Smart Electricity Monitoring System using NodeMCU Microcontroller and Blynk Application

Mohd Hazim Fahmi Mohd Ghafar[1*], Mohamed Amir Wakidi Rosli[2], Nur Hidayah Mohamed Yunus[1]

[1]Department of Mathematics Science and Computer, Politeknik Mukah, KM 7.5 Jalan Oya, 96400 Mukah, Sarawak, Malaysia

[2]Department of Information and Communication Technology, Politeknik Mukah, KM 7.5 Jalan Oya, 96400 Mukah, Sarawak, Malaysia

*Corresponding author: hazim.fahmi@pmu.edu.my

Abstract

Due to the present revolution of daily quick technology usage, which results in a decline in energy supply, the graph of energy consumption is rising. The primary cause of this issue is the unchecked wasteful conduct of customers when using power. The System Development Life Cycle (SDLC), Internet of Things (IoT) technology, Blynk application software as a database of created systems, a NodeMCU ESP8266 controller, a Direct 5V Relay (AT), and the ACS712 20A current sensor were chosen as the approach to carry out this project. The Arduino IDE version 1.8.3 and the C programming language are used for programming. The 5V Direct Relay (AC) relay output and the ACS712 current sensor are linked to the NodeMCU microcontroller ESP8266 as the reception and transmission systems, and the data will be shown on the Blynk application software display on the user's smartphone as a monitoring and control tool. Because of this project, it is now possible to operate the power supply system no matter where we are situated remotely and to monitor the cost of electricity usage over the course of a day or a month. In conclusion, this method has some benefits, including cost savings, simplicity, and ease of maintenance. It is intended that users may gain from it.

Keywords: - Smart electricity monitoring, current sensor, NodeMCU microcontroller, Bylnk apps

1. Introduction

In today's world, technological progress serves as a key indicator of a country's advancement on the global stage and is something that no nation can ignore or downplay. This is because the industrial revolution (Industry 4.0) involves technology that gives new challenges to all sectors in this country that require them to make changes along with the digital transformation to remain competitive (Schlein, 2016). The pace of progress in the modern world landscape includes the discovery of various new technologies such as automation, Internet of Things (IoT), analysis and big data, simulation, system integrity, the use of robotics and Biotechnology, and energy storage. This shows something very clear that the world must respond to this change in an integrated and comprehensive manner by involving all bodies of global political interest, from the public and private sectors, educational institutions, and most importantly the society itself.

So, if our country does not give due emphasis to new technological challenges, it may cause Malaysia to fall far behind in the global competition. Looking at the development of this industrial revolution, it is related to the use of electricity, which will increase dramatically with the use of various technological tools (Schlein, 2016).

The uncontrolled use of energy affects the cost of expenses, and if the amount of energy is reduced, it will have an impact on performance and quality, according to user satisfaction (Sindhuja & Balamurugan, 2015). This uncontrolled use is more of a wasteful attitude toward the use of electricity by consumers. In this case, if this attitude continues, this will cause the use of energy from commercial energy sources such as TNB, SESB, and SESCO to continue to experience an increase in the use of resources and will indirectly increase costs.

Most household appliances consume a large amount of power and energy. Consumers mostly tend to leave their lights, fans, freezer, air conditioner, and other appliances turned on when they are not in use, resulting in energy wastage, a tendency of human behavior (Hasan et al., 2021). Such a mindset puts people at risk for accidents or fires brought on by short circuits, especially when using electrical devices that generate heat, like an iron. If this occurs, the user will have to take some time from work to go home and turn off the electrical equipment, which will disrupt their regular workday activities. The presence of a system for tracking power usage and regulating the switch of electrical equipment can aid in reducing electricity use, improving safety measures, and preventing mishaps that cannot be avoided.

By installing this monitoring and control system, users will be able to keep track of the cost of power

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used by each electrical equipment in use, which will let them take indirect action to reduce electricity usage. Additionally, users of this system may operate the switch of electrical appliances whether at work or away from home using a smartphone. As a result, installing a system for tracking and managing power usage can lower the amount of electricity used.

