Faculty of Electrical and Electronic Engineering Technology

REAL TIME ELECTRICAL LOAD MONITORING THROUGH PHONE

MUHAMAD KHALIS LAMANI BIN SHAMSUDIN

Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

2022

REAL TIME ELECTRICAL LOAD MONITORING THROUGH PHONE

MUHAMAD KHALIS LAMANI BIN SHAMSUDIN

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this project report entitled “Real Time Electrical Load Monitoring Through Phone” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Student Name : Muhamad Khalis Lamani Bin Shamsudin

Date : 14/1/2023

APPROVAL

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

Signature : 

Supervisor Name : Ts. Dr. Mohd Firdaus Bin Mohd Ab Halim

Date : 31.1.2023

DEDICATION

I express my sincere dedication, honor and gratitude to my parents, my father Shamsudin Bin Ismail and my mother Norusmida Bt Nordin for the love, encouragement, support and sacrifice of throughout my life. I can't reach this level without them. I would also like to thank all my brothers and sisters for their constant support and advice in everything i do in life. Beside, all this wonderful work would not be success without my supervisor, Dr. Mohd Firdaus Bin Mohd Ab Halim who always support my works and give a good comment to make my works better Thank you to all the lecturers who have taught and guided through my research, and let's not forget all the friends who have always accompanied me on this fun journey of. I have no words to express my sincere gratitude to all.

ABSTRACT

The cost of utility bill has increased every year especially electricty bill. The consumption of the electricity in domestic house can only be monitored through the meter or TNB apps. However, the details of each load that connects to the house is not known. The purpose of this project is to evaluate the consumption of a single appliances in a house. This projects can be divided into two phase. In the first phase, the load needs to be determine using Arduino Uno. In this phase, the electrical parameters gathered from arduino will be used to determine the power consumed by the load. In the second phase, the power information from arduino will be send to the phone. In this phase, the communication between arduino and the phone is accomplished by GSM module. The result shows that when the electric consumption can be monitored real time with this project. The delay for the message to get through to the phone will take 5 seconds. The accuracy of this monitoring device is 78%. This project will help the user to save monitor and take neccesary action to manage their electric consumption.

ABSTRAK

Kos bil utiliti telah meningkat setiap tahun terutamanya bil elektrik. Penggunaan elektrik di rumah domestik hanya boleh dipantau melalui meter atau aplikasi TNB. Bagaimanapun, butiran setiap muatan yang bersambung dengan rumah itu tidak diketahui. Tujuan projek ini adalah untuk menilai penggunaan peralatan tunggal di dalam rumah. Projek ini boleh dibahagikan kepada dua fasa. Dalam fasa pertama, beban perlu ditentukan menggunakan rduino. Dalam fasa ini, parameter elektrik yang dikumpulkan daripada arduino akan digunakan untuk menentukan kuasa yang digunakan oleh beban. Dalam fasa kedua, maklumat kuasa daripada arduino akan dihantar ke telefon. Dalam fasa ini, komunikasi antara arduino dan telefon dicapai oleh modul GSM. Hasilnya menunjukkan bahawa apabila penggunaan elektrik boleh dipantau masa nyata dengan projek ini. Kelewatan untuk mesej dihantar ke telefon akan mengambil masa 5 saat. Ketepatan peranti pemantauan ini adalah 78%. Projek ini akan membantu pengguna untuk menjimatkan monitor dan mengambil tindakan yang perlu untuk menguruskan penggunaan elektrik mereka.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr. Mohd Firdaus Bin Mohd Ab Halim for his precious guidance, words of wisdom and patient throughout this project. I was able to complete all my project's writing stages because to his direction and assistance.

My highest appreciation goes to my parents, and family members for their love and prayer during the period of my study. An honourable mention also goes to Haida Syahida Binti Haron for all the motivation and understanding. And to all my housemates, thanks for helping me on designing to finish this project.

Last but not least, I would like to thank to my academic advisor, Ts. Dr. Mohd Hatta Bin Jopri for guiding me through my journey until today.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

V	-	Voltage
LCD	-	Liquid-crystal display
GSM	-	Global system for mobile
PWM	-	Pulse-width modulation
USB	-	Universal serial bus
CT	-	Current transformer
KB	-	Kilo byte
SRAM	-	Static random access memory
EEPROM	-	Electrically eraseable programmable read-only memory
g	-	Grams

CHAPTER 1

INTRODUCTION

1.1 Background

Recently, utility bills, especially electricity bills, are increasing year by year. Excessive power consumption can lead to wasted electricity, and users cannot monitor all electronic devices used in their homes [1]. Each device already has information, but this does not guarantee that electronic device usage can be accurately evaluated. As a result, electricity consumers pay a large and ever-increasing amount for their use.

1.2 Problem Statement

Power consumption refers to the electrical energy supplied per unit of time to operate things such as household appliances. Power consumption is usually expressed in watts (W) or kilowatts (kW). Consumer only can monitor their usage once in a month when they got the electricity bill or only the house that have smart metre can monitor their usage using TNB app. The energy consumed by the device will always be higher than the actual energy required because no device has 100% efficiency.

1.3 Project Objective

The purpose of this project is to propose a method to estimate electric consumption for a single appliance. To achieve this purpose, three objectives needs to be fullfill.

(i) To determine the value of power consumption in kW of a single load.

(ii) To transmit the power consumption information to the user's phone.

(iii) To evaluate the reliability of the proposed project.

1.4 Scope of Project

The scope of this project are as follows:

(i) Using simulation during design phase for the circuit.

(ii) Measure a single appliance.

(iii) Load that use in this project is predetermined.

(iv) Using GSM module.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter consists of overview about the power reading using current transformer sensor to get the actual reading of a single appliance. In general, the past case studies are related to this project are presented in article to be discussed as well.

2.2 Electrical consumption study

2.2.1 Programmable Energy Meter for Electrical Load Survey

The proposed system uses 8051 family of microcontrollers and a rectified power supply. Four pushbutton switches are connected to a microcontroller to provide electricity price information. A 16x2 LCD display is connected to the microcontroller to display information.

The system is connected to the load through a comparator IC with an energy meter. A microcontroller reads the pulses from the energy meter and determines the energy consumption of the power consumer. When the user enters the unit price and charging time into the microcomputer through the push button switch, it will be calculated according to the program and the relevant energy consumption and cost information will be displayed on the LCD display [2].

