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Research Article

Design and Implementation of a Light Intensity Monitoring System Using an LDR Sensor Based on Arduino

Muhammad Agil Ibrahim [1*], Ansar Rizal [2], Didi Susilo Budi Utomo [3]

[1] Teknik Komputer, Politeknik Negeri Samarinda, Indonesia ; email : agilbahar23@gmail.com
[2] Teknik Komputer, Politeknik Negeri Samarinda, Indonesia ; email : ansardeuy@gmail.com
[3] Teknik Komputer, Politeknik Negeri Samarinda, Indonesia ; email : dsbudiutomo10@gmail.com

* Corresponding Author : agilbahar23@gmail.com

Abstract: This study presents the design and implementation of a light intensity monitoring system based on Arduino using a Light Dependent Resistor (LDR) sensor. The proposed system is capable of measuring light intensity in real-time, displaying the measured values on an I2C-based LCD, and providing an audible alert through a buzzer when the detected light level falls below a predefined threshold. The methodology involves both hardware and software design, followed by system testing through simulation and real-world implementation. The LDR sensor is configured using a voltage divider circuit to convert variations in light intensity into analog voltage signals, which are then processed by the Arduino microcontroller. Experimental results indicate that the system can effectively classify light conditions into three categories: bright, moderate, and dark, with approximate values of 200, 150, and 50, respectively. Furthermore, the system demonstrates reliable performance by activating the buzzer automatically under low-light conditions. Therefore, the proposed system provides a simple, cost-effective, and efficient solution for real-time light intensity monitoring.

Keywords: Arduino; LDR; Light Intensity; Microcontroller; Monitoring System.

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1. Introduction

The rapid advancement of microcontroller technology has significantly contributed to the development of automated monitoring and control systems (Andri Saputra & Yuniansyah Yuniansyah, 2026; Ermaliza et al., 2026; Suryono et al., 2023). Among various platforms, Arduino has gained widespread popularity due to its ease of use, flexibility, and extensive support for embedded system applications (Dewi & Ramadhan, 2025). These advantages enable the transformation of conventional manual systems into automated and real-time systems.

Light intensity is a critical parameter in various applications(Pebralia et al., 2024). Including automatic lighting systems, environmental monitoring, and security systems. In automatic lighting applications, light intensity serves as a reference for controlling lighting devices, thereby improving energy efficiency and operational convenience (M. Iqbal Adhitama & Wirawan Wirawan, 2025; Kusumo et al., 2022)

To measure light intensity, a Light Dependent Resistor (LDR) sensor is commonly used. The resistance of an LDR varies inversely with the intensity of incident light. Specifically, its resistance decreases under bright conditions and increases in low-light conditions. This variation can be converted into an analog voltage signal that can be processed by a microcontroller such as Arduino (Rayhan Al Hayubi et al., 2024; Zeni Aprianti & Nurpulaela, 2024).

In practical implementation, the data obtained from the LDR sensor must be processed and presented in a user-friendly format. Therefore, an LCD is utilized to display the measured light intensity values. Additionally, a buzzer is incorporated as an alert mechanism to notify users when the light intensity falls below a certain threshold (Adrian et al., 2025; Nadziroh & Syafira, 2021).

Previous studies have demonstrated that Arduino-based light monitoring systems using LDR sensors are effective and widely applicable in real-world scenarios (Pambudi et al., 2025). Based on these considerations, this study aims to develop a real-time light intensity monitoring system using Arduino, LDR, LCD, and buzzer, which can serve as a simple yet effective monitoring solution.

2. Literature Review

Arduino

Arduino is an open-source microcontroller platform widely used in embedded system development due to its simplicity, flexibility, and ease of programming. It consists of both hardware (microcontroller board) and software (Arduino IDE) used to write and upload programs to the microcontroller (Rahmat & Yanti, 2022; Silalahi et al., 2022; Muhammad Fikri Mubarak et al., 2025).

