e-ISSN:2829-6192, p-ISSN: 2829-6184
DOI: https://doi.org/10.38035/ijam.v2i4
Received: 18 December 2023, Revised: 10 January 2023, Publish: 01 February 2024

GREENATION GLOBAL RESEARCH NATIONAL
IJAM
INTERNATIONAL JOURNAL OF ADVANCED MULTIDISCIPLINARY
E-ISSN: 2829-6192, P-ISSN: 2829-6184
https://greenpub.org/index.php/IJAM
editor@greenpub.org
0811 7401 455

Application Design of A Multiple Power Source Monitoring System Based On The Internet Of Things (IOT)

Abdul Multi[1], Mujiburohman[2*], Kun Wardana[3]
[1]Institut Sains Dan Teknologi Nasional, Jakarta, Indonesia, email: amulti@istn.ac.id
[2]Institut Sains Dan Teknologi Nasional, Jakarta, Indonesia, email: mudjiburochman98@gmail.com
[3]Institut Sains Dan Teknologi Nasional, Jakarta, Indonesia, email: kunwardana@gmail.com

[*]Corresponding Author: Mujiburohman[2]

Abstract: At the present time, technology is developing rapidly in various scientific fields. People continue to develop and research the latest technologies to make human life easier. One of them is in the field of IoT (Internet of Things) technology. The use of electrical devices in each power source has different electrical power consumption. And this often happens, so when using electrical equipment, each power source is a tool for monitoring the use of electrical power, so that the use of electrical power in multiple power sources is in accordance with the required power. Therefore, a tool is designed that can facilitate the performance of activities to monitor the use of electric power, the results of which can be displayed through LCD 16X2 and can be informed through the Internet. The purpose of this research is to design an IoT-based electric power monitoring system to facilitate the monitoring of electric power consumption in multiple IoT-based power sources. The method used in data collection is quantitative method. With the collection of several components needed, which are designed in this study such as voltage sensors, Ethernet shields, hub switches and Arduino Uno microcontrollers. This research will monitor IoT-based power, and can be monitored via the Internet in the form of a graphical display on a desktop application or in the form of a monitoring web page. The results showed that the average error value in testing the voltage sensor was 0.02%, the sensor for current readings had an error value of 0.19%, and the value of power was 0.18%. So it can be concluded that by having a fairly small difference and error, this tool is said to be quite good and then by testing the monitoring application system on the web page that is made capable of sending, storing and displaying data on the monitoring web page in real time every minute even with different power sources, in tests conducted with two different power sources and can be measured properly, so that testing the web monitoring application can be said to be good because it can monitor electrical power of multiple power sources.

Keyword: Monitoring, PZEM-004T Sensor, Ethernet Shield, Arduino Uno, Internet of things.

INTRODUCTION

Human needs in daily life, particularly in various activities in society and industry, are primarily energy-based. Monitoring energy consumption involves collecting data with real-time parameters between variables such as voltage, current, and time. This process is typically done using manual instruments and manual data collection processes, making it difficult to obtain accurate data.

The standard energy consumption monitoring system is commonly used by the public, which uses a kWh (Kilowatt Hour) meter. The kWh meter is a reliable tool for monitoring energy consumption, as it is often the primary source of energy consumption, including income and telecommunications. However, not all industries use a kWh meter, leading to manual data collection and potential errors.

Technology advancements have led to the development of a system that monitors energy consumption in real-time, either from a single source or multiple sources. This system, based on the Internet of Things (IoT), integrates Wireless Sensor Network (WSN) concepts, which include sensors connected to each other. The system can be integrated with a kWh meter or energy-saving sources.

The control and monitoring system are implemented using IoT communication using Local Area Network (LAN) module Ethernet Shield. The data collected is then transmitted to a computer server, and the data is stored in a web form that can be accessed via the internet connection.

This system aims to make energy usage more efficient, faster, and easier to use, enabling energy conservation and management. It can be used to monitor energy consumption more effectively by developing a web server and database, and also by using Ethernet connections to transfer data from microcontrollers to local servers, making it easier to manage and analyze data.

METHODS

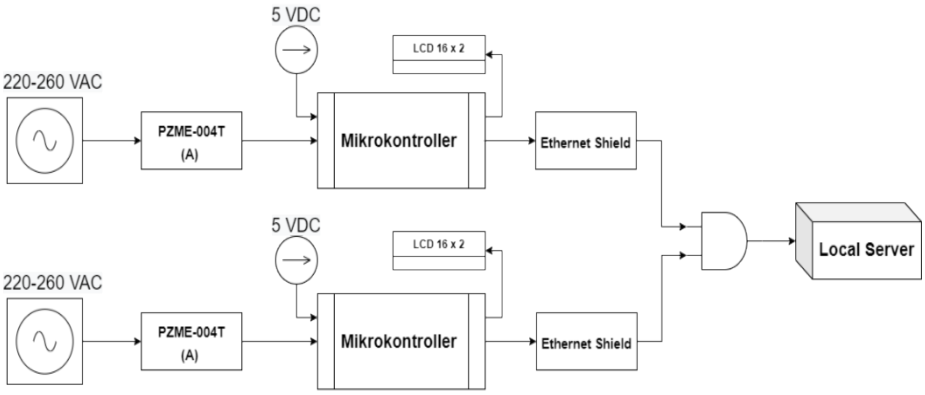
This research has been conducted to discuss how the use of electrical energy from multiple sources can be properly monitored in real time using a web application designed to display the results of electrical energy monitoring carried out by integrating supporting sensors that can be monitored remotely in real time.

