alert to your phone when there is motion is your backyard. The downfall of this system is that every time you let your own dog out by themselves or even if you go out with them you will get an alert on your phone. The Pet Pest Protector is unique in that it alerts for other creatures in the yard and can be turned off while the owner is outside with their pet. Another solution to pet protection took a mechanical approach to solving this issue with the Coyote Vest [7]. The Coyote Vest uses spikes and other pointed, straw-like features to deter coyotes from biting smaller dogs. This vest does not alert the owner of the presence of a threat to their pet. In addition, this vest is primarily geared towards coyote protection, whereas we seek to detect other pests in the user's back yard. This method will also allow for some amount of time to allow for intervention. If someone were to use the Coyote Vest, it may be too late to help the pet.

1.2 Visual Aid

Figure 1: Visual Aid

1.3 High-level requirements List

- The IR sensors must detect a creature in the backyard within 10 feet proximity.
- The Bluetooth transceiver must be able to connect with the UI app on the host's phone ninety-nine percent of the time.
- The lights on the collar must display when a creature is sensed and must be off when no creature is present.

2 Design

2.1 Block Diagram

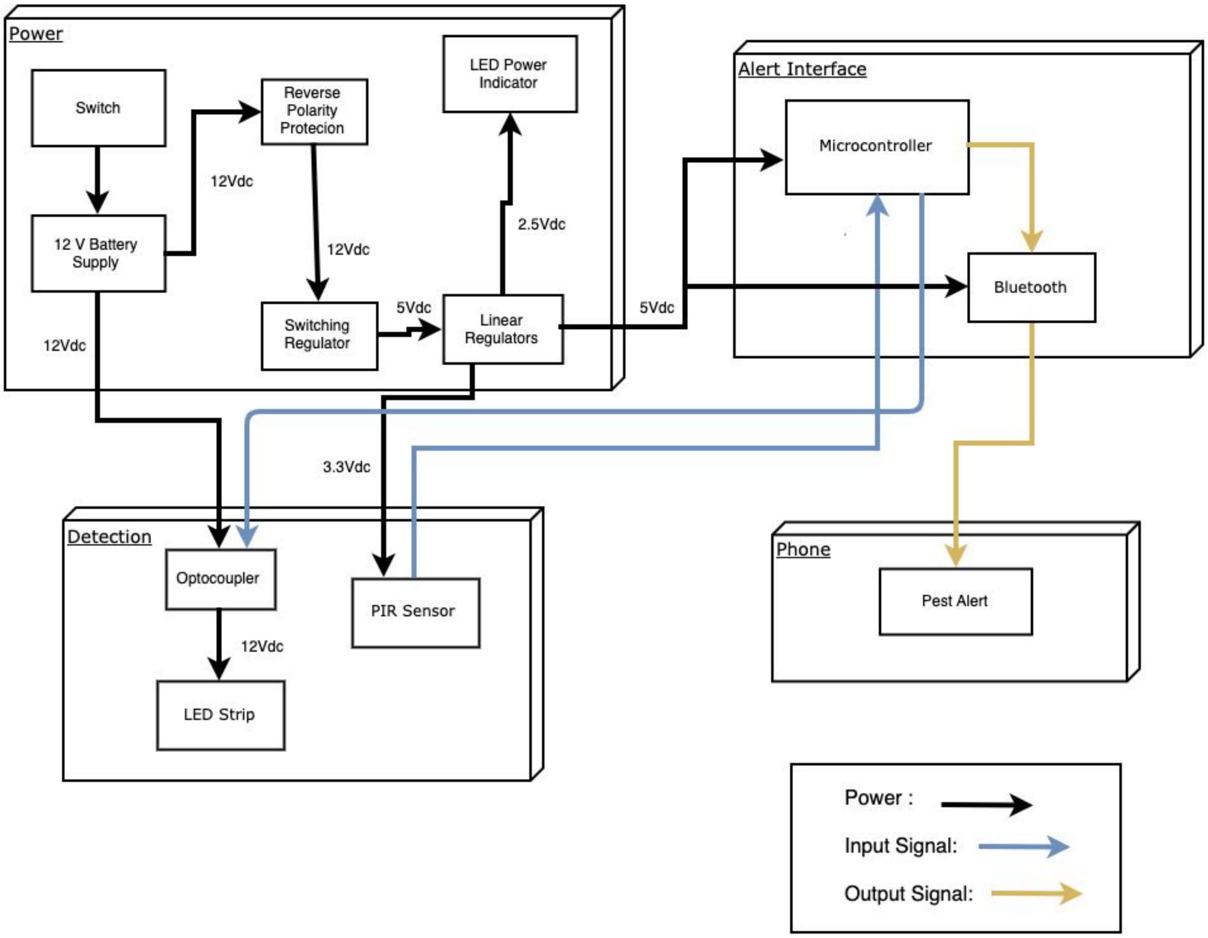

Figure 2: Block Diagram

In order to meet all of our high level requirements for the project we broke our system into four sections or blocks. It all starts with the power block. That ensures that we are able to provide all of the pieces of our system with the right power for them to be able to work in their typical manner. The power feeds into the alert interface that ensures the bluetooth connection is made with the phone and that the alerts are sent at the right time. This is why that block is connected directly to the user's phone. The power supply block also ensures that our lights and sensor get the appropriate power so that they can detect the creature and flash a light which allows us to fill all of our high level design requirements.