Arduino utilizes a simplified C/C++ programming language, making it accessible for beginners as well as advanced developers. Additionally, Arduino is supported by numerous libraries that facilitate integration with various sensors and external devices (Fiqih & Yangindrajat, 2026).

In this study, Arduino Uno is used as the main processing unit that receives input from the LDR sensor, processes the data, and controls the output devices such as LCD and buzzer. The availability of analog and digital pins allows Arduino to interface easily with multiple components (Andi Setiadi Manalu, et al., 2026; Prasetiyanto & Hadisusila, 2023).

Light Dependent Resistor (LDR)

A Light Dependent Resistor (LDR) is a type of sensor whose resistance varies depending on the intensity of light (Nurhayati & Maisura, 2021). It belongs to the category of non-linear resistors, where its resistance decreases when exposed to higher light intensity and increases in darker conditions.

This characteristic makes LDR suitable for detecting changes in environmental light conditions. In bright conditions, the resistance is low, allowing more current to flow, while in dark conditions, the resistance increases, reducing the current flow.

To enable the microcontroller to read the sensor data, the LDR is typically connected using a voltage divider circuit. This configuration converts resistance changes into voltage variations that can be read as analog values by the Arduino.

In this research, the LDR serves as the primary input device for detecting light intensity.

LCD I2C (Liquid Crystal Display)

Liquid Crystal Display (LCD) is an output device used to display data in the form of text or characters. It is commonly used in embedded systems due to its low power consumption and ease of integration.(Candra Supriadi & Priyadi, 2025)

In this study, an I2C-based LCD is used. Unlike conventional LCDs, the I2C module uses only two communication lines, namely Serial Data (SDA) and Serial Clock (SCL), which significantly reduces the number of pins required on the Arduino (Rizakir & Sukarno, 2025).

The LCD I2C is utilized to display the light intensity values obtained from the LDR sensor in real-time, allowing users to monitor the system easily.

Buzzer

A buzzer is an electronic device that produces sound and is commonly used as an indicator or alarm in electronic systems. It can be easily controlled using digital signals from a microcontroller (Oktodinata & Purnomo, 2024).

In monitoring systems, a buzzer is often used to provide alerts when certain conditions are met. In this research, the buzzer is activated when the detected light intensity falls below a predefined threshold (dark condition).

The inclusion of a buzzer enhances the functionality of the system by providing an automatic warning mechanism in addition to visual output.

Voltage Divider Concept

Several previous studies have developed Arduino-based light monitoring systems using LDR sensors (Diyajeng Luluk Karlina, 2026; Maharani et al., 2025). These studies demonstrate that such systems are capable of detecting light intensity changes in real-time and can be applied in various fields such as automatic lighting and environmental monitoring.

Other research also highlights the advantages of using Arduino in monitoring systems due to its flexibility and ease of integration with different sensors and output devices (Nasution et al., 2025).

Based on these studies, it can be concluded that the combination of Arduino and LDR provides an effective, low-cost, and easy-to-implement solution for light intensity monitoring systems.

3. Methodology

System Design

The proposed light intensity monitoring system consists of several main components, including an Arduino Uno microcontroller, a Light Dependent Resistor (LDR) as the input sensor, an I2C-based LCD as the display unit, and a buzzer as an alert indicator. The Arduino functions as the central processing unit that receives input signals from the sensor, processes the data, and controls the output devices accordingly.

The LDR sensor operates based on the variation of resistance according to the intensity of incident light. To enable the Arduino to read the sensor output, the LDR is connected using a voltage divider circuit. This configuration converts resistance changes into analog voltage values that can be read by the Arduino through its analog input pins.

The LCD I2C module is used to display the measured light intensity values in real-time. The I2C communication protocol allows efficient data transmission using only two lines, namely SDA and SCL. Meanwhile, the buzzer serves as an alert mechanism that is activated when the detected light intensity falls below a predefined threshold.