Figure 2.1 Project circuit

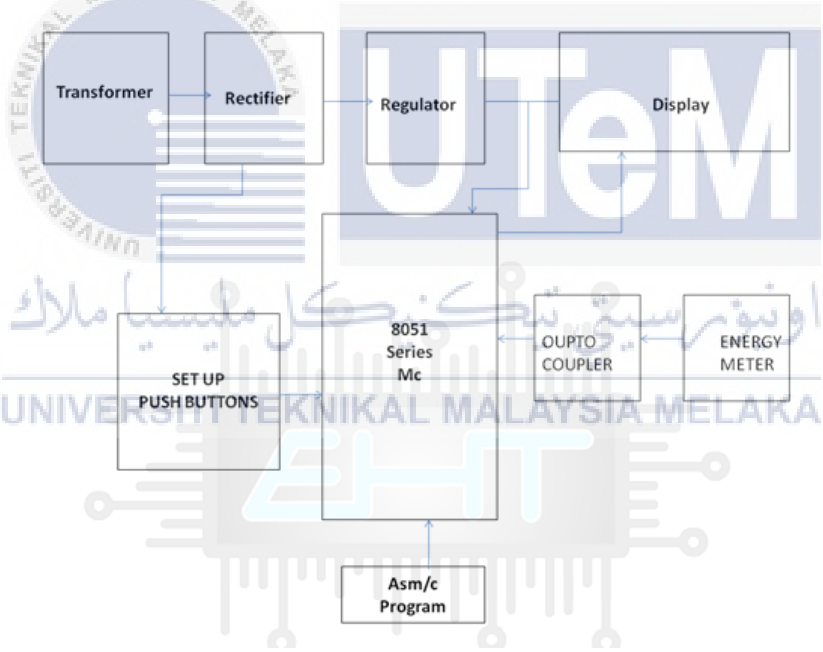

Figure 2.2 Block diagram of this project

2.2.2 Analysis of the Effectiveness of the Utilization of Power Monitoring Devices in Reducing Electric Energy Consumption

This study focuses on the analysis of uses of energy consumption control devices in combination with Wireless Fidelity (Wi-Fi) and mobile telephone technology. These devices combine monitoring, signaling and control functions. Any electrical appliances are connected that utilize electrical energy from a power plant to this energy consumption monitoring system.

According to the test results after installing these devices, savings measures showed a 15.88% reduction in daily energy consumption. Meanwhile, weekly consumption shows a decrease of 6.43%. Within 3 months of observation, energy expenditure decreased by 33.77% [3].

2.2.3 A Smart Voltage and Current Monitoring System for Three Phase Inverters Using an Android Smartphone Application

This researcher introduces a new intelligent voltage and current monitoring system "SVCMS". Use the Arduino platform as a microcontroller to monitor a three-phase electrical system, read voltage and current from sensors, wirelessly transmit the measured data, and monitor the results with a new Android application. The on-board SVCMS design uses Arduino Nano V3.0 as a microcontroller to measure the results from 3 voltage sensors and his 3 current sensors, after calculation, end this data via Bluetooth HC-05 Send to his user's android smartphone device. The Arduino Nano V3.0 Controller and Bluetooth HC-05 are inexpensive microcontrollers and wireless devices respectively. A new Android smartphone application that monitors voltage and current measurements uses the open-source MIT App Inventor 2 software and can monitor some basic power quality characteristics. These systems allow technicians, administrators, and managers to monitor and control the performance of devices from a safe distance [4].

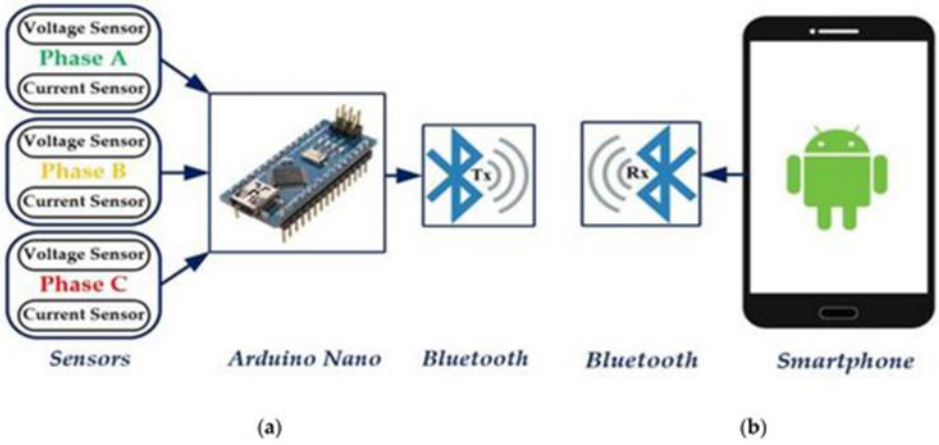

Figure 2.3 SVCMS project

An image on a smartphone is a inspection system or inspection application installed on a tablet or smartphone device. This application monitors data (three-phase voltage and current) received from a microcontroller. This document uses a new application developed using MIT App Inventor 2. This is Google's open source platform that can be used to design different types of applications that can be implemented on Android smartphones or tablets [5].

2.2.4 Measure Current Using Arduino And ACS712 Current Sensor

This researcher measure a DC current using an Acs712 Hall effect-based linear current sensor and an Arduino Uno. The Acs712 can exactly and accurately measure current if properly maintained. Researchers looked at various blogs on the internet about interfacing acs712 current sensors with arduino and other microcontrollers. The Acs712 current sensor can measure both direct current and alternating current.

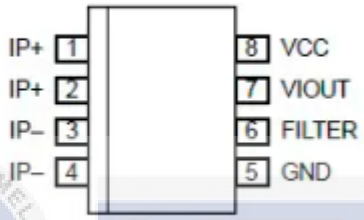

Figure 2.4 Pin-out Diagram

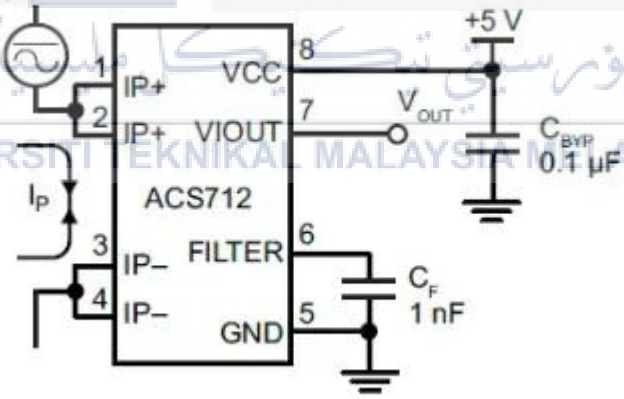

Figure 2.5 Typical Application

Connect the sensor in series with the system that measures the current. Cut the circuit wire and connect one end of the wire to IP+ and the other end to IP-.

Viout is the voltage output pin. The ACS712 outputs analog signals corresponding to changes on the IP+ and IP- pins. That is, it outputs an analog voltage on the VIOUT pin as the current changes [6].

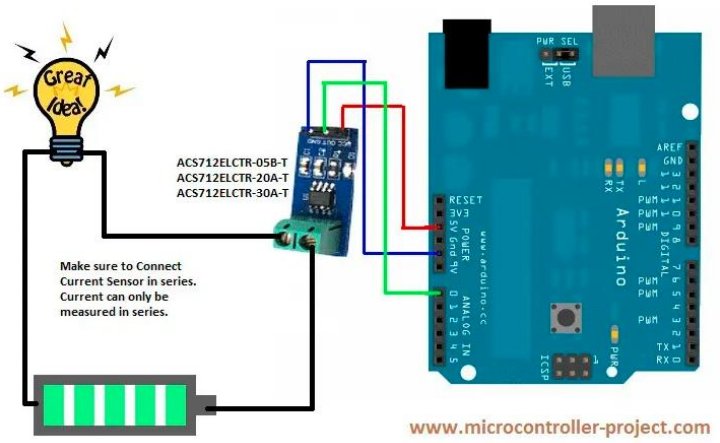

Figure 2.6 Acs712 with Arduino Uno -Circuit Diagram

2.2.5 AC Current Measurement System Using Arduino and CT Sensor

The researcher has built an Arduino-based smart energy monitoring system for AC power measurement. AC current measuring multimeter built by a professional engineer who can measure current very efficiently. However, these meters are expensive and cannot always monitor the current.

