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Online Monitoring for Multiple Devices Power Consumption

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Abstract: The electrical meter has evolved over the years alongside technological advancements, beginning with the classic mechanical energy meter and progressing all the way up to the most recent technologies based on the Internet of Things (IOT). The advantages of this project are it will be able to assist consumers in monitoring the amount of power used by each of their electrical appliances and also user is now able to monitor the power consumption of each electrical appliances using their smartphone (both iOS and Android versions are supported) or a computer running Windows OS thanks to the extra IOT system that has been integrated into this system. Consumers are also able to view the monthly utility bill that they get according to tariff by TNB. Because this system is totally wireless, customers can monitor their home appliances from virtually any location, provided they have an internet connection. There are 3 parameters need to be measured and compared which is voltage, current and real power using clamp meter and developed prototype to test the performance of this system prototype. The result of the test showed that the error that this developed prototype has in its reading of voltage for lamp 1 is 0.855%, table fan is 0.426% and lamp 2 is 0.819%. After that, the error that it has in its reading of current for lamp 1 is 3.333%, table fan is 2.083% and lamp 2 is 1.613%. Lastly, the error that it has in its reading of real power for lamp 1 is 8.383%, table fan is 12.848% and lamp 2 is 2.953%. By providing users with this information, it will be possible to raise their awareness of the need to minimize the amount of energy they use and develop a strategy for energy savings.

Keywords: Electrical Energy, IOT, Power Monitoring

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1. Introduction

The increasing number of commercial establishments and societies has led to the need to automate various aspects of their facilities. The Internet of Things (IoT) is a network of devices and sensors that can communicate with each other and transfer information. Each device has its own unique ID, which can be used to share and transfer information. IoT is used in a variety of industries, including automotive, logistics, healthcare, smart grid, and smart cities [1].

Day by day, our world has been transformed by the development of electric power infrastructure. With the invention of electricity, our way of life has been altered drastically. However, our energy requirements are growing faster than we anticipated, and energy supplies are diminishing at a corresponding rate. Our grid is approaching its capacity. Blackouts are becoming more common [2]. These factors necessitate the employment of a smart meter device, automatic meter reading (AMR), advanced metering infrastructure (AMI) capable of connecting with both the world of energy services and the world of the household which is consumers will be able to see their usage in real-time, eventually encouraging them to use less energy to save money. More energy savings or reductions may be possible at the home level using real-time energy usage feedback compared to traditional indirect feedback such as monthly bills, according to studies [3].

Energy monitoring and analysis are two of the most important steps in implementing ISO 50001's requirements for saving power in a building. Hu et al claim that the efficiency of many machine tools is below 30 % [4]. One of the first steps towards lowering energy consumption is gaining an accurate picture of how much energy is used by various machine tools and production processes [5]. Energy-saving opportunities, such as load balancing and preventative maintenance, rely on the accessibility of near-real-time data on energy usage trends [6]. Improving energy efficiency requires integrating energy management with production management [7].

As part of this effort, we'll be creating a Wi-Fi-based IoT energy monitoring system. The created system is able to offer precise measurements of energy consumption from a variety of appliances and the patterns of that consumption. Users can gain insight into their electricity consumption patterns and make adjustments to their habits to lower their energy consumption.

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 Project Flow Chart

Figure 1 shows the project flow chart that explains how the project works in sequence. Referring to the flow chart of project, the input of the project is voltage and current sensed by ACS712 current sensor and ZMPT101B voltage sensor. All the input data will be converted from analogue into digital signal by Arduino. Arduino Uno will perform a calculation to calculate V_RMS, I_RMS, real power, and utility bill. All the output data will be sent to cloud server using NodeMCU. Consumers will able to monitor their electrical appliance performance through Blynk platform.

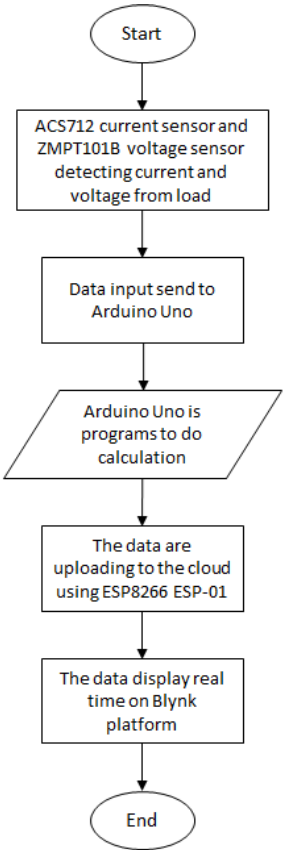

Figure 1: Project Flow Chart

2.2 Block Diagram

The development of this project consists of two input signals which provide real time voltage and current and there were two output displays which were on the Blynk platform. The current signal waveform was sensing by the current sensor - ACS712 while the voltage waveform was sensing by the voltage sensor - ZMPT101B. Arduino UNO development kits work as microcontroller which is used to do convert the analogue to digital signal and does the calculation for real power, Root Mean Square (RMS) voltage and RMS current. All the data transmitted by the NodeMCU module to the Blynk platform. After that, the power consumption was able to monitor via mobile through Blynk platform. The block diagram of this project is presented by Figure 2.

