SELF-SWITCHING LIGHT BULB

PROJECT REPORT

Group EN-18

Members:

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Abstract

Nowadays, there is an increasing demand for energy-saving techniques in residential, industrial, institutional, clinical, and other multipurpose indoor and outdoor applications. Our product aims to combine motion sensing abilities as well as natural light sensing abilities into a light bulb along with the necessary logical circuits in order to increase user convenience as well as to reduce unnecessary power consumption.

Problem Identification and Motivation

Among the several serious problems Sri Lanka is currently facing, the power crisis is one of the major issues that creates several other problems. When we try to identify the facts that exacerbate this issue, unnecessary power consumption can be considered a major factor, and there are various possibilities for how this unnecessary power consumption takes place. Through this design project, we decided to find an effective solution for the electricity waste that can be caused by household light bulbs.

Even though the power consumption value of a normal bulb is at a minimal level, continuing these power-consuming habits will cause a notable growth in the monthly power bills of consumers, and eventually, it will cause a considerable drawback in national power conservation. So, we thought that if we could come up with a solution to mitigate this power consumption of light bulbs, even on a small scale, it would be a help for both public consumers and the government.

When we were trying to find reasons for the waste that can be caused by household light bulbs, we came up with 3 main factors that keep bulbs in the "ON" state even though there is no use.

These are as follows,

1. Human carelessness
2. People’s busy schedules
3. Unusual power cut situations

1. Human Carelessness

   Due to careless human behavior, most people tend to forget to switch off light bulbs after using them. Furthermore, sometimes they keep bulbs in the ‘On’ state even though there is enough natural light to continue their work. Another careless situation that can be seen is that the places that have a huge number of bulbs do not have a proper labeling system for switches. As a result, every time someone wants to turn on a bulb, he has to turn on several bulbs to find the correct switch if he does not know the correct one or is careless enough to remember the correct one. Because of the irrational thinking pattern and immoral code of ethics, people ignore the loss that can emerge from these unhealthy power-consuming habits and the fact that they can have a severe effect on national power consumption in a destructive way.

2. People’s busy schedules

   Sometimes people leave the rooms hoping to return shortly and thereby keep the lights on even though they end up returning after a considerable amount of time because of busyness. When it comes to the industrial field, people continuously engage in their daily working routine, and most of the time, they forget to switch off the bulbs after using them for their purposes. Continuing these habits and keeping on many light bulbs will eventually cause a huge financial drawback in the industry. Also, this can happen in households. Most international surveys have shown that people who suffer from tension and depression because of their tight schedules naturally tend to ignore the purposes they must do as responsibilities.

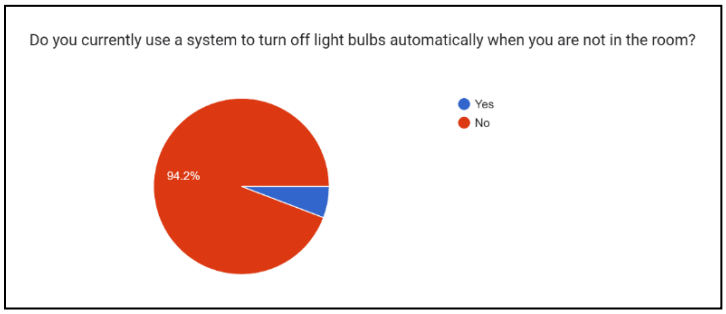
3. Unusual Power Cut Situations

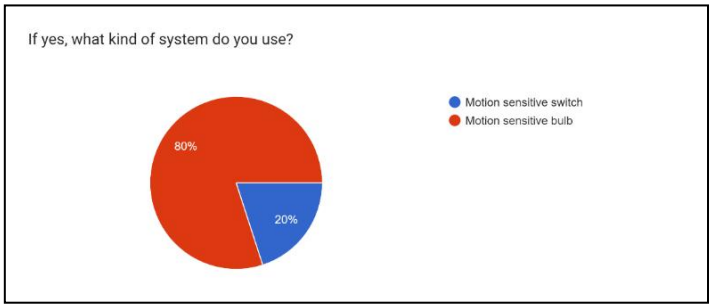
   When it comes to developing countries, the supply of electricity can be unreliable. Lights that were turned ON before the power cut will turn back ON after the power supply is restored without the knowledge of the user. This occurs since people may leave their rooms during the power cut. This will lead to unnecessary energy wastage.

After examining these three factors, we identified that if we could avoid the human-involved switching process of bulbs by automating it, we could turn on bulbs only during a real need. As a result, we decided to create a bulb with a motion sensor and a light sensor that can turn on and off automatically as needed.

Problem Validation

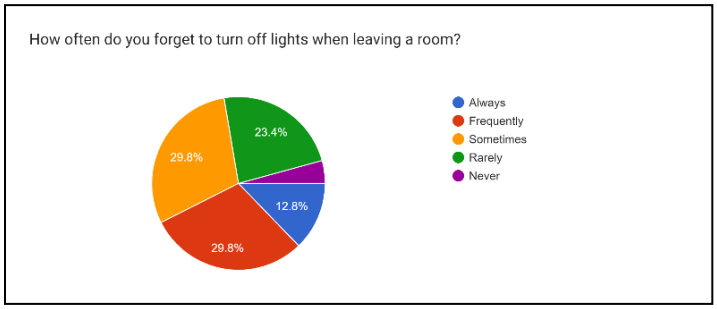
We did a survey to justify our problem selection and validate our solution and our sample was randomly selected 53 persons. The results of the survey are mentioned below.

