CONTROL AND MONITORING SYSTEM DESIGN OF INTERNET-BASED ELECTRICAL INSTALLATIONS

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Abstract

Technological developments encourage humans to be able to adapt to their developments so humans must open their horizons in thinking creatively and innovatively to maximize the performance of a job or security that can be developed to continue to produce the latest works. Technology can be used as a system or tool that can facilitate all daily human activities where it can be used manually or can be used automatically using technology. In this research, technology is used to alleviate human worries about using electricity at home, where researchers create a design system for controlling and monitoring electrical installations based on the Internet of Things that can control and monitor the use of electric power through the Blynk application using experimental research types to see success or failure. not used as a monitoring system and control system. The results obtained in this study are that the work system using electric power can be controlled manually and automatically via the internet using the Blynk application to turn on and turn off electricity with a response duration of 0.5 – 1 second. This tool is also used as a monitoring tool in the use of electric power at each load using the Bylnk application with manual measurement comparisons with a value of 0.95 – 2.00% which is used according to load usage.

Keywords: IoT, Control, Monitoring, NodeMCU ESP8266, Blynk.

1. Introduction

In the current era of globalization 4.0, information technology is developing rapidly and increasingly advanced, so it becomes an encouragement for humans to continue to innovate, think creatively, and not only create discoveries, but also optimize the performance of systems and technologies that have been created before in meeting maximum human work system [1]. Thus, this technology is also known as the Internet of Things (IoT). The Internet of Things is a future where all devices are connected to the internet to form a system that has its own intelligence and is very useful in technological developments, such as the application of smart homes. This can be achieved by using data analysis, and information representation with cloud storage as a data repository.

The Internet of Things has three characteristics, namely objects or materials assigned to measuring devices/devices, lines that are interconnected through network terminals, and intelligent services. Electronic devices used in a home installation can be controlled or controlled for their use through computer and Android applications. Computer applications are currently also used on gadget devices such as smartphones. The use of smartphone devices in the country has reached 61.7% of the total population [2]. Smartphones have completely developed or evolved in human life, work, and time with the tremendous growth of resources and services. Smartphones that are portable, personal, and easily connected to other devices can be used as an application of the Internet of Things. This proves that people are used to using mobile devices.

The use of Internet of Things can be utilized for various kinds of needs in everyday life to facilitate human work so that various design ideas arise that can be used in various ways. One of the Internet of Things tool designs that researchers have made is a system for controlling and monitoring electricity usage in households. Consumer negligence in using electricity at home is generally found when leaving the house, such as forgetting to turn off electrical devices such as electronic devices that consume electricity and can cause a house fire. Therefore, users often feel uncomfortable when traveling long distances or so on.

To overcome the concerns of home electricity users, researchers want to project an exchange switch into a series of electrical installations in the form of lighting installations and the use of electronic equipment that can be controlled manually and can also be controlled via internet media using the Cloud Network which has been programmed previously on NodeMCU ESP8266 using the Arduino IDE software using a Personal Computer (PC) or Smartphone. The advantages of the tools used by researchers to design control systems and monitor electrical installations are; first, the designed electrical installation design is designed to obtain more secure electricity use through application monitoring without the need for further supervision from any party. The safety example in question is such damage to the load which causes excess current or leakage so that the user can take follow-up by cutting off the electric current in the load through the Blynk application. Second, home users don't have to go back and forth to the house to check electricity usage on home appliances that have forgotten to turn off or turn on. Third, each of these electrical appliances has been installed in the form of a smart control media, users are calmer because all electrical equipment at home can be controlled anywhere using a smartphone/gadget.

The objectives of this research are: The application of a control system can minimize concerns about the use of electricity at home from negligence. As well as a user monitoring system that can control unwanted electricity usage remotely.

2. Theoretical Studies

2.1. Control System Design

The design of the control system used in this study is in the form of a feedback control system (closed control system), the working system of the research tool is a control device that can be controlled through network media using an application or web server using Google Assistant as a tool.

Relay is a device that is controlled by current. The relay has a low-voltage coil applied to a core component. There is an iron shield that will be attracted toward the core when current flows through the coil. This iron guard is attached to a spring lever. When the shield is pulled toward the core, the common line contact will change its position from a Normally Close (NC) contact to a Normally Open (NO) contact.