Build an Arduino-based system that can constantly sense current and display the results on an LCD display. Efficiently measures current using a CT (Current Transformer) sensor. The circuit also uses a rectifier and amplifier for signal conditioning. The current display uses a 16x2 LCD display [7].

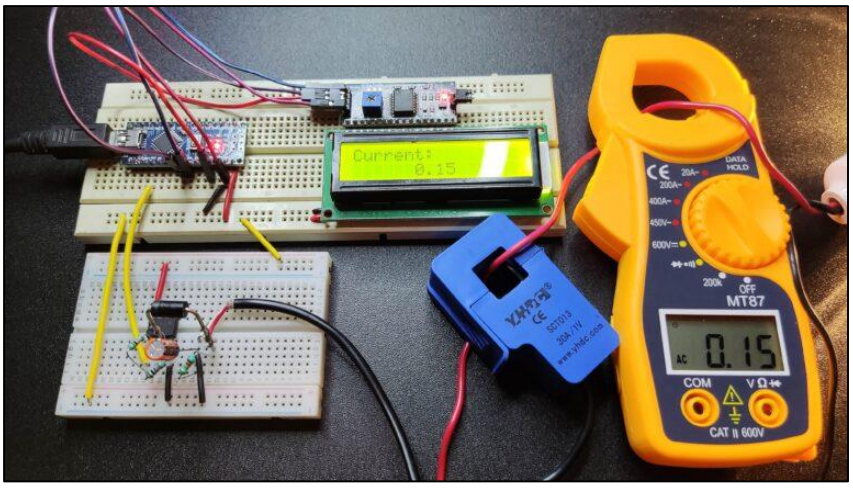

Figure 2.7 Project circuit with clamp meter

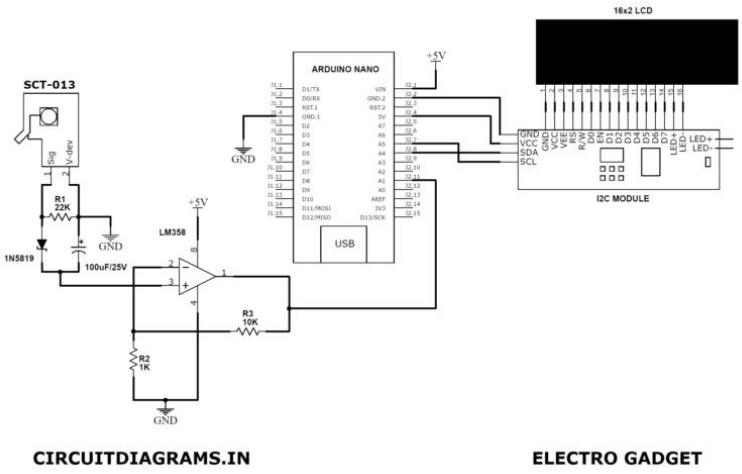

Figure 2.8 Circuit diagram of project

2.2.6 Arduino-based home fire alarm system with GSM module

This project has constructing a home fire alarm development is based on an Arduino board as the main control board interacting with the GSM module working on the communication part. The GSM module runs by sending the user it SMS, so this system works entirely with wireless network communication. The GSM module is responsible for the communication part of the circuit. It receives information from the Arduino about where to send information and what information needs to be sent. It uses a GSM SIM card for communication. It's basically just a modem that uses serial communication to communicate with the Arduino, and requires Hayes-compatible AT commands for communication [8].

The GSM SIM900A operates in dual-band 900-1800 MHz and is designed for use outside Europe and the US only. With proven performance, industrial-grade interface standards, and built-in TCP/IP protocol, it looks great and is suitable for electronics projects [9].

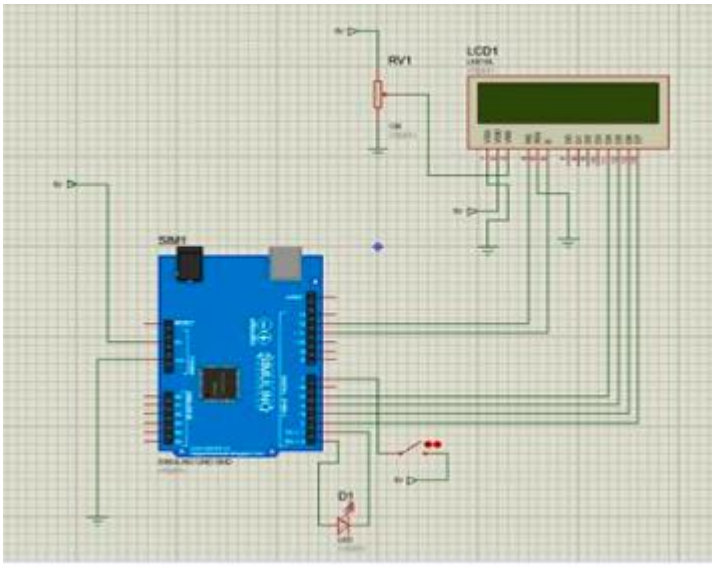

Figure 2.9 Project schematic diagram

2.3 Equipment which normally used in power consumption measurement

2.3.1 Microprocessor

A microprocessor is a device that process the data of a system and control that included of integrated circuit. It can also call the brain of the computer that is mounted on a single Integrated Circuit (IC) [10]. This means all functions of this processor are included in a single chip. The examples that can be discussed for the microprocessor part are the Raspberry Pi and the Arduino. Here both have a single chip installed on the board. These chips help to control and store processes that can be set by coding in its own language.

2.3.1.1 Raspberry Pi

Raspberry Pi is a series of small single board computers developed in the UK by the Raspberry Pi Foundation in partnership with Broadcom. The Raspberry Pi project was originally intended to promote computer science education in schools and developing countries. People are using Raspberry Pi to learn programming skills, create hardware projects, do home automation, implement Kubernetes clusters and edge computing, and even use them in industrial applications. The Raspberry Pi OS is primarily based on Linux, which uses the Python language to perform various activities. The Raspberry Pi Foundation also includes Python as its primary programming language due to its versatility and user-friendly syntax [11].

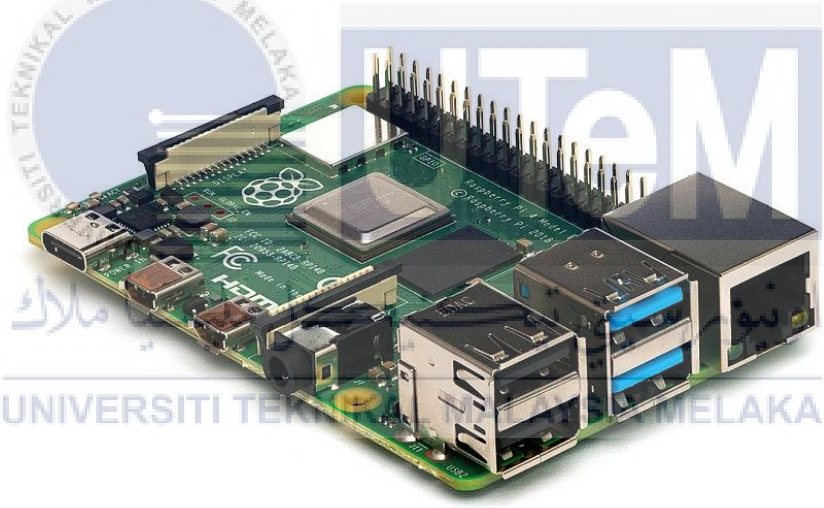

Figure 2.10 Raspberry Pi

Table 1 Specification of Raspberry Pi

System on a chip	Broadcom BCM2711B0
CPU	1.5 GHz quad-core A72 64-bit
Memory	1, 2, 4, or 8 GB LPDDR4-3200 SDRAM
Storage	MicroSDHC slot, USB Mass Storage device for booting
Power	5 V, 3 A

2.3.1.2 Arduino

A device that recieve inputs from any sensors that have connected to the board. It affect based on the coding that have been set by the arduino software into the arduino hardware. There are 6 top models of arduino that have been released. Arduino-UNO is the latest model compared to other like, Arduino MEGA, Lilypad Arduino, Arduino Leonardo, Arduino Red Board and Arduino Sheilds. The Arduino language is C++. Most of the time people use a small subset of C++ that looks a lot like C. If you're familiar with Java, you'll find C++ easier to work with and understand.

