INTERNET OF THINGS (IOT) BASED ELECTRICAL ENERGY CONSUMPTION MONITORING SYSTEM

MOHD. SYAHMI AIMAN BIN RADZUAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

INTERNET OF THINGS (IOT) BASED ELECTRICAL ENERGY CONSUMPTION MONITORING SYSTEM

MOHD. SYAHMI AIMAN BIN RADZUAN

A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled "INTERNET OF THINGS (IOT) BASED ELECTRICAL ENERGY CONSUMPTION MONITORING SYSTEM" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	MOHD. SYAHMI AIMAN BIN RADZUAN
Date	:	5 JULY 2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPROVAL

I hereby declare that I have checked this report entitled "INTERNET OF THINGS (IOT) BASED ELECTRICAL ENERGY CONSUMPTION MONITORING SYSTEM" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : 

Supervisor Name : IR. ALIAS BIN KHAMIS

Date : 5 JULY 2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENT

I have taken a lot of efforts including studying and doing research by referring through internet, books and many sources in order to complete this project for Final Year Project (FYP) subject in this semester. However, it would not have been possible without the kind support and help of many individuals and organizations. Therefore, I would like to extend my sincere thanks to all of them.

First and foremost, I would like to express my deepest gratitude to Allah for His goodness and grace that sustained my performance in completing this FYP Project entitled IoT Based Electrical Energy Consumption Monitoring System. I would not be able to complete this project without His permission.

Besides, I would also like to express my gratitude to my supervisor, Mr. Alias bin Khamis for guiding, helping and supporting me throughout the process of completing the project with success since the beginning until the ending.

Furthermore, I would like to express my special gratitude and thanks to Faculty of Electrical Engineering (FKE) in Universiti Teknikal Malaysia Melaka (UTeM) for providing this subject, which is BEKU4894 - FINAL YEAR PROJECT 2 in order to give a golden opportunity for me to apply all the knowledge and theory that I have learnt in the class into this project. As a result, I have understood many theory clearly after applying them in completing this project and also gained more new knowledge and experiences throughout the process of developing this project.

Lastly, I would like to thank my parents, family members, colleagues and all the people around me for their prayers, supports, advices, suggestions and contribution in helping me to successfully complete this project.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRACT

Generally, flow of electrical system consists of three stages, which are generation followed by transmission and distribution before the electrical energy is consumed by the consumers. In the generation stage, the electrical energy is generated by several power plants that use two types of resources, which are renewable and non-renewable energy. Renewable energy consists of solar, wind, biomass, geothermal and hydro while non-renewable energy consists of fossil fuel, coal and natural gas. After that, the electrical energy is transmitted or transferred through the transmission stage that consists of three types, which are short, medium and long transmission line. Next, in the distribution stage, the electrical energy is distributed according to the demand of the users such as residential, industrial and many more. Lastly, the electrical energy will be used by the consumers and it is called electrical energy consumption. The electrical energy consumption is measured for every building by using the power meter provided and the consumers or users need to pay the electric bill based on the electrical energy that has been consumed by them. Nowadays, there is a few problems or limitations with the conventional power meter as it is measured manually and needs more effort. Therefore, this project entitled "Intenet of Things (IoT) Based Electrical Energy Consumption Monitoring System", which uses current sensor to measure the data, Arduino Uno as the microcontroller, Wireless Fidelity (WiFi) and Internet of Things (IoT) as the medium for the users to display and monitor the electrical energy consumption through smartphone, is developed in order to overcome the limitations of the conventional power meter.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Secara amnya, aliran sistem elektrik terdiri daripada tiga tahap, iaitu penjanaan diikuti oleh transmisi dan pengedaran sebelum tenaga elektrik habis digunakan oleh pengguna. Pada peringkat penjanaan, tenaga elektrik dihasilkan oleh beberapa loji kuasa yang menggunakan dua jenis sumber, iaitu tenaga boleh diperbaharui dan tidak boleh diperbaharui. Tenaga boleh diperbaharui terdiri daripada solar, angin, biojisim, panas bumi dan hidro manakala tenaga tidak boleh diperbaharui terdiri daripada bahan bakar fosil, arang batu dan gas asli. Selepas itu, tenaga elektrik dihantar atau dipindahkan melalui peringkat penghantaran yang terdiri daripada tiga jenis, iaitu saluran penghantaran pendek, sederhana dan panjang. Seterusnya, pada peringkat pengagihan, tenaga elektrik diedarkan mengikut permintaan pengguna seperti kediaman, perindustrian dan banyak lagi. Terakhir, tenaga elektrik akan digunakan oleh pengguna dan ia dipanggil penggunaan tenaga elektrik. Penggunaan tenaga elektrik diukur untuk setiap bangunan dengan menggunakan meter kuasa yang disediakan dan pengguna atau pengguna perlu membayar bil elektrik berdasarkan tenaga elektrik yang telah mereka habiskan. Pada masa ini, terdapat beberapa masalah atau batasan dengan meter kuasa konvensional kerana ia diukur secara manual dan memerlukan lebih banyak usaha. Oleh itu, projek ini bertajuk "Sistem Pemantauan Penggunaan Tenaga Elektrik Berasaskan Internet of Things (IoT)", yang menggunakan sensor semasa untuk mengukur data, Arduino Uno sebagai mikrokontroler, Wireless Fidelity (WiFi) dan Internet of Things (IoT) sebagai media untuk dipaparkan oleh pengguna dan memantau penggunaan tenaga elektrik melalui telefon bimbit, dikembangkan untuk mengatasi batasan meter kuasa konvensional.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TABLE OF CONTENT

