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IMPLEMENTATION OF ENERGY MONITORING FOR SOLAR SYSTEM

MOHAMMAD AL AKEEF BIN ALAMIN

B011310072

SUPERVISED BY:

DR. MUHAMMAD NIZAM BIN KAMARUDIN

2017

"I hereby declare that I have read through this report entitle " Implementation of Energy Monitoring for Solar System " and found out that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)(Hons.)"

Signature	:..
Supervisor's Name	: Dr. Muhammad Nizam bin Kamarudin
Date	:..

IMPLEMENTATION OF ENERGY MONITORING FOR SOLAR SYSTEM

MOHAMMAD AL AKEEF BIN ALAMIN

A report submitted in partial fulfilment of the requirements for the degree of

Bachelor of Electrical Engineering (Control, Instrumentation and Automation) (Hons.)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

I declare that this report entitle entitle “Implementation of Energy Monitoring for Solar System” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Muhammad Al Akeef bin Alamin

Date : ....

Dedicated to my beloved family, father and mother Alamin bin Hawadan Shah & Siti Zauyah binti Abd Rahman@Ali.

The late Puan Hamidah binti Abu Mansor. Al-Fatihah.

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ABSTRACT

This project discusses about the energy monitoring for solar system. Nowadays the need of green energy becomes one of a development campaign all around the world. Despite other source of energy, solar energy is used widely for standard voltage and current especially house or any simple appliances. Solar panels that absorb the sun's power to generate electricity provide clean power for homes, communities and businesses, and help cut the carbon emissions. Solar photovoltaic (PV) modules generate electricity from sunlight, which can be fed into the mains electricity supply of a building or sold to the public electricity grid. Reducing the need for fossil fuel generation, the growing grid-connected solar PV sector across the globe is helping create jobs, enabling families and businesses to save money, and cut greenhouse emissions. This project aims to develop a solar energy monitoring system hardware by using Internet of things (IoT). The control protocol for energy monitoring system is designed in order to measure the real-time state-of-charge (SOC) of the battery through IoT facility. Through this facility, the effect of solar irradiance towards state-of-charge of the battery can be observed and analyzed. In the methodology, the use of IoT technology with help of Arduino microcontroller and android apps is needed so that the combination of the new technology can be replaced by GSM system..

ABSTRAK

Projek ini membincangkan tentang pemantauan tenaga untuk sistem solar. Pada masa kini keperluan tenaga hijau menjadi salah satu kempen pembangunan di seluruh dunia. Walaupun sumber tenaga yang lain, tenaga solar digunakan secara meluas untuk voltan standard dan terkini terutama rumah atau apa-apa peralatan yang mudah. panel solar yang menyerap kuasa matahari untuk menjana tenaga elektrik menyediakan tenaga bersih untuk rumah, masyarakat dan perniagaan, dan membantu mengurangkan pelepasan karbon. solar photovoltaic (PV) modul menjana elektrik daripada cahaya matahari, yang boleh diberi makan ke dalam bekalan kuasa elektrik bangunan atau dijual kepada grid elektrik awam. Mengurangkan keperluan untuk penjanaan bahan api fosil, sektor PV solar grid yang berkaitan yang semakin meningkat di seluruh dunia membantu mewujudkan peluang pekerjaan, membolehkan keluarga dan perniagaan untuk menjimatkan wang, dan mengurangkan pelepasan rumah hijau. Projek ini bertujuan untuk membangunkan perkakasan sistem pemantauan tenaga solar dengan menggunakan Internet perkara (IoT). Protokol kawalan untuk sistem pemantauan tenaga dirancang untuk mengukur masa nyata state-of-caj (SOC) bateri melalui kemudahan IoT. Melalui kemudahan ini, kesan sinaran solar ke arah negeri-of-caj bateri boleh diperhatikan dan dianalisis. Dalam metodologi, penggunaan teknologi IoT dengan bantuan Arduino mikropengawal dan android aplikasi diperlukan supaya gabungan teknologi baru boleh digantikan dengan sistem GSM.

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LIST OF ABBREVIATION

IoT	-	Internet of Things
SOC	-	State-of-Charge
PV	-	Photovoltaic
GUI	-	Graphical User Interface
DB	-	Distributed Board
WEF	-	World Economic Forum
MPPT	-	Maximum Power Point Tracking
UV	-	Ultra Violet
DC	-	Direct Current
AC	-	Alternating Current
TSC	-	Three Stage Charging
Volt	-	Voltage
Amp	-	Ampere
PSM	-	Projek Sarjana Muda
FYP	-	Final Year Project

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CHAPTER 1

INTRODUCTION

1.1 Project background

This project is focusing on design and analysis of solar energy monitoring system using IoT of an Espresso 2.0 devices that can be connected directly to android or apple operating system. The system is developed to monitor and read the harvested energy of photovoltaic (PV) panel that charge the battery that is efficient for the home usage.

The solar (PV) panel connected directly to the solar charger controller, then transfer the harvested energy to the battery. The battery connected to the solar charger controller so the state of charge (SOC) can be monitored through the system. Throughout the discharging of energy stored by the PV panel to the battery, connection of a switch, current sensor and voltage divider added in order to read all data thus could be controlled directly by using the IoT system.

This project prototype can be connect from the solar (PV) system directly to the Distributed Board (DB) in the house. It consumes the power from the charged battery automatically and provide information on how much energy of the electrical appliances are consumed.

Pointing down the reliability in SOC for the system, ammeter and voltmeter are connected directly in between the photovoltaic (PV) panel and battery. The reading will show the data of current (ampere) and voltage (volt) in term of charging while discharging of the battery will be indicated by using current sensor and voltage divider directly to Arduino microcontroller.

All data that been collected by the system to user give them advantage on calculation of how much energy from the solar system stored. This will make the overall system user friendly with controllable charge or discharge of the system.

Nowadays most people are demanding the simple and easy excess or control of any system that were capable in any distance or places. By implemented the IoT technology that connected directly to the system it can read, control and transfer the reading data via the apps, and email. But there were limitation of using the IoT which there were only 1 analog input and 4 digital input, so decision been made to use it for controlling on and off of the charging or discharging battery and data transfer for the energy stored by the battery in term of energy, current and voltage reading. The effect of solar irradiance based on sunlight radiation intensity towards state of charge of a battery been studied by using the energy data collection in this project.

Next, the user are capable to install the application directly to their smartphone as they just need to search it from the internet. This will satisfying the users because it is easier to control the system in distances, as long as they have the internet connection and the system is connected to Wi-Fi.

1.2 Problem Statement

The usage of alternative source of energy become more important nowadays. Solar energy is one of the most popular source of energy used by consumers because it's a simple platform that can be constructed anywhere with high durability of energy charge towards solar irradiance of sunlight intensity.

Throughout the potential and popularity of solar energy application, there is such incomplete interface (system) in term of monitoring and real time read and control of SOC (state of charge) or discharge energy and consumption of the stored energy.

User requested easier way for them to monitor or control any system when they were in other places far from the system. Nowadays users demanded the usage of internet in daily life and the technology of Wi-Fi give users some advantage for them to connect and doing some work far from any constructed system.

This project also propose and provide awareness to mobility & control of the system. The system empowered by integrate IoT into the control system mechanism plus development of GUI (graphical user interface) for user. Users also demanding the interactives, portable monitoring and control system.

1.3 Motivation

From the newly technology approached, the convenient aspect for users considered as important mechanism towards any product invented. Thus, the needed of easily monitor and new technology combination are recommended to construct the prototype or product as simple and useful for users. The energy monitoring for the solar system will be used with same application of cloud computing using internet of thing. The internet of things application were highlighted by World Economic Forum (WEF) in 2016 conferences at Geneva Switzerland as the new technology required for the future industrial forward. So it could be consider the internet of things application for industrial, is simpler and easily controlled even by using smartphones with android OS or iOS platform.

Besides the important of internet of things application, Gordon Research Conference 2016 at Hong Kong University of Science and Technology had mention about the important of solar energy, the direct conversion and utilization of solar energy is increasingly important as global demand for energy grows, and regulatory constraints on pollution as well as world concession about climate change become more pressing. Over the past few decades, great efforts have been devoted to the development and study of materials, physics and devices for advanced solar energy conversion.

