OREGON STATE UNIVERISTY

System Verification Final Documentation

Bike Team 3
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1 General Overview:

The goal of this project was to create a system that creates an automatic bike light. This system controls LEDS based on inputs from a light sensor, hardwired buttons and an accelerometer. Based on different changes LED patterns are displayed.

2 Customer and Engineering Requirements:

The system should be robust.

- Engineering Requirement: The system should maintain all functionality with no interruptions after dropping 3 feet onto pavement.

The system should be safe.

- Engineering Requirement: The system must use MC4 (or similar weatherproof) connectors, have a disconnect switch, and not have any exposed conductors. Wires must be organized in split loom or other protective materials. All devices must be rated at least IP64 (https://en.wikipedia.org/wiki/IP_Code).

The system turn signals should be automatic.

- Engineering Requirement: The system turn signals should turn off within 15 feet of completing a turn.

The system brake lights should be automatic.

- Engineering Requirement: The system brake lights should linearly adjust to maximum brightness and flashing speed as the bicycle slows down until fully stopping.

The system should be visible.

- Engineering Requirement: All system lights should be visible by a driver with 20/20 vision from 40 feet away in complete darkness with a light output of at least 1000 lumens.

Extra Requirements:

- The system will have a rechargeable battery that will last for 2 hours.
- The system will automatically turn on a white light for safety when biking in the dark. It will turn off during the daylight hours.

3 Electrical Schematic:

Below is the attached KiCad schematic of our entire electrical system for our automatic bike light. We used a light sensor, accelerometer and hardwired buttons. These inputs change the LED patterns on our system.