2.2 Physical Design

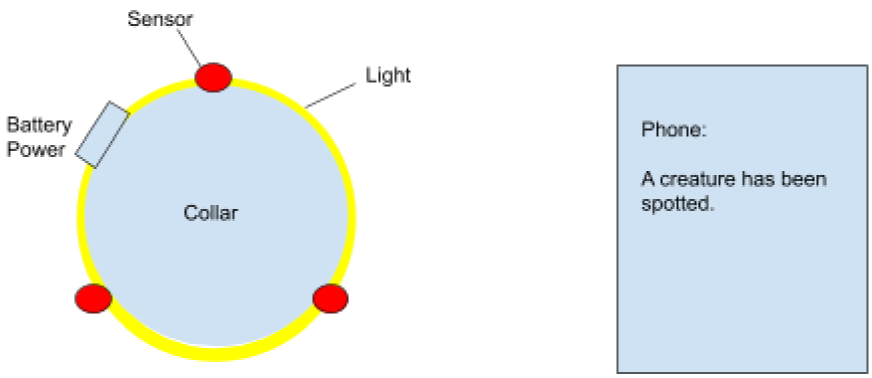

Figure 3. Physical Diagram

The complete system in this project consists of a user's phone and a dog's harness. The harness is equipped with PIR sensors that detect creatures within someone's backyard. As part of a deterrence system the collar contains lights that turn on when a creature is spotted. The collar also holds a bluetooth chip which is how it communicates with the phone. Upon spotting a creature an alert is sent to the user's phone that says that there is a potential hazard in their backyard.

2.3 Functional Overview and Block Requirements

2.3.1 Power

The power block was made in order to properly provide power to all of the components within our design. For the system to work together it is crucial that each chip and sensor gets provided a voltage that is within its tolerance to work in its typical manner. The system is powered by a combination of double A batteries that is equivalent to 12 V. The 12 volts is able to power the LED strip and then also gets stepped down to both 2.5 V, 5 V, and 3.3V to power the rest of the circuit. The power system is completed with a switch to turn the power on and off with an LED that indicates which state the power system is in.

2.3.1.1 Battery

Due to the fact that our system must be mobile it is powered by a battery. Our battery consists of eight 1.5V batteries in series to produce 12V. Combined these batteries will have enough voltage and current to turn on the LED strip while also powering the rest of the circuit. Whether the battery is on or off is determined by the switch that connects to it and its state is represented through the LED power indicator. The battery casing will consist of two 4-AA battery casings that will be soldered together to create a singular 8-AA battery casing. The output of the casing is a DC barrel jack connector. Because the casing has the batteries exposed, it will be necessary to create a mechanical housing to ensure that no shorts are created due to water exposure.

Requirement	Verification
The battery must turn on when the flip is switched and provide 12V to the circuit.	A. Flip the switch on the circuit with the battery connected B. Use a voltmeter to measure the voltage across the two terminals of the battery and ensure that it reads 12V within a five percent tolerance.
The battery must be able to power the circuit for 30 minutes.	A. Flip the collars switch into the on position and start a timer. B. When the timer hits thirty minutes use a voltmeter to measure the battery output and ensure that it is within the 5% tolerance of 12 V.
The circuit should not operate or become damaged if the battery is connected in reverse.	A. Wire the circuit improperly to confirm it does not power on. B. Take out a battery during operation to ensure that it powers down properly.

Table 1: Requirements and Verification for Battery

2.3.1.2 Linear Regulators

Many of the components in our system require a different voltage to operate, but we want them to run off of one battery system. With that linear regulators are used to bring our 5V supply down to a range of voltages for the various IC chips on the board. Without the step down the chips would burn out and the system would not work properly. Switching regulators will be used to perform the large step downs. We plan on having three additional supply rails in addition to the 12V DC supply. We will step down from 5V to 3.3V, 5V to 3.3V, and a regulator for 5V to clean up the ripple from the switching regulator. Most of these components can handle some amount of voltage variation, but for logic components such as the microcontroller or other sensitive components like the bluetooth module this is not the case. The low drop-out linear regulators will be used to ensure that the supply to the microcontroller and bluetooth transceiver to clean up and stabilize any leftover voltage variations due to non-idealities.

Requirement	Verification
The linear regulator must be able to generate 2.5 V from the 5V source within a 5% tolerance.	A. Connect the input of the linear regulator circuit to a 12 volt power supply and the output of the linear

	regulator that is designed to output 2.5V to a voltmeter. B. Once the circuit is powered ensure that 2.5 V are read within their 5% tolerance on the voltmeter.
The linear regulator must be able to generate 3.3 V from the 5 V source within a 5% tolerance.	A. Connect the input of the linear regulator circuit to a 12 volt power supply and the output of the linear regulator that is designed to output 3.3 V to a voltmeter. B. Once the circuit is powered ensure that 3.3 V are read within their 5% tolerance on the voltmeter.
The linear regulator must be able to generate 5 V from the 5 V source within a 5% tolerance.	A. Connect the input of the linear regulator circuit to a 12 volt power supply and the output of the linear regulator that is designed to output 5 V to a voltmeter. B. Once the circuit is powered ensure that 5 V are read within their 5% tolerance on the voltmeter.

Table 2: Requirements and Verification for Regulators

2.3.1.3 LED Power Indicator

The LED Power indicator is used to show if the collar is on or off. When the owner flips the switch to turn on the battery the led powers on. The led is on the entire time the collar is on to show the owner that the system should still be operating properly. When the owner flips the switch off the led turns off to clarify that the collar is no longer powered.

Requirement	Verification
The light must turn on within two seconds of the collar being powered.	A. Flip the switch to turn the collar on and start a timer. B. When the timer reads two seconds ensure that the LED is lit.
The light must be on at all times that the collar is on.	A. Flip the power switch to turn on the collar and start a timer. B. Leave the collar on for thirty minutes. At each ten minute increment within the thirty

	minutes check to ensure that the LED is lit.
The light must be able to be seen on the collar by the owner one foot from the dog.	A. Set the collar on a lab bench and measure one foot from the led on the collar. B. Have a person stand at the one foot distance mark and ensure that they can see the light from the led once the collar is turned on.

Table 3: Requirements and Verification for LED Power Indicators

2.3.1.4 Switch

A switch was added to the battery to ensure that we would be able to turn the collar on and off. We made this decision because we realized that a dog is not outside all the time so there will be a lot of times that the collar does not need to be powered. Without a switch the owner would have to take the batteries out to turn the collar off which is not a good design technique because the owner could forget to take them out or batteries could get misplaced.

Requirement	Verification
The switch must be easily moveable.	A. A person must move the switch from one side to the other and clarify that it can be done without putting themself through any strain.
The switch must be able to stay in its on and off state during light movements.	A. Have a person note which side of the collar the switch is on and shake the collar for thirty seconds. B. After the thirty seconds occur look at the switch to ensure that it is still in the same position that it started at. C. Move the switch to the other position and repeat steps A and B of the verification to ensure that the switch is stable in its two states.

