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Monitoring System for Electrical Energy Use and Charging Electricity Tokens Based on Website and Whatsapp Application

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ABSTRACT

The large number of equipment or electrical loads used causes large amounts of electrical energy usage. To determine the amount of electrical energy used, you can install an electrical energy meter whose results can be monitored via an LCD display. In this research, a website-based application was designed that can monitor electrical energy usage, by providing information in the form of voltage, current, power, and active power usage over time. Apart from that, this website can also top up electricity tokens as a feature to limit the use of electrical energy that will be used by users and is equipped with a notification message for remaining electricity tokens to the Whatsapp application. This system was developed using an ESP32 microcontroller which will provide data, process data, and present data from instrument measurements, then send the measurement results data every 15 seconds to the monitoring website. From the test results, the tool can measure electrical quantities such as current and voltage. The tool can also send measurement results to the website and store measurement data in a database. Test results for sending notification messages, the message was successfully sent to WhatsApp media if the electricity token met the specified conditions.

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1. INTRODUCTION

The use of electrical energy is very large in today's modern life. The large amount of electrical energy used is caused by the large number of equipment or electrical loads used. There are three types of loads in an electrical system, namely: resistive, inductive, and capacitive. The electrical loads commonly used are resistive and inductive loads, where the inductive load absorbs reactive power while the resistive load absorbs active power.

Saving electrical energy can be done in various ways, such as turning off electricity when not in use and using energy-saving items. Apart from that, there are also ways to maximize electricity savings, namely by directly monitoring the use of electrical energy.

To determine the amount of electrical energy used, especially for one phase, you can do this by installing an electrical energy meter and then displaying it via an LCD display. This means that to monitor the electrical energy used you must directly look at the location where the measuring instrument is installed. By utilizing current technological advances, monitoring can actually be carried out remotely, one of which can be using a website-based application that can be accessed anytime and anywhere.

From the description above, a system is needed that is able to monitor electrical energy use in real time on a website basis so that it can be monitored anywhere and at any time. This website application is also designed to be able to control relays to turn on or turn off the electricity source and can regulate

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the amount of electrical energy used or electrical tokens on the prototype device created, so as to limit the use of electrical energy that will be used by the user. To be able to realize this monitoring system, it is necessary to create a prototype tool that can measure voltage, current and electrical power.

It is hoped that the creation of this website-based monitoring application will make it easier for electrical energy users to find out how much electrical energy they use by displaying it in graphical form and equipped with historical data reporting on the use of electrical energy that has been used. This website application can also control the use of electrical energy by setting electricity tokens or limits on the amount of electrical energy to be used.

2. RESEARCH METHODS

The research begins with preparing the tools and materials that will be used, then continues with designing the tools and designing the website. The tool is used to measure current, voltage and electrical power which is made using a current sensor, voltage sensor and zero crossing detector circuit and programmed using an ESP32 microcontroller. After the tool has been successfully created, the next step is to design the website interface that will be used to display information related to electrical energy usage data.

The flow diagram of this research can be seen in Figure 1.

