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Development of Electricity Energy Meter Monitoring for Residential Purpose

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Abstract: The purpose of the project is to develop an automatic load energy reading monitor that can be used on a real-time basis. Energy meter monitoring is a tool for measuring and monitoring electricity from a 230 V power source. This metering monitoring system includes a sensor that detects the blinking of an LED attached to the meter and converts it to a voltage signal. The Internet of Things (IoT) may be used to track power and bills on a daily basis using a smartphone. The problem is that at the end of each month, the household energy bill displays an additional number many times, generating consumer dissatisfaction and complaints. Because consumers are unaware of their daily energy consumption, they frequently overspend to pay their bills at the end of the month. The user may monitor and estimate the rate of energy consumption using this technology, as well as improve the amount of money saved. It is also lightweight and compact due to the usage of ESP8266 as a System on Chip (SoC) for control units. It was discovered via the project analysis that the obtained data may be used to extract the consumption pattern as well as the faults in the existing system. This project's measuring source is a house energy meter that was installed and supplied to the household. This is a good source of power to use for calculating electricity consumption.

Keywords: Energy Meter, Monitoring System, IoT, ESP8266

1. Introduction

The Internet of Things (IoT) allows things to be digitally detected and controlled via existing network networks, allowing for more direct integration between the real world and computer-based structures while also increasing performance, precision, and cost savings [1]. The concept has gained traction as the number of wireless products on the market continues to rise. The hardware devices connect with one another over the internet. The system's Wi-Fi module, the ESP8266, allows it to connect to the Internet [2].

In the context of this project, everyone familiar with the electricity energy meters that are installed in everyone's home or workplace to monitor power usage. However, the home energy bill displays an

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extra number multiple times at the end of each month, causing consumer dissatisfaction and complaints. Because consumers are unaware of their daily energy consumption, they frequently overspend when it comes time to pay their bills at the end of the month. Additionally, consumers may utilize this initiative to educate themselves about their daily power usage and make changes to minimize consumption and save money. A smart energy monitoring system may assist users in monitoring and estimating energy consumption rates, as well as increasing savings[3,4]. Users will also be able to track their energy and bill on a daily basis using an Internet of Things (IoT) monitoring device.

The objectives of this research work are to develop an automated load energy reading monitor an immediate basis. Besides that, this project proposed to implement electricity monitoring and conduct an analysis of the data collected for energy usage and billing.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Materials

There are a few procedures that must be followed in order to accomplish the project. The procedures are separated into sections, starting with detecting voltage signals at an energy meter, processing data, storing data on a cloud platform, and finally displaying the results.

The energy meter's LED blinks is converted into a voltage signal by the optical sensor, which acts as an interrupt. The interrupt process uses the voltage spikes created by the sensor to compute the unit usage. The NodeMCU acts as both a power source and a controller for the sensor. Connecting the sensor's output to the interrupt enabled pin counts the pulses. The computed unit is added to the previous unit in the cloud. The process is repeated for each new sensing.

The major hardware components in this project are as follows:

i. ESP8266 WI-Fi microcontroller as the controller unit that receives information data from sensor.
ii. TCRT5000 optical sensor used to detect blinking of LED is attached to the energy meter works as an interrupt, coverts into voltage signals.

2.2 Methods

This project will through the process step by step, using a block diagaram to aid visualization. The block diagram in Figure 1 depicts how the energy meter monitoring from the energy meter will function.

The processor is built first when the controller is turned on. It connects to the wireless router using the provided SSID and password. After a successful IP address assignment, the energy meter monitoring system is internet enabled, allowing it to communicate consumption data over the internet.

Next, when the authorization procedure is finished using the internet passing method, the processor transmits the data to the cloud storage. The energy meter's LED blink is converted into a voltage signal by the optical sensor, which acts as an interrupt. The interrupt process uses the voltage spikes generated by the sensor to compute the unit usage. The computed unit is added to the previous unit in the cloud. The process is repeated for each new sensing.

The ESP8266 is set up and powered via a 5V battery bank. The ESP8266 functions as both a power source and a controller for the sensor. Connecting the sensor's output to the interrupt enabled pin counts the pulses. The sensor in this system is a high-sensitivity light-to-voltage optical converter with an integrated photodiode and a trans-impedance amplifier. The sensor has a rapid reaction time, allowing it to detect led pulses with pinpoint accuracy.

