# ECE 445 - Design Document
## Team 19
## Portable Traffic Manager

**TA:** Ruomu Hao
**Professor:** Jonathon Schuh
**Group:** Samira Tungare, Sarah Kolak, Edward Harper

# Table of Contents

# 1. Introduction

## 1.1 Objective

At intersections with either no traffic lights or one that is malfunctioning, a common practice to control the flow of cars is to have a traffic officer direct everyone. Similarly, after large events, traffic officers are used to help direct traffic out of crowded spaces and parking lots. The traffic control wand they use seems lightweight but after hours of use, they can suffer from fatigue. The directions they give to begin with can be hard to understand but can increase in difficulty the more tired the officer becomes. The method of using a human to physically direct traffic can be not only confusing but also dangerous for the individual in the middle of the intersection.

Our goal is to make a device that would take the place of the traffic officer in the intersection. This traffic signal display could be controlled by the traffic controller via a small controller device. The traffic signal display would have displays on four sides and would display red, yellow, and green colors. It would also be able to display arrows directing cars that are making left turns. This traffic control system would allow the traffic officer to safely monitor and direct traffic from the side of the road or in a parked vehicle without needing to stand in the center of the intersection.

Unlike current traffic control boxes, this standing device would be portable so that it can be moved from one intersection to another if necessary and can be easily removed when it is no longer needed.

## 1.2 Background

Many intersections with traffic signals have the ability to be controlled manually by public works personnel. This is helpful for directing vehicle and pedestrian traffic at an intersection after a large event. These utility boxes give the individual the ability to control the pedestrian signals, turn signals, and light signals at a given intersection [1]. Once the event has ended and the traffic at a given intersection has returned to its normal flow, the signals can return to their automated control. While this feature of current traffic signals is very useful, it is only available at intersections that have traffic signals and the utility box available.

When a traffic signal and utility box is not available at an intersection then a traffic officer is sent to stand in the intersection and manually direct the traffic. The officers standing in the intersection are required to wear reflective clothing and use traffic wands, especially when directing traffic at night. Aside from the gear, they have designated hand signals that signify “stop” and “go” and sometimes also use whistles or voice commands [2]. This is an adequate form of traffic control when a permanent signal is not available. However, this method can be dangerous for the traffic officer in the event that a driver does not properly understand or follow their command. Additionally, making hand gestures with traffic wands for multiple hours can be tiring for a traffic officer and can lead to fatigue which would only worsen the quality of the gestures.

In the Spring 2019 semester of ECE 445, Team 16 designed a pair of gloves and vest that could be worn by a traffic officer. The traffic officer can display a hand signal which will correspond to "stop" or "go". The vest can communicate with the gloves to process what gesture was just made and display either "stop" or "go" on the vest in red or green respectively. Both the front and back of the vest will light up so if the front reads "stop" then the back will read "go". The gloves also have LEDs that indicate the proper color as well. This implementation of traffic control was designed to make the gear more lightweight and the traffic control process safer for the traffic officer [3]. While this process does eliminate the need for wands, it does not guarantee a safer traffic control process for the officer. Displaying the words on the vest may allow drivers to clearly see what they should be doing but it does not mitigate the possibility of human error. Ultimately, the officer must still stand in the intersection to ensure that everyone can see them so if a driver ignores the vest or is not paying attention the officer is still at risk. Our solution of a portable traffic manager would eliminate the need for the traffic officer to be standing in the intersection. Additionally, instead of needing to create a new set of gear that would need to be distributed to traffic officers, they could safely direct traffic from the side of the road in reflective gear or sit in a parked vehicle. Lastly, our device is an improvement from utility boxes because it can be moved and used at any intersection where it is needed.

### 1.3 High-Level Requirements

1. Successful bluetooth communication between the traffic signal display and the controller device up to a distance of 30 meters.
2. The red, yellow, and green traffic signal display will be seen from 40 meters away.
3. The traffic signal display will successfully run for up to two hours.

### 1.4 Visual Aid

Below are some visual representations of one possible cycle of light control for the straight direction signals.

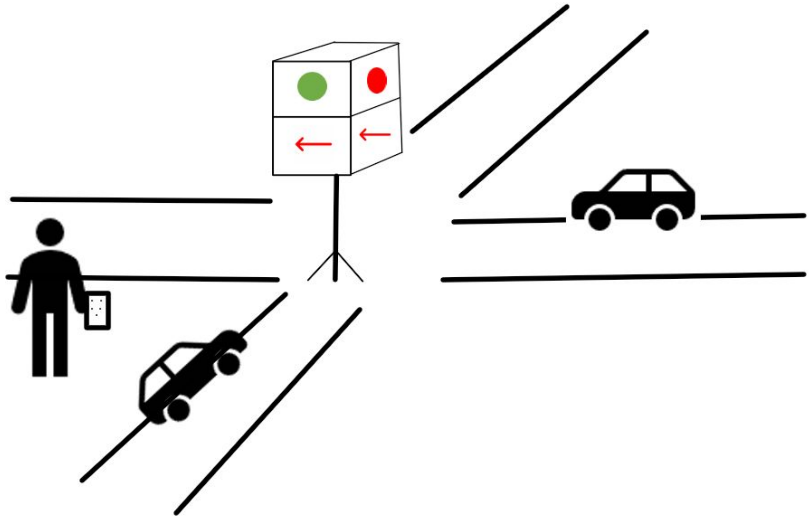

Figure 1: First mode of operation for the traffic system

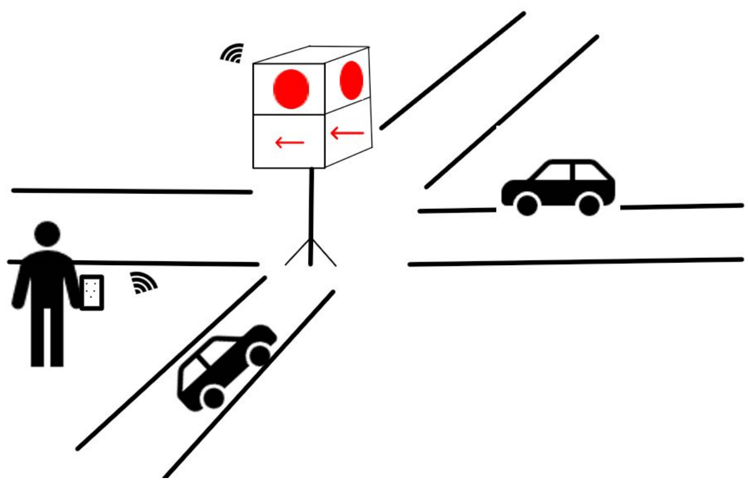

Figure 2: Second mode of operation for the traffic system (also the emergency operation)

