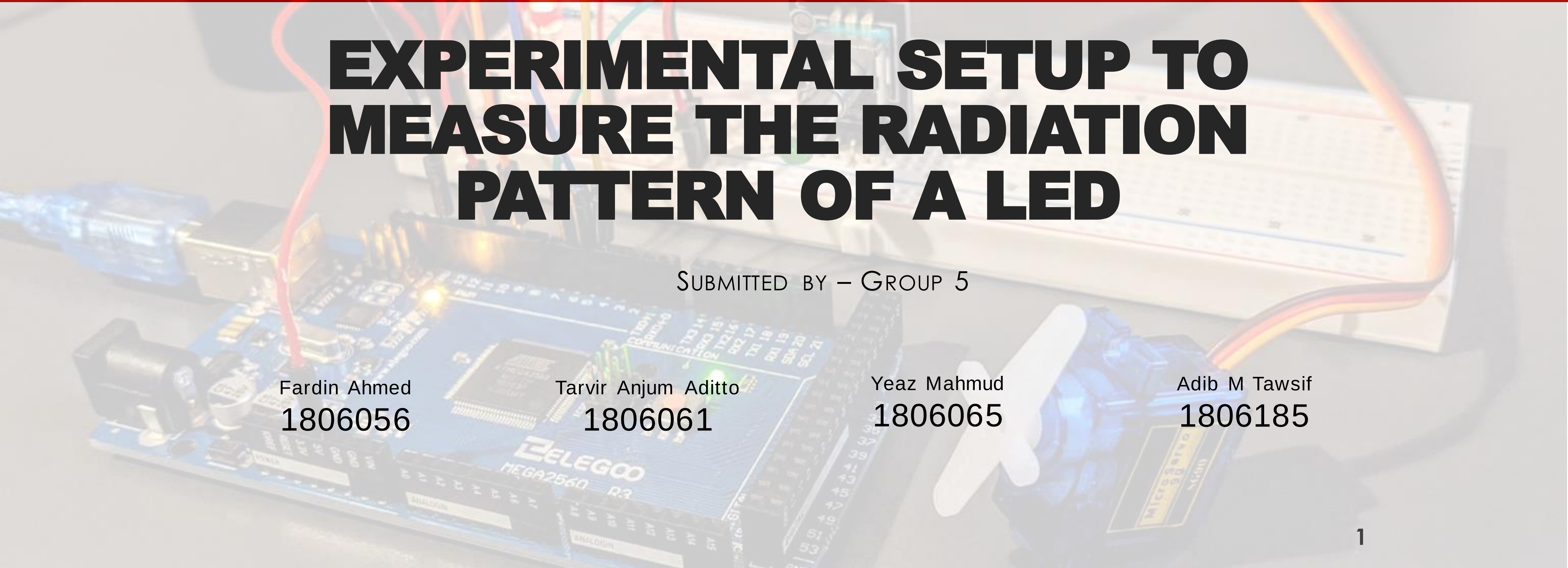
EEE 460 - Optoelectronics Laboratory

July 2023 Level-4 Term-2 Group 5

Final Project Demonstration



EXPERIMENTAL SETUP TO MEASURE THE RADIATION PATTERN OF A LED

SUBMITTED BY – GROUP 5

Fardin Ahmed
1806056

Tarvir Anjum Aditto
1806061

Yeaz Mahmud
1806065

Adib M Tawsif
1806185

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Outline

Summary

- In this presentation, we will explore the experimental setup used to measure the radiation pattern of a light-emitting diode (LED). LEDs are ubiquitous in everyday life, used in everything from traffic lights and car headlights to displays and electronic devices. Understanding their radiation pattern is crucial for optimizing their design and application in various fields.

Introduction

- Measuring the radiation pattern of an LED is crucial for optimizing lighting design, aiding in LED selection, and analyzing performance. Understanding how light is distributed in space provides valuable insights for achieving desired illumination effects, choosing the right LED for specific needs, and assessing efficiency and beam quality.
- **Lighting design:** Knowing the directionality of emitted light helps achieve desired illumination effects.
- **LED selection:** Comparing radiation patterns of different LEDs aids in choosing the optimal one for specific needs.
- **LED performance analysis:** Analyzing the pattern provides insights into efficiency and beam quality.

Introduction (Cont'd)

- In this project, we present a detailed overview of the experimental setup employed for measuring the radiation pattern of an LED.
- The setup encompasses :

❑ **Light sources**

❑ **Detectors**

❑ **Motors for varying radius and angle**

❑ **Microcontroller**

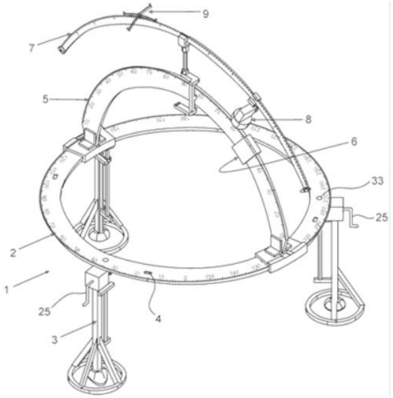
❑ **Power supply**.

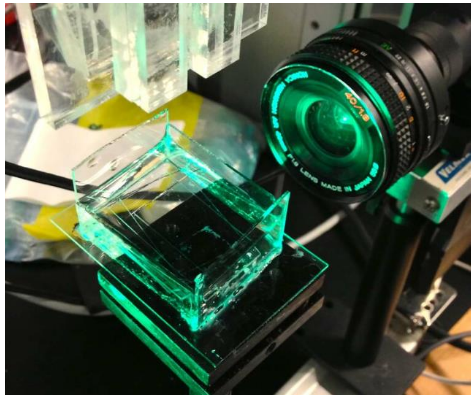
- By carefully controlling environmental conditions and calibrating the equipment, we can obtain reliable data that aids in understanding the LED's performance under different operating conditions.
- The ultimate goal of this project is to provide a comprehensive understanding of the LED's radiation pattern for different types, colour and size of LEDs under both varying angle and varying radius.

3.1 Design: Problem Formulation (PO(b))

3.1.1 Literature Review

- **Integrating spheres:** Provide accurate measurements but can be expensive and bulky.
- **Goniometers:** Offer precise angular control but may require specialized equipment and expertise.
- **CCD cameras:** Enable capturing full spatial distribution but might require advanced image processing techniques.





