University of Moratuwa

Department of Electronic and Telecommunication Engineering

EN2160 - Electronic Design Realization

Product - Report

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Executive summary

LUMINOVA is a rechargeable RGB table lamp, with color sensing capabilities and customizable lighting options. Switching between lamp modes (color-sensing, color cycle, custom color) and controlling lamp attributes (brightness) is done by built-in OLED display and touch input buttons. Works as a compatible power bank due to large battery capacity and an in-built power bank modules.

This report consists of several product development stages and product attributes of the product design including product specifications, conceptual designs, preliminary designs, software design, finalized designs, user manual and supply chains.

Contents

Product introduction

Introducing **LUMINOVA**, rechargeable RGB table lamp. With color sensing capabilities and customizable lighting options, it's easy to create the perfect ambiance. Switch between color sensing and normal mode effortlessly, and control lamp attributes and modes with the built-in OLED display and input buttons. Plus, with its large battery capacity, it also serves as a handy power-bank. Perfect for any home or office, this lamp is both practical and stylish.

Purpose and intended usage

- Enhancing the mood and ambience of the room using customized colors.
- Playful color sensing mode to pass the time.
- Keeping mobile and devices powered with a convenient power bank.

Target customers

- People who work in offices or at home and require a lamp that can provide customizable lighting for different tasks.
- Anyone who is interested in home décor and is looking for a stylish and modern lamp that can enhance the ambiance of a room.
- College students or people living in small apartments who need a lamp that can also serve as a power-bank to charge their electronic devices.

Product specifications

Dimensions	12cm x 19cm x 5cm – base 30cm flexible light holder 4.5cm x 4.5cm x 7cm lamp
Power-Module & Battery	18650 Li-ion battery 3.7V 3200mAh x 3 Input charging voltage 5V DC Output voltage 5V 2.4A
Operating temperature range	-20^0C~70^0C
Input / Output interfaces	Charging Input type –TypeC / MicroUSB / Lightning Charging Output type – USB X 2 Channel Capacitive touch switches x 3
Microcontroller	Atmega328PU - High performance, low power AVR® 8-bit microcontroller, 32Kbytes of in-system self-programmable flash program memory, 1Kbytes EEPROM, 2Kbytes internal SRAM
Display specs	Resolution: 128X64 Dimensions: 35.4mm x 33.5mm x 4.3mm OLED screen Internal drive chip: SH1106

Additional Features

OLED Display

- User-friendly menu is integrated to navigate through the available settings for the lamp.
- The main menu will turn off automatically after 10 seconds of inactivity to save power.
- OLED display provides super wide viewing angle up to 160^0.

Touch Buttons

- Touch buttons provide a sleek and modern looks and feels for the lamp.
- They are more responsive and reliable than conventional push buttons since there are no moving parts.
- Ease of cleaning and maintain.

Lamp Modes

- Default lighting – White will be the default color when the lamp is powered on.
- Color Cycle – Cycles through all the possible colors, while displaying the changing RGB values in the display.
- Color Sensing – Senses the color underneath the sensor and replicates that using RGB LEDs, while displaying the sensed RGB values in the display.
- Custom Colors – User can choose a custom color or input the desired RGB values to set a custom color to the lamp.

Brightness Adjustment

- Brightness of the lamp can be adjusted by 8 levels from the menu.

Power Bank

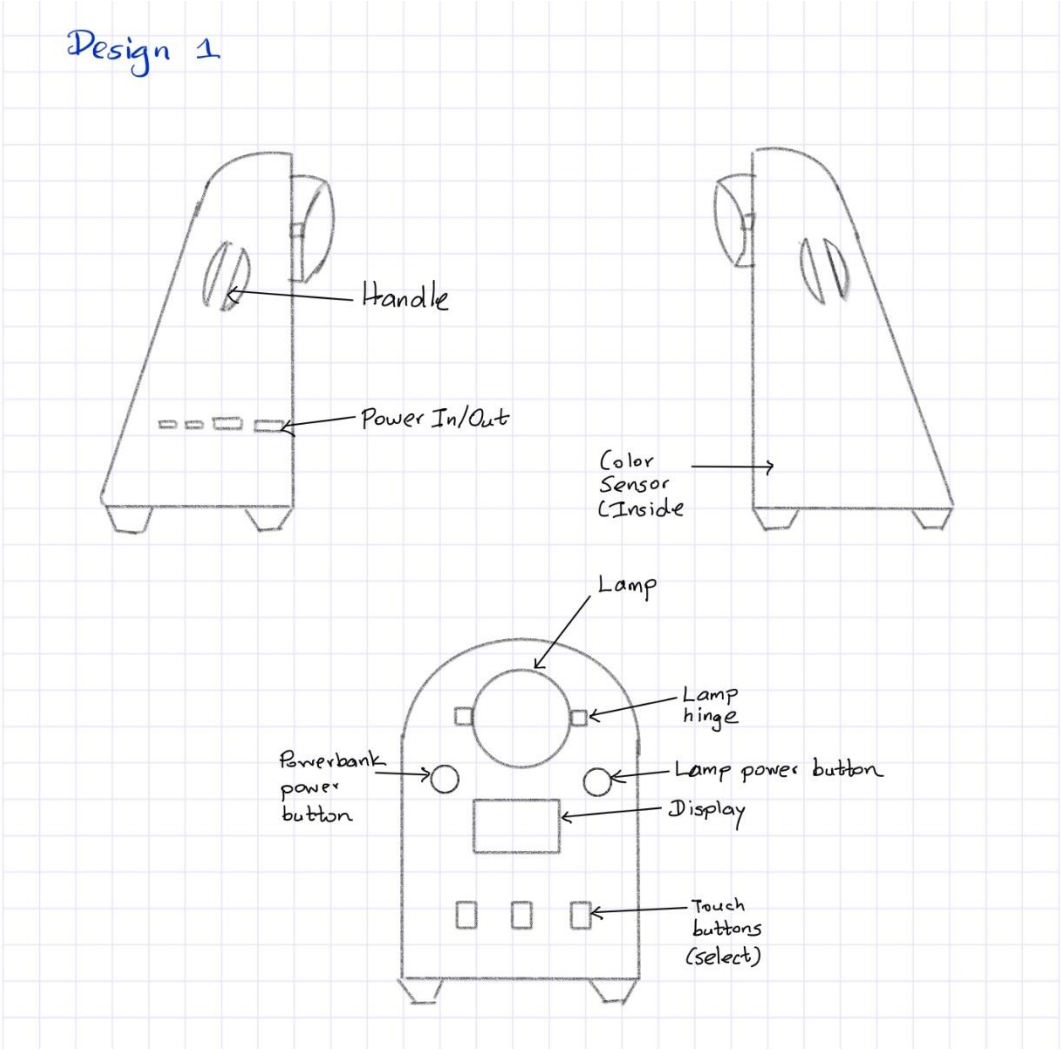
- Supports discharge while charging.

- Dual USB output. 3 kinds of input types (TypeC/MicroUSB/Lightning).
- Push and hold power button for 2 seconds to turn on/off the module.
- Battery percentage indicator display. Display turns-off after 30 seconds. Press power button to display percentage again.
- Power-bank can be used without turning on the lamp.
- Automatic turn-off during inactivity.