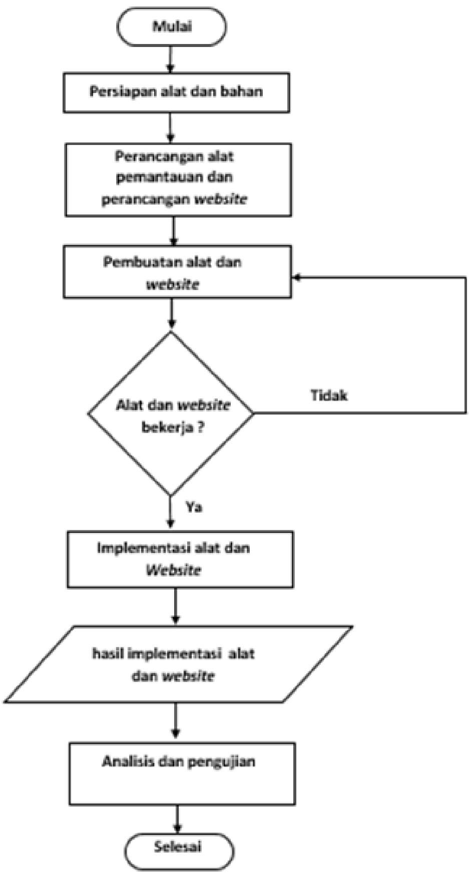

Figure 1. Research flow diagram

2.1. System Functional Blocks

The load current is measured using a current sensor and the load voltage is measured using a voltage sensor (voltage divider). After the current and voltage at the load are obtained, the current and voltage data are entered into the zero crossing detector circuit. The Zero crossing detector circuit is useful for detecting or obtaining the difference in voltage and current pulse waves. ESP32 is a microcontroller to process the output from the zero crossing detector circuit to calculate the power factor value. The output

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from the current and voltage sensors is also connected directly to the ESP32 analog pin to obtain the voltage and current values for the load. So you can calculate electrical power.

In carrying out power factor improvements, the ESP32 microcontroller will regulate the work of the relay according to the conditions specified in the program, the relay will work when the power factor in the system is low. A relay that is in HIGH (working) condition will connect the capacitor to the load as a reactive power compensator, so that the reactive power requirements of the load can be met as a result of which the previously low power factor can be improved.

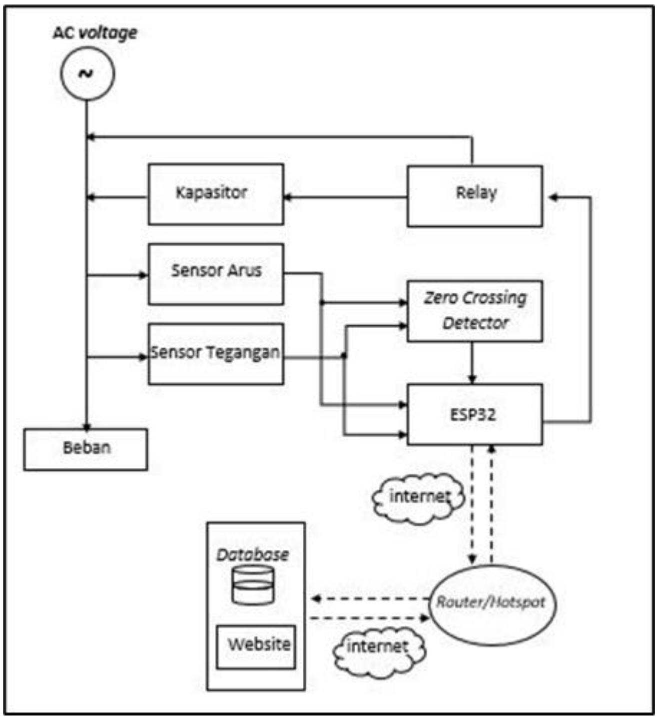

Figure 2. System functional diagram

Data on power factor values and measured electrical energy usage are then sent to the website for display. This data is sent via the internet network using the TCP/IP protocol. The ESP32 microcontroller equipped with a WiFi module makes it possible to carry out this communication. ESP32 will request a connection to the router/modem. If the request is successful, ESP32 will get an IP address. By getting this IP address, TCP/IP data communications can be carried out between ESP32 and the website. Data that is successfully sent from the ESP32 will then be saved into the MySQL database.

2.2. ESP32 Communication Architecture with Websites

In this research, the ESP32 will send measurement data such as voltage, current, power factor, active power, reactive power and apparent power values. Data is sent using the TCP/IP protocol every 15 seconds to the web server, then the web server will forward it to the backend of the website to display it to the user and store the data in the database.

The electricity token entered via the website will be saved into the database, then Laravel as the backend of the website will return the electricity token database in JSON format, so that the value of the electricity token data stored in the database can be retrieved by ESP32 via the HTTP GET protocol. Notification of the remaining electricity tokens that have been used will be sent to WhatsApp using the WhatsApp bot API. The data communication process between the ESP32 and the WhatsApp bot API is carried out using the HTTP POST protocol.

