DESIGN OF AN ENERGY EFFICIENT STREET LIGHT SYSTEM

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

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Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our original work while completing a degree at BRAC University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material that has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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Approval

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of Spring, 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of EEE on 27th April 2023.

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Ethics Statement

We followed a strict ethical code of conduct while we undertook our project to build an energy-efficient street lighting system. Our dedication to moral standards meant that people were secure, that property rights were honored, and that privacy issues were upheld.

The welfare of all interested parties came first and foremost. We were really careful to safeguard everyone's safety during the whole endeavor. We're delighted to report that nobody was harmed in the course of our job. We carefully observed safety regulations and put precautions in place to avoid mishaps or injuries. To ensure that our presence and actions complied with legal and ethical requirements, we also sought the required permits from property owners when conducting research in different places.

We acted openly and responsibly throughout our dealings with the academic community. Our project's nature was fully disclosed to and carefully monitored by the thesis lab supervisor for our lab. Their control and direction were crucial in preserving a lawful and safe working environment. We appreciate their help and dedication to preserving moral standards.

The protection of private rights was extremely important to us. We made sure that no one's privacy was violated during the whole endeavor. We only paid attention to increasing the effectiveness of street lighting and enhancing public safety. We took considerable effort to ensure that our system's design and implementation respected personal boundaries and didn't violate people's or their properties' privacy.

Abstract/ Executive Summary

This project focuses on building an automated street light system where street lights would adjust their intensity based on the detection of objects in the streets with the help of motion detection sensors.

In the current street light system, the lights get turned on manually after the sun goes down. We notice that even when there are no vehicles or pedestrians on the street the lights stay at full intensity which is considered a waste of electricity. If we take into consideration a whole year the electricity loss mounts up to a huge number.

We want to build a system where light intensity controlling using sensors would save unnecessary usage of electricity.

Keywords: Street light system, LED, LDR, IR, PIR, etc.

Dedication

Dedicated to our honorable ATC panel, whose steadfast support and direction were vital in completing this research. Your knowledge and enthusiasm for the subject have pushed me to go beyond my comfort zone and helped me have a better grasp of the subject. Thank you for being a mentor and a consistent source of encouragement along this journey.

Acknowledgment

The chair of our ATC panel Associate Professor, Dr. Mohammed Belal Hossain Bhuian sir is to be thanked especially for the thoughtful guidance and supervision in completing the project. He carefully observed every progression of our project. Lecturer, Abdullah Hill Kafi sir helped us immensely with his technical expertise and previous research knowledge. His input helped us to understand the complexity of the project. Last but not least Lecturer, Md. Mahmudul Islam sir was always there for us whenever we faced obstacles. He helped us to generate creative ideas for this project.

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Chapter 1: Introduction- [CO1, CO2, CO10]

1.1 Introduction

Streetlights light up roads, footpaths, parking areas, etc. They are the reason we can see clearly when there is darkness in the streets. We feel safe while walking the road; the drivers can see through the road and drive safely. Streetlights are used in those areas where there is not enough light and in the nighttime. Different kinds of lights are used in the streets in different conditions. In the current scenario, the most used type of street light is high-intensity discharge lamps. Based on the area there are several types. These are used in streets, highways, parking areas, intersections, and industrial areas. With the help of modern technology LED lights are the perfect solution for saving energy as well as high brightness. They require less maintenance and last longer than contemporary sodium bulbs. One key benefit of the street lighting system is that it improves the quality of life by artificially extending the hours of light to allow for activity while also encouraging security in both urban and rural areas.

There are various options to improve the street lighting system in conformity with current life by making simple changes to the existing system without wasting time, energy, or money. We may ease administration and maintenance problems by implementing a time-based automated system that automatically switches on and off the lights and controls their intensity whenever it is needed.

1.1.1 Problem Statement

A city's street lighting system is a crucial component nowadays. It gives drivers and passengers in cars on the road the required safety for nighttime commuting. This needs a constant power supply from dusk till dawn, which is a challenge for developing nations where load shedding is a typical occurrence owing to the global energy crisis. The constant reduction of the reservation and price hike of fuel has led us to face the problem of the electricity crisis.

There are several reasons why there is electricity wastage from street lights in Dhaka:

1. Outdated technology: Many of Dhaka's streetlights are outdated and use inefficient lighting technologies such as incandescent bulbs. These bulbs use more electricity than newer, more energy-efficient lighting technologies like LED lights.

2. Inadequate maintenance: Many streetlights in Dhaka are not operating correctly due to insufficient maintenance. This can lead to power waste since the lights may remain on during the day or stay on for longer than necessary at night.

3. Lack of automation: In certain circumstances, streetlights in Dhaka are manually operated, resulting in power waste. For example, if lights are not turned off manually, they may be kept on during the day or remain on longer than required at night.

4. Overlapping lighting coverage: In some places of Dhaka, streetlight coverage may overlap, resulting in power waste. To maximize illumination coverage, it may be possible in many circumstances to lower the number of lamps or alter their location.

In Bangladesh, street lights use a significant amount of the country's electricity, which also causes serious power loss. Between 6 p.m. and 10 p.m., there is a lot of traffic in the streets of Dhaka. In the residential areas of Dhaka after midnight we see a huge decrease in several vehicles and pedestrians. Even when the roads are empty the streets lights stay at their full intensity which causes huge electricity loss street lights (nearly 34 lacks per month **[1]**)

1.1.2 Background Study

Dhaka's street lights are designed in such a way that they turn on after the sun sets and stay on all night until dawn. This wastes a significant amount of electricity. According to an article, 420MW of power worth approximately 34 lakh taka is wasted each month by street lights. This amount of electricity could have supplied 4000 non-urban households' needs. To meet the electricity demand, Bangladesh generates a significant amount of power, approximately 25,566 MW. However, it has been discovered that Dhaka itself consumes 46% of the power generated **[1]**.

Most of the power plants in our country run on gas. Currently, the whole world is facing gas shortage issues. As a result, Bangladesh is falling short on electricity production and it has led us to frequent load shedding today. Dhaka being the center of commerce in Bangladesh it is essential to keep the power supply uninterrupted. So, if we can save the power from being wasted through street lights it will be helpful considering the current scenario. The power we save through street lights will be invested in other sectors.

Lighting systems in the public sector are still designed by outdated guidelines and they often do not benefit from the most recent technological advancements. Each year, ineffective lighting costs a substantial amount of money and leads to dangerous conditions. The expense of street lighting can be greatly reduced by using energy-efficient technologies and design principles.

The issue of power saving through intensity controlling of street lights deals with many technical aspects. Although we want to save power and it is related to lights operating at a lower intensity, we need to ensure the convenience of the people who use the road. There has to be enough light on the road still while the lights are dimmed. To design a light dimming system we may use a time-based, speed sensor-based, or image processing-based intensity controlling system which requires tools like motion sensor, speed sensor, cloud system, database, image processing, etc. These are all controlled by coding in the central processor.

The stakeholders of this project are Dhaka city corporation as the street lighting system in Dhaka is controlled and maintained by them. The system has to be built according to their requirements. Moreover, the people who will use the road are also part of it as the project directly deals with pedestrians and vehicles.

With the increment of load shedding and producing electricity being costly, this project can be a good helping hand to reduce the wastage and usage of electricity in the streets. Cities are becoming developed day by day and roads are being built in numerous numbers. The issue of excessive electricity consumption and wastage of power is quite relevant in the present and current power generation and distribution industry.

A study conducted by Ruchika Prasad from Chennai, India **[2]** dealt with designing an energy-efficient smart lighting system in the city of Nagpur. They mentioned that soon the majority of the world population will be living in urban areas where electricity demand will be huge. 2% of the total energy and 10-15% of the municipal budget is consumed by the big cities of India **[3]**. The study was conducted on 270 H.P.S.V. bulbs of 250 watts and 50 H.P.S.V. bulbs of 150 watts. To compare they used 29 LED bulbs of 150 watts. The method of the lighting system was both time-based and sensor-based. In the time-based approach, the lights got turned on after 6 p.m. and after 11 p.m. the whole system turned into sensor-based lights based on the motion of the vehicle. The study showed that the old H.P.S.V bulbs' energy consumption in February was 2218 kwh and LED bulbs were 10029 kwh. The saving was 54.9% in the month of February **[2].**

In another conference paper done by Modabbir and Arshad Mohammad of Aligarh Muslim University, India they analyzed smart technologies in street light systems. They mentioned that integrating smart technologies into street light systems would conserve energy and lower the cost as in India 20-40% of electricity is consumed by street lights **[4].** The study was done on 36 street lights with PIR sensors and a part-night lighting system. In the part-night lighting system, the intensity decreased as the night progressed and by PIR sensor the intensity was controlled through motion detection. After experimenting for 6 months the results showed that in part night lighting system the power consumption in 55% of a current conventional system and using PIR the consumption was 3.8% of the current system **[5]**

1.1.3 Literature gap

While various studies have looked into the use of Infrared (IR) sensors or Passive Infrared (PIR) sensors for object identification in street lighting systems, few have looked into the use of both sensors together for more effective object detection. Furthermore, while some research has different kinds of lights andd arestreetlightingghting systems, it is unknown how successful these algorithms are in real-world applications.

Our study intends to fill these gaps by combining IR and PIR sensors to improve object recognition in street lighting systems. In addition, we have created an efficient object detection algorithm for detecting and responding to the presence of pedestrians and cars. While our concept has shown promising results in a controlled environment, additional study is required to evaluate its usefulness in real-world situations and under various weather conditions. Furthermore, it would be beneficial to investigate our system's scalability and the possibility of its application in bigger, urban regions with more complex traffic patterns.

1.1.4 Relevance to Current and Future Industry

For various reasons, this study on using IR and PIR sensors for object identification in street lighting systems and building an effective object recognition algorithm has major importance to existing and future industries:

Energy efficiency: Your idea can assist decrease energy waste and increase energy efficiency by enhancing object recognition accuracy in street lighting systems. This is especially crucial in an age where energy conservation is becoming more vital.

Safety: Accurate object identification in street lighting systems can assist to increase safety by lowering the likelihood of accidents and increasing visibility for cars and pedestrians. This is especially significant in densely populated metropolitan areas.

Cost savings: Improving the accuracy of object identification in street lighting systems can result in cost savings by lowering energy consumption and the expenses associated with repairing or replacing malfunctioning lighting systems.

Competitiveness in the lighting industry: The development of more efficient and effective street lighting systems can assist to increase the competitiveness of lighting enterprises. Companies may differentiate themselves from the competition and get a greater market share by offering new solutions that increase energy efficiency and safety.

As the need for energy-efficient and safe lighting systems grows, the industry is anticipated to lay a larger focus on creating more advanced object-detecting technologies in the future. Our study has the potential to contribute to this trend by proving the viability of using infrared and passive infrared sensors for object detection and establishing an effective algorithm that may be enhanced and modified for future uses.

1.2 Objectives, Requirements, Specifications, and Constraints

1.2.1 Objectives

To approach the problem, we have aimed to develop this project. The major objective of this project is to create an automated street light system that will aim to save energy by controlling the intensity of street lights.

- Auto light intensity adjustment
- Introduce an updated lighting system with better maintenance feature
- Saving electricity through light intensity controlling

Auto light intensity adjustment:

The goal of automated light intensity control is to increase energy efficiency and minimize energy consumption by altering lighting system brightness in response to changes in ambient lighting conditions. It is feasible to guarantee that lighting systems offer appropriate illumination while minimizing energy loss by automatically altering the intensity of light based difdifferenttt klight olightLightht intensity management in outdoor lighting applications can be very successful in reducing energy usage during daylight hours when lighting systems are not required. It is feasible to cut energy consumption and improve the lifespan of lighting systems by automatically dimming or turning off lights during the day.

Introduce an updated lighting system with better maintenance features:

The introduction of an upgraded lighting system with improved maintenance features would increase the lighting system's dependability, longevity, and maintainability while lowering the operational expenses associated with lighting maintenance.

One of the primary goals of a lighting system with improved maintenance features is to reduce downtime and the need for frequent repairs and replacements. This may be accomplished by utilizing high-quality, long-lasting components and materials that can resist harsh climatic conditions and extensive durations of usage. Furthermore, by implementing diagnostic tools and monitoring systems into the lighting system, any faults that develop may be rapidly identified and addressed, limiting downtime and lowering maintenance costs.

Saving electricity through light intensity controlling:

The goal of reducing energy consumption and promoting energy efficiency through intensity management is to vary the brightness of lighting systems based on the surrounding environment and occupancy levels.

One of the key goals of intensity management is to prevent energy waste by ensuring that lighting systems only supply the brightness required for the given work or location. It is feasible to guarantee that lighting systems offer appropriate illumination while minimizing energy waste by automatically altering the intensity of lighting based on the surrounding ambient light levels and occupancy levels.

1.2.2 Functional and Non-functional Requirements

Functional

The overall system's functional needs define it. Here, we have to think about the related requirements to this project. To set the requirements of our project we need to think from the perspectives of the stakeholders.
A project focusing on electricity-efficient street lighting systems may have the following stakeholders:

Local Government: It is the responsibility of the local government to provide and maintain street lighting systems. They are important stakeholders in this project since they will be installing the new system.

Citizens and Residents: Because they will be utilizing the system, the citizens and residents of the area where the new street lighting system is erected are stakeholders. They will benefit from greater illumination and less energy waste.

Utility firms: Utility firms that supply power to the street lighting system are stakeholders since they will be influenced by lower energy use and may need to change their service offerings.

Business Owners: Owners of businesses in the area where the new street lighting system will be installed may be stakeholders since they will benefit from enhanced lighting conditions as well as increased safety and security.

Based on the stakeholders we set the following requirements-

Table: Functional requirements and reasons

Requirement	Reason
Proper illumination between 6 p.m and 5 a.m	On the road where the design will be applied, there has to be proper illumination irrespective of any design approach
Light intensity increases when the object approaches and decreases when moves away	There has to be an approach where the light intensity will change automatically when an object is near the radius of light
Safe and comfortable vision at night	Although the light intensity will be controlled no one should have any problem seeing through the road clearly

Proper illumination between 6 p.m. and 5 a.m.:
Proper lighting is essential between the hours of 6 p.m. and 5 a.m. for various reasons:

Safety: Proper lighting is required to protect the safety and security of those who are out and about during these hours. Adequate illumination aids in the prevention of accidents, crimes, and other potential risks.

Visibility: Adequate visibility for cars, pedestrians, and bicycles requires proper illumination. It aids in the prevention of accidents by allowing individuals to see clearly and securely navigate their environment.

Aesthetics: Proper lighting may improve the look of outdoor areas and architecture. It can assist to make a place more aesthetically attractive and emphasize essential landmarks and features.

Productivity: Proper lighting is crucial for outdoor workstations and locations where duties are conducted at night and in the evening.

Light intensity increases when the object approaches and decreases when moves away:
As the main program of our project is to control the intensity of the street lights it is very important that whenever the sensors detect any object the light intensity increases as soon as possible otherwise there would be a huge inconvenience. Also, to save energy it is required to lower the intensity when there is no object detection.

Safe and comfortable vision at night:
Street vision must be safe and comfortable to protect the safety and well-being of those who are out and about. Good illumination is required for individuals to view their surroundings clearly and securely navigate their route. Adequate illumination aids in the prevention of accidents, crimes, and other potential risks. It also offers a welcoming and pleasant environment for individuals to enjoy outdoor activities and mingle with others. When visibility is low in the evenings and at night, safe and pleasant eyesight is especially vital. Overall, secure and pleasant street vision is critical for providing a safe, inviting, and pleasurable environment for everybody.

Subsystems-

- Power supply system
- Central processing unit
- Sensors

Non-functional:
The elements that ensure the quality of the systems are called non-functional requirements. This includes the decisions our system must make to enhance the quality and dependability of our systems. The following are the non-functional requirements for our systems:

Table: Non-Functional requirements and reasons

Requirement	Reason
Solar panel	As a part of green energy, there could be an integration of solar panels as power sources.
Security surveillance	As there will be components attached to poles there is a possibility of theft. Security surveillance can be used to protect the components from being stolen

1.2.3 Specifications

Specifications are those aspects of the design that are quantitative. Through these specified area measurements and components, we will be able to design our two approaches.

Area specification

The area in that we will be implementing our design approach is stated below. Based on the area some of the aspects of our approach like illumination might change.

Table: Specification of the area of our project

Description	Parameters
Height of pole	6 to 8 meters
Distance between poles	22 to 25 meters
Width of the road	8 to 9.5 meter

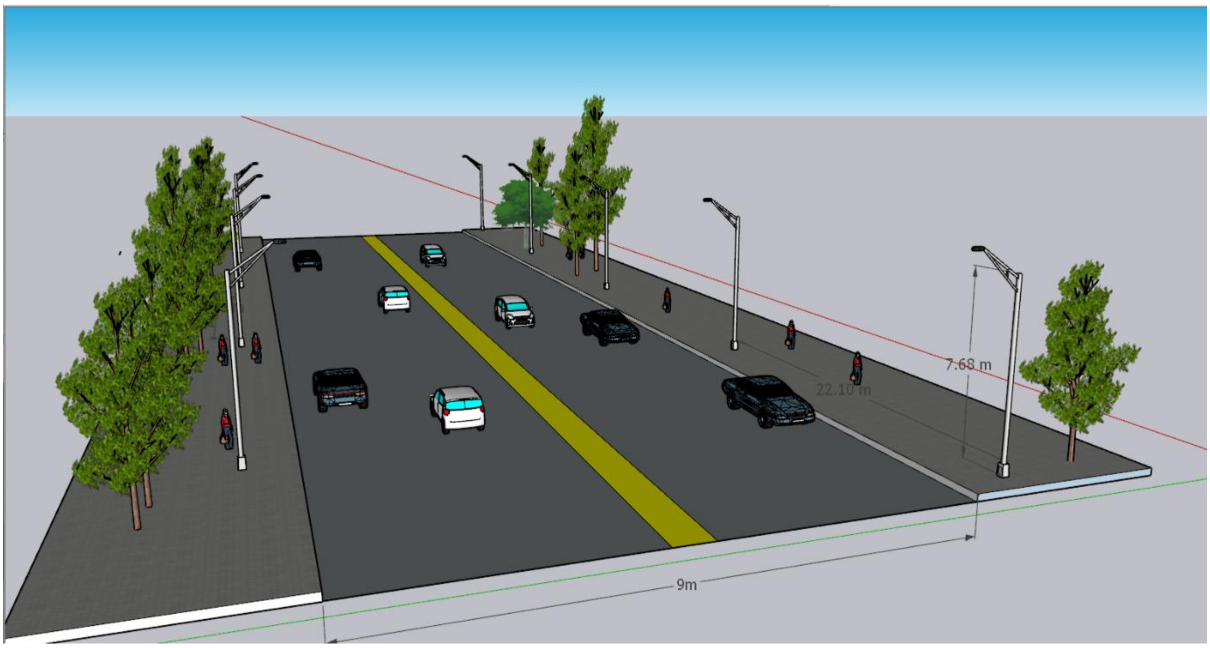


Figure: Design of the road according to area specification

Light intensity specifications and calculation

The light intensity of our approach depends on a couple of factors. We need to know the power, P in watts (W), and the luminous efficacy, η in lumens per watt (lm/W) of the light to calculate how much the intensity should be. After we get the power and efficacy, we have to multiply those values to get the luminous flux in lumens.

So,
Power = P(watt)

Table: Type of lights and their luminous efficiency

Light type	Typical luminous efficacy (lumens/watt)
Tungsten incandescent light bulb	12.5-17.5 lm/W
Halogen lamp	16-24 lm/W
Fluorescent lamp	45-75 lm/W
LED lamp	80-100 lm/W

Metal halide lamp	75-100 lm/W
High-pressure sodium vapor lamp	85-150 lm/W
Low-pressure sodium vapor lamp	100-200 lm/W
Mercury vapor lamp	35-65 lm/W

Luminous efficacy = η (lumens/watt)
Luminous Flux, Φ_v(lumen)= P*η

Note: The luminous efficacy given here are typical/average values

From Dhaka City Corporation and Filament engineering company, we got to know that in Dhaka City the power of the LED light used as street light varies from 60-120 watts. Most of the time companies use 100–120-watt LED lights.

So, using 110W of power and 90 lumen/watt of luminous efficacy the highest illumination in the case of our approach will be,

Luminous flux= 110w * 90lm/w= 9900 lumen

From the majority of our research papers, we found that the lowest intensity of street lights is 40% of the highest intensity. As the highest intensity of the street light in our case is 9900 lumens so 40% of that is 3960 lumens. So, the minimum intensity that the street light will give is around 3960 lumens.

Based on the above calculation and description the parameters of **LED lights** and their intensity is given below.