Table 4: Requirements and Verification for the switch

2.3.1.5 Reverse Polarity Protection

To protect our circuit from users improperly connecting a voltage source, we will need to include some method of reverse polarity protection. There are several methods of achieving this goal. First off, we do not need to worry about AC voltage sources. If a user were to connect the circuit to a wall plug (120Vac rms), then they would have more problems to worry about than reverse polarity i.e. components blowing up and potential fire hazards. However, it is very likely that someone could potentially put the battery in reverse. We could use a MOSFET to protect against reverse polarity; however, this is overkill as we are not dealing with high DC voltages. The simplest and cost effective way to achieve reverse polarity protection would be with the use of a single Schottky diode in series with the battery supply. Schottky diodes have low forward voltage, so it dissipates less heat as opposed to a regular diode as well as a fast switching and has less noise contribution.

Requirement	Verification
Connect the Schottky diode in reverse configuration and confirm that there is little conduction	A. Connect a 12V DC source across the diode in reverse configuration B. Measure the reverse saturation current
Measure breakdown voltage to confirm is much greater than the expected applied voltage for our circuit	A. Connect a DC voltage source to the diode in reverse configuration B. Apply a 12V DC voltage as noted in the datasheet C. Increase the voltage by 1V increments and measure the current until you read a reverse current as noted in the datasheet D. Once reverse breakdown current has been detected, record the voltage and compare to datasheet

Table 5: Requirements and Verification for the Reverse Polarity Protection

2.3.1.6 Switching Regulator

Most of the components in our design do not need a 12V input like the LED strip does so we have to step down the supply voltage to lower voltages. Before stepping down to lower voltages, we will step the 12V battery supply to an intermediate voltage at 5V. As a benefit of using a switching regulator, we will get better efficiency in our power conversion as opposed to a linear dc-dc converter due to the switching nature of switching regulator converters. As an added benefit this regulator has a wide input voltage range. Even though the design is intended to work off of a 12V DC battery supply, if for some reason a user decided to connect say a 15V battery, then the circuit would still work. The downside to using a switching regulator is that there is potentially some output voltage and current ripple. This can be rectified by either using a linear low drop-out regulator (see section 2.3.1.2) or some filter capacitors.

Requirement	Verification

Confirm that the switching regulator is able to achieve efficiency of >90%	A. Connect 12V DC supply to input of ADP2303
	B. Measure input DC current with a multimeter
	C. Attach a constant 5W load to the output
	    a. Output voltage should be configured in the 5V output configuration
	D. Measure the output DC current
	    a. Because the output voltage is 5V, and the load is 5W, we should expect 1A output
	E. Calculate Efficiency using Pout/Pin

Table 6: Requirements and Verification for the Switching Regulator

2.3.2 Alert Interface

The Alert interface is used to bring all of the pieces of the system together. It does this by taking in a signal from the PIR sensor to determine if an alert should be sent to the owner and if the lights on the collar should turn on. A bluetooth connection is used to send an alert to the owner.

2.3.2.1 Microcontroller

A microcontroller was used to act as a logic step between the PIR sensor and both the owner alert and the precaution light on the collar. The microcontroller takes in 5Vdc from one of the linear regulators to ensure that it is on and powered properly. The microcontroller will also take in the PIR sensor output to ensure that there aren't any false alerts. Once it determines that the alert is real it will trigger the bluetooth to alert the phone and the LED strip will be powered. Overall the microcontroller should be able to operate with multiple input and output signals from external devices which are controlled through its programming.

Requirement	Verification

The microcontroller should be able to operate multiple input and output signals from external devices	A. Schematics of the microcontroller should show multiple digital and analog output/input ports. These ports are to be used to connect the bluetooth, passive infrared sensor and LED strip. B. Ensure that the microcontroller can read when the connects change values through code verification of multiple signals at a time.
The microcontroller should be able to read data obtained from the passive infrared sensor.	A. Microntroller needs to process signals obtained from devices. In reading signals, the margin of error will be kept to a minimum, as we use data obtained through trials to properly filter out bad data with software. B. Signal a high output from the sensor and ensure that the microcontroller outputs the signal to turn on the bluetooth connection.
The microcontroller must be able to activate the LED strip when a creature has been detected.	A. Power the microcontroller circuit and ensure that the output to the LED strip shows that the LEDs should not be on by reading the microcontrollers output with an oscilloscope. B. Place a high connection into the sensor input of the microcontroller to act as through a creature has been detected. C. Read the LED strip output on the microcontroller again to ensure that it has changed to the right value that triggers the LEDs to be powered.

Table 7: Requirements and Verification for the Microcontroller

2.3.2.2 Bluetooth

The connection from the collar to the phone is made over bluetooth to ensure that it is reliable. With a bluetooth connection the collar can be used pretty much everywhere as long as the two are in range of each other. We also made this design because we deemed that WiFi wasn't as reliable because not all WiFi connection will stretch into someone's backyard or won't cover the entire area.

Requirement	Verification
Microcontroller should trigger the bluetooth transceiver to transmit a bluetooth signal at 2.4Ghz.	A. Measure output power with spectrum analyzer B. Record the power level at 2.4GHz and make sure that it is within an acceptable power level of the known technology
Phone application should successfully detect the incoming bluetooth transmitted signal.	A. Launch UI App to try and connect to bluetooth transceiver B. If the app connects then the test is passed
The bluetooth connection must be operable within a 10 meter distance of the dog's collar and the owner's phone.	A. Establish bluetooth connection between phone and collar by setting the output of the microcontroller to always say that a bluetooth connection is needed. B. Measure ten meters from the collar. C. Have a person bring the phone to the 30 meter mark with the collar left in place and ensure that there is still a bluetooth connection on the phone.

