Prototype Functionality of Electricity Monitoring System Using the Internet of Things (IOT)

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Abstract: **This prototype that has been developed focuses on the problems faced by domestic consumers, especially electricity consumption managers in small industries as well as homeowners. Prototype serves as a system that monitors and records data on electricity consumption using Internet of Things (IOT). This study aims to test the functionality of electrical energy monitoring systems using IoT. This quantitative study uses a questionnaire instrument to identify the opinions of experts on the prototype functionality electricity monitoring system that has been developed by researchers. Study respondents were selected using purposive sampling. Study data were analyzed using descriptive analysis. The results of this study found that the development of this system is seen to be quite good especially in helping users who want to do analysis on energy consumption. The ability to collect data in detail provides a lot of convenience compared to previous methods that require a lot of time and manpower. Besides, the data display presented in the Blynk application is also interesting and easy to read. Another function available by using this Blynk application is also that it is able to send notifications to users if there is excess power used by the load. This is also able to prevent the occurrence of current leaks and also short circuits that can cause unwanted fires or accidents.**

Keyword: **Internet of Things (IOT), electricity monitoring system, Blynk application.**

I. INTRODUCTION

Electricity is one of the important needs of human daily life. An important element in ensuring that the system of a building operates well is electricity [1]. Among the systems that use electricity found in a building are lighting, motor equipment, and communication. Experts argue that the 4.0 industrial revolution could improve the quality of life as well as extend human life. Thus, the use of advanced electronic devices provides convenience to users from various angles. For example, mobile banking, cashless society, reading books online, monitoring home security remotely, ordering food using a mobile phone, and so on [2].

In this modern world, electricity is the most basic requirement to ensure that daily activities run smoothly. Among the causes of insufficient electricity supply is during peak hours where excessive use of electricity often occurs [1,3]. Between 1990 and 2004, carbon emissions in Malaysia increased by 221 percent from the industrial and transportation sectors, resulting in Malaysia being classified as the country with the fastest rate of carbon dioxide emissions in the world [4].

Based on the growing industrial revolution 4.0, various new technologies and applications have been introduced such as automatic door and window control, temperature control as well as various types of devices that make it easier for users to control remotely. The concept of the Internet of Things (IoT) was created by members of the Radio Frequency Identification (RFID) development community in 1999 and it became more relevant to the practical world mainly due to the growth of mobile devices, cloud computing, and data analysis [5].

IoT is a term that symbolizes the relationship between objects or equipment using the internet. In line with technological advances [6]. The internet is not only capable of using computers, but it has grown into a network of all kinds of equipment, vehicles, smartphones, home appliances, toys, cameras, medical instruments and industrial systems, animals, humans, buildings, and all information protocol-based communication that has been set to achieve intelligent rearrangement, positioning, detection, security and security and even live monitoring [5].

Therefore, in line with the advancement of IoT technology, and energy monitoring tool to help monitor the energy consumption of electrical equipment so that it is in a stable condition such as an energy consumption monitoring system using IoT needs to be developed. This monitoring method can be done through various means including through the internet, smart applications, and so on. Previously, consumers had to use a lot of energy and time to manually calculate the amount of energy used for an electrical appliance by examining the specifications of each appliance. There are many problems such as not being able to monitor energy consumption remotely and not being notified when there is excessive energy use. This study aims to test the functionality of electrical energy monitoring systems using IoT that has been developed by researchers.

II. METHODOLOGY

This study aims to test the functionality of electrical energy monitoring systems using the Internet of Things (IoT). The testing phase is the phase where the product is tested by simulating the use of the product to ensure that the product developed meets the set development goals of the product. If there is any damage or fault, the researcher will detect the cause of the problem and repair the product. The testing phase

consists of two tests, namely system testing, and software testing. System testing is done to ensure that all connections or hardware devices can function properly and can conduct current without any problems. In this product, the connection starts from a kilowatt-hour meter. The kilowatt clock meter serves as a power supply that provides energy to the fuse box, namely the main switch, ELCB, and MCB. The use of components in the development of energy use monitoring systems using IoT is based on the actual situation of the wiring situation in a residential house. The connections in this circuit include sockets, switches, and lights that act as loads. Therefore, proper connection plays an important role so that the current flowing in the circuit can be detected by the current detector and in turn ensure that the system connection in the circuit is correct.

