Electronic Flip Sign

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***Abstract* — The Electronic Flip Sign is a device designed to convey a custom message to those around the user. The method to convey this message is a LED sign that allows the user to change and modify the message displayed in the most convenient manner available. The device aims to be both lightweight and portable to be used in one hand and on many different occasions. This project designs the display, device, and programs needed to make a device that will fulfill this goal.**

***Index Terms* — Diodes, Microcontrollers, MOSFET circuits, Transistors, Displays, Light emitting diodes, Graphical user interfaces, Programmable control.**

I. Introduction

The electronic flip sign is a handheld lightweight LED display that will allow the user to preprogram their message through a computer interface to make it visible for others to see with ease. This allows the user to communicate their short messages to people around them. This device will be used for communication and entertainment. The ideal use for this device will be to allow the user to communicate in situations like at a sports events, in traffic, or even as an idle display for a game room. This sign can hold custom messages and can display any capital letters, numbers and even a few emojis. The flip sign can help people in workplaces that have difficulties with hearing or communicating with others. For example, the flip sign can be used to direct construction workers while they are operating loud machinery, for taxi drivers to notify their rider where they are, or to direct traffic or crowds. The device will be composed of 2D surface mounted LED matrix display and will be configured via micro USB and Bluetooth through a software interface. The micro USB cable provided will also allow the user to charge the battery in the device.

The goal of this project is to create a device that can be used to convey messages that can be changed and used in a variety of locations and occasions. To accomplish this currently, items like paper signs or LED displays are used, but each of these have their own issues. There are various other LED signs out on the market. Some of these signs are programmable with text and icons, but they must either be plugged in or mounted somewhere. The key reason why there is a need for our sign is due to a lack of portable LED signs in the market. A device that can be used with one hand, on the go, and without being plugged in. The problem with the current LED displays on the market is that some are not battery operated and the ones that are do not have portability in mind since most are for a sitting wall display. We are taking what the current LED signs have and making it not only portable but also making it easy to change the display on the go as well as other features added to make using the device on the go easier and more efficient than anything on the market today.

This project's goal is not just to make a single working model. This project is to make a prototype for a production model that can then be sold at mass market. Making a product that can be used as a prototype for involves using parts that can be sourced for a much cheaper price to lower the bulk price. Other things that also must be considered include the materials being used as well as the type of battery. Each of these things are done to lower production cost as well as make a quality product for the consumer.

II. System Components

A system can only be as reliable as its most unreliable piece. Understanding how an overall system works is best understood deciphering and analyzing each individual part of the system to integrate the software and hardware. This portion will discuss the main subsystems of the LED Electronic Flip Sign. All the components of the device must be chosen for their ability to achieve the requirements and specifications, listed in the table 1 below are a few that we have for this device. This also applies to the programming side of things and as seen in table 2 there are a list of requirements for the programming as well that are to be obtained. When choosing these components there was quite a few different options so checking each against the specifications was the best way to determine which one to use. Sometimes there would be a few options that seem to meet the requirement, so both were tested to find the best one for the job through a trial and elimination. We had to use this process several times for different components to make the best end device, some of which will be discussed later on.

Item	What it is	Specification
Dimensions	LED display	Approximately 10”x5”x1”
	Handle	Approximately 5”x1.5”x1.5”
Battery	Located inside the device	Able to operate the display at full brightness for 15 minutes
		Rechargeable via USB port to PC port or wall adapter
Connectivity	Ways that the device can connect with other devices	Bluetooth and USB interfaces
Weight	Total weight not including USB cable	Approximately 8 ounces
Visibility	The distance that the device can still be read clearly	35ft away

Table 1

Item	What it is	Specification
Software	Characters	All capital letters, !, @, #, $, and 4 emojis
	Multilane	This will be an option for the user to choose either one line of text and two lines of text.
	Scrolling	This option allows the user to be able to set their messages as text that moves across the screen.
	Reverse Text	This function would mirror the text input.

