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Effectiveness Of Prototype Electrical Monitoring System Based On Internet Of Things (Iot) Technology For Residential Houses

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Abstract: The development of Internet of Things (IoT) technology is growing rapidly in line with the current needs of society. IoT technology can be used to facilitate various human affairs. However, it was found that wastage of electricity consumption often occurs among consumers. IoT technology to also make it easier for consumers to monitor electricity consumption for their homes to avoid wastage of electricity resulting in increased electricity bills. This paper presents effectiveness of prototype of electrical monitoring system based on internet of thing (IoT) technology for residential houses. This quantitative study uses experimental methods to test the effectiveness of a prototype electrical monitoring system based on IoT technology for residential homes. In this study, the researchers also identified the differences between the reading results using traditional methods (manual) and prototypes of electrical monitoring systems based on IoT technology for residential homes. The findings show that the prototype electrical monitoring system based on IoT technology has more accuracy and detail in analyzing energy consumption data as well as sensitivity by sending notifications about excess current found in residential wiring systems. The results of this study also show that the construction of this monitoring tool can also provide a new initiative in terms of data presentation to facilitate users to understand the data information presented because it is in the form of infographics (graphs) and in real-time. In conclusion, through the findings of this study, consumers can save money for electricity bill payments and save time to control electricity consumption only through mobile phones.

Keywords: Internet Of Things (Iot), Prototype Electrical Monitoring System, Electricity Consumption

1. Introduction

Electrical energy is one of the most crucial elements in ensuring that equipment related to daily activities and building systems operate properly (Luo, Wang, Dooner & Clarke, 2015). Technological

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advances demand the use of more sources of electrical energy to ensure that appliances can function. Among the systems found in a building that used electricity such as lighting, motor equipment, communication and ICT. The development of Internet of Things (IoT) technology is accelerating in line with the current needs of society. IoT technology is used in industry, medicine, education, manufacturing, agriculture, and transportation. However, wastage of electricity consumption often occurs among consumers (Ozoh, Adigun & Omotosho, 2019). In addition, consumers also sometimes hang out by leaving their homes by not turning off the electricity supply to fans, rice cookers and water heaters. This can result in electrical conduction even when equipment or hardware is not in use. Besides, if the temperature of the air conditioner setting to less than 24ºC contributes to the increase in electricity consumption. Among the systems found in a building that used electricity such as lighting, motor equipment, communication and ICT (Motlagh, Mohammadrezaei, Hunt & Zakeri, 2020). Air conditioning should be between 24 ºC and 26 ºC, should be in line with room size to reduce the cost of electricity bills (Khosla, Agarwal, Sircar & Chatterjee, 2021). Therefore, consumers should be sensitive to the consumption of electricity in their homes as efficient use of electricity can reduce the rate of electricity bills in their homes.

The problem of wastage of electricity consumption can also occur if consumers use electricity all the time. For example, use a handheld charger and a used laptop charger continuously. Besides, users also often allow the tuner (decoder) in standby mode, which can affect high energy consumption. For homeowners, the use of laptops is crucial to complete all matters related to their learning. Sometimes these students leave their laptops open, so that can contribute to the increase in electricity bills. This habit is difficult to prevent because it has become part of consumer behaviour. Generally, various alternatives have been introduced to consumers to assist consumers in the process of saving electricity consumption. However, the use of the facility can control the reduction of electricity consumption, but it cannot provide any notification or message stating the use of the excess current in the consumer's residence. Researchers expect IoT technology to also make it easier for consumers to monitor electricity consumption for their homes to avoid wastage of electricity resulting in increased electricity bills. Accordingly, this study aims to design a prototype of an electricity supply monitoring system for residential purposes to detect excessive electricity consumption to save energy consumption.