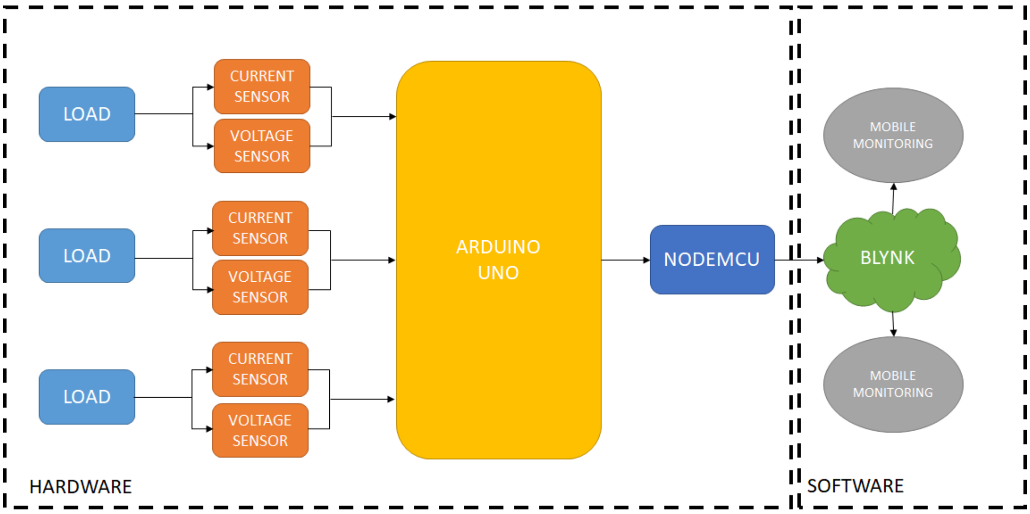

Figure 2: Block Diagram of the project

3. Prototype Design

For this project prototype, it is a combination of 2 sensors which is current sensor and voltage sensor to measure current and voltage of the load and Arduino Uno and ESP8266 ESP-1 used to send measured data from sensor to cloud server**.**

3.1 Circuit

Figure 3 shows the complete circuit of the project prototype using preboard after soldering process. The circuit is a combination of current sensor, voltage sensor, Arduino Uno and ESP8266 ESP-1.

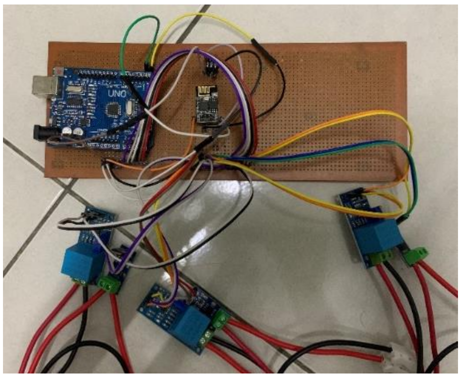

Figure 3: Project Prototype Circuit

3.2 Graphical User Interface

For this project, Blynk application used to display real time monitoring power consumption of electrical information which is current (A), voltage (V), power (W) and total bill charge (RM) for all load. Having this data laid out in front of them makes it much simpler and more efficient to keep tabs on how much power an individual is using. Figure 4 and Figure 5 show the graphical user interface through Windows OS and smartphone.

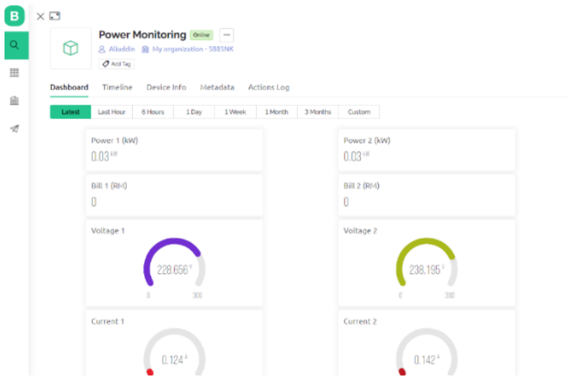

Figure 4: Blynk Interface on Windows OS

Figure 5: Blynk Interface on IOS

4. Results and Discussion

To analyze the performance of the developed prototype, there will be 3 loads need to be measure which is 2 lamp and 1 fan. All the data taken from the loads by using developed prototype and clamp meter will be recorded and compared to each other. Table 1 shows load specification.

