ENERGY USAGE IOT MONITORING SYSTEM FOR DOMESTIC TARIFF IN MALAYSIA

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This Report Is Submitted In Partial Fulfilment Of Requirements For The Bachelor Degree of Electronic Engineering (Computer Engineering)

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JUNE 2017

ABSTRACT

This project report aspires to help electric consumer in Malaysia to monitor electric usage and manage their electric usage wisely. This was conducted in order to develop a prototype of electric monitoring system with Internet of Things. This project will be use WemosD1 microcontroller to collect data and process calculation to get the data needed. The value of total electric usage and total cost of electric usage will be upload to cloud or server. The tariff calculation is according to Tenaga Nasional Berhad (TNB) which is Malaysia's electric utilities company. The power usage and total cost may be able to view or monitor by the consumer or user of this application in real-time via internet connection. The system will send notification to the user when the bill is exceeding the threshold that has been set. This notification will be send to the user email account and Blynk application. The usage of electric consumption also can be viewed in term of graph at Thingspeak's website. This may improve current system that only display power usage at the kWh meter in front of consumer house.

Keywords: Internet of things, WemosD1, Blynk, Thingspeak, monitoring system.

ABSTRAK

Karya ini bercita-cita untuk membantu pengguna elektrik di Malaysia untuk memantau penggunaan elektrik dan menguruskan penggunaan elektrik mereka dengan bijak. Kajian ini telah dijalankan dalam usaha untuk membangunkan prototaip sistem pemantauan elektrik dengan menggunakan *Internet of Things*. Projek ini akan menggunakan mikropengawal WemosD1 untuk mengumpul data dan prosess pengiraan untuk mendapatkan data yang diperlukan. Nilai jumlah penggunaan elektrik dan jumlah kos penggunaan elektrik akan dihantar ke pengkalan data internet.Pengiraan tariff adalah dengan mengikut tariff rate daripada Tenaga Nasional Berhad (TNB) yang merupakan syarikat utiliti elektrik di Malaysia. Penggunaan kuasa dan jumlah kos penggunaan elektrik dapat melihat atau memantau oleh pengguna projek ini dalam masa nyata melalui sambungan internet. Sistem ini akan menghantar pemberitahuan kepada pengguna apabila kos penggunaan telah melebehi had yang telah ditetapkan. Pemberitahuan ini akan dihantar ke akaun e-mel pengguna dan aplikasi Blynk. Kajian ini boleh meningkatkan sistem semasa yang hanya memaparkan penggunaan kuasa pada meter kWj di hadapan rumah pengguna.

Keywords: Internet of things, WemosD1, Blynk.

CHAPTER 1

INTRODUCTION

1.1 Project Overview

According to the recent study of Malaysia Energy Information Hub (MEIH), the electrical energy consumption in Malaysia have been increasing yearly [1]. This means, in this era of rapid advancement of technologies, electricity has become the most important source of energy for mankind. It is undeniable that electricity is the most important aspect in our lifestyle. The energy consumption efficiency in most buildings is unacceptable and the loss of substantial financial and gasses emitted by greenhouse which caused by this scenario can give a threat to the human society in terms of sustainable development. The electrical energy consumption in year 2000 was 5262 ktoe (61 Billion kWh) and rapidly increased until 2014 with a of total 11042 ktoe (128 Billion kWh) as shown in Table 1.1. The trend of increasing in the consumption of the electrical energy is shown in Figure 1.1. For the reasons, electric usage monitoring system is important to monitor so that there is no exceed usage of electricity .

