Journal of Engineering, Electrical and Informatics
Vol.4, No.2 June 2024
e-ISSN: 2809-8706; p-ISSN : 2810-0557, page 01-17
DOI: https://doi.org/10.55606/jeei.v4i2.3033

Smart Office Application With Iot-Based Light Monitoring And Controlling Features

Achmad Hamdan*[1]
Electronic Systems Engineering Technology Study Program, Faculty of Vocational Studies, Malang, Universitas Negeri Malang, Indonesia

Bagus Aditama[2]
Electronic Systems Engineering Technology Study Program, Faculty of Vocational Studies, Malang, Universitas Negeri Malang, Indonesia

Muladi[3]
Electronic Systems Engineering Technology Study Program, Faculty of Vocational Studies, Malang, Universitas Negeri Malang, Indonesia

Wahyu Nur Hidayat[4]
Informatics Engineering Education Study Program, Faculty of Engineering, Malang, Universitas Negeri Malang, Indonesia

Alamat: Jl. Ambarawa No.5, Sumbersari, Kec. Lowokwaru, Malang City, East Java 65145*Correspondent email : achmad.hamdan.ft@um.ac.id*

Abstract*. The activity of using office facilities such as turning on lights is usually carried out manually by human physical effort. Unbeknownst, this activity reduces the effectiveness of office users' performance and raises concerns about excessive electricity usage due to not knowing whether the lights are still on or have been turned off. Therefore, a smart office application based on the Internet of Things is needed to control the lighting conditions and monitor electricity usage. In this study, the device is developed using several sensors including Pzem-004T, RTC, LDR, and Firebase database. The research results in (1) light control can be done through an Android application utilizing the Firebase database divided into two modes: automatic and manual; (2) by utilizing serial communication from Esp32 with PZEM004T, the smartphone application can display real-time data and usage history to facilitate users in controlling and monitoring the lights; (3) light sensors (LDR) and Ultrasonic Sensors (HC_SR 04) function well to adjust the range of values as considerations for when the lights should turn on and off; (4) with PZEM004T-V3.0, the application can monitor energy usage, even up to the total cost of usage.*

Keywords*: Smart Office, IoT, Monitoring, Controlling, Lights.*

INTRODUCTION

Smart office or intelligent office is the implementation of a concept aimed at supporting human productivity. Smart offices should be designed to assist workers in the office according to their needs because too much interaction among colleagues or with surrounding objects will disrupt office workers' productivity. According to research conducted by (Harun Sujadi, et al.), it is concluded that a smart office system can create a representative office environment, thus enhancing the quality and effectiveness of employees' work. The concept of a smart office focuses on the people working within it, so the technological needs and services required for each office may vary.

Received Mei 30, 2023; Accepted June 07, 2024; Published June 30, 2024
* Tutut Alamin , Mayautami@gmail.com

Currently, smart offices are widely implemented using the Internet of Things (IoT). The concept of IoT-based smart offices can provide ease in control and monitoring as it can be combined with gadgets, enabling monitoring and control from anywhere and anytime. By implementing this concept, we can integrate control and monitoring tools into one, making activities more efficient. The additional feature in my research compared to other studies is adding the PZEM004T sensor for monitoring electrical energy and a database for real-time data access.

PZEM-004T is a sensor used to measure voltage, current, power, frequency, energy, and power factor. When combined with IoT, the PZEM-004T sensor can facilitate real-time monitoring of electricity usage through an Android application.

The Vocational Faculty at Universitas Negeri Malang is a relatively new faculty, so some of its buildings are either already completed or still undergoing renovation. Particularly in Building A24 of the Vocational Faculty's second floor, a common problem is lights being left on due to users forgetting to turn them off, often due to negligence in switching power from on to off. Additionally, there is no system to monitor or control the condition of the lights if they are no longer in use.

To address the above issues, the implementation of an IoT-based smart office in Building A24 of the Vocational Faculty, specifically in the second-floor meeting rooms, is necessary to control and monitor electronic devices (lights) in the office by applying IoT-based electronic devices with smartphones, which almost everyone possesses and carries with them. Based on the above elaboration, the researcher develops a Smart Office Application With Monitoring and Controlling Features for Lights Based on IoT.

