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Data Logger as Utility Meter Monitoring Device by Using Arduino: A Device to Improve the Utility Meter Monitoring Operation

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Abstract: Generally, an energy meter, electrical meter, or utility meter is a device that is installed, at least, a unit in every building or premise for electrical usage monitoring and billing purposes. Unfortunately, as time moves forward, the need for innovation is necessary to cater to the circumstances, and having only those two abilities is no longer sufficient. For instance, in Malaysia, the current pandemic has interrupted the conventional method of collecting electricity usage data used by electricity generation companies, which have caused dissatisfaction and rage among end-users or the customers. Hence, this project is proposed to help overcome the complication faced by replacing the physical work of collecting data with a non-physical interface. The method used to conduct this project is through qualitative study whereby observations on customers' end were carried out, case studies on published researches, and a few others. This project's key findings are improving the utility meter monitoring efficiency and developing the Internet of Things (IoT) on it. It is strongly believed to be doable as there is also an initiative taken by an electrical generation company for a similar device, which simultaneously strengthens, even more, the belief in this project's success for the time being and the development of its future features.

Keywords: Data Logger, Meter Monitoring, PZEM-004T-V30

1. Introduction

An energy meter is a tool that is embedded in the electrical system of each building or a premise. It is used to measure electricity consumption in the standard unit, kilowatt-hour. In Malaysia, it is compulsory to include the electric or utility meter in the electric system of a building as a part of the requirement set by Tenaga Nasional Berhad (TNB), the main electricity generator in Semenanjung of Malaysia. Energy Commission Malaysia or Suruhanjaya Tenaga regulates the standard for any electricity provider in Malaysia.

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Generally, there are only two types of energy meters: the mechanical meter and the digital meter. Currently, for a newly developed building, they are already implementing the usage of the digital meter. Even some of the older buildings and premises are shifting toward using the digital meter. However, both the meters have no significant difference aside from one being digitalized but not the other. They both require the workforce to record the readings physically every month for billing purposes. Hence, this project is an approach for a better-developed utility meter monitor device that does not require physical work but offering an online mobile application interface.

The project idea is in regards to the recent pandemic, Corona Virus 2019, whereby it has disrupted the system of collecting reading from the utility meter by the worker. Hence, this project is proposed to prepare for any similar event in the future or during a contingency. The device's heart lies on the wireless fidelity (Wi-Fi) connection to allow it to be viewed on the designed mobile application, Blynk. Nevertheless, even without it, the device will still record the meter readings but cannot display in on the app.

1.1 Data logger

Data loggers are electronic devices capable of monitoring and recording environmental parameters over time, allowing conditions to be measured, analyzed and recorded. They contain a sensor to receive the information and a computer chip to store it. Then the information stored in the data logger is transferred to a computer for analysis through electrical connections. In this case, the data logger of the project is the Wi-Fi module ESP8266 connected to the Arduino IDE software as well as, the current sensor module, PZEM-004T-V30. The Arduino-compatible module records data that are received from the current sensor and saves them in the built-in memory of 32 *Kibibyte* (KiB) storage. However, the data will be lost if there is no power to source the module or it is reset.

1.2 Programming software

Arduino Integrated Development Environment (IDE) is the software used to develop the programming for this device. It is a multi-compatible platform that is written in functions from C and C++. Hence, many non-Arduino modules can be programmed and connected to the software. A flowchart of the device system is designed before the program development on Arduino IDE.

1.3 Compatible module

The Arduino IDE compatible modules used for this device are, the ESP8266 and the PZEM-004T-V30. They both are connected in a system through programming. Since they both are not made by Arduino, therefore, their own libraries are needed to be downloaded from the software 'Library Manager' to allow them to be connected as a system.

2. Materials and Methods

There are only four primary materials or components for this device: Current Sensor (PZEM-004T-V30), Wi-Fi module (ESP8266), split current transformer coil, and a-two-pins plug. All of these materials are connected as a system. The materials used are flat-laid as Figure 1 below.

