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Research Paper

Real-Time Prototype Electricity Monitoring and Forecasting System based on Wemos D1 R1 ESP8266 and IoT

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Abstract

Technology helps people do things. IoT is a buzzword, but some need explanation. It means internet-connected devices. IoT seeks continuous internet benefits. Lighting, fans, automated doors. These things have internet-connected sensors. IoT technology allows internet-controlled household appliances. Internet-connected computers or smartphones monitor this tool. The purpose of this research is to create a system that can monitor the electric power in the room of the house in real-time through the Blynk application using a smartphone and make it easier for consumers to estimate the cost of electricity for a month. Systematics simplify and summarize this study. This study will use the Blynk smartphone app to monitor room electric power in real-time and anticipate monthly electricity expenses. Literature review expands research theories. Analysis and design, explaining the analysis based on the background and literature review, then constructing tools and designing the source code and workflow of the Wemos D1 R1 ESP8266 Microcontroller system. Implementation and testing discuss experimental results and how to test new technology. Study report analysis and development ideas conclude this section. This study produced a guide for designing IoT-based power monitoring device applications. Allow users to estimate their household electricity costs quickly and keep this option available. This research is limited by the Wemos ESP8266 D1 R1 microcontroller, INA219 current sensor, and LED for room lights. Wemos D1 R1 ESP8266 and IOT will be used to create a monitoring system tool and estimate electric power in real time using room fans. Future accomplishment. This method requires many components. This research may reveal how to lower electricity bills by monitoring and cutting usage online.

Keywords *Wemos D1 R1 ESP8266, INA219 sensor, Blynk*

INTRODUCTION

The rapid development of new technologies in the modern era has resulted in the creation of a wide variety of tools that assist humans in completing their work. There are still a few people who are having trouble comprehending what the word "Internet of Things" (IoT) means, even though we are inundated with encounters with this concept. In a general sense, it can be understood to refer to things in our environment that are capable of communicating with one another via the internet network.

The Internet of Things (IoT) is based on a concept that seeks to continuously broaden the advantages of being connected to the Internet network. Take, for instance, electronic items such as ceiling fans, automatic doors, lighting, and so on. These things can have sensors inserted into them,

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and those sensors can be always on and connected to the internet.
The Internet of Things (IoT) presents some fascinating opportunities, such as the possibility of equipping one's home with appliances that can be managed or supervised via an internet connection serving as the primary link in social interaction and the transmission of information regarding the state of affairs. Simply connecting a computer or smartphone to the internet and using this program to monitor the gadget is all that is required.

Given the context that was presented earlier, the issue at hand is figuring out how to apply IoT technology to the electrical monitoring equipment in the room. In the same breath, the creation of a monitoring system tool and an estimate of electric power based on Wemos D1 R1 ESP8266 and IOT in real time are the constraints of this work. It uses several different components, including the Wemos Esp8266 D1 R1 Microcontroller as a controller and the ability to access WiFi (Wireless Fidelity), the INA219 Current sensor to monitor the electric current, LED for room lights, and fans to cool the room down. The purpose of this study is to develop a method that makes it simpler for users to calculate how much it costs to run the power in the homeroom, as well as to monitor the consumption of electricity in the homeroom in real-time through an application on a smartphone called Blynk.

LITERATURE REVIEW

Internet of Things (IoT)

IoT is a concept that aims to extend the benefits of continuous internet connectivity. Capabilities such as data sharing, remote control, and so on are also included in real-world objects. For example, electronic objects such as lights, fans, and many more are all connected to local or global networks through embedded and always-on sensors.

IoT refers to objects uniquely identified as virtual representations in an Internet-based structure. With so many benefits, it makes all activities that the perpetrators interact with each other and are carried out by utilizing the internet easier. In IoT education, it is indispensable to carry out all activities using a system and an organized and proper filing system (Atzori et al., 2010).
The Internet of Things (IoT) is the concept of connectivity in devices that allows them to communicate and share data over the Internet. This allows devices to send and receive information without human interaction. IoT is part of the 4.0 industrial revolution that integrates internet technology with electronic devices and industrial machinery. This makes industrial equipment more efficient and productive, as they can coordinate with each other and share data to make better decisions. IoT also has applications in the consumer field, such as smart homes and wearable devices. Intelligent homes enable remote control of household appliances such as air conditioners, lights, and cameras, while wearable devices help monitor health and physical activity (Kader et al., 2019).