Problem Statement

From the background above, the problem formulations are determined as follows:

1. How to control the lighting through an Android application?
2. How to monitor electrical energy through an Android application?
3. How to design an IoT-based Smart Office along with the user interface of the Android application to control the lights and monitor electrical energy in the office area?

Research Benefits

The benefits obtained from designing this device are:

1. For building users, it can facilitate controlling and monitoring the building's electronic equipment (lights).
2. For the general public, this development can serve as an example of implementing IoT-based smart office systems in office areas.
3. For further research, the design of this device can serve as a reference for developing IoT-based smart office systems for further development and serve as the basis for future research in related or similar fields.

LITERATURE REVIEW

Smart Office

Smart Office combines technology and services specifically designed for office environments with the aim of enhancing the security, efficiency, and comfort of its occupants. Smart office systems typically include monitoring devices, control systems, and automated device performance. This application aims to provide supporting facilities for room occupants or users. According to (Fauzan Masykur and Fiqiana Prasetiyowati, 2016), the technology in Smart Office is designed to facilitate owners in monitoring the condition of connected electronic equipment from their gadgets.

The main components of the Smart Office concept include:

1. Sensors and IoT Devices: Placed throughout the office to collect data on temperature, light, humidity, sound, and other activities.
2. Automation Technology: Used to control various systems in the office such as lighting, heating, cooling, and security.
3. Energy Management: Integrating energy management systems to monitor and control energy consumption, thereby reducing operational costs and environmental impacts.
4. Security Technology: Includes smart door access, surveillance cameras, and smart security systems to maintain the physical security of the office and sensitive data.
5. Smart Applications and Software: Assist employees in task management, scheduling, and communication among employees. Smart rooms can adjust temperature, lighting, and ambiance according to employee preferences.

Internet of Things (IoT)

IoT is a human-made remote control system based on the Internet. The way IoT works involves automatic interaction between connected machines without human intervention, even over long distances. The Internet serves as a connection between electronic devices and users, while users act as controllers and supervisors of these devices. The benefits of IoT include faster, easier, and more efficient work. The basic system of IoT consists of three main components: Hardware, Internet Access, and Firebase Realtime Database as a cloud server.

1. Artificial Intelligence (AI)

AI is a human-made program aimed at making machine performance, such as computers, mimic human behavior. AI enables the replacement of tasks typically performed by humans. One aspect of AI is data collection systems, network building, and the development of intelligent algorithms. An example is the robot waiters in restaurants in Japan that use AI to function like human waiters because the robot control system is supported by complex AI.

2. Connectivity

Connectivity refers to the relationship between networks in the IoT system, allowing small devices to connect with each other and create effective and efficient performance. The cost of installing the system that wants to be implemented can be inexpensive or expensive.

3. Microcontrollers

Technological advancements allow the creation of small devices, which can lower costs to be more affordable yet highly effective and accurate. This makes IoT devices more convenient, precise, and efficient for future use.

4. Sensors

Sensors are data-collecting electronic devices based on their types. Sensors allow IoT to change the conditions of electronic devices based on values detected by the sensor. For example, IoT technology uses sensors for controlling or monitoring offices connected to the internet.

Firebase

Firebase is a service owned by Google that aims to facilitate software developers in creating applications, especially mobile applications. Firebase offers various features that are very beneficial for mobile app developers. These features include Authentication, Database, Storage, Hosting, and Analytics, which make it easier for developers to create high-quality and interactive mobile applications. By using Firebase cloud, developers can save time because this service provides intuitive APIs in one SDK package, minimizing the need for complex integration.

Arduino IDE

Arduino IDE is software used to write programs, compile binary code, and send it to Arduino microcontrollers serially. Arduino IDE uses a simplified version of the C++ programming language, making it easier to use. The program code in Arduino is commonly referred to as "sketch". Arduino IDE was developed from processing software specifically modified for Arduino programming (Hermawan, 2016).

