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# Monitoring and controlling the electricity usage of 2 Room rented house based on IoT

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**ABSTRACT**

Uncontrolled use of electrical energy in boarding houses and rentals often causes waste of power and high electrical loads. This research aims to design an Internet of Things (IoT)-based electric power monitoring and control system in two rooms using ESP32 microcontroller, PZEM-004T sensor, and OLED display. The system is integrated with the Blynk platform for remote monitoring, six relays to control electrical loads, and Google Sheet as a medium for storing monitoring data. Tests were conducted using several types of loads, including a 15-watt lamp, soldering iron, fan, cell phone charger, and 600-watt water heater. The test results showed a difference in readings between the sensor and multimeter with an average percentage error of 0.3% for voltage, 4% for current, and 0.53% for power. The current error is relatively high because the current value is so small that the difference slightly affects the percentage. In addition, testing on the relay shows that the system is able to automatically cut off the current when the cost limit is reached, as well as the buzzer works well when the cost limit is approaching. Based on these results, this system can be an effective solution in saving energy and controlling electricity usage based on IoT.

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## 1. INTRODUCTION

Electricity is a very important requirement in household and industrial life. However, problems in the uncontrolled use of electrical energy are still common, especially in shared dwellings such as boarding houses and rentals [1]-[4]. Inefficient electricity usage results in energy waste and spikes in monthly bills. One of the main causes of this problem is the absence of an effective and real time electric power usage monitoring system. Conventional monitoring, such as manually recording usage from electricity meters or waiting for monthly billing reports, is not able to provide detailed and fast power usage information [5]-[7].

Another problem is in rented accommodation that only has one main electricity meter for the entire room. The difference in the amount of power usage on electronic devices for each occupant makes the distribution of electricity costs often done by estimation, making it unfair and potentially causing dissatisfaction. In this case, a monitoring system that can display electricity consumption data separately for each room is needed so that costs can be shared fairly.

Several previous studies have developed electrical power monitoring systems based on microcontrollers and sensors, such as using Arduino Mega 2560 and SCT-013-000 current sensors with error results <3.68% [8], Utilized Arduino Uno with ZMPT101B and ACS712 sensors and SMS Gateway using SIM800L, with an error rate of 0.0055% for voltage and 0.00195% for current [9] and monitoring based on Arduino Uno, LCD, and Bluetooth HC-05 module, with a current error of ±2% [10]-[15]. However, most of these studies only display data locally on the LCD or via SMS/Bluetooth SMS/Bluetooth, so it does not yet support remote monitoring in real time and does not have an automatic control feature over electrical loads.

Based on the description of these problems, this research designs an Internet of Things (IoT)-based electric power monitoring and control system using ESP32 microcontroller and PZEM-004T sensor for two rented rooms. The system displays information on voltage, current, power, energy, and estimated cost through OLED display and Blynk platform. Six relays are used to automatically control the electrical load, while the monitoring data is sent to Google Sheets for long-term recording. With this system, landlords can monitor and control the electricity consumption of each room in real time and more efficiently, resulting in energy savings and fairer cost sharing among tenants.

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## 2. METHOD

The method used in designing and building the system on this device is the experimental method. The design and manufacturing stages are carried out to determine the components to be used so that the resulting device can work as needed. The process includes making block diagrams, explaining the working principle of the circuit, designing hardware as an initial stage, and developing software that functions as a monitoring tool for electric power consumption, so that the system can operate according to the planned design.

The ESP32 microcontroller acts as a processing center or input settings used. All input data will be stored and processed in the ESP32 Microcontroller in accordance with the program that has been made. PZEM - 004T sensor as a reading of electrical parameter values, namely voltage, current, power, frequency and power factor which will later be calculated and converted into electric power, estimated costs and sent to the Blynk application. OLED serves to display the monitoing data by the PZEM - 004T sensor. Relay is used as an automatic switch that can be controlled through the Blynk application and Buzzer as a warning that the cost has almost passed the predetermined limit. Power supply is used to convert AC 220 V voltage into 12V. The 12 V voltage from the power supply will be reduced to 5V as a voltage source for the ESP32 microcontroller. The design research method is carried out in the tool system in the form of a block diagram.