Software testing is all software or components related to software. Software is a key component that involves coding the data that connects between sensors as well as Blynk applications. Blynk is one application that allows users to create applications and then use them to control, collect data and even monitor data from detectors sent to microcontrollers or Arduino boards connected to a computer with internet access from anywhere. Software testing involves research in terms of data encoding made by researchers to give instructions to the NodeMCU microcontroller. Testing this data code is done by checking the programming using ArduinoIDE software. Besides, researchers use different loads to ensure that these products can detect and collect different data. This load difference test can be tested using a lamp for the first test. While for the second test, the load mounted on the socket is used to ensure that the two loads used are of different currents. This quantitative study used a questionnaire instrument to identify the opinions of experts on the prototype functionality electricity monitoring system that has been developed by researchers. Respondents were selected using purposive sampling. Study data were analyzed using descriptive analysis.

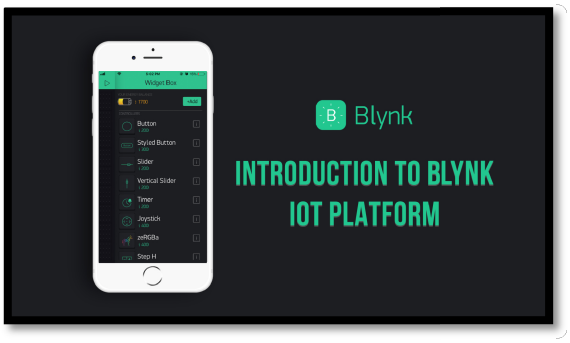


Figure 1: Blynk Application

III. FINDINGS AND DISCUSSIONS

Researchers have conducted product feasibility analysis to ensure that the product works well and has achieved the set objectives. In the productivity analysis of this product, it is divided into two namely detector functionality and application functionality.

Evaluation of hardware

The main hardware used in this project is the ESP32 circuit connection, current detector, and voltage detector.

3.1.1. The NodeMCU ESP32 microcontroller

The NodeMCU ESP32 microcontroller is a component that serves as an intermediary that sends data from the detector to the Blynk application. This microcontroller has been programmed using coding written through the Arduino IDE. Besides, the PIN legs have been connected and are in line with the instructions written in the encoding. This is because each PIN foot on the ESP32 has a different function. Figure 2 shows the schematic circuit for ESP32. This programming is very important and should be correct so that the microcontroller can function properly.

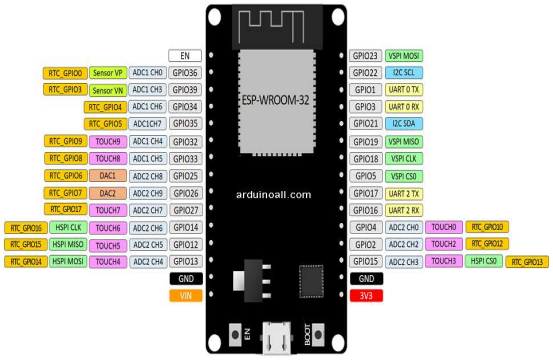


Figure 2: Schematic Circuit for ESP32 Micro Controller

3.1.2. Current Detector SCT013-000

For energy consumption monitoring systems, the component used as a current detector is the current detector SCT013-000. The use of this detector is to measure the current flowing through the live wire in the wiring system. Figure 3 shows the SCT013 current detector attached to a live wire.

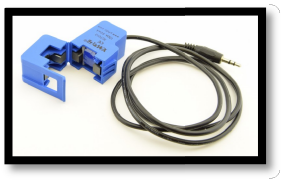


Figure 3: SCT013 current detector

To perform this method, the researcher only needs to write the appropriate encoding that is the value set to calibrate the detector so that it is parallel to the current value measured by the clamp meter. Several experiments have been performed to ensure that the current detector collects data parallel to the clamp meter.

Table 1: Clamp meter Test and Current Detector

Clamp meter	Current Detector	Circumstances
0.24A	0.49A	Before calibration
0.25A	0.24A	After calibration

3.1.3. *Voltage Detector ZMPT101B*

A voltage detector is a component used to detect a flowing voltage. To use this detector, live wires and neutral wires need to be connected to the terminals located on this detector. After wiring, the researcher needs to make a calibration because each detector has its calibration so that the data collected coincides with the total voltage measured. The researcher calibrates the voltage detector by adjusting the rotation of the potentiometer on the detector. Besides, the researcher also wrote some code to ensure that the voltage reading is parallel to the measured voltage value. Figure 3 shows the schematic circuit of the ZMPT101B voltage detector.

