H.A.P.P.I. SYSTEMS

Home Audio Programmable Pathway
Illumination Systems

Senior Design 2
Group 10

DECEMBER 6, 2016
UNIVERSITY OF CENTRAL FLORIDA
4000 Central Florida Blvd, Orlando, FL 32816

Authors:

Johnnie Alexandria Greene

Taylor Griffith

Phillip Bent

Sidney Jean-Baptiste

1 Table of Contents

1. Executive Summary

Time and change are two constants on Earth that is not being altered or halted any time soon. As times goes on, there is constant change and improvement in technology. With the change in technology, comes the evolution of how people interact with technology and its usefulness to us, one application is how you are welcomed when you come home.

What we seek to create is a home entrance system that welcomes you to your home with a music and light display of your choice. Our system will have the ability is to detect a human approaching the entranceway of a home using humanoid detection system which is a motion sensor. This detection will trigger a train reaction of music and lights to your preconfigured settings. We seek to make this energy efficient with the inclusion of solar panels to each individual speaker.

There are some similar existing products existing in the market, but none that add all of these capabilities together. A fairly common product are lights that are activated with motion detectors, rooted along your walkway. But even these might cause false positive detection as a result of animals. Other home detection systems might have other methods of sensing such as camera detection, but don't have lights to help navigate during the night.

This project provides opportunity for growth in all facets for all members in the group. Our group is diverse and composes of two computer engineers, a photonics engineer, and an electrical engineer. There's room in this project for all members to create, expand, and exercise our technical skills.

2 Project Description

2.1. Motivation

Front yard landscaping has been a highly discussed topic for years. This topic is so widely discussed that there are television shows on air since 1999 to now, like Curb Appeal, Landscape Man, Desperate Landscape and many others are dedicated to fixing the landscape of homeowners. One of the major key design specifications for every landscape design is outdoor lighting. Although for many homeowners outdoor lighting simple just provides them a sense of security while for others it is much more than security it is a major key instrument in every landscape design. According to many landscaping experts the entrance to a home is consider as the first impression that guest will have as well as it is supposed to give the homeowner and their family a sense of paradise before walking into the home. Homeowners are now looking for outdoor lighting that meets all of their specifications whether it be, weatherproof, recharge ability, motion sensor or just something that looks sleek, homeowners now want it all. They want to truly create their own personal paradise.

For many homeowners the lighting is not enough, they would like to include sound to their landscape as well. In the world of landscape adding sound to a landscape is not a new concept and is a practice that has been done for centuries. It first began with wind chimes made out of steel or shells or anything that can produce a sound if the wind present. Nowadays people use the popular style of waterproof motion sensor speakers that look likes rocks. These speakers allow the homeowner to wirelessly control the ambiance of their landscape. Unfortunately, the homeowner is only connected to one or two speakers, which does not provide the full ambiance that the homeowner desires to experience. Having motion sensor lights as well as speakers can cause a frenzy, especially when most product sensors are not programmed to differentiate between an animal and a human.

Our group has decided that we wanted to use our electrical engineering, computer science engineering as well as our photonics and optics engineering backgrounds to design a home welcoming system. As the homeowner and/or their guests make their way to the front door of a home, how wonderful would it be if they were greeted with any type of music and light show of their choosing. The home welcoming system will consist of multiple solar powered lawn spikes. The spikes will have lights that will come on when a person gets close, and to go along with the lights, there will be speakers to play any song of the owners pleasing. All spikes will be controlled by a base central hub that will consist of a Humanoid motion detection system, the owner will have the ability to configure the central hub and speakers using a user friendly phone application.

2.2. Goals and Objective

The main objective of the project is to create a network of wireless lawn spikes equipped with LEDs, speakers and motion sensors hosted by a single central hub and greet anyone that walks near the speaker devices with music and lights. To accomplish this project, much research was needed in order to read up on the requirements of each component used in the Bluetooth lawn spike and central hub, our main source of information came from the internet. Next will be testing of each component until we have the desired result. If the results are off even in the slightest way, we will be sure to circle back around and do some deeper research on the unsatisfying component.

Alternative objectives will include learning how to detect human motion, solar powered systems, Bluetooth A2DP and AT command communication, using Eagle CAD and other new software, and of course effective team communication skills. This project alone will allow us students to demonstrate our acquired knowledge through our UCF career and build a working device from ground up

2.3. Requirements and Specifications

2.3.1. Light Emitting Diodes

The Home Audio Programmable Pathway Illumination System's light emitting diodes shall…

- Run on 3V to 5V
- Must emit light
- Must be RGB LEDs

The light emitting diodes for the lawn spike is the main attraction. Its responsibility is illuminate the pathway of the users' choosing. Our groups' desires to use LEDs that can complete the color range as well as connect well with the other components in the lawn spike.

2.3.2. Humanoid Detection System

The central hub's wireless transceiver shall...

- Run on 5V
- Have a camera system
- Motion detector
- Have a sentry angle of at least 110◦ or greater

The humanoid detection system sole purpose is to detect whether or not the motion detected by the motion sensors in the lawn spike was a motion cause by human form or not. Once it has been confirmed that the motion was indeed made by a human, the humanoid detection system well then alert the lawn spike to turn on according to the already preset settings of the user's choice.

2.3.3. Motion Sensor

The Home Audio Programmable Pathway Illumination System's Motions shall...

- Run on 5V to 20V max
- Have a sentry angle of 110◦ or greater
- Be able to detect motion
- Be able to send alerts

The requirement for the motion sensors are set for an effective use. The motion sensors will alert the human detection system that a motion has occurred and tell the humanoid detection system to scan the here for a humanoid. If a humanoid is detected than the Humanoid detection system will tell the lawn spikes whether or not, they can turn on. Especially since we are programming our spikes to only turn on when there was motion made only by a humanoid.

2.3.4. Wireless Transceiver

The central hub's wireless transceiver shall…

- Run on 3V to 5V max
- Be able to wirelessly connect at least 10 meters
- Have output audio
- Be able to send instructions
- Be able to receive instructions

The requirements for the wireless transceiver are set for an effective use and give the user a reasonable amount of distance for placement of the Central hub and the spikes themselves. The voltage range for this device should be in the same range as our microcontroller so that we may easily power our wireless module, this keeps us from adding more complexity to our project. The module needs to be able to send and receive signal from at least a distance of 10 meters. This length is a good distance to place our speakers along a pathway. The device should be able to allow us to connect external speakers without an enclosure straight to the module with some simple soldering, this will lessen the complexity for our groups design. The transceiver should also be able to stream the audio without any extra coding; this will save time by not having to write an audio streaming codec. The audio output does not need to be exceptionally amplified from the transceiver for we will be able to develop an amplifier into our PCB board designs; this will give us a larger selection of components to choose from. The next two specifications are very important, sending and receiving information, for we need to be able to control our lawn spikes microcontroller with this wireless transceiver. These commands will be essential to the overall design for our product. They will be the main resource for communication between the central hub and the speakers and as well as give the central hub signals for when motion is sensed and LED controls.

2.3.5. Microcontroller

The microcontroller shall…

- run on 3V to 5V max
- have at least 10 MHz of processing speeds
- have at least 20 pins available
- have at least 12 digital pins
- have at least 2 analog pins
- have at least 12kB flash memory
- have at least 1kB RAM
- must have high level language capabilities

The microcontroller is the brain of our lawn spikes. The microcontroller is responsible for controlling all components associated with the devices. Picking the proper microcontroller is a very important aspect of our project in a whole. The power requirement lies in a standard range for the majority of microcontrollers. Most the components and sensors are within this voltage range as well and will allow our group to keep the lawn spike's overall design simpler. The ten million instructions a second may seem a bit of a stretch for a lawn spike, but our spike will need plenty of speed in order to run its lights and sensors. The different analog and digital pins will allow us to take input from our sensors and relay necessary communications with the central hub. Setting our requirement to have a minimum of 20 pins will give us 6 extra pins that can be used in the future development of the device, of course that is after the wireless transceiver, LED's and motion sensors. The board must also have 12kB of flash memory and 1kB of RAM. When wanting to add extra features to the device these specs will give us that capability without an entire redesign.

2.3.6. Single-Board Computer

The central hub's single board computer shall…

- run on 3V to 5V max
- have at least 512 MHz of processing speeds
- have at least 28 pins available
- have at least 12 digital pins
- have at least 4 analog pins
- have at least 12kB flash memory
- have at least 512MB RAM
- must have high level language capabilities

The single board computer in the central hub is essentially the brain of our product. Its responsibilities will consist of controlling all components associated with the product. Picking the proper microcontroller is a very important aspect of our project in a whole, we want to get a microcontroller that can fit these specs so that we are sure we can run all of our required components and sensors. When searching for a single board computer it may be suitable to settle with a device that may exceed some of our needed specifications, just as long it does

not negatively affect our overall outcome. The power requirement lies with in a standard range for the majority of single board computers, this will give our group a wide variety of boards to look into when selecting the final component. Many of the externals components our group tends to use also fall within the 3-5v range, making it very simple to integrate in the end.

2.3.7. Speakers

The speakers shall…

- have an impedance of 8 Ohms
- handle 1 watt
- 4 mounting tabs 60 mm apart

The speakers will allow our wireless lawn spikes to be heard! This is a system critical component, because without the speaker we lose all audio features for our project. Impedance for speakers determines the current allowed to flow through the speaker, a large impedance causes low flow and vice-versa. Speakers require a certain amount of current to work properly so if it has high impedance it will cause the speaker to have a low volume. The range selected is a market standard that is considered optimum, though many speakers can vary. The set power range will give our speakers enough power to heard, but not draw too much power so that the wireless lawn spikes can be as efficient as possible. The sensitivity of the speaker is another important aspect for the speaker in a whole, it determines the speaker's loudness, the decibel range selected is in the range of a normal human speaking voice and up to the range a lawnmower can reach. This range is good for allowing most general speakers to work for our purpose.

2.3.8. Power

The power supply is the key element for any part of the central hub. The power supply serves as the life force of an electronic. The central hub system will be composed of two different types of power supply. The power supply will have the ability of to have the plug in and play from any home outlet and also be charged from solar panels. Home outlets provide power, but sends power via alternating current. Therefore, AC/DC adapters are necessary to charge the batteries. The adapters will provide additional safety and efficiency of power. Later we'll see that the batteries are charged via direct current. The home outlet will serve as the suggested primary source for primary use.

Solar Panel

The second source of power, although not regarded as a secondary source, is solar energy. The solar power will charge the DC batteries as well. For outside use, the suggested primary source of power for the Central hub. This optimizes the portability function of the Central hub as well as the speaker. The Solar cells

will use the sun's energy and convert it to charge the rechargeable batteries for both the central hub and speakers.

Battery

Rechargeable batteries will be vital attachments to the central hub and spikes. The will serve as the power source for both devices when sunlight is not available. The batteries will be charged from the cells and solar panels, having an extended shelf life so they are not destroyed before any abundant use. The use of the spikes and central hub need to rival those of the market competitors while not used or charged; it needs to be able to be used for an extended time. We're aiming at 2-hour window of use, due to our budget constraints.

2.3.9. Mobile Application

The basic requirements and specifications for the application will be listed below. The requirements and specifications will be our guide to successfully achieving the goals and objectives stated in the previous section. The requirements and specifications will be split into several categories.

Functional Requirements

The functional needs that we feel necessary for the wholeness of the user interface are requirements that bring the concept of the project together, for without them the essence of this product might be lost.

Requirement ID	**Requirement Description**
No: FR01	The system should have a splash page.
No: FR02	The system should be able to turn the Central hub off and reboot it.
No: FR03	The system will have an interface for Google Play Music API.

Table 2.3 - 1

FR01: The application developer will create a splash page that will launch upon the clicking of the application. The page itself will feature animations while, waiting for the next page to follow to come up. The main purpose of this page is to inform and welcome the user of the application that is being launched.

FR02: One of the main menu options that will be presented after logging in will be the option to turn the central hub on or off. This will be accomplished with the

assistance of the Central Hub Software Developer because it will also include the task of creating a communication method or interface to allow these two pieces to work together. When directed to this page the user will have the option of the two commands and the application should successfully connect to the microcontroller of the central hub and execute the chosen command.

FR03: One of the major features of our project is the streaming of music. In order to facilitate that we will be using a google play API. An API or application program interface is a set of routines, protocols, and tools for building software applications. The API will need an interface to allow interaction with options. This activity will be presented after logging in on the main menu page.

User Interface Requirements

Our User Interface Requirements help with any of the member's interaction with the application. These needs help to allow fluidity through the navigation of the application to ensure it is naturally intuitive.

Requirement ID	Requirement Description
No: UIR01	The system should facilitate easy navigation throughout application.
No: UIR02	The system should be able to accept input from user.
No: UIR03	The system should have a main menu page.

Table 2.3 - 2

UIR01: One thing that was to be included with this application is ease of use, the user should be able to go from one screen or page activity to the next without too much trouble. To facilitate this, the application developer hoped to use things like image buttons, which would indicate the options available from the main menu screen followed by words to prompt the user on what is required of them.

UIR02: This more specifically applies to the responsiveness of the application itself, we want to make sure that it is fault tolerant. This meaning that when you press a button, it will launch the next activity, page or function. If this becomes an issue, the user will be unable to navigate through the page and execute their desired functions. The role this requirement plays in the execution of all other tasks makes it one of the most important preconditions.

UIR03: The main menu will put most of the functional features to be controlled via the application in one location for ease of use.

User Based Security Detailing

The establishment of these user conditions allows a monitoring of who is allowed to access this application, this product has many functional settings which should be up to the discretion of the product owner. The addition of these specifications aid in the protection of the users' configuration settings.

Requirement ID	**Requirement Description**
No: UBSD01	The system will require a login page.
No: UBSD02	The system will require a register page.

Table 2.3 - 4

UBSD01: Having a login page prevents security breaches within the system, the only allowed users for the application will be those that have registered in advance. This will prevent just anyone from using the application and will require some user details that will be logged in a database. The user attributes are: first name, last name, email, and password. After logging in a user has access to all of the SPA's functionality which is accessible through the main menu page that will follow when granted access.

UBSD02: If the user has not already registered with the system and needs to they will have to access this page. This will input their user attributes into the database for login access when required.

Setting Preferences

The following shows options that the application should provide in editing the configurations of components included in the SPA.

Requirement ID	**Requirement Description**
No: SP1	Light color selection for LEDs.
No: SP2	Wi-Fi Configuration
No: SP3	Turn LEDS on or off.
No: SP4	Activate flashing of LEDs.
No: SP5	Turn speakers on and off.
No: SP6	Turn speaker volume up or down.
No: SP7	Saving User Preferences

Table 2.3 – 5

SP1: This configuration will be sent from the phone to specify which color LED will be lit when turned on. It will require the cooperation of the LED lead to verify the lights are configured correctly to receive the code from the Central Hub Software Developer that changes the light.

SP2: This configuration will be sent from the phone to specify the Wi-Fi to be used by the central hub.

SP4: The user will select a frequency at which the light will repeated flash until another mode is activated.

SP7: The user will be prompted to choose the setting preferences of their liking and instead of directly sending it to the microcontroller, they will be sent to a database to be selected at a later time.

2.4. Projects Constraints

2.4.1. Single Board Computer, Microcontroller and Wireless transceiver

Single board computers, microcontrollers and wireless transceivers constraints start with the devices physical aspects. Each module has a rigid size, weight, power, cooling, computing performance, reliability, and cost. All of these potential problems could adversely affect our project since the single board computer and microcontroller is what makes our project operate. The physical dimensions of each module will force us to work around their rigid sizes so we must design our housing to properly fit them, fortunately with today's technology component sizes have reduced dramatically. Since the devices will be outdoors and exposed to the elements, we must make our device weatherproof. We all know what happens with electronics when introduced to water or high temperatures, they stop working. Water poses the largest problem because if it could cause a short within our circuitry, and that could lead to a fire hazard for our device. The fact that our devices will be subjected to direct sunlight means that they will act as mini ovens, so we must strategically design our housing to allow for a watertight seal but still allow for sufficient cooling. The computing power of the devices inhibits how much data we can process or how many components we may control. Reliability and cost are two constraints really affect each other, having a reliable device is a must for any project. When manufacturer begins to cut corners on the production lines it leads to a lower quality of product. These cheaply made products are attractive for their lost cost but one may have to purchase multiple ones if they are unreliable and break easily. When looking at

higher quality device the prices tend to be higher, but one can rest easily knowing the product will be reliable enough to serve its needs.

2.4.2. Power Supply

Our project will be directly funded from the students creating this project. As a result of the funding being only from the students, the cost of the items must be a fixed amount in accordance with the budget. For the power supply, strict and efficient purchases are a priority. The power supply consists from the wall outlets from US homes, solar cells and the rechargeable batteries that are with the central hub and spike. For each specific type of solar cells, they all have different prices which directly correlate with direct charging rate. That charging rate correlates with the size of the cell and thus continues the trickledown effect. Choosing the best cell which produces optimum size at a relatively nice price is necessary. With batteries on the other hand, the cost does not affect the size, it affects the charging rate. Regardless of the type of battery, in terms of its makeup, the battery size is the same throughout. Choosing the best battery type which is cost efficient and power efficient will be dire for this project.

Manufacturing and Sustainability

The purpose of the project is sustained use for the user. The solar cells and batteries need to account for that. Solar cells have specific requirements and ways to maintain solar cell use. Just like any electronic device, solar cells overheat. Solar cells burn and overheat when left out and not given the necessary manufacturing requirements. The suns optimum shining on the Earth in a given area is about 8 hours. Maintain the cells for that 8 hours or longer will be key to use of the cells.

Batteries also have an abundance of sustainability constraints. Battery rate of charge and battery shell life are the primary constraints for manufacturing. Each type of battery has its own battery life regardless if it’s rechargeable or non-rechargeable.

EHS Constraints

Battery safety will be a big issue when constructing this project. We have account for any damage that can be caused to the central hub, the spikes, the user, and the outdoor environment they’ll be placed in. Malfunctioning of batteries is caused in an assortment of ways. Overcharging and overheating are the two biggest issues that the central hub and spike may run into. Overcharging and overheating can damage the entire electrical device system and any party nearby whether that will be a user, animal, and environment. Over charging of the rechargeable batteries could result in the explosion of some batteries. Fires also rarely happen as a result of overheated batteries. Choosing the combination of a proper battery, power distribution, and power generation will prevent that.

3 Research Related to Project Definition

3.1. Existing Projects and Products

Due to the uniqueness of our project, there is not variety of projects and or products that are identical or similar to our project. We have found a few projects and products that have certain components that we would like to have in our project.

3.1.1. Projects

At the University of Central Florida there has never been project that has the same capabilities as our project will have, but there have been various projects that use some of the same technology that we will be using.

One of the past projects came from a group that titled their project the “UCF Smart Home”. Their project consisted of motion sensors that detect the occupancy in a room. Their system would automatically turn lights on and off as a person would enters or exit a room. The part of their system that is similar to ours, was controlled remotely through a graphical user interface otherwise known as a GUI. Their product was connected wirelessly similar to our project.

The second project that we felt were similar to ours was the “Smart Mirror”. This project was designed to be an interactive, productivity focused mirror that was for the bathroom. Although this mirror was designed to time management in the morning it utilizes a motion detection sensor involving a webcam which allows the mirror to wake or sleep to conserve power depending upon the presence of the user.

The third project that we took into consideration was one of the only other projects that was design for the homeowners’ landscape. Their project was entitled the “Dynamic Liquid Light Fountain. It is a home landscape accessory that uses LEDs, PIRs as well as ambient light sensors. The project is the closest to ours simply because of the technology that it uses. The PIR sensors that they use Nicera Philippines RE200B pyroelectric while we will be using a HC-SR501 sensor which is cheaper and with an angel up to 120 degrees.

3.1.2. Products

There are many products that have a similar look or provide some of the functionality the solar powered audio/lighting lawn spike provides. This section will provide a view of other existing products that implement an outdoor audio/lighting lawn ornament. The products that are offered currently are either

intended for only lighting purposes or for a constant audio stream to be playing, not many if at all any, have the full capability that our product is striving to accomplish. The goal for this project is to take some of the well design lawn ornaments and their features and merge them into one amazing product in the end.

Traditional Solar Spikes

Traditional solar powered lawn lights have one use and one use only; turn on when it's dark. That simplistic task makes it relatively easy to understand how the lawn light works. The lawn lights receive the energy from the sun and outputs that energy to power the LED light.

The solar powered lights are composed of fewer components than that of our spike, but even though it has fewer parts, the parts are still important. The spike is composed of the solar cell, the rechargeable battery, the LED light and its PCB with its various components. Similar to what we want to do with our central hub and lawn spike, the power components provide the same tasks needed but in a smaller quantity. The solar cell acts as the power source for the rechargeable battery, the battery is a safe battery and efficient source of power as well. The PCB for the spike will contain the necessary wiring to properly allocate the power for the light as well as another vital component, the photoresistor. The photoresistor is very useful for the traditional spike and in essence acts as the switch for the spike. A photoresistor is a light controlled resistor that changes with the presence of light. The photoresistor detects for light and the area; when there is no light in proximity, it turns on the battery and thus turns on the light. The amount of resistivity the photoresistor dissipates directly correlates for the amount of sunlight received. The light becomes brighter as less light is detected; resistivity is lowered and more power is sent to the LED light. As more light is not show the lower the resistivity becomes and the brighter the light becomes.

Many one bulb solar cells have the same elements. The spike will contain a 1.5 V LED light, a .45 volt solar cell, a 1.2 V rechargeable battery, and its PCB. Using these as references, the explanation of the solar cells working can thus begin. Solar cells work under a two-step process.

1. Absorb light from the sun
    a. The solar cells are wired directly to the rechargeable batteries, allowing the batteries to charge from optimal use of the sun
    b. The photoresistor mentioned earlier is simultaneous detecting for sun light
2. When less light is detected
    a. Light turns on as light continues to dwell

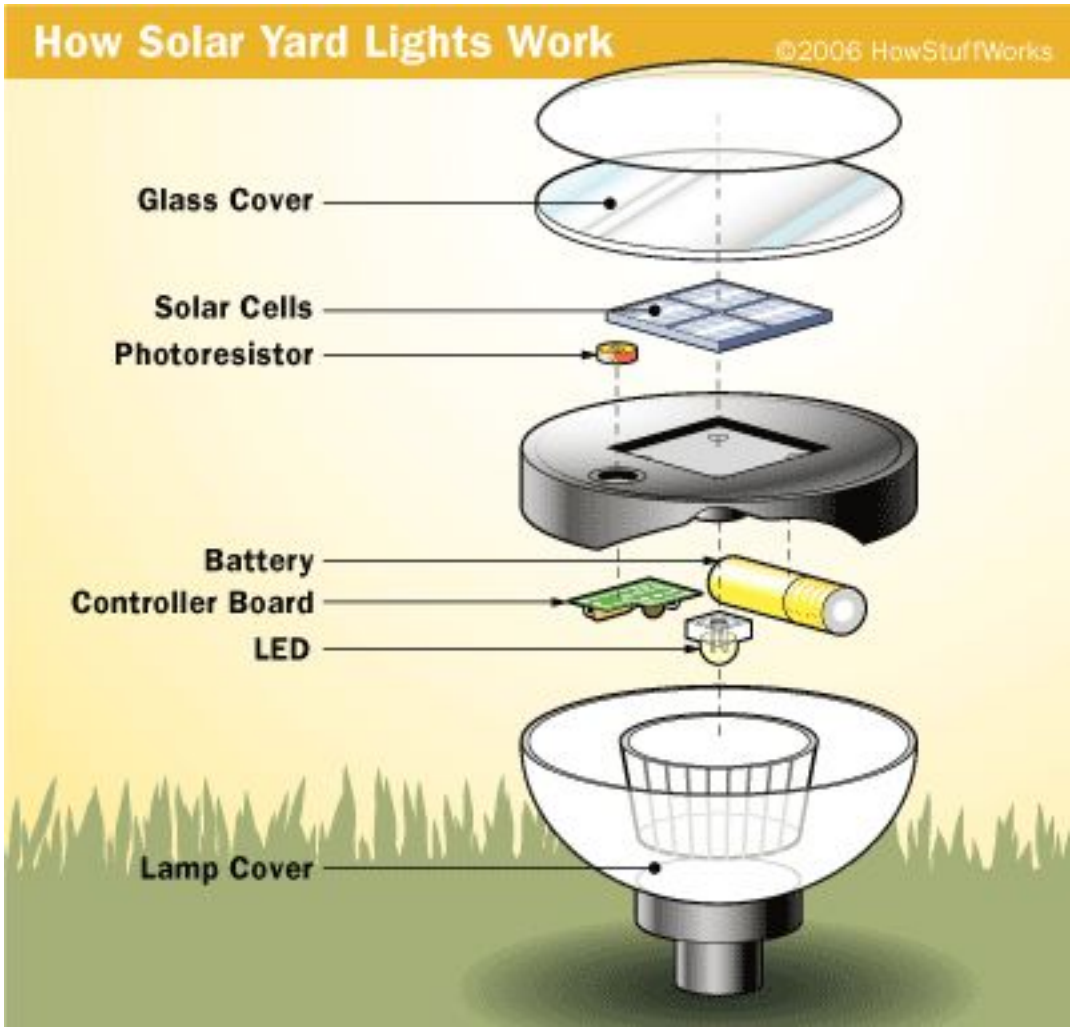


Figure 3.1 - 1: Traditional Solar Power Spike Components

*Permission Pending

Low Voltage Black 3-Tier Metal Path Light

One of the products that implement a small feature is the Hampton Bay metal path light. This is a full metal home path light; their intended use would be to place along any walkway connected to one's home. The product is lightweight and durable, though this product is not battery powered nor does it have solar charging capabilities, it requires the buyer to wire all the lights together, which can be cumbersome, and entail added expenses. This product and many more of its type are sold publicly to anyone who wishes to illuminate a walkway outdoors. They can be purchased from any of the major home good stores as well. The group has decided that this is a sleek and achievable design goal and have pursued products that mimics its design and features. The fact that this product is made for outdoor use, it will provide a good reference point for the group to work

from. The waterproof design used by Hampton Bay tends to be a screw type configuration with a gasket for a watertight seal. The Hampton Bay path lights only contain a single LED for its lighting purposes which will limit the amount of illumination casting from the device; the LED used only has a single color index which is a cool white. This path light does not have motion sensing capabilities either, so the lights will be on all throughout the night or will be placed on a timer, this will automatically consume more power for they will not get any guaranteed down time other than during the day time.

Solar Stone Wireless Speaker

ION Audio has an interesting approach to allowing users to play audio through a fake rock. The Solar Stone Wireless Speaker allows for subtle music without any bulky audio equipment to get in the way and the creative stone disguise will make any outdoor environment look natural but with the added feature of music anytime. The devices come as a pair and allow for wireless connectivity via Bluetooth. This product's design can help guide us through with the best approach to waterproof our device but still allow for clear and crisp audio. The faux rocks have a 48 hour rechargeable battery, and equipped with an embedded solar panel to allow continuous charging. The product features 6.5 inch full-range speakers with a powerful onboard amplifier to allow for loud volume setting. The speaker stone is a really inventive way to supply outdoor audio and is a great product to research. The method used for weatherproof speakers start with the materials used in the build. The speakers are made from a non-corroding metal such as stainless steel, aluminum, or brass. The diaphragm, or cone, of the speakers are also Mylar, which does not absorb water, but indoor speakers generally will have a paper cone, and be very sensitive when placed in the humidity. Next the speakers get covered with a polypropylene coating which will be an added protection for the elements. These few insights to waterproofing will allow our group to select speakers and treat them properly to work in our outdoor devices.

Cassia Central hub

The Cassia Central hub created by Cassia Networks is the one product closest to our SPA project. The Cassia Central hub is a home Bluetooth Router and the makers of the Cassia Central hub state they are the first technology of its kind. The central hub enables the user to control multiple devices all at the same time from a select distance. The Central hub extends the normal Bluetooth capabilities a device. The Cassia Central hub is controlled by the user via the Cassia App. It allows the user to control the Central hub from anywhere.

Technical Specifications of the Device:

- Central hub Color = Soft White

- Size = Diameter - 4.9 in.; Height - 7.8 in.
- Weight = 1.5 lbs.
- Wireless signals = Bluetooth 4.0 (dual mode: BLE and Bluetooth Classic); Wi-Fi – 802.11n (2.4GHz)
- Bluetooth range = 1000+ feet (300+ meters) open air or penetration of 3 walls
- Interface = Bluetooth, Wi-Fi, Ethernet (10/100), USB (2.0)
- Power = 12VADC adapter
- App Compatibility = iOS 7.0 and higher; Android 4.3 and higher
- Devices supported = Up to 22-Bluetooth devices
- Up to 22-BLE (Bluetooth low energy) devices (E.g. fitness monitors, etc.)
- Up to 3- Bluetooth classic devices (E.g. speakers, etc.);

The Cassia Central hub has an assortment of uses and capabilities. The Central hub connects with virtually every popular North American Bluetooth device.

Compatible Devices that Work with Cassia Central hub:

- Speakers –
    - Cassia – Bluetooth Speaker
    - Brookstone – Big Blue Speaker
    - Logitech – UEBoom II (& similar models)
    - Beats – Pill & Pill+
    - Sony – SRS X-33 (& similar models)
    - Bose – SoundLink Mini II (& similar models)
    - Harman Kardon – Onyx Studio Speaker
    - Sengled – Pulse Solo (audio control only)

      Note: Most 2.1 Bluetooth speakers should work with the Cassia Central hub.
- Speaker receiver (for standard speakers) –
    - Philips – HiFi adapter; AEA2000 Bluetooth Music Receiver
- LED's –
    - Cassia – Multi-Color LED
- Smart Plugs –
    - Cassia – Smart Plug
    - Revogi (Vemiter; MeterPlug-39BE) Smart Plug
- Wearable & other devices –
    - Cassia – Personal Safety Sensor

Figure 3.1 - 2: Cassia Central Hub

*Permission Pending

3.2. Component Research

The selection of each individual component for our Home Audio Programmable Pathway Illumination System is an essential step in the developmental process in design. The components that we have decided upon will affect further decisions for our design down the line because of the specifications will force limitations. This section will compare a variety of components and will highlight each components advantages and disadvantages and how that component can add to our project.

3.2.1. LED

For our project light emitting diodes are a key component to both the Central hub and the Lawn spikes. Light emitting diodes (LEDs) are PN junctions which are considered as a two lead semiconductor that can emit a light when activated.

The PN junction within the LEDs emits light due to forward bias. One LED is only capable in producing a single color of light.

Figure 3.2 - 1: LED

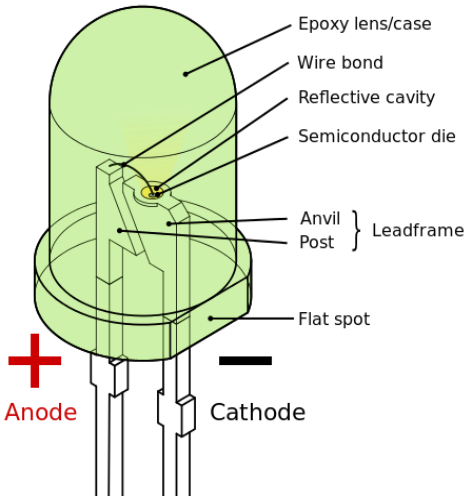


Figure 3.2 - 2: LED Details

There are multiple different types of LEDs that are commercially available. Commonly seen, most electronic components and devices are surface mounted. The LEDs we were looking at were all surface mounted devices (SMD) and the common through-hole. The SMD LEDs are chips that are flat and emits lights at an angle that is approximately 180 degrees. These devices customarily do not have lens and its sole purpose it so provides illumination and not necessary illuminate themselves. The through-hole LEDs are customarily shaped like a plastic miniature bullet. The through-hole LEDs commonly come in two sizes, 3 millimeters and 5 millimeters. They contain two or leads that extend out of the bottom and would traditionally through a printed circuit board (PCB). The plastic bullet-shaped casing for the LED was designed to provide the maximum light possible. These through-hole LEDS illuminate with an angle that is great than the 180 degrees which is the approximated maximum angle that the SMD LEDs have. Although the through-hole LEDs have a wider angle of illumination than the SMD LEDs, the SMD LEDs are more cost and space efficient to use that the single through-hole LEDs. This is one of the many reasons why our group decided to choose the SMD LEDS for our project. Overall it was clear that the SMD LEDs gives our group the various options that we need.