Table: Intensity and Wattage of Street Light

Highest light intensity range	6000 to 9000 lumens
Lowest light intensity range	2400 to 4000 lumens
Radius covered by street light	8 to 10 meters
LED power required	60 to110 watt

Subsystem component:

- Poles
- Arduino
- LDR
- IR obstacle sensor
- PIR proximity sensor
- LEDs

1.2.4 Technical & Non-technical Constraints

Technical Constraints	Power loss in auxiliary equipment like converters
	Sensors being damaged
Non-technical Constraints	Weather conditions

1.2.5 Applicable Compliance, standards, and Codes

- **IEEE 2700**

IEEE Standard for Sensor Performance Parameters.

Description: This standard applies to the accelerometer, magnetometer, gyro meter/ gyroscope, barometer/ pressure sensors, hygrometer/ humidity sensors, temperature sensors, light sensors, and proximity sensors.

- **IEEE 1789**

IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.

Description: The purpose of this document on suggested practices is to: Defining modulation frequencies for light-emitting diodes (LEDs) and discussing how they apply to LED lighting. - Describe LED lighting applications where user health may be in danger due to modulation frequencies. - Talk about adjusting the frequency of driving currents/voltages to dim LEDs. - Provide modulation frequency (flicker) recommendations for LED lighting and dimming applications to help guard against recognized possible negative health impacts.

- **IEEE 802.11**

IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems.

<u>Description</u>: The purpose of this standard is to provide wireless connectivity for fixed, portable, and moving stations within a local area. This standard also offers regulatory bodies a means of standardizing access to one or more frequency bands for local area communication.

- **<u>IEEE 802.21</u>**

IEEE Standard for Local and Metropolitan Area Networks

<u>Description</u>: By providing a framework and controls that various services, including the changeover service between heterogeneous IEEE 802 networks, can employ in a media-independent way, this standard aims to enhance the user experience of mobile devices. This framework can also be used to connect cellular networks with IEEE 802 networks.

1.3 Systematic Overview / Summary of the proposed project

After carefully evaluating the stakeholder's requirements and the huge energy lost by the street lights during no traffic at night, we determined a preferable system. We came up with a system that is automated to reduce human errors, a renewable energy-based system that consumes clean electricity and a sensor-based intensity alteration system to save energy as well as provide sufficient light for better commuting of pedestrians. This system will be fitting to reduce the extra energy consumption that is being wasted by a city.

1.4 Conclusion

From this chapter, the key part was that a smart street light system is an essential criterion for a city to step towards a smart city. As this system is much more reliable and swifter to follow commands. Moreover, the system is much more cost-efficient for developing countries to meet the high electricity demand.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

In this part of FYDP we are going to talk about the design approaches that we choose to achieve our desired outcome. We decided upon two optimal designs and to validate them we ran software simulations in two different software. The designs that we are going to show are based on the objectives, specifications, requirements, and constraints that have been mentioned above.

2.2 Identifying Multiple Design Approaches

2.2.1 Design Approach 1 with object detection through sensors

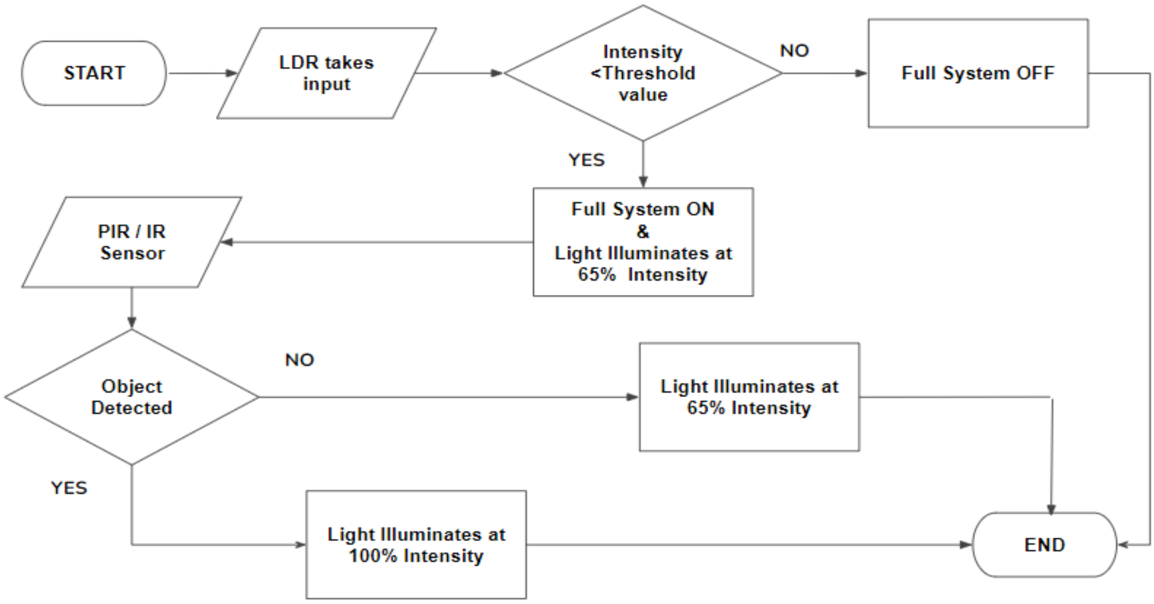


Fig: Flowchart of Design 1

2.3 Description: This model is based on a system that will mainly function by reading data from the object's movement. Here, the sensing units will be in performance mode to get each data of the objects around, whether moving or just standing inside the zone area. Based on the LDR reading, the system will be turned on or off. We shall set a threshold value for LDR. If it is less than the threshold value then the system will be powered up and do its functions; on the contrary, if it is equal to or higher than the threshold value it will assume that daylight is present. After the system is turned on the LEDs will glow at 65% of its total brightness, & will remain like that if no movement is being detected by the sensory units. Any movement detected by the

IR & PIR sensors within their specified range, the signal will be instantly sent to the Arduino UNO which will then send another signal to the lights to glow at 100% brightness, there will be a delay after that, within this delay if no movement is detected by the sensors the lights will automatically return to its initial low-intensity state. However, if a pedestrian decides to just stand under the light pole, the IR sensor will be able to detect the stationary person and the system will keep the lights glowing. Judging by the reading it will act.

2.2.2 Design Approach 2 with object detection using image processing

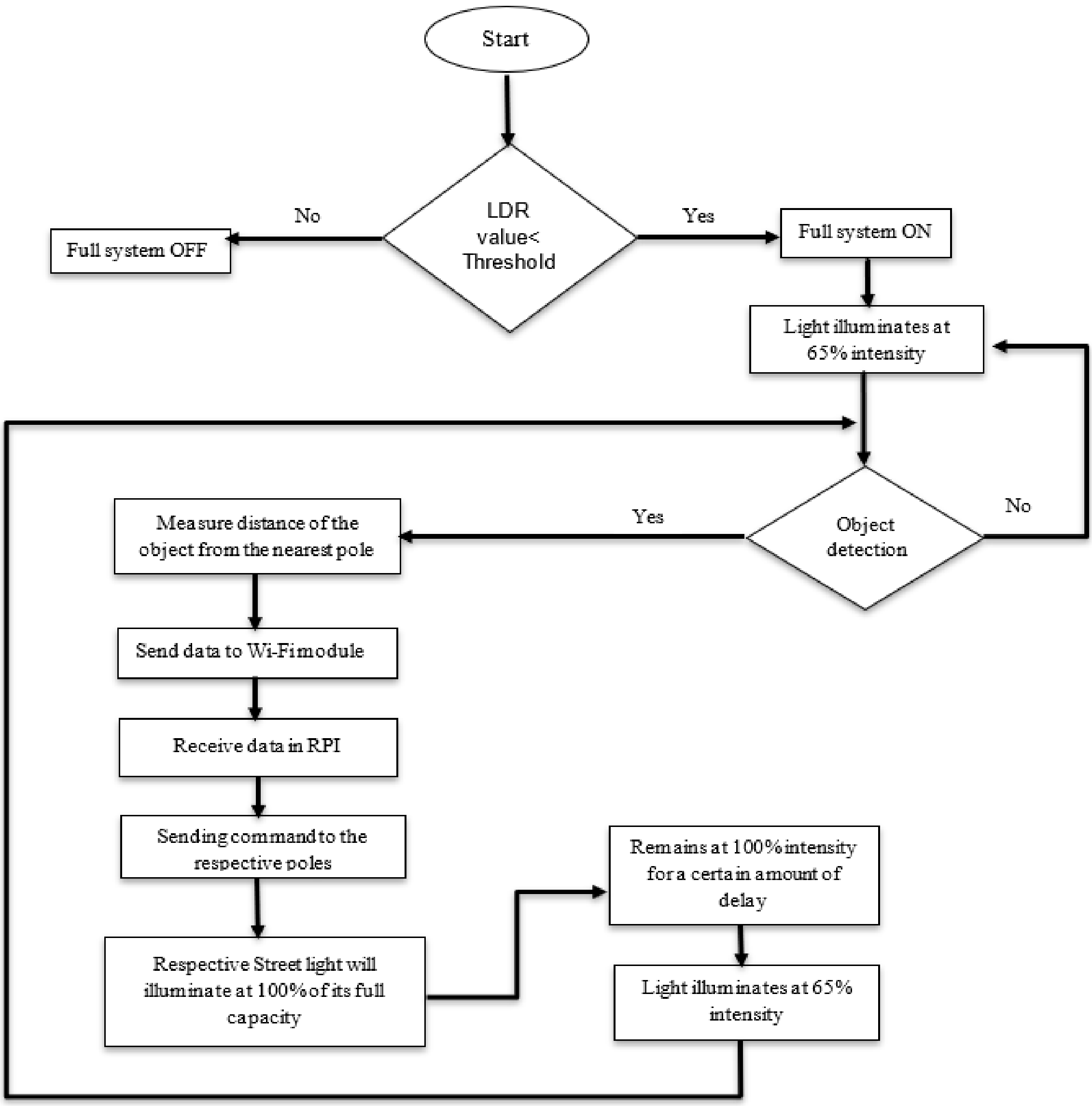


Figure: Flowchart of Design 2

2.3 Description: This model focuses exclusively on the video camera's image data. The entire system will carry out its functions based on this. The whole system will initially be in a "non-Operating" status. A light-detecting system will be in operation around-the-clock to determine whether it is day or night. It is important in this situation since the system is activated when it receives the signal (night or dawn) from the LDR. All the components receive the proper power through a connected medium. Every light pole has the same configuration, style, wireless communication system, and energy-efficient dimmable LED lights. In the residential area of Dhaka, the 180-degree camera will only be installed on two poles at the beginning and end of the road. Adding to that, the poles will be divided into block communication/same light flow systems. So, when a moving vehicle arrives, the nearest pole’s LED will be activated with 80% brightness, along with the following next pole. The cameras will continuously monitor any moving object. If anything comes into its range, it will immediately detect an object and measure its distance of it from the camera and send this continuous data, via a wireless network system, to the processing unit. Then the system will send its command to the poles on what to do. The system will function based on the set program on the controller. The length of the road has been programmed into our software as well as the position of each pole's distance. We have set the range area for detection for each of the respective poles. When an object is detected and the distance of the object is measured, it will check if the measured distance falls according to the range of the pole, then the respective street lights illuminate at 100% intensity from 65%. And again, it goes back to 65% intensity when no object is detected during the given delay. All the data collected from this will be sent out and the lights controlled through a cloud server. This will be the strong link between the camera and the processing unit.

2.4 Analysis of Multiple Design Approaches

2.4.1 Design 1

Here we assumed that the lowest intensity is 50% and the highest intensity is 80%

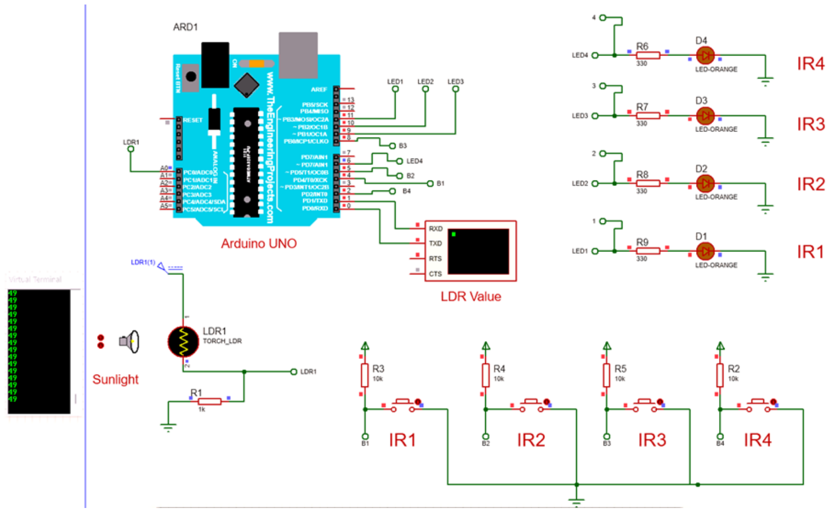
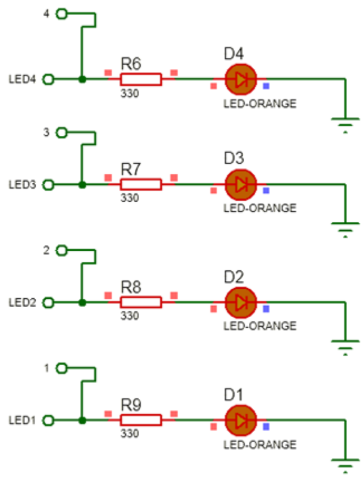
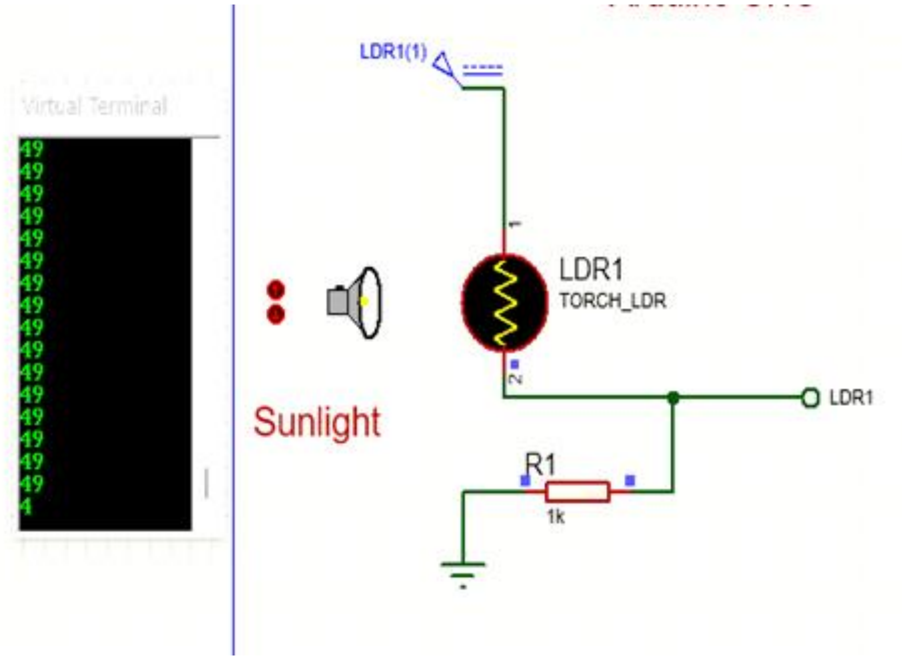


Figure: Simulation Design for the sensor-based system

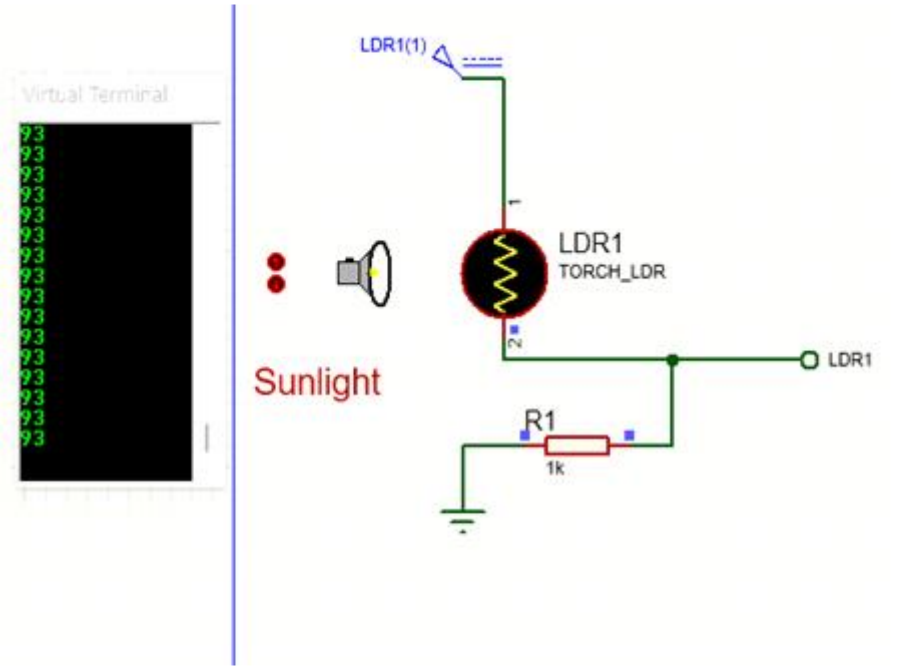
Here, we have used an Arduino UNO, LDR, led lights, and buttons which are functioning as IR sensors. The system is set in a way, where it will only get turned on when the LDR value is less than 50, in the simulation we can see the value is 49, and the system is functioning just as we want it to be. No button is pressed here, meaning no movement is detected by the IRs, that's why the LEDs are glowing at its 50% level.





