

IMPLEMENTATION OF LDR SENSOR AND ARDUINO UNO IN ENERGY CONSUMPTION BASED LIGHTING AUTOMATION SYSTEM

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Abstract: An automatic lighting system based on Arduino Uno is an automation system designed to improve energy efficiency and convenience in daily life. This system utilizes an Arduino Uno as the main controller and a Light Dependent Resistor (LDR) as a light intensity sensor. The LDR detects environmental light conditions and sends analog data to the Arduino for processing. Based on programmed logic, the system automatically turns the LED on when the environment is dark and turns it off when the environment is bright. The research method includes hardware design, programming using Arduino IDE, and system testing under different lighting conditions. The test results indicate that the system operates effectively and responds quickly to changes in light intensity. This system demonstrates the practical implementation of microcontroller-based automation technology in energy-saving applications.

Keyword: arduino uno, light dependent resistor (ldr), automatic lamp, microcontroller

Abstrak: Sistem lampu otomatis berbasis Arduino Uno merupakan sistem otomasi yang dirancang untuk meningkatkan efisiensi energi dan kenyamanan dalam penggunaan penerangan sehari-hari. Sistem ini memanfaatkan Arduino Uno sebagai pengendali utama dan sensor cahaya Light Dependent Resistor (LDR) sebagai pendeteksi intensitas cahaya lingkungan. Sensor LDR mengirimkan data analog ke Arduino untuk diproses berdasarkan logika program yang telah dibuat. Lampu (LED) akan menyala secara otomatis saat kondisi gelap dan mati saat kondisi terang. Metode penelitian meliputi perancangan perangkat keras, pemrograman menggunakan Arduino IDE, serta pengujian sistem pada berbagai kondisi cahaya. Hasil pengujian menunjukkan bahwa sistem bekerja dengan baik dan mampu merespons perubahan cahaya secara cepat dan stabil. Sistem ini membuktikan bahwa teknologi mikrokontroler dapat diterapkan sebagai solusi hemat energi dalam kehidupan sehari-hari.

Kata kunci: arduino uno, sensor ldr, lampu otomatis, mikrokontroler

INTRODUCTION

The development of microcontroller technology has led to the creation of various automation systems that simplify human activities. One essential requirement in daily life is lighting. However, manually operating lights often leads to energy waste due to neglecting to turn them off when it's already bright. This not only increases electricity consumption but can also shorten the lamp's lifespan.

To address these issues, an Arduino Uno-based automatic lighting system was designed that can detect light intensity using an LDR sensor. This system works by detecting changes in ambient light and automatically controlling the lighting conditions without human intervention. The LDR sensor, combined with a 10k Ω resistor as a voltage divider, produces a stable analog signal for the Arduino Uno to process.

The Arduino Uno acts as a control center, reading data from sensors, processing it based

on program logic, and then issuing commands to the LEDs as output. This system implements an input-process-output concept, with the LDRs acting as inputs, the Arduino as the process, and the lights as outputs. Decision-making is carried out in real time and repeatedly as long as the system receives power.

The objective of this research is to design and test an efficient, simple, and applicable automatic switch system as an energy-saving solution. Furthermore, this research also aims to provide an understanding of the application of microcontrollers in simple automation systems that can be further developed toward the concept of an embedded technology-based smart home.

The use of electrical energy in the household and industrial sectors continues to experience significant increases along with population growth and economic activity. One of the most dominant components of energy use is the lighting system. However, the efficiency of energy use is often overlooked due to human negligence in manually operating light switches. Lights that remain on during the day or when the room is already bright enough not only cause wasted electricity, but also accelerate the degradation of lamp components, thereby shortening their technical lifespan.

Therefore, an automation solution is needed that can control the lighting system intelligently and independently without relying on human intervention. The development of open-source microcontroller technology, such as the Arduino Uno, has provided great opportunities in the development of economical and effective automation systems. The Arduino Uno, which uses the ATmega328P microcontroller, offers flexibility through analog and digital pins that enable the integration of various types of sensors for real-time decision making. In the context of an automatic lighting system, the use of a Light Dependent Resistor (LDR) sensor is the most efficient choice because its resistance characteristics change dynamically according to the intensity of the light received.