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF TABLES

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF FIGURES

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF SYMBOLS AND ABBREVIATIONS

IoT	-	Internet of Things
W	-	Watts
kW	-	kiloWatts
TNB	-	Tenaga Nasional Berhad
ST	-	Suruhanjaya Tenaga
ktoe	-	kilo tonne of oil
kWh	-	kiloWatts hour
M2M	-	Machine-to-machine
LCD	-	Liquid Crystal Display
FKE	-	Faculty of Electrical Engineering
UTeM	-	Universiti Teknikal Malaysia Melaka

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF APPENDICES

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter will discuss about the research background, problem statement, motivation, objective and scope of this project, which is Internet of Things (IoT) Based Electrical Energy Consumption Monitoring System.

1.2 Research Background

Basically, in electrical system, there are three stages, which are generation, transmission and distribution before the electrical energy is supplied to the consumers. Consumers or users are related to the electrical energy consumption as the consumers utilize the electrical energy supplied to their buildings such as house, factory and many more. Electrical energy consumption is also known as electrical power consumption, which means electrical energy consumed per unit time and it is measured in watts (W) or kilowatts (kW). The electrical energy consumed by all the electrical appliances in a building are measured and the owner of the building must pay the electricity bill to the electric supplier, which is Tenaga Nasional Berhad (TNB) based on the amount of electrical energy consumed. At the same time, the electrical energy consumed by every building is measured and recorded by the electric power meter that has been installed at the building for monitoring and billing purpose. There are two types of electric power meter, which are analog and digital power meter but only digital electric power meter has been used nowadays because it is easier to monitor and display the amount of electrical energy consumed by the building. The electric power meter will provide the total electrical energy consumed in every month for the building and the owner will receive the electricity bill from the amount of electrical energy consumed for the building.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Nowadays, conventional electric power meter, which is digital power meter installed at every building in Malaysia has a few limitations that will lead to several problems. One of the problems due to the limitations of the conventional electric power meter is the excessive electrical energy usage that will cause waste of electrical energy due to lack of awareness among the consumers about their electrical energy consumption. Based on the electrical energy consumption statistics provided by Suruhanjaya Tenaga (ST), the annual total amount of electrical energy consumption from 2015 until 2017 increased for all sectors such as residential, commercial, industrial, transport, agriculture and many more as the usage of electricity among the consumers increased. The graph of the annual total electrical consumption is shown in the Figure 1.1.

Year	Final Electricity Consumption (ktoe)
	Total
2015	11,398
2016	12,394
2017	12,606

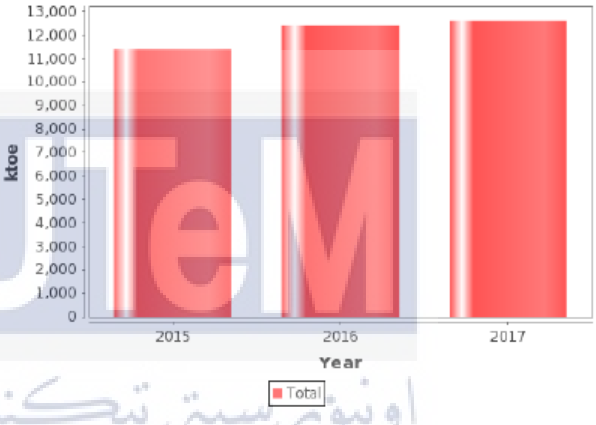

Figure 1.1: Statistics of annual total electrical energy consumption in Malaysia

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 1.1 shows the graph of annual electrical energy consumption in Malaysia from 2015 until 2017 provided by ST. Based on the graph, the annual total electrical energy consumption is measured in kilo tonne of oil (ktoe), which is 1ktoe is equal to 11,630kWh and it increases every year from 11,398ktoe (129,481,280kWh) in 2015 until 12,606ktoe (146,607,780kWh) in 2017. This means that the usage of electrical energy among the consumers in Malaysia will continue to increase and this will lead to many problems if this situation is not prevented.