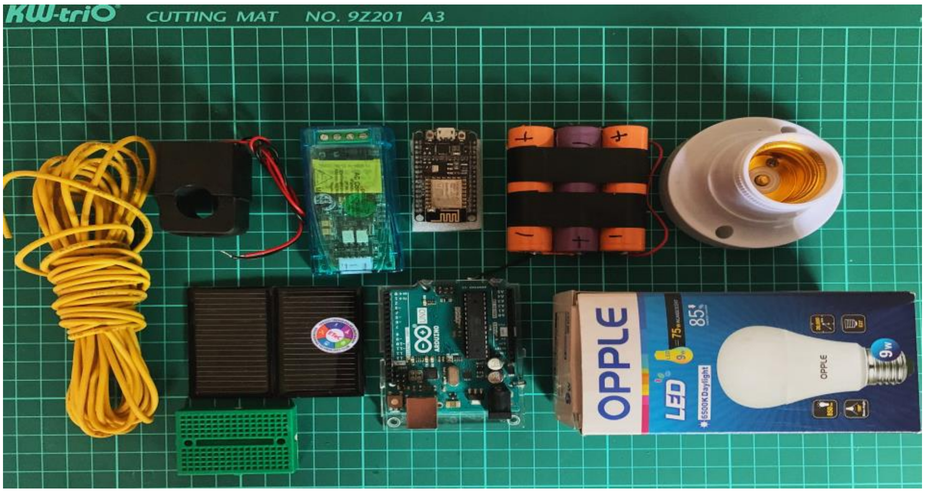

Figure 1: Materials used

Based on the materials laid above, few other materials are included, such as the Arduino board, the rechargeable batteries, and two solar panels plates. Those materials are the materials that will be used for the device's future features development.

2.1 Materials

Currently, the latest Malaysia's standard is 220 V to 240 V with a frequency of 50 Hz. The standard follows the countries as in the United Kingdom, Europe, Australia and most of Asia and Africa's applied standard. Hence, in this project, most of the materials used will be compatible with Malaysia's standard and approved by the Standard and Industrial Research Institute of Malaysia (SIRIM). The main components used for the device is described as Table 1 below.

Table 1: Primary materials of the device with descriptions

No.	Component	Description	Qty.
1.	Current Sensor Module	PZEM-004T-V30	1
2.	Wi-Fi Module	• ESP8266 MODBUS • Transistor-Transistor Logic (TTL) Communication Interface • Measuring Current Range: (0.02 – 100)A • Measuring Voltage Range: (80 – 260)V • Measurement accuracy: 0.5% • Frequency: 45Hz – 65Hz	1
3.	Current Transformer Coil	Split	1
4.	Plug	2 pins	1

When choosing these little modules, it is crucial to pay attention to their ratings and specifications to ensure that the selected modules can work well with the designed electrical system. For instance, there are abundant of current sensor and Wi-Fi module types and families in the market. All of them are different in usage. The inability to select a suitable one will affect the probability of the system to succeed.

2.2 Software and application

Software is a medium that allows the designers, developers, engineers, students and users in general, to design a specific algorithm to communicate with computerized electronic devices for specific purposes by using computer language such C and C++. The software used to program the programming is Arduino IDE and the mobile interface application used is Blynk.

2.2.1 Arduino IDE

Arduino Integrated Development Environment (IDE) is a cross-platform software that can accommodate various computer operating systems such as Windows, Mac Operating System (macOS), and Linux. The language used by this software is written in functions of C and C++. It is used to write and upload program designed to Arduino boards, and also, with the help of third-party cores, programming can be uploaded into other vendor development boards that are compatible with Arduino. Hence, in this project, it is used to program the utility energy monitoring device's system.

2.2.2 Blynk

Blynk is an Internet of Things (IoT) platform. It allows designed devices, applications, and, systems connected to the cloud to be monitored and analyzed through this platform. It is an application that can be downloaded from any application store on mobile gadgets. On the application interface, many things can be designed according to the designed system. This app opens up opportunities for more applications through the data extracted from the designed system and displayed on its interface.