Arduino UNO board is use microchip ATmega328 microcontroller that increase the rate of transfer data and contain a large memory. This board consists of 14 digital input and output pins in which 6 pins of PWM, 6 pins of analog inputs, USB connection, reset button and one power jack. Arduino UNO can be attached to computer system by USB port to transfer data also as the power supply to the board [12].

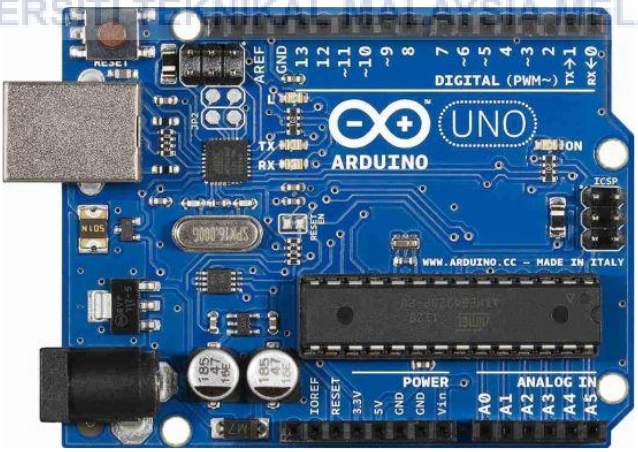

Figure 2.11 Arduino UNO

Table 2 Specification of Arduino-UNO

Microcontroller	Atmega328P
Operating voltage	5V
Input voltage	7V-20V
Digital I/O pins	14
Weight	25g

2.3.2 Measurement device

There are many types of meters that can be used to measure power consumption. Some of the most common types are electricity meters. These devices are typically installed by utility companies and used to measure electricity usage in homes and businesses. They can be digital or analog and provide measurements in kilowatt hours (kWh). Besides, you can also use sensors to measure power consumption. Examples of power consumption sensors are voltage sensors and current sensors [13].

2.3.2.1 Voltage sensor

A voltage sensor is a wireless tool that can be connected to any number of plants, machines, or devices. They offer 24/7 monitoring and are always looking for voltage data that could indicate a problem. Low voltage can indicate a potential problem, while high voltage can endanger other assets. Voltage sensors detect magnetic fields, electromagnetic fields and measure contact voltage. A voltage sensor measures and transmits the current of a device, appliance, battery, or other sensor. This helps the maintenance team identify areas that need immediate attention or alert the team to emerging issues [14].

Figure 2.12 Voltage sensor

Table 3 Specification of voltage sensor

Input voltage	0V to 25V
Voltage detection range	0.02445V to 25V
Analog voltage resolution	0.00489V
Dimensions	4 × 3 × 2 cm

2.3.2.2 Current Transformer Sensor

Current sensors, also commonly called as current transformer or CT. These sensors measure the flow of electricity and can be used to measure the power consumption of certain devices or devices. It can be used in conjunction with a data logger to track power consumption over time. Used with both AC and DC power supplies. A current sensor allows you to passively measure current without breaking the circuit [15]. They are placed around the conductor which current you want to measure. Current transformers are essential in many applications. For example, it is often used in sub-metering to determine individual tenant's energy consumption. It also helps facilities regulate by providing information on how much energy is being used and when to reduce costs and increase efficiency.

Figure 2.13 Split core AC Current Transformer

Table 4 Specification of PZCT-02

Environment temperature	-40℃~+85℃
Working frequency	50Hz~60Hz
Internal resistance	10Ω
Measuring range	0-100A
Weight	59g

2.3.3 Communication device

A communication device is a hardware device that transmits an analog or digital signal to telephone either through wire or wirelessly. The old communication device is a computer modem. It converts the information from digital to an analog signal for transmission through a telephone line. On the contrary, the modem receives the analog and the computer processing them to convert to digital signal [16].

2.3.3.1 GSM module

GSM is stand for Global System for Mobile communication device that communicate between a mobile device or computing machine that made from chip or circuit. This was created to describe for second-generation(2G) digital network cellular that were used by mobile phone [17]. Its use SIMs to identify their device to the network. The functional of this module is to send a message to the mobile phone.

Figure 2.14 GSM module

2.3.3.2 IoT module

A small electronic device embedded in objects, machines, things connected to wireless networks that sends and receives data. IoT module data circuits found in the mobile phone because it contains the same technology as wireless module, but it forms without features such as keypad or display [18]. This module must be connected to internet to give the signal.

Figure 2.15 IoT module

2.3.3.3 EFS-LTE1800 GPS

This module is the latest EFS-LTE1800 series E-bike IoT GPS module has an integrated LTE Cat M1&NB m1/EGPRS or 2G quad-band frequency network. An advanced GPS positioning system that can be easily embedded or hidden in a special tunnel section of the e-bike, suitable for multiple religions. It has a very long lifespan and can track and monitor remote targets via SMS or Internet. This module uses a compact ultra-sparrow design in a hidden tunnel tube. Includes Lte cat M1&NB m1&EGPRS or 2G. Positioning accuracy up to 2.5 meters. Onboard GNSS/GSM LTE antenna and external IPEX support. Support nano SIM card compatible with eSim. It is also built-in TCP/MQTT protocol to the server. Can change IP and Port via SMS [19].

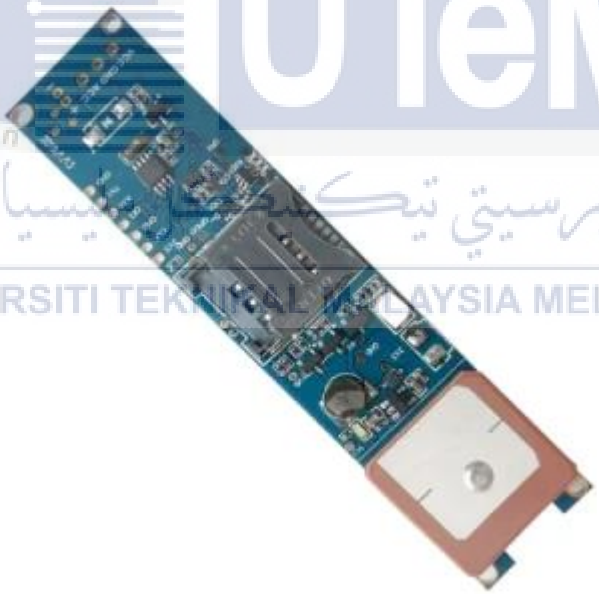

Figure 2.16 EFS-LTE1800 GPS module

CHAPTER 3

METHODOLOGY

3.1 Introduction

Based on the chapter before, the decision is Arduino that capable to calculate and will be combined with GSM module. Compared to the others Arduino, Arduino UNO is selected because the pins that have on the board are enough to complete this project. The language of Arduino use is easier to understand compared to raspberry pi module. GSM module is used because it can send the messages by SMS using prepaid compared to IOT that need to use internet connection to send messages.