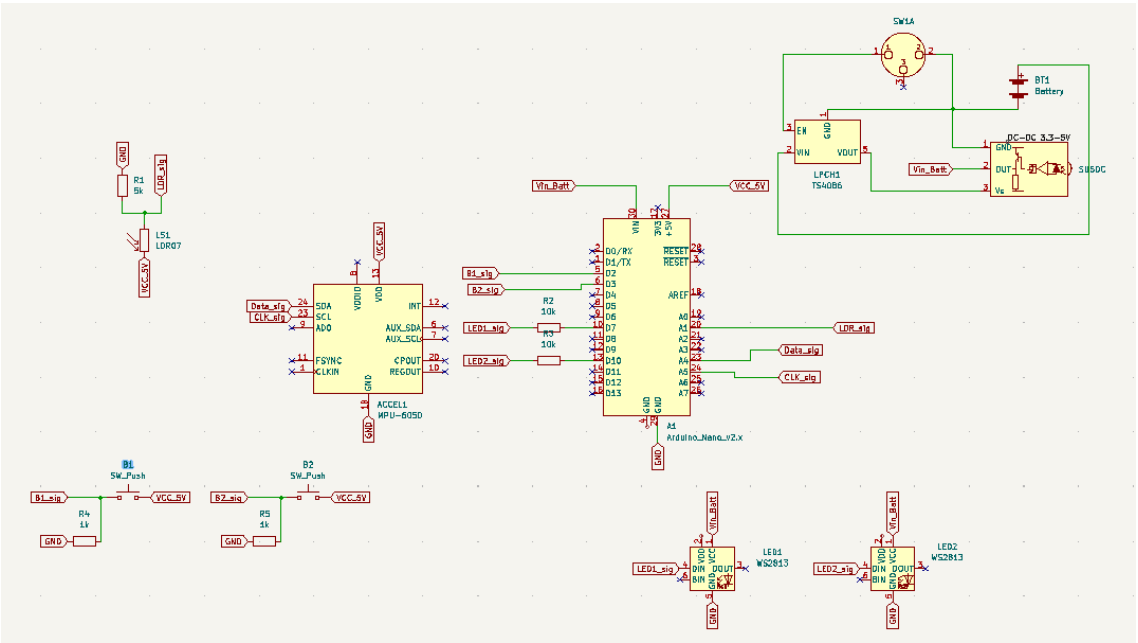


Figure 3.1: Entire Electrical System Schematic

4 Code:

This is our arduino code we used to carry out all our projects functionality. Our system is only using arduino code.

```
// Accelerometer libraries
#include <Adafruit_MPU6050.h>
#include <Adafruit_Sensor.h>
#include <Wire.h>
// LED libraries
#include <FastLED.h>
#define NUM_LEDS 50
#define BRIGHTNESS  20
#define NUM_LED_BLOCK 2
#define NUM_LED_PER_BLOCK 25
#define DATA_PIN 10
#define DATA_PIN2 7
// Accelerometer
```

```
Adafruit_MPU6050 mpu;
float acc_1;
float acc_2;
float acc_3;
// Button init values
int turnInd = 0; // int to decide to what direction has been selected for the directional signal
unsigned long button_time = 0; // for debouncing the interrupt
unsigned long last_button_time = 0; // " "          " "
const byte interruptPin1 = 2;// pins assigned to carry out interrupt for left turn
const byte interruptPin2 = 3;//pins assigned to carry out interrupt for right turn
volatile byte buttonState1 = 0;// int to check state of button 1
volatile byte buttonState2 = 0;// int to check state of button 2
// LED arrays for storing led output info
CRGB leds[NUM_LEDS];
CRGB leds2[NUM_LEDS];
void setup() {
  // put your setup code here, to run once:
  //  Serial.begin(115200);
  //LED setup
  FastLED.addLeds<NEOPIXEL, 7>(leds,0, NUM_LED_PER_BLOCK);  // GRB ordering is assumed
  FastLED.addLeds<NEOPIXEL, 10>(leds2,25, NUM_LED_PER_BLOCK);  // GRB ordering is assumed
  // light sensor setup
  pinMode(A1, INPUT);
  //Accelerometer Setup
  Serial.begin(115200);
  while (!Serial){
delay(10); // will pause until serial console opens
  }
  Serial.println("  ");
  Serial.println("Adafruit MPU6050 test!");
  Serial.println("test2");
   // Try to initialize!
  if (!mpu.begin()) {
       Serial.println("Failed to find MPU6050 chip");//if accelerometer chip is not found
       while (1) {
         delay(10);
       }
   }
   Serial.println("MPU6050 Found!");
   mpu.setAccelerometerRange(MPU6050_RANGE_8_G);//sets the sensitivity of the //accelerometer.
   Serial.print("Accelerometer range set to: ");
   switch (mpu.getAccelerometerRange()) {//shows other sensitivities available
      case MPU6050_RANGE_2_G://other possible sensitiity ranges
         Serial.println("+-2G");
         break;
      case MPU6050_RANGE_4_G:
         Serial.println("+-4G");
         break;
      case MPU6050_RANGE_8_G:
         Serial.println("+-8G");
         break;
      case MPU6050_RANGE_16_G:
         Serial.println("+-16G");
         break;
   }
   Serial.println("");
   delay(100);
   //Button Interrupt Setup
```

```
   pinMode(interruptPin1, INPUT_PULLUP);
   attachInterrupt(digitalPinToInterrupt(interruptPin1), interrupt1, CHANGE);
   //interrupts called for direction input
   pinMode(interruptPin2, INPUT_PULLUP);
   attachInterrupt(digitalPinToInterrupt(interruptPin2), interrupt2, CHANGE);
}
void loop() {
/* Get new sensor events with the readings */
// Light sensor
int analogValue = analogRead(A1);  // input pin for light sensor
// Turn the LED on, then pause
if (analogValue < 400) {           // checks if the light is below 100
//   Serial.println(" - Dark");
//   Serial.print("Analog reading 2: ");
//   Serial.println(analogValue);  // if below, print dark
      for(int i = 5; i < 20; i++){
          leds[i] = CRGB::White;    // set LEDs to white