The basic technology in the application of electrical energy monitoring systems from multiple sources using web applications that are carried out in real time can be realized using the Arduino Uno microcontroller as a processor that controls input from sensors and outputs that can be controlled so that it can monitor the electrical energy used from multiple electricity sources. By integrating the Arduino microcontroller with the created web system.

This system can facilitate users in monitoring the electrical energy used in multiple power sources. This provides convenience and security in monitoring the use of electrical energy used in real time. In addition, this system can also be accessed anywhere through a web page connected via the Internet.

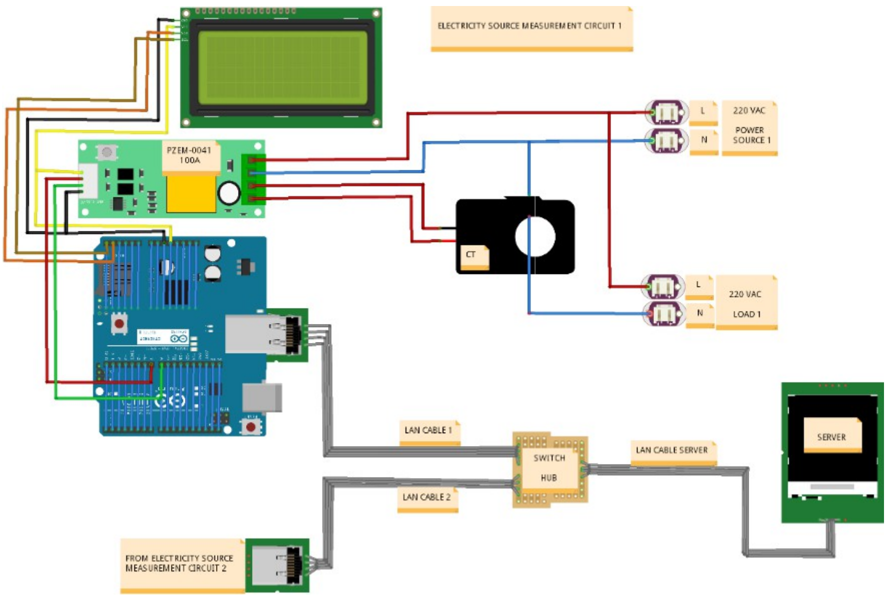
Planning Hardware

Planning hardware on application design of a multiple power source monitoring system based on the Internet of Things (IOT), is to take measurements of electrical energy sources or electrical voltage sources by integrating the PZME-004T sensor to measure the current and voltage used by multiple power sources, then the data obtained will be processed by the microcontroller and then displayed on the LCD screen, then transmitted to the Ethernet shield, then send the data to the local server via a LAN network. As shown in the block diagram in Figure 1



Picture 1. Block Diagram of Hardware Design

Using Arduino as the microcontroller, the Arduino Uno processes the data provided by the voltage sensors and current sensors and sends it to the server using an Ethernet Shield device. PZME-004T sensor module to read voltage, power factor and current at the load, kWh meter as energy consumption sensor and ADC as analogue to digital converter. Arduino Uno as a microcontroller processing the data obtained to be sent to the local server to then store the data in the database, in making this monitoring system, the PHP programming language is used for writing scripts in the creation or development of a website that will be used to display the results of monitoring data that has been obtained.



Picture 2. System Hardware Design Schematic

For the schematic or wiring diagram of the hardware design can be seen in Figure 2, where all components such as the Arduino microcontroller, Ethernet shield, pzem-004T sensor, 16 x 2 LCD and current transformer (CT) are integrated with a power source to measure the electrical energy flowing to the load, and communication from the Ethernet shield to the server is integrated with a LAN cable through a switch hub as a data transmitter of more than one measurement of the power source to be sent to the local server and stored in the database.

Planning Software

In making the monitoring application system first determines the flow of processes that will be made through a flowchart, the flowchart created describes the flow of system processes that will run in the monitoring application displayed on a web page in the form of data and graphs of power consumption. As shown in Figure 3. Some parts of the block are connected to other blocks so that it becomes a flow of interaction between processes.

The process starts with user login where only people who have access can enter the monitoring system by using a user ID and password, then after successful login the system will lead to the monitoring display on the website page, then the user selects the data to be viewed and the system will check the data in the database where if the desired data is in the database then the database will send the data to the website display and form a power graph that is desired in terms of monitoring power consumption in real time.