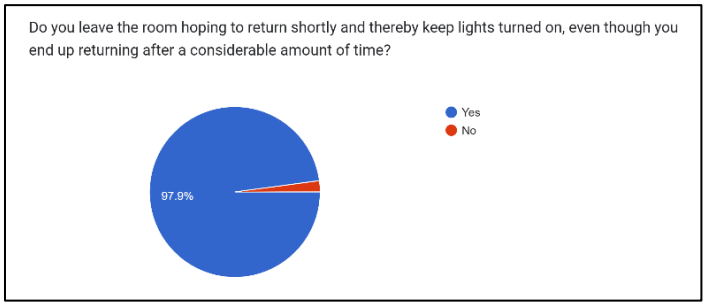


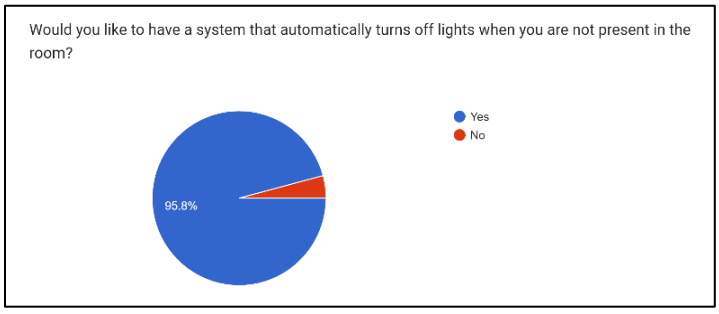


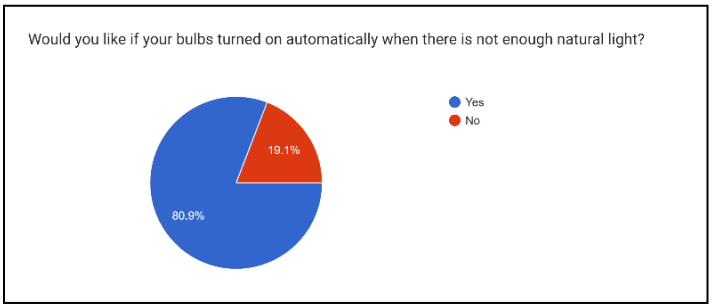
According to the result of the above two questions, we have found that only 5.8% use an automatic system to control the switching of lights.

Those who don't use such kind of system have responded to the below questions.



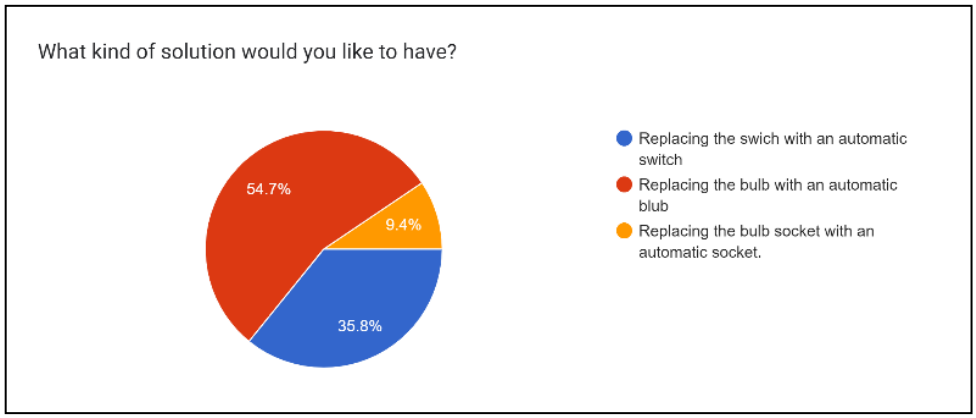




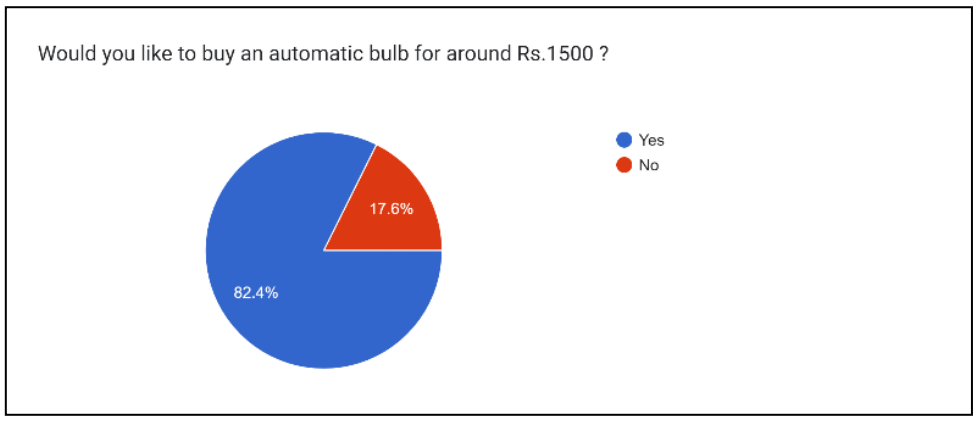


With the above results, we were able to verify that the problem we selected to solve is a real problem that most persons expect to get solved.