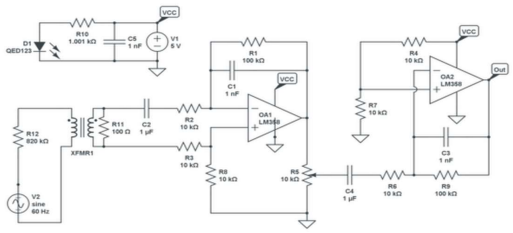


Figure 3: Schematic Circuit of ZMPT101B Voltage Detector

Table 2: Multiple Meter Reading Testing with Voltage Detector

Miscellaneous Meter	Voltage Detector	Circumstances
229V	250V	Before calibration
229V	230V	After calibration

3.2. *Evaluation of software*

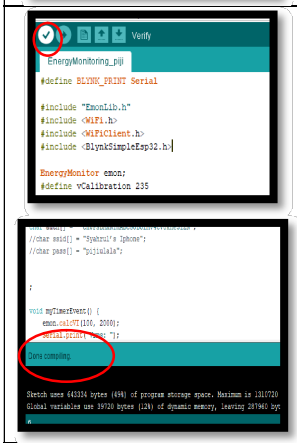
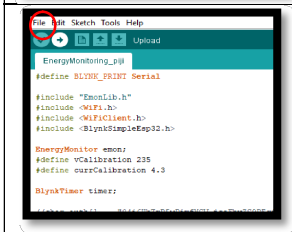
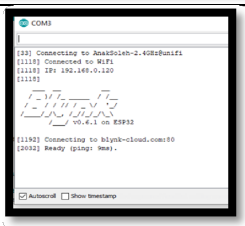
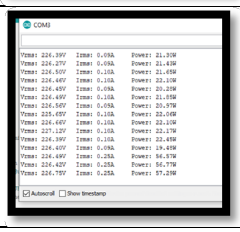
The use of software in the system of monitoring the use of electricity using the Internet of Things (IoT) should be emphasized because it is the backbone of the functionality of this system. There are two types of software used in this study, namely:

3.2.1. *Programming of Arduino IDE Program*

This Internet of Things (IoT) power consumption monitoring system requires proper programming so that every component used in this system can function properly. The use of Arduino IDE software is the most important element because this software is used to write coding that gives commands to the detector, ESP32 board, and Blynk application. This software allows the researcher to simulate on the ESP32 board whether the code is written is correct or incorrect.

The ESP32 board will be connected to a laptop using a USB cable for testing. If there is an error in the code writing, this software will issue a pop up indicating the incorrect code writing. Thus, it makes it easier for the researcher to correct the wrong code before uploading it to the ESP32 board. After the verification process (checking command error) is done, the upload button will be pressed and the written command will be uploaded into the ESP32 board. Table 3 shows program programming testing using Arduino IDE software.

Table 3: Program Programming Testing Work Steps

Testing	Work Steps
	a) The coding is written to give the command (command) on ESP32.
	b) The verify icon is pressed to merge the written instructions. c) If no errors are detected, done compiling is shown at the bottom
	d) The upload icon is pressed to upload the written code to the ESP32 board. e) Next, it will connect the ESP32 board with the Blynk application.
	f) An output display will appear showing the program software successfully connecting the ESP32 board with the Blynk application.
	g) The circuit is turned on and the data collected by the detector is displayed automatically.

3.2.2. *Blynk*

The Blynk application is a platform used to display the total electricity consumption used via a smartphone. Besides, the application also displays the total current and voltage usage based on the data collected by the current detector and voltage

detector. The form of a display displayed depends on the needs of the user with the selection of widgets that have been provided. Researchers have selected graph widgets to facilitate energy consumption monitoring (kWh).