      }
      FastLED.show();
      for(int i = 30; i < 45; i++){
          leds2[i] = CRGB::White;   // set LEDs to white
      }
      FastLED.show();// turn on LEDs
}
else if(analogValue > 400) {       // checks if value is above 100
      // Now turn the LED off
      clearLEDs();
}
// check if one of the interrupts has been set
buttonCheck();
// Accelerometer loop check
sensors_event_t a, g, temp;// gets variables for gyro and temp sensor,but only
mpu.getEvent(&a, &g, &temp);// gets the data from accelerometer and writes to variable a.
// Print out the values
   // Serial.print("Acceleration Y: ");   // acceleration on Y axis.
   // Serial.print(a.acceleration.y);
   // Serial.println(" m/s^2");
mpu.getEvent(&a, &g, &temp);
if(a.acceleration.y <= -1.0){        // checks if acceleration is negative
     Serial.println("Turn on one row of LEDs");
     Serial.print("Acceleration Y second event");
     Serial.print(a.acceleration.y);
     Serial.println("m/s^2");
     clearLEDs();
     oneLightCall();           // displays one row of lights on each LED
     buttonCheck();            // checks for button interrupt, signalling turn
     oneLightCall();
     buttonCheck();
     oneLightCall();
     buttonCheck();
     mpu.getEvent(&a, &g, &temp);
     acc_1 = a.acceleration.y;
     delay(25);
     mpu.getEvent(&a, &g, &temp);
     acc_2 = a.acceleration.y;
     delay(25);
     mpu.getEvent(&a, &g, &temp);
     acc_3 = a.acceleration.y;
```

```
      if(acc_1 <= -.5 || acc_2 <= -0.5 || acc_3 <= -0.5){   // checks if acceleration is still negative
          Serial.print("Acceleration Y Third event");
          Serial.print(a.acceleration.y);
          threeLightCall(); // displays three rows of lights on each LED
          buttonCheck();    // checks for button interrupt, signaling turn
          threeLightCall();
          buttonCheck();
          threeLightCall();
          buttonCheck();
      }
      buttonCheck();
      mpu.getEvent(&a, &g, &temp);
      acc_1 = a.acceleration.y;
      delay(50);
      mpu.getEvent(&a, &g, &temp);
      acc_2 = a.acceleration.y;
      delay(50);
      mpu.getEvent(&a, &g, &temp);
      acc_3 = a.acceleration.y;
      if(acc_1 <= 0 || acc_2 <= 0 || acc_3 <= 0){  // final check if still slowing down
          fiveLightCall();  // displays all rows of each LED
          buttonCheck();    // checks for button interrupt, signaling turn
          fiveLightCall();
          buttonCheck();
          fiveLightCall();
          buttonCheck();
          fiveLightCall();
          buttonCheck();
          fiveLightCall();
          buttonCheck();
      }
}
}
/*Function: Interrupt1
 * Input: N/A
 * Returns: This function interrupts when the left turn button is pushed!
*/
void interrupt1(){
button_time = millis();
//check to see if increment() was called in the last 250 milliseconds
   if (button_time - last_button_time > 250){
       Serial.println("left turn");
       turnInd = 1;
       last_button_time = button_time;
   }
}
/*Function: Interrupt2
 * Input: N/A
 * Returns: This function interrupts when the right turn button is pushed!
*/
void interrupt2(){
button_time = millis();
//check to see if increment() was called in the last 250 milliseconds
   if (button_time - last_button_time > 250){
       Serial.println("right turn");
       turnInd = 2;
       last_button_time = button_time;
    }
```