As the solution, we came up with three ways and among them, we initially decided to introduce an automatic bulb since the easiest thing for the users is replacing bulbs other than replacing existing switches or sockets. The result of our survey also verified our solution.



And also, we include a question in our survey to verify that people are capable to buy our product for the price we expect to charge for our product.



Technical Feasibility

According to the main architecture of our design, five main power-consuming units can be identified. They are

- PIR Module
- LDR Module
- LED Chip (Panel)
- NAND Gate IC Module
- Relay Module

The range of working voltage of the PIR HC-SR501 sensor module is typically 2.5V to 20V under a quiescent current of 0.05–0.1mA. So, it is a low-power-consuming device and even suitable for battery-powered applications.

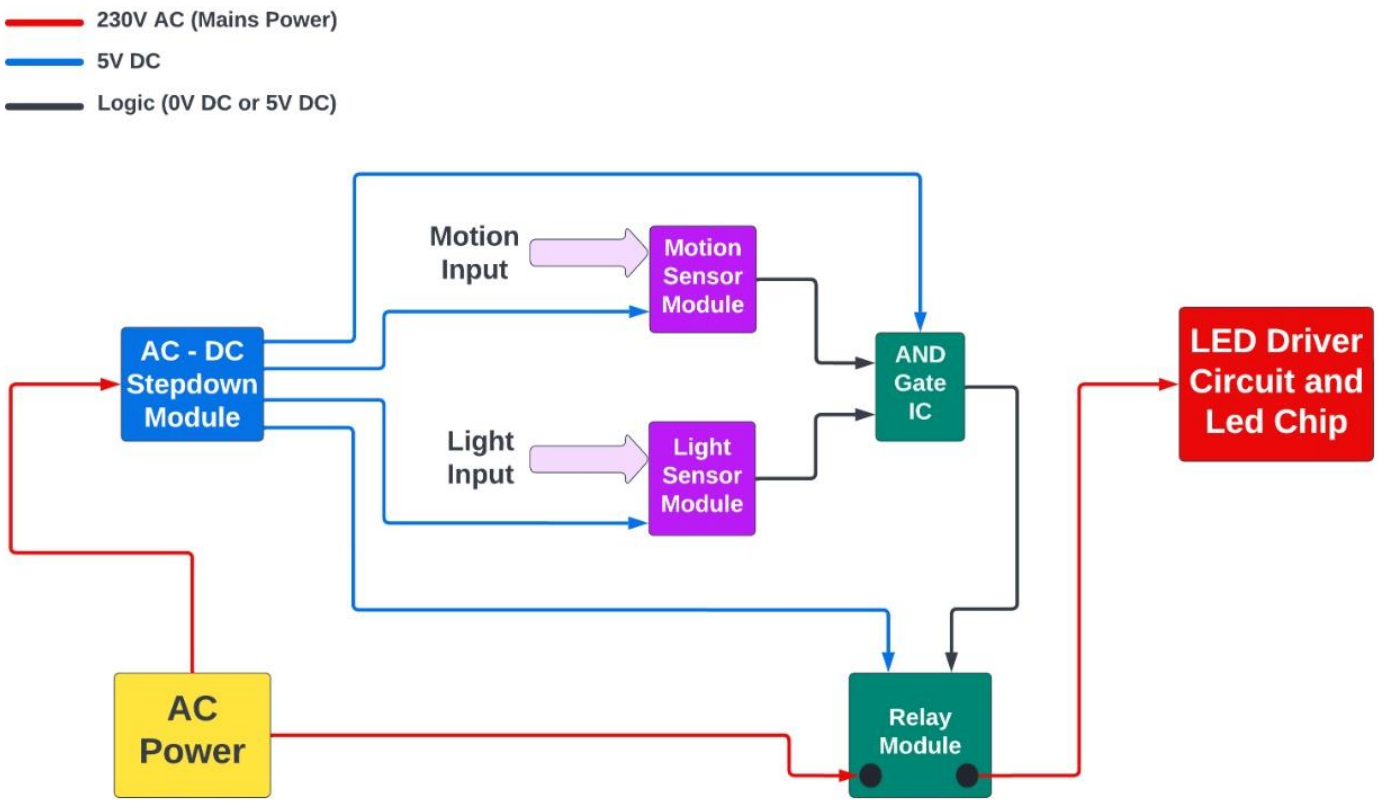
When it comes to the LDR module, the current drawn by the module will change since it has variable resistance. But the current drawn by the sensor is small, and even if the resistance changes between 10K and 1M in ohms due to the brightness change, the current change is less than 0.5mA. Also, the average power dissipation is typically 200mW.

The 74LS00 Quad 2-Input NAND Gate IC is typically a low power-consuming device since the operating voltage varies from 4.75V to 5.25V and has a low input current of 20µA. The relay module will be triggered based on the output voltage signal of the IC module, but the current required to activate the relay is much smaller than the current that relay contacts are capable of switching. But it still needs a relatively significant current for switching operation: 50mA for low-power relays and 500mA for high-power relays. But by implementing series and parallel configurations as necessary, we can manage the overall power demand of the circuit.

When it comes to the LED chip, we hope to use COB/MCOB chips rather than SMD chips because of their simplicity, low power consumption, and high efficiency. Also, it can produce many lumens for very little energy. So, it will meet our low power requirements.

Since our main power supply provides 5V DC regulated voltage and 700 mA maximum current, our supplied power for the design will be maximally 3.5W. So, according to the above power consumption details of the main units of the design, we'll have the opportunity to design our circuit to achieve maximum power optimization.