Table 8: Requirements and Verification for the Bluetooth Module

2.3.3 Detection

Detection of a creature is a crucial part of this project. If a creature is not detected then the protection system is not initiated. This module connects directly with the microcontroller to communicate when sightings occur. The sensors talk to the microcontroller to say when the sightings happen and the light receives that information so that it can properly display on the collar.

2.3.3.1 Passive Infrared Sensor

We are using a passive infrared sensor to detect creatures within the backyard. The sensor is designed to detect movement of infrared radiation which allows us to know if there are living creatures in the backyard which would cover protecting the dog from both humans and creatures. This means that the sensor won't detect any inanimate objects that would be in the backyard like a tree or patio furniture. Another reason we chose the passive infrared sensor is due to its movement detection. When the dog goes into the backyard the sensor will register its surroundings to know what the base level of infrared radiation is. When someone comes into view of the sensor the infrared radiation in that area will increase telling the sensor to send a high signal to the rest of the system. This works well in our situation because we are looking specifically for the movement of living creatures to operate the rest of our system properly. Within our design we will use two sensors to cover the entire 360 degree view around the dog. This was chosen because the sensor has approximately a 180 degree point of view [8].

Requirement	Verification
The PIR sensor should be able to detect IR radiation from at least 10 feet away.	A. With the sensor powered connect the output to an oscilloscope. B. Measure ten feet from a wall and have the sensor sitting at that ten feet point on the wall with no one in front of it to stabilize it. C. Have a person walk directly along the wall so that they are ten feet from the sensor and watch the oscilloscope screen to see if the output of the sensor changed. D. Ensure that the oscilloscope reads a one volt output showing that the human was detected.
The collar must be able to detect a human from all 360 degrees around it.	A. Power the circuit connected to the sensors and connect all four outputs from the four sensors into different oscilloscope channels. B. Have a person stand at one spot and ensure that at least one sensor has a high output. C. After a position's output is recorded have the person move roughly 45 degrees around the collar in a circle like manner. D. At each 45 degree mark ensure that at least one sensor gives a high output. This verification is

	complete once a person makes it all the way around the collar with a high output at all eight increments within the 360 degrees.

Table 9: Requirements and Verification for the Passive IR Sensor

2.3.3.2 Light

The light is the first line of defense as part of the protection over the animal. The sudden burst of light is used to stun the creature that entered into the backyard slowing down any harmful intents that they might have had allowing the owner to have more time to react to the situations. The light consists of an led array around the collar. The array turns on when a creature in sensed by the PIR Sensor. The actual trigger to start the light comes from the microcontroller to ensure that there aren't any false flashes of the light and so that it is timed out to not trigger anyone with epilepsy to have a stroke. We chose to use an LED array around the collar so that the light would be bright enough to be scene within the detection range.

Requirement	Verification
The light must be visible from 10 feet.	A. Turn the light on the collar on by connecting the leads of the strip to a 12V power source with 1A source. B. Measure 10 feet from the collar and stand there. While standing there ensure that the light can be seen.
The light must turn on within ten seconds of a creature being detected by the sensor.	A. Provide a high signal to the microcontroller as if it were the sensor creating the high signal and start a timer. B. Once the timer hits ten seconds ensure that the light is on.

Table 10: Requirements and Verification for the Collar Light

2.3.3.3 Optocoupler

We do not want to have our lights (LED strip) running constantly to avoid draining the battery supply quickly as we intend on using the device as emitting quick bright flashes as opposed to continuous bright lighting. The optocoupler will act as a switch that will close the circuit for the LED light strip by receiving an input from the microcontroller. An added benefit of using the optocoupler is that it will help isolate the ground node for the LED strip from the ground node from the rest of our circuit. This way it (optocoupler) will isolate the voltage variation and noise differences between the ground nodes.

Requirement	Verification
Forward Current of Optocoupler should be less than 55mA	A. Connect the optocoupler to an external 2.0V source to turn the internal diode on B. Measure the output terminals current coming out of the phototransistor node C. Compute the output power to make sure it is low dissipation
Measure the turn on voltage of the optocoupler (supposed to be 1.2V) as there could be variation due to fabrication	A. Connect the optocoupler with an external DC voltage source B. Start with 0.7V and increment the voltage by 0.1V C. Measure the forward current at each voltage increase increment D. Once the forward current reaches ~50mA (or measure value from the first verification), record the voltage

Table 11: Requirements and Verification for the Optocoupler

2.3.4 Phone

A phone will connect to the pets collar over a bluetooth signal. When an animal is spotted a notification will be triggered to tell the owner that a pest has been detected. We will not be building a phone for the project as it is out of scope for this class, although it is integral to have in order to run the alert app.

2.3.4.1 Application UI

Requirement	Verification
Application should be able to retrieve data from the bluetooth device.	A. Connect the phone to the bluetooth connection. B. Send a notification that a creature has been spotted and ensure that the phone receives that message.
The application should be easily usable by	A. Approach someone who is not in

the owner.	our lab group and ask if they will test out the application. B. Get their feedback to ensure that it is easy for a person to operate which will entice them to use our product.