However, there are several challenges to overcome in IoT implementation. Data security is essential, as internet-connected devices make them vulnerable to cyber-attacks. The need for interoperability standards must also be met to ensure that devices can work well together. Overall, IoT brings many benefits to industry and society. With improved connectivity and available information, IoT helps make better decisions and makes life easier for people. However, challenges must be overcome to ensure safe and effective IoT implementation (Holler et al., 2014).

Microcontroller

A microcontroller is a chip that acts as a controller for electronic circuit architecture and may store programming. In general, microcontrollers comprise a Central Processing Unit (CPU), memory, Input-Output (I/O), and additional supporting modules. In other words, a microcontroller is a digital electrical device having inputs and outputs that are controlled by writable and erasable instructions (Noviansyah and Abdulrahman, 2022).

A microcontroller is a control-oriented computer processor. Microcontrollers are constructed from the same fundamental components as personal and mainframe computers, albeit being much smaller. A microcontroller is a device that, like most computers, executes the instructions supplied to it. It implies that the most essential component of a computerized system is the programmer-created software itself. This program instructs the machine to carry out the programmer-specified difficult tasks (Kader et al., 2019).

Wemos D1 R1 (Microcontroller Unit) ESP8266

Wemos is an ESP-8266 microcontroller module-based microcontroller development. Wemos was developed as a solution to the expensive nature of previous microcontroller-based wireless systems. By utilizing Wemos, the costs associated with constructing a Wi-Fi system are reduced, and its capacity to provide Wi-Fi connectivity services is enhanced. It can give Wi-Fi networking facilities rapidly, and its 4 MB of RAM is enormous. Wemos is equipped with the CH340 chipset, which converts USB into a serial interface. For instance, is it a USB-to-IrDA adapter or a USB-to-printer application adapter? In serial interface mode, the CH340 transmits a common MODEM connection signal. The CH340 is used to expand the asynchronous serial interface of a computer or convert a normal serial interface device to connect directly to the USB bus. The CH340 driver or software can be obtained for free. USB cable such as micro USB OTG data cable. Wemos uses Arduino software, including its IDE, Library, and instructions. Replace only the Arduino Uno board with the Wemos D1 R1 (Deswar and Pradana, 2021).
The shape of the Wemos D1 R1 ESP8266 board is as follows:

Figure 1. Wemos D1 R1 ESP8266

Sensor INA219

A sensor is a component used to detect a physical quantity into an electrical quantity so that it can be analyzed with a specific electrical circuit. Almost all electronic equipment has sensors in it. At this time, the sensor has been made very small. This tiny size greatly facilitates usage and saves energy. The sensor is part of the transducer (energy converter), which functions to do sensing or "feel and capture" any changes in external energy that will enter the input part of the transducer so that changes in energy capacity captured are immediately sent to the converter part of the transducer. The converter part of the transducer is to be converted into electrical energy (Chandra and Kosdiana, 2020).

Electric current sensors are resistive; if the current has flowed in, they will output a voltage value by the law of electricity or Ohm's law. The sensor utilized in the design can already be linked to the microcontroller board, allowing direct access to sensor data. Direct entry With a set of instructions in a microcontroller, the amount of electricity can be shown on an LCD or data can be sent straight to a server or computer for storage and processing. Figure 2 is a device used to measure the strength of the electric current and the voltage of the direct current (DC) electricity that is flowing. It then transmits the results to the microcontroller to be processed (Habiburosid et al., 2019).

