UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF SMART DOMESTIC ELECTRICITY MONITORING SYSTEM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DEVELOPMENT OF SMART DOMESTIC ELECTRICITY MONITORING SYSTEM**

SESI PENGAJIAN: **2016/17 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor Electronic Engineering Technology (Bachelor's Degree in Electronics Engineering Technology (Industrial Electronic) with Honours) (Hons.)

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(WAN NORHISYAM BIN ABD RASHID)

ABSTRAK

Tujuan projek ini adalah untuk membagunkan dan mencipta satu Sistem Pemantauan Elektrik Domestik Pintar berasakan kuasa teknologi rangkaian, Arduino Yun mikropengawal, Google Spreadsheet dan Aplikasi Android. Tujuan system ini adalah untuk memantau penggunaan elektrik di dalam talian. Aplikasi telefon pintar membolehkan pengguna untuk memantau pengunaan elektrik dengan meghidukan Bluetooth dan disambungkan pada system. Penyimpanan maya membolehkan pengguna untuk memantau penggunaan elektrik dan trend dengan menggunakan Google Spreadsheet. System ini juaga boleh memantau luar talian degan memaparkan penggunaan pada paparan LCD. Sistem ini akan mengira bil berdasarkan tariff Tenaga Nasional Berhad(TNB). Sistem ini adalah dibangunkan untuk meningkatkan kesedaran tentang pembaziran elektrik.

ABSTRACT

The purpose of the project is to develop a Smart Domestic Electricity Monitoring System based empowered by networking technology, Arduino Yun microcontroller, Google Spreadsheet and Android application. The purpose of this system is to monitor the electricity consumption online. Smartphone Android application allows the users to monitor the electric consumption by turning on Bluetooth and connected to the system. The cloud storage allows the users to monitor electricity usage and trend by using Google Spreadsheet. This system also can monitor offline by displaying the usage on the LCD Display. The system will calculate the billing based on the Tenaga Nasional Berhad (TNB) tariff. This system is develop to increase the awareness about the wasting the electricity.

DEDICATION

Alhamdullilah, praise to the Almighty Allah S.W.T.

I dedicate this thesis to my beloved parents, for supporting me to complete this project.

Othman Bin Hassan, and Ruhani Binti Mohamed.

To my Supevisor that guidance and providing helps

En Wan Norhisyam Bin Abd. Rashid.

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Bismillahirahmanirahim,
In the name of Allah S.W.T, the most compassionate and the most merciful.

Firstly, thanks to Allah S.W.T because giving me a good health, huge courage and strength to complete this final project.

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I would like to extend my sincere to my family that's keep supporting, blessing and prays for me, and friend who has assisted and share the ideas to complete this thesis.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST OF ABREVIATION,SYMBOLS AND NOMENCLATURE

Wi-Fi	-	Wireless Fidelity
TNB	-	Tenaga Nasional Berhad
SoP	-	Standart of Procedure
IPP	-	Independent Power Procedure
kWh	-	kilowatthour
CO2	-	carbon dioxide
LCD	-	Liquid Crystal Display
Irms	-	Current root mean square
SoC	-	Small Computer
RAM	-	Random Access Memory
ROM	-	Read Only Memory
OTP	-	One Time Password
CT	-	Current Transformer
AMR	-	Automatic Reading System
SMS	-	Short Message Service
GSM	-	Global System for Mobile Communication
ADC	-	Analog Digital Converter
TCP/IP	-	Transmission Control Protocol/ Internet Protocol
USB	-	Universal Serial Bus
LED	-	Light Emmiting Diode
OS	-	Operating System

App	-	Application
HTML	-	Hyper Text Markup Language
IDE	-	Integrated Development Enviroment
ICSP	-	In-Circuit Serial Programming
URL	-	Uniform Research Identifier
AC	-	Alternating Current
DB	-	Decibel
ICT	-	Information and Communication Technology
IoT	-	Internet of Things

CHAPTER 1
INTRODUCTION

1.0 Overview

This chapter explains briefly about The Smart Domestic Electricity Monitoring System project. This chapter exists a background of study, problem statement, objective and scope.

1.1 Background

The Smart Domestic Electricity Monitoring System are to allow user to check the electricity consumption and billing based on TNB tariff. The system can be monitor through liquid crystal display (LCD) that accompanied together with the device. In others way, the system also can be monitor online by using Google Spread Sheet (email account) and Bluetooth on Android application. This project is divided into three sections;

i. Sensor ;
ii. Microcontroller ;and
iii. Monitor.

When the Microcontroller receives the signal from the sensor, it will calculate the data and be on display at LCD. At the same time, the data itself will transmit to Google account and Android Application via Bluetooth.

Wi-Fi is a highly created correspondence standard and it is broadly acknowledged by the technologies. This Wi-Fi technology easiers the extension to others application, which possibly to interfacing with sensors to monitor the electricity (Sanchez et al. 2014). Remote information, correspondence systems give lessened costs, better power management, easier upkeep and easy organization in remote and difficult to-achieve regions (Manfredi 2012). Notwithstanding the quick improvement of science and innovation, particularly the broad use of advanced mobile phones with Bluetooth remote innovation, by using Arduino HC 06 Bluetooth module with smartphone together, it have ability to make communication process the data then form the wireless monitoring system based on Bluetooth Smartphone and apps (Society et al. 2010). The most important is this device will increase the public awareness about energy saving. This device also will alert the user when it reaches the point of electricity uses or limit bill amount (limitation will be set by user). By monitors the electricity usage its leads to a significant cost reduction and to a reasonable administration of vitality asset valuable for nature (Sanchez et al. 2014).

1.2 Problem Statement

Electricity is the most demanded necessities for human nowadays. The worldwide utilizations of electricity have been progressing quickly and the industries started using a lot of power in lighting house, air conditioning and creating energy to all different innovations that require electricity (Ahmad 2014). On 9 March 2016, power utilization ranges to the most noteworthy in peninsular Malaysia, with Tenaga Nasional Berhad (TNB) recording an unequaled high pinnacle request of 17,175MW by The Star Online. From this statement its show that is was difficult for the users to know the electricity usage and updated bill charges. Wasteful and inefficient energy consumption

can result in environmental externalities in the forms of acid rain and global warming, which today has ended up vital worldwide concerns (Ahmad 2014).

Therefore, the mounting of the meter is high that distress the user to monitor the electricity usage and it depends on the TNB Standard of Procedure (SoP) to install the metering. The meter reading display in kWh per hour also gives difficulties to user that need to calculate in Ringgit Malaysia and knows the trend of usage. The electrivity cost relies on upon Fuel costs (e.gz gas, coal, and different sorts of energizes used by the generators). Independent Power Producers (IPP) and TNB generators control the pricing. Industry get the supply of the electricity from this company.(e.g. transmission and dispersion arrange, sub-stations, control focuses and control plants) .The price is known as tariff price depends on the usage of the power in kWh.

In other hand for example the business such as "Guest House", the owner facing problem to impose bill amount suitable with daily usage because of some rental not turn off their air-conditioner and television 24 hours. Other than that, the rising of households for quarters, dormitories and rental house especially for student hard to calculate and control the daily usage of electricity. This has suggestions both for the arrangement of fitting lodging and for energy use in homes. Without enhancing the energy productivity of homes, or the ways individuals utilize energy at home, development in family unit numbers and littler normal family unit size would prompt to higher per capita energy utilize. In Malaysia, the domestic area has been viewed by researchers as an important target group for energy management. The energy use of the residential sector represents around 15% of that devoured by all sector, energy consumption in the household segment has turned out to be critical on the grounds that the expansion of energy consumption will go about as a noteworthy danger to the maintainability where it will expand the CO2, and will create major worldwide issues like nursery gas impact, ozone layer exhaustion and corrosive rain (Siti et al. 2015) .

The most common reason why the energy conservation is high is the user didn't alert when the usage of electricity high. Family members or household need to learn about how to save energy and also need to be uncover on how to use energy efficiently, the users must find the alternative to decrease energy consumption for example by using technology (Siti et al. 2015).

1.3 Objective

1. To design device that can measure electricity usage.
2. To design the computing, data transfer between microcontrollers to Android Apps by Bluetooth.
3. To send the trend and data in LCD monitor, Android Apps and Google spreadsheet.
4. To integrate all circuits to become the complete monitoring system.

1.5 Scope

Display power consumption and bill amount.

The current clamp sensor will measure electrical load and generate output that. This sensor will measure the current flow through it. The winding current act as and react to the magnetic field around the sensor, that carrying conductor. Therefore, the data will send to microcontroller and produce an output (display) for the user. It will display power consumption and bill amount by setting the calculation and instruction in the microcontroller.

Display the output from the smartphone Google spreadsheet, Android Apps and LCD display.

Arduino Yun is an open-source prototyping and programming platform. Its can connect the hardware and software to become a complete system. Arduino yun microcontrollers can read inputs from the current sensor and turn it into digital input to monitor as output by using monitoring system. The system will compute a set of instructions on the board the microcontroller and will run the process based on programming. Arduino Yun allows

Wi-Fi communication, by using this microcontroller it will send the data that generated from the programming to the Google spreadsheet.

Bluetooth is a popular method of communication between devices. Smartphones have the capability to communicate using Bluetooth. So this system will monitor by the Smartphone Apps. Bluetooth terminal is a based application to monitor the data and Bluetooth module as a device to send the data.

Transmit power consumption bill through google account.

After microcontroller receive the data, it calculates the current usage and bill by following the instruction to be set in the microcontroller then the set of data are sent to the LCD monitor, Android Apps, and Google Spreadsheet.

Calculate tariff and usage.

After the sensor detects the current Irms(A) the value of Irms(A), the power consumption is calculated by using the calculation provided by Tenaga Nasional Berhad.

1.6 Conclusion

To conclude this project report consists of five major chapters. This chapter gives general overview of the entire project. It explains the synopsis of the project. It discusses more on the objective, scope, applications and advantage of this project.

The next chapter is literature review, the theory that will be discusses from the related research Development of Smart Domestic Electricity Monitoring System to get idea for complete this project to be complete monitoring system. The methodology and procedures applied in the project are clarified in detail in Chapter 3. This chapter also discusses theory of the element uses in this project.

CHAPTER 2
LITERATURE REVIEW

2.0 Overview

This chapter literature review was about summarized the whole of the project to obtain the realistic information for this project. The main sources for this project are previous projects carried out by engineers and other sources such as books, journals, articles and other reliable sources related to this project. This chapter also explains about related research which being conducted from previous projects.

2.1 Introduction to Monitoring System

Monitoring is the regular observing and recording of actions and reaction taking place in a system. It is a process of routinely gathering information on all aspects of the project. The overall system needs to monitor several kinds of data. The data can divide into two kinds; they are 1) the analog signal and 2) the digital signal. From the study many of the implemented systems and projects of smart monitoring for electricity are focus on measuring the total amount of energy consumption or electricity at a home. The system communication based on data exchange (Kim et al. 2011).

2.1.1 Variant of Electricity Monitoring System

Recent research shows that the main component of this system is microcontroller and act as brain of the system. A microcontroller is very basically simple. It contain small computer (SoC) on a single integrated circuit containing a processor, memory, converters, timers and programmable input/output peripherals. The program of a memory is in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in dissimilarity to the microprocessors used in personal computers or other general drive applications that contain various discrete chips.

Then the current sensor will collect and measure the value current flow. Fundamentally, there are two sorts of current detecting technique which is invasive and non-invasive. From the study of invasive system, the sensor is straight forwardly associated into the mains. Some common invasive current sensors are one-axis Hall Effect sensor, a simple inductor with a high inductance value, resistor, solid core CT and so forth. From the non- invasive method, direct association with the mains is stay away from. Some non-invasive sensors are split core current transformer, Hall effect sensor and so forth (Guimarães et al. 2015).A Hall effect sensor is a transducers that varies its output voltage in response to a magnetic field. The advantage of this sensor it can be used as proximity switches, speed detection, positioning, and current sensing application. The working principle of this sensor its operates as analog traducer and directly turning it to the voltage. The distance from the Hall plate can be determine by knowing the magnetic field. The relative position of the magnet can be deduced by using a group of sensors (Paun et al. 2013).Current transformers sensor are devices used to measure the large primary currents to a smaller.

2.2 Previous Related Project

Since 20th century there are many developments of the electricity monitoring system. Basically, smart online electricity monitoring system refers to intelligent communication between the monitor with sensor. Sub topic 2.2.2.1 to 2.2.2.5 shows that the previous research of the electricity monitoring system.

2.2.1 Design and Development of GSM based Energy Meter

This project present of plan and improvement of Automatic meter perusing (AMR) framework. Amr framework is a blast for remote checking and control residential energy meter. The AMR framework give the data of meter perusing, control cut, add up to stack utilized, control disengage and treating the demand or frequently in specific interim through SMS. This data being sent and got by the concerned energy company provider with the assistance of Global framework for versatile correspondence(GSM) organize. Energy provider receive the meter reading within a second without going on individual. Microcontroller At89s52 is used for controlling of complete AMR system and GSM module. AMR minimize the quantity of conventional visits required by employs of energy provider company. This framework decrease the work cost,, but also increase the meter reading accuracy and save time.