Table 1.1: Energy Consumption in Malaysia from 2000 to 2014 [1]

Year	Final Electricity Consumption (ktoe)					
	Agriculture	Commercial	Transport	Industrial	Residential	Total
2000	0	1478	4	2805	975	5262
2001	0	1579	3	2930	1081	5593
2002	0	1698	4	3059	1161	5922
2003	0	1818	5	3242	1248	6313
2004	0	1979	5	3340	1319	6643
2005	0	2172	5	3371	1395	6943
2006	5	2272	5	3475	1514	7271
2007	16	2480	4	3587	1598	7685
2008	19	2598	15	3687	1668	7987
2009	21	2743	12	3719	1792	8287
2010	24	3020	18	3994	1937	8993
2011	26	3172	18	4045	1974	9235
2012	30	3325	21	4509	2126	10011
2013	32	3466	21	4809	2262	10590
2014	36	3566	22	5072	2346	11042

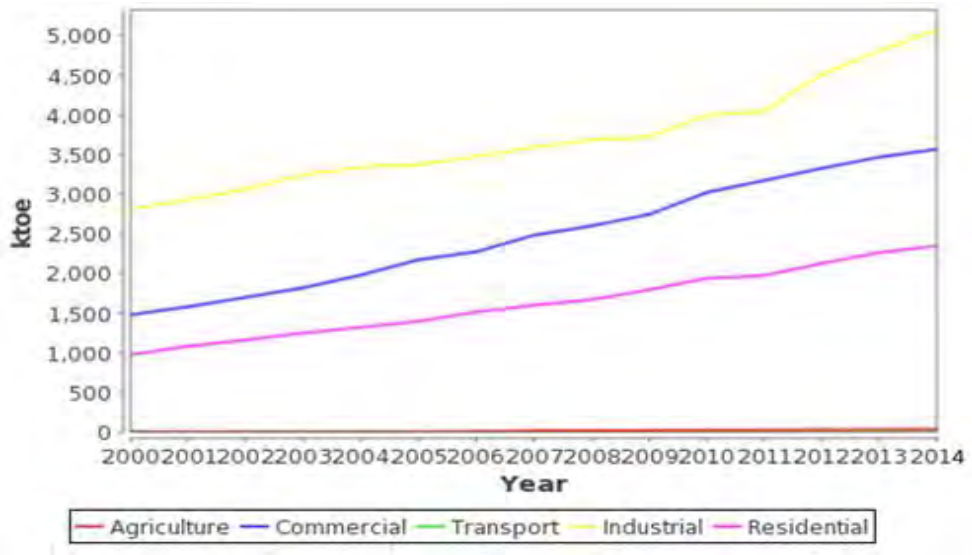

Figure 1.1 : Electrical energy consumption from year 2000 to year 2014[1]

The quick headway of innovations are developing winding up noticeably more progress and help individuals to have a superior life. The monitoring system may offers the vision of upgrading the effectiveness of power use. In the meantime, a powerful electric monitoring system utilization is relied upon to be exceedingly robotized, clever, intuitive, and have the capacity to bolster high level information communication technology (ICT) for data observation, conglomeration, accumulation and representation.

The Internet of Things (IoT) innovation has as of late procured an extensive consideration in the innovation and electric monitoring system looks into. It is a system comprises of items having characters, virtual identities working in shrewd spaces utilizing wise interfaces to associate and speak with the clients, social, and natural settings [2]. The abilities of IoT could assist this electric monitoring system with monitoring the utilization of power progressively. In view of these vitality and power related data, the utility could convey the suitable request side activities to the family units to bring down their power bills.

The important of managing power consumption brings the idea to develop a device that could monitor the usage of the electricity properly and help user to monitor in more efficient way. Calculating kilowatt-hour energy does not give any awareness to the user on how much power usage that they use, unless the total cost of the amount usage is shown as one of the parameter in managing the power consumption. Therefore in this project, an embedded system is designed using Microcontroller and a current transformer sensor. The WemosD1 will process the data collected by the sensor into valuable information such as kilowatt-hour, total cost according to the tariff, which in turn helps to monitor the power consumption. Users will be able to set their own threshold for their electrical energy usage.

