Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF INTERNET OF THINGS-BASED SMART ELECTRICITY HOME MONITORING SYSTEM USING ARDUINO

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Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

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DEVELOPMENT OF INTERNET OF THINGS-BASED SMART ELECTRICITY HOME MONITORING SYSTEM USING ARDUINO

DOMINIC LAADE

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology with Honours

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DECLARATION

I declare that this project report entitled "Development of internet of things-based smart electricity home monitoring system using Arduino" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Student Name	:	DOMINIC LAADE
Date	:	6 JANUARY 2023

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours

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Date	:	6 JANUARY 2023

Signature	:	
Co-Supervisor Name (if any)	:	
Date	:	

DEDICATION

I dedicate this thesis mainly to my supervisor, Ts. Zaihasraf Bin Zakaria who has helped me a lot to solve many questions about theory and simulations that I run on Universiti Teknikal Malaysia Melaka. I also want to remember my father who has helped me financially and emotionally to make this project a success. He never gave up giving me words of encouragement to me besides my mother no less great giving me advice. They are the people who give me the most encouragement. To my beloved father, may you find peace and happiness in Heaven. Finally, I dedicate this to my friends Addrian Thanasugang anak Douglas Anton and Mark Maxstein bin Edwin. They are my classmates and roommates throughout my studies at Utem. They helped me a lot in terms of energy and time in preparing and completing my project.

ABSTRACT

In recent years, the very rapid development of technology around the world has brought us to an era where the use of electricity is indeed very much needed by the whole society. Electricity seems to have become one of the basic needs in the life of society like water where it is very necessary in all things. As we have seen in industry, electrically powered machines help humans to do jobs that are beyond human capabilities such as the use of conveyors that move heavy goods from one place to another. Similarly, the same concept is applied in our homes, most of our home appliances in the house on average use electrical energy to function such as lights, fans, air conditioner units, ovens, refrigerators, and many more. As a result, our dependence on electricity and its complex production methods has resulted in the value of electricity consumption increasing every year. If we do not practice the concept of energy saving at home, we will definitely pay very expensive bills every month. Therefore, smart electricity home monitoring system will help us in saving electricity consumption at home by utilizing Internet of Things (IoT) technology that can reduce manual monitoring and control. We can track and control every use of electrical goods that are in our homes by simply using a cell phone. For examples, when we go to work early in the morning and forget to turn off the garage lights, instead of going back home we can actually turn them off using only a cell phone. In a nutshell, this project focuses on producing a tool that can show daily usage rates so that we can monitor early on without waiting for a billing statement from a power distributor that will come out at the end of the month only.

ABSTRAK

Sejak kebelakangan ini, perkembangan teknologi yang pesat di seluruh dunia membawa kita ke era dimana penggunaan tenaga elektrik sememangnya sangat diperlukan oleh seluruh masyarakat. Tenaga elektrik ini ibarat sudah menjadi salah satu keperluan asas dalam kehidupan masyarakat layaknya seperti air dimana ianya sangat diperlukan dalam segala hal. Seperti yang kita lihat dalam industri, mesin yang dihidupkan oleh elektrik membantu manusia untuk melakukan pekerjaan yang di luar kemampuan manusia seperti penggunaan konveyor yang memindahkan barang berat dari suatu tempat ke yang lain. Begitu juga konsep yang sama diterapkan di rumah kita, kebanyakkan peralatan rumah kita di rumah rata-rata menggunakan tenaga elektrik untuk berfungsi seperti lampu, kipas, penghawa dingin, ketuhar, peti sejuk dan lain-lain lagi. Hasilnya, kebergantungan kita terhadap tenaga elektrik ini serta cara penghasilannya yang rumit mengakibatkan nilai harga perngunaan elektrik semakin meningkat setiap tahun. Jika kita tidak mengamalkan konsep jimat tenaga di rumah sudah pasti kita akan membayar bil yang sangat mahal setiap bulan. Oleh itu, sistem pemantauan rumah elektrik pintar akan membantu kita dalam penjimatan penggunaan elektrik di rumah dengan memanfaatkan teknologi Internet of Thing (IoT) yang dapat mengurangkan pemantauan dan pengawalan secara manual. Kita boleh mengesan dan mengawal setiap penggunaan barang elektrik yang berada di rumah kita dengan hanya menggunakan telefon bimbit. Secara ringkasnya, projek ini fokus dalam menghasilkan sebuah alat yang dapat menunjukkan kadar penggunaan harian supaya kita dapat memantau dengan awal tanpa menunggu penyata bil dari pihak pengedar kuasa elektrik yang akan keluar pada hujung bulan sahaja.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Ts. Zaihasraf Bin Zakaria for his precious guidance, words of wisdom and patient throughout this project.

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My highest appreciation goes to my parents, my siblings, and other family members for their love and prayer during the period of my study. They never gave up giving me words of encouragement to me besides my mother no less great giving me advice. They are the people who give me the most encouragement.

Finally, I would like to thank all the staffs at the Faculty of Electrical and Electronic Engineering Technology, fellow colleagues and classmates, the Faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

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LIST OF SYMBOLS

$\times$	-	Multiplication sign
Ω	-	Ohm
%	-	Pencent

LIST OF ABBREVIATIONS

V	-	Voltage
I	-	Current
P	-	Power
E	-	Energy
t	-	Time
A	-	Ampere
s	-	Second
h	-	Hour
k	-	Kilo
W	-	Watt
s	-	Second
kWh	-	KiloWatt hour

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

The existing utility system only provides feedback at the end of the month in the form of a bill or the recent energy meter in Malaysia, which displays power consumption over a period of time. This bill or unit on the meter, as the case may be, is usually from the electricity supplier such as Tenaga Nasional Berhad (TNB). A consumer has no way to track their power usage on a more immediate basis. To that effect, a smart home energy monitoring and automation system is therefore developed to provide a clear picture of a home's energy usage. The information obtainable from the proposed device can be used by the user to optimize their energy usage. In addition, it also helps user to control some home appliance usage by turning on and off home appliances based on their electricity consumption cost through a mobile app to reduce electricity consumption and minimize energy waste.

1.2 Problem Statement

In our country Malaysia, each state has electricity prices and tariffs for domestic consumers that are different from each other. For example, prices and tariffs in Sarawak are relatively cheaper compared to Sabah and the states in the Peninsula Malaysia because the rate of electricity generation in Sarawak is higher than demand. This situation poses a great challenge in analyzing the usage rate that will be processed by the device later.

1.3 Project Objective

The main aim of this project is to design and construct a cost effective and efficient energy monitoring which provides a feature that can provide a lot of information on the use of electricity so that users are more aware of the electricity consumption. To achieve this goal, the project focuses on the following objectives as follows:

a) To design a centralized system that can control and manage the electrical load appliances at home by using smartphone

b) To develop a system that can monitor the consumption of electricity anytime and anywhere with the access of internet.

c) To design a system that can help to minimize energy waste at home.

1.4 Scope of Project

This project aims to develop and study a smart home energy monitoring and automation system. The power monitoring system consists of a data acquisition device, a user interface to be viewed on a smartphone. Home automation, on the other hand consists of a centralized control system that can be used to control and turn off all connected home appliances. Power and energy consumption data will be collected from distribution boards at home and the project is used as data acquisition hardware. The project requires specific software and programs to design a comprehensive graphical user interface and to build an organized data center. The scope of the project also covers wireless communication, as data obtained from project devices will be sent wirelessly to a smartphone to be viewed and also managed. Furthermore, the project requires planning, design, problem solving and problem solving to achieve its objectives.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In general, the rate of electricity consumption in the home actually depends on many factors such as from the electrical device itself that consumes a lot of electricity to operate to even including our own negligence factors. In line with the rapid development of technology, the concept and also the interest in smart home technology and Internet of Thing (IoT) has created a wide opportunity to conduct a comprehensive literature review on electricity home monitoring. In this chapter will discuss the studies of smart home technology concept in terms of monitoring and management of electricity, main motives and applications as well as other relevant information.

2.2 Internet of Thing (IoT)

Internet of Things (IoT) technology is a current internet connection for connection and communication between different devices. This equipment is very helpful and simplifies human life because it can control a system that is connected remotely which is also leads to energy management where we can control our appliance at home. Previously, there are several studies that have been done related to home automation systems where the paper presents the design and implementation of a prototype of a centralized control system using Wi-Fi technology as a network infrastructure.

Several projects have been done using the concept of the Internet of Things such as IoT based home automation system over the cloud written by Shahzeb Hussain [1]. This project focuses on controlling every home appliance that is connected to the system using only a smartphone. Among the features that are introduced is the ability of the system to warn and alert users if they forget to turn off the switch when not at home. If there is a weak internet connection around, the system will automatically find and connect the connection with the stronger internet. The whole system is indeed 100% dependent on the internet to communicate with users as shown in figure 2.1.

