# ECE 445

Spring 2019
Design Document

# WiFi Mousr

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# Table of Contents

# 1. Introduction

## 1.1 Objective

Pet care is one of the largest aspects of the modern era which has yet to be automatized. Recently, an issue has arisen for pets of the working class spending too much time alone inside the house being paired with a lack of a mechanism to let off steam and burn excess energy. This fact opens a new market focused on creating and updating pet toys to the automatic world, which gives pet owners the possibility of entertaining and caring for their pets while away from home [1].

Realizing this, three electrical engineers from the University of Illinois with a common passion for cats, founded a company called *"Petronics"* in 2014 [2]. After years of designing products for pets, they came up with a toy based on an advanced artificial intelligence technology, the Mousr.

A brief market study revealed that most of the existing electronic cat toys are very simple, consisting of automated parts moving in looped patterns ,which usually consist of lasers and feathers. They are commercialized as interactive toys, and yet they are not able to receive user input or collect and react to environment data. We therefore believe that there is an opportunity for Mousr to succeed in this field.

Nowadays, there are numerous startup companies making toys and other pet care essentials. One of the most important and biggest events in the country is the Global Pet Expo, an exposition with more than one thousand exhibitors and more than six thousand pet product buyers [3], which gives the opportunity to discover the best pet toys on the market. At the 2018 exposition, *"Petronics"* received the award for the best cat toy at the show [4] and the "APPA Best Cat Product 2018"`[5], achieving the first position in the cat toy market.

One notable competitor of the Mousr is *"Petcube"*, which allows pet owners to watch, listen and speak to their cats from their phones. It also features a moving laser. While there is an overlap between this product's and Mousr's functionalities, they each provide a different experience and can easily coexist. It is, however, a reasonable incentive for Petronics to keep updating their device.

Our goal is to develop new upgrades for the Mousr in collaboration with the company, in order to succeed in the market of automatic cat toys and maintain their status as top smart pet toy seller (achieved in 2018)[6]. The new version is meant to increase the functionality of previous robots by replacing Bluetooth connection with WIFI, which provides a stronger and more long-distance connection.

## 1.2 Background

Nowadays, the Mousr requires two microcontrollers, one in the head unit that communicates the robot with an app and processes sensor data and another in the body unit that works as a hub that controls wheel and tail movements. The toy is controlled by an Android or iOS app through the BLE functionality of the head chip. The use of Bluetooth in the microcontroller is inefficient in terms of cost and functionality.

Changing the head microcontroller to the ESP32 adds WIFI functionality as a form of communication with the app, giving us the opportunity to connect the Mousr to the internet and upgrading the interface between the user and the Mousr. For instance, it can be used to register the user's work schedule or to check in on statics and battery life remotely. WIFI offers many advantages to the device, mostly due to its faster data transfer rate and improved bandwidth. Additionally, the stronger signal significantly improves the pairing range.

Regarding product cost, the switch to the new microcontroller entails a smaller BOM, which will in turn reduce manufacturing and part costs.

## 1.3 High-Level Requirements

- The Mousr must be able to connect with the app through Bluetooth, and then establish a WIFI connection with the home router, with a 90% success rate, specified by Petronics.
- All the sensors must communicate with the new microcontroller, and performing their intended functionalities, which remain the same as in the current version of Mousr.
- The user must be able interact with the Mousr in two ways: through the WIFI connection with the phone application and through the scheduled auto-play capability. Proof of concept must be provided by interacting with the RBG LED.