Android Studio

Android Studio is software used for developing Android applications. Android Studio uses the Java and Kotlin programming languages. Android Studio replaces its predecessor in Android development, Eclipse ADT (Android Development Tools). Android Studio has many features that assist in Android application development. In Android Studio, each project has several types of modules such as application modules, library modules, and Google Cloud modules containing source code files and resource files from open source.

ESP32

ESP32 DevKit is a microcontroller that is an upgraded version of the ESP8266. ESP32 has several advantages such as built-in Wi-Fi and Bluetooth features on the board itself. This microcontroller also has a processor with fairly high speed with Dual-Core at speeds of 160/240MHz.

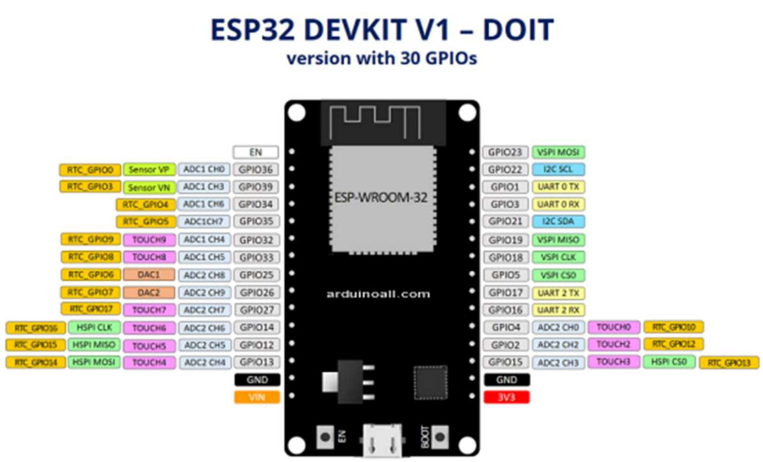


Figure 1. ESP32

ESP32 DevKit has additional internal Wi-Fi and Bluetooth capabilities. GPIO pins are General Purpose Input Output pins that function as both analog and digital input and output pins.

Relay

A relay is an electronic component that functions as an electronic switch operated by an electrical current. The working principle of a relay involves a switch lever with wire winding on an iron core (solenoid). When an electric current flows through the solenoid, the lever is attracted by the magnetic force, causing the switch contacts to close. When the current is interrupted, the magnetic force disappears, and the lever returns to its original position, opening the switch contacts. Relays are commonly used to control large currents or voltages with small currents or voltages. Relays operate based on the principle of electromagnetic field induction, which was first discovered by Joseph Henry in 1835 (Elangsakti, 2013).

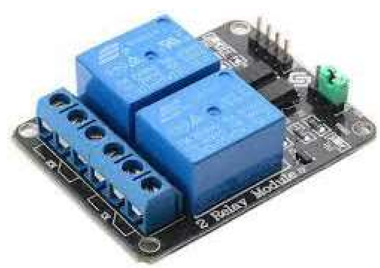


Figure 2. Two-Channel Relay

PZEM-004T V3.0 Sensor

The PZEM-004T V3.0 module is a multifunctional sensor that measures voltage, current, active power, frequency, and power consumption (wh). This module is equipped with a current coil. The working principle of the current measuring toroid is that when a wire is passed through an AC electric current, it will generate a magnetic field that induces voltage and electric current at the ends of the toroid coil. The strength of the magnetic field induction is proportional to the number of wire windings (RN Pambuka, DT Rahardjo, 2018).

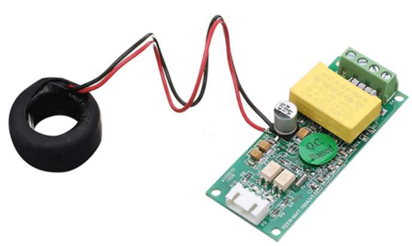


Figure 3. PZEM-004T V3.0

The Current Transformer (CT) in the PZEM-004T V3.0 module plays an important role in measuring the electric current flowing through a conductor without needing to disconnect the main circuit.

Light Dependent Resistor (LDR)

A Light Dependent Resistor (LDR) is a type of resistor whose resistance changes based on the intensity of light it receives. The darker the light, the higher its resistance; conversely, the brighter the light, the lower its resistance. LDRs are used as light conversion measurement devices. The resistance of an LDR in darkness is around 10 MΩ, and in brightness, it's around 1 KΩ.

