

Smart Street Light System with LDR And IR Sensors for Energy-Efficient Illumination

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Abstract: This project presents the design and implementation of a Smart Street Light System that incorporates Light Dependent Resistors (LDR) and Infrared (IR) sensors to optimize energy usage and enhance public safety. The primary objective of this system is to intelligently manage street lighting by adjusting the brightness of LED lights according to the surrounding environmental conditions and the presence of objects or movement in the vicinity. During daylight hours, the LDR detects sufficient ambient light and automatically turns off the street lights, conserving energy. At night, when the ambient light levels drop, the lights are turned on but at a dimmed intensity. The IR sensors further refine this by detecting movement, such as pedestrians or vehicles, and increasing the brightness of the lights as needed. This ensures that the lights provide adequate illumination only when necessary, reducing unnecessary power consumption. The Smart Street Light System is not only cost-effective but also environmentally friendly, significantly reducing energy consumption and maintenance costs while lowering carbon emissions. Additionally, the system enhances public safety by ensuring that streets are well-lit only when required, thereby reducing the likelihood of accidents or criminal activities in poorly lit areas. This project aligns with smart city initiatives, providing a scalable and efficient solution for urban infrastructure. By integrating advanced sensor technology with traditional street lighting, the system offers a practical approach to modernizing urban environments, contributing to the development of intelligent, sustainable cities. The successful implementation of this project demonstrates the potential of smart technologies to improve energy management and public safety on a broader scale, setting a precedent for future innovations in intelligent infrastructure.

I. INTRODUCTION

The implementation of smart technologies in urban infrastructure has become increasingly essential for enhancing sustainability and efficiency. This project presents a novel approach to street lighting by integrating Light Dependent Resistors (LDRs) and Infrared (IR) sensors to create an intelligent lighting system. The primary objective is to reduce energy consumption while maintaining optimal illumination levels based on ambient light conditions and the presence of objects. The project works Upon detecting darkness and the presence of objects, the MCU processes the sensor inputs and dynamically adjusts the brightness of the LED lights to provide adequate illumination. This ensures energy efficiency by dimming or turning off the lights when not required, thereby reducing unnecessary power consumption Key features of the system include real- time responsiveness to environmental changes, automatic adjustment of lighting intensity, and the ability to conserve energy without compromising safety and visibility

II. LITERATURE REVIEW

Solar Based Charging Station for E-Vehicle

The concept of smart street lighting systems has gained significant attention in recent years due to their potential to enhance energy efficiency, reduce costs, and improve public safety. Several studies have proposed various approaches to smart street lighting systems using advanced technologies such as the IoT, artificial intelligence (AI), and sensor networks Smart street lighting systems have gained significant attention in recent years due to their potential to enhance energy efficiency, reduce costs, and improve public safety. Several studies have proposed various approaches to smart street lighting systems using advanced technologies such as power electronics, wireless sensor networks, and the IoT The system was able to adjust the brightness of the street lights based on the ambient light level, as well as detect and report any faults in the system. Another study by A. Imran et al. (2019) proposed a smart street lighting system that utilized a combination of IoT, cloud computing, and big data analytics It is stated that the current traditional street lighting systems are inefficient, as they operate on fixed schedules and are not adaptive to real-time changes in traffic or weather conditions. The literature survey highlights that smart street lighting systems can improve energy efficiency, reduce maintenance costs, and enhance public safety They discuss various approaches, such as using sensors and wireless communication technologies to monitor and control the street lighting system. They also highlight some of the challenges associated with implementing such systems, including the need for reliable and secure communication protocols and the high cost of installation and maintenance They discuss various approaches, such as using sensors, wireless communication,

and machine learning algorithms, to monitor and control the street lighting system. They also highlight some of the challenges associated with implementing such systems, including the need for reliable and secure communication protocols and the high cost of installation and maintenance. The literature survey in this article discusses various studies related to smart street lighting systems and their applications. It includes research on different sensor technologies used in smart street lighting systems, such as IR sensors, PIR sensors, and ultrasonic sensors. The survey also examines different control strategies for these systems, including manual control, time-based control, and adaptive control. Additionally, the literature survey discusses the benefits of smart street lighting systems, such as energy savings, improved safety, and reduced maintenance costs. The survey also explores the 5 challenges associated with implementing these systems, including the initial cost of installation and the need for technical expertise to maintain and operate the system. The survey examines different sensor technologies used in smart street lighting systems, including IR sensors, PIR sensors, and ultrasonic sensors. Additionally, the literature survey discusses the benefits of smart street lighting systems, such as energy savings, improved safety, and reduced maintenance costs. The survey also explores the challenges associated with implementing these systems, such as the need for technical expertise and the initial cost of installation. Furthermore, the literature survey highlights the importance of using Lab.