3.2 Overall project flowchart

This shows the phase of the work progress to complete this project.

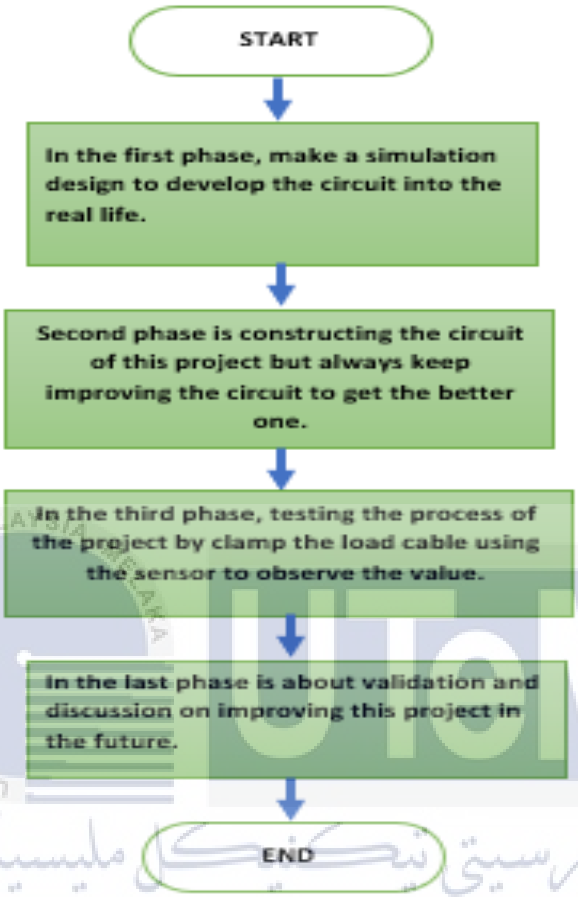

Figure 3.1 Project flowchart

3.3 Component List

3.3.1 Arduino UNO

Arduino-UNO has been choose to use in this project because of the pin that require for this project is enough. Arduino Mega has more extra pin and the cost for the Arduino UNO is more cheaper than Arduino Mega. A coding constructed and traansfer in the microcontroller of this board to make the process.

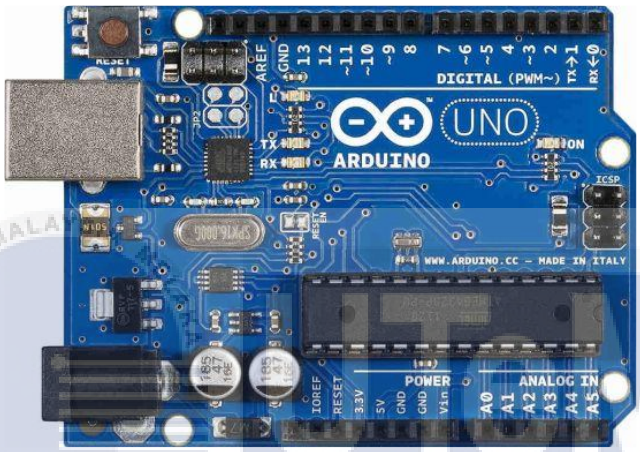

Figure 3.2 Arduino board

3.3.2 LCD display

A liquid crystal display (LCD) is a flat panel display or other electronically modulated optical device that uses the light modulation properties of liquid crystals in combination with polarizers. This component is use to display the information that send from the ardiuno that has been set in the coding.

Figure 3.3 LCD display

3.3.3 Current Transformer Sensor

The sensor that use in this project is PZCT-02 split core current transformer coil sensor model that designed for energy meter. This sensor will be a bit error due to the manual measurement.

Figure 3.4 Current sensor

3.3.4 GSM module

By using this module, the consumer will recieve the information that have been set by the arduino. LCD will display for one time view but when the consumer recieve the information is store permanently in the message inbox until the reciever delete the conversation or the message.

Figure 3.5 GSM module

3.3.5 Connecting wire

In this project, the important thing that needed to complete the connection of the system is the connecting wire. This will connect the current sensor, arduino, lcd and the gsm module. Without this apparatus it cannot complete and the system will not opearate.

Figure 3.6 Connecting wire

3.4 Parameters

The parameters in this project are to find out the power in kW of a single appliance usage. Then, it display to the lcd display and also the owner's phone the information that get from input through the arduino. This is the coding that has been set to the arduino to complete the project.

3.5 Circuit design

This figure shows the circuit design in this project that have been done.

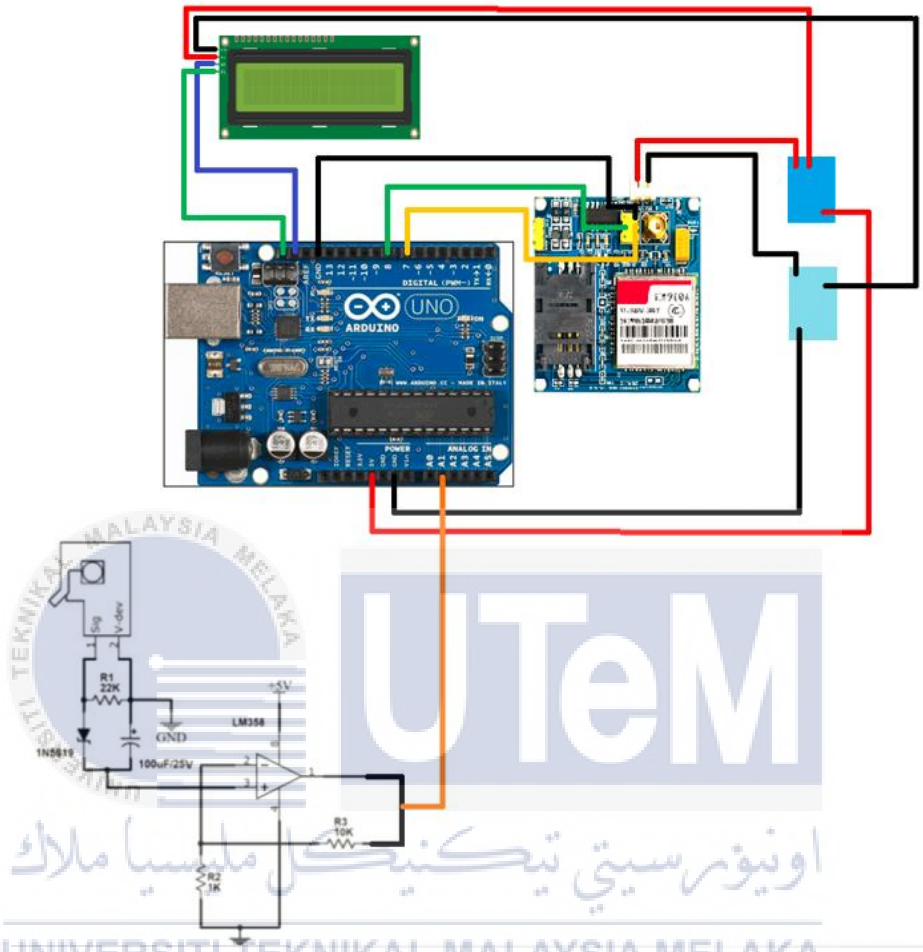

Figure 3.7 Circuit diagram

3.6 Block diagram

This part shows the flow of the project concept starting with the load to achieve the objective project.