Figure 4. Light Dependent Resistor (LDR)

Ultrasonic Sensor HC-SR04

The HC-SR04 ultrasonic sensor is used to measure the distance of objects based on the frequency of waves sent and received by the sensor. The Trigger pin functions to emit a signal, and Echo to receive the signal back after bouncing off the object. The operation of this sensor is when a positive voltage is applied to the Trigger pin for 10uS, the sensor sends 8-step ultrasonic signals, and then the signal is received at the Echo pin. The time difference between sending and receiving signals is used to measure the distance of the object.

Figure 5. Ultrasonic Sensor HC-SR04

RESEARCH METHODS

Research Flow

The objective of this research is to create a system and device capable of controlling and monitoring the illumination of a lamp. A microcontroller and an Android application interconnected with a database through internet connection are expected to control and monitor the lamp remotely. The success of the device design with the desired functionality includes:

lamp control from the Android application, real-time display of electricity consumption data along with its cost on the Android device, and recording of electricity consumption data.

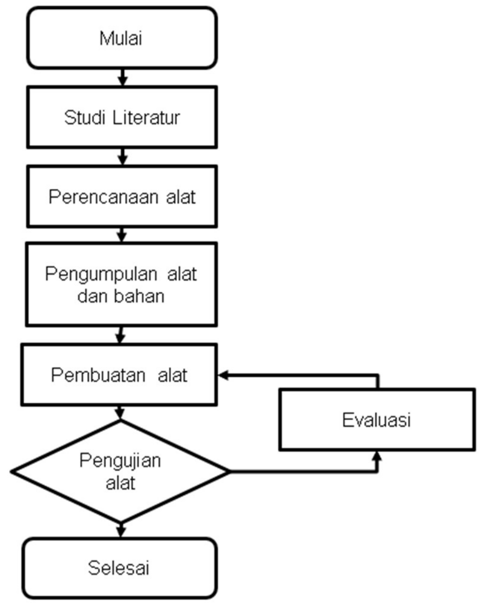


Figure 6. Research Flow Diagram

Literature Review

Literature review is utilized to find references relevant to the researched issue. Literature sources include books, several scientific articles obtained from the internet, and scientific journals to support the planning of the system and device in the research. Some literature sources used are:

1. Basic principles and an overview of smart office systems
2. IoT and Multiplatform Applications developed with Android Studio
3. IoT-based lamp control and monitoring system
4. Database and IoT (Internet of Things) integration on ESP-32.
5. Development of Android-based applications using Android Studio

Hardware Design

This research employs ESP32 as its microcontroller. It serves as the data receiver transmitted from Android to the database. Subsequently, the data is processed and provides output to the relay and interface so that users can ascertain the condition of the lamp.