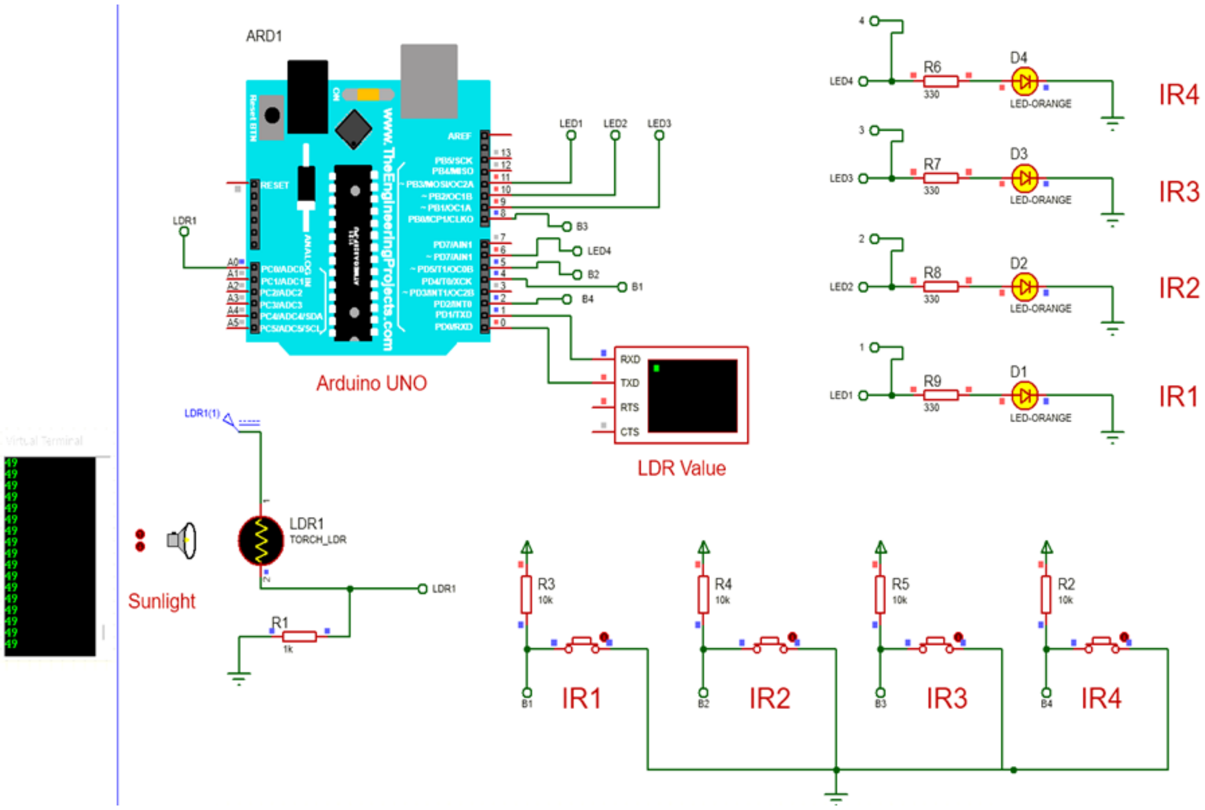
LDR value is set to 49<50

[Dusk & Night]

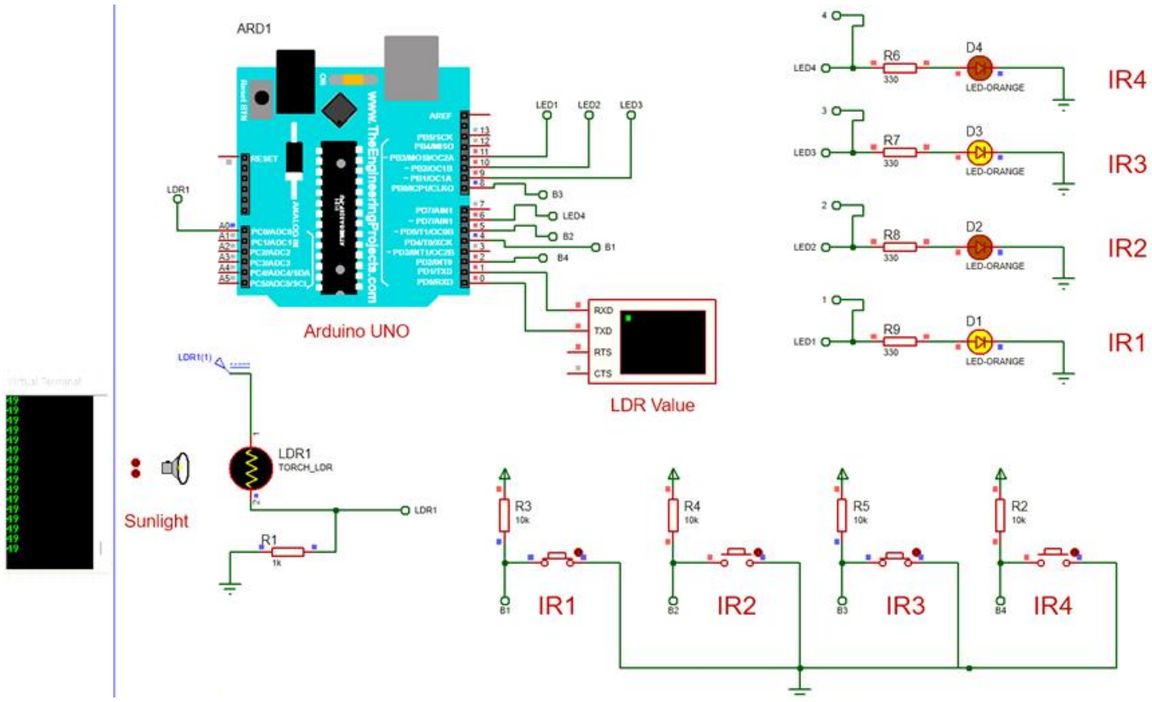


LDR value is set to 93>50

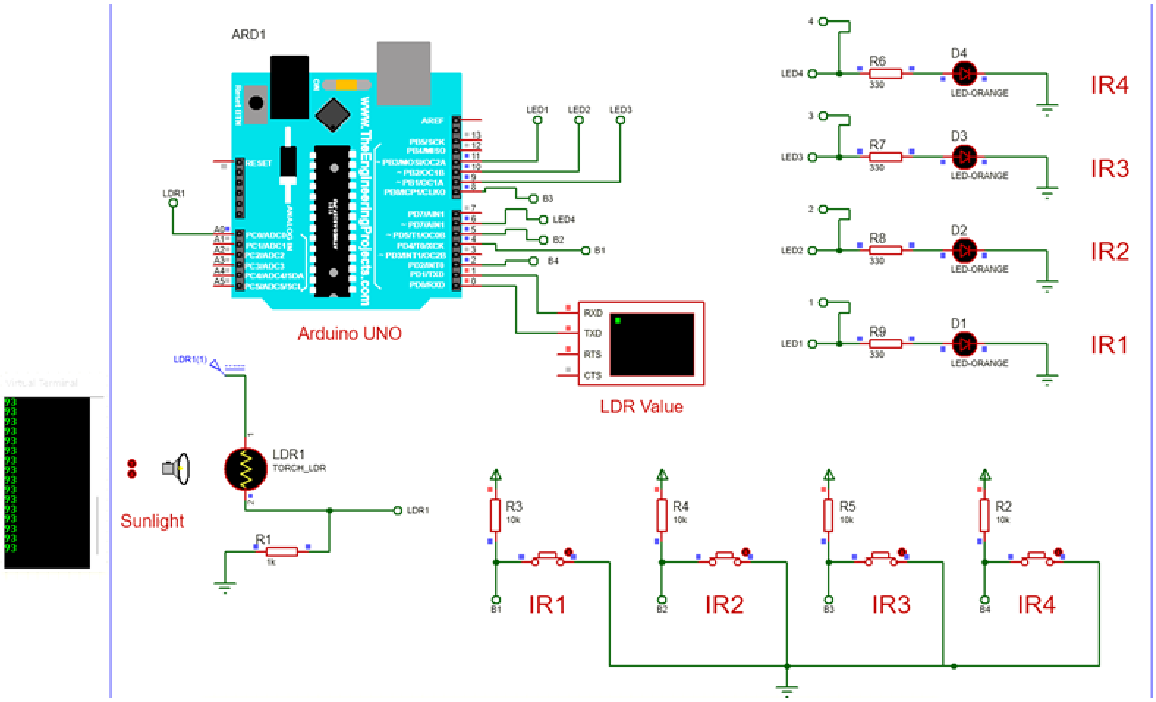
[Daylight]



Here, all the lights are glowing at 80% level, because in every pole the movement is occurring.



Here, the 1st and 3rd pole sensors are detecting movement, lights glow at 80% & at the 2nd and 4th ones no movement is present, that's why those lights have 50% brightness.



In this simulation, all the lights are off but the movement is present on the road because the LDR is set to 93 which is much higher than 50, meaning its day time, or the time of sunrise. There is enough light that requires no artificial lights on the road.

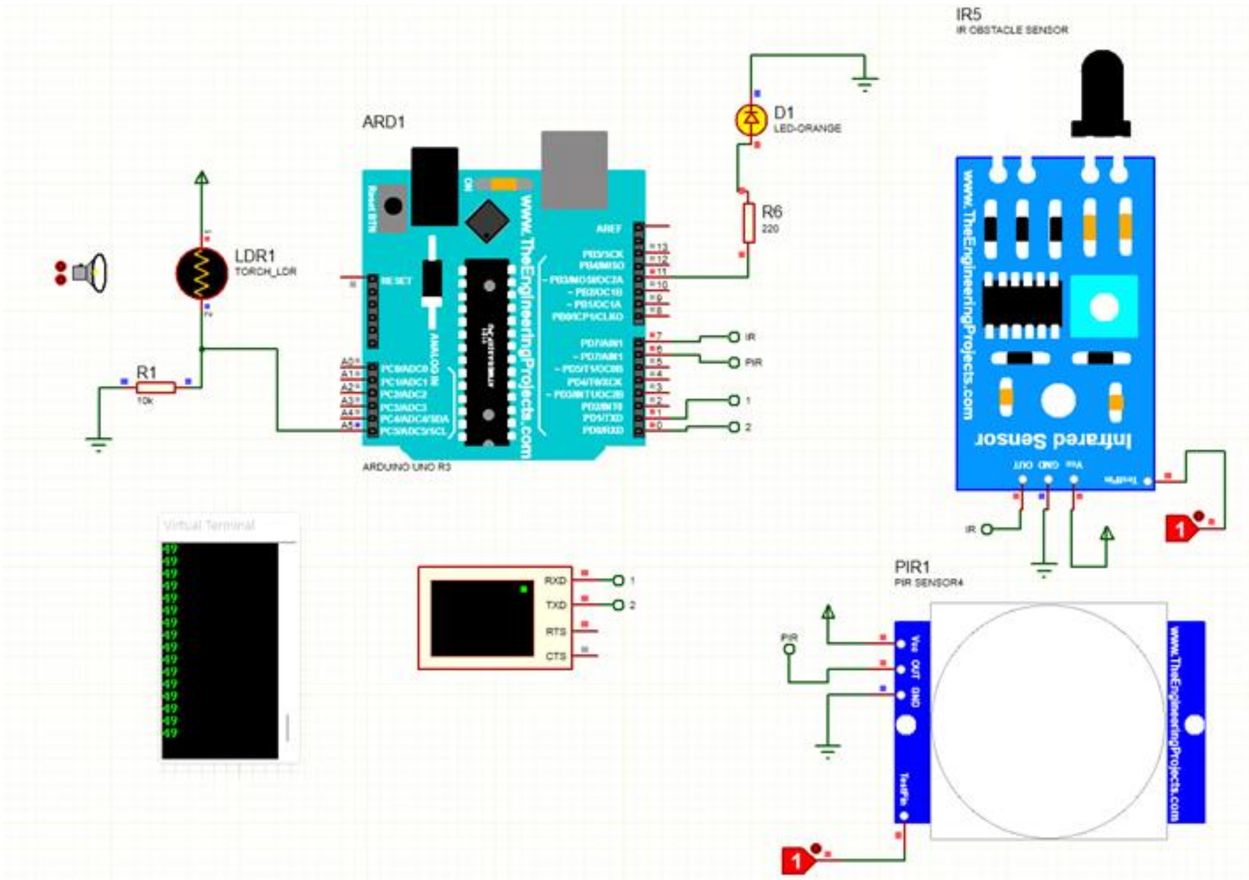
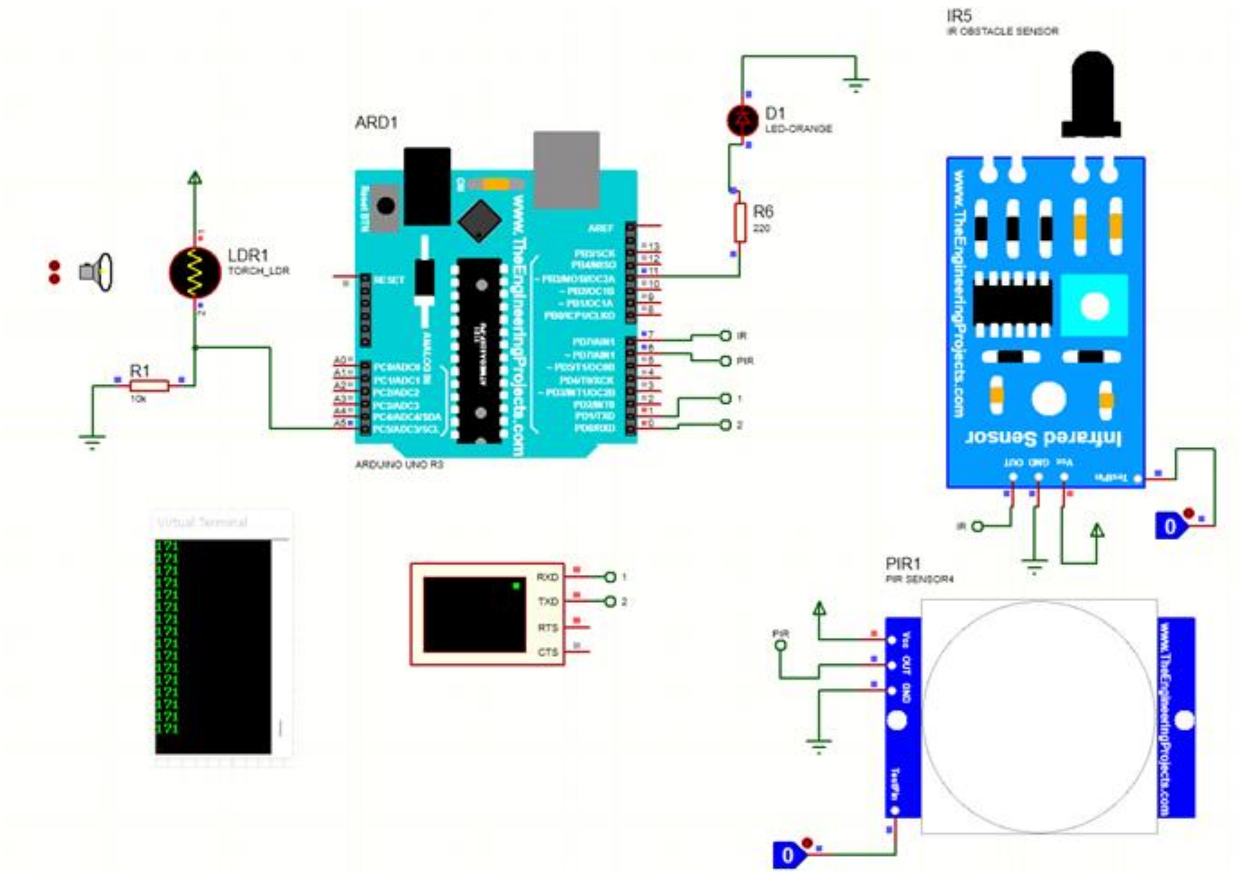


Figure: Simulation for a single pole

This is the circuit diagram for one pole, which presents an Arduino UNO, one IR, one PIR sensor, and one LDR for detecting light. After the night is detected by the LDR, the system gets power and immediately an IR, PIR sensor starts working, upon detection the lights will glow at 80% brightness with no movement then it will remain at 50%. The test value pins in IR and PIR sensors are set to 1, meaning objects detect others where they are within their range.



We can see that, the LDR value is 171 meaning its daytime. So, there is no power flow in that pole.

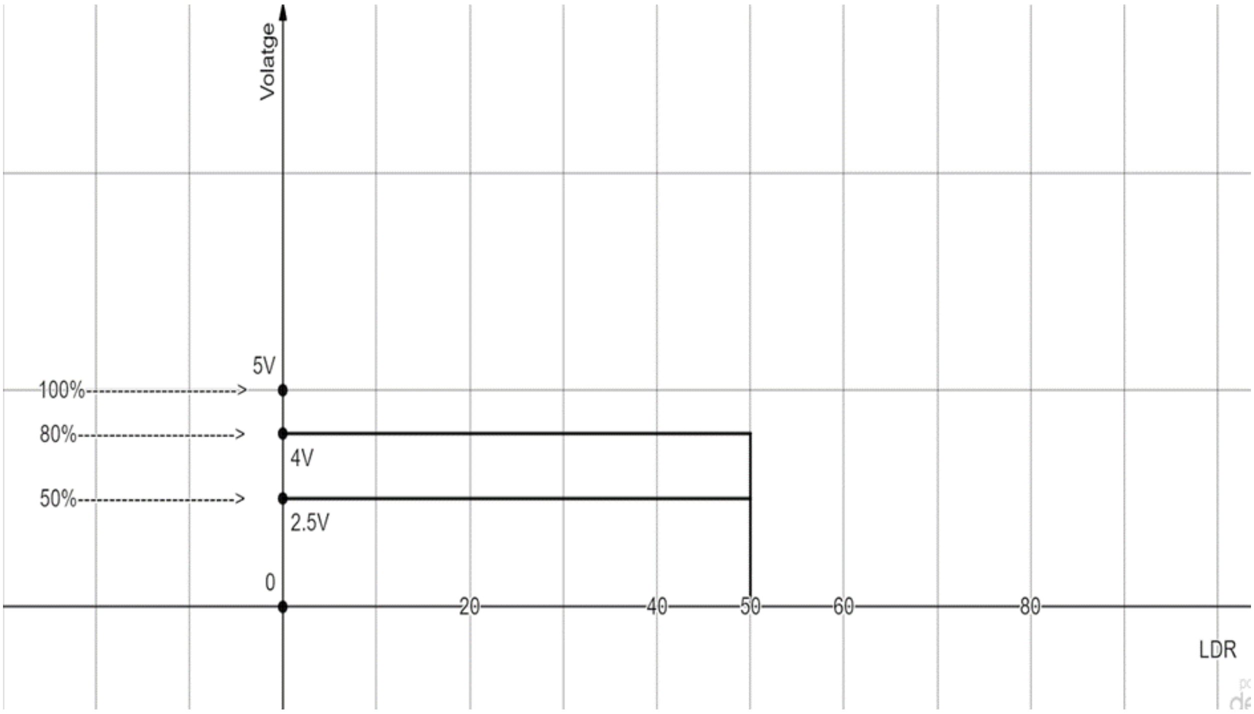


Figure: Graphical representation of Intensity percentage and voltage

The graph given above shows how the intensity of street light and voltage supply is interconnected in our design. First of all, we set the LDR threshold value to 50. That means when sunlight rises the LDR value over 50 the total system will turn off. When it is dark and the LDR value is below 50 the system will turn on.

In the X axis, we can see that when the light intensity is 80% which is our highest light intensity the voltage supply would be 4V. When the light intensity is 50%, in our normal condition, the voltage supply would be 2.5V. So, when the supply voltage is 2.5 it is less than 1.5V than the usual voltage supply. Thus, electricity consumption will be saved.

2.4.2 Design 2

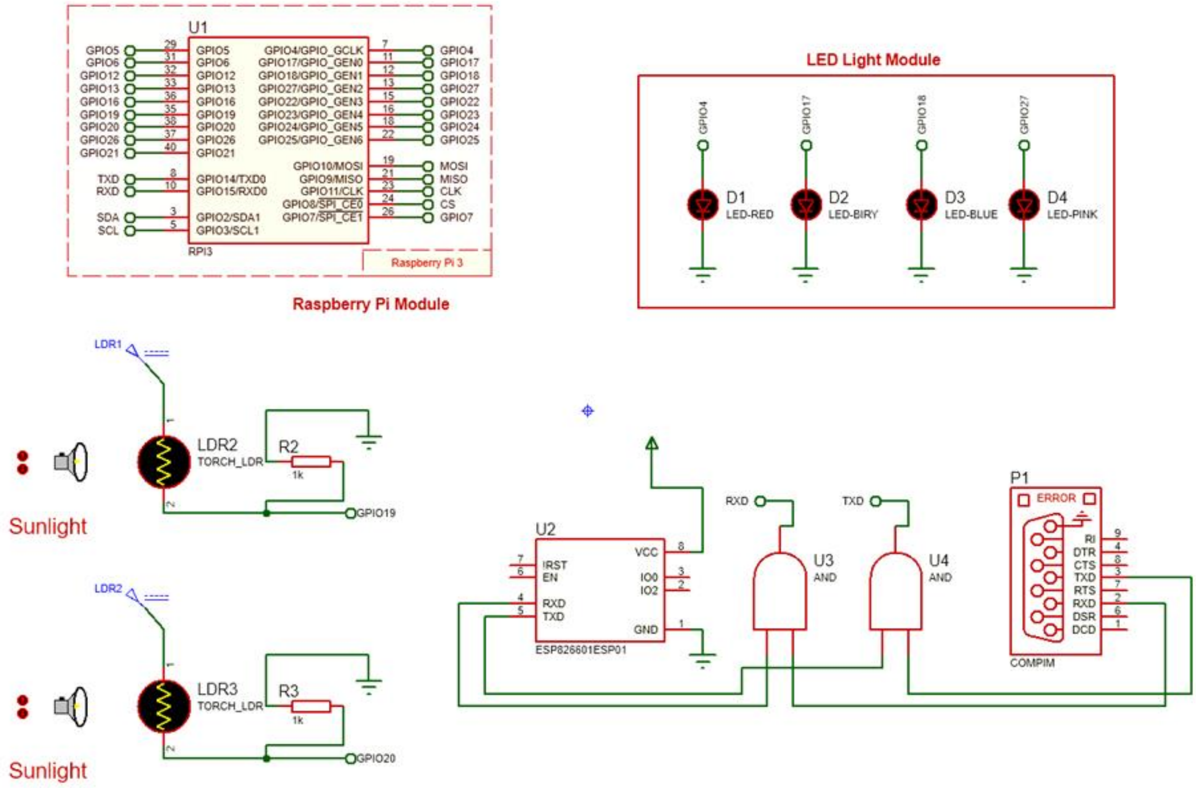


Figure: Circuit diagram

The connection diagram for our design 2 has been shown here. We have used the Raspberry Pi Module as our processing unit. We have used two Light Dependent Resistors where one of the LDR is connected if the first one fails to perform. An average threshold value has been set to 50 according to our preference. The processing unit has been programmed to work according to the object detection and distance measurement of an object. Each of the LED light modules shown here is represented a street on a light road. Each of the LED light modules has been programmed to increase the density D and lower the intensity according to the conditions of the road and all the commands for the respective LEDs have been carried out through the wireless module that we have used in our system.