For our design we need the full spectrum of colors and in order to produce that spectrum we need red, green and blue LEDs. The full color spectrum is important due to how humans perceive color. In our eyes we have sensors known as cones and rods. There are three types of photoreceptors in the retina. These

photoreceptors are responsible for color vision. The three photoreceptors are red, green, and blue. This is why it is important for our product to have red, green and blue LEDs.

For our Home Audio Programmable Pathway Illumination (HAPPI) System we wanted the lawn spikes and the central hub to have a multicolor light show. In order to meet that specific requirement, we first want to make sure we chose LEDs that can produce the full color spectrum. This will require the different color LEDs which include red, green and blue.

There are two different ways to display the full color spectrum, the first method is the single LEDs, where each single LED has its own separate color. The second method is the single tri-color LED where there are three LEDs that are housed under a single lens. The three LEDs that are typically housed are red, green and blue. Tri-color LEDs are usually more expensive than the single LEDs. They also produce more heat in comparison to the single-colored LEDs. Although single-colored LEDs are cheaper and produce less heat than the tri-colored LEDs, we decided to go with the tri-colored LEDs.

Types of SMD LEDs

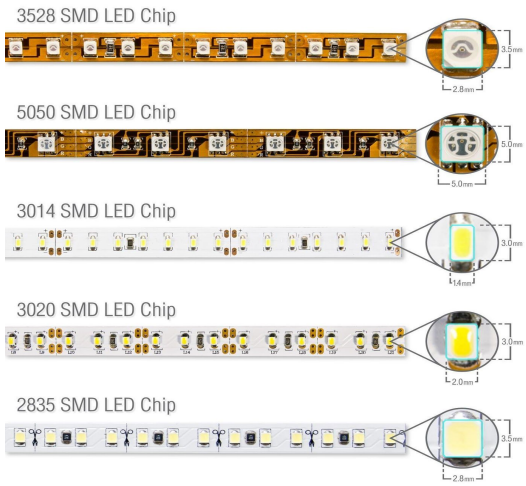


Figure 3.2 – 3: Permission Pending

The most common LEDs being offered on the market to are SMD 3020, SMD 3528 and the SMD 5050.

SMD 3020

The SMD 3020 LED has its name based off of its dimensions of the single LED chip. The SMD 3020 dimensions are 3.0 millimeter by 2.0 millimeter. These LEDs are commonly used for photography and simple light fixtures.

SMD 3528

The SMD 3528 LED has this name based off of it dimensions of the single chip. The chip's dimensions are 3.5 millimeters by 2.8 millimeters. These LEDs are typically used for indoor applications whether it be a bar, restaurant, family kitchens or even decorative lighting in a living room. These LEDs are also commonly used for basic lighting projects that require low luminosity. These LEDs are especially used when projects have a mono-color requirement and as well as power saving. The SMD 3528 LED only consist of one light emitting chip per light source. This means that only one color can be produce from one SMD 3528 LED.

SMD 5050

The SMD 5050 LEDs like the others gain their name due to their size. The dimensions for a SMD 5050 LED are 5.0 millimeter by 5.0 millimeter. This makes this LED the biggest that we have discussed. This LED has more surface area which allows for more options than the other two types of SMD LEDs. The SMD 5050 LED is a higher performing LED in comparison to the SMD 3020 LED and the SMD 3528 LED. The SMD 5050 LED is not only brighter than the other LEDs because of its surface area, it also allows for multitude of other options. The SMD 5050 LED is not confined to being mono-color like the SMD 3020 and the SMD 3528. The SMD 5050 can sometimes feature three chips under one housing lens. Another name for these type of SMD LEDs is typically known as tri-chips or triple core LED strips. These tri-chips allow for the SMD 5050 to be available in a single color or as a red, green, blue (RGB) color changing LED. The RGB version of the SMD 5050 LED requires an additional control unit. The RGB SMD 5050 LED features a multi- color mode that is highly flexible. This LED can adjust to a multitude of colors and color combinations. This feature is very unique to the SMD 5050. The SMD 5050 not only is a multi-color LED but it is three times brighter than the SMD 3020 and the SMD 3528. It is typically used as a replacement for traditional fluorescent lights.

Although the SMD 5050 LEDs are more expensive than the SMD 3020 and the SMD 3528 it provides our project with the options that we need. Our project requires RGB LEDs as well has super bright LEDs, from our research the SMD 5050 meets the standards and requirements that we have decided upon for our project.

LED Ring

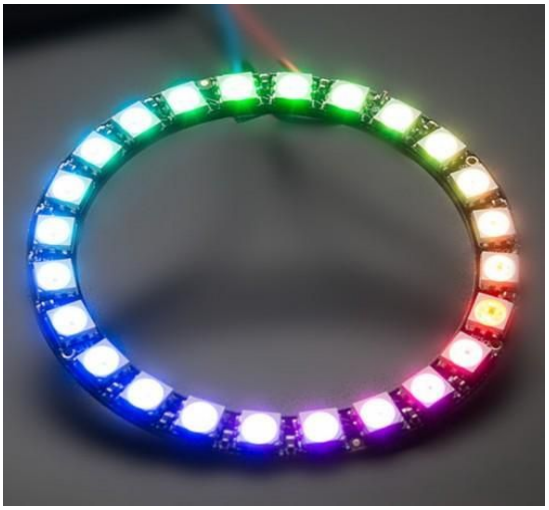


Figure 3.2 -3: LED Ring

The 24 5050 LEDs are assembled together into a circle with a diameter of 66 millimeters on the outside. These 5050 LEDs are connected together by connecting the output pin of one into the input pin of another. Due to this arrangement there will only be need for one microcontroller pin to control. The main advantage of using the 24 5050 LED circle in our project, is the fact there is no need to use an LED Driver because each light emitting diodes has a driver chip inside them. Each LED driver has a constant current of 18mA. This allows the color to be very consistent. This also holds true even if the voltage fluctuates. The driver also does not use external choke resistors to make the design slim. To our very surprise to power the 24 5050 LED ring only takes 5V, which made our decision much easier in picking the 24 5050 LED ring as our source of light for our HAPPI System lawn spikes.

3.2.2. LED Driver

While researching LEDs we knew in order to run the LEDs we needed an LED driver due to the design of LEDs. LEDs are nonlinear devices; this means that they do not obey Ohm’s law. They are PN junctions. Due to their similar qualities light emitting devices will block the flow of current in the reverse directions, but will let the current pass in the forward direction. This is why a LED Driver is needed. The LED driver is a power supply that is self-sufficient. The output from the LED driver is typically identical to the electrical characteristics of a light emitting diodes. LED drivers offer dimming, through the action of pulses. LED drivers are very important because they regulate the power to an LED. From our

research in the previous sections we decided to go with and LED that has a driver already within its systems. This eliminates the need for our system to have LED drivers.

3.2.3 Motion Sensors

From motion sensor flood lights to motion sensor cameras, motion detectors are used for a variety commercial and domestic applications. A motion detector typically is used to detect moving objects, usually those moving objects that are detected are people. A motion detector's sole purpose is to detect s that the conditions around it have changed. Every sensor has a state of normality. Not every sensor detects in the same way, for some only report when they return back to their normal state; while others only report when their normal state has been disrupted.

Motion sensors are more than often used as a major component to a security system. They are used to either trip the remote alarm system or trigger automatic lights that are a part of the alarm system. Motion sensors are commonly used to monitor the use of exits and entrances as well as the usage of windows. Generally, motion sensors all work on the same principle

There are two types of motion sensing, local sensing and area sensing. Local sensing is when motion is detected in a designated location is. There are a few motion sensors that used this type of sensing. A commonly used motion detector are contact switches. A momentary contact switch is a switch, when activated opens or closes a circuit then it will automatically return to its normal state.

Piezoelectric sensors are frequently used devices that use the piezoelectric effect. These piezoelectric sensors are used to measure the changes in the pressure, acceleration, temperature, strain or force. The piezoelectric effect is defined as the ability of certain materials to generate an electric charge in response to the applied mechanical stress. An external electric field is produced when a piezoelectric material has mechanical stress. Unusual characteristic that brings attention to the piezoelectric effect is due to the fact that while a material is experiencing the generation of electricity, mechanical stress is being applied, it is also experience the converse piezoelectric effect, which is the generation of stress when the electric field is applied.

This unique characteristic of the effect is known as reversible. There are a multitude of applications that use the piezoelectric effect from being involved in the detection of sound, the electronic frequency generation and even to focusing of optical assemblies.

There is an array of materials that display the piezoelectric effect; these materials are not limited to natural material, but also man-made materials as well. Natural

materials include cane sugar, salt, bone and quartz as well as belemnite; whose chemical structure is identical to quartz, but not limited too. A few of the man-made materials include barium titanate and lead zirconate titanate.

The applications that are best suited for the piezoelectric effect due the intrinsic properties that piezoelectric materials possess are as follows:

- High Voltage and Power Sources
- Sensors
- Piezoelectric Motors

Due to our project we are only concerned with the piezoelectric sensors. Piezoelectric sensors operate on a principal, where the physical element is transformed into a force. That force then acts on two opposing faces of the sensing element. A common sensor application that is frequently used is the detection of fluctuations in the form of sound. Piezoelectric sensors are not the only local motion sensors our group has been researching for our project. A sensor that is very similar to the piezoelectric sensor have peaked our interest. The other local sensor we were considering was the piezoresistor sensor. Piezoresistive sensors are devices that use the piezoresistive effect. Piezoresistor sensors are also known as strain gauges or strain sensors. Measuring the distortion of a component under load is by definition is exactly what a strain gauge device is used for. Similarly, like the piezoelectric sensor, strain is applied to the device, but unlike the piezoelectric sensor there is a change in the electric resistance of the material that is being used for sensing.

The piezoresistive effect is described as the change in the electrical resistivity of a semiconductor or metal when strain is applied to it. Unlike the piezoelectric effect which causes changes in the electrical potential, the piezoresistive effect only causes changes in the electrical resistance. Piezoresistive apparatus are frequently used in pressure measurements. This is displayed when pressure is applied to the piezoresistive resistor and the resistance is increased. From the research previously stated we realized that our home audio programmable pathway illumination system will need a motion detector that is more efficient than any of the local motion detectors we have researched. Next we will look the area sensing detectors.

Active Infrared Motion (IR)

Active infrared Motion detectors are forced to rely on the feedback that helps detect the changes in the local area, whether it is a naturally occurring change or not. These active infrared motion detectors also must rely on transmissions. The active infrared motion detectors all use an IR sensor as well as it is known as source of radiation. Infrared or as commonly known as IR is a range on the electromagnetic spectrum. The infrared range is directly between the microwave

range and the visible light range. What the physical meaning of why the infrared range is between the two previous stated ranges on the spectrum is that the infrared range is shorter than microwave ranges and longer than that of the visible light. Due to the active infrared motion detector being a source of radiation this gives the detector the ability to detect heat energy emitted by a human. The normal body temperature of humans is 37 degrees in Celsius which is the commonly known equivalent of 98.6 degrees in Fahrenheit; due to the normal body temperature of the human race, human tend to heavily radiate in the infrared range which is roughly around the wavelength 10 micrometers. This is the reason why infrared sensors have the ability to detect humans, along with the help of a transducer. A transducer is a device that sole purpose is to convert energy from one form to another form of energy, this quality of a transducer is very important because the motion sensor needs to convert the infrared signal to an electrical output. The transducer also ensures energy conservation. Although the active infrared detector is a viable option it is not commonly used in industry.

Continuous Wave Radar Motion Detection

Continuous wave radar motion detector is a system that emits an electromagnetic radiation which is known constant frequency continuous-wave radio energy at all time. The radar system will transmit energy as well as receive from object that are reflecting back to the radar system. Due to these feature a continuous wave radar motion detector will be able to notice the faintest changes in frequencies. This detection will be considering a disruption in the area. One of the main advantages of continuous wave radar is that energy is continuous and pulsated. This allows the device to have a simpler design to manufacture as well as to operate. Due to this design, continuous wave radar motion detectors are fully automated, cheap to upkeep and virtually free from failures. Due to this technology, the continuous wave radar motion detectors are customarily more expensive than other motion detectors. Although these sensors have a multitude of advantages they also have their limitations. For instance, distance cannot be measured if one is using an uncounted continuous wave radar. This is because the beam is usually broad with side lobes, which are the lobes of the far field radiation pattern, that perturb to the side of the radar antenna and as well as behind it. Smaller radar systems are only truly reliable when there is only one object in a lonesome environment because these small systems lack range modulation unlike bigger radar systems. This limitation is not necessary due to the design of the continuous wave radar motion detect, but from laws in physics. Therefore, these limitations cannot be overcome. The continuous wave radar motion sensors are highly sensitive and are extremely reliable over long distances, this is way they are more expensive than other sensors. Although the continuous wave radar motion sensors have the sensitivity that we need for our project, but they cost more than we would like to spend.

Ultrasonic Motion Detector

Our next option was to look at the ultrasonic motion detector. The ultrasonic motion detectors work on two different principles which include time of flight and the Doppler Effect. The Doppler Effect theory states that light, sound and radio waves can be reflected back by an object that is moving. The frequency of these waves will be complete different if the object was not moving. When an object is moving away, the frequency will decrease and vice versa if the object is moving towards you.

These types of motion detectors must use an electrostatic transducer. As previously stated, a transducer converts energy from one form to another. This transducer is electrostatic and acts like a microphone as well as the speaker. The transducer in the ultrasonic motion sensors as so transmit a fusillade of pulses that are ultrasonic. Ultrasonic motion detectors operator on a frequency higher than that of which a human can hear. The typical range that humans hear is from 20Hz to 20 kHz. The range that the ultrasonic motion detectors operate on is anything over 20 Hz. This range of frequency is typically used for medical applications. Similar to other motion sensors, once the ultrasonic wave is emitted nearby object will send a reflection that sensor will receive. One major downfall about this sensor is the sensitivity. The ultrasonic sensors are so sensitive that they will detect motion in an undesirable area where coverage is unneeded. Although this extended coverage as many perks especially for lighting a large area.

Passive Infrared Motion

The most commonly used motion sensor for applications similar to our project is the passive infrared motion sensors also known as PIR sensors, these sensors have a few distinctions between them and all of the sensors that we have been researching. The passive infrared motion sensors have a device that is sensitive to heat or otherwise known as the infrared light that it emitted by human and or other objects. Similarly, to the active infrared motion sensors, the passive infrared motion sensors operate on some of the same principals. One of the major differences between both the active and passive infrared motion sensors is the fact that the passive infrared motion sensors do not depend upon radiation source, like the active infrared motion sensors. These frequently used sensors are still able to detect change in the circumferential area's surrounding infrared radiation. As previously stated passive infrared motion sensors react to infrared energy that is emitted by humans. These devices are passive due to the fact that they do not emit radiation, but they do detect radiation. Passive infrared motion sensors are sensitive to objects that emit a heat energy that is at a wavelength around 10 microns. This wavelength is at the peak at which a human emits heat

energy. Passive infrared sensor can only detect a change in their field of view. They cannot detect what is outside of their particular field of view and a person and or humanoid will not be sensed if there is an interference such as a wall or column or even a partition that is between the human and the passive infrared motion detector.

Passive infrared motion sensors are work by detecting a significant change from its state of normality. The normal heat levels within the sensor's field of view will change drastically for a detection. The normal state of passive infrared motion detectors is determined by the circuit control. These passive infrared motion detectors have a toleration of gradual changes within its field of view. Once that change is complete and constant that will then be the new state of normality. A popular gradual change is that like the sunlight, the sunlight is constantly changing at a slow rate and should not cause the detector to have a false alarm. Due to the sensitively of the passive infrared motion sensors they are able to detect spasmodic to meager changes in temperature within the field of view, which is why for ultimate coverage the passive motion sensors should be mounted in the direction of entrance.

3.2.4. Humanoid Detection System

A humanoid detection system includes a camera and a motion detector along with facial detection software. During our research we have found that the preferred camera choice for do-it-yourself security systems was the Raspberry Pi IR Noir camera. This particular camera is able to provide a night vision recordings. We decided to go with this camera because it is compatible with the raspberry pi that we will be using in the central hub. Therefore, no further research was needed to be done.

As far as the motion detectors that will be communicating with the camera to make a complete humanoid detection system we decided to use the same passive infrared motion sensors that are being used in the lawn spikes. The PIR HC-SR501 provide us the sentry angle coverage that we will need for the humanoid detection system.

In order for our system to have the capability to detect humanoids we have to do some research on the type of soft we should use for programming. From all of our research has leaded us to OpenCV. OpenCV is the number one preferred program used on for do-it-yourself programs.

With the three of these components combined our group will be able to successfully create a humanoid detection system.

3.2.5. Wireless Transceiver

The wireless transceiver is the component in the project that will allow for the users to connect to the central hub wirelessly. Enabling the user to control all the features the project has to offer. The other aspect of our project that requires to be wireless is the lawn spikes. The lawn spikes must effectively communicate with the central hub and that is done through the wireless transceiver. For the many reasons stated above is why the selection of the proper transceiver is important to this project, but when accomplished is very rewarding by delivering exceptional results.

Wireless Transceiver Types

The market is full of different types of wireless transceivers, our project needs requires a module to operate within 3-5V and support audio, and I/O transmission. The different types researched for the project are as followed: Nordic RF, Wi-Fi, and Bluetooth. Each of the different type work off of a 2.4GHz frequency, this frequency is desired since it is a deemed openly usable by the FCC.

The Nordic transceivers are some of the least expensive modules on the market, and they are extremely efficient for near-field communication. Nordic Semiconductor offers a very appealing module called the nRF24Z1, it is made to be used for stereo audio streaming, which lines up exactly with what we would need. The best part of the device is its idle power consumption, the nRF24Z1 has the ability to “sleep” with only two microamps of current. This would allow for our device to conserve as much power as possible, and still achieve a good distance for communication. When looking for documentation on the device, Nordic Semiconductors seemed to have a sufficient amount of code examples and technical documents. Though the company has stopped all technical support on the module, so our group would need to rely heavily on 3rd party forums for any needed support. The availability of the device is very sparse and either requires a large bulk buy or the module can become very pricey for a single item. There are many other Nordic transceivers in the market but many would require the need to right our own communication protocol, which would be out of the scope of our project.

The next transceiver type researched is the Wi-Fi module. Wi-Fi is a very common method of wireless communication. The Wi-Fi module trumps on any other transceiver researched in the category of range, for it mainly relies on a central router to send then receive signals from a Wi-Fi dongle. The central router can be fitted with a 2-4 of antenna that can increase the distance the signal can reach and also create a greater spread of signal, to have a larger affected region. These modules would also allow rapid movement of data, since

other transceiver can achieve about 1-4 Mbps, the Wi-Fi module can achieve 11-1024 Mbps of data transfer speeds. Though with all the features Wi-Fi offers it is not free, the power required for transmission tends to be 10 times more than Nordic or Bluetooth.

The final transceiver is Bluetooth, over the past decade Bluetooth has been on a rapid increase in market presence, not only with smartphones but in the hobbyist community as well. These transceivers are extremely universal in what they can accomplish between SPI and modules that support audio. Different Bluetooth transceivers can operate with ranges from 10-100 meters, with the chance of extending the range by lengthening the device's antenna. The average data rate for majority of the Bluetooth transceivers are 2 Mbps, which is plenty for a crisp audio stream and periodic instructions from the central hub. The module that was researched was the OVC3860, this transceiver supports A2DP, audio streaming, and AVRCP, audio playback controls. Bluetooth transceivers use AT commands for configuring setting like the signal’s name for broadcasting or could be used to pass string through for communication. Bluetooth tends to costly on the power side as well, but with well written code some power management can be achievable.

Central hub’s Wireless Transceiver

The central hub is the base station for our project so this means it will be required to play music either locally or stream content from Google Play Music and in order to do this we need to be connected online. The central hub will also be in charge of streaming the audio to the wireless lawn spikes. With this knowledge the central hub will require two wireless transceivers, one will be a Wi-Fi transceiver and the other will be a Bluetooth transceiver. Both of these transceiver work on the 2.4GHz band but they will have their own functionality, in order to accomplish the several features the central hub provides.

Central hub’s Wi-Fi Transceiver

There are several different Wi-Fi transceivers, whether it be a dongle that interfaces via USB or a separate Wi-Fi module that we can wired into the GPIO pins of the microcontroller. Once we decide on the dongle or separate module we then must look into the different Wi-Fi extension; B, G, N, or AC. These Wi-Fi extensions are really just different revisions of IEEE standard 802.11. We care about them because if we get a transceiver that does not operate on the proper standard we will have difficulty connecting. The table below will go the differences in the 802.11 revisions;

Type	Speed	Range(indoor / outdoor)
B	11 mbps	115ft / 390ft
G	54 mbps	115ft / 460ft
N	130 mbps	230ft / 820ft
AC	1000 mbps	115ft / 460ft

Table 3.2 -1: Differences in the 802.11 revisions

Most routers will support G revision, and G is backwards compatible with B so this means most routers really support B/G. The N revision came out in 2009 and there have been good majority of manufactures too included the N revision in many routers. Though the AC revision was made back in 2014, so not many manufacture have been providing it in regular household wireless routers. Through this analysis are groups research will be more geared towards a transceiver that support at least revision G, since it will be the most common available.

The ESP8266 Wi-Fi Transceiver module is a very powerful device that would give the sufficient network connection we would need. This device would connect to our GPIO pins on our microcontroller, but would require step down in the voltage from the microcontroller's power source, since the device requires only a max 3.3v input. The ESP8266 is configured to operate with 802.11b/g/n so this will fit our need for running on routers that broadcast 802.11b/g signal. This device seems to be readily available online and has a huge presence in the Arduino community, so finding any material needed for operating the module is easily available. These devices would require minimal development up-front, making it a suitable transceiver for our project.

The next Wi-Fi device we researched is the Miniature Wi-Fi 802.11b/g/n USB dongle. The device would interface with our Raspberry Pi via its USB port, this would allow us to free up extra GPIO pins and allow simple installation into our microcontroller. The Miniature Wi-Fi dongle would provide access to all the major 802.11 standards, this would essentially guarantee our device to work with every standard household router. This dongle is sold by Adafruit, who sell all do-it-yourself (DIY) type electronics, this company has amazing documentation available online with countless amounts of tutorials for all of their products, also their user community is very extensive with a wide range of skills from different users. After much debate between the ESP8266 and the Wi-Fi USB dongle, the

choice was made to go with the USB dongle, for its simplicity and its large online support.

Central hub's Bluetooth Transceiver

When researching Bluetooth transceivers, our group made sure to look thoroughly through our choices. The choice in transceivers is similar to the Wi-Fi transceiver where you can get a dongle version that connects via USB or a standalone Bluetooth module that would connect via GPIO pins. The first Bluetooth module researched was the Bluefruit EZ-Link with breakout board, the module is sold by Adafruit, so we know the documentation and online community will be a sufficient amount of material for development. The module works off of a 3v input, which would require us to use a step down voltage circuit. This device also does not support audio transmission, this is a big feature for us, because it would then require us to get another transceiver with that capability. Through the material research we will not be able to use this transceiver and continue our research with a device that supports audio transmission.

The second device we looked into was a USB dongle version of a transceiver, the SoundBot SB340. This device would not require any need for an extra voltage regulator since it would interface with the microcontroller via USB. The dongle also supports A2DP for audio transmission, and AVRCP, for audio playback controls. The module has a gold plated connector which will allow for a solid transfer rate of data. Amazon sells this module with speedy delivery and has many of them in stock, so the availability of the item will not be a concern for our project. The documentation available for the dongle is very scarce, but the online community has many varying tutorials using this device with different microcontrollers. Though the documentation may be lacking the fact that we can just plug and play with this device will allow us a simple interface with the microcontroller. After this research we as a group decided to go with the SoundBot SB340; with its simplicity in design and tiny size makes it the only choice for our project.

Lawn Spike's Bluetooth Transceiver

The wireless lawn spike will require a slimmer Bluetooth transceiver then the one in the central hub, since our space is more limiting and the microcontroller won't have an USB interface, then it leaves us to research Bluetooth transceiver modules. After thorough research there are not many differences between Bluetooth transceivers that support the A2DP and AVRCP techniques, but we were able to find two different chipsets that would be sufficient for our project's needs. The first module researched is the BK8000L, this Bluetooth transceiver operates at full duplex, allowing two-way communication simultaneously, which is very important so that our audio will be able to work even when the sensors are

sending data back and forth with central hub. BK8000L requires 2.8-4.2v input, this range fits our requirement as well for we will be able to power the device with a step down voltage regulator. The availability of the item is what make this a very cautious component for it does not seem to be readily available in the states, and would require to order from an oversea provider, this could cause the delivery of the item to be too late for our need. Though the documentation and video tutorial could be very helpful when needing supplemental material for development. The second chipset researched is the OVC3860, this module also supports A2DP and AVRCP techniques similar to the first chip, and really the two chips are not to different other than the different chipset both of the chips provide the same functionality. The biggest difference is the availability of the OVC3860 module; Amazon offers the device with speedy delivery which would guarantee the module to arrive in time for development and testing. This chip also has a much larger presence with the online community so there are a multitude of example to work off of. Considering the devices have the same functionality the main factor for which component to select, would be based on availability of the item and the amount of supplementary material at our disposal. Weighing those factors our group has decided to go with the OVC3860 Bluetooth module for our wireless lawn spike.

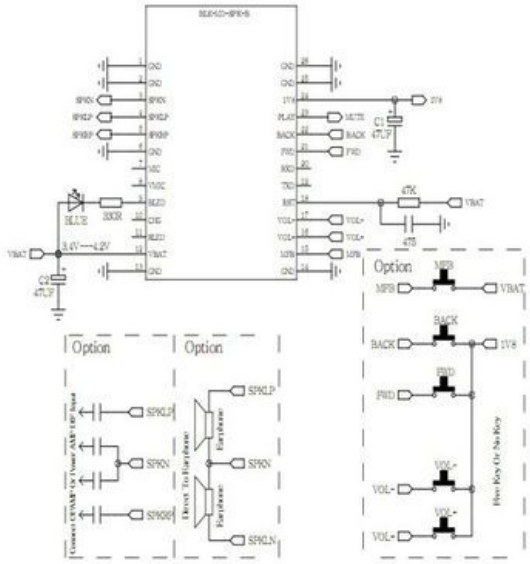


Figure 3. - Reprinted with Permission from http://www.elecfreaks.com/

3.2.6. Microcontroller

For an effective use of the wireless audio lawn spike all pieces of the product will be equipped with a microcontroller, each spike and the central hub will contain

one. This induced needed research to find the appropriate microcontroller to fit all the needs for each device in the project. There will have to be two different types of microcontroller, one for the central hub and a set of microcontroller for the spikes.

3.2.7. Microcontroller Brands

The microcontroller brand that we select for the project is very important, it will become the decision factor for every component we use. We must choose wisely to get a microcontroller that will be able to fulfill all of our specifications. The first brand that was researched was the ARM Architecture, they supply the market with a wide variety of microcontrollers and their chips can be found in over sixty percent of the mobile devices worldwide. The ARM online community presence is very large and has many dedicated developers. This is a huge bonus when selecting a microcontroller because not only is the hardware and documentation important, but external help is crucial for solving complex problems that could cause unwanted roadblocks. The Raspberry pi is a product that uses the ARM Architecture and is a viable microcontroller for the central hub. These controllers are readily available on most large online electronic stores. After ARM, we decided to look into the MSP430 microcontrollers, though they were not our first choice.

Every electrical and computer engineer at UCF must go through Embedded Systems. The UCF curriculum for Embedded Systems is based around the TI's MSP430 developer board. Due to this class being a requirement for three out of four members in our group most of the group members have a general understanding of the board and understand the basics on programming the board and using UART serial communications. The TI brand is widely known and holds a large percentage of embedded device market. The community for TI is very strong and has many knowledgeable people willing to help, but the documentation for most products are extremely lengthy. Due to our time constraints our group cannot spend time on documentation for simple functionality.

The microcontroller brand that we looked into next was Atmel. Atmel is huge in the 'Do-It-Yourself' community online. This is the same brand that the Arduino development boards use. Since this brand is used by a lot of hobbyist, it makes information very readily available. The documentation from Atmel is straightforward and easier to read than most documentation. After reviewing the three brands we felt like there was two clear winners for the best candidate in our project. The Arm processors, which seems to be equipped with the processing power we need in our central hub and the Atmel microcontrollers seemed to be the best fit for the individual lawn spikes. After this conclusion we needed to do a

bit more research to find the best approach to get the different controllers to communicate with each other.

3.2.8. Lawn Spike's Microcontroller

The microcontroller for the lawn spike does not need to have anywhere close to the same amount of processing power needed in the central hub. The microcontroller will need enough pins for connecting LED's, passive IR sensors, and a wireless transceiver. The microcontroller will need to relay information received from the IR sensor to the central hub and wait for instructions.

With this information to take into consideration we will have a wide variety of chips to choose from that will fit our needs perfectly for the lawn spike will not demand too much processing speeds. Though we wanted to make sure to leave some leeway in the specs of our microcontroller, in case we needed/wanted to add more modules to the lawn spike in the future. The first microcontroller series we looked at under Atmel was their ATtiny series, these are nice for they are very small, compact and are designed for low power situations. Though the main canceling factor for them was the limited amount of pins that the controllers supplied, for it would not allow us to expand our product for future development. The ATmega series was the main chipset that seemed to meet all the specifications we were looking into for our project, the microcontroller has plenty of GPIO pins for our intended use and the chips were equipped with the needed Serial Peripheral Interface(SPI) for communicating with the wireless transceiver. The ATmega328 seemed to be the best chip, for it has a reasonable amount of flash memory and its cost is affordable. This chip is the same chip that t the Adafruit Pro Trinket uses and could serve well as our development board used for testing before making our own PCB. Our ending deciding factor the for the microcontroller in the lawn spike is the ATmega328.

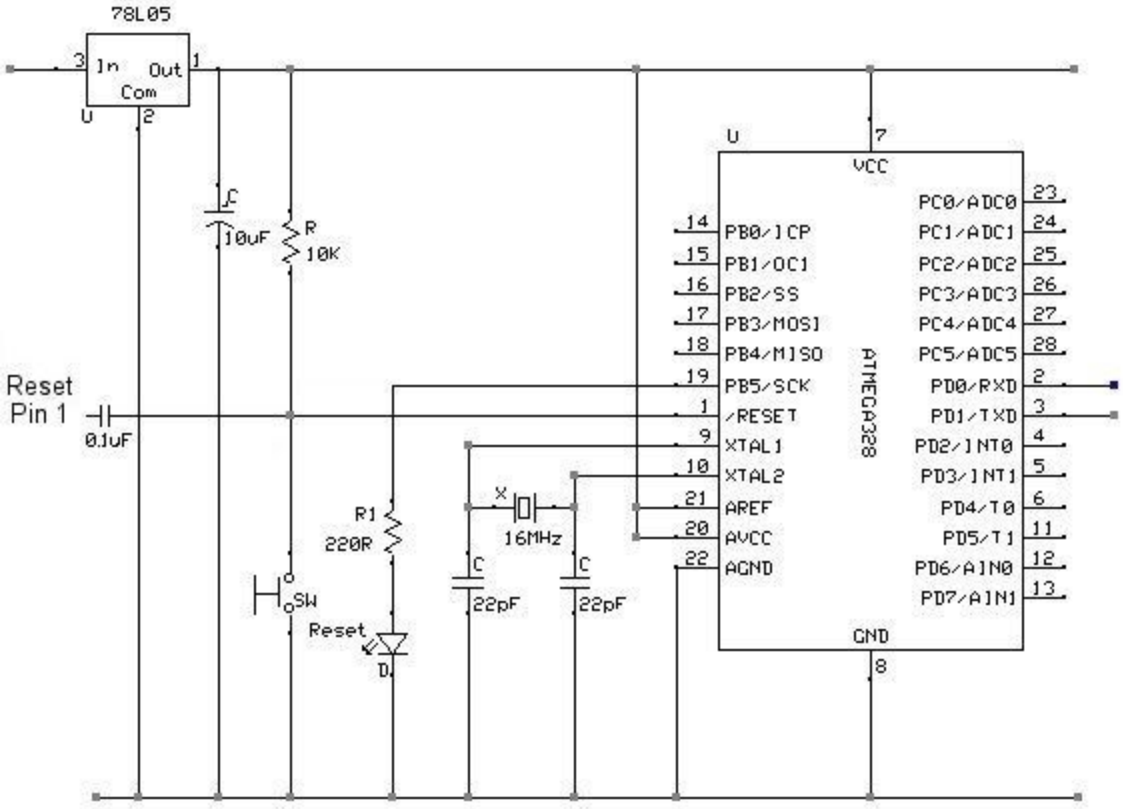


Figure 3. - Permission Pending

3.2.9. Single-Board Computer

The single board computer is a complete computer built on a single circuit board. The one circuit board is equipped with a microprocessor, RAM, Input/output, and other features one would find in a functional desktop computer. Though unlike the desktop computer most single board computers do not have available expansion slots, for they are very limited in their physical sizes. The small dimensions of single board computer are what makes them very useful in our project, for we will be able to have the power of a fully built computer in a small central hub. There are many different branded single board computers, the ones that fit our size requirement are Odroid and Raspberry Pi.