## 2. Design

### 2.1 Block Diagram

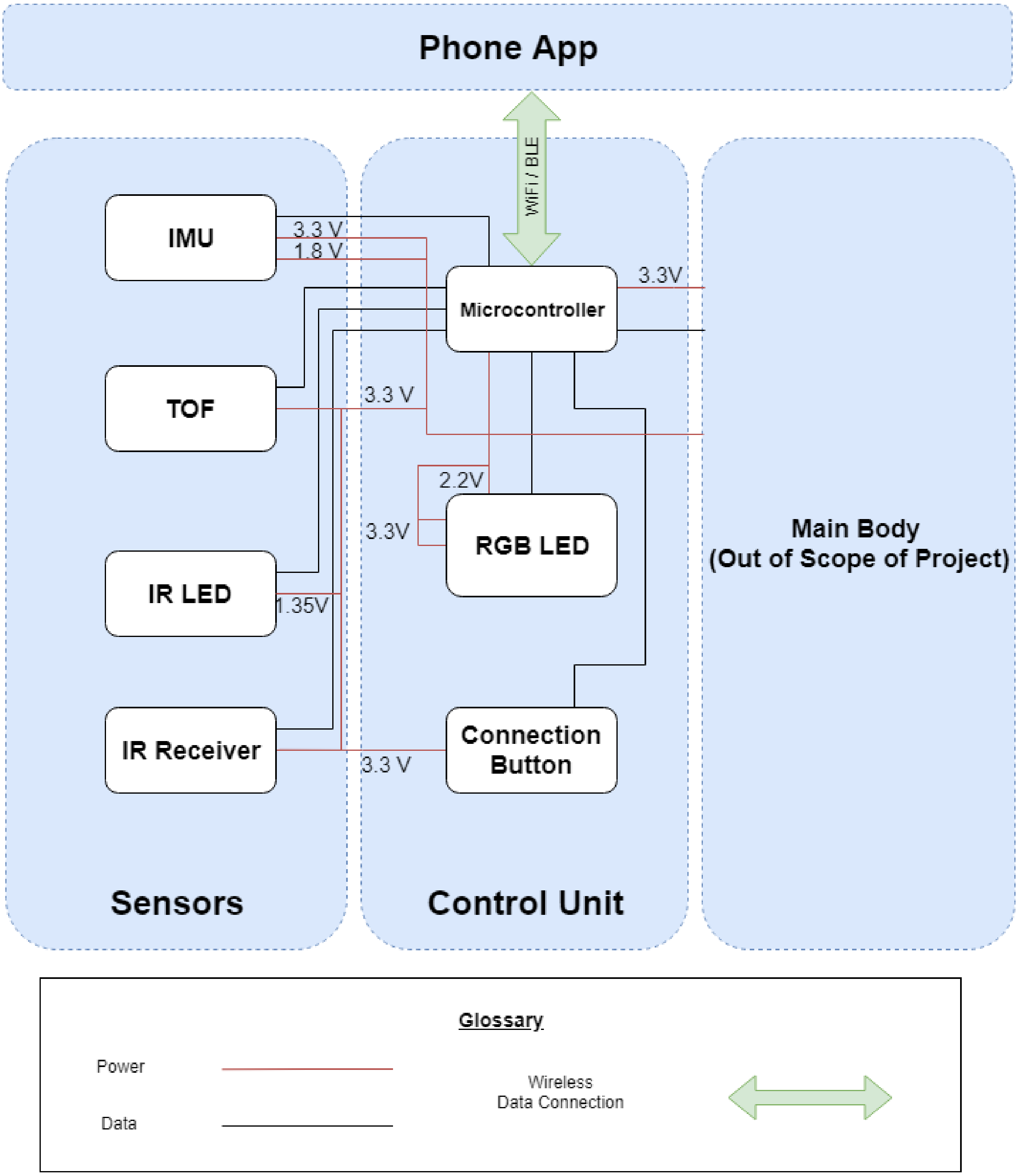


Fig.1 Block Diagram

## 2.2 Design

### 2.2.1 Functional Overview

The phone application represents the main interaction between user and product. First and foremost, it should allow the user to set or modify the scheduled-play for Mousr. This information must be stored, and the microcontroller must be notified whenever a change of operation mode is required. The App must also be able to send direct instructions to the sensors and actuators, which is essential for live-play mode. While *"Petronics"* will use this functionality to control the motors, our prototype will not interfere with the mechanical body components. We will simply aim to change the color of the LED through the phone.

Once this is accomplished, we will focus on creating a battery level display on the app, which provides the user with essential product information. We also intend to notify the user when the device needs charging, and when it is ready to be disconnected. We hope these modifications will simplify the process for the user.

The data transfer between the application and microcontroller is possible through a WIFI connection, which we will be implementing as a novelty to Mousr. Bluetooth will also play a part in sending router IP credentials. The APP must only pair with Mousr, and filter any other devices that may be within reach.

Regarding the control unit, it is a combination of the microcontroller, the LED and the pushbutton. The LED will be used as a visual indicator of the device's power mode at any moment. This will be achieved with different colors and blink frequencies. Similarly, the pushbutton is meant to allow the user to directly dictate power states and activate WIFI pairing.

Finally, the sensors block includes an IMU and a TOF module, as well as an IR receiver unit. They are essential in defining the Mousr movements by establishing position and trajectory, as well as detecting obstacles. They must be connected to the microcontroller through either I2C or a similar protocol, as specified by their respective data sheets. The microcontroller must provide the correct voltage and current quantities for the sensors to obtain valid measures.

Power consumption, which is important to optimize battery life, will depend on the operation mode selected for both the microcontroller and sensors. Low-power mode drastically reduces the necessary input, but cannot maintain a WIFI connection. The toy's behavior, which will be decided by *"Petronics"*, must optimize power efficiency.

### 2.2.2 Wireless Communication/Phone App Module

#### 2.2.2.1 Phone Application

The phone application represents the main interaction between user and product. First and foremost, the app must connect to the microcontroller over a WiFi connection which allows the user to set or modify the scheduled-play for Mousr. For the sake of this project, the schedule will be saved by the microcontroller, but in production this will be stored on a database connected to the users WiFi network and will notify the Mousr at the specified times. The app must also be able to set the Mousr in auto-play mode outside of the scheduled times, as well as directly control the RGB LED. While Petronics will use this functionality to control the motors, our prototype will not direct the mechanical body component movements. We will simply aim to change the color of the RGB LED through the phone.

Once this is accomplished, we will focus on creating a battery level display on the app, which provides the user with essential product information. We also intend to notify the user when the device needs charging by way of push notifications, and when it is ready to be disconnected since the device currently does not support auto docking and charging. We hope these modifications will simplify the process for the user.

| Requirement | Verification |
|---|---|
| Able to establish WIFI connection with Mousr with reliability of 90% | 1. From the home screen of the app, select the option that shows the WiFi symbol<br>2. Initiate pairing state of Mousr<br>3. From phone app, select the Mousr device<br>4. Select the desired WiFi network to connect to<br>5. Enter the network’s password<br>6. Ensure both app and RGB LED indicate connection is successful (app will show success screen. LED will show turn green)<br>7. Repeat 9 more times, ensuring a connection 9/10 |
| Set schedule that Mousr auto plays ± 5 minutes from | 1. Assure app is connected to the Mousr<br>2. From home screen of app, select Set Schedule option<br>3. Set time and date to be within a minute of the time at testing<br>4. Ensure that at the desired time the device begins moving |
| Able to change color of RGB LED | 1. Assure app is connected to Mousr<br>2. From home screen of app, select LED color option<br>3. Select color from available options<br>4. Ensure RGB LED is bright and visibly the selected color |

| | |
|---|---|
| Able to set Mousr to auto-play mode | 1. Assure app is connected to Mousr<br>2. From home screen of app, select auto-play option<br>3. Ensure Mousr is moving |

### 2.2.3 Control Unit

#### 2.2.3.1 Microcontroller

The microcontroller is easily the most important element of the Mousr circuit. It plays a part in every process, including WIFI and BLE transfers, device powering and sensor and actuator control. It is therefore essential that it is able to receive and interpret all digital inputs, including gathered data and sensor drivers.

