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Design of Controlling and Monitoring System for Room Temperature, Lighting, Power, and Energy Using Internet of Things

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ABSTRACT

One goal of a smart home is to save the use of energy. Savings can be made with a control system where the things related to electricity usage will be controlled automatically. This research designs a control system of several parameters in a replica of a room with a monitoring application. Those parameters include room temperature, lighting, voltage, current, power, and energy using the Internet of Things. The room temperature control system uses the DHT11 sensor, the light intensity controller uses the LDR HL01 sensor module, while measuring current, voltage, power, and electrical energy at the load uses the PZEM-004T sensor. The NodeMCU ESP8266 is used as a control center that receives, processes, and sends data to the Blynk application using WiFi. The core of the system is based on the detection of the room temperature threshold and the state of light intensity based on light or dark. From these two conditions, the control center will instruct the relay to turn on or turn off the fan and lighting according to the predefined conditions. If the load is on then the voltage, current, power, and energy data will be acquired and displayed on the Blynk application in real-time.

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1. INTRODUCTION

Almost every building, house, or office requires energy in their daily operation. This energy is usually used for various purposes, including lighting, regulating room temperature, or turning on various electronic devices and existing loads. Given its limited nature, energy needs to be saved in its use. One way to save energy is to implement an automated control system which is often called smart home [1] or home automation [2]. With this automation system, everything related to building or house electricity can be controlled and monitored. The technology that underlies all of this is the Internet of Things (IoT) [1][2]. IoT allows devices around us to be connected to the internet network so that they can be accessed remotely via mobile devices [3]. Furthermore, IoT also allows communication and data exchange between devices without human intervention so that automation can be done.

Considering that many human activities are carried out indoors, several studies on the automation of room temperature control have been carried out. The design of a temperature control system with Android was proposed by [3] with a temperature threshold of 29^{o}C. It was found that the Arduino Uno control distance using WiFi was 150 meters with a data processing delay of 2-3 seconds. Using the

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same Arduino Uno microcontroller, [4] developed smart insulation on an automatic room temperature controller using a fan processor with a temperature threshold of 28.5°C. On the other hand, [5] and [6] used a NodeMCU microcontroller with a temperature threshold of 30°C [5], while [6] used several temperature thresholds in the range of 25 to 31°C to set the fan's rpm (rotation per minute) speed. The speed of this fan will affect the use of electricity. The studies above show that the temperature threshold for turning on the fan is different in each study. However, they use the same sensor, namely the DHT11 sensor to measure room temperature.

In addition to room temperature, light intensity in the form of lighting is another parameter that is widely controlled in a home automation system. This is because these two parameters greatly affect the use of electrical power. Regarding room lighting, research carried out by [7] proposes an automation and remote control system for smart house lights based on NodeMCU ESP8266. Meanwhile, [8] designed IoT-based smart lighting for energy-efficient homes. On the other hand, [9] made an IoT-based room lighting decision support system using the MQTT and Tsukamoto Fuzzy protocols. Then [10] proposed optimization of artificial lighting systems, and [11] proposed lighting controller based on adaptive systems. All these studies lead to energy savings so that the electricity usage for lighting is not wasteful. For this reason, evaluation and optimization of lighting installations are necessary so that appropriate savings strategies can be implemented [12]. Furthermore, a monitoring system for electricity usage is needed. This can be conducted by measuring voltage (V), current (A), and power (VA) in real-time using IoT technology [13].

From the discussion above, it can be seen that only one parameter was studied in each study. Accordingly, this study aims to integrate the control of all parameters, namely temperature and light intensity along with monitoring the voltage, current, power and energy used by the load. The components used include a DHT11 sensor as an air temperature detector, an LDR sensor as a light intensity detector, a PZEM-004T sensor as a current, voltage, power, and load energy reader, and an ESP8266 NodeMCU as a data processor with Blynk as the basis for the IoT platform.

2. RESEARCH METHOD

This research was conducted using an experimental method which is divided into several stages starting from block diagram design, flowchart design, software design, hardware design, coding, implementation, testing and discussion.