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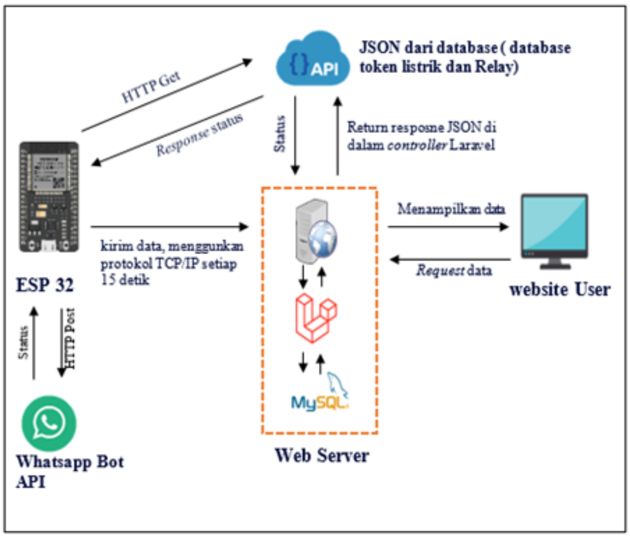

Figure 3. Data communication architecture

2.3. Designing Use Case Diagrams

A use case diagram is a description or representation of the interactions that occur between the system and its environment. A use case describes an interaction between one or more actors and the system to be created. In simple terms, use case diagrams are used to understand what functions are in a system and who can use these functions. The following is a use case diagram for a website monitoring electrical energy usage, which can be seen in Figure 4.

Seen in Figure 4, there are two actors on this monitoring website, namely super admin and admin. Both have the same task except the admin cannot add new data for users.

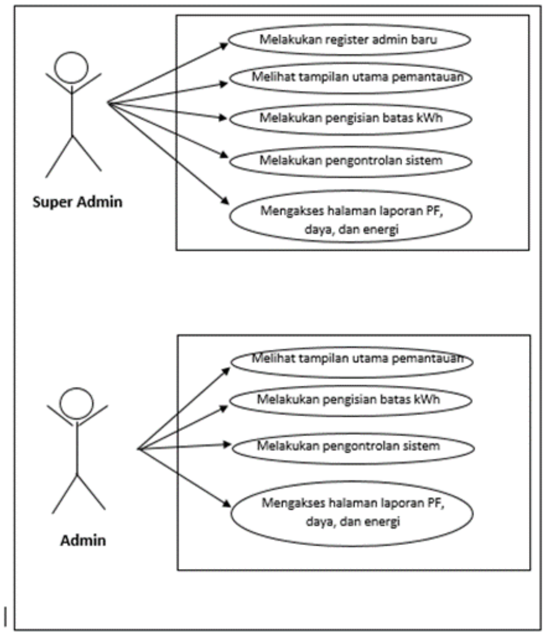

Figure 4. Website use case diagram

2.4. Test Method

The testing method in this research was carried out by testing notification messages, knowing that the system was successful in sending notification messages to WhatsApp in the form of text messages. A notification message will be sent when the regulated electricity token value limit is less than 5 kWh and less than 0 kWh. When it is less than 5 kWh the system will send the message "Refill Credit Immediately", whereas when the electricity token is less than 0 kWh the system will send the message

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"Electricity is Turned Off", and immediately turn off the relay on the device to disconnect the electricity source to the load.

3. RESULTS AND DISCUSSION

3.1. Results of Tool Design

Tools are made based on designs that have been carried out and can function as desired. This tool can measure electrical quantities such as current and voltage and improve power factor. The tool can send measurement results to the website and store measurement data in a database. The relay as a switch to turn the electricity source on or off can be controlled via the control panel on the website. The tool created can also run an electricity token feature to limit the use of electrical energy which is controlled via the website. The designed tool also has the advantage of storing calculation data on electrical energy usage, so that in the event of a power outage the value of the last electrical energy used is still stored. Figure 5 below is a display of the tool that has been created.