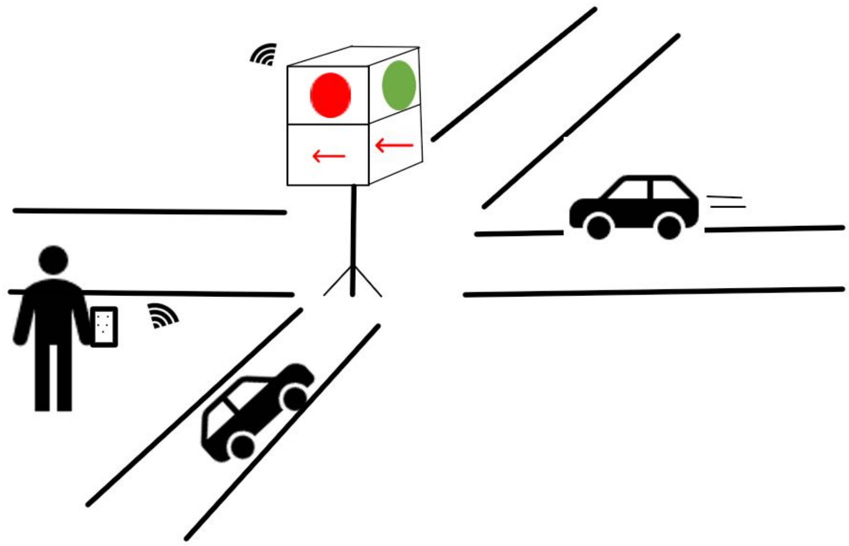

Figure 3: Third mode of operation for the straight signals

# 2. Design

## 2.1 Block Diagram

- The power module will be used to power the various components in each module as well as power the traffic display and controller device.
- The controller hardware module will consist of the processing system for the controller device as well as the controller device (push button device).
- The display hardware module will consist of the processing system for the display as well as the LED panels that will make up the display device.

The interactions between the various modules outlined above are shown in the Block Diagram in Figure 4.

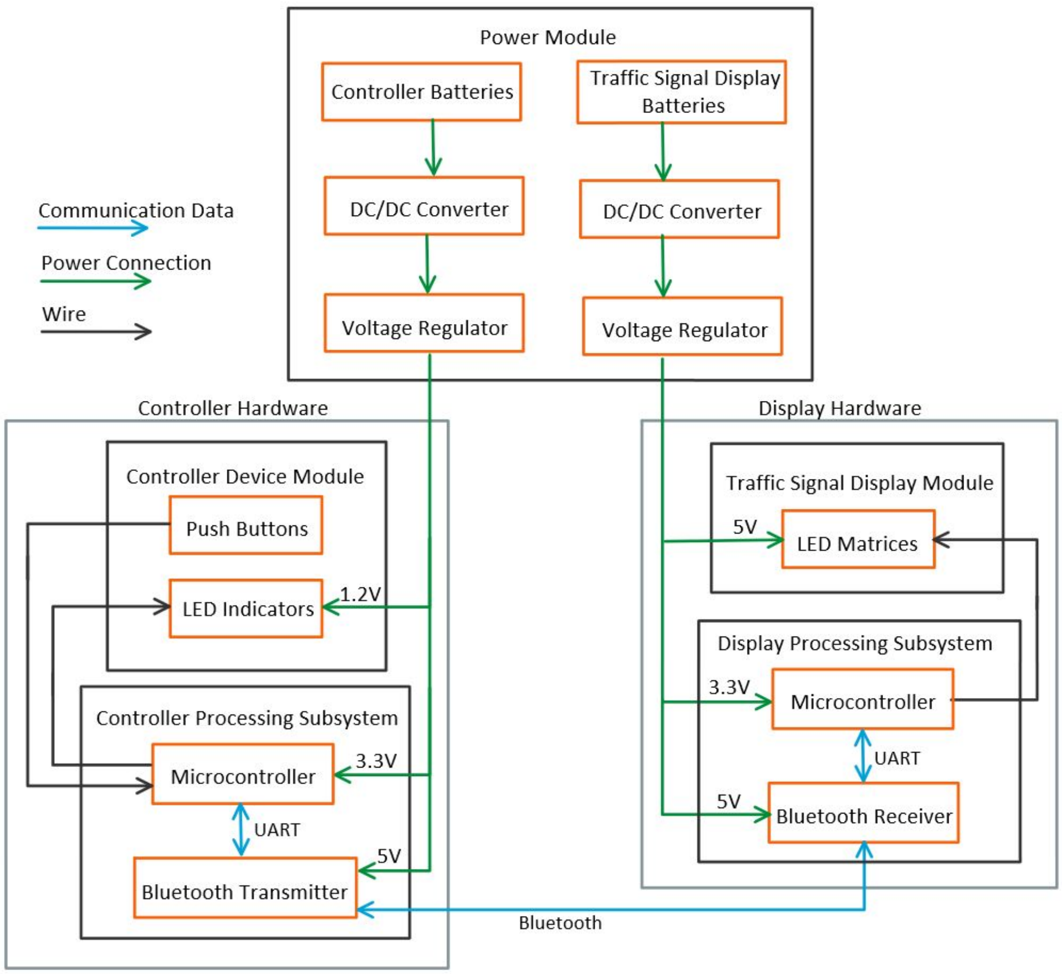


Figure 4: Block diagram for portable traffic manager system

**2.2 Physical Design**

The controller device will utilize multiple push buttons for the different traffic signals needed to direct the flow of traffic. Being roughly the size of a smartphone, the controller will be a lightweight handheld device. The traffic signal display that the controller communicates with will consist of two vertically stacked square LED matrices, with a length of 6.3”. One display will be an arrow for left turn signals and the other will be solid colored signals. Both signals will be able to cycle color from green, to yellow, to red so both the arrow and the solid signal will be able to display commands for traffic going both straight and turning. This design will be repeated on all four sides of the structure making it a rectangular box to ensure that every direction in a four way intersection will have its set of signals. Since the drivers need to see the signals from further distances when approaching the intersection, the top of the display will need to be raised up to seven feet. In order to keep the traffic signal portable, the structure will have a pole that screws into the bottom of the traffic signal. The pole will have four legs that fold out to give it enough support while keeping it lightweight. To avoid the structure from tipping from being too top heavy or blown over, a separate square piece can be placed on the ground inside the legs which is connected to each of the four legs. Additional weights can then be placed on top of the metal sheet to provide a more stable base.