1.1 Internet of Things (IOT)

Electrical power supply systems for residential homes consist of two main types, single-phase supply and three-phase supply. Single-phase supply refers to the current distribution of an electrical supply system with live phase lines and neutral lines. The three-phase electrical supply consists of three live lines and a neutral line and is the most commonly used method in electrical distribution grid systems and a power source for large electric motors and other high load applications. A three-phase system is the most economical system because it uses less conductive material to transmit electricity than a single-phase or two-phase system equivalent to the same voltage. Electricity supply to a residential house is single-phase connection consist of the live and the neutral wire (Bank, 2020). The standard voltage rating of a single-phase power supply is 230 V 50 Hz according to MS IEC regulation 60.038. Recently based on the government website, the electricity supply of residential houses needs to be upgraded to three phase electricity supply. The three-phase power supply uses four wires, three wires and one neutral wire cord. The standard voltage rating for a three-phase power supply is 400 V 50 Hz. The Internet of Things is a topic that is often a scam right now.

According to Patel, K. K (2016), IoT refers to a type of network to connect anything with the internet, based on a set protocol through information sensing equipment to exchange information and communication to achieve smart, positioning, tracking, monitoring, and administration. It is a concept that has the potential to influence the way we live and the way we work. The simple concept is to connect all devices that have ON and OFF buttons to the Internet. These include cell phones, washing machines, lights and anything else we can think of. Also includes engine components such as jet engines

in aircraft and others. Analyst firm Gartner says that by 2020 there will be over 26 billion devices connected. So the Internet of Things is a giant network with "things" connected. The initial definition of Internet of Things that had the potential to change the world as the Internet once did, perhaps for the better (Ashton, 2009).

2. Methodology

For the prototype of this system, the researcher only focused on single-phase loads found in a house such as lamp and electric fans. The system uses the SCT 013 current detector as a data collector as well as sending data to the NodeMCU ESP32 and the blynk application as an information delivery platform as the application is capable of receiving information from the microcontroller and translating it into graphs or infographics. Figure 1 shows the block diagram of electricity consumption monitoring system using IoT.

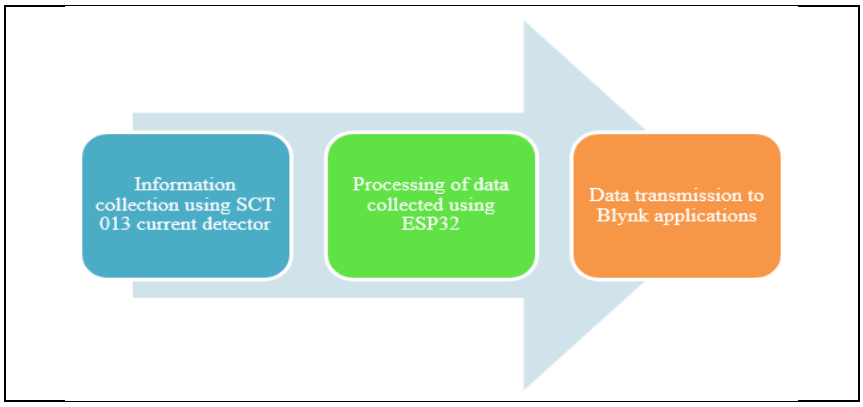

Figure 1: Block diagram of energy consumption monitoring system using IoT

A microcontroller is a computer located on a single integrated circuit consisting of a CPU, RAM, some form of ROM and an I/O port. Unlike ordinary computers, microcontrollers are dedicated to performing specific tasks and executing single applications. Automatically controlled products such as automatic engine control systems, remote controls, power tools, toys and office tools namely photocopiers, printers and fax machines are programmed using microcontrollers (Chen, Liu, Kuo & Yang, 2017). The SCT013 current detector is a current transformer that supports main currents from 0 to 30A, with an equivalent output signal of 0 to 1 volt. The error tolerance for this detector is 1% of the measured value and the rotation ratio of the secondary winding is 1800 to 1. It is a robust detector and suitable for application in industrial and residential that require accuracy to measure high currents (Miron-Alexe, 2016). Figure 2 shows the SCT013 current detector.

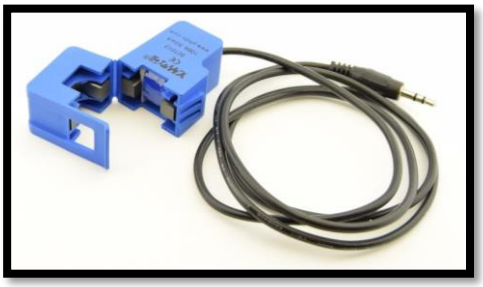

Figure 2: SCT013 current detector

ESP32 is a better microcontroller board than ESP8266 because this microcontroller has additions

in terms of specifications namely CPU core, faster Wifi, supports Bluetooth 4.0 and Bluetooth low energy (Foltynek, Babiuch & Suranek, 2019). The construction of the ESP32 is intended for mobile, wearable electronics as well as Internet of Things (IoT) applications. Figure 3 shows the ESP32 Micro Board and figure 4 shows the functional block diagram for ESP32 microboard.