The use of relays in electronic circuits is as an executor as well as a liaison/interface between loads and electronic control systems that have different power supply systems. Physically the contactor or switch with a separate electric magnetic between the load and the control system is separate. The main part of the electro-mechanical relay is the switch electromagnet coil or the Swing Armature Spring contactor [3]. Relays are also called electronic switches, that is, switches can be controlled with other electronic devices such as Arduino.

2.2. Electrical Installation Monitoring

Electrical Monitoring is the monitoring of electric power which is mostly done by combining several electrical measuring devices in the form of sensors before connecting to the load used. The advantage of this monitoring is that electric power consumption can be monitored in real-time from anywhere through the application [4]. The hardware used for monitoring electricity use is Pzem 004 –T.

Figure 1. PZEM 004-T Sensor Shape

PZEM 004-T is an electric power sensor that is multifunctional in monitoring and can calculate the accuracy of power usages such as voltage, current, active power, and power consumption. This module has its own Time To Live (TTL) pin which is a pin that supports serial data communication with other hardware using a computer's USB or RS-232 port [5].

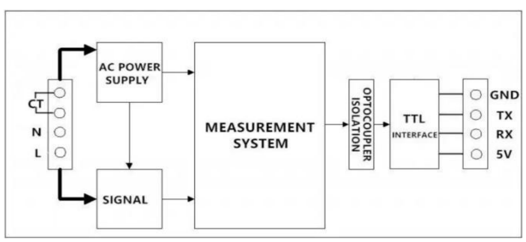

Figure 2. Form of sensor functional blog diagram

Based on the sensor functional blog diagram in the Pzem 004-T working system image, the application can be seen in the Open System Interconnection (OSI) section of the application layer on the Pzem 004-T sensor using the Modbus protocol system - Remote Terminal Unit (RTU) in communication or serial.

2.3. Internet of Things

Internet of Things technology can be applied to create a new concept and development related to smart homes to provide convenience. This aims to help improve security and provide convenience for someone who uses the device by utilizing the network. The hardware used in the Internet of Things is NodeMCU ESP8266 as shown in Figure 3.

Figure 3. NodemMCU ESP8266 Shape Image

NodeMCU is an electronic board based on the ESP8266 chip with the ability to perform microcontroller functions and also an internet connection. NodeMCU has several Input / Output pins so that it can be developed into a monitoring/monitoring application as well as a control tool for IoT projections. NodeMCU ESP8266 can be programmed with the Arduino programming language using the Arduino IDE application. The physical form of the NodeMCU ESP8266 has a Universal Serial Bus (USB) port so that users can easily program it [6].

NodeMCU ESP8266 is a development module derivative of the Internet of Things device module ESP8266 family type ESP-12. The function of this module is almost similar to the Arduino module device, but what distinguishes it is that it is specifically used for "Connected to Internet" internet connections.

2.4. Electrical Installation System

The basic need for electricity has a very important role in everyday life, almost all buildings such as housing, offices, and so on require electrical energy. Electrical installation is a method or process of channeling electrical energy from an electric power source to a load that is adjusted to the provisions stipulated in existing electricity regulations and standards [7]. There are two parts to the electrical installation: first, the electric lighting installation is an installation that is used to provide electrical power to lamps. Both electric power installations are installations that are used for distribution in the form of electric current through a socket so that it can be used to turn on electrical devices such as washing machines, televisions, and others [8].

The most important electrical circuits needed in a circuit are the components used in various ways in electrical installations. Electrical installation components themselves can be grouped into several sections, including Switches, Sockets, and Lights.

3. Research Methodology

In designing this tool, researchers used experimental research types. Conducting experiments on the design of control and monitoring systems is a process of testing the previous theories to prove their truth. The experimental objective to be achieved from this research is to design an electrical installation for power and lighting Internet of Things control, with this tool home users no longer need to worry about negligence in using lights or electronic equipment which can be turned off using a smartphone remotely using internet media, NodeMCU ESP8266 serves as the central microcontroller that controls all the performance of this automatic controller.