2.1. Block Diagram Design

The design of the system block diagram is shown in Figure 1. This is the planning and design stage of the input, process, and output to be made. This block diagram makes it easier for us to read the flow of the system as a whole so that the components that act as inputs, controllers, and outputs will be known. From this block diagram, it can be described that the input section consists of 3 sensors, namely the DHT11 temperature sensor, the LDR module light intensity sensor, and the PZEM-004T current, voltage, power, and energy sensors. At the input, there is also a DC source. In the process section, there is a NodeMCU as a controller which will be the center for processing and sending data. This microcontroller already supports IoT functionality because it is equipped with an ESP8266 module that can be connected to the internet network. While at the output 2 relays will be connected to the load in the form of lights and fans. One more output is the Blynk application which will display the control interface and monitoring results remotely on iOS and Android devices.

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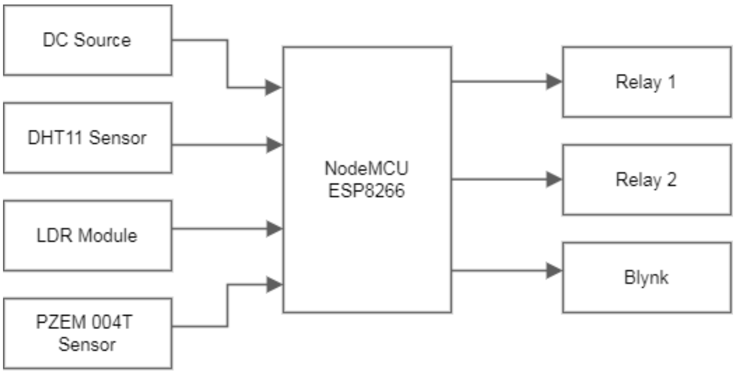

Figure 1. Block diagram of the system

2.2. Flowchart

The flow chart that describes the logic of the system can be seen in the flowchart Figure 2. The system work starts when the equipment is turned on and then immediately initializes the connection with WiFi. If connected then the system will configure the sensor. The three sensors will read the state of the room. When the room temperature has reached > 32°C, the fan will turn on automatically, when the room is dark, the lights in the room will turn on automatically, and when the lights are on, the voltage, current, power, and electrical energy sensors will work. The control parameter data will then be sent to the Blynk application via WiFi in real-time. Thus monitoring can be done remotely from a distance.