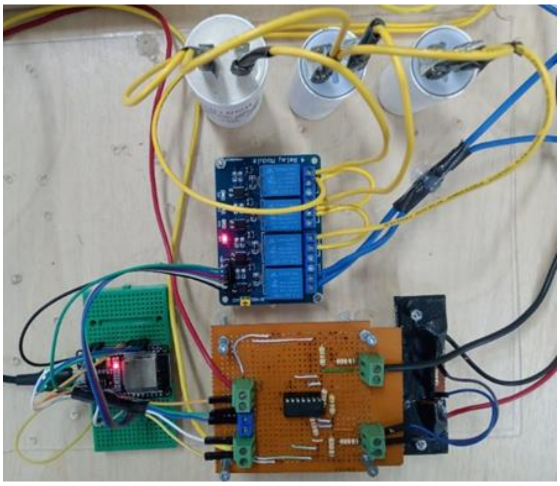

Figure 5. Instrument results

3.2. Results of Website Design

The interface of the software is created based on the design that has been carried out. Website applications can be run in a web browser. The interface results are displayed from a screenshot of the monitoring website page.

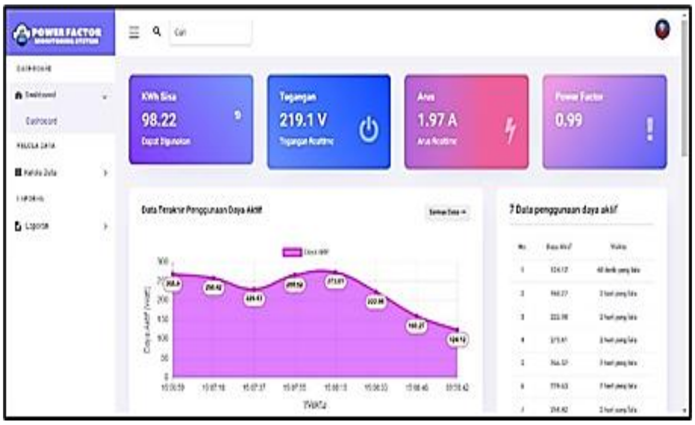

Figure 6. The results of the main page design

Figure 6 above is the result of the main monitoring page containing information starting from voltage values, current values, energy usage data graphs, power factor data graphs before and after repairs as well as power value graphs (active power, reactive power and apparent power). The data is displayed in real time with data updates every 15 seconds. This page also displays the remaining kWh

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value as a feature for limiting energy use, the value of which is input by the user in the data management page menu.

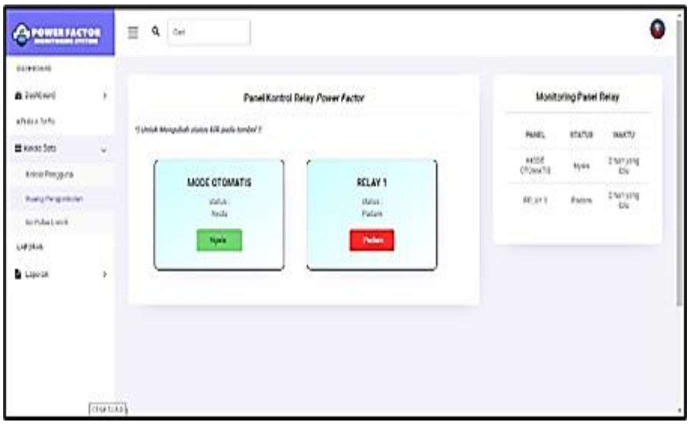

Figure 7. Results of control page design

Figure 7 above is a control menu page containing two system control panels, namely a panel for selecting automatic mode or manual mode for the system and a panel that is used to control relays. In automatic mode, the relay as a switch to disconnect the electricity source works based on the electricity token limit conditions given in the kWh limit content menu as in Figure 8 below. The relay will be in LOW condition (turning off the electricity source) when the remaining kWh pulse is less than 0 kWh. Meanwhile, in manual mode or when automatic mode is turned off, the relay can be controlled directly to turn the electricity source on or off according to needs without being influenced by the controlled kWh limit value. When relay 1 is in the "on" status, it will change the condition of the relay on the device to be on, indicated by the relay light being on, while when relay 1 is in the "off" status, it will change the condition of the relay on the device to be off, marked by the relay light being off.