Table 12: Requirements and Verification for the Phone

2.4 Schematics

2.4.1 Power Subsystem Schematics

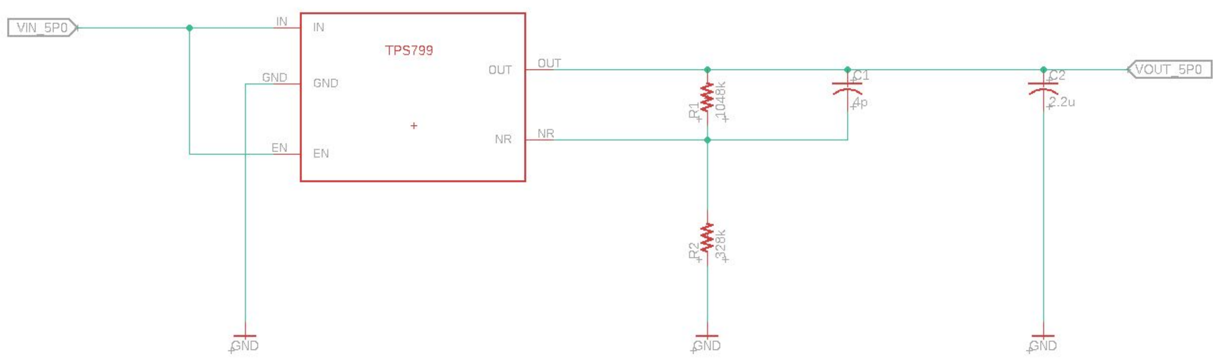

Figure 4: Schematic of the Regulated 5.0V Source

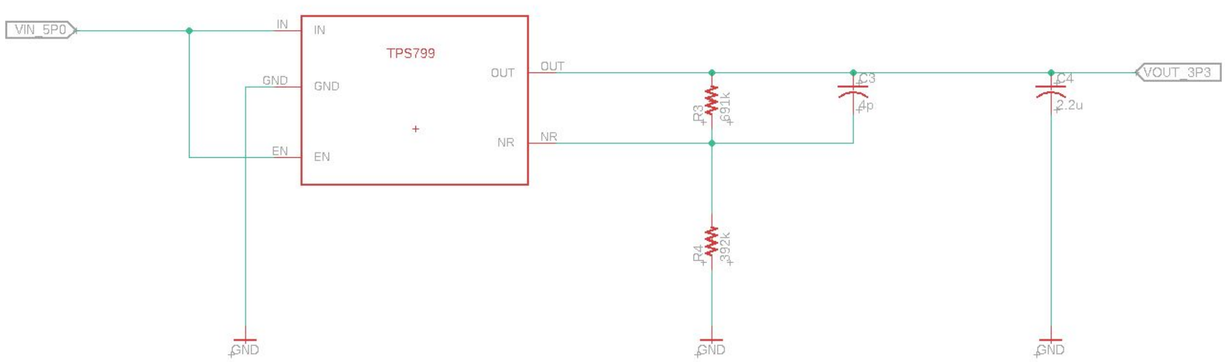

Figure 5: Schematic of the Regulated 3.3V Source

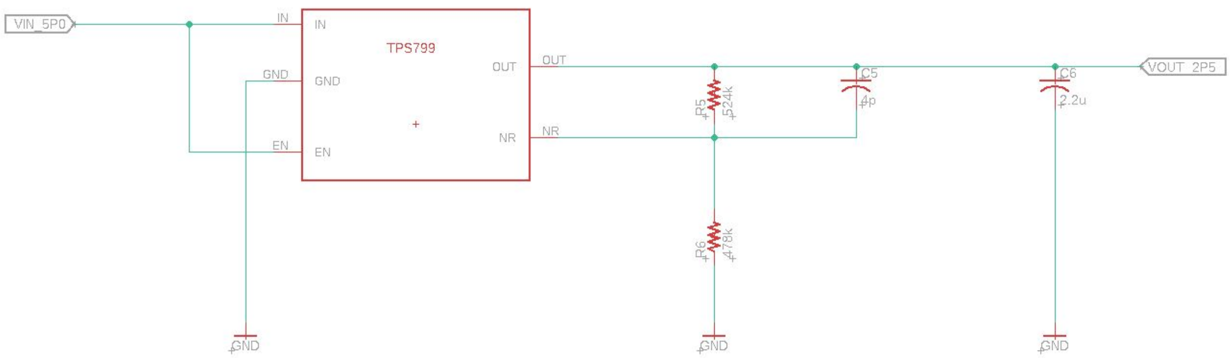

Figure 6: Schematic of the Regulated 2.5V Source

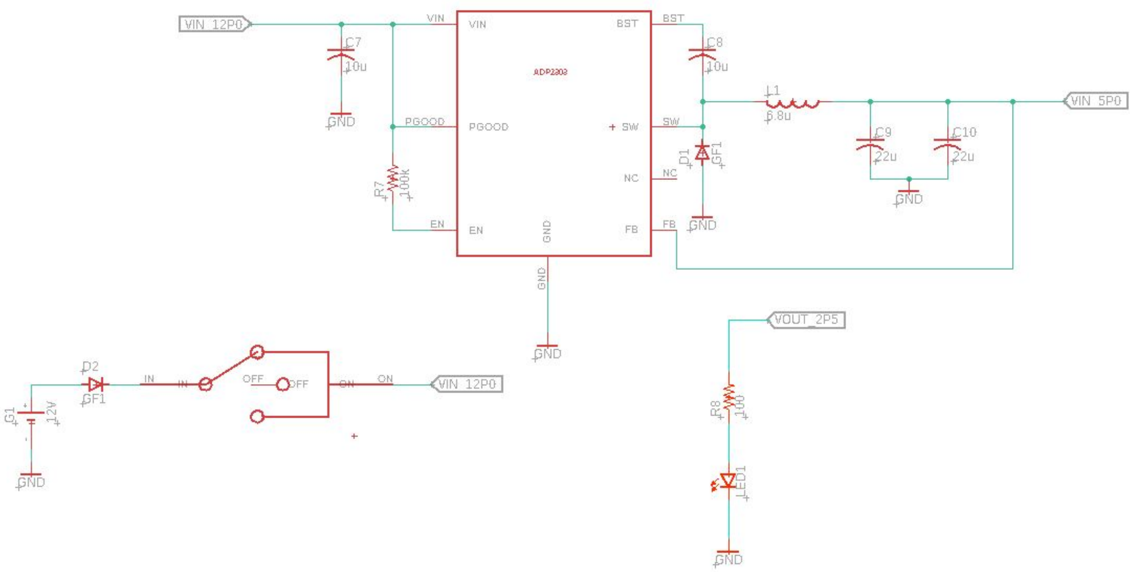

Figure 7: Main Power from Battery and Buck Converter

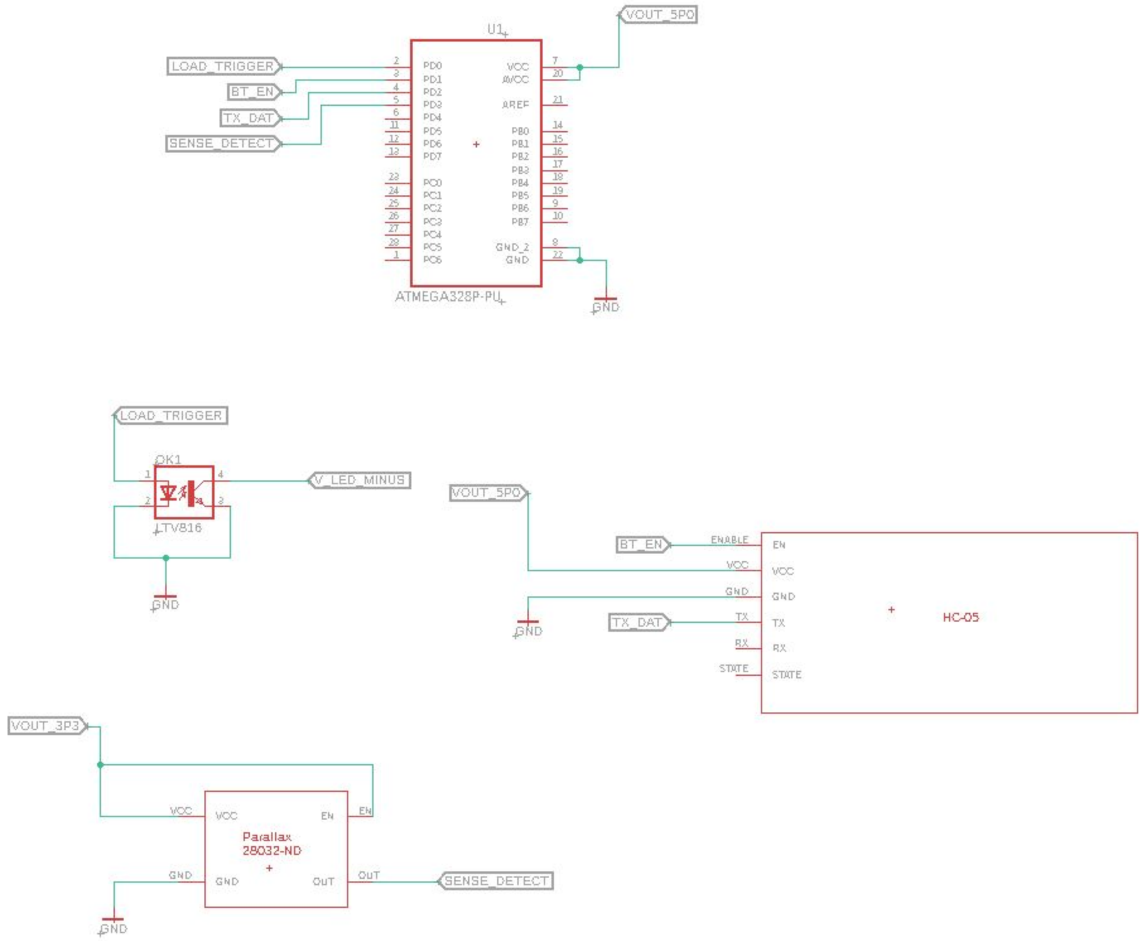

Figure 8: Detection Circuit and Bluetooth

2.5 Software Description

The user interface for the application will be written in javascript. In order to create the application so that it is mobile friendly, it will be written using react native. The application will be written using react libraries that will help create the best user experience possible. Furthermore, when it comes to the software that will be used to control the microcontroller, through research, we have found that the microcontroller is arduino friendly. This means that because the microcontroller is arduino friendly, both the passive infrared sensor and the bluetooth module will be programmed using arduino friendly language.

Furthermore, the design of our application is to give the user access to monitor the surroundings of his pet. We will able to give the user a 360 degree radar like view of their pet. Through this, the user will know if there are multiple pests surrounding their dog. In order to achieve this, we will be using two sensors that will each measure 180 degrees, allowing us to program both sensors the same. The sensors will be connected to the microcontroller, which, through the use of C language and the Arduino IDE version 1.6.2 the Arduino IDE.