The user may monitor the power consumption from their smartphones through Internet of things platform which is Blynk and Thingspeak. The data from the WemosD1 will send to cloud computing system by the help of Wi-Fi module ESP 8266. When the threshold is met, it will send notification alert to the user's

email and notify through the Blynk app. The idea of this project are develop by using the current technology which is IoT. The system is reasonable and can be easily implemented in all buildings in the country. The system also has the provide real-time monitoring of power usage. As this method, the information can be retrieve rapidly and help people managing their power usage.

1.2 Project objectives

The aim of this project is to improve current system. The objectives are as following:

1. To build an energy usage monitoring system that give real-time monitoring of power consumption and tariff calculation through internet server.
2. To design a prototype with control settings and indicators for household energy usage monitoring.
3. To implement Internet of Things (IoT) in the hardware and the system.

1.3 Problem statement

Electricity is an important thing these days as the technologies are growing and abundance of new gadgets are produce to make life easier. Therefore the power usage of a household can be increase day by day. The uncontrolled daily electricity consumption causes the monthly electricity bill to increase until the user did not realize that their electrical usage exceeds their budget. The electrical energy consumption is proportional to the usage of electricity, the higher usage of electricity leads to the higher bill costing. In addition, users are unable to determine their electricity usage in real-time and not being able to estimate how much amount of cost of current usage they have been use. The total cost of current usage will help the user to alter their lifestyle by controlling and minimising electrical energy consumption.

Cost of living is increasing and therefore people nowadays is focusing on reducing their bills and cut short of every expenses. Therefore, if focusing on

electrical energy bills, recently increasing in rate of tariff have hit Malaysian harshly and change our lifestyle. This is getting worse when El-nino phenomenon engulf Malaysia on early 2016. Usage of electrical energy is at its peak due to people using air-condition for a longer hour [3]. People have no idea how many unit kWh have they use daily or weekly and that will keep them on comfort zone until end of the month when they receive their high usage bills. That will cause them financial problem if it exceeded their budget.

Besides that, some user did not receive the bill receipt that should be mailed at the end of month. Sometime the bills are not send to the house or it might have been misplaced or the bill are not been mailed. This problem may leads to the late payment of the electric bills. Therefore this project may help the users to check their electricity bills and this will be more convenient for the utilities company rather than posting the bill to each house every month.

Therefore, it will be a huge change of game if there are a device that allow them to monitor their real-time electrical energy usage. Advance real-time monitoring system of electrical energy usage in addition with automated tariff calculation will help people to monitor their usage and avoid them from using it exceeding their budget. This will bring a very good impact to our society due to they can manage their monthly cash flow efficiently. Besides that it also help in reducing electrical energy overdue payment that usually cause by over budget usage.

1.4 Scope of project

This project will contributes in energy saving due to the consumer will be able to monitor their real-time power usage and allow them to change their usage pattern to minimize power consumption. Real-time energy consumption graph can be plotted and analyze in real-time therefore this will contribute for optimum power usage. Therefore in this project, WemosD1 microcontroller will be used as the

processor. This processor will be used to read and process the data from the current transformer.

The current transformer SCT-013-000 will measure the magnitude of current and it will send the data signal to the microcontroller. The current transformer can be operate and measure the current up to 100A maximum current and have a ratio of 100:0.05. It is very easy to use since it only requires users to clip on the device over the current carrying wire that need to be measure. Before the measured current send to WemosD1, the current will get through a potential divider. This potential divider is used to ensure a suitable voltage which is below 5v is fed into the WemosD1. Then, ESP8266 Wi-Fi module that is embedded into WemosD1 will give the processor access to the internet in order to send all the data to the server/cloud.

The cloud storage and the microcontroller is connected by using API key. The user of this electric monitor system may check their electrical usage through their smartphone and webpage. Blynk app and Thingspeak website are connected by their own unique API key that had been programed at the WemosD1. Besides that, the information also can be read at the Liquid Crystal Display module.