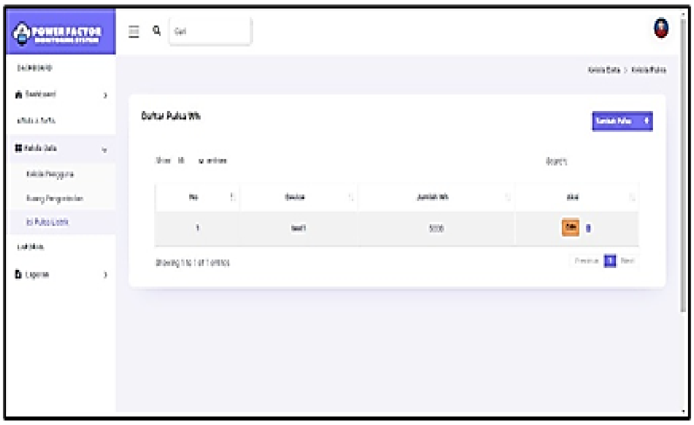

Figure 8. Results of the design of the electricity token charging page

Figure 8 above is the electricity token filling page. This page displays the history of previous kWh usage limit charging data or electricity tokens and there are action buttons to add, change and delete kWh limit data values. The kWh limit value or electricity token is input using Watt-hour (Wh), if you want to enter 5 kWh into the system you must input 5000 Wh. The value of electricity tokens that have been successfully input will be reduced by the amount of energy consumption used by the user and displayed on the main page.

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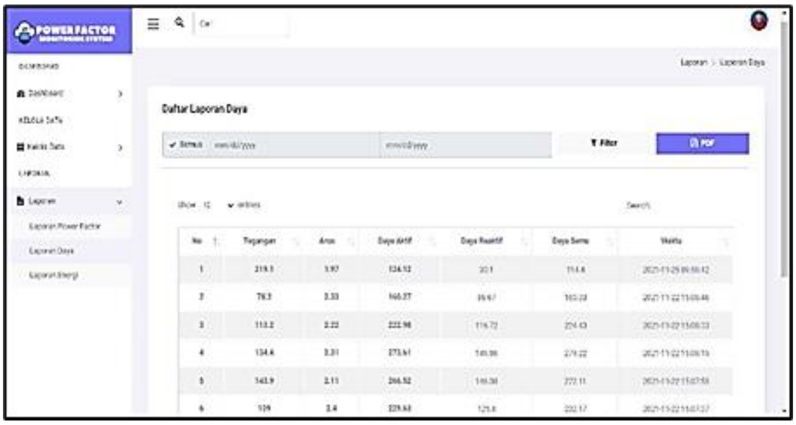

Figure 9. Results of the design of the power, voltage, and electric current report page

Figure 9. This is a report menu containing recap report information including voltage values, current values, active power values, reactive power and apparent power stored in the database. This menu also has a time filter feature to filter data based on a certain date and there is also a feature for downloading report recaps in PDF document form.