Product Architecture



Components and Functionalities

- **Motion Sensor (Occupancy Detection) Module**

Occupancy Detection Control is modeled by checking the motion or presence to trigger the light bulb. This can also be implemented with vacancy sensors.

Passive Infrared Sensor (PIR)

PIR only responds to infrared radiation emitted by other living objects within its detection sphere. The sensor mainly consists of two different slots which are made of special material sensitive to IR. In a motion detection, they will make positive and negative differential changes between two slots at a time. This differential change pulse will be the input to our main circuit. For this project, we hope to use the HC-SR501 PIR sensor module with the following specifications:

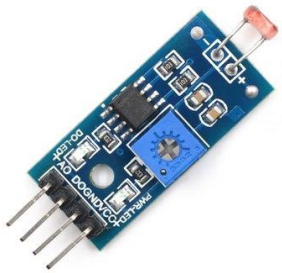
- Voltage: 5V – 20V
- Power Consumption: 65mA
- TTL output: 3.3V, 0V
- Sensing range: less than 120^0, within 7 meters.
- Temperature: – 15^oC ~ $+70^oC$

- **Light Sensor (Daylight Control) Module**

The Daylight Control Unit is modeled by checking the intensity of the ambient light and adjusting the resistance of a photosensitive resistor to implement a particular logic. The intensity of natural light will be the input for this unit.

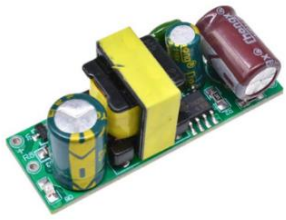
Light Dependent Resistor (LDR)

A Light-Dependent Resistor, also known as a Photo Resistor, is a device which works on the principle of photo conductivity. When the ambient light hits its surface, which is made from a photo-sensitive material, the resistance will change (normally this value varies between 1 MΩ and 1kΩ). When a constant voltage 'V' is applied to the LDR, the current through the resistor will be controlled by the intensity of natural light. So, it can be implemented constructively in smart lighting systems. For this project, we hope to use an LDR module with an adjustable potentiometer to adjust the brightness of the light detection and an operating voltage of 3.3V–5V.



- **Voltage Step-Down Modules**

For all of the modules in this project, the input should be a regulated 5V DC voltage. So, we hope to use a 5V 700mA SMPS AC-DC Stepdown Module. With an AC 85 ~ 265v 50/60 HZ input, we can get a 5V regulated voltage. Apart from the voltage conversion, this module provides temperature protection, over current protection and short-circuit protection, high and low voltage isolation.



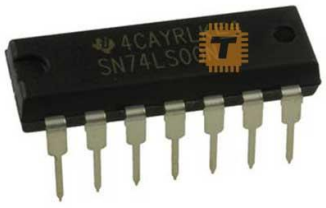
- **IC Module (Logical Operation Unit)**

In this unit, we are checking the outputs from the Motion Sensor Module and Light Sensor Module and controlling our final output (lighting up the LEDs) accordingly. The operation will occur based on the following simple logic.

Natural Light Condition	Human Presence	Switching State of Bulb (Output)
In Dark	Yes	ON
In Dark	No	OFF
In Light	Yes	OFF
In light	No	OFF

NAND Gates Integrated Circuit Module

To implement the basic logic of the circuit, we hope to use 74LS00 Quad 2-input NAND gate IC. NAND gates utilize advanced silicon-gate CMOS technology to achieve operating speeds with the low power consumption of standard CMOS integrated circuits. There are 4 independent NAND gates in the IC and all gates have buffered outputs.



- **Single Channel Relay Module**

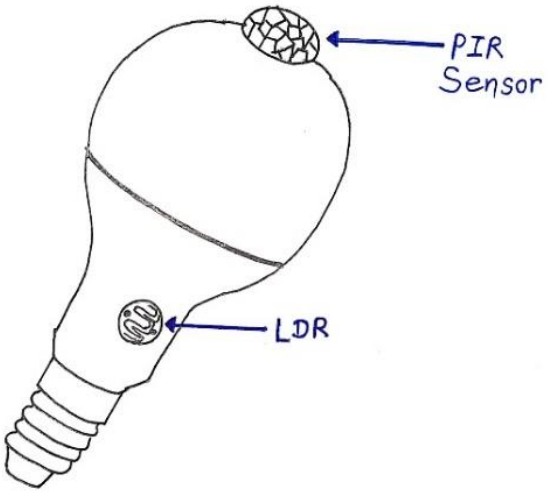
Based on the output of the NAND gate IC module, we hope to provide 230V AC supply voltage to the LED driving circuit by using a Single Channel Relay module. This is a 5V DC 1 way, 1 channel relay module that uses genuine, high-quality relays. It has the maximum load of the normally open interface: AC 250V/10A, DC 30V/10A. Its trigger current is 5mA and its working voltages are 5V, 12V, and 24V. It features two indicators: a power indicator (green LED) and a relay status indicator (red LED). It has strong driving ability and stable performance.