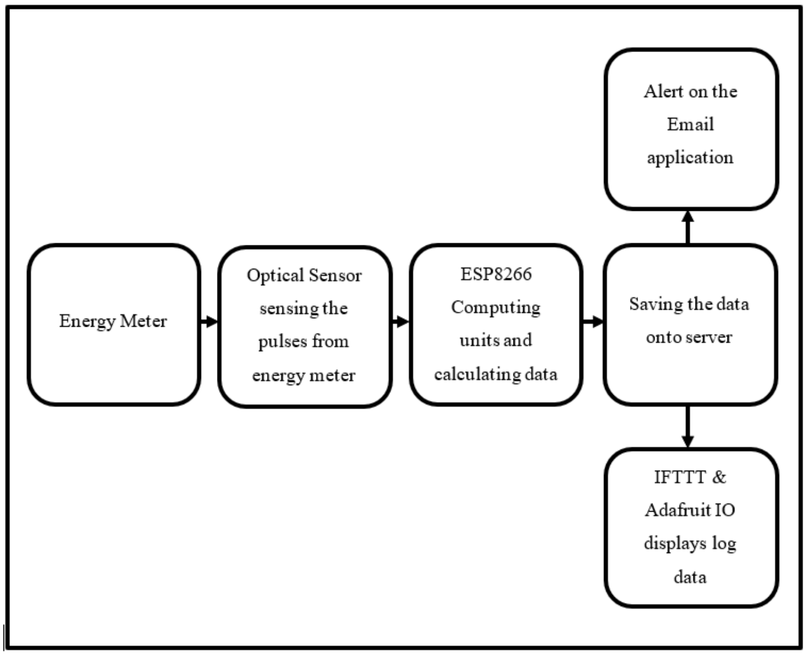

Figure 1: Block diagram process of project

3. Results and Discussion

This section discusses the outcomes gained during the project, from the beginning to the end. This section also covers the hardware implementation and any issues that arose as a result of the project's completion.

3.1 Results

The proposed system is now in implemented at the residential energy meter, allowing for real-time monitoring of energy consumption. Figure 2 shows the proposed system of electricity energy meter monitoring connection of the project.

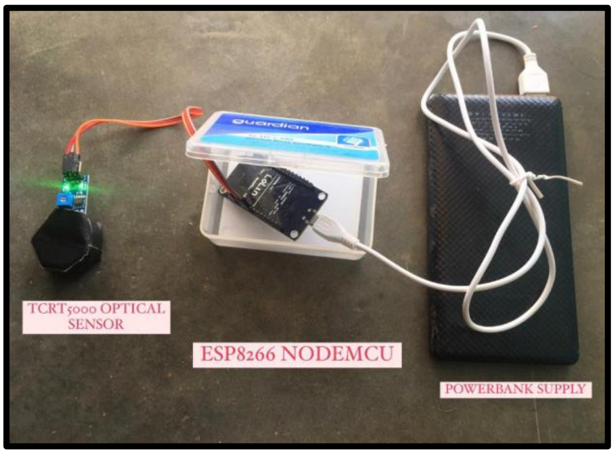

Figure 2: The proposed system of electricity energy meter monitoring connection

Next, the optical sensor will take the count of LED blinks from the energy meter and convert it to a voltage signal that will be sent to the ESP8266 microcontroller, which will act as a controller unit. In the cloud, the calculated unit is added to the preceding unit. The data obtained is saved in Adafruit IO, and IFTTT sends the data to the user's email address. The hardware testing connection at the energy meter is shown in Figure 3.

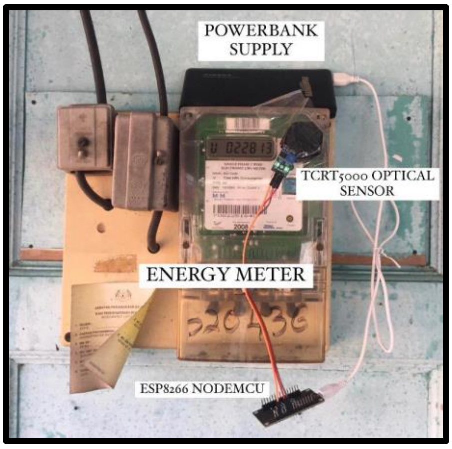

Figure 3: Overview of the hardware testing connection at energy meter

The meter readings received at the cloud are tabulated, as shown in Figure 4, and contain the consumption unit and rate. Figure 4 is referred to every 10 minutes consumption unit in 1 hour. After testing, the total energy used for one hour is 0.38556 kWh, or RM0.0839.