III. PROPOSED SYSTEM

The smart street light system dynamically adjusts the brightness of LED lights based on ambient light levels and detected presence of objects, significantly reducing energy consumption by only illuminating when necessary.

- The implementation of energy-efficient LED lights and intelligent control mechanisms reduces operational costs over time, providing long-term cost savings despite initial investment in smart technology.
- By optimizing energy usage and reducing carbon footprint, the smart street light system promotes environmental sustainability and aligns with green initiatives aimed at mitigating climate change.

IV. BLOCK DIAGRAM

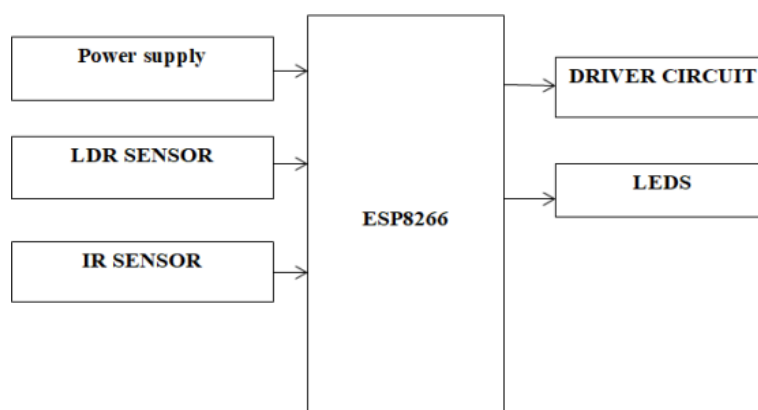


Fig 1- Block Diagram

V. HARDWARE COMPONENTS

Power Supply:

The power supply section is the section which provides +5V for the components to work. IC LM7805 is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down the ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

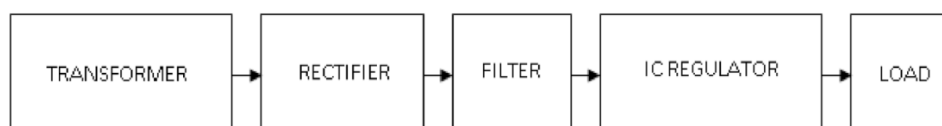


Fig 2-Block diagram of power supply

Esp32 Module:

Wi- The ESP32 module is a low-cost, low-power system-on-chip (SoC) microcontroller with integrated Wi-Fi and Bluetooth capabilities. It is manufactured by Espressif Systems, and is designed for use in a variety of applications, including Internet of Things (IoT) devices, wearable electronics, and other embedded systems. The ESP32 module features dual-core processors running at up to 240 MHz, as well as a variety of built-in peripherals, including touch sensors, analog-to-digital converters, and pulse width modulation (PWM) controllers. It also includes support for a wide range of communication protocols, including Fi, Bluetooth, and Ethernet.



Fig3: Esp32 Module

IR Sensor:

An IR (Infrared) sensor is a type of electronic device that is used to detect the presence of infrared radiation. Infrared radiation is a form of electromagnetic radiation that is invisible to the human eye, but can be detected by electronic sensors. IR sensors typically consist of an IR source, such as an LED, and an IR detector, such as a photodiode or phototransistor. The IR source emits a beam of infrared radiation, which is reflected off of objects in its path. The reflected radiation is then detected by the IR detector, which generates an electrical signal that is proportional to the intensity of the reflected radiation. IR sensors are commonly used in a variety of applications, including motion detection, temperature measurement, and proximity sensing.

For example, they can be used in security systems to detect the presence of intruders, in temperature measurement systems to monitor the temperature of a room, and in robotics to detect obstacles in the path of a robot. IR sensors, as previously mentioned, are devices that can detect infrared radiation. Infrared radiation is a type of electromagnetic radiation that has a wavelength longer than that of visible light, but shorter than that of microwaves. This type of radiation is produced by all objects with a temperature above absolute zero, including humans, animals, and even inanimate objects like walls and floors.