Power consumption, which is important to optimize battery life, will depend on the operation mode selected for both the microcontroller and sensors. Low-power mode drastically reduces the necessary input, but cannot maintain a WIFI connection. The toy's behavior, which will be decided by Petronics, must optimize power efficiency.

| Requirement | Verification |
|---|---|
| Analog/Digital/PWM pins to make the connections. | 1. Connect RGB LED circuit<br>2. Set PWM signal to 2.2 V for microcontroller to allow red output of LED<br>3. Ensure LED is bright and showing red color |

#### 2.2.3.2 Push Button

The pushbutton is meant to allow the user to directly dictate power states and activate Bluetooth pairing. User can access both functionalities depending on press duration.

| Requirement | Verification |
|---|---|
| Must easy to press | Press button without unnecessary amount of work |

#### 2.2.3.3 RGB LED

The LED will be used as a visual indicator of the device's power states (on/off), pairing, as well as while the device is on and connected what the battery level is, which will be achieved with different colors and blink frequencies.

| Requirement | Verification |
|---|---|
| Colored light must be clearly visible, for all three colors. | 1. Connect RGB LED circuit<br>2. Set PWM signal to 2.2V from microcontroller to allow red output of LED<br>3. Ensure LED is bright and showing red color<br>4. Repeat steps 2 & 3 for green and blue except instead setting signal to 3.3V |
| LED should allow for flashing lights | 1. Connect RGB LED circuit<br>2. Generate 3.3V pulse signal from microcontroller to blue pin of LED<br>3. Ensure LED is flashing and blue |

### 2.2.4 Sensor Module

Finally, the sensors block includes an IMU and a TOF module, as well as an IR receiver unit. They are essential in defining the Mousr movements by establishing position and trajectory, as well as detecting obstacles. They must be connected to the microcontroller through either $I^2C$ or a similar protocol, as specified by their respective data sheets.

#### 2.2.4.1 TOF

The TOF sensor is meant to determine the distance to the closest obstacle in its field of vision. In Mousr devices, it facilitates room navigation and reduces crashes. This is essential for both functionality and useful life of the product.

| Requirement | Verification |
|---|---|
| Performance should accomplish a field of vision of 20° ± 1° | 1. Power TOF sensor on breadboard and connect to oscilloscope<br>2. Measure out 20° area<br>3. Hold notebook 80cm away from sensor and sweep through measured FOV<br>4. Ensure oscilloscope signal indicates an obstruction |
| Should reliably detect between 800-900mm ± 50mm | 1. Power TOF sensor on breadboard and connect to oscilloscope<br>2. Measure out area 800-900mm away from sensor<br>3. Sweep a notebook through area<br>4. Ensure oscilloscope signal indicates an obstruction |

#### 2.2.4.2 IMU

The IMU unit is standard for a motorized robot. It provides three-dimensional data which can be used to calculate position and displacements along different axes. It contains a gyroscope and accelerometer, which determine Mousr's engine rotation parameters and detect when the device has been flipped. This information will be sent to the microcontroller through digital high/low values

| Requirement | Verification |
|---|---|
| IMU is operating in selected [by micro] power consumption mode | 1. For high performance mode: current input must be 0.65 mA ±10%<br>2. For normal mode: current input must be 0.45 mA ±10%<br>3. For low power mode: current input must be 0.29 mA±10% |
| Able to recognize when it has been flipped | 1. Put the device on a straight surface and read output with oscilloscope<br>2. Flip device and read output again<br>3. Change in output should be indicative of 180 degree turn. |
| Speed/acceleration output is consistent with movement direction | 1. Move device forwards and check output values<br>2. Move device backward and repeat<br>3. Change in magnitude must reflect change of direction |

#### 2.2.4.3 IR LED

The IR LED is used to provide a reference value for the IR Receiver, which is designed to detect variations in heat intensity, rather than presence of heat.

| Requirement | Verification |
|---|---|
| Must emit IR reference frequency | 1. Set up IR receiver and IR LED circuits<br>2. Probe IR receiver output pin<br>3. Ensure that pin produces signal verifying a wavelength of 940 ± 20nm is detected |

#### 2.2.4.4 IR Receiver

Mousr is able to detect a cat’s presence through this sensor. It senses movement or changes which happen in the IR light frequency, including heat. Therefore, any moving heated object inside the receiver’s field of vision will be spotted, allowing play to be interactive rather than random.

| Requirement | Verification |
|---|---|
| The directivity angle should allow for a tolerance of 40° ± 5° | 1. Power sensor on breadboard and connect to oscilloscope<br>2. Measure out 40° area<br>3. Sweep a notebook through area<br>4. Ensure oscilloscope signal indicates an obstruction |

### 2.2.5 Supporting Material

We created a first draft of the PBC board, showing the circuit and connections required. The connector holes represent the microcontroller, which will be attached and soldered to the PBC. Correct dimensions will be inputted later on. All other sensors are shown as black boxes and include correct measures and pin layout. Below are several views of the schematic:

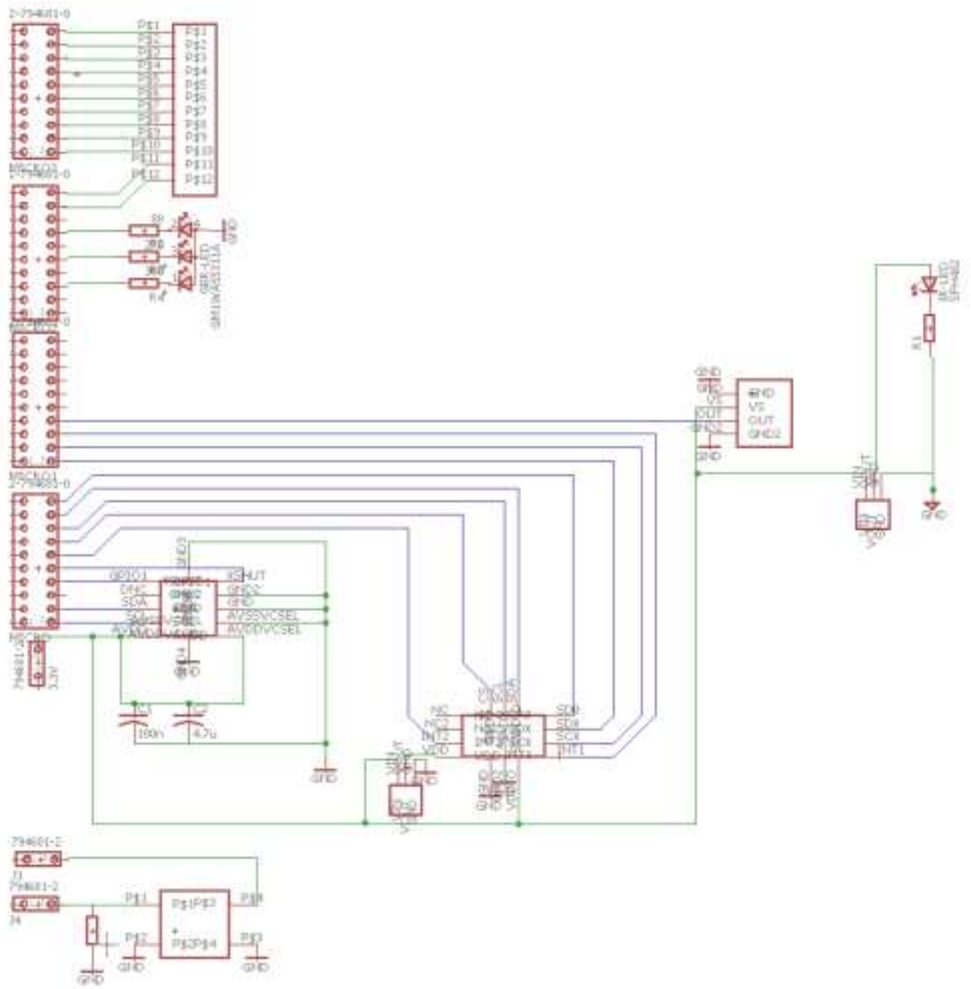

**Figure 2. Main View of PCB Schematic**

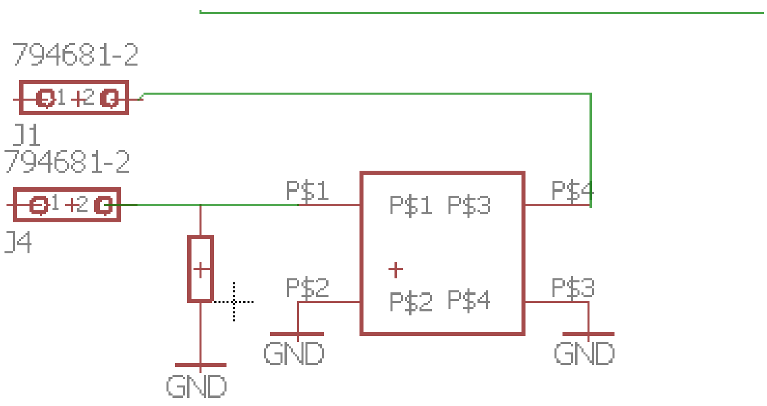


**Figure 3. Pushbutton in PCB Schematic**

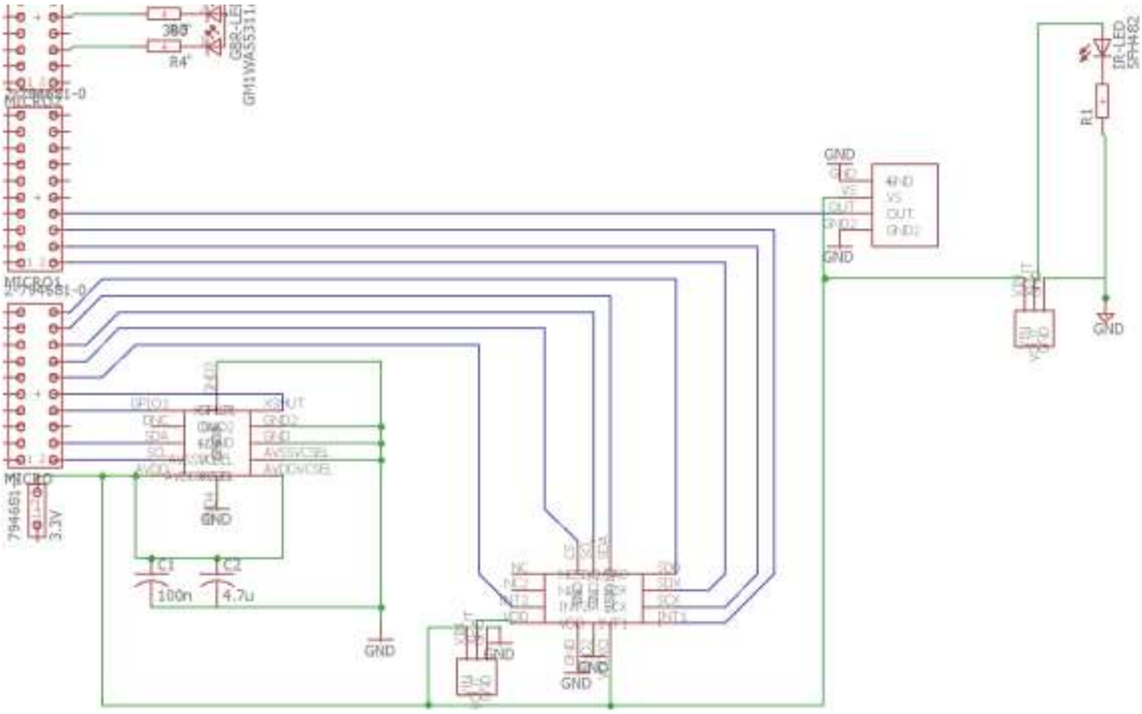


**Figure 4. TOF, IMU, IR Receiver and voltage regulators in PCB schematic**

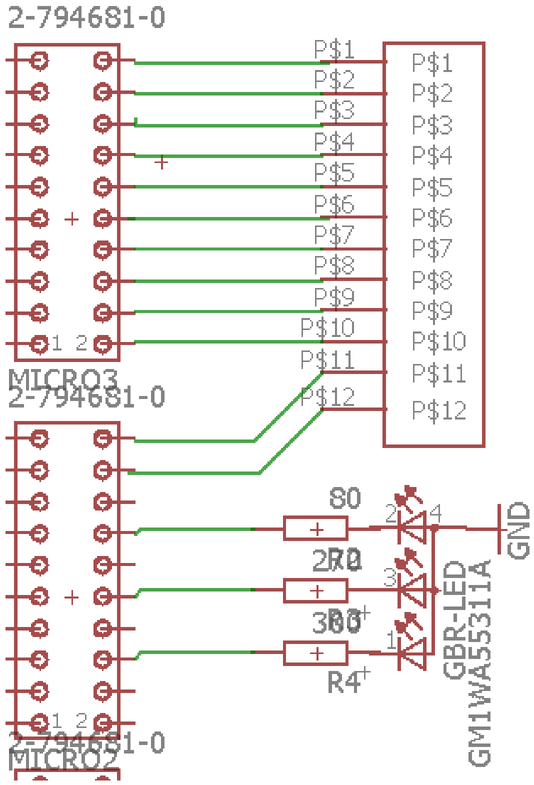


**Figure 5. RGB LED and Main Connector in PCB Schematic**

The RGB resistor values are selected so that each LED cathode receives the correct voltage. By looking at the nominal values provided in the datasheet, we obtain each diodes internal resistance as follows:

$$R_{int} = V_{nom} / I_{typical} \qquad \text{(Eq 2.1)}$$

The datasheet also specifies that the necessary voltages for the red, green and blue light diodes. We can assume the LED is connected to a 3.3 volts inout pin, and write a simple voltage divider:

$$V_{LED}=(R_{int})/(R_{int} + R_x) \qquad \text{(Eq 2.2)}$$

When inputting the corresponding values, we obtain the resistor values (Rx) shown in the following table:

| LED COLOR | $R_{int}$ (Ω) | $V_{LED}$ (v) | $R_x$ (Ω) |
|---|---|---|---|
| Red | 140 | 2.1 | 140 |
| Green | 270 | 2.7 | 270 |
| Blue | 300 | 3 | 300 |