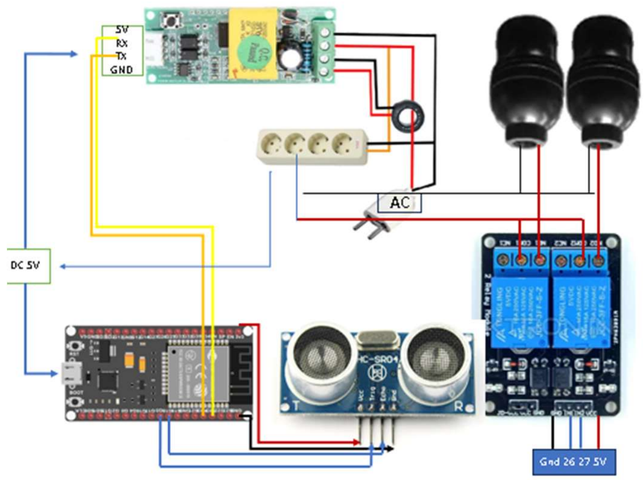


Figure 7. Wiring Diagram

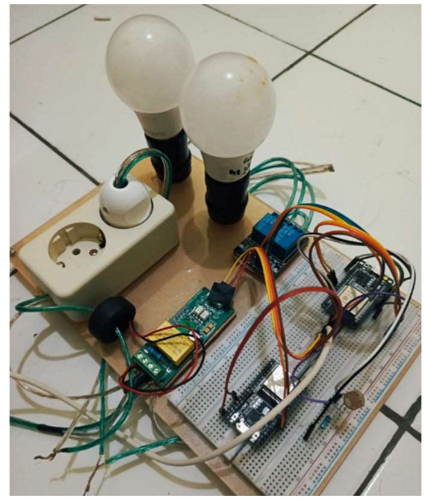


Figure 8. Device Design

Components that are used include ESP32 Devkit V1, PZEM-004T V3.0, Dual Channel Relay, USB Cable, Ultrasonic Sensor (HC-SR04), Light Sensor (LDR), Philips 6Watt Bulb, Jumper Wires, and Project Board.

Block Diagram

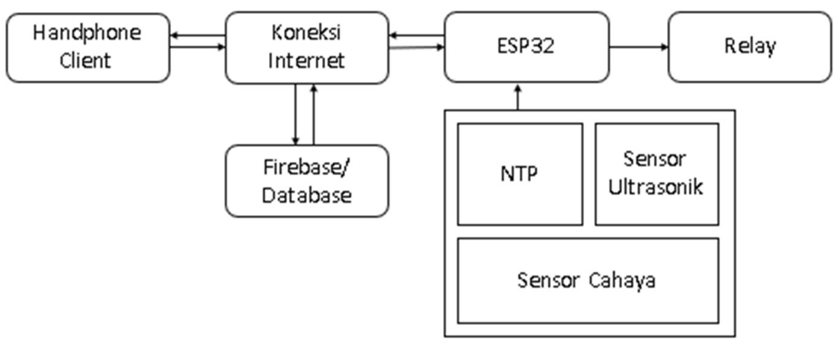


Figure 9. Block Diagram

Explanation of the above 10-block diagram is as follows: (1) Input Block, (2) Internet Access Block as a connector, (3) Database Block, (4) Microcontroller Block, (5) Sensor Block, and (6) Output Block. In the Input Block, an Android application is used in the form of buttons or toggle switches. The Android application functions as a data sender to Firebase, which is then retrieved by the microcontroller.

Within the database block, an internet connection is required to access the database in order to send and retrieve input data. The database serves as a data storage medium, and communication is required for data retrieval and transmission, utilizing stream communication. This means that the user interface on the application will change when there is a change in data on the server.

The Microcontroller Block serves as the storage location for data built on the Firebase infrastructure. Data input from the Android application via Firebase will be retrieved by the microcontroller, stored, and forwarded to the output block. The Sensor Block functions as a more detailed parameter before the input data is forwarded to the output. The output condition will change according to the data stored on the microcontroller, based on commands from the Android application and the sensor data.

Figure 10. Monitoring System Block Diagram

From the above diagram (Figure 11), it can be understood that the sensor readings will be sent to the microcontroller via the RX and TX pins. Afterward, the data will be transmitted to the database, and the values from the database will be retrieved by the Android application to be displayed on the screen.

Software Design

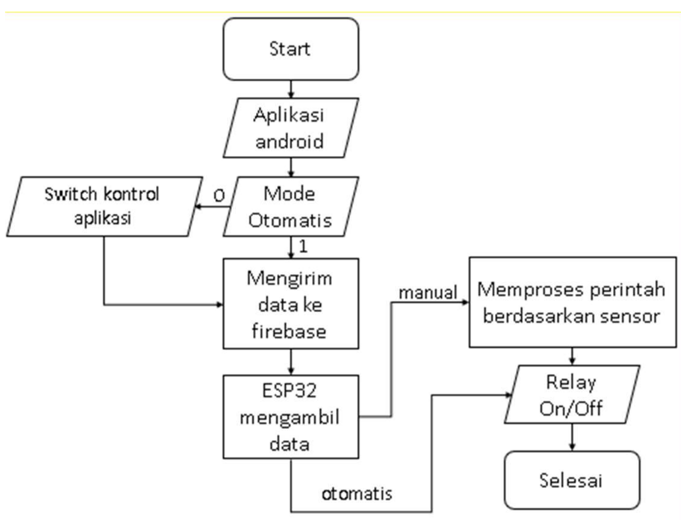


Figure 11. Software Flowchart

In the flowchart built for the IoT-based lamp control and monitoring system (Figure 12), it can be divided into several stages. The first stage is 1) User/Input, which relates to the activities performed by the user. The next stage is 2) Communication Process carried out by the application. The subsequent stage is 3) Database, which involves how the system communicates and processes data. The last stage is stage 4) Output, which is the final stage where the data processed by the microcontroller is presented.