1.5 Project Methodology

This project is divided in two parts which is the hardware development and software development. The development of hardware project will be using microcontroller to collect data and also works as processor that will perform calculation to get real power P, apparent power S and reactive power Q and others. The hardware part will involves circuit design, circuit testing and troubleshooting and PCB fabrication.

Besides that, the software development part including for the application design and the setting of microcontroller. The data that we have collected will be send cloud or server. In order to complete the project prototype model, project

methodology is an important part which it shows the work procedure. Project methodology will created to make the time table for the overall project flow. Without this procedure, this project will not finish completely.

1.6 Report Structure

The report of this project is divided into five main chapters. There are Chapter 1, Chapter 2, Chapter 3, Chapter 4 and Chapter 5. Chapter 1 is an Introduction of this project. In this chapter, the explanation includes the project overview, the objective of project, problem statement, scope of work, and project methodology. Chapter 2 is about the background study. Literature review is an important thing in order to understand the background of the circuit regarding to my electronic project. It will covers the circuit theory and circuit design which is going to use in this project.

Chapter 3 is devoted to the Project Methodology. This chapter explains the procedures that have been done to complete this electronic project. It is include circuit design , construct the prototype, circuit testing and troubleshooting. Chapter 4 is about discourse about the Result and Discussion for this project. Prototypes that have been constructed at the previous chapter used to figure out the result of this project. The discussion from the results obtained is discussed in this chapter. Chapter 5 is about Conclusion and Future Recommendation. Conclusion has been made due to overall project. Future recommendation is upgrade that can be made to this project to make it more reliable.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The awareness on managing electrical energy consumption effectively is very important on this era. The electric utility company tariffs rate that is increasing depending on how much consumption in a month is to encourage consumer to use electrical energy wisely. This project helps in delivering the information of consumption to the consumer as to give ability to estimate bills from the collected information and thus manage their energy consumptions to reduce their electric bills[8 from pdf dev. This review will focus on low cost power monitoring system which is e-monitoring device. Implementation of internet of things (IoT) system in electrical energy monitoring system and method identifying electrical appliances will also be included in this review.

2.2 Electric Energy Meter

Electric energy meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically powered device where it is typically calibrated in billing units of kilowatt-hours (kWh). It is operate by continuously measuring the instantaneous voltage and current and finding the product of these to get the instantaneous electrical power (watts) which is then integrated against time to get the energy used [4][5].

There are two types of supply voltage from electrical provider, Single-phase and three-phase supply. A single-phase measures usage from a 240 volt supply through two wires while three-phase supply is supplied with 415 volts through four wires. These project will be more focus on the single-phase input first, rather than three phase input.

The electrical energy meters fall into two basic categories, electromechanical and electronic meter. Electromechanical meter is an analog type meter that operates by counting the revolutions of a non-magnetic metal disc which is made to rotate at a speed proportional to the power passing through the meter, while the electronic meter is a digital type meter that operates the input of loads, voltage, current and instantaneous time to a digital signal processing system and convert the energy to the pulse signal form [6][7].

However, both energy meters as described earlier cannot show the total bill and the energy usage (kWh) is hard to understand for user that are not familiar on reading the meter. This means, the meter are not user friendly because of it do not provide updated power consumption. The meter is only helping the consumer to calculate the electric usage.

2.3 Review of Previous Related Works

There are several research projects conducted related to this system where the electricity energy meter was developed digitally using several types of digital signal processor or microcontroller. The development of these products in research market shows the variety of system with different way of integrating digital energy meter based on the functions and application involved.

Sudin et. Al [4] presented the Digital Household Energy Meter, where this product consist of a digital electrical pricing system which composed of a communication system that upload usage data from the meter to a central computer for data processing. The display panel is using computer interfaces developed using Visual Basic software that connected via RS-232 communication cable to MK-6 Genius, a type of digital energy meter. However, this proposed idea is not a hardware because only the simulation of the amount cost are calculated internally by using software interfaces.