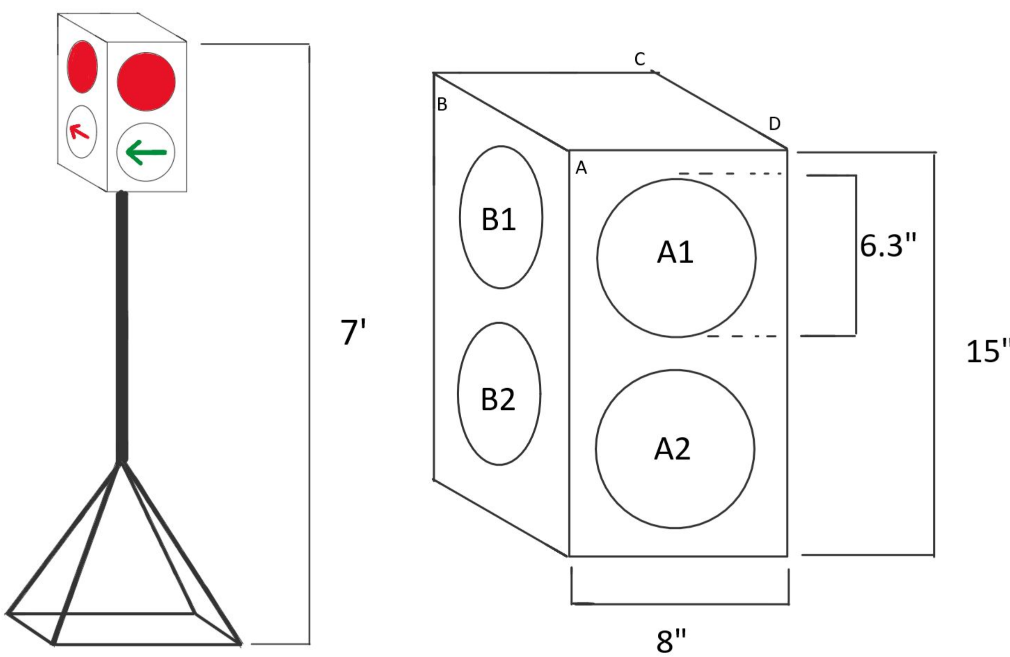


Figure 5: Physical design diagram for the display device

## 2.3 Subsystems

### 2.3.1 Power Module

The power module is meant to provide power to the various components in the circuit. It is imperative that components such as the microcontrollers, bluetooth modules, and LEDs are properly powered in order for the Portable Traffic Manager to function as expected. Table 1 summarizes the various components in the system and their respective required supply voltages.

Table 1: Circuit components and required supply voltages

| **Component** | **Supply Voltage Required** |
|---|---|
| HC-05 Bluetooth Module | $4V < V_{dd} < 6V$ (typically 5V) |
| STM32F070F6P6TR microcontroller | $2.4V < V_{dd} < 3.6V$ |
| WS2812B LED Matrix Panel | 5V |
| LED indicator forward voltage | Between 1.2V - 2V |

**Batteries**

Two Panasonic NCR18650B Li-ion batteries will be used to power each LED matrix in the traffic display. One of the LED matrices will also share its batteries with the microcontroller and bluetooth module for the display device. Similarly, the controller device will use one Panasonic NCR18650B Li-ion battery.

These batteries supply 3.6V and up to 4.9A. The nominal capacity is 3500 mAh. In order to satisfy the operating time constraints for the project, a total of 17 batteries will be in the system. These batteries are protected which eliminates the concern of a battery immediately discharging or for a short circuit occurring in the device.

**DC-DC Converters**

DC-DC converters will be used to step down the voltage from the batteries so that the LED matrices, microcontroller, and bluetooth module can all receive a steady supply of the required voltage. Each pair of batteries associated with a matrix will also have a DC-DC converter connected to it. The LM2596 Buck converter will be used to step down the voltage from 7.2V to 5V. This converter has an input range of 4.5V to 40V which means it will allow a 7.2V input and it outputs 5V. The 5V will then be supplied to the matrix and bluetooth module.

For the controller device, the RM-3.305S converter will be used to step up the voltage from 3.6V to 5V for the bluetooth module. This converter takes an input voltage range of 3V to 3.6V and outputs 5V.

**Voltage Regulators**

One linear voltage regulator will be used in the controller device and one in the display device to step down from 5V to 3.3V to power both of the microcontrollers. The input will come from the DC-DC converter. The NCP164CSN330T1G linear voltage regulator will be used in each device.

### 2.3.2 Controller Device Module

The controller device will consist of a processing subsystem, push buttons, and small LED indicators. The details of the processing subsystem are discussed in Section 2.3.3. The processing subsystem will send signals to the LED indicators and will receive signals from the push buttons.