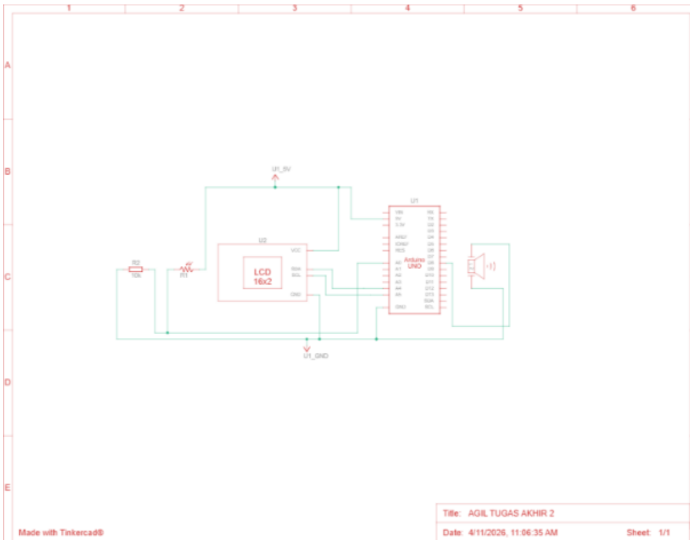

Figure 1. Circuit System Schematic.

Hardware Design

The hardware design involves connecting all system components according to their respective functions. The LDR sensor is connected to the analog input pin of the Arduino through a voltage divider circuit. The LCD I2C module is connected to the SDA and SCL pins, while the buzzer is connected to one of the digital output pins.

The system is powered by a 5V supply from the Arduino, ensuring stable operation of all components. Proper circuit design is essential to maintain the accuracy and stability of sensor readings. A well-structured hardware configuration minimizes noise and ensures reliable system performance.

The LDR was connected in a voltage divider configuration using a 10 kΩ resistor. The output voltage was calculated using:

$$Vout = Vcc \times \frac{R_{fixed}}{R_{LDR} + R_{fixed}}$$

The analog voltage was then converted into a digital value by the Arduino Uno's 10-bit ADC (0–1023).

The components of the configuration and their corresponding Arduino pins are presented in Table 1.

Tabel 1. Results Table.

Component	Arduino Pin
LDR	A0
LCD SDA	A4
LCD SCL	A5
Buzzer	D8

Software Design

The software for this system is developed using the Arduino IDE with a programming language based on C/C++. The program is designed to continuously read analog values from the LDR sensor and process the data to determine the light intensity category. The classification of light intensity is based on predefined threshold values as follows:

1. **Bright** : value > 170
2. **Moderate** : value between 100 and 170
3. **Dark** : value < 100

Based on these thresholds, the system determines the current light condition. If the detected value falls below the threshold (dark condition), the buzzer is activated. Otherwise, the buzzer remains inactive. The measured values and corresponding conditions are displayed on the LCD in real-time.

This approach follows a simple threshold-based classification method commonly used in sensor-based monitoring systems.

System Flowchart

The system flowchart describes the overall operational process of the monitoring system. The process begins with system initialization, where the Arduino, LDR sensor, LCD, and buzzer are configured.

After initialization, the system continuously reads analog data from the LDR sensor. The obtained value is then compared with predefined threshold values to determine the light condition.

1. If the value is **below the threshold (dark condition)** → the buzzer is activated
2. If the value is **above the threshold** → the buzzer remains inactive

The result is displayed on the LCD, and the process repeats continuously in a loop. This looping mechanism ensures real-time monitoring of light intensity.

Flowcharts are commonly used in embedded system design to represent system logic clearly and systematically.