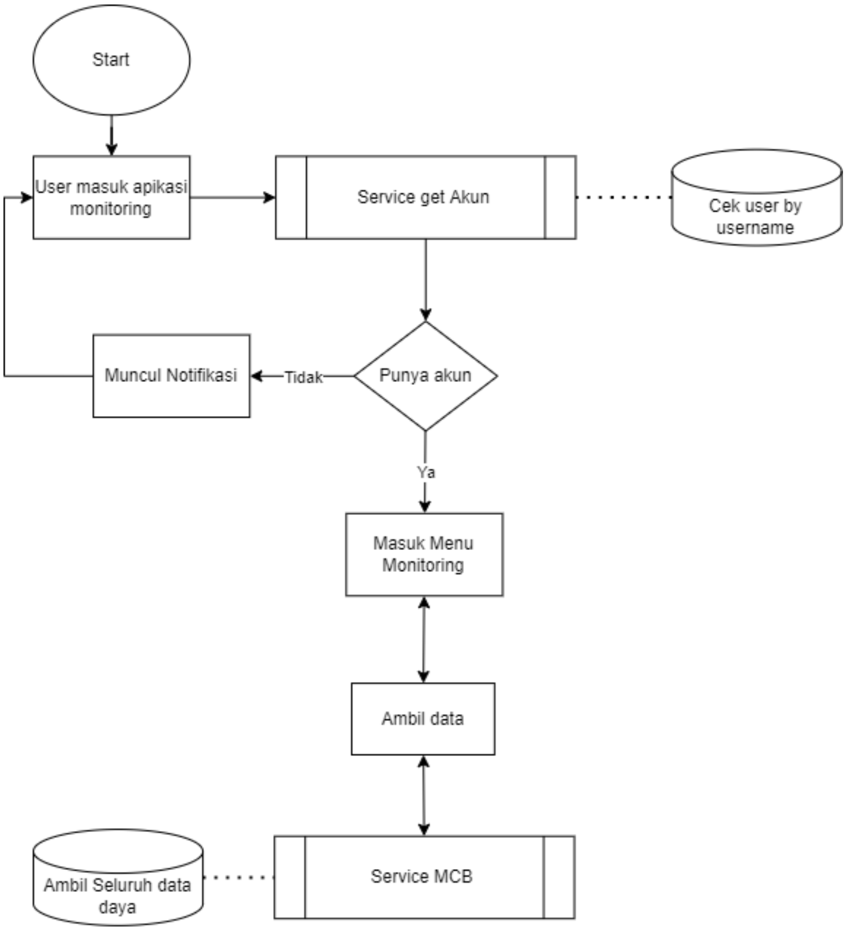


Figure 3. Application design flowchart

Figure 3 shows the flow of the application design process, it is also necessary to design a data storage system to store the data obtained from the sensor before it is displayed on a web page. A flow chart of the data storage process is shown in Figure 4.

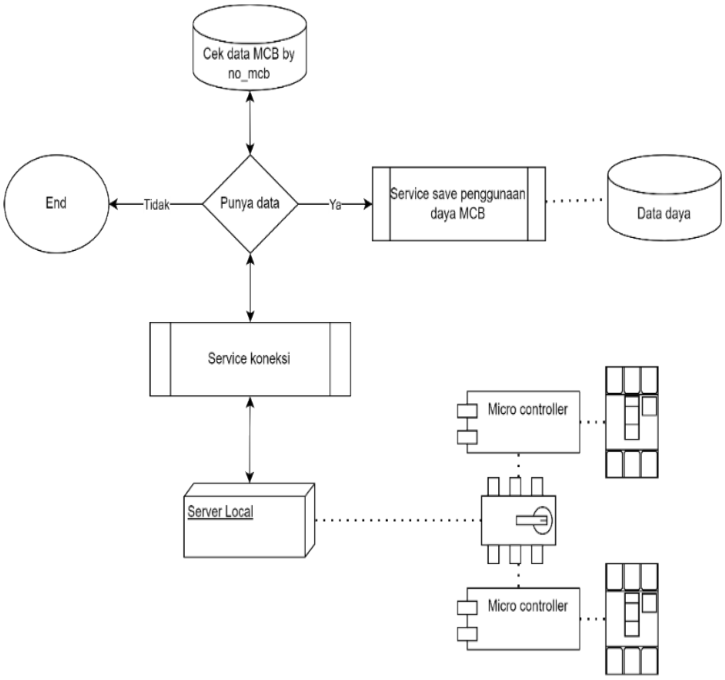


Figure 4. Data storage Process Flow Diagram

In data storage processing, the data that has been obtained by the sensor is then processed by the microcontroller and sent via an Ethernet shield to go to the local server or PC and the system will validate whether the data exists or not, if not then the system will end but if the data obtained then the system will process the data into the database to be stored. A flow chart of the data storage process is shown in Figure 4.

System Evaluation

Program testing aims to determine whether the program that has been made is in accordance with the use of the desired system without causing errors in the program, the program tested includes the Arduino IDE program on the microcontroller, the Python program as communication from the hardware to the data storage system or database, then testing the PHP program as a web page that displays the monitoring data. Before testing and analyzing this tool, it is necessary to know how to operate it so that no errors occur during testing.