Time (Every 10 Minutes)	Consumption Unit (kWh)	Rate (RM)
0 – 10 Minutes	0.05931	0.0129
10 – 20 Minutes	0.06042	0.0132
20 – 30 Minutes	0.06284	0.0136
30 – 40 Minutes	0.06576	0.0143
40 – 50 Minutes	0.06729	0.0147
50 – 60 Minutes	0.06994	0.0152
Total	**0.38556**	**0.0839**

Figure 4: Output of consumption unit in every 10 minutes

The user can choose a threshold value below which an email should be sent, as shown in Figure 4. If the data on the bill feed is higher than or equal to the value selected by the user, the information will be emailed to the user. Figure 5 shows the bill rate value that the user wants to specify as the trigger. The trigger value in this project is set to 2, which is 2 Ringgit Malaysia.

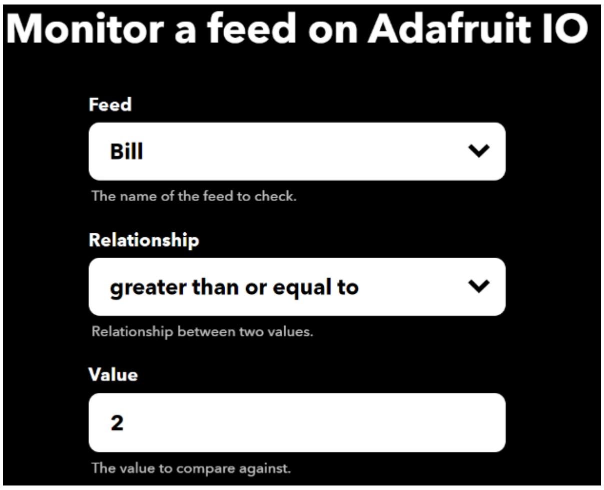

Figure 5: Monitor a feed on Adafruit IO

The triggered data for an email layout that is sent to a user is shown in Figure 6. IFTTT is a website and smartphone application that allows you to automate tasks. Every time the data collected reaches the trigger threshold, an email will be sent to the user. This application is highly user-friendly and does not need a great deal of interface knowledge.

Figure 6: IFTTT application triggered field for email layout

The proper response is then returned if the captured trigger is a defined command. Figure 6 depicts the output of the email platform's triggered data. The bill's amount, the day's date, and the hour are all mentioned in the email. Figure 7 shows the consumption bill rate for the Day 1, as stated in Table 1. The information provided is clear and easy to grasp for the user. The meter reading may be obtained quickly and easily via the email app.

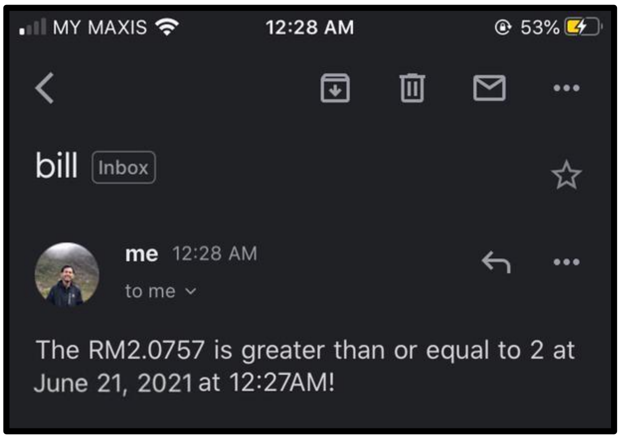

Figure 7: Output of the triggered data sent by e-mail

3.2 Discussions

The analysis is based on a week's worth of data. The unit consumption is carried out every minute, and it is uploaded to the cloud every 10 minutes. In the case of a power loss, the controller re-initializes and gets the previous value stored in the cloud on a request–response basis. At first, the pulses are detected every 1 minute, and the associated units are gathered. Every 10 minutes, the most recent computed value (units) is sent to the cloud for storage. When data is successfully transmitted, an acknowledgement is sent. The tariff rate in use is 0.218 based on Tenaga Nasional Berhad tariff.