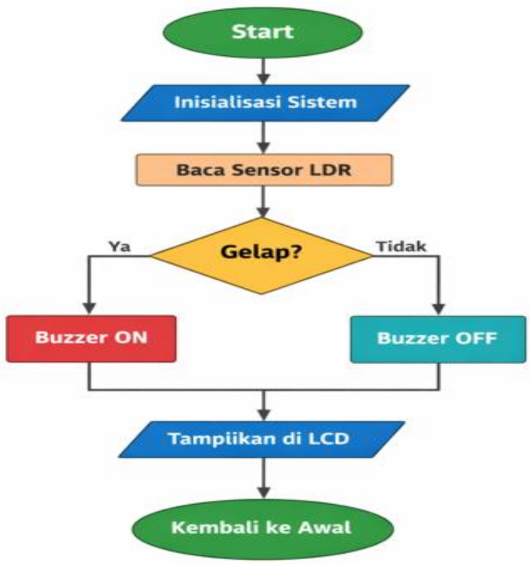

Figure 2. System Flowchart.

Testing Method

The validation process was conducted through simulation testing to verify the functionality of the proposed system. Various light intensity conditions were simulated by changing the input values of the LDR sensor. The simulation results showed that the system successfully classified light conditions into bright, moderate, and dark categories according to the predefined thresholds. Furthermore, the LCD displayed the corresponding sensor values correctly, and the buzzer was activated only when the sensor reading indicated a dark condition. These results confirm that the system logic and control algorithm operate as designed.

The testing method is conducted to evaluate the performance of the system in detecting light intensity and responding accordingly. The system is tested under three different lighting conditions: bright, moderate, and dark. Each condition is tested multiple times to ensure consistency and reliability of the results. The measured data are recorded and analyzed to evaluate system accuracy and responsiveness.

The purpose of this testing is to verify that the system operates according to the design specifications and meets the criteria of a good monitoring system, which include accuracy, responsiveness, and stability.

4. Results and Discussion

System Implementation

The proposed light intensity monitoring system was implemented using a physical hardware setup on a breadboard. The system consists of an Arduino Uno as the main controller, an LDR sensor as the input device, an I2C LCD as the display unit, and a buzzer as an alert indicator.

The LDR sensor is connected to the analog input of the Arduino through a voltage divider circuit, allowing variations in light intensity to be converted into analog voltage signals. These signals are then processed by the Arduino to determine the corresponding light condition. This implementation follows standard analog signal acquisition principles in embedded systems.

The LCD I2C module is used to display real-time light intensity values, providing a user-friendly interface. The buzzer is connected to a digital output pin and functions as an alert system when the detected light intensity falls below a predefined threshold.

The implementation results show that all components operate correctly and are well integrated, demonstrating stable system performance.

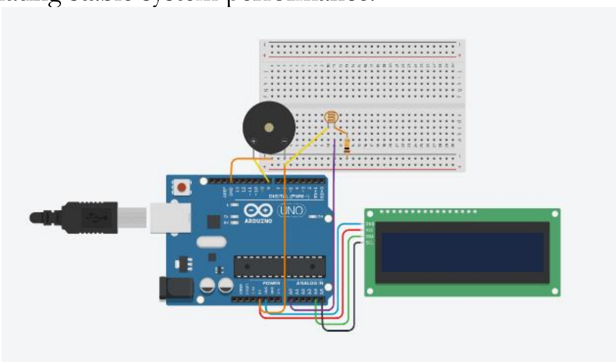

Figure 3. Breadboard circuit.

System Testing Results

System testing was conducted to evaluate the ability of the system to detect light intensity changes and provide appropriate responses. The tests were performed under three different lighting conditions: bright, moderate, and dark.

In bright conditions, the LDR sensor produces higher analog values due to lower resistance. Conversely, in dark conditions, the resistance increases, resulting in lower analog values. These results are consistent with the theoretical characteristics of LDR sensors.

The system successfully reads light intensity values in real-time and displays the results on the LCD. Additionally, the buzzer is activated automatically when the system detects dark conditions.

These findings are consistent with previous studies that demonstrate the effectiveness of Arduino-based monitoring systems in real-time environmental sensing.

