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IoT on Power Monitoring and Protection for Home Energy Consumption

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ABSTRACT
Electrical hazards can occur due to inadequate protection systems, often leading to fires in homes or buildings. One major cause of this issue is users' lack of knowledge regarding standard electrical installations. To overcome this, the Internet of Things (IoT) offers a promising solution by enabling remote and real-time control and monitoring of electrical devices. By integrating IoT technology with home electrical systems, users can enhance safety and manage energy consumption more effectively. A practical implementation involves using a digital kWh meter, which allows accurate measurement of electrical quantities such as current, voltage, power, and power factor (cos Φ) without requiring additional sensors. The system was tested using three household loads: a 5W smartphone charger, a 40W lamp, and a 100W single-phase motor. Monitoring is done through an Android application and a web browser interface, making it accessible and user-friendly. These platforms display real-time electrical parameters and provide estimates of energy costs. Additionally, the system includes a current limitation feature, which is configured via Arduino and can be adjusted through the Android or web interface. This adds an extra layer of protection against overloads, enhancing the safety and efficiency of household electrical usage. The integration of IoT and digital metering contributes significantly to smarter and safer energy management.

Keywords: Internet of Things, Monitoring, Protection System, Smart Devices, Energy

ABSTRAK
Bahaya listrik dapat terjadi karena sistem proteksi yang tidak bagus, yang sering kali menyebabkan kebakaran di rumah atau gedung. Salah satu penyebab utama masalah ini adalah kurangnya pengetahuan pengguna mengenai instalasi listrik standar. Untuk mengatasi hal ini, Internet of Things (IoT) menawarkan solusi yang menjanjikan dengan memungkinkan kontrol dan pemantauan perangkat listrik secara jarak jauh dan waktu nyata. Dengan mengintegrasikan teknologi IoT dengan sistem kelistrikan rumah, pengguna dapat meningkatkan keselamatan dan mengelola konsumsi energi secara lebih efektif. Implementasi praktis melibatkan penggunaan meteran kWh digital, yang memungkinkan pengukuran akurat besaran listrik seperti arus, tegangan, daya, dan faktor daya (cos Φ) tanpa memerlukan sensor tambahan. Sistem ini diuji menggunakan tiga beban rumah tangga: pengisi daya ponsel pintar 5W, lampu 40W, dan motor fase tunggal 100W. Pemantauan dilakukan melalui aplikasi Android dan web, sehingga mudah diakses dan ramah pengguna. Platform ini menampilkan parameter listrik waktu nyata dan memberikan perkiraan biaya energi. Selain itu, sistem ini menyertakan fitur pembatasan arus, yang dikonfigurasi melalui Arduino dan dapat disesuaikan melalui antarmuka Android atau web. Hal ini menambah lapisan perlindungan ekstra terhadap kelebihan beban, meningkatkan keamanan dan efisiensi penggunaan listrik rumah tangga. Integrasi IoT dan pengukuran digital memberikan kontribusi signifikan terhadap manajemen energi yang lebih cerdas dan aman.

Kata kunci: Internet of Things, Pemantauan, Sistem Proteksi, Perangkat Cerdas, Energi

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1. INTRODUCTION

Smartphones are an inseparable part of the development of the internet. Statistics record that about 143.26 million people from the total population of Indonesia access the internet for various needs. Using the internet, each device can send data to other devices [1]. A system where physical objects can be connected to the internet via sensors [2]. The Raspberry Pi 3 Model B serves as a local server and stores data in InfluxDB, a time series database. The experimental results showed that the developed energy monitoring system can successfully monitor voltage, current, active power, and cumulative power consumption [3]. The number of internet users in Indonesia is in line with the development of internet-based devices.

According to the McKinsey Global Institute analysis, the Internet of Things is a technology that allows us to connect machines, equipment, and other physical objects with network sensors and actuators to obtain data and manage their performance, allowing machines to collaborate and even act on new information that is obtained independently. A publication about the Internet of Things explains that the Internet of Things is a condition when objects have an identity, can operate intelligently, and can communicate with social, environmental, and users. The goal is to make humans interact with objects more easily, so that objects can also communicate with other objects.

In an article written by Michael Hendrix, the Internet of Things will become one of the technologies that will be vigorous in the future. This institution predicts that the opportunity for economic influence from the Internet of Things will reach 2.7 to 6.2 trillion United States Dollars. The economic influence of the Internet of Things industry ranks third-largest after the mobile internet and automation of knowledge work. This proves that one day, the technology of the Internet of Things will develop and become a trend in the world. The true meaning of technology is accomplished only when it reaches the grassroots level and makes a difference in the lives of the community. The smart grid is the most revolutionary technology in the present era. The integration of information and communication technology with an existing passive power grid is a critical aspect of this revolution [4].