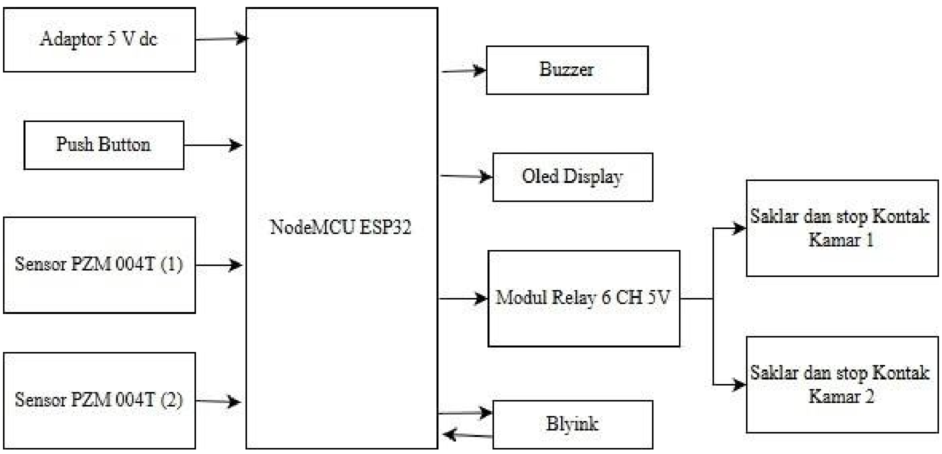


Figure 1. Block Diagram

Based on the block diagram in Figure 1, the function of each block diagram can be described as follows: 1) PZEM - 004T sensor as an input that functions to read the value of electrical parameters, 2) ESP 32 microcontroller as a process where all data and commands from sensors and push buttons will be processed in ESP32 and forwarded to the output, 3) OLED as a visual display output from the reading by the sensor, 4) Blynk as a virtual display and internet-based automatic control, 5) Relay as an output to disconnect and connect the load that is divided into rooms 1 and 2 which are controlled in the Blynk application, and 6) Buzzer as a warning output. For more details of the workings and processes of the monitoing tool system and control of electric power usage can be seen in the flowchart in Figure 2.

Flowchart contains symbols that can be used according to their function. In the first process, namely start. Continue initializing the sensor and Blynk where the sensor and Blynk can already be used according to the address for data reading. After the sensor and Blynk have been initialized, the ESP 32 will process the data sent by the sensor and display via local and internet. Via local electrical parameter data is directly displayed on OLED without using an internet connection. On display via the internet there are two conditions if it is not connected to WiFi then the process will be repeated in ESP 32 for data processing, if it is connected to wifi then the process continues and can be seen in the Blynk application for monitoring and controlling relays. The process does not end there, then the relay control process for rooms 1 and 2 can be used and the relay will be active and can be used henceforth if the cost limit in the program is almost up, the buzzer will sound and if not, the relay will continue to live until the cost limit is up. The cost limit that has been exhausted will automatically turn off the relay until the reset button on the ESP32 is pressed to reactivate the system from the beginning.

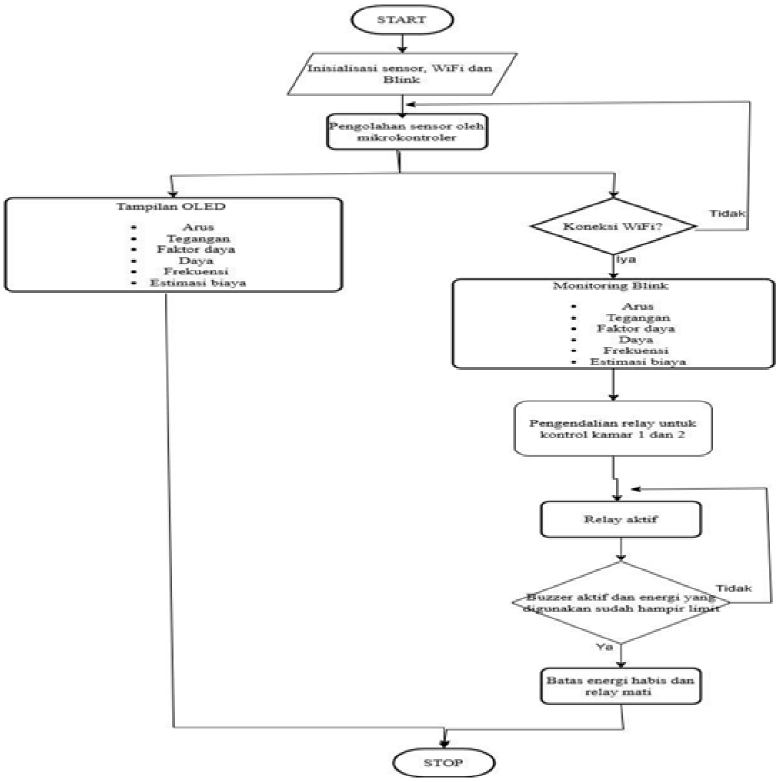


Figure 2. Flowchart of how the tool works

The entire system that is being developed is made using the Fritzing application to create a circuit diagram or installation on this testing tool. The overall installation of the tool can be seen in Figure 3

