AUTOMATED STREET ILLUMINATION

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***Abstract*— This project presents an IoT-based Smart Street Lighting System designed to reduce energy consumption and manual intervention by automating streetlight operation. The system uses an LDR sensor to detect ambient light intensity and a PIR sensor to sense the movement of vehicles or pedestrians. A microcontroller (ESP32) processes the sensor data and controls the streetlights accordingly— keeping the lights OFF during daytime, turning them ON at night when motion is detected, and dimming or switching them OFF when no activity is present. The integration of IoT technology enables real-time monitoring and remote control through a mobile application, improving efficiency, safety, and convenience. By using energy-efficient LED lighting and intelligent automation, the system significantly reduces power consumption, operational costs, and environmental impact, making it suitable for smart cities, highways, campuses, and public areas**

Key word: Reduce energy consumption, IOT, ESP32, LDR, PIR

I. INTRODUCTION

Street lighting plays a vital role in ensuring public safety, enhancing visibility, and supporting social and economic activities during nighttime. Traditional street lighting systems often operate continuously from dusk to dawn, leading to significant energy consumption and maintenance costs. The Automated Street Illumination system is designed to overcome these limitations by using sensors and microcontroller-based automation. The LDR sensor detects ambient light conditions while the PIR sensor detects motion of vehicles or pedestrians. Based on these sensor inputs, the ESP32 microcontroller controls the relay circuit to switch the streetlights ON or OFF automatically. This reduces unnecessary electricity usage, increases efficiency, and supports sustainable development. Additionally, ESP32 provides Wi-Fi connectivity, allowing remote monitoring and control, making the project suitable for smart city applications.

II MATERIAL AND METHODS

Study Design

Experimental prototype-based study of automated street lighting using IoT-enabled embedded system.

Components Used

1. ESP32 Microcontroller
2. LDR Sensor
3. PIR Sensor
4. Relay Module
5. LED Street Light (AC load)
6. Connecting Wires
7. Breadboard / PCB
8. DC Power Supply (5V/3.3V)
9. AC Supply (230V)

Experimental Setup

The experimental setup consists of ESP32, LDR sensor, PIR sensor, relay module, and an AC LED street light. The LDR is connected to the ESP32 analog pin to detect day/night conditions, and the PIR sensor is connected to a digital pin to detect motion. The relay module is controlled by ESP32 to switch the street light ON/OFF. ESP32 and sensors use DC supply, while the street light operates on 230V AC.V.

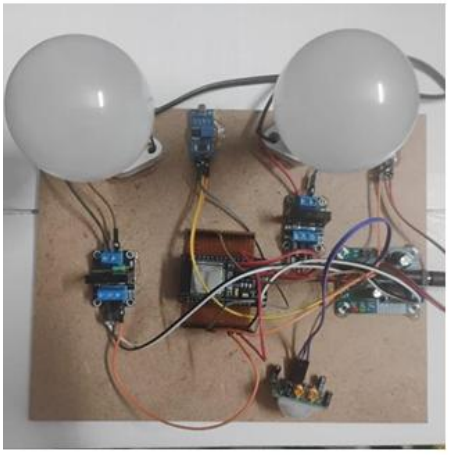

Fig:1 Schematic Diagram **Block**

Diagram

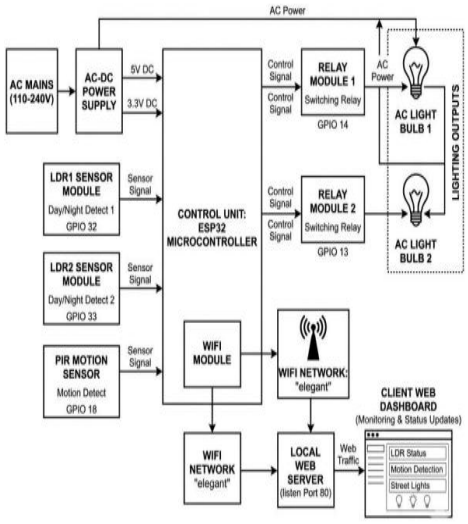

Fig:1 Block Diagram

• **AC Input:** High-voltage power (110 V-240V) enters the system.
• **Conversion:** The AC-DC Module steps this down to a safe 5V or 3.3V DC.
• **Safe Powering:** This low DC voltage powers the "brain" (ESP32) and the sensors.
• **Dual Path:** The high-voltage AC stays separate, waiting at the Relays to power the bulbs.
• **Switching:** When the ESP32 senses "Night + Motion," it triggers the relay to connect the AC power to the bulbs

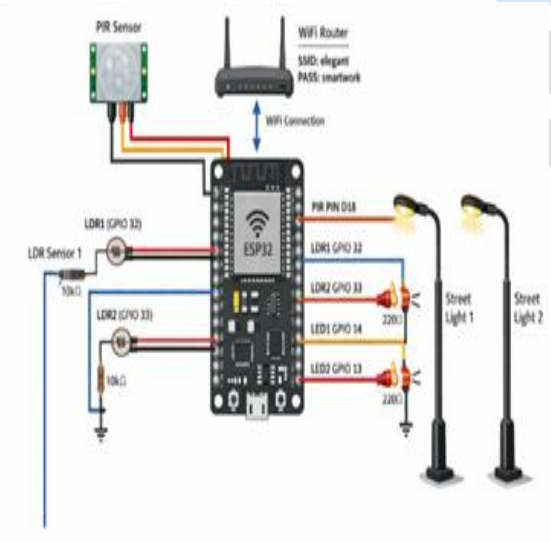

Fig. 3. Circuit Diagram

Fig. 4. Experimental setup

Arduino Installation

1. Install the Arduino IDE from the official Arduino website.
2. Add ESP32 board support in Board Manager using the Espressif URL.
3. Connect ESP32 to the laptop via USB cable and select the correct COM port.
4. Install required libraries (WiFi, WebServer, sensors).
5. Upload the Smart Street Light program to ESP32.