Figure 4: Blynk application layout

3.2.3. *Microsoft Excel*

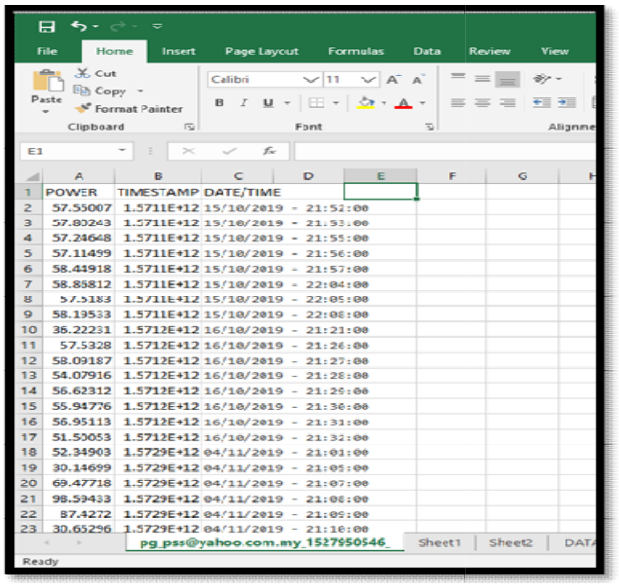


Figure 5: Layout of data collected in Microsoft Excel software

Microsoft Excel software is important for storing data or to make it easier for users to analyze the data that has been stored in the Blynk server. The data emailed to the user will be downloaded by the user to be converted into a readable language by Microsoft Excel software. In this software, users can do a more detailed analysis of the data that has been collected because it can display the time and date for each data. The diagram shows the data collected during the system experiment.

3.3. *Analysis of product functionality*

Functional monitoring of energy consumption is tested by using three different types of loads namely lamps, telephone chargers, and even electric fans. This is to ensure that the detector can detect different currents correctly. This Internet of Things (IoT) energy consumption monitoring system can detect current, voltage value, and also the amount of energy consumption used. Besides, it will also send notifications to users if there is excess energy used. For this test, the researcher has set the power limit to 100kW. The data view can be accessed through the Blynk application as well as Microsoft Excel software.

Table 4: Functionality Test Results for Detectors and Applications

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

Table 1: Energy Consumption Monitoring Display Through Blynk Application

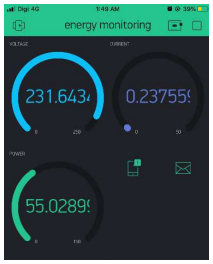
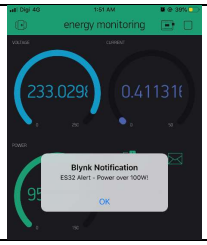
Types of Electrical Loads	Data View	Current, Voltage, and Energy
Lamps		a) Current = 0.23A b) Voltage = 231V c) Energy = 55kw
Lamps and Mobile Phone Charger		a) Current = 0.25A b) Voltage = 233V c) Energy = 60kw
Lamps, Mobile Phone Charger, and Electric Fans		a) Current = 0.40A b) Voltage = 233V c) Energy = 94kw
Excess Power Notification		a) Current = 0.41A b) Voltage = 233V c) Energy = 100kw

Table 6: Data display when using filament lamp load

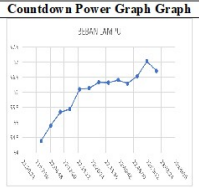
Load	Data View			Countdown Power Graph Graph
Filament Lamp	POWER	TIMESTAMP	DATE/TIME	
	54.39283	1.57478E+12	26/11/2019 - 22:00:00	
	54.89869	1.57478E+12	26/11/2019 - 22:05:00	
	55.35106	1.57478E+12	26/11/2019 - 22:10:00	
	55.44894	1.57478E+12	26/11/2019 - 22:15:00	
	56.1114	1.57478E+12	26/11/2019 - 22:20:00	
	56.14295	1.57478E+12	26/11/2019 - 22:25:00	
	56.33841	1.57478E+12	26/11/2019 - 22:30:00	
	56.32749	1.57478E+12	26/11/2019 - 22:35:00	
	56.41302	1.57478E+12	26/11/2019 - 22:40:00	
	56.29382	1.57478E+12	26/11/2019 - 22:45:00	
	56.54279	1.57478E+12	26/11/2019 - 22:50:00	
	57.02785	1.57478E+12	26/11/2019 - 22:55:00	
	56.71686	1.57478E+12	26/11/2019 - 23:00:00	