This research focuses on the design of a lighting control system that implements the input-process-output principle. At the input stage, the LDR sensor works by converting light intensity into an electrical signal. To ensure the accuracy of data reading, this study applies a

voltage divider configuration using a 10k Ω resistor to produce a stable analog signal for processing by the Arduino. At the process stage, the programming logic embedded in the Arduino IDE will determine the threshold to trigger the on or off command on the LED lamp that acts as an output. Specifically, this study aims to test the reliability of the system in responding to changes in environmental conditions from light to dark or vice versa precisely.

In addition to offering practical solutions for energy savings, this research also provides educational contributions regarding the application of embedded system technology that can be replicated and further developed into more complex systems, such as IoT-based smart home architecture. With this system, it is hoped that the efficiency of electricity use can be significantly increased while minimizing monthly operational costs for users.

Arduino Uno

The Arduino Uno is an ATmega328P-based microcontroller board used as a system control center. It has several digital and analog pins that allow sensor readings and control of output devices. In an automatic lighting system, the Arduino Uno reads analog values from the LDR sensor via the analog pins, then processes the data based on a program created in the Arduino IDE. The results are used to determine whether the LED should automatically turn on or off.

Light Dependent Resistor (LDR) Sensors

A Light-Dependent Resistor is an electronic component whose resistance value changes depending on light intensity. In bright light, the LDR's resistance decreases, and in dark light, its resistance increases. In this system, the LDR functions as a light detector. Changes in the LDR's resistance are converted into voltage through a voltage divider circuit, which is then read by the Arduino to determine whether it's light or dark.

10k Ω resistor

A 10k Ω resistor is used with the LDR as a voltage divider. This component helps generate a stable voltage for more accurate sensor readings by the Arduino. The use of this resistor is important so that the system can distinguish light and dark conditions more clearly and prevent unstable readings.

Automatic Light System

The automatic lighting system is a sensor-based control system that operates on the input-process-output principle. The LDR acts as the input, the Arduino Uno as the data processor, and the LED as the output. When darkness is detected, the Arduino turns on the LED. Conversely, when light conditions are present, the LED automatically turns off. This system helps improve energy efficiency and simplifies lighting operation without manual operation.

METHOD

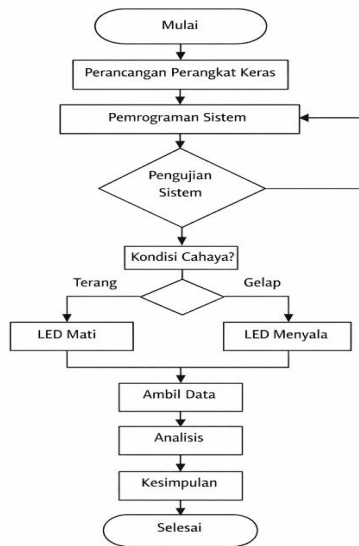


Image 1. Flow Diagram

Research Flow

The research process begins with the identification of problems related to electrical energy waste. This is followed by a literature review, hardware design, writing the program code (scripts) using the Arduino IDE, and system validation testing. If failures or instabilities are detected during the testing phase, the system is re-evaluated at the programming stage until the desired performance is achieved.

Hardware Design

The design of this system is based on the **Input-Process-Output** architecture. The main components utilized in this construction include: **Arduino Uno**: Serves as the primary control center that processes analog signals from the sensor and issues commands to the output.

LDR (Light Dependent Resistor) Sensor:

Used as a detector for ambient light intensity.

10kΩ Resistor: ConImaged as a voltage divider to convert the LDR's resistance changes into an analog voltage readable by the Arduino's analog pins.

LED (Light Emitting Diode): Acts as the representation of the automatic lamp to be controlled.

Software Design

Programming is conducted using the Arduino Integrated Development Environment (IDE). The program logic is designed using an if-else control structure to compare the sensor's input value against a predetermined threshold. Technically, when the analog value read by the sensor indicates a "Dark" condition, the digital output pin is set to a HIGH state to turn on the LED. Conversely, if a "Bright" condition is detected, the output pin is set to LOW.