Table 2

A. Main Microcontroller

The microprocessor is the brain and the central control unit of the LED flip sign. This component stores and runs the code that will allow the user to interact with the device. Some of these aspects are the price, operating voltage, the amount of RAM, data memory size, program memory and the speed of the CPU. The AtMega32u4 chip costs $3.98 per unit. The operating voltage ranges from 2.7V to 5.5V. The program storage capacity for this chip is thirty-two kilobytes. The CPU speed is sixteen megahertz. This microcontroller also has a built-in USB device peripheral that can be used if your device needs to be plugged in via USB. This makes this processor the best option for our device as it has all the needed components without a lot of the bulk that can come with using some other chips this also makes it more convenient for the PCB design as well as the code itself.

B. LED Display

An LED is a light emitting diode. This component transforms electrical energy into light. The LEDs are one of the main components of the LED flip sign. They are used to illuminate the messages on the device. LEDs are turned on by LED drivers on the PCB. The dimensions come in at 3.5mm x 2.8mm (metric 3528) even for one sign 960 LED’s are needed to create a sign to the dimensions desired. Surface mount device (SMD) is the type of mounting that is used to save space and be more space efficient as seen in the image bellow in comparison to through hole LEDs.

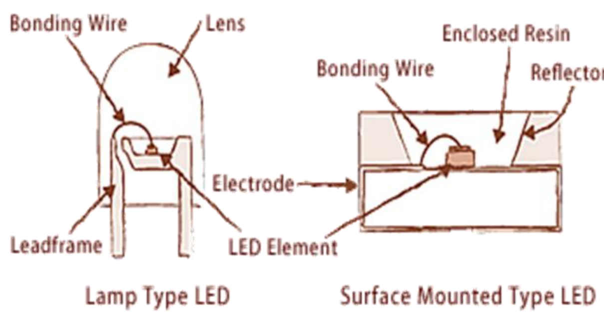


Fig. 1 Through hole and SMD [1]

C. Bluetooth module

The Bluetooth module on the LED flip sign will allow computers and mobile devices that have Bluetooth to communicate wirelessly with the device. Having wireless connectivity to program custom messages is one of the goals of this project. Having the ability to customize the messages for the display without having to plug the device in, takes care of any hassle with using a cable, after the initial pair. The Bluetooth chip needs to be low powered so that the battery can last as long as possible. Security protocols need to be implemented so that only people with permission can access and modify the device's functions.

D. Power Supply

The Electronic Flip Sign key features are its potability, lightweight, and size, each of these are heavily dependent on the battery that is chosen and used in the device. This device will be powered using a 3.7-volt lithium polymer single cell battery. The battery will be connected to a charging circuit as well as a battery monitoring device. It will power the microprocessor and the rest of the device. When the battery's charge becomes low the user can connect a micro USB cable to the device's micro USB port to charge. The lithium polymer battery is small and light for the amount of power it can produce making it ideal for our application. Due to some of the needs of our system a high discharge battery was selected so that it can produce the needed amount of current for the system.

E. Casing

The skeletal structure of the case will be composed of very efficient cheap material. The solution we came up was utilizing Solid works composer studios to laser cut wooden material to construct the exact desired dimensions of the PCB board and it's very sturdy, cheap and lightweight that meets all design requirements. This case style will most likely be for the prototype design only and for the production run there will be a more mass produce friendly type of case made. The general style of the case is show below.

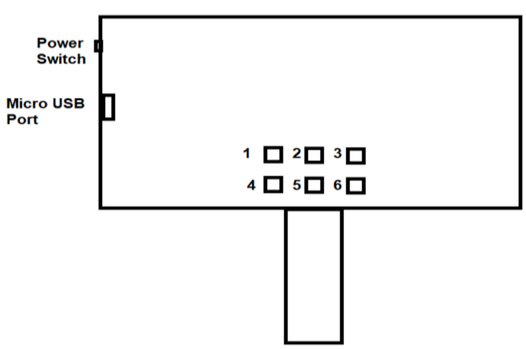


Fig. 2 The rear of the device showing key components

F. Charging module

A major potent feature of the electronic flip sign design. It will be able to be able to function on the go via mobile. In this case, if the battery source dies out it would be extremely convenient for the user to recharge their power supply anywhere via USB. For a more accurate design using MCP73831.