1.4 Objective

This project embarks into following objectives:

1. To develop a solar energy monitoring system hardware prototype by using Internet-of-things (IoT) technology that can measure voltage, current and power of the charged battery.
2. To analyses the effect of solar irradiance of sunlight intensity towards state-of-charge of the battery.

1.5 Scope

This project focuses on the development of monitoring and control the system constructed based on charging and the usage of energy from the charged battery that connected to solar panel via IoT application. Besides, this project is significant to Malaysia that nowadays is soaring forward towards renewable energy implementation. The development of the hardware part consists of system configuration and wiring. The simulation of the performance of the system is conducted by using ARDUINO IDE, PROTEUS and FRITZING software. The results are evaluated in real-time basis where the energy stored is monitored by smartphone and the data also can be transmit directly to users via email. From the data study, investigation of the state-of-charge toward solar irradiance in term of sunlight intensity could be made.

1.6 Project Outline

This report consists of 5 chapters. Chapter 1 discusses about the project background which is explain about the project. Then, the problem statement of this project and the scope of the research also will be discussed. Chapter 2 elaborates literature review, reviews of the previous researches project that are related with this project will be discussed. The information will become additional source for the project in to be able more successful. To have a brief understanding of the researches related to the project, a few literature reviews had been done. This chapter will describe the related to the literature reviews. Chapter 3 discusses the explanations about the flow chart of the project from the beginning to the end of the project. For this chapter, it will explain the principle of the methods and techniques that are using by the previous researcher. The selected techniques must be chosen to approach the objective of this project. The data will record from the experimental setup. The Gantt chart also discuss in this chapter. Chapter 4 presents result of the project will be discussed. This will include the data collection, simple analytical analysis and so on. The complete work for the project also been discussed which will describe clearly on what and how the result fully achieve based on the project objectives. Chapter 5 concludes the findings until to-date and discuses about the overall conclusion of the project.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, the review that had been done will be discussed. Review and reference been done by various source such as journal, book, website and others. The reviews are the most important parts to complete this project.

The main reviews for this entire project are:

- Solar energy
- Photovoltaic (PV) panel and Efficiency of solar
- Solar charge controller
- State of charge (SOC)
- Internet of Thing (IoT) in term of monitoring

2.1 Solar Energy

One of widely use renewable energy is the solar energy that receive from the solar radiation of the sun then being absorb by photovoltaic (PV) panel. The sun provided the radiation that is known as isolation energy when it reach to the earth, which make the production of solar electricity possible. The electromagnetic wave from the sun also produce heat and other radiation such UV. The implement of solar energy consumption could be used by the whole community in Malaysia as an alternative to electricity produced by coal, hydroelectric or fossil fuel. [1]

2.2 Photovoltaic (PV) panel and efficiency of solar

The solar system provide an unlimited source of energy and feature in many application, for the endless of the usage of a photovoltaic (PV) panel it is easy and clean to use energy from it. There are some factors lead the effectiveness of absorbing energy by photovoltaic (PV) panel such light intensity, temperature and load. This will lead to the amount of charging whereas to make it as maximum as much to store energy in the battery, the method of efficiency calculates known as Maximum Power Point Tracking (MPPT) to extract the maximum value of power known as Maximum Power Point (MPP). [2]

Due to limited time of energy from PV panels that depend on the sunlight and weather or any environment condition the system could be lack of reliability, efficiency or effectiveness thus it does not receive it maximum power from PV. The system will be reliable as the battery being added, however the system need to be more than one huge battery to maintain it efficiency of charging and make it consistence due to charging and saving time compare to single huge battery that need longer time of charging.[5][7] From the step before could lead to quickly charge of the battery and can prevent the overcharging or undercharging that could decrease the lifetime of battery. To make all the statements below as reality the MPPT will control and the charging control processes combined in the same system. [1]

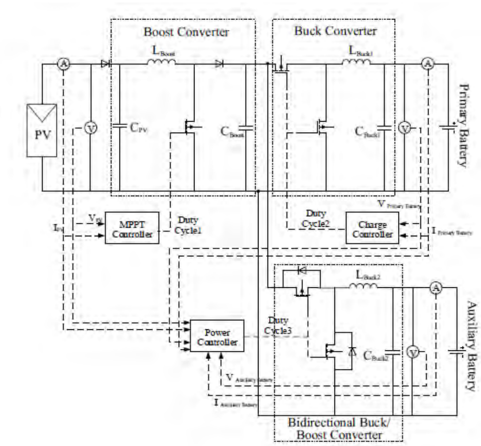

Figure 2.1: circuit of solar harvesting system

For the applications of small-scale harvesting, there were condition where internal consumption of circuitry are often to eat up the energy harvested. [8] The alternative of operation at more or less constant of voltage need to be done by coupling directly the solar cells to a fixed voltage, thus the rechargeable battery is used. For application with high solar irradiations areas, fragments from the harvested energy can be use by the MPPT, or the voltage can be operate with a constant value could be more efficient to lower solar input appliances. [6][9]

2.3 Solar charge controller MPPT

2.3.1 MPPT Technique

The standard method used to control the harvested solar energy is by using a solar controller or known as MPPT (Maximum Power Point Tracking) devices. The MPPT is an electronic device that are DC to DC converter can optimizes the match between PV panel, battery, and load. The function of MPPT also can simply convert a higher voltage DC output from PV panels then step down to lower voltage that needed to charge batteries. [1]

The solar cells are a neat things. Unfortunately the cells are not a smart, neither are batteries. Most PV panels are built to put out a nominal 12 volts. The catch is "nominal". In actual fact, almost all "12 volt" solar panels are designed to put out from 16 to 18 volts. The problem is that a nominal 12 volt battery is pretty close to an actual 12 volts - 10.5 to 12.7 volts, depending on state of charge. Under charge, most batteries want from around 13.2 to 14.4 volts to fully charge - quite a bit different than what most panels are designed to put out.

Other reason of using MPPT is to increase the efficiency of the power from PV panel.

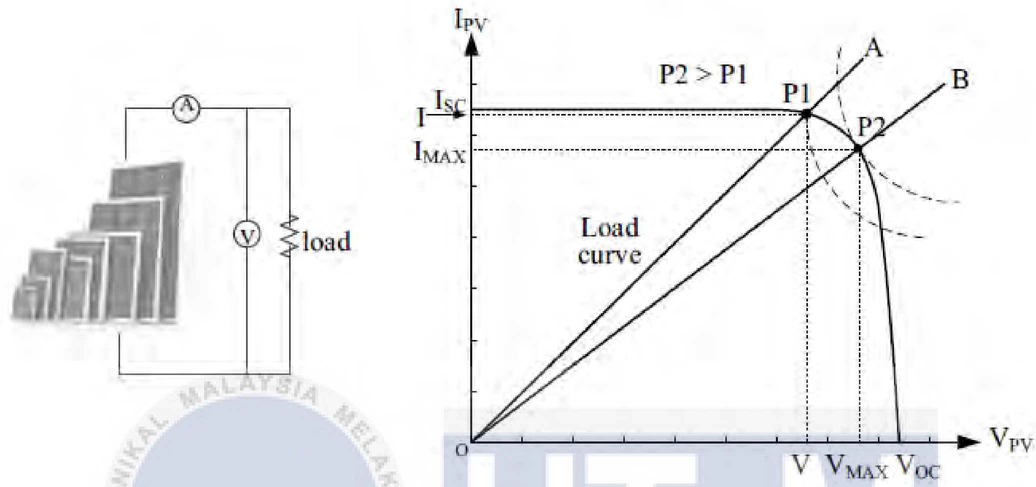

Figure. 2.2: The operation of the MPPT.

In the MPPT process, it work continuously to make sure the system operate at or round the MPP (Maximum Power Point). There are many ways to track the MPP, and the common method to track the maximum power is Perturb and Observe method (P&O method).

The basic principle of the P&O method been done by adjusting the duty cycle of the converter, that is indirect disturbance to the output power of the PV. Comparison being made and compares the new and old power for adjustment. It is define as

$$dP = P(k) - P(k\text{-}1) \qquad (1)$$

- If the value $P(k)>P(k-1)$ positive, the system will adjust the voltage by adjusting the duty cycle of the converter in the same direction.

- If the value $P(k)<P(k-1)$ negative, the system will adjust the voltage by adjusting the duty cycle of the converter in the opposite direction.