Therefore, this project entitled “Internet of Things (IoT) Based Electrical Energy Consumption Monitoring System” is designed and developed to improve the monitoring system of electrical energy consumed at every building in Malaysia in order to overcome the problems

mentioned before. According to Qazi Mamoon Ashraf, Mohd. Izhan Mohd. Yusoff, Amir Alif Azman, Norbaizura Mohd. Nor, Nor Aliya Ahmad Fuzi, Mohd. Shahril Saharedan, Nurul Afzan Omar [1], IoT allows connection between machine-to-machine (M2M) that embedded with electronics, software, sensors and actuators that assists the users to control and monitoring devices remotely and efficiently. This project uses IoT as it is widely used now in the industry and it also has many benefits and advantages. The advantages of using IoT in this project are it can save time as the users can monitor and display the electrical energy consumption anywhere and anytime at their smartphone, has low operation cost that will lead to money saving and more efficient as it can provide more accurate data.

1.3 Problem Statement

There are two problems that have been found with the conventional power meter, which are needed to be solved by developing this project. Firstly, the main problem or limitation of the conventional power meter is it does not display or monitor more detail about the electrical energy consumption of a building, which means it only displays overall or total amount of electrical energy consumed by the building. So, the users or consumers cannot know the electrical energy consumed by each electrical appliance in the building such as lighting, air conditioning and many more. They only know the total amount of electrical energy consumed by all electrical appliances in the building. According to A. Zulkflee, M. F. Abdul Khanan, H. A. Umar, M. Z. Abdul Rahman, and F. Nik Mohd Kamil [2], electric power meter, which is Smart Meter supplied and installed by TNB at every building only display, monitor and record the overall electrical energy consumption of all electrical appliances in the building. Thus, this situation means that the conventional electric power meter as known as Smart Meter has a main limitation, which it only monitor the total amount of electrical energy consumed in a building and its monitoring system is not specific for each electrical appliance in the building. Therefore, the users do not know more detail about the electrical energy that has been consumed by each electrical appliance in their building. At the same time, the conventional electric power meter needs manual reading in order to obtain the electrical energy consumption of a building. So, the TNB staff needs to read the power meter manually to get the amount of electrical energy consumed by the building at the end of every month in order

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

to obtain the amount electricity bill needed to be paid by the owner of the building. Therefore, this situation will lead to more man power or effort in order to monitor the electrical energy consumption of a building and this problem must be solved or overcame immediately in order to improve the electrical energy consumption monitoring process.

Besides, the second problems due to the conventional power meter that does not show the detailed data about the electrical energy consumed by each electrical appliance in a building is it will cause the waste of electrical energy to be happened among the users as they do not know if their electrical appliances in the building have low efficiency, broken or damaged that will lead to high usage of electrical energy and then cause the waste of electrical energy. Furthermore, the users also have lack of awareness or concern about their usage of electrical energy in their building as they do not know the electrical energy usage of each electrical appliance that also will lead to electrical energy wastage.

Therefore, this final year project entitled, "IoT Based Electrical Energy Consumption Monitoring System" is designed and developed to overcome and solve these two main problems due to the conventional power meter in order to improve the efficiency of electrical energy consumption monitoring process and save the earth.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.4 Motivation

This project is motivated by the problems and limitations of the conventional electric power meter, which is Smart Meter supplied by TNB that will lead to electrical energy wastage. Therefore, this project is designed and developed in order to solve the problems of the conventional electric power meter so that the work efficiency and quality of electrical energy consumption monitoring system can be improved.

1.5 Objective

1. To study and understand about the basic concept and knowledge about the electrical energy consumption monitoring system.
2. To design and develop electrical energy consumption monitoring system by using IoT.
3. To observe and analyze the electrical energy consumed in the building by referring the display on Liquid Crystal Display (LCD) and smartphone in order to improve electrical energy usage.