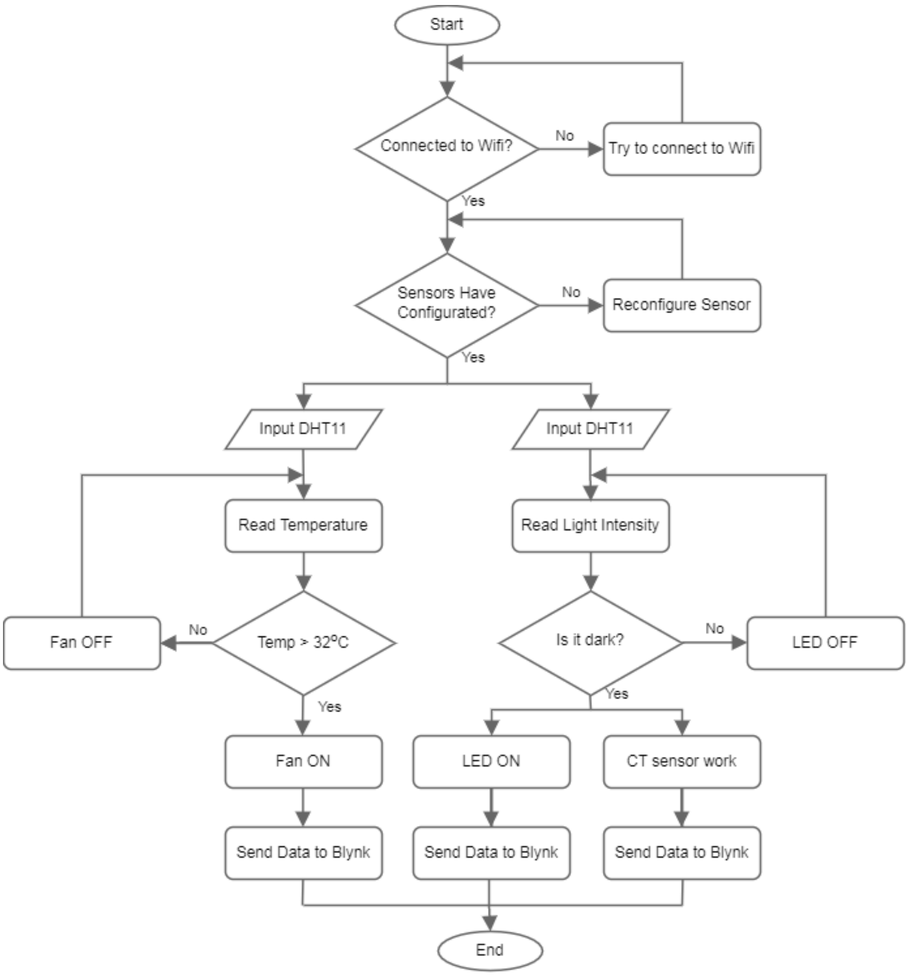

Figure 2. Flowchart of the system

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2.3. Software Design

The software design is made so that the device can control the temperature, power, energy, and lighting of the room and then sends data to the Blynk application for monitoring. The software used is Arduino IDE. The program code which is made according to the flowchart design above is in the form of a sketch as shown in Figure 3. After the code is complete, it is uploaded to the NodeMCU board by compiling and uploading it.

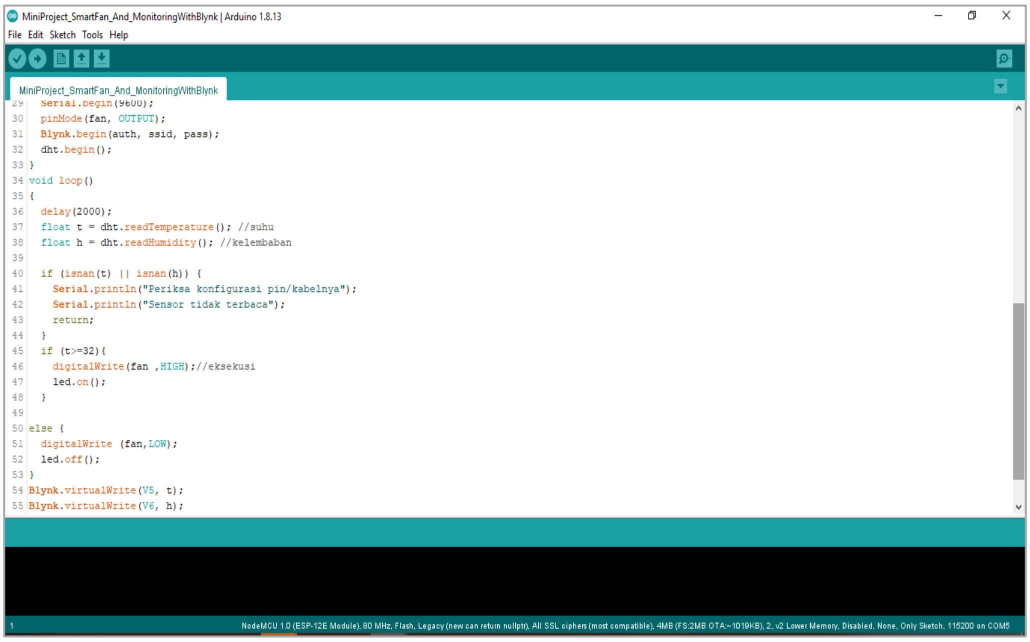

Figure 3. Coding in Arduino IDE

The Blynk application is used as a medium to display data sent by NodeMCU ESP8266. Figure 4 shows the architecture of the Blynk application that can exchange data with the NodeMCU ESP8266 via the Blynk Cloud using the internet network. In this case, the Blynk server receives data on temperature, current, voltage, power, energy, and fan and light status to be displayed on the smartphone.

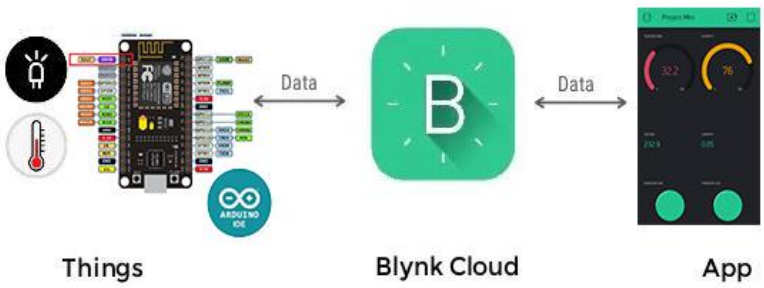

Figure 4. Blynk architecture: Things – Cloud - Apps

2.4. Wiring Diagram

The design of the hardware wiring of the tool made is shown in Figure 5. This wiring diagram contains the electrical circuit between components which will later be used as a reference for manufacturing the tool. The software used for this design is Fritzing.