3.1 Design: Problem Formulation (PO(b))

3.1.3 Formulation of Problem

Key considerations from reviewed literature:

- **Sensor selection:** Matching the sensor sensitivity to the LED wavelength for accurate measurements.
- **Calibration and error analysis:** Ensuring the accuracy and reliability of the collected data.
- **Data visualization and analysis:** Choosing appropriate techniques to effectively interpret the radiation pattern.

Gaps identified:

- **Simplified setup:** Exploring cost-effective and user-friendly alternatives to complex setups.
- **Automation:** Implementing methods to automate data acquisition and analysis for increased efficiency.

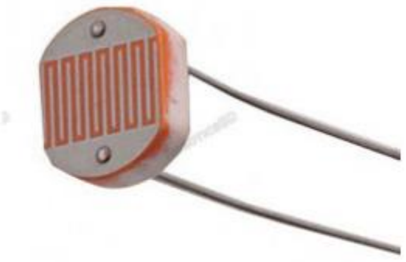
3.2 Design Methods (PO(a))

Components used

1. **MG996R Servo Motor :** To control the radius of measurement.
2. **NEMA 17 Stepper Motor:** To vary the angle.
3. **Arduino Uno:** The main microcontroller of the project.
4. **LDR (BIG Size) :** The main sensor.
5. 22K ohm resistor
6. TB6600 Stepper Motor Driver
7. Toggle Switch
8. LM2596 DC to DC Buck Converter
9. Digital Ammeter and Voltmeter
10. Lithium Ion Battery
11. 10K ohm Potentiometer
12. Zero PCB Board
13. Crocodile Clip
14. **LEDs of different sizes and shapes:** The main source.
15. Wire Tie
16. PVC Board