Figure 3: ESP32 Micro Board

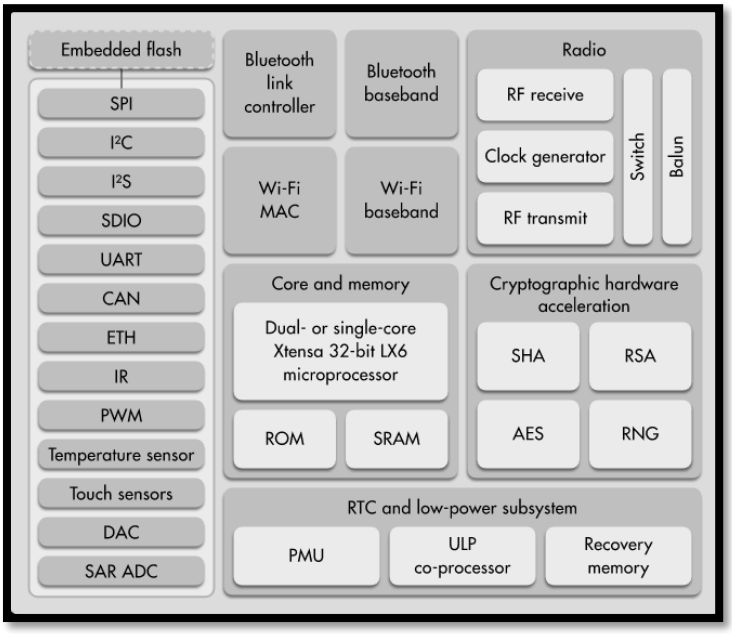

Figure 4: Functional block diagram for ESP32 microboard

Blynk is one of the applications that allow users to create applications and then use them to control, collect data and even monitor data from detectors sent to microcontrollers connected to computers with internet access from anywhere (Todica, 2016). Connections can also be established using Bluetooth or Wifi between the smartphone and the microcontroller. The Blynk app can be downloaded from the Google Playstore and Appstore where it will provide a dashboard as well as virtual connectivity to the microcontroller. Blynk programming is very easy with widgets already provided in the application that only requires the user to set a pin on the micro board of the controller. The Blynk application is a platform used to display the amount of electricity used and the amount of current and voltage through a smartphone or mobile phone. The form of the displayed display is a graph widget to facilitate the monitoring of energy consumption (kWh). The Blynk application also displays the amount of energy used directly or according to the desired time. Figure 5 shows the Blynk display.

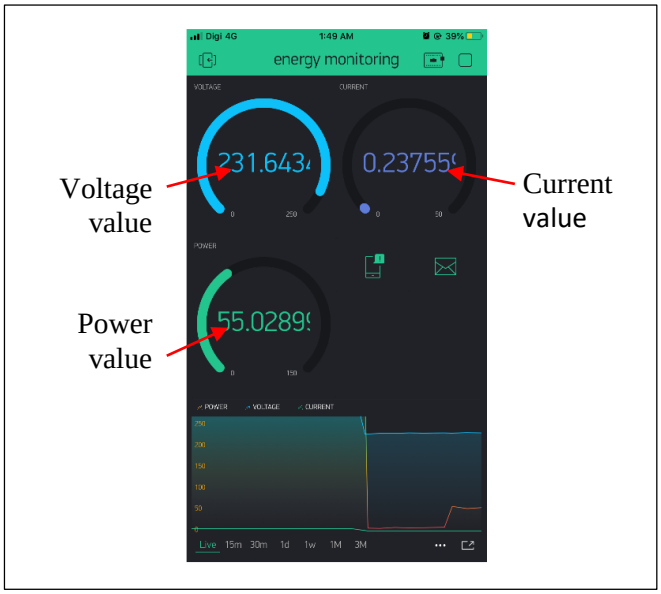

Figure 5: Blynk application display

The prototype of an electricity monitoring system based on IoT technology focuses on the problems faced by domestic consumers especially managers of electricity consumption in small industries as well as homeowners. The prototype serves as a system that monitors and records data on electricity consumption using the IoT. The results of this prototype developed are expected to facilitate users who are concerned about trends as well as to analyze the data collected on the use of electricity. In the development of this product, researchers used lamp loads and two types of loads with different uses energy that uses sockets as a simulation of the wiring system in a building. Figure 6 shows the constructed a prototype of an electricity monitoring system design.