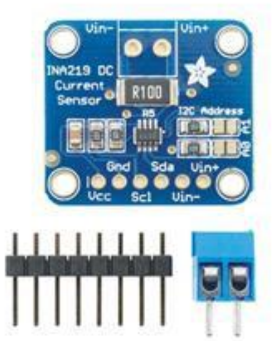

Figure 2. The INA219 sensor

LED (Light Emitting Diode)

LED is a semiconducting device that can convert greater amounts of electrical energy into light energy. Several compounds inside the LED will emit light if electrons travel across it. Figure 3 depicts the transfer of electrons within an LED. The distinction is in the utilization of energy. The diode releases energy in the form of heat, whereas the LED releases energy as light (Yam and Hassan, 2005).

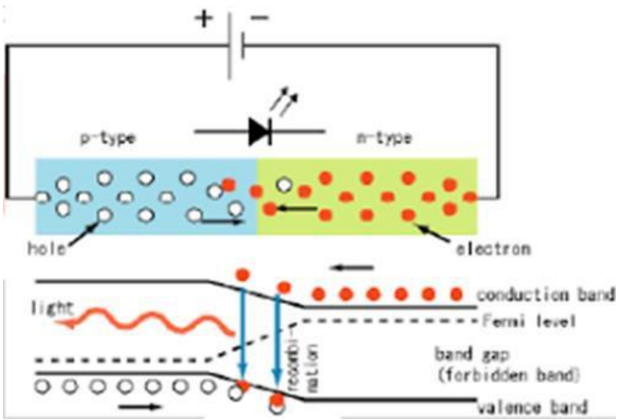

Figure 3. Electron displacement on the LED

Dc Fan

The usage of DC fans to produce wind. Air conditioning, air purifiers, ventilation (exhaust fans), and dryers are standard features (generally using heat-generating components). Fans can also be found in vacuum cleaners and numerous decorative items. In addition, fans can be classified as axial fans or centrifuge fans (Fan et al., 2020). The shape of the DC fan can be seen in Figure 4 below:

Figure 4. DC fan

Blynk

Blynk is a server service with an Android and iOS mobile user experience that supports the Internet of Things initiative. In the creation process, Blynk is a digital dashboard with a graphical user interface shown in Figure 5. On Blynk, input and output components can be added through drag-and-drop without the need for scripting. Blynk was designed to monitor and operate electronics over the internet or a local area network (LAN). There are three primary components of Blynk:

1. Blynk Apps
   Blynk Apps can be used as an interface with several inputs and outputs that support transmitting and receiving data as well as graphical representations of data.
2. Blynk Server
   Blynk server is a cloud-based Backend Service facility that manages communication between cutting-edge phone applications and hardware. Additionally, Blynk exists as a local server that manages local communication without the use of the Internet.
3. Blynk Library
   Blynk Library is used to facilitate the development of code that is compatible with numerous hardware platforms, making IoT development more accessible.

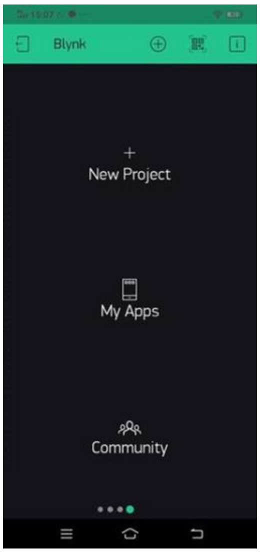

Figure 5. Blynk application

METHODOLOGY

The design stage of this tool is broadly divided into several stages: Circuit Block Diagram, Working Principle, INA219 sensor circuit, Fan and Lamp circuit, Processing circuit, Overall circuit, Flowchart, and Program Design. Before generating or compiling a program on the Wemos D1 R1 ESP8266, a flowchart, also known as a Flowchart, must be compiled. This step will be used as a guide for microcontroller programming. The diagram is depicted in Figure 6. According to the flowchart below, this system will initially initialize all devices comprising WiFi, which is active when searching for an AP with a HIGH (1) status, an INA219 sensor with a HIGH (1) status, an initial HIGH (1) status fan, and a LAMP with a HIGH (1) status on the microcontroller.

After the application executes, the Wemos D1 R1 ESP 8266 will connect to the determined AP (Access Point). If it fails to connect to the AP, it will attempt to reconnect until it succeeds and obtains an IP address. This IP address can then be used to access the newly-created Blynk Application page.