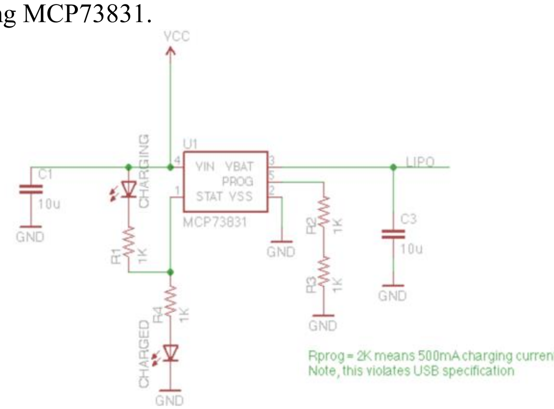


Fig. 3 Charging Circuit Schematic [2]

This advanced design can automatically set itself to conserve power when the input voltage falls below the threshold voltage for the circuit. Over this feature prevents voltage to be drained out of the battery when the voltage supply dose not remain.

III. Hardware Detailed Design

The first core component of the design that holds and connects all the components of the device together is the printed circuit board (PCB). The main changes in the PCB is the use of 2-layer verses 4-layer, for this device the best option was to use the 2-layer option, this turned out to be cheaper and with the current design restraints there is not a problem with the size that will be taken by the use of two 2-layered boards one for the LEDs and one for all other circuitry. The LEDs are going to be wired across the full length of each row and column with cathodes and anodes respectively. The LEDs are going to be spaced at about 5.5mm from each other. The LEDs are designed in this manner so that the device is able to control each LED independent of the next, this is done by having NPN and NMOS transistors controlling the rows and columns all independently letting the device apply a voltage and ground to a specific LED at will. The figure below shows the hardware block diagram showing how each of the components are connected to each other.

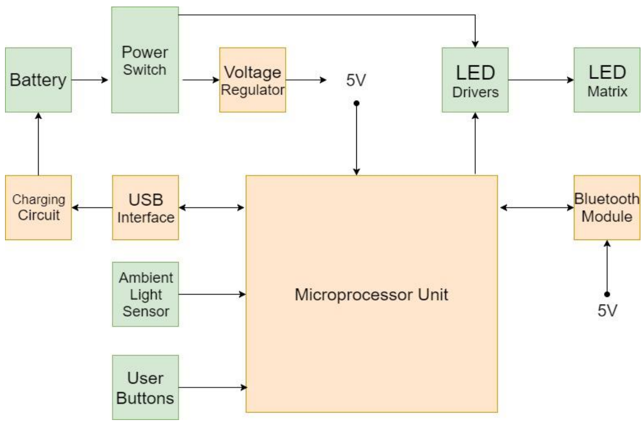


Fig. 4 Hardware Block Diagrams [5]

The schematic as seen below is the layout of our device. The first figure below (figure 5) is of the left-hand side of the schematic highlighting the CD4017. This image shows how the decade counter will be connected. On the right side of the picture the LED matrix can be seen, and this is wired in a grid format as stated. There are two decade counters each with their own clock and reset from the processor completing the height of 20 LEDs for the device.

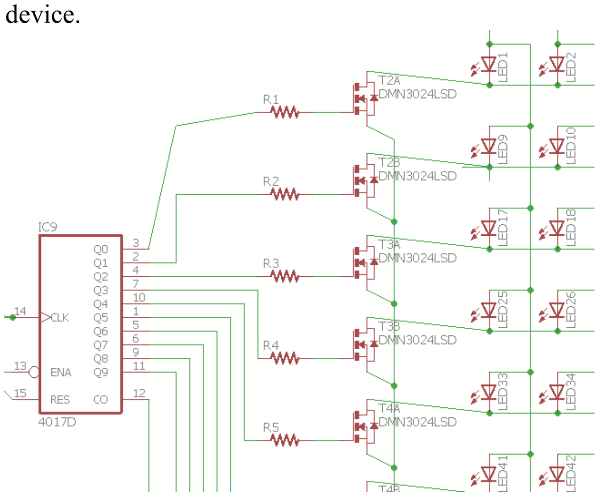


Fig. 5 Final schematic part 1

Both chips will scroll down the rows at a rapid pace to make the displays shown by the shift registers seem like there on constantly and display a desired outcome.