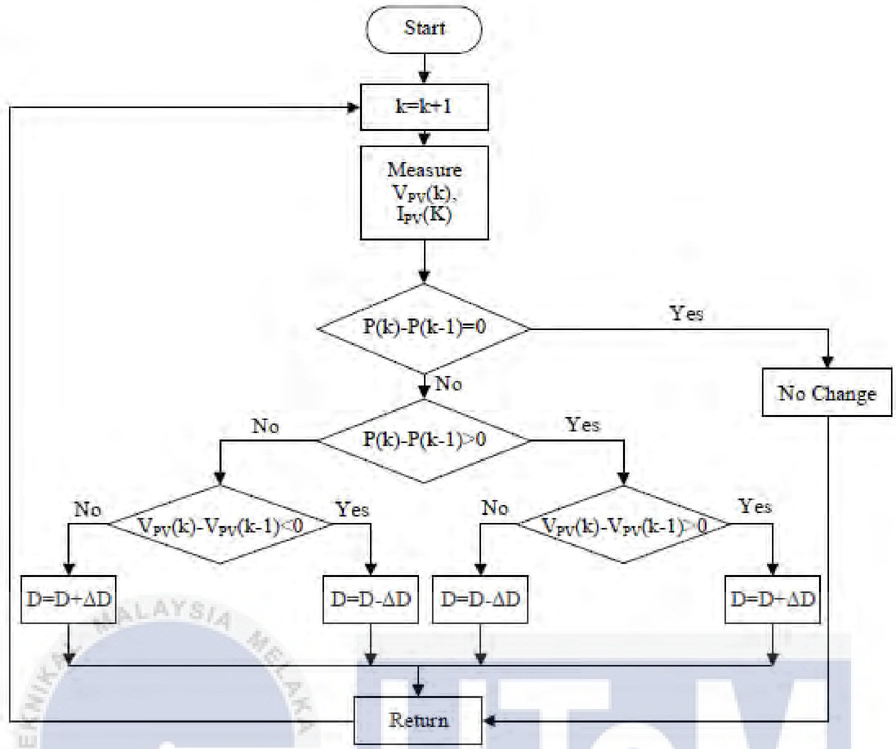

Figure.2.3: Diagram method of P & O

Diagram above shows the P&O method. The method advantage is simple for MPP determination. This method can also work at steady state when light and temperature change slowly. [1]

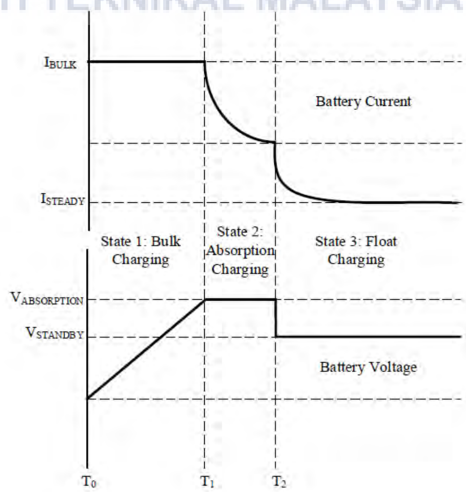

Figure.2.4: Three stage charging the voltage and the current curve

2.3.2 Charging Technique

There will be no constant voltage and current that the PV panel could provide because it depend on light intensity and temperature. Thus the PV panel is not suitable energy source for battery charging. From the statement if the battery will be used in the PV system, the performance of the battery will be decreased, the lifetime of the battery will be shorter. In state of varying light intensity the battery may experience a low State Of Charge (SOC). Typically, the charging of the battery will be controlled by a converter to adjust the duty cycle for the value of the voltage and current in charging process, for quick charging and protecting the battery.

To archive a quick, safe, and complete charging process of the battery, the method was implemented in the most practical way of the Three Stage Charging (TSC), which is divided into three stages as indicated in Figure.4 above

1) *Bulking charging:* This state kind of charging, the current is kept constant, which will reduce the time to charge the battery. It will continually charge in this state until the

2) battery voltage reaches the absorption voltage. This stage will recharged the battery 70-80% of the battery capacity. This is the fastest state of charging.

3) *Absorption charging:* The charging voltage is kept at constant. At the absorption voltage, it will be about 1.2 times of the normal voltage of the battery. Besides, the current charge is reduced closed to zero. This state, the battery will be charged additionally 20-30% of its capacity.

4) *Float charging:* The voltage level will be reduced to a constant value that is called as standby-voltage. It is approximately 1.13 to 1.15 times of the nominal voltage of the battery. This stage indicate that the battery is charged by a small current to maintain the voltage of the battery & it is also important to maintain the voltage of the battery in a full state of charge. [1]

2.3.3 Principle of operating

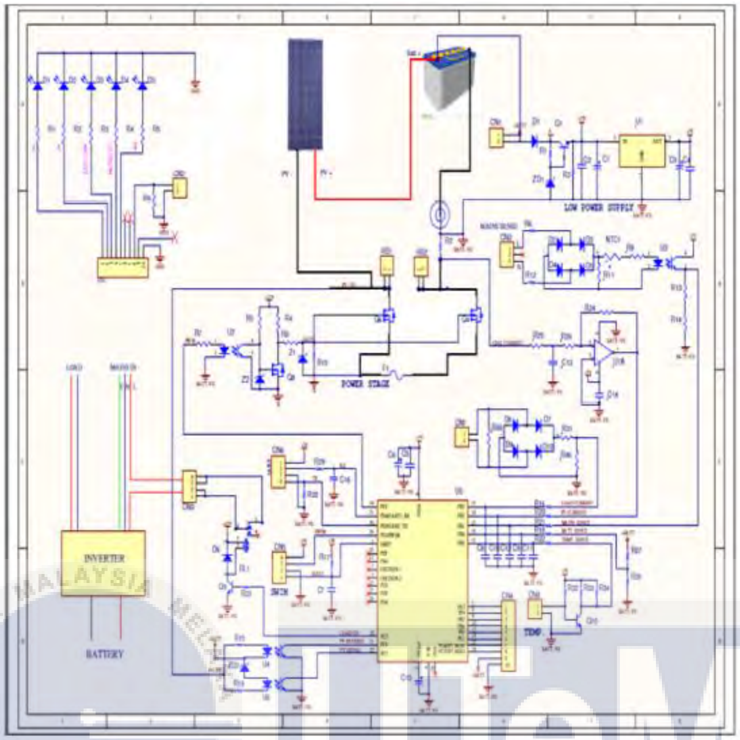

Figure 2.5 Circuit of operating MPPT

Low voltage power supply section is designed to provide regulated supply for relay as well as controller. This section is responsible convert the supply to regulate the voltage control.

2.4 State of charge (SOC)

The state of charge (SOC) is a marker that speaks to the rest capacity of a battery. The SOC estimation is additionally a standout amongst the most key procedures in the plan of battery management system (BMS). In spite of the significance of the component, the SOC can't be measured straightforwardly by sensor.[12] [16]

Knowing the measure of vitality left in a battery contrasted and the vitality it had when it was full gives the user a sign of how much longer a battery will keep on performing before it needs energizing. It is a measure of the transient ability of the battery. Utilizing the similarity of a fuel tank in an auto, State of Charge (SOC) estimation is regularly called the "Gas Gauge" or "Fuel Gauge" work. [14]

The SOC is characterized as the accessible limit communicated as a rate of some reference, some of the time its evaluated limit however more probable its current (i.e. at the most recent charge-release cycle) limit yet this equivocalness can prompt to disarray and blunders. It is not ordinarily an outright measure in Coulombs, kWh or Ah of the vitality left in the battery which would be less confounding. [13]

The favoured SOC reference ought to be the evaluated limit of another cell as opposed to the present limit of the cell. This is on the grounds that the cell limit step by step diminishes as the cell ages. For instance, towards the end of the cell's life its genuine limit will approach just 80% of its appraised limit and for this situation, regardless of the possibility that the cell were completely charged, its SOC would just be 80% of its evaluated limit. Temperature and release rate impacts lessen the powerful limit much further. This distinction in reference focuses is vital if the client is relying upon the SOC estimation as he would in a genuine gas gage application in an auto.