RESULT AND DISCUSSION

Hardware Result and Discussion

For the reliability of a device, it is necessary to test and discuss the device itself. So that a circuit that works and can be operated properly can be created when using this tool. In this test, the parameters of the hardware components included in the designed system are measured. In order to produce tests that are in accordance with the design and measurement of this tool. The test of this tool has several parts, such as:

1) Voltage measurement of PZEM-004T Sensor

The voltage measurement on the sensor is done by measuring the changing voltage. This PZEM-004T sensor is a voltage sensor that uses a step-down transformer as a medium to convert actual voltage parameters into voltage parameters that can be read by Arduino for further processing. Until getting the right value comparison with a measuring instrument that is more accurate. The sensor used in this test is the PZEM-004T sensor from the multimeter. In this test were performed 5 experiments aimed at collecting data directly connected to the

PLN 220V AC voltage. Where the used sensor uses only 1 voltage sensor. After testing the voltage sensor, the test results data are shown in Table 1.

Table 1. Voltage Measurement Result (Volts)

No	PZEM-004T (V)	Multimeter (V)	Error (%)
1	224	219	0.02%
2	224	219	0.02%
3	224	219	0.02%
4	223	219	0.02%
5	225	219	0.03%

Based on the measurement data above, calculations can be made to find the average error value of the PZEM-004T voltage sensor as shown in the formula of Equation 1 below:

$$Average\ error = \frac{Number\ of\ error\ values}{Number\ of\ errors\ that\ occurred} \quad (1)$$

So that the measurement results of the PZEM-004T voltage sensor test with the calculation of Equation 5 above, the average error value is 0.02%.

2) Current Measurement of PZEM-004T Sensor

This time what is measured is the electric current measured on the PZEM-004T sensor, then the value of the calculation results is compared with the results of reading the current measurement using the current clamp. The value of the calculation results is compared with the results of the reading of the current measurement using the current clamp. After this test is performed, all data is recorded and entered into the table. The results of this test consist of current and power data shown in Table 2 and Table 3, respectively.

Table 2. Measurement Result of Current (Amperes)

No	Load	PZEM-004T (V)	Current Clamp (A)	Error (%)
1	Lamp LED 5W	0.01	0.019	0.47%
2	Solder 20-40W	0.12	0.13	0.08%
3	Lamp 100 W	0.48	0.50	0.04%
4	Iron 300 W	1.55	1.340	0.16%

Based on the above measurement data, calculations can be made to find the average error value of the PZEM-004T sensor current. According to the calculation of equation 5 above, the average error value is 0.19%.

Table 3. Power Measurement Result (Watts)

No	Load	Sensor PZEM-004T (P)	Multimeter (P = V · I ·cos φ)	Error %
1	Lamp LED 5W	1.88	3.49	0.46%
2	Solder 20-40W	22.6	23.9	0.06%
3	Lamp 100 W	90.3	92.0	0.02%
4	Iron 300 W	291.6	246.5	0,18 %

Based on the measurement data above, calculations can be made to find the average error value in the power value. Therefore, with the calculation of equation 5 above, the average error value on the power value is 0.18%.

From the data obtained, the error value of the PZEM-004T sensor is still relatively small, so the performance of this sensor can be said to be good, and for the error value of the current and power values resulting from the reading and calculation of this sensor is still relatively small, so the performance of this sensor can be said to be good.

In addition, these results are sent by the Arduino microcontroller and transmitted through the Ethernet shield module, and then connected with a LAN cable connection through a router to a local server to store data in the database as data that is later displayed on a page on the web. The data is displayed in the form of a graph of the value that has been processed and sent by the Arduino microcontroller. The data is then received by the server so that the electrical power monitoring can be accessed via the Internet.

Software Results and Discussion

The software used can be accessed through browsers such as Google Chrome, Mozilla Firefox, Microsoft Edge browser and other popular browsers. This method is designed so that the displayed data can be accessed from anywhere. The purpose of this is to facilitate access in applications for monitoring power consumption from multiple power sources through the implementation of an Internet of Things (IoT) system. The following is a picture of the display of the results of the software design made. The display of the user login home page can be seen in the figure 5.

Figure 5. Main page display of user login

Starting from the user login process, where only people who have access can enter the monitoring system using a user ID and password, then after successful login the system will lead to the monitoring display on the web page.