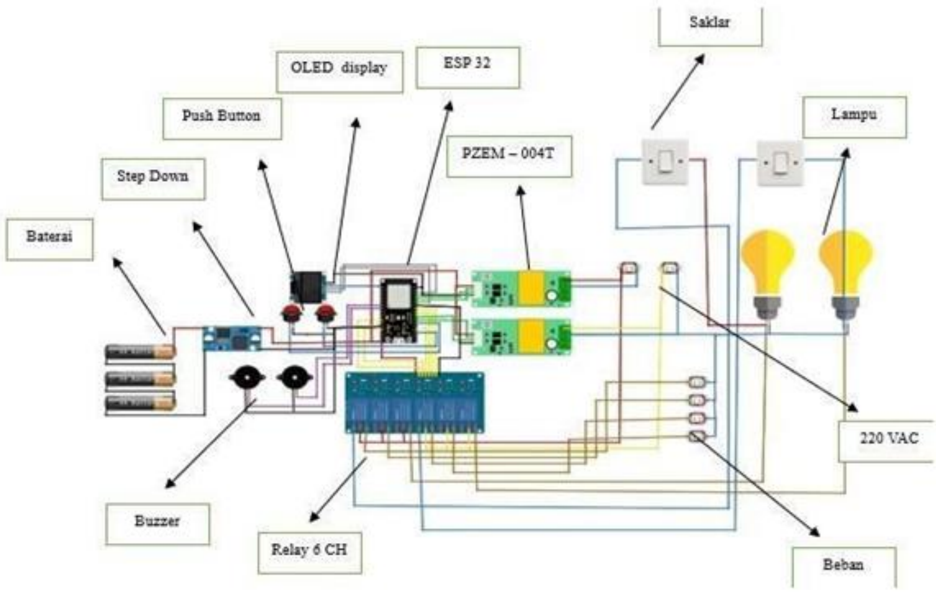


Figure 3. Circuit Schematic

Figure 3 is an overall circuit where the process of making tools can be easy. There are 38 pins on the ESP32 which consist of analog, digital, SDA and SCL pins used on OLED displays and Rx and TX for UART communication on sensors and other pins. For the final results of mechanical design or finished tools can be seen in Figure 4.

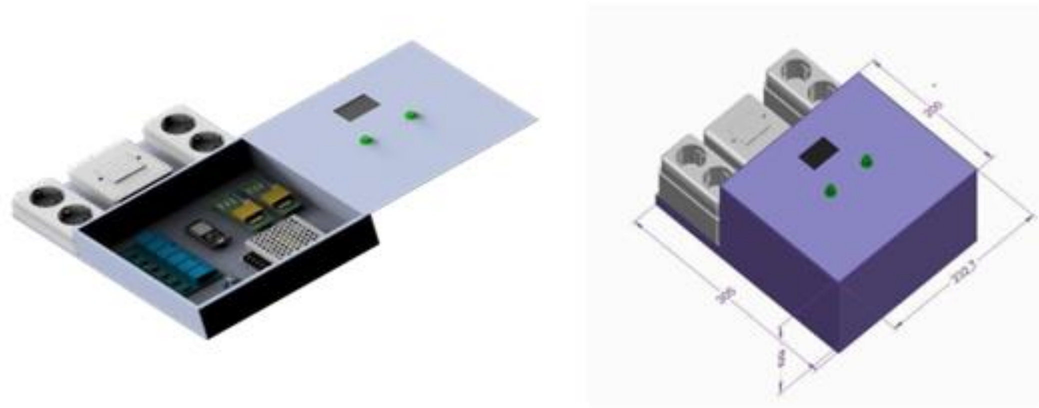

Figure 4 Tool Design

## 3. RESULTS AND DISCUSSION

This test is carried out with several stages, such as using different loads to vary the amount of voltage, current, and power in the circuit. In testing the tool, the parameter reading process can be seen from the results of the OLED screen display, the display of the blynk application and can also be seen from the measuring instruments used. After ensuring that each component is functioning properly, the next step is to conduct testing and analysis to evaluate whether each circuit operates correctly in accordance with the program module design. To find out whether the designed program runs as expected based on the module design, the test data is obtained in the table below with the calculation of the percentage of error in this tool using the following formula:

$$Error\% = \frac{Nilai\ Pengukuran - Nilai\ Pembacaan}{Nilai\ Pengukuran} \times 100\%$$

After testing the voltage, current and power, the next step is to test the device as a whole by testing the device within a predetermined time. In this test, the system is turned on for 30 minutes using 4 loads such as lights, fans, solder and cellphone cas. The data results will be displayed on Blynk and the data will be stored on google sheets as shown below.