Figure: Objection detection using the camera

Here in our program, we have used a 20-sec video of the road where people are walking by, and the presence of vehicles is also seen. And from the simulation result, we can see that using image processing can detect objects such as cars. A

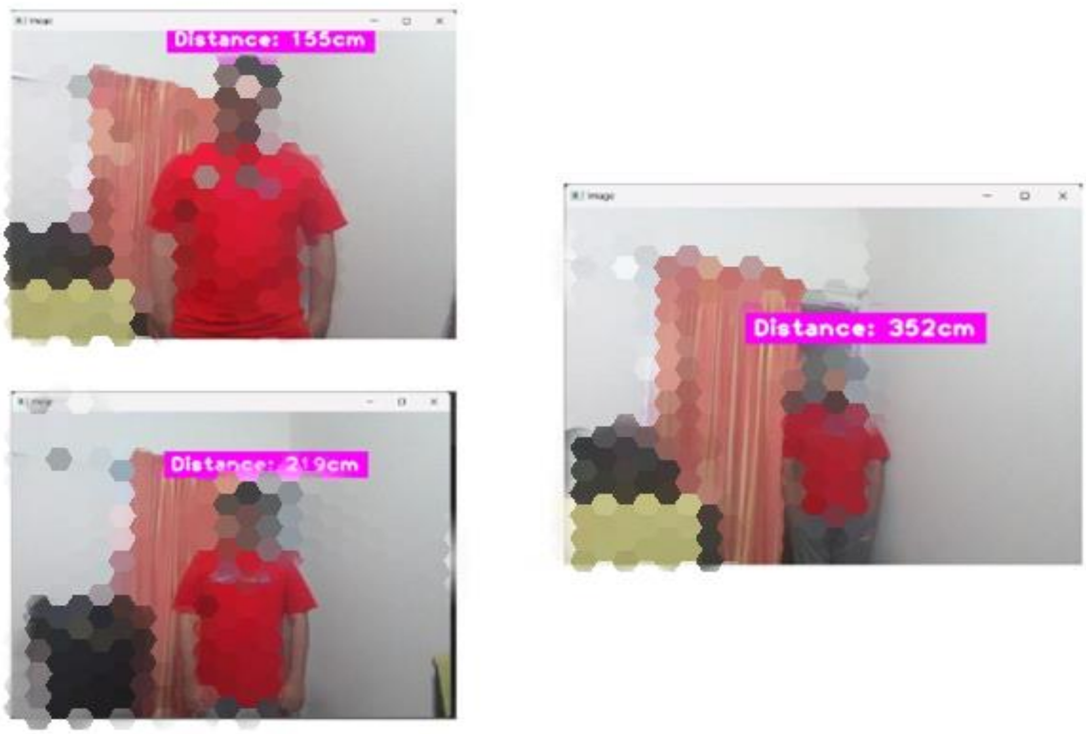


Figure: Object Measurement from Camera

Here we can see a person standing at different positions from the camera and the distance is measured and shown on the screen. The distance changes according to the movement of the person towards or away from the camera.

Depending on the various scenarios on the road we have conducted some simulations.

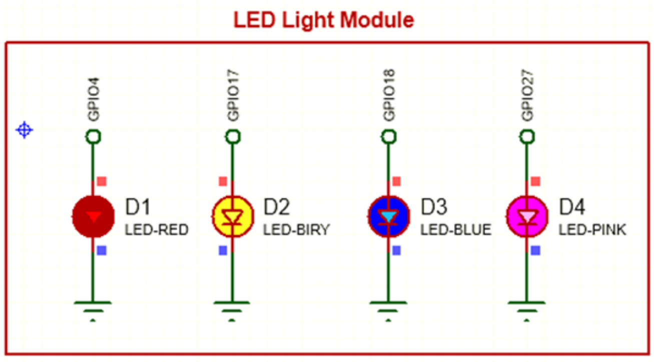


Figure: Scenario 1.

In this scenario, when heavy traffic is detected on the road, the camera will detect the presence of objects continuously, and thus all the LEDs representing the street lights will illuminate at 80% of their full intensity.

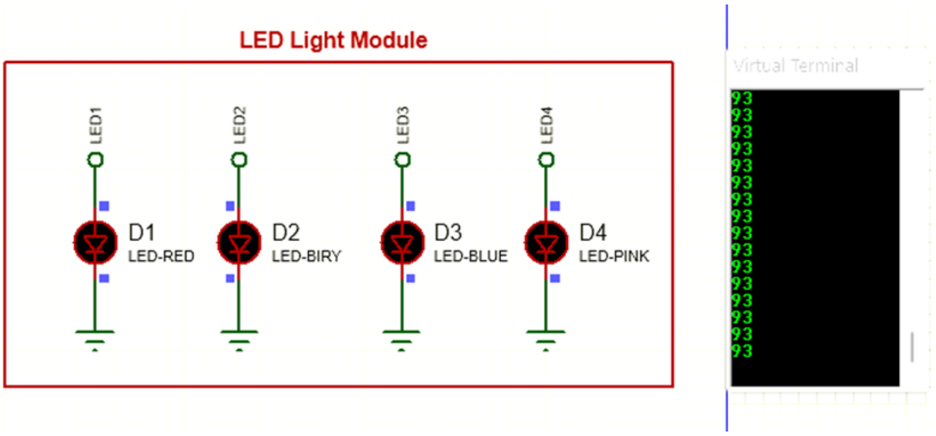


Figure: Scenario 2

In this scenario, on the right side we can see the threshold value of the LDR that we set at 50 is showing approximately 93 which is greater than the threshold set value. It indicates that the presence of sunlight is detected and so by default our system is turned OFF and all the lights are OFF as well.

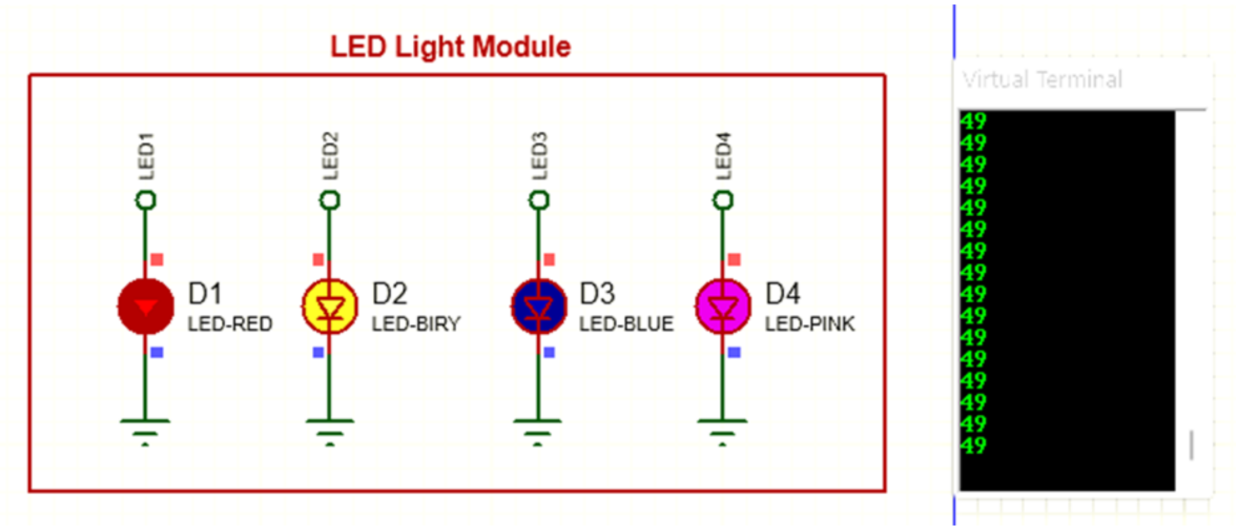


Figure: Scenario 3

In this scenario, when movement is detected near poles 1 and 2 represented as LEDs D1 and D2 then only those street lights illuminate at 80% intensity of their full brightness on the other hand since no activity is detected near D3 and D4 the intensity of the light is 50% therefore depending on the movement and detection object LEDs will glow at different intensity

2.5 Conclusion

Simulations were done on both of the proposed designs to ensure they are working. We accumulated lots of numerical and graphical data which will come in handy to decide the optimal design for our project. Furthermore, from these output results, we can distinguish whether any more optimization is needed for our design or not.

Chapter 3: Use of Modern Engineering and IT Tools. [CO9]

3.1.1 Introduction

One of the conditions of this part of the FYDP is to select modern engineering tools to design, develop and validate the solution. To validate the proposed solutions, we needed to go through a lot of background research to find out the best software tools we can use. We used two software tools here. To represent our project design which is a sensor-based system, we used Proteus.

3.2.1 Selection of appropriate engineering and IT Tools for software simulation

Table: Comparison Between different software

Software	Portable	Runs on Moderate PC specs	Import Facilities	Crash Issue	Free	Familiarity	Available Components
Proteus	Yes	Yes	Yes	Yes	No	Yes	Yes
MATLAB	Yes	No	No	No	No	Yes	No
TinkerCad	No	Yes	Yes	No	Yes	No	No
Pspice	No	Yes	No	No	No	No	No

To select the tools, we set up some criteria and marked them according to their potential. The software that we wanted to compare is Proteus, MATLAB, Tinker CAD, and Pspice. After analyzing all of the software and marking them we can see that Proteus is the most convenient software as it has most of the advantages.

3.3.1 Use of modern engineering and IT Tools for software simulation

Proteus: An exclusive toolset for automating electrical design is called the Proteus Design Suite. It is a Windows program for designing printed circuit boards (PCBs) and simulating schematics. Depending on the number of designs being created and the specifications for microcontroller simulation, it may be found in a variety of forms. An autoroute and fundamental mixed-mode SPICE simulation capabilities are included in all PCB Design solutions. The program is primarily employed by electronic design engineers and technicians to produce schematics and electronic prints for the production of printed circuit boards (PCBs) as well as a fast-prototyping tool for research and development.

In Proteus, we found almost all the components related to our project. Design 1 of our solution can be represented well enough through this tool. Proteus has a component named LDR which we used to turn on and off the whole system according to the source of light. Proteus gives us the accessibility to Arduino Uno which we used as our central processing unit. We can add our designed programming into Arduino Uno. In Proteus, we have LED lights which we represent as street lights.

To represent the IR sensor, we used switches in the proteus. Proteus also allows us to integrate PWM into the system to showcase the output variety

3.4.1 Conclusion

To summarize, Proteus is a flexible and user-friendly software simulation tool that provides several benefits for the creation and testing of electrical circuits and systems. I picked Proteus as my software simulation tool because it has a variety of functions that allow me to properly and effectively simulate, test, and debug my circuit designs. Proteus has a clear graphical user interface, robust simulation capabilities, and huge device libraries, allowing me to rapidly and efficiently develop and test complicated electrical systems. Proteus also includes full support for programming and debugging microcontrollers, as well as the ability to simulate microcontroller-based systems. Overall, I feel Proteus is a fantastic solution for software simulation in my project and will assist me in achieving my objectives successfully and quickly.

3.1.2 Introduction

The selection of hardware tools for developing a project is crucial in current times. The selection of hardware tools has a significant influence on the project's usefulness, efficiency, and performance. To guarantee that the project achieves its goals, it is critical to use hardware tools that are current, dependable, and simple to use. High-speed data processing, minimal power consumption, and wireless communication are just a few of the sophisticated features and capabilities available in today's hardware tools. They also provide simple integration with other systems and devices, allowing for continuous connection and operation. By employing current hardware tools for the project, we can ensure that it is developed using the most up-to-date technology, which can improve its performance, reliability, and usefulness.

3.2.2 Selection of appropriate hardware engineering and IT Tools

1. **LED lights**

Figure: Pictures of LED streetlights

**2.	Arduino Uno:**

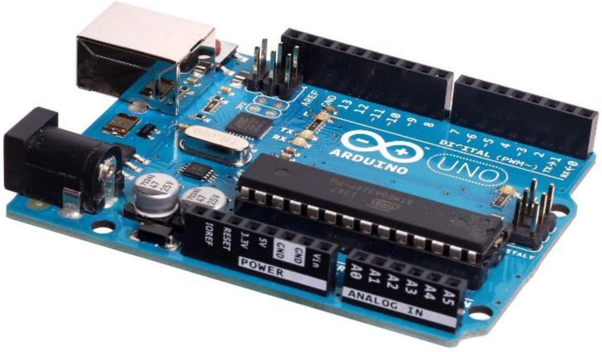


Figure: Picture of an Arduino Uno

**3.	PIR sensor**

Fig: Picture of a PIR sensor

**4.	IR sensor**

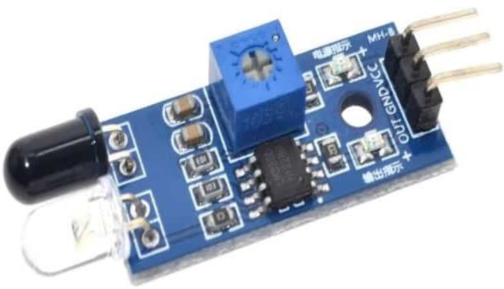


Fig: Picture of an IR sensor

5. **Buck converter**

Fig: Picture of a Buck converter

6. **Relay**

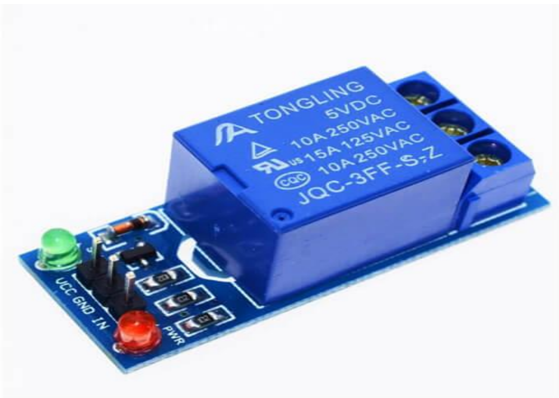


Fig: Picture of a Relay

7. **LDR**

Fig: Picture of an LDR

3.3.2 Use of modern hardware engineering and IT Tools

- **LED Lights:**

In our design, we must see LED lights as they save a lot of energy. We also can increase and decrease the intensity of the LED lights according to our required parameters. LED lights can range from 25W to 60W in our design.

- **Arduino UNO:**

Arduino Uno is a powerful microcontroller board that is quite useful in the building of a reliable and effective automatic light intensity control system. The Arduino Uno, with its advanced capabilities and simple interface, may be programmed to adjust the intensity of lights in a variety of ways, such as by using sensors or timers. Additionally, Arduino Uno may be used to communicate with additional hardware components, such as light sensors or relays, to improve system functionality. Furthermore, the Arduino Uno has several advantages, including low cost, a tiny form factor, and an easy-to-learn programming language, making it an excellent choice for quick prototyping and testing. We may take make of Arduino Uno's superior capabilities and flexibility in this project by employing it to construct an efficient and effective automatic light intensity regulating system that satisfies our project objectives.

- **PIR Sensor**

PIR sensors, or Passive Infrared Sensors, detect the presence of moving objects by detecting the infrared radiation they emit. We would utilize a PIR sensor in our project to detect the presence of people or vehicles moving in the vicinity and boost the light intensity to improve visibility and safety.

The PIR sensor detects variations in infrared radiation released by moving objects. When a person or vehicle travels inside the sensor's range, the sensor detects the change in infrared radiation and generates a signal that may be utilized to raise the light intensity. As a result, the system may deliver a suitable amount of illumination based on the number of people or cars in the area.

One of the primary benefits of employing a PIR sensor in our project is that it may assist save energy by only increasing the intensity of the light when necessary. Furthermore, the PIR sensor is readily linked with other system components such as microcontrollers or relays to produce a dependable and effective automated light intensity controlling system. Overall, the usage of a PIR sensor is an effective and practical option for detecting moving things and enhancing lighting in the area, making it a necessary component of our project.

- **IR sensor**

We would utilize an IR (Infrared) sensor in conjunction with a PIR (Passive Infrared) sensor in our project to detect both moving and stationary objects and regulate the light intensity accordingly. The IR sensor detects infrared radiation by emitting it and measuring its reflection from stationary objects. When a person is motionless, the PIR sensor detects no movement, but the IR sensor detects the person's presence and increases the light intensity.

The inclusion of an infrared sensor in our study is critical because it can identify stationery items that the PIR sensor cannot detect. This allows us to manage the intensity of the light even when there is no movement in the region, resulting in a more precise and efficient automated light intensity control.

Furthermore, an infrared sensor is a dependable and cost-effective alternative for detecting stationary objects. It is readily integrated with other system components, such as microcontrollers or relays, to give a smooth and efficient functioning. We can improve the safety and comfort of people in the region while conserving energy by integrating PIR and IR sensors into our project.

- **Buck Converter**

A buck converter would be used in our project to control the voltage and current delivered to the LED lights. A buck converter is a type of DC-to-DC converter that controls the voltage and current output using high-frequency switching. It operates by rapidly switching the input voltage on and off and then filtering the output voltage to obtain a constant DC value.

The use of a buck converter is critical in our project because it allows us to control the voltage and current delivered to the LED lights, ensuring that they work at their best. We can prevent LED lights from being overloaded and preserve their longevity by managing the voltage and current.

A buck converter is also a more energy-efficient solution than standard linear regulators since it wastes less energy in the form of heat. This implies our project will be able to run more effectively and conserve energy.

- **Relay**

A relay is employed in our project to manage the power supply to the LED lights. It operates by opening or closing a circuit with an electromagnetic switch, enabling or inhibiting the passage of electrical current. The relay is linked to the microcontroller and is controlled by the PIR and IR sensors' input. When the sensors detect movement or a stationary item, the relay activates, allowing electricity to flow to and increasing the intensity of the LED lights. In our project, the use of a relay guarantees that the LED lights are regulated properly and effectively, leading to a more sustainable and environmentally friendly lighting system.

- **LDR**

In this project, we will use an LDR (Light Dependent Resistor) to switch on and off the lighting system automatically. The LDR detects changes in ambient light intensity and adjusts its resistance accordingly. When there is inadequate light (i.e., when it is dark), the LDR's resistance increases, causing the system to switch on the LED lights. When there is enough sunshine, the LDR's resistance diminishes, and the system switches off the lights. This automatic method guarantees that the lighting system is only activated when necessary, conserving energy and contributing to a more sustainable environment. Furthermore, the use of an LDR eliminates the need for manual lighting system control, increasing convenience and lowering maintenance requirements.

3.4.2 Conclusion

The selection of contemporary hardware tools is crucial to the success of our project's execution. We chose tools like the Arduino Uno, PIR sensor, IR sensor, Buck converter, LDR, and Relay because they provide a variety of capabilities and functions that are critical for the effective and long-term administration of the lighting system. We can automate the lighting system by monitoring and responding to changes in light levels and movement in real-time utilizing these contemporary hardware tools. This automation increases energy efficiency, minimizes maintenance needs, and provides a more sustainable and environmentally friendly lighting system. Furthermore, the utilization of current hardware tools such as the Arduino Uno provides a flexible and scalable framework for future lighting extension or customization.

Chapter 4: Optimization of Multiple Designs and Finding the Optimal Solution. [CO7]

4.1 Introduction

Optimization of multiple design options is an important process in engineering and design, as it allows for the identification of the most effective solution to a problem based on specific criteria. In the case of street lighting systems, different designs can offer varying levels of accuracy, cost-effectiveness, social impact, and ease of maintenance. In this context, it is essential to evaluate multiple design options and determine which one is the most optimal based on the needs of the project. In this analysis, we will consider two different designs for a street lighting system, Design-1, and Design-2, and explore their strengths and weaknesses. By comparing and contrasting these designs in terms of their accuracy, cost, social impact, and ease of maintenance, we aim to identify the optimal solution for a street lighting system that meets the requirements of our project.

4.2 Optimization of multiple design approach

Optimizing multiple design options involves a systematic approach to evaluating each design based on specific criteria and determining the most optimal solution for a given project. In the case of street lighting systems, this involves considering factors such as accuracy, cost, social impact, and ease of maintenance when evaluating the different design options.

For Design-1, the approach to optimization would involve evaluating the accuracy of the sensor system, the cost of the components, the social impact of the system on the community, and the ease of maintenance of the system. This would involve analyzing data related to the performance of the sensors in detecting objects and adjusting lighting levels, as well as estimating the cost of the sensors, wiring, and other components necessary for the system. Additionally, social impact factors such as energy consumption, light pollution, and community feedback would need to be considered. Finally, the ease of maintenance would be evaluated based on the complexity of the system, the frequency of required maintenance, and the skills necessary to perform maintenance tasks.