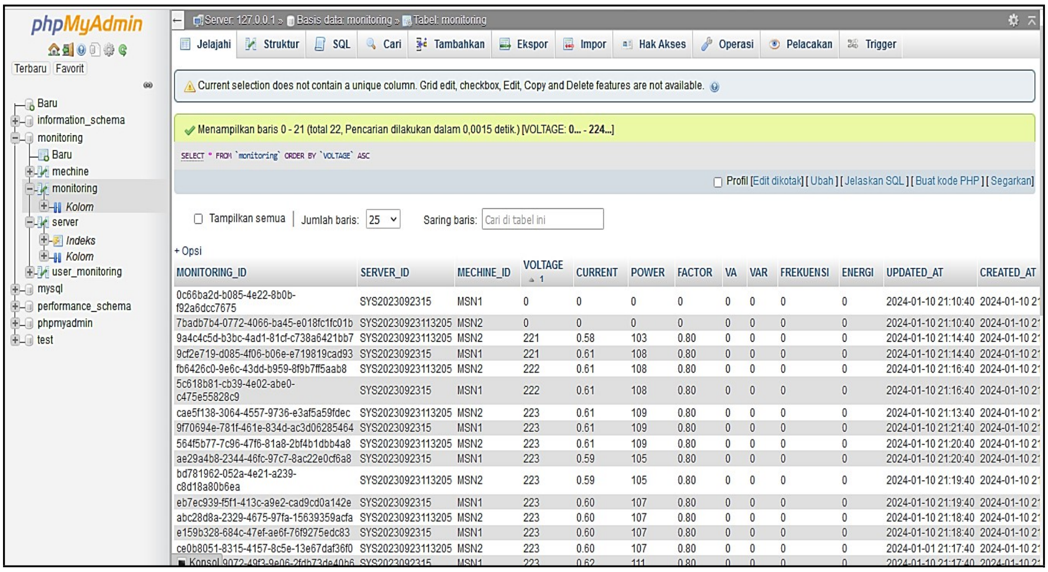


Figure 6. Display of the data coming in from the device on the database page of the phpMyAdmin program

Then the user selects the data to be viewed and the system will check the data in the database phpMyadmin, where if the desired data is in the database, the database will send the data to the website display and form a power graph that is desired in terms of power consumption monitoring in real time. The display of the data table web page can be seen in the figure 7.

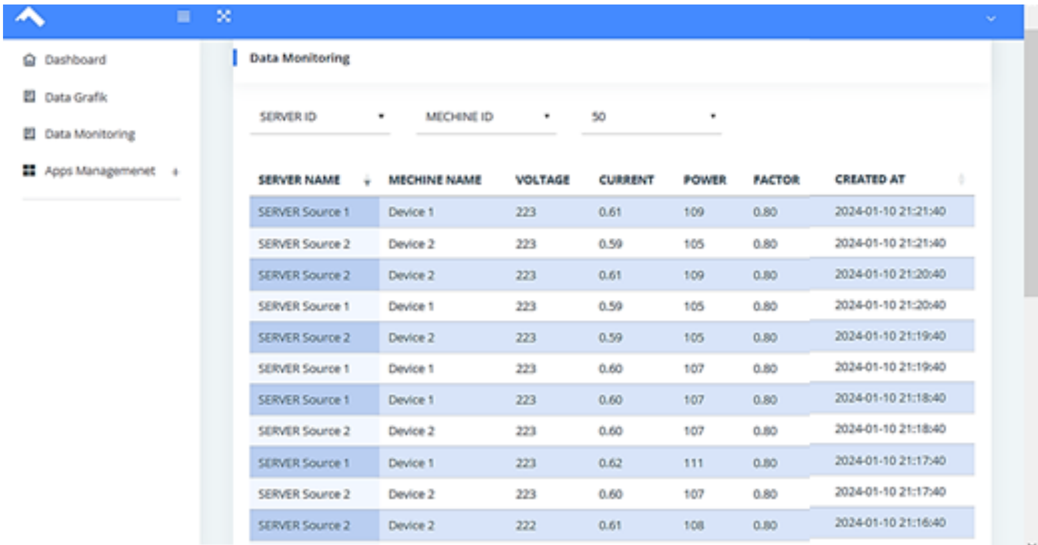


Figure 7. Data table display on the monitoring web page

The Monitoring Data page displays data collected from 2 sensors or 2 devices from different power sources and is displayed on the web page, the data is updated every 1 minute. Shown in Figure 7.

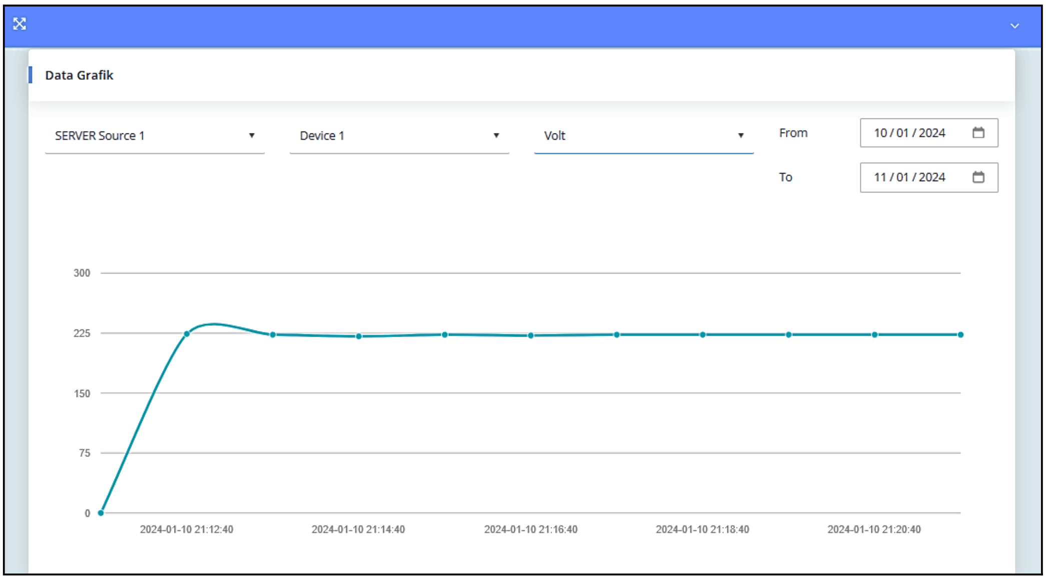


Figure 8. Graphical display for voltage value against time on the monitoring web page.