The Electricity Monitoring System in this room will collect data in the form of current, voltage, cost per minute, and monthly cost from the microcontroller-processed INA219 sensors and display it via Blynk. If the INA219 sensor detects a change in temperature or humidity, the obtained data will be updated every second and uploaded to Blynk for display. Delay every 1 second, which means automatically reloading the Blynk page using the Arduino IDE software.

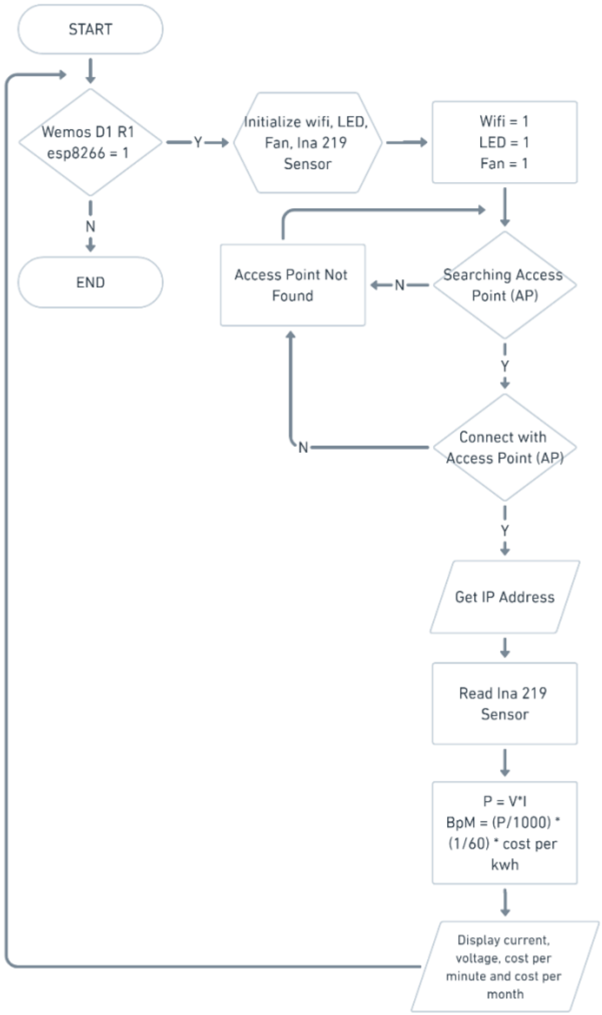

Figure 6. Program flowchart

The following is a description of how each circuit block works in the block diagram in Figure 7:

1. INA219 sensor is a sensor that measures two parameters simultaneously, namely voltage (volt) and current (ampere). The voltage that can be measured is up to 26v, while for currents up to 3.2 A. For communication, this sensor uses I2C, namely SDA and SCL.
2. Wemos D1 R1 ESP8266 functions to process the input given by the data reading from the environment based on the detection by the INA219 sensors so that the output is obtained in the form of voltage, current, and power to be displayed in the Blynk application. Wemos also processes in Blynk.

3. Lights and Fans function as outputs to cool and illuminate the room connected to the Blynk application so that the voltage, power current, and estimation will come out.
4. Blynk functions as an output to display the results of digital data readings from INA219 sensors that have been processed in the form of voltage, current, power, and estimated electricity.

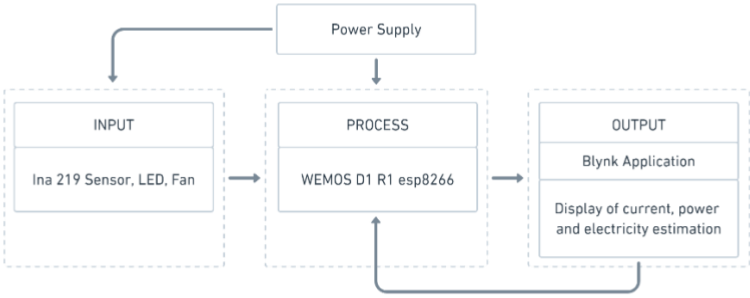

Figure 7. Circuit block diagram

FINDINGS AND DISCUSSION

Working Principle of the Circuit

In this IoT-based prototype manufacturing research made by utilizing Wemos D1 R1 ESP8266, which is used to process data received by the INA219 sensors, Wemos D1 R1 ESP8266 is also used to control resources and connected components to perform data processing and processing.