Unfortunately the SOC estimation reference is regularly characterized as the present limit of the phone rather than the evaluated limit. For this situation a completely charged cell, nearing the end of its life, could have a SOC of 100% however it would just have a compelling limit of 80% of its evaluated limit and conformity variables would need to be connected to the assessed ability to contrast it with its appraised new limit. Utilizing the present limit as opposed to the evaluated limit is typically an outline shortcut or trade off to maintain a strategic distance from the multifaceted nature of deciding and taking into consideration the age related limit modification which are advantageously disregarded.[16]

Amid the periods in which the produced vitality is more prominent than the primary load-request the battery bank might be either in charging mode when the battery SOC is not exactly a foreordained low charging-level or help the created energy to supply another assistant burdens when the battery SOC is more prominent than the low charging level (releasing mode) until the battery SOC spans to low charging level. Consequently, at least one of the helper burdens are separated and the battery-bank is in charging mode till high charging level. [12]

Estimation of State-of-Charge (SoC)

In request to enhance battery's security and unwavering quality, forestall overshoot and over release, broaden battery's cycle life and upgrade electric vehicle execution, estimation exact for SOC is required by the battery administration framework. In this paper, through utilizing MATLAB/SIMULINK to construct battery numerical model and SOC estimation calculation, and making the battery demonstrate blend with calculation. Looking at the recreation tests and through the stage of battery administration arrangement of test, the exactness of procedure which is utilized as a part of this paper on the battery's SOC estimation is approved. In the event that the lithium-particle battery SOC needs to be evaluated precisely, it is important to choose a reasonable lithium-particle battery display. Fig 2.4 is the Thevenin show which can speak to static and element qualities of the battery[10].

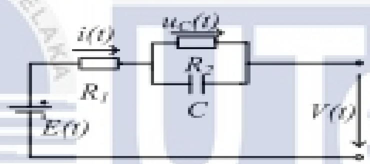

Figure 2.6: Thevenin battery model

$$E(t) = V(t) + R_1 i(t) + u_c(t) \quad (2.5)$$

$$i(t) = \frac{u_c(t)}{R_2} + C\frac{du_c}{dt} \quad (2.6)$$

2.5 Internet of Thing (IoT) in term of monitoring

2.5.1 Internet Of Thing (IoT)

Kevin Ashton proposed the term of Internet of Things (IoT) before 2000 with regards to inventory network administration. Presently the IoT it is more comprehensive and incorporates an extensive variety of applications. Likewise the idea of IoT system hubs, known as Things, was developed as a result of innovation advancement, specifically due the MEMS gadgets progresses. [3][4]

Extensively, IoT is characterized as a sort of system which not just can interface the items, can be completely programmed, can gather, transmit and handle data cleverly additionally can understand the logical administration at whatever time and anyplace through an assortment of detecting gadgets and the Internet. The fundamental attributes of IoT are: arranged, instrumented, computerized and intelligentized. [3]

The vitality administration framework in view of IoT can take care of the issues of gathering, transmitting and sparing the information in vitality running forms by utilizing an assortment of systems, for example, advanced instruments, imparting systems, programming, databases and so on.

The technology of IoT is based on the communicating network, solving interconnection of thing to other issues. For this system it can be divided into 3 levels as shown in figure below. From the top to bottom are the application layer, transport layer and perception layer. [3]

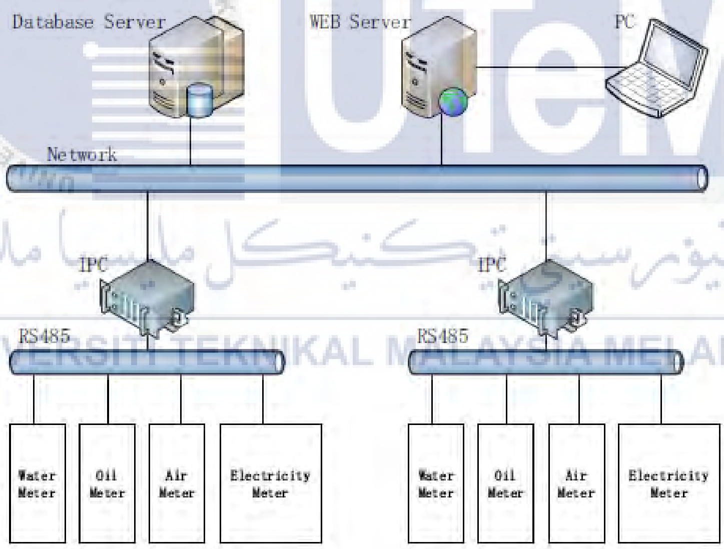

Figure 2.7: Energy monitoring system structure

2.5.2 Monitoring (cloud computing)

The newly technologies shows the important and often of using cloud computing and managing smart system. This technology also provide various in services platform such that the resources, information and software from the computer to the internet [5].

The cloud computing indicate the resources and infrastructure as a source that is minimum in term of cost rather than spend too much on the resources cost [15]. In other opinion IBM said the cloud computing can decrease 40% of payments in term of maintenance of hardware and software itself, that can minimize 30% of the full system.

CHAPTER 3

METHODOLOGY

3.0 Overview

This chapter will describe the method of experimental procedure and task developing the solar system by using Arduino and Proteus, and Fritzing software. The software is use as tool to develop the circuitry and process for finding the solution for the project development. All collected data being used to proceed next objective of effect solar irradiance towards state of charge of the solar battery.

3.1 Flow Chart Process

The flow of the process starts with studying the journal and documentation that related with this research and understand the flow to design. After that, the data the solar monitoring system recorded. After the data has been collected, then the data will be computed by using Arduino and Espresso 2.0 (IoT device software). Lastly the analysis of the performance and energy produced in a period of time for all the data collected will be discussed. All the phase and step written below.

Phase 1: Installation of the equipment

This phase is about the installation of the equipment below:

Step 1: Part list

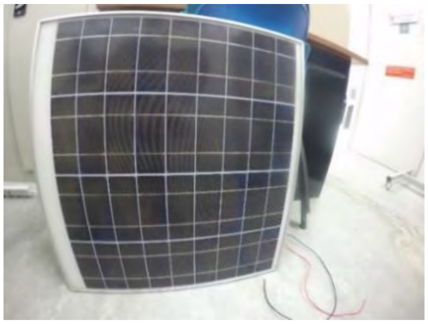

Figure 3.1: PV Panel

Figure 3.2: 12V Lead acid battery

Figure 3.3: Ammeter voltmeter

Figure 3.4: Solar charge controller

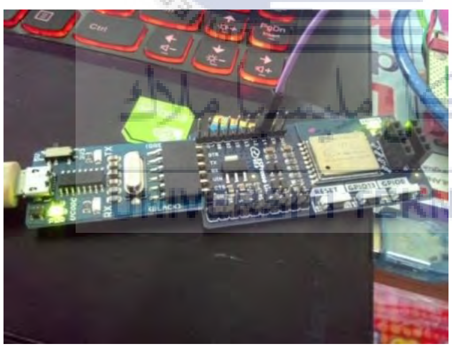

Figure 3.5: Espresso Lite 2.0

Figure 3.6: Arduino Uno

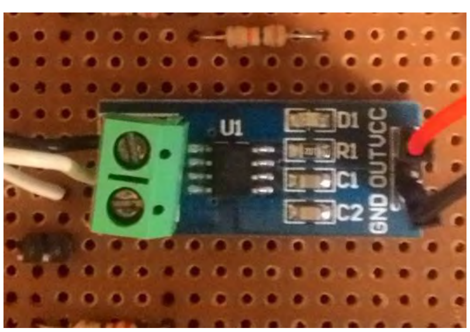

Figure 3.7: 20A Current sensor

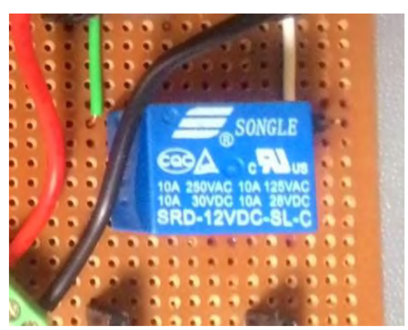

Figure 3.8: Relay

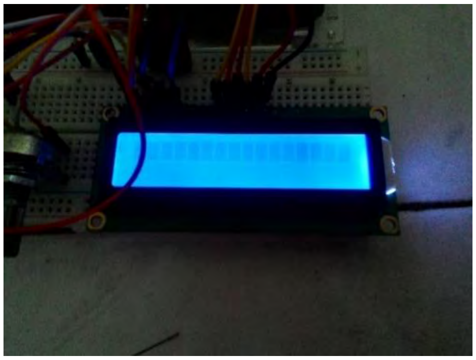

Figure 3.9: LCD Panel

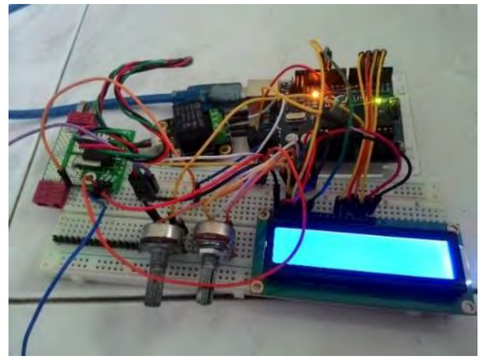

Figure 3.10: Tested circuit

Figure 3.11: Load 12V an

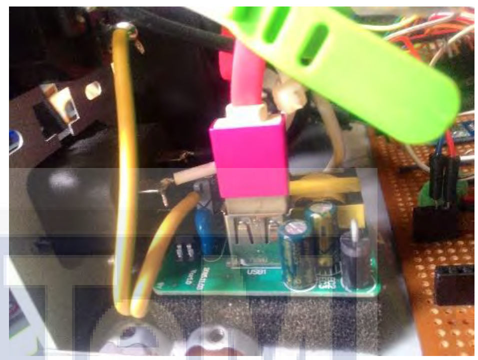

Figure 3.12: Rectifier 12V-5V

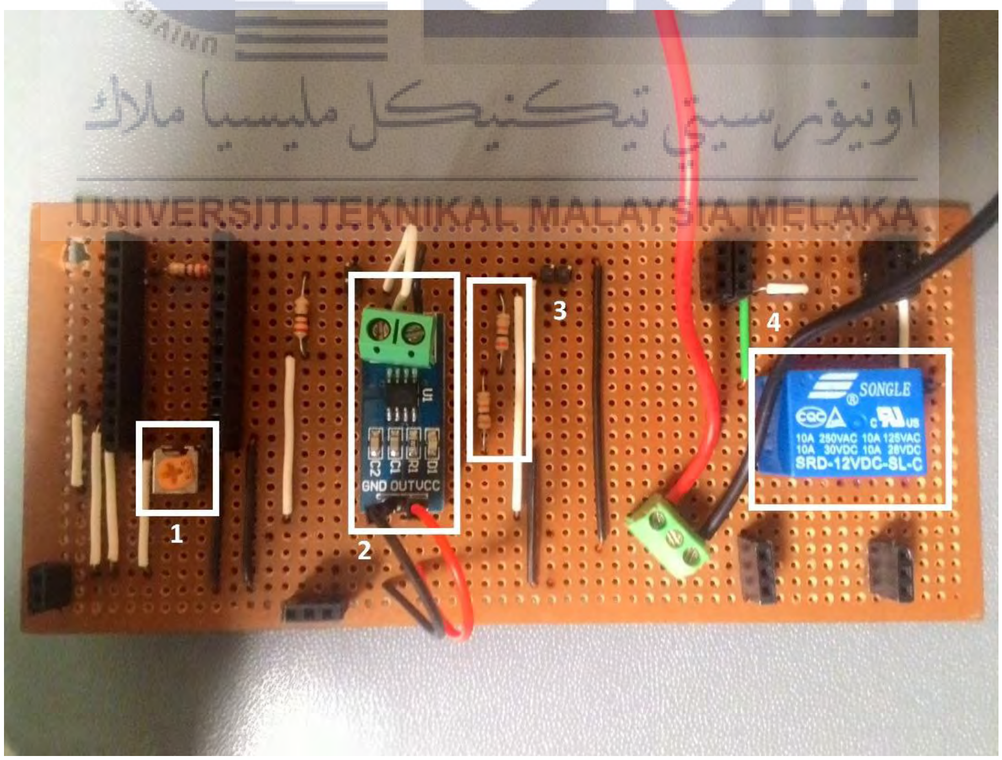

Figure 3.13: Constructed circuit (label describe below)

1. **Potentiometer**
2. **Current sensor**
3. **Voltage divider**
4. **Relay 5-12V**

Step 2: Design and code the circuit by using Fritzing, Proteus and Arduino IDE software.

Step 3: Install the circuit on breadboard to test

Step 4: Troubleshoot any problem involving tested circuit

Step 5: Set up the solar (PV) panel, solar charge controller and battery

Step 6: Connect the set up with tested circuit

Step 7: Read the data of voltage and current from the load through the Arduino.

Step 8: Recheck and calibrate the code and sensor as desired.

Step 9: Choose the right component and solder on the stripboard as mainboard.

Step 10: Attach all the component on mainboard, combined all in the prototype box.

Step 11: Test all the combined component and set up.

Step 12: Troubleshoot if any.

Step 13: Built the IoT apps by using Blynk application on Android platform.

Step 14: Record and collect the data. Make the analysis.

Step 15: Survey being made to study how much users interested towards the prototype.

Basically, the Arduino and Espresso Lite 2.0 working with 5V-9V DC current. So the rectifier is needed to change the 240V AC current from plug supply to step down into 5V DC current. The selected relay used also need the direct 5V supply form the rectifier. Load is connected directly from the main circuit for current reading.

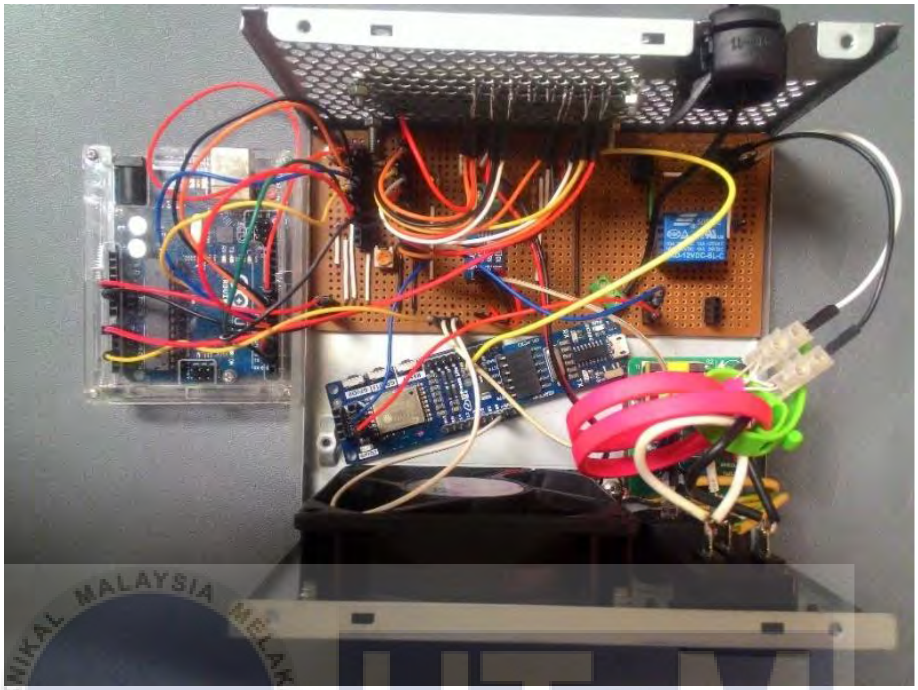

Figure 3.14: Component combined in the prototype box.

Figure 3.15: Complete prototype box with component inside

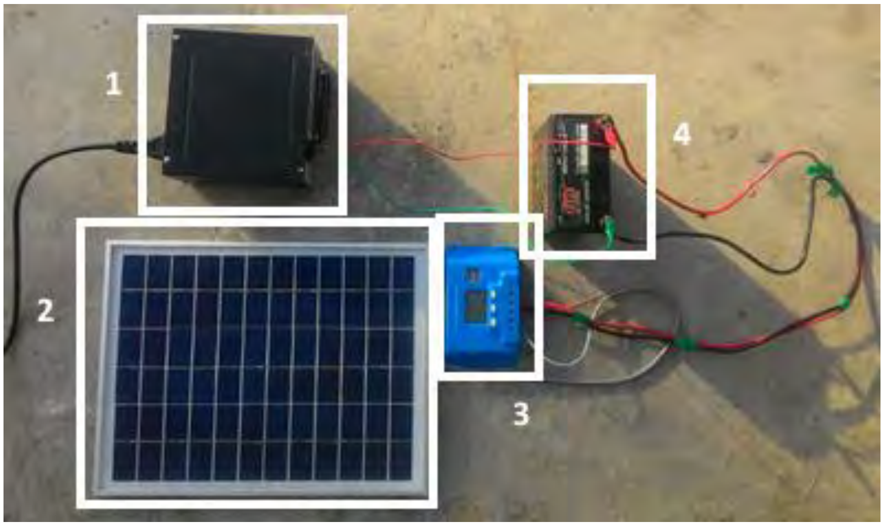

Figure 3.16: Combined solar setup and prototype box.