2.3 Block diagram

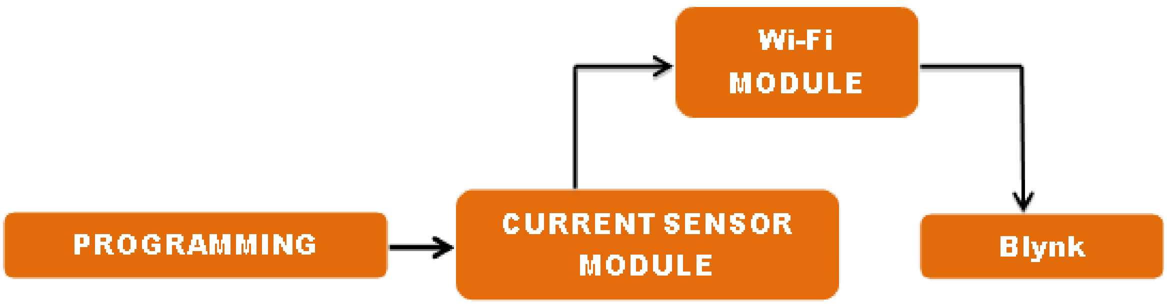

Figure 2: The overview of the project's system

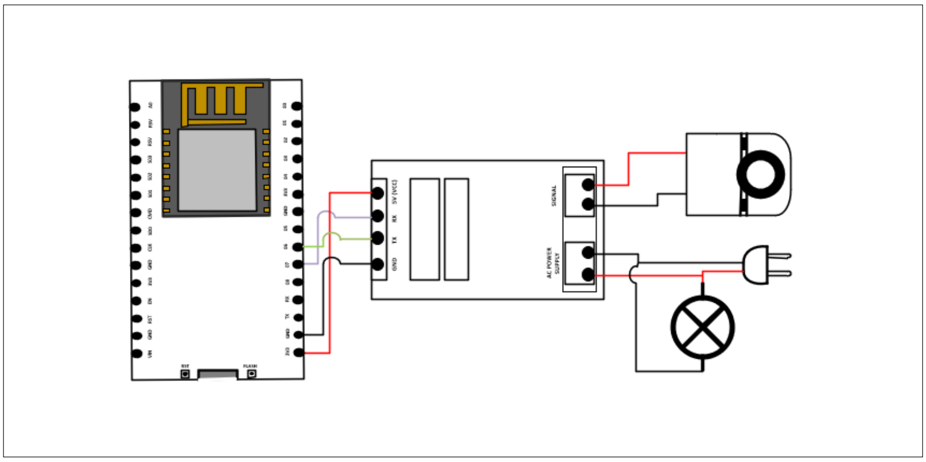

Figure 3: The overview of prototype's circuit diagram

Figure 2 illustrates an overview of the project's system, while Figure 3 shows the components' connections' circuit diagram. The Wireless Fidelity (Wi-Fi) is the heart and the mastermind of the system as it supplies electrical source to the current sensor to turn on the module and with the programming embedded into it, it instructs the system of this project. As stated above, ESP8266 has its built-in memory storage. The Wi-Fi module store data or current readings in its storage sensed by the current sensor as long as it has a power supply or is not reset. The Wi-Fi module will then log the data into Blynk through the internet connection to be viewable on the downloaded mobile gadget's app. However, if there is no internet connection, the system will still read the extracted data from the current sensor but cannot be viewable on the app. Figure 4 below shows that this system reads the Wi-Fi module's data connected to the current sensor without a Wi-Fi connection. It proves that the sensor still reads data from the displayed info on the Arduino IDE's window. For safety purpose, however, the connection for AC load is disconnected. Hence, the readings on the Arduino IDE monitor displays *'Fail to Read (V)', 'Fail to Read (A), 'Fail to Read (kWh)', and 'Fail to Read (kW)'*. Nevertheless, if the AC load is connected to the system, the monitor will display the set variables' readings.

Currently, the Wi-Fi module is powered by a 3.6 Volt (V) power supply. Therefore, any power above the rating will need to be level shifted before going through the IC to avoid being damaged by overvoltage. It is unnecessary to be connected to Arduino IDE if the Wi-Fi module has already been programmed. Any equivalent source with 3.6 V will do.

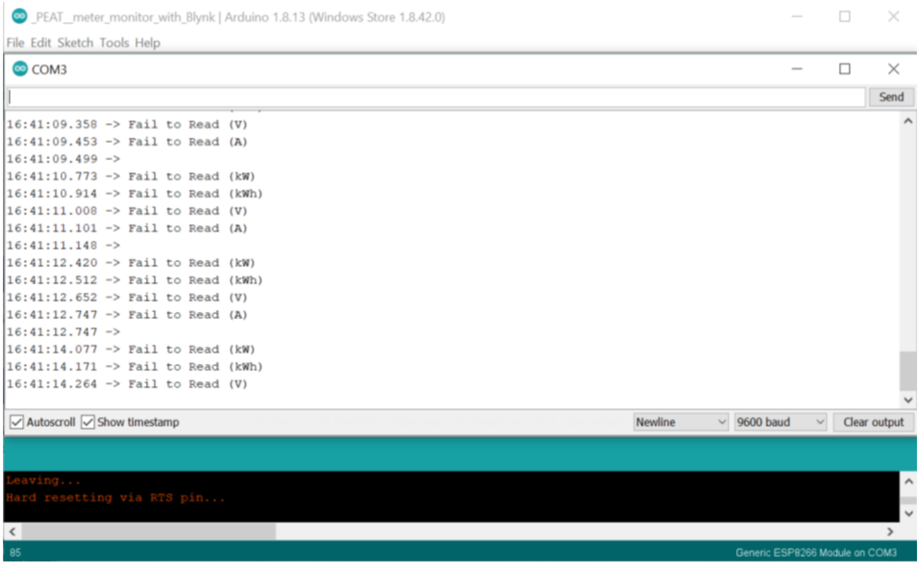

Figure 4: The display of serial monitor

2.4 Methods

The method used to develop the programming of the project's system is first through idea sketches. From the sketches, they are assembled and extracted into a flowchart. Nevertheless, need to be mindful that understanding the whole system working of the project is the fundamental step. A strong understanding will help to pave the way towards the success of programming development. Hence, Figure 5 below explains the working system of the project's programming.