The internet allows it to be used as a monitoring device that can monitor devices remotely. A new trend in user technology is the Internet of Things (IoT), which can collaborate with protection systems. Consumers will be able to see their usage in real time, eventually encouraging them to use less energy to save money [5]. Today's internet technology can be used not only for communication between individuals but also for communication between objects [6]. A breakthrough is needed to create the necessary protection systems and also control the load [7]. This can create protection and monitor electricity consumption in a home or building. In addition to being able to cut off electricity when there is an overload, the user can also monitor it via a smartphone or web application if there is a mismatch between the incoming power and the load used, so that it can be used to prevent accidents due to electrical hazards.

2. RESEARCH METHOD

This Electric Power Monitoring and Protection system uses an SDM120C digital KWH meter to read the frequency, voltage, current, and power of the load. Then, the digital kWh meter reading results are sent to Arduino via serial communication. Then, the data that has been received will be processed if the current, voltage, and frequency have continuously exceeded the safe value limit for a certain time. Then, the Arduino pin will instruct the relay to turn off so that it will cut off power to the load. The data is also converted into a URL that will be sent to the web server via ESP8266. Then, the data will be stored in the database. The data in the database can be accessed by the user using the Android app or a web browser. The data on the kWh meter can be monitored from a distance.

2.1. Android Application

The block diagram system application for the electric power monitoring and protection system is shown in Figure 1. The process starts, and then the application checks the internet

connection; if there is an internet connection on the smartphone, the application will make a data request to the server. The data obtained in the form of power that has been used, as well as the current value, voltage, and frequency, will be displayed on the application. Then, the application checks the flow data. If the current value exceeds the specified nominal value, the application will display a notification so that the user can know if there is an excess current.

Arduino flowcharts on the Cayenne-based lighting control system are shown in Figure 2. The process starts, initializing data. The kWh meter SDM120C is used to detect current, voltage, frequency, and power used. If the current value exceeds the specified nominal limit value, the relay will turn off and cut off power to the load (Figure 3). Then Arduino will send data to the web server via ESP8266. The process has finished running.

Figure 1. Block Diagram System

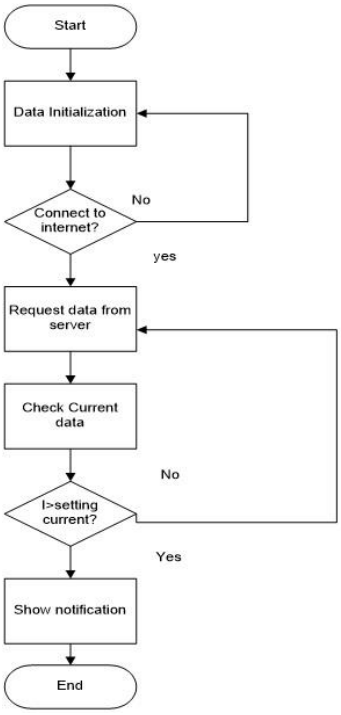

Figure 2. Android Flowchart

Based on the Flowchart design that has been made above, the next step is to implement the design, which in this study involves fabricated prototypes.

Tests carried out include:

- System testing and evaluation per section.
- Testing and evaluating the overall success of the prototype.

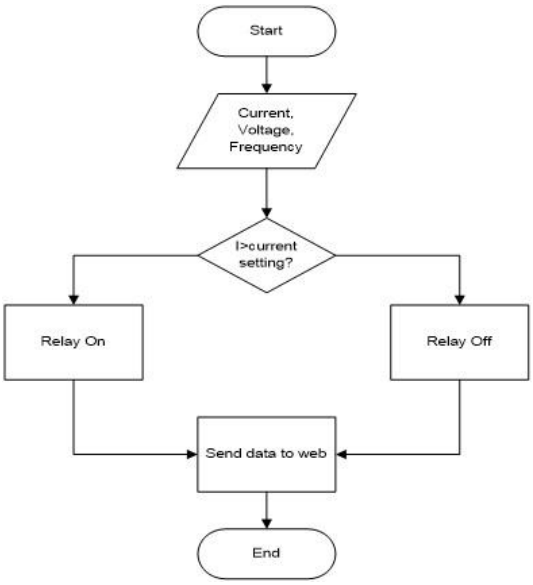

Figure 3. Protection Flowchart

3. RESULTS AND DISCUSSION

Figure 4 is a series of drawings of the tools used. The reading of the electrical quantities on a digital kWh meter is assembled with an Arduino microcontroller as a processor and sender of data to the web server via the Wifi ESP 8266 module.