For Design-2, the optimization approach would be similar but would involve evaluating different factors specific to image processing technology. This would include assessing the accuracy of the image processing system in detecting objects and adjusting lighting levels, estimating the cost of the cameras, processors, and software necessary for the system, and considering the social impact of the system on the community. Additionally, the ease of maintenance would be evaluated based on the complexity of the image processing technology, the frequency of required maintenance, and the skills necessary to perform maintenance tasks.

Ultimately, the optimization approach for both designs would involve gathering data on the performance, cost, social impact, and maintenance requirements of each design, and then analyzing this data to determine which design is the most optimal for the specific needs of the project. This may involve weighing the trade-offs between accuracy, cost, social impact, and ease of maintenance to arrive at the most optimal solution.

4.3 Identify optimal design approach

To identify the optimal design approach for a street lighting system, it is necessary to compare and evaluate the strengths and weaknesses of each design based on specific criteria. In the case of Design-1 and Design-2, this involves considering factors such as accuracy, cost, social impact, and ease of maintenance.

Based on the evaluation of these criteria, the optimal design approach will depend on the specific needs of the project.

Accuracy

Design-1 uses simple sensors, namely the LDR IR sensor and PIR sensor, to detect the presence and movement of objects in their range. These sensors are designed to detect changes in light and heat, respectively, and can be used to trigger the street lights to turn on or adjust their brightness. Because the sensors have a limited range and respond to specific stimuli, they are less prone to errors than more complex systems. The advantage of Design-1 is that it is a simple and reliable system. The sensors are easy to install and require minimal maintenance, and the system can be programmed to adjust the brightness of the lights based on the specific needs of the location. For example, the lights can be set to turn on at a certain time o day or to dim when there is no movement detected.

Design-2, on the other hand, uses image processing to detect objects and calculate their distance from the street lights. This is a more complex system that requires specialized hardware and software and is more prone to errors. Image processing relies on complex algorithms to identify objects and calculate their position, which can be affected by factors such as lighting, weather conditions, and camera quality. If the distance measurement is not precise, the system may adjust the brightness of the wrong street light, which could lead to unnecessary energy consumption. The advantage of Design-2 is that it provides more precise control over the street lights. The system can be programmed to adjust the brightness of the lights based on the distance of the objects detected, which can be useful in areas with high pedestrian traffic or where cars are driving at high speeds. However, the complexity and cost of the system may outweigh these benefits.

In summary, Design-1 is a simple and reliable system that uses sensors to detect the presence and movement of objects, while Design-2 is a more complex system that relies on image processing to detect objects and calculate their distance. While Design-2 provides more precise control over the street lights, it is also more prone to errors and is more costly to implement and maintain. Ultimately, the decision between the two designs will depend on the specific needs and constraints of the project.

Cost

Design-1, which uses an LDR IR sensor and PIR sensor, is generally a more cost-effective solution compared to Design-2, which relies on image processing. The sensors used in Design-1 are relatively inexpensive and can be easily integrated into the street light system. The installation and maintenance costs associated with Design-1 are also relatively low, as the system is simple and does not require a lot of specialized expertise or equipment. This makes Design-1 an attractive option for locations where budget is a major concern.

Design-2, on the other hand, is typically more expensive to implement and maintain due to the complexity of the system. The image processing technology used in Design-2 requires specialized hardware and software, which can be costly to purchase and install. The cameras used in the system must also be high quality, which adds to the cost. In addition, the system requires regular maintenance and updates to ensure that it continues to function correctly. All of these factors contribute to a higher overall cost for Design-2 compared to Design-1.

In conclusion, while Design-2 may provide more precise control over the street lights, it is generally more expensive to implement and maintain compared to Design-1. Therefore, the decision to choose between the two designs will depend on the specific budget and cost constraints of the project.

Social Impact

Design-1, which uses the LDR IR sensor and PIR sensor, provides a relatively simple and cost-effective solution for street lighting. By automatically adjusting the brightness of the lights based on the presence or absence of people, the system can help to reduce energy consumption and carbon emissions, while also improving safety and security for pedestrians and drivers. This can be particularly beneficial in areas where there are limited resources for street lighting, or where traditional lighting systems are not practical or effective.

Design-2, which relies on image processing technology, can also have significant social impacts. By providing more precise control over the brightness of the lights, the system can help to reduce light pollution and minimize the disruption caused by bright street lights. This can improve the quality of life for people living in urban areas, as well as reduce the impact of artificial lighting on wildlife and ecosystems. Additionally, the use of advanced technology in street lighting can help to create a more innovative and modern image for the city, which can have positive impacts on tourism, investment, and economic growth.

However, there are also potential social impacts to consider for both designs. For example, the use of sensors and cameras in street lighting systems can raise concerns about privacy and surveillance, particularly if the data collected is not properly secured or managed. Additionally, there may be concerns about the reliability and durability of the technology used in the systems, particularly in areas with extreme weather conditions or high levels of vandalism.

In conclusion, both Design-1 and Design-2 can have significant social impacts, but these impacts will depend on how the systems are designed, implemented, and managed. It is important to carefully consider the potential benefits and drawbacks of each design, as well as the specific social, economic, and environmental context in which the systems will be deployed, to ensure that they contribute to positive outcomes for communities and society as a whole.

Ease of Maintenance

Design-1, which uses an LDR IR sensor and PIR sensor, is generally considered to be relatively easy to maintain. The sensors used in the system are typically durable and can withstand exposure to the elements, meaning that they should not require regular cleaning or replacement. Additionally, the system is designed to be self-regulating, meaning that it should be able to operate autonomously with minimal intervention from maintenance staff.

However, there may be some maintenance requirements associated with the power supply and wiring for the system. For example, the system may need to be periodically inspected to ensure that the wiring and connections are in good condition and that there are no issues with the power supply or battery backup. Additionally, the sensors themselves may need to be occasionally calibrated or adjusted it maintain optimal performance. Design-2, which relies on image processing technology, can be more complex to maintain. The cameras and processors used in the system can be sensitive to environmental conditions, such as changes in lighting or weather conditions, which can impact the accuracy and reliability of the system. Additionally, the software used to analyze the images and control the lighting may require periodic updates or adjustments in order optimal performance. Maintenance for Design-2 may also require a higher level of technical expertise compared to Design-1. For example, maintenance staff may need to have specialized skills in image processing and software programming to affect and resolve issues with the system.

In conclusion, while both designs have maintenance requirements, Design-1 may be easier to maintain due to its simplicity and self-regulating nature. Design-2 may require more specialized skills and equipment for maintenance, but the level of maintenance required will depend on the specific components and technology used in the system. Ultimately, proper planning, training, and maintenance schedules can help to ensure that both designs are maintained effectively and efficiently over time.

4.5 Conclusion

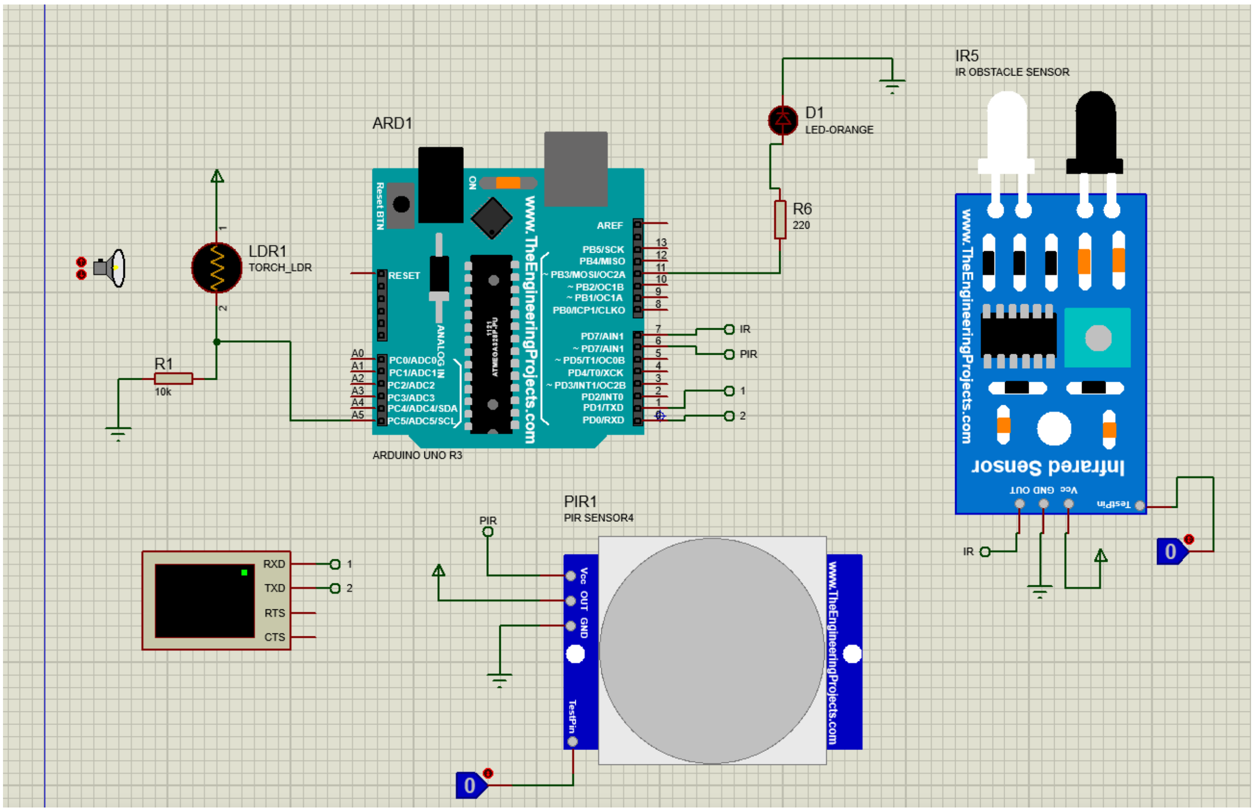
To evaluate the performance of the developed solution for the street lighting system, we assess its performance against the original design criteria, which include accuracy, speed, cost, social impact, and ease of maintenance. For accuracy, we evaluate how well the solution detects the presence of objects and adjusts lighting levels accordingly. In the case of Design-1, we assess the reliability of the LDR, IR, and PIR sensors in detecting objects accurately. For Design-2, we evaluate the performance of the image processing technology in detecting objects and adjusting lighting levels accurately. Speed is another important factor to consider when evaluating the performance of the developed solution. We measure the time it takes for the system to detect an object and adjust lighting levels accordingly. In addition, we evaluate the response time of the system to changing conditions, such as changes in ambient light levels or movement of objects. Cost is also an important consideration when evaluating the performance of the developed solution. We compare the cost of the system, including the cost of components, installation, and maintenance, with the original design and other similar systems in the market. Social impact is another important factor to consider when evaluating the performance of the developed solution. We evaluate the impact of the system on energy consumption, light pollution, and safety. The system is designed to minimize light pollution and energy consumption while ensuring safety and security. Finally, ease of maintenance is an important consideration when evaluating the performance of the developed solution. The system should be easy to maintain, with minimal downtime and easy access to components for replacement or repair. Overall, the performance of the developed solution is evaluated based on a comparison with the original design criteria and industry standards. The evaluation considers all relevant factors, including accuracy, speed, cost, social impact, and ease of maintenance, to ensure that the developed solution provides the best balance of these factors.

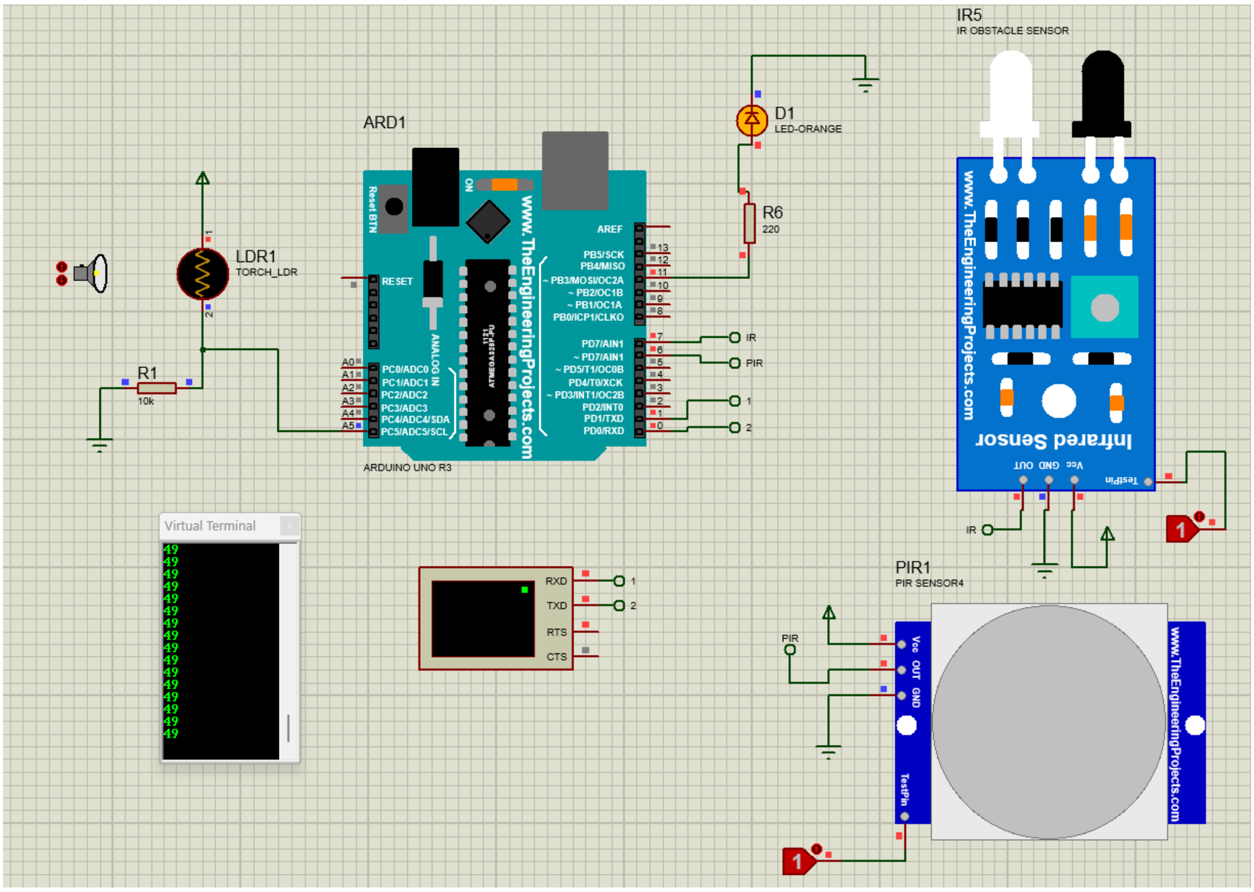
Chapter 5: Completion of Final Design and Validation. [CO8]

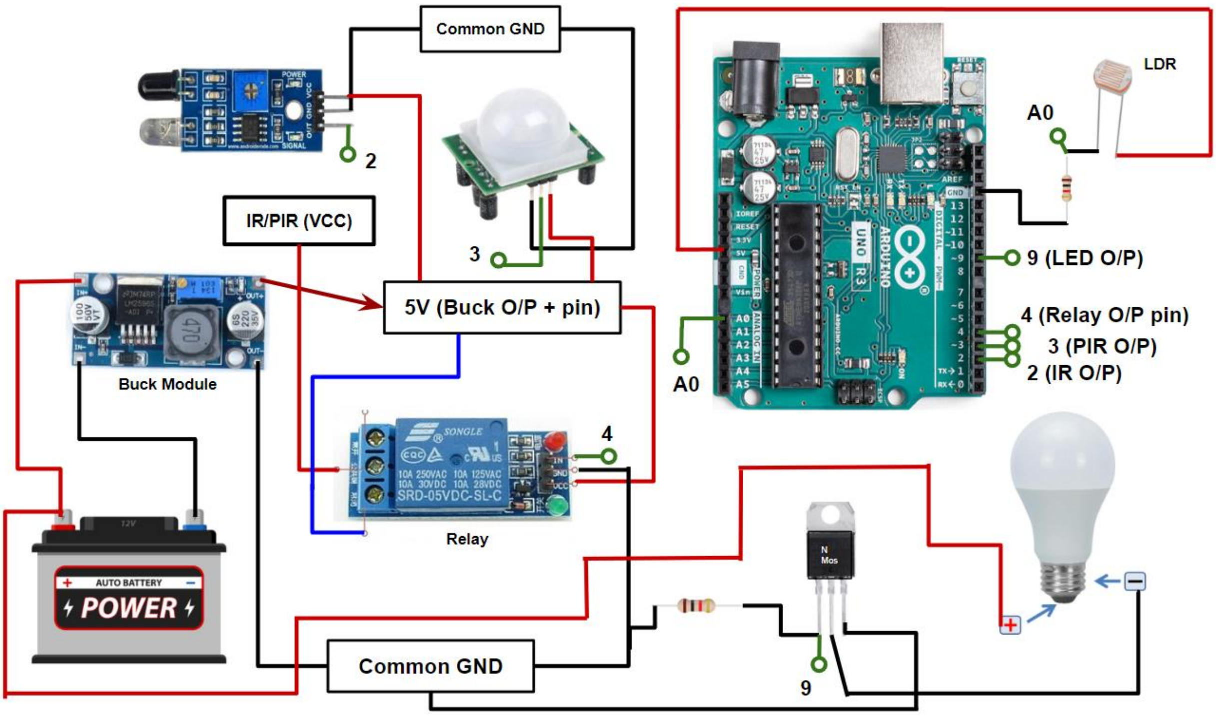
5.1 Introduction

Design-1 is a street lighting system that utilizes the LDR IR sensor and PIR sensor to provide efficient and accurate object detection and adjust the brightness of lights accordingly. This project has gone through various stages of development, from the initial design concept to the optimization of multiple designs to find the optimal solution. The final design has been developed and validated, ensuring that it meets the design criteria and industry standards for accuracy, speed, cost-effectiveness, social impact, and ease of maintenance. In this report, we will discuss the details of the final design and the validation process, highlighting its key features and benefits.

5.2 Completion of the final design




ARD1
LDR1
TORCH_LDR
R1
10k
D1
LED-ORANGE
R6
220
IR5
IR OBSTACLE SENSOR
PIR1
PIR SENSOR4
Virtual Terminal
ARDUINO UNO R3
www.TheEngineeringProjects.com
Infrared Sensor
RXD
TXD
RTS
CTS
IR
PIR


Common GND
IR/PIR (VCC)
5V (Buck O/P + pin)
Buck Module
Relay
LDR
A0
9 (LED O/P)
4 (Relay O/P pin)
3 (PIR O/P)
2 (IR O/P)
2
3
4
9
Common GND
POWER

This design is built to operate seamlessly once the Light Dependent Resistor (LDR), a light-detecting sensor, detects a darker environment. Initially, the Arduino and LDR sensors operate independently, but once the LDR detects darkness, the relay switch activates, and power flows through the Infrared Obstacle Sensor and Passive Infrared Sensor, initiating the full system to function.

The system commences motion detection, and when the Passive Infrared Sensor (PIR) detects movement, the LED light illuminates to its maximum brightness level, providing a 180-degree viewing angle within its detecting zone. Upon detection, the light remains at full brightness and gradually starts dimming down to 65% brightness.

Regarding the Infrared Obstacle Sensor, it only sends a command to the LED light if an object obstructs its front path, such as an individual standing in front of a street pole. When this happens, the system runs the same functions as when PIR detects movement. The N-Mosfet is connected to the LED to allow it to function like dimming, utilizing Pulse Width Modulation (PWM).

5.3 Evaluate the solution to meet the desired need

The sensor-based street lighting system has been designed to meet the desired needs of an efficient and sustainable lighting solution. The use of IR and PIR sensors ensures accurate object detection, allowing the system to adjust the lighting levels based on the presence or absence of people or vehicles. This feature improves energy efficiency and reduces light pollution, which is beneficial for both the environment and the community.

The system uses a relay as a switch to turn on the lights, which is a reliable and cost-effective solution. It allows the system to be controlled by the sensors, ensuring that the lights are only turned on when needed, further improving energy efficiency and reducing maintenance costs. Moreover, the use of LED lights in the sensor-based system provides a high-quality lighting solution that is long-lasting and cost-effective. LED lights require less maintenance than traditional lighting solutions, reducing maintenance costs and minimizing the need for frequent bulb replacements.

Overall, the sensor-based street lighting system provides an efficient, sustainable, and cost-effective solution that meets the desired needs of a street lighting system. It offers accurate object detection, efficient lighting adjustment, cost-effectiveness, minimal social impact, and ease of maintenance, all while meeting industry standards and criteria.

Validation:

Test Results-

We completed building the prototype according to our proposed design approach and went for testing with the proper setting.