- **COB/MCOB LED Chip**

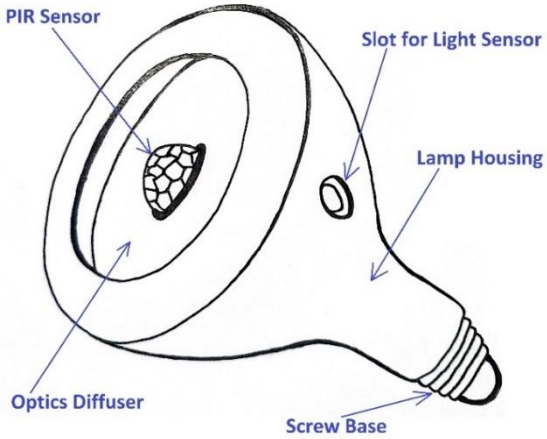
  MCOB (Multiple Chips On Board) LED panels are commonly used in LED lighting systems nowadays. MCOB devices differ from COB (Chip On Board) devices because they are better for low-wattage situations and produce a lot of light. Also, it has high optical density: 1cm2 area of the substrate can be set to 70 chips. Because of their low maintenance and high energy efficiency, MCOB LEDs cut down on their costs by a huge margin. Typically, these chips can pull between 0.05W and 0.08W (single diode) and produce between 50 and 100 lumens per watt.