The microcontroller can work by connecting it through the Universal Serial Bus (USB) port to get the voltage needed to work at 3.3V. The electricity monitoring system is used to see the conditions in the house room. INA219 sensor is used as input media for Wemos D1 R1 ESP8266 so that when the sensor takes a reading, the data will be sent to the microcontroller to display the electricity used through the Blynk application so that it will display the page.

INA219 sensor circuit

The INA219 sensor is an alternative to the ACS712 sensor model to measure DC. This is a small but excellent sensor module because it measures current and voltage via l2C communication with a precision level of 1%. It can also calculate the wattage power by utilizing the multiplication of Ohm's law. The power that can be measured using this module can reach more than 75 watts. The INA219 sensor circuit is shown in Figure 8 below:

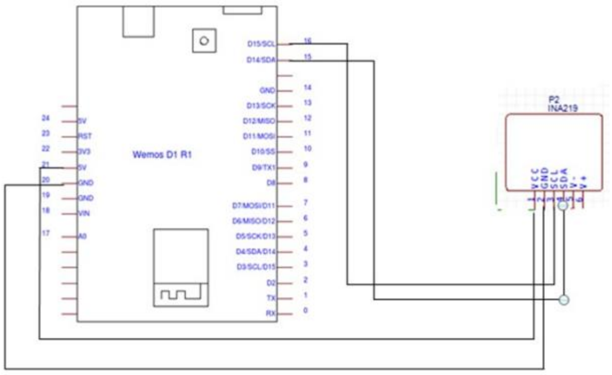

Figure 8. INA219 Sensor Circuit on Wemos D1 R1 ESP8266

The working principle of the INA219 sensors is that using the l2 C communication type can connect more sensors with only two cable lines. The SCL and SDA pins are connected to pins D15 (scl) and D14 (SDA) of the Wemos D1 R1, respectively. At the same time, the VCC and GND pins are connected to the 5V and GND pins of the Wemos D1 R1, respectively. The INA219 sensor has the same concept as other DC sensors, but this sensor not only measures current but voltage and power can be measured using this sensor. The design of this software is to create an algorithm on the Wemos D1

R1 for data communication to wifi, as well as an algorithm for sending data to the Blynk platform.

Fan Circuit with Light

The fan is a Brushless Motor DC (BLDC) using an electronic circuit. It provides voltage output to the coil/ winding so that the winding raises force (thrust) to rotate the propeller (impeller). This distinguishes BLDC motors from DC motors which use mechanical brushes on the commutator to set the time and provide a magnetic field in the winding. The fan circuit can be seen in Figure 9 below:

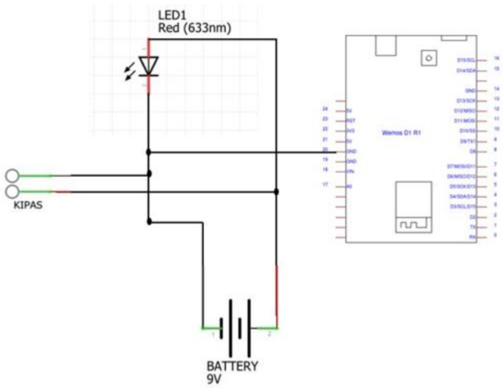

Figure 9. Fan and light circuit on Wemos D1 R1

In terms of its operating principle, the fan is a DC electric motor that makes use of electromagnetism. When an electric current is provided to the coil, the surface of the north coil will face the south-polar magnet, while the surface of the south coil will shift to face the north magnet. As the north pole of the coil hits the south pole of the magnet or the south pole of the coil meets the north pole of the magnet, mutual attraction will occur, causing the coil to cease moving. Simultaneously, Lights are a family of Semiconductor-based Diodes. It functions similarly to a diode with two poles, the Positive Pole (P) and the Negative Pole (N) (N). The LAMP will only emit light if its anode is biased toward the cathode. The lamp comprises the doping process in semiconductors, which is the addition of impurities to pure semiconductors to achieve the necessary electrical properties. When the LAMP is biased from the anode (P) to the cathode (K), the surplus electrons in the N-Type material will flow to the positively charged excess hole area (P-Type material). When electrons collide with holes, photons are released and monochromatic light is emitted (one color). In this circuit, the fan and lamp output the ina 219 sensors. The module is then given a 9v power supply for additional voltage because a 5v power supply will result in a lower voltage, preventing the fan and lamp from turning on.

