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Automatic Street Light Controller with Energy Consumption Measurement using Arduino

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Abstact: This project presents the design and implementation of an Automatic Street Light Controller with Energy Consumption Measurement using an Arduino microcontroller. The primary objective is to reduce energy wastage by automating the operation of street lights based on ambient light levels and to monitor the energy consumed by each light.

The system uses a Light Dependent Resistor (LDR) to detect the intensity of surrounding light. When the ambient light falls below a predefined threshold (e.g., during night-time or cloudy conditions), the Arduino activates the street lights. Conversely, when sufficient daylight is detected, the lights are automatically turned off. This intelligent switching helps conserve electricity and extend the life of lighting fixtures. The sensor readings are processed by the Arduino and can be displayed on an LCD module or transmitted to a remote monitoring system for further analysis. This feature allows municipalities or maintenance teams to track energy usage and identify malfunctioning units.

By combining automation with energy monitoring, the proposed system offers a cost-effective and energy-efficient solution for street lighting management, contributing to sustainable urban infrastructure and smart city development.

Keywords: Automatic Street Light, Arduino, LDR Sensor.

I. INTRODUCTION

Street lighting is a critical aspect of urban infrastructure, providing safety and security during nighttime hours. However, conventional street lighting systems are often inefficient, relying on manual control or fixed timers that do not adapt to real-time environmental conditions. This results in unnecessary energy consumption and increased maintenancecosts.

With the growing demand for smart and energy-efficient solutions, automation in street lighting has become an essential step toward sustainable development. This project aims to design an Automatic Street Light Controller that uses an Arduino microcontroller and Light Dependent Resistor (LDR) to automatically switch street lights on and off based on the surrounding light intensity. In addition to automation, the system incorporates a current sensor (such as ACS712) to measure the energy consumption of the lighting system in real-time. This allows for efficient monitoring and management of electricity usage, aiding in preventive maintenance and cost analysis. By integrating automation and energy monitoring, the proposed system contributes to reducing electricity wastage, lowering operational costs, and supporting the development of smart cities. It also minimizes the need for human intervention, enhancing reliability and operational efficiency. The system is cost-effective, scalable, and can be implemented in both urban and rural areas.

II. LITERATURE REVIEW

The concept of automating street lighting systems has been extensively explored in recent years, especially in the context of smart cities and sustainable develop -ment. Various studies have investigated methods to improve energy efficiency, reduce maintenance, and implement intelligent control mechanisms using embedded systems IoT technologies.

1) Traditional Street Lighting Systems: Traditional systems rely on manual switching or fixed timers, which are not responsive to real-time changes in ambient light or actual usage needs. **1 .**This often leads to unnecessary energy consumption and increased operational costs. Several researchers have highlighted the inefficiencies in such systems and the need for automation (Kumar et al., 2016).
2) LDR-Based Automation: Light Dependent Resistors (LDRs) have been widely used in automatic lighting systems. They offer a simple and cost-effective way to detect ambient light levels. Studies have shown that integrating LDRs with microcontrollers like Arduino enables reliable switching of street lights based on environmental conditions (Sharma & Gupta, 2018).
3) Microcontroller-Based Control Systems Arduino a popular open-source microcontroller, has been used in numerous projects for street light automation due to its ease of use and flexibility. Researchers have demonstrated that Arduino-based systems can handle multiple sensors and execute control logic effectively, making them ideal for low-cost smart lighting solutions (Patel et

al., 2019).

4) Energy Consumption Monitoring: Monitoring energy usage is essential for assessing system efficiency and identifying faults. The use of current sensors such as ACS712 allows for real-time measurement of electrical parameters. Recent works have integrated energy monitoring with control systems to enable data logging and remote diagnostics (Rao & Babu, 2020).
5) IoT and Smart City Integration: Some advanced systems incorporate IoT features, enabling remote monitoring and control via cloud platforms. Although not always feasible for low-budget projects, these systems set the foundation for scalable smart city infrastructure (Singh & Mehta, 2021).

III. PROPOSED WORK

The proposed project aims to develop an automated street lighting system that operates based on ambient light conditions and simultaneously measures the energy consumption of the system using an Arduino-based microcontroller. The system is designed to improve energy efficiency, reduce manual intervention, and provide real-time monitoring of electricity usage.

A. System Overview

The system will use an LDR (Light Dependent Resistor) to detect ambient light levels. When the light intensity falls below a certain threshold (indicating night or low visibility), the Arduino will automatically turn ON the street lights.