3.2.10. Single-Board Computer Brands

The Odroid was created by Hardkernel, a South Korean company, these boards have many different variants, so it would allow our group to really hone in on a device most suited to our needs. The top three boards Hardkernel sell are the Odroid-XU4, Odroid-C2 and the Odroid-C1+. The table below will show their specs

	Odroid-XU4	Odroid-C2	Odroid-C1+
CPU	Exynos5422 Cortex™-A15 2Ghz and Cortex™-A7 Octa core	ARM® Cortex®-A53 2Ghz quad core	ARM® Cortex®-A5 1.5GHz quad core
Instruction Set		ARMv8	ARMv7
GPU	Mali-T628 MP6	Mali™-450	Mali™-450 MP2
RAM	2Gbyte LPDDR3	2Gbyte DDR3 SDRAM	1Gbyte DDR3 SDRAM
Storage	HS400 Flash Storage	MicroSD	MicroSD
GPIO	30pin GPIOs + 12pin I2S	40pin GPIOs + 7pin I2S	40pin GPIOs + 7pin I2S
Audio Output	no	no	no
Price	$74.00	$40.00	$32.00

Table 3.2 - 2: Single Board Computer Brands

These boards have very amazing specs and at an affordable price too, but one of the downsides is the online community. Although they have a very dedicated team of developers to assist at any time. The documentation is very abundant and goes into great detail about using the devices, though there seems to be a lack of tutorials and other projects with the single board computer. Though these machines really demonstrate how amazing today's technology is and how far we have gotten.

The next single board computer researched is the Raspberry Pi. These boards are made by a UK based company called the Raspberry Pi Foundation. The

Raspberry Pi has many different variants, just like the Odroid. The top 3 single board computers are the Raspberry Pi 3 Model B, Raspberry Pi Zero, Raspberry Pi 2 Model B. The following table will show the specs for each board.

	Raspberry Pi 3 Model B	Raspberry Pi Zero	Raspberry Pi 2 Model B
CPU	ARM® Cortex®-A53 1.2Ghz quad core	ARM® ARM11 1Ghz	ARM® Cortex®-A7 900Mhz quad core
Instruction Set	ARMv8-A	ARMv6	ARMv7-A
GPU	400MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV
RAM	1GB SDRAM	512MB SDRAM	1GB SDRAM
Storage	microSD	microSD	microSD
GPIO	40	40	40
Audio Output	yes	yes	yes
Price	$35.00	$5.00	$35.00

Table 3: 2 - 3

These board have great specs and the prices are very reasonable. The online community for the Raspberry Pi single board computer is massive and has many dedicated developers ready to help any time. These boards are recommended for many different types of projects and has the resources to back it up.

3.2.11. Central hub's Single-Board Computer

The central hub is the brain to HAPPI, it has the responsibility of controlling each lawn spike simultaneously. The best way to handle all the data the central hub is required to digest is with a single board computer. The computer will need to have a good amount of General Purpose Input/Output(GPIO) pins for connecting external components and any possible future development. The single board

computer needs a fair amount of memory for the central hubs program will be quite large. The Odroid is a very impressive single board computer, but the specs on all of the boards were overkill and a small online community is not what our group is looking for, so this points us to the Raspberry Pi. When reviewing the table for the Raspberry Pi's we can see a viable option that is the most cost efficient would be the Raspberry Pi Zero, but the 512MB of RAM could cause a bit of a problem especially since our device is going to require to do image analysis; we will require a higher amount of RAM in comparison to what the Raspberry Pi Zero has to offer. This knowledge stirs our attention to the Raspberry Pi 2 Model B and as well as the Raspberry Pi 3 Model B to fulfill our project's needs. The Pi 3 is a good choice but may be a bit much with the 1.2GHz Quad Core processor, since we will not require that high of processing speeds, and we want our device to be as efficient as possible so to conserve energy we look into the Pi 2 since its processing speeds are more in range with what our project will truly require. With this analysis at hand we will be going with the Raspberry Pi 2 Model B for our projects microcontroller in the central hub.

3.2.12. Printed Circuit Board

Printed Circuit Boards have been around since the early 1940s. Printed Circuit Boards (PCB) have long evolved since then. The biggest influence for the evolution of the PCBs was from government agencies. They wanted to new and improved weapons and communication equipment. The boards have evolved in every sense from electronic devices to construction because of that influence. PCBs have always been used for creating a critical path for electrical components. The first working PCB was used for a radio. It replaced the bulky wiring for the radio. Now PCBs are used for almost any and all electrical devices. They're used for TVs, computers, game consoles, and even cars.

The creation of the Printed Circuit Board (PCB) is essential to the central hub. A PCB is used in virtually every electronic device. The PCB mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. There is no basic PCB Board. Every board has its own specific components. The PCB will allow signals and power to be routed throughout the central hub and solar powered spike electrical devices.

The evolution of the construction created the ease of creating and manufacturing them to be used in those electrical devices and many others as well. PCBs were originally made with such materials such as Bakelite, Masonites, layered cardboard, and wooden planks. Now PCBs are made with much different and lighter weight material and as a result PCB boards can be fragile. PCBs are most commonly made with glass fiber reinforced epoxy resin with a copper foil bonded onto one or both sides. All are now made of those materials. Prior to using copper using brass as the metal of choice to carry the current. Later PCBs used

later used copper because their ability to carry electrical current, its cost is lower than brass, and manufacturing is easier. Different PCBs are made of different reinforced components. PCBs made from paper reinforced phenolic resin with a bonded copper foil are less expensive and are often used in household electrical devices. The printed circuits are made of copper, which is either plated or etched away on the surface of the substrate to leave the pattern desired. The copper circuits are coated with a layer of tin-lead to prevent oxidation. Contact fingers are plated with tin-lead, then nickel, and finally gold for excellent conductivity.

There are three different types of PCBs: single-sided, double-sided, and multi-layered. A single sided PCB is a basic board that has one conductive layer and has low density designs. The single side PCB is the simplest board and are most productive for high volume products. A double sided PCB is the most common type PCB. The board contains a top and bottom layer, where routing and traces around each other by jumping between the two. This process is completed using the board's electrical connections between layers, known as VIAs (vertical interconnect access). The double sided layer allows for more flexibility in designing and it increased circuit densities. A multi-layer PCB is the most complex of the three types of PCBs and is the densest. Multilayer PCBs have double sided configuration produced by the additional layers. These PCBS are the best for high powered designs. The double sided PCB is best for both the central hub and spike. The PCB for both components are not simple enough for the single sided board and don't need the power that a multi-layer board (containing more than two boards) can dissipate. The board ordered from Elecrow would be a 2 two-layer board tin/lead plating board with a silkscreen and solder mask. The board would also be sized at most 3.8 X 2.5 in board. After the creation of the solar spike the PCB would ultimately size down to a 2.97 in X 2.94 in board.

Having a PCB in an electrical device comes with its multitude of advantages and disadvantages.

Advantages

PCB Components are Fixed	The printed circuit boards allow for no wiring at all. Maintenance of the boards become easier and the inner workings of a device are cleaner.
Few Short Circuit Issues	The wiring of the boards is embedded in the circuit. The lack of wires results in fewer shorts and fewer chances of mistakes with wires.

Less Inspection Needed	All design and testing is done via a computer application and software. It eliminates inspection on the product when it's printed.
Inexpensive	The production of PCBs is cheap and inexpensive. They are made from a set design. Printing a design and etching it into a board is much cheaper than manually wiring a design and creating a board.
Easier Reproduction	Identical boards are easy as well. The set design can be transferred and the design can be used and reproduce the board.

Table 3.2 - 4: PCB Advantages

Disadvantages

Can't Repair When Damaged	The PCB components are embedded into the board, therefore when one component gets damaged essentially the whole board is damaged. The only way to fix the board is to replace the whole board.
Pose Harmful Effect to Environment	PCBs are the least environmentally friendly when it comes to circuit design. The products used to build the board and etch the components into the board use harmful chemicals in respect to the environment.
Boards can't be Updated	Similarly, to repairs, changing, add, or remove one component on the board isn't a feasible feat. If any of those feats need to be accomplished a whole new board needs to be reprinted.
Specified	PCBs are fixed and specified for the one purpose they are designed for. They are not interchangeable.

Table 3.2: 4: PCB Disadvantages

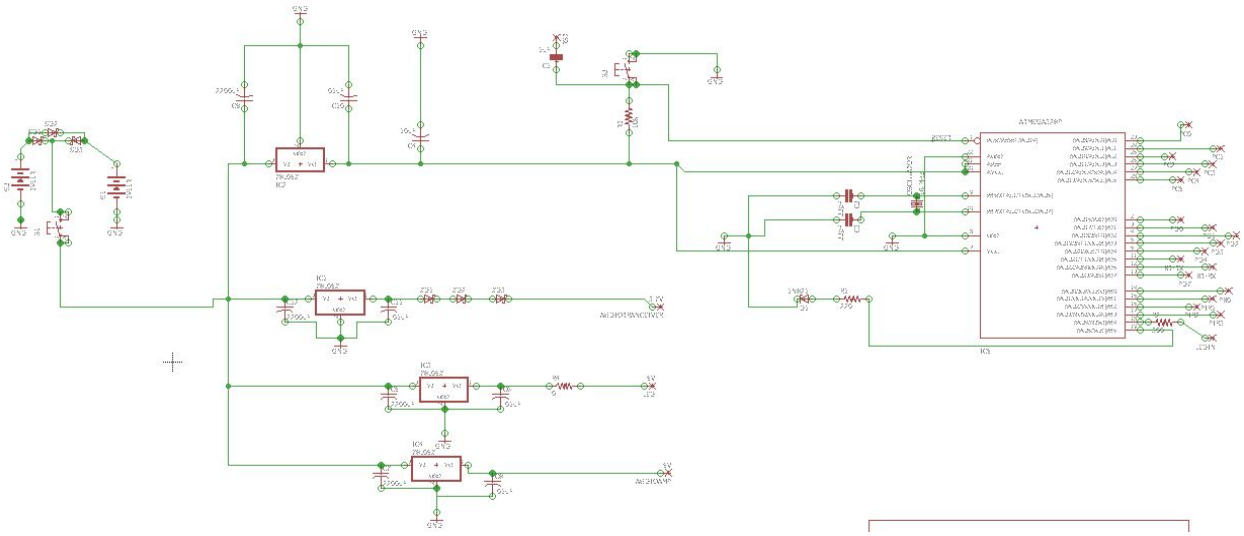
The company we originally were using for creating our PCB is ExpressPCB. ExpressPCB has CAD software that allows us to draw the schematics and design the PCB layout. They will allow us to design and submit the design needed for our design. The CAD software we will use for our PCB Design contains ExpressSCH (for the schematic) and the ExpressPCB (for the layout software).

As stated prior, ExpressSCH is the schematic design software. This software allows for easy user interface. The software has a multitude of components that can be placed on the electronic circuit. ExpressSCH includes a large library with hundreds of component symbols including integrated circuits, resistors, capacitors and any and all components that you can use to draw your electronic circuits. Along with selecting the components, positioning the components is also a viable function of the software. An easy snap to grid feature allows us to align the symbols to our desired location. Along with selecting the components, adding the wires is a capable function of the software. Which allows us to connect parts together. With any creation made by humans, there is human error. Luckily, the ExpressSCH software allows of editing. The PCB editing works with the standard copy, cut, and paste commands. Also, editing can be done with dragging and moving components with the mouse. Similarly, to other commonly used schematic software, moving the schematic does not harm the placement of the wires. The wires stay connected to the pins even when the schematic is moved. Once all components have been added, the schematic can be linked to the circuit board layout file. In closing, the ExpressSCH lets the user select the components, position components, add wires, edit the schematic, and link the schematic to the PCB.

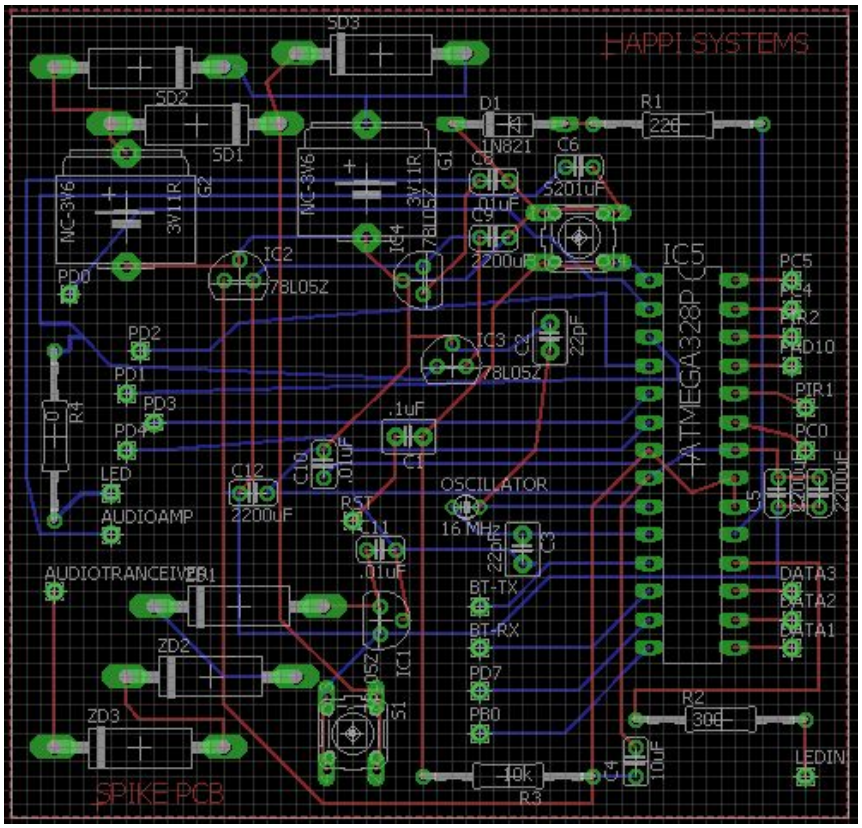
ExpressPCB is the PCB layout software. This layout software works similarly to the schematic software. Similarly, to the schematic software, the layout software allows the use to select and place components. The software also has the snap to grid feature. Each component can be dragged to each location on the desired board. The layout software also has the capabilities of adding traces to the board. Traces electrically connect various connectors and components. Adding tracing is done by selecting one pin of a component and dragging the pin to another. Additionally, linking the schematic to the layout file highlight the pins. As formatting and completing the layout is complete, editing becomes a possibility. In a like to that of the ExpressSCH software, editing in the ExpressPCB software is an easy task for the user. Editing can be done with the copy, cut, and paste commands. Editing can also be done with dragging and moving components with the mouse. Comparably to the wires not being harmed in the dragging in moving

components in the schematic, traces don't get harmed. Traces stay connected to their pins, even when they get moved around. As a result of the final editing and creation of the layout, we can proceed in the ordering of the board. The ExpressPCB program tells the user the cost of the board. In closing, the ExpressPCB lets the user select the components, position components, add traces, edit the schematic, and link the schematic to the PCB.

Although the use of ExpressPCB and ExpressSCH provides its advantages, we had to change both the manufacturer and design software. The ExpressPCB's cost serves to be too high for the iterations needed to perfect the PCB served too high. We changed the manufacturer to Elecrow. Elecrow is an open hardware facilitation company based in Shenzhen, China. The price of the manufacturing is $10.99 for 10 boards and is approximately 20% of what it would cost to have the same amount of boards from ExpressPCB. The change in manufacturer forced a change in schematic CAD software. ExpressSCH is only compatible with the ExpressPCB manufacturer. We moved to use the EAGLE (Easily Applicable Graphical Layout Editor) CAD software. The EAGLE CAD software has similar capabilities and it was a smooth transition recreating the spike schematic and formulate the board. The EAGLE CAD schematic and board can be seen below.



Eagle CAD Schematic



Eagle CAD Board

3.2.13. Power Supply

The power supply is the heart of any electronic device. It has the blood to the body of the electronic component and it provides what's needed for the device to work. The Central hub's power will be comprised of and come from solar energy as well as the option of plug and play capabilities. The Central hubs solar energy will provide the Central hub with its portability and outside capabilities that we desire. But when developing our Central hub understanding solar power and the most efficient rate of use. The central hub's portability is one of the primary functions of the central hub. The central hub of the power supply will need to power the central hub in any circumstance. The central hub will have plug and play capabilities as well as being charged outside of any home or residence. By plug and play, the central hub will have the ability to be plugged into a wall outlet or socket and charge the batteries of the central hub as well as play the central hub at the same time. The Central hub's power will also be comprised of and

come from solar energy. The Central hubs solar energy will provide the Central hub with its portability and outside capabilities that we desire. When developing our Central hub understanding solar power and the most efficient rate of use.

As for the spike, traditional lawn spikes composed of the solar cells or panels, the battery, the charge controller, a LED light and the inverter. Solar powered lawn lights have been around for decades, but never has there been lawn lights with wirelessly enabled and also have speakers connected to project sound from a given device. Our spike will have those components as well as speakers, an amplifier, and wireless components. The goal is adding those parts while remaining power efficient and sustaining an abundant battery life.

Solar Cells

A solar cell is a device used to create electricity, generated by solar energy. Solar cells use photovoltaics (PV) to generating electric power and converting that energy into a flow of electrons. Photovoltaics is the direct conversion of light into electricity at the atomic level. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.

Not all solar cells are created equally. Solar cells have several different grades and efficiency rating. There are several different types of solar cells. The three most commonly used are monocrystalline silicon solar photovoltaic system, polycrystalline silicon PV system, and thin film solar cells. All three produce different efficiency ratings and thus all have varying price values. The efficiency rating involves the measure of power the solar panel generate from the sun. The sun's irradiance averages to about 1000 watts per square meter.

The monocrystalline silicon (MS) solar cells have the highest efficiency rating and are the most expensive. The monocrystalline solar cells typically have an efficiency rating of 15-20%. Because the MS solar cells are the most efficient they will require the least amount of space to acquire the same amount of power compared to the other solar cells. In reference to the sun's irradiance, the MS solar cells would generate about 150-200W per square meter when faced directly with the sun. Also, as later discussed the MS solar produce as much as 4 times as much electricity as the thin film solar cells. MS Solar cells are made with the corners of their grids removed to optimize performance and lower costs. It's made using the Czochralski process and taking those crystals, and later molding those silicon blocks into the solar cell shape.

The polycrystalline silicon (PS) system is regarded as the best solar cells on the United States market. The polycrystalline silicon system have typically have an

efficiency rating of 13-16%. On average the solar cells generate 130-160W per square meter. The PS solar cells have a lower efficiency rating due to the lower the material of the solar cells. The purity of the silicon crystals of the cells is less than that of the MS solar cells, which causes the lower efficiency rating as well as the creation of the cells.

The thin film solar cells have the lowest levels of efficiency. Thin film solar cells have an efficiency rate of 7-13% depending on the technology used to create the cell. The low efficiency rate renders this form of solar cells as not a viable option for our central hub. Mass production of these cells are needed to power our solar cells. Anywhere from about 70-130W per square meter is far from ideal conditions when powering the central hub. The time it would take for the central hub to charge the central hub would take the longest time of the three types of solar cells.

Thus in terms of budget and efficiency, the polycrystalline silicon solar cells are the best value. It gives us the optimal charge we need, with an abundant efficiency rate that will allow us to charge the Central hub as fast as possible. The PS solar cells are right in between the two other types of cells in terms of efficiency and price. The MS solar cells would be the best option but MS solar cells aren't sold to the public that aren't ready made into solar panels. All the panels would be entirely too large to be portable.

The power source of our spike and the traditional lawn spike will be one in the same. Efficiency is a major factor when determining which solar cells to use as stated prior. The only major difference is the amount of power generated in our spike.

The solar cells for the spike must make optimum use of space to maintain the portability of the spike. Most lawn spikes are lower than 24'' in height and no more than 8" in width. The spike's solar cells of course will need to be smaller in dimensions and maintain optimum portability.

As stated prior, the polycrystalline silicon (PS) system is regarded as the best solar cells on the United States market. The polycrystalline silicon system has typically have an efficiency rating of 13-16%. The PS solar cells have a lower efficiency rating due to the lower the material of the solar cells. The purity of the silicon crystals of the cells is less than that of the MS solar cells.

To best ensure the use of our cells and maintain the power efficiency of the cells proper protocol should be used. The sun is at optimum use approximately 8 hours per day, at approximately 1000 watts per square meter. Absorbing energy and maintain best use of the cell is important. Heat tolerance is a major factor when implementing these solar cells. The solar powered spikes will need be are built to be outside during the day to absorb the daylight. Solar panels based on monocrystalline and polycrystalline solar cells will have a temperature coefficient in the –0.44% to -.50% range. The sun power does the best in this regard with a temperature coefficient of –0.38%. It is also the most efficient commercially

available solar panel – making it an excellent choice for high temperature areas. Heat buildup causes this loss of electricity. As an additional precaution, air flow above and below the panels must be there. It helps the panel keep cool.

The degradability of the cells also is an important factor when deciding which solar cells we will implement with our Central hub. The heat causes the degradability of the cells and the heat affects the cells differently. The rated power output of solar panels typically degrades at about 0.5%/year. However, thin-film solar panels degrade faster than panels that are compared to MS and PS solar cells.

Thus in terms of budget and efficiency, the polycrystalline silicon solar cells are the best value. It gives us the optimal charge we need, with an abundant efficiency rate that will allow us to charge the spikes as fast as possible. The PS solar cells are right in between the two other types of cells in terms of efficiency and price. The MS solar cells would be the best option but MS solar cells aren't sold to the public that aren't ready made into solar panels. All the panels would be entirely too large to be portable.

Battery

As the Central hub generates its power via solar cells, there needs to be a recharge unit for our Central hub for use without the energy from cells. The solar cells will provide energy needed but do not have steady flow of energy to perform the task of powering the central hub during any and all uses. A rechargeable unit is necessary for the use of solar panels. The recharge unit will have the continuous flow of energy to the central hub as well as store energy to the batteries.

Types of Batteries

Rechargeable batteries are need for a rechargeable unit thus we need to have the proper batteries for the Central hub. The four different types of rechargeable batteries are Nickel Cadmium, Nickel Metal Hydride, lithium ion, and lead acid. All four batteries have distinct advantages and disadvantages. Each type specializes in different uses because of their various uses

Nickel Metal Hydride (NiMH)

NiMH batteries have its advantages and disadvantages, especially compared to the NiCd batteries. NiMH batteries have a higher capacity over the NiCd and are less prone to memory than NiCd batteries. NiMH are 30 – 40 percent higher capacity over a standard NiCd. The NiMH has potential for yet higher energy densities. As the NiMH batteries are less prone to memory to the NiCd batteries, the periodic exercise cycles are required less often. NiMH batteries have simple storage and are environmentally friendly. The NiMH battery's simple storage

provides transportation advantages. They are not subject to regulatory control. NiMH do not have regulatory control because they contain only mild toxins and are profitable for recycling which makes them environmentally friendly.

NiMH batteries also have its disadvantages. The NiMd disadvantages consist of its service life, discharge current, its self-discharge, its temperature performance, its high maintenance and its cost compared to NiCd batteries. NiMH batteries are limited in service life and discharge current. If repeatedly deep cycled, especially at high load currents, the performance starts to deteriorate after 200 to 300 cycles. Shallow rather than deep discharge cycles are preferred. Although a NiMH battery is capable of delivering high discharge currents, repeated discharges with high load currents reduces the battery's cycle life. Best results are achieved with load currents of 0.2C to 0.5C (one-fifth to one-half of the rated capacity). Compared to NiCd batteries the NiMH generates more heat during charge and requires a longer charge time than the NiCd. The trickle charge is critical and must be controlled carefully. Also compared to NiCd the NiMH has about 50 percent higher self-discharge compared to the NiCd. New chemical additives improve the self-discharge but at the expense of lower energy density. The performance of the NiMH degrades if stored at elevated temperatures. The NiMH batteries should be stored in a cool place and at a state-of-charge of about 40 percent. The cost is the last of the disadvantages. Compared to the NiCd batteries, the NiMH batteries are about 20 percent more expensive. The NiMH batteries designed for high current draw are more expensive than the regular version.

Nickel Cadmium (NiCd)

The Nickel Cadmium battery has the second highest charge density and has a longer shell life relative to the previously mentioned NiMH battery. The NiMH charges and energy forms from a certain way to cause it to perform in its distinct manner as stated prior. The Nickel Cadmium battery on the has its own distinct elements as well. The active components of a rechargeable Nickel Cadmium (NiCd) battery in the charged state consist of nickel hydroxide (NiOH) in the positive electrode and cadmium (Cd) in the negative electrode. For the electrolyte, potassium hydroxide (KOH) is normally used. Due to the low internal resistance of it and the relatively good current conducting properties, the NiCd batteries can supply extremely high currents and can be recharged rapidly. These cells are capable of sustaining temperatures down to -20°C. The selection of the separator (nylon or polypropylene) and the electrolyte (KOH, LiOH, NaOH) influence the voltage conditions in the case of a high current discharge, the service life and the overcharging capability. In the case of misuse, a very high-pressure may arise quickly. For this reason, cells require a safety valve. NiCd cells generally offer a long service life thereby ensuring a high degree of economy. For this long life service NiCd is one of the leading sells on the market for rechargeable batteries.

NiCd batteries has its advantages and disadvantages. NiCd batteries have fast charging capabilities, high charge/discharge cycles, relatively good load performance, its long shelf life, temperature performance, cost, and its performance options. NiCd batteries have a fast and simple charge, even after prolonged storage. With that charge rate it has a high number of charge/discharge cycles; can provide over1000 charge/discharge cycles. They also have great load performance and can perform in low temperatures, also having a long shelf life in any state of charge. Its pricing is great in a multitude of circumstances. The NiCd batteries are the lowest in cost of all the battery types and are developed to provide a wide range of sizes and performance options.

NiCd have low energy density, memory effect, it's environmentally unfriendly, and its high self-discharge rate. The NiCd has relatively low energy density compared to the other batteries. The NiCd battery's memory is not efficient. They must be periodically exercised to prevent memory. It's environmentally unfriendly nature is not desirable. The batteries contain toxic metals and are harmful if spilled.

Lithium Ion (L+)

Lithium Ion batteries are a commonly known type of battery and the most expensive battery on the market. Lithium Ion batteries are most expensive battery not for nothing. The term lithium ion battery refers to a rechargeable battery where the negative electrode (anode) and positive electrode (cathode) materials serve as a host for the lithium ion (Li+). Lithium ions move from the anode to the cathode during discharge and are intercalated into (inserted into voids in the crystallographic structure of) the cathode. The ions reverse direction during charging. Since lithium ions are intercalated into host materials during charge or discharge, there is no free lithium metal within a lithium-ion cell. In a lithium ion cell, alternating layers of anode and cathode are separated by a porous film (separator). An electrolyte composed of an organic solvent and dissolved lithium salt provides the media for lithium ion transport. For most commercial lithium ion cells, the voltage range is approximately 3.0 V (discharged, or 0 % state-of-charge, SOC) to 4.2 V (fully charged, or 100% SOC).

Lithium ion batteries do come with its set of advantages and disadvantages. The advantages of the lithium ion batteries are the high energy density, self-discharge, there is no requirement for priming, there is low maintenance required, and there are various types available. Lithium ion batteries are used in a multitude of power applications ranging from power tools to electric vehicles. Li+ batteries are used for different machines and applications because of the potential for higher capacities. The Li+ self-discharge is great relative to NiCd and NMH batteries. Li+'s self-discharge is much lower than that of other rechargeable cells such as Ni-Cad and NiMH forms. Some rechargeable cells need to be primed when they receive their first charge. There is no requirement for this with lithium ion cells and batteries. Additionally, Li+ batteries do not

require and maintenance to ensure their performance. There is no periodic discharge needed. No periodic discharge ensures that they did not exhibit the memory effect. The various types of Li+ batteries allow a lot of opportunity for use. Some forms of lithium ion battery provide a high current density and are ideal for consumer mobile electronic equipment. Others are able to provide much higher current levels and are ideal for power tools and electric vehicles.

Li+ batteries also have his distinct disadvantages. Li+ batteries require protection with use, the aging Li+ batteries undergo, transportation restrictions, its cost is high compared to the other batteries, and it's still a developing type of battery. Li+ batteries requires a protection circuit. The protection circuit limits voltage and current. Battery is safe if not provoked, they require protection circuitry incorporated to ensure they are kept within their safe operating limits. The Li+ batteries are subject to aging even not in use. Li+ batteries and cells need to be stored it should be partially charged - around 40% to 50% and kept in a cool storage area. Storage under these conditions will help increase the life. These disadvantages especially are far and away not ideal for the portability and outdoor use of the central hub. The transportation of the batteries has distinct restrictions as well. Also, last but not least Li+ the cost of the batteries is very high. Typically, they are around 40% more costly to manufacture than Nickel cadmium cells.

Lead Acid

Lead acid batteries are known as the oldest rechargeable battery. Rechargeable small sealed lead acid (SSLA) batteries, which are valve-regulated lead acid batteries, (VRLA batteries) do not require regular addition of water to the cells, and vent less gas than flooded (wet) lead-acid batteries. SSLA batteries are sometimes referred to as "maintenance free" batteries. The reduced venting is an advantage since they can be used in confined or poorly ventilated spaces. Other advantages of the lead acid batteries are they cost, the maturity in technology, the low self-discharge, low maintenance requirements and it's capable of high discharge rates. Lead acid batteries are inexpensive and simple to manufacture. The lead acid batteries are the lowest in cost per watt compared to the other batteries. Its maturity in technology causes its use to be durable and provides dependable service. The low maintenance requirements cause no memory need and no electrolytes to fill.

Although SSLA batteries has advantages, the SSLA batteries are still not ideal for the central hub. Lead Acid batteries has its disadvantages. It can't be stored in discharged condition, it has a low energy density, it has a low discharge cycle, it's environmentally unfriendly, and it has transportation restrictions. Since the lead acid batteries have a very low energy to weight ratio as well as a very low energy to volume ratio, it limits the use to stationary and wheeled applications. The size and the weight of the average SSLA batteries are too large in

occupancy of space and weight too much in weight. One of the most common uses of the lead acid battery is the vehicle battery.

The lead acid battery's contents make it environmentally unfriendly. Its lead and electrolyte content can cause damage in the case of spillage.

After review, the battery types used in our central hub come down to the NiCd and NiMH types. The two types are best from the environment and our budget. The lead acid battery is the cheapest but it's harmful to the environment and does not have the charging capacity needed for the central hub. Our Central hub will be using the nickel metal hydride rechargeable battery. Although it is not the cheapest battery, it's the best battery on the market and is well in line with our project. Its high charge density is best to suited to provide the power needed for our Central hub. As well as having an appropriate size for the central hub.