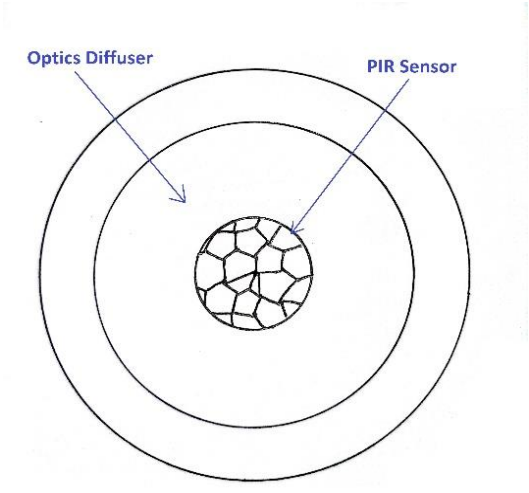
Product Enclosure

1. Initial sketch

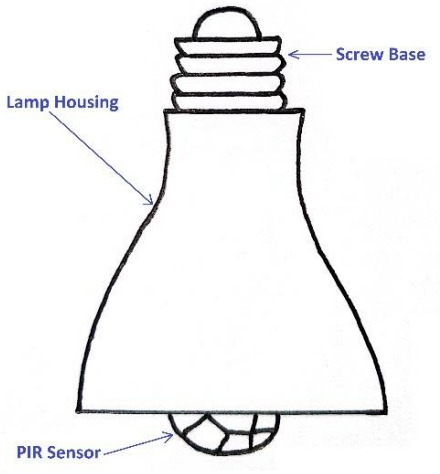


2. Final sketch



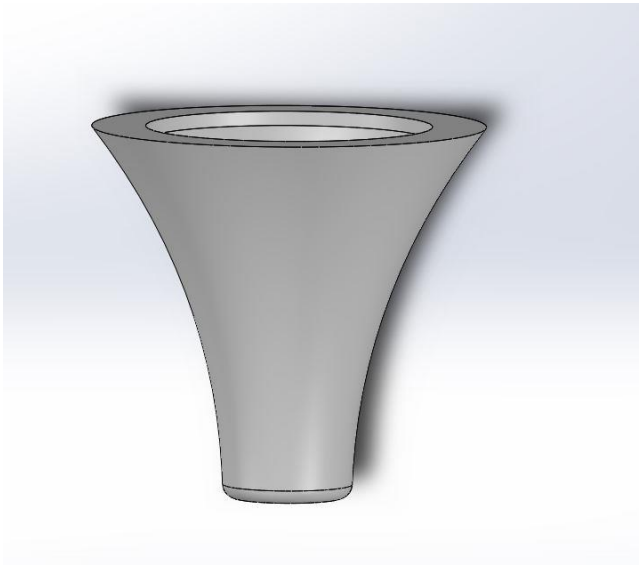


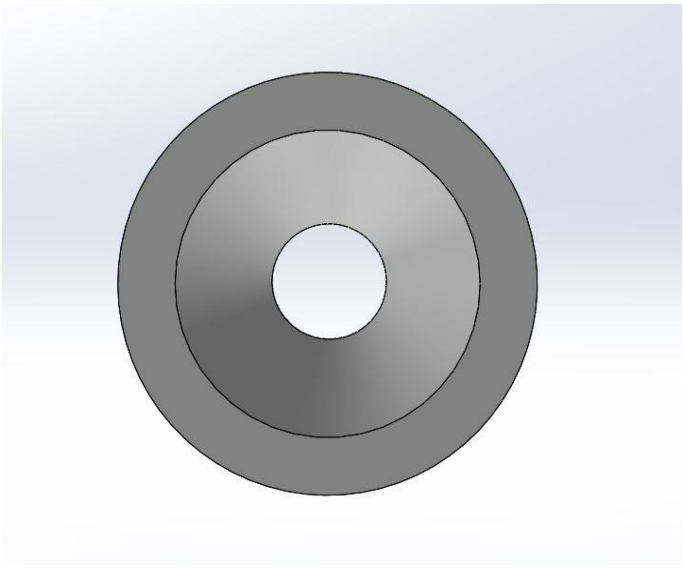
Bottom View

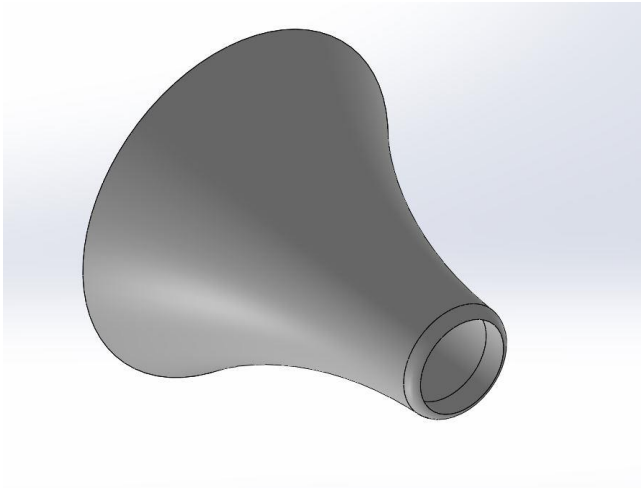


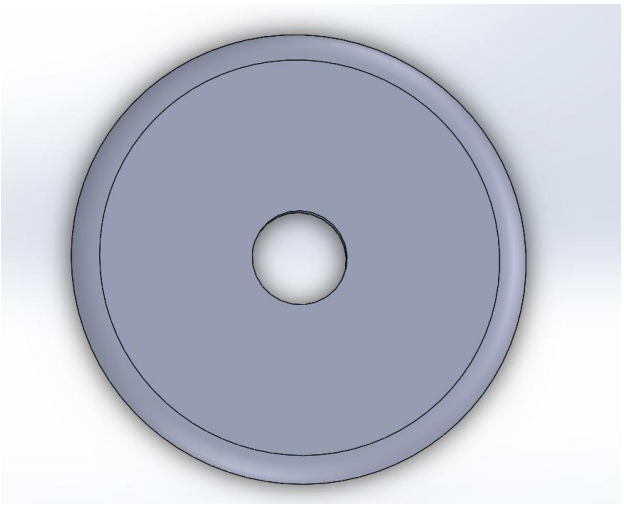
Side View

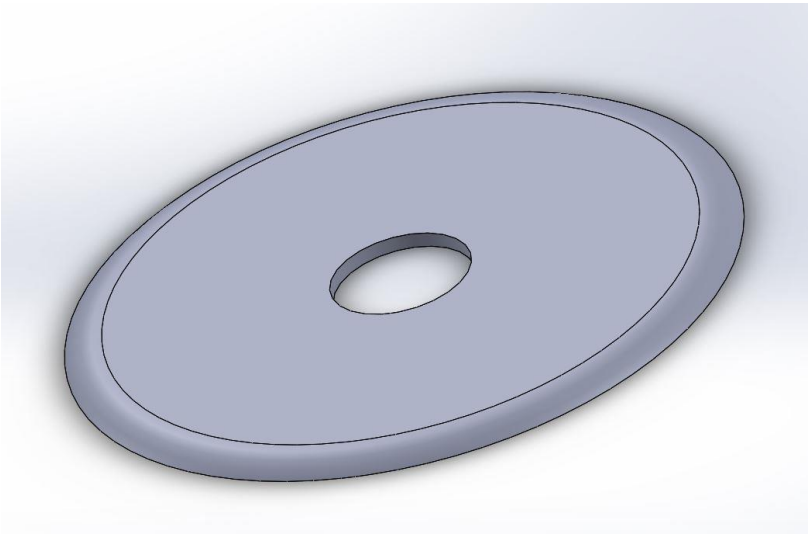
3. Solid Works designs



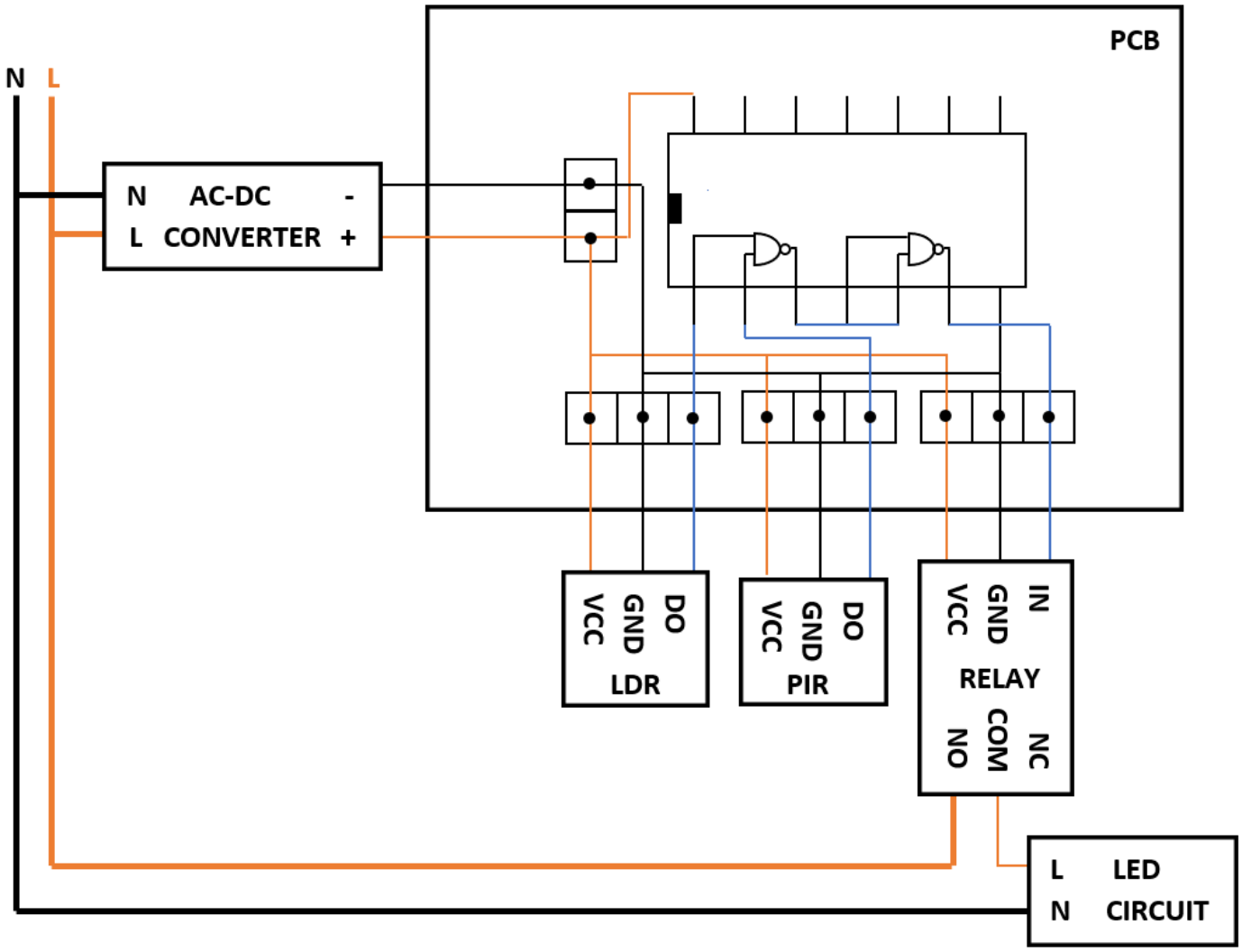






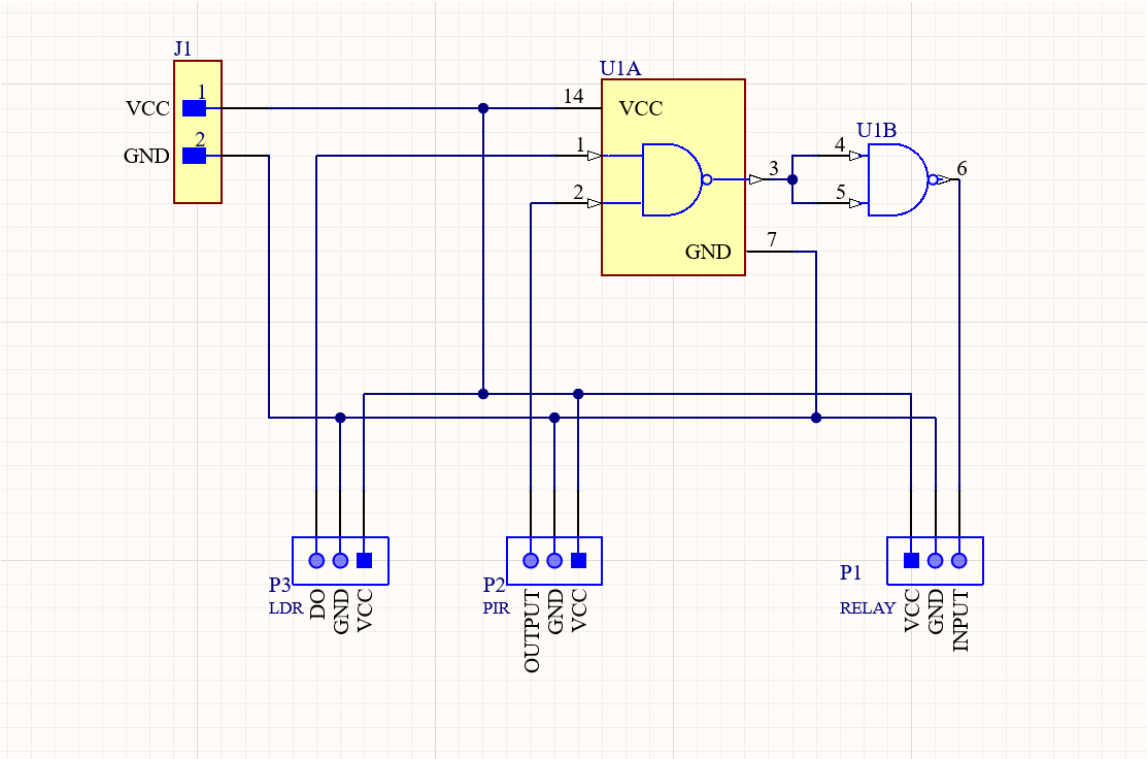


Final Circuit Diagram

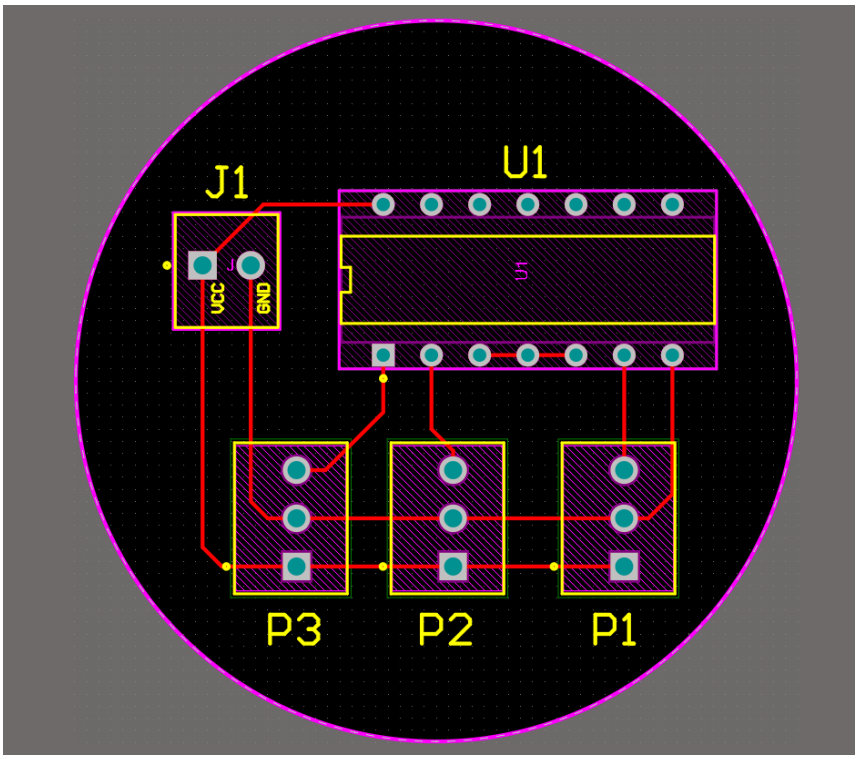


Altium Designs

1. Schematic



2. PCB 2D view



Marketing Plans

We expect to market our product by,

- using social media like Facebook, Instagram, etc.
- sharing flyers
- sharing videos about our product (comparing with other similar products and explaining the uniqueness of our product)
- maintain a website and a hotline for customers to be aware of our product and clarify their doubts about the product immediately.
- marketing our product by using the cold-calling method (telemarketing).
- collecting a list of potential customers
- getting feedback about our marketing plan from our customers just after buying the product.

Sales Plans

We expect to

- sell the product directly.
- sell our product by using the cold-calling method.
- sell our product to wholesalers and retail companies.
- sell our products through the internet by connecting with online selling platforms like eBay.