The second figure shown below is of the same schematic, but it is the top left corner top side instead of left. This figure highlights the 74HC595 shift register and shows how it is wired In the middle top is the shift register and can be seen going to each 8 columns if the full schematic was shown there would be 6 of these chips across the top of the LED matrix with 2 4017 on the left but this is a very large circuit and showing the entire circuit is just a green blur. On the bottom of the figure is the LED matrix. The processor is sending the clock, latch, and data to the 74HC595. The shift register has 5 wires going down and these go to the next shift register they sync the clocks and are a ground as well as the latch, the data is also sent but it is received through pin 14 and then sent to the next shift register through pin 9. Together these two drivers control the NPN transistors, also getting voltage strait from the battery, that in turn control the LEDs and the drivers are controlled by the processor all being powered from the 3.7V battery and this make the workings of the device. Note that the transistors this is controlling is NPN but in a lot of cases it would be PNP and this is because the voltage we get from the 74HC595 is lower than that coming from the source this makes it so we are unable to fully turn off a PNP in this instance. An NPN is used and we lose about 1 volt across it but the LEDs only require about 1.6 volts and the source supplies 3.7 volts so even after the drop in voltage we are still able to run the LEDs and the changes are just to the current limiting resistors to make up for the new voltage levels.

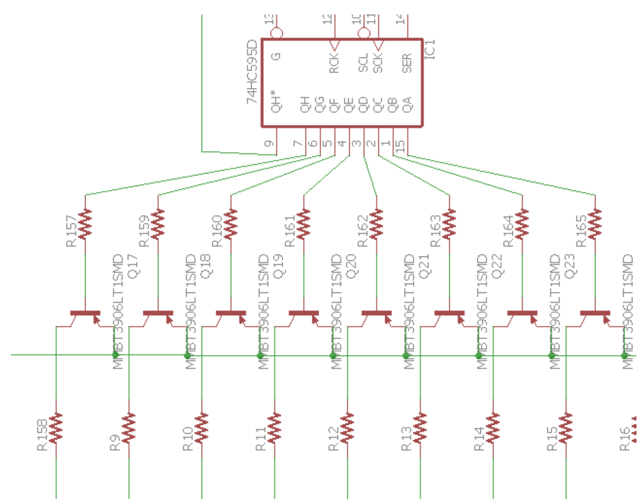


Fig. 6 Final schematic part 2

Both pictures above are the two corners that will make up the main display. The CD4017 is controlling rows by sending a voltage through a 10k ohm resistor to switch on a NMOS that will open a path to ground. A MOSFET was used in this case because there will be a larger amount of current going through this path since the display only turns on a row at a time the current of all the on LEDs will go through this MOSFET, so it is rated up to 7.5A more then will ever be used. On the other hand, the 74HC595 has a 1k resistor to a NPN this is because only enough power for one or two LEDs will be sent through this path and they can handle up to 100mA each which is more than enough for our application and they come in cheaper that getting more NMOS transistors.

A. Pulse Width Modulation

The PWM is the pulse width modulated signal. It is integrated into multiple circuits and electrical applications. It will be constructed to manipulate data signals using a microcontroller which has an integrated PWM. With this type of utility, it can be incorporated to encode a message into a pulsing signal. In the electronic sign its main purpose will be to control the brightness of the device. The average voltage applied to the load can be controlled by turning the switch between the supply and the load on and off at an extremely fast rate. In other words, the longer the period the switch is on there will be an increase in total applied power and vice versa when the power is turned off.

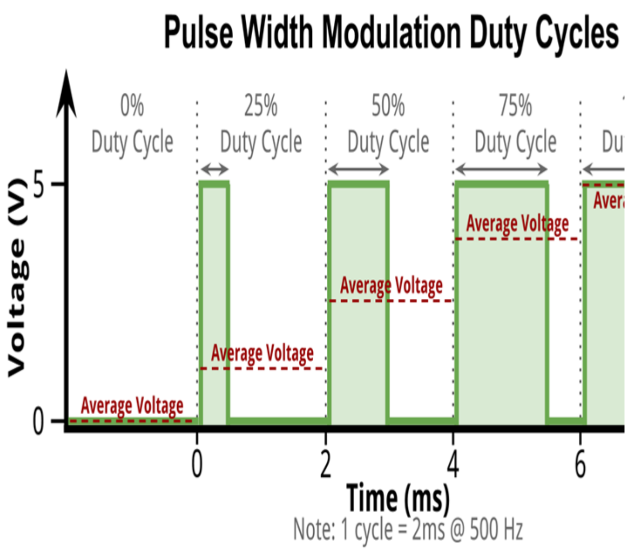


Fig. 7 Duty Cycle Percent Value [3]