The battery life for solar lawn spikes on the market range from 6-10 hours when fully charged. Duplicating that battery life with the addition of the speakers & wireless components are not easy task.

The battery types most lawn spikes on the market use are the nickel metal hydride, nickel cadmium, and lithium ion batteries. Mainly for the reasons listed prior; Nickel metal hydroxide has a higher charge density, nickel cadmium lasts longer, and lithium ion batteries are at the highest of consumer electronics. The simplicity of the solar lawn spikes the spikes only need one 1.2-1.5 V nickel metal hydride battery. With the added capabilities of the wireless components the speakers attached to our spike, more batteries will be needed to provide the constant charge of our spike. Luckily the high charge density will have the power all components of the spike. Battery

As the Central hub generates its power via solar cells, there needs to be a recharge unit for our Central hub. The solar cells will provide energy needed but do not have steady flow of energy. A rechargeable unit is necessary for the use of solar panels. The recharge unit will have the continuous flow of energy to the central hub as well as store energy to the batteries.

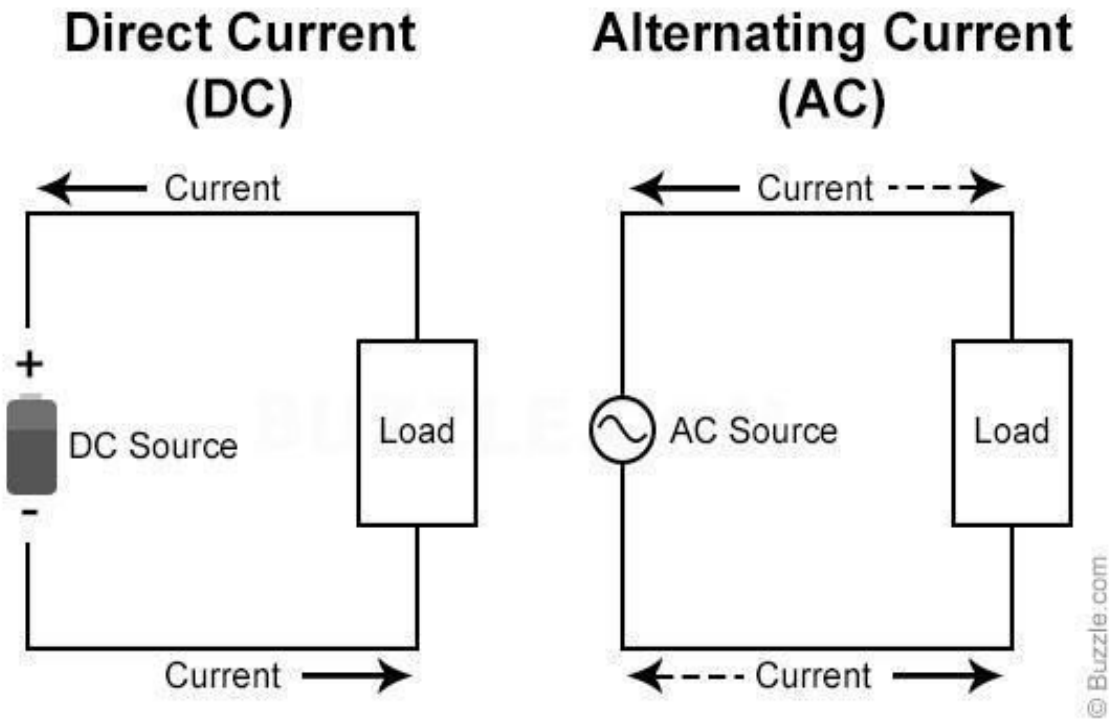
3.2.14. Wall outlets

As stated before the power supply for the central hub comes from two components, the wall outlet and for solar power. Wall outlets produce different levels of output voltage and current. Throughout the world, different countries produce different levels of electricity. As there are several different levels around the world, there are also different types of wall sockets. According to the US Department of international Trade Administration, there are 15 types of socket types. The two sockets listed below are the two most common in North America.

Figure 3.2: 5: Type B Socket

North American outlets including United States wall outlets produce electricity between 110 volts (V) and 120 V AC and the output frequency of the outlet is 60 Hz.

With the use of the wall outlet, an adapter or converter will be needed. Wall outlets provide alternating current. Alternating current (AC) is the flow of charge that changes direction periodically. That includes current and the voltage level reverses. Batteries on the other hand are powered by direct current. Batteries provide direct current, regardless if they are rechargeable or not. Direct current (DC) is the unidirectional flow of current.



Basic DC & AC Circuit

*Permission Pending

In order for the AC from the wall unit to generate the voltage for the DC batteries, an adapter needs to be used. An AC adapter is a device with a cord that plugs into the electrical outlet and functions as an external power supply. The adapter contains a transformer, a rectifier, and a filter. The transformer is an electrical device that transfers electrical energy between two or more circuits through electrical induction. The transform serves as an apparatus for reducing or increasing the voltage of the wall outlets AC. The transformer will take the voltage from the wall and change it into the correct voltage. The rectifier will convert the AC to DC providing the correct energy needed for the batteries. The rectifier periodically reverses the direction of the AC to DC to have the current flow only in one direction. The final part of the AC adapter is the filter. The filter smooths the waveform of the outlet to DC. That protects the device when being powered.

3.2.15. Speakers

Implementing Speakers

Both the Central hub and solar spikes will contain speakers that output the sound the user wants when connected. The central hub will serve as the home base and the spikes would be used comparably to speakers of a surround sound system or home theatre.

To implement the correct speakers, understanding sound and how humans hear sound is a priority. Sound itself is a set of vibrations that travel through a medium that can be heard when it reaches a person or animal. The vibrating air causes the eardrum to vibrate, the brain then interprets that vibration as sound.

Speakers have been around since the 1870s. They have long since evolved and grown in a multitude of ways. Ranging from sound to use to power needed etc. As they evolve, the how speakers work have not changed that much. The general way speakers work is that speakers transmit an electrical signal into an audible sound.

The signal creates that audible sound similarly to any other sound, using its driver. A driver produces sound waves by rapidly vibrating the diaphragm. A speaker's diaphragm causes the sound to travel. The diaphragm contains a cone, suspension, a basket, a voice coil, and a spider. The speaker's driver produce the sound waves; it rapidly vibrates a flexible cone. The driver sends those vibrations through the medium eventually reaching a human or animal. That cone is attached to the suspension. The suspension is the flexible material allowing the cone to move back and forth. All the parts mentioned prior are contained in the basket; the basket being the driver's metal frame.

In order for the speaker and diaphragm to work, the speakers contain an electromagnet. That electromagnet is the voice coil. When the electrical current is flowing, the coils polar orientation reverses causing the vibrations to occur.

The Central hub and speakers must maintain optimum portability for it to satisfy this project. It must be able to be used indoors and outdoors. Not only should the speakers be waterproof, they should weatherproof. Speakers are generally used indoors, but as technology grows, manufactures have devised ways to achieve high quality audio speakers that are to be used in the outdoor environment and can handle most weather situations. Multiple factors to apply for speakers containing the capabilities to be weatherproof. It should be guarded from potential damage such as rain, heat, humidity, and any other bad weather conditions except for floods. The only condition which would be virtually impossible to protect the speakers are during floods because the speakers, spike

and/or central hub would be submerged in water. In which case all parts of the central hub & spike components would be damaged.

There is an assortment of ways of weatherproofing speakers. To stay fiscally responsible and within the means of our budget, what must be used is a high gloss polymer. The high gloss polymer does not affect the sound of the speakers nor does it alter its appearance in that great of deal. The high gloss polymers are waterproof and improve resistance. It's commonly used to refinish and reinforce floors. The gloss polymer is also environmentally friendly. The chemical compound of the high gloss polymer is nontoxic and chemically resistant.

An alternative viable material used should be made of a non-corrosive metal. The elements of the non-corrosive metals should not damage the speaker. It will not eat away at the integrity of the speaker's structure neither will it erode the speaker's. The best material to look for in the speaker is either stainless steel or aluminum, for they will hold up the best in all weather conditions. The humidity can warp the paper cone and cause either distorted sound or possible blow the speaker entirely. The diaphragm is made of, most are paper, and are intended for indoor use only. The most common material for the speaker's diaphragms that can withstand most types of weathering would be either Mylar, aluminum, or polypropylene. We can eliminate the aluminum diaphragms due to the cost, they are typical more than what our group wants to invest into an outdoor speaker. The polypropylene cone would most probably be a good fit, but the cone could warp due to high heats. The polypropylene cone tends to be the cheapest out of the other materials that we are considering. Mylar would be our projects best material to select for it doesn't warp in the heat nor will it warp in high humidity climates. Through the intense research we also found an alternative method for having waterproof speakers that does not rely as heavily on the material the speakers are made of; polypropylene spay can be applied to most speakers and will create a watertight seal to prevent any type of damage to the speaker. One of the drawbacks to the spray is that they can cause a distortion in the sound, though if applied lightly and evenly the distortion and be lessened or possibly eliminated.

Speakers are one of the key components in our project. The speakers are devices that will transmit our audio for the users to hear. There are an immense multitude of various different types of speakers and manufactures. A few of the different types are woofers, for low frequencies and tweeters, for high frequencies. Subwoofers are used for sounds that are lower than 20 kHz and midrange. This covers the middle spectrum for audible frequencies. The woofers/subwoofers and tweeters are generally used to enhance the sound overall. Woofers and subwoofers are commonly used for the bass of any song or movies and thoroughly enhance the effect. Every audio system contains midrange speakers as they are crucial speakers.

Of the three different types of speakers, the midrange speakers are the speakers of choice. The midrange speakers will be able to supply a good crisp audio that does not favor high or low frequencies. Neither of the devices will provide the type of driver to enhance the sound quality of the other speakers. They all will have their own standalone sound quality of the spike.

The central hub and spike has specific requirements that also force specific requirements to that of our speaker.

3.2.16. Mobile Application

Android Studio

The application will be constructed in android studio, an IDE made by google, specified for the development of android apps only. The coding language used by this tool is based in java, serving as a catalyst for the functionality of the application, while xml serves for the aesthetics. Include are added java methods specific to building android applications.

This IDE or Integrated Development Environment's first stable build was released in December 2014. It is now available for download on Windows, Linux and Max. It is based on the IntelliJ IDEA software and has replaced Eclipse Android Development Tools as Google's primary IDE for android development.

Android Studio provides the fastest tools for building applications on every type of Android device and has them divided by SDK level. It provides code editing, debugging, performance tooling, and a flexible build system. In combination with its instant build/ deploy system that when put together allows for the creation of some pretty high quality applications.

The IDE is also very team friendly by integrating version control tools which include some notable names like Subversion and Gitcentral hub.

It also allows the use of an emulator, which is compatible with all android phones, tablets, and devices. This was a big plus in the creation of the application because of a lack of android phones to actual launch the app on.

Android Studio isn't the only IDE that can makes applications, Xcode was also an IDE we took into consideration. In fact, initial there was a big discussion based on the direction that these IDEs would result in, due to the two popular brands that sponsor their creation. One being the previously mentioned Android Studio and the other being Apple.

Xcode provides tools to manage your entire development workflow for iPhone, iPad, Mac, AppleTV and AppleWatch—from creating your app to testing, optimizing, and submitting it to the App Store. Essentially the android studio for Apple applications. It even provides some new features with Xcode 8 that made it

a hard IDE to reject. Such as the new runtime issues that point out errors like memory leaks and Memory Debugger. Not to mention Swift 3 including some more consistent API naming to allow better experimenting.

Ultimately the familiarity of the developers with Android Studio and its associated languages was the biggest deciding factor when choosing the IDE for this project. Either IDE would have been fine in the creation of the application but Android Studio allows for coding in Java and C++ and has a reputable brand that would provide support if the situation arisen.

PHP

PHP in a nutshell is an open source general-purpose scripting language that is suited for web development. It is mainly server-side scripting, which makes it capable of collecting form data, generating dynamic page content, and so much more. In this situation we use it for its database connectivity. This is done by having an HTTP client request sent from the phone application that will hit the webserver and more specifically the PHP code that will present a command.

PHP was initially developed in 1994 but didn't make an actual stable release until sometime later on because PHP was never intended to be a new programming language, but grew organically. This can be seen by the numerous updates and new releases; the newest release PHP 7 was released around 2015.

PHP plays a big role in this project, and is used in activities such as the Login Page and Register page. It serves as the intermediary between the code actually implemented in the application itself and the database we seek to use.

PHP made server-side scripting relatively easy by the list of commands that the programmers were already introduced to, which was the mysqli_connect, mysqli_prepare and mysqli_stmt_execute.

There are many server-side programming languages: Perl, Python, Ruby, ASP.NET and many others. This language was chosen because of the Application's Developers familiarity with the language. Not only that, but the webserver being used to support the use of phpMyAdmin which slimmed down the selection process to say the least. phpMyAdmin is an open source tool written in PHP intended to handle the administration of MySQL over the internet.

MySQL Database

MySQL is an open-source relational database management system and is one of the most popular to be exact. In fact, it is used by the world's largest and fastest-growing companies such as Google, Adobe, and Facebook. Primarily,

because it seems to be relatively cost-effective for its high performance and reliability.

As a result of MySQL's success it has sectioned off into multiple different editions for use including: MySQL Standard, MySQL Enterprise, MySQL Classic, MySQL Embedded and many others.

The actual implementation of the database is relatively easy though, all it requires is the creation of a database, user and host. The host in this project will be provided by our webserver. Once created, the creation of a table is required to actually house the information to be gathered. The actual inputting of information is done via PHP but encompasses SQL statements which is the code that facilitates the selection of data from the database.

The primary use of the database in this experiment will be to contain the user attributes, the attributes of the users are used in the implementation of the Register and Login Page. The database also will hold the available songs that the Google Play Music API has to available to stream.

Google Music Play API

Google Play Music is a service presented by the company google that allows the storage and streaming of music. The service offers more than 35 million tracks for purchase or streaming and is usable by iOS devices, web browsers, media players, and Android devices. This platform is granted to users of google and generally requires a cost if the standard user is not used. The standard user is allowed to listen and upload to up to 50,000 songs from their personal libraries. The large amount of users will facilitate proper use for all android users.

An API or application program interface is a set of routines, protocols, and tools for building software applications. It will be used as a plugin to allow the streaming of music from our actual central hub. The API help accomplishes this goal of streaming music by providing an application that is already configured to come together with our design.

What we want as a result of this API is the creation of a hash table that we will then parse and send the information to the database, this hash table will be a listing of all the available songs to be played from that users Google Play Account. The songs will be accompanied by song attributes such as the name, artist, and stream ID number.

3.2.17. Interfaces

Bluetooth

Background: Bluetooth in a nutshell is a standard for the short-range wireless interconnection of cellular phones, computers and other electronic devices. In our specific situation it will be restricted to cellular phones and speakers. A product that uses it, like a headset, contains a tiny computer chip with a Bluetooth radio and software that makes it possible to connect. Bluetooth operates in a specific band of 2.4 to 2.485 GHz, and uses a technology known as frequency hopping to prevent devices operating at a comparative frequency to cause interruptions. This added feature actually determines the viability of this project and without it would possibly cause major complications between the multiple transmitters. This feature is achieved by constant signal hops around the frequency at approximately 1600 times per second. Constant changes in the wavelengths ensure that even a consistent signal will not interrupt for longer than 1/1600th of a second.

The process of connecting Bluetooth devices together begins with the pairing of devices or the connecting of devices that you want to talk to each other. This connecting over ad hoc, short range networks are known as pico-nets, which usually consists of 2 to 8 devices. When a pico-net is established on device plays the role of a master and the others a slave.

When connected to our devices we can then use AT commands to help in the transmission of information from one device to the next. The AT commands are an attention command determining the presence of the serial port adapter. With the use of these commands, strings can be sent that will allow us communicate from the mobile phone application to the microcontroller.

Implementation: Bluetooth connectivity affords another way of communicating with your microcontroller. All that is required is plugging in a USB dongle into a spare port of the controller. The device might then see the dongle but might require some additional software to comply with Bluetooth functionality. After adding in the additional software, all that would be required is to set the microcontrollers settings to always visible so it can be reached whenever the device is on.

For actual use of the AT commands the developers will have to work with the command line prompt of the microcontroller to see that strings can be passed to and from the device.

IEE 802.11

The IEEE 802.11 is a set of physical and media access control specifications for implementing wireless Ethernet networks and was created in 1997. They are created and maintained by the Institute of Electrical and Electronics Engineers, there are several specifications in the 802.11 family and new ones are occasionally added. More specifically 802.11b also known as Wi-Fi provides 11 Mbps transmission, and was derived from the same modulation technique

defined in the original standard. It falls in the 2.4 GHz frequency band and is accompanied with direct-sequence spread spectrum.

Devices using the 802.11b experience interference from other products operating in the same frequency band, 2.4 GHz. Other notable devices in this range include microwave ovens, baby monitors, cordless telephones, and of course Bluetooth.

Implementation: This would require the microcontroller to act as a webserver, which is a program that uses HTTP to server the files that form web pages to users, in response to their requests. The primary purpose of the server will be to hold the code which will control the execution of the commands. Both the code for the command execution and webserver software would have to be installed on the microcontroller to allow interoperability. When the webserver is set up it will have a specific IP address for it to be reached or URL.

The connection of the application and the microcontroller becomes bridged when a HTTP client is executed from the mobile application itself to the url of the microcontroller. The client will have the location of the code on the webserver and when called by a function will execute.

Zigbee

The wireless communication method is based off the IEEE 802.15.4 standard which is used in order to build personal area networks with low power digital radios. The technology behind Zigbee is intended to be cost effective and simpler as compared to regular wireless personal area networks such as Bluetooth and Wi-Fi. Zigbee devices are low latency which further reduces average current. Unfortunately, though as a result they produce low data rates. This medium operates with a Zigbee chip that are typically integrated with a microcontroller and have between 60-256 KB of flash memory.

Implementation: However, supporting the 802.15.4 standard would require a specific transceiver and receiver chip that will support this specific technology. This hardware isn't included in most phones, so it would require another additional hardware design to be connected to both the phone and central hub.

4 Standards

In today's day and age there are standards on everything, whether it be on vehicle emissions or just standards used in everyday life like a measuring cup. These standards can help manufacturing by setting rules on what is needed in a specific product field, so they are not required to custom build each of the components by order. This allows for a more streamlined production, but standards also tell us how to use a product for public safety. The members of IEEE have developed a code of ethics, in which its members abide by, for showing the importance of technology in affecting the quality of life around the world. The members of IEEE set these standards and together with the code of ethics, keeps the world’s technology and industrial products up to date and functioning.

4.1 Related Standards

Standards generally describe the anticipated quality and the possible manufacturability. For instance, when you buy new tires they must have 5-10% recycled materials. These standards are made for public safety concerns and customers satisfaction. The designs used should be able to be produced, and reproduced with the appropriate material in order to achieve a useful tire. The wireless lawn spike and central hub will require a microcontroller, wireless communication, and camera, image processing software, motion sensor, LEDs, solar charging circuit, phone application and power distribution from a battery source. The following standards will be used for insight in construction/assembly and other standards will be used to add to our complete understanding,

1. 12207-IEEE: Software Life Cycle Processes provides a general framework for the development of software. The standard delves into development, operation, maintenance, and removal of software from a system.
2. 15288-2015-IEEE: Systems Life Cycle Processes establishes a general framework for the development of human created systems. The standard goes into the full lifecycle; conception, development, production, utilization, support and retirement.
3. 802.11-IEEE: Telecommunications and information exchange between systems Local and metropolitan area networks standards cover the Wi-Fi specifications for wireless communications.
4. 802.15-IEEE: Telecommunications and Information Exchange between Systems standards covers the Bluetooth specifications for short-range radio frequency based connectivity for personal portable devices, it defines the physical and Media Access Control (MAC) layers requirements of the stack protocol for Bluetooth connectivity.

5. 208-1995-IEEE: Video Techniques: Measurement of Resolution of Camera Systems describes how the measuring of resolution is done by counting the number of horizontal and vertical TV lines.
6. 1789-2015-IEEE: Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers covers the concept of frequency modulations and how the effects of quick flashing bright LEDs could cause adverse health effects.
7. 24765-2010- Systems and software engineering Vocabulary was created to document the new terms continually being generated, and new meanings for already existing terms for the standardization of software terminology. It also intends to serve as a reference for software engineers to promote clarity and consistency in the vocabulary of programming.
8. 610.4-1990- IEEE Standard Glossary of Image Processing and Pattern Recognition Terminology contains the current terms of use in the field of image processing and pattern recognition.
9. 802.11-IEEE is the media access control and physical layer specifications for the governing of wireless local area networks. The standard and amendments provide the basis for wireless network products using the Wi-Fi brand.
10. 1789-2015-IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers, defines the concept of modulation frequencies for LEDs and the possible health risks to users.
11. ANSI C18.2M, Part 1-2013: American National Standard for Portable Rechargeable Cells and Batteries— General and Specifications
12. ANSI C18.2M, Part 2-2013: American National Standard for Portable Rechargeable Cells and Batteries— Safety Standard
13. ANSI C18.3M, Part 2 (Portable Lithium Primary Cells and Batteries - Safety Standard)
14. UL 61010-1: Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements
15. UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels

4.2 Design Impact of Relevant Standards

4.2.1. 15-IEEE

The Bluetooth IEEE standard 802.15 will not impact our design for we will be developing with pre-assembly Bluetooth modules and only designing a PCB for incorporating it into the project. The modules have already been tested and confirmed to meet the standards to operate on the unregulated 2.4GHz frequency band.

4.2.2 15288-2015-IEEE

The IEEE standard 15288-2015 System's Life Cycle Processes will have a great effect on our team’s efforts. This standard delves into the importance of communication and planning between a group of people and for us it will guide us in the best way to approach our systems overall design and the methods on which we accomplish the project. The standard starts with initiation and this was done with our initial paper submission on the general idea of what our project is, the initiation should show the need for our proposal. Next step will be the System Concept Development, this is what will solidify our project and our main objectives, by setting our project boundaries and analysis. After having the concept down we move to planning, this is where a lot of confusion should be ironed out and a timeline has been set in order to accomplish certain items by specified dates. After planning our next step was Requirement Analysis and in this step we analysis our project requirements and specifications. This is done by researching similar items or components to have a greater understanding of the things required for the project to function properly. Once the requirements have been made and a general idea of what components are needed we can begin the design processes, this when we take our requirements and create a detailed design on how the device will deliver the specified functionalities. Once we have a concrete foundation for a design we next move on to Development step. This step is when we begin to take existing components and start to physical build our individual devices and ready them for testing. Once the subcomponents are created we begin Integrations and testing step. This is the time we power up our device and begin connecting subcomponents together and making sure they function with their given intent. Implementation will start after the testing is complete and all final results are as expected. When a complication appears, we will identify the problem within the test and will revert back to the design step and work our way through the process with a different solution to alleviate said problem. Once we have a functioning product we will begin the second to last step which is Operations and Maintenance. This step will require us to explain the proper use of the device so that any user may understand the full capabilities and how to control the features of the device. Finally will be Disposition; this is for the end of system activation, and it emphasis the proper preparation to data.

4.2.2. 11-IEEE:

This standard is very critical to the functionality of the mobile application because it acts as an interface to other functional components of the application. The 802.11 and 802.11x IEEE standards refers to the family of interrelated standards or specifications for wireless Local Area Networks or LANs. This standard contains the set of media access control and physical layer requirements that allow for the working of independent wireless LANs, for a product that is implemented with the standard to be referred to as “Wi-Fi certified” it would have to pass a test. This standard commonality of the lower 2 levels of the OSI model allow these networks to come together and communicate. So when one Wi-Fi request sent from the phone reaches another Wi-Fi device they can exchange data as requested. The data that we want to be sent in the case of the user based security detailing is user attributes: first name, last name, email, and password.

So when a user wants to enter the application and types in the required email and password into the login page this information goes the process of hitting the webserver. The webserver stores the MySQL database that holds the user attributes that are used to validate user credentials to allow access to the application. It is also required for the sending of information from the Register page back to the database. If the standards of 802.11 were not implemented this would affect the mobile application significantly.

The mobile application relies on an HTTP client that is sent via the 802.11 standard from the phone itself. If no HTTP client is usable due to a lack of this standard the interaction with the database would cease to exist. So whenever the application is not allowed to use Wi-Fi no user will be able to have credentials validated by the database and all user attempts we be incorrect. This will allow no members to interact with the application, which will prevent the use of the SPAs functionality.

Our microcontroller also requires the use of 802.11 because it interacts with a Google Play Music API, as well as the database previously mentioned. Google Play is a service that allows the storage and streaming of music from a web browser. The web browser is reached via the 802.11 standard because no other medium of transmission is accessible. If no connection is established there will be no music played from the SPA as a result. Without the use of this standard we would require other ways interfacing between networks, such as Ethernet cables. However this would severely affect our range of mobility, especially in the case of the mobile application.

4.2.3. 12207-IEEE

This standard was crucial to the development and implementation of the software code written for this application. It covers the software life cycle process and its affiliated terminology. In the standard it creates a framework for software by defining a set of processes that result in a set of defined activities, which are also further translated into a set of tasks or objectives.

The standard includes the use of three general categories: the Primary Life Cycle Processes, Supporting Life Cycle Processes, and Organizational Life Cycle Processes. The Organizational Life Cycle Processes in our case will not prove to be to useful and is primarily for use in larger groups because it includes the Management, Organizational, and Training processes which will be irrelevant with the lack of numbers in our particular group.

Focusing on the Primary Life Cycle, it includes processes such as the Acquisition, Supply, Development, Operation, and Maintenance. The Acquisition process as it relates to the mobile SPA includes building the general concept of the application itself and what you hope to accomplish with it. The first activity for this process is Initiation, which includes tasks like developing system requirements or in our case design requirements and the evaluation of other options, like off-the-shelf products or APIs to enhance the product. In the Supply process, a plan of execution is developed that includes a list of different milestones to be reached for the project and their associated deadlines. This process will aid in the execution of the next process or the development process. As the name suggest this is where the code for the application is designed. During this process

we have activities that include: creating high level and module designs, coding, module testing, and integration testing. The Operation and Maintenance, occur simultaneously this includes any generally enhancements and additions that enhance the general product.

The Supporting Life Cycle Processes as the name suggest contains processes that facilitate the primary life cycle with the following processes: Audit, Configuration Management, Joint Review, Documentation, Quality Assurance, Problem Solving, Verification, and Validation. We will have limited coverage of the following processes because this is not sold and marketed application but have implemented as much as the processes as possible to help with the legitimacy of our product. This standard has helped in the development and support of the software portion of our design by providing a guideline of tasks to aid us in the delivery of the application and other software needs.

4.2.4. ANSI C18.2M, Part 1-2013

The standard of ANSI C18.2M, Part 1-2013: American National Standard for Portable Rechargeable Cells and Batteries— General and Specifications is one of many standards that effects of the central hub and spike build. This standard's purpose is:

a. To ensure the electrical and physical interchangeability of products from different manufacturers;

b. To minimize proliferation of cell and battery types;

c. To define standard performance tests and provide guidance for their assessment; and,

d. To provide guidance to consumers, manufacturers, designers, and other end users.

The battery types this standard is based on the Nickel-cadmium, Nickel-metal hydride, and Lithium-ion (including lithium ion polymer) battery. These are all batteries that are in consideration for the use of the spike and central hub. These standards will allocate proper use of the batteries and dictate which battery to use.

4.2.5. ANSI C18.2M, Part 2-2013

The standard of ANSI C18.2M, Part 2-2013: American National Standard for Portable Rechargeable Cells and Batteries— Safety Standard, directly affects the project. According to the ANSI, this American National Standard specifies performance requirements for standardized portable lithium-ion, nickel cadmium, and nickel metal hydride rechargeable cells and batteries to ensure their safe operation under normal use and reasonably foreseeable misuse, and includes information relevant to hazard avoidance.

This standard sets safety standards for a "use when applicable" basis. The ANSI understands that there are no perfect set of safety standards for any and all cases. We'll

use these standards to provide as much safety with the use of batteries with the central hub and spike.

4.2.6. ANSI C18.3M, Part 2

The standard of ANSI C18.3M, Part 2 (Portable Lithium Primary Cells and Batteries - Safety Standard) is another one of many standards that affects the central hub and spike devices as well. This standard is an additional safety standard, primarily for the use of lithium cells and batteries. It specifies tests and requirements for portable primary lithium cells and batteries to ensure their safe operation under normal use and reasonably foreseeable misuse. These standards provide proper provisions to adhere to if the use of these batteries are necessary.

4.2.7. UL 61010-1

The UL 61010-1: Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements are is the standard specifies general safety requirements for the following types of electrical equipment and their accessories, wherever they are intended to be used. This standard will provide guidance for testing that will be later discussed later in our safety procedures.

4.2.8. UL 1703

The standard of UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels are in line with the solar panels of that needs to be created for the devices. Within the standards, the requirements cover flat-plate photovoltaic modules and panels intended for installation on or integral with buildings, or to be freestanding (that is, not attached to buildings), in accordance with the National Electrical Code, NFPA 70, and Model Building Codes. This standard is used for voltage source solar panels with a maximum of 1000 V.

4.2.9 208-1995-IEEE

The standard of 208-1995-IEEE: Video Techniques: Measurement of Resolution of Camera Systems describes how the measuring of resolution is done by counting the number of horizontal and vertical TV lines.

4.2.10 1789-2015-IEEE

The standard of 1789-2015-IEEE: Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers covers the concept of frequency modulations and how the effects of quick flashing bright LEDs could cause adverse health effects.

5 Design Summary

5.1. High Level Design

The highest level of design for the HAPPI system includes only the most general components. The figure below describes the system by listing the individual type of components HAPPI will require. A summary of functionality is provided for all major hardware and software components. The data flow will go over user interaction with the mobile application, all the way to functioning pathway lights. The following selections will contain descriptions, features interaction and data flow to further explain the workings of HAPPI.

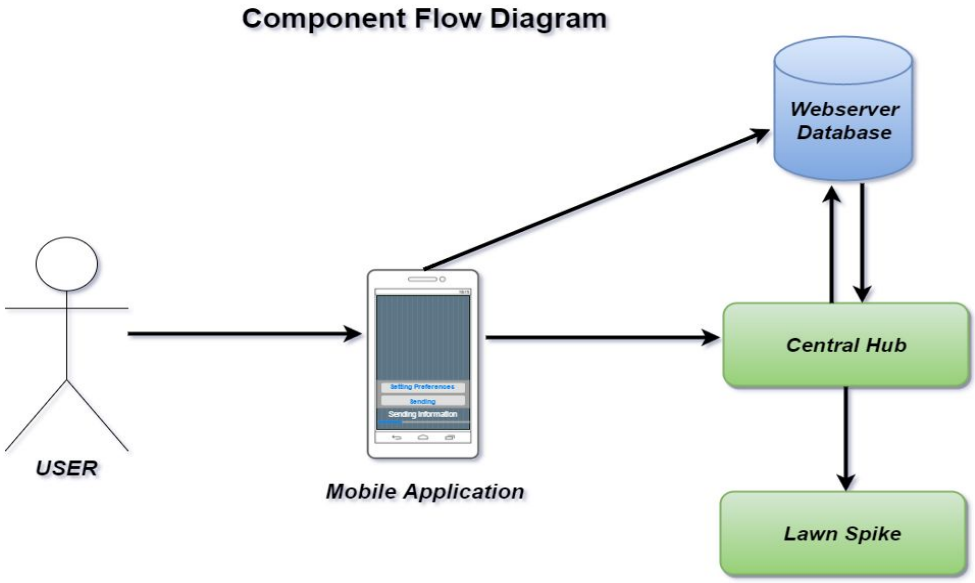


Diagram 1:Component Flow Diagram

5.2. Hardware

The high level design of the hardware is broken down into the two devices being created for this project: central hub and lawn spike. The following section will summarize each device separately and how they operate together. The following section will contain a diagram of each of the systems essential components.