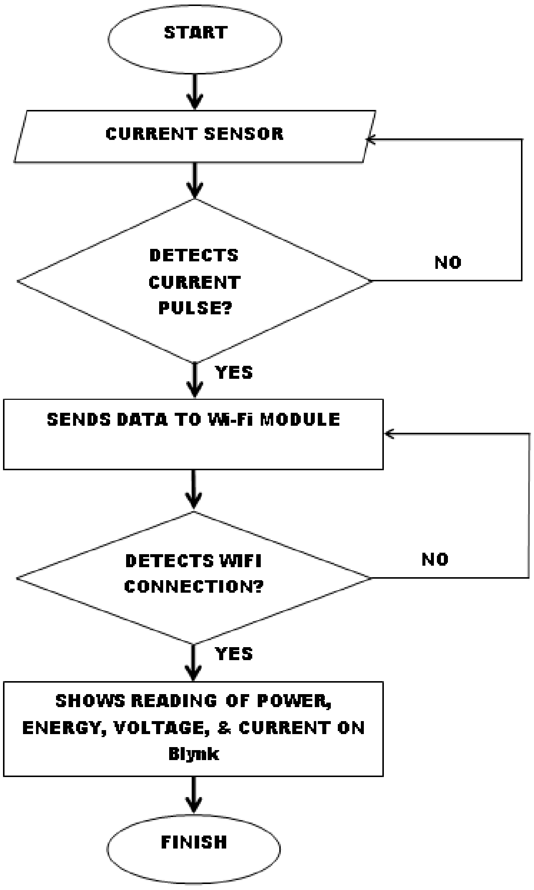

Figure 5: The overview of the project's programming

3. Results and Discussion

The results and outcome of this project are presented and discussed in this section. Ideally, the results or the outcome of a project should be as it is expected and as to how it is designed. However, practically, some human errors and technical errors may contribute to the project not functioning as it is supposed to be.

3.1 Results

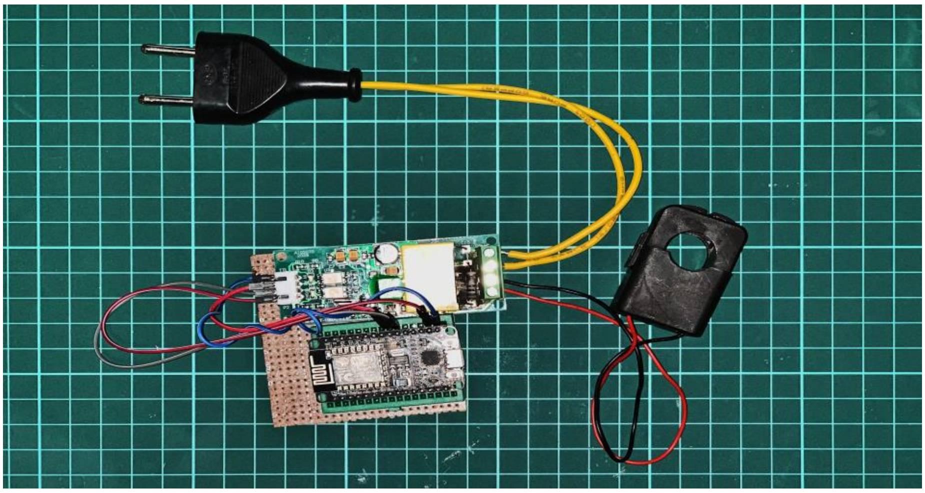

Figure 6: The prototype of the project

Figure 6 shows the materials for this project connected as a system that makes the prototype of this project. Since this is merely a prototype, the Wi-Fi module and the current sensor module are not permanently soldered to the stripboard to enable them to be re-used for a different project. However, they should be soldered on a stripboard permanently to look neat and tidy on the actual product.