This pulsing frequency must be much higher to support the power supplied to the electronic device. This type of switch depends on the duty cycle. In which it is the portion of time spent on to a regular period. A low duty cycle thus corresponds to low power output. Since there is a ratio of time spent on and off. Duty cycle is expressed as a percentage in this case 100% means full power, 50% means on half the time and 0% means completely off.

IV. SOFTWARE

A. The Graphical User Interface

The Graphical User Interface, also known as the GUI, is used to help make the operation of software and other electronic devices streamlined, so that there is an easier way to operate the software without using the command line. The Customizable options that are presented for each message are scrolling text, scrolling speed, display time, single line display, and Two-Line display. These options can be selected using drop down menus, checkboxes, and textboxes. The scrolling speed drop down menu allows the user to select preset speeds. These options make the scrolling speed one times, two times, three time or four time the normal scroll speed. The check boxes allow for the option of choosing single line or two-line display, and auto scrolling for your message. If the single line option is selected, this will cause a character limit of six characters. If the two-line option is selected, the new character limit is increased to twelve characters. The Display Time section allows the user to determine how many seconds the message will display. If the user does not set a display time, then the message will not display. The drop-down menu, check boxes and text boxes described can be seen in the figure below.

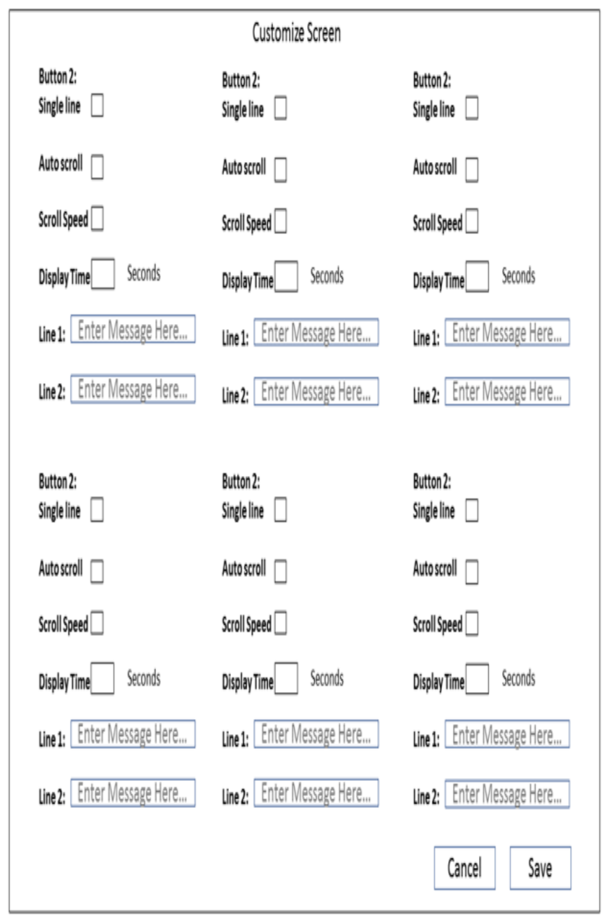


Fig. 8 Custom Screen for GUI design

B. Scrolling Text Code

This code will handle scrolling the text on the display when enabled from the graphical user interface. This code will loop through the message that the user is displaying on the sign and have the letters scroll across the screen of LEDs in a consistent motion. The movement of letters will be handled by shifting the display one column of LEDs at a time to the left at a specified rate, this rate will be determined in the GUI. The rate will be passed in from the GUI in terms of speeds. There are four speeds and are represented as a one, two, three, or four as an integer datatype. When the speed is passed in, that number will trigger a conditional statement that will set the speed of the LEDs. When the message reaches the last letter, the message will start over and repeat, starting with the first letter after five blank columns These actions will give a scrolling illusion to the display which allows for the user to create a message that is too long for the screen to normally display as a still message with the limited size of the screen.