Table 1. Monitoring Results on Google Sheet

| No | Date & Time | Room | Voltage (V) | Current (A) | Power (W) | Energy (kWh) | Estimated Cost (Rp) | Power Factor | Frequency (Hz) | Relay Status | Buzzer Status |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 19/07/2025 15:08:40 | 1 | 238,1 | 0,2 | 48,3 | 0,00 | 0,07 | 1 | 50,00 | Live | Off |
| 2 | 19/07/2025 15:08:44 | 2 | 237,9 | 0,21 | 38,2 | 0,00 | 0,07 | 1 | 50,00 | Live | Off |
| 3 | 19/07/2025 15:15:07 | 1 | 237,6 | 0,2 | 69,3 | 0,004 | 6,01 | 1 | 49,98 | Live | Off |
| 4 | 19/07/2025 15:15:10 | 2 | 237,5 | 0,2 | 36,7 | 0,0031 | 4,68 | 1 | 50,00 | Live | Off |
| 5 | 19/07/2025 15:22:12 | 1 | 237,6 | 0,2 | 47,5 | 0,0088 | 13,18 | 1 | 50,01 | Live | Off |
| 6 | 19/07/2025 15:22:50 | 2 | 237,5 | 0,2 | 36,4 | 0,0068 | 10,18 | 1 | 50,00 | Live | Off |
| 7 | 19/07/2025 15:24:41 | 1 | 237,5 | 0,2 | 47,5 | 0,01 | 14,93 | 1 | 50,00 | Live | Off |
| 8 | 19/07/2025 15:24:44 | 2 | 237,2 | 0,2 | 36,5 | 0,0077 | 11,55 | 1 | 50,00 | Live | Off |
| 9 | 19/07/2025 15:25:56 | 1 | 237,2 | 0,2 | 47,3 | 0,0107 | 16,12 | 1 | 50,02 | Off | On |
| 10 | 19/07/2025 15:25:22 | 2 | 237,1 | 0,2 | 36,5 | 0,008 | 12,00 | 1 | 50,00 | Live | Dead |

Table 1 above is the result of testing the entire tool by displaying all data stored on a google sheet consisting of voltage, current, power, frequency, power factor, energy, estimated cost and relay status. This test started at 15:07 and ended at 15:25. Data from costs is obtained by multiplying energy (Kwh) x 1500. In this test also displays the status of the relay, this allows monitoring and controlling the use of electric power every time.

From the experiments in Table 1, it proves that the monitoring tool that has been designed and built is able to record the amount of kWh used and can calculate the estimated costs that must be incurred based on the electrical loads used. The stability in the calculation of costs is also influenced by the ups and downs of the voltage used by electrical equipment. This is because the sensor has a measurement *error* that has been discussed in the previous section. This system is also very possible in controlling the power of electrical equipment, so that when the system exceeds predetermined limits the electrical load (fan, lamp, solder, cellphone case, and water heater) will turn off so that the landlord can control the use of electrical equipment and can save electricity costs.

## 4. CONCLUSION

Based on the results of the design, manufacture, and testing of monitoring and control of electrical power usage for two rooms using the PZEM-004T sensor, ESP32 microcontroller, OLED, buzzer, Blynk application, and Google Sheet, it can be concluded that the designed system is able to monitor electrical parameters such as voltage, current, power, energy, frequency, and power factor in real-time. The measurement data is displayed through OLED, sent to Blynk application for remote monitoring, and automatically saved to Google Sheet. The electrical load control system that uses relays through the Blynk application also works well, where the relay can cut off the electric current when the usage fee exceeds the predetermined limit and the buzzer will give a warning when the fee approaches the limit. The test results show that the average voltage error is 0.3%, current is 4%, and power is 0.53%, where the error in voltage and power is still within the tolerance limit of the PZEM-004T sensor, while the error in current is relatively higher but still acceptable for monitoring needs. Thus, this system can assist users in reducing energy waste by providing energy consumption information and cost estimation periodically, as well as providing automatic control over the use of electrical loads.

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