The research model used in the design of this control and monitoring system is the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) [9]. This model is widely used and applied in conducting research related to the assessment of a tool or the development of a tool.

At this research stage, researchers want to use a tool that everyone can use so that with this tool the use of the electric current in the house can be controlled and home security can also be monitored remotely using a smartphone.

The stages used in this study started from the planning stage of the model to the final results of the study. In this research design stage, the researcher made a focus point related to the type of research model. The explanation of the stages used in the research flow includes Literature Study, Planning Stage, Tool Design Stage, Tool Programming Stage, Tool Testing, Tool Implementation, and Test Results.

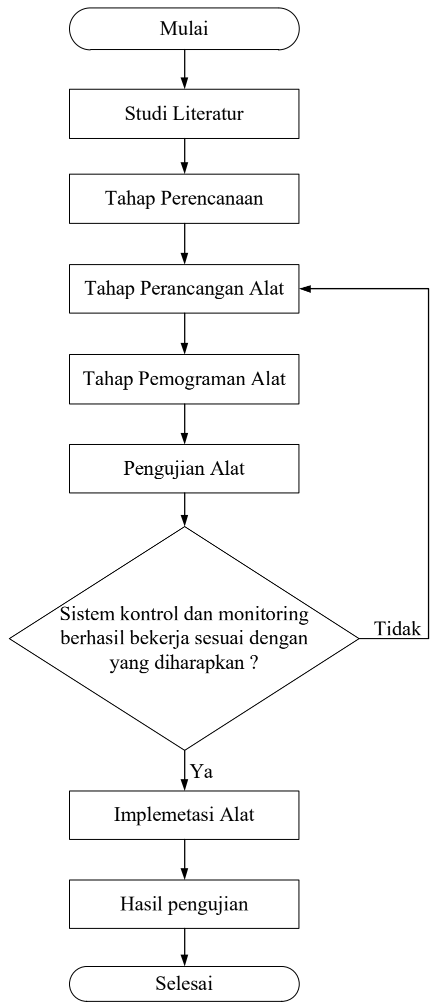

Figure 4. Form of Research Flow

4. Research Results and Discussion

In installing the electrical installation of this control and monitoring system device, does not require its electrical installation, the installation that is applied to this tool is only changing the basic electrical installation in the Figure below.