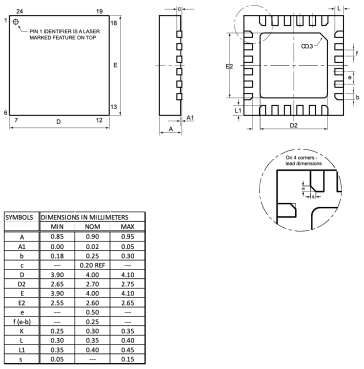
```
}
/*Function: Right Turn
 * Input: N/A
 * Returns: After being called, it clears the outer 2 rows of the 5x5 arrangement for the left pair
 * and lights the other 3 to red. It then flashes the outer 2 lEDs on the right pair yellow.
 * The reduced amount of LEDs is to save power.
*/
void leftTurn(){
   Serial.println("Made to left turn");
   clearLEDs();
   for(int i = 0; i < 25; i++){
       leds[i] = CRGB::Black;
   }
   FastLED.show();
   for(int i = 25; i < 50; i++){
       leds2[i] = CRGB::Black;
   }
   FastLED.show();
   for(int i = 5; i < 20; i++){
       leds[i] = CRGB::Red;
   }
   FastLED.show();
   int j = 0;
   while(j < 6){
       for(int i = 25; i < 35; i++){
           leds2[i] = CRGB::Yellow;
       }
       FastLED.show();
       delay(500);
       for(int i = 25; i < 35; i++){
           leds2[i] = CRGB::Black;
       }
       FastLED.show();
       delay(500);
       j++;
   }
   clearLEDs();
   turnInd = 0;
}
/*Function: Left Turn
 * Input: N/A
 * Returns: After being called, it clears the outer 2 rows of the 5x5 arrangement for the right pair
 * and lights the other 3 to red. It then flashes the outer 2 lEDs on the left pair yellow.
 * The reduced amount of LEDs is to save power.
*/
void rightTurn(){
   Serial.println("Made to right turn");
   clearLEDs();
   for(int i = 0; i < 25; i++){
       leds[i] = CRGB::Black;
   }
   FastLED.show();
   for(int i = 25; i < 50; i++){
       leds2[i] = CRGB::Black;
   }
   for(int i = 30; i < 45; i++){
       leds2[i] = CRGB::Red;
```

```
   }
   FastLED.show();
   int j = 0;
   while(j < 6){
       for(int i = 0; i < 10; i++){
           leds[i] = CRGB::Yellow;
       }
       FastLED.show();
       delay(500);
       for(int i = 0; i < 10; i++){
           leds[i] = CRGB::Black;
       }
       FastLED.show();
       delay(500);
       j++;
   }
   clearLEDs();
   turnInd = 0;
}
/*Function: button Check
 * Input: N/A
 * Returns: checks to see what button has been pressed and carries out the command for the button press
*/
void buttonCheck(){
if (turnInd == 1){
       leftTurn();
}
if(turnInd == 2){
       rightTurn();
}
}
/*Function: displays no color on LEDs. Turns them off
 * Input: N/A
 * Returns: LED turned off
*/
void clearLEDs(){
   for(int i = 0; i < 25; i++){
       leds[i] = CRGB::Black;
   }
   FastLED.show();
   for(int i = 25; i < 50; i++){
       leds2[i] = CRGB::Black;
   }
   FastLED.show();
}
/*Function: First Brake Signal
 * Input: Accelerometer
 * Returns: If the accelerometer reports that the bike has started slowing down
 * then the middle row of each LED will turn on and blink slowly.
*/
void oneLightCall(){
    for(int i = 10; i < 15; i++){
         leds[i] = CRGB::Red; // set LEDs to yellow
    }
    FastLED.show(); // turn off LEDs
    for(int i = 35; i < 40; i++){
         leds2[i] = CRGB::Red; // set LEDs to yellow
    }
```

```
    FastLED.show(); // turn off LEDs
    delay(150);
    clearLEDs();
    delay(125);
}
/*Function: Second Brake Signal
 * Input: Accelerometer
 * Returns: If the accelerometer reports that the bike is still slowing down
 * after it has already completed the first brake signal calls, then the three
 * middle rows of each LED will turn on and blink a bit faster.
*/
void threeLightCall(){
   Serial.println("Turn on three rows of LEDs");
   for(int i = 5; i < 20; i++){
       leds[i] = CRGB::Red;       // set LEDs to yellow
   }
   FastLED.show();               // turn of LEDs
   for(int i = 30; i < 45; i++){
       leds2[i] = CRGB::Red;        // set LEDs to yellow
   }
   FastLED.show();                 // turn of LEDs
   delay(100);
   clearLEDs();
   delay(75);
}
/*Function: Final Brake Signal
 * Input: Accelerometer
 * Returns: If the accelerometer reports that the bike is still slowing down
 * after it has alread completed the first brake signal calls, and the second
 * then all five rows of each LED will turn on and blink the fastest.
*/
void fiveLightCall(){
  Serial.println("Turn on all LED's");
  for(int i = 0; i < 25; i++){
      leds[i] = CRGB::Red;        // set LEDs to yellow
  }
  FastLED.show();                 // turn of LEDs
  for(int i = 25; i < 50; i++){
      leds2[i] = CRGB::Red;        // set LEDs to yellow
  }
  FastLED.show();                 // turn of LEDs
  delay(75);
  clearLEDs();
  delay(50);
}
```