There were three scenarios we tested for.

1. The LED lights would be at 100% intensity and there would not be any movement detection
2. The LED lights would be at 65% intensity and there would not be any movement
3. The system runs according to our design and there would be intensity controlling based on movement detection

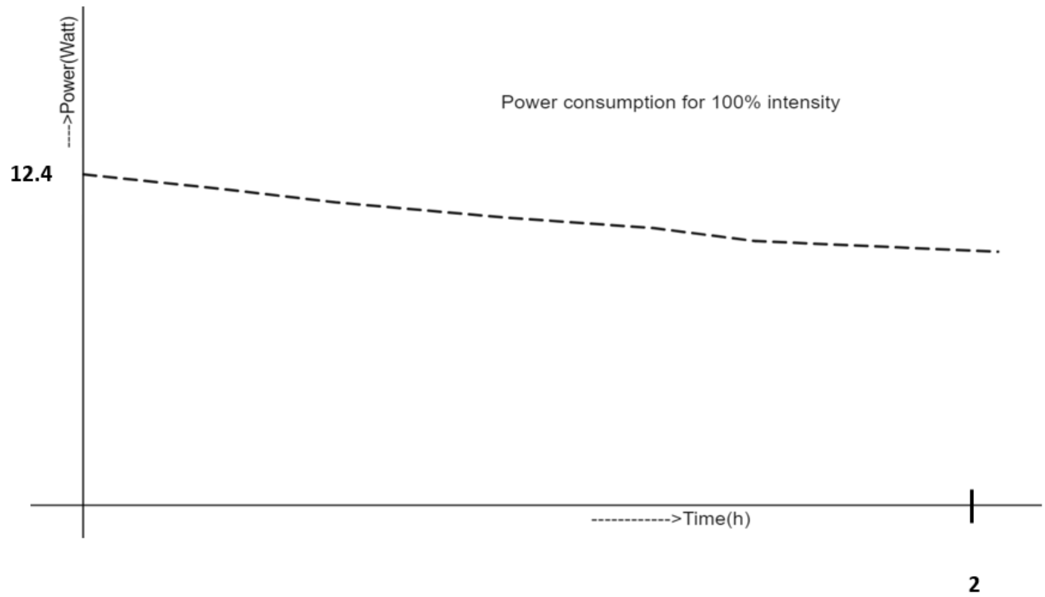
After running the system for several hours, we got the following results-

Test results

Light Intensity (%)	Voltage supplied (V)	Current drawn (A)	Power consumed (W)	Time battery lasted for (Hour)
100	15	0.83	12.4	2
65	15	0.34	5.1	3
Normal condition	15	-0.83 for 100% -0.34 for 65%	-12.4 for 100% -5.1 for 65%	2.5

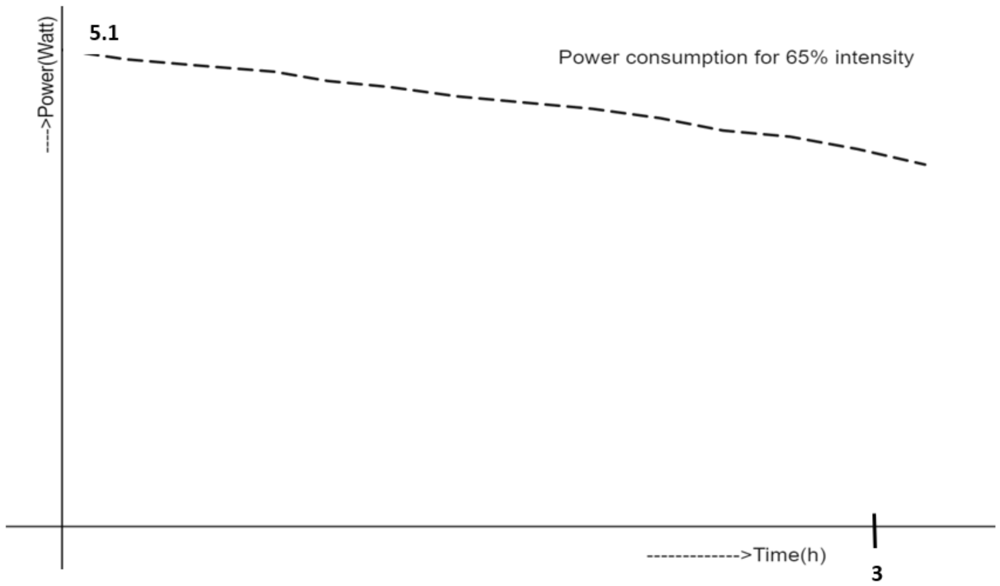
Table: Prototype Test Results

Case-1(For 100%):



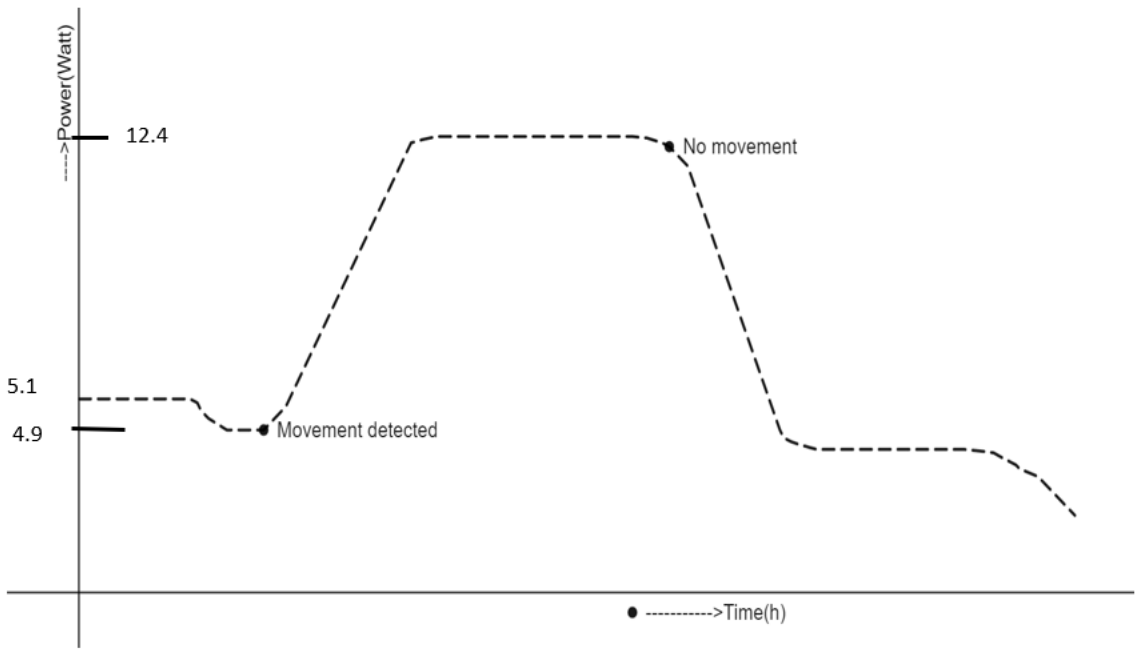
In this case, we ran the whole system at 100% intensity and there would not be any movement detection. While supplying 15V voltage to the system the current rating was 0.34A. So, the power consumption we were getting was 5.1W. So, with increasing time the power dropped gradually and the battery lasted for around 3 hours. We observed that when the light intensity is kept low

Case-2(For 65%):



In this case, the light intensity was kept at 65% which is the lowest intensity we kept for our design approach and there would not be any movement detection. While supplying 15V voltage to the system the current rating was 0. A. So, the power consumption we were getting was 12.4W. So, with increasing time the power dropped gradually and the battery lasted for around 2 hours. We observed that when the light intensity is kept low the battery lasted for long as we were saving power.

Case-3(For normal condition):



At last, we tested for normal conditions where the light intensity would be normally 65%, and when there would be any movement detection the intensity would rise to 100%. We observed that when there is no detection the power consumption is 5.1W and when there is any detection the power consumption rises to 12.4W. This condition gives us battery backup for 2.5 hours which is greater than when kept at full intensity.

5.4 Conclusion

In conclusion, the completion of the final design and validation of Design 1, a street lighting system using LDR, IR, and PIR sensors, has been successfully achieved. The design process involved a thorough analysis of the problem statement, consideration of various design options, and systematic optimization to achieve the optimal solution that meets the design criteria. The design solution provides accurate object detection, efficient lighting adjustment, and cost-effectiveness while also being socially responsible and easy to maintain. The final design has been validated through performance evaluation, which confirmed that it meets the design criteria and industry standards for accuracy, speed, cost, social impact, and ease of maintenance. The successful completion of this project highlights the importance of a well-structured design process that emphasizes optimization and validation. The project has demonstrated the significance of the application of appropriate tools and techniques in the design process, which is crucial in achieving the optimal solution. Furthermore, the project highlights the importance of performance evaluation in determining the effectiveness of the solution and identifying areas for further improvement.

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

Impact analysis and project sustainability are two major parts of a project which are intertwined with each other. To figure out the planned and unplanned social, economic, environmental, and political impacts of the project, impact analysis is used. However, project sustainability is about making the desired benefits of the project viable, even after the project has ended. Thus, through impact analysis the potential danger and challenges are identified that may hamper the sustainability of the project, and then necessary steps are taken to diminish the threats and make the project more sustainable.

6.2 Assess the impact of the solution

Impact	**Impact details**
Environmental	• No toxic waste will be released • Reduced light pollution after midnight
Social	• Cost saving
Legal	• To implement our design on the streets of Dhaka certain rules and guidelines must be followed that are imposed by Dhaka City Corporation
Cultural	• Our system does not affect any culture or norm in the society

Economic	• Less energy is consumed, so the electricity bill will be significantly less • The equipment used is compact and comparatively less expensive • The components have a longer lifetime so the cost of maintenance will be low
Financial	• The street light system is an essential part of modern society. So, there is a good chance of getting financial support to implement this system which will make the street lights smart.
Safety	• The intensity of light is only reduced to 35% of the rated intensity to allow pedestrians to see through the whole road.

Table: Impact Analysis

1. Economic impact:

- No toxic waste will be released
- Reduced light pollution after midnight

The components used in this project do not emit any substance in the environment that is harmful. Moreover, we see that if the lights stay at full intensity all night it might irritate the nearby household as they are trying to sleep and high intensity might hamper their sleep.

2. Social impact:

    - Cost saving

Street lighting systems that use less energy might result in cost savings for both the local government and the community. Municipalities may shift funds to other crucial services and infrastructure development by cutting back on their use of power. Additionally, cost savings could be transferred to residents in the form of lower utility costs.

3. Legal impact:

    - To implement our design on the streets of Dhaka certain rules and guidelines must be followed that are imposed by Dhaka City Corporation.

    To mount our devices on the poles of street lights it is necessary to take permission from the Dhaka City Corporation as the responsibility of these poles falls under their jurisdiction. Moreover, placing the devices is a time-consuming process and to complete our work without creating any problems for the people we will need the authority's help. Also, after installing the devices we will hand over the control of the system to the Dhaka City Corporation so it is important to cooperate with them.

4. Cultural impact:

    - Our system does not affect any culture or norm in the society

5. Economic impact:

    - Less energy is consumed, so the electricity bill will be significantly less
    - The equipment used is compact and comparatively less expensive
    - The components have a longer lifetime so the cost of maintenance will be low

    Here, the power output is lessened which means less electricity is being consumed and the electricity bill will also be less. The components that are used to build our devices are small in size and they are not much expensive so this indicates that the project is cost-friendly. Furthermore, the equipment can operate for a long time without any hindrance so the equipment will not need to be replaced that often as well as the maintenance cost will be reduced.

6. Financial impact:

    - The street light system is an essential part of modern society so there is a good chance of getting financial support to implement this system which will make the street lights smart.

To implement any project the most important aspect is to receive funds and if the addressed problem is considered severe, which needs to be handled as soon as possible, the investors are more likely to fund the project. Bangladesh is entering the stage of being a smart country and for that to happen the capital city Dhaka needs to become a smart city. One of the steps to do it is by implementing our device, which will make the street lights smart.

7. Safety impact:

- The intensity of light is only reduced to 65% of the rated intensity to allow pedestrians to see through the whole road.

Typically, there is no foot traffic after midnight, and due to that reason, it is normal to suggest that the street light should be turned off. This will result in saving more energy and less waste. However, it is not guaranteed that after midnight there will not be any pedestrians, so considering the situation it is decided that when the sensors do not detect any humans the light will dim down to 65% of the full intensity. This will help any late-night pedestrian to walk safely to their destination without any fear and it will also reduce crime.

6.3 Evaluating the Sustainability

Sustainability evaluation through SWOT analysis:

SWOT analysis is used to identify the Strengths, Weaknesses, Opportunities, and Threats of the project through strategic planning and strategic management. This technique is used in the early stage of project planning to detect the internal and external factors of the project that will be advantageous and harmful. Strength and weakness focus on the internal part of the project which can be controlled and altered at our own will. However, opportunity and threat are external factors where the project can be benefited from the opportunities, and different ways can be discovered to mitigate the threats, but they cannot be changed. In our project, we tried to find out the strengths, weaknesses, opportunities, and threats.

Strengths

- Reduce electricity consumption and increase sustainability
- Cost effective
- No extra cable connection
- Simple to control from the server
- Maintenance is easier

The first and the most important strength of this project, which also turns out to be the prime focus, is to use as little electricity as possible without hindering the main objective of a street light. The objective is to provide the adequate intensity of light so that people can continue their work even after daylight and travel safely to their endpoint without any concern. Also, to increase the sustainability of the product highly efficient LED lights are used which are much longer lasting than the bulbs used earlier. Moreover, this project is a cost-effective one because the building blocks of the device are not very expensive and thus the initial cost is insignificant compared to the amount of money being saved by lowering the electricity consumption. Furthermore, it is easier to control the whole system as they will be connected via a Wi-Fi module and because Wi-Fi modules are being used there will not be an extra cable connection. Lastly, as the mounted devices do not have extra cable they will not be cluttered and this makes the maintenance process much easier.

Weaknesses

- Possible coverage gaps from sensors
- Complicated setup process

In association with the strengths, there are very few weaknesses of this device. Here, two different sensors are being used to track both moving people and idle people and both of the sensors have range. In the case of the PIR sensor the range in distance is adequate and the wide area range is excellent as the range angle is 120 degrees. However, the IR sensor does not have a wide-angle range even though the distance range is phenomenal. This concludes that if a person remains stationary anywhere other than in front of the pole the device will not be able to detect them. There is one more weakness and it is that the internal connection of the device is quite complicated as there are so many components present in it.

Opportunities

- Technology maturity may reduce system cost
- Waste reduction
- Lower negative environmental impact
- Attract a larger target customer

Regarding this project, there is a possibility that in the future, due to technological advancement, there might be some new inventions of sensors, microcontrollers, and relays that may work better than the components we are using now and they might be within the same price range. This means we can have a much better performance without adding any extra cost. It is also possible that because of the new inventions the price of the components being used may decrease which dictates that the production cost will decrease without having any effect on the quality of the device. Another opportunity that can be achieved in the future is waste reduction and it can be done by using recyclable parts and things that have a longer lifetime. Through this, we can lower the electronic waste or e-waste which has become a serious problem in the present time and this will also have minimal damage to the environment. Finally, by improving the equipment in the future with the latest technology the smart street light system will become more reliable which may attract other potential customers' attention and they might be interested to install this in their city.

Threats

- Network disturbance due to obsolescence
- IC chip shortage
- Competitors' advanced technologies

Similar to any other project the smart street light system also possesses some threats which cannot be removed as they are caused due to external factors yet they can be mitigated by figuring out different ways. One of the threats that this project will face is network disturbance due to obsolescence and it is a serious problem. Every year new technologies are being developed which are faster and better with new features included. So, to keep our network connectivity smooth and reliable it is necessary to update the system with the latest technology available in the market. Secondly, there might be a shortage of IC chips in the market which is an essential element to build the device. Recently, during the global pandemic in 2020, there were shipments of IC chips that created a scarcity in the market and resulted in a price rise. Finally, there is a possibility of having competitors and they might use advanced technology and enhanced design of the system on their device. The only way to keep our device relevant to the consumers will be by introducing a new and unique design with new features that will give our competitors a challenge.

6.4 Conclusion

The dynamics of how several distinct projects are carried out are changing as project sustainability management becomes more established. Economic sustainability refers to the ability to satisfy environmental demands from both consumers and businesses without jeopardizing the environment's capability to support future generations.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

Project management is to accomplish specific project goals and objectives through planning and organizing resources. To do that it is necessary to have the required knowledge and skill that are relevant to the project so that it can be completed within time and budget.

7.2 Define, plan, and manage an engineering project

7.2.1 Defining project management

There are five important phases of project management which are initiation, planning, execution, monitoring and controlling, and closing. The objective of the project is discussed alongside figuring out the stakeholders and the feasibility of this project in the initial phase. Next, all the important information necessary to complete the project successfully is decided in the planning phase and they are schedule, budget, scope, and resources. Then the project works are assigned to each project member and they are monitored by the project manager so that progress is visible and the goals assigned during the planning phase are met. This part covers the execution, monitoring, and, controlling phases of the project. Finally, the overall success of the project is evaluated by the project manager at the closing phase.

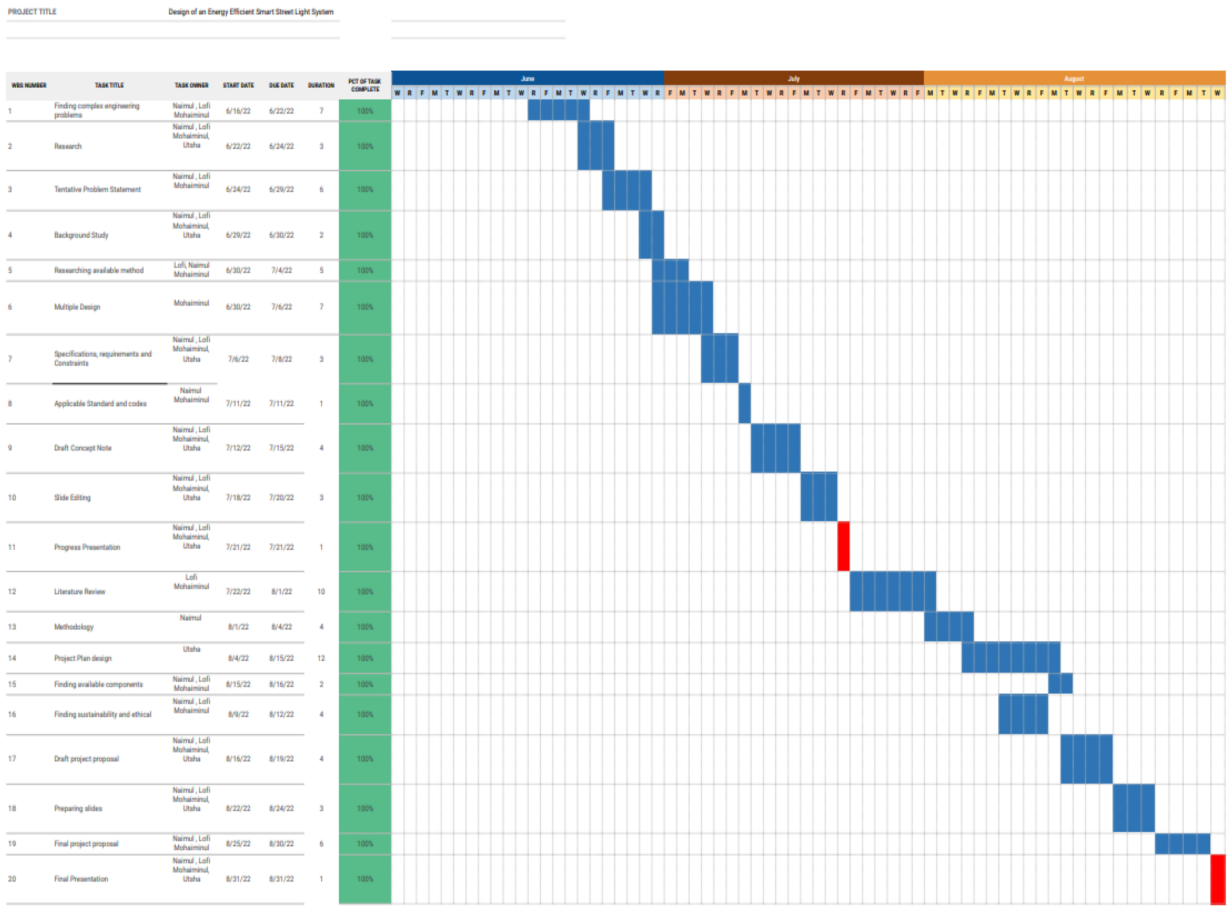
7.2.2 Project management in planning the proposal preparing phase

The first thing that we did in our Final Year Design Project was to identify a complex engineering problem that everyone faces in their daily life. Later on, we narrowed down our problem to a specific area and identified the possible stakeholders to be interviewed. Upon interviewing the stakeholders, we came to discover the severity of the problem and the requirements that we will need to achieve as an outcome of the solution to the problem. The problem that we are focused on solving was cutting out energy waste from the streetlights that are placed in residential areas. The issue here is that in residential areas during night time there is not much foot traffic after midnight. However, it is necessary to provide adequate light for pedestrians to walk safely and also prevent crime. So, after finding out the root of the problem, we started our research regarding the problem and we did a lot of literature reviews. Then we decided on the objective of our project and based on that we prepared two design approaches. The first one is about object detection through sensors and the other one is about object detection through image processing.