The research carried out to produce this project aims to achieve the objectives carried out, which are:

1. Control operation design of an intelligent electricity consumption monitoring system using cloud storage.
2. Developing a prototype of an Intelligent Electricity Consumption Monitoring System Using Cloud storage.
3. Testing the Prototype Functionality of an Intelligent Electricity Consumption Monitoring System Using Cloud Storage.

2. Literature Review

In this literature review, it focuses on how to find sources and information to be adapted in carrying out the research that will be conducted. The sources and information sought must unravel the questions that help in the implementation of the study and be in line with the objective requirements of the study that have been set.

2.1 Internet of Things (IoT)

Technology is a crucial factor in a country's development, driving it toward becoming well-developed. Innovations in technology have the potential to significantly impact people's lives, fostering a more sustainable and inclusive world. The Internet of Things (IoT), an expanding network, is increasingly popular in discussions about modern technology. The IoT applications have already brought attention to and shown the performance of monitoring modern household appliances' energy usage toward a sustainable and improved quality of urban lifestyle. IoT is beneficial and recommended in smart home applications (Stojkoska & Trivodaliev, 2017). It has enhanced our quality of life and can also help reduce unnecessary daily expenses. This advanced system is utilized for various purposes, including monitoring and controlling household electricity. Data is uploaded to a website via a server using the cloud server's local home gateway. However, concerns about security and privacy have arisen due to the reliability and dependability issues of the Internet. These concerns stem from the connections between cyber and physical environments to meet consumer demands. It is expected that these issues will be resolved in the future.

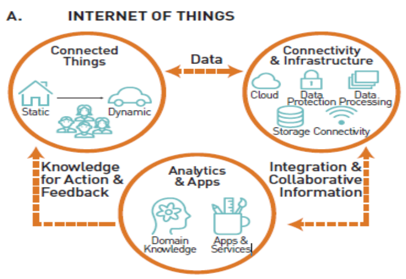


Fig. 1. IoT technologies analysis and applications

2.2 Wireless Sensor Network (WSN)

The primary advantage of the Internet of Things (IoT) lies in its global awareness, intelligent processing, and reliable information transfer. The core aspect is facilitating interactions between humans and devices or between devices themselves. These devices, which include embedded systems, control and automation systems, and Wireless Sensor Networks (WSNs), share information across various environments to enable IoT functionalities (Omran et al., 2022). Consequently, data can be transferred across different networks without human intervention. In practical IoT applications, smart cities and smart homes are the most prevalent areas. These applications typically consist of three layers: perception, network, and application (Ahmad et al., 2022).

High-power devices that ensure data security implement the network and application layers, while the perception layer is implemented in a low-power WSN. The WSN comprises multiple sensor nodes that communicate using different radio frequencies to perform various tasks such as sensing, surveillance, measurement, and tracking(Ahmad et al., 2022). These wireless nodes are resource-constrained, characterized by low processing power, narrow bandwidth, limited battery life, and restricted memory capacity (Ahmad et al., 2022). The communication between WSN layers is illustrated in Fig. 2.

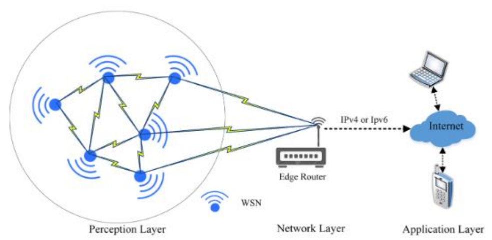


Fig. 2. The communication among the WSN layers

Based on Fig. 2, wireless sensor networks (WSNs) are responsible for establishing the network topology and updating the routing table in the perception layer using various protocols to maintain the network infrastructure. Subsequently, the WSN collects data from multiple locations and forwards it to the network layer (edge router). WSN nodes form the fundamental building blocks of this layer and possess characteristics that set them apart from other wireless networks (Ahmad et al., 2022). These characteristics include:

- Independent nodes without centralized control
- Stationary or mobile WSN nodes
- Limited transmission range
- Constantly changing network topology
- Multi-hop connections
- Limited bandwidth

WSN nodes typically operate in untrusted environments that are not regularly monitored, making them vulnerable to data leaks and posing significant security and privacy risks.