The software will be written so that there are no notifications to the owner when the dog is outside safely. Once the microcontroller receives the signal from the sensors that a dog has been spotted then the bluetooth software will be trigger to send an alert to the owner. The microcontroller will also be programmed in a way where it can tell the strip of lights on the collar to turn on when it receives input that a creature has been spotted. To further explain how this set of lights are going to work, the microcontroller will be reading data obtained from the sensor, when it sees that there is a high incoming signal, it will trigger a high signal on the bluetooth module, as well as triggering a high signal on the lights, turning them on. Once there is nothing surrounding the dog, the radar will pass a low signal, turning off the light and sending a low bluetooth signal.

2.6 Tolerance Analysis

Our design will be powered by the use of a battery, so it is important to immediately realize the limitations that battery operated devices have. The absolute worst case scenario in our design is if the LED light strip is continuously running due to a fault in our circuit or under constant IR detection that would set the lights to go off. The goals is to be able to have the system running properly under a ~3W load due to the LED strip for 30 minutes. The datasheet specifies that per unit foot of the LED strip it will consumer ~2.35-2.75W of power, and we decided to plan for 3W as a safety measure. With that power consumption and a 12 volt supply it can be seen in figure 8 that the Coppertop AA Constant Current batteries will be able to operate the collar for over an hour, which means that we will still be able to meet our battery life requirement.