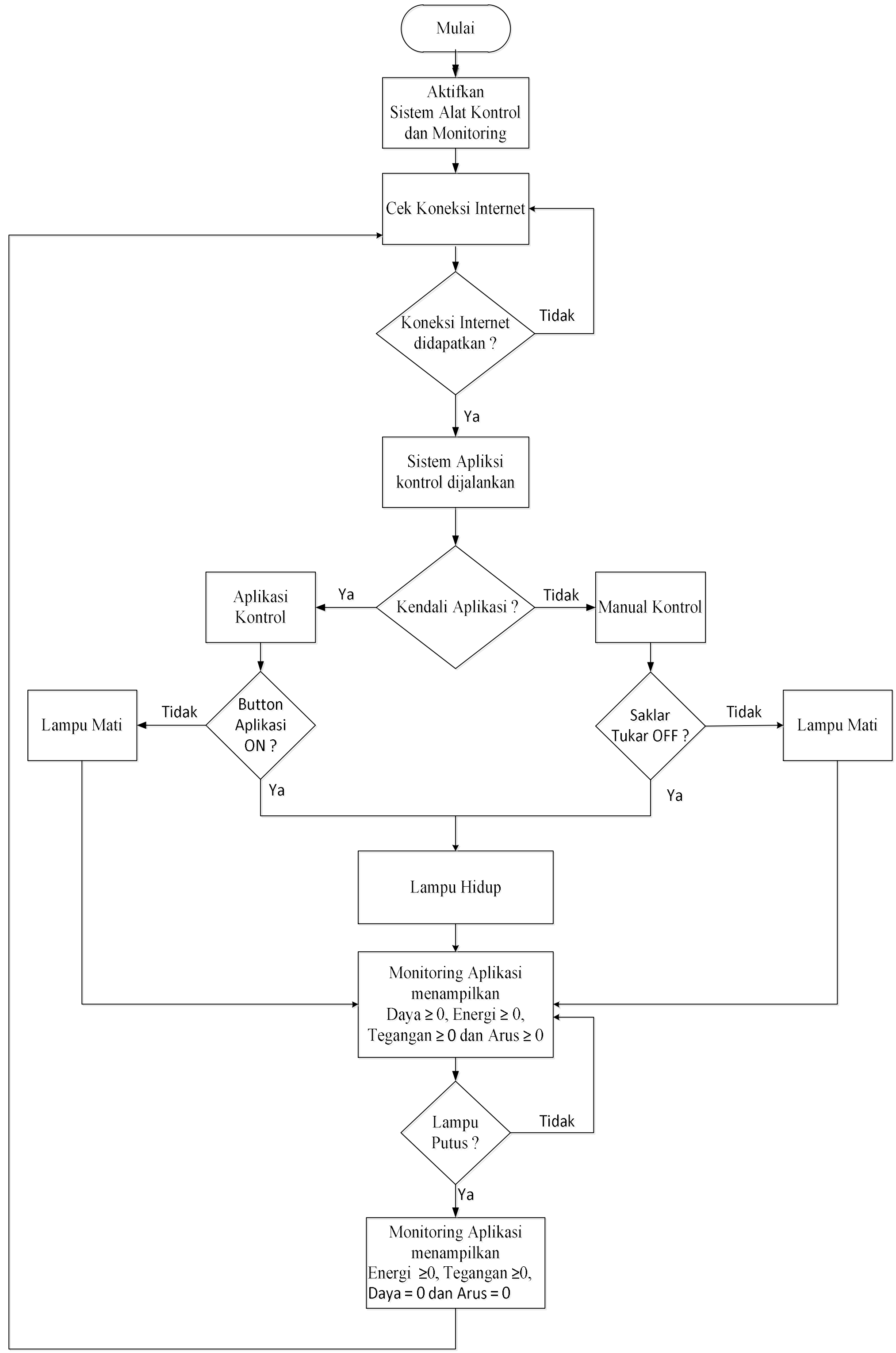

Figure 5. Flowchart of IoT-based and manual electricity control and monitoring work systems

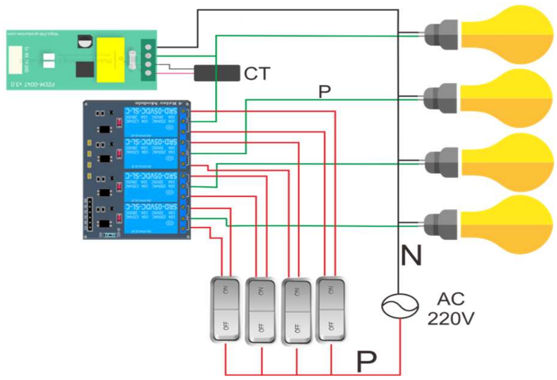

Figure 6. Basic electrical installation circuit

The process of the working system of the control and monitoring tool is turned on for the first time, then the tool will continue to search for the internet network that has been programmed in the circuit so that it will continue at the next stage the user can choose which control system he wants. Users can control using the Blynk application the use of electricity on one or more loads and users can turn off the electricity flowing at these loads using a swap switch manually without having to turn off the control application on the Blynk screen. Follow-up of the use of this control system will display power, voltage, and current energy on the monitoring display of the Blynk application. So that the user can find out how much power and energy usage is spent on the load the user can limit himself in the use of power on the load. The monitoring display will always display each load used so that if an error occurs in the load such as a broken lamp, the next step that must be taken is to turn the light on and off first so that the user can make sure the lamp is broken or is being turned off.

4.1.Results of Electrical Circuit Installation Control System Design

The results of this electrical installation control system design work with the programming logic that was made previously using the C programming language through the Arduino IDE application, the programming logic embedded in this tool has 2 conditions (working system state), in the first condition the researcher makes a control input system design relay to each load switch that is used to disconnect or connect electrical power. In the second condition, the control system can be carried out directly without the need for a control application to disconnect and connect the electric power to the load, but the monitoring system will automatically display the use of the electric power being used by the load.