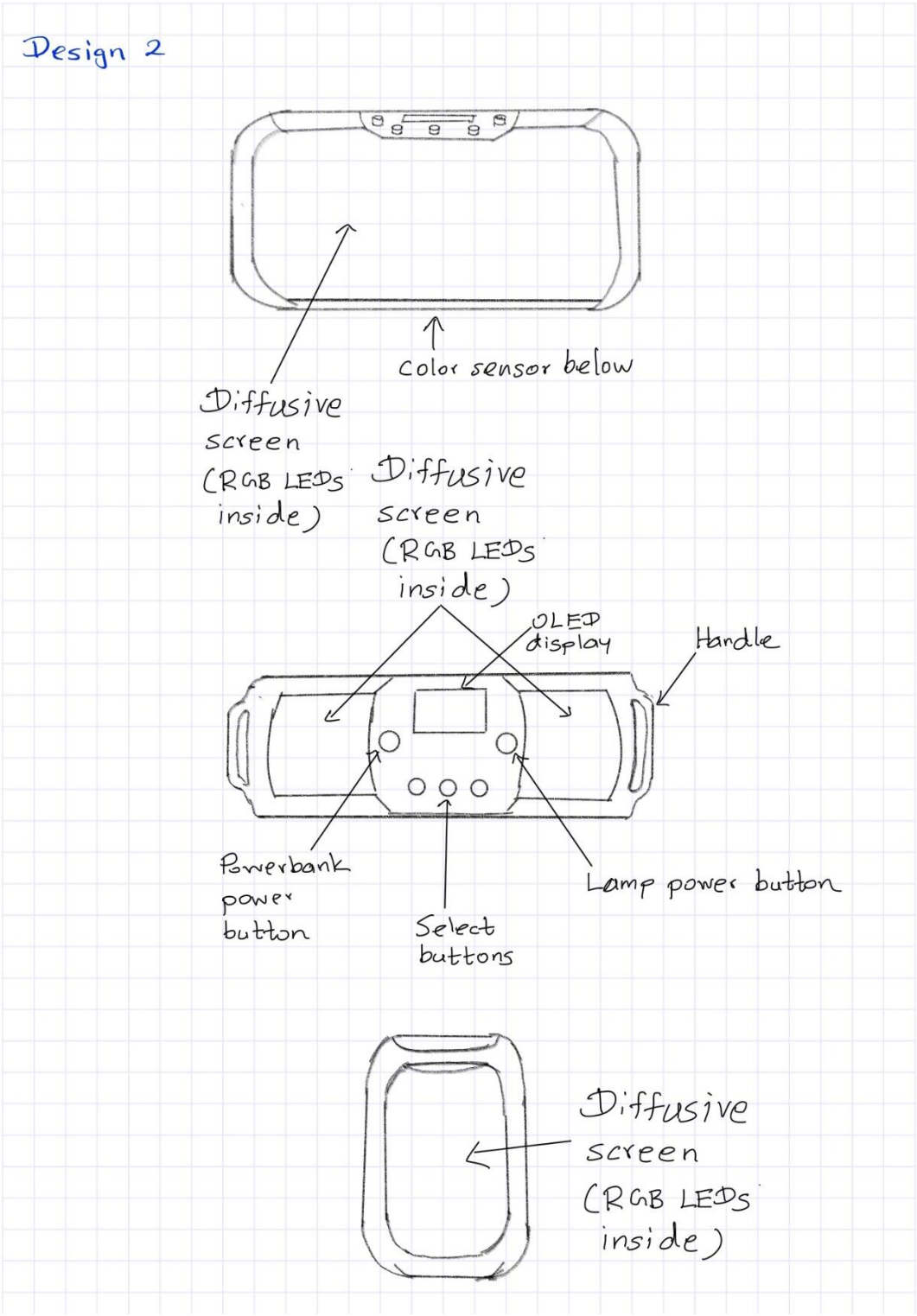
Design process

Conceptual Designs

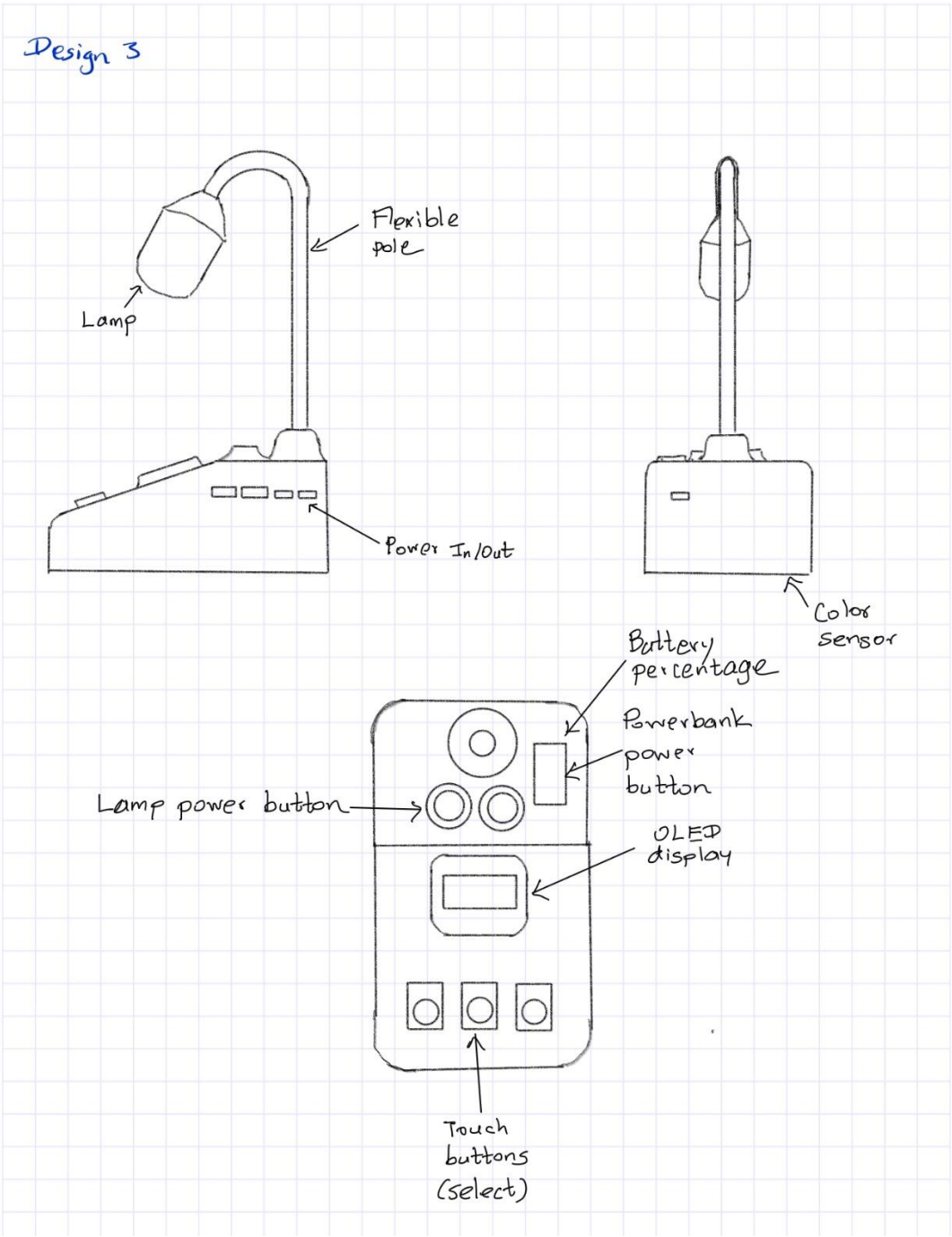
Hand Sketches



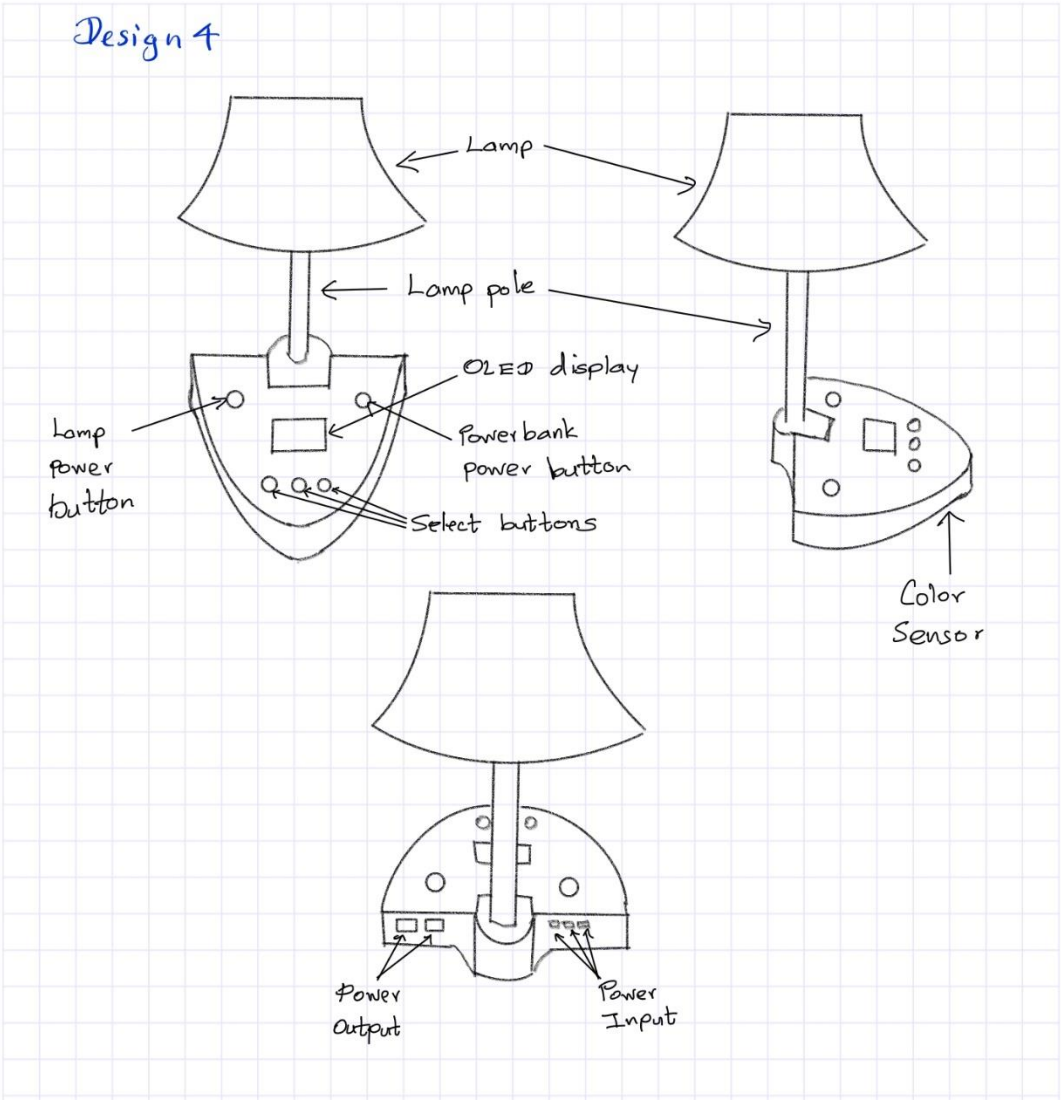
- Lamp orientation can be adjusted vertically.
- Two handles in the sides.
- User might feel uncomfortable when accessing the menu in display when the lamp is turned on.



- Party design.
- Illuminates in 360^0.
- Very compact.



- Flexible lamp head.
- User friendly interface on base.
- Accommodation for battery percentage indicator.
- Accommodation for high-capacity battery for power-bank.
- Portable.



- Big lamp head.
- Less portable.
- Cannot adjust lamp head orientation.

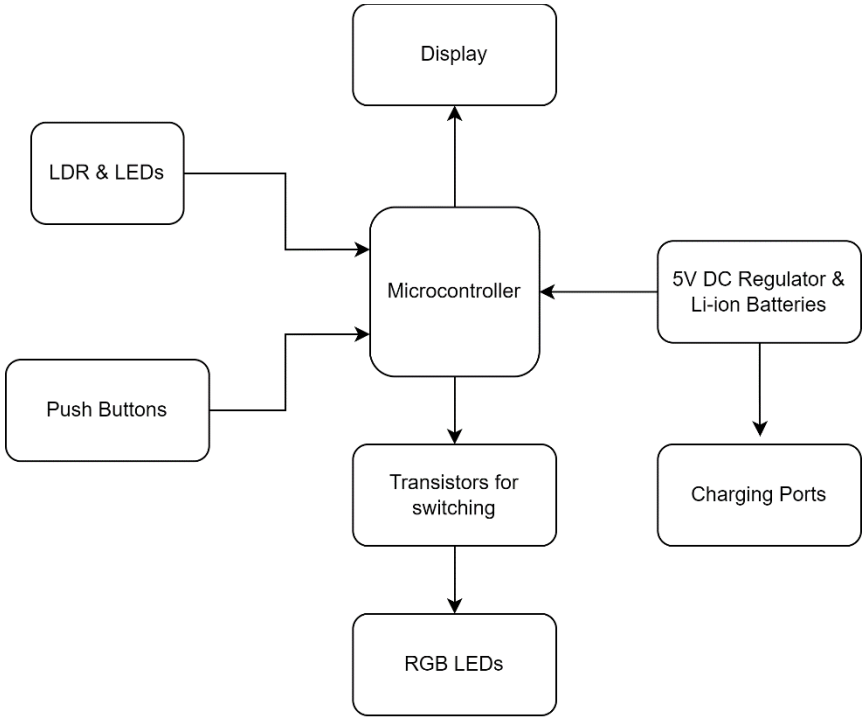
Selection Matrix for Sketches

Criteria	Design1	Design2	Design3	Design4
Portability	8	9	9	6
Compactness	6	9	6	6
User friendly interface	6	8	8	8
Ease of handling	6	8	8	7
Battery capacity	9	4	9	9
Availability of parts	7	4	8	7
Ease of molding	9	4	6	6
Attractiveness	3	9	6	7
Color sensor placement	6	7	8	6
Accommodation for internal circuitry	8	6	8	8
Robustness	8	7	8	8
Adjustable lamp orientation	4	4	9	4
	80	**79**	**92**	**82**

Selected design is **Design 3**

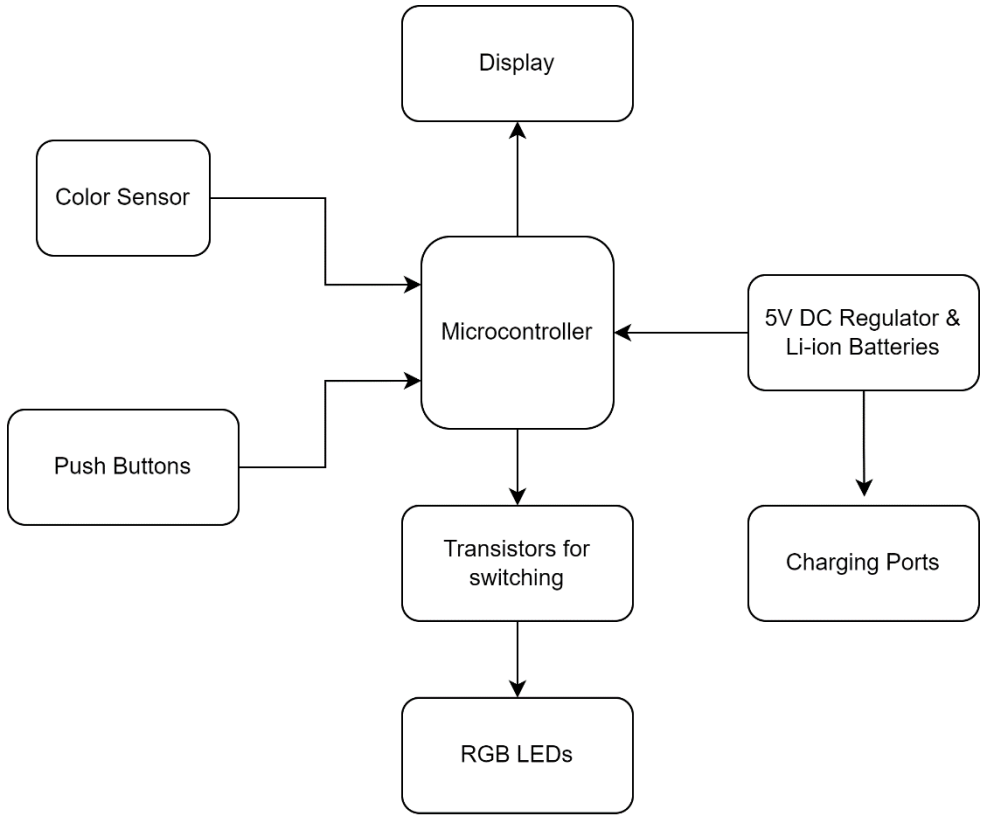
Block diagram

Block diagram 1



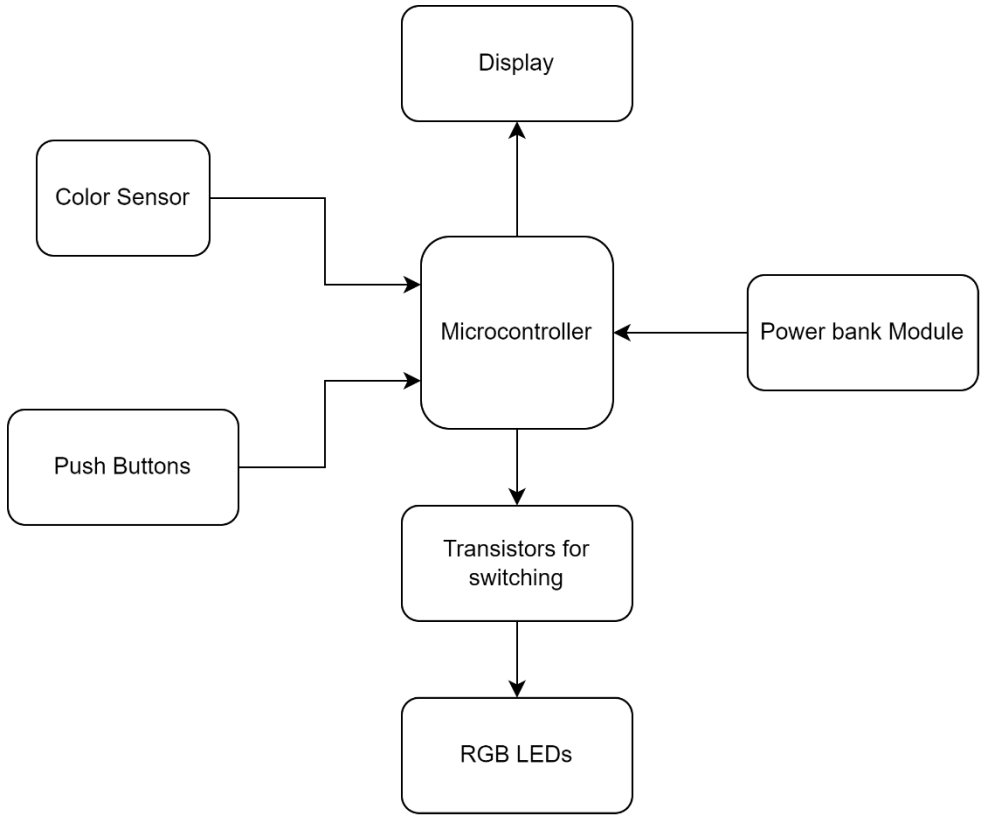
- Color sensing with LDR and red, green, blue colored LEDs.
- 5V DC convertor and 3.3V Li-ion batteries to supply power.
- Separate charging ports to charge batteries and to get 5V output for charging devices.
- Transistors as switches to switch the RGB LEDs according to PWM signals from microcontroller.
- Push buttons to select in the menu.

