Automatic Control System for Room Electrical Devices Based on Arduino Microcontroller and RTC

Ray Sandy Keliat, Solly Aryza Lubis

Abstract
Inefficient use of electrical energy, such as leaving electrical devices turned on without supervision, is a common problem that can lead to energy waste and increased operating costs. This study aims to design and implement a microcontroller-based electrical room control system that can automatically turn electrical devices on and off based on a specific time or command. This system uses an Arduino UNO microcontroller combined with a DS1307 RTC module as a timer, a relay as an electrical load controller, and a SIM800L GSM module as a medium for sending and receiving information via SMS. In addition, a buzzer is used as an active time indicator. Testing was conducted to observe the accuracy of the timer and the reliability of notification delivery when the device experienced interference. The test results show that the system can work according to the specified time, provide notifications when a malfunction occurs, and is able to control electrical devices with a success rate of 90%. The implementation of this system is expected to increase energy efficiency, reduce waste, and support automation in residential and office environments.

Keywords: Microcontroller, Electrical Control, Arduino UNO, RTC, Relay, GSM, Automation

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Introduction

In today's modern era, the need for electrical energy in various types of rooms, whether in residential, office, or industrial environments, has become very important to support daily activities. However, in reality, there are still many cases of inefficient electricity use. This is due to the habit of users who often leave electrical devices such as lights, fans, or computers turned on even when they are no longer in use. This habit not only causes energy waste but also has a negative impact on the environment and reduces comfort and operational efficiency (Rahmadani et al., 2022).

To overcome these problems, one solution that can be implemented is the development of a microcontroller-based electrical room control system. This system allows electrical devices to be controlled automatically based on time or certain conditions, so that energy use can be more efficient and controlled (Suryanto & Hidayat, 2021). Microcontrollers such as Arduino UNO can be combined with RTC (Real Time Clock) modules, relays, and other supporting sensors to form an automatic control system that is energy efficient, affordable, and flexible in its settings.

This study aims to implement a microcontroller-based electrical room control system that is capable of automatically controlling electrical devices in a room according to a predetermined schedule or based on commands sent via SMS. With this system, it is hoped that users can save electricity, reduce potential waste, and increase comfort and safety in the use of electronic devices.

In addition, this study will also identify and evaluate various technical obstacles that may arise during the implementation process, such as the selection of appropriate sensors, the complexity of module integration, and the handling of system errors that may occur during operation (Putra & Nasution, 2023). This study is expected to make a positive contribution to the development of microcontroller-based automatic control technology and serve as a reference for its application in various environments, such as homes, offices, laboratories, and other public facilities.

Literature Review

1). Real Time Clock (RTC)

A Real Time Clock (RTC) is a chip (Integrated Circuit/IC) that functions as a real-time time and date storage device even when the main system is turned off. One type of RTC that is commonly used is **the DS1307**, which is capable of storing complete time data, including seconds, minutes, hours, days of the week, dates, months, and years, with validity until the year 2100.

The RTC DS1307 works with an I2C (Inter-Integrated Circuit) serial communication interface, enabling easy integration with microcontrollers such as Arduino. This chip also features 56-byte Non-Volatile RAM (NVRAM) that allows storage of user data in addition to time. One of its main advantages is its very low power consumption (<500 nA) when using backup battery mode, allowing it to operate continuously even when the main power supply is off.

Figure 1. Real Time Clock

Other important features of the DS1307 are: Programmable square wave output: allows for the configuration of digital clock signal output. Automatic power-fail detect and switch circuitry: automatically switches to a backup power source in the event of a main power failure. Industrial temperature range: operates between -40°C and +85°C, making it ideal for extreme environmental applications. Available in 8-pin DIP or SOIC packages, which are compatible

with many types of development boards. The presence of an RTC in a room control system is very important, especially if time-based electrical control is required, for example in daily load management, automatic lighting schedules, and so on.

