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Intelligent Ambient Light-Controlled Street Lighting System for Power Optimization

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Abstract: Street lighting is a significant expense for many cities, primarily due to the high power consumption of sodium vapour lamps. The financial resources allocated to street lighting could be better utilized for other developmental projects. Traditional manual systems, which turn lights on in the evening and off in the morning, often result in substantial energy wastage. This paper proposes an automated system to address these issues, leveraging ambient light sensors to dynamically adjust street light intensity based on surrounding brightness. This eliminates the need for rigid time-based operation schedules, reducing energy consumption and associated costs.

The proposed system is cost-effective and easy to maintain, employing Arduino and Light Dependent Resistors (LDRs) to monitor environmental light levels and control the brightness of LED streetlights accordingly. By replacing High-Intensity Discharge (HID) lamps with LED clusters, the system offers a more energy-efficient solution, consuming approximately one-third to one-half of the power required by HID lighting. Additionally, LEDs have a lifespan over three times longer than HID lamps, minimizing maintenance and replacement efforts. This intelligent street lighting system not only enhances energy efficiency but also contributes to significant long-term savings and sustainability.

Keywords: Sodium Vapour Lamps, Arduino, Light Dependent Resistor, High Intensity discharge.

I. INTRODUCTION

In the 21st century, conserving electrical energy is a critical goal. Automation is becoming prevalent as we progress towards development, especially for developing countries where energy conservation is crucial. Despite the essential nature of street lights, their high cost and energy consumption are problematic. This paper proposes a cost-effective and time-efficient system to upgrade the existing street lighting infrastructure. Optimizing street lighting to be affordable and energy-efficient is necessary. Manually controlling street lights is tedious and can lead to significant energy waste and potential hazards. Indian streets typically use high-wattage sodium vapour lights, making a complete overhaul challenging. The traditional binary operation of street lights (ON/OFF) is inefficient and often results in unnecessary power consumption.

Automation offers a solution by enhancing productivity, efficiency, and reliability while minimizing resource usage, reducing operating costs, and saving energy. Streetlights are crucial for night time safety but consuming substantial energy when left on unnecessarily throughout the night shortens the lifespan of lighting equipment like LEDs, incandescent bulbs, and discharge lamps. This excessive consumption is a significant expense for cities. Therefore, an automated system that adjusts lighting based on actual needs is proposed. Our system, which integrates solar and conventional energy sources, uses Arduino connected to Light Dependent Resistors (LDRs) to control the lights based on *ambient* light levels. This simple and economical approach not only conserves electricity but also extends the life of lighting components, contributing to substantial energy savings for the country.

II. LITERATURE REVIEW

The concept of implementing a light control system using LDR and Arduino represents a pioneering approach in the realm of street lighting. Traditional research in this area has primarily focused on the functionality of lighting systems, neglecting crucial aspects such as energy consumption and efficiency. Our endeavour aims to revolutionize street lighting by developing a novel system that minimizes energy consumption while efficiently illuminating large areas with high intensity.

The Smart Street Lights system constitutes a fundamental component of building a smart city, as it accounts for a significant portion (10-45%) of total power consumption, highlighting the imperative need for innovative energy-saving solutions. Unlike existing approaches reliant on infrared collectors or remote GSM/GUI systems, which often

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entail substantial energy consumption, our system harnesses the power of LDR and LED technology, leveraging clock-based or human-centric control methods.

Inspired by the concept of automation, akin to the Flintstones' famed "bird" mechanism, our Automatic Street Light system intuitively activates and deactivates street lights based on ambient light levels, thereby minimizing energy wastage. By transcending the conventional binary "on/off" paradigm of ancient lighting systems, which invariably led to energy inefficiencies, our system dynamically adjusts light output according to environmental conditions, optimizing energy utilization.

Building upon prior research, Gong Siliang proposed a remote streetlight monitoring system utilizing wireless sensor networks, operating in tandem with a Sunrise and Sunset Algorithm to regulate streetlight intensity. This innovative approach not only enables real-time monitoring but also incorporates environmental parameters such as temperature and humidity, enhancing system functionality and efficiency.