Block diagram 2



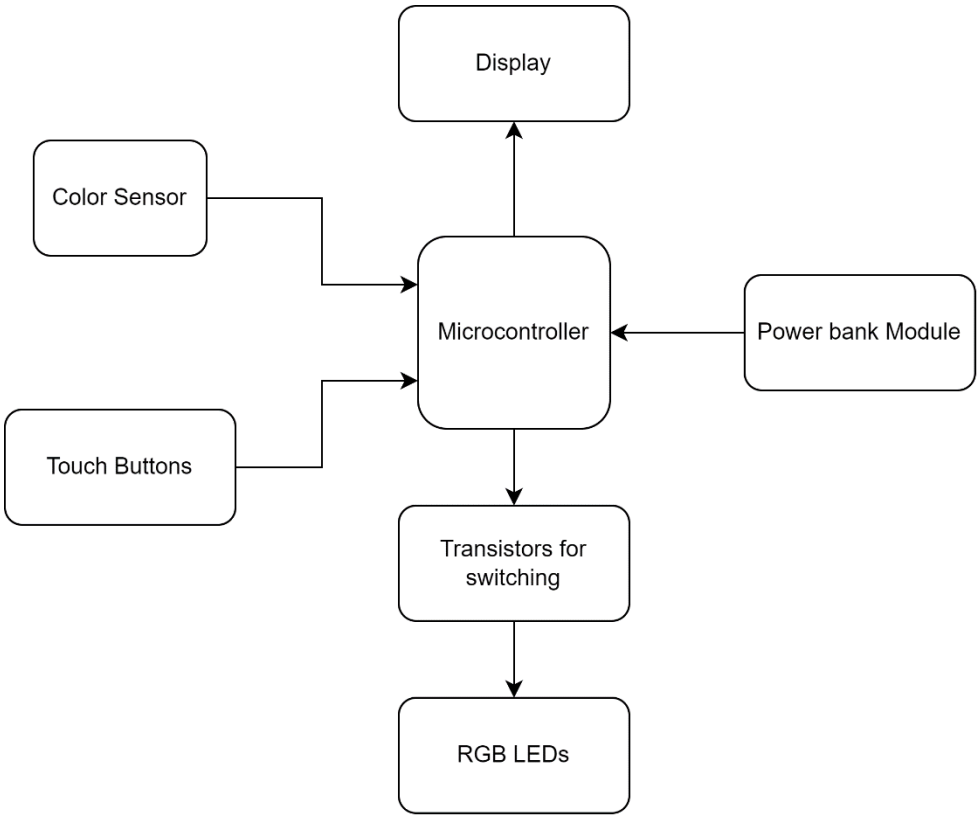
- LDR and 3 color LEDs lacked accuracy and didn't perform under different surface conditions.
- Added color sensor module instead to get accurate readings.

Block diagram 3



- Power bank module has improved facilities to charge the batteries like supporting multiple types of ports (USB type C, USB micro, Lightning) and Battery level indication, overcurrent protection.
- Therefore, removed 5V regulator and charging ports and added Power Bank Module.

Block diagram 4



- To improve user experience and to prevent degradation of push buttons touch buttons are used instead.

Selection Matrix for Block diagrams

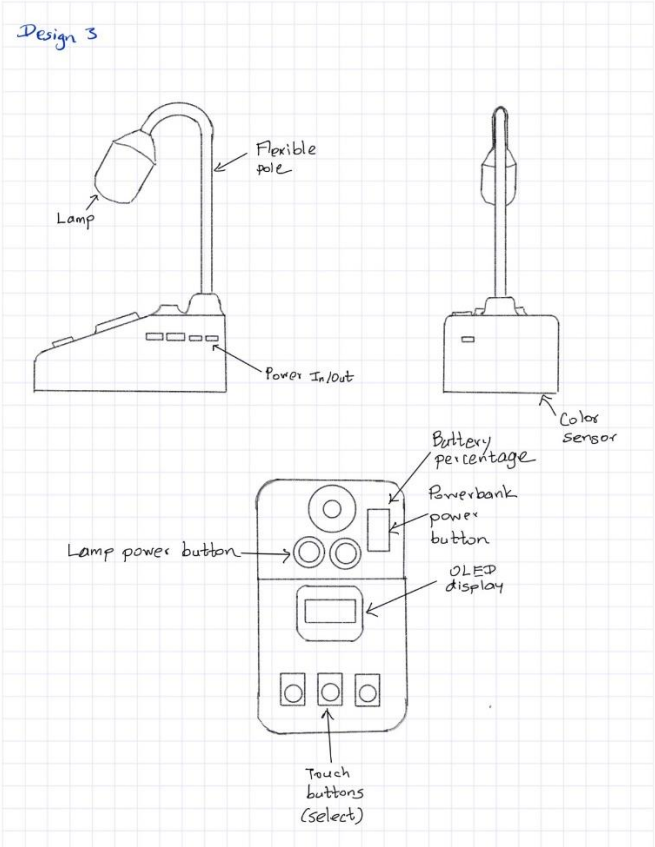
Criteria	Diagram1	Diagram2	Diagram3	Diagram4
Color sensor accuracy	5	8	8	8
Compactness	6	7	9	9
User friendliness	6	6	7	9
Overcurrent protection	6	6	9	9
Battery management	5	5	9	9
Availability of parts	9	8	8	7
Complexity (less)	6	7	9	9
	43	**47**	**59**	**60**