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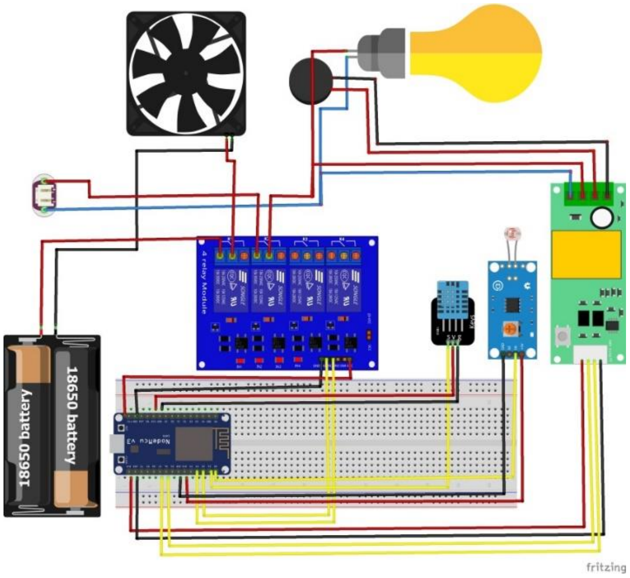

Figure 5. Wiring diagram of the system

From the wiring diagram above, it can be seen that the components used are NodeMCU, breadboard, 12V fan, DHT11 sensor, LDR module sensor, PZEM-004T sensor, relay, LED light, and DC power supply. The real components of the sensors are shown in Figure 6.

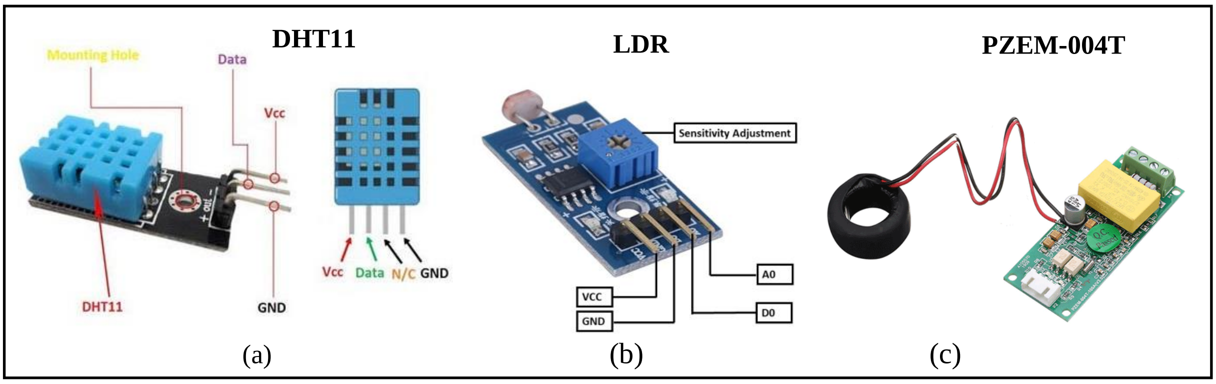

Figure 6. (a) DHT11, (b) LDR, and (c) PZEM-004T Sensors

The DHT11 sensor as shown in Figure 6 (a) is used to measure room temperature and humidity. Inside the DHT11 sensor there are 3 main components, namely the thermistor type NTC (Negative Temperature Coefficient) to measure temperature, humidity sensor with resistive characteristics to changes in water content I n the air, and a chip that converts analog to digital and produces output in single-wire format, bi-directional or single bi-directional cable.

Meanwhile, Light Dependent Resistor (LDR), Figure 6 (b), is a type of resistor that is sensitive to light where the resistance value is influenced by the intensity of the light it receives. In this system the LDR sensor is used to sense the light intensity to turn on or turn off the room lights.