C. Message Display Code

This code will take in the message that was stored into a string that was passed from the graphical user interface and display the message on the LED panel. This will be done with by converting the string to 8-bit binary byte arrays. Once we have these values, the program can then convert the values to be able to be displayed on the LED matrix. One major method to displaying messages on a LED dot matrix is to scan the columns to get the correct values for the rows [4]. This concept can be seen in figure 17 below. This will all be done at a rate so fast that the human eye can not see the shifting on the display making it appears as a solid text.

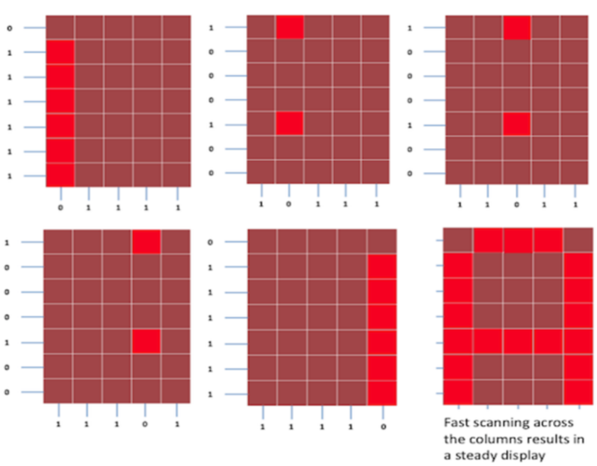


Fig. 9 Scanning Method for LED Display [4]

D. Button Functions Code

This code will handle input from the buttons. When the user presses a button, the code will trigger certain commands depending on the button or combination of buttons. There will be conditional statements handling these actions. When a conditional statement is true, the code for that statement will be executed and the corresponding action will be taken. Once the action is completed, the code will continue to run and loop. If there are no buttons being pressed the code will loop for the display time that is set. If there are no buttons that were pressed within the set time, then the microcontroller will go into a continuous loop waiting for another button press. If the first button is being pressed, then the conditional statement will bring the code to a section that will send the message that was assigned to button one to be sent to the LED display to be displayed. If the second button was pressed, then a conditional statement will take the code to a route that will send message two to be displayed. This will be the same for buttons three, four, five, and six. There will be a conditional statement that looks for how long a button is pressed and if a button is pressed for more than three seconds then the message that is displayed from that button will flash. There will be a conditional that looks for a combination of buttons like pressing two buttons at the same time and entering dim control.

The process in which the code implemented in the device goes through during the operation of the Electronic Flip Sign. When the user is operating the device, the user starts with powering on the device. If the power is off, then the code doesn't continue to loop till the power is turned on for the device. Once the device has been turned on, the code moves on to checking if any of the six buttons are being pressed. If none of them are being pressed, the code waits a set amount of time before moving on to turning the power back off on the device. If the set amount of time has not been passed, then the code follows back to checking which buttons are being pressed. The purpose of this portion is to continue to display a message based on the amount of preset time give in the software when customizing the messages.

When a button is pressed the code moves to whichever button has been pressed and displays its respective message along with the features given to this message by the user. There is also a side feature that whenever button 6 is pressed at the same time as another button, it will trigger the brightness setting feature. Once button 6 is pressed in combination with either 3,4 or 5, the code moves onto changing the brightness feature. Whenever button 4 is pressed during this feature, the messages brightness becomes lower. If button 5 is pressed, the brightness is set to auto. And finally, when button 3 is pressed during this phase, the brightness is increased. Once the proper message is displayed and the brightness setting is set to the desired specifications, the code loops back around to checking the buttons pressed.

E. GUI Design Mobile

This mobile GUI will be used for quick customizations on the go.by using an Android device. Just like the other GUI designs, the first thing that will be asked once the software is installed and launched is to attempt to connect to the Electronic Flip Sign. Once the sign is connected to the Android device using Bluetooth, the app can be used to customize the sign. The application will provide the user with all the same features as the desktop application. This way the user isn't limited while mobile.

