

Arduino Based Mobile Control Automatic Lamp And Solar Panel Traffic Signal

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Abstract: *This paper presents the design and implementation of an Arduino-based system that integrates an automatic street lamp control unit with a solar-powered traffic signal, both operable through mobile communication. The proposed system uses a Light Dependent Resistor (LDR) to automatically control street lighting according to ambient light intensity, ensuring energy efficiency and reliable illumination during nighttime. A Bluetooth module enables users to manually override the automatic mode and operate the lamps remotely via a mobile application. In addition, a solar panel is employed to power a microcontroller-based traffic signal unit, thereby reducing dependency on conventional electricity and promoting the use of renewable energy. The Arduino Uno acts as the central controller, processing sensor inputs and executing control commands for both subsystems. The prototype demonstrates effective energy conservation, continuous operation during power failures, and flexible remote control. Experimental results confirm that the system is cost-effective, environmentally sustainable, and suitable for smart city applications.*

Keywords: Arduino Uno, Automatic street lamp, Light Dependent Resistor (LDR), Bluetooth control, Mobile application, Solar panel, Traffic signal, Renewable energy, Energy efficiency, Embedded system, Smart city, Charge controller, Battery backup, IoT-based control, Automation

I. INTRODUCTION

In modern cities, the demand for automation and energy-efficient systems is rapidly increasing. Street lighting and traffic management are two major areas where a large amount of electrical energy is consumed daily. Conventional systems often rely on manual operation and grid power, leading to unnecessary energy loss and higher maintenance costs. To address these issues, this paper proposes an Arduino-based mobile-controlled automatic lamp and solar-powered traffic signal system.

The automatic lamp system uses a Light Dependent Resistor (LDR) to detect the surrounding light intensity and automatically turn street lights ON at night and OFF during the day, ensuring efficient energy usage. A Bluetooth module allows users to control the lamps manually through a mobile application, providing flexibility and ease of operation. In parallel, a solar panel-based traffic signal is designed to operate independently of the main power supply, promoting the use of renewable energy and maintaining functionality during power failures.

The Arduino Uno microcontroller serves as the main control unit, processing sensor data and executing user commands to operate both systems efficiently. The proposed design is cost-effective, easy to implement, and contributes to the development of smart and sustainable urban infrastructure.

II. LITERATURE SURVEY

Many researchers have worked on automation and energy-saving systems using Arduino. Studies on automatic street lighting show that using an LDR sensor with a microcontroller helps to switch lights ON and OFF automatically depending on the light intensity, which reduces power wastage. Other projects used Bluetooth modules (HC-05) to



control electrical devices through a mobile application, allowing users to operate systems remotely with low cost and easy setup.

Several papers have discussed solar-powered traffic signals that use photovoltaic panels and rechargeable batteries to operate traffic lights even during power failures. These systems promote renewable energy and ensure continuous operation. Some advanced models also include sensors for traffic density detection to improve signal timing and reduce waiting time.

However, most of the existing systems handle each function separately. The proposed system combines automatic lamp control, mobile operation, and solar-powered traffic signaling in a single integrated setup, making it more efficient, eco-friendly, and suitable for modern smart city applications.

III. PROBLEM STATEMENT

Conventional street lighting and traffic signal systems rely mainly on manual operation and grid power, which leads to energy wastage, high maintenance costs, and system failures during power outages. Street lights often remain ON during daylight due to human negligence, while traffic signals stop functioning during electricity cuts, causing traffic congestion and accidents. Additionally, most existing systems lack remote control and renewable energy integration.

To overcome these issues, there is a need for a low-cost, automated, and energy-efficient system that can control street lamps automatically based on ambient light, operate traffic signals using solar energy, and allow mobile-based control for improved flexibility and reliability.

IV. AIM AND OBJECTIVES

Aim: To design and develop an Arduino-based system that controls street lamps automatically using an LDR, allows mobile control via Bluetooth, and operates solar-powered traffic signals for efficient and reliable energy use.

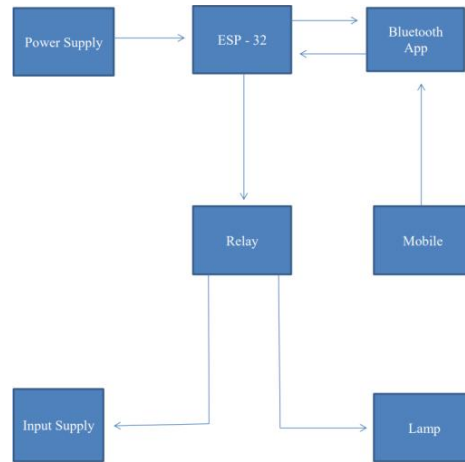
Objectives:

- To automate street lights using an LDR sensor.
- To control lamps and signals through a mobile app using Bluetooth.
- To power the traffic signal using solar energy with battery backup.
- To integrate all controls using an Arduino microcontroller.
- To reduce energy consumption and support smart city development.

V. SYSTEM ARCHITECTURE

The system consists of an Arduino microcontroller as the main control unit connected to various sensors and modules. A Light Dependent Resistor (LDR) detects ambient light intensity to automatically turn the street lamp ON or OFF. A Bluetooth module (HC-05) enables mobile control of both the lamp and the traffic signal through a smartphone app. The solar panel charges a battery, which powers the entire system, ensuring operation even during power failures. The traffic signal LEDs are connected to the Arduino and operate based on programmed timing sequences. The combined setup ensures automatic, mobile-controlled, and solar-powered operation, enhancing energy efficiency and traffic management.