The results of the control system testing using the Blynk application carried out on the network aim to see the response time to the working system turning on and off on lamp 1 having an average value of 1.2 seconds. The results of the work system response test carried out on lamp 1 can be seen in Table 1.

Table 1. Test the response of the work system to lamp 1

No	Testing With Blynk On Lights 1	
	Blynk Application ON / OFF Testing	Response Time
1	Testing 1	1 second
2	Testing 2	2 second
3	Testing 3	0.5 second
4	Testing 4	2 second
5	Testing 5	0.5 second
6	Testing 6	0.5 second
7	Testing 7	0.5 second
8	Testing 8	1 second
9	Testing 9	2 second
10	Testing 10	2 second
Rate - Rate		1.2 s second

The results of testing the control system using the Blynk application which is carried out on the network on the working system of turning on and off lights 2 aim to see the response time has an average value of 1.2 seconds. The results of the work system response test carried out on lamp 2 can be seen in Table 2.

Table 2 Test the response of the working system on lamp 2

No	Testing with Blynk on lamp 2	
	Testing ON / OFF the Blynk application	Response time
1	Testing 1	2 second
2	Testing 2	2 second
3	Testing 3	1.5 second
4	Testing 4	2 second
5	Testing 5	1 second
6	Testing 6	0.5 second
7	Testing 7	0.5 second
8	Testing 8	1.5 second
9	Testing 9	0.5 second
10	Testing 10	1 second
Rate - rate		1.25 second

The results of subsequent testing of the working system of turning on and off lamp 3 aim to see the response time have an average value of 1.25 seconds. The results of the work system response test carried out on lamp 3 can be seen in Table 3.

Table 3. Testing the response of the work system to lamp 3

No	Testing with Blynk on lamp 3	
	Testing ON / OFF the Blynk application	Response time
1	Testing 1	0.5 second
2	Testing 2	1.5 seconds
3	Testing 3	0.5 second
4	Testing 4	2 second
5	Testing 5	0.5 second
6	Testing 6	0.5 s second
7	Testing 7	0.5 second
8	Testing 8	1 second
9	Testing 9	0.5 second
10	Testing 10	1.5 seconds
Rate - rate		0.9 second

After the tests were carried out on each load 10 times repeatedly, it can be concluded that the response speed of the work system on this control device greatly affects the network connection, the better the network speed used, the better the work system will be in responding to commands given.

4.2. R esults of Electrical Installation Monitoring

The steps in designing an Internet of Things-based electrical installation control and monitoring system are as follows:

a. Prepare the tools and materials to be used
b. Connect all the modules and components as shown in Figure 7 of the network module.
   1) NodeMCU ESP8266

NodeMCU ESP8266 is a module used in designing an Internet of Things-based electrical installation control and monitoring system that functions as a central controller tasked with giving orders and the brain of the system in controlling all commands given by the user.

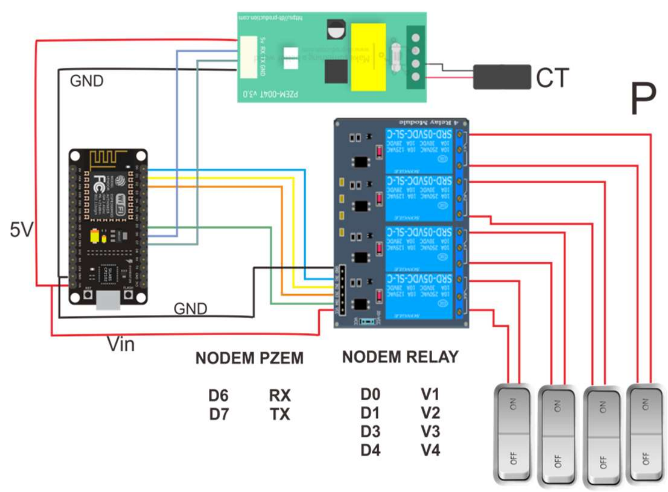

Figure 7. NodeMCU installation circuit with relays and sensors

2) Sensor Pzem 004-T

The Pzem 004-T sensor has 4 output pins that function as detection pins for the use of current, voltage, active power, and AC power energy which can be used to measure 0 – 100A current, 80 – 260V voltage, in the use of these output pins usually 2 pins are used The first is to connect the AC neutral phase and the next 2 pins are used to connect the Current Transformer (CT).