V. Progression

The Electronic Flip Sign has gone through a lot of changes and modifications over the course of this semester. The furthest from what we have now is using the MAX7219 LED drivers these make the build a lot simpler but they were rated to a minimum of 5 volts and we wanted to run the device off of a single cell battery so 3.7 volts, on testing we did find that these chips could run rather well at that lower voltage but anther problem we found was that the chips were expensive unless they were Chinese knockoffs and the cheap chips are what we believe to have given the most errors when we ran them ultimately putting the nail in the coffin of that design. The next design was similar to the design we went with in the end, but we had gone through several changes the NPNs went from NPNs to PNPs and back, the resistors changed places and were rearranged to make the currents through the LEDs accurate and constant. The decade counters had to be wired independently of each other to allow control of the desired number of rows on the display. The programming for the device has gone through similar changes as we changed the design each new design needed different code some things didn't need to be changed as much as others like the GUI was the same for each but the way that LEDs were controlled changed completely after the major design change.

VI. Production

One of the objectives of this project is not just to make a working project but to design it for mass production and for the price at mass production levels to be under $40. Listed in the table below is a chart that shows the components needed and then a list of prices per unit for both buying at a single part by part to build a single device and then the cost of a single unit if enough parts were bought to build 1000 units. The price of each unit greatly differs with the single prototype costing much more than the bulk price, this is good because the goal is to make the cost in bulk as low as possible because to make the device into a production device the prices need to be low so that the price to consumer is lower making it marketable. Though the goal of production price is $40 this is not what the consumer will pay, this is why the price is so low as some of the competitor devices, even though they do not do the same thing, they are priced around $60 and we will have to be in this realm in order to compete in this market. The cost estimates can also be seen in Table 3 below.

Components	**Rev A Cost Prototype**	**Production Cost 1000 units**
PCB	$90.00	$3.00
Case	$10.00	$2.00
Battery	$5.00	$2.00
LED's	$8.00	$6.00
LED Drivers	$20.00	$8.00
Bluetooth Module	$10.00	$5.20
Ambient Light Sensor	$0.70	$0.30
6 Buttons	$5.00	$0.50
MPU	$4.20	$3.50
USB Port	$0.80	$0.50
USB Interface & Cord	$3.55	$2.20
Power Switch	$0.50	$0.30
Passive Components	$0.75	$0.40
Power Circuitry	$1.00	$0.60
Total	**$159.50**	**$34.50**

Table 3

VII. CONCLUSION

The Electronic Flip Sign has many ways to be built and designed. In the end the device can only have one design and one build that must be decided upon to pass each of the tests on the specifications. The decided build also needs to be able to meet the customer's needs when operating the device. The final goal of this device is twofold, to create a device that works and functions with ease and optimal results, and then to make a mass-produced device that can be made to sell. The device uses the components chosen and makes a device that is easy to use and is functional making a device that is user friendly and can produce results that will accomplish the initial goals and the needs of the device. The second goal of this device is the mass market prep this comes in the part price line that was set as constraint and this was done so that the mass market price is as low as possible while still making a quality piece of hardware and for this the pricing of the device at bulk order was also a constraint for this device as this is one of the goals for the device.

ACKNOWLEDGEMENT

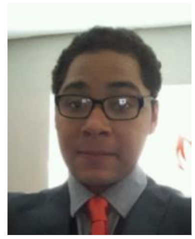
This project was given to us by Professor Michael F. Young, along the way he has provided guidance and has offered to buy the device at the end of the term if it is to his specifications.

BIOGRAPHY

Brennan Schild is currently a senior at the University of Central Florida, soon to graduate with his Bachelor of Science in Computer Engineering. He transferred to UCF after obtaining his Associates Degree from St. Johns River State College and is currently gaining experience by working as a software developer.

John Meehan is currently a senior at the University of Central Florida, soon to graduate with his Bachelor of Science in Computer Engineering. He is currently gaining experience by interning at the Orange County ISS department. He will be pursuing a Career in the workforce to further his experience.

Richard Parise a senior at the University of Central Florida and will graduate may of 2018 with Bachelor of Science in Electrical Engineering specializing in power systems. He transferred from Eastern Florida State College after obtaining his Associates Degree and will continue on to seek a job in the workforce after graduating.



Dominick Pena is currently a Senior a University of Central Florida and will receive his Bachelor of Electrical Engineering and mathematics Minor May of 2018. He has attended University of Central Florida for 4 years and plans to obtain his Masters in Power electronics and PhD studies at the University of Central Florida.

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