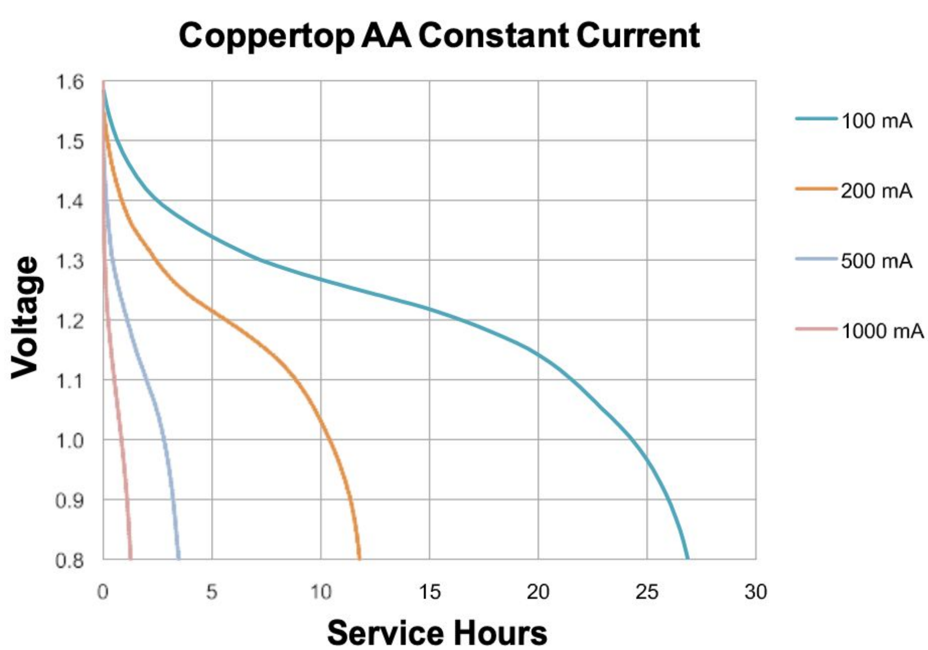

Figure 9 - Battery Life [9]

For demo purposes/testing, we will use commercial off the shelf batteries. However, the system must still be able to power the other components as the battery's voltage drops due to constant discharge. The way to solve this is by using components that do not have specific/tight input voltage requirements. For example, our primary buck converter to step down to 5Vdc, will have a wide input voltage range to account for the battery's discharge. In addition, the remainder of our circuit will be mostly low power, so fortunately it will not draw ~200-230mA that the LED strip will draw. To also mitigate the current draw from the 3W load, we will opt for the use of an optocoupler to control the conduction of the LED strip. The optocoupler will not only isolate the voltages between the LED light strip and the rest of the circuit, but it will also serve as a type of switch to either turn on or off the LED light strip.

Furthermore, we should be cautious with the gauge of wiring that is used to deliver the current to the LED strip. The voltage to turn on the strip will most likely not require exactly 12V to turn on as there are probably some variations in the LEDs and resistors on the strip. If the light strip were to turn on at even 11.0V, then we would be drawing slightly more current to deliver the 3W to load. This also does not take into account user error. Someone could try to power the system with a different rated voltage, the system must be able to safely operate under these conditions to keep the system safe.

For the PIR sensor that we will be using, the datasheet specifies that the IR sensitivity distance drops off at higher temperatures. It would be wise to not assume that the user will be using the sensor at ideal temperature conditions. In figure 9 it can be seen that even at high temperatures of 95 degrees the sensor can still detect about eighteen feet away. Given that sometimes in the summer it goes into the 100 degree range we still have eight feet of distance to loose to meet our requirements. If the decrease is sensitivity stays consistent at the higher temperatures we will still be meeting our requirement at 110 degrees Fahrenheit which is typically warmer than the average Illinois summer day.

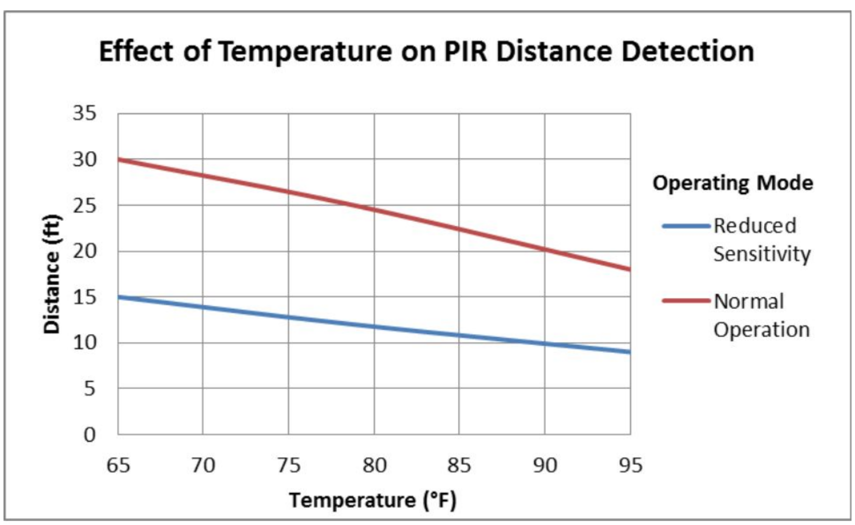

Figure 10 - Sensitivity over temperature [8]

3 Cost and Schedule

3.1 Cost Analysis

Our development costs are estimated to be \$34/hour, working 10 hours/week for three people. Full development costs are laid out in equation 1.

*Labor cost = Number of people * pay per hour * hours per week * number of weeks * 2.5* (1)

$$3people * \frac{\$34}{hr} * \frac{10hr}{week} * 12weeks * 2.5 = \$30,600$$

This brings the estimated labor cost to be \$30,600.

Description	Manufacturer	Part #	Quantity	Cost ($)
PIR Sensor	Parallex	28032-ND	2	25.98
Switch	APEM Inc.	GH36P010001	1	4.39
LED Power Indicator	Visual Communications Company	5381H1	1	0.91
Bluetooth Module	HiLetgo	HC-05	1	7.99
AA Battery	Duracell	MN1500	8	8.18
Collar Lights	Inspired LED, LLC	12V-UB-PW-12M	30	30.24
Microcontroller	Microchip Technology	ATMEGA328P-PU	1	2.14
Voltage Linear Regulator	Texas Instruments	TPS799285DDCR	3	2.76
Voltage Switcher DC/DC Step Down Converter	Analog Devices	ADP2303ARDZ-5.0-R7	1	2.73
Optocoupler	Lite-On Inc.	LTV-816	1	0.41
Dog Harness	Peak Pooch	N/A	1	12.99
Dog Collar	Blueberry Pet	N/A	1	9.99
Total Part Cost				**$108.71**

Table 13: Cost of Parts Layout

When we combine the labor and the part cost the entire project will cost around \$30,708.71.