NEMA 17 Stepper Motor

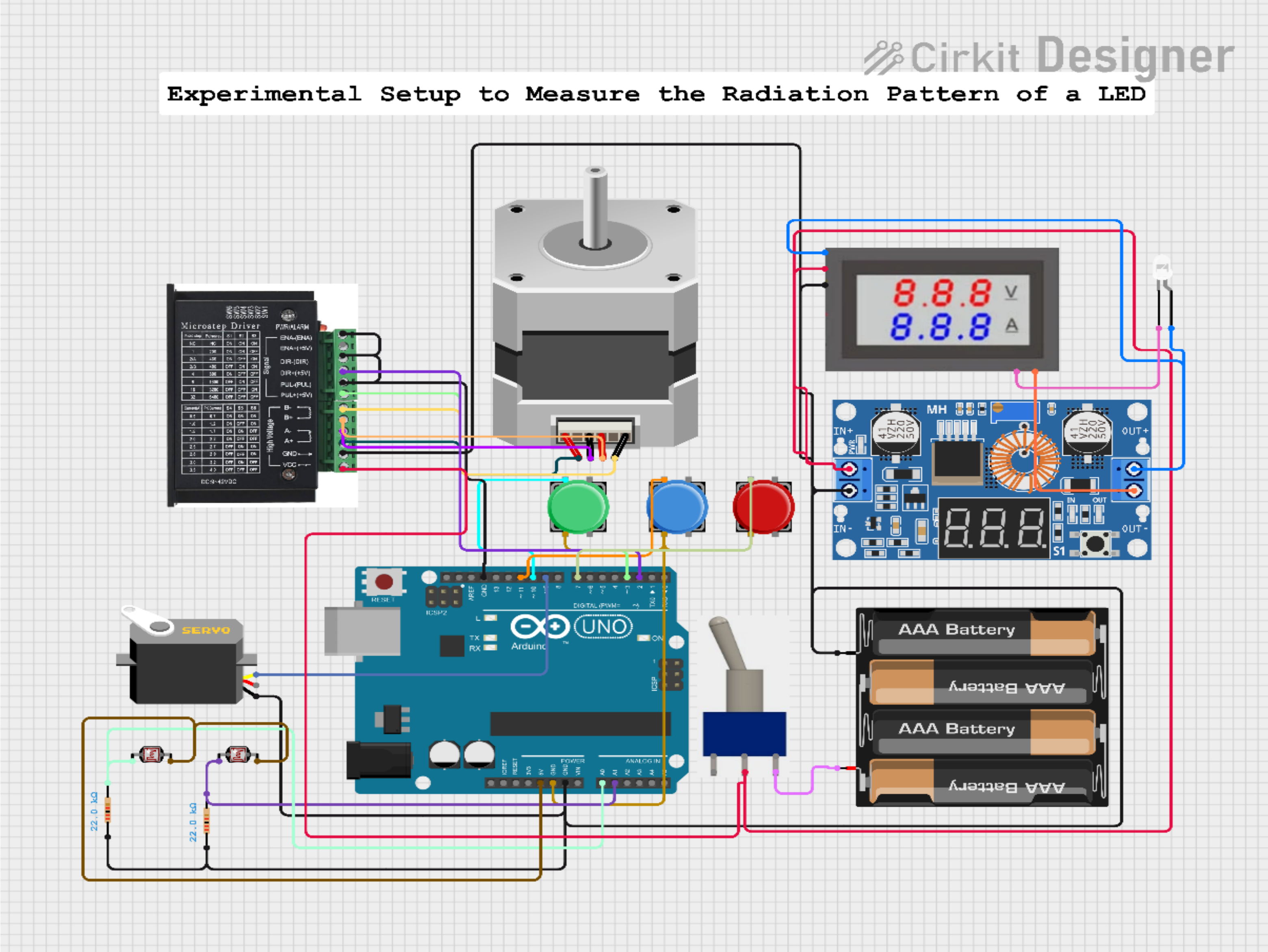
MG996R Servo Motor



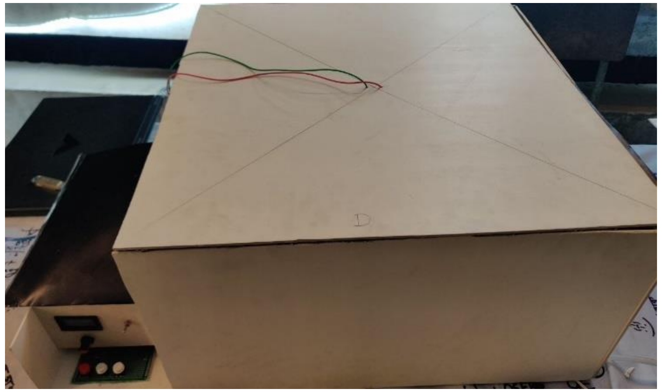
LDR

Arduino UNO

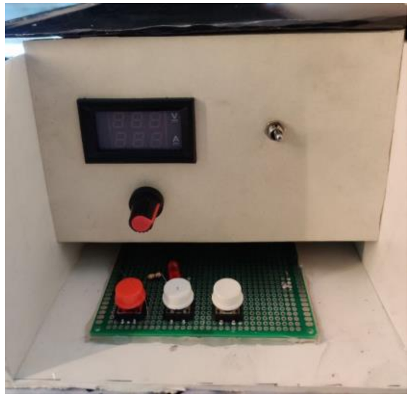
3.3 Design: Circuit Diagram



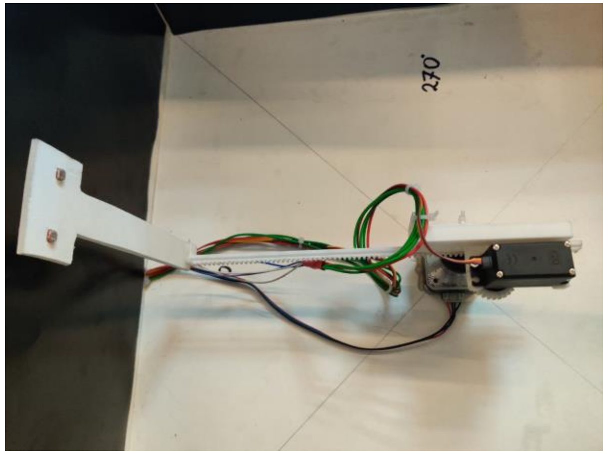
3.4 Design : Actual Setup



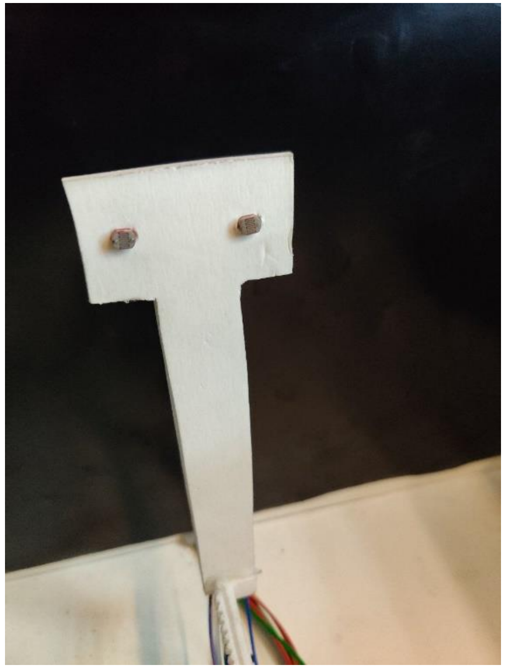
Whole Setup with Dark Room



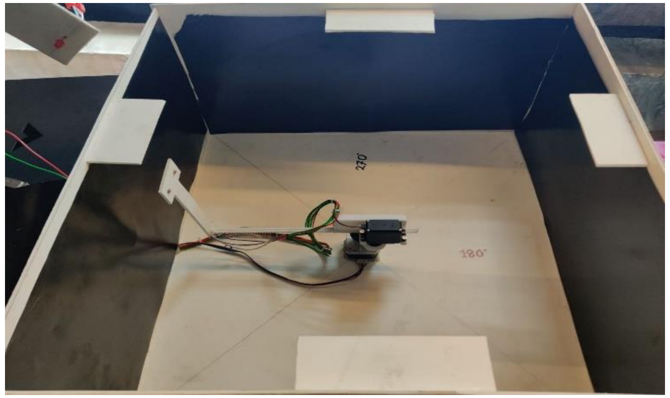
Control Panel



Actuator System with LDR



LDR



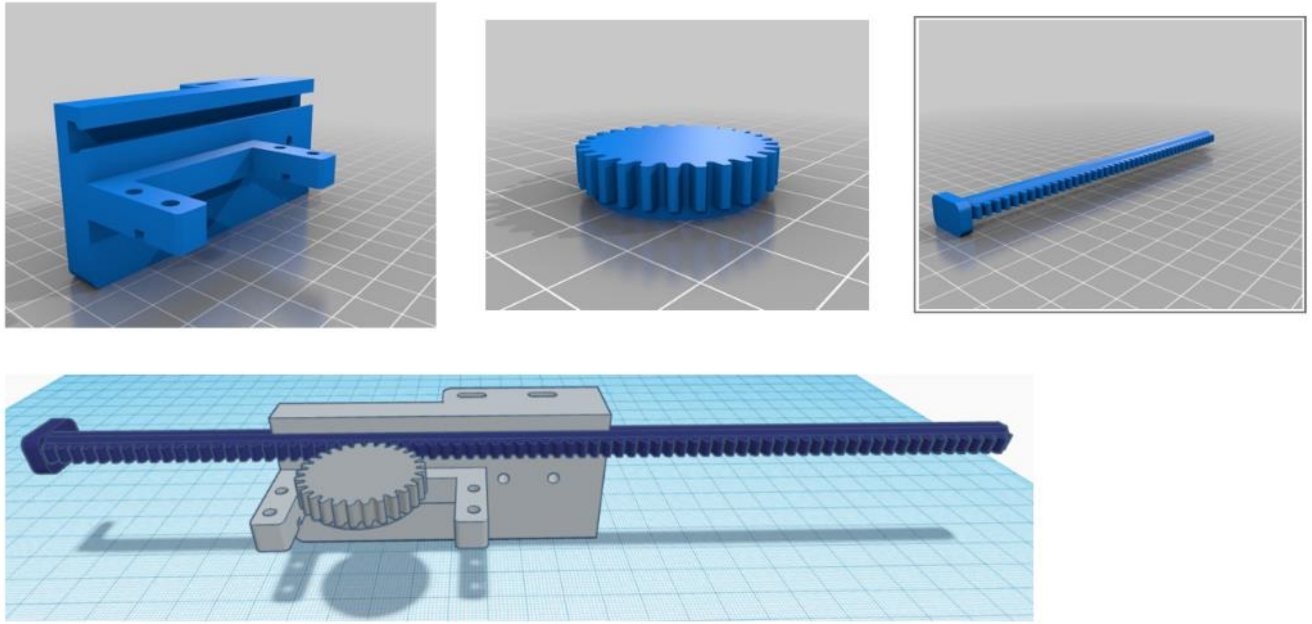
Dark Room

Control Panel Circuitry

LED at the upper Surface of the Box

3.5 CAD/Hardware Design : 3D Model For Angular and Radial Control

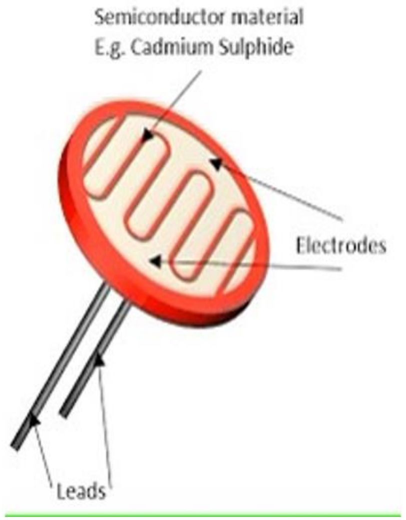
- The 3D model is made for the ease of control of radius. The model is placed above the stepper motor and it rotates at a fixed radius.

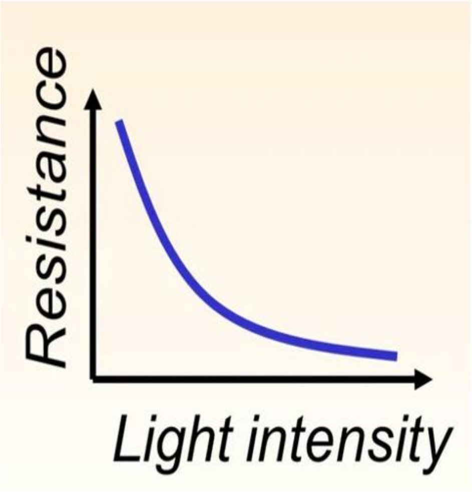


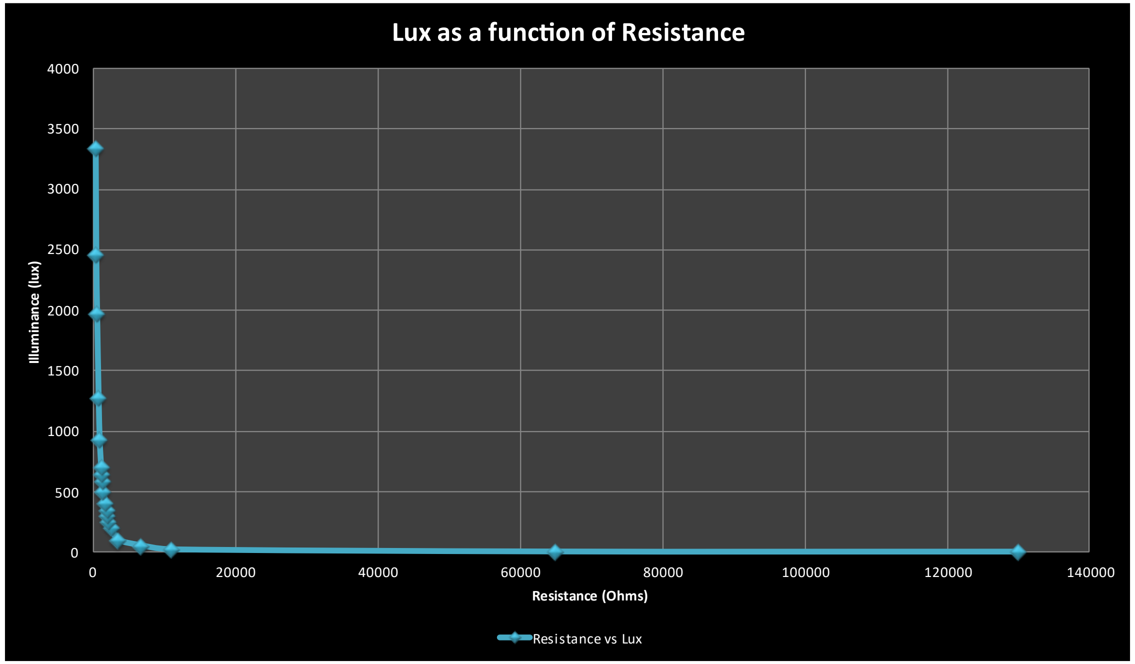
Actuator Model

3.6 Calibration of LDR with PM100D

The relationship between resistance and lux for an LDR is not a nice linear relationship. It is instead an exponential relationship. A related work[1] has been done and the results obtained are stated below:





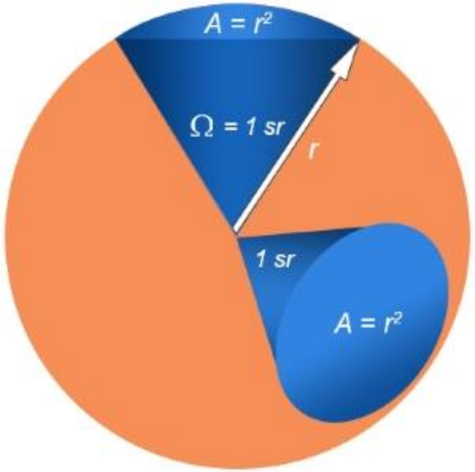


Illuminance vs LDR Resistance *taken from [1]*

So, **lux** and the **LDR** resistance has an exponential relationship.

There is a formula which is commonly used to find the Optical Power in Watts[2] from Illuminance(lux) for a given light source(lm/W) and for a given light capturing system. The formula is stated as:

$$\text{Power (W)} = \frac{\text{illuminance (lx)} \times 4\pi \times r_{(\text{meters})}{}^{2}}{\text{Luminous Efficacy (lm/W)}}$$



Where '**r**' is the radius of the sphere in feet.
We can see that optical power is proportional to illuminance (lux).
So, an **exponential** relationship exists between **Optical Power and LDR** Resistance.

PM100D Power Meter

- In our project we used the model S120VC. The S120VC power head is designed for general purpose optical power measurements. The head is optimized for small thickness to fit in tight spaces. The high sensitive photodiode with large active area in combination with a reflective, diffused ND filter enables power measurements up to 50 mW in free-space and fiber-based applications.