Selected diagram is **Diagram 4**

Selected Designs

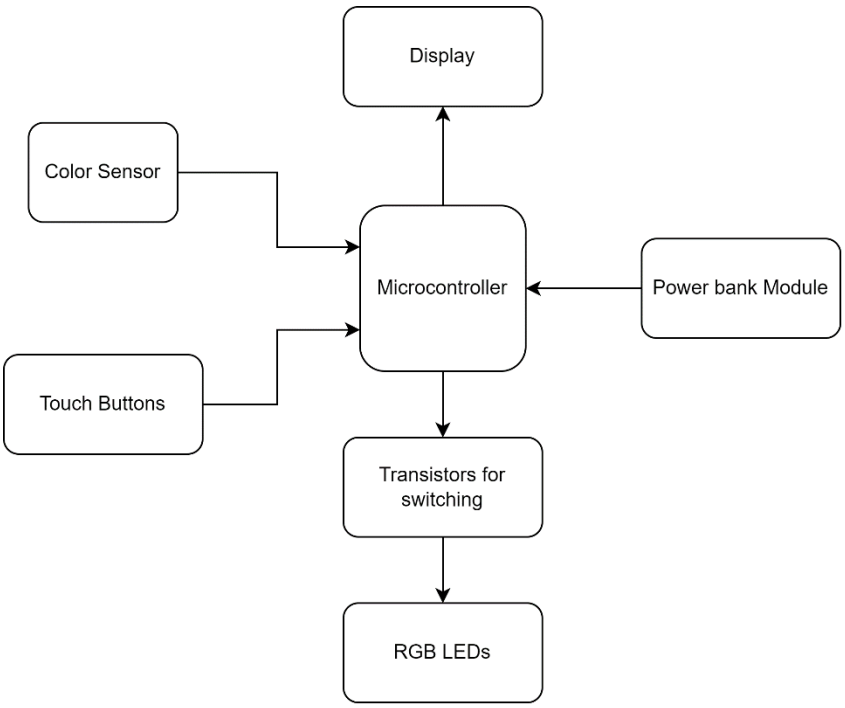
Sketch

Design 3



Block diagram

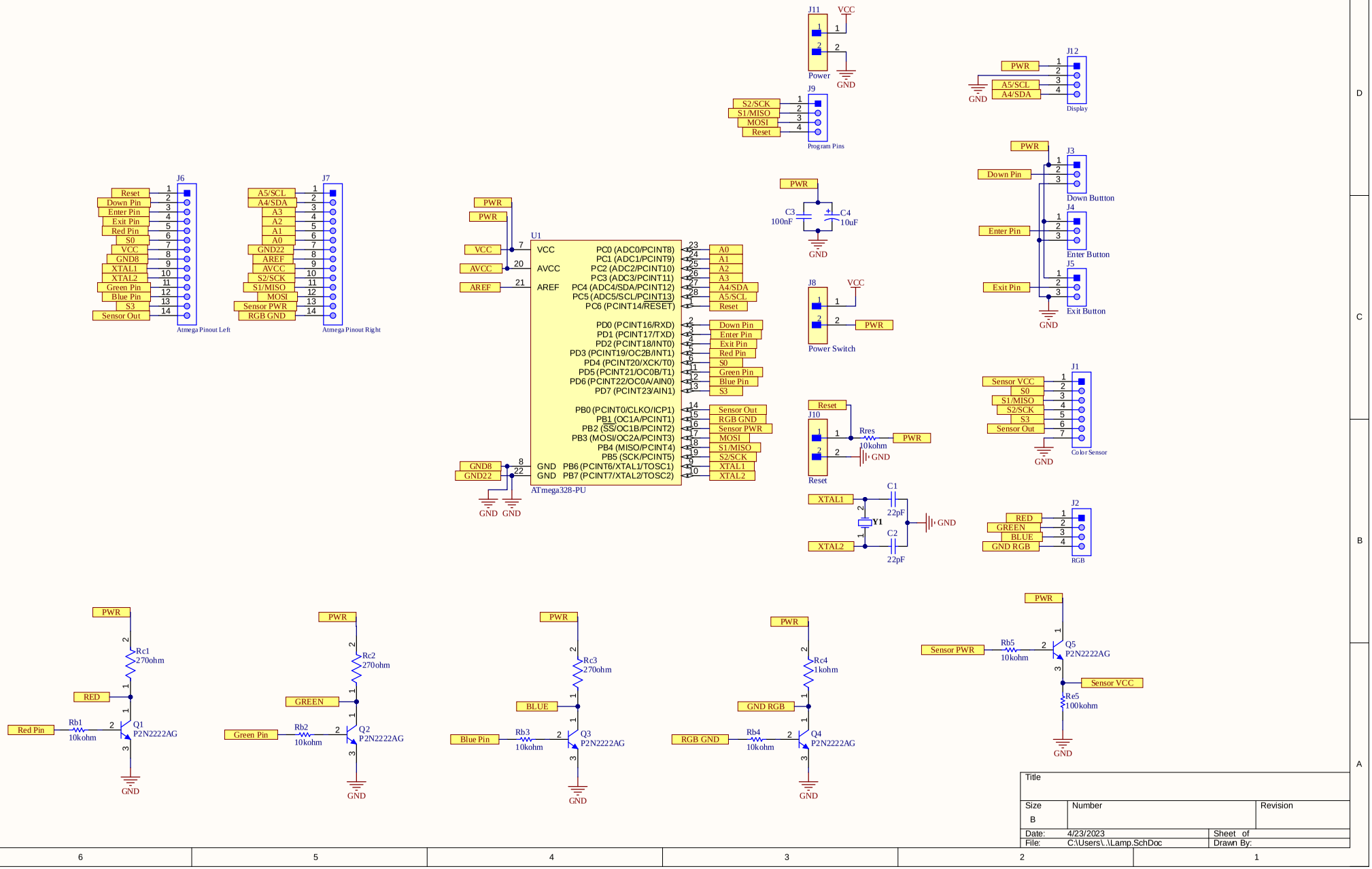
Diagram 4



Preliminary Design

Schematic

Next Page

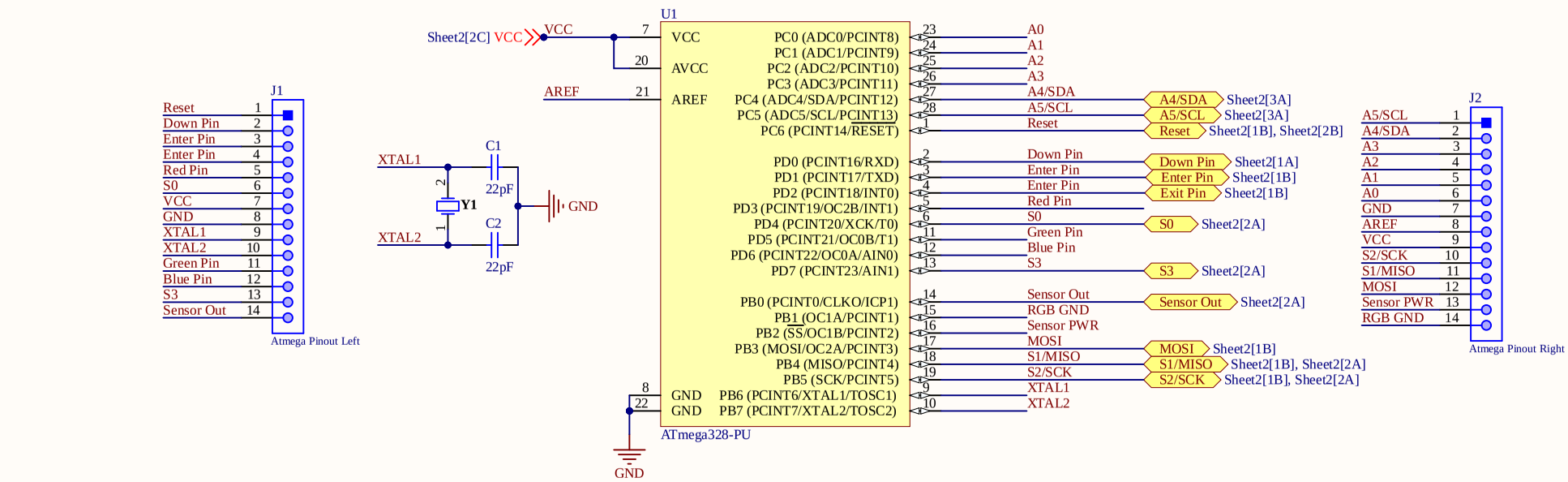


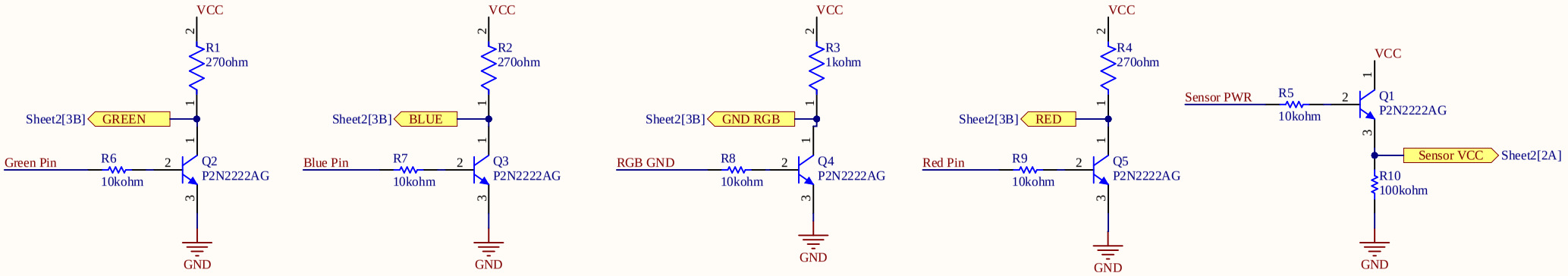
Title		
Size: B	Number	Revision
Date: 4/23/2023		Sheet of
File: C:\Users\..\Lamp.SchDoc		Drawn By:

Problems identified considering the course content.

- Unordered numbering of components.
- Not used multiple sheets to better understanding and documentation of the schematic.
- Incomplete schematic header/title box.

Improved Schematic





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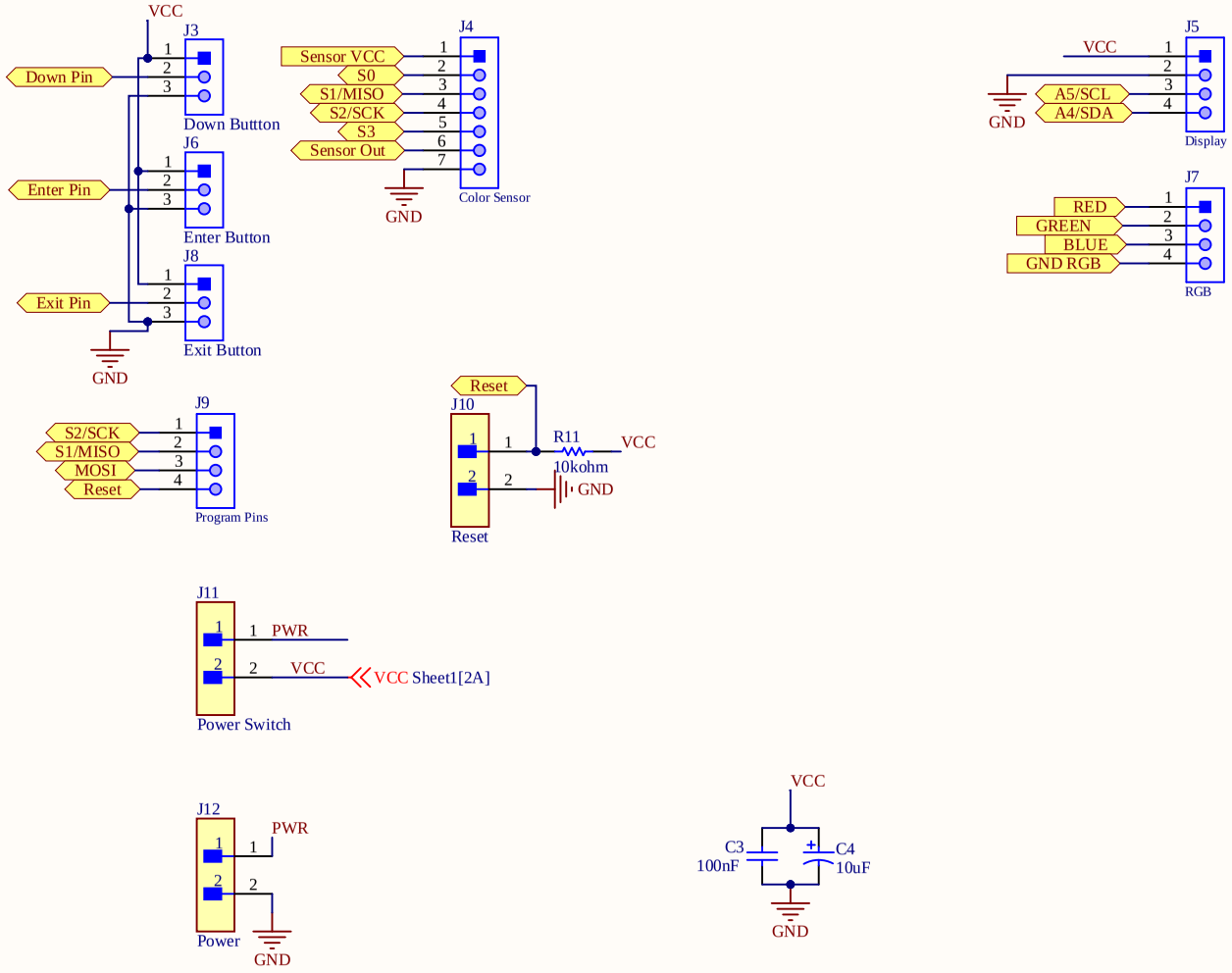
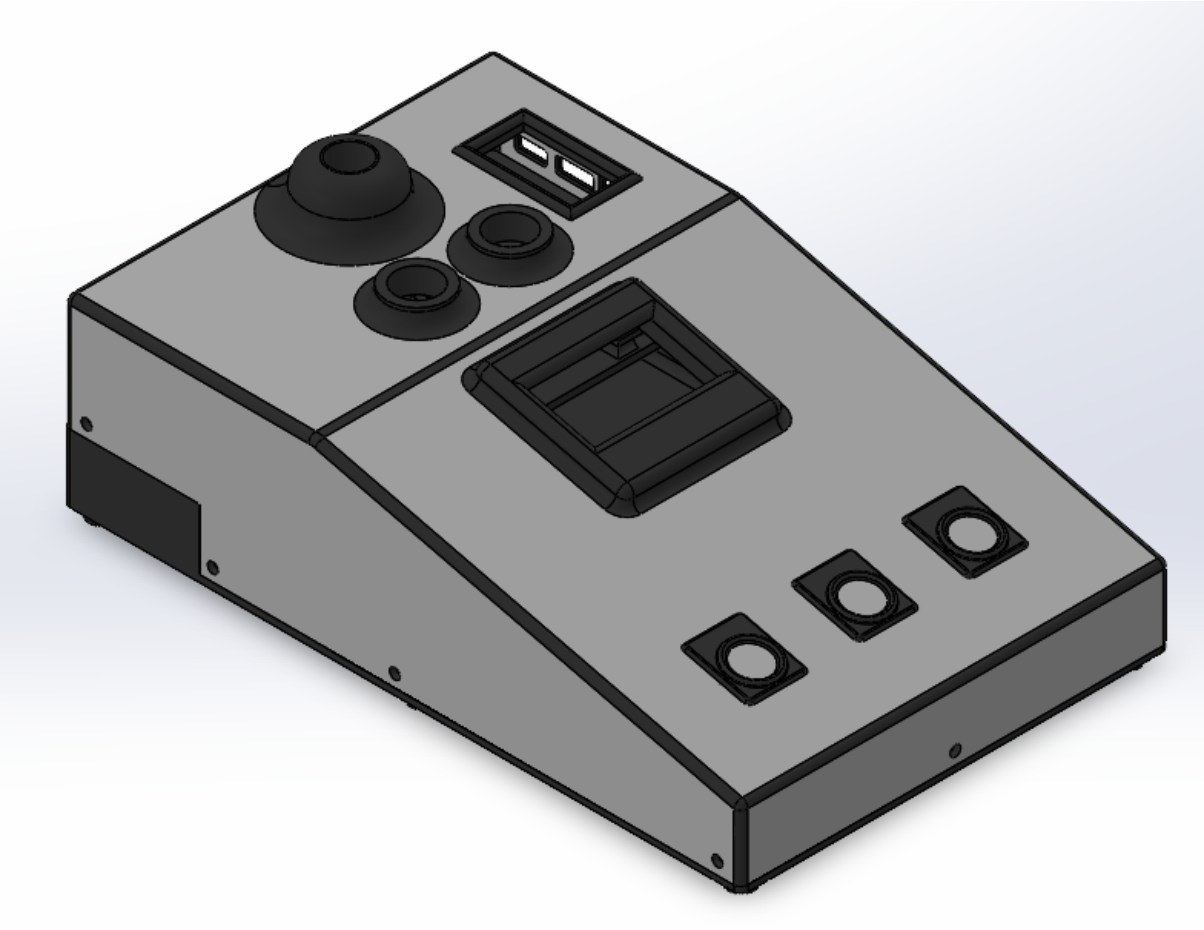
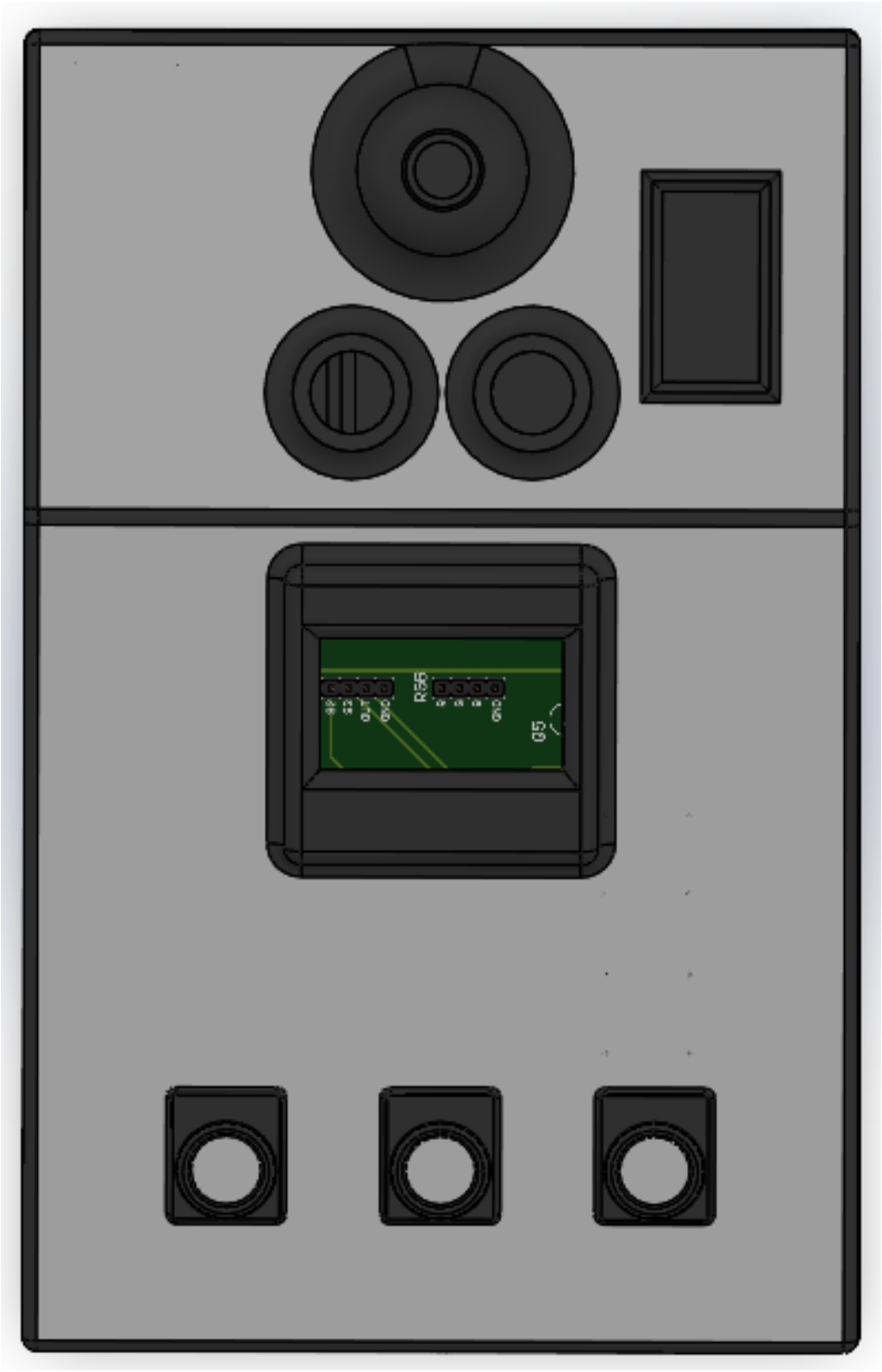
Size A4	Number 1	Revision
Date: 5/10/2023		Sheet 1 of 2
File: C:\Users\..\Sheet1.SchDoc		Drawn By: V Kurrshanth 200331T