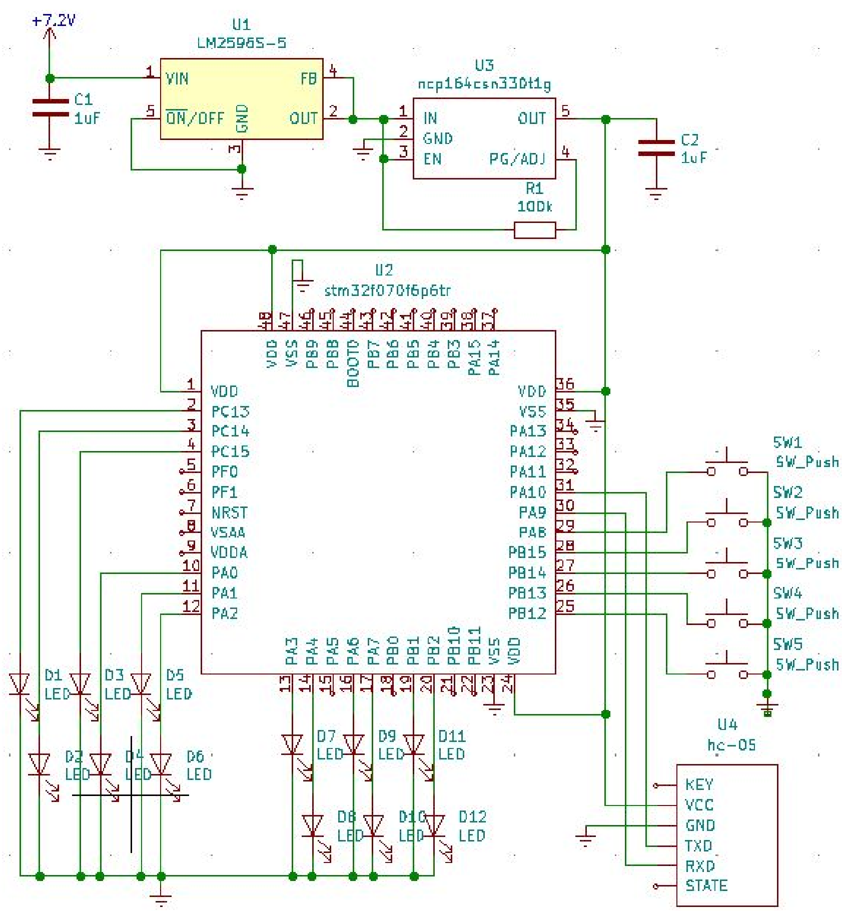


Figure 6: Controller device schematic

**Push Buttons**

On the controller device there are 5 push buttons to control the signals. Each pair of lights such as A1/C1 or B2/D2 (refer to Section 2.2) , will have its own push button to signal it to turn green. A single push button will be used to turn all the signals red. Using one button to control all of the signals makes operating the controller much easier and makes the processing simpler. This master push button for the red signals can also be used when an emergency vehicle needs to pass through the intersection. It would halt all directions in order to allow a safe passage of the emergency vehicle.

**LEDs**

Common LEDs from the lab will be used on the controller device next to each push button to indicate which matrix panels are displaying green signals. This will allow the traffic officer to always know what each side of the display is showing even if they are not able to see every side from their location. These LEDs have a forward voltage of between 1.2V to 2V depending on the color being used.

### 2.3.3 Controller Processing Subsystem

The controller processing subsystem will consist of a microcontroller and bluetooth device (See Section 2.3.6 for details on bluetooth). This processing subsystem will be responsible for communicating with the display processing subsystem as well as controlling the LED indicators on the controller device itself.

**Microcontroller**

The STM32F070F6P6TR microcontroller will be used in the controller processing subsystem. The microcontroller will communicate with the bluetooth transmitter via USART [11]. This microcontroller will be responsible for accurately commanding the indicator LEDs on the controller device with respect to the signal received from the microcontroller on the display device. It will also need to determine which push button has been pressed and send the corresponding signal to the traffic display microcontroller using the bluetooth module.

### 2.3.4 Traffic Signal Display Module

The traffic signal display will consist of a processing subsystem and LED matrices. The details of the processing subsystem are discussed in Section 2.3.5. The processing subsystem will primarily communicate with the LEDs to correctly control the display colors of each LED in the matrix panel.

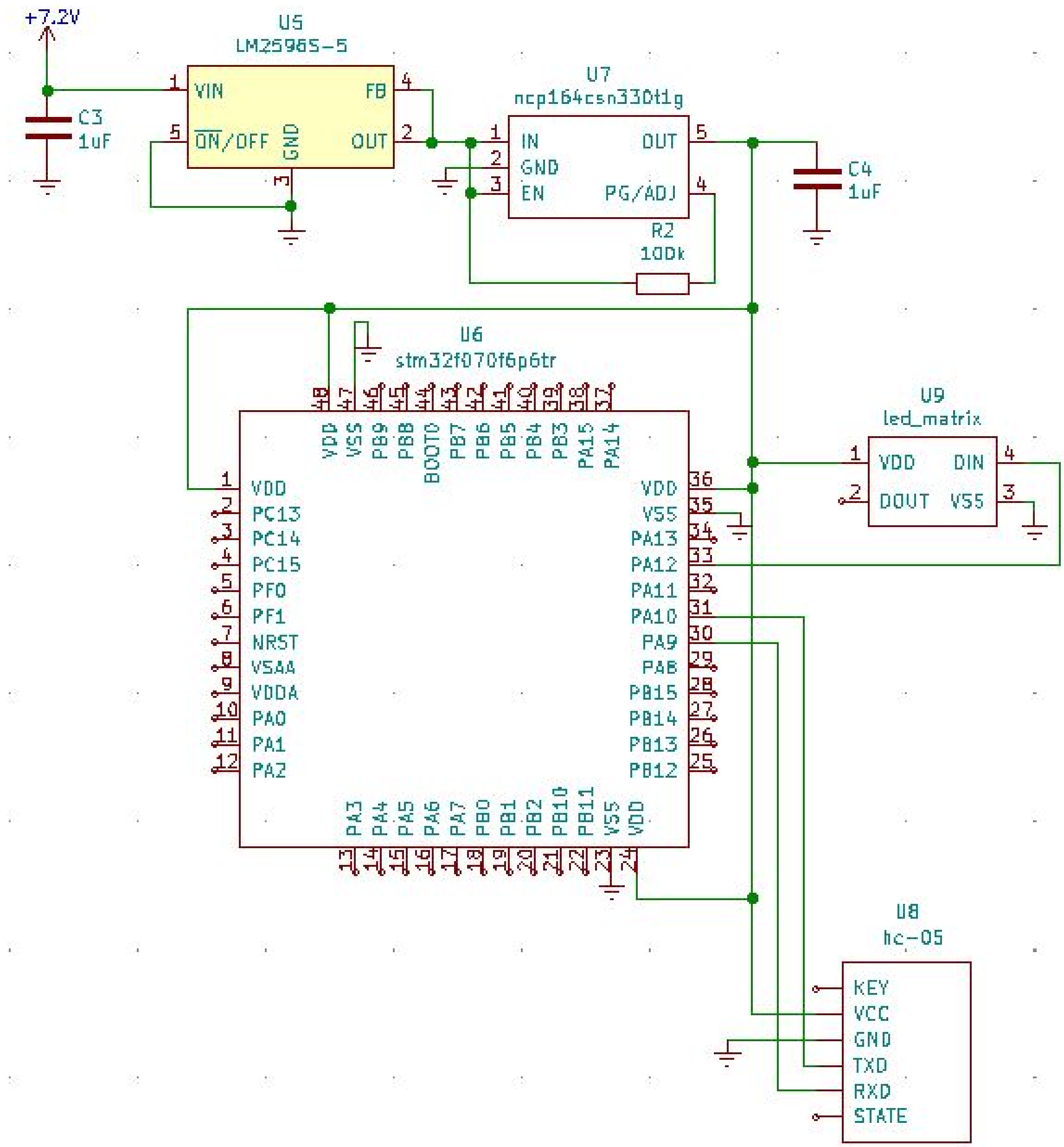


Figure 7: Traffic signal display schematic

**LED Matrix**

Eight WS2812B RGB Flexible 16 cm x 16 cm Pixel Panel Matrix Screens will be used on the display device. Two matrices will be stacked on each side of the display. The lower matrix will display a left arrow signal in either red, green, or yellow. The upper matrix will display a green, yellow, or red circle. A preliminary diagram of the matrices are shown in Figure X.