2). GSM/GPRS SIM800L Module

To enable remote control and notification systems in electrical room control systems, GSM/GPRS-based communication modules, such as SIM800L, can be used. This module supports serial communication with microcontrollers and can be used to send SMS, make calls, and access the internet via the GPRS network.

The mini version of the SIM800L is small in size and compatible with micro SIM cards. It supports operation in a DC voltage range of 3.2V to 4.6V, with a current consumption of up to 3A at maximum conditions, especially during burst transmission.

Figure 2. GSM/GPRS SIM 800L Module

Some of the main features of SIM800L include: Compatibility with various microcontrollers such as Arduino, ESP32, and AVR. Supports AT commands for serial communication. Can be used for remote monitoring systems or SMS-based control. Since not all microcontrollers provide an operating voltage compatible with SIM800L, a voltage regulator circuit (DC-DC converter) is required.

3). Voltage Converter Module (Step-Down Power Supply)

To support modules that require a specific voltage, such as the SIM800L, a DC to DC step-down converter is needed, which reduces the voltage from the main power source (e.g., a 7.4V Li-Ion battery or a 12V source) to the module's operating voltage (3.7V – 4.2V). One commonly used converter is the LM2596.

Figure 3. Step-Down Power Supply Module Converter

This converter module operates with high efficiency and has the ability to regulate the output voltage according to the module's requirements. In certain cases, voltage reduction can also be achieved by using resistors, but this is not recommended for modules with high current consumption fluctuations, such as SIM800L. The use of the right DC to DC converter ensures that the system runs stably and prevents damage to electronic components due to over-voltage.

Research Methodology

1. Timer Design in Electrical Control Systems

In the design of a microcontroller-based electrical room control system, two Arduino UNO pins are used, namely pins A4 and A5, which function as communication channels with the DS1307 RTC module using the I2C protocol. Pin A4 functions as SDA (data) and pin A5 as SCL (clock).

This RTC module will provide real-time time data to the Arduino. Based on this time data, the Arduino will control the relay to automatically turn electrical devices on or off according to a

pre-programmed schedule. For power supply, the GND pin of the module is connected to the negative (-) pin of the power supply, while the VCC pin is connected to the positive (+) pin of the power supply with a voltage of 5V. This configuration ensures that all components receive a stable and appropriate power supply. This circuit is shown in Figure 4, which illustrates the connection between the Arduino, RTC, relay, and power supply.

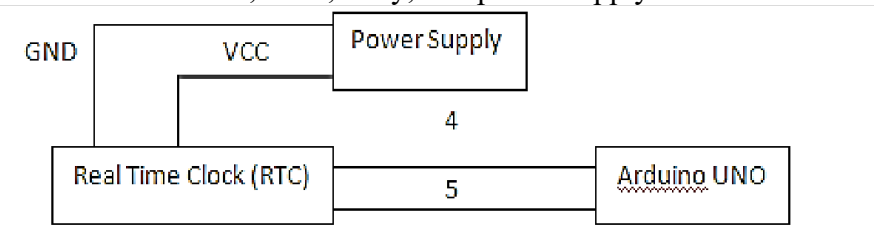

Figure 4. Real-Time Clock (RTC) Circuit Design

2. Buzzer Circuit in the Electrical Control System

The buzzer circuit functions as an audible indicator in a microcontroller-based electrical room control system. This component requires only one data pin to receive logic signals from the Arduino, as well as power pin connections (VCC and GND) for voltage supply. In this design, digital pin 12 on the Arduino UNO is used as the control pin that sends signals to the buzzer via a relay module. The relay is used as an electronic switch to break or connect the current to the buzzer, especially if the buzzer used has a higher voltage or requires a larger current than can be supplied directly by the Arduino.

1) The buzzer's VCC pin is connected to the 5V voltage from the power supply.
2) The buzzer's GND pin is connected to the negative (-) pin of the power supply as ground.
3) Meanwhile, the data pin is controlled by pin 12 of the Arduino, which is connected to the relay module input.

With this configuration, the buzzer will activate (sound) when the Arduino sends a HIGH signal to pin 12, which then activates the relay to conduct current to the buzzer. Typically, buzzers are used as notifications when the system turns certain devices on or off, or as alarms in certain conditions.