5 Mechanical Drawings:

Below are the dimensions of the light sensor, accelerometer, LEDs, Battery, step-up and our enclosure



SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	0.85	0.90	0.95
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
c	---	0.20 REF	---
D	3.90	4.00	4.10
D2	2.65	2.70	2.75
E	3.90	4.00	4.10
E2	2.55	2.60	2.65
e	---	0.50	---
f (e-b)	---	0.25	---
K	0.25	0.30	0.35
L	0.30	0.35	0.40
L1	0.35	0.40	0.45
s	0.05	---	0.15

Figure 5.1: Accelerometer chip dimensions from data sheet

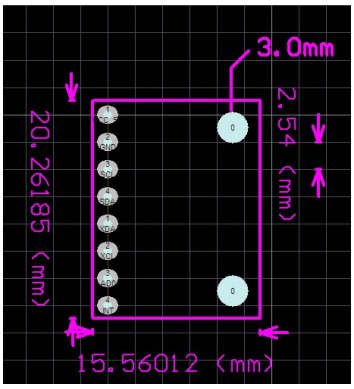


Figure 5.2: Accelerometer board dimensions

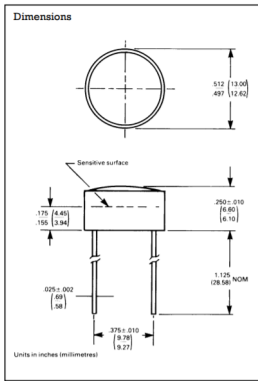


Figure 5.3: Light Dependent Resistor

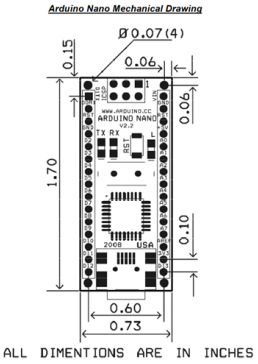


Figure 5.4: Arduino Nano datasheet dimensionsc

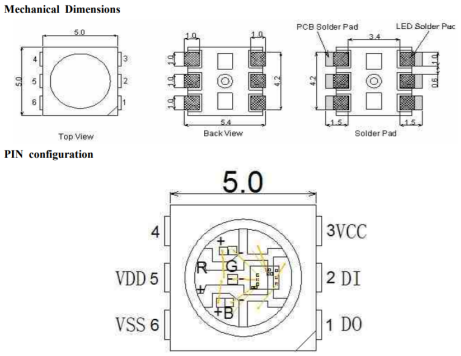


Figure 5.5: Data Sheet WS2812 LEDs
Total Dimensions: 3.46 x 2.32 x 0.47 inches

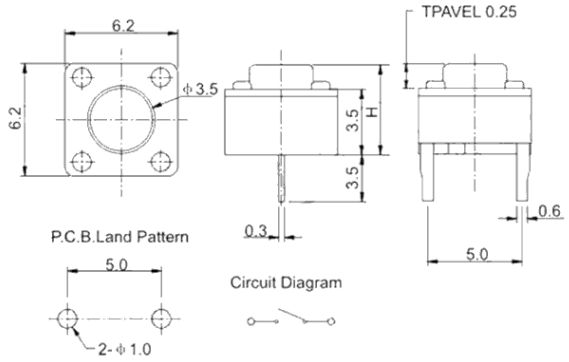


Figure 5.6: Button dimensions - units are mm

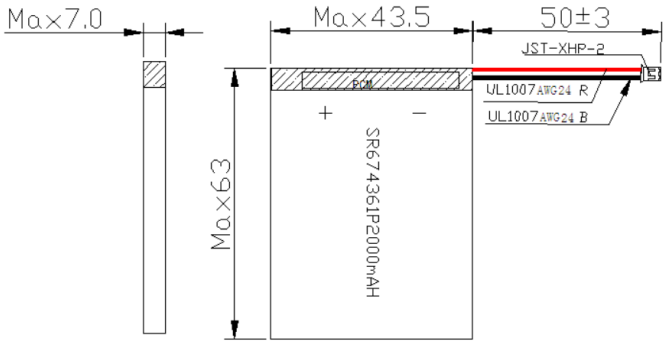
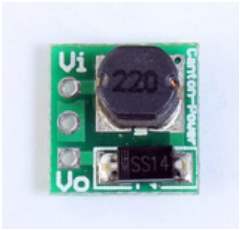
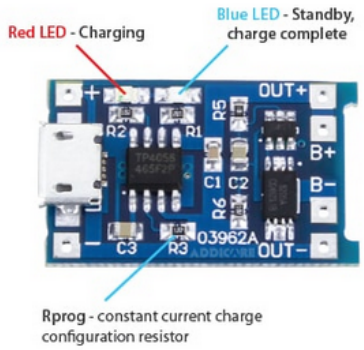