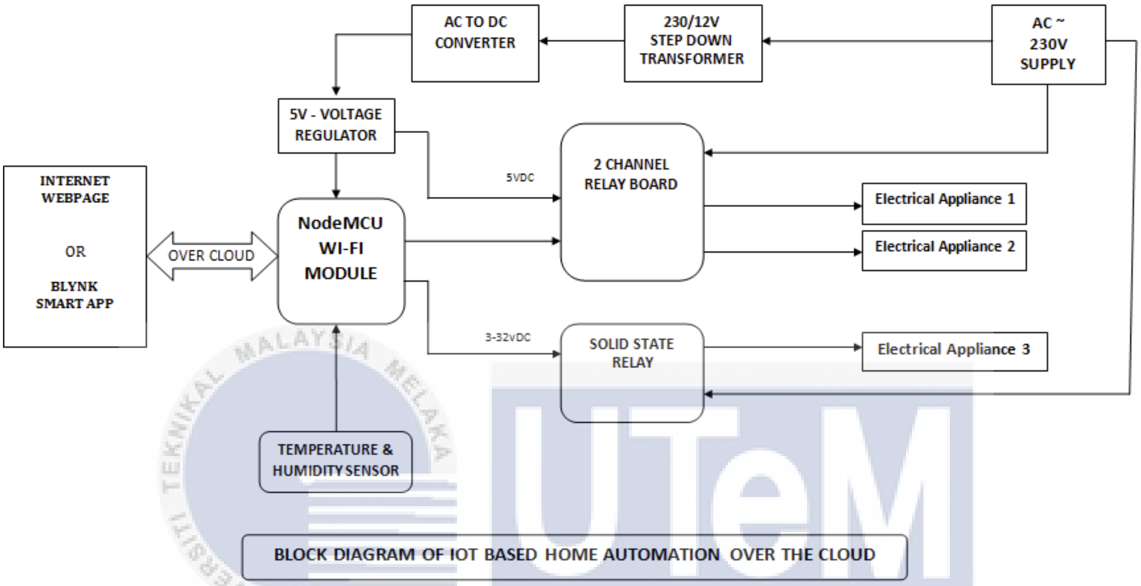


Figure 2.1 System Block Diagram of Based Home Automation Over The Cloud

The next research is entitled Internet of Things-Based Smart Electricity Monitoring and Control System Using Data Usage conducted by Mohammad Kamrul Hasan, Musse Mohamud Ahmed, Bishwajeet Pandey, Hardik Gohel, Shayla Islam, and Izzul Fitrie Khalid[2]. This research focuses on helping consumers save electricity consumption by using the concept of IoT where a centralized system that will connect to a smartphone via an internet connection as shown in Figure 2.2. With this, users can control every electrical appliance in the house using only a smartphone. In addition to controlling, users can also check the rate of electricity consumption at home using this system.

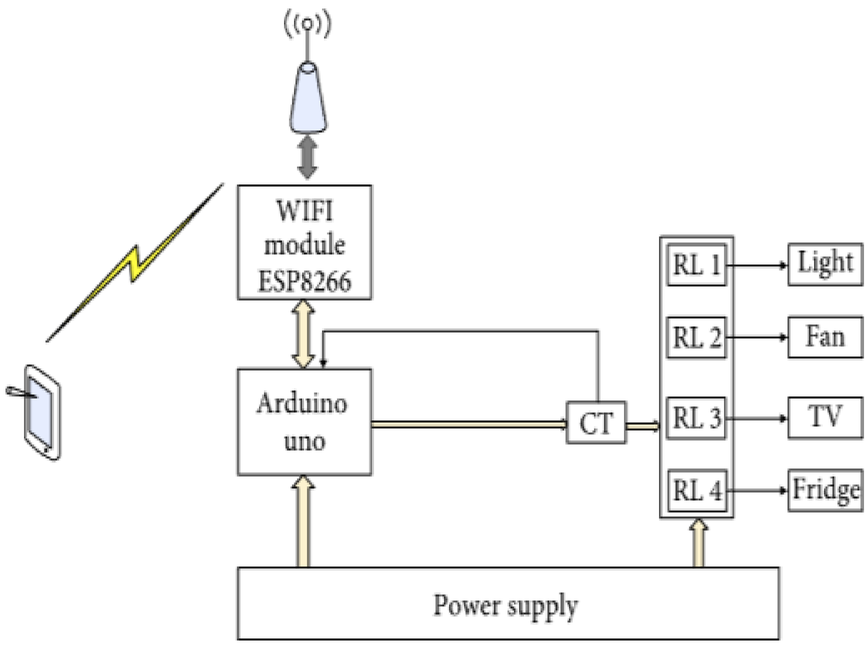


Figure 2.2 System Block Diagram of IoT-Based Control

2.3 Energy Monitoring

In general, although electricity suppliers place a meter in each of our homes, only a few know how to use the meter to monitor and control electricity consumption. This is because this process involves manual calculations using data obtained from the meter so that we can value the current electricity consumption rate. So, the existence of a suitable technology is a solution that can help every consumer control, manage and record their home electricity consumption, so that they can be aware and act earlier to apply the concept of saving electricity.

Research on the development of energy monitoring systems using WiFi technology and the Internet of Things (IoT) was conducted by Mohamed Hadi Habaebi, Qazi Mamoon Ashraf, Amir Alif Bin Azman, and Md. Rafiqul Islam[3]. In this research, a study on technological communication devices used in Home Energy Monitoring System (HEMS) applications was conducted to monitor energy consumption in deep sleep mode. The results of the study showed an increase of 0.3W in each cycle and an average power dissipation of less than 0.1W/s by refering figure 2.2 and figure 2.3.

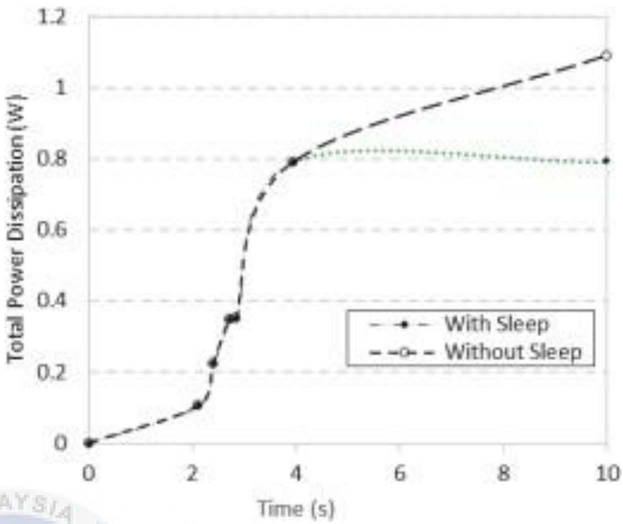


Figure 2.3 Comparison of power consumption with and without sleep

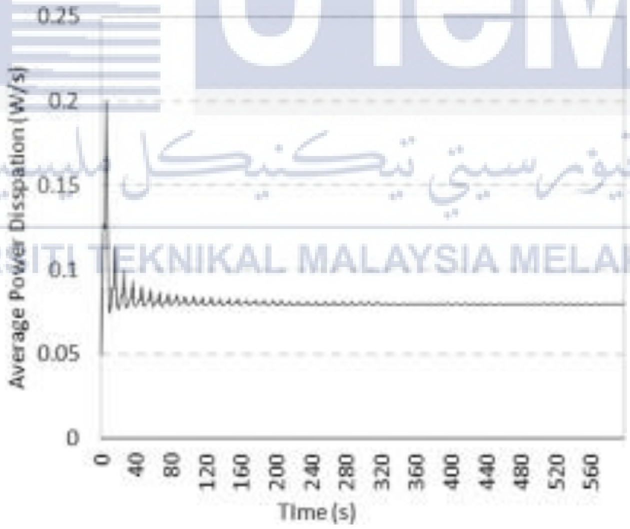


Figure 2.4 Average power dissipation over a period of one hour

After that, M G Hiremath, V Pujari and B Gadgay conducted a development system to look at the energy consumption of some household appliances as well as actions to highlight energy saving[4]. Their energy monitors device development using Arduino and ESP8266 technology. Energy measurements are carried out on the assumption that each voltage for each device is 230Vrms. In my opinion, the determination of voltage values using only assumptions is a shortcoming of the study conducted by them.

While the development of applications for intelligent energy measurement and research, the use and combination of arduino and GSM SMS (Short Message Service) communication has been carried out by Padmojethi et al[5]. The results obtained show the effectiveness of reporting and reduce energy costs, but will indirectly result in communication costs that are not examined in this study. The development of control and automation technology is now so advanced, in line with the development of wireless technology facilitates the management of electricity in the home.

2.4 Energy Management

Among the main factors in energy management at home is of course the efficiency of the device, but the most important thing is the user skills and knowledge in managing energy. When talking about the efficiency of appliances, the authors observe that the average energy efficiency of appliances is below the best level because there are appliances that still use old and less efficient technology. Although strict standards have been implemented for the purpose of increasing efficiency, our role as consumers is still a key role in saving electricity. As discussed in the previous, their awareness of the use of electricity as well as the corresponding energy can raise awareness about the appropriate equipment and is very helpful to improve their control over the use of electricity. Therefore, the presence of a technology with the concept of centralized control allows us to control and manage electricity in our homes.

Research on home appliance control using smartphones conducted by Sachhin Kishor Khadke which aims to control home appliances remotely [6]. Users can access and control all home appliances anytime and anywhere unlike we have to go back home only to turn off the corridor lights for forgetting. This app uses wireless radio frequencies to control and monitor every home appliance. This paper actually focuses fully on lighting control in our homes. Figure 2.5 shows an overview of this system.