Device Construction

The design process involves gathering the necessary materials. The device construction is done gradually, starting from designing the hardware and software. The device is built and tested to ensure that the circuitry works correctly or not, using Arduino IDE to input the program.

Device Testing

Several tests on the hardware need to be considered, namely: testing the function of each component, database response when given input from the application, and then testing the database connected to the components. Continued with testing the Android application by retrieving and sending data to the database.

Device Evaluation

Evaluation is conducted once the design is completed. Data collection is done from each input, process, and output. This helps identify any bugs in both the application and the device. If the evaluation does not meet the desired criteria, which include: sending data from the PZEM004T sensor to the database, retrieving control data from the database, real-time monitoring feature from the Android application, sending control data to the database with a switch, and printing data from sensor readings for 1 month. If it does not meet the criteria, then retesting is done, and measurements can also be taken to determine which part is malfunctioning.

RESULTS AND DISCUSSION

This section discusses the test results and data analysis, including testing the sensor values from PZEM004T V3.0 and control from the Android application, as well as cloud testing, where the output results will be analyzed to provide an understanding of the test data.

A. Testing of Dual Channel Relay Module

This test aims to determine whether the relay module can function properly when used.

1. Tools and Materials

Table 1. Tools and Materials for Relay Testing

Tools and Materials	Quantity
Esp32	1
Computer	1
Dual Channel Relay	1
Project Board	1
USB Cable	1
Jumper	As needed

2. Testing Procedure
   a. Prepare the tools and materials.
   b. Arrange the tools and materials according to the pins used.

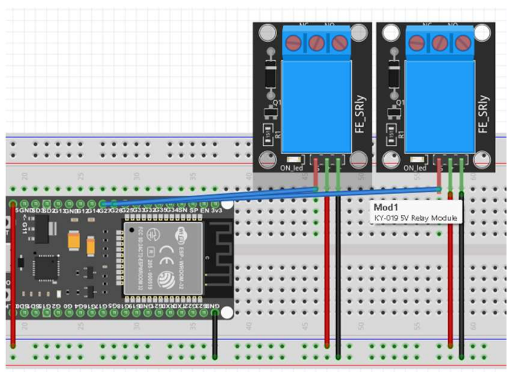


Figure 12. Testing of Dual Channel Relay

   c. Connect the Esp32 to the laptop using the USB cable.
   d. Use the available library in Arduino IDE and adjust the pins used.
   e. Upload the program to Esp32.
   f. Observe and record.
3. Test Results and Analysis

The obtained test data results are as shown in table 2, where when channel 1 is high, it will be in the normally closed condition, and when low, it will be in the normally open condition.

Table 2. Test Results Data of Dual Channel Relay

No	Logic of Relay Output Pin	Condition
1	High	NC
	Low	NO
2	High	NC
	Low	NO

Testing of PZEM004T-V3.0 Sensor

This test aims to determine the comparison between the sensor measurement results and manual measurements. It should be noted that the stability of electrical voltage at the location and the accuracy of the measuring device in the form of a multimeter during testing can affect the overall results. It is expected that the accuracy level value approaches that of the PLN Kwh Meter.