Meanwhile, Eng [7] produced a device called Cost Monitoring Digital Power Meter which is calculating the electrical energy and convert into cost. It uses the PIC 16F877A microcontroller as the main component to interface the input and output. Input of the system is voltage from the supply, current from the load, and time taken for the device running, while the output is LCD display and LED indicator. The 240 volts AC Voltage is being reduced using step down transformer. The measurement of this device is using Energy Meter Chip that integrates the voltage and current together before the outputs of the integrated circuit goes to the PIC microcontroller and produce the output in the form of pulses. This system has a problem which it is not really accurate as the real energy meter did. Based on the report, the transformer used in this system resulting the high percentage of loss voltage while the input being stepped down.

Another research that are using the concept of converting the power consumption to the microcontroller is Smart Energy Meter [8] where the system is

producing the amount cost of current electricity usage to the LCD display. This system is using 16F62A PIC Microcontroller, the output from Energy Metering IC ADE7756AN is being processed to produce output of energy. This type of IC is connected to the microcontroller via a serial interface port. The LCD display shows information includes the elapsed time, power consumption in watts, and energy consumption in kilowatt-hours.

The almost similar concept to this project is Internet of Things based Smart Electricity Meters [9]. The smart electricity meters will produce the amount of power usage and send it to the website. This smart electricity meters are creating the network in the residential area by using wired connection. The smart meter able to communicate to the utility providers, it sends the data read from the meter to the server of the analyzer and receive the operational response. Moreover, this project need of a communication system that highly reliable and secure to transfer high volume of data. It is able to collect the data from the local smart meters in the network and send it to the authorities concerned for it. However, this system is not showing the calculated amount of power consumption basically the system is more helping the provider on collecting the data of the power consumption.

Table 2.1 : Review Of Previous Related Work

Title/Author/Year	Method	Hardware/Software tools	Improvement/ Suggestion
N. Sudin [4]	Digital electrical pricing system which composed of a communication system that upload usage data from the meter to a central computer for data processing.	1. MK-6 Genius 2. RS-232 communication cable 3. Visual basic	1. No hardware and it is just using software. 2. Simulation of the amount cost are calculate internally using software interface
L. S. Eng [7]	These projects need to step down the voltage before it been integrated with the energy meter chip to produce the pulse and process to calculate the usage and cost.	1. LCD display 2. PIC 16F877A microcontroller 3. Step down transformer. 4. Energy Meter Chip	1. Not really accurate 2. High percentage of loss voltage due to the stepped down transformer
K. A. Mohammed [8]	These projects use the concept 'Pay first use later'. Users have to pay first and the bill amount remaining will in the meter gradually decreases as he uses electricity.	1. LCD display 2. PIC 6F62A microcontroller 3. Energy Metering IC ADE7756AN	1. Not very efficient as it only display the output on the LCD module. 2. Can be improved by adding IoT to the system.
S. Rastogi [9]	This project is almost similar because it implements IoT but this project will create a network of the entire resident electric meter.	1. Server: collected information 2. PLC Modem 3. IRM: an interface between PLCs and Server	1. High cost 2. Need large server memory. 3. Only show the amount usage not the total cost.

2.4 Energy Calculation

Electric energy is the presence and flow of an electric charge and newly derived from electrical potential energy [10]. The electric energy is basically derived from the power that consumed in a unit of time. The unit of electric energy is kilowatt-hours. Based on the formula 2.3.1 below, to calculate the electric energy the electric power should be define first.