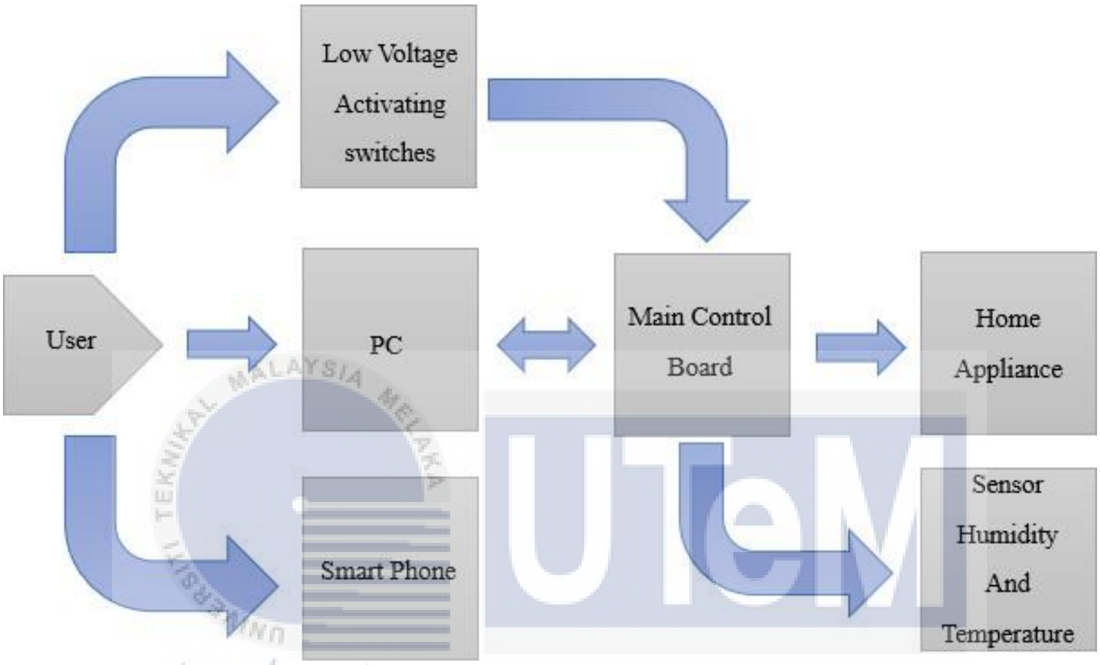


Figure 2.5 Full System Architecture

Next is a study entitled Smart Home Automated Control System Using Android Application and Microcontroller conducted by Mohamed Abd El-Latif Mowad, Ahmed Fathy, and Ahmed Hafez [7]. Based on the title written, the purpose of this home automation and remote monitoring is to control the indoor environment such as humidity, temperature, fault detectors and management using a smartphone. The system design is based on a microcontroller (Arduino Uno), sensors and even wireless Internet connection used for remote control.

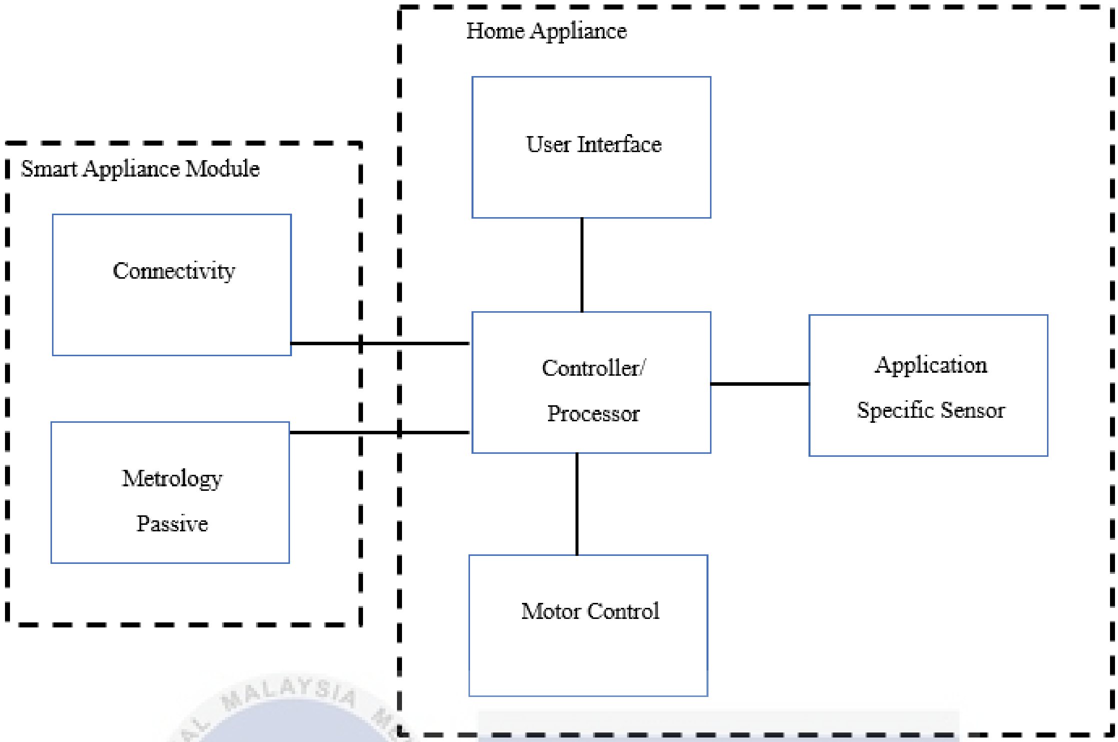


Figure 2.6 Block Diagram of Complete System

Last but not least is Smart Home-Control and Monitoring System Using Smart Phone written by Rajeev Piyareand and Seong Ro Lee [8]. The project presents a low-cost and flexible smart home control system using an embedded micro-web server with the use of IP connectivity that helps control home appliances anywhere and anytime using a smartphone. The overview of the system shown in figure 2.7 consists of three main modules, namely a Web server based on Arduino Ethernet, hardware modules and Android applications. The work also provides a remote connection to the Home Gateway for device control and monitoring, and schedule management as shown in figure 2.8.

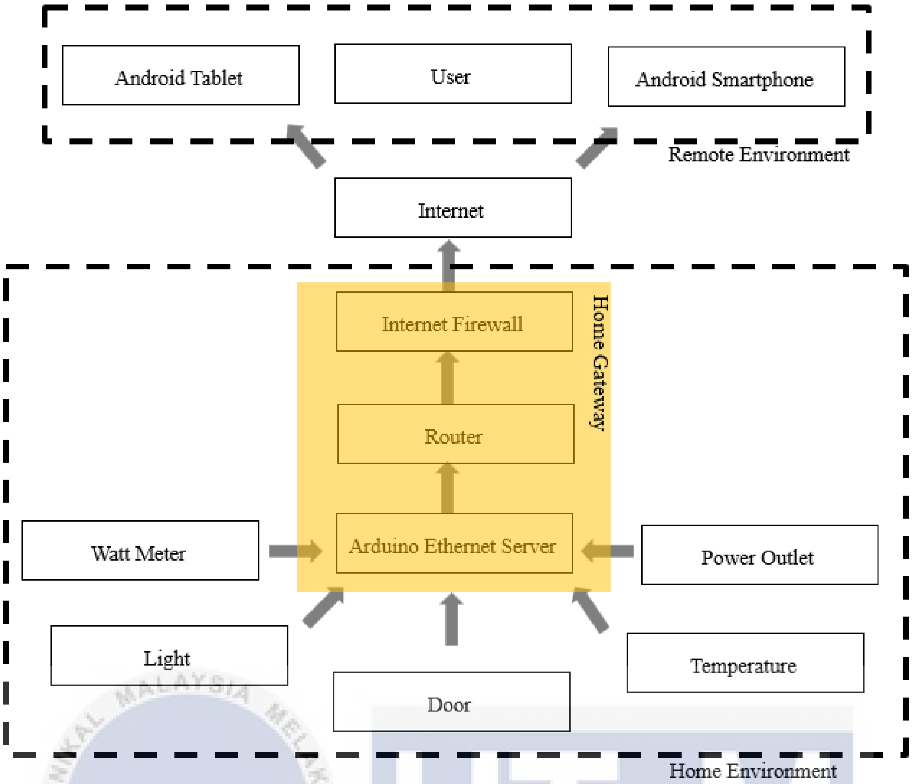


Figure 2.7 Overview of the Conceptual Architecture

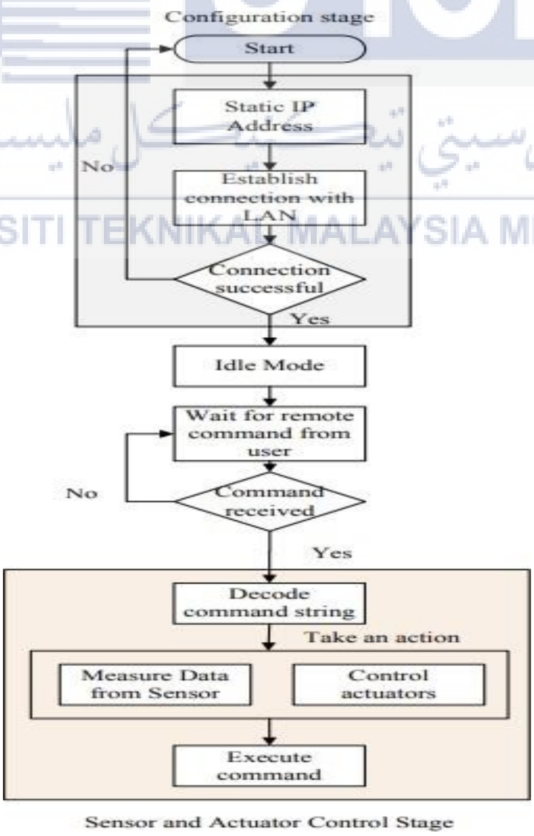


Figure 2.8 Flowchart for the connection with the internet

2.5 Summary

Literature review is a survey of scholarly source on a specific topic which is in this project is more about the implementation of Internet of Things (IoT) in our home as a power monitoring system. Here I will summarize, synthesize or identify many things such as the advantages and disadvantages, things to improve and suggestions that will help me on my project. Among them is the improvement in terms of the number of parameters that can be displayed to consumers such as the cost of electricity consumption throughout the day, every week and every month, these data can be stored for some time. The selection of components here is also very important since each component has its own capabilities.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In general, a very important methodology in in a field of study is the theoretical analysis and systematic methods used to ensure that the results we get do not conflict with what we expect. In this case, accuracy and efficiency are two important entities in developing an electrical power consumption monitoring technology. resolution refers to the ability of this device to record and provide information on energy consumption accurately, The higher the accuracy the better the device. Furthermore, efficiency refers to the ability of the device to detect changes even if only a small change in the use of electricity because it will be very useful in the concept of energy saving.