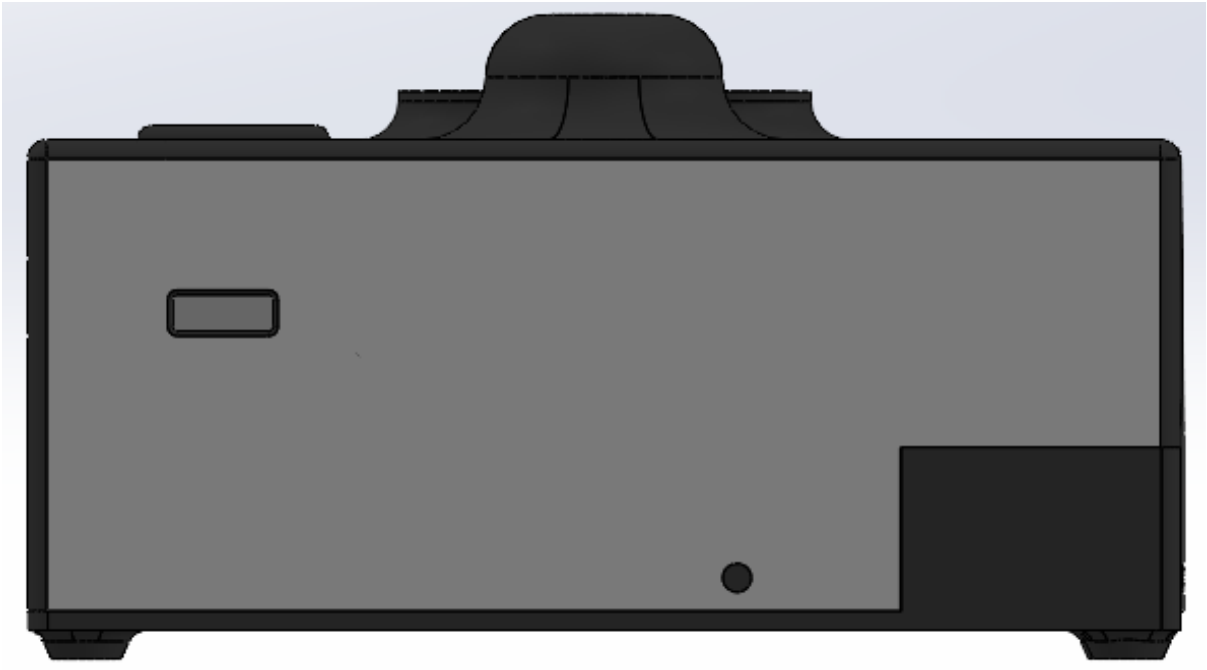


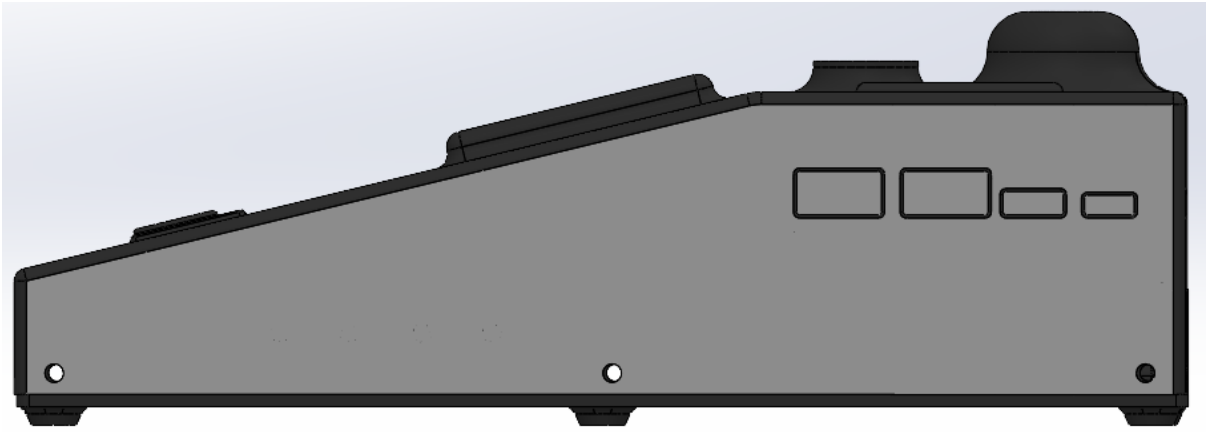
Title	Lamp Schematic - I/O & Power	
Size: A4	Number: 2	Revision:
Date: 5/10/2023		Sheet 2 of 2
File: C:\Users\..\Sheet2.SchDoc		Drawn By: V Kurrshanth 200331T

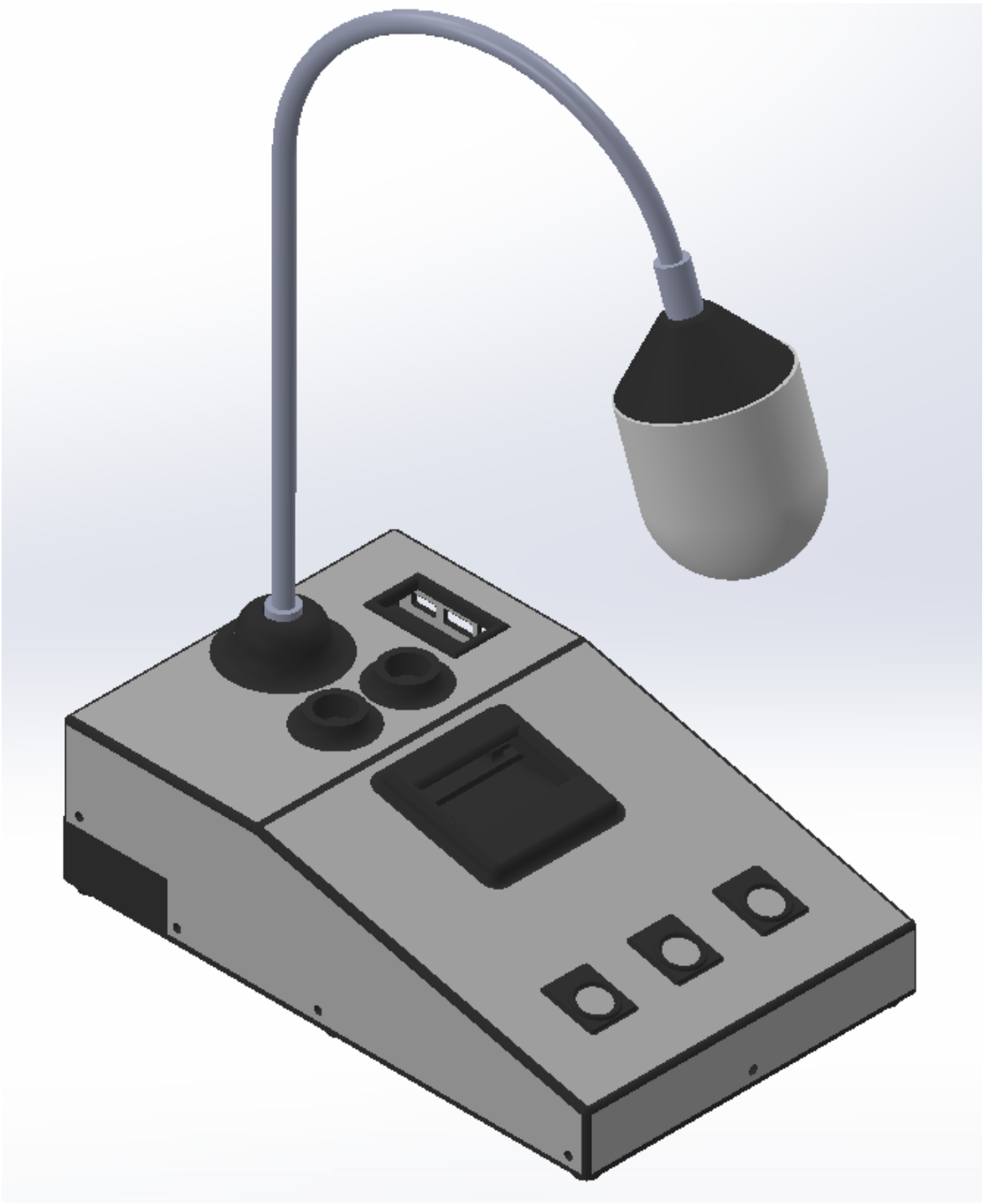
Enclosure











Problems identified considering the course content.

- Design is not moldable.
- Lack aesthetic curves and structure.

Problems/Improvements identified/proposed by members of the group.

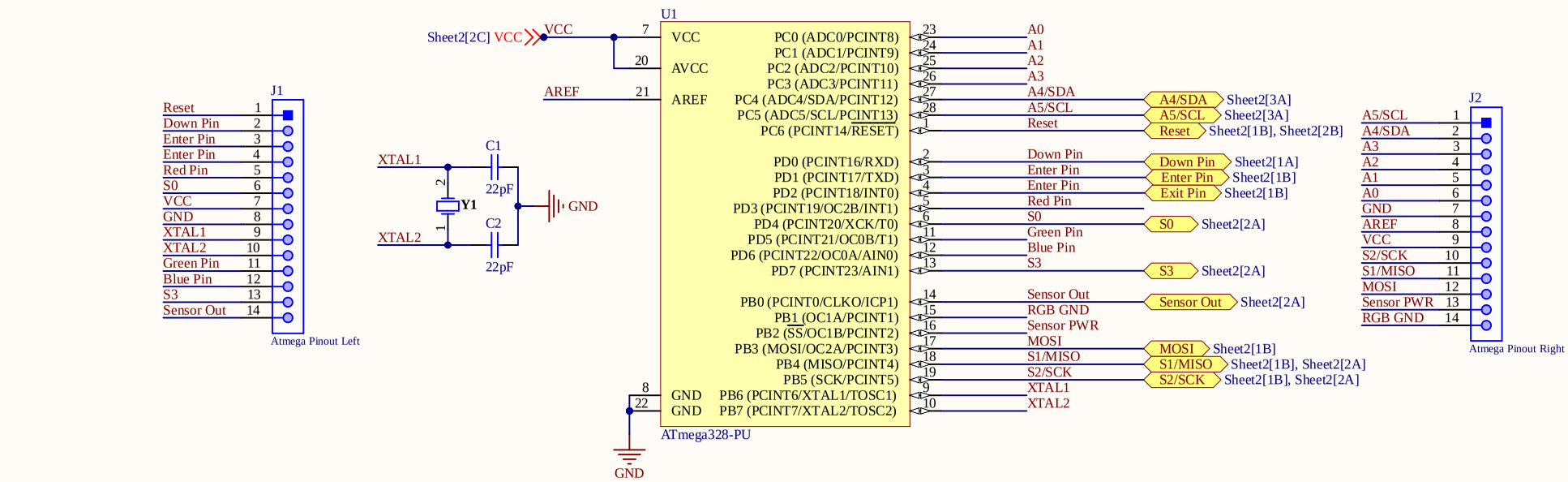
- Ability to remove the lamp head with lamp hose to improve portability.
- Ability to detach the color sensor from the lamp to sense colors without moving the lamp.

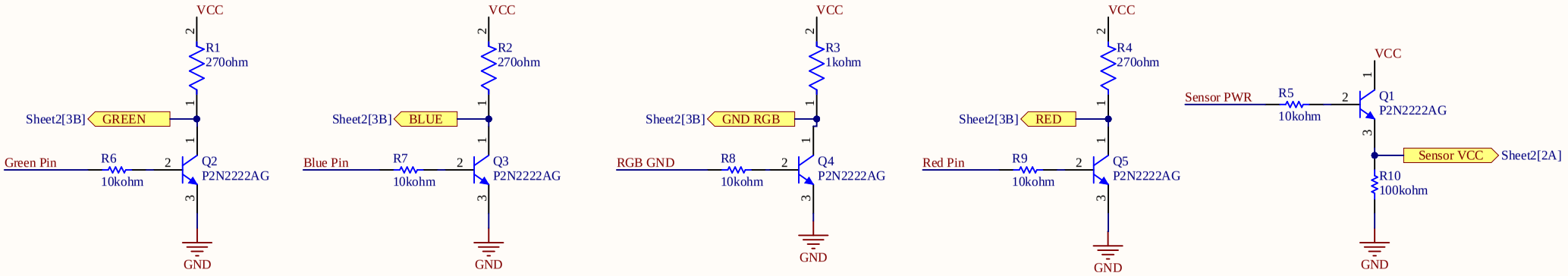
Problems/Improvements identified/proposed by users.