Table.1: Load Specification

Load	Voltage	Power
1	165V-265V	12W
2	220V-265V	10W
3	165V-265V	12W

4.1 Voltage (V)

The first parameter that will be measured using the developed prototype and clamp meter is voltage. The voltage of the load can be obtained by connecting the probe of the clamp meter in parallel with the load and by using voltage sensor from the prototype. After collecting voltage from all loads, the data will be recorded onto a table. Table 2 shows the value of voltage collected from Blynk and clamp meter measurement.

Table.2: Value of voltage collected from Blynk and clamp meter measurement.

Load	Clamp Meter (V)	Blynk (V)	Error (%)
1	248.5	246.375	0.855
2	245.5	244.455	0.426
3	249.3	247.259	0.819

The values of voltage measured with a Blynk, and a clamp metre differed. This is because complicated data processing and extraction are beyond the capabilities of the Arduino Uno. Voltage readings were taken with both a Blynk and a clamp metre, and the Error was quickly calculated so that we could determine which one was more accurate.

4.2 Current (A)

The second parameter that will be measured using the developed prototype and clamp meter is current. The current of the load can be obtained by clamped the clamp meter around live wire of the load to measure it's carrying and also by using current sensor from the prototype. After collecting current from all loads, the data will be recorded into a table. Table 3 shows the value of current collected from Blynk and clamp meter measurement.

Table 3: Value of current collected from Blynk and clamp meter measurement.

Load	Clamp Meter (A)	Blynk (A)	Error (%)
1	0.060	0.062	3.333
2	0.048	0.049	2.083
3	0.062	0.063	1.613

Based on the value of current obtained from the measurement and device, value of current from Blynk and clamp meter were different. To know the accuracy of current reading from Blynk and clamp meter, a simple calculation of Error was made.

4.3 Real Power

According to data obtained which is current and voltage, real power now can be calculated. For customers taking supply at 33 kV or below, the value of the power factor to be maintained is ≥ 0.85. Power factor < 0.85 will result in power factor surcharge [12]. So, for the power factor it will declare as 0.85. To calculate real power, the formula shown below:

$$Real\ Power\ (W) = Vrms \times Irms \times pf \quad \text{(Eq.1)}$$

After calculating real power from all loads, the data will be recorded into table. Table 4 shows the value of real power collected from Blynk and clamp meter measurement.

Table 4: Value of real power collected from Blynk and clamp meter measurement.

Load	Clamp Meter (W)	Blynk (W)	Error (%)
1	14.910	13.66	8.383
2	11.784	10.27	12.848
3	13.138	12.75	2.953

Based on the value of current obtained from the measurement and device, value of real power from Blynk and clamp meter were different. To know the accuracy of real power from Blynk and clamp meter, a simple calculation of Error was made.

4.4 Bill (RM)

Next, there are few steps to convert real power that obtained from the loads into bill in ringgit Malaysia. All the steps shown below:

Step 1: Firstly, the real power (W) needs to convert into Watt-hour. The calculation to get Watt-hour shown below:

$$Wh = Watts \times 24 \quad \text{(Eq.2)}$$

Step 2: Then, the value must be converted into kWh. The calculation to convert Wh into kWh shown below:

$$kWH = \frac{Wh}{1000} \quad \text{(Eq.3)}$$

Step 3: Lastly, the power consumption will be multiplied with TNB price rating to get value of bill in ringgit Malaysia. Table 5 shows the TNB rating price. The calculation to get value of bill in ringgit Malaysia shown below:

$$Bill\ (RM) = kWh \times 0.128 \quad \text{(Eq.4)}$$

Table 5 shows TNB Price Rating.

Table 5: TNB Price Rating

TARIFF CATEGORY	UNIT	CURRENT RATE
Tariff A - Domestic Tariff		
For the first 200 kWh (1 - 200 kWh) per month	sen/kWh	21.80
For the next 100 kWh (201 - 300 kWh) per month	sen/kWh	33.40
For the next 300 kWh (301 - 600 kWh) per month	sen/kWh	51.60
For the next 300 kWh (601 - 900 kWh) per month	sen/kWh	54.60
For the next kWh (901 kWh onwards) per month	sen/kWh	57.10
The minimum monthly charge is RM3.00		

5. Conclusion

As a conclusion, the design of Online Monitoring for Power Consumption of Three Devices for single phase residential in Malaysia is feasible. An initial prototype of an Online Monitoring for Power Consumption of Three Devices has been built, and its performance has been studied. Findings and experimental results show that this project may be applied at home levels for power consumption monitoring. Two separate sensors, one for current and one for voltage, feed their readings into an Arduino Uno, which then uses them to determine power consumption and an associated cost. A Wi-Fi connection to the internet was incorporated into the system. To monitor power consumption, Blynk platform will be used as graphical user interface which can be accessed through smartphone (IOS and Android) and Windows OS. The error of voltage reading is below 1%, the error of current reading is below 4% while for real power is below 12%. This error percentage shows that it is still reliable for consumer user.

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