1. Prototype box
2. PV panel
3. Solar charge controller
4. 12V Battery

Figure 3.17: The Solar Energy IoT (Blynk) app on smartphone.

1. Real time energy read
2. Application stop button
3. Notification alert
4. On/off button for system
5. Graph of voltage, current and energy read from the system.

Specification:

- Nominal input 5V-12V
- Max load current at once 20A
- Maximum data save for 3 month
- Reset setup data available
- Operating temperature: -40 to 85ºC
- IoT application

Features:

1. Solar charge direct to battery
2. Load connect directly to charged battery
3. LCD display
4. Smartphone display as data collection
5. Internet of Things application.
6. Interactive feature for IoT apps user
7. Battery protection with on off button applied to the application

Phase 2: Field data collection

In this phase the charging data of the battery from solar source being collected from 12-4p.m, this time chosen because of the high intensity of sunlight we can get for a single day.

Phase 3: Data collection

Data collection being made by using real time reading from the sensor and voltage divider based on per 30 minutes time interval. The data also collected by the Blynk (IoT) application on smartphone that can read and save the data then send all the data via email.

Phase 4: Overall finding and recommendation

For this phase, is all about to do the analysis for overall finding based on collected data and survey that being make. All the data plotted in form of graphical for easier comparison and analytic study of solar irradiance towards state of charge of the battery. Some calculation needed as the requirement for state of charge study.

3.2 Literature Review

The literature reviews is regarding on previous researchers work in identifying any important issues about solar monitoring system using IoT from IEEE journal, articles, technical paper and others. Literature review part gives information about the general information and also the performance of solar monitoring system by using IoT.

3.3 Data collecting from current and voltage sensor in Arduino

The data collected is one of the key for the project researches to compute weather the project status is functioning or not. The data collected being saved as evidences for the running circuit with different load as contribution to rely the system are stable and compatible with the load or not.

3.4 Compute Data and Control the System

The data compute from the system transferred directly via Arduino throughout the solar system for the real time monitoring. After the data collected, it can be control based on user instruction via IoT application.

3.5 Analysis Performance and Energy monitor by IOT

The data from Arduino being collected and will be transfer directly to IoT device Espresso v2.0 (ESP8622). Then the data will be displayed in the application of IoT in android devices. All the on off or monitoring by the android apps can be made and response directly by the IoT devices through Arduino and the solar system itself.

3.6 Project Planning

3.6.1 Flowchart of Research Activities

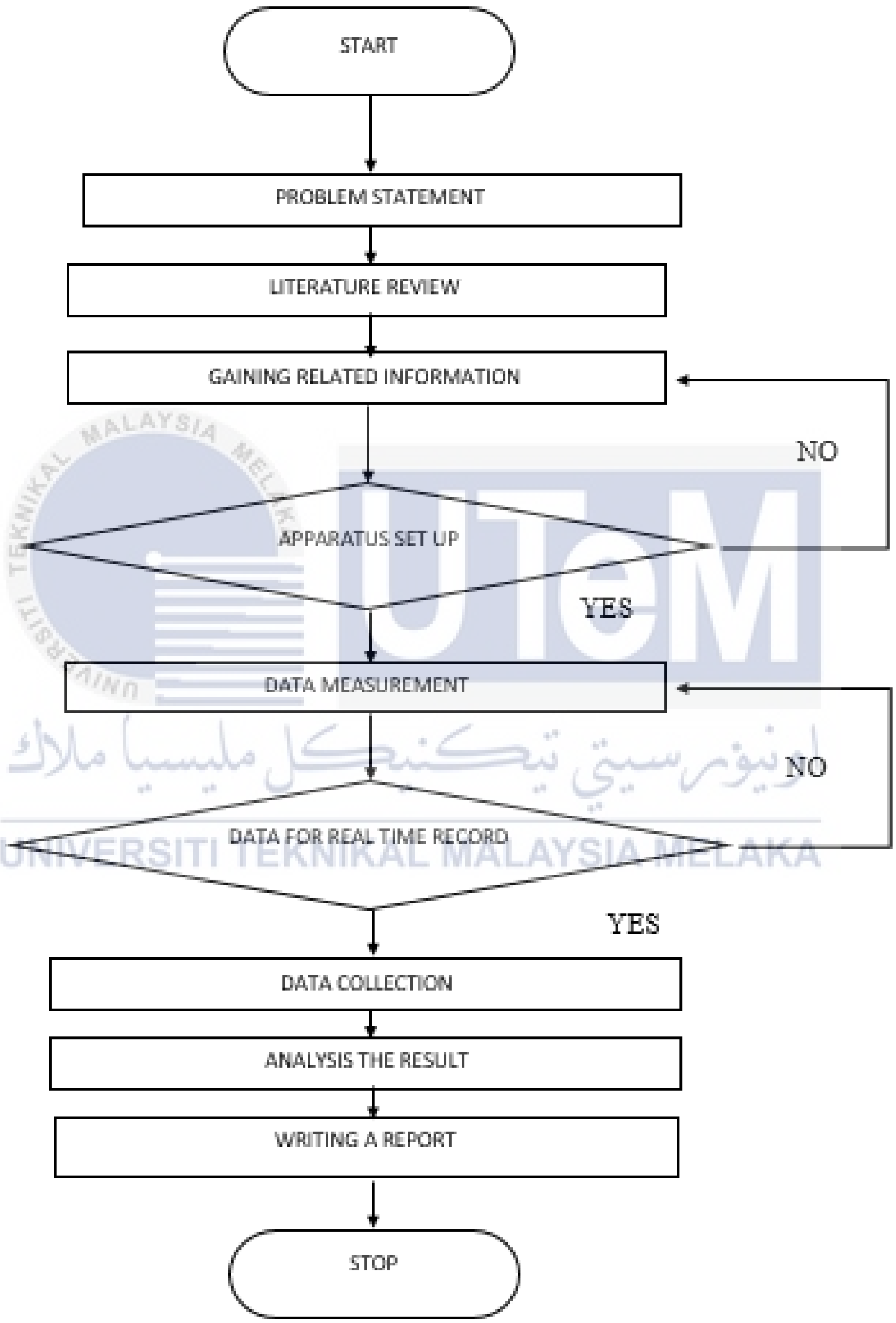

Figure 3.18: Project Flow Chart.

3.6.2 Gantt Chart of Research Activities

Table 3.1: The project Gantt chart PSM 1

Task	PSM 1													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Design Circuit by using Proteus, Fritzing, and Arduino IDE Software.														
Construct code for Arduino Uno and Espresso Lite 2.0.														
Do troubleshoot for the component and system tested														
Modification of circuit (if need)														
Result Analyzation														
Collect the caparison data and analysis to the final report														

Table 3.2: Project Gantt chart for PSM 2

Item														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FYP TITLE														
Find Supervisor														
Title Confirmation														
Familiar With Topic														
Log Book Preparation														
CHAPTER 1														
Objective & Scope														
Problem Statement														
Report Outline														
CHAPTER 2														
Theory & Basic Principle														
Find Sources														
Literature Review														
CHAPTER 3														
Methodology														
CHAPTER 4														
Result														
CHAPTER 5														
Conclusion														
Panel Feedback Form														
Report Submission														
FYP Presentation														

3.7 Key Milestone

Table 3.3: Key Milestone

No.	Milestone	Date
1	i. Literature Review in field study ii. Study on Solar system, Arduino and IoT application iii. Investigate all of the data collected & try to design own project	**September – November 2016**
2	i. Report Writing for PSM 1 ii. Presentation of PSM 1	**December 2016**
3	i. Redesign circuit and complete all the circuit constructed ii. Built application by using Blynk IoT application iii. Data collected, investigate and analyst all the data	**February – May 2017**
4	i. Report writing for PSM 2 ii. Presentation of PSM 2	**May 2017**

CHAPTER 4

RESULT & DISCUSSION

4.0 Overview

This chapter will cover on the research of the system that been constructed, basic knowledge of solar charging system and monitoring using IoT. Next learning about the basic information before using Arduino IDE, Proteus and Fritzing software. The result of this project is shown in this chapter.