2.3 Blynk Application

Blynk is a platform using iOS and Android applications to control Arduino, Raspberry Pi, and the internet. Having a digital display where it can build the graphic shape for the project that the user wants by simply selecting various types of widgets, such as control and information data display, depending on the application that wants to be used, Instead, it supports the hardware of the user's choice. Whether using an Arduino or Raspberry Pi linked to the Internet via Wi-Fi, Ethernet, or this new ESP8266 chip, Blynk will bring its users online and ready for the Internet of Things.

The platform consists of three key components Blynk Apps to allows users to create impressive interfaces for their projects using a variety of provided widgets, meanwhile Blynk Server handles all communications between the smartphone and the hardware (Rif'an, 2019). Users can utilize the Blynk Cloud or set up a private Blynk server locally, which is open source, can manage thousands of devices and last is Blynk Libraries. These facilitate communication between all popular hardware platforms and the server, processing all incoming and outgoing commands. When a user presses a button in the Blynk application, the data is sent to the Blynk Cloud, which then routes the data to the installed hardware almost instantaneously. The process works in reverse just as quickly as illustrated in Fig. 3.

Fig. 3. Blynk application

3. Methodology

The architectural framework for the smart electricity monitoring system using cloud storage can be seen in Fig. 4. The system consists of two major technical components.

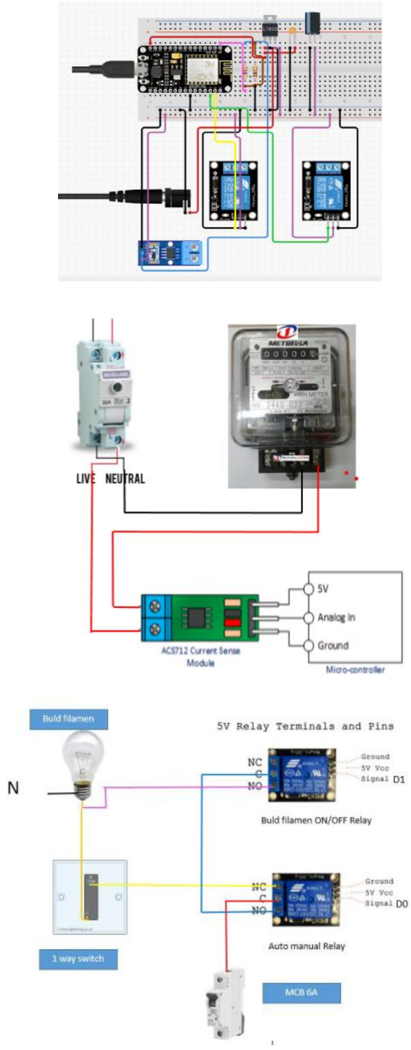


Fig. 4. Architectural framework of the system

4. Result and Analysis

4.1 Analysis of Smart Electricity Monitoring

Cloud storage based on the smart electricity monitoring system is reliable to communicate between load and metering end. Smart electricity monitoring able to measure current, power consumed together with daily and monthly cost. The daily and monthly cost for power used was calculated based on the electric tariff fixed by Tenaga Nasional Berhad (TNB) as shown in equation (1). Fig. 5 to 7 show the current, energy, power, cost per month measured by smart electricity monitoring for different types of loads. Smart electricity monitoring can evaluate and calculate the total power consumed, daily and monthly cost. The daily current and power consumed for filament lamp and phone charger are 0.179 A and 40.902 WH, 0.142 A and 32.431 WH respectively. While for fan, the daily current and power consumed is 0.260 A and 59.576 WH respectively. If all the loads are turned on for one day, the total current is 0.509 A and power consumed is 135.059 WH.

$$Time\ (h) \times \frac{Power\ consumed\ (WH)}{1000\ WH} \times RM\ 0.218 \qquad (1)$$

Fig. 5. Smart electricity monitoring for filament lamp

Fig. 6. Smart electricity monitoring for phone charger

Fig. 7. Smart electricity monitoring for fan

Fig. 8. Smart electricity monitoring for all loads

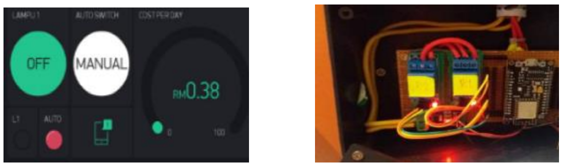
The total cost for power consumed for different types of loads is shown in Table 1. Daily costs for filament lamp, phone charger, fan and all loads are RM 0.21, RM 0.17, RM 0.31 and RM 0.71 respectively.