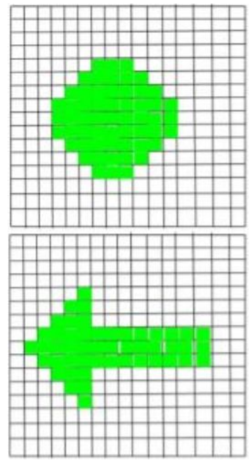

Figure 8: Diagram of LED matrix displays for one side of the traffic display

The LED matrix requires a 5V voltage supply and each pixel consumes 0.3W of power. There are a total of 256 pixels in the matrix therefore when all of the pixels are on the matrix will be consuming 76.8W of power. Using Equation 1, this would imply that approximately 15.36A of current needs to be supplied to each matrix.

$$P = I * V \quad (1)$$

Typical traffic signals using LEDs emit approximately 15W of power and these are visible from up to 40 meters away [7][8]. Therefore, an LED matrix would not need all of the pixels to be illuminated, rather it would only need a minimum of 50 pixels illuminated to achieve 15W of output power. Additionally, the matrix panel selected does not recommend operating at 15A. The recommended current draw is 5A or lower. With an output power of 15W and a supply voltage of 5V, the LED matrix would need to be supplied at least 3A of current.

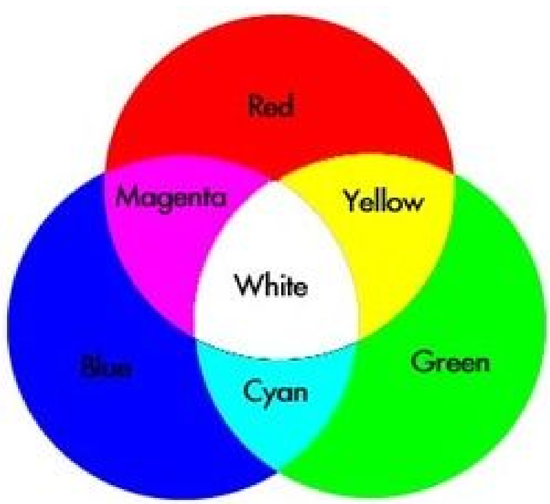

Figure 9: Diagram of the primary colors of light and the combinations they create [18]

The LED matrix displays lights similarly to how a television display does. Red, green, and blue are the primary colors of light. Any color can be made by combining the three colors in different intensities, which can be seen in Figure 9. Yellow is the only color that needs to be created on the traffic light by mixing red and green together. The intensity of each color is determined in software and is sent to the LED matrix in arrays. Each pixel has an intensity scale of 0-255 for red, green, and blue. In order to get yellow, the software will set the red, green, and blue values will be 255, 255, and 0 respectively [12]. The flowchart in Figure 10 below roughly outlines how the microcontroller from the display processing subsystem will control the LED matrices.

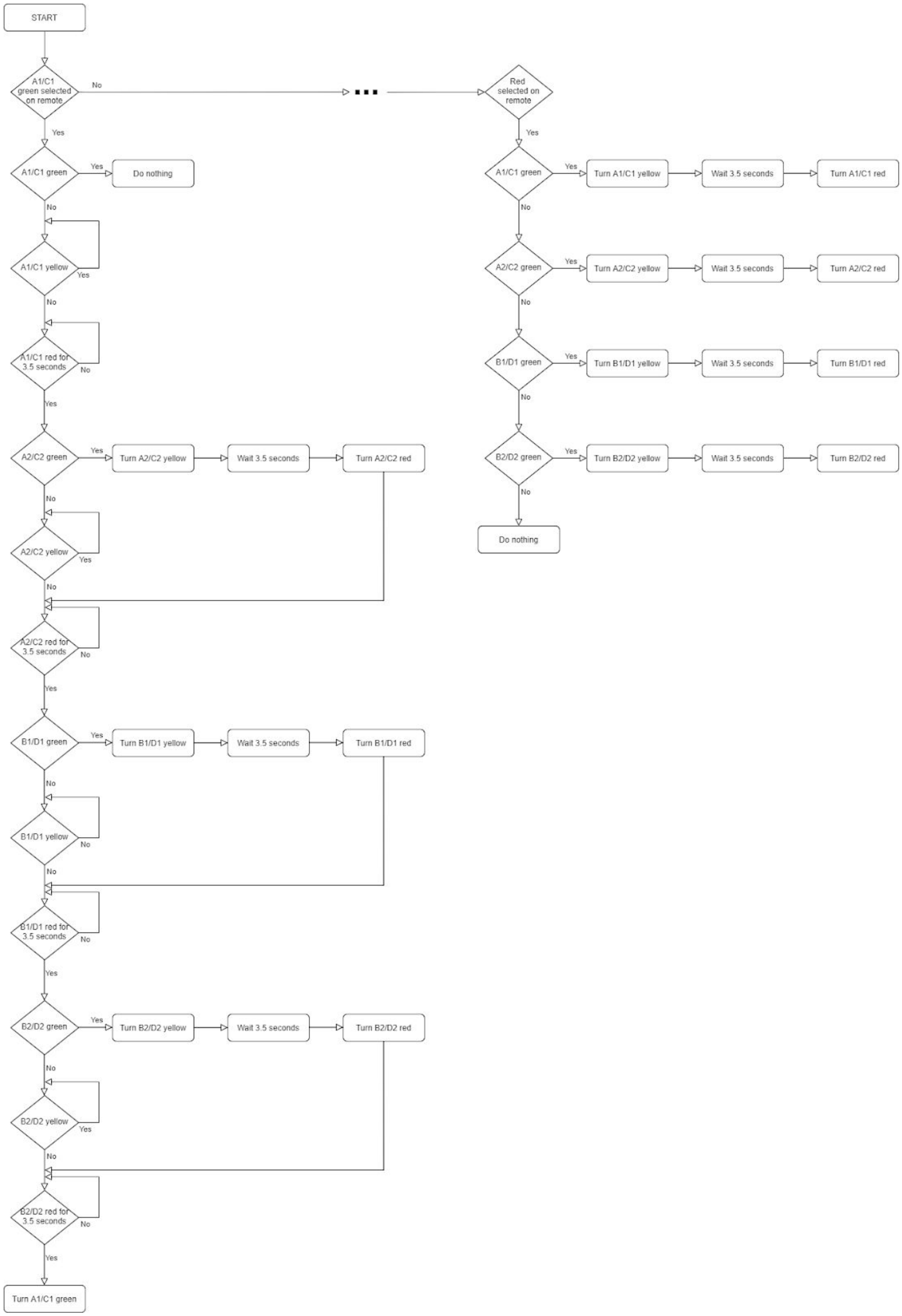


Figure 10: Flowchart for controlling the LED matrices on the traffic display

### 2.3.5 Display Processing Subsystem

The display processing subsystem will consist of a microcontroller and bluetooth device (See Section 2.3.6 for details on bluetooth). This processing subsystem will be responsible for communicating with the controller processing subsystem as well as controlling the traffic signal display.