4.1 Finished of Circuit Design and Hardware Work

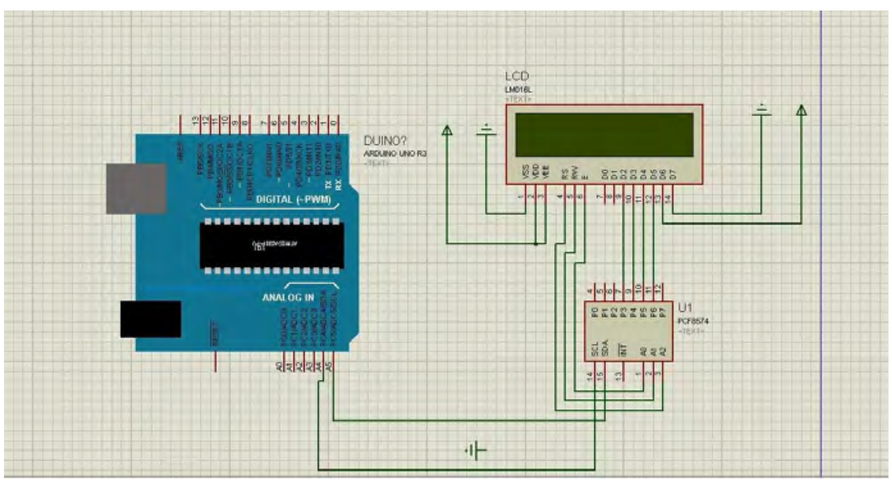

Figure 4.1: Circuit design using Proteus software

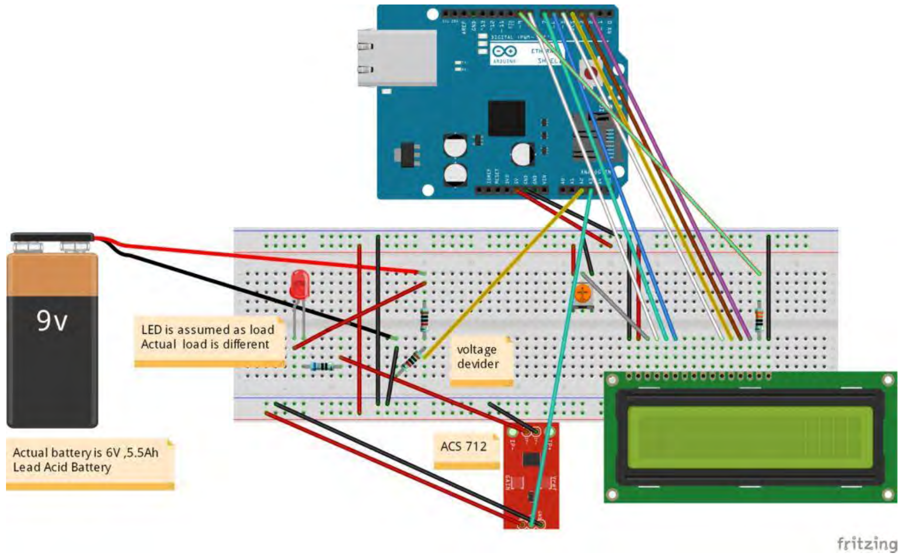

Figure 4.2: Circuit design using Fritzing software


sketch_apr27b | Arduino 1.6.11

File Edit Sketch Tools Help

sketch_apr27b

```

#include <LiquidCrystal.h>
LiquidCrystal lcd (8, 7, 6, 5, 4, 3, 2 );
int backLight = 9;

float sample1=0.0; // read the Vout from voltage divider
float sample2=0.0;
float val=0.0;
float voltage=0.0;
float actualval=0.0;
float amps=0.0;
float totamps=0.0;
float avgamps=0.0;
float amphr=0.0;
float watt=0.0;
float energy=0.0;



void setup()
{
  Serial.begin(9600);
delay(2000);

 {
pinMode(backLight, OUTPUT); //set pin 9 as output
analogWrite(backLight, 150); //controls the backlight intensity 0-254
```


sketch_apr27b | Arduino 1.6.11

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sketch_apr27b

```
voltage=6*2*sample1/1000;

// taking 150 samples from sensors with a interval of 2sec and then average the samples
for(int i=0;i<150;i++)
{
sample2+=analogRead(A3); //read the current from sensor
delay(2);
}
sample2=sample2/150;
val =(5.0*sample2)/1024.0;
actualval =val-6; // offset voltage is 2.5v
amps =actualval*10;

long milisec = millis(); // calculate time in milliseconds
long time=milisec/1000; // convert milliseconds to seconds

totamps=totamps+amps; // calculate total amps
avgamps=totamps/time; // average amps
amphr=(avgamps*time)/3600; // amp-hour
watt =voltage*amps; // power=voltage*current
energy=(watt*time)/3600; //Watt-sec is again convert to Watt-Hr by dividing 1hr(3600sec)
// energy=(watt*time)/(1000*3600); for reading in kWh


{
lcd.setCursor(16,1); // set the cursor outside the display count
lcd.print(" "); // print empty character
```

Figure 4.3 Figure 4.4

Figure 4.3 – Figure 4.4: Arduino IDE code for circuit design of Aduino circuit design

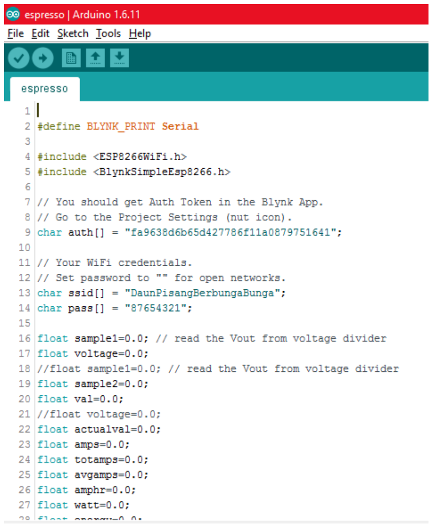


Figure 4.5

Figure 4.6

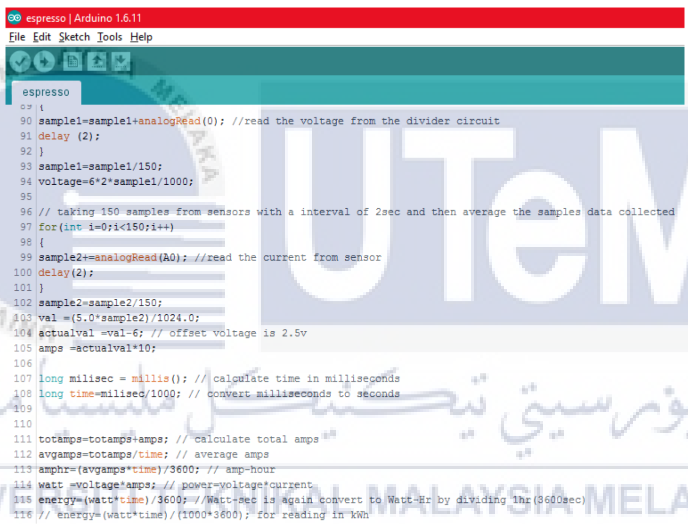


Figure 4.7

Figure 4.5 – Figure 4.7: Blynk code in Arduino IDE for Espresso Lite 2.0 circuit design and application for smartphone.