Figure 6 : A prototype of an electricity monitoring system design

3. Results and Discussion

Expert verification must be done in each development of a product to ensure that the product developed is suitable for marketing. The experts in this study consist of lecturers from Universiti Tun Hussein Onn Malaysia (UTHM) who have expertise in the field of the IoT. Experts in this study were selected using purposive sampling. Experts have directly observed the functionality of a prototype of

an electrical monitoring system based on IoT technology. The findings of this study found that three experts have agreed that this energy monitoring system works well, and every component found in this system works properly according to the objectives of this research. Experts also agree that the use of components in electrical monitoring systems based on IoT technology is appropriate and correct. Moreover, the experts in this study gave praise by stating that the system developed is in line with the government's efforts in training consumers to use energy efficiently.

In addition, the researcher has also conducted a product functionality analysis to ensure that the product works well and has achieved the set objectives. Table 1 shows the functionality test results for detectors and applications.

Table 1: Functionality test results for detectors and applications

No.	Functionality Testing	Results
1	SCT 013 Current Detector	Works well
2	ZMPT101B Voltage Sensor	Works well
3	Programming	No mistakes
4	Display on Blynk application	Displays the data correctly

Through a study conducted by Mohamad Najib Bin Norhan (2018) with the title 'Developing an Overcurrent Detection System for Residential Homes', was developed to build an overcurrent monitoring system that helps users to detect any problems found in the wiring circuit in the house residence. To test the effectiveness of the prototype electrical monitoring system based on IoT technology for this residential house, the researcher only focused on one-phase load, namely lights and electric fans. Lamp and fan loads are placed to detect varying currents and calculate the amount of electrical energy used. Researchers have made calculations to detect the current for the lamp load using conventional methods (manual) and prototype electrical monitoring systems based on IoT technology. The results of the calculations are shown in Table 2.

Table 2: Current detection at lamp load using conventional methods and prototype electrical monitoring system based on IoT technology

Time	Power (W)	
(minute)	Conventional	Prototype
0	56.85	54.39
5	57.06	54.90
10	56.88	55.35
15	56.91	55.45
20	56.85	56.11
25	56.91	56.14
30	56.81	56.34
35	56.89	56.33
40	57.21	56.41
45	56.86	56.29
50	57.13	56.54
55	57.15	57.03
60	57.23	56.72

Based on Table 2 it is obtained that the prototype electrical monitoring system based on IoT technology has readings in the same range as conventional methods. This proves that the prototype electrical monitoring system based on the IoT technology developed is reliable to detect current and it is accurate. Figure 6 shows the current detection at a lamp load using a prototype of an electrical monitoring system based on IoT technology having readings in the same range as the conventional method.

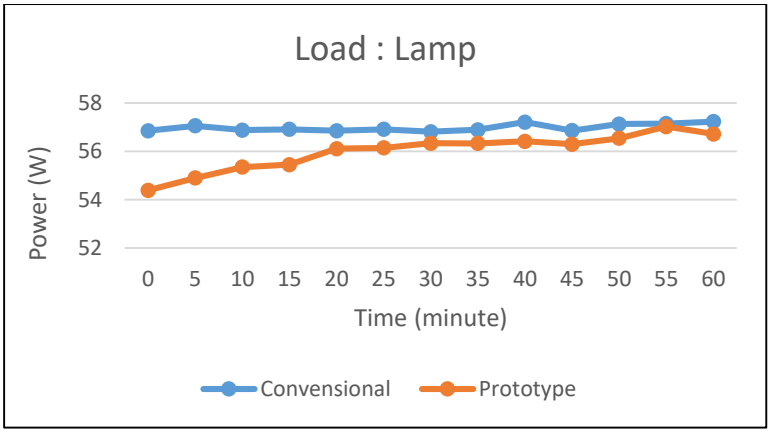

Figure 6: Current detection at lamp load

In the second experiment, the researchers tested the differences in the effectiveness of the prototype electrical monitoring system based on IoT technology and conventional methods that focus on single-phase loads, namely lamps and electric fans. The experimental results in this study, are shown in Table 3.