2.2.2 Real-time Energy Monitoring and Controlling System based on ZigBee Sensor Networks

This project proposed an energy management and controlling system. Based odf this project is wireless sensor network. The proposed of this projects is compose of two main parts, which is wireless sensor network and intelligent home gateway.

Remote sensors are utilized for detecting and transmitting power information and remote observing and control of home appliance are enable user to save energy by monitoring, controlling and managing home appliance thought web and cell phones. A smart grid measures and read the usage of electricity, remotely using smart meter and the communication organize network. Sensor measure the actual power usage, send the information and the on/off status of electronic yields to the information processing module via the ZigBee communication protocol. Therefore, the information processing module will receive the energy consumption and status. the This system will save the information. The information waiting the user to request for monitoring the status and power usage information ACS712 sensor is a hall effect based sensor to measure AC and control power outlets. This sensor is universal from home appliances or electronic product. A wireless sensor in this system contain of three main part which is controller with Analog to Digital converter, ZigBee transceiver, and sensing unit of information data processing module. It receives the data of the electricity usage from each sensor through ZigBee interface. Then this system will stores the information in the data based and respond the request by the user. When the web service receive the user request and transfers the to the sub technical component. The data of the instantaneous electricity consumption is showed in the monitoring package.

2.2.3 DEHEMS: A User-Driven Domestic Energy Monitoring System

This project is building DEHEMS. Its provide large energy monitoring system. This system contain three phase of cycle design which is development, usability and environmental awareness. The purpose of this system is to integrate and test the effectiveness of innovative influential ways delivered by future electronic system. Its able to infer and reason the energy behavior of the user.

This system cycle 1 focus in design DEHEMS home infrastructure and the consumer interface. A sensor usage manufactured by current transformer 433MHz

FM radio is clamped on the main circuit. The process of induction, outputs a sensor reading current onto Analog to Digital converter. For the determination of the data collection and keeping sensors within the home lean on processing power, memory and is abilities. The DEHEMS gateway is built that compromises the data observation mechanism and data aggregation fuction for processing the information receive from the sensor. The external communication module uses TCP/IP to interfacing with DEHEMS server by the home broadband router. The gateway was implemented on a router base that contain Ethernet ports, USB and serial header for the insertion of radio receiver (433MHz). The data obtain by the Gateway are send to the Web Service and attribute to the user at the server.

This system cycle two is tide the sensors to the appliances for example water heater, television and others. Therefore, its transmits electricity measurement via ZigBee Gateway. The ZigBee ia a connect to the network until get the USB receiver interfaces through the USB port on the side of Gateway.

2.2.4 Smart Energy Monitoring System with ADE7758 IC

This project is about the implementing the smart energy system incorporating features monitoring energy parameter of equip and perform real time energy monitoring, power factor and alerts the user when the system detect overvoltage and overcurrent. This system uses the ADE7758IC or as kwon as ATmega16 microcontroller. This research based on the development of monitoring and protection appliance for residential and industrial electric installation that will bringing together in a single device diagnostic of electrical variables and protection on supported device. This system monitoring system consist of integrated circuit (IC) ADE7758 which is powerful energy meter, low cost and able to interfacing with ATmega16 microcontroller. The ADE7758 is high accuracy three phase electrical energy measurement with a serial interface. The component chip has 24pin SOIC-W package. ADE7758 comes with digital integrator, reference source

and temperature sensitive elements. It has signal processing circuit which is can be used to measure the active power, reactive power apparent power, RMS calculation and error in the system in the digital form. This chip is very suitable for a variety of three phase circuits or four wire. The voltage signal by the reaction of amplification and analog to digital converter (ADC) is change to corresponding digital signal. The instantaneous power obtained by multiplying current and voltage signals. This system has differential inputs which is three input for the current sensing and three inputs for the voltage measurement. Data is obtain from the ADE 7758 via the SPI serial interface. Arduino is the microcontroller that acts as brain of the main device. The arduino will set the ADE7758 system from stimulation, data register configuration, data storage and data access. The current sensor used in this project is split core type. The sensor is non-invasive AC current sensor that can measured the maximum current value of 10A and the secondary of the current transformers outputs a maximum voltage of 100V

2.2.5 Energy Monitoring System using Sensor Networks in Residential Houses

This project is about Home Energy Management System (HEMS) which is integrates sensors and home appliance in a residential house through a home-based network. Energy monitoring system based on the home networks have been estimated as future energy saving and management solution. The system aggregates the energy consumption statistic for home appliance and visualizes it into understandable form. From the visualization the fine grained data enable the user to understand the details of their energy consumption and tend of the usage. The special sensor nodes are used to monitor the energy consumption of appliances. The researcher called the sensor smart power strips nodes. A smart power strip node measure the energy consumption of the connected appliance and send the measured value to the sink node. Fine-grained data are required to conduct a complete analysis of the energy uses. Likewise, a low power remote correspondence

innovation is required to decrease the upkeep expenses of these hubs. The smart power strip nodes can quantify the vitality utilization of an associated apparatus consistently. There must be many solicitations from the visualization component. In order to instantly to various request, the data save parts has to compose the deliberate information to the DB proper form. The visualization shows the residents several charts of the saved information. These diagrams need to indicate the present values as well as the past ones.

2.3 Advantage and Disadvantage Of Related Project

Table 2.1 : Advantage And Disadvantage of Related Project From Literature Review

Related Project	Description of project	Advantage	Disadvantage
Design and Development of GSM based Energy Meter(Kedia 2012)	Development of an automatic meter reading (AMR) system to give statistics of meter reading, power cut, total load use and power cut off.	The information sent to user by SMS(GSM Network) Accurate meter reading	The information can sent to single user at once time GSM not suitable now Its need cost to send SMS
Real-time Energy Monitoring and Controlling System based on ZigBee Sensor Networks(Kim et al. 2011)	Energy management system based on wireless sensor network	Wireless sensor are used for detect and transmit the electricity data. Have home intelligent gateway for monitor and control home appliance	Only show on and off status of appliance Not calculate the current usage (only show overall) Not provide statistical analysis Not alert the user

DEHEMS: A User-Driven Domestic Energy Monitoring System(Sundramoorthy et al. 2010)	This project develop DEHEMS, a large scale energy monitoring system. Its can help assist energy literacy and environmental responsiveness	It can monitor energy use for appliance use It use transmitter frequency 433MHz to send the data to DEHEMS gateway.	The monitor only suitable for PC only. User cannot monitor and control via smartphone The range between DEHEMS gateway with transmitter is limited
Smart Energy Monitoring System with ADE7758 IC(Guimarães et al. 2015)	Development of monitoring energy parameter of equipment. Real time energy monitoring, power factor and alert against overvoltage and overcurrent	Real time monitoring energy parameter It uses ADE7758 meter IC for three phase measurement	Not monitoring online, only monitor on LCD display.
Energy Monitoring System using Sensor Networks in Residential Houses(Hashizume et al. 2012)	This project proposed a home energy monitoring system using sensor network	Data energy use can monitor visual online(Web Interface) Connected to appliance	Only display on web

2.4 Propose of Smart Online Domestic Electricity Monitoring System

This project proposed is to monitor online electricity consumption. Online means the users can monitor the energy use by Google Spreadsheet, Smartphone and also offline on LCD display. Rapid changes in the digital world through the Internet and information and communication technology (ICT) , generation of innovators need to be trained and equipped with 21st century skills such as digital learning , effective communication , technology and problem solving. The purpose of this project related to the Internet of things. The internet of things or as kwon as (IoT) is the network or communication od physical objects such as device, vehicles, structure and other things connected with electronic, sensor, software and network connectivity that allows these objects to gather and exchange data. The internet of things enable the objects to be sensed and controlled remotely across existing network infrastructure, produce chance for more direct integration of the physical world into computer based syste, and resulting in upgraded efficiency, accuracy and economic benefit. This things is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet organization. (Anon n.d.).

From understanding the literature review of others related project, this project will used microcontroller Arduino Yun, this is because the major advantage of this microcontroller is it consist of built in Wi-Fi (IEEE 801..11b/g/n) support, USB port, memory micro SD card slot ,three reset button, serial programming header,16 MHz oscillator, 20 digital input or output pin and 12 Analog input channels. (Sedhumadhavan & Saraladevi 2014).

2.5 Tenaga Nasional Berhad Tariff Rate

Domestic consumer means a consumer occupying a private residence, which is not use as any form of business, trade, professional activities, industries or service.

Tariff means the price of the power consumption that provide by Tenaga Nasional Berhad (TNB) for the electric use in kilowatt-hour (kWh). From 1st January 2014 the table bellows show the pricing tariff from TNB.

Table 2.2 : Tariff Rate For The Domestic Consumer

	TARIFF CATEGORY	UNIT	CURRENT RATE (1 JAN 2014)
	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
1.	For the next 300 kWh (301 - 600 kWh) per month	sen/kWh	51.60
	For the next 300 kWh (601 - 900 kWh) per month	sen/kWh	54.60
	For the next kWh (901 kWh onwards) per month	sen/kWh	57.10
	The minimum monthly charge is RM3.00		

CHAPTER 3
METHODOLOGY

3.0 Introduction to Methodology

There are an exhaustive arrangement in composing this strategy that incorporates finding an appropriate tittle of the project through understanding and reading a journal and article, planning on a project design and equipment that will be use, software and hardware operation according to this project, testing and analysis the result, troubleshooting the problem that take place in this project and report writing.

3.1 Flow of project

A flowchart is a graphic illustration of a logic sequence, manufacturing process, organization chart, or structure. The general purpose of a flow chart is to provide people with a common language representation when trade with a project or procedure.

This main project is divide into four phases which is identifying requirement, design, implementation and verification. Firstly is to find the conceptual design requirement of the system through hardware and software specification. Therefore, to design the Smart Domestic Electricity Monitoring System based on the planned system planning. After that is to implement the process of the system based on the construction using programming on the planned hardware. Lastly is to authenticate the rationality of the

system design by doing analysis to guarantee the designed system follow the flow to accomplish the target.

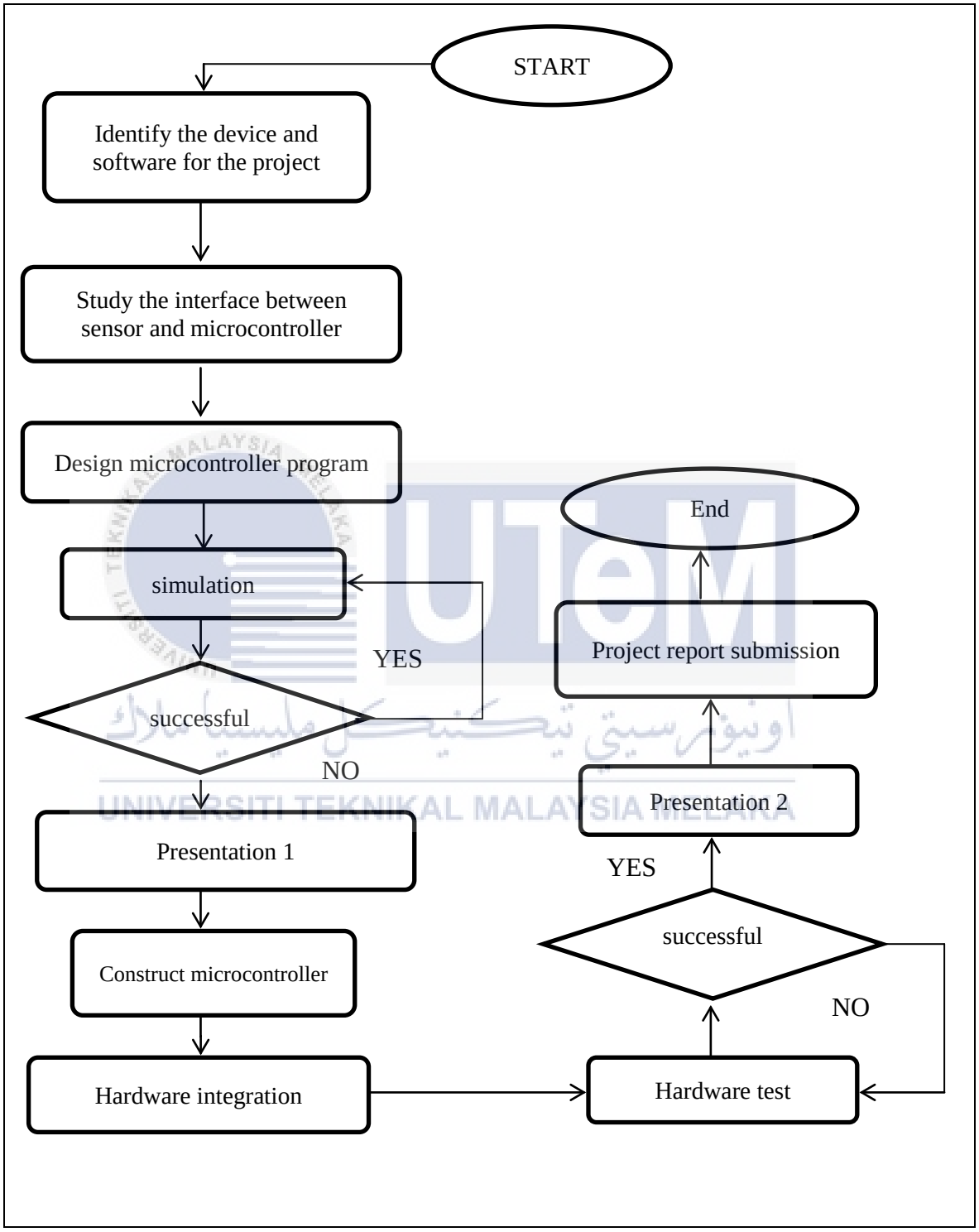

Figure 3.1: The Flowchart Of The Complete Project Planning

3.2 Elements in Smart Online Domestic Electricity Monitoring System

Smart Online Domestic Electricity Monitoring system is system that monitor the power consumption and TNB bill. The monitor of the output from this system will be monitor by user using interface devices for example a smartphone or tablet (Android Operating System). The networking of the system can be wired or wireless depending on the user.