3) Relay Module

In the relay module, there are 3 input pins namely VCC is used as a current input pin of 5V, GND is used as grounding and IN1 is used as a data input connected to NodeMCU. The output of the relay has 3 pins called Normally Open (NO), COM and Normally Closed (NC). The working system of this relay is that when it is turned on for the first time, the relay is activated when the input is LOW and the output is NO and if the relay input is HIGH and the relay output is NC. In the installation that the researcher made, the relay output pin is connected to the third phase cable, namely the NO and NC pins connected to the phase cable which is connected to the exchange switch.

The experimental results of the design of the electrical installation monitoring system use the Blynk android OS application and can be seen via the website as a monitoring medium. In monitoring the power that is being used or not it will automatically appear in the Blynk application with a duration that varies from time to time because it depends on the network connection. The stability of the internet network greatly affects the maximum results of the data monitoring system. Vice versa, if the internet connection is unstable, the duration of time received for commands given through the application for the control system will take a long time to run or it may even fail to send data to the user, on the monitoring screen display will also affect the appearance of power usage data on the burden. Whereas in the use of a manual control system that is carried out on an exchange switch, there are no obstacles or any duration of time that occurs because the function of this exchange switch is only to disconnect or connect the flow of electric power manually.

In this monitoring system, we can see the power usage of the load used such as the use of lights or other electronic devices so comparisons in load power usage can be seen in table 4.2 which displays a comparison of power in manual measurements and automatic measurements using the Blynk application. The formula used to calculate power manually is the basic formula for calculating power.

$$P = V\ x\ I$$

Formula description:
P = Power (W)
IN = Voltage (V)
I = Current (A)

The Blynk application also displays the energy used in the load with kWh units automatically in the application. Energy serves as a medium for calculating the amount of power used at a certain time. Energy has a unit value of joules (J) which has its value, namely:

$$1\ Wh = 3.600\ J$$

Or 1

$$1\ J = 0.000277\ Wh$$

As for calculating the amount of electricity used in the load, you can use the basic formula, namely:

$$E = P \ x \ t \quad (2)$$

Formula description:
E = Energy (Wh)
P = Power (W)
t = Time (h)

An example is known in the use of power in a house of 57.2 watts for 1 hour, the question is how much kWh of energy is used in the house?

Solution :
Is known :
P = 57.2 Watt
t = 1 jam
Asked: W?

Answer:
W = P x t
W = 57.2 Watt x 1 jam
W = 57.2 Wh = **0.057 2** kWh

The comparison of the results of current measurements that have been carried out in this study is a comparison of manual measurements and measurements using the Blynk application for monitoring. In manual measurements using an AC current multimeter the comparison of data monitored in the use of electric power manually and using the Blynk application can be seen in Table 4.5 with data calculations using the relative error formula in percentage (%) [10].

$$Error = \left|\frac{V - M}{M}\right| \ x \ 100\%$$

Formula description:
Error = Measurement data error
V = Actual manual measurement data
M = Blynk application measurement data

The results of manual calculations to determine power consumption and load energy use the formulas (1), and (2). The calculation of power and energy can be seen in table 4. While the formula in equation 3 is used to determine the percentage of error data comparison to manual measurements and measurements using the Blynk application.

Table 4. Comparison of manual electric current measurements and automatic measurements using the Blynk application

Burden			Manual Measurement			Measurements on the Blynk Application			ErrorD ata (%)
Lamp 1	Lamp 2	Lamp 3							
220 - 240 V / 40 W	220 - 240 V / 25 W	220 - 240 V / 40 W	IN	A	Kwh	IN	A	Kwh	
0	0	0	0	0	0	0	0	0	0
0	0	1	57.2	0.26	0.0572	55.10	0.25	0.0551	1.04
0	1	0	26.4	0.12	0.0264	24.30	0.11	0.0243	1.09
0	1	1	90.2	0.41	0.0902	92.40	0.43	0.0924	0.95
1	0	0	41.8	0.19	0.0418	40.60	0.19	0.0406	1.00
1	0	1	72.6	0.33	0.0726	74.20	0.35	0.0742	0.94
1	1	0	55	0.25	0.055	62.90	0.29	0.0629	0.86
1	1	1	118.8	0.54	0.1188	114.90	0.53	0.11409	1.02