Furthermore, A. C. Kalaiarasan deal's exploration into solar energy-based street lights with auto-tracking systems underscores the quest for maximizing solar power output. By incorporating sun-tracking mechanisms, these systems can boost solar panel efficiency by 30% - 60%, demonstrating the potential for significant energy savings. Embracing this philosophy, our smart lighting system endeavours to adapt light intensity dynamically in response to external conditions, thereby maximizing energy efficiency and sustainability.

In summary, our endeavour represents a paradigm shift in street lighting technology, prioritizing energy efficiency and environmental sustainability through innovative approaches such as LDR and Arduino-based control systems, real-time monitoring, and solar energy integration. By embracing these advancements, we pave the way for smarter, greener cities of the future.

III. SYSTEM MODELLING

The paper discusses the model operating in two modes: RTC Mode and LDR Mode. In RTC Mode, street lights automatically turn on and off based on predetermined times set in the code. In LDR Mode, street light intensity is controlled according to the ambient light detected by the LDR sensor.

The code is uploaded to the Arduino board, which initially runs in RTC Mode. Two specific times, the on time and off time, are programmed into the code. The Arduino compares the current time from the RTC Module with the on time, and when they match, it turns on the LED. It then waits for the off time, and when the RTC Module time matches the off time, the LED is turned off.

Once the LED is ON in RTC Mode, the Arduino transitions to LDR Mode. In this mode, the Arduino reads the LDR value and adjusts the LED intensity based on the detected light level. This adjustment is achieved using a Pulse Width Modulation (PWM) signal generated by pin 11 of the Arduino, which modulates the LED's brightness.

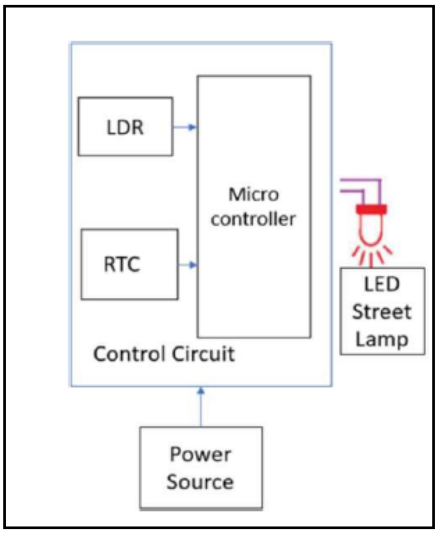

Figure 1: Block Diagram of Proposed System for Light Monitoring System

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IV. HARDWARE COMPONENTS

The Arduino Uno used here features a removable ATmega328p microcontroller. The code, written in Embedded C, is uploaded to the ATmega328p via the Arduino Uno. After uploading the code, only the microcontroller is used, eliminating the need for the Arduino board. The Arduino board is removed after the code has been uploaded, and the ATmega328p microcontroller is placed on a breadboard using the necessary connections.

A Light Dependent Resistor (LDR), also known as a photo resistor, is a device whose resistance varies based on the incident electromagnetic radiation. As such, LDRs are sensitive to light. They are also referred to as photoconductors, photoconductive cells, or simply photocells.

RTC stands for Real Time Clock. RTC modules are systems that keep track of time and date, equipped with a battery to maintain operation in the absence of external power. This ensures that the time and date remain accurate. As a result, precise time and date information can be obtained from the RTC whenever needed.

V. RESULTS

For a comparative study, we made following assumptions Street lights on Indian streets are typically switched on from 6:00 pm to 7:00 am. However, lights are not needed when there is sufficient sunlight. Therefore, this automatic system will switch the lights based on the presence of sunlight. The calculation for the amount of energy saved using this system is detail tabulated in table 1. By assuming that each street light is unnecessarily kept on for 2 hours per day. According to a survey, the street lights used on Indian streets are primarily 400-watt sodium vapour lights.

Table 1: Calculation of Energy Saved by Automating n=50 Street Lights for a Year

Parameter	Value
Number of Bulbs	50
Wattage per Bulb	400 watts
Wasted Hours per Day	2 hours/day
Energy Wasted per Day	50 x 400 x 2 =40,000 WH/day =40 KWH/day
Energy Wasted per Month	40 KWH/day x 30 =1,200 KWH/month
Energy Wasted per Year	1,200 KWH/month x 12 =14,400 KWH/year
Total Energy Saved by Automating 50 Lights	14,400 KWH/year

When RTC mode is active and the LED is on, the LCD displays the current time and the scheduled off time, which is the next operation for the Arduino.