**Microcontroller**

The STM32F070F6P6TR microcontroller will be used in the display processing subsystem. The microcontroller will communicate with the bluetooth receiver via USART [11]. This microcontroller will be responsible for accurately commanding each LED on the traffic display with respect to the signal received from the microcontroller on the controller device. It will also then need to determine which LEDs on the display are on and send a signal to the controller device so that the traffic officer operating the controller device will be able to know which LED is illuminated on each side of the display even if they are unable to see all four sides from their location.

### 2.3.6 Bluetooth

There will be two bluetooth devices being used. One will be located on the traffic signal display (bluetooth transmitter) and the other will be located on the controller device (bluetooth receiver). These two chips will communicate with each other so that we can send data from the controller device microcontroller to the traffic signal display microcontroller.

The HC-05 bluetooth module will be used in the display and the controller. This bluetooth module was selected because it is able to operate in a range of <100m. Since the controller needs to be able to communicate with the display at a distance of up to 30m, this bluetooth module can operate comfortably at this distance. Additionally, each of these bluetooth modules will communicate with their respective microcontroller via USART. The bluetooth transmitter will receive signals from the microcontroller indicating which buttons have been pressed. It will then send this data to the bluetooth receiver on the display device. The bluetooth receiver will pass the signals from the bluetooth transmitter to the display microcontroller. It will also receive signals from the display microcontroller indicating what LEDs on the display are actually on. This information will be passed back to the bluetooth transmitter and then to the controller microcontroller so that the controller device LED indicators can light up accordingly.

## 2.4 Requirements and Verification Tables

Table 2: Requirements for project components and respective verification tests

| **Requirements** | **Verification** |
|---|---|
| Bluetooth | a. Place one bluetooth module in a set |

| | |
|---|---|
| The bluetooth modules will be able to communicate with one another at a distance of 30m +/- 5%. | location<br>b. Measure 30 meters away from the the stationary bluetooth module<br>c. Ensure that a bluetooth connection still exists between the two devices at this distance. |
| LED Matrices<br><br>The LED Matrix will be visible up to 40 meters away +/- 5% | a. Place LED matrix in a set location<br>b. Measure 40 meters away from the matrix<br>c. Ensure that the symbols and colors are clearly visible from this distance.<br>d. If not visible, determine approximately where the LEDs become not clearly visible.<br>e. Repeat this test in daylight and at night |
| LED Matrices<br><br>The LED Matrix will display the proper circular and arrow symbols. | a. Program the matrix<br>b. Look at matrix and ensure that the symbols look the way we |
| Microcontroller<br><br>Microcontroller outputs correct signals based on the inputs. | a. Probe the output pins of the microcontroller with an oscilloscope<br>b. Check display to ensure correct signals are being output after processing |
| LED Indicators<br><br>LEDs will indicate what signals are being displayed form the traffic signal display. | a. Change the traffic command with the controller<br>b. Compare the LED indicators with traffic signal display to make sure the correct direction and signal are shown<br>c. Repeat for all directions and signals |
| Step-Up Converter<br><br>The converter will step up from 3.6V to a steady 5V +/-2% output voltage. | a. Provide a 3.6V input from a power supply<br>b. Connect the output of the converter to a voltmeter.<br>c. Measure the output voltage. |
| Step-Down Converter<br><br>The converter will step down from | a. Provide a 7.2V input from a power supply<br>b. Connect the output of the converter to |

| | |
|---|---|
| 7.2V to a steady 5V +/-2% output voltage. | a voltmeter.<br>c. Measure the output voltage. |
| Voltage Regulator<br><br>The voltage regulator will be able to supply a 3.3V output when given a 5V input. | a. Provide a 5V input from a power supply<br>b. Connect the output of the regulator to a voltmeter.<br>c. Measure the output voltage. |

**2.5 Tolerance Analysis**

The LED matrix allows colors to be selected by varying the RGB values. The RGB can take on values in the range of 0-255. The maximum load that would occur is when each RGB value is at its highest intensity value of 255. The minimum load that would occur is when only one value is used, for example the RGB values would be [255, 0, 0], [0, 255, 0], or [0, 0, 255]. The LED matrices will be consuming a large amount of power so it is important to ensure that when operating at the maximum and minimum cases the LEDs will still operate for the desired length of time. The maximum number of LEDs will be 56 which will occur for the circular symbol since the arrow symbol will only use 50 LEDs. The matrix will be supplied 5V and each LED consumes 0.3W. Table 3 displays the discharge current for the WS2812B RGB matrix when operating at the maximum and minimum loads.

Table 3: Current consumption data for LED matrix panel

| **Discharge Current for 1 LED at minimum load** | **Discharge Current for 1 LED at maximum load** | **Discharge Current for 56 LEDs at minimum load** | **Discharge Current for 56 LEDs at maximum load** |
|---|---|---|---|
| 20mA | 60mA | 20mA*56 = 1120 mA | 60mA*56 = 3360 mA |

Ultimately, if all of the components in the traffic display are not properly powered for the entire length of desired time then the requirement is still not satisfied. For this purpose it is important to also consider the current consumption of the other components such as the microcontroller and the bluetooth module. This data is displayed below in Table 4.

Table 4: Current consumption data for other components

| **Component** | **Discharge Current at minimum load** | **Discharge Current at maximum load** |
|---|---|---|
| STM32F070F6P6TR Microcontroller | 25 mA | 80 mA |
| HC05 Bluetooth Module | 1 mA | 30 mA |

For a maximum load, the total current consumed is 3530mA. Two Panasonic NCR18650B Li-ion batteries will be used to power each LED matrix. Therefore, the usage time can be calculated using Equation 2 below.

$$Operation\ time\ =\ \frac{mAh\ capability\ of\ battery}{total\ current\ discharged\ from\ components}\quad (2)$$

Plugging in the values from the tables above, the total hours of usage that the display will last can be found to be

$$Operation\ time\ =\ \frac{3500\ mAh\ *2}{3360\ mA + 80\ mA + 30\ mA}\ =\ 2.02\ hours$$

This proves that the display satisfies the constraint of expecting the device to work for up to two hours even assuming the device was working at its maximum load the entire time. Since only one LED matrix will be sharing its batteries with the microcontroller and bluetooth modules, the others will be able to run for a little longer when operating at the maximum load as shown below.

$$Operation\ time = \frac{3500\ mAh\ *2}{3360\ mA}\ =\ 2.08\ hours$$

Similar calculations can be done for the minimum load case and it can be shown that in both the maximum and minimum case the operation time constraint is satisfied.

$$Operation\ time = \frac{3500\ mAh\ *2}{1120\ mA + 25\ mA + 1mA}\ =\ 6.11\ \ hours$$

$$Operation\ time = \frac{3500\ mAh\ *2}{1120\ mA}\ =\ 6.25\ hours$$

As demonstrated from the calculations, when operating at both the maximum and minimum loads, all eight matrices will indeed be able to operate for up to two hours before the batteries will need to be recharged.