Table 3.1 : Element In This Project

Element In This Smart Monitoring System	Example
Control Device (Brain)	Microcontroller,PIC
Sensor	Current sensor, Voltage sensor
User interface device	Smartphone, Computer, and Tablet
Types of networkng	Wi-Fi, Bluetooth

3.3 Hardware and Software Required For Monitoring System

3.3.1 Hardware Specification

Table shows that the hardware required of Smart Online Domestic Electricity Monitoring System. Sub topic 3.4.1.1 to 3.4.1.5 will explain briefly about the hardware use in this project.

Table 3.2: Hardware Information

No	Device Type	Hardware Information
1	Microcontroller	Arduino Yun
2	Bluetooth Module	HC 05 Master and Slave
3	Sensor	Non Invasive SCT 013-000-000
4	LCD Display	20x4 LCD 2004A
5	Wi-Fi connection	Internet Connection

3.3.1.1 Arduino Yun

Arduino yun is use as microcontroller of this project, its act as brain of the main-device(Guimarães et al. 2015).The Arduino yun is open source of physical interface programming platform based on the simple board of input and output . This microcontroller can be progress stand-alone communicating object or connected to the cloud software. Arduino yun board is based on the microcontroller AT Mega u32un and Atheros AR9331. The advantage of this microcontroller has built in Ethernet and Wi-Fi support. It also contain USB port, memory micro SD card slot, 20 digital input which is 7 of them can used as pulse width modulation outputs and 12 as analog input.

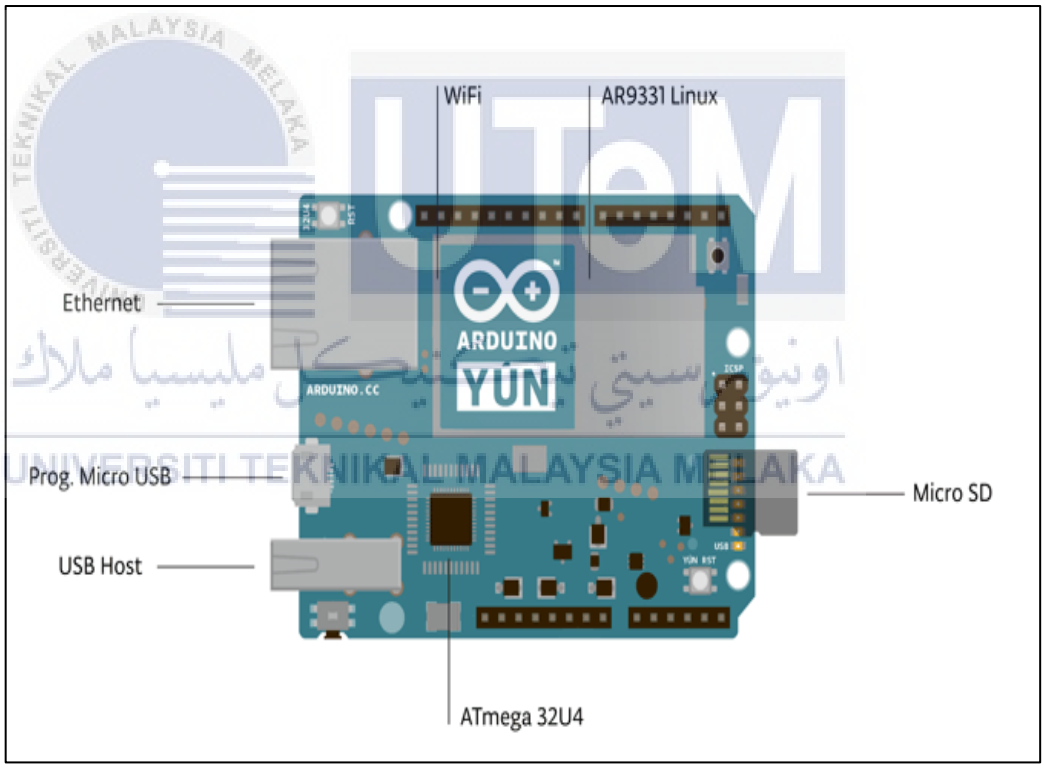

Figure 3.2 : Arduino Yun microcontroller

The arduino yun is difference from other arduino board. Its can communicate with the linux distribution on board, that offer a power networked computer interface with ease of arduino.in addition to linux command like cURL, that can write own shell and phyton scrips for robust interactions.

The arduino yun is same with Leornando in that ATmega32u4 .This will allows arduino yun to seem appear to a connected computer as any device.

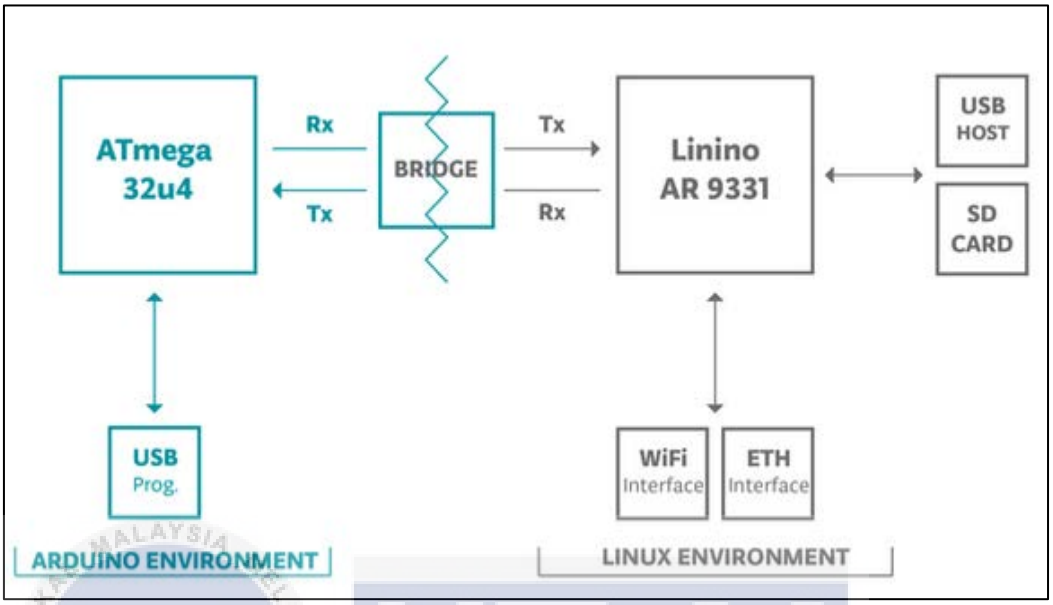

Figure 3.3: Arduino Yun communication

The bride library encourages correspondence between the two processors. This will give Arduino draws the capacity to run shell script, communicate with the system interfaces, and get data from the AR93331 processor.

The USB port, network interface and SD card are not associated with the 32u$, but rather the AR9331, and the Bridge library additionally empowers the Arduino to communicate with those peripherals.

3.3.1.2 Bluetooth Module AT command mode of HC-05

Bluetooth is wireless technology, its can transmit information or data over short distance. The range of the data can transmit is depend on the bluetooth module. It use short wavelength UHF radio waves in the ISM band from 2.4 to 2.485 Ghz from fix mobile device, and constructing personal area networks . The ranges of the bluetooth communications is approximately 10 meters or 30 foot.

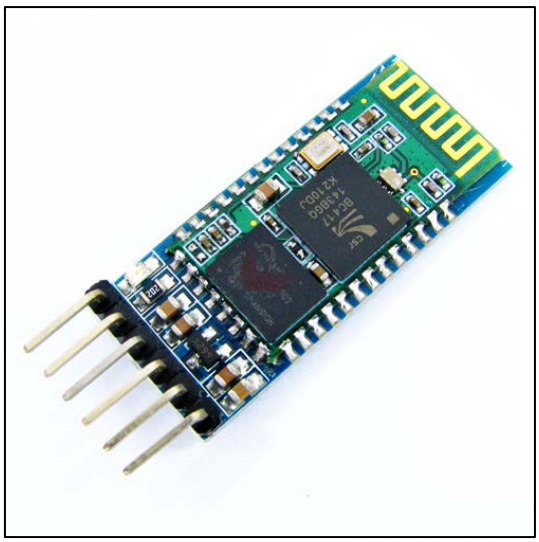

Figure 3.4 : Bluetooth Module

This low cost Bluetooth module will work well with the arduino and others peripheral.HC-05 module can be set to be either master or slave. This module can connect on 3.3V with 3.3v signal levels. This module has two method operations, which is Command Mode where user can send AT orders to it and Data Mode where its can transmits and gets data to another Bluetooth module or device.

3.3.1.3 Non-invasive current sensor (SCT 013-000-000) 100A max

Current transformers (CTs) are sensors that are used for measuring alternating current.

Figure 3.5 : Current transformer sensor

The split core sensor type such as SCT 013 in the picture above is used in this project. It can be clipped straight on either the live or neutral wire at energy meter or wiring system. Like some other transformer, a present transformer has primary winding, an magnetic core, and secondary winding. The secondary winding includes many turns of fine wire housed inside the packaging of the transformer.

3.3.1.4 LCD Display

LCD(Liquid Crystal Display) screen or monitor is an electronic digital display part and can be used in any application, Figure shows the 20x4 LCD display that commonly use to monitor the many data. Its can display 34 lines in one period. These module is commonly used in electronic device. This modules are preferred over seven segments and other multi segment LEDs. The reasons to used LCD are cheap compared to others and is easy to programmable. There are no limitation of displaying special & even custom characters on LCD.

A 20 LCD means it can display 20 characters per line. In this LCD each character is displayed in 5x7 pixel matrix. This LCD contain two registers, which is command and data.

The command registers stores the instruction or guideline to given for LCD. A command is an instruction given to LCD to do redefined assignment, for example initializing, clearing screen, setting the cursor position, controlling the output, and observing. This LCD contain information enlist stores the information to be shon on the LCD. The information arrangement is ASCII format to the character to be show on the screen.

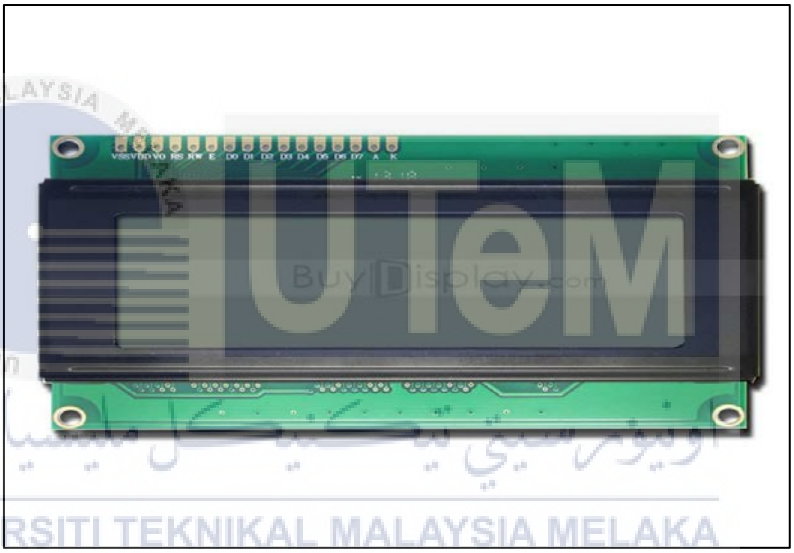

Figure3.6 : LCD Display 20x4

3.3.2 Software Specification

Table shows that the software required of Smart Online Domestic Electricity Monitoring System. Sub topic 3.4.2.1 to 3.4.1.4 will explain briefly about the software use in this project.