5.2.1. Central Hub

The hub is the project's central brain, all components will at some point have to communicate with it and the project would not function properly without it. The single board computer will be responsible for controlling the system as a whole. This means it is required to handle user interaction through bluetooth transmission, and over WiFi. Once the user has updated any new input for the system to digest, the single board computer will then pull the new information

from an online database so that it may be ready to send the updated configuration for the lawn spiked to operate under. These configuration will also be put into effect for central hub to operate under. The LEDs on both devices the lawn spike and the central hub will be controlled from these configurations. The bluetooth transceiver in the central hub will be used to do any initial setup for the setup, like passing WiFi credentials and the other use will be to wirelessly stream our audio. The central hub will be equipped with a human detection system which entails the use of a night vision camera and motion sensing. The camera will be used to check for humanoid features only when a lawn spike has sensed motion. Once the figure is determined to be of humanoid origins then it will allow the lawn spikes to begin the light show and audio streaming.

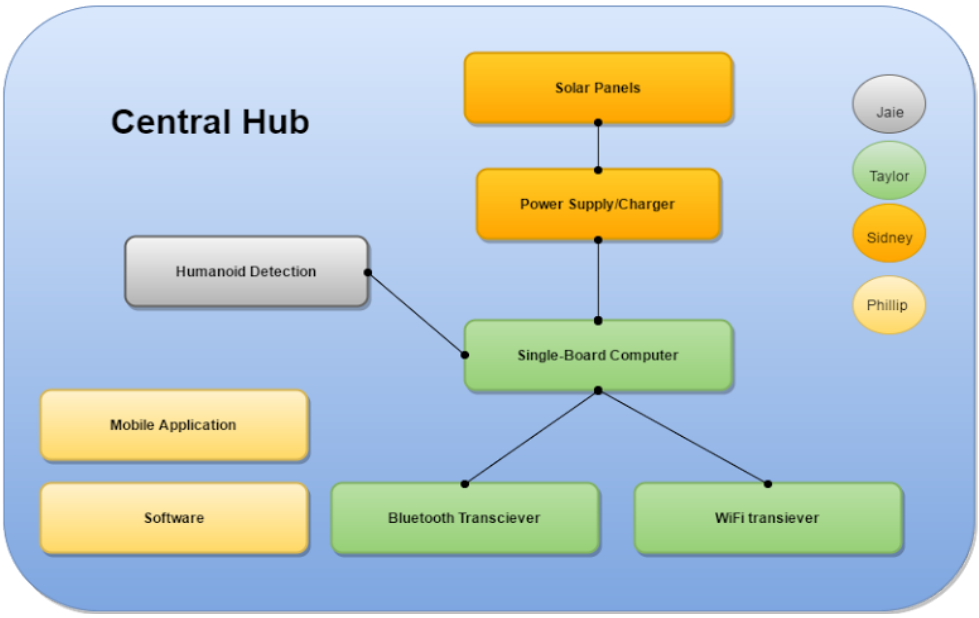


Diagram 2: Central Hub

5.2.2. Lawn Spike

The lawn spike will be responsible for illuminating the area around it and immersing the user in his/hers predefined music selection. The lawn spike will have its own microcontroller to run all the external components. The lawn spikes will be configured in such a way that makes them the slaves, and the master for them will be the central hub. The Bluetooth transceiver used in the device will be configured as an audio receiver, this is required in order to capture the transmitting streaming coming from the central hub. The Bluetooth transceiver will also have the responsibility of transmitting signals to the central hub in concerns with the motion sensors, meaning once a sensor detects motion it needs to translate that to the hub is some way. The lawn spike will also utilize the transceiver to receive commands from the central hub. The types of information to be relayed will have to deal with which mode for the spike to be in and what arguments to use when displaying lights and streaming audio. The lawn spike will

be fitted with a self-charging system that will utilize the sun's rays for actively charging the batteries in order to power our lawn spikes. The chart below will show the different components the lawn spike is utilizing and how they are incorporated into our system.

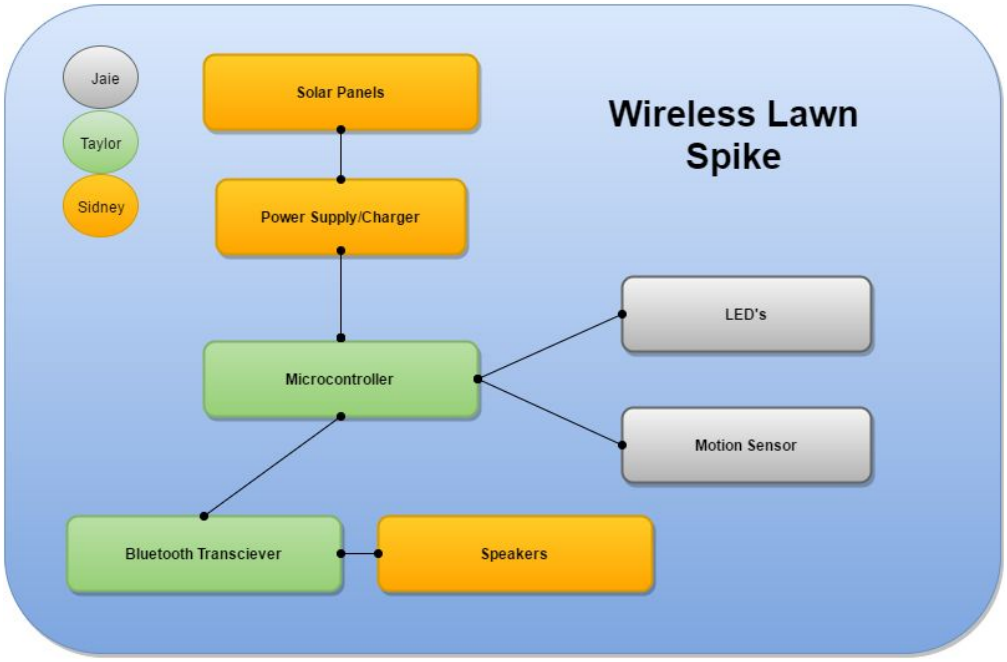


Diagram 3: Spike

Modes of operations

The lawn spike will have different modes or states the device will be put in depending on the surrounding environment and the commands it receives from the central hub. The different modes will be idle, ready and active. The different modes will help conserve energy and give the users an effective understanding of the systems. The chart below will go over each of the different modes.

Modes of Operations	
Idle	This mode is when the device is not currently being used. The only component that is running on the lawn spike will be the PIR motion sensors. The device will leave this state once motion is detected.
Ready	This mode is then the device has sensed motion and waiting further commands from the central hub in order to determine if a human triggered the motion sensors. If not a human, device reenters the Idle mode.
Active	This mode is when the lawn spikes are playing lights/sounds. The spike will only enter this mode if the central hub has determined the motion captured was of human origins.

Table 1: Modes of Operations

5.3. Software

The software section of this project has 2 major components that define this project: component connectivity and human detection. With the main components being the lawn spike and central hub, the software in most cases acts as a bridge to allow interconnectivity and communication between devices.

5.3.1 Phone Application to Central Hub Data Handling

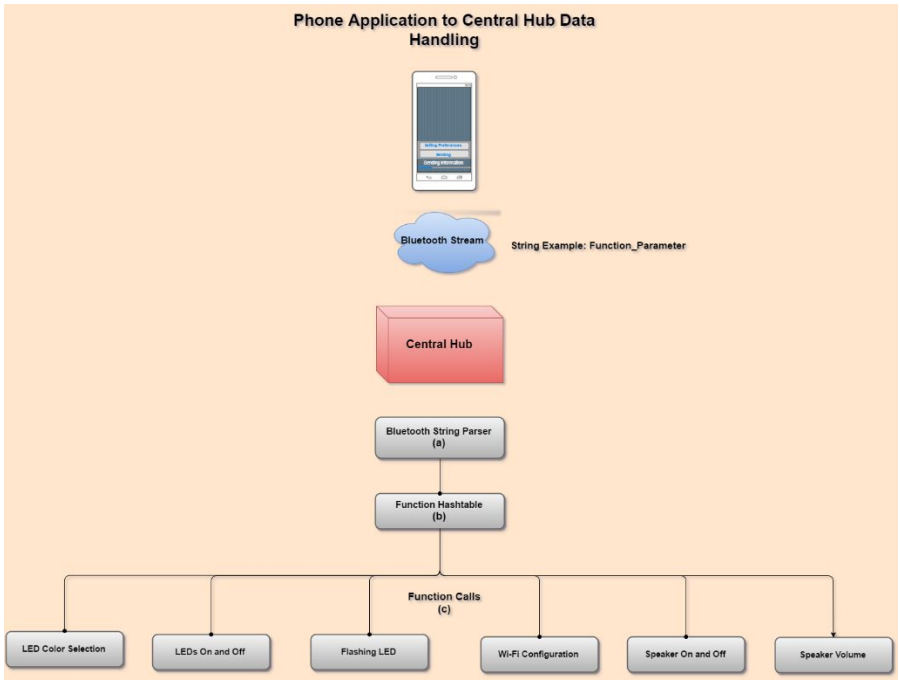


Diagram 4:Mobile App to Central Hub

Data handling as it pertains to HAPPI will be restricted to catching the Bluetooth strings that will be sent from the phone application and appropriately triggering a function to achieve the specified user preference.

Bluetooth String Parser: Strings sent from the phone will be given in a format to promote proper decoding by sending the appropriate function or keyword, following will be a corresponding parameter for setting the desired component. This will be fed through a parser that will be responsible for reading the received string and digesting the command into its key components: function call and parameter. In between these two components will be a delimiter, a delimiter is a sequence of one or more characters used to denote the boundary between independent or separate regions in a text. An example of this is LED_ Off where “LED” will be the function call, “_” will be the delimiter and “Off” will be the parameter. Once the delimiter is recognized and separates the keyword from the

parameter a command will be used to verify the keyword is the actual word the specified term.

Function Hash table: A hash table or hash map as it is sometimes referred to as is a data structure in computer science used to construct an associative array, an arrangement that will map keys to their associated functions or values. Once the text is parsed properly it will be introduced into a hash table where the appropriate keyword will initiate a function to be triggered that will be set with the following parameter. The list of keywords will be located in this hash table and will have the function to call when they are verified as a match.

Function Calls: The function calls will be the segment of code that actually accomplishes the desired action of configuring a functional component to the setting specified. There will be 6 function calls for the 6 different setting preferences to be chosen. The function calls will be initiated from the central hub, where they will be sent over to the Lawn Spikes to actually be executed.

5.3.2. Human Detected Activation

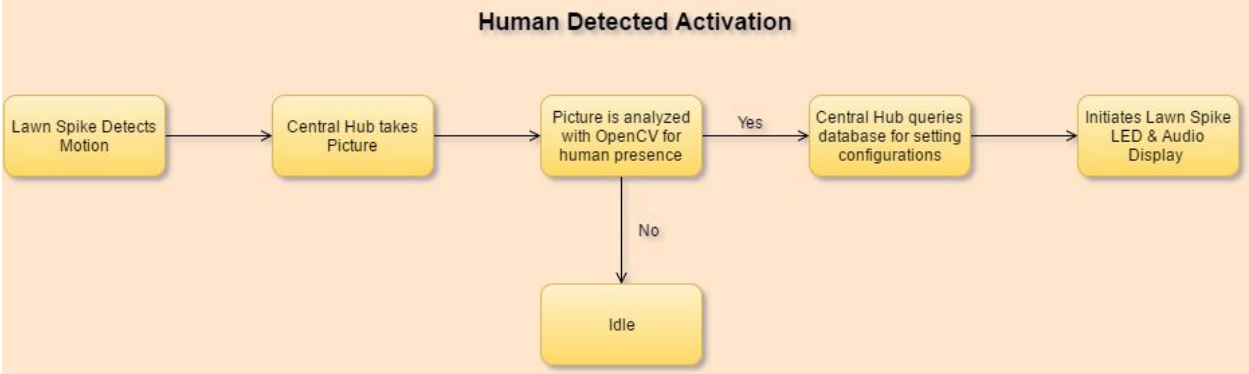


Diagram 5: Human Detected Activation

The detection of a human will launch a series of actions to initiate the LED and Audio display, this is developed in a series of steps as seen in diagram 5.4.3. The first action taken is recognizing any activity within jurisdiction of the motion detectors connected to the Lawn Spikes. This triggers a command to be sent back to the central hub which will cause it to take a picture. The picture taken will be analyzed with OpenCV to detect for a human's presence. From there a case statement will be implemented that will decide the hub's next steps based on analyzed pictures. If a human has been observed it will query the database for the setting configurations picked from the user application. The settings will be sent from the central hub to the Lawn Spikes were they will be kicked off.

6 Design Details

6.1 Initial Design

In the initial design for our central hub, we came up with a cylindrical prism that would be used to house all the components required for the hub to function. The goal was to effectively place each component in the best possible position. The batteries will be placed at the bottom with a gap leading up to our LEDs, this gap is for heat dissipation so that we do not cook all of our components from the heat the battery may left off. This is just an Initial design and plans for rework will be considered when it comes down to the assembly of the product. These ideas were also taken into consideration for our wireless lawn spike. The main goal for the spikes layout is to conserve as much space as possible, so that these lawn ornaments do not look tacky in the front yard.

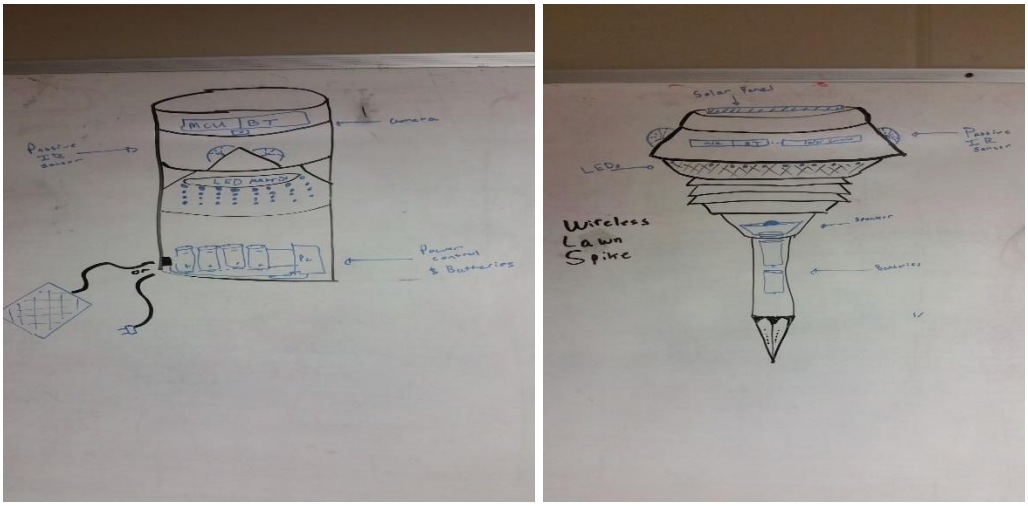


Figure 1 - Initial Design

6.2 Hardware

The design for the hardware used in the HAPPI system is composed of a variety of materials and electronics. This will require a meticulous configuration for each component to behave as intended. The following layouts have been designed to be as simple and as straightforward as possible. The HAPPI system will be mostly self-contained with only require a minimal amount of user interaction to be completely working. The bill of materials these design entails are as follows.

Bill of Materials - Central Hub				Bill of Materials - Lawn Spike			
Item	Quantity	Item	Quantity	Item	Quantity	Item	Quantity
Raspberry Pi 2 Model B	1	3D Printed Housing	1	ATmega328p	1	150 ohm resistor	1
Raspberry Pi Infrared Camera	1	4.15 ohm resistor	2	OVC3860 Bluetooth Transceiver	1	47 kohm resistor	4
SB340 USB Dongle	1	8 ohm resistor	1	24 bit WS2812 Ring	1	10 kohm resistor	1
802.11b/g USB Dongle	1	120 kohm resistor	3	12 bit WS2812 Ring	1	120 kohm resistor	3
SMD RGB WS2812	24	140 kohm resistor	1	8 Ohm 1 watt speaker	1	140 kohm resistor	1
4 Ohm 3 watt speaker	2	.1 uF capacitor	2	6x3 Polycrystalline Solar Panels	1	.1 uF capacitor	3
6x3 Polycrystalline Solar Panels	4	1 uF capacitor	4	PIR Motion Sensor	3	1 uF capacitor	4
PIR Motion Sensor	3	10 uF capacitor	1	NiMH Batteries	4	10 uF capacitor	1
NiMH Batteries	4	15 pF capacitor	24	3D Printed Housing	1	47 uF capacitor	1
				1.1 ohm resistor	2	22 pF capacitor	2
				.15 ohm resistor	1	16 MHz crystal	1
				330 ohm resistor	1	Tact Switch	1
				220 ohm resistor	1	Red LED	1
						78L05 Voltage Regulator	1

Table 2 - Bill of Materials

6.2.1 Central Hub

Single-board computer

The single board computer used in our project will be the Raspberry Pi 2 Model B. This component will handle all the initial communications between the user's android device and handle the wireless audio stream to the lawn spikes. The single board computer chosen has plenty of processing speeds to handle all the communications and subsystem components. The schematic below is how we plan on interfacing with the Raspberry Pi 2 Model B, it will include USB interface, camera port interface, and GPIO pin interface.

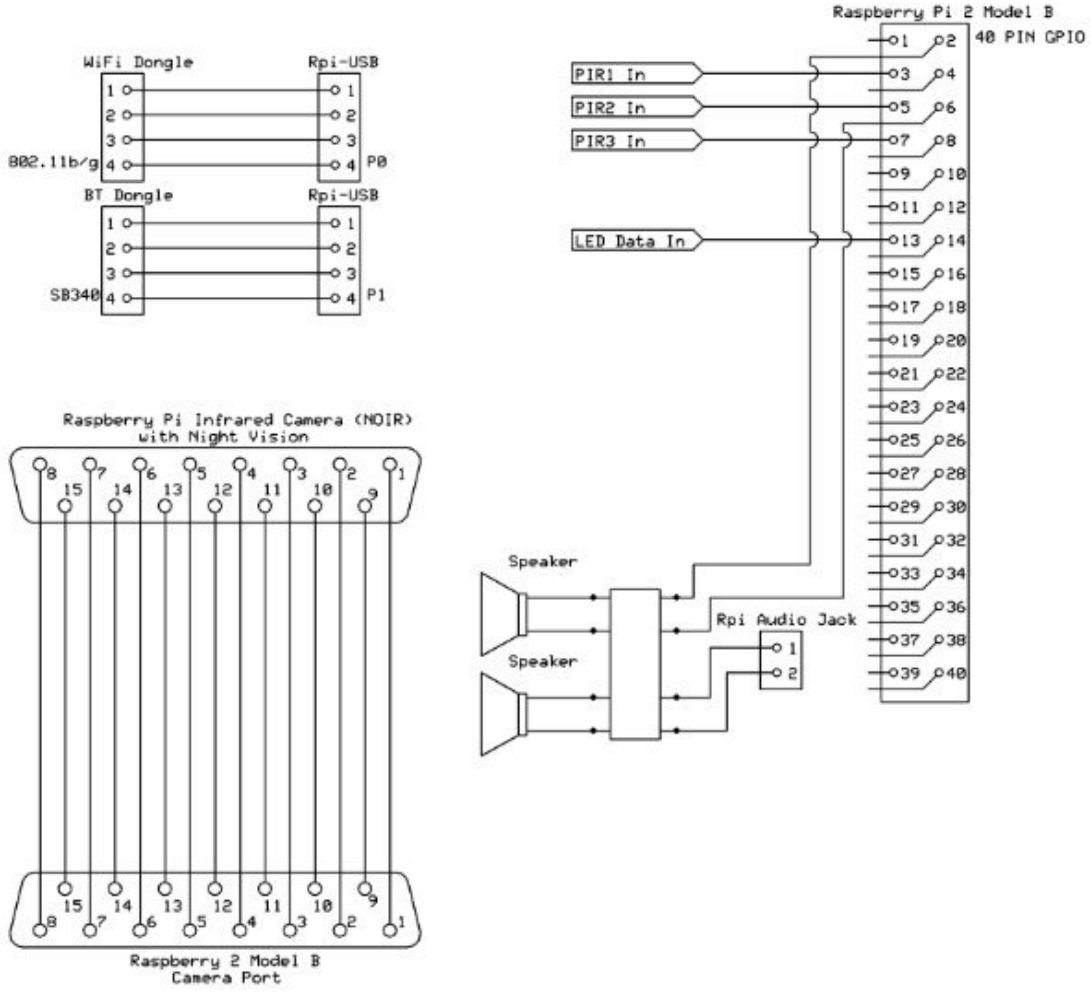


Figure 2 - Single Board Computer Schematic

The OS needed to run the Raspberry Pi 2 Model B will be Raspbian. This is a lightweight Debian based OS that will be powerful enough to run the Pi but also not consume too much of the processing power. Raspbian can be placed onto any SD card and be ran directly off of said SD card. We can either interface with

the SD card through a port on many laptops or connect the Pi via USB to any computer.

The Raspberry Pi 2 Model B contains a 15-pin ribbon cable port, this port will be fully utilized by the camera module selected for the project. The Raspberry Pi Infrared Camera Module is specifically made for our single board computer; this should help eliminate any type of compatibility issues. The camera uses a 5MP native resolution and has the capability for night vision, this is crucial since our systems time to shine is at nighttime.

The 40 GPIO pins that the Raspberry Pi 2 Model B comes with will be plenty for the intended purposes of our central hub. These pins will control the input sensor data from the motion sensors and control all LEDs within the device. Pins 3, 5, and 7 will be utilized for the data output signal from each of the PIR sensors.

The two USB ports on the Pi will be fully utilized to hold the Bluetooth dongle and Wi-Fi dongle. This will help alleviate any extra soldering brought on when introducing non-USB modules. The HAPPI system will need to interact with majority of wireless networks, we will utilize the TCP/IP stack protocol, to remove the need for a custom protocol layer. This design makes it very simple for any user to connect the central hub to most wireless networks without any difficulties. The Bluetooth dongle used will utilize the A2DP wireless audio transmission protocols and the SPP profiles, this helps remove any complexity required in encoding and decoding the audio streams over a Bluetooth network and the SPP will give us the ability to have bidirectional communication between the hub and lawn spike.

The Raspberry Pi 2 Model B also is equipped with an auxiliary output port, we will utilize this port to connect a set of speakers too so that the user will be fully immersed in audio no matter what device they are passing. These speakers will require a 5v input which they will be able to receive from the 2nd GPIO pin on the Raspberry Pi and they will be grounded with pin 6. The speaker’s wills will have a aux plug on them which we will plug directly into the Pi.

Humanoid Detection Subsystem

Humanoid detection is a subsystem to our central hub, it will encompass motion sensors and a camera. The motion sensor is important for picking up any type of movement that could be caused by a human. The camera will be the eyes to our project, this will determine whether the motion the sensors picked up are of human origins or just an animal or the wind blowing items around. This design will be used to conserve energy, so that the camera only runs when motion is sensed. The following section will go into further details of the subsystem’s components.

Motion Sensor

The project will utilize Passive Infrared motion sensors (PIR), these are very unique for they have an extremely wide Field of View (FOV) of 110 degrees. The project will require 3 motion sensors in each device in order to cover as close to 360 degrees as possible. The sensors will be configured into a triangle formation similar to the one in the figure below.

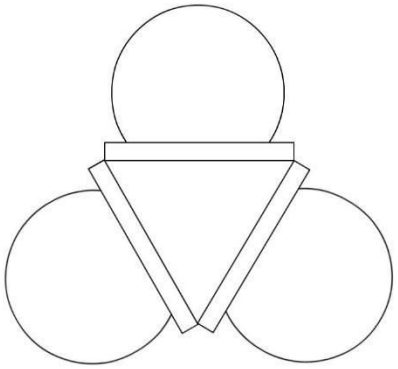


Figure 3 - PIR Sensor

This formation will give the sensor the largest FOV without much overlapping signals. Each sensor is created with 3 pins, the outer pins will be used to power and ground each sensor then the middle pins will connect to the Raspberry Pi 2 Model B using the GPIO pins 3,5, and 7. The schematic below will demonstrate our design.

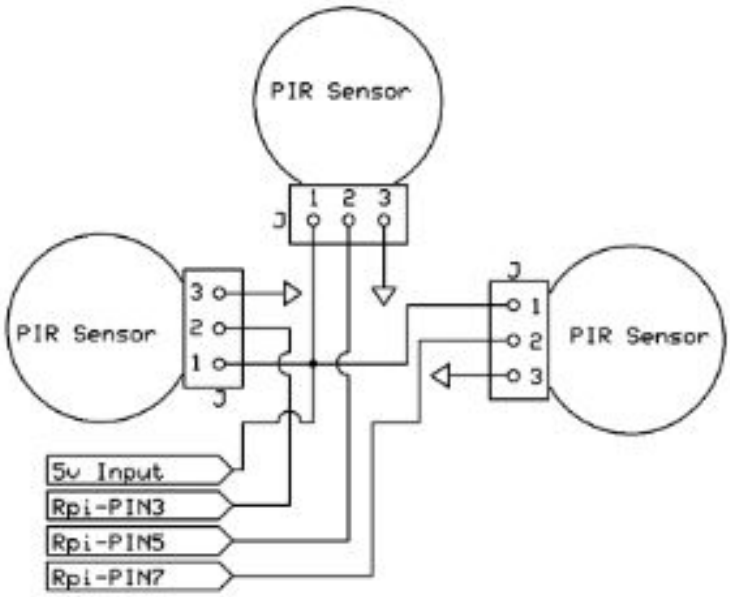


Figure 4 - PIR Sensor Interior Schematic

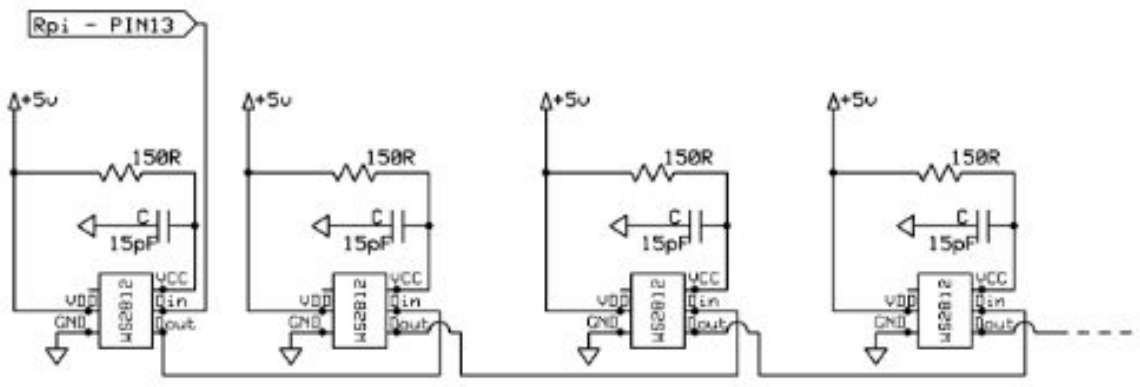
Camera

The camera setup for the project will be quite simple, since the Raspberry Pi 2 Model B is equipped with a specific 15-pin port only for a camera module. The camera will communicate with the Pi over the CSI bus, a higher bandwidth link which carries the captures pixels to the processor. The camera will have its own hole bored out of the housing, towards the top of the central hub in order to obtain the best vantage point for image capturing. The camera will only need to capture images and not worry with recording, since video recording will produce a lower quality resolution of 1080p at 30fps. The image captured by the camera module will have a resolution of 2592 x 1944, these images should supply a high enough fidelity that will give the image processing a crisp photo to work off of.

Lighting Subsystem

The lights used in the central hub will be 24 SMD RGB WS2812 LEDs, these are very unique LEDs for they include the red, blue, and green spectrum of visible light compacted into one component. These LEDs will be connected in a daisy chain fashion; this means we only need one data line to control all the LEDs. The output of the first LED will become the input for the next LED in the chain and this will continue for each individual LED. The WS2812 have the LED drive included in the component, this eliminates a need for an external LED driver which makes the design of our system a bit easier. The daisy chain configuration makes this design very modular and scalable in the aspect that we would be able to add more LEDs to the hub if needed and the redesign would be very minimal. Our data line used for the WS2812 will be connect to the GPIO pin 13 on the

Raspberry Pi. The following schematic will demonstrate our approach to the daisy chain configuration.



Power Supply

The power supply will be outlined in the discussion of this section. The sections would range from the power supply from wall outlets and the solar panel sets. The power supply is composed of the Wall outlet, the solar panel, and the battery packs respectfully for the central hub and the solar powered lawn spike**.**

Adapter

As previously discussed, the components to power the central hub is the wall outlet. The wall outlets provide alternating current which differs from what is needed for the NiMH batteries. Originally the central hub had a solar powered rechargeable battery unit, however as the process of creating the hub the went underway changes occurred. The power for the hub will come from the wall to the AC/DC adapter to the previously mentioned Raspberry Pi 2 Model B and trickle to the rest of the components of the central hub.

The AC/DC adapter will not only convert the voltage from AC to DC, it will also provide a step down sequence. The wall outlet output is 120V and DC voltage will need to step down much lower voltage and current. Protecting the NiMH batteries will no longer be a priority when powering the hub, so a DC adapter is all that is required to power the Raspberry Pi. We will be using a 5V adapter to step down the voltage of the wall output.

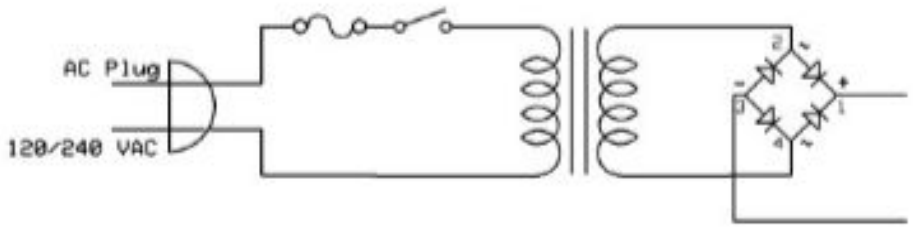


Figure 5 - AC/DC Conversion Schematic

The central hub and is composed of different components and require various input voltage and input currents. The central hub connects to the simple computer (Raspberry Pi), LEDs, and the PIR motion sensor. Each of the components in terms of input voltage and current are listed below.

Item	Input Voltage in Volts	Input Current in Amperes
Raspberry Pi	5	2
LEDs	5	2
PIR Motion Sensor	3.3	1

Table 3 - Central Hub Output Table

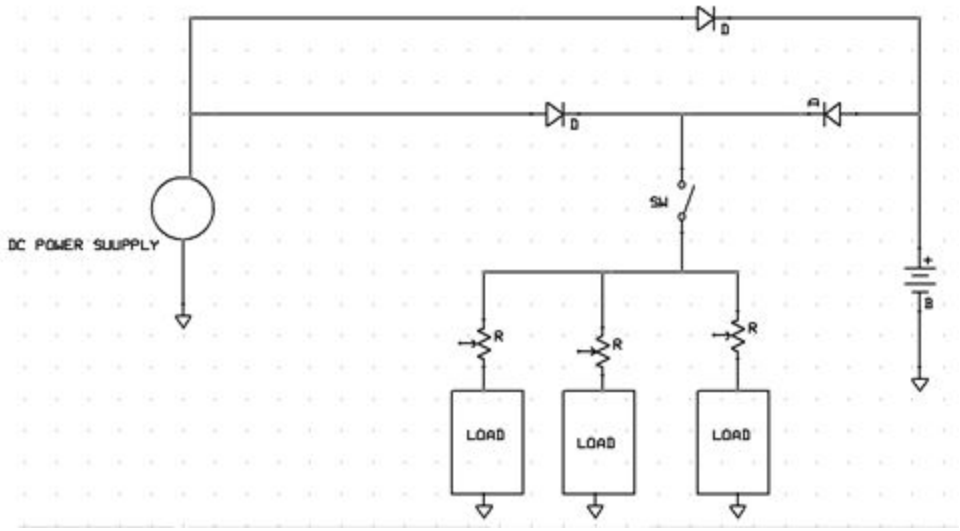


Figure 6 - Battery Output Schematic

Solar Energy Charging

When charging any battery source, it's important that the source's output voltage matches that of the battery. When constructing the charger circuitry for the battery, the circuit is not as simple as energy from the cells directly into the rechargeable battery. The battery needs to be protected from overcharging and current flowing back to the panel. Schottky diodes are added to the schematic to protect the batteries.