Processing Logic

Following the execution of the software, Wemos D1 R1 will connect to the specified Access Point (AP). If it fails to connect to the AP, it will attempt to rejoin until it succeeds and obtains an IP address. Dynamic Host Configuration Protocol (DHCP) is a service that allows devices to automatically assign IP addresses to hosts on a network. It is used to retrieve the IP address. The AP's DHCP Server will react to queries issued by the Microcontroller's DHCP Client. This IP address can then be used to access the Blynk application that has been developed to display the output of the ina 219 Sensor in the form of real-time current and voltage.

The ina 219 sensor module circuit in the VCC module is connected to the 5 V pin as a power source. The GND foot on the module is attached to the GND pin as Ground. R1 ESP8266, which is the sensor's SDA pin, is connected to pin D14 on the Wemos D1 ESP8266. When the sensor is active, the data sent by the ina 219 sensors are digital, therefore no conversion such as an analog-to-digital converter is necessary (ADC). The data transmitted by the ina 219 sensors are digital. The data received from the Analog-to-Digital Converter (ADC) will be processed by the Microcontroller and shown on the BlynkApplication page in the form of voltage and current monitoring and estimation. When the sensor is inactive, the digital data will cease to be transmitted, since it will neither be

processed nor displayed on the Blynk Application page.
This Fan and LAMP circuit just displays the output in the Blynk application, then an additional 9V voltage is supplied to the lights and fans. On pi, the cathode and anode lights and positive and negative on the fan are positive and negative, respectively. Fans and lights will display the current and voltage released and appear in the Blynk application. Upon entering the homepage, the fans and lights will also be active. If the fans and lights are out, there is no voltage and current entering the system to be converted to rupiah.

Overall circuit
This circuit is comprised of all the circuits of each component that are interconnected into one on this prototype Electric Power Monitoring System, as depicted in Figure 10. All components work and have their respective functions, namely the ina 219 sensor as a data input medium that will be sent to the Wemos D1 R1 to be processed and produce outputs in the form of electric current and voltage, and when you wish to cool the room's temperature.

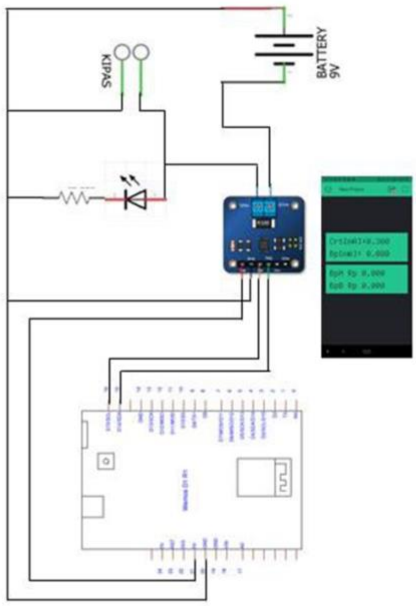

Figure 10. The overall circuit

Design of System Program
This programming design is accomplished by writing the program to the memory of the Wemos D1 R1 ESP8266 using specialized software, particularly the Arduino IDE, which is free software that users can download. The Arduino Integrated Development Environment allows users to add and remove existing libraries.

In this programming design, the Wemos D1 R1 Module board is equipped with a USB-to-serial chip, allowing users to program the microcontroller without extra hardware. Only the required USB voltage is required for the Wemos D1 R1 ESP 8266 board to function. Before beginning to write the program code that will be downloaded to the microcontroller, the ESP8266 board must be added and the port must be checked to determine whether the Wemos D1 R1 ESP 8266 is connected.