On the Monitoring Data Graphs page, the user can select from the Server, Device, and Electricity Amount menus, where the menu is used to select the data to be displayed on the web page; the data is updated once every minute, as shown in Figure 7, displaying the voltage data for Source 1 and 2.

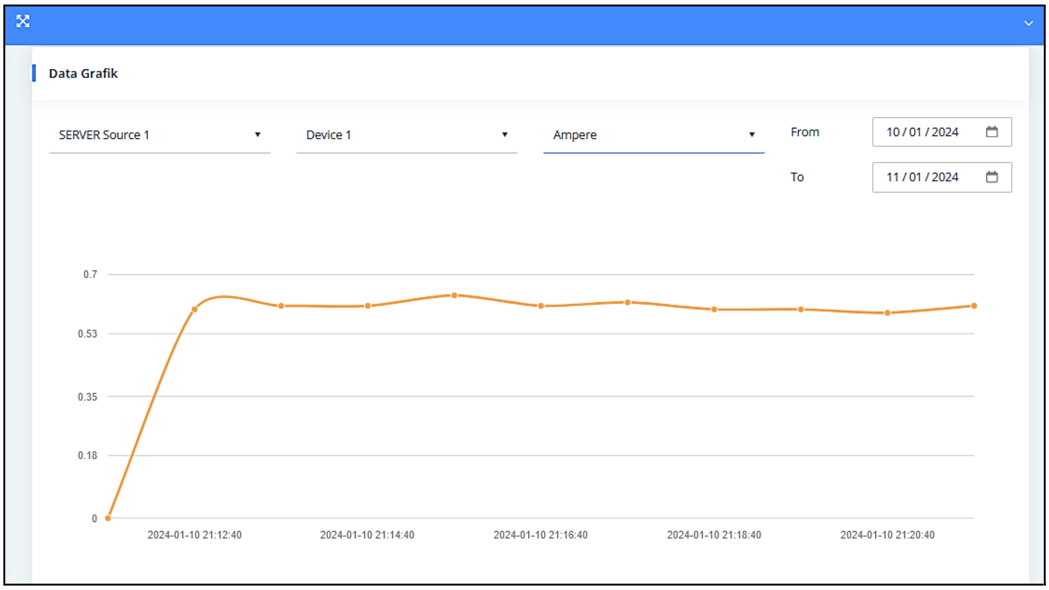


Figure 9. Graphical display for current value at source 1 against time on the monitoring webpage.

The Monitoring Data graph page above displays the electric current data collected from sensor 1 or device 1 from a different power source to the second power source and is displayed on the web page, the data is updated every 1 minute. Shown in Figure 9.

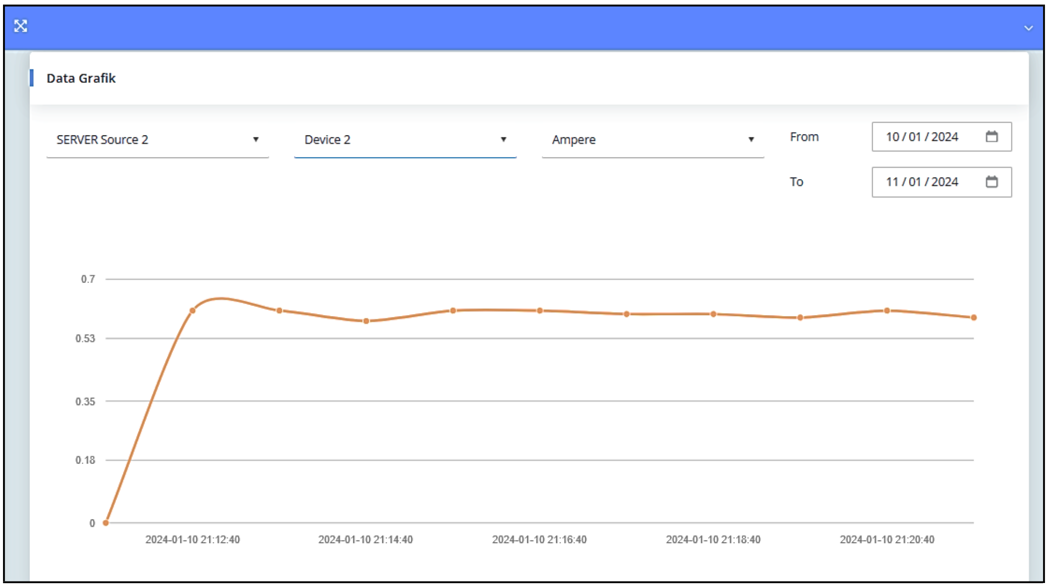


Figure 10. Graphical display for current value at source 2 against time on the monitoring webpage

The Monitoring Data graph page above displays the electric current data collected from sensor 2 or device 2 from a different power source to the first power source and is displayed on the web page, the data is updated every 1 minute. Shown in Figure 10.