Table 3.3 : Software information

No	Device Type	Software Information
1	Arduino Yun	Arduino IDE Compiler
2	Interface Smartphone	MIT apps inventor
3	Cloud Storage	Google spreadsheet (Google drive)
4	Network	Wi-Fi signal (internet)

3.3.2.1 Bluetooth Terminal

Bluetooth terminal is an application for android that develop by Qwerty. This application can act as monitor to receive and send data. After connected the Bluetooth module, then configure the pin on the Arduino IDE. The Bluetooth terminal application will searching another Bluetooth connection. The paired device will appeared on the screen. Figure 3.6 show the screen that need connected to the module, after connecting the output can be observed. This configuration on the coding use the software serial libraries to send the data to the application.

Figure 3.7 : Android Smartphone Application

3.3.2.2 Google Spreadsheet

Google spreadsheets is a Web-based application that allows users to construct, update and modify spreadsheet. The Ajax based program is compatible with Microsoft excel and CSV(comma separate value) files. The spreadsheet can also save as format HTML.

Google product offers typical spreadsheet features, such as the ability to add, delete, add row, sort row and columns. The application also enable multiple, geographically disperses users to cooperate on a spreadsheet in real time. User can upload spreadsheet directly from their computers. The Google spreadsheet has full functionality like excel.

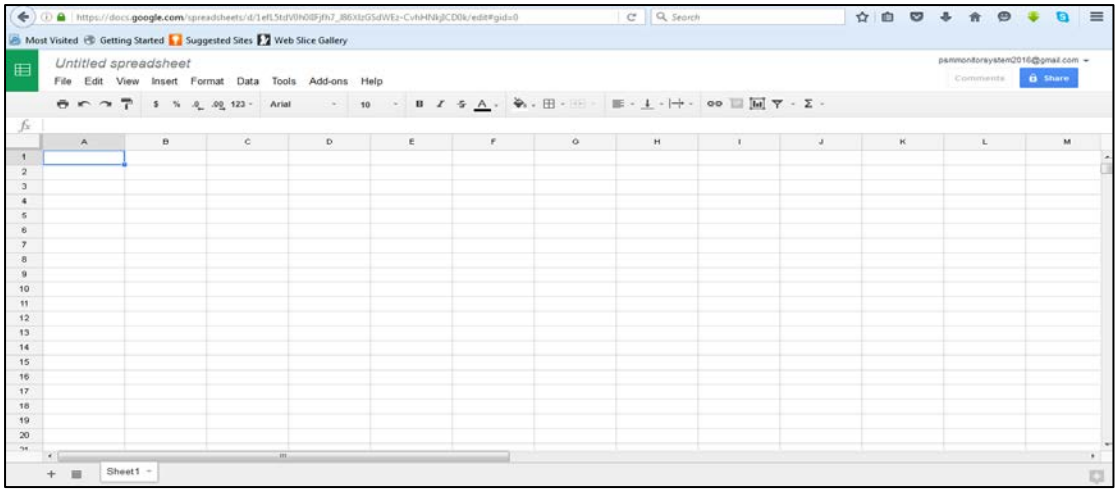

Figure 3.8 : Example Google Spread Sheet

For this project I have created new Google Account: psmmonitoringsystem2016@gmail.

3.3.2.3 Arduino Software (IDE)

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a field of text editor for writing programming code, a massage area, a text console, a toolbar with others function and a series of menus. Its can connect the Arduino and Genuino hardware to upload programs and interphase with them. Programs written using the Arduino Software (IDE) are called sketches. These sketches are written in text editor and are saved with the file extension. The editor has features for cutting/pasting and for searching/replacing text. The massage area gives feedback while save, export and displays errors. The console displays text output by the Arduino Software IDE , including complete error massage and other information, The toolbar buttons function to verify and upload a programs, create, open, save sketches and open the serial monitor.

3.4 System Design

The smart online domestic electricity monitoring system composes of wired and wireless system monitors between sensors with monitoring device. The LCD display will wire connection with microcontroller to display real time consumption and TNB tariff bill value.

For the wireless communication between Arduino yun, Google Spreadsheet and android apps, arduino yun must be connected to Wi-Fi and Bluetooth module must be connected to the Smartphone. Block Diagram in figure 3.8 show that how the system is designed.

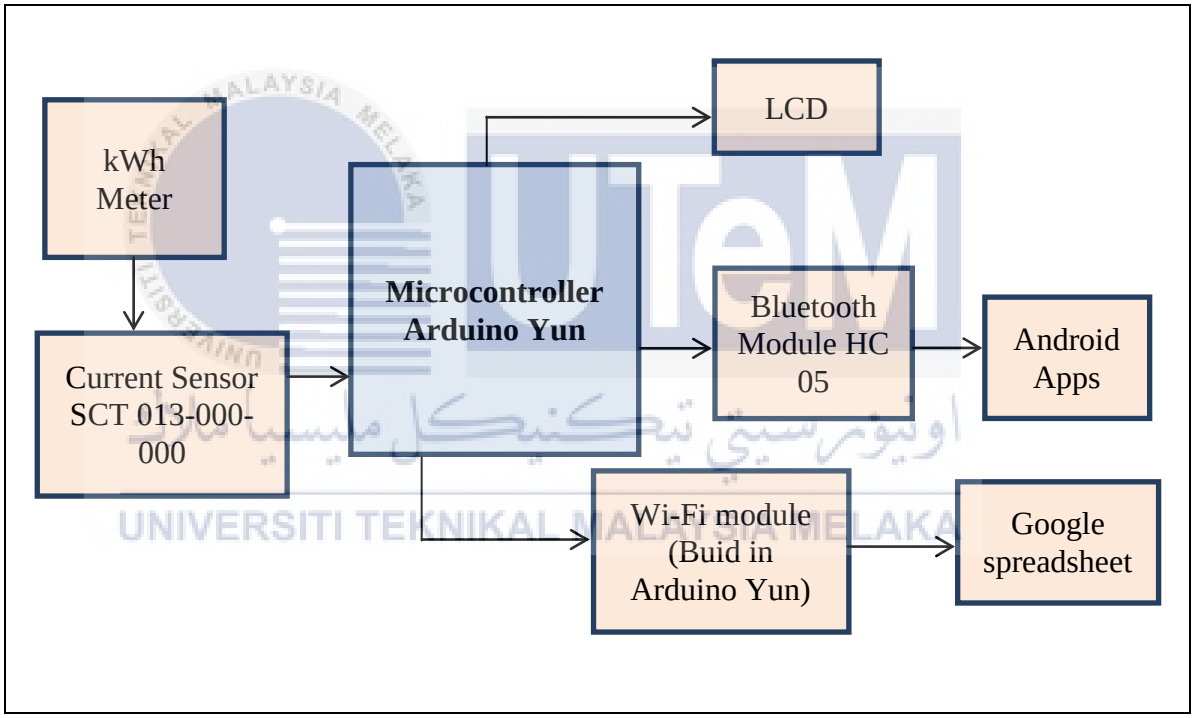

Figure3.9 : Block Diagram of designing Smart Domestic Electrcity Monitoring System

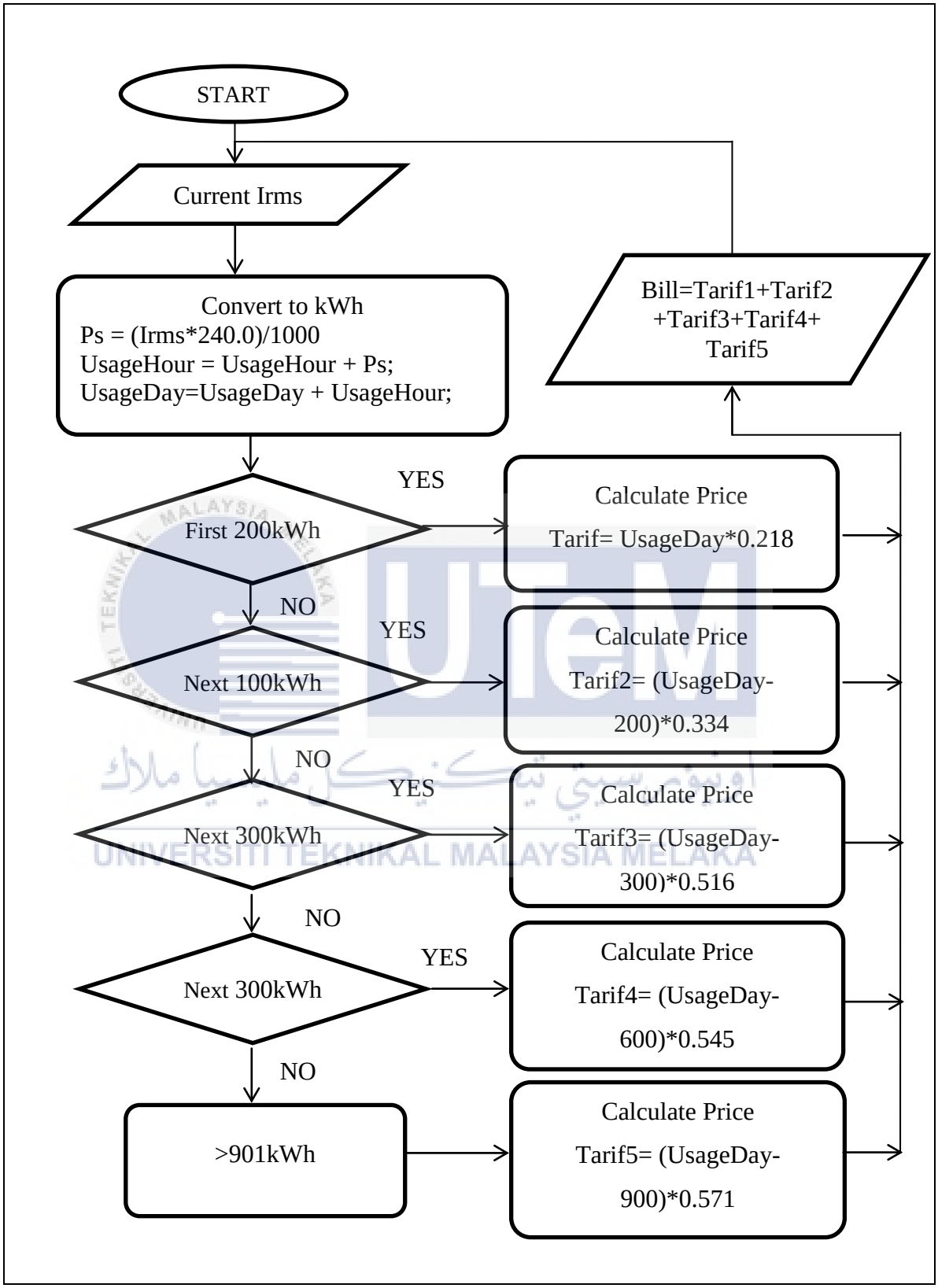

Figure3.10: Flowchart of the calculation Bill based on TNB tariff Rate

3.5 System Circuit

The system architecture Figure 3.10 shows the connection of the microcontroller Arduino Yun, Bluetooth module, LCD monitor and Current Sensor on the breadboard. The LCD pin is assigned at pin 12,11,5,4,3,2, then the Bluetooth module is assigned at pin 8,9 and the current sensor is assigned at Analog input (A1).

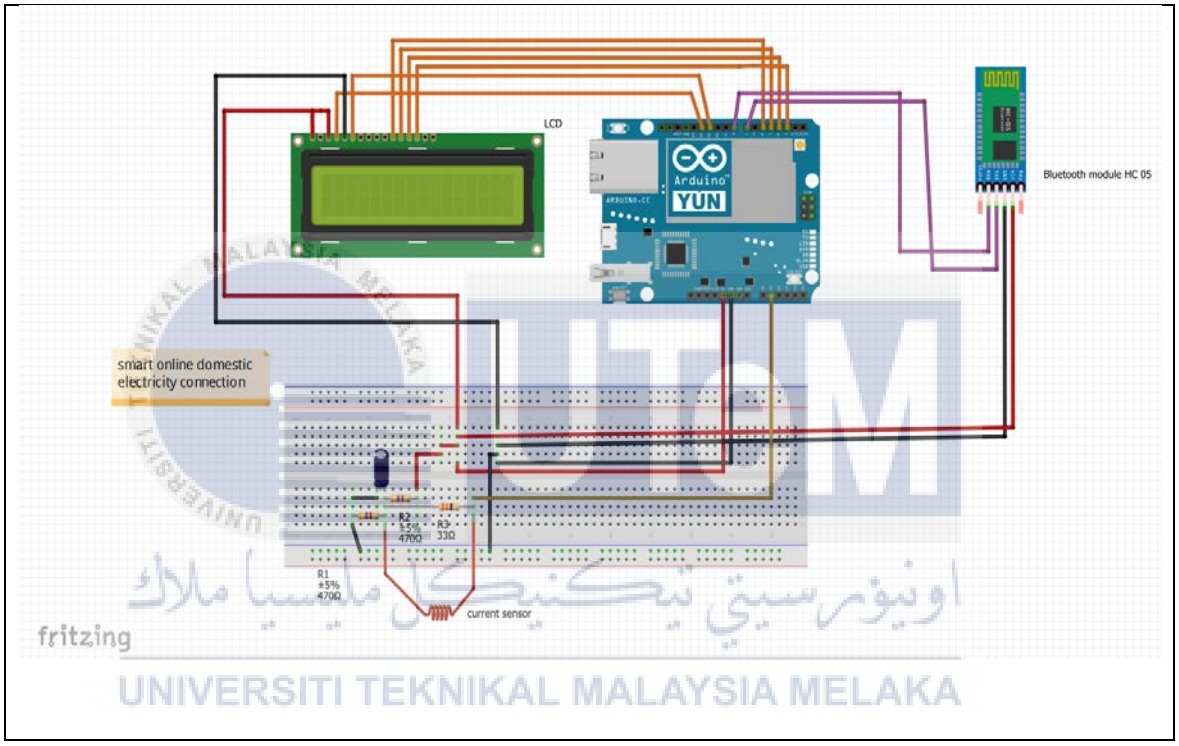

Figure 3.11 : The Breadboard/Connection diagram of the system

The schematic diagram is a drawing to show the connection of all part of the component or task of a circuit by using standard symbol elements to be easier interpreted by viewer. This schematic diagram show the detail of the connection pin between the component and parts. Figure 3.11 shows the schematic diagram of the smart domestic electricity monitoring system.