After connecting the Wemos D1 R1 board to the laptop or desktop, the following step is to create the coding or program code that will be downloaded to the board's memory. Before downloading the application, the user must compile it by pressing the Verify button or Ctrl + R. When the download is complete, if the program code is valid and there are no mistakes, the next download procedure is initiated by pressing the Upload button or Ctrl + U, as illustrated in Figure 11.

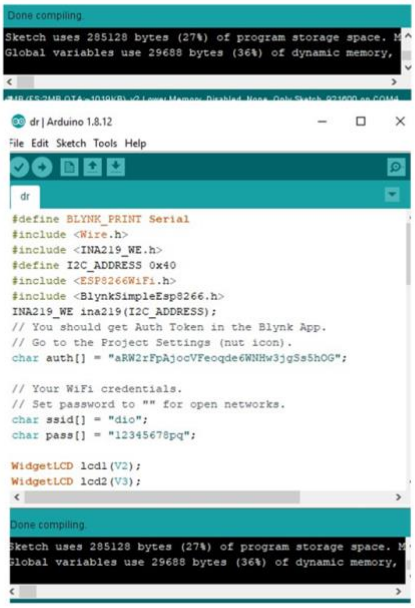

Figure 11. Compile and download process successfully

Implementation And Testing

In evaluating the tools that will be used on the power estimating system in an IoT-based room, a program test will be conducted on the Wemos D1 R1 to determine the performance of the tools and programs that have been developed so that the truth can be gained from each system component. Technical, functional, and experimental analyses comprise the testing. Technical tests involve measuring the electrical quantity standards of components. Then, the functional test comprises the performance and responsiveness of the Blynk application page's electricity monitoring results for the room. Concurrently, the experiment analysis evaluates the conducted experiments.

The initial test consists of testing the INA219 sensor with a serial monitor to determine the resulting output, namely monitoring and estimating electricity by activating and programming the connectivity on the INA219 sensor pins with the Wemos D1 R1 pin.

In writing and making this prototype IoT-based monitoring and control system design, there are still many parts that can be developed in the future so that an improvement can be made, namely the Wemos D1 R1 must use a stable signal so that the Blynk application can process data correctly. This IoT-based prototype system can be developed for various electronic devices such as AC, doors, TV, etc., and this tool can add a button to turn off electronic items remotely if electricity consumes a large voltage as shown in Figure 12.

Figure 12. Blynk application display

The input from the INA219 sensor is successfully processed by the microcontroller. The serial monitor will display the output in the form of monitoring and estimating of electricity detected from the surrounding environment, with changes occurring every 2 seconds. The second test consists of a lamp with a fan. This test determines the outcomes obtained when the fan and lamp receive input to control the fan via a microcontroller pin. Then, using a digital multimeter, the measurement results can be examined when the fan and lamp are in the HIGH (ON) and LOW (OFF) states. Testing of fans and lamps is seen in Figure 13.

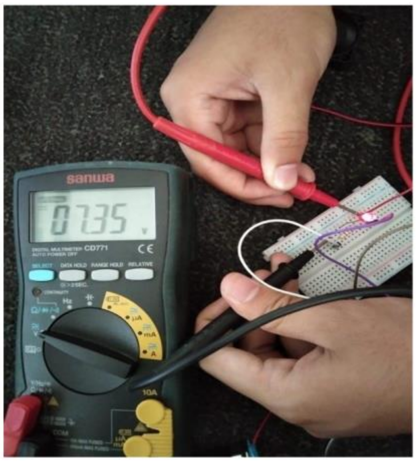

Figure 13. Voltage when the lights and fans are on

This third test is carried out to see the Blynk page display using a device that is connected to the AP with each other, it will be able to open the Blynk application on a smartphone using the IP address that has been obtained. The Blynk Application display can be seen in Figure 14.