- Brighter lamp.
- Compact enclosure.

Implemented final designs

Schematic





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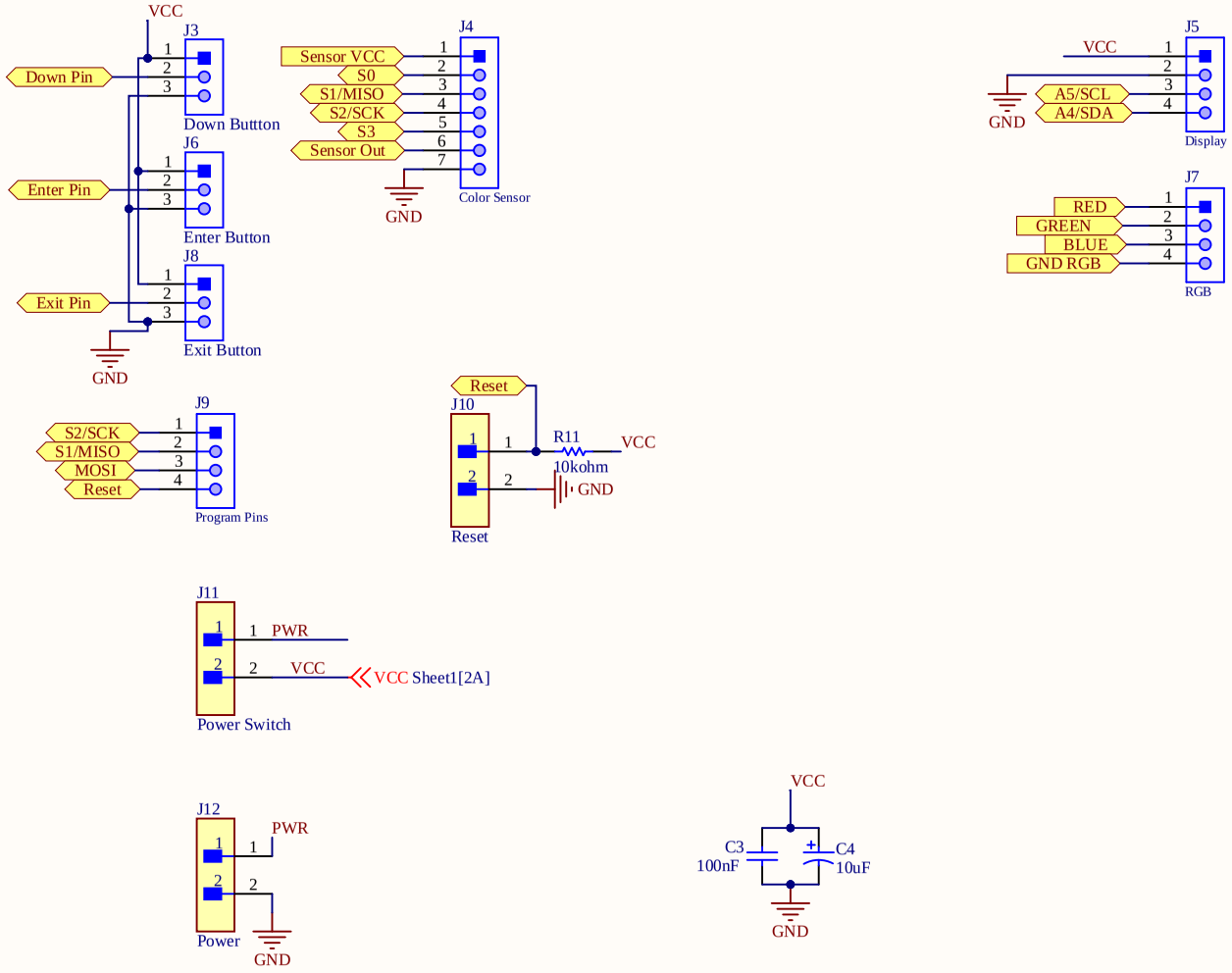
File: C:\Users\..\Sheet1.SchDoc		Drawn By: V Kurrshanth 200331T



Title	Lamp Schematic - I/O & Power	
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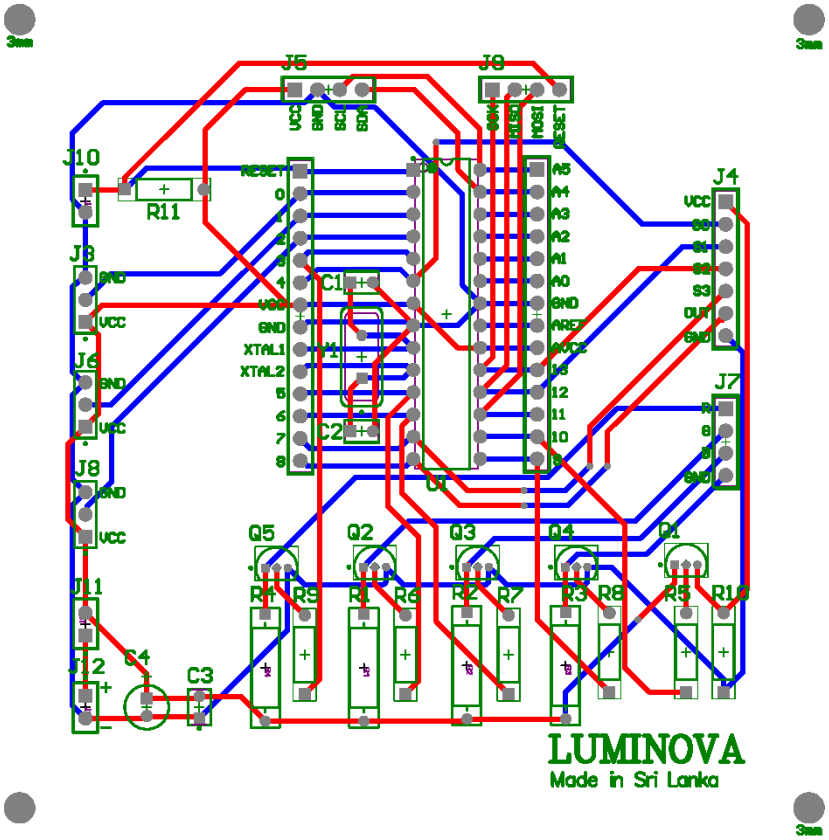
Date: 5/10/2023		Sheet 2 of 2
File: C:\Users\..\Sheet2.SchDoc		Drawn By: V Kurrshanth 200331T