To monitor energy consumption, a current sensor (e.g., ACS712) will be integrated into the system. This sensor will measure the real-time current drawn by the street lights, allowing the Arduino to calculate and log energy usage. This data can be displayed on an LCD screen or sent to a remote server for monitoring (optional in future enhancement).

B. Hardware Components

Arduino Uno (or compatible microcontroller)
LDR sensor
ACS712 current sensor
Relay module or MOSFET (to control AC lights)
Street light (LED or small AC bulbs for prototype)
LCD Display (16x2 or similar)
Power supply unit
Resistors, wires, breadboard/PCB

C. Software Implementation

The Arduino will be programmed using the Arduino IDE with logic to:
Read LDR values and determine light conditions.
Control the relay module to switch lights ON or OFF.
Read analog current sensor data.
Calculate energy consumption using current × voltage × time.
Display status and energy usage on an LCD.

D. Expected Outcomes

Automatic switching of street lights based on ambient light.
Real-time measurement and display of energy consumption.
Significant reduction in energy wastage.
A scalable and low-cost system suitable for urban and rural deployment.

E. Future Enhancements

Integration with IoT platforms for remote monitoring and control.
Use of motion sensors (PIR) for further energy savings.
Solar panel integration for renewable energy sourcing.
Data logging to an SD card or cloud storage for analysis.

1) Arduino Uno

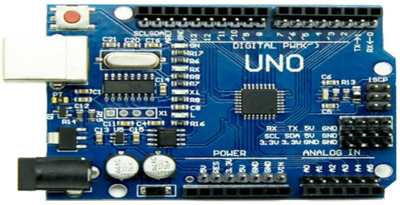

Fig 1. Arduino Uno

The Arduino Uno is a compact, budget-friendly, and user-friendly microcontroller board designed to help users build a wide range of electronic projects. Acting as the control center of a device, it manages the operation of sensors, motors, LEDs, and other electronic elements. It runs on an ATmega328P microcontroller and is programmed through the Arduino IDE (Integrated Development Environment), which allows users to write and upload code easily. Due to its simplicity and accessibility, it's a popular choice for beginners and electronics enthusiasts. From basic tasks like making an LED blink to more advanced creations like robotic systems, the Arduino Uno offers a simple and effective platform for turning creative ideas into functional projects.

2) IR (Infrared) Sensor

Fig 2. IR(Infrared) Sensor

An Infrared (IR) sensor is an electronic component used to sense infrared light, commonly applied in detecting motion, measuring distance, and tracking objects. It operates by sending out infrared signals and then detecting the reflected light from nearby objects. Because of their reliability and ease of use, IR sensors are extensively utilized in areas like robotics, automation, and security technologies.

3) Relay

Fig 3. Relay

A relay is an electrically operated switch that controls the opening or closing of a circuit through an electrical signal. It functions much like a remote switch—when a low-power current is applied to the relay, it activates and enables a higher-power current to pass through another part of the circuit. Relays are commonly used to manage high-voltage or high-current devices, such as lights or motors, by using low-power control inputs. For instance, in vehicles, a relay can be used to operate the horn or headlights, allowing a small switch to control larger electrical loads safely. In essence, a relay serves as a bridge that allows low-power signals to manage more powerful electrical components securely.

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4) Jumper Wires

Jumper wires are small, insulated wires used to connect different components on a breadboard or circuit. They help transfer electrical signals without soldering and are essential for building and testing circuits easily.

5) Programming Environment

The programming environment for the anti-sleeping alarm for drivers should provide the necessary tools to interface with hardware components (e.g., sensors, buzzers), process data from sensors, and implement the logic that determines when to trigger. The alarm. the programming environment of an anti-sleeping alarm for drivers, the focus will be on the tools, software, and frameworks used to program the microcontroller or embedded system that powers the alarm. This involves selecting an appropriate programming environment for developing the system's logic, interfacing with sensors, processing input, and triggering alarms based on drowsiness detection.

6) Programming Languages

a) C/C++ (Primary Language for Embedded Systems)

- Platform: Arduino, microcontrollers, embedded systems
- Use: C/C++ is the most widely used programming language for building anti-sleeping alarm systems, particularly for microcontroller-based platforms like Arduino. These languages offer direct hardware control, efficiency, and real-time processing, essential for detecting fatigue indicators from sensors (e.g., IR sensors, accelerometers, steering wheel sensors).

b) Python (For Advanced Systems and Data Processing)

- Platform: Raspberry Pi, high-level systems, machine learning

Use: Python is often used for more advanced anti-sleeping systems, particularly when facial recognition, machine learning, or image processing is involved. For systems that rely on cameras for detecting signs of drowsiness (e.g., eye closure or facial fatigue), Python's ecosystem provides powerful libraries such as OpenCV for computer vision and TensorFlow for machine learning.