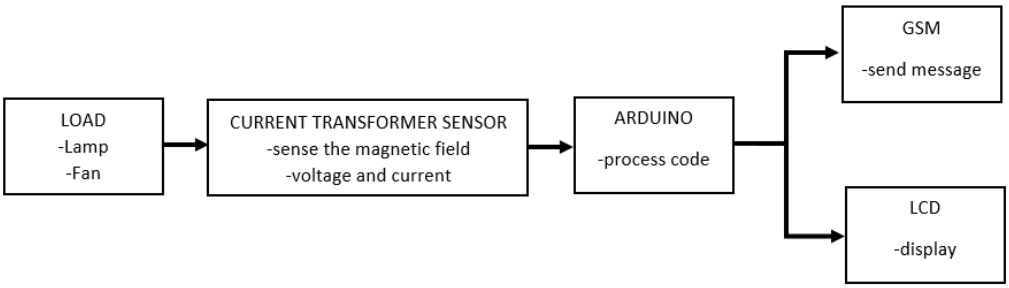

Figure 3.8 Block diagram

3.7 Process flow

This shows the process flow of this project.

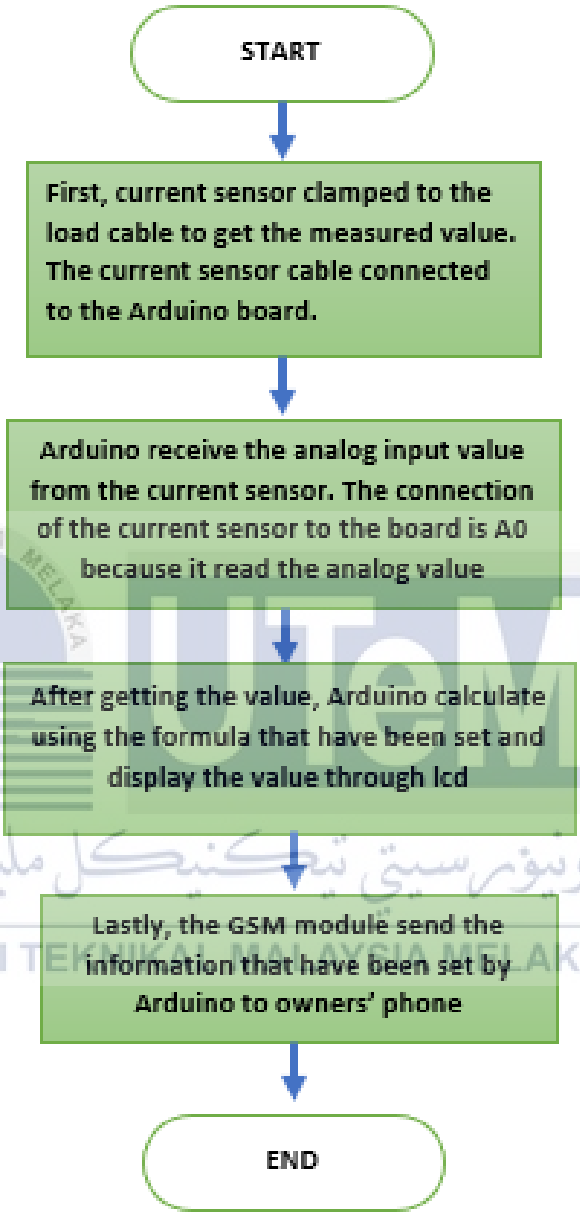

Figure 3.9 Process flow

3.8 Summary

This part shows the devices used in this project. This project used an Arduino UNO as the brain of the project controller. The Current Transformer Sensor is the input sensor for this project to get the values of the appliances. The GSM module will send a message to the user's phone after the Arduino receives the input value from the current sensor and does the calculation. Coding built for this project to upload to an Arduino board is easy compared to other microcontrollers. Since this project is a hardware project, it can cause some error of reading value and the consumption will a little bit different to the actual electricity bill. This purpose project is to get the immediate electricity consumption of a single appliance.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter will present the process and the work during make this project to be done. The process took a several part such as constructing coding, transfer the code to Arduino, testing and assemble the equipment of this project.

4.2 Experimental setup

This subchapter will explain briefly about the setup to accomplish this project. This procedure is shows the step of project work flow that start with load setup as the measrement input for this project. Then, it is follow by constructing the circuit for this project.

4.2.1 Load sample

These are the load that have been set up for the current sensor to get the measurement. The bulb that uses in load sample 1 is 5W E27 LED bulb with AC 220~240V. The plug socket use 13A. For the load sample 2, there is a simple load circuit that consist of main switch, ELCB and MCB as the input. This circuit use a 10W lamp and the plug connected to a fan.

Figure 4.1 Load sample 1

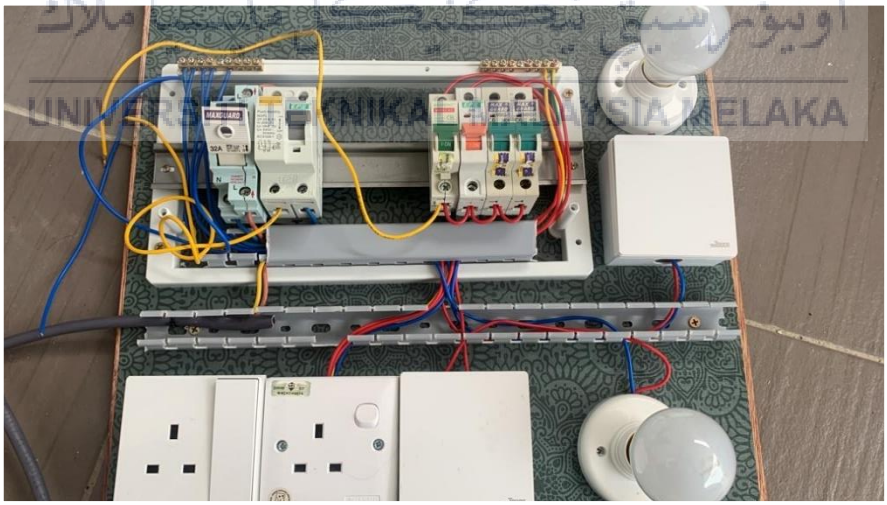

Figure 4.2 Load sample 2

4.2.2 Main circuit

This circuit is the main cicuit without combine with the sensor. The function of this circuit is to determine that lcd and GSM are in a good condition by sending a signal to accomplish the function for both equipments.GSM and LCD power input are

connected to the 5V pin of the arduino board that have been loop to the other breadboard to turn on the components. Tx and Rx pin from the GSM module connected to pin 3 and 2 of Arduino board based on the coding that have been set.