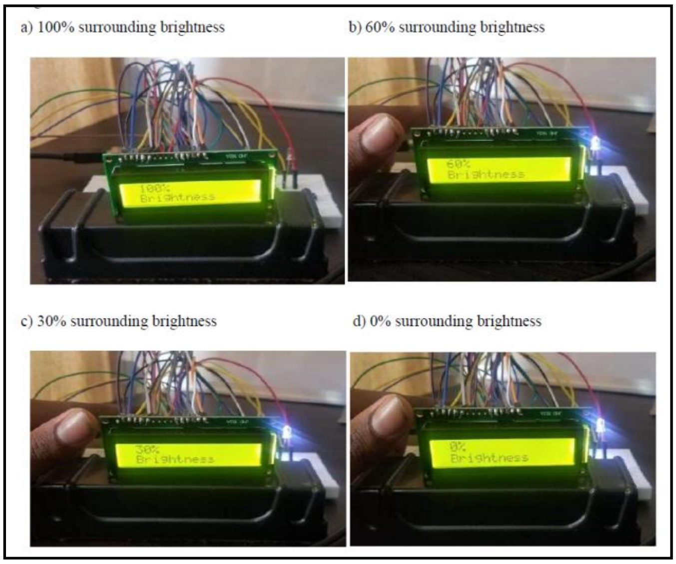

Figure 2: RTC Mode with LED Varying according to intensity of light

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VI. CONCLUSION

This paper focuses on developing a Smart Street lighting control framework circuit designed to efficiently manage the activation and deactivation of street lights. The circuit operates effectively based on two main conditions: the LDR sensor and the RTC. Once these conditions are met, the circuit performs the desired actions according to the specified program.

Arduino UNO effectively controls the street lights, with instructions from the controller dictating when the lights should be illuminated based on the surrounding brightness levels. This system not only helps in conserving energy but also has the potential to be deployed along lengthy roadways connecting urban and rural areas, thereby contributing to the overall development of the country.
The system boasts economic feasibility and simplicity in implementation, potentially serving as a viable replacement for the current system. Notable advantages of this proposed system over the existing one include its full automation, eliminating the need for manual intervention. Moreover, the switching time adapts to varying climatic conditions, ensuring optimal energy usage throughout the year.

REFERENCES

[1] Automatic Street Lights On/Off Application Using IoT", International Journal of Mechanical Engineering & Technology (IJMET) Volume 8, Issue 8, August 2017, pp. 38– 47, Article ID: IJMET_08_08_005
[2] Farah Ramadhani, and Kamalrulnizam Abu Bakar, and Muham-Mad Gary Shafer. "Optimisation Of Standalone Street Light System with Consideration Of Lighting Control", IEEE, 2013.
[3] ViswanathNaik.S, S.PushpaBai, Rajesh.P and Mallikarjuna Naik.B, IoT Based Green HouseMonitoring System International Journal of Electronics and Communication Engineering & Technology (IJECET), Volume 6, Issue 6, June (2015), pp. 45-47
[4] Dr. Kavitha, C. Ramesh Gorrepotu and NarendraSwaroop, "Advanced Domestic Alarms with IOT", International Journal of Electronics & Communication Engineering and Technology 7(5),2016, pp. 77–85.
[5] KeniPrashanthet. "Automated street lighting system using IoT". International Journal of Advance Research, Ideas and Innovations in Technology
[6] Cho,S.K., and Dhingra, V. (2008). "Street Lighting Control Based on Lon Works Power Line Communication", IEEE International Symposium on Power Line Communications and Its Applications, Jeju City, 2-4 April 2008, pp. 396- 398.
[7] "Analysis of solar energy-based street light with auto tracking system", International journal1,2012.
[8] Schwab R N, Walton N E, Mounce J M and Rosenbaum M J. Synthesis of safety research related to traffic control and roadway elements. Volume 2, Chapter 12, Highway Lighting. Report No.FHWA- TS-82233. Federal Highway Administration, 1982.
[9] Sharath Patil G S, Rudresh S M, Kallendrachari K, Vani H V. Design and implementation of automatic street light control using sensors and solar panel. International Journal of Engineering. Research and Applications, 5(6):97-100,2015.