Product Life Cycle

- Product Packaging

  - We expect to make our product packaging using cardboard.
  - We expect to include our product's features as content in the package in an attractive way.
  - We expect to wrap the bulb using bubble wrap for its safety before it is packaged.

- Maintenance

  - There is no major maintenance for our product.
  - We have planned to give a 1-year Warranty period to our customers.

- Repair

  - If the malfunction can be found (e.g., a faulty diode), it can be easily repaired even at home, as all the necessary tools can be found at home (e.g., replace the old LED with a new one of the same type/install the conductor instead of the damaged diode).

- Reuse/Recycle

  - Some of the circuit components in our circuit are reusable.
  - Since we expect to use eco-friendly plastics to create the enclosure, we will be able to recycle it, and some of the circuit components of our product can be recycled.

- Disposal

  - The product should be carefully disposed of.
  - We expect to collect our disposable products for recycling. Therefore, as an encouragement, we have planned to give a 10% discount to the buyer to buy a new one after returning our disposable product after its lifetime.

Bill of Quantities

	Component	Quantity	Rate (Rs.)	Amount (Rs.)
1	*5V 700mA SMPS Power Supply Open Type PS0045*	*1*	*450.00*	*450.00*
2	*LDR Light Sensor Module for Arduino MD0222*	*1*	*200.00*	*200.00*