Power breaker control testing on Android is done with a 100-watt motor load. The setting on the Arduino for current limits is limited to only 0.4 A. When testing with a 100-watt motor load, the relay breaker will work. The protection relay works after being given a delay of 15 seconds. If the test is carried out with a motor load, the relay will not be off when the electric motor is starting. Testing via the Android application and testing with the web on the relay indicator when given a 100-watt motor load, showing the relay off. The current limit setting when the relay is off can be changed in Arduino. If the current value is not up to the limit but we want to break the load, then we just have to press the off button on the web or in the application.

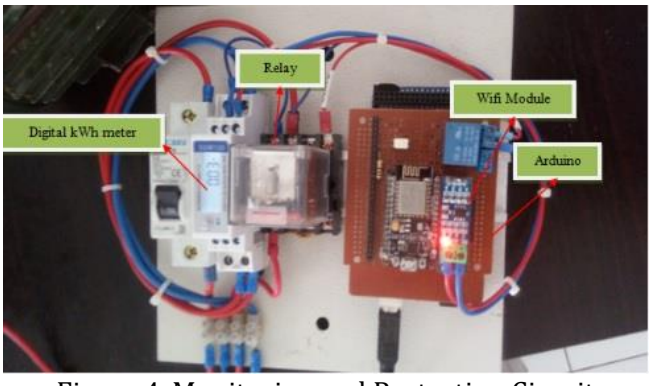

Figure 4. Monitoring and Protection Circuit

The power monitoring and power breaker were designed via a web browser using Sublime text and Filezilla software. The menu displayed on the web browser makes it possible to see the amount of electricity used, such as current, voltage, power factor (cos phi), and estimated cost. In addition, we can see the history of power consumption through a graph that can display data in real-time. Arduino will send data every 5 seconds, and the bus graph will show a maximum display of 300 data points. The result is shown in Figures 5-7 for the web and Figures 8-9 for the Android application. Power monitoring testing on the web is done using three loads as a test. Monitoring results in the form of power consumption, cost estimates, voltage, current, power factor, and frequency are shown in Table 1.

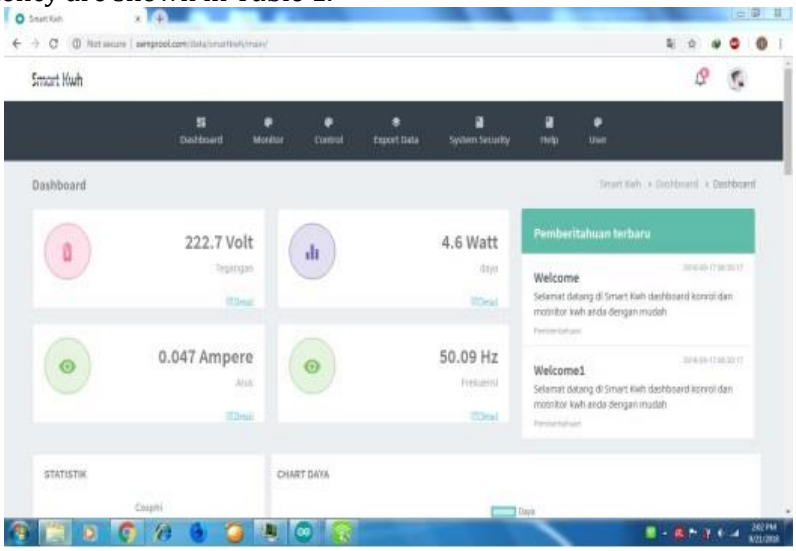

Figure 5. Display Electrical Quantities (voltage, current, power, and frequency)