Finally, we drew a schematic showing the power circuit, which will be integrated in the PCB. Once we obtain the sensors we will proceed to measure their resistance using a multimeter, and then complete the necessary calculations to solve the circuit. This will allow us to check whether we need resistors to decrease the power, and whether we are drawing enough power from the microcontroller.

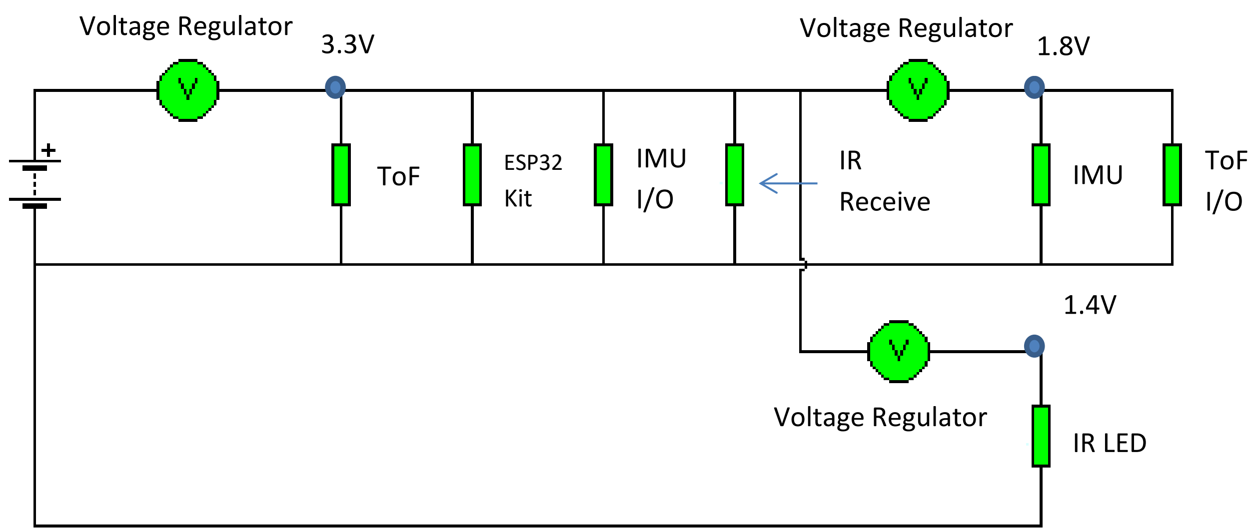


**Figure 6. Power Circuit Schematics**

Regarding the device's hardware, the standard Mousr device requires a flexible PCB due to the reduced space availability inside the head. However, we will not be using a flexible PCB in our prototype. Instead, we intend to place all the components in one rigid layer. Part positions and distances will be maintained whenever possible. In Figure X, shown below, we can see the current disposition of the components inside Mousr.

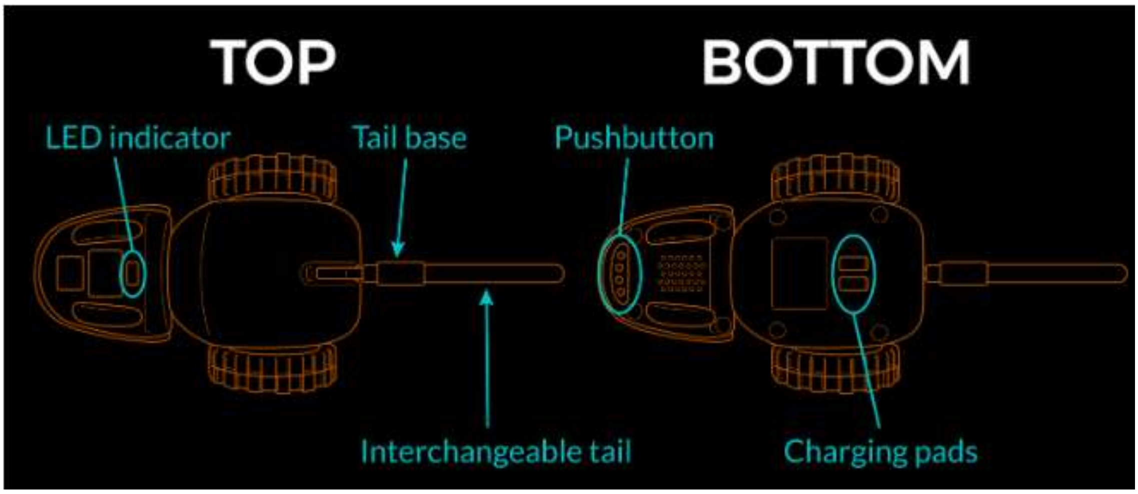


**Figure 7. Sensor Location Diagram**

### 2.2.5.1 WiFi Connection Algorithm

Our WIFI connection protocol, chosen by Petronics, will rely mostly on the APP. Basic patterns are displayed in the flowchart Figure 2:

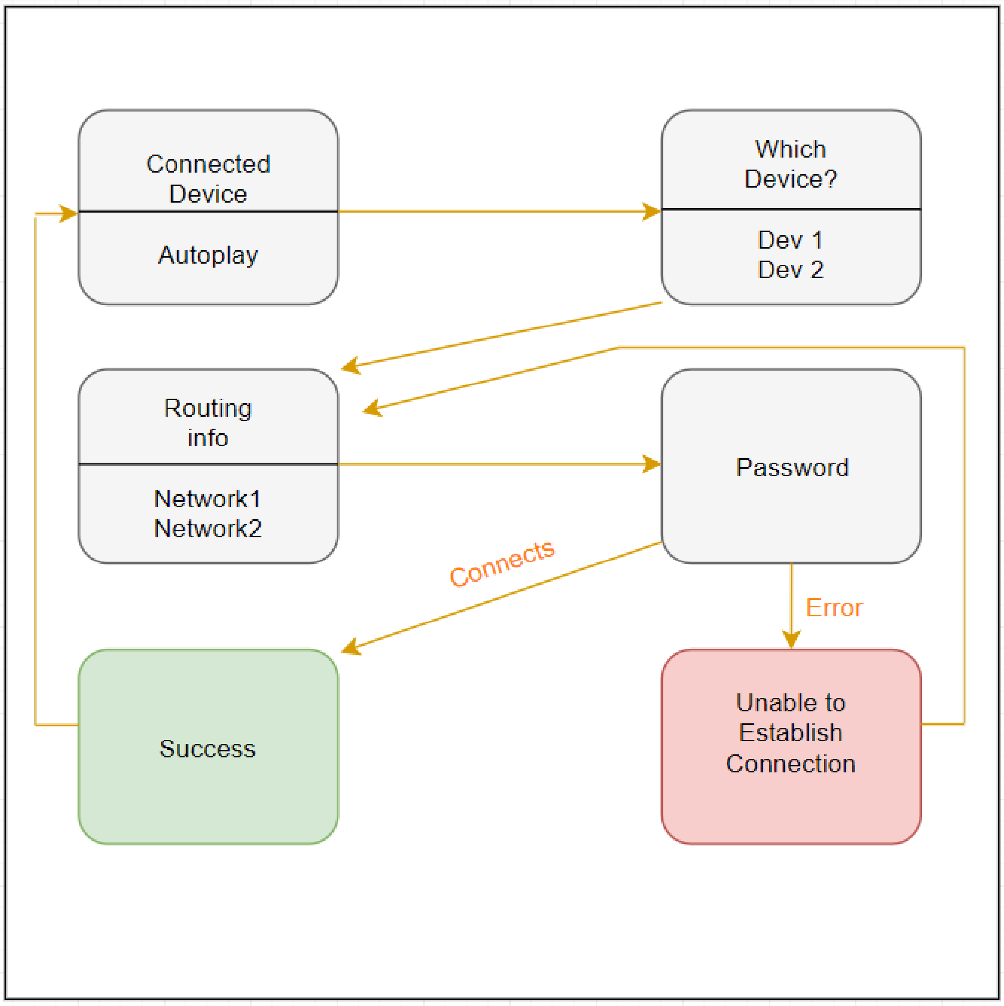


**Figure 8 Flow of App "Connection" Screens**

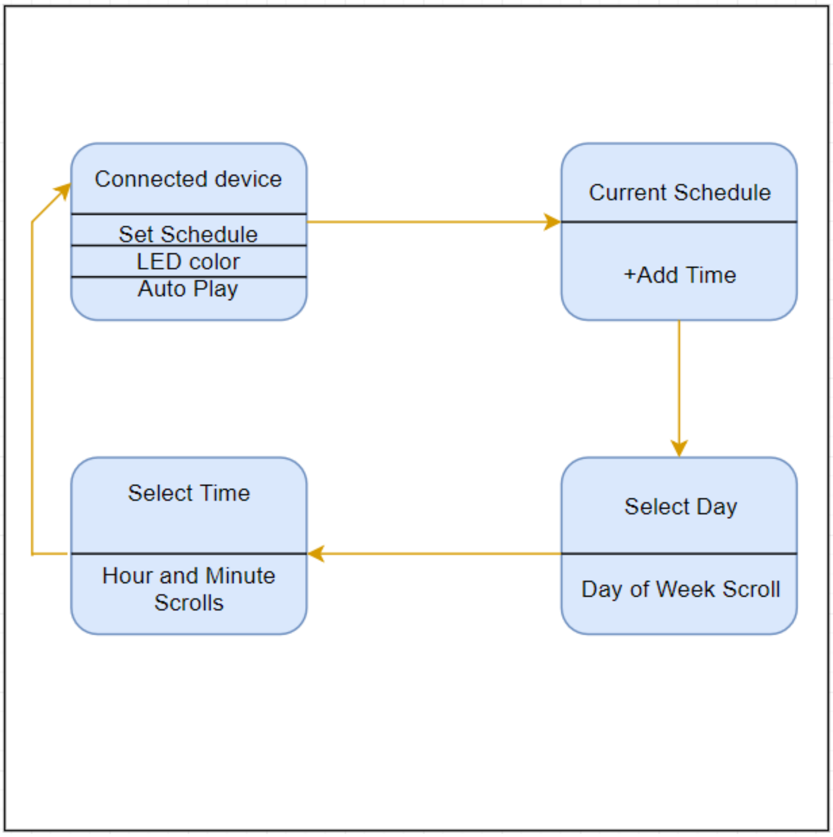


**Figure 9. Flow of App "Set Schedule" Screens**

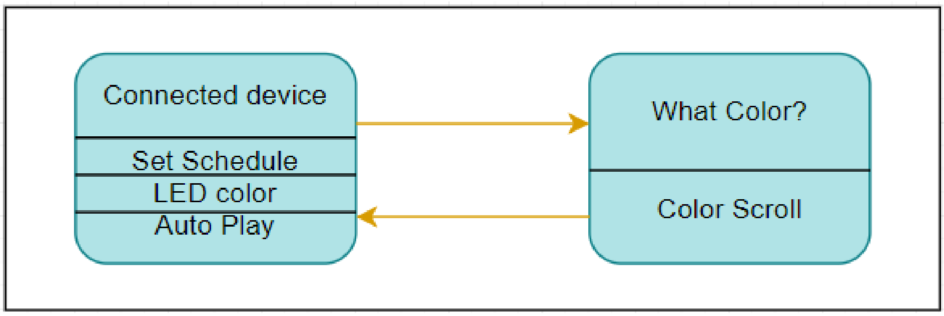


**Figure 10. Flow of App "Set LED color" Screen 1**

### 2.3 Tolerance Analysis

For us, the trickiest part of the project is the control unit block. This can be attributed to the need for the microcontroller to collect signals from all of the sensors as well as any data from the phone application and then process this for movement, LED color change, and schedule planning. If the control unit fails to process information correctly, all the other blocks' functionalities become useless.

Besides the sensors transferring properly and the algorithms within the microcontroller being correct, the pertinent limiting factor is the data transfer rates. The microcontroller has a variable data transfer rate.

Its maximum:

$$\frac{240\ M\ cycles}{sec} * \frac{32\ bits}{48\ cycles} = 20\text{Mbps} \qquad \text{(Eq 2.3)}$$

Its minimum:

$$\frac{40\ M\ cycles}{sec} * \frac{32\ bits}{1600\ cycles} = 10\text{ kbps} \qquad \text{(Eq 2.4)}$$

The latencies are directly correlated to the clock cycles, faster frequencies have less latency. The minimum above is the worst case as it can barely handle the IMU, which as a data output rate of 25 kbps. Although the IMU has the highest output rate of the sensors, the WiFi and BLE modules both use the UART data bus, which allows for up to 5 Mbps per channel, which cannot be handled at the minimum clock frequencies. A latency versus frequency plot is not given for the microcontroller, so testing would need to be done to find an equilibrium frequency for the microcontroller transfer rate to match the data input/output rate exactly, but assuming two UART channels, one for WiFi and one for BLE, and processing power for the IMU and TOF sensors, a minimum of ~10.1 Mbps is needed. Assuming linear trends between latency (cycles), clock frequency (MHz), and the data transfer rate(Mbps):

$$\text{Latency (cycles)} = 2080.38 - 8.31\omega\ [\text{MHz}] \qquad \text{(Eq 2.5)}$$

$$\text{DTR} = 0.065\omega - 0.00455 * \text{latency} + 4.71$$

$$10.1 = 0.065\omega - 0.00455(2080.38 - 8.31\omega) + 4.71$$

$$\omega = 144\text{ MHz}$$

This a large assumption, but given this, the clock frequency need to satisfy the data transfer rate needed is 144 MHz, which is within range of the microcontroller’s ability as well leaves room if an increase is needed due to the assumption being incorrect.