$$Energy = Power\ x\ Time\ ;\ unit\ kWh \quad (2.1)$$

The electric power is the rate at which electric energy is transferred by an electric circuit where the unit is watt or one joule per second [3]. The derivation of formula power is basically used the parameter voltage, current and power factor. The formula of power is defined as formula 2.3.2 and 2.3.3 :

$$Power = Voltage\ x\ Current\ x\ Power\ Factor \quad (2.2)$$

$$P = V\ I\ (cos\ \ )\ ;\ unit\ Watt \quad (2.3)$$

Power Factor is an index or rated used to compute the efficiency level of electricity usage. In AC electrical power system, the power factor is defined as the ratio of the real power flowing to the load to the apparent power in an electrical circuit [3]. The index is measured from 0 to 1. A higher index of power factor shows the efficient usage of electricity and vice versa. Low power factor will shortens the lifespan of electrical appliances and causes power system losses to the energy supplied from the electric energy provider. The understanding of power factor calculation and theory is based on the three basic terms of power; (i) Real Power, (ii) Reactive Power, and (iii) Apparent Power.

2.5 Tariff Rates based on Tenaga Nasional Berhad (TNB)

TNB is the largest utility company in Malaysia that responsible on the peninsular Malaysia electricity generation, transmission and distribution. The other national utility provider in Malaysia is Sabah Electricity Sdn Bhd which handling the Sabah electricity and Sarawak Energy Bhd for Sarawak. The reason TNB is chosen as the reference electrical energy provider for this integrated Electricity Cost Calculator Meter project is since the location where the project is executing and run is under TNB electricity territory. As TNB is chosen, the electricity tariff rates, system and law that related to this project are accordance to their determination.

There are two classification consumer by TNB; residential and business consumer. Since this project is focusing on the residential consumer, the system built is also accordance to the residential system and tariff rates. The tariff rates for the actual meter reading are as the Table 2.1:

Table 2.2 : Tenaga Nasional Berhad Domestic Consumer Tariff Rates.

TARIFF CATEGORY	**RATES/UNIT**
First 1 – 200 kWh	RM 0.218 / kWh
Next 201 – 300 kWh	RM 0.334 / kWh
Next 301 – 400 kWh	RM 0.40 / kWh
Next 401 – 500 kWh	RM 0.402 / kWh
Next 501 – 600 kWh	RM 0.416 / kWh
Next 601 – 700 kWh	RM 0.426 / kWh
Next 701 – 800 kWh	RM 0.437 / kWh
Next 801 – 900 kWh	RM 0.453 / kWh
Next 901 kWh onwards	RM 0.454 / kWh

2.6 Low cost power monitoring system

Every year, cost of living is increasing and therefore people are focusing more on reducing their bills and cutting short every expenses. Installing power monitoring system is one of the way in helping reducing the electrical energy consumption. However, power monitoring instruments are well known for its complexity and its expensive cost. Therefore, people will be reluctant on spending huge portion of their monthly budget to install this power monitoring system in their house even though it will help in reducing electrical energy consumption. There are a few factor that cause this power monitoring system to be expensive which is [11]:

1. The cost of developing the instruments
2. The quantity of instruments produced
3. The cost of manufacturing the instruments
4. The cost of installation
5. The cost of supporting the instruments, especially the cost of supporting special purpose software, throughout the life of the instruments.

In the last few years, most of all of the cost listed above have been driven down simultaneously. This is because the traditional power monitoring instrument is built as a special purpose instruments. All its hardware, firmware and software have been developed specifically for this instrument. Currently, rapid development of digital signal processor have caused the price to drop far from usual. New digital signal processors are inexpensive and have built-in analog-to-digital and digital-to-analog conversion. Besides that, it also operate in minimal power [11]. This low cost processor greatly helps in reducing the cost of developing an electrical energy monitoring instrument. ATmega8 microcontroller is commonly use in developing a low cost project. This ATmega8 microcontroller is also commonly known as Arduino microcontroller. Many papers have been published with a design of low cost electrical energy monitoring system built using Atmega8 microcontroller such as in [12] and [13]. Below in Figure 2.1 shows one of the design of electrical energy monitoring system that have been proposed in [13].