Table 3: Current detection at lamp loads and electric fans using conventional methods and prototypes of electrical monitoring systems based on IoT technology

Time (minute)	Power (W)	
	Conventional	Prototype
0	85.85	83.39
5	86.92	84.76
10	86.54	85.01
15	86.94	85.48
20	86.65	85.91
25	87.48	86.72
30	87.22	86.75
35	87.56	87.00
40	87.54	86.75
45	87.71	87.14
50	87.65	86.89
55	87.78	87.34

Figure 7 shows the current detection at a lamp load and electric fan using a prototype of an electrical monitoring system based on IoT technology having readings in the same range as the conventional method.

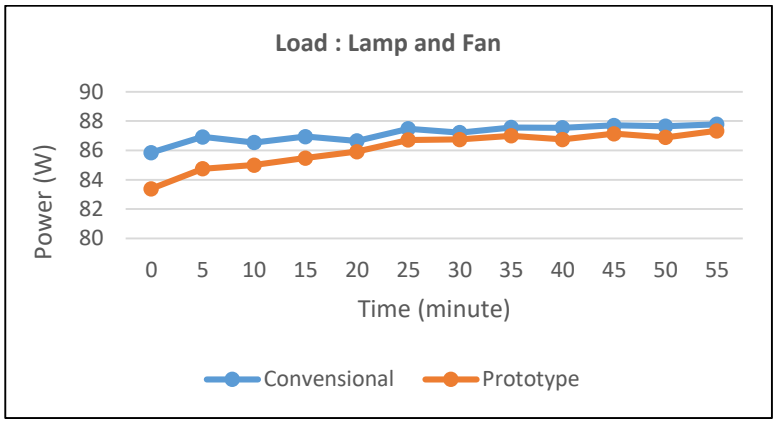

Figure 7: Current detection at lamp load and electric fan

This study proves that the prototype electrical monitoring system based on the IoT technology developed can be reliable to detect current accurately, save time, more convenient, efficient and accurate. In this study, it was found that the system uses SCT 013 current detector as a data collector as well as sending data to NodeMCU ESP32 and blynk application as information delivery platform because the application is capable of receiving information from a microcontroller and translating it into graphs or graphical information. If there is a load that exceeds the set minimum level, a notification will be sent to the user's smartphone. The data collected by the microcontroller will be sent to the Blynk app and can be saved into a user's email to make it easier for users to perform data analysis or read electricity usage trends. The system uses the SCT 013 current detector as a data collector as well as sends data to the NodeMCU ESP32 and the blynk application as an information delivery platform as the application is capable of receiving information from the microcontroller and translating it into graphs or graphical information.

4. Conclusion

With the development of this system, the researchers hope to help further facilitate users in monitoring, collecting and analyzing data on electricity consumption using the IoT. The use of smartphones that are no strangers in this millennium can also help facilitate researchers to explain the methods used by this system. However, after examining some aspects in terms of design, size and also the limitations of this system, it is hoped that this system can be improved in the future. Some suggestions from the questionnaire will also be applied in future studies. In conclusion, this energy consumption monitoring system using IoT has successfully achieved the objectives set by the researchers. With this system, researchers want to apply the attitude of efficient energy use in addition to facilitating the affairs of users who want to analyze data on energy use. The findings show that the prototype electrical monitoring system based on IoT technology has more accuracy and detail in analyzing energy consumption data as well as sensitivity by sending notifications about excess current found in residential wiring systems. The results of this study also show that the construction of this monitoring tool can also provide a new initiative in terms of data presentation to facilitate users to understand the data information presented because it is in the form of infographics (graphs) and in real-time. In conclusion, through the findings of this study consumers can save money for electricity bill payment and save time to control electricity consumption only through mobile phones.

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