IV. METHODOLOGY

The development of the Automatic Street Light Controller with Energy Consumption Measurement is carried out in several systematic phases, including hardware design, sensor integration, software development, and testing. The methodology follows a modular approach to ensure clarity, reliability, and ease of implementation.

A. System Design and Architecture

The system is composed of two primary modules:

- Light Control Module – Automatically turns street lights ON/OFF based on ambient light levels using an LDR sensor.
- Energy Monitoring Module – Measures real-time energy consumption using a current sensor (ACS712).

The Arduino microcontroller acts as the central processing unit, collecting sensor data and executing control logic.

B. Component Integration

- LDR Sensor: Connected to an analog input pin of the Arduino. It detects ambient light levels and sends corresponding voltage values to the Arduino.
- Relay Module: Used to switch the street light ON or OFF based on commands from the Arduino.
- ACS712 Current Sensor: Measures the current flowing through the street light circuit. This data is used to calculate energy consumption.
- LCD Display (16x2): Displays real-time status (Light ON/OFF) and energy consumption data.

C. Software Development

The Arduino is programmed using the Arduino IDE. The software performs the following tasks:

- Read LDR Sensor Data:
  - If light intensity < threshold → Turn ON lights
  - Else → Turn OFF lights
- Read Current Sensor Data:
  - Measure analog voltage from ACS712
  - Convert to current using calibration formula
  - Calculate power (P = V × I) and energy over time (E = P × t)
- Display Output:
  - Display light status and energy consumed on the LCD screen

D. Energy Calculation Formula

- Current (I) is calculated from ACS712 sensor readings.
- Power (P) = Voltage (V) × Current (I)
- (Assuming voltage is constant at 220V or 12V depending on system setup)
- Energy (E) = Power × Time (in kWh or Wh)

E. Testing and Validation

- The system is tested in different lighting conditions to validate the accuracy of the LDR sensor.
- Current sensor readings are compared with a multimeter for validation.
- Light switching and energy display functions are continuously monitored to ensure correct operation.

F. Deployment (Prototype)

- The prototype is assembled on a breadboard or PCB.
- Real or simulated light sources are used to test the automatic switching.
- Small-scale LED bulbs are used to simulate street lights.

V. RESULT

This is the complete model of our project. In this traffic system for controlling traffic light and time management. We used Arduino to control our system.

VI. ADVANTAGES

1. Saves Electricity
   - The lights turn ON only when it's dark and someone is nearby.
   - They turn OFF automatically when there's no one around.
   - This avoids wasting power and saves money on electricity bills.

2. Measures Energy Use
   - It tells you how much energy each light is using.
   - This helps in checking for faulty or high-consuming lights.

3. Reduces Human Work
   - No need for a person to manually switch lights ON/OFF every day.
   - The system works automatically without human help.

4. Increases Lamp Life
   - Lights are used only when needed.
   - This reduces wear and tear, and the lamps last longer.

5. Improves Safety
   - Streets stay properly lit when people are around, reducing chances of accidents or crime.
   - It also helps pedestrians feel safe at night.

6. Eco-Friendly
   - Lower energy usage means less pollution and a smaller carbon footprint.

7. Low Cost and Easy to Build
   - Arduino Nano is cheap and easy to program.
   - The whole system is affordable and simple to set up, even for beginners.

8. Can Work with Solar Power
   - It can be combined with solar panels to become a fully green and self-sufficient system.

VII. FUTURE SCOPE

The proposed system demonstrates a practical and efficient solution for automated street lighting with real-time energy monitoring. However, there is significant potential to enhance and expand its functionality to meet future technological and urban infrastructure needs.

A. Integration with IoT and Cloud Platforms

The system can be upgraded to send energy data and light status to a centralized cloud server for remote monitoring and control. Using platforms like Blynk, Thing Speak, or Firebase, authorities can access real-time information from any location.

B. Fault Detection and Alerts

The system can be programmed to detect faults in bulbs, sensors, or circuits and send SMS or app notifications for maintenance alerts.

C. Data Logging and Analytics

Historical data on light operation and energy usage can be stored and analyzed to optimize system performance, predict maintenance needs, and improve budgeting for utilities.

VIII. CONCLUSION

This project successfully demonstrates the design and implementation of an automatic street light control system combined with real-time energy consumption measurement using an Arduino microcontroller. By utilizing a Light Dependent Resistor (LDR), the system efficiently detects ambient light levels and automatically switches street lights ON or OFF, reducing human intervention and preventing unnecessary energy usage.