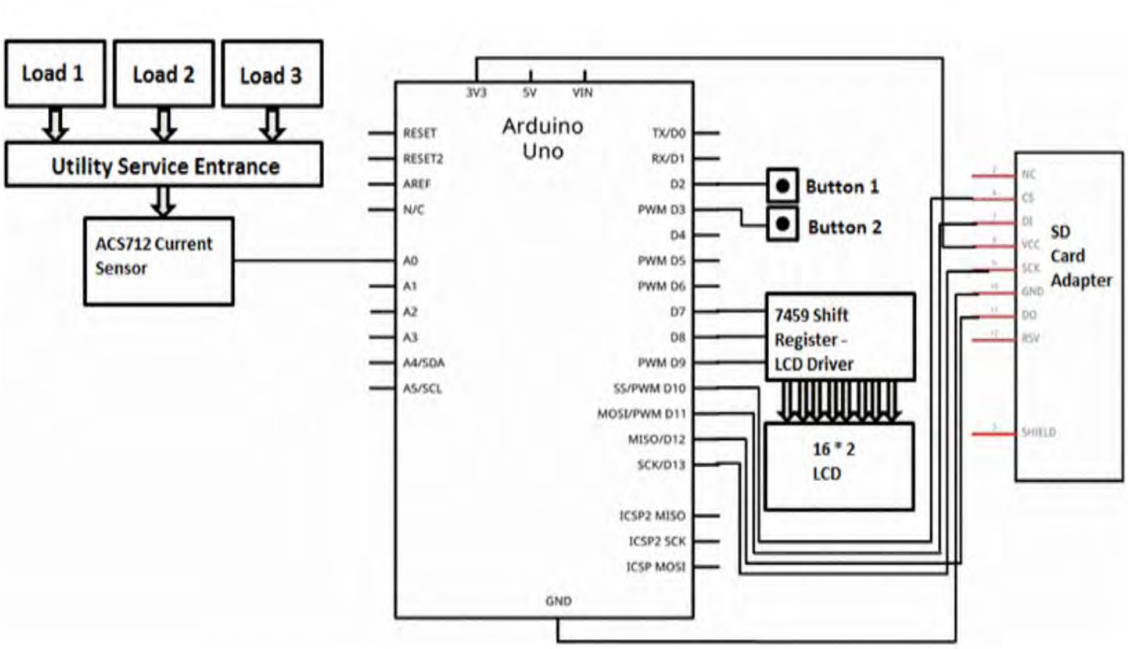

Figure 2.1: Electrical energy monitoring system schematic [13]

Microcontroller that is used in this project is WemosD1. This microcontroller is small in size and also is a powerful processor. In this project it is used as a processor and data acquisition device. The system that is developed will be able to obtain the following data:

a) RMS Voltage
b) RMS Current
c) Apparent power
d) Real power
e) Reactive power
f) Power factor

All this data is used to monitor the electrical power consumption of a residence. This data is displayed on an LCD and also can be displayed on a laptop via cable. Short range application which transmits data to smartphones using Bluetooth is also a convenient way for users to monitor their power consumption.

2.7 Component Selection

The study of this project includes in researching suitable components used for this project. this study is focused on main components that contribute to the major process of developing circuit.

2.7.1 Microcontroller

The Arduino board is reasonable and economical if contrasted with other microcontroller. The least expensive adaptation of the Arduino module can be amassed by hand, and even the pre-gathered Arduino modules cost not as much as MYR 60. Other than that's, the Arduino board can cross platform where is the Arduino programming can keeps running on Windows, Macintosh OSX, and Linux working frameworks. It can work in different operating system however the most of microcontroller system are constrained to Windows. Other than that, Arduino additionally make an easier the way toward working with microcontroller, it also give some advantage to instructor and intrigue beginners over other systems.

This programming of the Arduino is clear and simple programming environment. The Arduino programming is easy to use even for beginners, and it flexible enough for advanced users to take advantage. For instructors, it is conveniently based on the Processing programming environment for teaching, so students learning to program in that environment will be familiar with the look and feel of Arduino. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it.