# 3. Cost and Schedule

## 3.1 Cost Analysis

### 3.1.1 Labor

We obtained an approximation of cost of labor using the following equation:

(Eq 3.1)

$$Total\ Cost = \frac{(Avg\ Salary\ of\ BS\ in\ EE) + (Avg\ Salart\ of\ BS\ in\ CE)}{2} * \frac{1\ Year}{Labor\ Weeks * 45\ Hours} * (Total\ Time\ [h]) * (Number\ of\ Team\ Members)$$

The average salary data was obtained from the ECE website of UIUC. Total time was estimated to be 100 hours per worker. The resulting value is shown below:

$$Total\ Cost = \frac{\$67000 + \$84250}{2} * \frac{1\ Year}{52 * 45\ Hours} * (100) * (3)$$

$$Total\ Cost = \$\ 9695.51$$

### 3.1.2 Parts

For our project, we are going to order some extra quantity of parts to have some stock, in case we have to issues during the assembly process. The expected cost of the parts required for our prototype is detailed in the following table:

| Part | Part Specification /Manufacturer | Supplier | Cost / Unit (USD) | Quantity | Total Cost (Prototypes) (USD) | Total Cost of Manufacturing (USD) |
|---|---|---|---|---|---|---|
| ESP32Wrover Kit V4.1 | *GC-ESP-WROVER-KIT / Espressif* | GridConnect | $40.00 | 1 | $40.00 | $5.00 |
| IMU | LSM6DSLTR / STMicroelectronics | Mouser | $3.98 | 4 | $15.92 | $2.50 |
| TOF | VL53L0CXV0DH/1 / STMicroelectronics | Mouser | $4.5 | 4 | $18.00 | $2.83 |
| RGB LED | CLY6D-FKC-CK1N1D1BB7D3D3 / Cree Inc | Digikey | $0.38 | 10 | $3.80 | $0.29 |
| IR Receiver | TSSP77038TT / Vishay Semiconductors | Mouser | $1.79 | 4 | $7.16 | $0.82 |
| IR LED | VSMB3940X01-GS08 / Vishay Semiconductors | Digikey | $0.81 | 5 | $4.05 | $0.34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pushbutton | PTS810 SJG 250 SMTR LFS / C&K | Digikey | $0.34 | 5 | $1.70 | $0.24 |
| FCC Connector | 687112183722 / Wurth Electronics | Mouser | $1.83 | 4 | $7.32 | $1.22 |
| Voltage regulator 3.3V | LM1117T-3.3/NOPB / Texas Instruments | Mouser | $1.54 | 4 | $6.16 | $0.89 |
| Voltage regulator 1.8V | LM1117T-1.8 / Texas Instruments | OnlineComponents | $1.01 | 4 | $4.04 | $0.68 |
| Voltage regulator 1.4V | NCP699SN14T1G / ON Semiconductors | Mouser | $0.47 | 4 | $1.88 | $0.14 |
| PCB | - | PCBWay | $5.00 | 2 | $10.00 | $0.50 |
| Breadboard Jumper Wires | EL-CP-004 / ELEGOO | Amazon | $6.98 | 1 | $6.98 | - |
| Assorted resistors, capacitors, sockets | | Digikey | $10 | 1 | $10 | $0.60 |
| | | | | TOTAL COST | $127.01 | $16.05 |

This cost is merely estimation with a wide variance, as we might need to order extra parts, implement several PCB designs, and the hours spent is heavily dependent on software debugging.