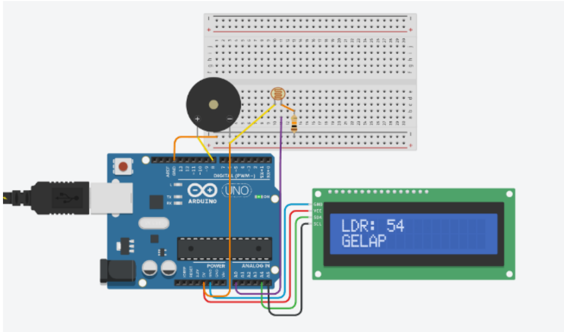

Figure 4. LCD Results.

Testing Data Table

The results of the system testing under different lighting conditions are presented in Table 2.

Tabel 2. Results Table

NO	Light Condition	LDR Value	Category	Buzzer Status
1.	Bright	200	High	Off
2.	Moderate	150	Medium	Off
3.	Dark	50	Low	On

The table shows that the system can effectively classify light conditions based on sensor readings. The variation in values indicates that the LDR sensor has good sensitivity to changes in light intensity.

Result Analysis

Based on the experimental results, the system demonstrates stable and reliable performance in detecting light intensity variations. Sensor readings of approximately 200 were categorized as bright because they exceeded the upper threshold of 170. Likewise, readings around 150 fell within the moderate range (100–170), while readings near 50 were classified as dark because they were below the threshold value of 100. This confirms that the LDR sensor responds appropriately to changes in light intensity according to its physical characteristics.

Furthermore, the system response aligns with the predefined logic. When the LDR value falls below the threshold (less than 100), the buzzer is activated as an alert signal. Otherwise, the buzzer remains inactive. This indicates that the implemented control algorithm functions correctly.

From a performance perspective, the system shows a fast response time with no significant delay in reading and displaying data. This makes the system suitable for real-time monitoring applications.

Discussion

Overall, the developed Arduino-based light intensity monitoring system performs effectively in fulfilling its intended functions, including sensing, processing, and displaying light intensity data in real-time.

The LDR sensor proves to be a reliable and cost-effective component for detecting light variations. The Arduino microcontroller successfully processes the sensor data and controls the output devices. The LCD provides clear visualization of data, while the buzzer enhances system functionality by providing an audible alert.

The results of this study are consistent with previous research, which indicates that sensor-based monitoring systems offer good accuracy and responsiveness in detecting environmental changes.

However, the system still has some limitations. It does not include data storage capabilities and is not connected to the internet. The LDR sensor is sensitive to ambient temperature and exhibits nonlinear characteristics, which may affect measurement accuracy. In addition, the system currently uses raw ADC values. Variations in power supply voltage may also influence sensor readings. Therefore, future improvements may include the integration of wireless communication modules such as WiFi or Bluetooth, as well as the implementation of IoT-based monitoring systems for remote access.

5. Conclusions

Based on the design, implementation, and testing of the Arduino-based light intensity monitoring system using a Light Dependent Resistor (LDR), it can be concluded that the system has been successfully developed and operates according to the intended objectives.

The system is capable of detecting light intensity changes in real-time using the LDR sensor and processing the data through the Arduino microcontroller. The measured values are displayed on an I2C-based LCD, allowing users to easily monitor environmental light conditions.

In addition, the system is able to provide an automatic response by activating a buzzer when the detected light intensity falls below a predefined threshold. This indicates that the control logic implemented in the system functions properly and reliably.

The experimental results show that the system can classify light intensity into three categories: bright, moderate, and dark, with approximate values of 200, 150, and 50, respectively. These results demonstrate that the LDR sensor has good sensitivity in detecting variations in light intensity.

Overall, the proposed system can serve as a simple, effective, and low-cost solution for real-time light intensity monitoring. Furthermore, the system has the potential to be enhanced in future work by integrating data storage capabilities or Internet of Things (IoT) features for remote monitoring and control.

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