Furthermore, it is important to also ensure that the controller device will operate for up to two hours. The controller device will consist of the components listed in Table 4 and twelve LEDs. Only four LEDs will ever be on at a time in the controller device. The exact same calculations that were done for the display device can be repeated to check that this constraint is met. The results are shown below:

$$Operation\ time = \frac{3500\ mAh}{190mA}\ =\ 18.4\ hours$$

# 3. Project Differences

## 3.1 Overview

The previous Traffic Control Smart System was essentially a technological upgrade on the equipment used by traffic officers. A new safety vest was designed for the traffic officer to wear. This vest would display the words “Stop” and “Go” in red and green respectively. This vest was paired with a set of gloves that also had LEDs embedded in them. These gloves would light up red and green and would allow the traffic officer to change the vest symbol and LED colors with a simple hand gesture. This eliminates the need for traffic officers to carry heavy wands and therefore reduces the amount of fatigue from the equipment. By using LEDs and clear commands on the vest this also reduces the chances of a driver misunderstanding a gesture provided by the traffic officer.

Since the vest was designed to be lightweight (no more than 5lbs) this implementation does reduce the weight of equipment used. Although, in terms of safety this equipment still requires that the traffic officers be standing in the intersection. Therefore, if a driver is not paying attention or chooses to disobey the officer then the officers life is still at risk.

The Portable Traffic Manager eradicates the need for a human to be standing in the intersection but still allows for human control of traffic. This improves the clarity of the traffic control because it will no longer be reliant on hand gestures but rather the symbols will be clear and similar to what an individual would see on a stoplight. The traffic device can be used at any intersection since it is portable and it allows the traffic officer to be safely located on the side of the road out of harm's way.

## 3.2 Analysis

The Traffic Control Smart System and Portable Traffic Manager work to solve the issues of fatigue and safety for traffic officers. Although there are some similarities in the types of components necessary, each project utilizes these components uniquely to produce fundamentally different solutions.

Both projects implement similar power modules since the devices are battery operated which requires the use of converters and voltage regulators. Selection of the batteries for the Portable Traffic Manager is a crucial part of the project since this device utilizes many LEDs and thus consumes more power than the Traffic Control Smart System. When selecting the batteries for the Portable Traffic Manager, a tradeoff needed to be made between the number of batteries and the size. As discussed in Section 2.3.4, LED matrices will be used in the Portable Traffic manager and each consists of 256 LEDs. Although only a portion of the LEDs will be used, each matrix will still be outputting around 15W of power. Therefore, a larger number of batteries are necessary to adequately supply the eight different LED matrices. In contrast, the Traffic Control Smart System utilized LED pixel strips. It consisted of 50 LEDs for the gloves and 112 for the vest [3]. So there were significantly less LEDs used and thus less power consumption from the lights.

The processing subsystems for the two projects also differ. The state machine for the gloves requires checking signals from the contact sensors to determine when the LEDs on the gloves should be changed. The gloves each control one side of the vest so there are only two panels that need to be controlled for the vest state machine. In the Portable Traffic Manager, the signals from the push buttons, instead of contact sensors, are what determine when the LEDs will change color. Additionally, the Portable Traffic Manager requires checking at least two sides (four matrices) of the traffic display. The signal changing process is dependent on the functionality of this processing subsystem therefore extra precautions needed to be put into place such as implementing a short “grace” period of two seconds to protect against the possibility of two adjacent sides both displaying green signals. Whereas, in the previous project a human was still ultimately gesturing so not as many precautions needed to be taken for the processing.

# 4. Cost and Schedule

## 4.1 Labor

Table 5: Labor costs

| Name | Hourly Rate | Hours | Total | Total x 2.5 |
|---|---|---|---|---|
| Samira Tungare | $50 | 200 | $10,000 | $25,000 |
| Sarah Kolak | $50 | 200 | $10,000 | $25,000 |
| Edward Harper | $50 | 200 | $10,000 | $25,000 |
| **Total** | | | | $75,000 |

## 4.2 Parts

Table 6: Components cost

| Description | Quantity | Manufacturer | Vendor | Cost/unit | Total Cost |
|---|---|---|---|---|---|
| Wireless Bluetooth RF Transceiver | 2 | HiLetgo | Amazon | $7.99 | $15.98 |
| STM32F070 | 2 | STMicroelectronics | Digikey | $0.63 | $1.26 |
| Push Button 1301.9314 | 5 | Schurter | Digikey | $0.24 | $1.20 |
| RM-3.305S converter | 1 | Recom Power | Digikey | $5.83 | $5.83 |
| LM2596 converter | 1 | Texas Instruments | Amazon | $6.50 | $6.50 |
| LED Matrix Panel | 8 | Adafruit | AliExpress | $12.15 | $97.20 |
| NCP164CSN330T1G linear voltage regulator | 1 | ON Semiconductor | Digikey | $0.20 | $0.20 |

| | | | | | |
|---|---|---|---|---|---|
| Panasonic NCR18650B Li-ion battery | 17 | Panasonic | 18650 Battery Store | $4.75 | $80.75 |
| **Grand Total:** | | | | | $208.90 |

**4.3 Schedule**

Table 7: Theoretical design schedule for the project

| **Week** | **Task** | **Assigned To:** |
|---|---|---|
| 1 | a) Design Document | Everyone |
| 2 | a) Design Review<br>b) Order Components<br>c) Peer Review | Everyone |
| 3 | a) PCB design | Everyone |
| 4/5 | a) Programming Microcontrollers<br>b) Configuring Bluetooth<br>c) Testing LED Matrices<br>d) Testing Power Components | a) Eddie<br>b) Samira<br>c) Sarah<br>d) Samira |
| 6 | a) Soldering PCB for Display<br>b) Soldering PCB for Controller<br>c) Testing/Debugging | a) Eddie<br>b) Sarah |
| 7 | a) Assemble Controller Device and Display Device<br>b) Final Testing | Everyone |
| 8 | Mock Demo | Everyone |
| 9 | Demonstration | Everyone |
| 10 | Final Presentation/Report | Everyone |