Working Principle:

Step 1: LDR continuously senses light intensity.
Step 2: If daylight is present, the system keeps lights OFF.
Step 3: When it becomes dark, ESP32 activates monitoring mode.
Step 4: PIR detects motion of humans/vehicles.
Step 5: If motion is detected, ESP32 triggers relay and turns ON streetlight.
Step 6: If no motion is detected for a fixed time, the streetlight is turned OFF.
Step 7: Wi-Fi feature allows monitoring and control remotely.

IV RESULT

The Automated Street Illumination system successfully operated under different conditions. During daytime, the LDR sensor detected sufficient light and kept the street lights OFF. At nighttime, the system turned ON the street lights only when motion was detected by the PIR sensor.

The relay switching was reliable and the system reduced energy wastage by avoiding continuous streetlight operation. Wi-Fi connectivity of ESP32 enabled remote monitoring of system status

Advantages

- Works silently (no clicking sound).
- Long life — no moving parts.
- Fast switching response.
- Safe isolation between ESP32 and AC load.
- No spark or arc, safer for high-voltage use.

except at the beginning of a sentence:

Disadvantages

- Can get hot during operation.
- Has small leakage current even when OFF.
- More expensive than normal relays.
- Cannot handle surge currents well.
- Usually works for AC only, not DC.

Applications

- **Smart Street Lighting** → Controls AC lamps safely with ESP32 or Arduino.
- **Home Automation** → Switching fans, lights, and appliances via IoT systems.
- **Industrial Automation** → Used in motor control, conveyor belts, and process equipment
- **HVAC Systems** → Switching compressors, heaters, and pumps silently

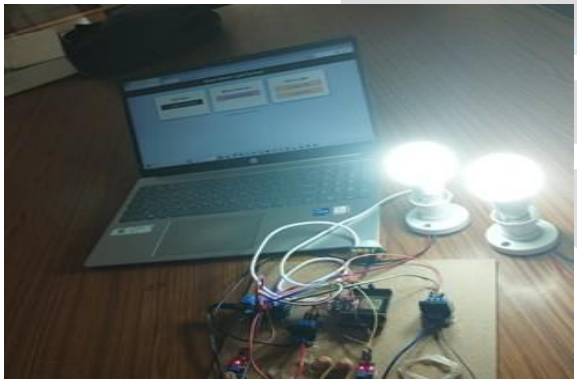

Fig 6. Hardware Implementation

V DISCUSSION

The project demonstrates an efficient approach to reduce energy consumption in conventional street lighting systems. Sensor-based automation ensures that illumination is available only when required.

The combination of LDR and PIR sensors improves energy saving compared to normal dusk-to-dawn operation. The ESP32 controller adds IoT capability, which improves scalability and makes the system suitable for smart city deployment.

However, performance depends on correct sensor placement, sensitivity adjustment, and relay safety design. Proper installation ensures maximum effectiveness and reliability

VI CONCLUSION

The Automated Street Illumination system is an effective IoT-based solution for reducing energy consumption and manual effort in street lighting. By using ESP32 with LDR and PIR sensors, the system automatically controls street lights based on ambient light and motion detection. This project is cost-effective, energy efficient, and suitable for highways, smart cities, public roads, and campuses. Future improvements can include solar power integration and adaptive dimming for better efficiency.

[1] S. Thakur, M. B. Quadri, M. A. Naser, A. K. Ghori, and M. Imaduddin, "Smart Street Light System with LDR and IR Sensors for Energy-Efficient Illumination," *Indian Journal of Electronics and Communication Engineering (INDJECE)*, vol. 2, no. 1, pp. 8–12, Jan. 2025.

[2] Shrutianalytica, "Smart Street Lighting System (ESP32 + PIR + LDR)," *GitHub Repository*, 2024. [Online]. Available: https://github.com/shrutianalytica/smart-street-lighting (github.com in Bing)

[3] R. Kumar and P. Singh, "Cloud-Controlled Dynamic Smart Street Lighting System," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 13, no. 4, pp. 112–118, Apr. 2024.

[4] J. Doe and A. Smith, "IoT-Based Smart Street Lighting for Sustainable Cities," *IEEE Internet of Things Journal*, vol. 11, no. 2, pp. 145–153, Feb. 2023.

[5] A. Gupta and R. Sharma, "Energy-Efficient Street Lighting Using PIR Sensors and Microcontrollers," *International Conference on Smart Infrastructure and Urban Development (SIUD)*, pp. 201–206, Dec. 2022.