1.6 Scope

This project focusses on two users, which are the owner or users in the building and the staff of TNB that have problem in monitoring the electrical energy consumption with the conventional electric power meter as stated before. Moreover, this project will be applied and installed in Faculty of Electrical Engineering (FKE) buildings located in Universiti Teknikal Malaysia Melaka (UTeM) in order to monitor and display the electrical energy consumed by each electrical appliance in the buildings. The overall system is shown in Figure 1.2.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

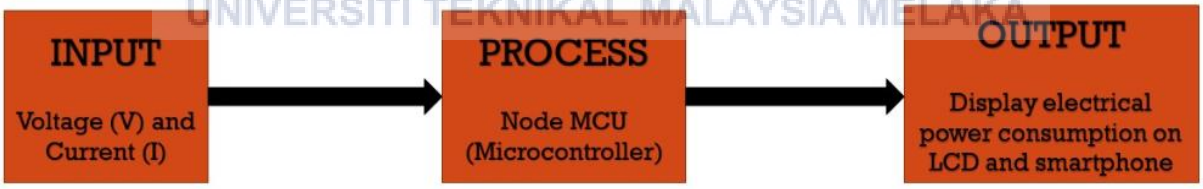

Figure 1.2: Basic block diagram of project

Based on Figure 1.2, the inputs of this project are voltage and current of the load connected to the socket that will be measured by current sensor or transducer. At the same time, the electrical power consumed by the load is also measured by using the current transducer. Meanwhile, the output of this project is the display of the electrical energy consumption on LCD and smartphone. At the same time, Node MCU microcontroller is used as the brain or center to control all the

process of the whole system. Furthermore, as IoT is applied in this project, the WiFi module is used in order to be the medium for recording the data and then transferring them to the user. Lastly, the users can monitor the electrical energy consumption of the electrical appliance by using the LCD and the BLYNK application on their smartphone anytime and anywhere.

1.7 Summary

The research background, problem statement, motivation, objective and scope of this project have been introduced in this chapter. Next, chapter 2 will explain about the overview and previous study about this project followed by chapter 3, which will discuss about the methodology of this project. After that, chapter 4 will explain about the expected result of this project and lastly, the conclusion and future works of this project will be explained in chapter 5.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will discuss about the study and researches that have been done from the literature reviews of journal and article. There is a few terms, concepts and knowledge gained from this chapter that can be used for developing this project.

2.2 Electrical Energy Consumption

Electrical energy consumption or electrical power consumption refers to electrical energy per unit time that has been supplied and consumed by electrical appliances. It is measured in unit kilowatts hour (kWh). Consumers or users are related to the electrical energy consumption as the electrical appliances in their building consume electrical energy supplied to them by TNB and they need to pay the electricity bill for each month to TNB based on the amount of electrical energy that has been used. The basic formula for calculating the electrical energy consumption is shown below.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

$$Power\ factor, pf = \cos\theta$$

$$Power, P = Voltage, V \times Current, I \times pf = IV\cos\theta$$

$$Electrical\ Energy\ Consumed, E = \frac{Power, P \times Time, t}{1000}$$

$$Efficiency, \eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{P_{out}}{V_{in} \times I_{in}} \times 100\%$$

Based on formula above, the value of voltage, current and power factor can be obtained from the electrical appliance in order to get the value of power consumed by the electrical appliance, which is measured in unit of watts (W). After that, the value of power consumed must be multiplied by time of usage for the electrical appliance and then divide them by 1000 to convert

in kilowatts hour (kWh) in order to find the amount of electrical energy consumption of the electrical appliance. Meanwhile, the value of efficiency of an electrical appliance also can be determined by using the formula as shown above.

2.3 Electric Power Meter

Figure 2.1: Electric power meter

Electric power meter is a device used for measuring and recording the amount of electrical energy consumed by electrical appliances in the buildings. Basically, the electric power meter is installed by TNB at every building to monitor the electrical energy consumption by the building. At first, the electric power meter with analog reading is installed at the building and then it is upgraded into digital electric power meter because the analog electric power meter has a few limitations. Nowadays, the smart meter is used and installed at every building by TNB to monitor and measure the electrical energy consumption by the electrical appliances in the building. At the same time, the owner of the building also can see the usage of electrical energy from myTNB application. From the application, the users can know the total electrical energy consumption monthly if the digital electric power meter is used meanwhile they can know the total electrical energy consumption daily nowadays when the smart meter has been used and applied to their building. Therefore, the owner of the building must pay the electricity bill to TNB based on the amount of electrical energy that has been consumed by the electrical appliances in the building. Unfortunately, the smart meter has a limitation, which is it can only measure and record the total

UNIVERSITI TEKNIKAL MALAYSIA MELAKA