Table 3. Voltage Testing Data

No	PZEM004T-V3.0	Avometer
1	209	211,5
2	209,3	212,1
3	208,6	211,7
4	208,9	210,9
5	209,2	211,3

Table 3. Current Testing Data

No	PZEM004T-V3.0	Digital Avometer
1	0,07	0,0924..
2	0,08	0,0915..
3	0,06	0,0923..
4	0,07	0,0924..
5	0,09	0,918

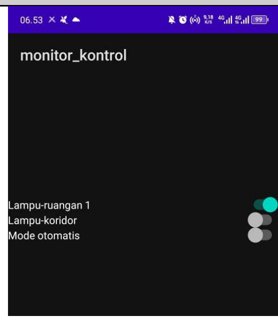
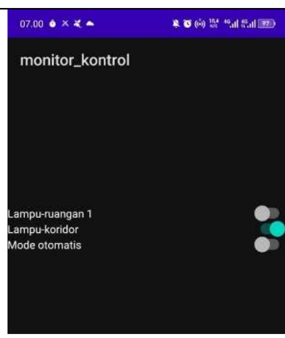
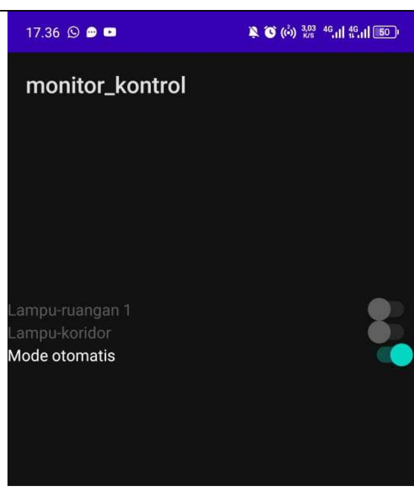
Table 4. Power Testing Data

No	PZEM004T-V3.0	2 pieces of Philips 6-watt bulbs
1	11,6	12
2	11,5	12
3	11,7	12
4	11,7	12
5	11,6	12

Overall Device Testing

This testing involves controlling the device from the application based on settings made according to manual and automatic controls. In automatic control, lamp 1 will be active if the ultrasonic sensor detects a person within a distance of less than 2 meters and the light sensor within the range of 500. Lamp 2 will be active if it is between 6 PM and 5 AM, with the light sensor value range set at 500.

Table 5. Application Control Testing and Device Response

Application Control	Device Response
	
	
	 

1. Testing of Exporting History File

In this test, the history of total KWh readings will be exported in the form of a .txt file containing valid data. The test data should cover one month of operation, with the exported data being condensed into 1-minute intervals. This is intended as proof that the program code is successful.


Estimasi Biaya: Rp. 77.069

Date: 2024-05-13 13:26:48 WIB
Rata-rata Tegangan: 214.80003 V
Rata-rata Arus: 1.0 A
Rata-rata Daya: 1.0 Watt
Rata-rata Frequency: 50.0 Hz
Rata-rata Power Factor: 1.0
Total Energy: 0.06 Kwh
Estimasi Biaya: Rp. 77.069

Date: 2024-05-13 13:26:48 WIB
Rata-rata Tegangan: 214.80003 V
Rata-rata Arus: 1.0 A
Rata-rata Daya: 1.0 Watt
Rata-rata Frequency: 50.0 Hz
Rata-rata Power Factor: 1.0
Total Energy: 0.06 Kwh
Estimasi Biaya: Rp. 77.069

Date: 2024-05-13 13:27:48 WIB
Rata-rata Tegangan: 214.80003 V
Rata-rata Arus: 1.0 A
Rata-rata Daya: 1.0 Watt