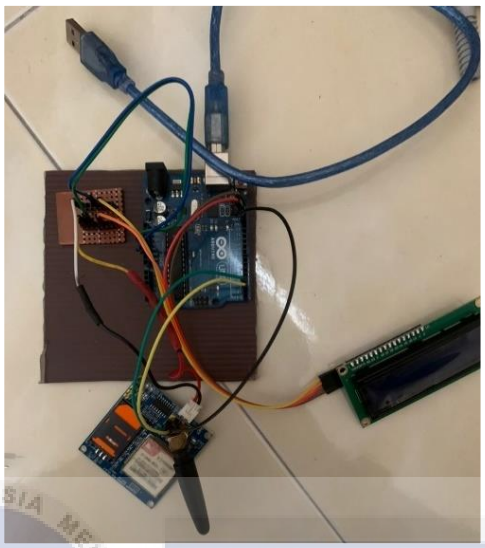

Figure 4.3 Main circuit

4.2.3 Sensor circuit

This is the sensor circuit where the function is to measure the current flow through the load by clamp the live load cable. On this circuit, it consist resistors of 1k, 10k and 22k ohm, LM358 Op-Amp, 100uF/25V electrolyte capacitor, 1N5819 schottky diode and PZCT-02 current transformer sensor. PZCT-02 CT function as the input to measure the magnetic value that produce from the load cable.

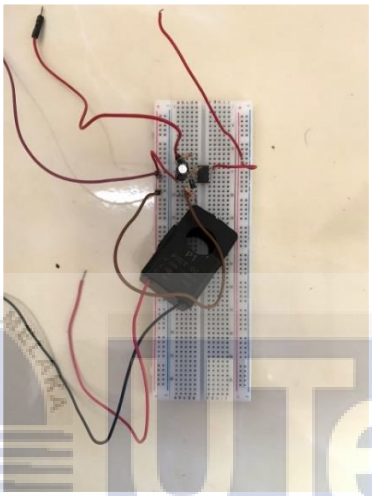

Figure 4.4 Sensor circuit

4.3 Testing

This part will show the testing of this project about the functional of LCD with GSM and LCD with current sensor. Accomplish the 4.2.2 when the signal is given to the Arduino, it displays on the LCD and GSM send the message to the user's phone.

Figure 4.5 LCD and GSM module

This shows the current sensor that have been clamp to the load cable to ensure that sensor can read the value of the load and test the combination with the lcd and Arduino.

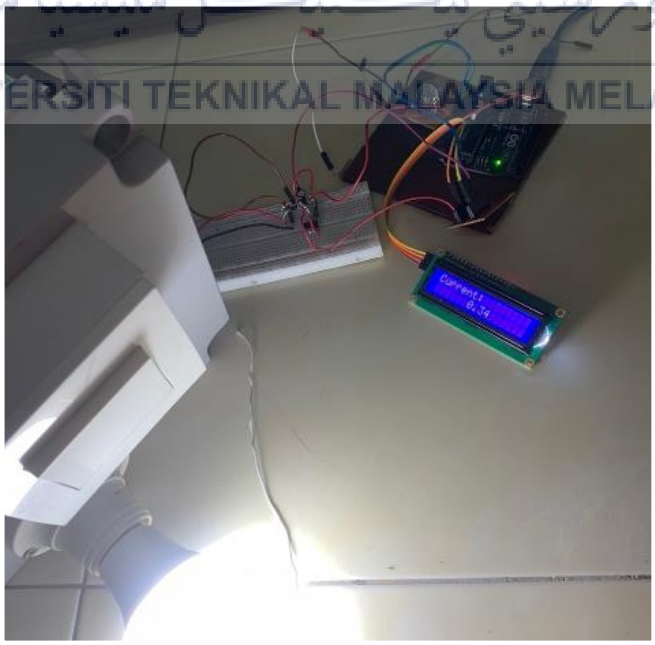

Figure 4.6 LCD with Current sensor

4.4 Result

This is the final result circuit after combine all of the separate circuit. The sensor clamp to the load cable to measure the power that use of this appliance.

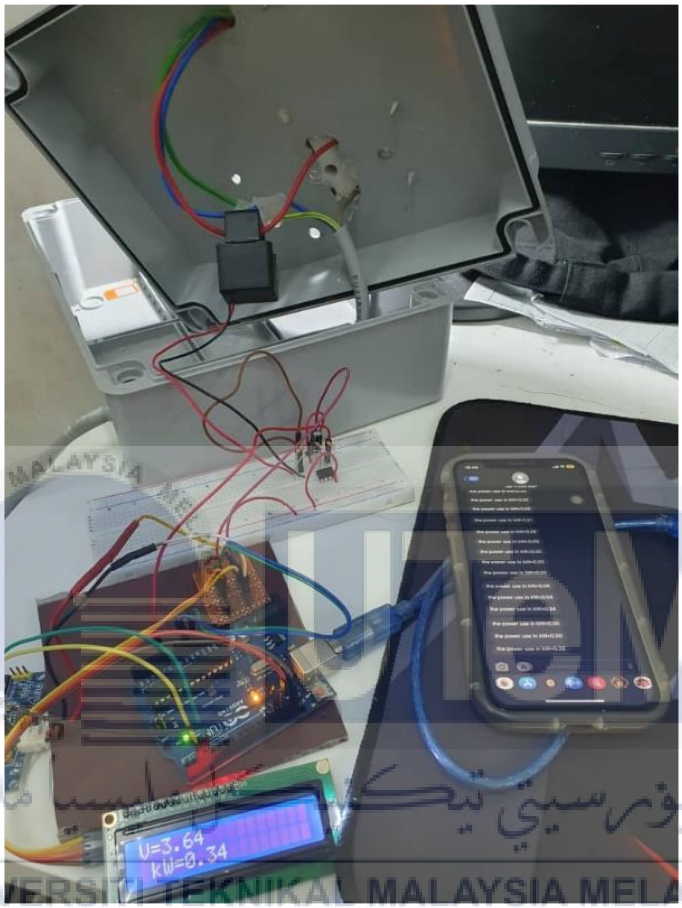

Figure 4.7 Project circuit

4.4.1 Data table

On this subchapter, it will shows the data that have been collected on a single appliance that use in a house. It is show the comparison of measurement based on this project between using a calibration equipment. To determine the accuracy of this project, find the different value of power from both measurements and divide it by the value measured by the calibration equipment. Then multiply by 100.

Table 5 Result data

	Measurement using this project			Measurement using a calibration equipment		
Type of load	voltage	current	power	voltage	current	power
Sample load 1	3.64	0.34	1.24	3.4	0.3	1.02
Sample load 2 (lamp)	3.5	0.33	1.15	3.1	0.3	0.93
Sample load 3 (fan)	3.64	0.34	1.24	3.4	0.3	1.02

4.5 Summary

From this part, the objective of this project have been achieve by the GSM module send the information to the user's phone. The accuracy of the current sensor was determined corresponding to the calibration equipment, which had an accuracy value of 78%. The current sensor should be replaced with another extra accurate sensor.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter describes the achievements of this project in view of the expansion outlook and objectives that are given in the introductory chapter. Performance findings consistent with the objectives and outline of this project are included in this chapter. Next, this chapter also provides suggestions for improvement in the future projects also belong to this chapter.