3.2 Methodology

In line with the development of Internet of Things (IoT) technology, the use of a combination of arduino and WiFi modules should be given priority to implement the concept of smart technology. This project focuses on the collection of electricity consumption data in terms of current and voltage using sensor capture to be calculated and to be analyzed. The results of this analysis will then be sent and shown to the user via an application on the smartphone. Figure 3.1 shows an estimate of the general process flow that occurs from the beginning of data collection to the end of data presentation to users

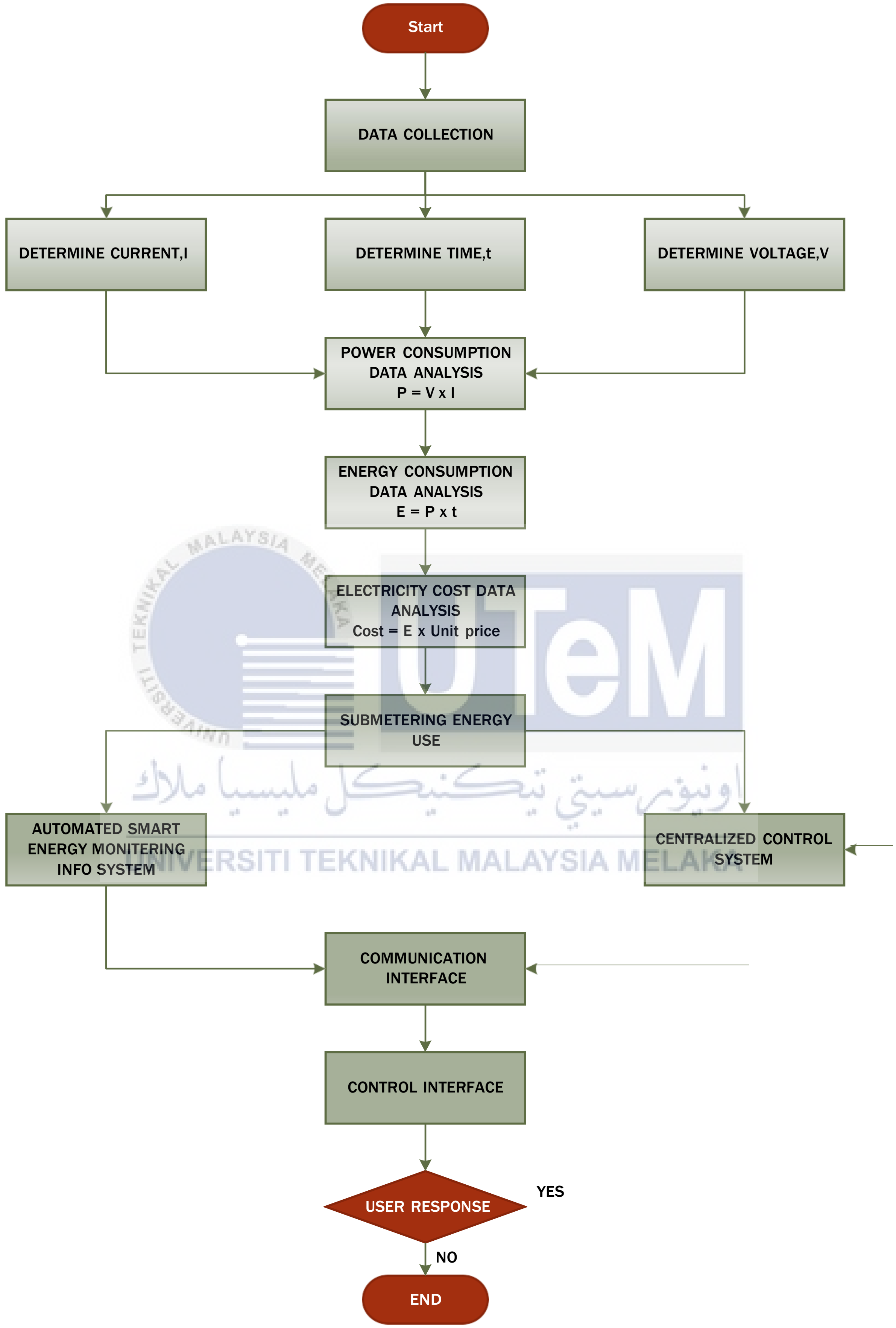


Figure 3.1 Estimation general process flow

3.2.1 Experimental setup

This thesis presents an analytical approach in estimating the rate of electricity consumption in the home according to the standards set by power distributors such as Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn. Bhd. (SESB) and Sarawak Energy Berhad (SEB). The essence of the approach used in this project is focused on the concept of Internet of Thing (IoT). This chosen approach is in line with the development of current technology where the internet is acting as a medium of communication to humans with devices. With this, users can monitor and control every electrical appliance in the house from anywhere as well as ignore manual control.

3.2.1.1 Parameters

The success of this project depends on several parameters that have their respective dependencies on each other, for example the values of current and voltage are required to find the power values.

i. Current (I) and Voltage (V)

   Current and Voltage can be measured by using respective sensor that will connected to our home system.

ii. Time (t)

   For time measurement, there is no need to install any external hardware because the Arduino itself already has an inbuilt timer. We can use the advantage of it by enable the function using programming. The downside is the timer is still measured in second, so we need to understand properly to avoid mistakes.

iii. Power (P)

Power consumption can be measure by the product of Voltage (v) and Current (I), the unit of power is in Watt (W);

$$\text{Power, } P = \text{Voltage, } V \times \text{Current, } I$$

iv. Energy (E)

Energy that has been consumed can be measure by product of power (P) and time (Hour), the unit for energy is in Watt Hour or kilowatt hour (kWh);

$$\text{Energy, } E = \text{Power, } P \times \text{Time, } t$$

v. Cost

The cost of electricity can be obtained by certain formula but it also depends on the pricing and tariff that has been set by each power distributor company.

Table 3.1 Domestic Pricing & Tariff by Tenaga Nasional Berhad

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

Table 3.2 Domestic Pricing & Tariff by Sarawak Energy Berhad

TARIFF CATEGORY	RATE PER UNIT (CENT)
Tariff D - Domestic	
For 1 to 100 units per month	18.00
For 1 to 150 units per month	18.00
For 1 to 200 units per month	22.00
For 1 to 300 units per month	25.00
For 1 to 400 units per month	27.00
For 1 to 500 units per month	29.50
For 1 to 700 units per month	30.00
For 1 to 800 units per month	30.50
For 1 to 1300 units per month	31.00
For above 1300 units per month	31.50
Minimum monthly charge	5.00

Table 3.3 Domestic Pricing & Tariff by Sabah Electricity Sdn. Bhd.

TARIFF CATEGORY	UNIT	RATES
Tariff DM - Domestic Tariff		
For the first 100 kWh (1-100kWh) per month	sen/kWh	17.50
For the next 100 kWh (101-200kWh) per month	sen/kWh	18.50
For the next 100 kWh (201-300kWh) per month	sen/kWh	33.00
For the next 200 kWh (301-500kWh) per month	sen/kWh	44.50
For the next 500 kWh (501-1000kWh) per month	sen/kWh	45.00
For the next kWh (1001 onwards) per month	sen/kWh	47.00
The minimum monthly charge is RM5.00		

By using these pricing and tariffs we can obtain consumption cost at our homeby multiplying the power consumed in kWh with the rate per unit.

Cost = Energy used in kWh x Rate per unit

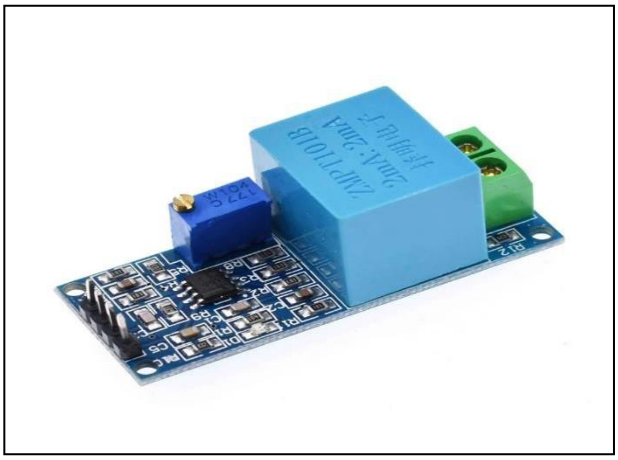
3.2.1.2 Equipment

The equipment used to implement this project can be divided into two important parts, namely hardware and software. The hardware refers to the physical and can be seen in a system such as the capture sensor for current and voltage, the MCU board which is arduino, and wireless board that will enable us to connect to the internet. Meanwhile, this part of the software refers to the programs running in the arduino and the Graphical User Interface (GUI) that the user will use to interact with the system.