Table 1 shows the variations in time and consumption unit over the course of a week. For seven days in a row, data was collected. The total energy used throughout the course of seven days is 69.89999 kWh, costing RM15.24.

Table 1: The differences of time and energy usage in a week

Day	Energy Usage (kWh)	Rate (RM)
1	9.52164	2.0757
2	9.74331	2.1240
3	9.81279	2.1392
4	9.90146	2.1585
5	10.33101	2.2522
6	10.01947	2.1842
7	10.57031	2.3043

The collected data is analyzed to identify the consumer's consumption patterns in a week. The analysis reveals the consumer's base, peak, and average consumption levels. Real-time data may be used to conduct a more thorough analysis of the monthly consumption rate. Any time of the day can be identified as the highest consumption period.

The x-axis shows time in seven-day intervals, while the y-axis shows the amount of energy used. Figure 8 shows the consumer's consumption behaviour during a seven-day period. The research determines the consumer's base, peak, and average consumption. The data for the first day is 9.52164 kWh, as seen in the graph below, and it continued for a week. Day 7 had the highest peak of 10.57031 kWh. Based on all data obtained for a week, the average consumption unit is 9.9857 kWh.

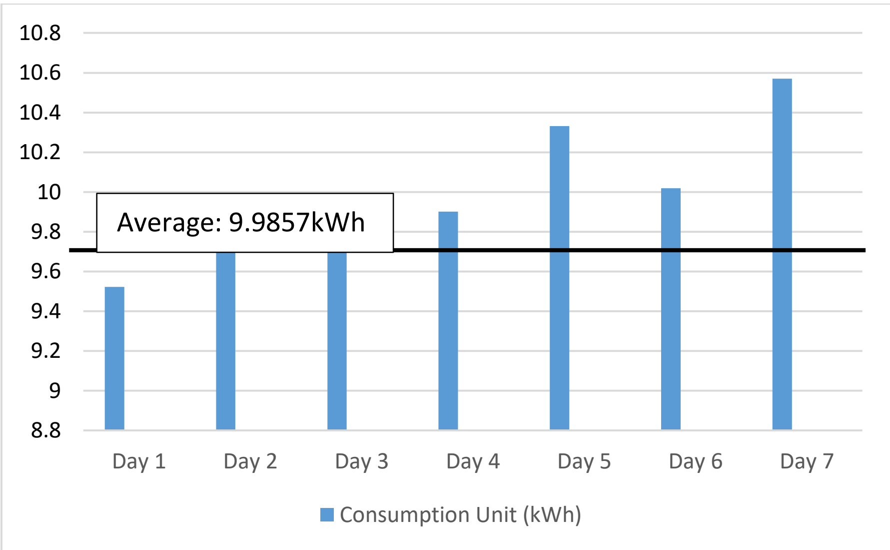

Figure 8: Consumption unit per day

The project inadvertently involves a lot of testing since an optical sensor detects a change in a physical parameter, such as LED blinks, that correlates to a billing rate change. Next, data was collected according to a predetermined period as a parameter to measure overall energy usage. Time intervals of every 10 minutes, every 1 hour every day, and every 7 days were used to complete the project. When heavy-load equipment such as a laptop and television are utilised from afternoon until nighttime, more energy is used. As a result, because individuals utilise electrical devices to perform work throughout the day, energy consumption is higher.

4. Conclusion

In a nutshell, the suggested system makes advantage of emerging IoT technologies for real-time residential energy metering. This project can help users manage and estimate energy consumption rates, as well as save money using these approaches. It allows for continuous and all-encompassing energy use monitoring. The significance of the study is that it will reduce the number of people needed to analyze energy measurements, as well as the number of errors made. Besides that, to sense, calculate, and send real-time data, a low-cost single-module system is being developed. Users can also engage in interactive experiences using a user-friendly platform. In addition, the developed work may be expanded up to compute the load distribution across a large area. As a result, it may be possible to design a technique to improve the present system.

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