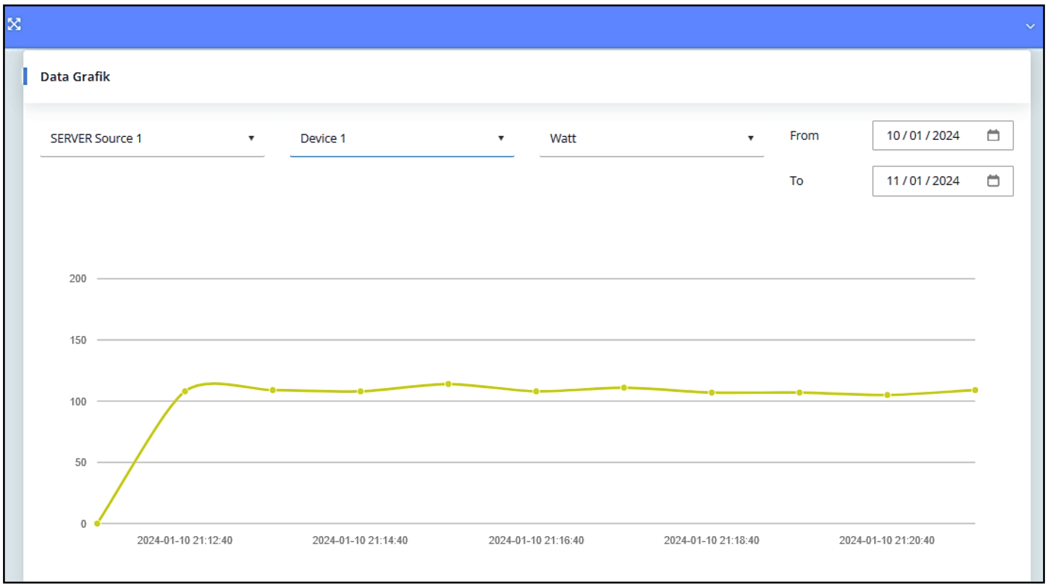


Figure 11. Graphical display for power value at source 1 against time on the monitoring web page

The Monitoring Data graph page above displays the electrical power data collected from sensor 1 or device 1 from a different power source with a second power source and is displayed on the web page, the data is updated every 1 minute. Shown in Figure 11.

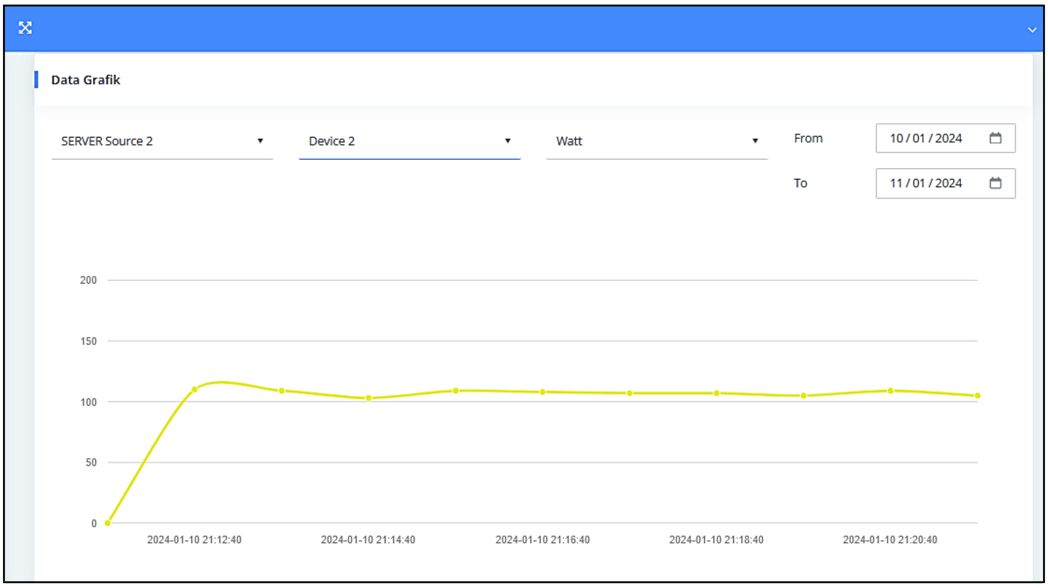


Figure 12. Graphical display for power value at source 2 against time on the monitoring web page

The Monitoring Data graph page above displays the electrical power data collected from sensor 2 or device 2 from a different power source to the first power source and is displayed on the web page, the data is updated every 1 minute. Shown in Figure 12.

The picture above is a graphical display on the web page created. Each image is the result of plotting the current, voltage, and power values against the time read by the PZEM-004T sensor. These values are also recorded and entered into the table. In this test, we apply all loads directly to each power source used, the loads include 5W LED lights, 20-40W solder, and 100W lamps. The results of this test are shown in Table 4.