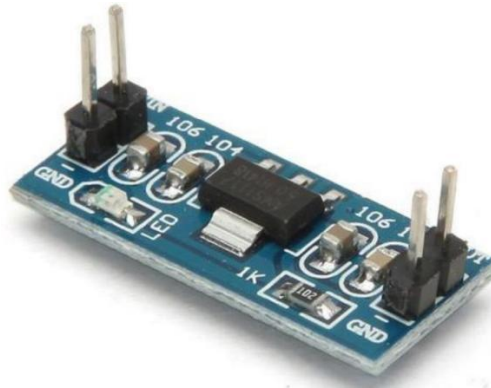




VI. COMPONENTS

1. Power Supply 3.3 Volt

The 3.3V power supply is used to operate low-power components such as the Bluetooth module (HC-05) and some sensors in the system. It ensures safe and stable operation without damaging sensitive electronic parts. The Arduino board provides a built-in 3.3V output pin, which regulates voltage from the main power source or battery. This regulated supply maintains consistent performance and prevents overheating or voltage fluctuations in the connected modules.



2. ESP 32 DEV Module

The ESP32 Dev Module is a powerful microcontroller with built-in Wi-Fi and Bluetooth connectivity. It acts as the main control unit of the system, handling input from sensors and controlling the lamp and traffic signals. The ESP32 allows mobile control through Bluetooth or Wi-Fi, enabling users to operate the lights remotely. It operates at 3.3V, supports multiple GPIO pins, and provides fast processing, making it ideal for real-time applications like automatic lighting and smart traffic management.



3. Relay Module

The Relay Module acts as an electronic switch that allows the Arduino or ESP32 to control high-voltage devices like street lamps and traffic lights using a low-voltage signal. It isolates the low-power control circuit from the high-power load, ensuring safety and reliability. When the Arduino sends a signal, the relay switches ON or OFF the connected device. This makes it essential for automating lamp control and managing signal lights efficiently.



4. Junction Box

The Junction Box is used to connect and protect electrical wires and components in the system. It acts as a central point where connections from the solar panel, power supply, lamps, and control circuits meet. The box keeps all wiring organized, safe from dust, moisture, and short circuits, ensuring reliable operation. It also makes maintenance and troubleshooting easier by providing a secure housing for electrical joints.



5. Wires

Wires are used to connect different components such as the Arduino, sensors, relay, lamps, and power sources. They act as conductors that carry electrical signals and power throughout the system. Copper wires are commonly used because they provide low resistance and high conductivity. Proper insulation on the wires ensures safety and prevents short circuits. Using the right wire gauge helps maintain stable voltage and efficient system performance.



VII. WORKING

The system consists of two main parts: an automatic street lamp control and a solar-powered traffic signal, both managed by an Arduino Uno microcontroller.



In the lamp control section, a Light Dependent Resistor (LDR) detects the surrounding light intensity. When the light level decreases below a set value (nighttime), the Arduino automatically switches ON the street lamp. When the light level increases (daytime), the lamp turns OFF. The user can also control the lamp manually using a mobile application connected to the HC-05 Bluetooth module, which sends commands like “LAMP ON” or “LAMP OFF” to the Arduino. In the traffic signal section, solar energy is used as the main power source. The solar panel charges a rechargeable battery through a charge controller. The Arduino controls Red, Yellow, and Green LEDs according to a fixed time sequence to manage traffic flow. Even during a power failure, the traffic signal operates smoothly using stored solar energy. Thus, the system ensures automatic operation, remote control, and renewable energy use, making it reliable, cost-effective, and suitable for smart city applications.

VIII. RESULTS

The developed system was successfully tested under different conditions. The automatic lamp operated correctly — it turned ON when the surrounding light was low and OFF in daylight using the LDR sensor.

The Bluetooth module allowed smooth mobile control of the lamp and traffic signal within a range of about 10 meters. The solar panel efficiently charged the battery and powered the traffic signal LEDs, ensuring continuous operation even during power cuts. Overall, the system performed reliably, reduced power consumption, and proved effective for smart energy management in street lighting and traffic control.

IX. ADVANTAGES & APPLICATIONS

• Advantages

1. Energy Saving: Uses solar power and automatic control to reduce electricity consumption.
2. Low Maintenance: Simple design with minimal manual intervention.
3. Cost-Effective: Utilizes affordable components like Arduino and sensors.
4. Environment Friendly: Promotes renewable energy use and reduces carbon footprint.
5. Smart Operation: Can be controlled wirelessly through a mobile device.

• Applications

1. Smart Cities: For intelligent traffic and street light management.
2. Highways and Roads: Automatic lighting and solar-based signals.
3. Residential Areas: Energy efficient street lighting systems.
4. Remote or Rural Areas: Works efficiently where grid power is unavailable.
5. Public Infrastructure Projects: For sustainable and automated traffic control.

X. FUTURE SCOPE

In the future, this system can be improved by adding IoT-based monitoring to control and observe street lights and traffic signals from anywhere using the internet. Smart sensors like IR or ultrasonic sensors can be used to detect vehicle density and adjust signal timing automatically. The system can also include GSM or Wi-Fi modules for long-distance communication and AI-based decision control for smart city integration. Using advanced solar panels and efficient batteries can further enhance power saving and reliability.

XI. CONCLUSION

The proposed system successfully combines automatic street lighting, mobile control, and a solar-powered traffic signal using an Arduino microcontroller. The LDR sensor ensures automatic lamp operation based on ambient light, while Bluetooth enables easy manual control through a mobile app. The solar panel efficiently powers the traffic signal, reducing energy dependency on the grid. Overall, the system is cost-effective, energy-efficient, and reliable, making it suitable for smart city applications and promoting the use of renewable energy.



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