Figure 5.7: Power dimensions - units are mm



- DC-DC boost converter module, operating frequency 150KHZ, typical conversion efficiency of 85%.
- Pin 2.54MM pitch.
- Input voltage: 0.9-5V, output voltage: 5V, maximum output current: 480 mA.
- Dimensions: 11mm x 10.5mm x 7.5mm (ultra-small module, 1mm=0.0393inch)
- Weight: about 1g

Figure 5.8: Step-up dimensions



Dimensions	
Length	28 mm (~1.103")
Diameter	17 mm (~0.669")
Weight	1.6 g (0.057 oz)

Figure 5.9: Battery Charger

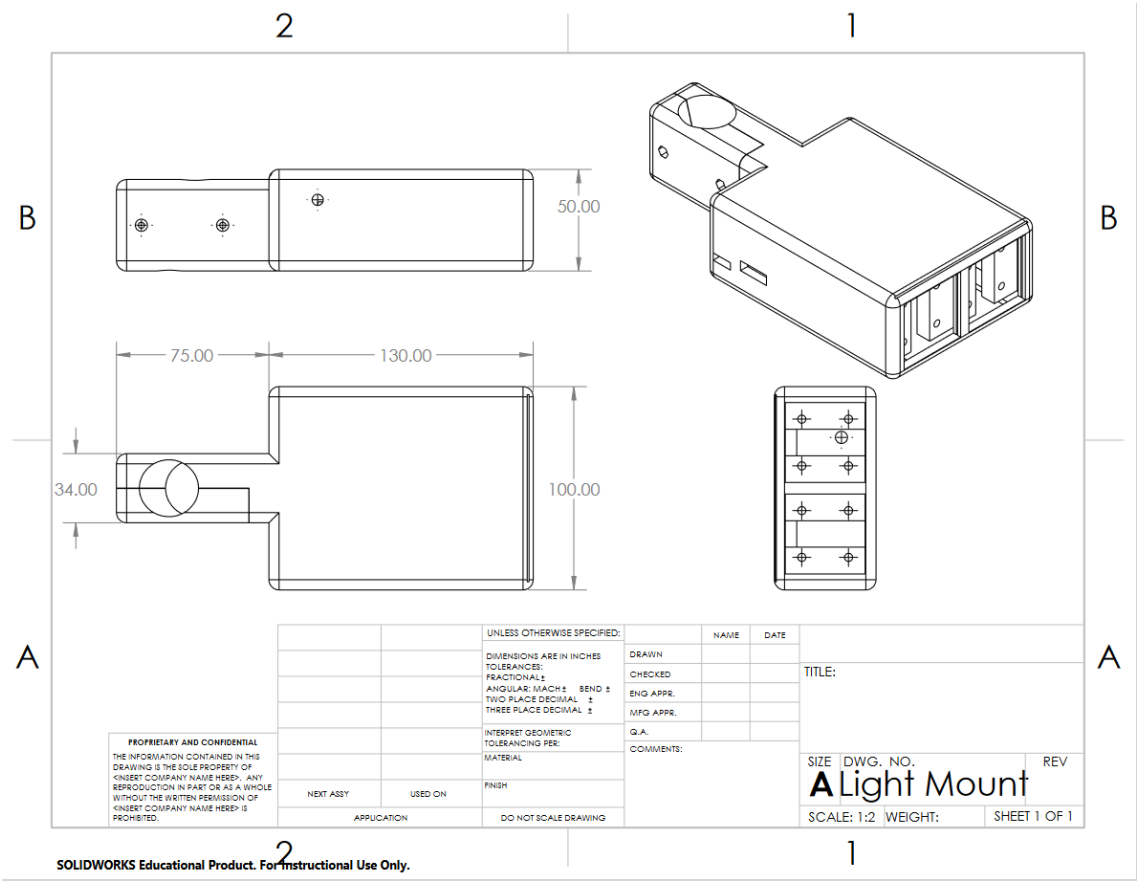
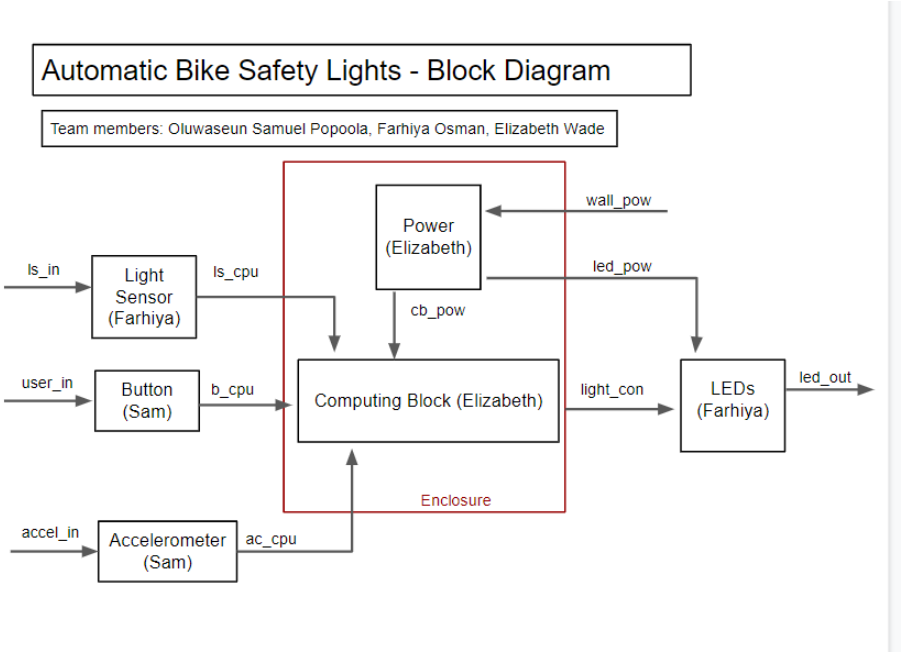