The solar cell components generating a voltage of 12 V with a current of 45 milliamperes (mA), with these measures the time it would take to fully charge the battery unit. With the range of Sunlight, the power and energy from the sun varies throughout the day.

Battery Output

The power supply will contain a battery charger and would have the capabilities to charge the battery as well as power the spike; as mentioned prior the hub no longer will have a rechargeable battery unit. The battery output has the capabilities to charge from the power supply and send energy to the desired load. As seen below the battery charger depicting how our batteries will charge.

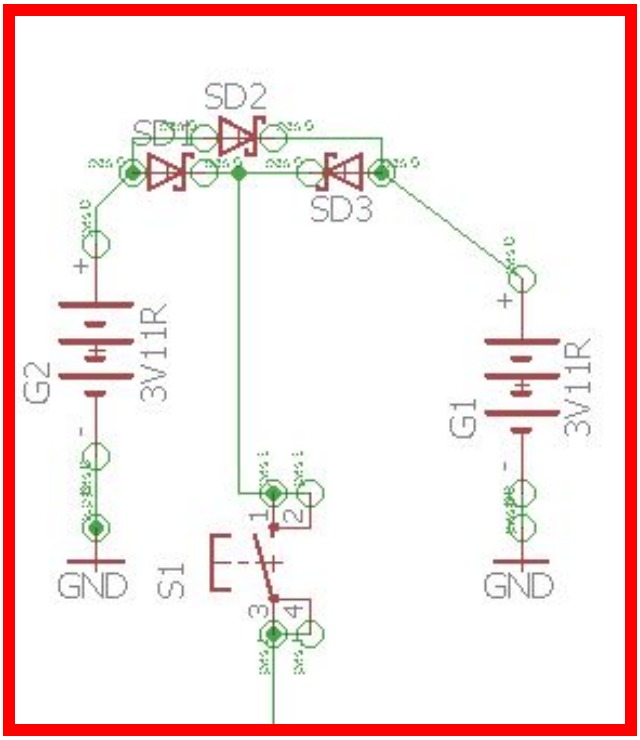


Figure 7- Battery Charging Unit

As seen above in the diagram, Schottky diodes are contained in the circuit. The Schottky batteries are set so that the charge from any power supply flows in one direction.

To combat for the various loads that need to be powered for the and spike will both be using a 9V battery pack which has 2500 mAh (milliampere-hours). For a NiMH battery of those specifications, the usage time before unable to be used without additional charge is dependent upon its discharge rate. For the battery, to fit the requirements of the battery life needing to last at least 2 hours, the discharge rate is at most 1.5 Amperes (A).

Run Time = Current Capacity of Battery / Discharge Current Rate
2 Hours = 2.5 Amp-Hours / At most Discharge Current
Discharge Current = Current Capacity of Battery / Run Time
Discharge Current = 2.5 Amp-Hours/ 2 Hours = 1.5 A

Figure 8 - 1.5 V AA Batteries

The wall outlet and solar cells have different charge rates. The wall outlets output current and charge varies depending on the adapter. For the solar cells, the current rate of 12V 45 milliamperes, it would take at most 15 hours to charge. That charge time more than suffices for the devices, especially with the ranging sunlight throughout the day.

Charge Time = Current Capacity of Battery / Charge Current of source

The lawn spike's connectivity is similar to the central hub but has differences. The 9V battery unit will be outputting voltage to four loads. Each load requires different types of input voltage. In order to maintain the proper input voltage levels to each load, separate resistor levels. It's connected to the microcontroller, the LEDs, the audio transceiver, and the audio amplifier. In the two images shown below, depicts the complete schematic of the batteries powering the solar spike as well as the live version of the PCB after completion of the board.

Item	Input Voltage in Volts	Input Amperes in A
Microcontroller	5	2
LEDs	6	2
Audio Transceiver	3.8-4.2	1

Audio Amplifier	2.7-5.5	.7778 - .38181

Table 4 -Spike Output

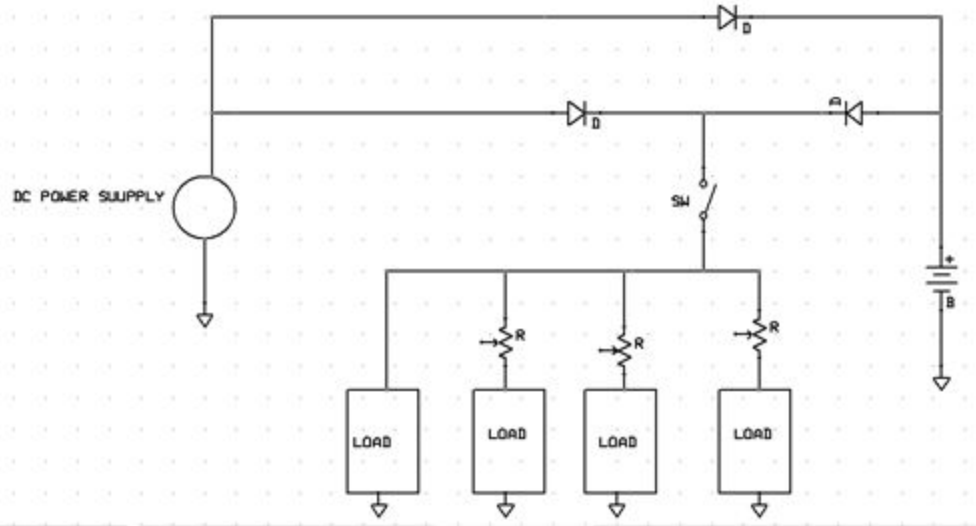


Figure 9 - General Battery Output Spike Schematic

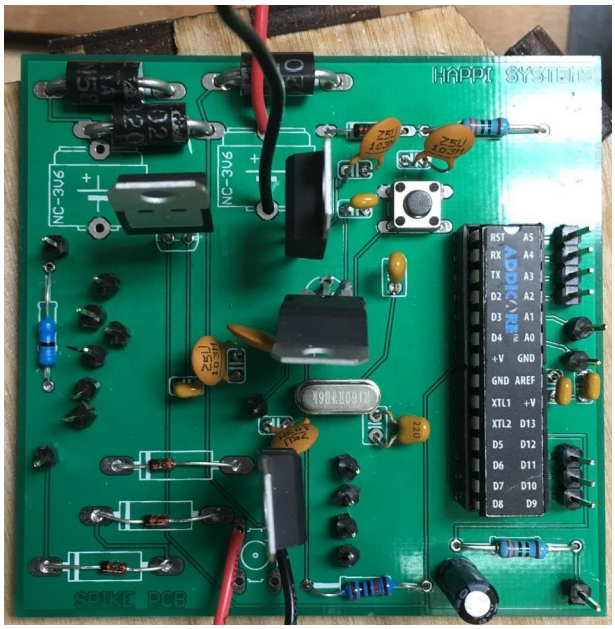


Figure 10 - Complete PCB

6.2.2 Lawn Spike

The wireless lawn spike will be one of the most complex part to our project. The design will require a PCB design for holding the devices microcontroller, resistors, diodes, wireless transceiver, and other external devices connections. These designs will only go over a single lawn spike, but the designs will be the same for each individual spike.

Microcontroller

The microcontroller will require the most design for our lawn spike, this is expected since it will be required to control all necessary components. The ATmega328p was selected as the microcontroller to use in each lawn spike, since they have plenty of processing power to utilize. The schematic below goes over our intended design for the microcontroller, the schematics layout was generated to have all the GPIO pin to be on the right hand side and the other pins will be on the left. The microcontroller can run on either a 12MHz or a 16MHz crystal. The 12MHz crystal only requires a 3.3v input but our group decided to use a fast crystal so we will use the 16MHz crystal which requires 5v input, this input will be outputted from our power supply. The other pins on the left handed side of our design follows the schematic provided in the research section. The pins on the right hand side will be the GPIO and receiving/transmitting terminals. We will be utilizing pin 23 for controlling our LED rings, the LED rings will connect in a fashion that only requires a single input similar to the central hub. The motion sensors data output line will be connecting to pins 24-26, we separate each one individual so that we do not overload the microcontroller with a single line that has all three of the signal on, if more than a single motion sensor detects motion then it will send a voltage of 6v and higher which will be too much for the ATmega328p to handle. The pins 27 and 28 will be used to control the volume of the Bluetooth audio transceiver. Finally, the RXD and TXD terminals, pins 2 and 3 respectively, will be used to connect to the TXD and RXD terminals on the Bluetooth transceiver.

The microcontroller will need to be burned with the Arduino bootloader, this is a painless process and only requires us to have an Arduino Uno to start. First we must ATmega onto a breadboard with the desired clock, we will be using the 16MHz crystal for this. Next we will need to connect our ATmega to the Arduino UNO, doing so only requires connecting the ATmega pins 17-19, to the UNO's pins 11-13 respectively. Finally, the AVCC and VCC pins need to be supplied with a 5v power source, we can utilize the UNO's 5v output pin for this. Once the board is fully setup we can connect the UNO to a computer via USB cable. Final we need to open the Arduino IDE and open up the ArduinoISP sketch, then we just run the burn bootloader. Once that is all finished we will have an ATmega328p successful burned with the Arduino bootloader, ready for initial setup.

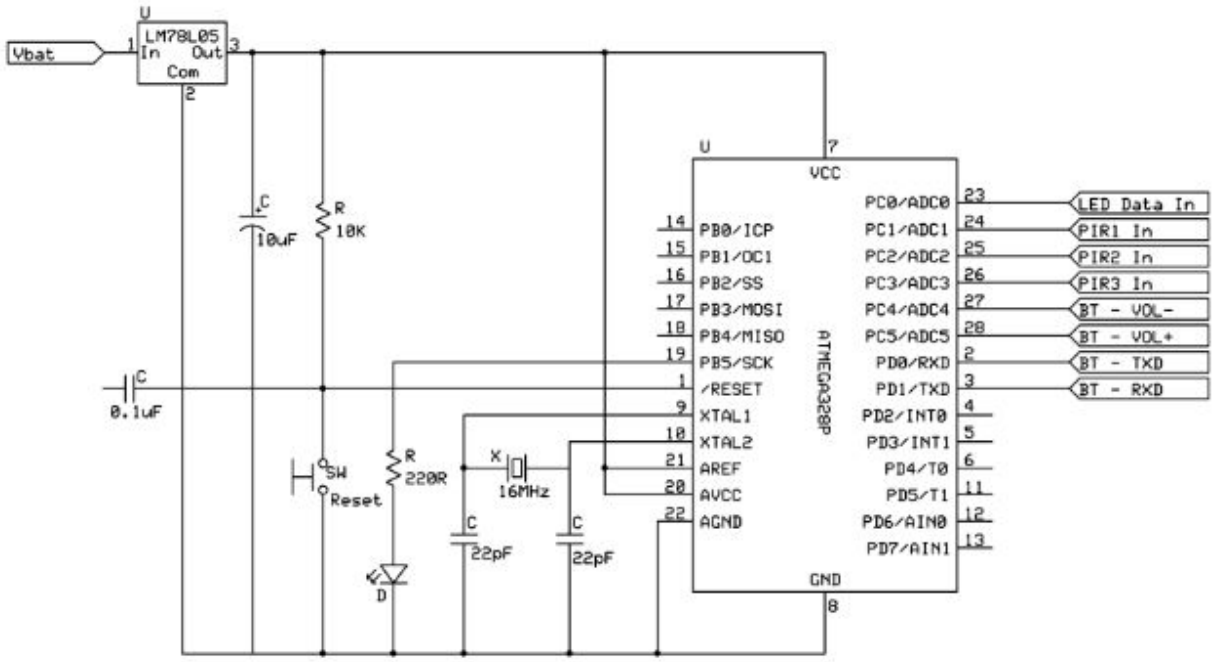


Figure 11 - ATMEGA38P Schematic

Bluetooth

The wireless lawn spikes circuitry will require more complexity to it then the simple USB dongles for the central hub. The Bluetooth transceiver, RN-52, will require through hole soldering so we will be adding jumper wires for the RX and TX connections to a section of our PCB to allow for ease of connecting. The wireless lawn spikes Bluetooth module will act as the spikes audio receiver to accept the signal from the central hubs Bluetooth transmitter. The RN-52 is equipped to work with A2DP and SPP transmission profiles, this is important since our hub will be operating with the same two profile. The schematic below will go over how the RN-52 module will be wired and which components its leads go to.

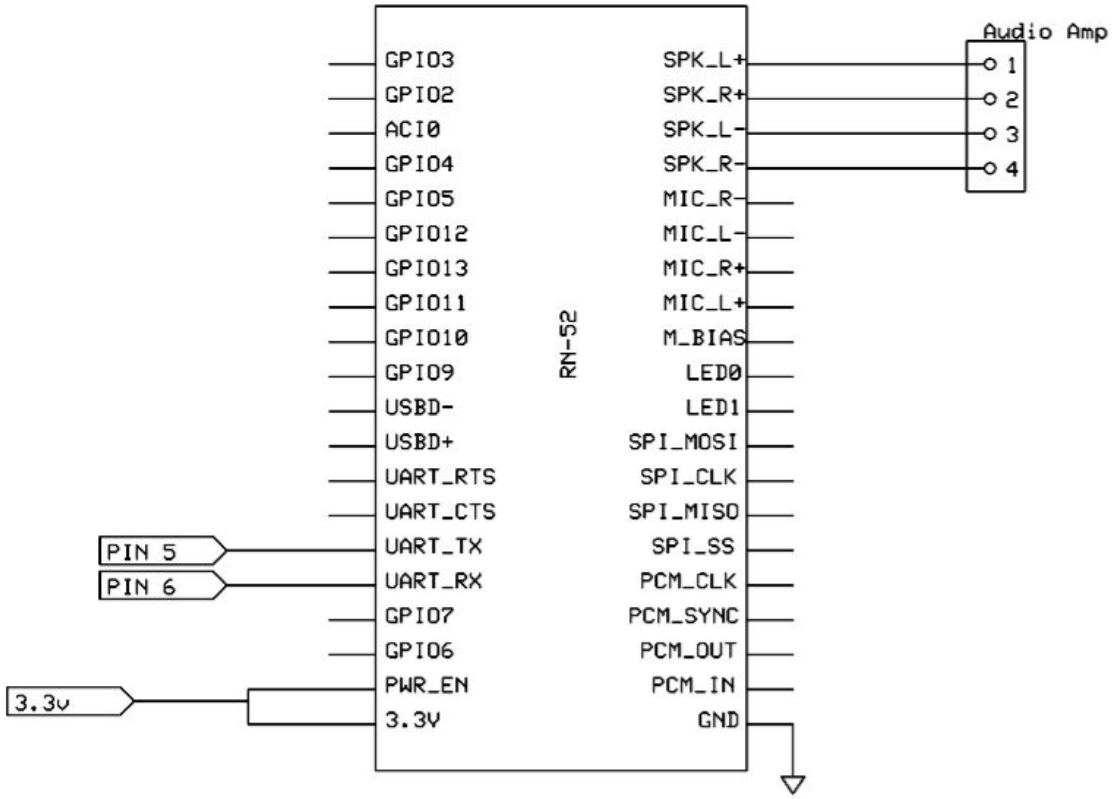


Figure 12 - Bluetooth Schematic

The SPKN pin is our stereo differential output negative terminal, this is where our negative wire from our speakers will go. Next is the SPKLP and SPKRP, these pins are for a stereo connection with multiple speakers. The VBAT is our power input terminal and will take the positive lead from our device's power distribution board. The TXD and RXD terminals will connect straight to our microcontroller, this will allow us to communicate with the central hub via Serial Port Profile. The AVRCP terminals include MUTE, BACK, FWD and MFB, these correspond to the GPIO10 - 12. These terminals will give us complete control over audio playback, but we will not be using these for our project, we will use the VOL+ and VOL-. These will be connected to the GPIO pins on the microcontroller. The Last terminal to be mentioned are the GNDs these will be connecting to a grounded plate within each device, and in the diagram above we can see which pins will use common grounds though we must be sure separate the common grounds between the audio circuit and the other grounds. The reason for separating the grounds is so we do not get any interference on the audio lines, this would cause our speakers to play a static/white noise which is not favored in any audio system.

Motion Sensing Subsystem

The motion sensors on the lawn spike will act as an extension for the hubs motion sensing. Since the spikes will be further away from the central hub's motion sensing range it, the lawn spike will be able to communicate when they detect motion. The sensors will be the same make and model as the ones used in the hub itself. The motion sensors will have the same triangular configuration used in the central hub, since this will supply the largest FOV and conserve the most space. The data output for the motion sensors will utilize their own pin on the microcontroller, pins 24-26. The schematic below will be very similar to the one used for the central hub but with different output tags.

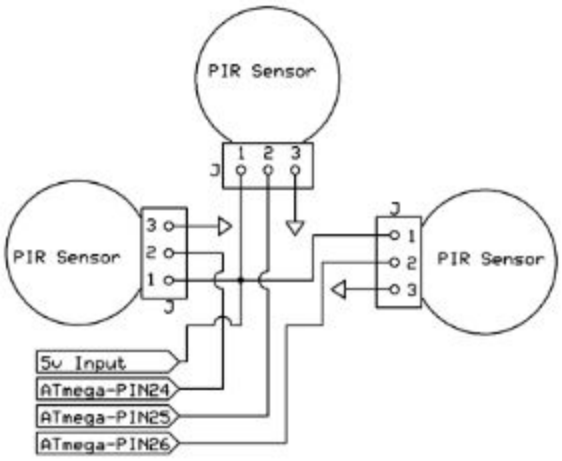


Figure 13 - Spike PIR Senser Schematic

Lighting Subsystems

The lighting used in the lawn spikes will be two concentric rings, with one ring containing 24 LEDs and the other will have 12 LEDs. The LEDs to be used on the rings will be the same as the central hubs, SMD RGB WS2812. The LEDs on the rings will have the same daisy chain configuration as the schematic provided in the central hub. This daisy chain configuration allows for a simple integration into our system. The rings will only require a single data input line, meaning we will only need one pin to connect to on the ATmega328p. The data line will be connected to the PC0 port on the ATmega328p also known as pin 23. The schematic below will show the two concentric rings and their wiring configuration.

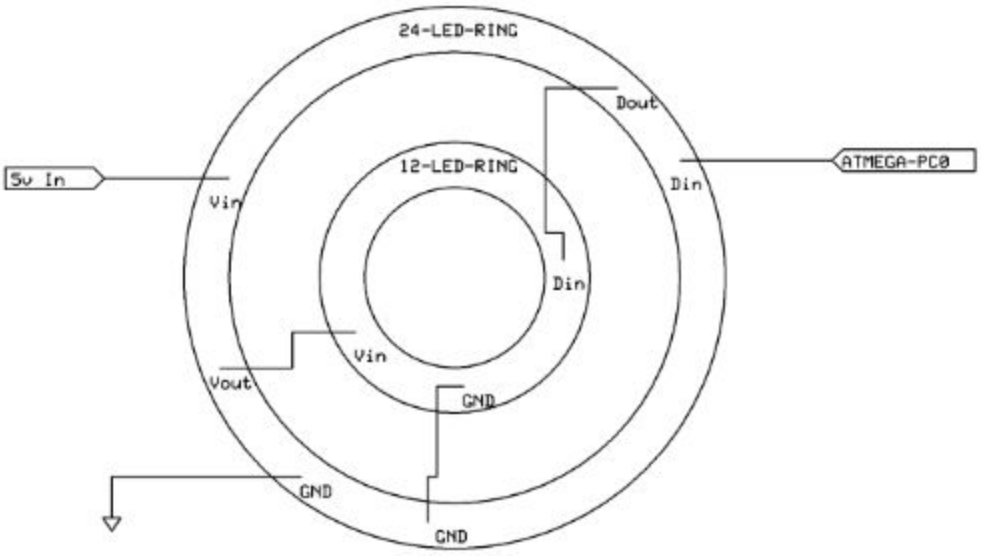


Figure 14 - Neopixel Ring Schematic

Speaker

The solar powered lawn spike has its limitations in size because HAPPI must remain portable. With its limited size, thus sets its limited parts i.e. the speakers. The solar powered lawn spike will have one speaker with the capabilities to produce enough sound. The speaker used for the spike will be an 8 ohm 1-watt speaker. The data will be transmitted from the Bluetooth function to the amplifier then matriculating to the 8 ohm 1-watt speaker. Amplifiers are traditionally built to set and disperse the audio to two speakers (one for the left and one for the right). The amplifier the solar powered spike will contain is a 2.1 W Class D Audio Amplifier and its schematic is similar to most amplifiers. As the speaker needs to set to output to one speaker without losing the effects of another, a passive stereo to mono converter must be used. The conversion can be seen below as well as the convertor being attached to our amplifier.

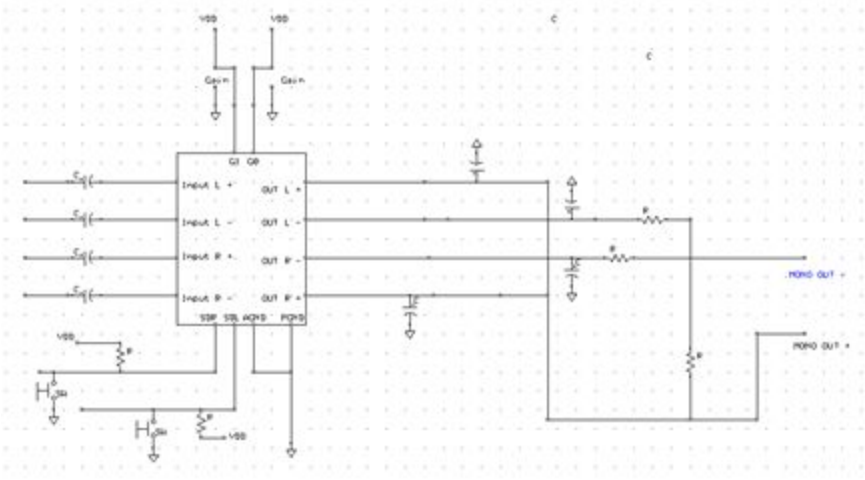


Figure 15 - Stereo to Mono Conversion Schematic

6.3 Software

The design for the software components of HAPPI will primarily encompass human detection, component connectivity and the graphical user interface. Each of which playing an instrumental part in the core functionality of our project. The sections below will unfold the role these components play and how they have been implemented.

6.3.1 Humanoid Detection

The human detection system will utilize the OpenCV library for handling all the image processing. OpenCV is a very robust library and is mainly used for object detection or machine learning applications. We will be using the CascadeClassifier class within OpenCV, this class is used for object detection and allows the computer to visually detect items and object within a 2d image. The human detection system will rely on two distinct features that humans all have: facial features and body shape. When detecting the face of a human OpenCV will be looking for 3 key items: two eyes and a circular face. In general, everyone on earth has two eyes and this is something computers are very good at picking up on, and to expand on that the two eyes but be surrounded by another circle. This second circle being the outline of one's face, the system will utilize these features and be able to determine whether the object that triggered the motion sensors as a humanoid feature. This method of humanoid detection will only work for people that are walking towards the central hub but we must make sure we can detect a human's presence without their face directed towards the camera. The second method for human detection will be with the person body form. This method will be a bit more tedious and require a lot of training in order for the system to determine if a human is present. In order to train our

system, we will be required to subject our program to many different images with humans in them. We must be sure the humans are facing different direction and in different stances in order for the system to accurately determine the motion generated was of human origins. This will be one of the more labor intensive designs for the software aspect of the HAPPI system.

6.3.2 Mobile Application

The phone application in this project will serve as the graphical user interface for controlling the hub. The following will cover the software design of the mobile application that will be incorporated within HAPPI. The software languages included will be primarily Java, XML, and PHP.

Functional Components

Splash Activity

No: FC01
Statement: The system should have a splash page.
Source: Application Developer
Dependency: None
Conflicts: None
Supporting Materials: None
Evaluation Method: The application upon launch will have welcoming screen.

Table 5 - Splash Activity

When you launch the user interface the first thing you will see is the splash page; it serves to welcome users to the application and our services. What occurs during its initial launch is a couple animations, the first being our logo spinning and secondly a text message zooming across the background layout. The animations will fade out in about 5 seconds and the login activity will then flash to the screen.

To do this we edited the AndroidManifest.xml (a root directory that presents essential information about our application) to call this specific activity first, delaying the default launcher that was initially configured to the Main Activity. In the actual Splash Activity, the majority of the code is called in the onCreate method, which activates all code within its jurisdiction to react when the page is initially put up. This includes the text and image we have being animated, which are initialized in the code according to their identification string specified in the

xml code for the corresponding splash activity. The animations are a datatype of their own as well and are required to be initialized too for them to be called. In this code we have 3 animations being utilized: fade out, rotate, and size. As the name suggest, fade out allows the object to dissolve out of view and was a built in animation. Rotate and size are animations the application developer had to create in another xml file. Rotate, as the name suggest spins the picture in a clockwise fashion from 0 degrees to 360 degrees. Size, leaves some room for interpretation because although it does increase the size of the letters it also shows the words coming in from left to right, until they are centered in the middle of the screen. The animations, size and rotate, are called and started in the onCreate method where they're initialized; fade out differs by being called in the onAnimationEnd method. This is a result of its timing as compared to the other two animations, fade out ends the splash activity and starts when both size and rotate are finish. After which the login activity pops up to the screen.

Google Play Music Interface

No: FC04
Statement: The system will have Google Play Music interface
Source: Application Developer
Dependency: API
Conflicts: Finding adequate API
Supporting Materials: Component Research-Google Play Music Interface
Evaluation Method: The application will have a google play API to facilitate the playing of music.

Table 6 - Google Play Music Interface

This page will be used to interface with the Google Play Music API that will be launched from the central hub microcontroller. It will facilitate the viewing of all songs available to be played.

The xml layout will contain textView headers for the attributes associated with the songs such as artist and title. Below will be a listView to display the song attributes per song with each row of the listView element.

There will be also be a class for the attributes associated with each song, along with getters and setters to facilitate the accessing of traits. We will use this class in the ServerRequest for accessing all of the songs from the database, with each song an instance of that class with its associated attributes will be created and initialized to the values derived from the database. This new instance of the class

will be added to an adapter class where its attributes will be the information showed in a row.

The listView previously mentioned in the xml layout will be initialized to this adapter class with the function called setAdapter, this will create each row of the listView. When a song is grabbed from the database it will be added to the Adapter java class. This java class will have a static layoutHandler with the same associated song attributes, these will be initialized with the song's class attributes thanks to the getter functions mentioned earlier. The attributes will then be displayed by row when the getView function is called. When clicked a song will send its streamID (which is an identification string to play its corresponding song) to the microcontroller to inform it which song is to be played next.

User Interface Components

Easy Navigation of Application

No: UIC01
Statement: The system should facilitate easy navigation throughout application.
Source: Application Developer
Dependency: None
Conflicts: None
Supporting Materials: None
Evaluation Method: The user must be able to click buttons to allow navigation of application.

Table 7 - Easy Navigation of Application

Within the application we hope to accomplish a natural an intuitive feel, which will promote easy navigation through the user options. This will heavily rely on the page layout and user prompts to direct the user where to go.

In the case of the page layout the application developer thought it would be effective to have everything play off of the menu page which will be the first thing the user sees after he or she has successfully logged in. From the main menu page most of the included functionality will be offered in succession for the user to select. The application developer thought to put the offered options in order of importance to develop a natural flow of how interactions with the central hub should go. The first being the option to turn the central hub off or to reboot. The next being Bluetooth connection because it is required for the other two options which are the interface and the setting preferences. This can be seen in diagram 5.4.2.1. To couple this is the inclusion of imageButtons to help with the menu

selection process, pictures will help indicate the next desired feature to be picked.

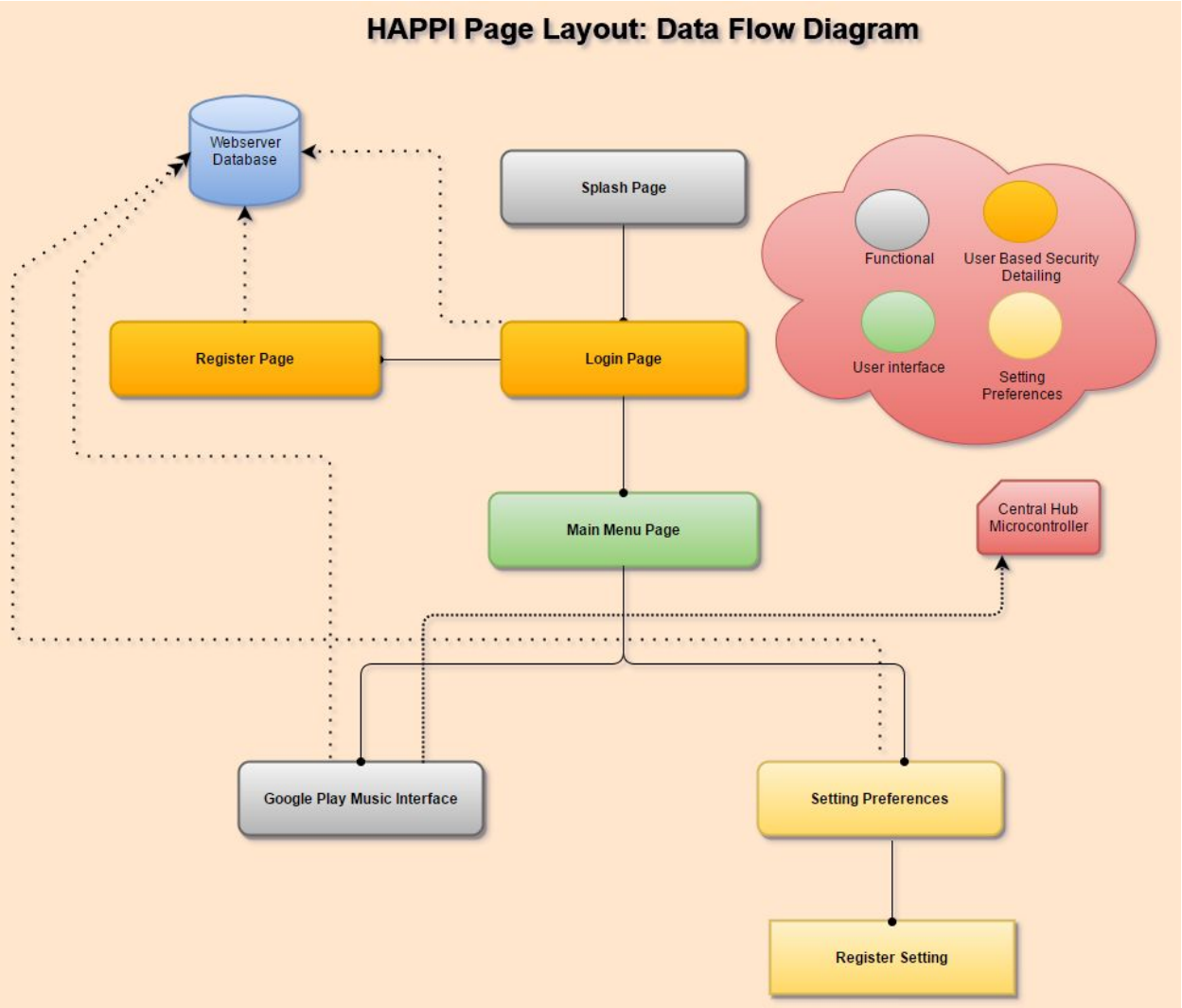


Diagram 6 - Data Flow Diagram

7 Project Prototype Testing

The following section we will go over the testing procedures for the wireless lawn spike and central hub. We will start with discussing the test environment in which our project development will take place. Next we will go over the steps to testing each of individual integrated hardware. Finally we will discuss the methods for testing the individual software.