The connection diagram between the buzzer, Arduino, and relay is shown in Figure 5.

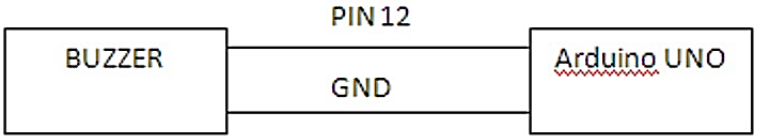

Figure 5. Buzzer Circuit

Results

1. Testing the Automatic Timer System

Testing was conducted to ensure that the microcontroller-based electrical room control device that had been designed could function according to the expected logic. The main focus of the testing was on the accuracy of the timer function in turning on electrical devices based on the time that had been programmed using the RTC (Real Time Clock) module. The testing method was carried out directly using **a stopwatch** as a tool to observe the accuracy of the system's timing. Each test was conducted by setting the device's power-on schedule through the microcontroller program, then recording whether the device turned on at the right time, experienced a delay, or did not function at all. The results of these tests were recorded and summarized in Table 1 below:

Table 1. Timer Test Results

Date	Set Timer	Test Scenario	Test Results	Status
July 11, 2025	5:00 PM	Set the time to turn on according to Schedule 1	Turned on at the specified time	On time

July 11, 2025	6:00 PM	Set the on time for Schedule 1	Turns on beyond the scheduled time	2-minute delay
July 12, 2025	1:00 PM	Set the on time for Schedule 1	Turned on at the specified time	On time
July 12, 2025	3:00 PM	Set the on time for Schedule 1	Device does not turn on	Error

From the above test results, it is known that the system is able to work on **time** in most scenarios, such as in the tests on July 11 at 17:00 and July 12 at 13:00. However, there was **a delay** in the test at 6:00 p.m., which indicates a possible **data communication disruption** between the RTC and the microcontroller or a system load that caused the microcontroller to respond indirectly.

During testing on July 12 at 3:00 p.m., **an error** occurred in which the device did not turn on at all, indicating the need for further inspection of the pin connections, relay module condition, or running program logic. In general, the RTC-based timer system was able to perform its functions properly, but **improvements** are still needed **in terms of program and hardware stability** to avoid delays or malfunctions. Further testing is recommended in various time and load scenarios to improve the overall reliability of the system.

Testing the SMS Notification System Based on Component Status

This test aims to ensure that the SMS notification system can detect and inform the status of electrical components such as lights, fans, and computers, especially when there is a disturbance or damage to one or more of these components. These notifications are sent via the SIM800L GSM module, which is integrated with the microcontroller system. The system is designed to automatically send short messages (SMS) to users when a component is found to be off or malfunctioning, even though it should be active. The information is sent in the form of short text messages, such as "Light 1 off," "Fan off," or a combination of several statuses.
The test results are summarized in Table 2 below:

Table 2. SMS Testing if Components Are Not Functioning (Year 2025)

Date	Component Status	SMS Information Sent
July 11, 2025	Light 1 On, Light 2 On, Fan On, Computer On	No information
July 11, 2025	Light 1 On, Light 2 On, Fan Off, Computer On	Fan off
July 11, 2025	Light 1 Off, Light 2 On, Fan On, Computer On	Light 1 off
July 12, 2025	Light 1 On, Light 2 Off, Fan On, Computer On	Light 2 off
July 12, 2025	Light 1 off, Light 2 off, Fan on, Computer on	Light 1 off, Light 2 off
July 12, 2025	Light 1 On, Light 2 On, Fan Off, Computer Off	Computer off, fan off

Manual Testing via Keyword

In addition to automatic testing based on component status, the system is also tested manually using **commands (keywords)** via SMS to verify the two-way interaction between the user and the system.
In this case, users can send an SMS with specific keywords such as:

- #9: To **request the** real-time **status** of **all components**. The system will respond with the current status of the lights, fan, and computer.
- #0: To **reset** or turn off all devices automatically through the system.