Figure 2.2 : Wemos D1

Wemos D1 as in Figure 2.2 is a microcontroller that almost similar than Arduino Uno. This board are using Arduino IDE for the programming part. This board have 11 digital input output pins. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. This Wemos are more advance than Arduino Uno because it have wifi module that are already embedded to it.

2.7.2 Wifi Module

Figure 2.3: ESP8266 Wi-Fi module

The ESP8266 Wi-Fi Module as in Figure 2.3 is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266

module comes pre-programmed with an AT command set firmware that can simply hook this up to the Arduino device and get about as much WiFi-ability. The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

2.7.3 AC Current Sensor

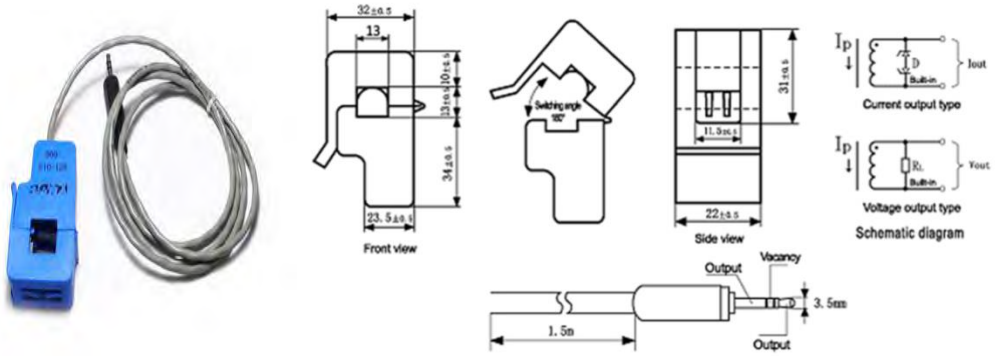

Figure 2.4: Current Transformer and it schematic design.

There is a lot of current sensors and one of the sensors that measure alternating current is Current Transformers (CTs). These CTs are for all intents and purposes valuable for measuring entire building power utilization or generation. As in Figure 2.4 above, the split core type is especially reasonable for DIY utilize. This is on account of it can be clipped onto either the live or unbiased wire coming into the building, without the need to do any high voltage electrical work.

This current transformer resembles some other transformer. It has an essential winding, an magnetic core and an secondary winding. For the situation to gauge entire building observing, the primary winding of this CTs where live or neutral wire coming into it or which is gone through the opening in the CT and the secondary winding is made of many turns of fine wire housed inside the transformer case.

Magnetic field in the core are produce when the alternating current flowing in the primary winding. At that point, it will induces a current in the second winding circuit. The current in the secondary winding is proportional to the current streaming in the primary winding :

$$Isecondary = CTturnsRatio \times Iprimary \quad (2.4)$$

$$CTturnsRatio = TurnsPrimary/TurnsSecondary \quad (2.5)$$

2.8 Internet of Things (IoT) and ThingSpeak™

Internet of Things (IoT) is a major focus in development scope in this era. Explosion of data and connection is occurring in this era of digital economy. IoT is defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual things have identities, physical attributes and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network [14].

However in this era, the definition of IoT has been changed in parallel with the evolution of technology. The definition of IoT is implied as the use of computers to detect information without the use of human beings, not only focusing on sensing information from the environment but also using the internet as standard service for transferring information, analysing information, application and communications [14]. Development of IoT leads to advancement of cloud computing, robotics and increasing the capabilities of the internet.

ThingsSpeak™ is a free web service that offers free platform to gather and store data in the cloud. This cloud is the instrument used for interconnection of physical electronic devices such as sensors, and microcontrollers to the Internet. Registration as a user is required in order to use this cloud service. The user will be given a channel to display and monitor the data they harvest from the sensor. This is a public access channel which allows other users to read the data that we have obtained. Figure 2.5 shows the IoT system module of ThingSpeak™ application and Figure 2.6 shows the implementation of the PC application [14].