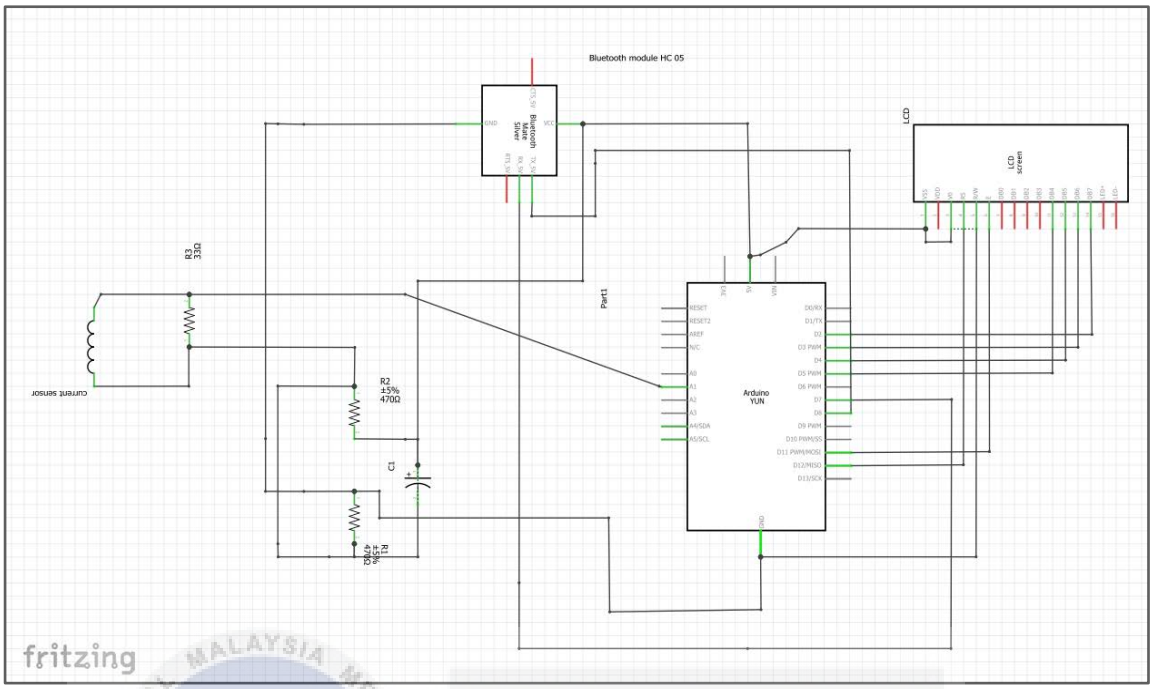

Figure 3.12: schematic diagram of the Smart Domestic Electricity Monitoring System

3.6 Arduino Yun Configuration (Wi-Fi)

Arduino yun has capability to act as an Access Point and it also can connected to current network surrounding. For this system we need to create the network that connected to the internet. Arduino yun can connect to unencrypted networks for example WEP, WPA and WPA2 encryption depends on which network available. To connected to the network its must have password to connected to the internet.

When the arduino yun started connected to the source it will create its own WiFi hotspot. To configure the arduino yun connection the computer must connected to this network. Once the IP address is obtained, connect the web browser to the http://arduino.local or 192.168.240.1 on the address bar. The web page will appear requesting for a password to log in to the arduino yun. The general password is “arduino”.

The page will appeared with diagnostic information about the current network connection. Then press configure button, the new page will configure the arduino yun.

Then set which networks want to connected and insert the password, for this project the WiFi connection is ‘psmmonitoringsystem” and the password is “psm12345”. Then press configuration and restart button, the arduino will reset itself and joined to specific network. After configure the WiFi the arduino will connect automatically when the specified network is opened. Figure shows the Address, Netmask, MAC Address and memory transmit between the arduino yun and WiFi internet networks connection.

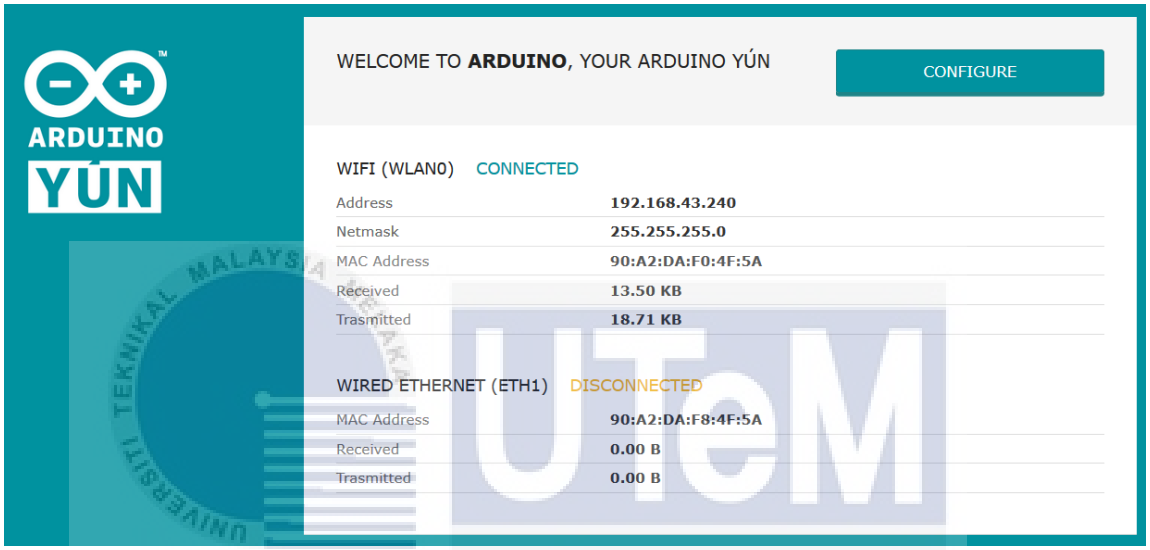

Figure 3.13 : the diagnostic information about the arduino yun access

3.7 Temboo platform

Arduino yun contain two components that easy to connect with hundreds of APIs and cloud service. Temboo is a accessible, fault-tolerant environment for organization and managing smart code snippets that called choreos.

The request from the yun temboo client causes the choreo specified in the Arduino programming to be executed on the temboo platform. It allows the third-party API, performing the API interaction between the microcontrollers and internets.

```
#define TEMBOO_ACCOUNT "smartmonitorsystem"  // Your Temboo account name
#define TEMBOO_APP_KEY_NAME "myFirstApp"  // Your Temboo app key name
#define TEMBOO_APP_KEY "fGBIvfuFTZDKloFL5bqJqqaCLGPlvytF"  // Your Temboo app key
```

Figure 3.14 : The TembooAccount.h header file.

Figure The TembooAccount.h that contain the information of the account that registered to the temboo.

This temboo information hold Temboo account, Temboo app key name and Temboo app key.

3.8 Google programming interface (APIs) and Google Access

Google APIs is a set of application programming interface develop by Google that permit communication between Google service and integration to other service.

Figure 3.15 : Step enabling Library Google API (spreadsheet)

The figure shows the web screen of the google API to allow the access Arduino Yun to API google spreadsheet. By enabling the spreadsheet API it will enable the third party to manage the account.

Figure 3.16 : The step to create Client ID to get the client ID and Client Secret.

Figure 3.17 : The Client ID for Web Application

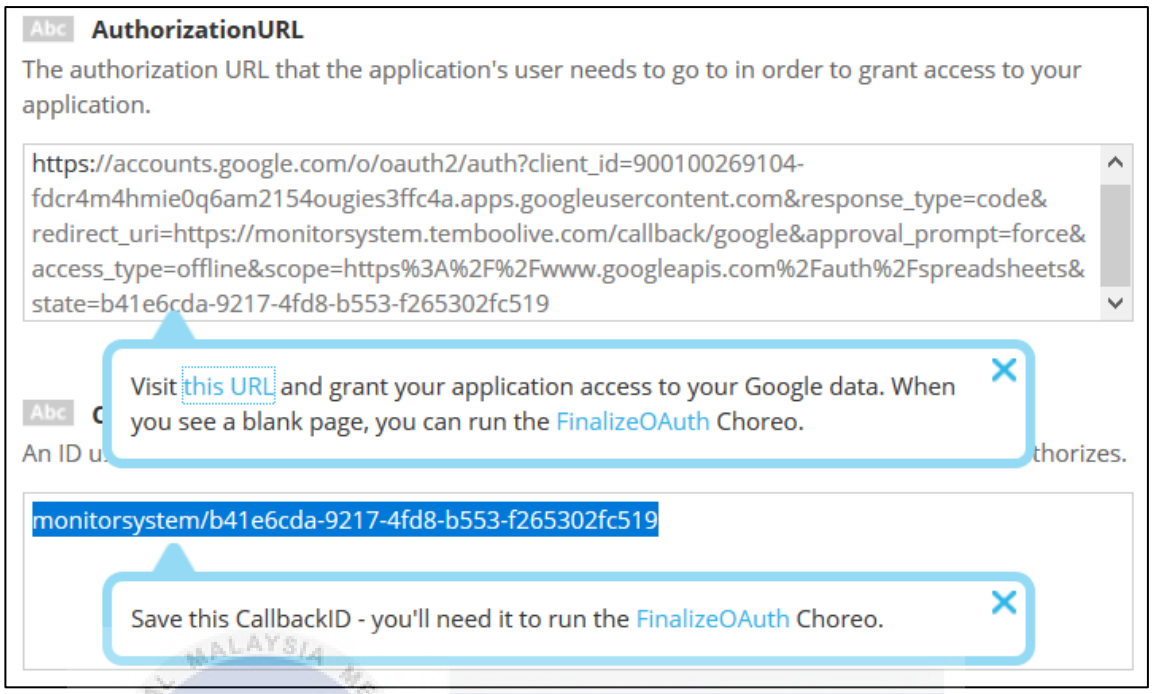

Figure 3.18 : Web screen from the temboo pages to Authorize the URL to get access to the Google.

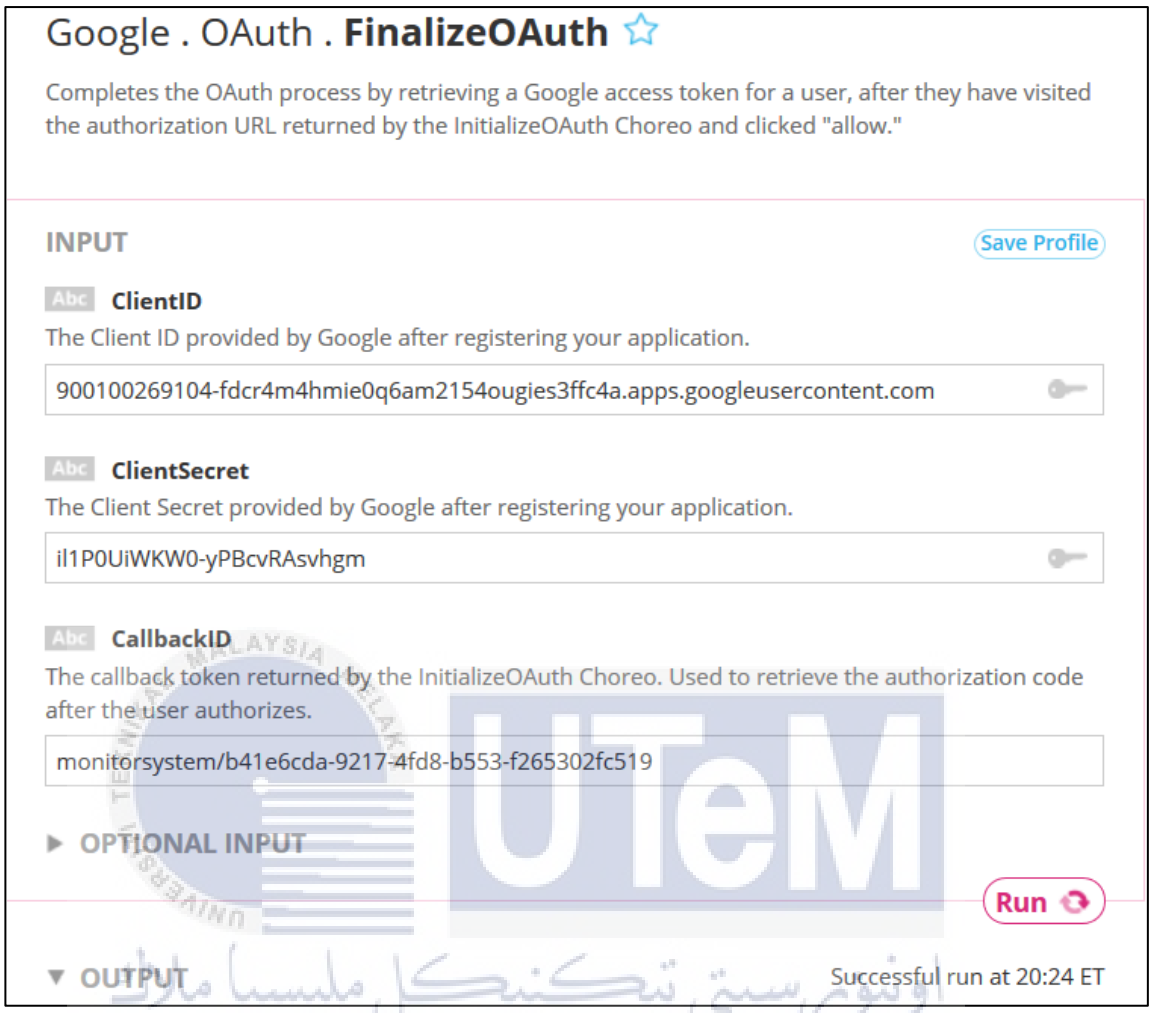

Figure 3.19 : The OAuth process to retrieve the refresh token.