The PZEM-004T sensor, Figure 6 (c), is a sensor that functions to read directly the output value of the voltage, current, active power and energy used in the load. Serial communication is used by the PZEM-004T sensor to output.

3. RESULTS AND DISCUSSION

In accordance with the purpose of this study which is to create and test a room temperature and lighting control system automatically along with monitoring voltage, current, power, and energy, controlling and monitoring all these parameters was carried out on a replica room measuring 30 cm x

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15 cm x 15 cm. Then the control and monitoring results are displayed in real-time on the Blynk application.

Tests are carried out directly on the prototype of the room that has been made. In this case, the DHT11 sensor was tested with a match to get a fast temperature change, while the LDR sensor was tested with a smartphone flash to get a dark to light change, and the PZEM-004T sensor was tested with a light load. For the load, 3 LED lamps were used with different types of watts which are 8, 15, and 18 watts. The results of these experiments can be seen in Tables 1, 2 and 3 below.

Table 1. Testing result of DHT11 sensor

Temperature condition	Fan
Initial temp 29°C	OFF
temp 32.5°C	ON
temp 29.1°C	OFF

Table 2. Testing result of LDR sensor

Room condition	LED
Dark	ON
Flashlight is ON	OFF
Flashlight is OFF	ON

Table 3. Testing result of PZEM-004T sensor

LED in 10 minutes ON	Voltage (V)	Current (A)	Power (W)	Energy (Kwh)
8 watt	223.2	0.05	7.6	0.03
15 watt	224.5	0.09	14	0.03
18 watt	223.2	0.10	15.7	0.03

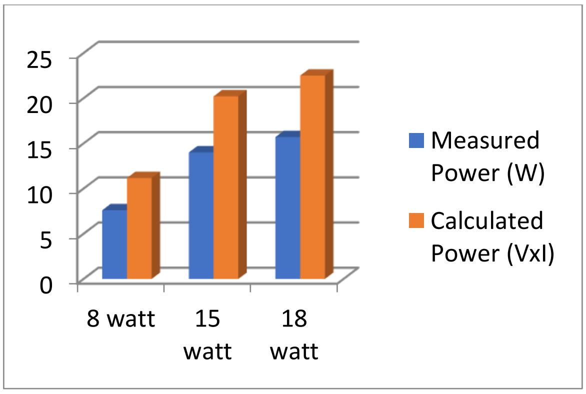

Figure 7. Comparison of measured power (W) with calculated power (VxI)

Table 1 shows the results of testing the DHT 11 temperature sensor where the fan works according to the set temperature threshold, which is 32°C. The fan will be OFF if the temperature is less than 32°C and ON if the temperature is higher. Likewise, the LDR sensor is already working to turn the lights on and off when they are light and dark, Table 2.

Meanwhile, Table 3 shows the measurement results of the PZEM-004T sensor for voltage (V), current (A), power (W) and energy (Kwh) for 8 watt, 15 watt and 18 watt lamp loads. The voltage when the lamp is ON is relatively the same, while the current increases according to the wattage of the lamp. There is a power difference between what is stated on the lamp, the measurement results, and the theoretical calculation (V x I) as shown in the graph of Figure 7.