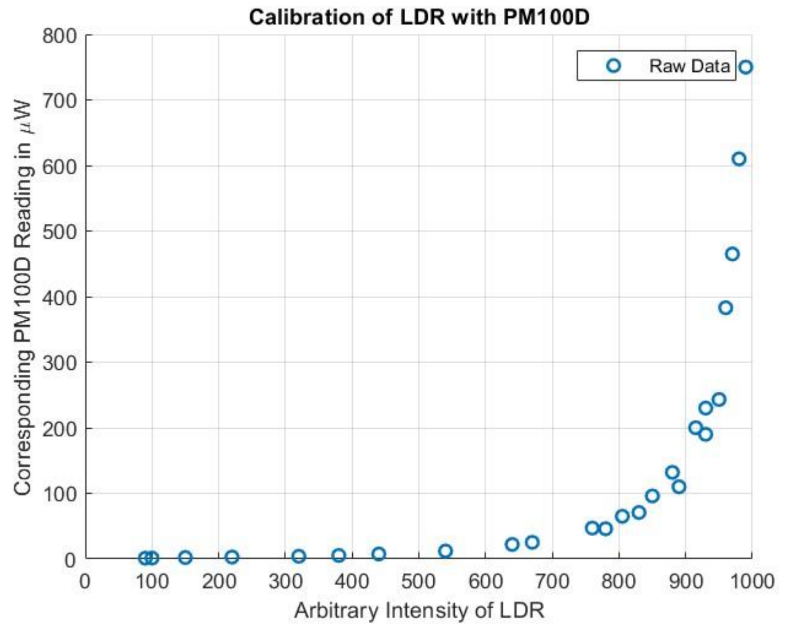
PM100D

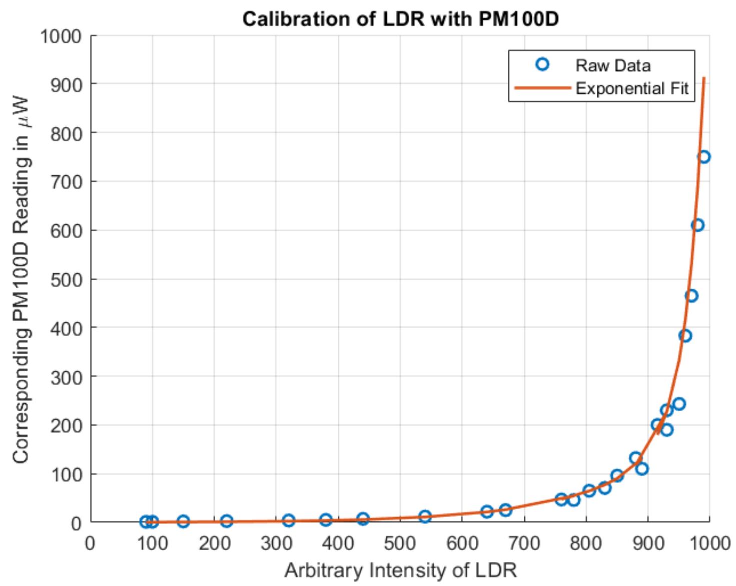
S120VC

Calibration

- As we used the **AnalogRead** function of Arduino, the LDR data is limited to 1024.
- We increased the intensity of light by increasing the supply voltage.
- To get the optical power corresponding to the LDR reading, after each LDR data reading we placed the photodiode sensor S120VC of the power meter PM100D in place of the LDR and recorded the values.

Data Trend: After collecting the data, when we visualized it, we saw an increasing trend of the power meter data with the increasing of the LDR data.

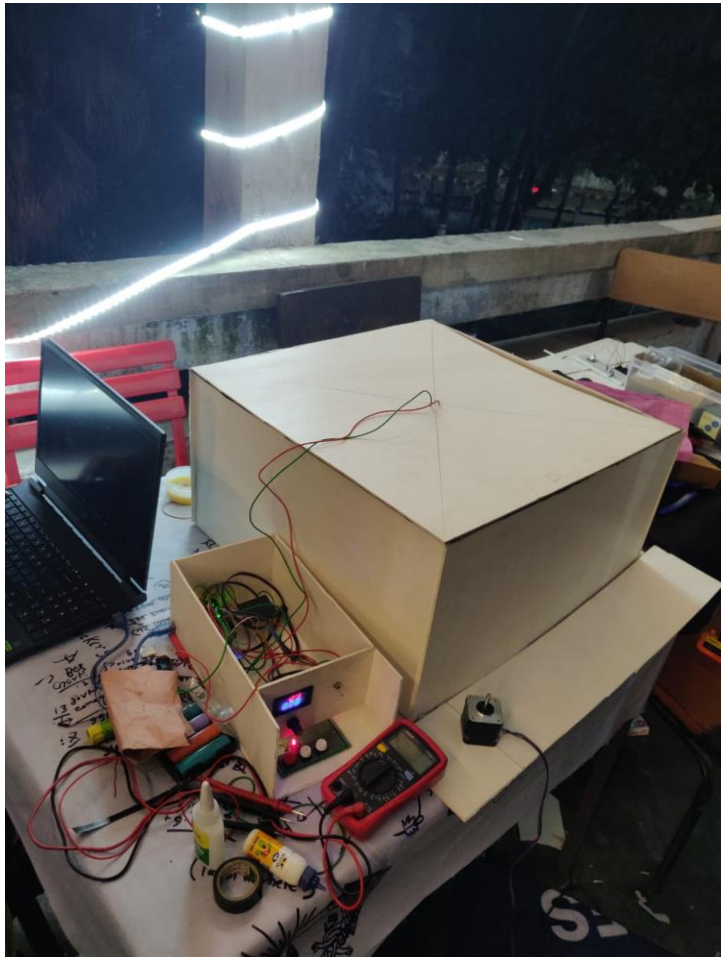




4 Implementation: Demonstration

If you could implement the project in hardware (even in a breadboard), add it in the slide. You may also add a short (no more than 20 second) video