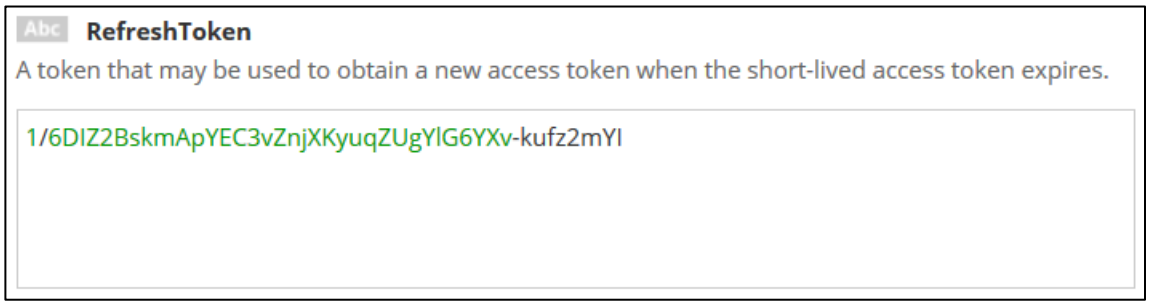

Figure 3.20 : The example of the Refresh Token after the Google allow the third party access

3.9 Gant Chart

Project planning														
Project activity	**2016**													
week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Meeting and discussion about Title, problem statement, Objectives, scope.														
Literature review														
Research and prepare about project proposal.														
Submission of the project and construct project proposal														
Define hardware and software needed.														
Simulation circuit.														
Project report writing (chapter 1-3)														
Presentation psm 1														
Submission report 1														

Project Planning														
Project activity	**2017**													
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Experiment monitoring the power consumption														
Identify and solve the problem.														
Analyzed the data from the experiment														
Project report writing (preparing full report)														
Submission project reports to supervisor														

3.10 Conclusion

Smart Online Domestic Electricity Monitoring System design approach is based on the project flowchart in system design. System design started by determining the concept and specification of this project. Then studying the interfacing of microcontroller by Smartphone and Google Spreadsheet. This project can be done by follow the schedule of Gant chart from week 1 to week 14.

CHAPTER 4
RESULT & DISCUSSION

4.0 Introduction

This chapter will cover the result, analysis and findings of the Smart Domestic Electricity Monitoring System. This chapter will discuss the progress of the system and the data will be collected to response the objective of this system.

This chapter will deliberated how to calculate the electricity usage from the system, the flow of the system function, and accuracy of the system.

4.1 Analysis Data

Analysis data is the process of inspecting, observing, discovering and support the decision making. This data will generate the predict data and objective of the development of the Smart Domestic Electricity Monitoring System.

The analysis of data is to observe the trend of Electricity Usage, accuracy of sensor and distance device application can connected to the system.

4.2 Result from LCD Display

The LCD Display act as offline monitor system which is once the supply is connected to the system the LCD started to read the Irms(A), Total Usage Hour in kWh, Total Usage Day in kWh, Bill in Ringgit Malaysia(RM) and the existing tariff.

Figure 4.1 : The result from the LCD screen

This system able measure and monitor electricity usage. It's also help the user to monitor their usage every times. Such as state in the problem statement the energy meter is mounted high from the ground (6ft). From the Figure is the example the mounting of this system at the energy meter. From Tenaga Nasional Berhad procedure, energy meter must mounted at 6 feet(183cm) from the ground.

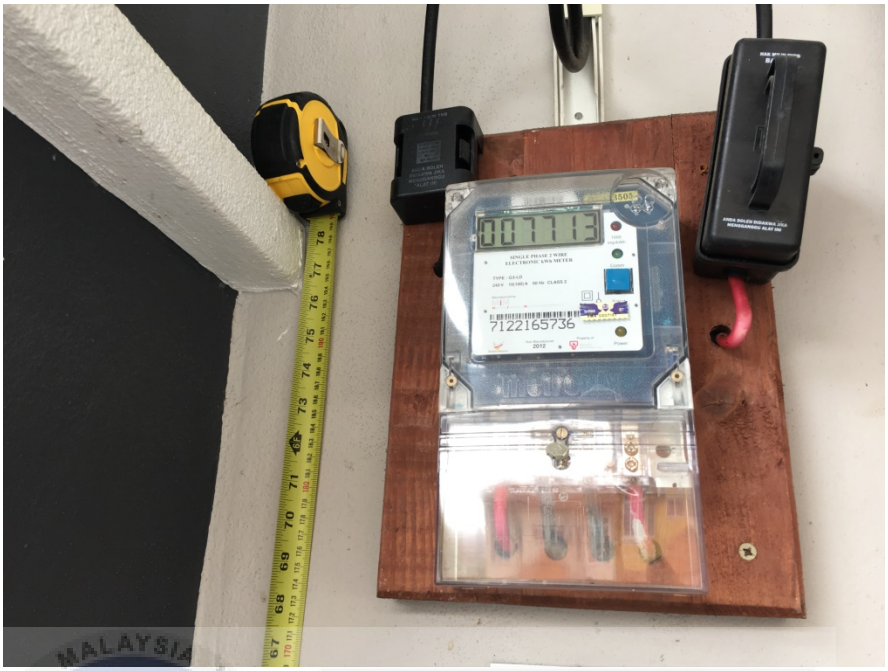

Figure 4.2 : Measurement height of Energy Meter from ground

Problem statements state that it hard for some people to monitor electricity from energy meter. Then, the energy meter shows the usage in power consumption in kWh. To calculate the usage and bill, we must know the last reading of the power consumption in kWh. This reading can be look at the monthly TNB Bill. The new reading of power consumption on the energy meter must be minus by last reading from energy meter and divide by tariff. From my study, more than 80% people do not know how to calculate the bill and monitor their electric usage.

The Smart Domestic Electricity is the device that can be used to solve this problem. This device is allowed to put everywhere depends on the length of the sensor wire. By using this system, once the sensor is clamp on the live wire and turn on the system, the device start to monitor and calculate the Electricity usage. Figure show the system installation at the energy meter.

Figure 4.3 : The installation of the Smart Domestic Electricity Monitoring System

4.3 Result From the Bluetooth Terminal

This Smart Domestic Monitoring able to monitor by using smartphone. Application Bluetooth terminal allowed the device to connect and the data will send from the system to the smartphone. While the Bluetooth is turning on the system will search the nearby Bluetooth connection. We are using HC 05 so we need to connect the application with the system. After that the data from the device will send to the smartphone.

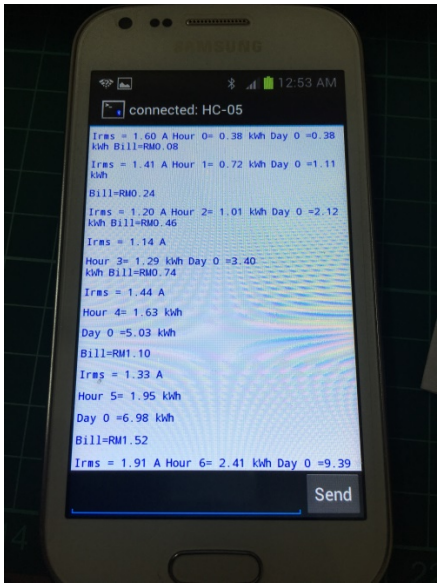

Figure 4.4 : The result from the Android Smartphone

4.4 Analysis trend of electricity usage of electricity at rent house

This experiment is conduct to identify and monitor the trend of the usage of electricity. A properly installed and configured monitoring system is very valuable asset to the domestic electricity user. A data generate by this system can reveal the trend of electricity usage. From this experiment we can observe the trend of electricity usage and manage the usage.

Table 4.1 : The result of the measurement of Current Irms(A), Total Usage per Hour. Total Usage per Day, and Bill(RM).

Date and Time	Irms(A)	Hour (kWh)	Day (kWh)	Bill (RM)
5/12/16 7.32AM	1.07	0.26	0.26	0.06
5/12/16 8.32AM	0.47	0.47	0.73	0.16
5/12/16 9.32AM	1.37	0.80	1.53	0.33
5/12/1610.32AM	0.80	0.99	2.52	0.55
5/12/1611.32AM	0.82	1.19	3.71	0.81
5/12/1612.32PM	0.99	1.42	5.13	1.12
5/12/16 1.32PM	1.42	1.77	6.90	1.50
5/12/16 2.32PM	2.62	2.39	9.29	2.03
5/12/16 3.32PM	1.22	2.69	11.98	2.61
5/12/16 5.32PM	1.66	3.08	15.06	3.28

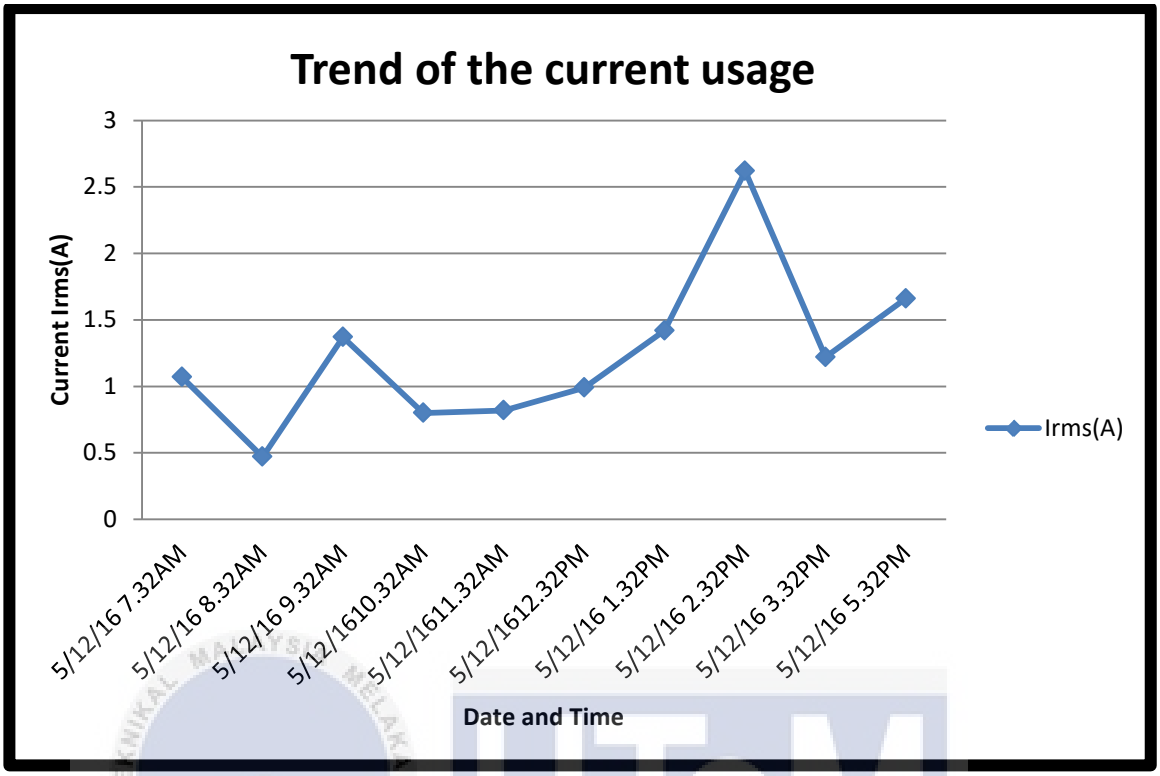

Figure 4.5 : The trend of current usage

From the monitoring the trend electricity usage we have opportunities to save energy, estimating the bill from TNB.