Table 2: Data display when using filament lamp and fan loads

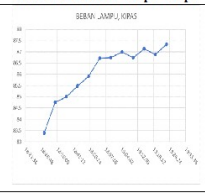
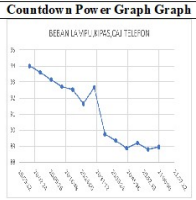
Load	Data View			Countdown Power Graph Graph
Lampu Filamen, Kipas Elektrik	POWER	TIMESTAMP	DATE/TIME	
	83.39366	1.57485E+12	27/11/2019 - 18:30:00	
	84.75517	1.57485E+12	27/11/2019 - 18:35:00	
	85.00697	1.57485E+12	27/11/2019 - 18:40:00	
	85.48117	1.57485E+12	27/11/2019 - 18:45:00	
	85.91347	1.57485E+12	27/11/2019 - 18:50:00	
	86.71721	1.57485E+12	27/11/2019 - 19:00:00	
	86.7474	1.57485E+12	27/11/2019 - 19:05:00	
	86.99849	1.57485E+12	27/11/2019 - 19:10:00	
	86.7471	1.57485E+12	27/11/2019 - 19:15:00	
	87.14003	1.57485E+12	27/11/2019 - 19:20:00	
	86.88614	1.57485E+12	27/11/2019 - 19:25:00	
	87.33777	1.57485E+12	27/11/2019 - 19:30:00	

Table 3: Data display when using light loads, fans, and telephone chargers

Load	Data View			Countdown Power Graph Graph
Filament Lamp, Electric Fan, Phone Charge	POWER	TIMESTAMP	DATE/TIME	
	93.99503	1.57486E+12	27/11/2019 - 20:00:00	
	93.59779	1.57486E+12	27/11/2019 - 20:05:00	
	93.14326	1.57486E+12	27/11/2019 - 20:10:00	
	92.71166	1.57486E+12	27/11/2019 - 20:15:00	
	92.53503	1.57486E+12	27/11/2019 - 20:20:00	
	91.65327	1.57486E+12	27/11/2019 - 20:25:00	
	92.65903	1.57486E+12	27/11/2019 - 20:30:00	
	89.75955	1.57486E+12	27/11/2019 - 20:35:00	
	89.34734	1.57486E+12	27/11/2019 - 20:40:00	
	88.88407	1.57486E+12	27/11/2019 - 20:45:00	
	89.19685	1.57486E+12	27/11/2019 - 20:50:00	
	88.8103	1.57486E+12	27/11/2019 - 20:55:00	
	88.9621	1.57486E+12	27/11/2019 - 21:00:00	

Based on the data collected, it can be observed that each load gives a different current and has an impact on energy consumption. With the use of an energy monitoring system using the Internet of Things (IoT) as well, researchers can analyze, observe changes in trends, and monitor remotely on energy consumption. Therefore, the researcher has achieved the objectives to be achieved with the development of this system.

Table 9: Average level of measurement for product functional items

No	Item	Expert			Percent Agree
		1	2	3	
1.	This system can function well and systematically	/	/	/	100%
2.	The monitoring system can function properly when the load is turned on	/	/	/	100%
3.	The selection of the type of load used is appropriate	/	/	/	100%
4.	Current detectors can detect current well and correctly	/	/	/	100%
5.	The voltage detector can detect the voltage well and correctly	/	/	/	100%
6.	Notification of excess energy detected works well	/	/	/	100%
7.	The collected data can be safely stored in the user's email	/	/	/	100%
	Average Size Level				100%

IV. CONCLUSIONS

This study aims to test the functionality of electrical energy monitoring systems using the Internet of Things (IoT). Several experts have evaluated the system developed. As a result of feedback through an evaluation conducted by experts, the development of this system is seen to be quite good, especially in helping users who want to analyze energy consumption. The method of monitoring and collection using only smartphones is in line with technological advances and also in line with the government's efforts in training consumers to use energy efficiently. The ability to collect data in detail provides a lot of conveniences compared to previous methods that require a lot of time and manpower. Besides, the data display presented in the Blynk application is also interesting and easy to read. Another function available by using this Blynk application is also that it can send notifications to users if there is excess power used by the load. This is also able to prevent the occurrence of current leaks and also short circuits that can cause unwanted fires or accidents.

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