The integration of a current sensor (ACS712) enables continuous monitoring of electrical consumption, which can be displayed in real-time, allowing for improved transparency, fault detection, and future optimization. This makes the system not only energy-efficient but also cost-effective, reliable, and environmentally friendly.

The project addresses common issues in traditional street lighting systems and provides a scalable foundation for future smart lighting solutions. With enhancements like IoT integration, motion detection, and solar power, the system can evolve to become a key component of smart city infrastructure, contributing to both urban sustainability and modern energy management.

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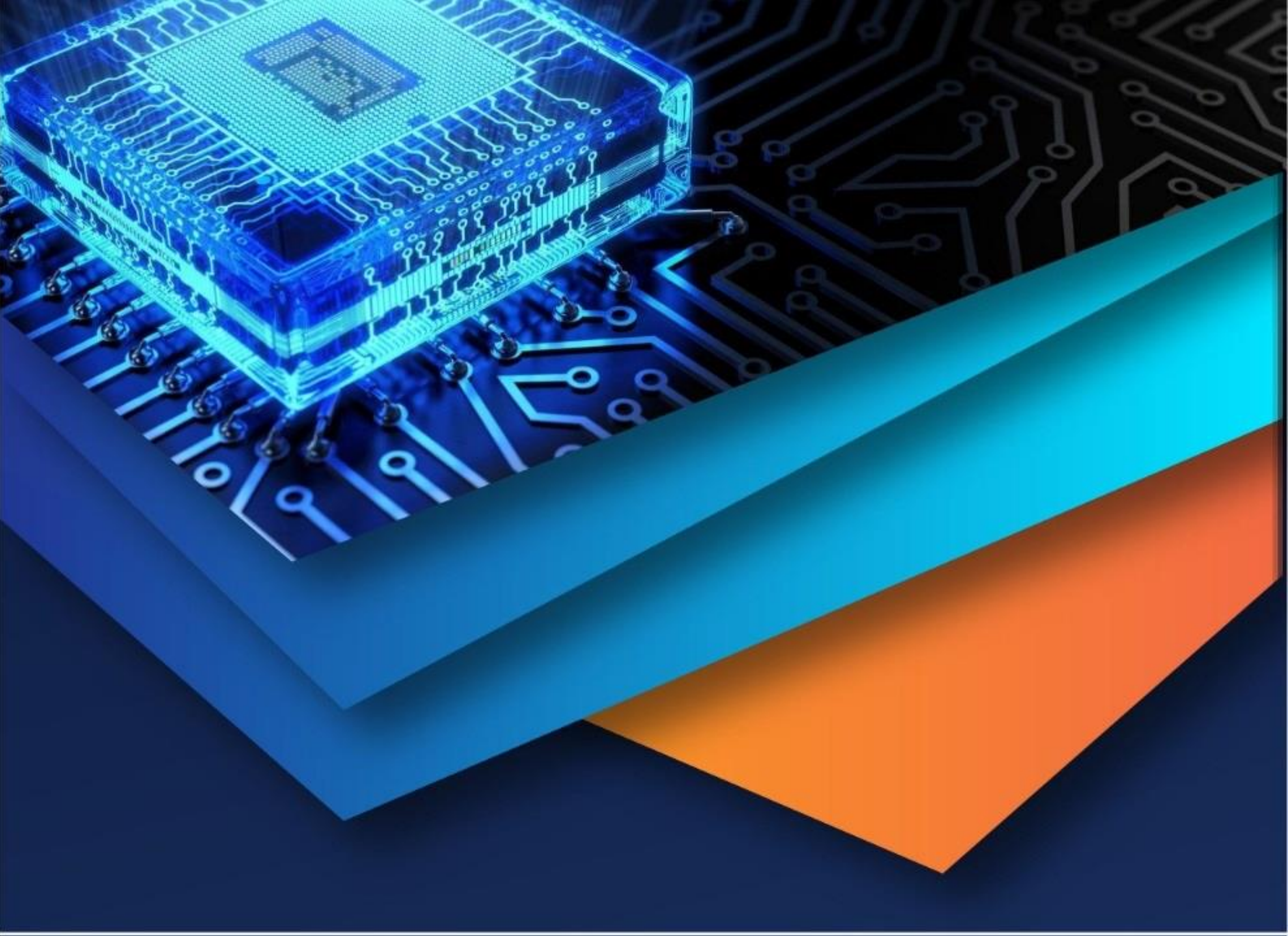

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