4.5 Comparison calculation of bill between TNB Calculator and System

TNB website has provide the Bill calculator to ensure the user keep track of the billing information. The disadvantage of this calculator is the user need to insert the energy consumption. The energy consumption can observe from the energy meter but need to minus the last energy consumption (from latest bill). From the smart domestic electricity monitoring system the user simply can monitor their bill.

This experiment is conduct to compare the Bill calculation between the TNB calculator and system to prove the calculation of the system in true.

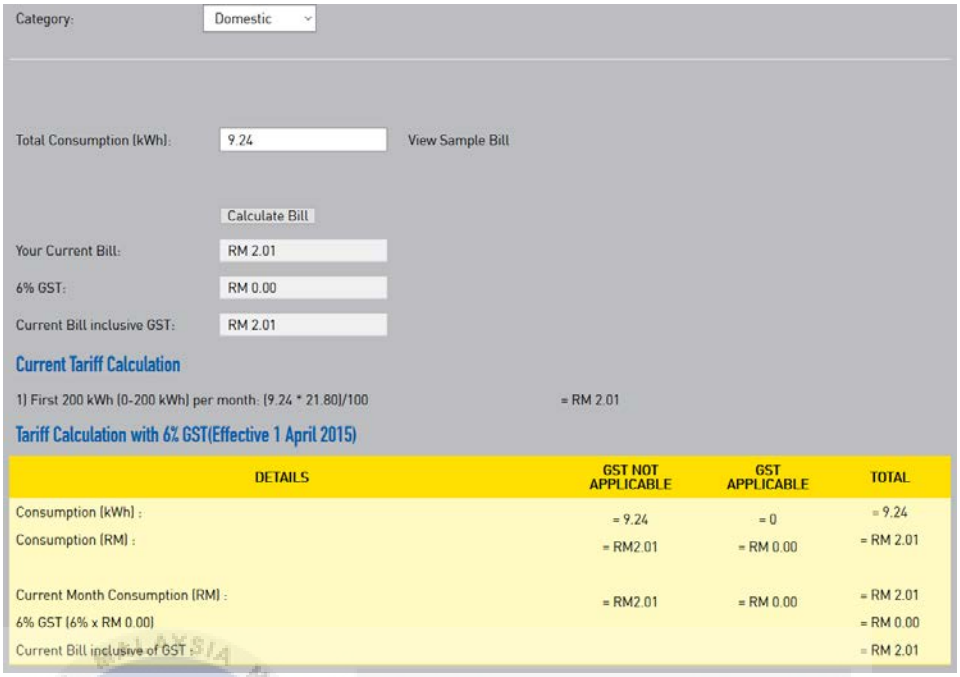

Figure 4.6 : TNB calculator that provide by TNB website

Table 4.2 : The comparison calculation perform by system and TNB calculator.

Date and Time	Calculation from the System (RM)	Calculation from the TNB bill calculator(RM)
4/12/16 7.41PM	0.24	0.24
4/12/16 8.41PM	0.46	0.46
4/12/16 9.41PM	0.74	0.74
4/12/16 10.41PM	1.10	1.10
4/12/16 11.41PM	1.52	1.52
5/12/16 12.41AM	2.01	2.01
5/12/16 1.41AM	2.57	2.57

From the observation, the calculation of the system is totally 99% same with the TNB calculator. So the advantage from this system the user can manage their electricity.

4.6 Electricity Measurement

4.6.1 Physical setting for the Current Sensor

The Current Transformer SCT 013-000 produces a current that proportionally to the current flowing through the magnetic circuit. This sensor measured the alternating current, it has primary winding, a magnetic core, and secondary winding.

This sensor is calibrated to measure a max of 100A AC, because the maximum current for domestic use is around that. This case current transformers act as current source and need a load. So, its needs a load R Burden to converts the current to a limited voltage. This resistor has special function to discharge the capacitor when the circuit is open.

To ensure the Burden resistor is correct value its need to calculate.

Assume that max peak current is 100 A

i(measured) = √2*(rms_current)
1.414*100A= 141.4A

The current output of the sensor is defined by numbers of turn.

Number of turn = 2000
i(sensor)=i(measured)/Numbers of turn
141.4A/2000=0.0707A

The Burden Resistor Value

R(burden)=U(sensor)/I(sensor)

2.5V/0.0707A = 35.4Ω

The ideal Burden Resistor Value is 35.4Ω, but in this circuit uses 33 Ω because this resistor is nearest to the ideal value. Therefore, the two voltage divider resistor 10k Ω is used to avoid many energy consumption and capacitor 10uF used parallel to the Resistor 10 Ω because its has low reactance and provides an alternative path for the alternating current to bypass the resistor.

4.6.2 Program code to measure the Current Irms(A), Electricity Usage and Bill

Program code below shows the Programme on the arduino IDE for calculation and measurement of the Current Irms(A), Electrcity Usage and Bill(RM). This program use Emon.lib library to measure the current, at line 15 is the code to called measurement from the Analog input Pin 1 and the calibration for the sensor.
From the line 18 is the calculation Irms(A) then converted to Power Consumption in kWh. From this data the Total Usage per Day and Hour can be calculated. Therefore, the Total Usage per Day is calculated by multiply with TNB Tariff calculation.


```
1. unsigned long time;
2. double Irms, Ps, usage;
3. double totalUsageDay =0;
4. double totalUsageHour = 0;
5. double tarif1 = 0;
6. double tarif2 = 0;
7. double tarif3 = 0;
8. double tarif4 = 0;
9. double tarif5 = 0;
```

```
double bill = 0;
unsigned int hour = 0;
unsigned int day = 0;

void setup() {
emon1.current(1,30);         // Current: input pin, calibration.initially 66.6
}
void loop()
{
Irms = emon1.calcIrms(1480);  // Calculate Irms only
Ps = (Irms*240.0)/1000; //Power Consumption in kW
//usageHour=Ps*hour; //Power Consumption perhour kWh
totalUsageHour = totalUsageHour + Ps;
totalUsageDay=totalUsageDay + totalUsageHour; //Power Consumption perday
lcd.clear();
if(totalUsageDay<=200){
tarif1 = totalUsageDay*0.218;
bill = tarif1;
lcd.setCursor(13, 3);
lcd.print("(0.218)");
}
else if(totalUsageDay>=201 && totalUsageDay<=300){
tarif2 = (totalUsageDay - 200)*0.334;
bill = tarif1 + tarif2;
lcd.setCursor(13, 3);
lcd.print("(0.334)");
}
else if(totalUsageDay>=301 && totalUsageDay<=600){
tarif3 = (totalUsageDay - 300)*0.516;
bill = tarif1 + tarif2 + tarif3;
lcd.setCursor(13, 3);
lcd.print("(0.516)");
}
```

```
42. else if(totalUsageDay>=601 && totalUsageDay<=900){
43. tarif4 = (totalUsageDay - 600)*0.546;
44. bill = tarif1 + tarif2 + tarif3 + tarif4;
45. lcd.setCursor(13, 3);
46. lcd.print("(0.546)");
47. }
48. else if(totalUsageDay>=901 ){
49. tarif5 = (totalUsageDay - 900)*0.571;
50. bill = tarif1 + tarif2 + tarif3 + tarif4 + tarif5;
51. lcd.setCursor(13, 3);
52. lcd.print("(0.571)");
53. }
```

Figure 4.7 : The programming calculation of the system

This calculation is perform based on the tariff that provided by Tenaga Nasional Berhad (TNB).

4.7 Accuracy of the sensor

This analysis is to observe the accuracy of the sensor. Every one hour, the data is observe and collected by manually measured the current reading with using clamp meter. The clamp meter is measure the current flow through the wire, then it need to divide by surd 2 to get the Irms(A). From this data the analysis comparison of the sensor value and clamp meter can be observe.

Figure 4.8 : The example analysis accuracy of sensor

Table 4.3 : The reading of the Smart Domestic Electricity Monitoring System

Date and Time	Irms(A)
4/12/16 7.41PM	1.41
4/12/16 8.41PM	1.20
4/12/16 9.41PM	1.14
4/12/16 10.41PM	1.44
4/12/16 11.41PM	1.33
5/12/1612.41AM	1.30
5/12/16 1.41AM	1.15

Table 4.4 : The reading of current I0(A) from the clamp meter

Date and Time	Current /I0 (A)	Irms (A)
4/12/16 7.41PM	2.45	1.73
4/12/16 8.41PM	2.15	1.52
4/12/16 9.41PM	1.40	0.99
4/12/16 10.41PM	1.90	1.34
4/12/16 11.41PM	1.81	1.27
5/12/16 12.41AM	1.70	1.20
5/12/16 1.41AM	1.65	1.17

Table 4.5 : The comparison between the System and Clamp Meter Irms(A) reading

Date and Time	Irms from System (A)	Irms from Clamp Meter(A)
4/12/16 7.41PM	1.41	1.73
4/12/16 8.41PM	1.2	1.52
4/12/16 9.41PM	1.14	0.99
4/12/16 10.41PM	1.44	1.34
4/12/16 11.41PM	1.33	1.27
5/12/1612.41AM	1.30	1.20
5/12/161.41AM	1.15	1.17

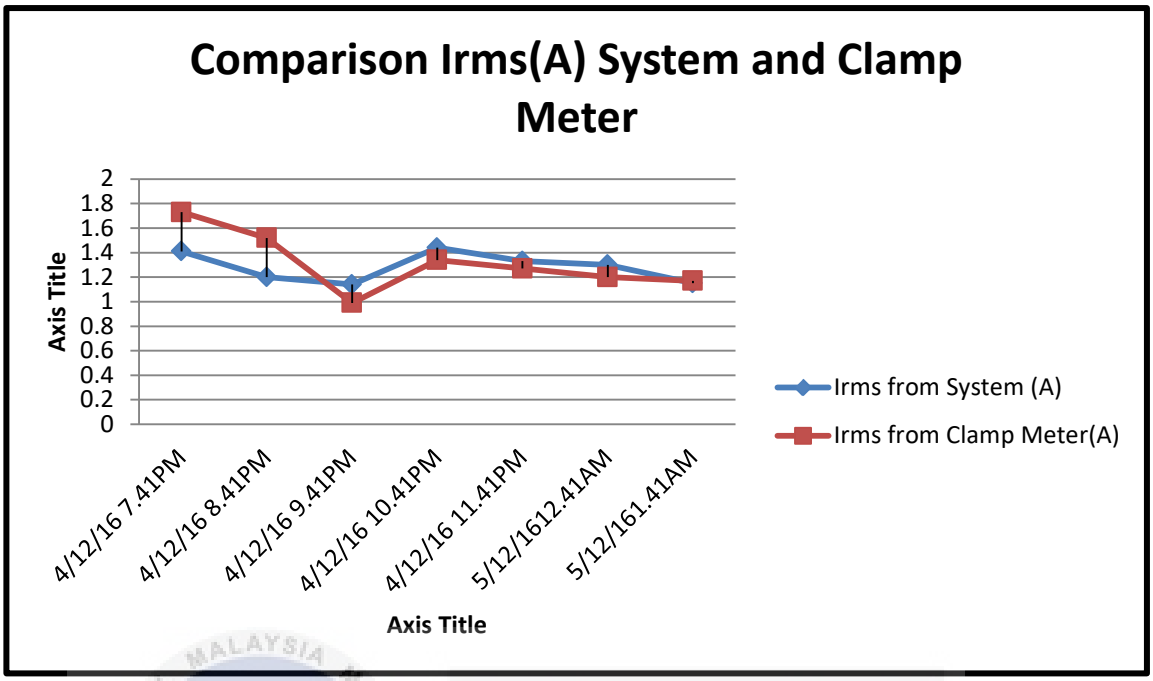

Figure 4.9 : The comparison between the Current Irms(A) reading from system and clamp meter.

From the graph we can observe the measurement of the sensor is mostly accurate. This is because of the sensor can develop sufficient voltage to fully utilize the determination of the Arduino's analogue input, and waveform distortion due to saturation at the secondary voltage is insignificant for normal purpose.

4.8 Bluetooth range analysis

The Bluetooth range analysis is to know the range of the connection between the systems with the system can be executed. This is important because the system is located at nearest energy meter, and to prove that user can monitor the electricity inside the house.

This experiment conduct by connect the apps serial monitor with the system and observe how far the system connection can be connected. This experiment is done at the open place.