The test was conducted by sending both keywords to the SIM number installed on the SIM800L module. The system successfully responded to the command by sending a reply SMS containing the component status or performing the action according to the command sent.
Based on the testing conducted:

a) The system successfully detected the non-functioning component and automatically sent SMS information to the user.
b) The system is also capable of receiving manual commands via specific keywords and providing responses according to the instructions.

c) However, ongoing testing is required to ensure the system's long-term reliability, especially in GSM network communications, which may experience signal interference.

With the implementation of this system, users can easily monitor and control the condition of electrical components remotely, thereby improving the efficiency and safety of electricity use in the room.

Test Data: When typing #9 in an SMS, the result will turn on the electricity in the room shown in Figure 6.

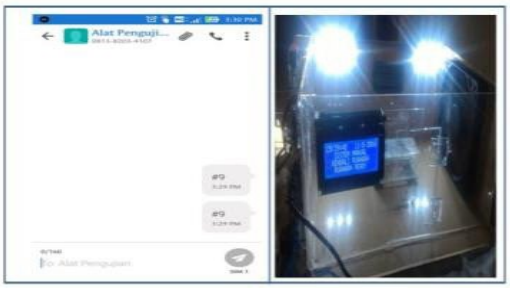

Figure 6. Test Results for Keyword #9 Turning on Electricity

Automatic Activation Mechanism via Timer and Buzzer

Once the time specified by the timer system based on real-time data from the RTC module has been reached, the system will automatically sound a warning signal via a siren buzzer. This buzzer will sound as an initial indicator that the room usage time has started or will soon be used. This time information can also be displayed via a monitor display or connected interface system.

The duration of the buzzer sound is designed to be approximately 1 minute, but can be reset according to user needs through a program or SMS-based control system. This function aims to provide early warning to users or occupants of a room, such as in classrooms, meeting rooms, or laboratories, before the system automatically turns on all electrical devices.

After the buzzer duration ends or when the system receives confirmation of active time via SMS command, the buzzer will automatically turn off. At the same time, the system will activate the configured relay to control the flow of electricity to the equipment inside the room. This command is processed by the Arduino UNO microcontroller, which has been programmed to regulate the timing logic and device control based on input from the RTC and/or commands from the user via the SIM800L GSM module.

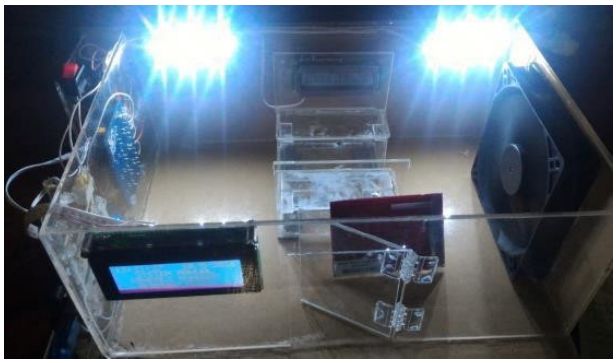

Figure 7. Test Results of the Room Electrical Control Device when in use

Overall, this process consists of three main stages:

1) Detecting active time via RTC → Triggering the buzzer sound.
2) Automatic buzzer shutdown based on time or SMS command.
3) Activation of electrical devices via relay by microcontroller.

Controlled electrical flow includes devices such as lights, fans, computers, or other equipment according to the system configuration. This process is illustrated visually in Figure 7, which shows the system workflow from time reading to electrical device activation.

Conclusion

Based on the results of the design, implementation, and testing that has been carried out, it can be concluded that the microcontroller-based electrical room control system that was developed successfully functions as intended ( ) in accordance with the research objectives. This system is capable of automatically controlling electrical devices based on a predetermined time through the DS1307 RTC module, as well as receiving and responding to SMS commands using the SIM800L GSM module. The buzzer feature, which serves as an active time indicator, also functions properly, alerting users before electrical devices are turned on. In addition, the system can detect if there is a malfunction in one of the devices and automatically send an SMS notification. Testing shows that the system works with a high degree of accuracy and success, although there are still some obstacles such as delays and dependence on the stability of the GSM network. Overall, this system provides significant benefits in increasing the efficiency of electricity use, reducing waste, and providing easy automatic and remote control of devices. Therefore, the implementation of this system is feasible for residential, office, or other public facilities.