PCB


3mm
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J3
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J8
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C4
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Y1
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U1
J4
J7
Q5
Q2
Q3
Q4
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R4
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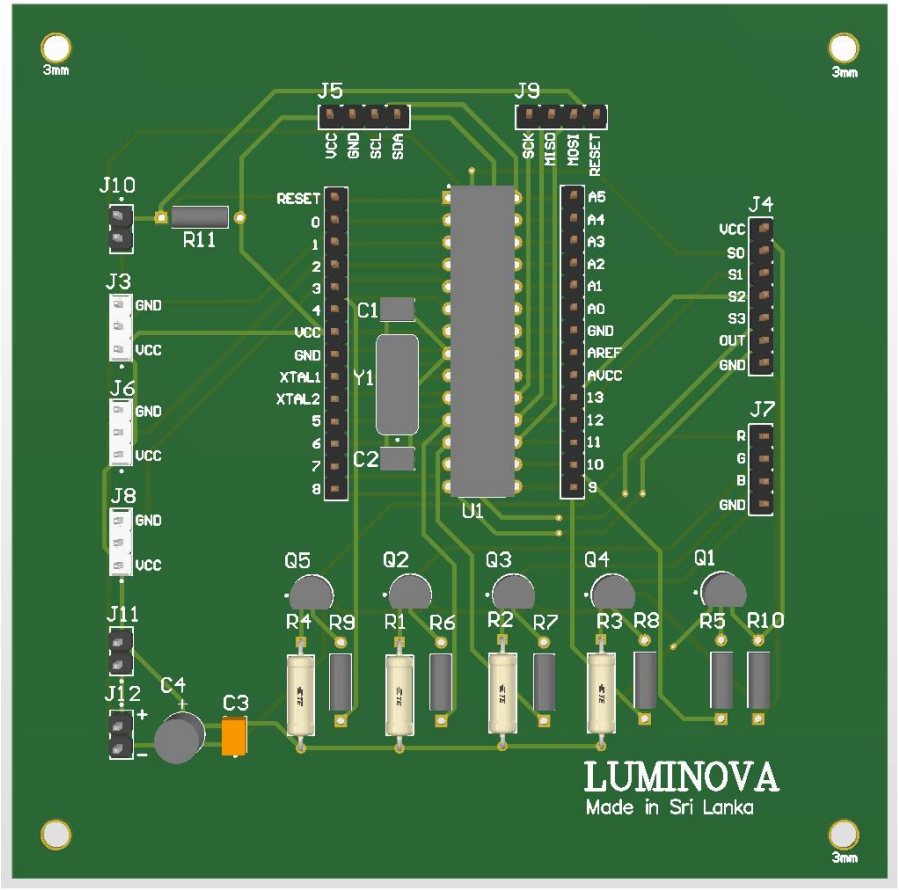
R1
R6
R2
R7
R3
R8
R5
R10
LUMINOVA
Made in Sri Lanka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U1
J4
J7
Q5
Q2
Q3
Q4
Q1
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R3
R8
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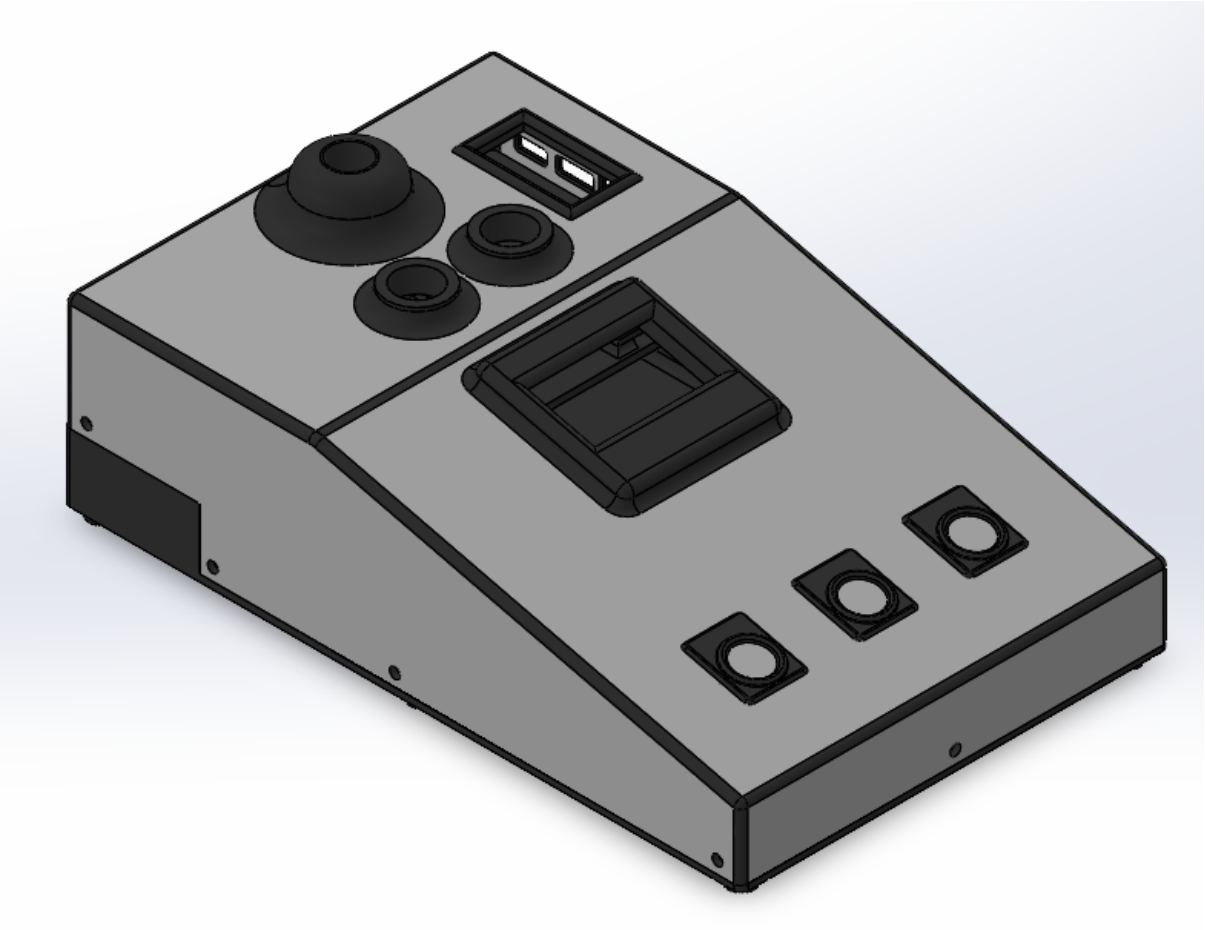
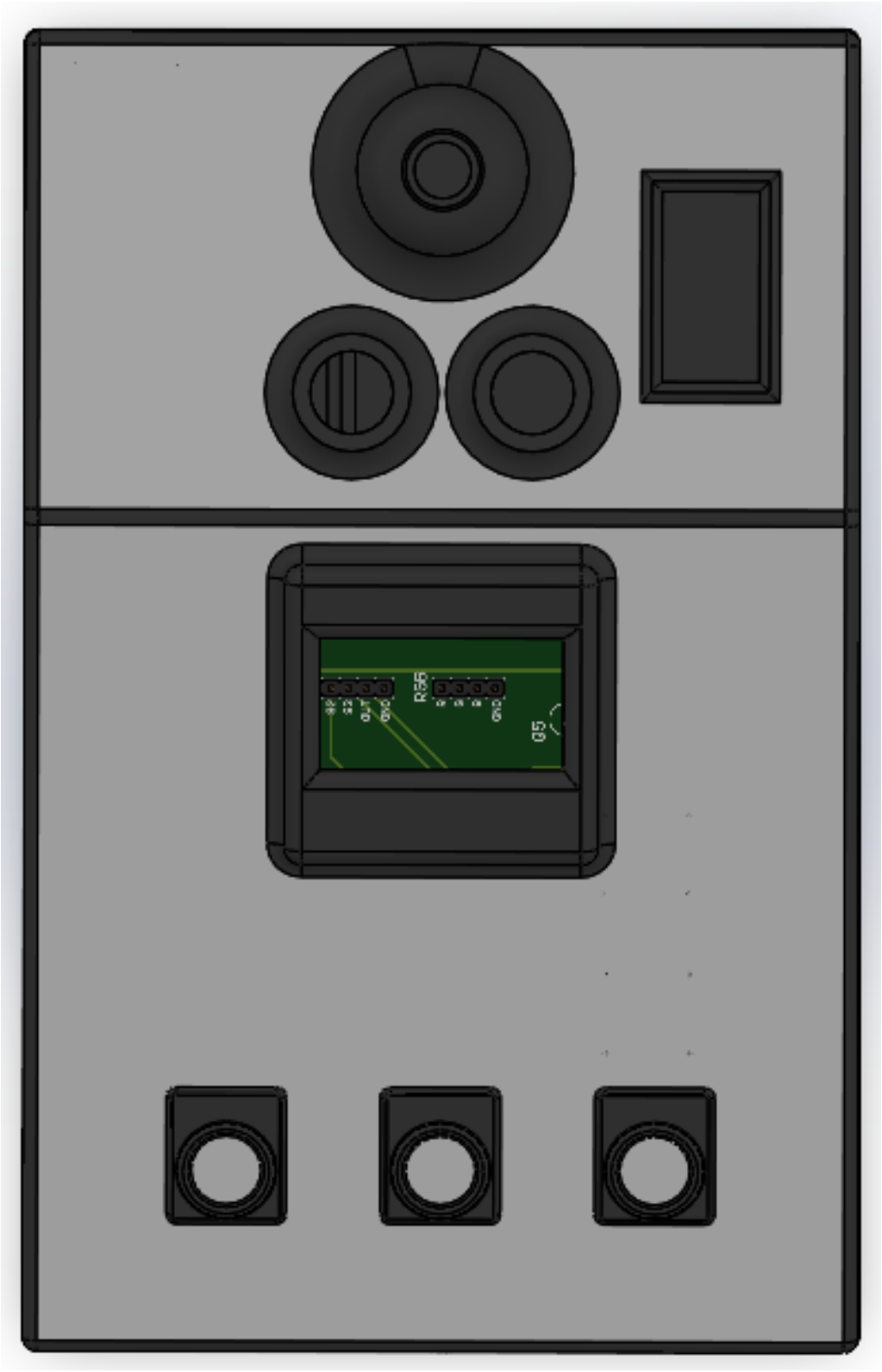
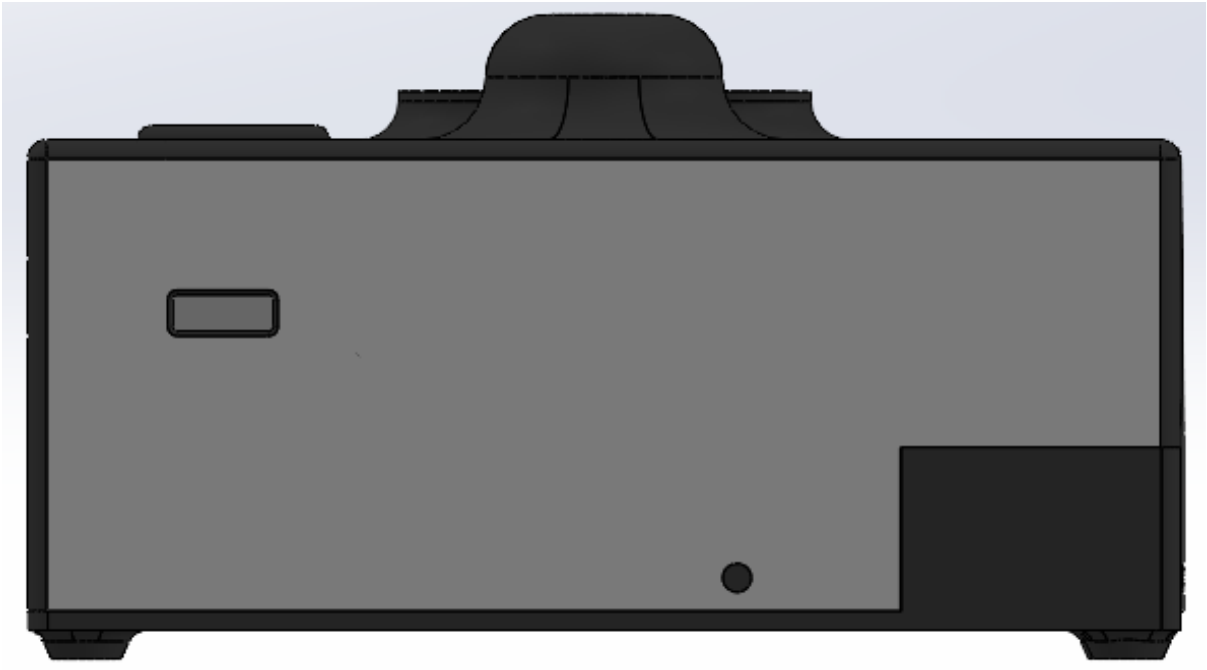
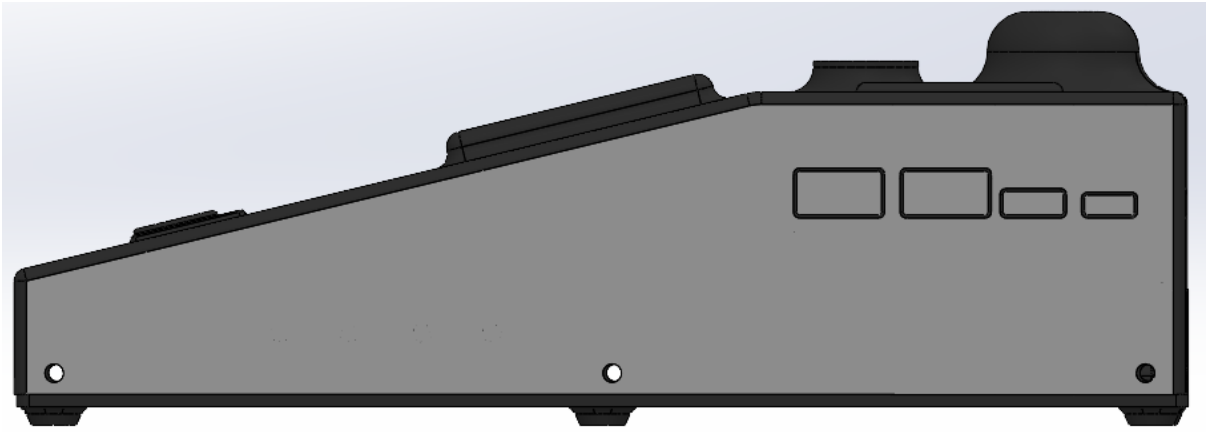
LUMINOVA
Made in Sri Lanka
3mm

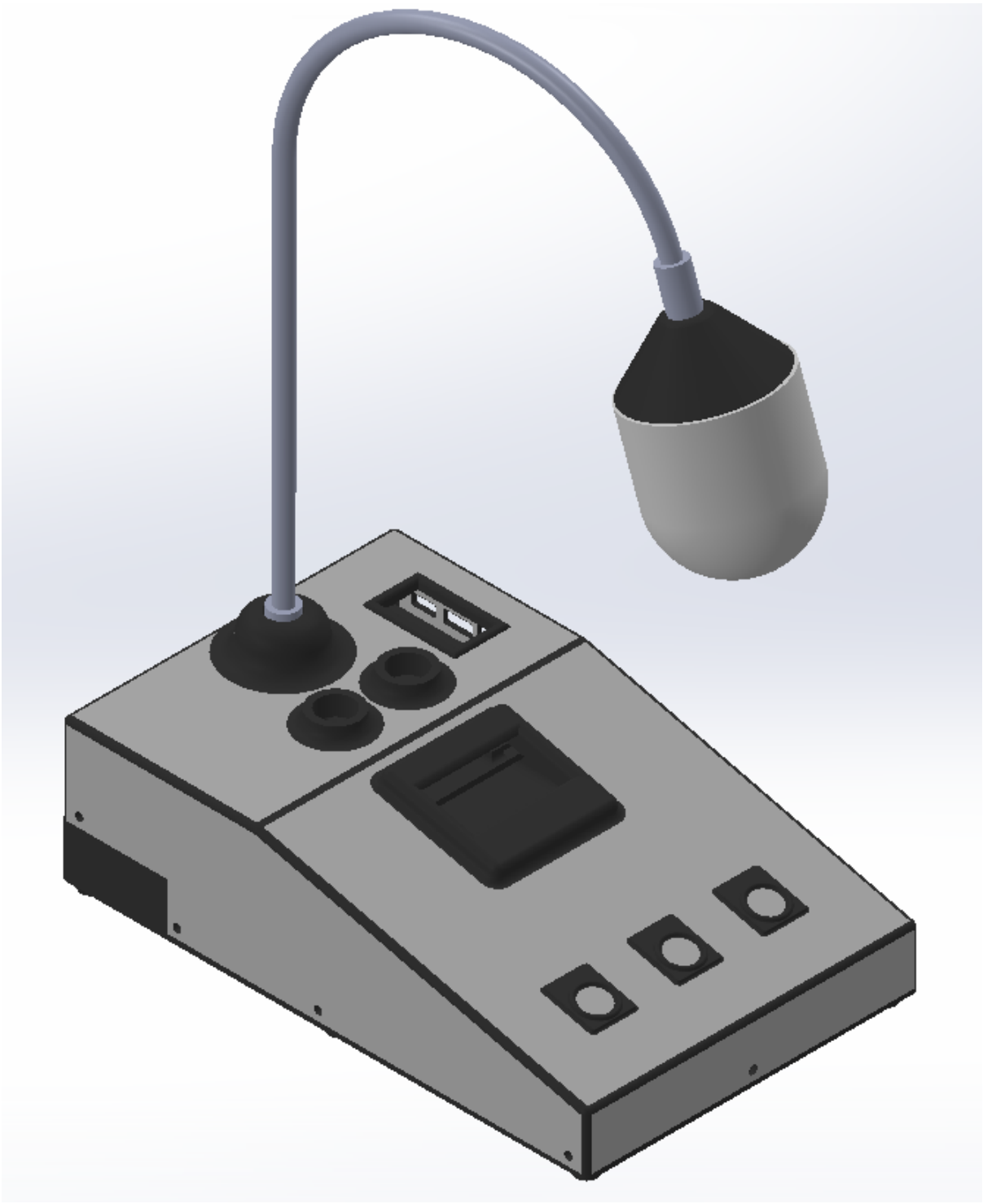
Enclosure











Software Design

The Atmega328PU microprocessor is programmed with Arduino code using Arduino Uno as programmer. The code contains bitmaps for the menu frames, pin assignments, menu navigation codes and various functions for operations like color sensing, RGB value setting, color cycle mode, brightness adjustment etc.

Complete code

Visit the following repository to view the complete Arduino code.

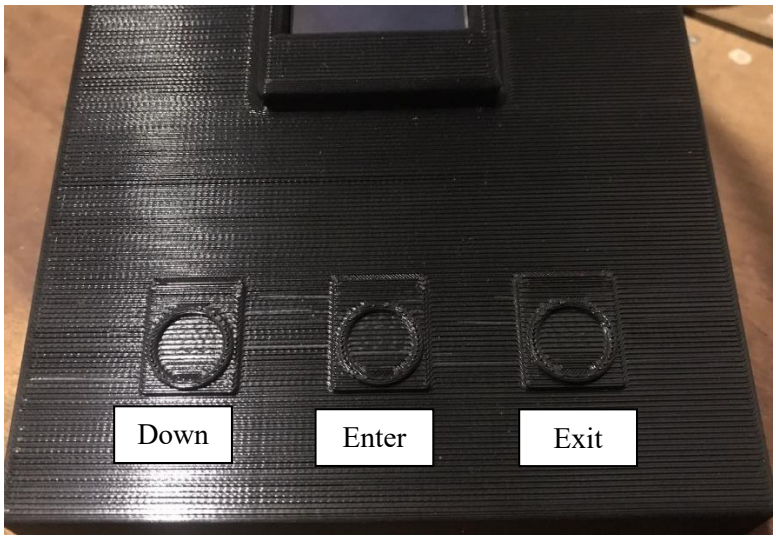
Color-Sensing-Lamp-Project/Arduino Code/new_menu_5 at main · VijthanKurrshanth/Color-Sensing-Lamp-Project (github.com)

User manual

Identify the product parts

Touch buttons

There are 3 touch buttons *down button, enter button, exit button.* Down button is used to move down in the menu. Enter button is used to select a menu item. Exit button is used to go back to the previous menu.