3	*HC-SR501 PIR Sensor Module for Arduino MD0138*	*1*	*350.00*	*350.00*
4	*74LS00 Quad 2-input NAND Gate (74HC00) IC0143*	*1*	*40.00*	*40.00*
5	*5VDC 1 way 1 Channel Relay Module (Transistor Version) MD0486*	*1*	*300.00*	*300.00*
6	*LED Bulb*	*1*	*400.00*	*400.00*
7	*Headers*	*1*	*35.00*	*35..00*
8	*PCB*	*1*	*500.00*	*500.00*
9	*Enclosure*	*1*	*1950.00*	*1950.00*
			Total amount	*Rs.4225.00*

Final Selling Price

Total Expense	*Rs.4225.00*
Profit for one item	6.5 %
Selling Price	*Rs.4499.00*

Task Allocation

Allocated Task	Member
Identifying the problem.	Perera N.W.P.R.A
Validating the problem and finding a solution.	All members
Validating the solution.	All members
Initiating market research and collecting results.	Pramuditha R.M.I.D
Meeting technical feasibilities	Pramuditha A.A.H
Product architecture (Block diagram view) and Schematic designing	Perera N.W.P.R.A
Finding necessary components and technical specifications	Pramuditha A.A.H
Enclosure designs (Sketches)	Perera N.W.P.R.A
Creating market plans, sales plans, and product life cycle	Prabuddhika M.W.R
PCB designing	Pramuditha R.M.I.D, Prabuddhika M.W.R
Enclosure designing	Pramuditha A.A.H
Handing PCB and Enclosure designs for manufacturing	All members
Assembling and finalizing the prototype	All members
Bill of quantities	Prabuddhika M.W.R
Profit Allocating and finalizing the selling price	Pramuditha R.M.I.D
Documentation	All members