i. Capture sensor

Figure 3.2 SCT-013-030 Non-invasive AC Current Sensor

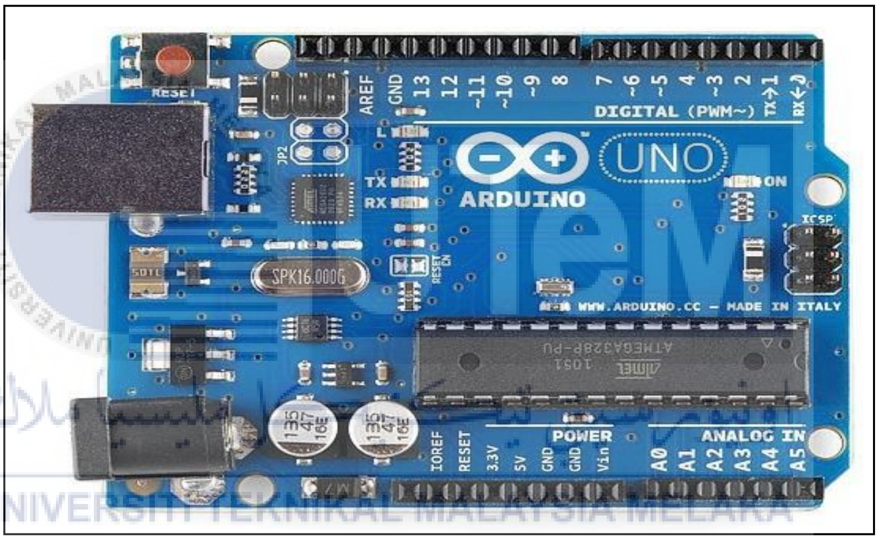
Figure 3.3 ZMPT101B AC Voltage Sensor Module



This selected voltage sensor is a single-phase sensor that is very suitable for use in our homes because most of the systems there use only single-phase. The module has the ability to measure up to 250 AC voltage. The current sensor can measure up to 100 amperes of AC current. The advantage of this sensor is that we do not have to physically connect with the main circuit of our house.

ii. Arduino

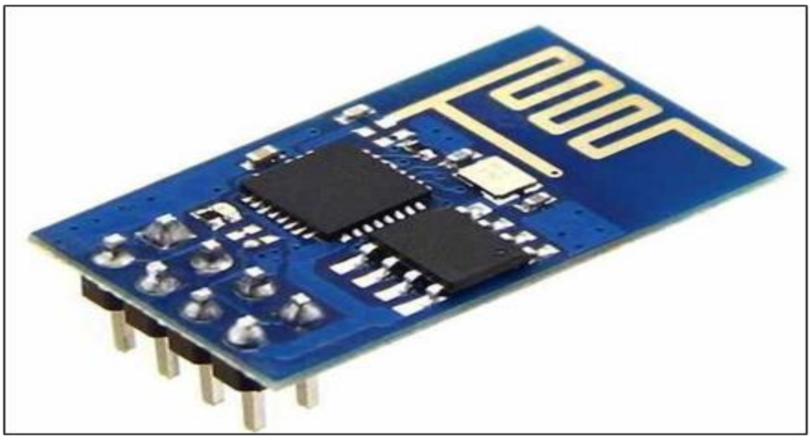
Figure 3.4 Arduino UNO



The Arduino UNO is a microcontroller with a fully equipped USB development board based on the ATMega328P. Power for the board operates only 5V which can be obtained from a USB connection, 9V DC connection or a battery connected to the input pin terminal.

iii. Wireless board

Figure 3.5 ESP8266 Wi-Fi Module



This WiFi module is indeed compatible with arduino which allows us to connect our system with an internet connection.

iv. Arduino Software and Graphical User Interface (GUI)

The software that will be used to create the code and upload to the arduino is the Arduino Software application (IDE) and the GUI used is the application that will be produced on the android smartphone.

3.3 Limitation of proposed methodology

Limits are an obstacle that has to be overcome in developing a project. The selection of components used in this project is only suitable for use in homes that have a voltage of less than 250V. This is because the sensor voltage detection range is only up to 250V and if more, the system will experience an error. In addition, the development of this project which focuses on a single-phase system only is one of the limitations that had to be faced as well. In line with the advancement of technology today causes many people to own electrical devices at home as an example of those who intend to make a mini workstation in their own home. As a result, they will be attracted to a three -phase system configuration so as to get enough power for all heavy machinery.

3.4 Summary

Briefly, this chapter presents the methodology used to fully realize this project. An effective approach to the Internet of Things (IoT) is one of the best ways in line with the rapid development of technology today. The selection of the right equipment and process also helps in producing devices that have high accuracy and efficiency which will reduce the loss of results significantly. this is because each equipment has its own capabilities such as voltage range and current. However, the main purpose of this method is to obtain efficiency, ease of use, and practicality of use on large -scale networks.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter presents results and analysis on the rate of electricity consumption in our home. Generally, these measurements focus on obtaining current and voltage values. Next with these values, we will be able to analyzed and processed using the arduino to obtain the power value and then proceed to the calculation for the value of electricity consumption in kilowatt hours. All equipment that is used in obtaining these results were tested with procedures according to the correct specifications to obtain the correct configuration. Further measurements of electricity consumption will be carried out later according to the measurement range that has been set.

4.2 Results and Analysis

To make this project a success, Blynk application is used to produce all the calculation results such as energy consumption and cost for each region in Malaysia. It also acts as a communication medium for users if the user wants to monitor energy consumption of all the home appliances that are connected to the system. In addition, this project also focuses on the calculations that will be made by the system leading to a simple circuit diagram where the load and power supply according to the actual needs. Based on figure 4.1, 4.2 and 4.3 we can see the difference in value of current flow through the system shows by Blynk application and actual current in respective time taken.