3.2 Schedule

Week	Kyle	Madison	Zuriel
9/31	Start power board schematics	Start detection schematics	Microcontroller and bluetooth connection schematics
10/7	Start power board PCB layout	Detection board PCB layout	Microcontroller and Bluetooth board layout
10/14	Finalize power board in Eagle and send through audit	Finalize detection board and talk to machine shop	Program microcontroller Start on cell phone app
10/21	Start verification tests on power board to anticipate needed updates	Start verification tests on detection board	Make cell phone app Begin testing of microcontroller and data
10/28	Update power schematic for final round PCB order	Update detection board for final round PCB order	Update bluetooth schematic for final round PCB order
11/4	Complete battery and led power indicator verification tests	Complete PIR Sensor and lights verification tests.	Complete Microcontroller verification tests
11/11	Complete switch and voltage regulator verification tests	Start mock presentation	Complete Bluetooth verification tests
11/18	Mount power section on collar	Mount sensor and lights on collar for demo	Finalize app for mock demo
11/25	Taking thanksgiving break off		
11/2	Work together to fix things that failed in mock demo before final demo and make mock presentation.		
11/9	Complete final presentation, final paper, and extra credit poster		

	session if needed.

Table 14: Schedule of work for the semester

4 Ethics and Safety

Depending on the size of the device that is wearable on the collar, it could pose a choking hazard to peoples pets. Even if a pet is not able to sufficiently swallow the device, it is still very well possible that if it were to come detached, then if a curious pet decides to tear it open there are numerous small and hazardous electrical components that could pose a threat. In order to mitigate this, several measures could be put into place. The most obvious is to ensure that the device is snuggly secure to the collar or harness such that even during frantic movement it will remain in place. This also could place responsibility on the owner to ensure that they have a proper fitting and adjusted collar. In addition, it could also be constructed to ensure significant damage must be down in order to crack it open to expose the circuitry. As a last measure of safety, it is possible that we could coat the device with an odorless coating that would be distasteful to the pet to make it not want to put it in their mouth again, discouraging it from eating or chewing on the device.

The housing for the device must be constructed in order to handle outdoor conditions to ensure that the pet is kept safe in all environmental conditions. The most common conditions would be to safeguard the electrical components from rain and mud. It would probably be in our best interest to ensure that the device could also handle some amount of underwater exposure as someone may have a pool in their backyard. A pet could be tempted to jump in while wearing the device thus exposing it to serious water damage.

IEEE's Code of Ethics, #9 states that we need "to avoid injuring others" which is a concern in our project since we will have a flashing lights on the collared device. We will prevent these flashing lights from randomly flashing in quick instances as it could pose a risk to someone that is sensitive to flashing lights (i.e. a person that has been diagnosed with epilepsy) [10]. To mitigate this, we plan on using a microcontroller to keep track of the timing of the lights to ensure that the flashing lights will behave in a more controlled manner. By ensuring that the light does not flash randomly we are ensuring that we keep the safety and the health of the user at our utmost priority which follows IEEE Code of Ethics #1 by not endangering the creatures that are in the yard.

Another cause for concern regarding the lights on the collar is the actual brightness of the lights. When choosing a light to use for the device, we must be mindful that it is not so overly bright that it could risk potentially temporarily blinding someone. This could have numerous adverse effects, and it is known that bright light exposure to the eyes can cause some amount of permanent damage if exposed over a long period of time. A typical 100W bulb is around 1600 lumens, and if it is uncovered (without a lampshade), it can be rather bright up close. We will opt for an LED type of light as it will draw less power, but still be relatively bright. We will pick a light that will not exceed a typical luminosity value say in comparison to our 100W bulb example.

As noted in IEEE's Code of Ethics, #10, we as a team will make sure to hold each other accountable as well as encouraging each other to do our very best. If someone needs assistance, it is the responsibility of all team members to put forth his or her best effort towards aiding the one in need.

References

[1] Insurance Information Institute, ‘Facts + Statistics: Pet statistics’, 2019. [Online]. Available: https://www.iii.org/fact-statistic/facts-statistics-pet-statistics. [Accessed: 12 Sep. 2019].
[2] Salvi Schostok & Pritchard. ‘Dog Bites and Animal Attacks - Facts & Figures in Illinois’, 2019. [Online]. Available: https://www.salvilaw.com/dog-bite-injury/dog-bite-animal-attack-facts-figures/ [Accessed: 12 Sep. 2019].
[3] National Wildlife Removal. ‘Are skunks dangerous to cats, dogs, or other pets?’, 2019. [Online] Available: http://www.aaanimalcontrol.com/Professional-Trapper/skunkpetdanger.html [Accessed: 12 Sep. 2019].
[4] dogtime.com. ‘Top 10 animals that attacks pets’, 2019. [Online]. Available: https://dogtime.com/dog-health/general/16043-top-10-animals-that-attack-pets [Accessed: 12 Sep. 2019].
[5] T. Dunn, ‘Snake Bites and Dogs | Most Venomous Snakes for Dogs’, *petMD*, 2019. [Online]. Available: https://www.petmd.com/dog/care/evr_dg_snake_bites_and_dogs# [Accessed: 12 Sep. 2019].
[6] Google Store, ‘Nest Cam Outdoor - Weatherproof Security Camera - Google Store’*, 2019*. [Online] Available: https://store.google.com/us/product/nest_cam_outdoor?hl=en-US [Accessed: 12 Sep. 2019].
[7] CoyoteVest, ‘CoyoteVest Pet Body Armor’, 2019. [Online] Available: https://www.coyotevest.com/ [Accessed: 12 Sep. 2019].
[8] Parallex Inc, ‘Wide Angle PIR Sensor with LED Signal’, 2019. [Online] Available: https://www.parallax.com/product/28032 [Accessed: 26 Sep. 2019].
[9] Duracell, ‘Product Technical Data Sheets’, 2019. [Online] Available: https://www.duracell.com/en-us/techlibrary/product-technical-data-sheets?region=262&type=265 [Accessed: 01 Oct. 2019].
[10] IEEE, "IEEE Code of Ethics", 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 17 Sep. 2019].