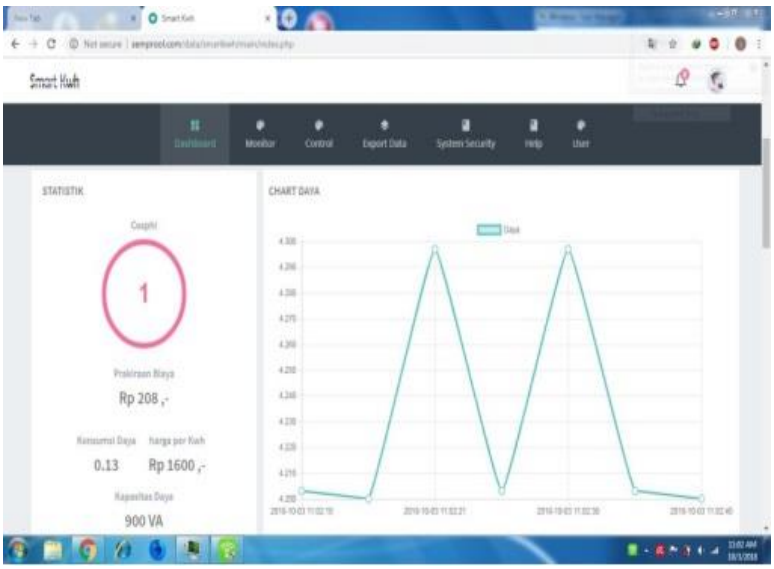

Figure 6. Display of power consumption and cost estimates on the web

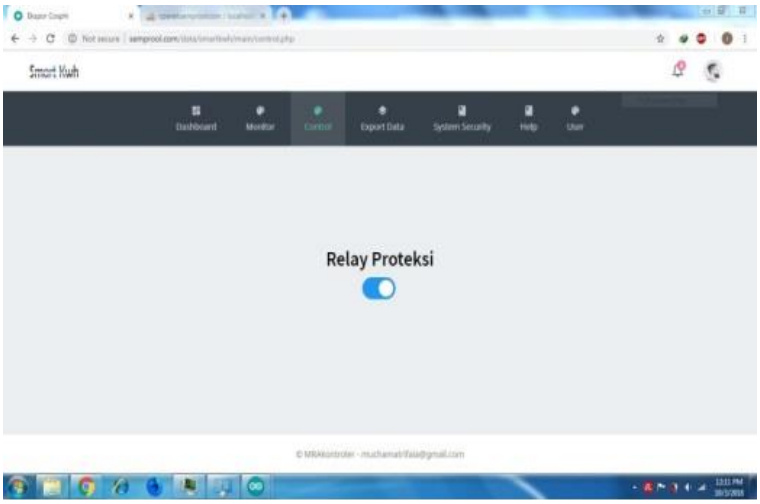

Figure 7. Display of protection relay on the web

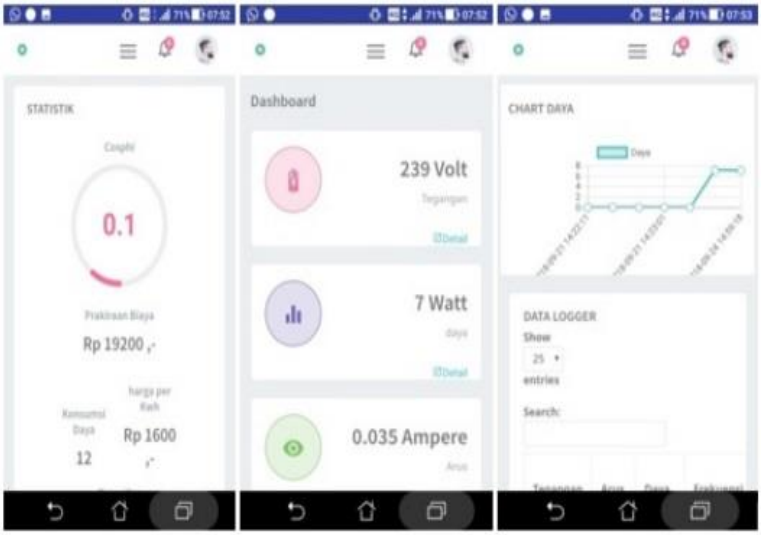

Figure 8. Display monitoring of electrical quantities in the Android application

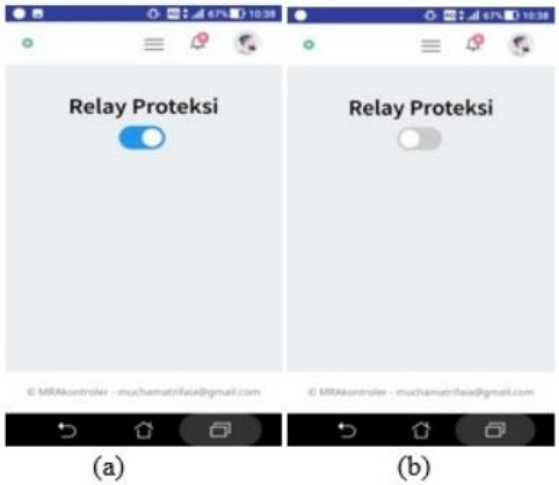

Figure 9. Display Android applications when the protection relay is on (a) and off (b)

Table 1. Testing results with three types of loads

No	Load	V (Volt)	I (A)	Cos Q	Power (W)	Freq (Hz)
1	Mobile phone charger 5 W	220,7	0,046	1	4,2	50,00
2	Lamp 40 W	226,6	0,174	1	38,8	50,29
3	1-phase induction motor 100 W	226,6	0,751	0,6	102,2	50,29

4. CONCLUSION

The results of the research conducted can be concluded monitoring power at household load with IoT via web browser and Android can function according to the current limit settings in the Arduino program. The control system with IoT can turn off the load automatically via a web browser and an Android application.

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