Figure 4.1 Current Test Comparison For AC Fan

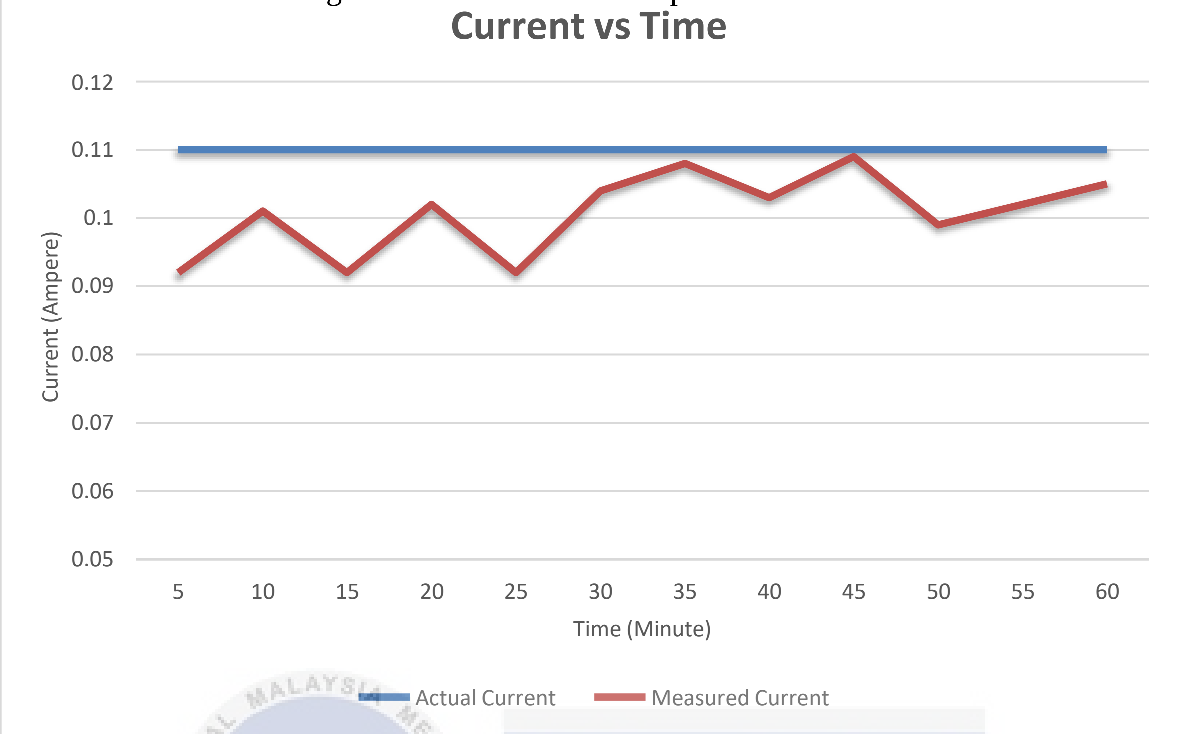


Figure 4.2 Current Test Comparison For Lamp

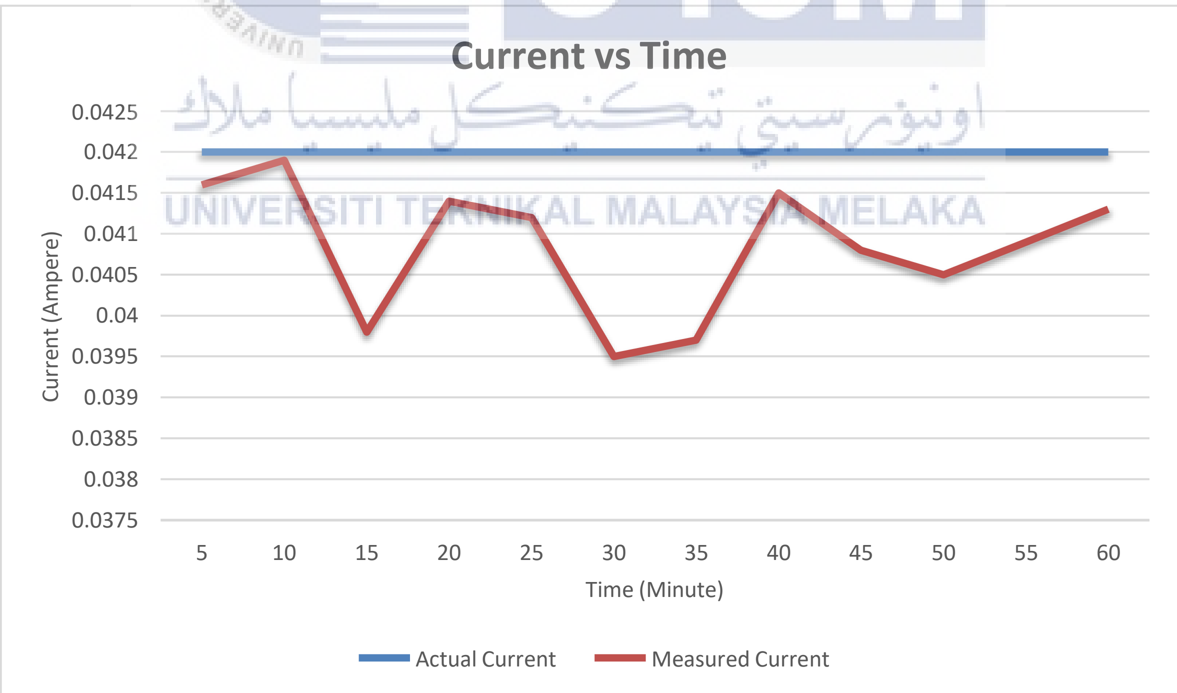
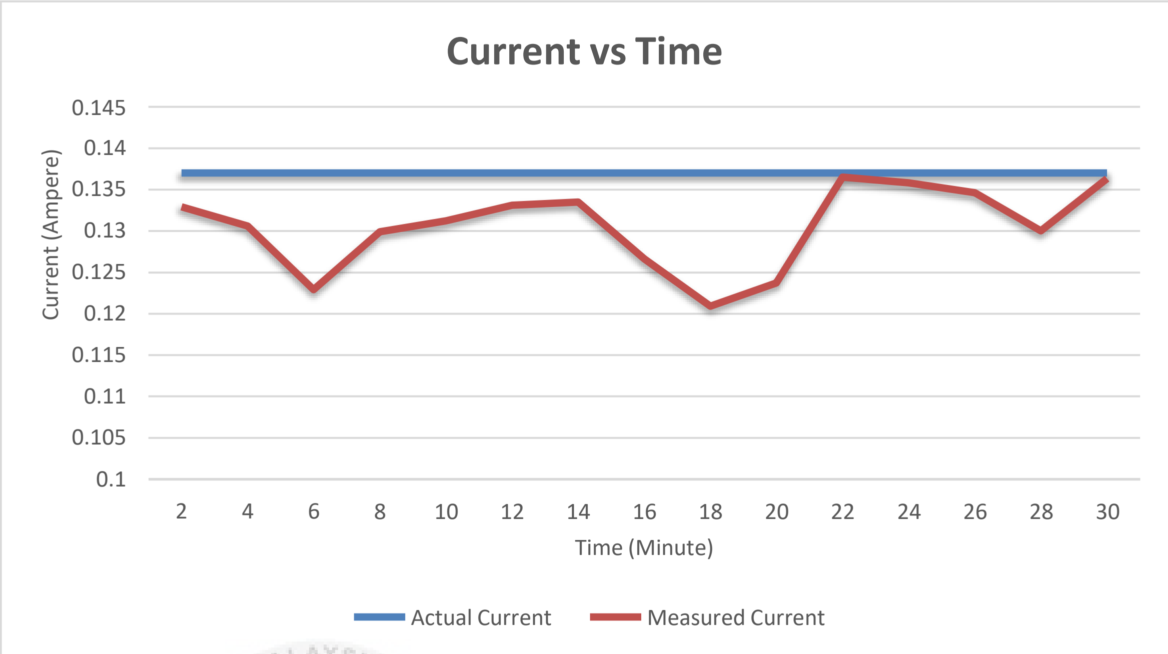
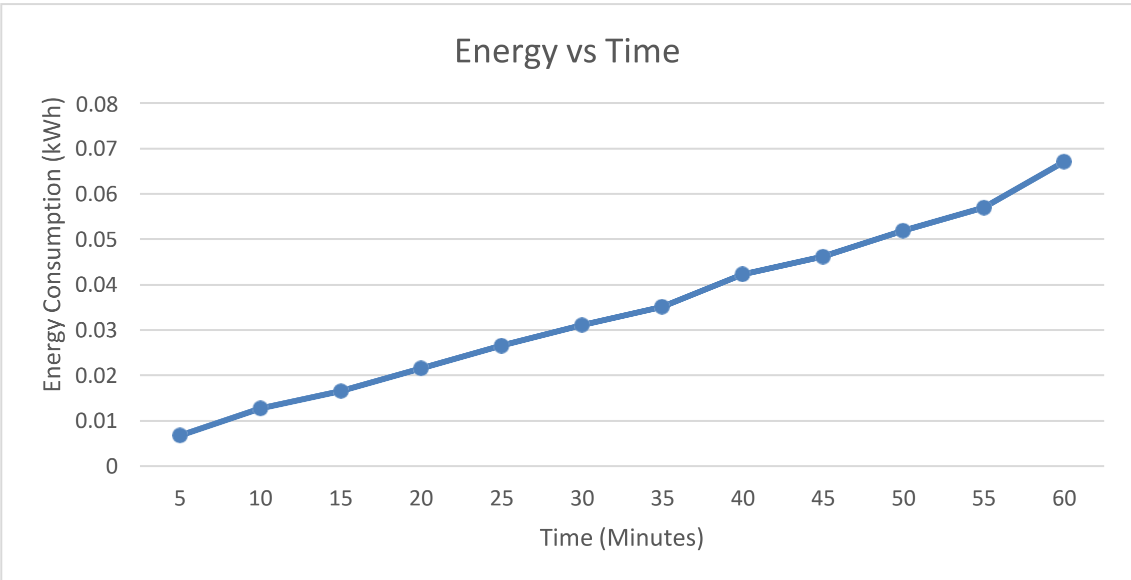


Figure 4.3 Current Test Comparison For Socket Outlet



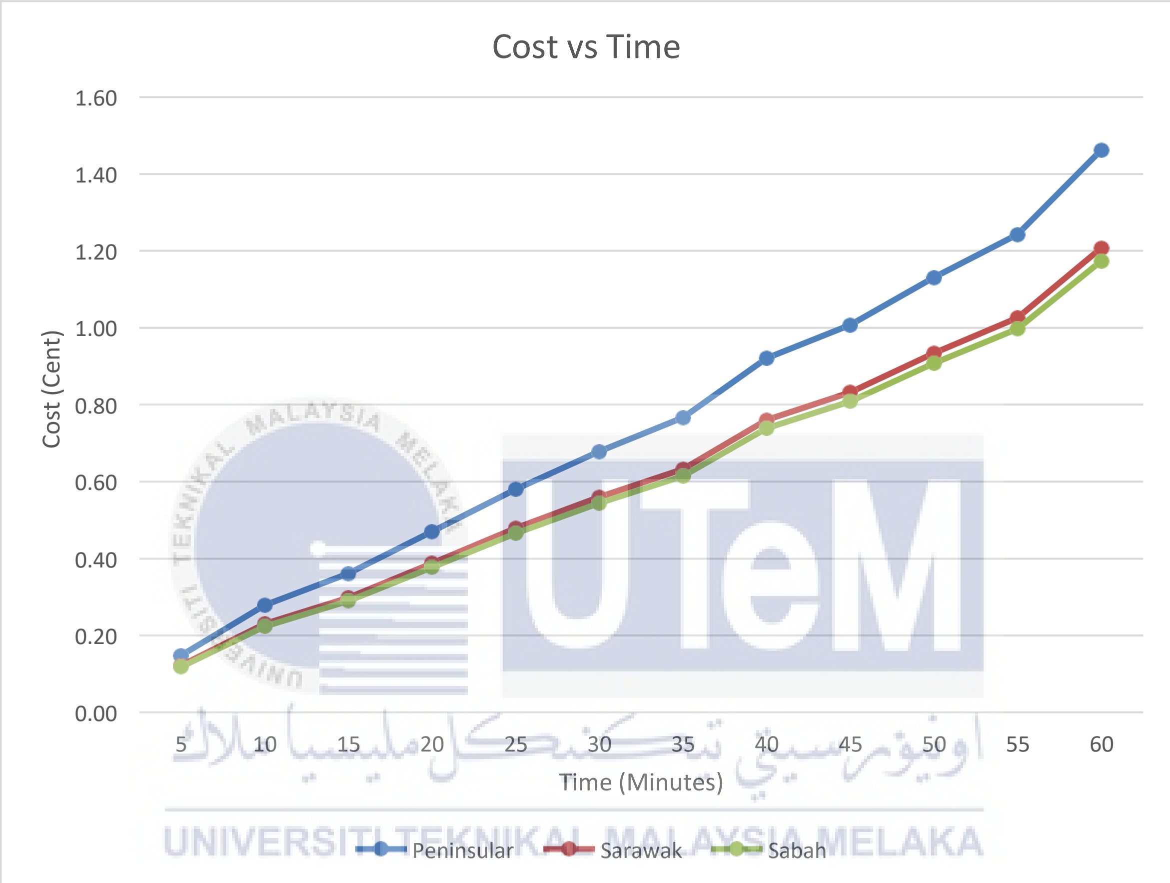
When comes to energy consumption, I have measured the consumption of all three load for an hour to compare it with my theory analysis. This time is set to an hour due to the load for socket outlet is phone charging so mostly mobile phone can be charge in one hour to full charge. Instead, I playing games on the mobile phone to make sure the battery is not full to see the full potential of current flow through the load in an hour and get the final result 0.06707 kWh.

Figure 4.4 Energy Consumption For All Three Load in 1 Hour



Meanwhile for the cost of energy consumption, there are 3 main region in Malaysia that have its own tariff that I need to consider. The theory analysis is 1.51 cent, 1.24 cent and 1.21 cent for each region respectively. It is a little bit different due to many error occur during measurement but measured values can be tolerated.

Figure 4.5 Rated Cost for Three Region in Malaysia for 1 Hour



In theory, the calculated power consumption for all three load use in an hour is 69 Watt or 0.069 kilowatt per hour as shown in table 4.1 below.