Figure 13. Exported Data Results

2. Real-time Monitoring Testing

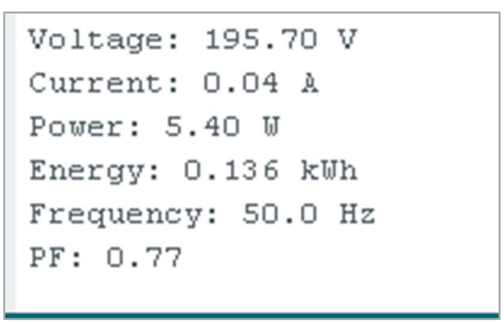


Figure 14. Results in Serial Monitor

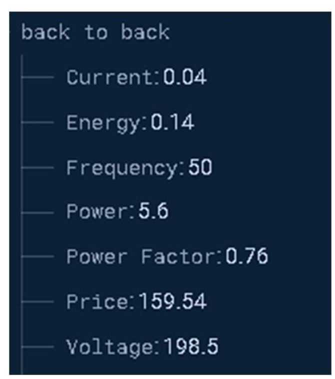


Figure 15. Firebase

Figure 16. Android Application Data Result

CONCLUSION

The results of this research indicate that (1) light control can be done through an android application by utilizing a Firebase database divided into 2 modes: automatic and manual; (2) by utilizing serial communication between Esp32 and PZEM004T, the smartphone application can display real-time data and usage history to facilitate users in controlling and monitoring the lights; (3) the light sensor (LDR) and Ultrasonic Sensor (HC_SR 04) function well to adjust the value range as a consideration for when the lights should turn on and off; (4) by using the PZEM004T-V3.0 component, the application can monitor the energy used, including the total price or cost of usage.

REFERENCE

Adiwiranto, dkk. (2022). "Prototipe Sistem Monitoring Konsumsi Eenergi Listrik Serta Estimasi Biaya Pada Peralatan Rumah Tangga Berbasis Internet Of Think. Jurnal Edukasi Elektro". Volume 06, No. 1, May 2022, page 32-41.

Developers Android, (2019). Mengenal Android Studio https://developer.android.com/studio/intro/index.html?hl=id, Diakses pada 30 September 2019.

Firdaus. (2014). "Wireles Sensor Network, Teori dan Aplikasi". Graha Ilmu Yogyakarta.

Habibi, F. N., Setiawidayat, S., & Mukhsim, M. (2017). "Alat Monitoring Pemakaian Energi Listrik Berbasis Android". Prosiding Seminar Nasional Teknologi Elektro Terapan, 01(01), 157-162.

Hermawan. (2016). "Panduan praktis mempelajari aplikasi microcontroller dan pemrogramannya menggunakan Arduino", Yogyakarta: Penerbit Andu.

Kosasih B, Wibowo T. 2021. "Perancangan Dan Implementasi Sistem Smart Office Pada Pt. Dunia Berjaya Abadi Menggunakan Internet Of Things".

Kusama, D.E, Tarunay, I. O., Lunardi, L., Andika. (2023). "Prototipe Sistem Otomasi Smart Office dengan Menggunakan Lock Door, Motion Sensor, dan LCD Berbasis Arduino UNO".

M. Saleh and M. Haryanti. (2017). "Rancang bangun sistem keamanan rumah menggunakan relay," J. Teknol. Elektro, vol. 8, no. 2, pp. 87–94.

Masykur, Fauzan, and Fiqiana Prasetiyowati. (2016). "Aplikasi Rumah Pintar (Smart Home) Pengendali Peralatan Elektronik Rumah Tangga Berbasis Web." Jurnal Sains, Teknologi dan Industri 3(1): 51– 58.

Nusa, T. (2015). "Sistem Monitoring Konsumsi Energi Listrik Secara Real Time Berbasis Mikrokontroler. E-journal Teknik Elektro dan Komputer", 4(5), 19- 26.

Pratama, E. R., Laksana, P. E., 2021. "Desain Dan Simulasi Smart Office Berbasis Internet of Things (Iot)".

Rodiah, 2018. "Fungsi – Fungsi Arduino IDE", Penerbit Elex Media Komputindo, Jakarta.

S. Mustafa and U. Muhammad "Rancang Bangun Sistem Monitoring Penggunaan Daya Listrik Di Rumah Tangga," J. MEDIA Elektr., vol. 17, no. 3, pp. 6–27.

Setiawan, Evan Taruna. (2010). "Pengendalian Lampu Rumah Berbasis Mikrontroler Arduino Menggunakan Smartphone Android." TI-Atma STMIK Atma Luhur Pangkalpinang: 1–8.

Suliswanto Tri. 2016. Rancang Bangun Sistem Kantor Pintar Berbasis "Internet Of Things".

Syahri Alfi, Bintoro Andik. (2023). "Monitoring dan Controling Daya Berbasis Arduino Uno Menggunakan Sensor PZEM-004T". Volume 12, no. 1.

Turban, Efraim. (1995). "Decision Support Systems And Expert Systems". USA : Prentice Hall International Inc.