Table 4.6: The analysis of bluetooth signal range

Experiment	Measurement Meter (m)
1	9.46
2	9.63
3	9.60
4	9.50
5	9.55

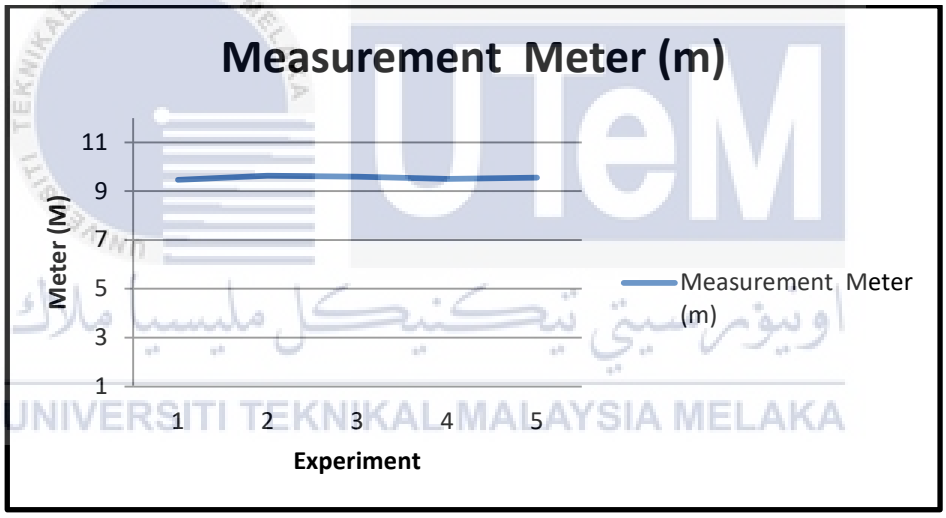

Figure 4.10 : The measurement of the range between system and smartphone

From this result prove that the theoretically Bluetooth range of HC 05 is approximately 10Meters. The range of Bluetooth connection is affected by the obstacle such as wall.

The graphs show the measurement of the Bluetooth connection range from the system. The measurement proves that the range of the Bluetooth is approximately 10M.

4.9 Google Spreadsheet Monitor

For the monitoring the electricity by using Google spreadsheet is not success this is due to the Google has update their security. The different version of Google Spreadsheet not allows the Arduino yun to send the information to the Google Spreadsheet. Before this the Google APIs allowed the access for the third party device to access the Google spreadsheet Version 3, but since the software is upgrades the Arduino Yun cannot send the data to Google due to the authorization error.

CHAPTER 5
CONCLUSION & RECOMMENDATION

5.0 Introduction

This chapter will describe briefly about conclusion and recommendation of development Smart Domestic Monitoring System from the process of system and technical. This project has potential in the market, because its help the consumer to manage their electricity usage and bill.

5.1 Summary of project

According to the project Smart Electricity Monitoring System, aimed of this project is allowed the user to monitor their electricity usage and bill. Three main part of this system is sensor, microcontroller, and monitor. This system will read the current in Irms(A) by using Current Sensor SCT 013-000-000 and the analog signal will interpreted by the microcontroller. Therefore, microcontrollers will calculate the power consumption. Furthermore, the bill pricing will be calculated based on the tariff that provide by Tenaga Nasional Berhad (TNB).

This system only can measure the electricity for the single phase power only because the domestic consumers mostly use single phase power supply to their house.

Development of Smart Domestic Electricity Monitoring System will give advantage for the user and environment. For the user, its able to manage and control their energy

consumption by monitoring the usage for every hour. The monitoring trend allows the user to identify the excessive usage. For example if the trend of Irms(A) or Usage Per Hour(kWh) is sudden upward so its sign the appliance usage is many. So the user can check the appliance use and control the usage. For the environment, as we know the power in Malaysia generated by Hydropower plant is 20% and others 80% is generated by the fuel, gas and etc. Imagine that every domestic consumers use this electricity management system or provide by government. We assume that every user can control the electricity, so it will reduce the energy produce in the power plant by fuel or gas indirectly it will save the nonrenewable source. The development of Smart Domestic Monitoring System will reduce the cost, such as state in the literature review the energy cost is increase from year to year. Besides that, it will reduce the carbon emission and the environmental damage, because when energy generates by the fuel the carbon gas is produce simultaneously. From this system also can reduce risk, the more energy use the energy billing will increase. Besides it will affect the family or household economy. With energy management it will reduce the risk by reducing the demand of electricity usage by controlling it.

5.2 Achievement of project objective

At the end the goals to design the device that can measure the electricity usage and bill is archive. Its can computing the data transfer between microcontroller to the smartphone by the Bluetooth. This device can send the data usage in LCD monitor and Bluetooth Terminal application.

5.3 Significance of research

The significance of this research is to increase the ability of the energy meter that allows the user monitor the usage trend and current billing. This device improve the method of energy meter monitor and billing service.

5.4 Recommendation

For the next improvement, suggestion of this system will be measure and monitor electricity usage the 3 phase power source and for commercial and industrial usage. The energy management in industry is the key to saving energy, in others words it can reduce the company cost. The importance of the energy saving for the global is to reduce the usage of nonrenewable resources which is its can affected the environment. Therefore, the next suggestion is to calculate the power factor, with the power factor this is to ensure the company no needs to pay the penalty of extra power factor. Then the future improvement is when the electricity reach the limit, the system will give the alert by sending an e-mail and signal (Buzzer or led) will beeping. So the user can take and fast action to control the usage. This system also can use solar energy to replace power supply.

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APPENDICES

```
/*
  SendDataToGoogleSpreadsheet

  Demonstrates appending a row of data to a Google spreadsheet from the Arduino Yun
  using the Temboo Arduino Yun SDK.

  This example code is in the public domain.
*/
#include <SoftwareSerial.h>
#include <Bridge.h>
#include <Temboo.h>
#include "TembooAccount.h" // contains Temboo account information
#include <Process.h>
#include <LiquidCrystal.h>
#include "EmonLib.h"                   // Include Emon Library
EnergyMonitor emon1;                   // Create an instance

SoftwareSerial bluetooth(7,8);
/*** SUBSTITUTE YOUR VALUES BELOW: ***/

// Note that for additional security and reusability, you could
// use #define statements to specify these values in a .h file.
// for debugging, wait until a serial console is connected

const String GOOGLE_CLIENT_ID = "900100269104-
fdcr4m4hmie0q6am2154ougies3ffc4a.apps.googleusercontent.com";
```

```
const String GOOGLE_CLIENT_SECRET = "il1P0UiWKW0-yPBcvRAsvhgm";
const String GOOGLE_REFRESH_TOKEN =
"1/6DIZ2BskmApYEC3vZnjXKyuqZUgYlG6YXv-kufz2mYI";

// The ID of the spreadsheet you want to send data to
// which can be found in the URL when viewing your spreadsheet at Google. For
example,
// the ID in the URL below is: "1tvFW2n-xFFJCE1q5j0HTetOsDhhgw7_998_K4sFtk"
// Sample URL: https://docs.google.com/spreadsheets/d/1tvFW2n-
xFFJCE1q5j0HTetOsDhhgw7_998_K4sFtk/edit
const String SPREADSHEET_ID =
"1sYMwwwktMI_A61Rvsol3H39b5QJk4bmjOtaDYtVe6KM";

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

unsigned long time;
double Irms, Ps, usage;
double totalUsageDay =0;
double totalUsageHour = 0;
double tarif1 = 0;
double tarif2 = 0;
double tarif3 = 0;
double tarif4 = 0;
double tarif5 = 0;
double bill = 0;
unsigned int hour = 0;
unsigned int day = 0;

Process date;
```

```
void setup() {

 Serial.begin(9600);
  // put your setup code here, to run once:
  lcd.begin(20, 4);
  // Print a message to the LCD.
  lcd.setCursor(4, 0);
  lcd.print("Smart Domestic");
  lcd.setCursor(5, 1);
  lcd.print("Electricity");
   lcd.setCursor(2, 2);
  lcd.print("Monitoring System");
  bluetooth.begin(9600);
  delay(100);
  emon1.current(1,10);        // Current: input pin, calibration.initially 66.6

Bridge.begin();

time = millis();
if(!date.running()){
date.begin("Date");
date.addParameter("+%D-%T");
date.run();
  }
  delay(100);

}

void loop()

{
```

```
Irms = emon1.calcIrms(1480);  // Calculate Irms only
Ps = (Irms*240.0)/1000; //Power Consumption in kW
//usageHour=Ps*hour; //Power Consumption perhour kWh
totalUsageHour = totalUsageHour + Ps;
totalUsageDay=totalUsageDay + totalUsageHour; //Power Consumption perday
lcd.clear();
if(totalUsageDay<=200){
  tarif1 = totalUsageDay*0.218;
  bill = tarif1;
  lcd.setCursor(13, 3);
  lcd.print("(0.218)");
}
else if(totalUsageDay>=201 && totalUsageDay<=300){
  tarif2 = (totalUsageDay - 200)*0.334;
  bill = tarif1 + tarif2;
  lcd.setCursor(13, 3);
  lcd.print("(0.334)");
}
else if(totalUsageDay>=301 && totalUsageDay<=600){
  tarif3 = (totalUsageDay - 300)*0.516;
  bill = tarif1 + tarif2 + tarif3;
  lcd.setCursor(13, 3);
  lcd.print("(0.516)");
}
else if(totalUsageDay>=601 && totalUsageDay<=900){
  tarif4 = (totalUsageDay - 600)*0.546;
  bill = tarif1 + tarif2 + tarif3 + tarif4;
  lcd.setCursor(13, 3);
  lcd.print("(0.546)");
  bluetooth.print("0.546");
}
```

```
else if(totalUsageDay>=901 ){
  tarif5 = (totalUsageDay - 900)*0.571;
  bill = tarif1 + tarif2 + tarif3 + tarif4 + tarif5;
  lcd.setCursor(13, 3);
  lcd.print("(0.571)");
}

lcd.setCursor(0, 0);
lcd.print("Irms = ");
lcd.print(Irms);
lcd.print(" A");
lcd.setCursor(0, 1);
lcd.print("Hour ");
lcd.print(hour);
lcd.print("= ");
lcd.print(totalUsageHour);
lcd.print(" kWh");
lcd.setCursor(0,2);
lcd.print("Day ");
lcd.print(day);
lcd.print(" =");
lcd.print(totalUsageDay);
lcd.print(" kWh");



//Bill Calculation
lcd.setCursor(0, 3);
lcd.print("Bill=RM");
lcd.print(bill);
```

```
bluetooth.print("Irms = ");
bluetooth.print(Irms);
bluetooth.println(" A");

bluetooth.print("Hour ");
bluetooth.print(hour);
bluetooth.print("= ");
bluetooth.print(totalUsageHour);
bluetooth.println(" kWh");

bluetooth.print("Day ");
bluetooth.print(day);
bluetooth.print(" =");
bluetooth.print(totalUsageDay);
bluetooth.println(" kWh");

//Bill Calculation

bluetooth.print("Bill=RM");
bluetooth.println(bill);

//delay(3600000);//60 minit
delay(36000);
```

```
 hour++;
   if (hour==24){
      day++;
      hour=0;
      totalUsageHour=0;
   if(day == 30){
      day = 0;
      totalUsageDay=0;
      bill = 0;
      }
      else{
      day = day;
      totalUsageDay = totalUsageDay;
     }
     }else{
     hour = hour;
     day = day;
     }

  runAppendValues(Irms, totalUsageDay, bill);

}
    //this function append row in google drive
   void runAppendValues(double current, double usage, double bill){
   // we need a Process object to send a Choreo request to Temboo
   TembooChoreo AppendValuesChoreo;

   // invoke the Temboo client
   // NOTE that the client must be reinvoked and repopulated with
   // appropriate arguments each time its run() method is called.
   AppendValuesChoreo.begin();
```

```
  // set Temboo account credentials
  AppendValuesChoreo.setAccountName(TEMBOO_ACCOUNT);
  AppendValuesChoreo.setAppKeyName(TEMBOO_APP_KEY_NAME);
  AppendValuesChoreo.setAppKey(TEMBOO_APP_KEY);

  // identify the Temboo Library choreo to run (Google > Sheets > AppendValues)
  AppendValuesChoreo.setChoreo("/Library/Google/Sheets/AppendValues");

  // set the required Choreo inputs
  // see https://www.temboo.com/library/Library/Google/Sheets/AppendValues/
  // for complete details about the inputs for this Choreo

  // your Google Client ID
  AppendValuesChoreo.addInput("ClientID", GOOGLE_CLIENT_ID);

  // your Google Client Secret
  AppendValuesChoreo.addInput("ClientSecret", GOOGLE_CLIENT_SECRET);

  // your Google Refresh Token
  AppendValuesChoreo.addInput("RefreshToken", GOOGLE_REFRESH_TOKEN);

  // the title of the spreadsheet you want to append to
  AppendValuesChoreo.addInput("SpreadsheetID", SPREADSHEET_ID);



// Restart the date process:
 if (!date.running())  {
  date.begin("date");
  date.addParameter("+%D-%T");
```

```
   date.run();
  }

 // Get date
  String timeString = date.readString();

 // JSON
 // String rowData = "";
  String rowData = "[[\"" + timeString + "\", \"" + String(Irms) + "\", \"" +
String(totalUsageDay) + "\",\"" + String(bill) + "\"]]";

 // Set Choreo inputs
 AppendValuesChoreo.addInput("Values", rowData);

unsigned int returnCode = AppendValuesChoreo.run();


 AppendValuesChoreo.close();

}
```