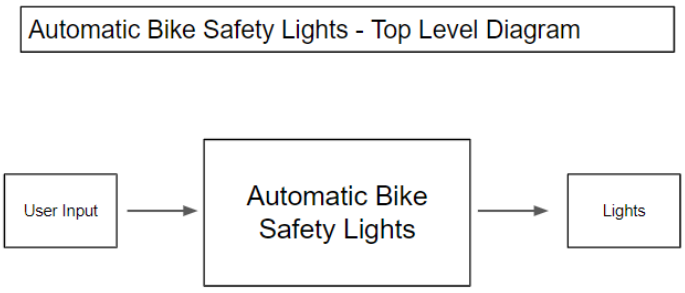
Figure 5.10: Enclosure - all measurements in mm

6 Block Diagram:

This is our final block diagram that encompasses the functionality of our whole system.



7 Top Level Diagram



8 Interface Specifications:

ls_CPU	The light sensor will measure light outside and report that to the Computing block.Expected value: An 1.95 V indicates "dark" and above 1.95V indicates "light".	Vmeasured = 3.88 V Vmax = 5 V DC Pmax = 100 mW Imeasured = 0.248mA
b_cpu	One push of the button (active low) leads to a change in LED. If the left button or right button is pushed it will be reported to the Computing block. Expected value: 0 indicates button pushed while 1 indicates no button has been pushed.	Vmeasured = 3.87 V Vmax = 5 V Vmin = 3.3 V Imeasured = 3.76mA
ac_cpu	If the bike speed is decreasing it will be reported to the computing block. Expected value: A speed decrease of at least one mph. It has an acceleration sensitivity range from +-2g to +-16g	Vmeasured = 3.87V Vmax = 5V Vmin = 3.3V Imax = 5.7 mA
light_con	If a decrease in speed, a button is clicked or the light sensor outputs that its dark outside an specific LED pattern will be displayed. If a button is clicked a one LED will blink while the other remains solid, if the rider decreases in speed both LEDs will increase in brightness and if the light sensor indicates darkness outside both LEDs will turn on. Expected Value: Light > 1.95 V and Dark < 1.95 V for light sensor.	Vsig_measured = 0.09 V Vmax = 5.0 V P = 0.7W Scan Frequency:400 Hz/s Duty Cycle Range: 48-52(%) Imeasured = .003mA

cb_pow	LiPo battery supplies power to our controlling block. It supplies 4.95 V to the arduino nano which controls all interfaces.	Vnom = 5 V Vmin = 4.7 V Vmeasured = 4.96V Imin = 12.7 mA Imax = 16.7 mA
wall_pow	Battery pack is charged using a wall connector. It uses a usb-c connection to plug into the wall. This plug uses 5V and 2.0A.	Vnom = 5.2 V Vmeasured = 4.97 V Imeasured= 2.4 A Pmax = 12W
led_pow	Battery pack supplies power to our LEDs directly. This is connected before the step up, so the LEDs are supplied 3.68 V.	Vnom = 3.7 V Vmin = 3.5 V Vmeasured = 3.68 V Imeasured = 800mA
ls_in	Light input to the light sensor	N/A
user_in	User input via button press	N/A
accel_in	Acceleration input	Acceleration_Max: 78.4 m/s^2
led_out	Light output from the LED	N/A