Table 1. Ten power data downloaded from websites based on time filters

NO	Tegangan (V)	Arus (A)	Daya Aktif (W)	Daya Reaktif (VAR)	Daya Semu (VA)	Waktu
1	213.75	1.31	243.27	138.46	243.65	2021-12-31 09:53:57
2	214.88	1.3	238.55	145.26	238.64	2021-12-31 09:54:13
3	217.25	1.3	243.17	145.57	243.25	2021-12-31 09:54:29
4	214	1.32	240.74	148.25	240.77	2021-12-31 09:54:45
5	215.62	1.29	240.86	137.68	241.28	2021-12-31 09:55:02
6	215.75	1.29	241.25	137.01	241.72	2021-12-31 09:55:17
7	213.62	1.29	233.74	144.15	233.87	2021-12-31 09:55:34
8	216	1.29	240.82	139.17	241.16	2021-12-31 09:55:49
9	214.75	1.29	235.91	143.55	236.06	2021-12-31 09:56:05
10	216	1.29	235.54	147.72	235.58	2021-12-31 09:56:21

In Table 1 are measurements of power, voltage and electric current values downloaded from the website application based on time filters.

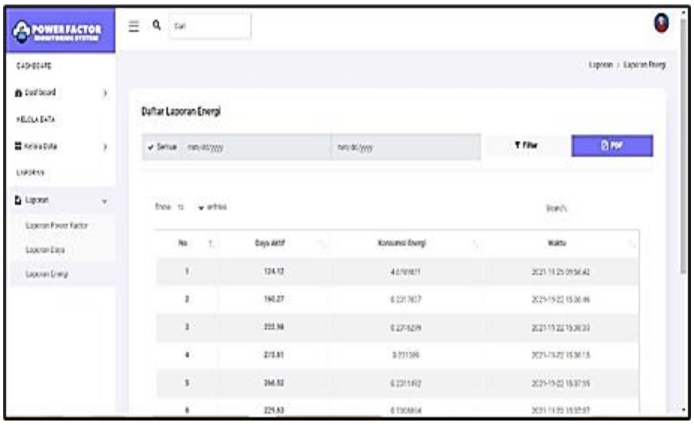

Figure 10. Results of energy report menu page design

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The energy report menu contains summary report information on user energy consumption stored in the database. This menu also has a time filter feature to filter data based on a certain date and there is also a feature for downloading report recaps in PDF document form.

Table 2. Ten electrical energy data downloaded from websites based on time filters

NO	Daya Aktif (W)	Konsumsi Energi (kWh)	Waktu
1	243.27	0.1091188	2021-12-31 09:53:57
2	238.55	0.1095183	2021-12-31 09:54:13
3	243.17	0.1099231	2021-12-31 09:54:29
4	240.74	0.1103239	2021-12-31 09:54:45
5	240.86	0.1107231	2021-12-31 09:55:02
6	241.25	0.1111211	2021-12-31 09:55:17
7	233.74	0.1115187	2021-12-31 09:55:34
8	240.82	0.1119152	2021-12-31 09:55:49
9	235.91	0.112313	2021-12-31 09:56:05
10	235.54	0.1127125	2021-12-31 09:56:21

In Table 2 are measurements of power, voltage and electric current values downloaded from the website application based on time filters.

3.3. Testing Notification Messaging

This monitoring system will send a notification if the remaining kWh limit value meets the specified conditions. The system will send a notification message with two conditions, namely first if the kWh limit used is less than 5 kWh and second if the kWh limit used is less than 0 kWh. Sending notifications via WhatsApp messaging media. The following is an example of sending a notification shown in Figure 11.

Figure 11. Display of notifications via WhatsApp messages

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It can be seen in Figure 11 that the system has successfully sent notifications via WhatsApp messages. Notifications containing the message "Refill Credit Immediately" occur when the remaining kWh limit used is less than 5 kWh, while notifications containing the message "Electricity is Turned Off" occur when the remaining kWh limit used is less than 0 kWh. In this case, the success of sending notifications is 100% after testing.

4. CONCLUSION

The website-based application created can monitor and provide information on the power factor value before and after repairs, as well as the use of electrical energy. Monitoring can be done via a web browser, with a data update interval of 15 seconds. The application can be used to control relays to turn power sources on or off online and remotely. The application can also set electricity tokens or the amount of electrical energy (kWh) that can be used by users and send notification messages when minimum conditions are reached. The test results for sending notifications show that data will be sent to WhatsApp media if the specified conditions are met and notification delivery success is 100%.

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