Table 4.2 Total Cost in 1 Hour

Socket Outlet	Power = V x I = 240V x 0.137A = 32.9 W Energy Consumption = P (kW) x Time (hour) = 0.0329 x 1 = 0.0329 kWh

Lamp	Power = V x I = 240V x 0.042A = 10.08 W Energy Consumption = P (kW) x Time (hour) = 0.0101 x 1 = 0.0101 kWh
Fan	Power = V x I = 240V x 0.11A = 26.4 W Energy Consumption = P (kW) x Time (hour) = 0.0264 x 1 = 0.0264 kWh
Total Energy Consumption (1 Hour)	Total = P1 + P2 + P3 = 0.0329 kWh + 0.0101 kWh + 0.0264 kWh = 0.0694 kWh

Table 4.1 Total Energy Consumption in 1 Hour

Cost	Peninsular Malaysia Cost = E (kWh) x 21.8 (cent) = 1.513 cent
	Sarawak Cost = E (kWh) x 18 (cent) = 1.249 cent
	Sabah Cost = E (kWh) x 17.5 (cent) = 1.214 cent

Next, for the automation system that is applied to this system, it uses the Internet of Things concept where it is completely dependent on the internet connection. In this situation, I use the Blynk application to wirelessly control all electrical devices connected to this system. Based on figure 4.5. and figure 4.6 below, the communication connection between the microcontroller and the blynk application is successfully connected because the light and fan will turn on when I press the power button on the blynk application respectively.

Figure 4.6 Connection Between Blynk App and Hardware

The calculation results obtained in this project are based on tariff rates in three different regions in Malaysia which is Peninsular Malaysia, Sarawak and Sabah. The complexity of the tariff rates in each of these areas poses a challenge so that I can expand the coding more widely in advance. In this project, the component that I used will not exceed the first 100kWh and 200kWh allows me able to simplify the coding.

4.3 Summary

In conclusion, this chapter presents the results of the study presented using hardware as well as the results obtained. Through the results of these results, it gives a complete picture of the process carried out by the system as a whole even if there are slight errors that occur such as the value of voltage and current flowing in the system which can affect other calculation values. This error occurs as a result of the accuracy of the detection done by the sensor which results in the computer calculation value being different from the manual calculation such as the number of decimal points taken and also the value rate of each component used. The computer's ability to calculate in detail means that it does not include a decimal point while manual calculations need to include 3 decimal points to simplify the calculation process. In addition, the measurement results obtained based on the proposed approach show consistency with the change of current value to cost value in producing accurate and reasonable results.

CHAPTER 5

CONCLUSION

5.1 Conclusion

This thesis presents ways and methods to get the cost of electricity consumption at home without having to wait for the bill statement at the end of the month. The methodology presented is effective and robust to obtain good results by using only relatively accurate information and with minimal network measurement information. The proposed simulation approach to calculate and analyze power consumption and electricity consumption cost rates can be implemented considering the relevant tariff rates. There are 3 tariffs that can be used as a reference for calculating the cost of consumption, namely the tariff rate from Tenaga Nasional Berhad (TNB) for those living in peninsular Malaysia, Sarawak Energy Berhad (SEB) for Sarawak and Sabah Electricity Sdn. Bhd. (SESB) for Sabah. These three tariffs have different rates according to their respective places.

Overall, the research presented in this thesis has successfully provided an understanding of an effective and practical methodology for the calculation of electricity consumption rates. The method is presented using a reasonable type and amount of data input, using appropriate mathematical manipulations, yet capable of producing fast and reliable results as expected. Furthermore, the work carried out which involves the development of methodology helps in ensuring that all objectives and targets are achieved.

5.2 Recommendation

For future work, the accuracy of calculating the cost of electricity consumption can be improved in several ways such as:

i) Further develop the program code in advance so that the system can calculate the cost of use based on the tariff rate accurately.

ii) Conduct analysis and simulation by consider the accuracy and losses that apply as conditions in the real world.

iii) Advancing the time tracker to get more accurate operation time for each load operates in the system.

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APPENDICES

Appendic A Pricing & Tariff by Tenaga Nasional Berhad

ELECTRICITY TARIFF SCHEDULE

(This tariff is effective from 1st January 2014 and supersedes the previous tariff schedule which was effective from 1st June 2011)

Schedule 1
TNB tariff rates are set out as follows:-

Tariff Category	Unit	Existing Rates (1 June 2011)	New Rates (1 January 2014)
1. 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 100 kWh (301 – 400 kWh) per month	sen/kWh	40.00	
For the next 100 kWh (401-500 kWh) per month	sen/kWh	40.20	
For the next 100 kWh (501-600 kWh) per month	sen/kWh	41.60	
For the next 100 kWh (601-700 kWh) per month	sen/kWh	42.60	
For the next 100 kWh (701-800 kWh) per month	sen/kWh	43.70	
For the next 100 kWh (801-900 kWh) per month	sen/kWh	45.30	
For the next kWh (901 kWh onwards) per month	sen/kWh	45.40	
The Minimum Monthly Charge is	*RM*	*3.00*	
New Structure			
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	*RM*		*3.00*
2. Tariff B - Low Voltage Commercial Tariff			
For overall monthly consumption between 0-200 kWh per month:			
For all kWh	sen/kWh	39.30	
The Minimum Monthly Charge is	*RM*	*7.20*	
For overall monthly consumption more than 200 kWh per month:			
For all kWh (from 1kWh and above)	sen/kWh	43.00	
The Minimum Monthly Charge is	*RM*	*7.20*	
New Structure			
For the first 200 kWh (1 -200 kWh) per month	sen/kWh		43.50
For the next kWh (201 kWh onwards) per month	sen/kWh		50.90
The Minimum Monthly Charge is	*RM*		*7.20*
3. Tariff C1 - Medium Voltage General Commercial Tariff			
For each kilowatt of maximum demand per month	RM/kW	25.90	30.30
For all kWh	sen/kWh	31.20	36.50
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
4. Tariff C2 - Medium Voltage Peak/Off-Peak Commercial Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	38.60	45.10
For all kWh during the peak period	sen/kWh	31.20	36.50
For all kWh during the off-peak period	sen/kWh	19.20	22.40
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*

Tariff Category	Unit	Existing Rates (1 June 2011)	New Rates (1 January 2014)
5. Tariff D - Low Voltage Industrial Tariff			
For overall monthly consumption between 0-200 kWh per month:			
For all kWh	sen/kWh	34.50	
The Minimum Monthly Charge is	*RM*	*7.20*	
For overall monthly consumption more than 200 kWh per month:			
For all kWh (from 1kWh and above)	sen/kWh	37.70	
The Minimum Monthly Charge is	*RM*	*7.20*	
New Structure			
For the first 200 kWh (1 -200 kWh) per month	sen/kWh		38.00
For the next kWh (201 kWh onwards) per month	sen/kWh		44.10
The Minimum Monthly Charge is	*RM*		*7.20*
Tariff Ds – Special Industrial Tariff (for consumers who qualify only)			
For all kWh	sen/kWh	35.90	42.70
The Minimum Monthly Charge is	*RM*	*7.20*	*7.20*
6. Tariff E1 - Medium Voltage General Industrial Tariff			
For each kilowatt of maximum demand per month	RM/kW	25.30	29.60
For all kWh	sen/kWh	28.80	33.70
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
Tariff E1s – Special Industrial Tariff (for consumers who qualify only)			
For each kilowatt of maximum demand per month	RM/kW	19.90	23.70
For all kWh	sen/kWh	28.30	33.60
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
7. Tariff E2 - Medium Voltage Peak/Off-Peak Industrial Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	31.70	37.00
For all kWh during the peak period	sen/kWh	30.40	35.50
For all kWh during the off-peak period	sen/kWh	18.70	21.90
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
Tariff E2s - Special Industrial Tariff (for consumers who qualify only)			
For each kilowatt of maximum demand per month during the peak period	RM/kW	27.70	32.90
For all kWh during the peak period	sen/kWh	28.30	33.60
For all kWh during the off-peak period	sen/kWh	16.10	19.10
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
8. Tariff E3 - High Voltage Peak/Off-Peak Industrial Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	30.40	35.50
For all kWh during the peak period	sen/kWh	28.80	33.70
For all kWh during the off-peak period	sen/kWh	17.30	20.20
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
Tariff E3s - Special Industrial Tariff (for consumers who qualify only)			
For each kilowatt of maximum demand per month during the peak period	RM/kW	24.40	29.00
For all kWh during the peak period	sen/kWh	26.70	31.70
For all kWh during the off-peak period	sen/kWh	14.70	17.50
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*