Table 4. Results of overall system testing

			Source Energy 1			Source energy 2		
No	**Time (S)**	**Power Factor (Pf)**	**Volt (V)**	**Ampere (A)**	**Power (W)**	**Volt (V)**	**Ampere (A)**	**Power (W)**
1	34:50:00	0.80	224	0.60	108	224	0.61	110
2	35:06:00	0.80	223	0.61	109	223	0.61	109
3	35:22:00	0.80	221	0.61	108	221	0.58	103
4	35:37:00	0.80	223	0.64	114	223	0.61	109
5	36:08:00	0.80	222	0.61	108	222	0.61	108
6	36:23:00	0.80	223	0.62	111	223	0.60	107
7	36:39:00	0.80	223	0.60	107	223	0.60	107
8	36:54:00	0.80	223	0.60	107	223	0.59	105
9	37:09:00	0.80	223	0.59	105	223	0.61	109
10	37:25:00	0.80	223	0.61	109	223	0.59	105

From the data obtained from the tests carried out, the values of voltage, current and power produced have almost the same value. But the accuracy of the sensor used is the PZEM-004T sensor is still less accurate. However, from the calculations made, the value obtained is not too far from the direct measurement with a multimeter, then from testing the monitoring application system on the web page created is able to send, store and display data on the monitoring web page in real time every minute, even with different power sources, in tests conducted by measuring two different power sources and can be measured correctly, so the tests conducted can be said to be good.

CONCLUSION

In this device research, there are 2 PZEM-004T sensors that are used as current and voltage sensors, and the power reading is sent to the local server via serial communication using an Ethernet cable, so that the data obtained will be sent to the monitoring server via the Internet network, so that it can be monitored online through the monitoring web page that has been created. The results of the tests carried out have an average error value in testing the voltage sensor of 0.02% the results can be seen in Table 1, the current sensor has an error value of 0.019% the results can be seen in Table 2, and the error value on the power of 0.18% the results can be seen in Table 3, which is used still has a difference and the error is quite small, so this tool is said to be good, but can still be used in this study because it has a small measurement difference compared to measurements using multimeter and current clamp measuring instruments.

Then by testing the monitoring application system on the web page created is able to send, store and display data on the monitoring web page in real time every minute even with different power sources, in tests conducted with two different power sources and can be measured properly, so that testing the web monitoring application can be said to be good because it can monitor electrical power multiple sources of electricity.

REFERENCES

Purwania Ida Bagus Gede, Satya Kumara I Nyoman, and Sudarma Made, “Application of IoT-Based System for Monitoring Energy Consumption,” International Journal of Engineering and Emerging Technology, vol. 5, pp. 81–93, 2020.

I. S. Hudan and T. Rijianto, “Rancang Bangun Sistem Monitoring Daya Listrik Pada Kamar Kos Berbasis Internet of Things Rancang Bangun Sistem Monitoring Daya Listrik Pada Kamar Kos Berbasis Internet Of Things (Iot),” 2018. Doi : https://doi.org/10.26740/jte.v8n1.p%25p.

E. Kurniawan, D. S. Pangaudi, D. Eko, N. Widjatmoko, and P. P. Surabaya, “CYCLOTRON : Jurnal Teknik Elektro Perancangan Sistem Monitoring Konsumsi Daya Listrik Berbasis Android,” 2022.

J. Lianda, D. Handarly, and A. Adam, “Sistem Monitoring Konsumsi Daya Listrik Jarak Jauh Berbasis Internet of Things,” JTERA (Jurnal Teknologi Rekayasa), vol. 4, no. 1, p. 79, May 2019, doi: 10.31544/jtera.v4.i1.2019.79-84.

T. D. Hendrawati, Y. D. Wicaksono, and E. Andika, “Internet of Things: Sistem Kontrol-Monitoring Daya Perangkat Elektronika,” JTERA (Jurnal Teknologi Rekayasa), vol. 3, no. 2, p. 177, Dec. 2018, doi: 10.31544/jtera.v3.i2.2018.177-184.

J. Lianda, D. Handarly, and A. Adam, “Sistem Monitoring Konsumsi Daya Listrik Jarak Jauh Berbasis Internet of Things,” JTERA (Jurnal Teknologi Rekayasa), vol. 4, no. 1, p. 79, May 2019, doi: 10.31544/jtera.v4.i1.2019.79-84.

D. H. Manik, R. Nandika, and P. Gunoto, “Penerapan *Internet Of Things* (Iot) Pada Sistem Monitoring Pemakaian Daya Listrik Rumah Tangga Berbasis Mikrokontroler Dan Website,” Sigma TeknikA, Vol. 4, No. 2, Pp. 255–261, Nov. 2021, Doi: 10.33373/Sigmateknika.V4i2.3618.

K. Luechaphonthara and V. A, “IOT based application for monitoring electricity power consumption in home appliances,” International Journal of Electrical and Computer

Engineering (IJECE), vol. 9, no. 6, p. 4988, Dec. 2019, doi: 10.11591/ijece.v9i6.pp4988-4992.
A. M. Syaiful Romadhon, "Design and Development of Real-Time Monitoring & Controlling Infant Incubator with Tilt Stabilizer Using Raspberry Pi Remotely Controlled via PC and Smartphone to Reduce Tilt during Baby Transfer," International Journal of Advanced Multidisciplinary, vol. 2, no. 2, pp. 1–12, 2022.
Z. Kuroma, N. Dwi Saputro, G. Pusat Lantai, and J. Sidodadi Timur, Perancangan Aplikasi Monitoring Jurnal Kegiatan Badan Pusat Statistik Kota Pekalongan Berbasis Web, Vol. 6. 2021.