#### 3.1.3 Total

| Chapter | Description | Cost($) |
|---|---|---|
| 3.1.1. | Labor……........................................................................ | **9695.51** |
| 3.1.2. | Parts………………………................................................... | **127.01** |

**TOTAL COST………………….......................................................$9822.52**

### 3.2 Schedule

In the table we have 4 colors to identify the different area: blue define the Hardware, red define the Software and green is the documentation of the project. Inside each cell is the name of the responsible person. This schedule will be updated during the project, to make sure that we are achieving the dates. All the tasks have to be done before the week 9, week when we will make the demo.

| **Activity** | **Time Schedule** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 |
| PCB Schematic | Isabel | | | | | | | | | |
| Order Components | Marc | | | | | | | | | |
| PCB Layout (V1) | | Isabel | | | | | | | | |
| Print PCB (V1) | | | | | | | | | | |
| Soldering PCB (V1) | | | Marc | | | | | | | |
| Check Electrical Connections | | | Marc | | | | | | | |
| Prototype Assembly | | | | All | | | | | | |
| Prototype Test V1 | | | | All | | | | | | |
| PCB Layout Refine (V2) | | | | | Isabel | | | | | |
| Print PCB (V2) | | | | | | | | | | |
| Soldering PCB (V2) | | | | | | Marc | | | | |
| Check Electrical Connections | | | | | | Marc | | | | |
| Prototype Test V2 | | | | | | | All | All | | |
| Prepare Mock-up | | | | | | | | All | | |
| Flow Chart App | Nick | | | | | | | | | |
| iOS App Code | Nick | | | | | | | | | |
| Test iOS App with ESP32 | | Nick | | | | | | | | |
| iOS App Finish | | | Nick | | | | | | | |
| Android App Code | | | | Nick | | | | | | |
| Test Android App with ESP32 | | | | | Nick | | | | | |
| Android App Finish | | | | | | Nick | | | | |
| Flow Chart ESP32 | Marc | | | | | | | | | |
| ESP32 Code | | Marc | | | | | | | | |
| Software /Hardware Integration | | M/I | | | | | | | | |
| S/H Integration (PCB V1) | | | M/I | M/I | | | | | | |
| Software debugging/refine | | | | M/I | M/I | | | | | |
| S/H Integration (PCB V2 + App) | | | | | | All | All | | | |
| Software debugging/refine | | | | | | | All | All | | |
| Prepare Mock-up | | | | | | | | All | | |
| Mock-up TA | | | | | | | | | | |
| Final Demonstration | | | | | | | | | | |
| Design Document | | | | | | | | | | |
| Start Final Paper | | | | | | | | | | |
| Check / Update Schedule + Cost | | | | | | | | | | |
| Design Procedure + Details | | | | | | | | | | |
| Explain Verification (Data) | | | | | | | | | | |
| Check / Update Schedule + Cost | | | | | | | | | | |
| Start Presentation | | | | | | | | | | |
| Finish Final Paper | | | | | | | | | | |
| Finish Presentation | | | | | | | | | | |

## 4. Discussion of Ethics and Safety

Our product is a household item, and as such it will work at direct interaction with not only pets, but also families and other electronics devices. It is then our responsibility to ensure no harm comes to the mentioned parties.

As a pet toy, it is not subject to a specific legislation. However, it must comply with the safety requirements established nationally by the Consumer Products Safety Commission. These regulations include respecting environmental standards [7], avoiding hazardous materials present in plastics such as phthalates and enabling customers to submit a public report of harm if the need arises [8]. Safety and durability standards are also essential.

However, this first set of requirements are to be handled by the company ‘Petronics’ and do not directly relate to our project. We will focus on the WIFI connection and App regulations.

Any wireless or smart product needs to be FCC (Federal Communications Commission) certified in order to be sold in the US. To obtain Product Certification the product must pass all required testing and reviews. The two main aspects of this review are “General Emissions” and “Intentional Radiation” [9]. This is an expensive and lengthy process which can be avoided by utilizing a certified RF module [10]. This decision will be handled by ‘Petronics’.

Regarding the App, privacy policies [11] are the main ethical issue to be considered. We will be connecting to the house router, and must ensure to the best of our ability that both the connection and the data stored in the device remain secure. This is clearly stated in sections II and VI of the ACM code of ethics, “do no harm” and “respect privacy” [12].

We will follow the principles stated by Maciej Ceglowski regarding data management. He claims personal data is similar to radioactive waste, and therefore easy to generate, dangerous if released and impossible to dispose of. Our app will discard the information it processes whenever possible. If we decide to distribute the App using iOS or Androids’ App store we must create a privacy policy document, specifying what data we collect and its purpose, as well as inform users that their data might be shared with an external party, under the Fourth Amendment’s third party doctrine.

Lastly, we are aware that if our App is to be commercialized to other countries it is necessary to accommodate their privacy policies.

When broaching the topic of lab safety, the main issue that arises is working with the electric equipment. This includes the power source in the lab, as well as the battery pack and PCB board. When dealing with power, there is a risk of suffering electric shock or contact burns as well as provoking a fire by releasing sparks. As we learned during lab training, control measures include working in groups, locating the lab main emergency switches and not using damaged equipment. It is also very important to keep liquids away from the equipment [13].

In case of electric shock, contact time is always the defining factor of the severity of the injury, along with voltage value and point of contact with our body. A commonly recommended safety measure is the “rule of one hand”, which states we must never touch a circuit or piece of equipment with both hands simultaneously [14]. This will stop electrical current from flowing through vital organs such as the heart or brain.

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