Tariff Category	Unit	Existing Rates (1 June 2011)	New Rates (1 January 2014)
9. Tariff F - Low Voltage Mining Tariff			
For all kWh	sen/kWh	32.60	38.10
The Minimum Monthly Charge is	*RM*	*120.00*	*120.00*
10. Tariff F1 - Medium Voltage General Mining Tariff			
For each kilowatt of maximum demand per month	RM/kW	18.10	21.10
For all kWh	sen/kWh	26.80	31.30
The Minimum Monthly Charge is	*RM*	*120.00*	*120.00*
11. Tariff F2 - Medium Voltage Peak/Off-Peak Mining Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	25.50	29.80
For all kWh during the peak period	sen/kWh	26.80	31.30
For all kWh during the off-peak period	sen/kWh	14.70	17.20
The Minimum Monthly Charge is	*RM*	*120.00*	*120.00*
12. Tariff G - Street Lighting Tariff			
For all kWh (including maintenance)	sen/kWh	26.10	30.50
For all kWh (excluding maintenance)	sen/kWh	16.40	19.20
The Minimum Monthly Charge is	*RM*	*7.20*	*7.20*
13. Tariff G1 - Neon & Floodlight Tariff			
For all kWh	sen/kWh	17.80	20.80
The Minimum Monthly Charge is	*RM*	*7.20*	*7.20*
14. Tariff H – Low Voltage Specific Agriculture Tariff			
For overall monthly consumption between 0-200 kWh per month:			
For all kWh	sen/kWh	36.90	
The Minimum Monthly Charge is	*RM*	*7.20*	
For overall monthly consumption more than 200 kWh per month:			
For all kWh (from 1kWh and above)	sen/kWh	40.30	
The Minimum Monthly Charge is	*RM*	*7.20*	
New Structure			
For the first 200 kWh (1 -200 kWh) per month	sen/kWh		39.00
For the next kWh (201 kWh onwards) per month	sen/kWh		47.20
The Minimum Monthly Charge is	*RM*		*7.20*
15. Tariff H1 – Medium Voltage General Specific Agriculture Tariff			
For each kilowatt of maximum demand per month	RM/kW	25.90	30.30
For all kWh	sen/kWh	30.00	35.10
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*
16. Tariff H2 – Medium Voltage Peak/Off-Peak Specific Agriculture Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	34.90	40.80
For all kWh during the peak period	sen/kWh	31.20	36.50
For all kWh during the off-peak period	sen/kWh	19.20	22.40
The Minimum Monthly Charge is	*RM*	*600.00*	*600.00*

Notes:

1.6% for Feed-in-Tariff (FiT) is imposed on consumers' monthly bill (excluding Domestic consumers with monthly consumption of 300kWh and below) effective from 1st January 2014

Schedule 2

Tariff rates for Topup and Standby Services (only for Co-generators) are set out as follows:

Tariff Category	Unit	New Rates (1 January 2014)	
		Top-Up	Standby**
1. Tariff C1 - Medium Voltage General Commercial Tariff			
Maximum demand charge per month	RM/kW	30.30	14.00
For all kWh	sen/kWh	36.50	
2. Tariff C2 - Medium Voltage Peak/Off-Peak Commercial Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	45.10	14.00
For all kWh during the peak period	sen/kWh	36.50	
For all kWh during the off-peak period	sen/kWh	22.40	
3. Tariff E1 - Medium Voltage General Industrial Tariff			
Maximum demand charge per month	RM/kW	29.60	14.00
For all kWh	sen/kWh	33.70	
4. Tariff E2 - Medium Voltage Peak/Off-Peak Industrial Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	37.00	14.00
For all kWh during the peak period	sen/kWh	35.50	
For all kWh during the off-peak period	sen/kWh	21.90	
5. Tariff E3 - High Voltage Peak/Off-Peak Industrial Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	35.50	12.00
For all kWh during the peak period	sen/kWh	33.70	
For all kWh during the off-peak period	sen/kWh	20.20	
6. Tariff F1 - Medium Voltage General Mining Tariff			
Maximum demand charge per month	RM/kW	21.10	14.00
For all kWh	sen/kWh	31.30	
7. Tariff F2 - Medium Voltage Peak/Off-Peak Mining Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	29.80	14.00
For all kWh during the peak period	sen/kWh	31.30	
For all kWh during the off-peak period	sen/kWh	17.20	

Tariff Category	Unit	New Rates (1 January 2014)	
		Top-Up	Standby**
8. Tariff H1 - Medium Voltage General Specific Agriculture Tariff			
For each kilowatt of maximum demand per month	RM/kW	30.30	14.00
For all kWh	sen/kWh	35.10	
9. Tariff H2 - Medium Voltage Peak/Off-Peak Specific Agriculture Tariff			
For each kilowatt of maximum demand per month during the peak period	RM/kW	40.80	14.00
For all kWh during the peak period	sen/kWh	36.50	
For all kWh during the off-peak period	sen/kWh	22.40	

*****Notes:***

1. This new Standby rate (as of 1st January 2014) is applicable to the following customers:-

- *All new co-generation customers; and*
- *Existing co-generation customers who wish to migrate to this new Standby rate*

2. For existing co-generation customers who wish to maintain the previous Standby (Firm and Non-Firm) rates, the previous Standby (Firm and Non-Firm) rates together with the new Top-Up rate (as of 1st January 2014) will be applicable

3. 1.6% for Feed-in Tariff (FiT) is imposed on consumers' monthly bill (excluding Domestic consumers with monthly consumption of 300kWh and below) effective from 1st January 2014

Appendic B Pricing & Tariff by Sarawak Energy Berhad

Tariff Category	Units
Domestic, D	1 to 150 units: 18 sen
	1 to 200 units: 22 sen
	1 to 300 units: 25 sen
	1 to 400 units: 27 sen
	1 to 500 units: 29.5 sen
	1 to 700 units: 30 sen
	1 to 800 units: 30.5 sen
	1 to 1300 units: 31 sen
	For above 1300 units: 31.5 sen
	Minimum monthly charge: RM 5.00
Commercial, C1	1 - 100 units 20.0 sen
	1 - 200 units 24.0 sen
	1 - 300 units 26.0 sen
	1 - 400 units 28.0 sen
	1 - 500 units 30.0 sen
	1 - 3000 units 31.5 sen
	1 - 10000 units 32.0 sen
	1 - 20000 units 31.0 sen
	1 - Above 20000 units 30.0 sen
	Minimum monthly charge RM 10.00
Commercial Demand, C2	All Consumption: 24.5 sen
	For each kilowatt of maximum demand per month: RM16
	Maximum monthly charge: RM16 per kilowatt X Billing Demand
Commercial Peak/Off Peak Demand, C3	Peak: 24.5 sen
	Off-Peak: 13.9 sen
	For each kilowatt of maximum demand per month during the peak period: RM20.00
	Minimum monthly charges: RM20 per kilowatt X Billing Demand
Industrial, I1	1 - 100: 24.0 sen
	1 - 3000: 25.0 sen
	1 - Above 3000: 26.0 sen
	Minimum monthly charge: RM10.00
Industrial Demand, I2	All consumption: 21.7 sen
	For each kilowatt of maximum demand per month: RM16.00
	Minimum monthly charge: RM16.00 per kilowatt X Billing Demand
Industrial Peak/Off-Peak Demand, I3	Peak: 22.9 sen
	Off-Peak: 13.9 sen
	For each kilowatt of maximum demand per month during the peak period: RM20.00
	Minimum monthly charge: RM20 per kilowatt X Billing Demand
Public Lighting, PL	All consumption: 47.0 sen
	Minimum monthly charge: RM10.00

Appendic C Pricing & Tariff by Sabah Electricity Sdn. Bhd.

NEW ELECTRICITY TARIFF STRUCTURE AND RATES
For Sabah & F.T. Labuan
Effective 1st January 2014

TARIFF CATEGORY	UNIT	NEW RATES
1. Tariff DM – Domestic Tariff		DM
For the first 100 kWh (1-100 kWh) per month	Sen/kWh	17.5
For the next 100 kWh (101-200 kWh) per month	Sen/kWh	18.5
For the next 100 kWh (201-300 kWh) per month	Sen/kWh	33.0
For the next 200 kWh (301-500 kWh) per month	Sen/kWh	44.5
For the next 500 kWh (501-1000 kWh) per month	Sen/kWh	45.0
For the next kWh (1001 kWh onwards) per month	Sen/kWh	47.0
The Minimum Monthly Charge is :	RM	5.00
2. Tariff CM1 – Low Voltage Commercial Tariff		CM1
For the first 200 kWh (1-200 kWh) per month	Sen/kWh	38.5
For the next kWh (201 kWh onwards) per month	Sen/kWh	39.5
The Minimum Monthly Charge is :	RM	15.00
3. Tariff CM2 - Medium Voltage General Commercial Tariff		CM2
For each kilowatt of maximum demand per month	RM/kW	23.20
For all kWh	Sen/kWh	32.4
The Minimum Monthly Charge is :	RM	1,000.00
4. Tariff CM3 – Medium Voltage Peak/Off-Peak Commercial Tariff		CM3
For each kilowatt of maximum demand per month during Peak Period	RM/kW	32.60
For all kWh during the Peak Period	Sen/kWh	32.4
For all kWh during the Off-Peak Period	Sen/kWh	19.5
The Minimum Monthly Charge is :	RM	1,000.00
5. Tariff ID1 – Low Voltage Industrial Tariff		ID1
For all kWh	Sen/kWh	37.6
The Minimum Monthly Charge is :	RM	15.00
6. Tariff ID2 – Medium Voltage General Industrial Tariff		ID2
For each kilowatt of maximum demand per month	RM/kW	21.75
For all kWh	Sen/kWh	26.8
The Minimum Monthly Charge is :	RM	1,000.00
7. Tariff ID3 – Medium Voltage Peak/Off-Peak Industrial Tariff		ID3
For each kilowatt of maximum demand per month during Peak Period	RM/kW	28.00
For all kWh during the Peak Period	Sen/kWh	28.6
For all kWh during the Off-Peak Period	Sen/kWh	18.0
The Minimum Monthly Charge is :	RM	1,000.00
8. Tariff PL – Street Lighting Tariff		PL
For all kWh (without maintenance)	Sen/kWh	20.3
For all kWh (including maintenance)	Sen/kWh	36.3
The Minimum Monthly Charge is :	RM	15.00

Appendic D AC Fan Specification

TYPE	DESCRIPTION
Model	DP200A 2123HSL
Size/Dimension LxHxW	120mm x 120mm x 38mm
Fan Type	Tubeaxial
Bearing Type	Sleeve
Air Flow	105.0 CFM (2.94m^3/min)
Voltage Rating	220 – 240VAC
Current Rating	0.110A
Power (Watts)	26.00W
RPM	2900RPM
Noise	48.0dB
Termination	2 Wire Leads
Material - Frame	Aluminium
Material - Blade	Polybutylene Terephthalate (PBT)