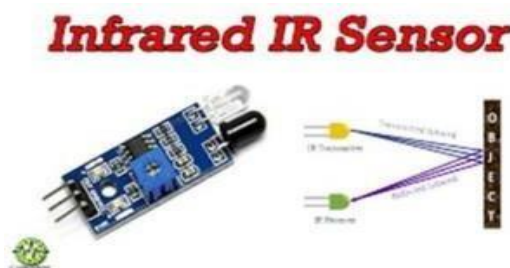


Fig 4-IR sensor

LDR Sensor:

LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically. When the light level is low the resistance of the LDR is high. This prevents current from flowing to the base of the transistors. Consequently the LED does not light. However, when light shines onto the LDR its resistance falls and current flows into the base of the first transistor and then the second transistor. The LED lights.



Fig 5: LDR sensor

ULN2003:

The ULN2003A is an integrated circuit produced by Texas Instruments. It consists of an array of seven NPN Darlington transistors capable of 500 mA, 50 V output. It features common-cathode flyback diodes for switching inductive loads (such as servomotors). It can come in PDIP, SOIC, SOP or TSSOP packaging. In the same family are ULN2002A, ULN2004A, as well as ULQ2003A and ULQ2004A, designed for different logic input levels. The ULN2003A is also similar to the ULN2001A (4 inputs) and the ULN2801A, ULN2802A, ULN2803A, ULN2804A and ULN2805A, only differing in logic input levels (TTL, CMOS, PMOS) and number of in/outputs (4/7/8). Darlington Transistor A Darlington transistor (also known as Darlington pair) achieves very high current amplification by connecting two bipolar transistors in direct DC coupling so the current amplified by the first

transistor is amplified further by the second one. The resultant current gain is the product of those of the two component transistor.

Hardware kit:

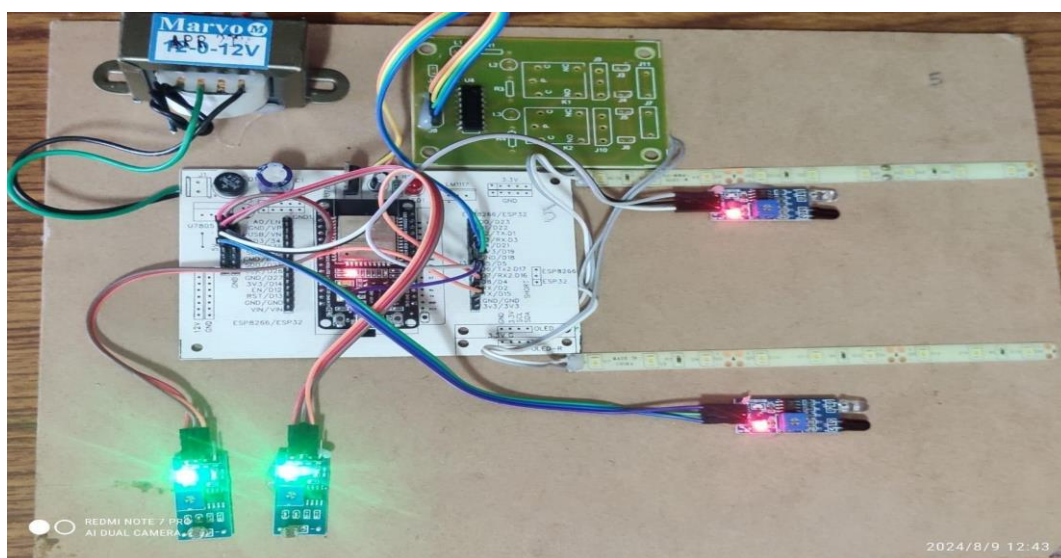


Fig 6: The hardware kit

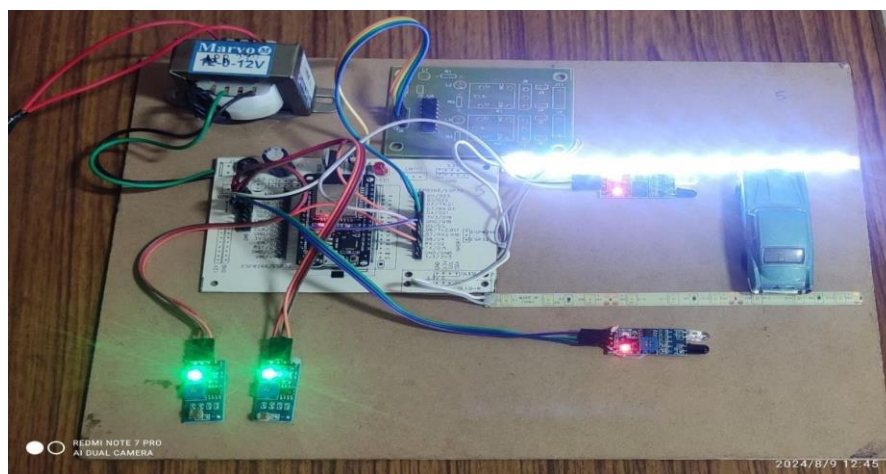


Fig 7: When The Object Is Sensed By The Sensor During Night Time

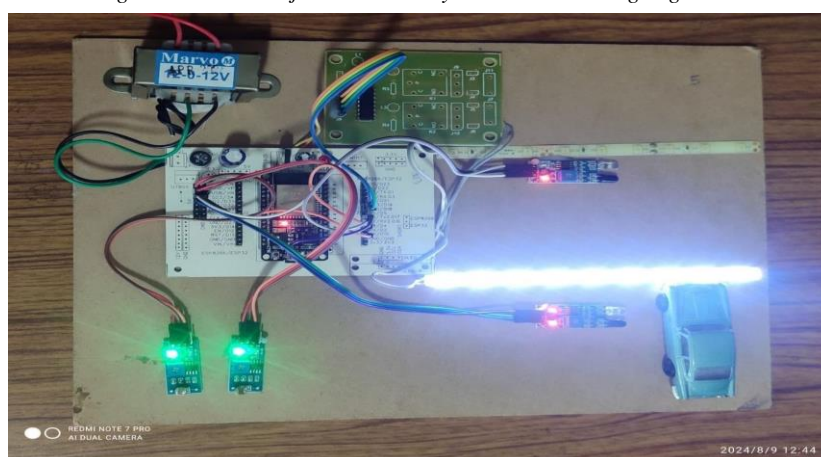


Fig 8: The 1 Street Light Turns Off When The Object Moves Further So Energy Is Conserved

VI. RESULT

Implementing a smart street light project using LDR and IR sensors typically yields the following results: □ **ENERGY SAVINGS:** Significant reduction in energy consumption due to lights being on only when necessary. Quantifiable decrease in electricity bills, often between 30% to 60%, depending on the area's activity level and previous lighting practices.

● **ENHANCED SAFETY AND SECURITY:** Improved visibility in public areas during low-light conditions. Increased pedestrian and vehicular safety, reducing the number of accidents and incidents. Enhanced security due to better lighting in

presence of people and potential integration with surveillance systems.

- **COST EFFICIENCY:** Lower operational costs due to reduced energy usage. Decreased maintenance costs through real-time monitoring of street light status and proactive maintenance alerts.
- **AUTOMATION AND SMART INTEGRATION:** Improved urban infrastructure through the integration of smart technology. Contribution to smart city initiatives by providing data that can be used for further urban planning and management.

VII.CONCLUSION

The smart street light project using LDR and IR sensors demonstrates a practical and effective approach to modernizing urban lighting systems. The main conclusions drawn from the implementation and analysis are:

- **EFFICIENCY:** The system efficiently manages street lighting based on real-time ambient light and movement, ensuring lights are used only when needed. The automation provided by LDR and IR sensors reduces the need for manual intervention, enhancing operational efficiency.
- **COST-EFFECTIVENESS:** Significant cost savings are realized through reduced energy consumption and maintenance efforts. The initial investment in the smart lighting system is typically offset by the long-term savings in operational costs.
- **ENVIRONMENTAL BENEFITS:** The project contributes to sustainable urban development by lowering the carbon footprint and reducing light pollution. The environmentally friendly approach aligns with global initiatives for energy conservation and climate change mitigation.
- **IMPROVED QUALITY OF LIFE:** Enhanced safety and security through better-lit public spaces. Increased public satisfaction due to the reliable and adaptive street lighting system.
- **SCALABILITY AND FUTURE INTEGRATION:** The project provides a scalable solution that can be expanded to other urban areas. It lays the groundwork for further integration with other smart city technologies, fostering a connected and intelligent urban environment. In summary, the smart street light project using LDR and IR sensors proves to be a successful initiative that balances technological innovation with practical benefits, leading to a more efficient, safe, and sustainable urban lighting infrastructure

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