After finishing the task of the design approach, we dive into the specifications of the design and here we used several block diagrams to figure out the overall system design. Again, we did some literature review regarding the design specifications through which we came face to face with some more constraints. These constraints were, later on, dealt with logical proposals and we calculated the overall budget of our project, determined the expected outcomes & impacts, sustainability analysis, applicable codes, and standards, ethical considerations, risk management, safety, and siconsiderationsAlso, we determined how our problem statement is a complex engineering problem based on some different parameters.

Gantt Chart for Phase 1

Before proceeding with any kind of work regarding the preparation of project proposal and planning we created a Gantt chart to organize the sequence of the work and to manage the time perfectly so that we could finish the work within the due date.



WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	Finding complex engineering problems	Naimul , Lofi Mohaiminul	6/16/22	6/22/22	7	100%
2	Research	Naimul , Lofi Mohaiminul, Utsha	6/22/22	6/24/22	3	100%
3	Tentative Problem Statement	Naimul , Lofi Mohaiminul	6/24/22	6/29/22	6	100%
4	Background Study	Naimul , Lofi Mohaiminul, Utsha	6/29/22	6/30/22	2	100%
5	Researching available method	Lofi, Naimul Mohaiminul	6/30/22	7/4/22	5	100%
6	Multiple Design	Mohaiminul	6/30/22	7/6/22	7	100%
7	Specifications, requirements and Constraints	Naimul , Lofi Mohaiminul, Utsha	7/6/22	7/8/22	3	100%
8	Applicable Standard and codes	Naimul Mohaiminul	7/11/22	7/11/22	1	100%
9	Draft Concept Note	Naimul , Lofi Mohaiminul, Utsha	7/12/22	7/15/22	4	100%
10	Slide Editing	Naimul , Lofi Mohaiminul, Utsha	7/18/22	7/20/22	3	100%
11	Progress Presentation	Naimul , Lofi Mohaiminul, Utsha	7/21/22	7/21/22	1	100%
12	Literature Review	Lofi Mohaiminul	7/22/22	8/1/22	10	100%
13	Methodology	Naimul	8/1/22	8/4/22	4	100%
14	Project Plan design	Utsha	8/4/22	8/15/22	12	100%
15	Finding available components	Naimul , Lofi Mohaiminul	8/15/22	8/16/22	2	100%
16	Finding sustainability and ethical	Naimul , Lofi Mohaiminul	8/9/22	8/12/22	4	100%
17	Draft project proposal	Naimul , Lofi Mohaiminul, Utsha	8/16/22	8/19/22	4	100%
18	Preparing slides	Naimul , Lofi Mohaiminul, Utsha	8/22/22	8/24/22	3	100%
19	Final project proposal	Naimul , Lofi Mohaiminul	8/25/22	8/30/22	6	100%
20	Final Presentation	Naimul , Lofi Mohaiminul, Utsha	8/31/22	8/31/22	1	100%

Figure: Gantt chart for phase 1

Flow diagram of a planning

In the initial phase of the project which is proposal preparation, we followed a certain path to present a suitable design based on the proposal the following flow diagram represents our approach:

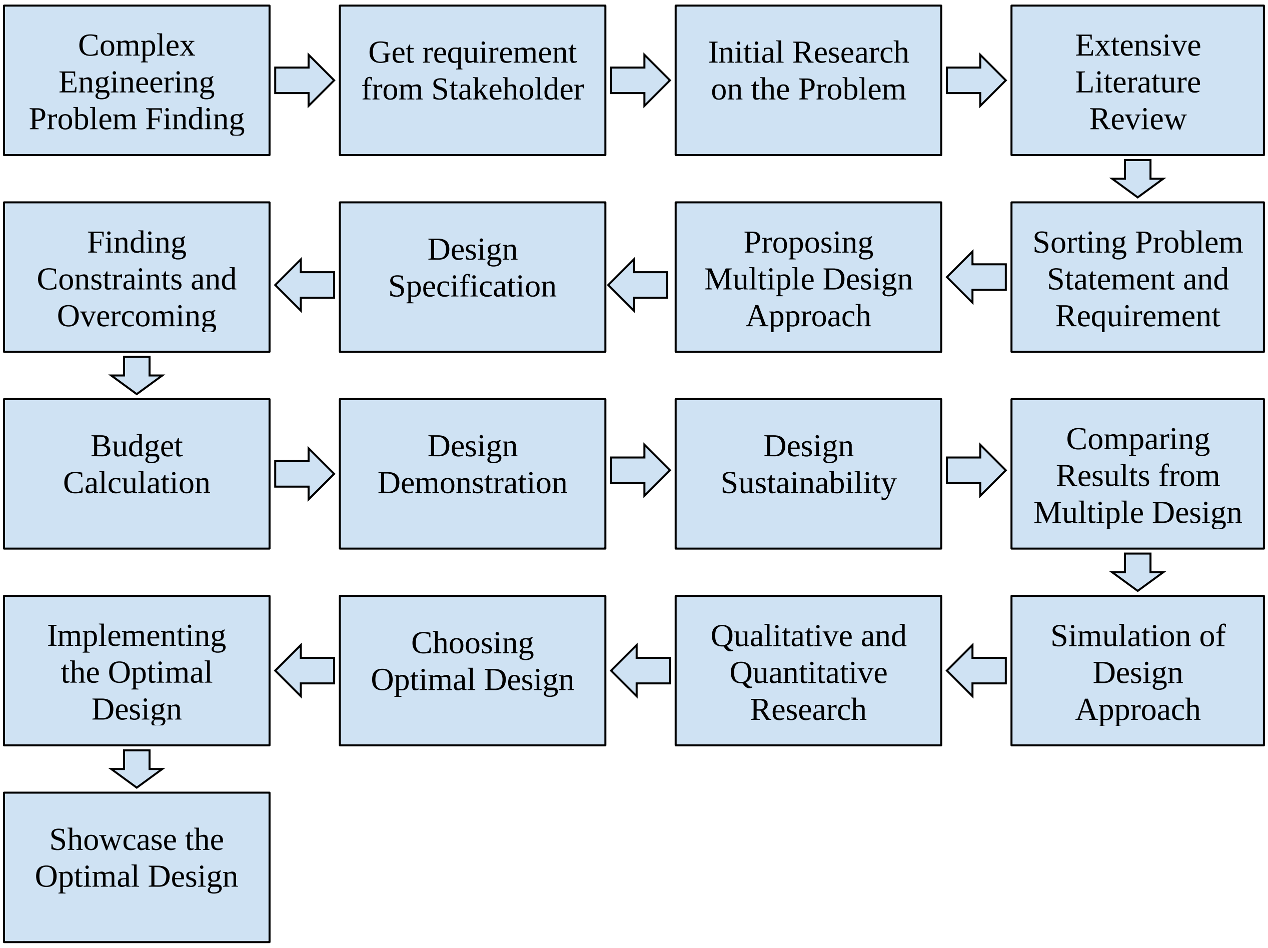


Figure: Project Planning Flow Diagram in Phase 1

7.2.3 Project Management in the Designing and development phase

The design phase was initiated following a similar plan that we used for the proposal phase. In this phase, we identified the most relevant and reliable software for simulation to design and develop our project. After the simulation, we had to look into the optimization process to make our system more sustainable. Lastly, we selected our final design by analyzing the energy loss, cost-effectiveness, and sustainability of the project.

Figure: Gantt Chart for Phase 2

Flow diagram for the design phase

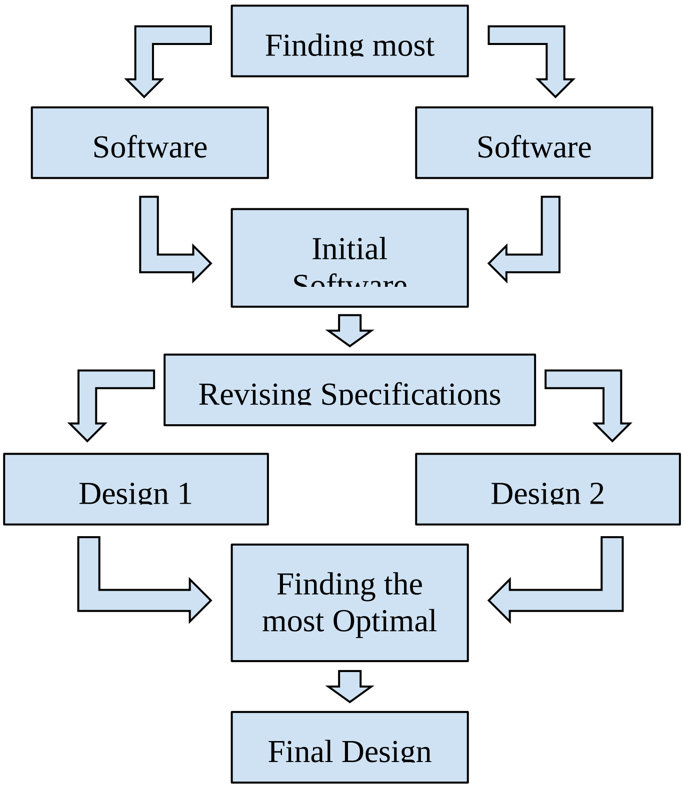


Figure: Flow Diagram of Design Phase

7.2.4 Project Management in Completion and execution phase

This is the last phase of our Final Year Design Project and in this phase, we developed a model of our project and executed it. In this phase, we worked with many hardware components which were specified previously in the design and development phase. The outcomes obtained from our hardware design were constantly compared with the simulation results to ensure that our final design was working perfectly. Even though there were some problems to get the desired output in the end we performed some troubleshooting methods and came up with solutions to optimize our project.

7.3 Evaluate project progress

To make progress in our project it was necessary to have group discussions, attend meetings with the ATC panel, and try to follow the Gantt chart designed for each phase. During group discussion, we talked about the problems that each of the members faced in doing their designated work, and through this discussion, we are also able to keep track of the progress of everyone. Furthermore, we arranged meetings every week with our ATC panel to keep them up-to-date about our project, notify them about our next plan of action, and ask for advice if we get stuck on a particular problem.

7.4 Conclusion

We tried to follow the Gantt chart which we prepared at the beginning of each phase and to support our work we organized a logbook. The logbook contains information about what work is being done when it is being done, and who is responsible for it. Also, we recorded information regarding our ATC meeting which contains details about the date of the meeting and the topic of discussion in that meeting.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

The need for sustainable and energy-efficient solutions is increasingly important, and the sensor-based street light system is one such project that has the potential to bring significant financial and economic benefits to urban areas. Implementing a sensor-based street light system can lead to cost savings in energy consumption and maintenance costs, as well as improved safety and security by illuminating streets and public spaces only when needed. An economic analysis of the sensor-based street light system will evaluate the project's financial feasibility by comparing the costs of implementing and maintaining the system to the benefits it will bring. It will also examine the project's potential social and environmental impact, including its contribution to reducing light pollution, and carbon emissions, and improving public safety and security.

8.2 Economic Analysis

The economic analysis of sensor-based systems in urban areas has become an important area of research in recent years. The implementation of these systems can have significant economic benefits for cities and urban areas. A sensor-based system has several advantages over traditional street lighting systems, including energy efficiency, reduced light pollution, and enhanced safety and security. The initial cost of installing a sensor-based system may be higher than traditional systems, but the long-term cost savings and benefits can outweigh the initial investment.

One of the main benefits of sensor-based systems is their ability to improve energy efficiency and reduce energy costs. By using sensors to detect the presence or absence of people or vehicles, the lighting levels can be adjusted accordingly, resulting in significant energy savings. In addition, the use of LED lights can further reduce energy consumption and maintenance costs. Another economic benefit of sensor-based systems is their ability to reduce maintenance costs. By using sensors to control the lighting system, the need for manual maintenance and inspections is significantly reduced. This can result in lower maintenance costs for cities and urban areas. Furthermore, the implementation of sensor-based systems can improve the safety and security of urban areas. By providing adequate lighting levels in areas with high foot traffic or crime rates, sensor-based systems can help reduce crime and increase public safety. This can result in lower costs associated with crime and healthcare. In the context of Dhaka city, the implementation of a sensor-based street lighting system could have significant economic benefits. With a population of over 20 million people, Dhaka is one of the most densely populated cities in the world. The use of a sensor-based system could help reduce energy costs and improve safety and security in the city. Additionally, the reduced maintenance costs associated with sensor-based systems could provide significant cost savings for the city.

Overall, the economic analysis of sensor-based systems in urban areas highlights the potential for significant cost savings and economic benefits. The implementation of these systems could have a positive impact on cities and urban areas by reducing energy consumption, maintenance costs, and crime rates while improving public safety and overall quality of life.

Budget of our project:

Name of Components	Price per Quantity (BDT)	Quantity	Price
Light Detecting Resistor	5	1	5
Arduino Uno R3	950	1	950
Infrared Obstacle Sensor	80	1	80
Passive Infrared Sensor	110	1	110
LED light 15W 12V	60	1	60
LM2596 DC-DC Buck converter	80	1	80
Single Channel Relay 5V	100	1	100
Resistors (1k, 330)	5	2	10
TIP122 Transistor	30	1	30
DC battery 3.7V 18600 mAh	80	5	400
Wires	80	2 set	160
Miscellaneous			200
Total			2185

Table: Budget calculation of the system that we built

8.3 Cost-benefit analysis

We want to build a streetlight system, where based on the movement of the objects the light will adjust its intensity. Whenever there will not be vehicles or pedestrians on the road the intensity will be low. So, for the duration in which the intensity will be low in that time, power will be saved. Based on the traffic pattern of Dhaka city we can say that between 6 P.M. to 12 A.M., there remains heavy traffic in the street. So, the light intensity would be around 90% between these hours. After midnight till dawn, there is not that much traffic on the roads. So, the light intensity would be 65% between these hours. As in our proposed system after the intensity would be low when there is no object in the street the energy consumed in these situations would be lower than usual situation. At first, we will calculate the energy consumed forpresent-daynt day street light system then we will calculate the energy for our proposed street light system. Then we will compare the electricity bill for those two scenarios.

Calculation:

Electricity bill according to DESCO,

DESCO Retail Electricity Rate

Consumer class	Energy rate/charge (Taka)	Demand rate (Taka)
LT-D2: Street light and Water pump	8.91	75.00

Table: Retail electricity bill

Assuming four 60W led street light is glowing from 6:00 PM to 5:00 AM

Applying the full rated voltage for the whole time,

Energy = Power(W)×Time(hrs)

= 60 W × 11 hrs × 4

= 2640 Wh or 2.64 Units

One-month energy consumed = 2.64 Units ×30 days

= **79.2** Units

Apply 90% of the rated voltage from 6:00 PM to 12:00 AM

Energy = 54 W ×6 hrs ×4

= **1296** Wh or **1.296** Units

Apply 65% of the rated voltage from 12:00 PM to 5:00 AM

Energy = 39 W ×5 hrs ×4

= **780** Wh or **0.78** Units

The total energy consumed by the alternate system is,

Energy = 1.296 + 0.78 = **2.076** Units

One-month energy consumed = 2.076 Units ×30 days = **62.28** Units

If we consider the bill of DESCO,

Bill for street lights and water pump: 8.91 taka

Electricity bill of normal system = (75 ×8.91) = **668.25 TK**

Electricity bill of our proposed system = (62.28 ×8.91) = **554.91 TK**

Emphasizes optimization and validation to achieve the optimal solution that meets the design criteria and industry standards.

8.4 Financial and Economic Aspects

The financial and economic aspects of the sensor-based street light system are critical in determining its feasibility and sustainability. The system's financial aspects include its capital costs, installation costs, and maintenance costs, while its economic aspects include the system's potential for energy savings, reduced maintenance costs, and improved safety and security.

In terms of capital costs, the sensor-based system may require a higher initial investment than traditional street lighting solutions. The cost of sensors, control systems, and LED lights can add up to a significant amount. However, over the system's lifetime, energy savings and reduced maintenance costs can offset the initial capital investment. For instance, if Dhaka city installs a sensor-based street light system that costs $2 million but saves $1 million annually in energy and maintenance costs, the system can pay for itself in just two years. After that, the city can continue to save $1 million per year, resulting in significant cost savings over time. With the rapid growth of the population and increasing energy demands, investing in energy-efficient systems like sensor-based street lights can be a cost-effective solution for the city's economy in the long run.

Another economic benefit of the sensor-based system is its potential to reduce energy consumption and greenhouse gas emissions. By adjusting the lighting levels based on the presence or absence of people or vehicles, the system can significantly reduce energy consumption compared to traditional street lighting solutions. Additionally, the use of LED lights in the system can further reduce energy consumption and maintenance costs. LED lights have a longer lifespan and require less maintenance than traditional lighting solutions, resulting in lower replacement and maintenance costs. Finally, the sensor-based system's improved safety and security features can provide additional economic benefits. By ensuring that the lights are only turned on when needed, the system can reduce light pollution and energy waste, while also providing a safer and more secure environment for pedestrians and drivers.

In conclusion, the financial and economic aspects of the sensor-based street light system can be favorable over its lifetime. While the initial capital costs may be higher, the potential for energy savings, reduced maintenance costs, and improved safety and security can offset these costs and provide significant economic benefits for cities and communities.

8.5 Conclusion

We may conclude that installing a sensor-based street lighting system can help cities and metropolitan regions economically. The long-term cost savings and benefits, such as greater safety and security, lower maintenance costs, and increased energy efficiency, can more than make up for initial capital expenses. Long-term cost-effectiveness for the city's economy can be achieved through the possibility of ge savings through decreased maintenance and energy use. Additionally, putting in place a sensor-based system may aid in lowering energy usage and greenhouse gas emissions, both of which can benefit the environment. As a result, the proposed system's capacity to reduce power costs further enhances its viability and sustainability.

Chapter 9: Ethics and Professional Responsibilities CO13, CO2

9.1 Introduction

Ethics and professional responsibilities are crucial aspects of any project that involve a diverse range of stakeholders, including customers, users, employees, investors, and the wider community. In the context of our project, which involves the design and implementation of a street lighting system, several ethical and professional considerations need to be taken into account. These include issues such as safety, privacy, social impact, and environmental sustainability, as well as the responsibilities of the project team towards their stakeholders. In this section, we will discuss these issues and examine how they have been addressed in the project.

9.2 Identify ethical issues and professional responsibility

In any project, there are several ethical issues and professional responsibilities that need to be considered. Some of the ethical issues and professional responsibilities that arise in this project are as follows:

Data privacy and security: One of the main ethical issues in this project is the need to ensure the privacy and security of the data collected by the sensors used in the street lighting system. The data collected by the sensors can include sensitive information about individuals, such as their location, movements, and behavior. It is the responsibility of the project team to ensure that the data is collected and used in a way that respects an individual's privacy rights and is secured against unauthorized access and use. Example: The project team should implement appropriate data encryption and access controls to protect the data collected by the sensors from being accessed by unauthorized parties.

Environmental impact: Another ethical issue that arises in this project is the environmental impact of the street lighting system. The system should be designed to minimize its impact on the environment, including reducing light pollution and energy consumption. The project team should also consider the impact of the system on local wildlife and ecosystems. Example: The project team should use energy-efficient lighting sources and design the system to only turn on when it is needed, minimizing the amount of energy consumed and reducing light pollution.

Professional responsibility: As professionals, the project team has a responsibility to design and implement the street lighting system in a way that meets the needs of the community while adhering to industry standards and best practices. They should also ensure that the system is designed and installed in a way that is safe for both the users and the environment. Example: The project team should conduct regular safety inspections of the street lighting system to ensure that it is functioning as intended and is safe for users. They should also ensure that the system is installed in compliance with local building codes and safety regulations.

Cost-effectiveness: The project team has a responsibility to design and implement the street lighting system cost-effectively, ensuring that it provides value for money to the community and stakeholders. Example: The project team should evaluate different lighting sources and technologies to determine the most cost-effective solution for the street lighting system while maintaining the required level of quality and performance.