Testing and Analysis Procedures

The system is tested through two primary scenarios to ensure responsiveness and stability:

- **Bright Condition Test**: The sensor is exposed to sufficient light to verify if the Arduino can identify high intensity and accurately turn off the LED.
- **Dark Condition Test**: The sensor is covered or placed in a low-light environment to validate whether the system automatically activates the LED.

The data obtained from these tests are analyzed descriptively to draw conclusions regarding the system's effectiveness in energy efficiency applications.

Table 1 Sensor Test Data

No	LDR Sensor	Environmental Conditions	System Response	LED Condition
1	Light Detected	Bright	Arduino reads high intensity	Dead
2	Low Light Detected	Dark	Arduino reads low intensity	Light up

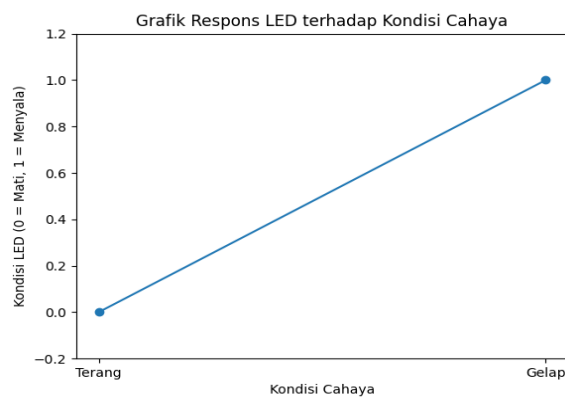


Image 2. Test data graph

System Implementation

The automatic lighting system was successfully assembled according to the proposed hardware design. The integration of the LDR sensor and the 10kΩ resistor created a functional voltage divider circuit that allowed the Arduino Uno to read ambient light levels as analog values. The software logic was then uploaded to the microcontroller, enabling it to process these inputs in real-time.

Testing Results

The system underwent rigorous testing under various lighting conditions to validate its responsiveness. The test results are summarized in Table 1 below:

Table 2. Sensor and System Response Testing

No	Environmental Condition	LDR Sensor State	ADC Value (Analog Read)	LED Condition
1	Bright (Natural/Room Light)	High Intensity Detected	> 500	OFF (Dead)
2	Dark (Covered/Night)	Low Intensity Detected	< 500	ON (Light up)

As shown in the table, the system consistently differentiated between light and dark environments. In bright conditions, the

Arduino interpreted the high intensity as a command to keep the LED off to save energy. Conversely, when the light intensity dropped below the programmed threshold, the system immediately activated the LED.

Discussion and Analysis

The performance of the system relies heavily on the sensitivity of the LDR sensor and the stability of the voltage divider circuit. Based on the experimental data, the 10kΩ resistor proved effective in stabilizing the analog signal, preventing "flickering" or unstable readings when the light intensity was near the threshold. The response time of the system was found to be nearly instantaneous, demonstrating that the ATmega328P microcontroller is highly capable of handling simple automation tasks in real-time. From an energy efficiency perspective, this system eliminates the risk of human error, such as forgetting to turn off lights during the day. By automating this process, the operational duration of the lamp is optimized, which not only reduces electricity consumption but also potentially extends the lifespan of the lighting components. This implementation confirms that microcontroller-based automation provides a low-cost yet highly effective solution for energy management in residential or small-scale applications.

CONCLUSION

The design and implementation of the Arduino Uno-based automatic lighting system have been successfully executed and validated through experimental testing. The results demonstrate that the LDR sensor is highly effective in detecting ambient light changes, allowing the system to distinguish between light and dark conditions with high precision. A critical technical component, the 10kΩ resistor, functioned optimally as a voltage divider, ensuring that the analog signals processed by the Arduino remained stable and free from interference.

Furthermore, the Arduino Uno proved its reliability as a control center by processing sensor data in real-time and executing commands to the LED output according to the programmed logic. The integration of these

components results in a responsive automation system that minimizes human error in energy management. In conclusion, this system provides a simple, cost-effective, and applicable solution for improving energy efficiency, serving as a foundational model for future developments in smart home and embedded technology application.

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