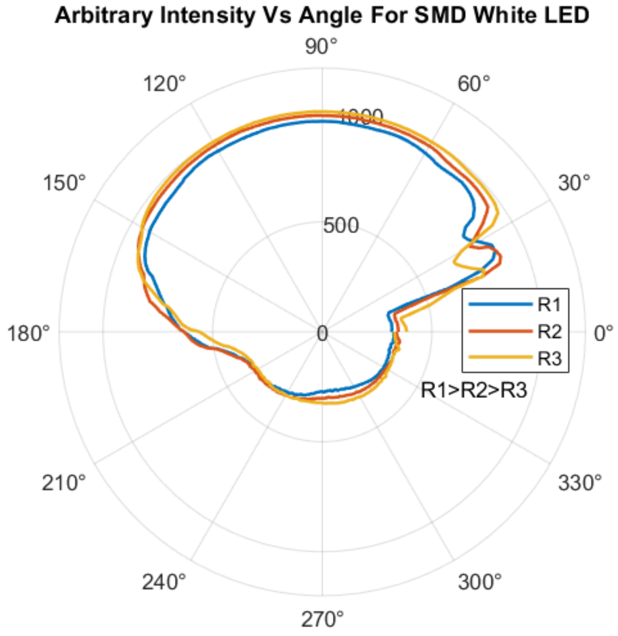
4.1 Implementation: Photo Gallary

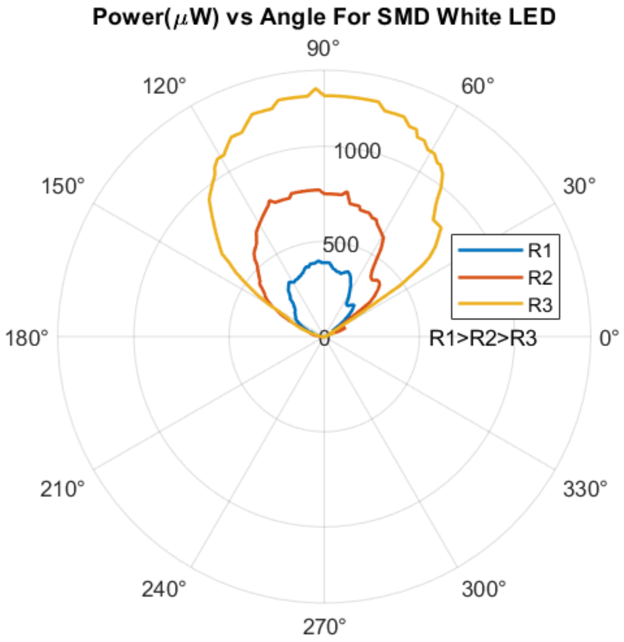


5. Result Analysis and Discussion

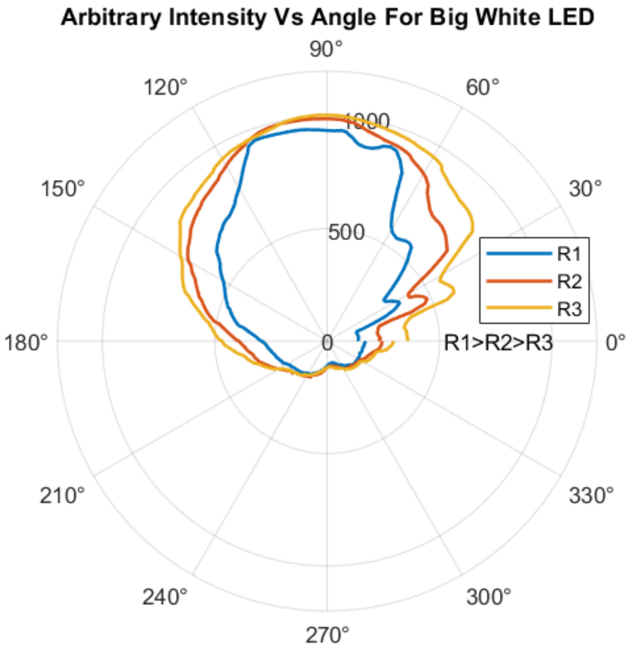
- 5.1 Radiation Patterns of Different LEDs
- 5.2 Discussion and Analysis
- 5.3 Limitations of Tools
- 5.4 Novelity

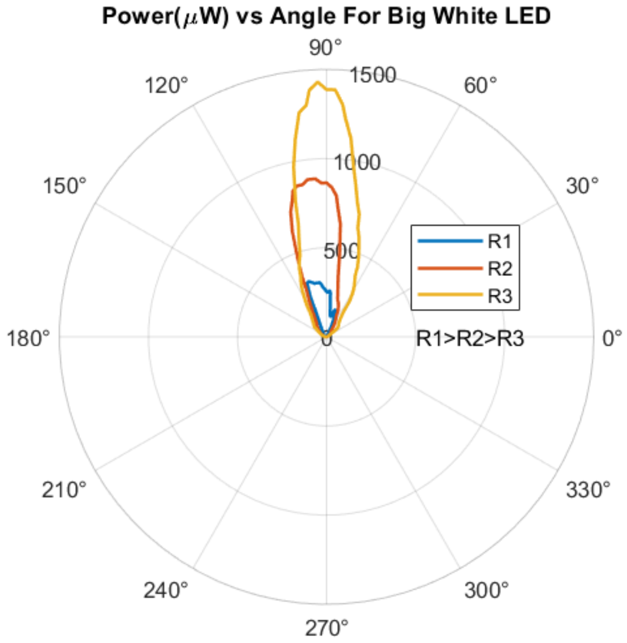
5.1.1 Radiation Pattern of a SMD White LED