5.2 Conclusion

This project has determine the power consumption in kW of a single load and multiple load by using the current sensor. The next stage is transmit the information by sending it to the user's phone using the GSM module. The delay of the transmit data is 500ms. Lastly, compared results that have been collect with the calibration equipment to get the precision of this project. This stage has shown that the project is manage to get the 78% of the accuracy measurement. So this project that monitor the load of a single appliance in a house by using lcd display and GSM module has been achieve. The main purpose of this project is to help users efficiently manage their home power consumption and reduce their monthly electricity bills.

5.3 Future Works

Recommendations on this project are improve the accuracy of the measurement and improving the communication module. For the improvement of the accuracy measurement can provide some of current sensor and compare between them to get the best accuracy due to the calibration equipment. Then, for the improving of the communication module is can change the GSM module to IoT module. Using IoT modules can save a lot of costs. This is because the GSM module needs to use a SIM card. Sending messages to users requires credit on the SIM card. This can cause to send messages with a lot of credits.

REFERENCES

[1] May 02, 2022 B. P. (2022, May 2). Energy vampires: Keep your devices from Wasting Energy and Money. NRDC. Retrieved November 13, 2022, from https://www.nrdc.org/stories/keep-your-devices-wasting-energy-and-money

[2] Programmable energy meter for electrical load survey. Electrosal. (n.d.). Retrieved December 28, 2022, from https://www.electrosal.com/product/programmable-energy-meter-for-electrical-load-survey/

[3] Mursid1, S. P., & Santoso1, H. B, "Analysis of the Effectiveness of the Utilization of Power Monitoring Devices in Reducing Electric Energy Consumption," IOPscience. Journal of Physics: Conf. Ser. 1364, 2019.

[4] Mnati, M. J., Van den Bossche, A., & Chisab, R. F, "A smart voltage and current monitoring system for three phase inverters using an Android smartphone application," Sensors, vol. 17(4), pp. 872, 2017.

[5] Arvindan, A.N.; Keerthika, D, "Experimental investigation of remote control via Android smart phone of arduino-based automated irrigation system using moisture sensor," Proceedings of the 2016 3rd International Conference on Electrical Energy Systems, 2016

[6] Projects, E. G. (2018, June 28). How to measure current using Arduino and ACS712 current sensor. Engineers Garage. Retrieved January 4, 2023, from https://www.engineersgarage.com/acs712-current-sensor-with-arduino/

[7] Electro Gadget, Ari, Dushyant, & Solanki, B. (2022, September 10). AC current measurement system using Arduino and CT Sensor. Electro Gadget. Retrieved January 3, 2023, from https://circuitdiagrams.in/ac-current-measurement-using-arduino/

[8] Mahzan, N. N., Enzai, N. I. M., Zin, N. M., K S S K M Noh, "Design of an Arduino-based home fire alarm system with GSM module," IOPscience. Journal of Physics Conf. Ser. 1019, 012079, 2018.

[9] Z Jifei, "Intelligent power failure alarm based on ATmega128 and SIM900A," Knowledge Guide, 2014

[10] Wardynski, D. J. (2019, October 10). What is a microprocessor and how does it work? Custom Software Development and Consulting Services Denver. Retrieved October 22, 2022, from https://www.brainspire.com/blog/what-is-a-microprocessor-and-how-does-it-work

[11] What is a Raspberry Pi? Opensource.com. (n.d.). Retrieved December 12, 2022, from https://opensource.com/resources/raspberry-pi

[12] Types of arduino: Complete guide to 6 different types of Arduino. EDUCBA. (2021, March 4). Retrieved June 1, 2022, from https://www.educba.com/types-of-arduino/ *(references)*

[13] Sensing and measurement instruments. Sensing and Measurement Instruments | Engineering360. (n.d.). Retrieved November 28, 2022, from https://www.globalspec.com/productfinder/labware_test_measurement/sensing_measurement_instruments

[14] UpKeep. (n.d.). How does a voltage sensor work? definition and common uses. onupkeep. Retrieved January 2, 2023, from https://www.upkeep.com/learning/voltage-sensors#:~:text=Voltage%20sensors%20are%20wireless%20tools,when%20voltage%20is%20too%20high.

[15] Morris, E. (2020) Everything you need to know about current sensors, Aim Dynamics. Available at: https://aimdynamics.com/everything-about-current-

sensors/#:~:text=What%20is%20a%20current%20sensor,both%20AC%20and%20DC%20current. (Accessed: November 5, 2022).

[16] What is a communication device? What is a Communication Device? (2019, October 7). Retrieved May 28, 2022 from https://www.computerhope.com/jargon/c/communication-devices.

[17] Rathore, A. (2021, August 31). What is GSM module and GPRS module?: Expert class notes. Electronics For You. Retrieved May 29, 2022, from https://www.electronicsforu.com/resources/gsm-module

[18] Understanding IOT modules - step by Step (2022 update). Thales Group. (n.d.). Retrieved June 1, 2022, from https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/inspired/iot-modules.

[19] EFS-LTE1800 LTE-M12G /4G e-bike IOT GSM GPS module GPS track. Made. (n.d.). Retrieved January 4, 2023, from https://b30665d88c4627c3.en.made-in-china.com/product/qdLnHUzyhPWr/China-Efs-Lte1800-Lte-M12g-4G-E-Bike-Iot-GSM-GPS-Module-GPS-Track.html

APPENDIX

Coding for the project

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>
SoftwareSerial SIM900(3,2); // gsm module connected here
String textForSMS;  // Set the LCD address to 0x27 for a 16 chars and 2 line
display
LiquidCrystal_I2C lcd(0x27, 16, 2);
const int VOL_PIN = A0; // set for the input from the current sensor
String stringOne;
void setup()
{
 randomSeed(analogRead(A0));
 Serial.begin(9600);
 SIM900.begin(9600);// for sim900D 19200. while enter 9600 for sim900A

 Serial.begin( 9600 );// initialize the LCD
 lcd.begin();// Turn on the blacklight and print a message.
 lcd.backlight();
 stringOne = ("the power use in kW= ");
}
void loop()
{
```

```
int value;
float volt;
float po;
float cur;
  value = analogRead( VOL_PIN );
  volt = value * (5 / 1023.0) ; //
  cur = volt / 10.680;
  po = volt * cur;// to find the value of power
  // adding a variable integer to a String:
  stringOne += po ;
  Serial.println(stringOne);  // the command to combine two variable which is
po + power uses
  textForSMS =  ( stringOne  );
  sendSMS(textForSMS);
  Serial.println(textForSMS);
  stringOne= "the power use in kW=";
 Serial.print( "Value: " );
    Serial.print( value );
    Serial.print( "  Volt: " );
    Serial.println( volt );
    Serial.print( "  current: " );
    Serial.println( cur );
 lcd.clear();
 lcd.print("V=");
 lcd.print( volt );
```

```
 lcd.setCursor(1,1);
 lcd.print("kW=");
 lcd.print( po );
 delay(1000);
}
void sendSMS(String message)
{
  SIM900.print("AT+CMGF=1\r");  // AT command to send SMS message
  delay(1000);
 SIM900.println("AT + CMGS = \"+60164640803\"");// recipient's mobile number, in international format
  delay(1000);
  SIM900.println(message ); // message to send
  delay(1000);
  SIM900.println((char)26);  // End AT command with a ^Z, ASCII code 26
  delay(1000);
  SIM900.println();
  delay(100); // give module time to send SMS
 // SIM900power();  // turn off module
}
```