## 5. Safety and Ethics

### 5.1 Safety

There are many safety concerns to take into account given that this device will be used in the street to control the flow of traffic. We plan to abide by the Occupational Safety and Health Administration (OSHA) Manual on Uniform Traffic Control Devices (MUTCD) which states that “during any time the normal function of a roadway is suspended, temporary traffic control planning must provide for continuity of function” and also that “effective temporary traffic control enhances traffic safety and efficiency, regardless of whether street construction, maintenance, utility work, or roadway incidents are taking place in the work space” [5]. A traffic officer will have control of the device and manage the flow of traffic by providing clear and efficient signals. This will provide a typical flow of traffic as well as allowing the officer to change signals based on any other work going on in the area. Also, “all workers should be trained in how to work next to traffic in a way that minimizes their vulnerability” [5], so this device should only be operated by police officers who have gone through proper training. This will ensure that the controller of the device has the proper knowledge and background to control traffic in crowded areas. “It is essential that concern for traffic safety, worker safety and efficiency of traffic movement form an integral element of every temporary traffic control zone, from planning through completion of work activity” [5]. Therefore, safety is a top concern for this product and measures will be taken to ensure the safety of all involved.

### 5.2 Ethics

This system will be used to control a large number of people on the road. Therefore, it is important that we follow the IEEE Code of Ethics and agree “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to disclose promptly factors that might endanger the public or the environment” [4].

Each state has their own Department of Transportation which provides standards relating to traffic devices. According to IDOT specification 39-2.02(d), the display will need to be located such that it will be clearly visible during the night and also special attention should be given to the orientation angle [6]. This standard was taken into consideration when determining the physical design of the traffic signal display.

We also need to consider emergency situations on the road and make a decision in order to keep the people safe. This is why there will be an emergency stop button which will stop all four directions of traffic so that an emergency vehicle can easily get by.

Another ethical issue comes from the use of Bluetooth communication. If this product were to become marketable, it is important that there is a secure bluetooth connection so that other devices cannot arbitrarily connect to and control the display device. The HC-05 bluetooth device selected for this application follows IEEE 802.15.1 standardized protocol [17].

## References

[1]"Traffic Control Systems Handbook: Chapter 7 Local Controllers - FHWA Office of Operations", *Ops.fhwa.dot.gov*, 2020. [Online]. Available: https://ops.fhwa.dot.gov/publications/fhwahop06006/chapter_7.htm. [Accessed: 31- Mar- 2020].

[2]"16.140 - Traffic Direction and Control - Police Manual | seattle.gov", *Seattle.gov*, 2020. [Online]. Available: https://www.seattle.gov/police-manual/title-16---patrol-operations/16140---traffic-direction-and-control. [Accessed: 31- Mar- 2020].

[3]M. Pilar Galainena Marín, M. Rawat and W. Wang, "Traffic Control Smart System Design Document", *Courses.engr.illinois.edu*, 2020. [Online]. Available: https://courses.engr.illinois.edu/ece445/getfile.asp?id=14623. [Accessed: 31- Mar- 2020].

[4]"IEEE Code of Ethics", *Ieee.org*, 2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 2- Apr- 2020].

[5] "IEEE Code of Ethics", *Ieee.org*, 2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 2- Apr- 2020].

[6]*Idot.illinois.gov*, 2020. [Online]. Available: http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Split/Local-Roads-ad-Streets/Chapter%2039.pdf. [Accessed: 03- Apr- 2020].

[7]"LED Traffic Signals | Streets & Traffic", *Streets & Traffic*, 2020. [Online]. Available: https://www.yakimawa.gov/services/streets/led-traffic-signals/. [Accessed: 14- Apr- 2020].

[8]"C40: LED Traffic Lights Reduce Energy Use in Chicago by 85%", *C40*, 2020. [Online]. Available: https://www.c40.org/case_studies/led-traffic-lights-reduce-energy-use-in-chicago-by-85. [Accessed: 14- Apr- 2020].

[9]*Cdn-shop.adafruit.com*, 2020. [Online]. Available: https://cdn-shop.adafruit.com/datasheets/WS2812B.pdf. [Accessed: 15- Apr- 2020].

[10]"1301.9314 Schurter Inc. | Switches | DigiKey", *Digikey.com*, 2020. [Online]. Available: https://www.digikey.com/product-detail/en/schurter-inc/1301-9314/486-3465-ND/2643951. [Accessed: 15- Apr- 2020].

[11]"STM32F070F6P6TR STMicroelectronics | Integrated Circuits (ICs) | DigiKey", *Digikey.com*, 2020. [Online]. Available: https://www.digikey.com/product-detail/en/stmicroelectronics/STM32F070F6P6TR/497-17354-2-ND/7313047. [Accessed: 15- Apr- 2020].

[12]*Htmlcolorcodes.com*, 2020. [Online]. Available: https://htmlcolorcodes.com/. [Accessed: 15- Apr- 2020].

[13]P. Battery, "Panasonic NCR18650B Flat Top 3400mAh 4.9A Battery - 18650 Battery Store", *18650BatteryStore.com*, 2020. [Online]. Available: https://www.18650batterystore.com/Panasonic-18650-p/panasonic-ncr18650b.htm. [Accessed: 15- Apr- 2020].

[14]"NCP164CSN330T1G ON Semiconductor | Integrated Circuits (ICs) | DigiKey", *Digikey.com*, 2020. [Online]. Available: https://www.digikey.com/product-detail/en/on-semiconductor/NCP164CSN330T1G/488-NCP164CSN330T1GCT-ND/11593207. [Accessed: 15- Apr- 2020].

[15]2020. [Online]. Available: http://www.ti.com/lit/ds/symlink/lm2596.pdf. [Accessed: 15- Apr- 2020].

[16]"RM-3.305S/E Recom Power | Power Supplies - Board Mount | DigiKey", *Digikey.com*, 2020. [Online]. Available: https://www.digikey.com/product-detail/en/recom-power/RM-3.305S-E/945-1688-5-ND/3593390. [Accessed: 15- Apr- 2020].

[17]"IEEE 802.15.1", *Ieee802.org*, 2020. [Online]. Available: http://www.ieee802.org/15/pub/TG1.html. [Accessed: 17- Apr- 2020].

[18]"Mixing Colored Light", *Light and Color*, 2020. [Online]. Available: https://595519701575103976.weebly.com/mixing-colored-light.html. [Accessed: 17- Apr- 2020].