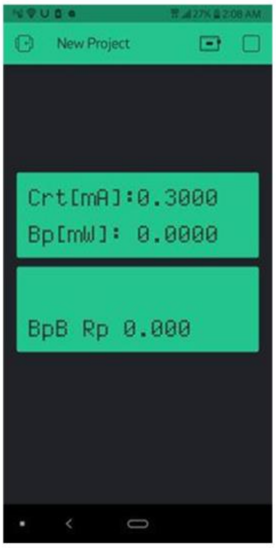

Figure 14. Blynk display test

In an active state, the complete design of the tool is tested, followed by testing using a small that depicts electricity monitoring and IoT-based estimation to detect the state of the INA219 sensor. When the INA219 sensor receives input from the surrounding environment, it may then be observed. After obtaining the data, the sensor in the input circuit is manipulated so that the input circuit supplies electrical voltage to the output pin.

After implementing the tool, which includes technical testing to identify the amount of voltage on the INA219 sensor and the Fan with lamp, and functional testing to determine the initialization of each circuit, it is determined whether or not it functions and operates as planned. Then, the implementation's results are received. The following are outcomes of the tool functionality test implementation are shown in Table 1 below.

Table 1. Testing results of wemos d1 r1 data delivery effectiveness distance

No	Wemos D1 R1	LCD Display in Blynk App
1	1 m	ON
2	2 m	ON
3	3 m	ON
4	4 m	ON
5	5 m	ON
6	6 m	ON
7	7 m	ON
8	8 m	ON
9	9 m	ON
10	10 m	ON
11	11 m	OFF
12	12 m	OFF
13	13 m	OFF
14	14 m	OFF
15	15 m	OFF

Overall Evaluation

A device typically consists of three components: input, processing, and output. This tool's input is an INA 219 sensor that gives readings of tension, current, and electrical power to the data processor as input signals. The data processor is a vital component of the circuit since it transforms data from input into output as required. Wemos D1 R1 is utilized by the information processor. The gathered process data is subsequently transmitted to the Blynk application, which assists in displaying the sensor's output. The fan and lights are then employed to cool and illuminate the room.

Tests were conducted on the sensoria 219 by scanning the surrounding environment observed by the sensor to determine the range of attainable readings. The INA 219 will detect input reception. The test data will be transmitted to the microcontroller and displayed on the Blynk application as output, as shown in Table 2.

Table 2. Overall trial results

No	Wifi	INA219 Sensor	Lamp	Fan	Blynk Application Page			
					Current (mA)	Power (mW)	Cost Per Minute	Cost Per Month
1.	Active	Active	Active	Active	58,30	62,00	Rp.0,0001676	Rp.18,11
2.	Active	Active	Inactive	Active	48,70	50,00	Rp.0,0001352	Rp.14,60
3.	Active	Active	Active	Inactive	26,20	26,00	Rp.0,0000703	Rp.7,59
4.	Active	Active	Inactive	Inactive	38,80	42,00	Rp.0,00011636	Rp,12,27
5.	Active	Inactive	Active	Active	-	-	-	-

6.	Active	Inactive	Inactive	Active	-	-	-	-
7.	Active	Inactive	Active	Inactive	-	-	-	-
8.	Aktif	Inactive	Inactive	Inactive	-	-	-	-
9.	Inactive	Aktif	Aktif	Aktif	-	-	-	-
10.	Inactive	Aktif	Inactive	Aktif	-	-	-	-
11.	Inactive	Aktif	Aktif	Inactive	-	-	-	-
12.	Inactive	Aktif	Inactive	Inactive	-	-	-	-

CONCLUSIONS & FURTHER RESEARCH

This research has produced a prototype design of a monitoring system for voltage, current, power, and electricity estimation in an IoT-based room using INA219 sensors, Wemos D1 R1, Fans, and LIGHTS. The stages of testing and analysis have been completed, so several conclusions are obtained as follows INA219 sensors can read voltage, current, and power every 1 second so that the resulting data is stable to display. DC fans and lights require an additional 9V power supply to turn on fans and lights, and Blynk pages to view the output of the monitoring system can be accessed using the server IP address connected from the client (user). The test results on this IoT-based system design can work in one output: monitoring voltage, current, power, and estimation displayed on the Blynk Application page through INA219 sensor readings in the environment.

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