9 PCB Layers:

This is a diagram of the PCB we decided to use for our project. This image showcases the different connections and components we decided to use on the PCB.

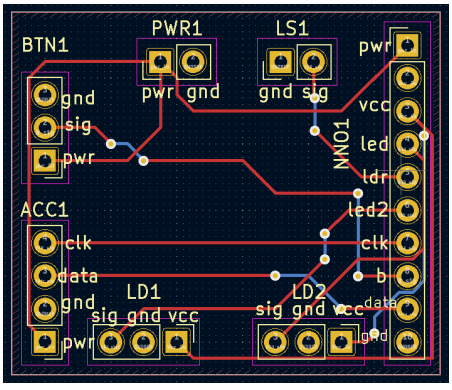


Figure 9.1: PCB layer;

10 Bill of Materials:

Ref.	Block	Part	Part Number	Seller	Purchase Link	Datasheet Link	Qty	Unit Cost	Cost
LS1	Light Sensor	LDR Resistor	GM5539	Amazon	Link Here	Datasheet Link	1	0.22	0.22
R1	Light Sensor	5K Resistor	5KQBK-ND	DigiKey	Link Here	Datasheet Link	1	0.10	0.10
LED1, LED2	LED	5X5 25 LED Matrix - RGB	WS2812	Amazon	Link Here	Datasheet Link	2	3.66	7.32
R2, R3	Light Sensor	10K Resistor	10KQBK-ND	DigiKey	Link Here	Datasheet Link	2	0.10	0.20
B1, B2	Button	Tactile Switches (Push Buttons)	CKN9092-ND	Amazon	Link Here	Datasheet Link	2	1.00	2.00
R4, R5	Button	1K Resistor	1KQBK-ND	DigiKey	Link Here	Datasheet Link	2	0.10	0.20
N/A	Button	Spiral Cable Wrap	B0918 XNP8J	Amazon	Link Here	N/A	1	6.99	6.99
ACCEL1	Accelerometer	3 Axis Accelerometer Gyroscope Module 6	GY-521 MPU-6050	Amazon	Link Here	Datasheet Link	1	5.99	5.99
BT1	Power	Li-ion Lithium Battery Charger	TP4056	Amazon	Link Here	Datasheet Link	1	0.80	0.80
SU5DC	Power	5V DC-DC Step Up Power Module	20484253	Amazon	Link Here	Datasheet Link	1	1.46	1.46
SW1A	Power	Switch	G0Q2GA	Tekbots	Link Here	Datasheet Link	1	0.33	0.33
LPCH1	Power	Lipo Battery Rechargeable	505573	Amazon	Link Here	Datasheet Link	1	10.99	10.99
A1	Computing	Arduino Nano	CH340G	Amazon	Link Here	Datasheet Link	1	6.33	6.33
N/A	All blocks	Wire	AWG UL3239	Amazon	Link Here	Datasheet Link	10	1.00	10.00
N/A	All blocks	Protoboard	P1421 783775	Tekbots	Link Here	N/A	2	2.00	4.00
N/A	Enclosure	PLA for 3D print	3D8545 25007156	Amazon	Link Here	N/A	1	10.00	10.00
N/A	Enclosure	M3 Hex Cap Screw	M3 *12mm	Amazon	Link Here	N/A	6	0.04	0.24
N/A	Enclosure	M3 Nut	M3 Nuts	Amazon	Link Here	N/A	6	0.04	0.24
N/A	PCB	PCB	N/A	Osh Park	N/A	N/A	1	2.70	2.70

11 Team Time Report:

Team Members	Time spent in hours
Oluwaseun Samuel Popoola	55
Farhiya Osman	70
Elizabeth Wade	75