Table 1. Electric cost for different types of loads

Load	**Power (WH)**	**Cost (RM)**	
		Daily	**Monthly**
Filament Lamp	41	0.21	6.42
Phone Charger	32	0.17	5.02
Fan	60	0.31	9.41
All loads	135	0.71	21.19

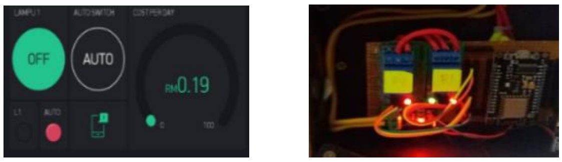
4.2 Functionality Test for Load Control

The functionality test used to load control to monitor the system is hotspot. The system consists of blynk software and relays. Fig. 9 to 11 and Table 2 show the input and output of the functionality test for lamp load. When Relay 1 and 2 are normally closed, the output lamp will not turn on as shown in Fig. 9. Meanwhile when Relay 1 is normally open and Relay 2 is normally closed, one lamp will turn on as shown in Figure 10 and both lamps will turn on when Relays 1 and 2 are normally open show on Fig. 11.



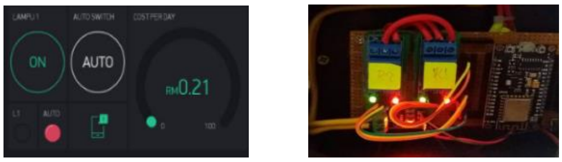
(a) (b)

Fig. 9. Functionality test for lamp load control when (a) Input Relay 1 and Relay 2 are normally closed and (b) Output lamp



(a) (b)

Fig. 10. Functionality test for lamp load control when (a) Input Relay 1 is normally open and Relay 2 is normally closed and (b) Output lamp



(a) (b)

Fig. 11. Functionality test for lamp load control when (a) Input Relay 1 and Relay 2 are normally open and (b) Output lamp

Table 2. Functionality test for lamp load control

One-Way Switch		**Relay Condition**		**Lamp**	
		Relay 1	**Relay 2**		
Off	On	NC	NC	LF	LF
Off	On	NO	NC	LF	LO
Off	On	NO	NO	LO	LO

*NC = normally closed, NO = normally open, LF = light off and LO = light on

4.3 Power Control using Network

The types of networks used to monitor and control the power of the system over a long-distance network are Wi-Fi, broadband and hotspot. The system consists of blynk software, NodeMCU and relays. Table 3 shows the result for the distance of power electricity monitoring with different networks. The distance between NodeMCU control box and smartphone are longer by using a Wi-Fi and broadband as compared to the distance between NodeMCU and router. The network connection for hotspots is limited as compared to Wi-Fi and broadband.

Table 3. Distance of power electricity monitoring

Network	Distance of Control Box NodeMCU (m)		Network Connection
	Router	Smartphone	
Wi-fi	< 100	> 100	Wide
Broadband	< 100	> 100	Wide
Hotspot	< 50	< 100	Limited

5. Conclusion

The Smart Electric Power Usage Monitoring System Using Cloud Storage has achieved its objective where the control operating system design can be applied by remote users and the delivery signal is appropriate depending on the type of circuit the user is using. This has been proven by reviewers in the technical analysis section where its capabilities have been measured. It is thus the discovery of a new technology, namely Internet of Things (IoT) technology, which helps in the whole project. In addition, in the development of prototype design, it has also been successfully implemented where its suitability is used for domestic users. The results of the analysis that has been carried out on the experts that this system is concise and easy to use. The discovery of a new science, namely the Blynk application, was very helpful in the development of this project. This product can also help users in making savings plans and users can take wiser and more careful steps in the use of electric power.

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