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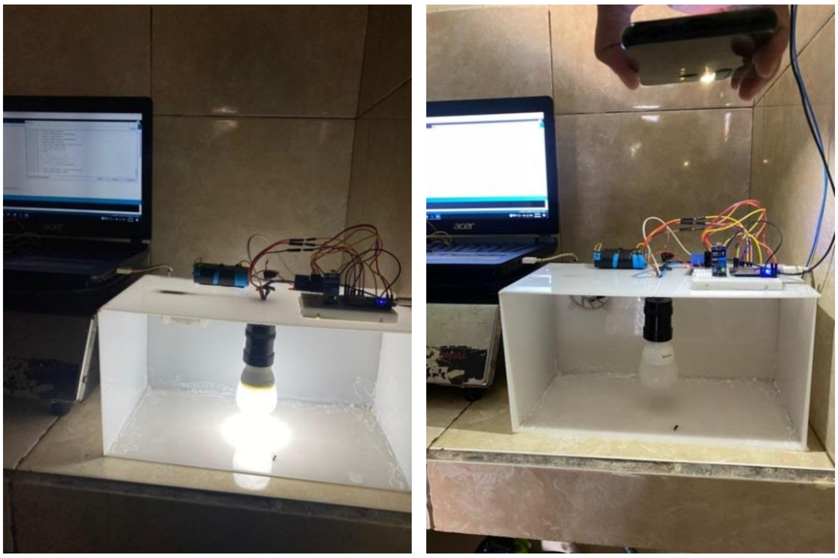
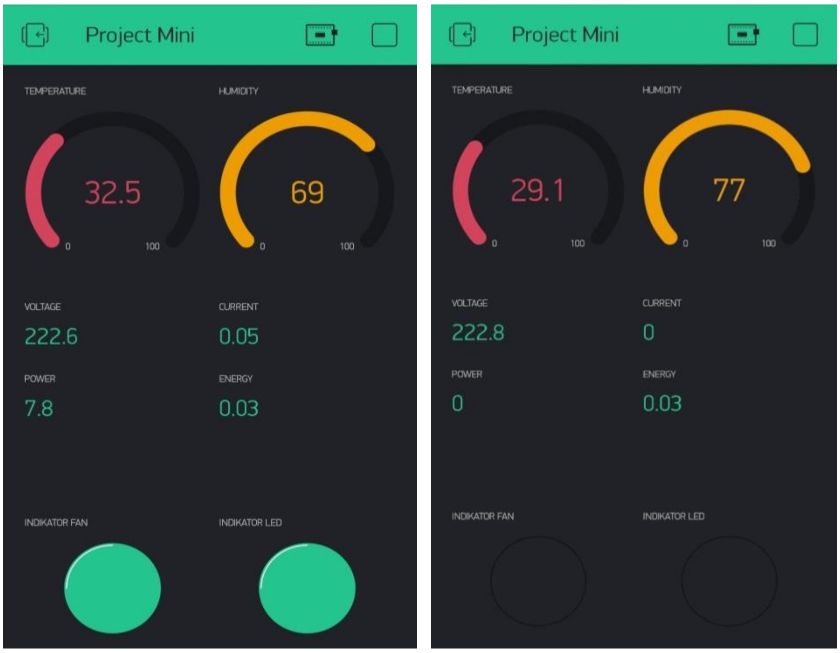


(a) (b)

Figure 8. (a) Condition when light is ON and (b) OFF

Figure 8 show the test display where the room is dark and the lights are on (a) and vice versa (b). All measured and controlled parameter data are then sent to Blynk, Figure 9. The state that Blynk displays is when it is dark and a temperature of 32.5°C where the lights and fan will turn on (the fan indicator and the light are green), Figure 9 (a).



(a) (b)

Figure 9. (a) Blynk display when light and fan turn on, (b) when light and fan turn off

Subsequent testing is carried out in the opposite situation, namely in a bright state where the LDR is given light from the cellphone flash light. The data on Blynk, Figure 9 (b), shows the indicator light is off and the LED in the room is also off. The temperature decreased to 29.1°C and the fan also went out. In this state, the measured voltage on the PZEM sensor is 235.5 V while the current flowing in the LED lamp load is 0.00 A.

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All the experiments that have been carried out above show that the controlling and monitoring system created and applied to the replica room has been running well. In this case, the integrated parameters of temperature, lighting, voltage, current, power, and energy can be monitored from a single mobile-based application using a smartphone through an internet connection. Furthermore, not only those parameters, humidity, voltage, and current are also can be acquired and displayed as complements, Figure 9 (a) & (b). This system can provide insights into the energy usage of the building or homes on a daily basis. Knowing this real-time energy usage pattern, it is expected that a further energy savings scenario can be implemented.

4. CONCLUSION

This research has created and tested a control and monitoring system for room temperature, lighting, power, and energy as well as humidity, voltage, and current as complements based on the Internet of Things using the NodeMCU ESP8266 microcontroller and the Blynk application. The core of the system made is based on detecting the room temperature threshold with a DHT11 sensor and identifying light and dark conditions or light intensity with an LDR sensor. Then from these two conditions, the NodeMCU as a processor will instruct the relay to turn on or turn off the fan and lighting according to the conditions required. If the load is on, the PZEM-004 sensor will work to acquire voltage, current, power, and energy data. Furthermore, all parameters will be sent and displayed on the Blynk application in real-time. This prototype system has worked well and can be further developed to include more controllable parameters for complete home automation, such as visitor authentification and counter, security system, and audio-video.

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