In summary, this project involves several ethical issues and professional responsibilities, including data privacy and security, environmental impact, professional responsibility, and cost-effectiveness. The project team must consider and address these issues and responsibilities to ensure that the street lighting system meets the needs of the community while upholding ethical and professional standards.

9.3 Apply ethical issues and professional responsibility

The application of ethical issues and professional responsibility is essential for ensuring the success of this project while upholding ethical standards and fulfilling professional responsibilities. Here are some examples of how ethical issues and professional responsibility can be applied in this project:

Confidentiality: The project team should ensure that all confidential information, such as customer data, is kept confidential and not disclosed to unauthorized parties. For example, if the project involves collecting data from sensors, the project team should ensure that the data is stored securely and only accessed by authorized personnel.

Data privacy: The project team should ensure that data privacy laws and regulations are followed, especially if the project involves collecting and processing personal information. For example, if the project involves using facial recognition technology, the project team should ensure that appropriate consent is obtained and that the data is used for the intended purpose only.

Environmental impact: The project team should consider the environmental impact of the project and take steps to minimize it. For example, if the project involves replacing existing streetlights with LED lights, the project team should ensure that the old lights are disposed of responsibly and that the new lights are energy-efficient.

Safety and security: The project team should ensure that the project does not compromise the safety and security of users or the public. For example, if the project involves controlling the brightness of streetlights, the project team should ensure that the lights remain bright enough for pedestrians and drivers to see clearly.

Professional conduct: The project team should follow ethical principles and professional conduct standards, such as honesty, transparency, and accountability. For example, if the project team encounters a problem, they should report it to the appropriate authorities and take steps to address it.

By applying ethical issues and professional responsibility, the project team can ensure that the project is successful while upholding ethical standards and fulfilling professional responsibilities. This can lead to increased trust from stakeholders, improved reputation, and increased customer satisfaction.

9.4 Conclusion

In conclusion, the ethical issues and professional responsibilities associated with this project are significant and must be carefully considered and addressed throughout the design and development process. It is the responsibility of the project team to ensure that the system meets the ethical standards of the industry and that it is developed in a socially responsible and sustainable manner. Failure to do so could result in negative consequences for the users, stakeholders, and the environment. By identifying the potential ethical issues and professional responsibilities associated with this project and taking appropriate actions to address them, the project team can demonstrate their commitment to ethical and responsible design practices. This will not only help to ensure the success of the project but also enhance the reputation and credibility of the team and the organization. Overall, it is essential to prioritize ethical considerations and professional responsibility throughout the project lifecycle to ensure the development of a system that is not only technically sound but also socially responsible and sustainable.

Chapter 10: Conclusion and Future Work.

10.1 Conclusion:

Finally, our proposal for an energy-efficient street light system was created to conserve power and minimize energy waste while maintaining safe and comfortable street lighting conditions. To automate the lighting system and make it more energy-efficient and sustainable, we used current hardware tools such as the Arduino Uno, PIR sensor, IR sensor, Buck converter, LDR, and Relay.

We created a system that detects moving and stationary objects using PIR and IR sensors, respectively, and increases light intensity as appropriate. In addition, we have added an LDR to control the lighting system based on ambient light levels. The use of a Buck converter enables effective power management and eliminates energy waste, while the Relay precisely and efficiently regulates the power supply to the LED lights.

Our solution addresses the requirement for adequate street lighting, particularly at night when safe and pleasant eyesight is necessary. We built a lighting system that maintains acceptable lighting conditions while saving power and decreasing energy waste by utilizing advanced hardware tools and automation. This system is cost-effective, environmentally friendly, and simple to operate, making it a perfect alternative for places with power outages like Dhaka.

Overall, our initiative represents a huge step toward a more sustainable and efficient street lighting system. It provides a scalable and adaptable foundation for future growth and alterations, making it a viable option for towns experiencing similar difficulties. The project's importance to present and future industries stem from its capacity to give a cost-effective and sustainable solution to many cities' energy issues.

10.2 Future work:

Various potential future work areas might be addressed to improve the capabilities and efficacy of your energy-efficient street light system project. Among these possible future works are:

- Integration of sophisticated communication technologies:

Such as Bluetooth or Wi-Fi, which might enable remote monitoring and control of the lighting system. This might lead to more effective lighting system control and improved energy-saving options.

- Sensor placement optimization:

The positioning of PIR, IR, and LDR sensors might be improved to enhance their usefulness while minimizing energy waste. This might be accomplished by using simulations and testing to discover the best placement locations and angles.

- Adaptive lighting control implementation:

Adaptive lighting control might be used to modify lighting settings based on real-time traffic and pedestrian density. This might result in even more energy savings and a more energy-efficient lighting system.

- Integration of renewable energy sources:

Integration of renewable energy sources, such as solar panels, might minimize reliance on the power grid and improve the lighting system's sustainability.

- Integration of smart city technology:

The integration of smart city technology may enable the automation of various urban processes, such as waste management or transportation, resulting in a more sustainable and efficient urban environment.

Overall, these prospective future works might improve your project's capabilities and effectiveness while also contributing to a more sustainable and energy-efficient urban environment.

Chapter 11: Identification of Complex Engineering Problems and Activities.

11.1: Identify the attribute of complex engineering problem (EP)

Attributes of Complex Engineering Problems (EP)

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	The extent of applicable codes	√
P6	The extent of stakeholder involvement and needs	
P7	Interdependence	

11.2: Provide reasoning for how the project address the selected attribute (EP)

P1-Depth of knowledge required:

The design of an electricity-efficient street light system for our project calls for in-depth expertise in several different sectors.

First and foremost, designing and implementing the system's physical components, such as the sensors, controllers, and power supply units, requires a solid grasp of electronics. Circuit design, programming, and testing of electronic devices are all necessary for this.

Second, to optimize the lighting system for energy economy while guaranteeing safe and comfortable vision for pedestrians and cars, a working understanding of photonics and lighting design is necessary. Understanding light sources, optics, photometry, and lighting calculations are necessary for this.

Fourth, designing an energy-efficient lighting system that eliminates waste and lowers the overall carbon footprint requires knowledge of sustainability and energy management. This calls for expertise in carbon accounting, energy audits, and renewable energy sources.

Overall, the breadth of expertise needed for our project spans a variety of fields, including electronics, photonics, control systems, and sustainability. Designing an effective and efficient street lighting system requires an interdisciplinary approach that integrates information from various domains.

P3-Depth of analysis required:

A project that entails creating a system of energy-efficient streetlights would need in-depth research across several disciplines. To start, it would be necessary to analyze the present lighting setup in the target area to pinpoint any spots where energy is being wasted. This would entail gathering data about energy use and lighting levels throughout the day, as well as analyzing that data to spot patterns and trends.

To identify the ideal illumination levels and spectral features essential for safe and pleasant eyesight, it would also be necessary to analyze the local environmental circumstances. Understanding the human visual system, lighting design concepts, and how lighting affects the surroundings would be necessary for this.

Thirdly, to choose the best solutions for the project, a study of the numerous sensors and hardware components needed for the system would be required. This would entail investigating the technical details of different parts, like sensors, controllers, and power sources, and examining how they would interact with the system as a whole.

Fourth, to choose the best method for operating the lighting system, a control system analysis would be required. Understanding feedback control, system modeling and analysis, and an examination of the trade-offs between various control systems would all be required for this.

P4-Familiarity of issues:

We are familiar with the problems addressed in the street light project since we regularly run across them in our everyday lives, such as energy efficiency, cost-effectiveness, and efficient illumination. Inefficient lighting systems not only waste electricity but also raise energy costs and pollute the environment. Therefore, it is crucial to develop a way to increase the effectiveness of lighting systems. To achieve the goal of energy-efficient street lighting, the employment of cutting-edge sensors, such as PIR and IR sensors, and contemporary hardware tools, such as Arduino Uno and Buck converters, can be very helpful. Additionally, we are aware of the necessity for safe and pleasant nighttime vision because it has a significant influence on our everyday lives, particularly in cities.

Authorities in charge of street lighting frequently struggle with the difficulty of performing adequate maintenance on lighting systems. To assure the system's durability and effectiveness, a new lighting system with greater maintenance features must be implemented. As a result, we are also aware of the project's goal of implementing an updated lighting system because it is pertinent to the present and future of the business.

P5-Extent of applicable codes:

The street light project is connected to the applicable IEEE regulations because it uses cutting-edge hardware tools and sensors to increase the efficacy and efficiency of street lighting. For the creation and use of technology in several sectors, including lighting systems, IEEE offers standards and recommendations. In automated lighting systems, PIR and IR sensors are frequently utilized, and their use complies with IEEE guidelines for lighting that uses as little energy as possible. Additionally, the usage of the contemporary Arduino Uno microcontroller board complies with IEEE regulations for the creation of intelligent lighting systems.

In addition, IEEE offers standards and recommendations for managing and maintaining lighting systems, which are equally pertinent to the project's goals. IEEE rules for the administration of street lighting systems are aligned with the launch of an upgraded lighting system with greater maintenance features. Since the project uses IEEE-provided technology and standards to increase the efficiency and efficacy of street lighting systems, it is tied to the appropriate IEEE codes.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

	Attributes	**Put tick (√) as appropriate**
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for Society and the Environment	√
A5	Familiarity	√

11.4 Provide reasoning for how the project address the selected attribute (EA)

A1- Range of resources:

We were able to learn a great deal about energy-efficient street lighting systems through a thorough analysis of the literature. We were able to use this to pinpoint the essential traits and elements needed for our project. We also had the chance to speak with businesses and industry leaders, which provided us with important information about current trends in technology and norms in the business.

Additionally, we were successful in finding dependable providers of top-notch hardware parts and software tools. As a result, we could create our project using the most up-to-date and dependable technology.

Overall, having access to these resources enabled us to create a very effective and efficient street lighting system that satisfied the demands of the stakeholders while also preserving energy and cutting expenses.

A2-Level of interaction:

For our project to be successful, it was essential to have several meetings with business people and specialists in the field of street lighting. We had the chance to talk about our concept with a filament business that produces streetlights. This allowed us to gain insights into the practical aspects of street light technology and understand the challenges that are faced in the industry.

Additionally, we had in-depth discussions with our ATC panel, who were able to provide us with valuable feedback on how the lighting system could be integrated with the traffic control system. We were able to improve the system's effectiveness and safety by taking into account their ideas.

A4-Consequences for society and the environment:

The environment and society benefit from our project on automated light intensity regulation. We can support a sustainable environment by decreasing power waste and implementing efficient lighting solutions. Additionally, by supplying the proper illumination at the right moment, the initiative seeks to offer safe and pleasant eyesight on roadways, hence lowering the chance of accidents and promoting safe transportation. The initiative also seeks to lower neighborhood energy expenditures, which may eventually have a positive economic impact.

A5- Familiarity:

Reduced energy consumption and the promotion of sustainable development are the two objectives that our project to install an effective street light system has in common with other initiatives of a similar nature. Our project, however, stands out in terms of the strategy and elements employed to fulfill this objective. Our concept uses cutting-edge hardware techniques to automate street lighting management depending on pedestrian activity and ambient light levels. This strategy lessens energy waste and lowers carbon footprint compared to conventional street light systems, which rely on manual switch controls.

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Appendix

Logbook

Final Year Design Project (C) Spring 2023			
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Md. Nuhul Najiul Huda Lofi-19121132	md.nuhul.najiul.huda.lofi@g.bracu.ac.bd	01789139196
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ATC Details:			
ATC 4			
Chair	Mohammed Belal Hossain Bhuian, Ph.D. (Associate Professor)	belal.bhuian@bracu.ac.bd	
Member 1	Abdulla Hil Kafi	abdulla.kafi@bracu.ac.bd	
Member 2	Md. Mahmudul Islam, Lecturer	mahmudul.islam@bracu.ac.bd	

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
22.01.2023	1. Naimul 2.Lofi 3.Mohaiminul	Discussion about the approach for building the project with ATC	1. Mohaiminul 2. Naimul 3. Lofi 4. Utsha	

29.01.2023	1.Mohaiminul 2.Naimul 3.Lofi 4.Utsha	Discussion about the components of the projects and cost	1. Mohaiminul 2. Naimul 3. Lofi	
03.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Extensive research on the components and their functionality	1. Mohaiminul 2. Naimul 3. Lofi	
06.02.2023	1. Mohaiminul 2. Naimul 3. Lofi 4. Utsha	-Meeting with ATC about the progress of the projects -Review the design of the final proposal	1. Mohaiminul 2. Naimul 3. Lofi	
10.02..2023	1.Mohaiminul 2.Naimul 3.Lofi	-Buying components for initial tests	1. Naimul 2. Lofi	
11.02..2023	1.Mohaiminul 2.Naimul 3.Lofi	Writing programming codes for the project	Mohaiminul	
12.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Testing the components with programming	1. Mohaiminul 2. Naimul 3. Lofi	
13.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Meeting with ATC. Showing the Updated design of the prototype	1. Mohaiminul 2. Naimul 3. Lofi	

14.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Calculating the budget for building the prototype	1. Mohaiminul 2. Naimul 3. Lofi	
18.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Testing the LED light with Arduino and controlling the intensity of it	1. Mohaiminul 2. Naimul 3. Lofi	
20.02.2023	1.Mohaiminul 2.Naimul 3.Lofi 4.Utsha	Testing the detection of IR and setting the range	1. Mohaiminul 2. Naimul 3. Lofi	
22.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Correlating IR PIR with LED	1. Mohaiminul 2. Naimul 3. Lofi	
25.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Discussion on how the prototype would be designed and deciding the size and parameters of it	1. Mohaiminul 2. Naimul 3. Lofi	
28.02.2023	1.Mohaiminul 2.Naimul 3.Lofi	Assembling the structure of the prototype for the progress presentation	1. Mohaiminul 2. Naimul 3. Lofi	
29.02.2023	1.Mohaiminul 2.Naimul 3.Lofi 4.Mohaiminul	Meeting with ATC regarding progress presentation	1. Mohaiminul 2. Naimul 3. Lofi	

01.03.2023	1. Mohaiminul 2. Naimul 3. Lofi	-Building the initial prototype and integrating all the components into the structure	1.Mohaiminul 2.Naimul 3.Lofi	
01.03.2023	1. Mohaiminul 2. Naimul 3. Lofi 4. Utsha	-Making the presentation slide for the progress presentation	1.Mohaiminul 2.Naimul 3.Lofi	
02.03.2023	1.Mohaiminul 2.Naimul 3.Lofi 4.Utsha	Progress presentation	1. Mohaiminul 2. Naimul 3. Lofi 4. Utsha	
14.03.2023	1.Mohaiminul 2.Naimul 3.Lofi	-Discussion with ATC about the feedback on the progress presentation - Advised to focus on the impact of the project	1. Mohaiminul 2. Naimul 3. Lofi	
16.03.2023	1.Mohaiminul 2.Naimul 3.Lofi 4.Utsha	Finding a more accurate design for the project	1. Mohaiminul 2. Naimul 3. Lofi 4. Utsha	
21.03.2023	1.Mohaiminul 2.Naimul 3.Lofi	Research on how to make the project more efficient keeping in mind the requirements of stakeholders and including more appropriate components to make the whole design circuit technically sound.	1. Mohaiminul 2. Naimul 3. Lofi	
25.03.2023	1.Mohaiminul 2.Naimul 3.Lofi	Buying more project-related components like a buck converter, connector, wires, pins, and relays.	1. Mohaiminul 2. Naimul 3. Lofi	

	4.Utsha			
01.04.2023	1.Mohaiminul 2.Naimul 3.Lofi	Testing the new components	8. M ohaiminul	
03.04.2023	1.Mohaiminul 2.Naimul 3.Lofi 4.Utsha	Discussing with ATC about how to use different components to make the design function properly	1. Mohaiminul 2. Naimul 3. Lofi 4. Utsha	
06.04.2023	2.Naimul 3.Lofi	Buying different instruments to build the prototype	2. Naimul 3. Lofi	
09.04.2023	1.Mohaiminul 2.Naimul 3.Lofi	Start building up the final prototype and setting the parameters	1. Mohaiminul 2. Naimul 3. Lofi	
11.04.2023	1.Mohaiminul 2.Naimul 3.Lofi	Setting up the whole prototype and arranging the circuit with proper programming and making adjustments	1. Mohaiminul 2. Naimul 3 . Lofi	
12.04.2023	1.Mohaiminul 2.Naimul 3.Lofi	Setting up the whole prototype and arranging the circuit with proper programming and making adjustments	1.Mohaiminul 2.Naimul 3.Lofi	
14.04.2023	1. Mohaiminul 2. Naimul 3. Lofi	-Setting up the whole prototype and arranging the circuit with proper programming and making adjustments - Start working on the final report	1.Mohaiminul 2.Naimul 3.Lofi	

15.04.2023	1.Mohaiminul 2.Naimul 3.Lofi	Setting up the whole prototype and arranging the circuit with proper programming and making adjustments	1.Mohaiminul 2.Naimul 3.Lofi	
19.04.2023	1.Mohaiminul 2.Naimul	Buying extra components as some of them were malfunctioning	1. Mohaiminul 2. Naimul	
20.04.2023	1.Mohaiminul 2.Naimul	Adjusting the components according to the requirements	1. Mohaiminul 2. Naimul	
25.04.2023	1.Mohaiminul 2.Naimul	Finish setting up the whole prototype - Testing the prototype and taking data from it	1. Mohaiminul 2. Naimul	
26.04.2023	1.Lofi 2.Mohaiminul 3.Naimul	Preparing Poster for the project showcase	1. Lofi 2. Mohaiminul 3. Naimul	
27.04.2023	1.Lofi 2.Mohaiminul 3.Naimul 4.Utsha	Final project showcase	1. Lofi 2. Mohaiminul 3. Naimul 4. Utsha	

Assessment Guideline for Faculty

[The following assessment guideline is for faculty ONLY. **This portion does not apply to students**.]

Assessment Tools and CO Assessment Guideline

	Distribution of assessment points among various COs assessed in different semesters														
PO	l	c	f	g	c	b	d	c	e	l	k	k	h	i	j
CO	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	CO 7	CO 8	CO 9	CO 10	CO 11	CO 12	CO 13	CO 14	CO 15
EEE 400C/ ECE 402C (Out of 100)							30	24	6	4	4	6	7	7	12
Project Final Report/ Project Progress Report							x	x	x	x	x	x	x		x
Demonstration of a working prototype							x								x
Progress Presentation/ Final Presentation								x			x				
Peer-evaluation*													x	x	
Instructor's Assessment*													x	x	
Demonstration at FYDP Showcase								x							x

Note: The star (*) marked deliverables/skills will be evaluated at various stages of the project.

Mapping of CO-PO-Taxonomy Domain & Level- Delivery-Assessment Tool

Sl.	CO Description	PO	Bloom's Taxonomy Domain/Level	Assessment Tools
CO7	**Evaluate** the performance of the developed solution concerning the given specifications, requirements, and standards	d	Cognitive/ Evaluate	• Demonstration of a working prototype • Project Progress Report on a working prototype
CO8	**Complete** the final design and development of the solution with necessary adjustments based on the performance evaluation	c	Cognitive/ Create	• Project Final Report • Final Presentation • Demonstration at FYDP Showcase
CO9	**Use** modern engineering and IT tools to design, develop and validate the solution	e	Cognitive/ Understand, Psychomotor/ Precision	• Project Final Report
CO10	**Conduct** independent research, literature survey, and learning of new technologies and concepts as appropriate to design, develop and validate the solution	l	Cognitive/ Apply	• Project Final Report
CO11**	**Demonstrate** project management skills in various stages of developing the solution of engineering design project	k	Cognitive/ Apply Affective/ Valuing	• Project Final Report • Project Progress presentation at various stages
CO12	**Perform** a cost-benefit and economic analysis of the solution	k	Cognitive/ Apply	• Project Final Report
CO13	**Apply** ethical considerations and professional responsibilities in designing the solution and	h	Cognitive/ Apply	• Peer-evaluation,

	throughout the project development phases		Affective/ Valuing	• Instructor's Assessment • Final Report
CO14**	**Perform** effectively as an individual and as a team member for the successful completion of the project	i	Affective/ Characterization	• Peer-evaluation • Instructor's Assessment
CO15**	**Communicate** effectively through writings, journals, technical reports, deliverables, presentations, and verbal communication as appropriate at various stages of project development	j	Cognitive/ Understand Psychomotor/ Precision Affective/ Valuing	• Project Final Report • Progress Presentations, • Final Presentation • Demonstration at FYDP Showcase

Note: The double star (**) marked CO will be assessed at various stages of the project through indirect deliverables.