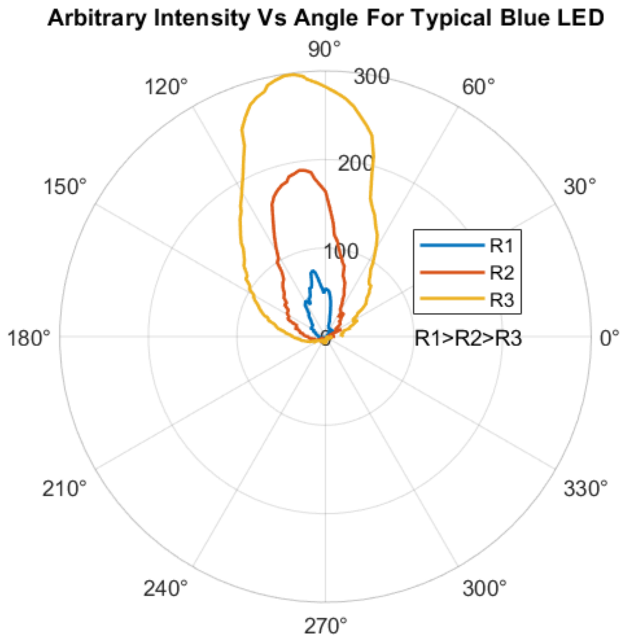


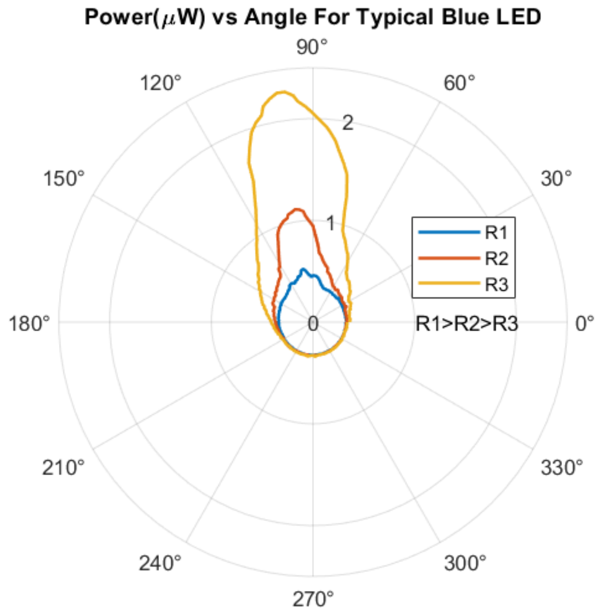
5.1.2 Radiation Pattern of a Big White LED



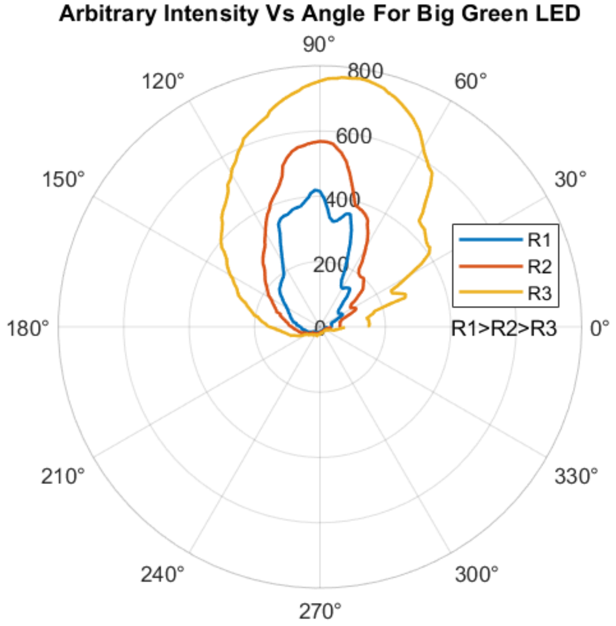


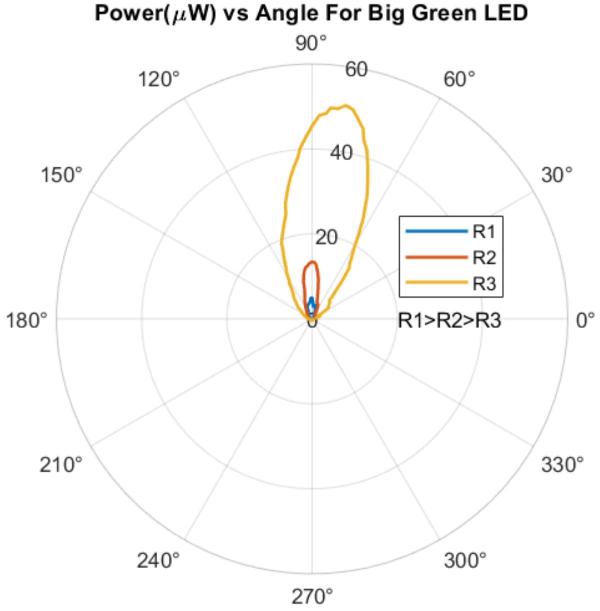
5.1.3 Radiation Pattern of a Typical Blue LED



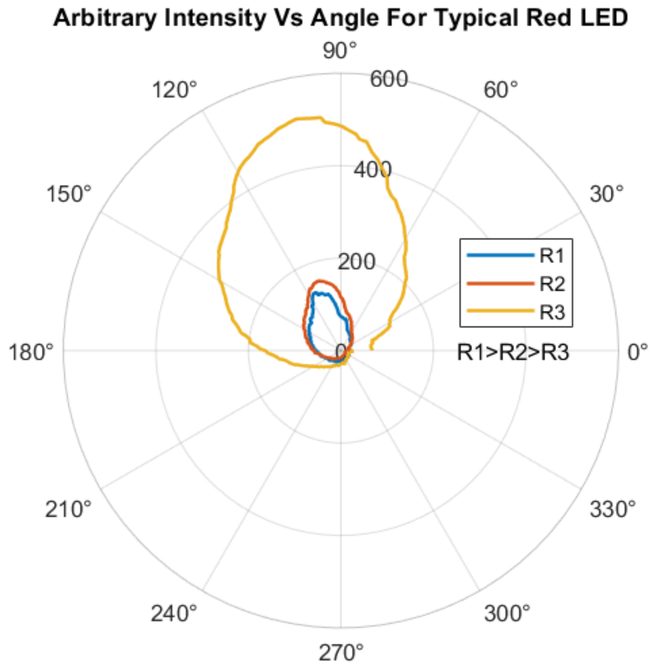


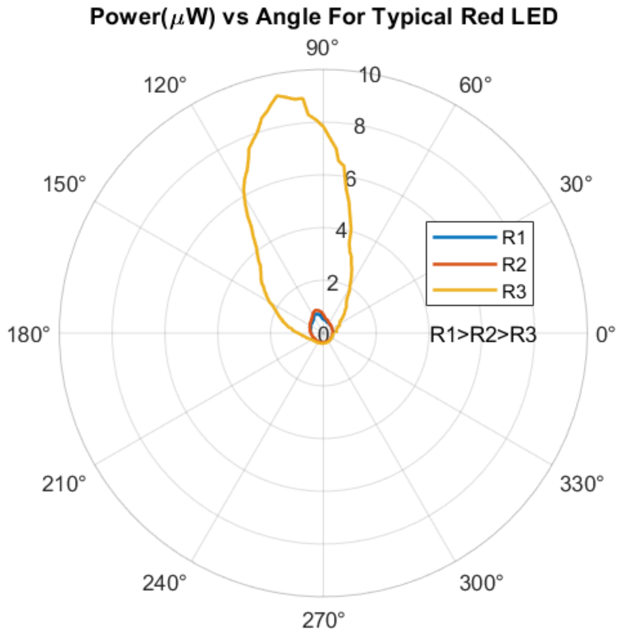
5.1.4 Radiation Pattern of a Big Green LED