References

[1] Anisah, S., Tharo, Z., Hamdani, H., & Butar, A. K. B. (2023). Optimization Analysis Of Solar And Wind Power Hybrid Power Plant Systems. Proceedings of Dharmawangsa University, 3(1), 614-624.

[2] Hamdani, H., Sastra, A., & Firmansyah, D. (2023). Study of the Development of a 50 Kg Capacity Smart Goods Lift with Solar Power Generation (PLTS). INTECOMS: Journal of Information Technology and Computer Science, 6(1), 429-433.

[3] Hamdani, H., Tharo, Z., Anisah, S., & Lubis, S. A. (2020, September). Design of a Modified Sine Wave Inverter in Solar Power Plants for Residential Use. In Proceedings of the UISU National Engineering Seminar (SEMNASTEK) (Vol. 3, No. 1, pp. 156-162).

[4] Tharo, Z., Hamdani, H., & Andriana, M. (2019, May). Hybrid solar and wind power plants as an alternative source to address the fossil fuel crisis in Sumatra. In Proceedings of the UISU National Engineering Seminar (SEMNASTEK) (Vol. 2, No. 1, pp. 141-144).

[5] Tharo, Z., Hamdani, H., Andriana, M., & Yusar, J. H. (2022). Implementation of environmentally friendly generator sets based on solar panels in Tomuan Holbung Village. Journal of Higher Education Lecturer Service (Jurnal Deputi), 2(2), 98-101.

[6] Tharo, Z., Syahputra, M. R., Hamdani, H., & Sugino, B. (2020). Analysis of Medium Voltage Network Protection System Using Etap Application at Kualanamu International Airport. JOURNAL OF ELECTRICAL AND SYSTEM CONTROL ENGINEERING, 4(1), 33-42.

[7] Wibowo, P., Lubis, S. A., & Hamdani, Z. T. (2017). Smart home security system design sensor based on pir and microcontroller. International Journal of Global Sustainability, 1(1), 67-73.

[8] Yusup, M. (2022). Radio Frequency Identification (RFID) technology as a tool for automatic door opening systems in smart houses. Jurnal Media Infotama, 18(2), 367-373.

[9] Endo.A.S., Hansi E., "Arduino-Based DC Motor Speed Control System Using the Open Loop Method," Journal of Electrical Engineering and Vocational Education, 6(1), pp. 1-12, 2020.

[10] Ayu L., Oriza. C, "Prototype of a Goods Sorting System in Industry Using Arduino Uno-based Loadcells," Journal of Electrical Engineering and Vocational, 7(1), pp. 27-36, 2021.

[11] Muhammad.K, Aswardi.A., "Design of a Goods Sorting Control Device Based on Four Color Codes," Journal of Electrical Engineering and Vocational, 6(2), pp. 391-402, 2020.

[12] Renol.F, Hambali, "Design of a Non-Invasive Blood Sugar Radar Measuring Device Based on Arduino Uno Microcontroller," Journal of Electrical and Vocational Engineering, 6(1), pp. 69-76, 2020.

[13] Try Y.C., Taali, “Separate Gain DC Motor Speed Control System with Arduino-Based PWM Control Technique”, Journal of Electrical Engineering and Vocational, 6(1), pp.199-210, 2020.
[14] Fergiawan.I.P, Ali.B.P., "Arduino-Based Areca Nut Drying Device," Journal of Electrical Engineering and Vocational Education, pp. 89-97, 2020.
[15] Muhammad.K, Aswardi, "Arduino Uno Microcontroller-Based Voltage Control System," Journal of Electrical Engineering and Vocational Studies, pp. 134-144, 2020.