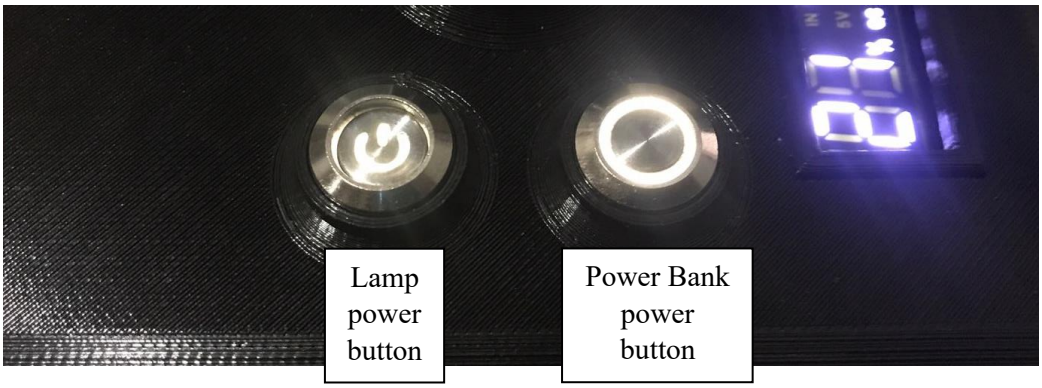


Display

OLED display for the menu.

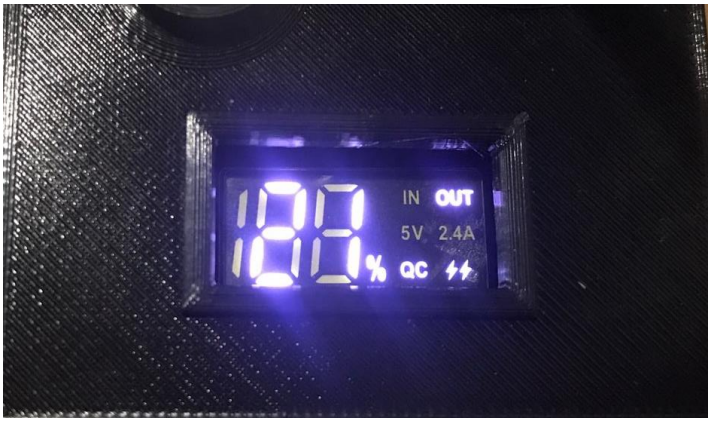
Power buttons

There are two power buttons, one for the lamp and the other for the power bank. The *lamp power button* turns on/off the lamp and the *power bank power button* is used for turning power bank on/off and checking battery level. *Lamp power button* is a toggle button, toggling it turns on or off the lamp. *Power bank power button* is a push button, keeping it pushed for 1 second turns on/off the power bank, when discharging pushing once shows the battery level.



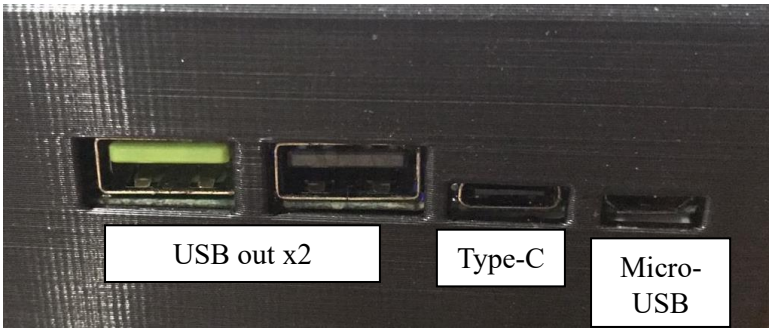
Battery level indicator

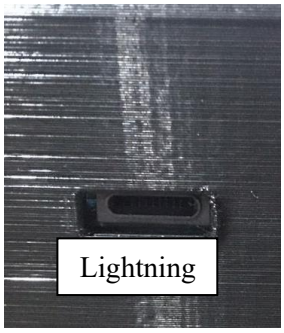
Battery level indicator displays the current battery capacity on the 7segment display. It will not always stay on; it will go off after 30 seconds to save battery consumption.



Input/Output ports

There are 2 output USB ports for charging devices. There are one type-C port, one lighting port and one micro-USB port to charge the power bank. Power bank automatically turns on after plugging a device in for charging.



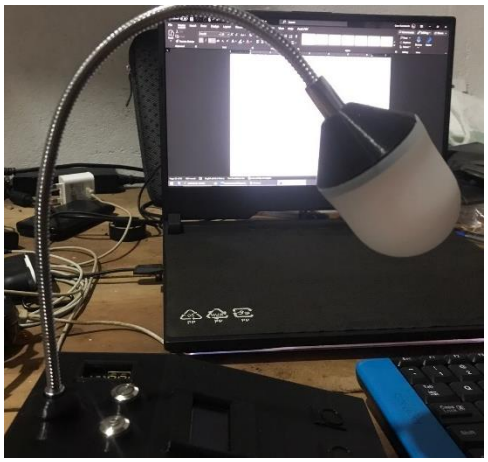


Color sensor

Color sensor is at the left top corner of the lamp. The enclosure has an opening at bottom for the color sensor. Color sensor only turns on after the user selects the color sensing mode or calibration otherwise it idles.

Lamp and lamp hose

Lamp hose is made of metal and is flexible. Lamp is consisted of 3 RGB LEDs.



Navigating through the menu

Main menu

Lamp mode

Entering the lamp mode displays another menu for selecting lamp mode.

Brightness

Selecting this enters a graphical interface showing the current brightness. User can adjust the brightness using the *down button, exit button* after adjusting pressing *enter button* will exit the brightness adjustment.

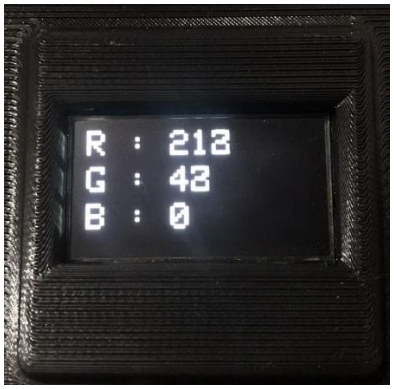
Calibrate

Entering the calibrate menu shows a menu showing *Black* and *White* the user must put the color sensor of the lamp on a white surface and select *White* to calibrate the sensor and must put the color sensor of the lamp on a black surface and select *Black.* The surfaces should be of the same type the user intends to sense other colors.

Lamp mode

Color cycle

Selecting color cycle mode enables the RGB LEDs to cycle through all the colors in the spectrum and show the corresponding R,G,B values in the display at the same time.

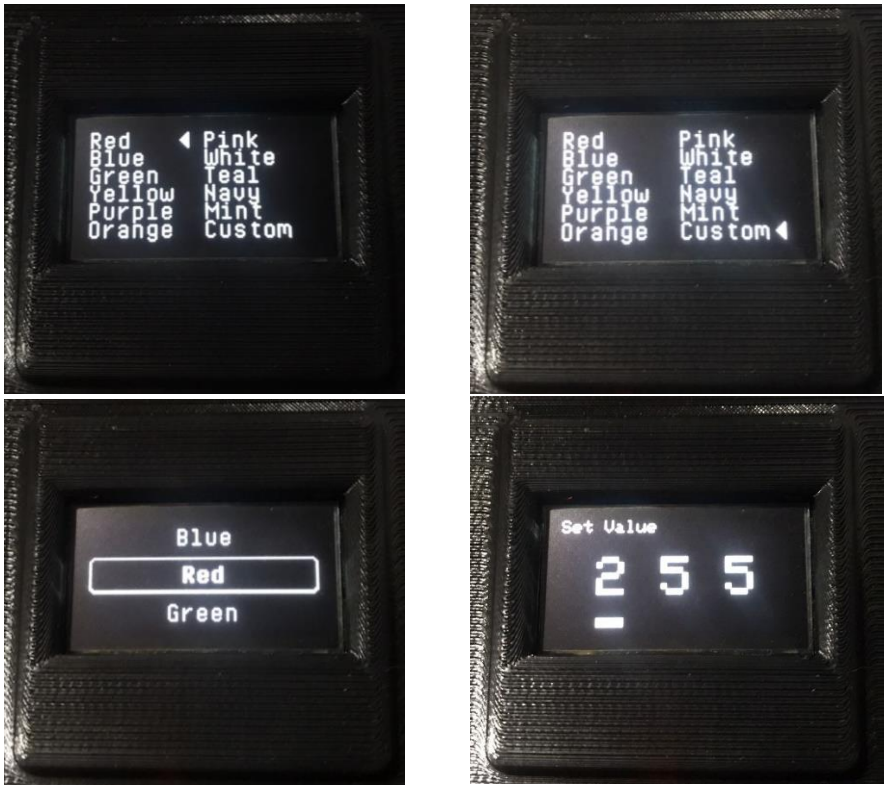


Color sensing

Entering color sensing mode enables the color sensor and the color of the surface beneath the color sensor is replicated in the lamp and the corresponding R,G,B values are displayed in the display.

Custom color

Entering custom color mode displays another menu with predefined colors to select from, and a *custom* option to set a custom color with R,G,B values. Selecting a color will light the lamp with the respective color. If *custom* option is selected, a menu for setting the R,G,B values is displayed the user can then set each value to light up the desired color. When in the *set value* mode, the user can use *down button* and *exit button* to set each digit for the value (0 – 255) and use the *enter button* to set and move to next digit. After setting the values for R,G,B the user must exit the menu in order to light up the set color.


Red
Blue
Green
Yellow
Purple
Orange
Pink
White
Teal
Navy
Mint
Custom
Red
Blue
Green
Yellow
Purple
Orange
Pink
White
Teal
Navy
Mint
Custom
Blue
Red
Green
Set Value
2 5 5

Manufacturing and Cost Analysis

Manufacturing process used

The PCB of the current prototype is manufactured in China and imported, and enclosure is 3D printed. For mass production injection molding can be used for enclosure manufacturing. The components on the PCB are hand-soldered in the prototype. For mass production the PCB design should be changed from through-hole to SMD to reduce time for manufacturing.

Bill of Materials

Component	Unit Price (Rs.)	Quantity	Total price (Rs.)
Atmega328PU	731.60	1	731.60
2N2222 Transistor	8.00	5	40.00
16Mhz Crystal Oscillator	35.00	1	35.00
22pF Capacitor	2.00	2	4.00
100nF Capacitor	2.00	1	2.00
10uF Capacitor	5.00	1	5.00
270ohm Resistor	1.00	3	3.00
1kohm Resistor	1.00	1	1.00
10kohm Resistor	1.00	6	6.00
100kohm Resistor	1.00	1	1.00
2-pin JST connector	40.00	3	120.00
3-pin JST connector	45.00	3	135.00
4-pin JST connector	60.00	3	180.00
7-pin JST connector	75.00	1	75.00
3.7V 3200mA 18650 Li-ion Rechargeable Battery	800.00	3	2 400.00
Male header pins	30.00	1	30.00
Touch switch TTP223	24.80	3	74.40
1.3" OLED 128X64	675.80	1	675.80
RGB LED	120.90	4	483.60
Power Bank Charging Module	564.20	1	564.20
Flexible lamp holder	1391.90	1	1 391.90
Lamp diffusor	635.50	1	635.50
Push buttons	336.35	2	672.70
Copper wire (1 yard)	35.00	2	70.00
Heat shrink tubes (1 feet)	15.00	1	15.00
Total			**8 351.70**

Enclosure 3D printing	14 000.00
PCB Manufacture	3 030.00

Total cost for the prototype = Rs. 25 381.70

Suppliers

Supplier	Components
Farnell	Atmega328PU
	2N2222 Transistor
	16Mhz Crystal Oscillator
	22pF Capacitor
	100nF Capacitor
	10uF Capacitor
	270ohm Resistor
	1kohm Resistor
	10kohm Resistor
	100kohm Resistor
	2-pin JST connector
	3-pin JST connector
	4-pin JST connector
	7-pin JST connector
	3.7V 3200mA 18650 Li-ion Rechargeable Battery
	Male header pins
	RGB LED
Reland Sun	Touch switch TTP223
Teyleten Robot	1.3" OLED 128X64
MDYBF	Power Bank Charging Module

Summary and future improvements

The current prototype is fully functional, and every function, modes and attributes are working. 3D printed enclosure has a nice look and feel and is compact. All components have a steady supplier and second sources.

Improvements to be made

- More brighter LEDs can be used.
- Enclosure can be made more compact.
- Enclosure design should be modified for molding.
- PCB should be modified with SMD components for mass production.