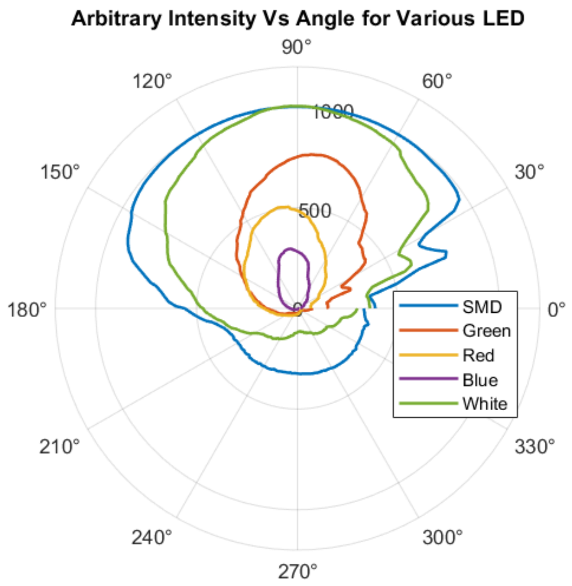


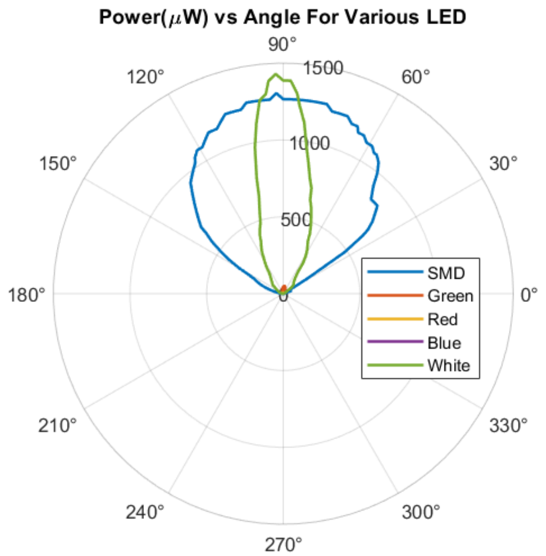
5.1.5 Radiation Pattern of a Typical Red LED





5.2 Discussion and Analysis





1. **Radiation Pattern Alignment:** LEDs exhibit peak radiation around 90 degrees due to setup alignment, with slight deviations due to setup variability.

2. **Radius Impact:** Smaller LED radii increase intensity and sometimes broaden emission patterns, highlighting the importance of physical dimensions in radiation characteristics.

3. **Voltage Variability:** LEDs operate at varying voltages, emphasizing the need to consider electrical properties alongside radiation patterns.

4. **Power Comparison:** Maintaining minimal radius allows for comparing LED power output, aiding in selecting high-performance LEDs for applications.

5.3 Limitations of Tools

- The structural framework of our setup, primarily composed of handmade PVC and 3D-printed components, imposes certain limitations on its robustness and precision.
- During scans with extended radii, the movement of the scanning arm containing the LDR sensors may experience vibrations induced by the stepper motor, potentially introducing distortions in our collected data.
- Our utilization of locally sourced LDR sensors, while functional, may not meet the standards required for precise industrial applications. Employing higher quality LDR sensors designed for industrial use could enhance the accuracy of our measurements.
- The inherent fluctuations in the reference voltage of the Arduino, typically set at 5V, can introduce minor errors in the analog readings obtained from the sensors, albeit within a negligible range.
- Our current setup relies on visual feedback for manually setting the radius length, making it challenging to achieve precise, automated adjustments to the radius length.

5.4 Novelty

6. Reflection on Individual and Team work

6.1 Individual Contribution of Each Member

All of our group Members are hall residents. All of us had almost equal contribution in the project. We worked together in Suhrawardy Hall, BUET. The Contributions of the members are:

- 1806056- Hardware Development, Coding, Design of Overall Structure. .

- 1806061- Calibration, Data Processing and Plotting, Hardware Development.

- 1806065- 3D Modelling, Hardware Development, Power Supply Management, Coding.

- 1806185- Calibration, Data Processing and Plotting, Hardware Development.

7 Communication to External Stakeholders (PO(j))

1. **Github Link**
2. **YouTube Link**

https://www.youtube.com/watch?fbclid=IwAR3wG0VDodRZir_sqG2tnlJuKnu4BK5ZydGYGNTxtm6CKZrUTIjvOetM8jQ&v=JPtsAixPLfk&feature=youtu.be

8. Project Management and Cost Analysis (PO(k))

1. **Bill of Materials**
2. **Calculation of Per Unit Cost of Prototype**
3. **Calculation of Per Unit Cost of Mass-Produced Unit**
4. **Timeline of Project Implementation**

*This section is mandatory to write if the course outcomes address PO(k) Read the PO Statement in the website first, before writing this section (*Program Outcomes and Program Educational Objectives | Department of EEE, BUET*) . If not needed, remove this entire section. If needed, DO NOT Change the title of this section.*

Use multiple slides for bill of materials if needed
Show costs in a single slide

9. Future Work (PO(I))

- **1. Improved Structure:** Enhance structure to reduce vibration during scanning.
- **2. Advanced Sensors:** Upgrade to high-quality sensors for more accurate measurements.
- **3. Automated Adjustment:** Develop systems for automated radius control based on sensor feedback.
- **4. Calibration and Compensation**: Implement calibration and error compensation methods to enhance measurement accuracy.
- **5. Advanced Analysis Techniques:** Explore machine learning for deeper insights from data.
- **6. Optimized LED Mounting:** Investigate optimal LED mounting techniques for consistent illumination.
- **7. Simulation Integration:** Develop virtual models for testing and optimization before physical implementation.

10. References

- [1] https://www.allaboutcircuits.com/projects/design-a-luxmeter-using-a-light-dependent-resistor/
- [2] https://www.gophotonics.com/calculators/lux-to-watts-conversion-calculator