7.1 Testing Environment

The testing environment for the prototyping will consist of different area, UCF engineering senior design lab, UCF CREOL senior design lab, UCF physics undergrad room, UCF Idealab, and the team member's individual homes. The UCF labs will provide most of the commercial equipment needed for testing our electrical hardware components, any other equipment required will be supplied by the team members. The following list will be the equipment needed for effective testing and the suppliers;

UCF provided equipment:

- Tektronix Dual Channel Function Generator
- Tektronix Digital Precision Multimeter
- Agilent Triple Output DC Power Supply
- Dell Optiplex Desktop Computers
    - Multisim
    - Matlab
- 3D Printers

Team member supplied equipment:

- XPower 900m series Soldering and Heat Gun Station
- Soldering Helping Hand with Magnification lens

7.2. Safety Procedures

Safety Procedures will be composed of three sections: Personal Protective Equipment, Work Area, and Procedures. These three sections will provide examples as well as an outlook and various tasks can be performed. However, before going in the tasks understanding the three sections is also key.

As the construction of the electronic devices occur, Personal Protective Equipment (PPE) needs to be taken in account. The devices intended to be built include electronics and humanoid detection. Both of which can be harmful if improperly built. It is the responsibility of all parts involved in the time of any

construction of the devices to make sure all in the work environment have the proper PPE. Types of PPE that we'll cover include:

- Eye Protection
- Hand Protection
- Foot Protection
- Skin Protection

The workstation, or work area, is very important to the safety procedures as well. Working at an area where all the important equipment is provided as well as clear of non-useful equipment is extremely vital. Tasks can of course not be completed if the proper tools, software, and safety equipment is not provided. Also, improper tools and any other clutter in the way will cause one to make mistakes, potentially harm themselves, potentially harm someone else and/or prevent one from completing their tasks.

The last section of the safety procedures is the procedures themselves. The procedures will be a culmination of the PPE, the work area, and the duties one needs to perform. The procedures should ensure a safe working environment and a safe use of equipment.

7.3. Hardware and Software

7.3.1. Central Hub

The following sections will go over the testing procedures for each individual component that will be going inside the central hub. The test will be laid out in a very easy to read table, with test name, objective, preparation, Procedure, and the expected results.

Single Board Computer Test

The single board computer test objectives will be to ensure that the device powers on properly and have the capabilities to load the Raspberry Pi's OS. This step will allow us to proceed to adding the required code and connect the external components needed for the central hub to function properly. The supplies needed for testing will be:

1. Raspberry Pi 2 Model B
2. Power Supply
3. USB keyboard
4. HDMI Monitor with cables
5. SD Card

The preparation for testing will be minimal for all we will need to do beforehand is format the SD card and install the proper OS, Raspbian. The procedures for accomplishing this test will go as follows:

1. Plug the HDMI Monitor into the HDMI port on the Raspberry Pi Model B
2. Plug USB keyboard into one of the USB ports on the Raspberry Pi Model B
3. Plug power supply into wall outlet then into the Raspberry Pi Model B
4. Plug in SD Card into SD slot on Raspberry Pi Model B
5. Wait for status lights to turn on and blink
6. Go through OS setup from SD card
7. Wait for OS to load
8. Interact with OS and run HelloWorld.py

The expected results from this test will to have the Raspberry Pi Model B power up and install the proper OS, and then be able to interact with the OS just install and run a simple python script to print out a string “Hello World” to the terminal window.

Wi-Fi Connectivity Test

The Wi-Fi Test’s objective is to ensure that the microcontroller will have Wi-Fi capabilities and be able to connect to a Local Area Network (LAN). This step will allow our device to wirelessly interact with our database needed for the project. The supplies need to accomplish this test are as follows:

1. 802.11b/g Wi-Fi USB Dongle
2. Raspberry Pi 2 Model B
3. Power Supply
4. USB Keyboard
5. HDMI Monitor with cables
6. Local Wi-Fi network
7. Local machine on network

The preparation needed for this test will be to setup an online database that we may interact with from the Raspberry Pi Model B, we should be able to simply connect to the database with username and password credentials. The procedures for stepping through this test will include:

1. Plug in USB Wi-Fi Dongle into a USB port on the Raspberry Pi Model B
2. Plug in USB keyboard into a USB port on the Raspberry Pi Model B
3. Plug in HDMI monitor into the HDMI port on the Raspberry Pi Model B
4. Plug in power supply to wall outlet then into Raspberry Pi Model B
5. Wait for LEDs to blink and OS to load
6. Install proper Wi-Fi Dongle drivers
7. Connect to Local Wi-Fi network

8. Run IFCONFIG in the OS's terminal and get IPv4 address
9. Ping the IP address from local machine to ensure properly connected to Wi-Fi network
10. Run DatabaseConnectionTest,py

The expected result from this test will be to receive a good ping response on the local machine, then also be able to connect to the database properly and extract data wirelessly.

Bluetooth to Android Connectivity Test

The Bluetooth to Android test will ensure we are able to properly connect our central hubs Raspberry Pi Model B to an Android device via Bluetooth. This test will allow us to control our central hub wirelessly and further our progress into the project. The supplies required to accomplish this test will be:

1. Raspberry Pi Model B
2. SoundBot SB340 Bluetooth USB Dongle
3. Power supply
4. USB keyboard
5. HDMI Monitor with cables
6. Bluetooth enabled Android device

There will not be any preparation needed for this test. The procedures taken to complete this test will be as follows:

1. Plug USB Bluetooth Dongle into USB port on Raspberry Pi Model B
2. Plug USB keyboard into USB port on Raspberry Pi Model B
3. Plug HDMI monitor into HDMI port on Raspberry Pi Model B
4. Plug Power supply into wall outlet then connect to Raspberry Pi model B
5. Wait for status LED's to blink and OS to load
6. Install proper drivers for Bluetooth Dongle
7. Make the Bluetooth signal discoverable on the Raspberry Pi Model B
8. Turn on Bluetooth on Android device
9. Scan for Bluetooth connection on Android device
10. Connect to the Raspberry Pi Model B's Bluetooth connection
11. Transfer a file from Android phone to Raspberry Pi Model B

The expected results from this test is to successfully pair the Raspberry Pi Model B to an Android device via Bluetooth. Then after a connection has been established we can send a text file from the Android device to the Raspberry Pi Model B and properly open said text file.

Bluetooth Audio Test

The Bluetooth Audio test will ensure we are able to properly connect our central hubs Raspberry Pi Model B to a Bluetooth enabled speaker and stream audio. This test will confirm whether the audio streaming protocols work properly when streaming from a USB Bluetooth Dongle. The supplies required to accomplish this test will be:

1. Raspberry Pi Model B
2. SoundBot SB340 Bluetooth USB Dongle
3. Power supply
4. USB keyboard
5. HDMI Monitor with cables
6. Bluetooth enabled speakers

There will not be any preparation needed for this test. The procedures taken to complete this test will be as follows:

1. Plug USB Bluetooth Dongle into USB port on Raspberry Pi Model B
2. Plug USB keyboard into USB port on Raspberry Pi Model B
3. Plug HDMI monitor into HDMI port on Raspberry Pi Model B
4. Plug Power supply into wall outlet then connect to Raspberry Pi model B
5. Wait for status LED's to blink and OS to load
6. Turn on Bluetooth signal for Raspberry Pi Model B
7. Turn on Bluetooth enabled speakers
8. Scan for Bluetooth speakers from the Raspberry Pi Model B
9. Connect to the Raspberry Pi Model B to the speakers
10. Begin streaming audio off of Raspberry Pi Model B

The expected results from this test will be to successfully pair the Raspberry Pi Model B to a Bluetooth enabled speaker and then be able to properly stream audio to the speakers.

Motion Sensor Test

The motion sensor test will ensure we are able to properly detect motion. This test will confirm that our PIR motion sensor are accurately picking up motion within their FOV. The supplies required to accomplish this test will be:

1. Raspberry Pi Model B
2. PIR motion sensor
3. Power supply
4. USB keyboard
5. HDMI Monitor with cables
6. Breadboard
7. Jumper Cables

The only preparation needed for this test will be setting up the PIR sensor onto the breadboard and powering it. The procedures taken to complete this test will be as follows:

1. Plug USB Bluetooth Dongle into USB port on Raspberry Pi Model B
2. Plug USB keyboard into USB port on Raspberry Pi Model B
3. Plug HDMI monitor into HDMI port on Raspberry Pi Model B
4. Connect the Data line from the PIR sensor to GPIO pin 3
5. Plug Power supply into wall outlet then connect to Raspberry Pi model B
6. Wait for status LED's to blink and OS to load
7. Load PIRtest.py

The expected results from this test is a ‘yes’ in the terminal window when the sensor detection motion and a ‘no’ when nothing is moving.

7.3.2. Wireless Lawn Spike

The following sections will discuss the test procedures for each individual component that will be used for each of the wireless lawn spikes. The layout for these test will be similar to ones in the previous section.

Microcontroller Test

The microcontroller test will ensure that the lawn spikes microcontroller is turning on and operating properly. This test allows us to continue testing more components to our lawn spike since the microcontroller is the brain of the device. The supplies need to complete this test will be as follows:

1. ATmega328P
2. Breadboard
3. Capacitors from schematics
4. Resistors from schematics
5. Crystal from schematic
6. Tact switch from schematic
7. Power supply
8. FTDI USB Cable
9. Jumper Cables
10. Computer
11. Arduino IDE

The preparation for this test will be cumbersome for it requires the group to setup the device with the needed passive components to work properly and also to protect our microcontroller from any type of misuse. We will be setting up our microcontroller on breadboard for testing then later getting a PCB’s for our final design. The microcontroller will straddle the middle break in the breadboard and will then be wired with the needed resistors and capacitor in the same fashion as the schematics. Once we have completed the initial setup we can begin the procedures needed to test the microcontroller is working, the preparation step includes:

1. Place Breadboard on sturdy non-metal table with antistatic mats if possible
2. Place ATmega328P so that it straddles the middle break in the breadboard
3. Connect all the passive components so that it resembles the schematics
4. Place the tact button and crystal into the breadboard to resemble the schematic
5. Connect a jumper cable to the RXD and TXD, pins 2 and 3.
6. Connect the RXD jumper on the ATmega328P to the TXD cable on the FTDI USB cable

7. Connect the TXD jumper on the ATmega328P to the RXD cable on the FTDI USB cable
8. Set up a power and ground rail on the breadboard from the FTDI USB cables positive and negative connections, but do not connect to the board yet

After the preparation we should have the breadboard setup with all the necessary components to operate properly. The next part we will step through the procedures to ensure the microcontroller was setup correctly and is capable of running code.

1. Connect jumper cables from the FTDI USB cable to the power rail and ground on the breadboard
2. Plug the FTDI USB plug into the computer's USB port
3. Start the Arduino IDE on the computer
4. Push the Blink sketch
5. Wait for status lights to start blinking

The expected results from the lawn spike's microcontroller test is to have the status LEDs on the breadboard start to blink once the test program has been pushed to the device.

Bluetooth Transceiver Test

The Bluetooth transceiver test will ensure the transceiver is able to properly pair with an android smartphone. This test will allow the group to continue moving forward with the ability to wirelessly play music from the transceiver. The components required to accomplish this test:

1. OVC3860 Bluetooth Stereo Audio module
2. Breadboard
3. SMD to DIP PCB
4. Stereo to Mono Converter
5. Speaker
6. Power Supply
7. Jumper Cable
8. Bluetooth Enabled Android Device
9. Solder with Rosin Core

The preparation for this test will only require heating the soldering gun to 345° C. The procedures to be taken to complete the test are as follows:

1. Solder the OVC3860 to the SMD to DIP PCB
2. Plug OVC3860 into the breadboard so that it straddles the middle break
3. Connect jumper cables pins 1-6,12-14, 18, 25-26
4. Create a power and ground rail on the breadboard with jumper cables
5. Connect the following pins to the ground rail 1, 2, 6, 13, 14, 26, and 25
6. Connect pin 3 to the negative terminal in Stereo to Mono converter
7. Connect pins 4 and 5 to the left and the right speakers respectively
8. Connect pin 12 and 18 to the power rail to turn device one

9. Pair with transceiver using Android device
10. Stream a song

The expected results for this test are that we will be able to successfully pair with the Bluetooth transceiver. Once we begin streaming the song, we expect to hear music being played

Power Supply

The following sections will go over all of the tests required for a proper power supply. We separated this section from all the other hardware because we want to make sure the power supply works as intended before connecting any components to it.

Basic Charging

The battery charger test objective is to ensure that the battery pack charges. This step will allow our device to be powered while not charging. The supplies needed to accomplish this test are as follows:

1. NiMH Battery Pack
2. Polycrystalline Solar Cells
3. AC/DC Adapter
4. 3 Schottky Diodes
5. Breadboard

The preparation needed for this test will be to set up the battery to be the only component or accessory to receive the voltage and energy from the power supply. The procedures for stepping through this test are as follows:

1. Connect all components in the likeness of the schematic
2. Clock the charge time

The expected result from this test will be that the batteries charge efficiently and effectively. From the wall output the batteries should charge in 2 hours or less, from the battery was nearly empty and have essentially no use. As for charging directly from the solar cells, the charging of the batteries should charge in less than 10 hours.

Powering Components Central Hub/Spike

The test of powering and testing the components of the singular components and parts of the central hub and solar powered spike with the power only being provided from the battery pack. The supplies needed to accomplish this test are as follows:

1. NiMH Battery Pack
2. Breadboard

3. Voltage Regulator
4. Each Individual component

The preparation needed for this test will be repeated for each component. The procedures for stepping through this test are as follows:

1. Connect the batteries to each component
2. Turn to each component
3. Review to view if the component is operation without damage

The expected result from this test will be that the power dissipated from the batteries will power each component without damage to the component.

Power Required Battery w/ Charging Source

The test of powering and testing the components of the singular components and parts of the central hub and spike. The supplies needed to accomplish this test are as follows:

1. NiMH Battery Pack
2. Polycrystalline Solar Cells
3. AC/DC Adapter
4. Solar Cells
5. 3 Schottky Diodes
6. Breadboard
7. Voltage regulator

The preparation needed for this test will be repeated for each component. The procedures for stepping through this test are as follows:

1. Establish which charging source will be used (both charging sources will be used
2. Connect charging source with battery in accordance to the schematic
3. Connect charging source and battery with component in accordance to the schematic
4. Review to view if the component is operation without damage
5. Turn off power source and review power and voltage level of battery pack
    a. The battery pack should charge at

The expected result from this test will be that the power dissipated from the batteries will power each component without damage to the component while also charging the battery pack.

Battery Providing Energy w/ Charging Power Supply

This test's objective is to ensure that the battery pack discharges. This step will allow our device to be powered while not charging. The supplies needed to accomplish this test are as follows:

1. NiMH Battery Pack
2. Polycrystalline Solar Cells
3. AC/DC Adapter
4. 3 Schottky Diodes
5. Breadboard
6. All Components

The preparation needed for this test will be the opposite of the charge rate testing. To set up, the battery to be the only component or accessory to send the voltage and energy acting as the only power supply. The procedures for stepping through this test are as follows:

1. Connect all components in the likeness of the schematic
2. Use the components to play

The expected result from this test will be that the two power sources will be able to power the components for the central hub and spike respectively while also charging. The charging time for the battery should take a little

Battery Total Components Discharge Rate

The battery charger test objective is to ensure that the battery pack discharges. This step will allow our device to be powered while not charging. The supplies needed to accomplish this test are as follows:

1. NiMH Battery Pack
2. 3 Schottky Diodes
3. Breadboard
4. All components of Central hub/Spike

The preparation needed for this test will be the opposite of the charge rate testing. To set up, the battery to be the only component or accessory to send the voltage and energy acting as the only power supply. The procedures for stepping through this test are as follows:

1. Connect all components in the likeness of the schematic
2. Clock the discharge time

The expected result from this test will be that the batteries will discharge in a time long enough to fit the scope of the design details.

7.3.3. Application

For the testing of the code included in the creation of the application, a standard practice of using the tools provided by the IDE were available or useful in solving the errors developed. Android Studio includes a debugger that allows you to debug apps running on the Android Emulator or a connected Android device. With the Android Studio debugger, you can:

- Select a device to debug your app on.
- Set breakpoints in your code.
- Examine variables and evaluate expressions at runtime.
- Capture screenshots and videos of your app

The application developer went through the process of creating a routine of testing code by segments or objective. Our software system is built up of smaller subsystems with known inputs and outputs, which come together for added cohesiveness. Providing modularity in your project allows for constant checking and testing of sections of your code that allows for the pinpointing of errors. This was coupled with the IDE providing line by line error recognition. However the consistent problem with IDE recognition of errors is that it detects the problem itself and not the source. An example of this is attempting to call a method from a null instantiation of a class. It will call an error on the illegal calling of that method but doesn't tell you how or where the null instantiation was created, or the situation that lead to the null instance.

This general method of testing and debugging was used with the creation of the following pages and any pages that are subsequent to them:

- Splash Page
- Login Page
- Register Page
- Main Menu Page
- Central hub Power Page
- Bluetooth Connection Page
- Setting Preferences Page
- Google Play Interface Page

The following sections will go over the testing procedures for each subcomponent or interface that will going into developing the applications functionality. The test will be laid out in a very easy to read table, with test name, objective, preparation, Procedure, and the expected results.

User Input

User Input and Menu Transition

The User Input and Menu Transition test objective will test and verify the application receives user input and correctly navigates through selected menu options. This test will serve as the foundation for user navigation. The supplies needed for testing will be:

1. Android mobile device or emulator

The preparation for testing will be minimal since all we need to do beforehand is launch the emulator and select the appropriate device with SDK version 22 or higher, or install application on mobile device. The procedures for accomplishing this test will go as follows:

1. Open the application
2. Navigate through Splash and Login page
3. Choose a button via the menu page

The expected results from this test is that the application should navigate or launch the correct page based on the user's selection.

Database Connectivity

Send Data-Register Page

The Send Data-Register Page test's objective is to test and verify the application successfully connects to the database and correctly inputs strings entered by users. This step will allow information to be sent to the database and have new information entered into the database to be stored. The supplies needed to accomplish this test are as follows:

1. Android mobile device or emulator
2. Database

The preparation for testing will be to launch the emulator and select the appropriate device with SDK version 22 or higher, or install application on mobile device. The procedures for stepping through the test will include:

1. Open the application
2. Navigate to Register Page
3. Enter user attributes
4. Wait for prompt to verify submission
5. Open the database
6. Browse through entries to verify the new user attributes have been added.

The expected results from this test will be to verify if the database will include new user attributes entered by the user from the Register Page.

Receive Data-Login Page

The Receive Data-Login Page test's objective will be to test and verify the application successfully connects to the database and receives strings from database. This step will verify that the login page will work by receiving attributes from the web server. The supplies needed to accomplish this test are as follows:

1. Android mobile device or emulator
2. Database

Preparation for the test will be as follows:

1. Launch the emulator and select the appropriate device with SDK version 22 or higher, or install application on mobile device.
2. Create function to print user attributes to prompt.

The procedure will be as follows:

1. Open the application
2. Navigate to Login Page
3. Enter user attributes
4. Wait for prompt to verify submission
5. Look to prompt for user attributes

The expected results from this test will be for the database to print all four user attributes.

Interface Connectivity

Bluetooth Connectivity-Bluetooth Connection Page

The Bluetooth Connectivity-Bluetooth Connection Page test's objective was to test and verify the application successfully connects to other Bluetooth devices more specifically the microcontroller. The supplies required to accomplish this test will be:

1. Android mobile device or emulator
2. Microcontroller

Preparation for the test will be as follows:

1. Launch the emulator and select the appropriate device with SDK version 22 or higher, or install application on mobile device.
2. Turn on microcontroller

The procedure will be as follows:

1. Open the application
2. Navigate to Bluetooth page
3. Navigate through user options

The expected results from this test will be for Bluetooth connectivity to be acquired.

Send Bluetooth Commands-Sending Commands

The Send Bluetooth Commands-Sending Commands test's objective will be to test and verify the application successfully sends serial commands. This is required to verify communication between the application and the central hub. The supplies required to accomplish this test will be:

1. Android mobile device or emulator
2. Microcontroller

Preparation for the test will be as follows:

1. Launch the emulator and select the appropriate device with SDK version 22 or higher, or install application on mobile device.
2. Turn on microcontroller

The procedure will be as follows:

1. Open the application
2. Navigate to one of the setting preferences
3. Navigate through user options
4. Confirm that the serial command was sent

The expected results from this test will be for the microcontroller to receive commands from the application.

7.3.4. Final Integration

The final integration will be a system wide test. This test will require a fully assembled central hub and lawn spike though we won't need the housing for either of them. Once we have our two devices assembled and connect to our newly created power supply we can begin our final test. This test will ensure that we have a working system and will allow us to finish building our other lawn spikes. Once we connect all the components together we will run the user application on the phone and begin stepping through the process of setting up the central hub. Once the central hub is initialized and configured to the Wi-Fi we can then sign into our Google Play account start creating our playlist of songs. After that is complete we will be able to stream music to the lawn spikes once any type of motion has occurred. The expected results from the final integration test is a fully functional system with one lawn spike

Application User Input

No: UIC02
Statement: The system should be able to accept input from user.
Source: Application Developer
Dependency: None
Conflicts: None

Supporting Materials: None
Evaluation Method: The user must be able to select configuration settings and launch activities

Table 8 - Application User Input

This was addressed as a concern primarily because of how much it affects every other component of the application. Issues like this often arise from the lack of care in the code written. When an element is included in the xml, the identification string for it must match that of the initialized variable that it will represent it in code. To make sure this is addressed accurately constant revision of the code is necessary.

To help with this we have created a design pattern that ensures that the button to be pressed is one that is applicable. We have also included a couple safety measures to ensure operability and a lack of confusion on the part of the application. A great example of this is seen when connecting your Bluetooth on your phone through application. If Bluetooth is already on it will not prompt you to connect. Pressing the connect button when the Bluetooth adapter is already on will one cause confusion on the part of the member, and secondly launch a series of commands that will have no effect, if not a negative one. What we want the user to interact with is the disconnect button, so based on the status of the Bluetooth adapter and functions called the visibility of these user options will toggle on and off.

Main Menu Activity

No: UIC03
Statement: The system should have a main menu page.
Source: Application Developer
Dependency: None
Conflicts: None
Supporting Materials: None
Evaluation Method: The user should be able to access key components from a central page.

Table 9 - Main Menu Activity

This page will be placed right after the login page and will be the first thing the user sees after being granted access. It will serve as the homepage; from this screen the user will choose where to navigate throughout the rest of the

application. To make the screen visually appealing we will choose imageButtons to launch intents to the next page.

In the xml this will then require ImageButton tags, the elements for the tags are to be decided. But they will determine the location, size, color and many other factors that control the aesthetics of the design. Not only that, but the source file for the image to be shown in the button. Things to also take into consideration is the location of the buttons relative to themselves and the layout that will be put in place. There will also be a regular button at the bottom of the page to facilitate logging out.

As for the functionality, it will be relatively simple with the exception of the logout button. Requiring the initializing of an ImageButton to the identification string specified in the xml. All of these buttons also having an associated setOnClickListener method to start an intent when the button is clicked that will lead to the next activity. While the logout button would have to also account for the logged in user details. The attributes would be cleared from the application which is accomplished by erasing the SharedPreferences from the UserLocalStore class with the function clearUserData. The status of the logged in user would also be changed by another function in the same UserLocalStore class. Once logged out the application the user will navigated back to the login page for another member to use.

User Based Security Detailing

User Based Security Detailing aids in the monitoring of who is allowed to access this application, this product has many functional settings which should be up to the discretion of the product owner. To do this we have implemented a database which will contain all of the users to enter through the application, as well as a login page and register page to allow navigation through the application.

This added design has not come short with its long list of multiple challenges including finding a suitable way to couple the data, setting up connectivity with the server where your database is located, the php code to supplement the actual transferring of information to the database and not to mention the database itself. A pictorial representation of this is shown in class diagram 5.4.3.1 and sequence diagram 5.4.3.2 below.

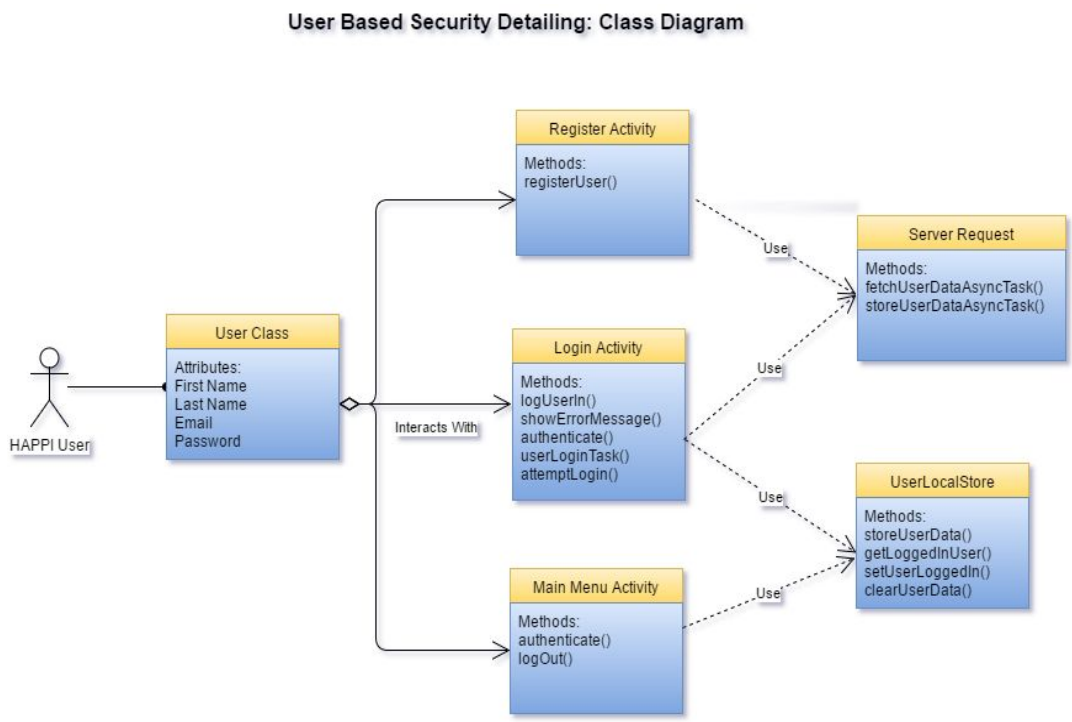


Diagram 7- User Based Security Detailing

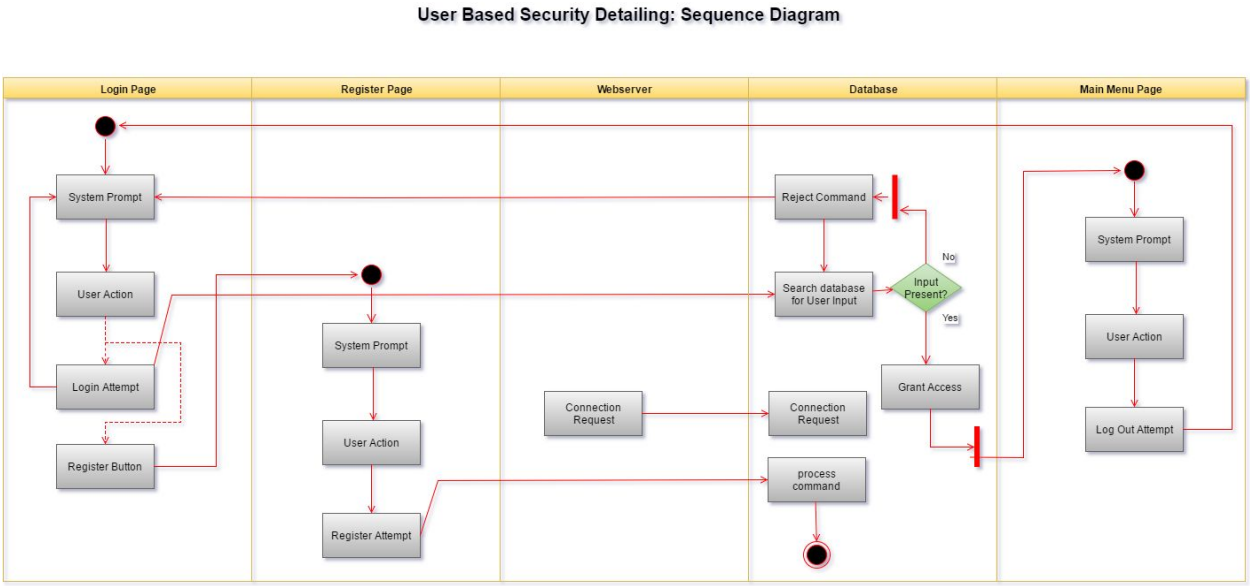


Diagram 8 -User Based Security Detailing

Login Activity

No: UBSD01
Statement: The system will require a login page.
Source: Application Developer
Dependency: Database
Conflicts: None
Supporting Materials: Component Research- Wi-Fi
Evaluation Method: The Login button should grant access to users with the correct email and password, while also denying access to users with the incorrect email and password.

Table 10 - Login Activity

The current xml layout holds a button for signing into google. This will serve as an option to add in some extra functionality in the future but currently holds no value now. We then have EditText tags for users to input their information, in the tags holds the identification string element which is very important because it references the information entered against what's in the database. We have 2 EditTexts tags, one for the user's email and another for their password. In the tag carries a variety of elements from the size of the EditText, to the string displayed. We also have a button for logging in, whose size matches the parent element or fits the size of the screen. Lastly is the register link, which is just a textView fitted with an id to identify when to launch the RegisterActivity.

Before we get into the information of what each activity does we need to understand some logged in user attributes. These attributes are encapsulated in the User Class, and are: first name, last name, email, and password, we also introduce two ways to call the class, the first having a string parameter for all attributes and another only including the email and password parameters. And the reason for this is because of the attributes given. The second case of the class will be used when authenticating the user via the email and password attributes with the login details given through the xml layout, in other cases all attributes are used, such as sending information through the register page.

We also have the UserLocalStore class that monitors the status of logged in individuals. In this class we have 5 functions created to keep user attributes without the need of another server request to the database. We have the storeUserData function which enters the user attributes from the recent server request to the editor. Another function, getLoggedInUser takes the information from the editor and creates a new user. And lastly getUserLoggedIn and setUserLoggedIn which get and set the user login status when called.

Now we will touch on how this user information is sent and received from the server. This is done as a result of the ServerRequest Class, which holds the details to getting to our webserver where our database is located. We currently have the database stationed at http://cop4331surveyapp.net16.net/ which is a url given by 000webhost.com (a free webhosting domain). Most of the functions located in this class are to fetch and retrieve data from the app to the database or vice versa.

For information sending purposes we wrap our data in an array list to couple the actual information with its label. We then prepare for connection to the web by initializing httpRequestParams (which is a data type to help configure our request in attempting to connect with the internet) and use it with the method setConnectionTimeout to set the duration of the server request. We also developed a client and a post; the client is initialized with the previously mentioned httpRequestParams configurations. While the post is initialized to where the php code is actually located on the webserver, http://cop4331surveyapp.net16.net/cop4331fetch.php. The post is what is used to send the information that we have wrapped up in the array list, and we execute it with the client. When executed the information sent interacts with the php code to return the results of the request, the information sent is captured in an httpEntity via the httpResponse. The httpEntity is converted to a string and that string is converted to a JSON object (JavaScript Object Notation; JSON is a lightweight data-interchange format) where we now initialize the result as one of the user attributes and we return the user.

Before we discuss the php code's role in this activity let us take a brief look at how it is useful. PHP in a nutshell is an open source general-purpose scripting language that is suited for web development. It is mainly server-side scripting, which makes it capable of collecting form data, generating dynamic page content, and so much more. In this situation we use it for its database connectivity and will be illustrated going forward.

The first line of code in the php file is always the initialization of the variable con. This variable specifies the details of the actual database we are connecting to using the function mysqli_connect. The parameters for this code are the localhost, user, password and database. This command is what allows access into the actual database. We then have variables initialized by a post command. The post command allows us to gather the information sent from the server request.

This specific example we are looking at is actually the fetch request of all user attributes after the user has been successfully logged in. So the information sent is actual the email and password the initial attempted user typed into the login activity xml layout. It was then grouped as user attributes and sent through the ServerRequest class.