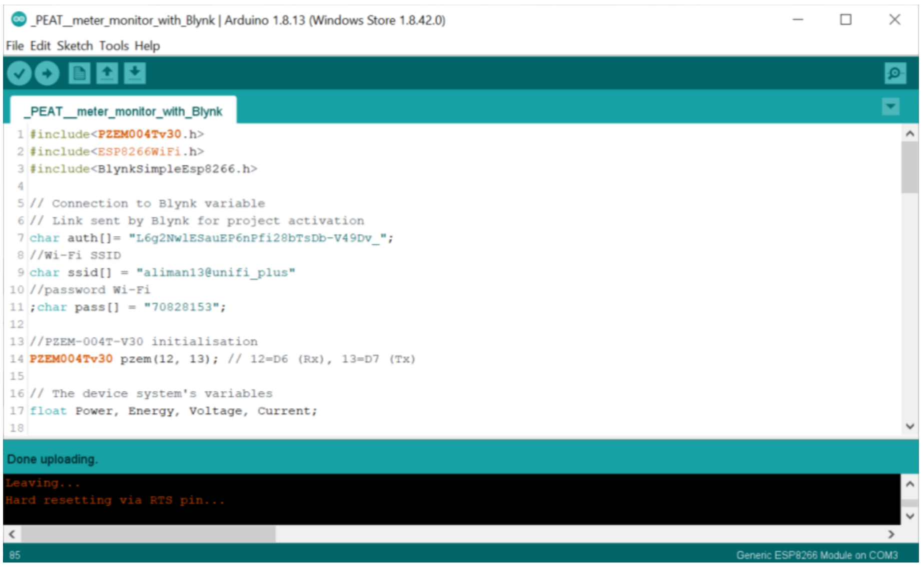

Figure 7: The programming uploaded

Figure 6 shows a quarter part of the programming that had been successfully uploaded into the Wi-Fi module. As shown in the module, three libraries are included, which are the current sensor module (<PZEM004Tv30.h>), the Wi-Fi module (<ESP8266WiFi.h>), and the Blynk (<BlynkSimpleEsp8266.h>)'s. The interface of the connection between the prototype to Blynk is shown in Figure 8 below.

Figure 8: The connection's interface

On the left side of Figure 8, it shows that when the Wi-Fi module is connected to the Internet. Hence, it will show the values of the four-set variables. On the right side of Figure 8, the display shows that the Wi-Fi module is offline. The possible reason for the earlier mentioned situation is that no

Internet connection or the power supply to the Wi-Fi module is cut-off or the Wi-Fi module is reset. However, on both sides of the figure, they show no reading or value read from the current sensor displayed. It is because there is no AC load connected to the prototype.

3.2 Discussions

This section will discuss the current prototype's issues and how they are handled for the time being. In this section, as well, future developments will be discussed for this project's improvement and betterment.

3.2.1 Current issues

There are several issues with the current prototype that need to be improved for the device to become more efficient and reliable. Regardless of the issues, they do not deteriorate the project's device's prototype to function well and accordingly. However, it is crucial to improve and modernize a developing technology in line with the people's need.

Firstly, the device was not built as a remote or a mobile device. It has to be connected to the main-line in order for it to be able to operate accordingly. It is not a significant issue as it does not interrupt the device operating system. However, it would be more practical if the device can function on its own like a clamp-meter or a multimeter where the user can plug-in and plug-off the device upon desire. Next, the issue is on the Wi-Fi module's power source that is currently powered by a 3.6 V of battery. Although the batteries can be replaced from time to time, it is inconvenient for the device users. Considering that the users might forget to replace the batteries since there is no notification feature embedded, they will lose the Wi-Fi module's stored data. As mentioned in the previous section, the module will lose its data when reset or its power supply is cut-off.

3.2.2 Improvement and future developments

For the future technology development and to make this device a more reliable meter monitoring and data logging system, enhanced storage capacity system is considered to be implemented. Its capacity is 32 Kibibyte(KiB), equivalent 32.768 Kilobyte(KB). To improve the storage capacity to its maximum potential is by connecting an external data storage connection or a memory card slot in parallel to the current connection. This measure will allow users to have options on the data storage capacity according to their desire using the memory card with desired capacity size. Furthermore, this will simultaneously overcome the issue of when the Wi-Fi module is out-source. The data will still be safe and saved in the external data storage connected in parallel.

4. Conclusion

In a nutshell, this project had been successfully developed into a prototype. Furthermore, the objectives of the project have been successfully achieved, as well. Based on the result, it can be a good alternative for the conventional utility meter. It may improve the efficiency of manually taking the utility meter reading that is conventionally used, and it is also, a part of moving in line with the fast-growing technology. It is a commitment to innovation or else; the World will remain still with no improvement or backwards without innovation to improve the conventional.

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