In the calculations in Table 4 the researcher explains that the calculations are carried out by turning on and off 3 lights alternately so that in the test there are eight conditions. The statement that the condition of the light is on is symbolized by 1 and the statement that the condition of the light is off is symbolized by 0. Comparison of the results from measurements using the Blynk application is obtained not too far from manual measurements using the multimeter measuring instrument so it can be concluded that the percentage of error in measurement is low or it does not reach more than 3% so that the use of this tool is feasible [11].

4.3. Discussion of Electrical Installation Monitoring Control System Tools Internet of Things

In general, research on the design of this control and monitoring system functions as a media tool that functions to reduce people's worries about using electricity at home when traveling or when they are outside the home so that with this tool, the person can control the use of electrical devices from a distance. remotely using a smartphone through the Blynk application as a control medium in turning on and turning off electricity on loads such as house lights, fans, televisions, and so on. Users can find out how the control system is running according to the instructions given by viewing the monitoring page on the Blynk application which displays voltage, current, power, and energy flowing at the load.

Manual electricity usage can be identified through the Blynk application on the monitoring page which automatically detects electric current and can be turned off via the Blynk application if electricity usage is not desired. The control and monitoring system can be carried out without any distance limits in its use so that users can carry out monitoring anywhere, both within the country and users who are abroad, the main requirement is to be connected to the internet network. The internet speed used on this tool is also very influential on the work system of this control device, if the implementation of this tool uses slow internet or a bad connection, the work system of this tool will work slower in carrying out the commands given or a failure may occur in executing the command. system error". The current measurement accuracy that appears in the monitoring application can be compared to direct measurements using a current meter with the same results.

As for the use of control system tools and monitoring of electrical installations, there are still deficiencies so the use of this tool requires several revisions to maximize the use of these tools, namely:

1. When using electricity manually, the application only detects the current that appears on the monitoring screen without knowing which point the electricity is being used, so we have to see and turn on one control button at a time in the application so that later it will display the cut-off current.
2. Using this tool requires a strong and stable network to maximize the monitoring process and control system in the network.

Comparison of research results from previous studies with the results of research on the design of electrical installation control and monitoring systems is that the accuracy of calculations in monitoring electricity usage at load has a data error value of 0.94 – 2.00%. For the use of the control system itself, it has an average value in carrying out the commands given, which has a speed of 0.9 seconds. Meanwhile, the test results of Riny Sulistyowati and Dedi Dwi Febriantoro in the comparison of current calculations have an average value of 4.88% and an average comparison of electric power monitoring of 2.76%. The work system of this study is repeated calculations, if the control and monitoring system is not being used, the data calculation system starts from 0 again.[12] The results of the tests carried out by Kurniawan were testing the feasibility of the control system tool which obtained an average comparison value of 97.14%, but this study only tested the feasibility system without monitoring so the drawback of this research was the limited use of the control system because if the user gives the order to turn on or turn off the load on the control system outside the home, the user will not know whether the control system is running or not.[13]

5. Conclusion

The work system of this control device can be done manually and using the Blynk application that has been programmed on NodeMCU to turn on or turn off the use of electric current on the load. Using electricity manually can be done by pressing the ON/OFF button on the exchange switch installed. Meanwhile, the use of the Blynk application functions as a medium that can be used to turn on or turn off the use of electric current remotely. The results obtained in this study are that the work system of this control device can work with the work system of the physical exchange switch and the control media system through the Blynk application. So that the existence of this control media can help consumers control electricity usage remotely and can save electricity usage costs.

The monitoring system in this control and monitoring system design tool will display a power monitor automatically on the Blynk application when the control system is activated in the application or activated manually using a switch. The resistance in measuring the power usage of electricity obtained from the comparison of monitoring which is done manually using amperage pliers and automatic measurement using the Blynk application is 0.95 – 2.00% which is carried out 8 times in testing so that the use of this control and monitoring system design can be declared feasible to use.

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