The email and password will now be the qualifier for the statement variable, where in it they will be used in conjunction to pick which user in the database will have its information sent. The statement variable is initialized with the mysqli_prepare function where the parameters are mysqli_connnect variable con and a string query which poses a SQL statement. (A SQL statement is used to perform tasks such as update or retrieve data from a database. It is the standard language for relational database management systems.) In this statement is where the email and password are represented with question marks to stand in for their unknown values. We also select the table within in the database and the fields to be used. We then have the mysqli_stmt_bin_param function to prepare the mysqli_prepare function for execution. Its parameters include the statement variable where the prepare function was used, the qualifying variables which in this case are the email address and password, and lastly their data types.

These three functions mysqli_prepare, mysqli_stmt_bind_param, and lastly mysqli_stmt_execute work in conjunction to formulate a request to the actual database in an adequately packaged way that the relational database management system can interpret and understand. A kind of 1,2,3 method of making a command, understanding it and executing it.

Next we have to prepare for the result of the request made, this is done by the two functions: mysqli_stmt_store_result and mysqli_stmt_bind_result. One is used for storing the result of the statement variable, while the latter binds the result gathered from the fields of the database to actual variables we want initialized by the information. This doesn't mean the command is actual executed but instead prepares where they should go upon execution. This results in the variables: fname, lname, email, and password. With these new found results we need a way of sending them back to the app together, just as we have sent our code in the array list. In this php code however we will be using a simple array. We now use the mysqli_stmt_fetch to execute the fixed request. We do this in a while loop and initialize the array with the variables assigned in the mysqli_stmt_bind_result function. We then send the information encoded in json with echo.

This is all possible as a result of the database provided by 000webhost.com, it is accessible through phpMyAdmin, in it we have numerous tables but the one that holds all of the user information is named tableone. There are four fields included and they hold the user attributes: first name, last name, email, and password. The name of those four fields are: fname, lname, email, and password. These fields are all of type varchar because they are strings.

All of the previous classes discussed are what make the LoginActivity a possibility and together allow this login process to be a success. When the login button is actually hit it triggers the attemptLogin command that gathers the

information typed into the EditText boxes into string and creates a user with the two parameters entered and launches the authentic function.

The authentic function then creates a server request to process the new user created and uses the function fetchUserDataAsyncTask to validate the user given through the process outlined earlier of: encoding the information, creating a httpResponse, client and post, then lastly hitting the php code for a response. If the returned user is null then the showErrorMessage method is kicked off, otherwise the LogUserIn command is triggered.

The showErrorMessage method is just to alert the attempted user that the information typed does not correspond with the fields documented in the database, in hopes to they will try again. This is done by creating an alert builder and setting the message. This message is will have to include an ok button as well.

In the case of the LogUserIn method, this function is used to store the user details and kick off the next activity with an intent. This brings the userLocalStore class back into play by storing the user data and setting the user logged in status to true. After which the MainMenuActivity is launched and access has been granted!

Register Activity

No: UBSD02
Statement: The system will require a register page.
Source: Application Developer
Dependency: Database
Conflicts: None
Supporting Materials: Component Research-Wi-Fi
Evaluation Method: The Register button should place strings entered into database.

Table 11 - Register Activity

This page is built off of a lot of the same functionality exhibited in the login page, it uses the same ServerRequest and UserLocalStore class however a lot of times it requires different functions. We will go through the similarities and differences between the login pages.

First we will go over the xml code, like the login page it contains EditText tags, four tags for the user attributes of a new user. Each of them containing a string to

inform the users of the correct attribute they are typing into. After which is a register button, with the proper id to launch the register function. At the top of the page we also have a TextView tag to inform the user to fill out the following with the string “Please enter the information needed to register to this account”.

When this information is then grouped we treat it a lot like our login page in that we use the ServerRequest class, what differs primarily are the functions called although they utilize most of the same components. We now use the store function within this class to wrap this information and send it to the database, which will be done very similarly to the fetch function with our login page however they differ in the fact that we don’t expect a response. The function couples the data with its label in an array list and initializes an httpRequestParams, client and post. We then prepare the information to be sent with the post and execute the command with the client execute function.

After this stage it again goes to the webserver to interface with the database, however we now reference another segment of code to input information into the database instead of taking it out. Like the other php code referenced in the login page we start with the mysqli_connect function with the necessary information to establish a connection. We then branch off into establishing variables for the information to be received from the ServerRequest class: first name, last name, email, and password. After establishing variables for the post command to receive, we have the sql statement which is packaged by the mysqli_prepare function. This sql statement “INSERT INTO tableone (fname, lname, email, password) VALUES (?, ?, ?, ?)” inputs the values represented with question marks into the table named tableone specifically into the fields named after the table. The parameters are then sent in via the mysqli_stmt_bind_param to fill in the question marks, accompanied by data type until executed by the mysqli_stmt_execute function. We then finish the statement with the mysqli_stmt_close and do the same for the database connection, with the mysqli_close.

In the actually RegisterActivity, we start by initializing all of the EditText variables by referencing their ids from the xml code, we do the same for the register button. Within the onClick function we convert the EditText variables into strings with the toString function. After which we create a new user and enter the string values for the user attributes, and call the registerUser method.

The registerUser method creates a new ServerRequest and launches the storeUserDataInBackground function with the newly created user. It also launches a new intent back to the login page.

Setting Preferences

Sending Command to the Microcontroller

No: FC02 and SP1-6
Statement: Sending commands to the microcontroller
Source: Application Developer, Hub Software Developer, Speaker and LED Lead
Dependency: LEDs and Speaker
Conflicts: Forwarding command to lawn spikes
Supporting Materials: Component Research-Bluetooth
Evaluation Method: Microcontroller responding to the selected command.

Table 12 - Sending Command to Microcontroller

This feature will be the primary method of communicating to the microcontroller, in a nutshell this will be done by creating a Bluetooth connection and socket that will be our method for sending strings but we will dive a little deeper into the process.

As a result of the interface method, the user will have to first connect with the microcontroller via the Bluetooth Connection Page. This will go through process of turning the Bluetooth adapter on, then finding and pairing to the microcontroller of the central hub.

When this is done you can then navigate to the page of your preference option. When there you will have a user interface element that will allow your option to be entered whether it be: button, dropdown menu, etc. This will then launch a function that will reference the Bluetooth connection already established and create a socket. From here we can create an OutputStream variable and initialize it with the function socket.getOutputStream(). We will then create an OutputStreamWriter datatype to help with the conversion from bits into their actually strings. These strings will be sent to the central hub where they will launch an associated function for the execution of the command.

Saving User Preference

No: SP7
Statement: The system should save user preferences.
Source: Application Developer
Dependency: Database
Conflicts: None

Supporting Materials: Component Research-MySQL Database
Evaluation Method: Have user preferences saved in a database and have those forwarded to microcontroller on command

Table 13- Saving User Preference

This function will allow for user options to be saved, to prevent having to go through all of the setting preferences specified for functionality. It will be accomplished in two steps, the first is saving the settings entered to the database and after having an option to select the preferences.

The functionality for the first half of this component will reference a lot of the same subcomponents from other requirements, more specifically the register page. How they will differ specifically will be the interface for submitting information. The register page only allowed the entering of strings but this interface will include more options for interacting with the application. We will initialize variables with the identification strings specified for each respective element in the xml code to be used in the ServerRequest class where we will couple the data with a label in an array list. The post is what is used to send the information that we have wrapped up in the array list, and we execute it with the client. When executed the information sent interacts with the php code.

The code will begin with the mysqli_connect function with the necessary information to establish a connection. We then branch off into establishing variables for the information to be received from the ServerRequest class, this will consist of the entered user preferences. After establishing variables for the post command to receive, we have been sql statement which is packaged by the mysqli_prepare function. This sql statement inputs the values represented with question marks into the table specified by the statement, specifically into the fields named after the table. The parameters are then sent in via the mysqli_stmt_bind_param to fill in the question marks, accompanied by data type until executed by the mysqli_stmt_execute function. We then finish the statement with the mysqli_stmt_close and do the same for the database connection, with the mysqli_close. This will account for the first segment of this component which is saving the user preferences. The second segment of this component will list the saved preferences entered for the user to select. This will require a listView element in the xml layout for each saved user preference will be available to be selected.

This requires a class that will include each individual preference associated with each user option, along with getters and setters to facilitate the accessing of specific options. We will use this class in the ServerRequest for accessing all of the saved user preferences from the database, with each user preference an instance of that class with its associated attributes will be created and initialized to the values derived from the database. This new instance of the class will be

added to the adapter class where its attributes will be the information showed in a row.

A listView will be used and initialized to this adapter class with the function called setAdapter, this will create each row of the listView. When a selected user preference is grabbed from the database it will be added to the adapter java class. This java class will have a static layoutHandler with only the saved user preference title and other selected options to be displayed, via the getView function. When clicked a user preference will send all of the entered user options for their configuration setting.

8 Owner's Manual

8.1. Product Set-up

8.1.1. Solar Panel Tilt

The solar power spike will be built with a swivel motion to angle the solar cells for optimal use and attain the most solar energy. The solar cells' positioning varies every year depending on the geological location of the spike relative to planet earth. As the sun rises and sets the positioning of the solar panel needs to be a fixed location and degree. In order to see which angle the solar panel must be tilted, a fixed equation (as seen below will solve

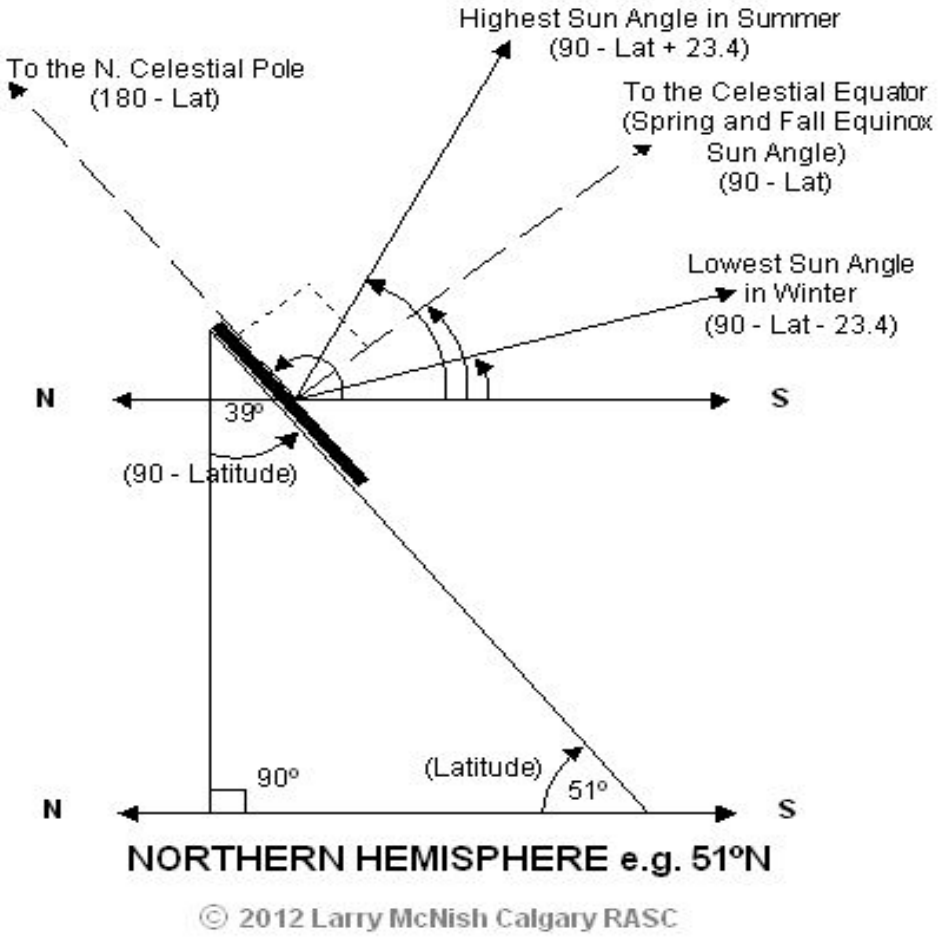


Figure 16: Solar Tilt Layout Permission Pending

For example, the city of Orlando's coordinates are positioned at 28.56348° N, -81.37239° E. According to these coordinates and the figure above. The angles the cells must be positioned must be as follows:

Season	Tilt (Approximately)
Summer	38°
Spring	62°
Fall	62°
Winter	86°

Table 14: Solar Panel Tilt Table

8.2. Application Use

8.2.1. User Interfaces

From the user's android phone the user interface will be launched from the main menu screen. This will require the member to find the location on the screen and click on it to launch the application. This will initiate the user interface, which will begin the splash screen that will welcome you and redirect you to the login page.

Login Screen:

The login screen is what grants the users access to the main menu page of the actual application which houses all of the functional interfaces that will in turn cause the central hub to perform. This places a lot of importance on the user's ability to login, if he or she fails at this duty then the user preferences and functional settings will be left unset. At the login page the member will be prompted for specific user attributes to validate user access: email and password. After the texts are entered the member will click the "Sign In".

Note: If the user does not yet have an email and password they should click on the "Register" link right below the "Sign In" button.

Troubleshooting:

When trying to be granted access through the login page a couple issues could arise while attempting to sign in. If access is not granted a prompt will appear that will inform you that an error has occurred with the message "Incorrect user details". This can result from the following:

- · Entering of the wrong email
- · Entering of the wrong password

- · Email and password not registered
- · Lack of internet connection

In the case that the prompt appears, it shows that one of the previously mentioned errors occurred and requires a resubmission. It is suggested that the user begins troubleshooting with the texts, to confirm that they were entered properly and were not the cause of the problem. If the prompt is continually being shown this may indicate a lack of internet connectivity that is not allowing the application to reach the database where the entered texts are validated. In this case you will have to reconfigure your data connectivity or connect to Wi-Fi to allow user access. This is usual done in the phone's setting preferences.

Register Page:

This page allows for user attributes to be registered within the system. The prospective user will enter the four user attributes: first name, last name, email, and password. After typing in the required strings the user will need to press the "Register" button to have the information entered into the system.

Troubleshooting:

Registering information into the system is usually unproblematic, however there will be some instances when errors will be generated. There will be no application based prompt to inform the user that the error has occurred. The error will be seen in the login page prompt when an attempt to login is done. The only foreseen error that can result within this page is the lack of internet connectivity. To confirm that the proper user information has been entered follow the subsequent steps:

1. Type in the desired user information
2. Click on the "Register" button
3. Navigate to the login page
4. Enter newly registered information
5. Click on "Sign In" button

If you are allowed access into the application then no errors have occurred. If you are not granted access verify you are connected to internet, and follow the previously mentioned steps.

Main Menu Page:

This page will be placed right after the login page and will be the first thing the user sees after being granted access. It will serve as the homepage, from this screen the user will choose where to navigate throughout the rest of the application. The main menu will put most of the functional features to be controlled via the application in one location for ease of use. Navigating through the main menu page will be intuitive and be guided by images and texts that will prompt the user on where to go next.

Functional Interfaces:

From the main menu page functional interfaces will be there to aid user setting configurations. This will be done through user interface elements that will allow your option to be entered whether it be: button, dropdown menu, etc.

Troubleshooting:

The functional interfaces are broken down into quick and slow responses that have different methods of transmission. Quick responses are functional interfaces that we have sent directly to the central hub via Bluetooth such as selecting the Wi-Fi and songs to be played. Slow responses are setting configurations that will be sent to the database and loaded from the central hub such as the LED flashing frequency, the troubleshooting of these options require differences in techniques.

Quick Response Interfaces:

1. Click on functional interface element to trigger a response.
2. If no response is registered, reconnect to central hub with Bluetooth Connection Page.
3. Reattempt until response is delivered

Slow Response Interfaces:

1. Configure setting preferences.
2. Click “Submit” Button
3. Verify settings
4. If settings aren’t loaded, reconnect to Internet.
5. Reattempt until response is delivered.

9 Administrative Content

9.1 Milestone Discussion

Designing a project requires excellent multitasking and time management skills to put forth the required effort necessary for the completion of this project. In attempt to provide structure and help forecast desired execution of component requirements project milestones are put in place for the synchronization of the overall project and efficiency. Within senior design 1 this phase includes a majority of research and design ideas, this will assist in the transitioning into senior design 2 where the prototyping and testing will be executed. The milestones will be demonstrated in table 8.1.

Job	Start	End	Responsible
Senior Design			
Group Assimilation	5/16/2016	5/23/2016	Everyone
Brainstorming	5/23/2016	5/30/2016	Everyone
Project Report			
Initial Document-Divide and Conquer	5/23/2016	6/3/2016	Everyone
Divide and Conquer(Resubmission)	6/6/2016	6/14/2016	Everyone
Table of Contents	6/29/2016	7/1/2016	Everyone
Current Draft of Senior Design	6/3/2016	7/8/2016	Everyone
Final Document Due	7/8/2016	8/2/2016	Everyone
Research & Design Preparation			
Ordering of Parts	6/14/2016	6/28/2016	Everyone
Speakers	6/14/2016	6/28/2016	Sidney
Microcontroller and Software	6/14/2016	6/28/2016	Phillip & Taylor
Camera	6/14/2016	6/28/2016	Johnnie
Solar Panel	6/14/2016	6/28/2016	Sidney

Motion Sensors	6/14/2016	6/28/2016	Johnnie
Lights	6/14/2016	6/28/2016	Johnnie
Power Source/PCB	6/14/2016	6/28/2016	Sidney
Software			
Component Interface			
Initial Design	7/4/2016	8/8/2016	Phillip & Taylor
Programming	8/8/2016	9/26/2016	Phillip & Taylor
Testing	9/26/2016	10/10/2016	Phillip & Taylor
Integration with Central hub	9/5/2016	9/26/2016	Phillip & Taylor
Integration with Lawn Spike	9/5/2016	9/26/2016	Phillip & Taylor
GUI			
Initial Design	7/4/2016	8/8/2016	Phillip
Programming	8/8/2016	9/26/2016	Phillip
Testing	9/26/2016	10/10/2016	Phillip
Integration with Single Board Computer	9/12/2016	9/26/2016	Phillip
Integration with Database	9/12/2016	9/26/2016	Phillip
Hardware			
Central hub			
Component Design	7/4/2016	8/15/2016	Everyone
Component Testing	8/15/2016	9/26/2016	Everyone
Lawn Spike			
Component Design	7/4/2016	8/15/2016	Everyone
Component Testing	8/15/2016	9/26/2016	Everyone

Physical Assembly			
Lawn Spike Assembly	9/26/2016	10/31/2016	Everyone
Central hub Assembly	9/26/2016	10/31/2016	Everyone
Testing	10/31/2016	11/10/2016	Everyone
Final Design	11/10/2016	11/20/2016	Everyone

Table 15:Milestone

9.2. Budget and Finance

The HAPPI system was estimated to cost $255. The project will be completely funded from the group members, each member has agreed on a budget of $250, totaling to $1000 between four people. The $255 estimated value does not include any testing materials or extra components, so if the cost of the project happens to exceed the $1000, the overages will be split evenly among the group members. After the project was complete the total price for our project came to $516, the price doubled because of the need to buy more expensive Bluetooth/Wi-Fi dongles and wireless transceivers.

Items	**Cost**
Single-Board Computer	$35
Microcontrollers	$10
Speakers	$20
Motion Sensors	$20
Camera	$30
Batteries	$40
Solar Panels	$48
LEDs	$55
3 BT/Wi-Fi USB Dongles	$48
3 Wireless Transceiver	$150
3 Audio Amp	$30

Passive components	$30
Total	$516

Table 16: Component Cost

9.3. Work Distribution

The work distribution for HAPPI is divided into several parts among the four members for this senior design project. Each group member was delegated to specific roles matching their skill set and major. Taylor served as our Integration Engineer, putting everything together that was relevant to hardware for both the Wireless Lawn Spike and Central hub. Sidney who is an Electrical Engineer, was responsible for power supply and distribution throughout the project. Johnnie who is our photonics engineer was responsible for all photonic related items and helped with general integration. Phillip served as our Software Engineer and was responsible for all programming assignments. Johnnie served as our Paper Manager and delegated specific sections in our documentation, while Taylor played the role of Product Manager. Johnnie and Taylor both worked collectively together as well as worked with everyone to reach component deadlines for the integration of our overall design. This paper and project have truly been a collaborative effort, and has allowed for all group members to rise to the occasion in their specific area of expertise.

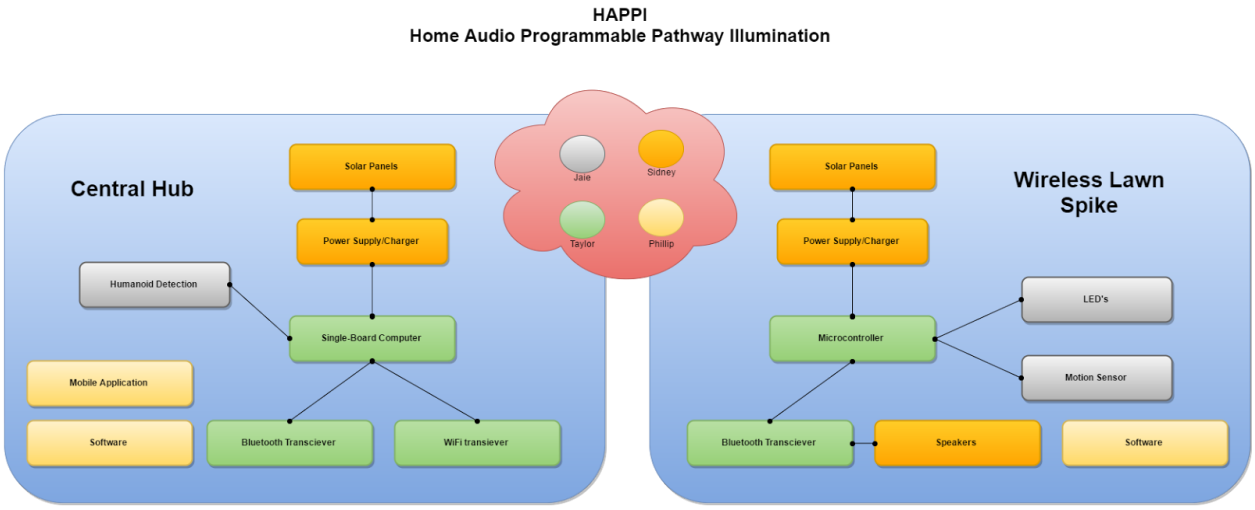


Diagram 9: Work Distribution

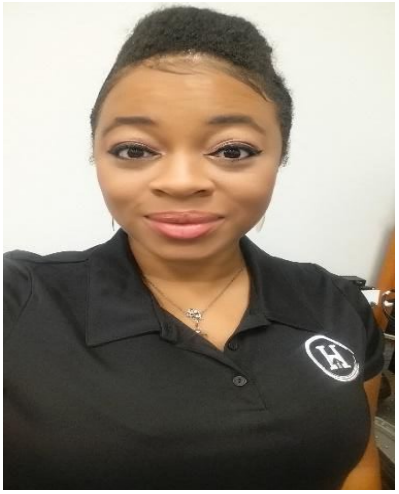
9.4. Group Member Information

Haitian-American University of Central Florida student, Sidney Jean-Baptiste, is hoping to follow the footsteps and excel similarly to his father. Sidney was born August 24, 1991 in New Brunswick, NJ and attended high school in Port St. Lucie, FL at St. Lucie West Centennial High School. Sidney is now a second generation college student and is working towards becoming a second generation professional engineer. Currently a senior at the University of Central Florida and will graduate December 2016 with a Bachelor of Science in Electrical Engineering to pursue his interest in power generation. Over the course of Sidney's attendance at the University of Central Florida, Sidney has had various internships with different companies. Thus expanding his mind in the field of engineering and helping him to gain a strong understanding. Sidney has had internships with United Airlines, Power Engineers Inc., and currently Siemens. Those internships specified in avionics, power generation and utilities, and project management Sidney is very interested in circuit design, power, and the aerospace industry.

Phillip Bent was born May 18th, 1993 in Miami FL and was raised in Broward County. Phillip had the pleasure of attending Stranahan High school, which he graduated from May of 2011. From here he went on to the University of Central Florida where he plans to graduate with a major in Computer Engineering and a minor in Business. In his free time, Phillip enjoys playing sports such as basketball and football if he is not listening to music and

spending time with his friends. Phillip also likes to travel, and has made it a goal to visit each continent with the exception of Antarctica. He one day hopes to procure a job and get married and live happily ever after.

Taylor Griffith was born September 24, 1993 in Merritt Island, FL. and was raised in Central Florida. Having graduated Titusville High School in the spring of 2012 with one year of college credit taken at Brevard Community College (BCC). Taylor anticipates graduating with his Bachelors of Science in Computer Engineering in December 2016 to pursue a career in simulations. Taylor has worked at Lockheed Martin for his final two and half years at UCF. Taylor worked in the database group as a scriptwriter for simulations. The company he interned with is one of the largest DOD contracted companies nationwide. Other than furthering his career in simulations he also plans on continuing his favorite hobbies; embedded systems, computer repair, and of course PC gaming.



African Native American University of Central Florida Student, Johnnie Alexandria Greene was born August 9, 1990 in Minot, North Dakota and was later raised in Orlando, Florida. During her high school career, she was a professional ballerina. After graduating from Timber Creek high school in 2008, she continued her career as a ballerina while attending Valencia Community College. During her attendance at Valencia Community College she became very passionate in her love of physic. She later decided to focus on physics. Johnnie Alex anticipates on graduating as a double major in Physics and Photonics Science and Engineering in May 2017. Johnnie Alex has worked for Dr. Ayman Abouraddy for two and half years as an undergraduate researcher in biophotonics and bio-optics. Dr. Ayman Abouraddy is a professor at the College of Optics otherwise known as the world renowned C.R.E.O.L. She currently works in the Non-linear Optics Group under Dr. MJ Soileau who is a founder of C.R.E.O.L. She is very focused on furthering her career in both engineering and physic. She hopes to inspire young girls as well as young Native Americans to

take an interest in the STEM field. Johnnie Alex is very interested and well-rounded in fiber communication, nanoscience, biophotonics, nanophotonics, non-linear optics and image display and motion detection systems.

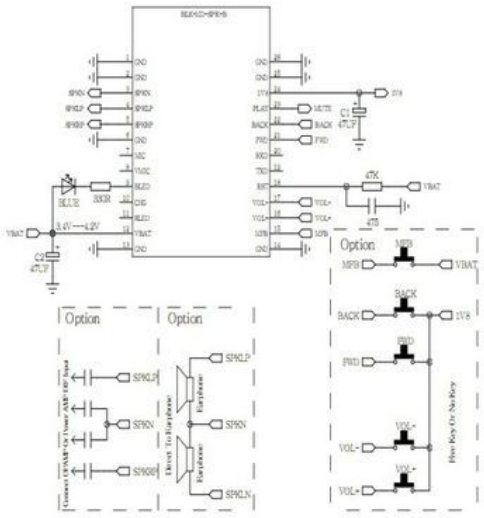
10 Conclusion

The completion of this documentation for our project has given our group a clearer and a more precise direction on how to complete the assembly of our prototype of the Home Audio Programmable Pathway Illumination (H.A.P.P.I.) System. During the researching phase of our project, each of the four group members have shown that they are competent on every component in each of the four group members respective areas of concentrations and or interest, while retaining an overall knowledge of all the areas of the project. Each of our members' skills began to shine during the design phase. The group had to provide an immensely detailed design. Collective as a group we are confident in each of the group members' knowledge and training to complete the final assemble of our project. Every phase of the design process was careful outlined and then documented tediously. This forces accountability on all four of the group members to be accurate to the best of their ability. Accuracy is important to this project due to all of the specifications and limitations we are decided upon as a group.

The research phase of the project was the number one important phase. The research that was conducted led many of group members to better components as well as components that are identical, but have a more reasonable in price. The research phase helped us design the structure of the lawn spikes as well as the structure of our central hub.

The most significant result gain from completing this document is the unexpected learning experience of the four individual group members and as well as collectively. At the start of senior design, we were unaware of the task placed before us. During the research and design phase every group member began with doubt in their own ability to contribute to this project. Over time not only did every member reclaim their self-confidence in their own abilities, but was assured that every other member can contribute successfully to the project. This documentation forces our group to manage four different personalities as well as learn how to effectively communicate with each member. If it was for our communication skills, we would have had trouble setting specifications and limitations as well as meeting those specifications and limitations. Our group is looking forward to the completion of our senior design project in its totality.

11 PERMISSIONS



Permission granted for the above image:

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material

for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give **appropriate credit**, provide a link to the license, and **indicate if changes were made**. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the **same license** as the original.

No additional restrictions — You may not apply legal terms or **technological measures** that legally restrict others from doing anything the license permits.

Permission requested for above image:

Name:*

Taylor Griffith

Email:*

t.griffith2815@gmail.com

Subject:*

Permission of use

Message:*

Hi duino4projects,

I am a senior at UCF and i am required to request permission for any images id like to use with our project, we are creating music and light playing lawn ornaments and will be utilizing the ATmega328P, I wanted to know if i can put the image that has to deal with the ATmega wiring from this page

http://duino4projects.com/arduino-atmega328-hardcore-using-arduino/

Please let me know at T.griffith2815@gmail.com

12 Works Cited

"Adafruit Feather M0 Bluefruit LE." *Overview*. Web. 02 Aug. 2016.

"Adding Basic Audio Ouput to Raspberry Pi Zero." *Overview*. Web. 02 Aug. 2016.

"BU-107: Comparison Table of Secondary Batteries." *Secondary (Rechargeable) Batteries – Battery University*. Web. 02 Aug. 2016.

"Bose® Free Space® 51 Environmental Speakers." *Crutchfield*. Web. 02 Aug. 2016.

"Czochralski Process - Google Search." *Czochralski Process - Google Search*. Web. 02 Aug. 2016.

"DIY Bluetooth Speaker." *Instructables.com*. Web. 02 Aug. 2016.

"ExpressPCB." *ExpressPCB*. Web. 02 Aug. 2016.

"HC-06 Comandos AT." - *Laboratorio De Garagem (arduino, Eletrônica, Robotica, Hacking)*. Web. 02 Aug. 2016.

"How to Program the XS3868 Bluetooth Audio Module through Arduino?" *Instructables.com*. Web. 02 Aug. 2016.

"Installing the Raspberry Pi Nano Bluetooth Dongle." *Cases for Your Raspberry Pi*. Web. 02 Aug. 2016.

"Introducing Trinket." *Downloads*. Web. 02 Aug. 2016.

"Make a Simple Audio Amplifier." *Instructables.com*. Web. 02 Aug. 2016.

"Product Development from the Ground up." *: Shrinket, Arduino Compatible ATtiny85 Development Board*. Web. 02 Aug. 2016.

""Projects | UCF ECE Senior Design." *Projects | UCF ECE Senior Design*. Web. 02 Aug. 2016.

"Raspberry Pi Transmit A2dp to Bluetooth Speakers - Technical Support." *Last 10 Submissions RSS*. Web. 02 Aug. 2016.

"Raspberry Pi • View Topic - Bluetooth Audio Streaming." *Raspberry Pi • View Topic - Bluetooth Audio Streaming*. Web. 02 Aug. 2016.

"Solar Cell Comparison Chart – Mono-, Polycrystalline and Thin Film - Energy Informative." *Energy Informative*. Web. 02 Aug. 2016.

"Stereo Enclosed Speaker Set - 3W 4 Ohm." *Adafruit Industries Blog RSS*. Web. 02 Aug. 2016.

"TMRh20/RF24Audio." *GitHub*. Web. 02 Aug. 2016.

"Types of Solar Panels - Pure Energies." *Pure Energies USA*. Web. 02 Aug. 2016.

"USB Powered Speakers." *Adafruit Industries Blog RSS*. Web. 02 Aug. 2016.

"What Are the Different Types of Solar Modules?" *Solar Power World*. Web. 02 Aug. 2016.

"What's the Best Battery?" *Basic to Advanced Battery Information from Battery University*. Web. 02 Aug. 2016.

"Which Solar Panel Type Is Best? Mono-, Polycrystalline or Thin Film?" *Energy Informative*. Web. 02 Aug. 2016.