Figure 4.8: Voltage reading test

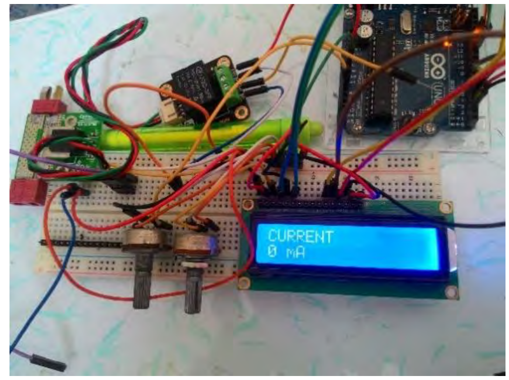


Figure 4.9: Current reading test

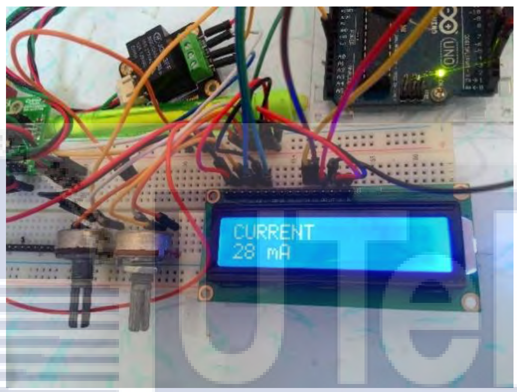


Figure 4.10: Current reading test from the output load

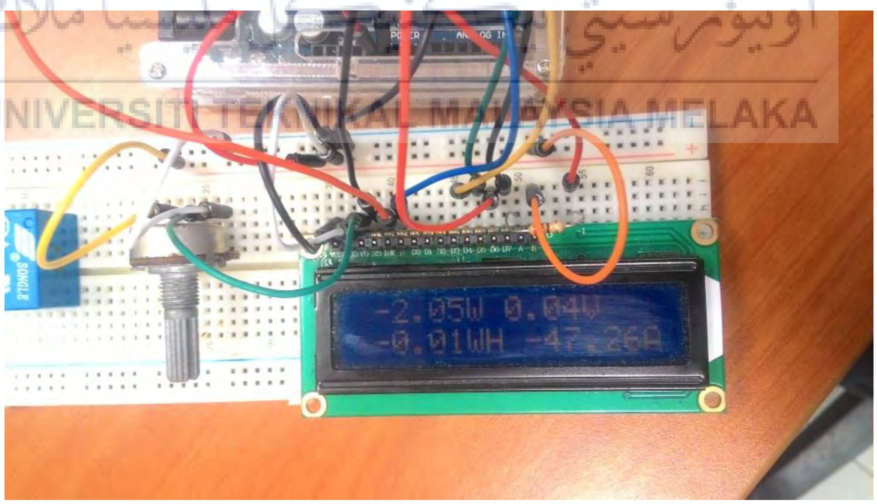


Figure 4.11: Parameters tested in arduino circuit in term of Voltage, Current, Watt and Watt per hour *negative value indicate the energy consumed by the load.

Figure 4.12: Parameters tested in arduino circuit in term of Voltage, Current, Watt and Watt per hour *negative value indicate the energy consumed by the load.

Figure 4.13: Completed Product Prototype box

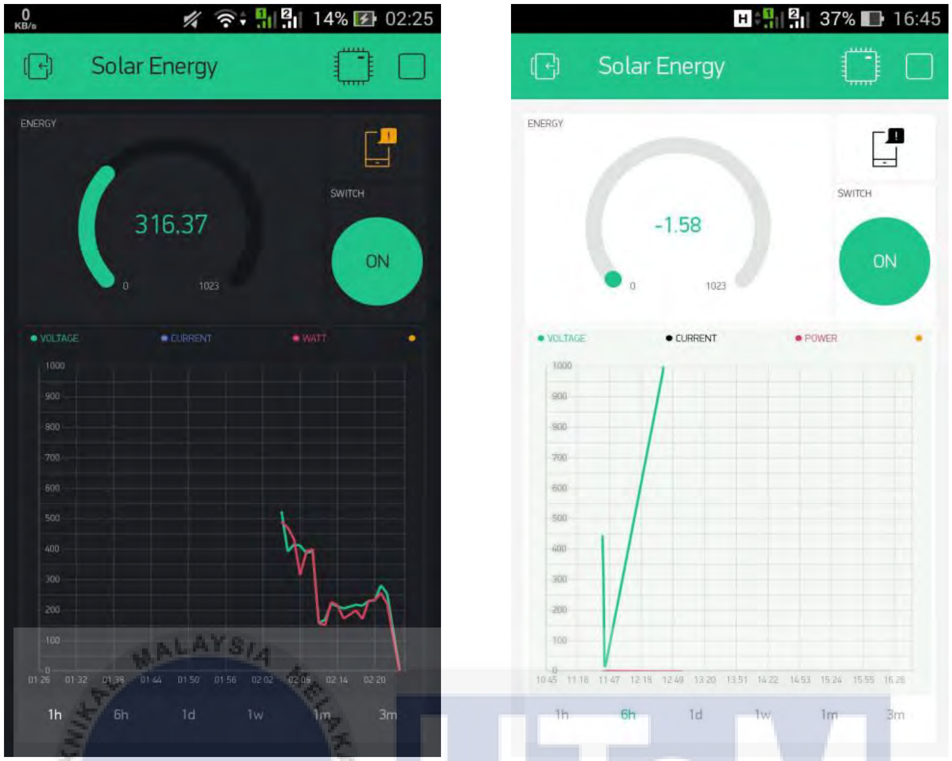


Figure 4.14: BLYNK Apps for smartphone that connected via internet to monitor the Espresso V2.0 IOT device.

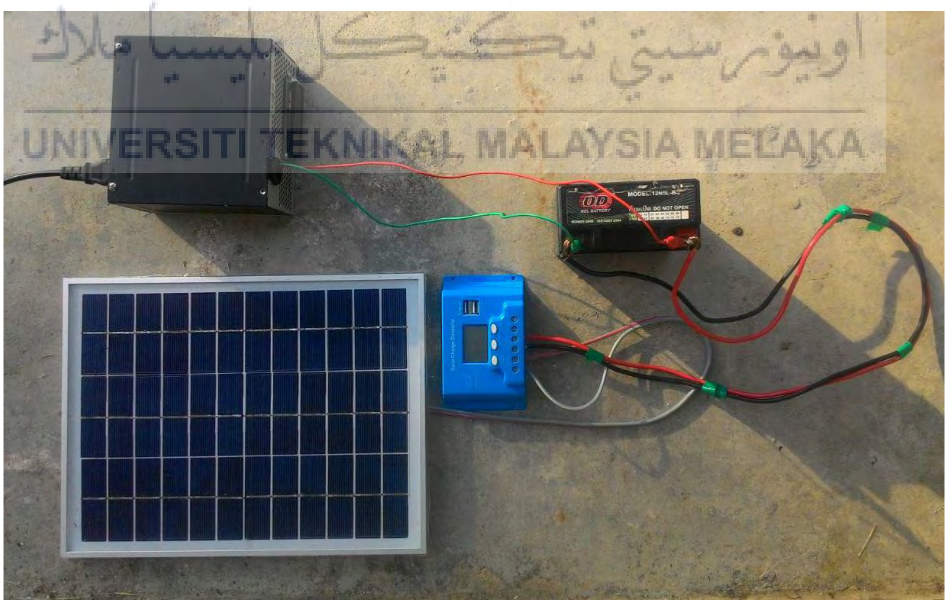


Figure 4.15: Completed combine circuit of all component for solar energy monitoring system.

The completed prototype need some calibration to read the voltage from voltage divider that built in the system. Voltage is measured by the help of a voltage divider circuit. As the ARDUINO analog pin input voltage is restricted to 5V, thus designed of voltage divider in such a way that the output voltage from it should be less than 5V. The battery used for storing the power from the solar panel is rated 12v, 11Ah. So it have to step down this 12v to a voltage lower than 5V. This project used R1=60k and R2 =33K. The value of R1 and R2 can be lower one but the problem is that when resistance is low higher current flow through it as a result large amount of power ($P = I^2R$) dissipated in the form of heat. So different resistance value can be chosen but care should be taken to minimize the power loss across the resistance.

$$Vout = \frac{R2}{(R1 + R2)} \times Vbattery$$

Vbattery = 12.7V when fully charged.

R1=60k and R2=33k

Vout = 33k/(33k+60k)×12V=4.51V which is lower than 5v and suitable for ARDUINO analog pin.

4.2 Data Collecting and Data Plotting

To obtain the graph of the studied system, first all set data need to be collected. All the data of Voltage, Current, Energy and Energy per hour obtained from transferred data reading that connected to 12V battery been recorded in form of Microsoft Excel format. All the data been collected between 12-4p.m on 25-30 April 2017. These data recorded in different day to make a comparison. All these data been recorded with different condition of that particular day with static installation place for PV panel. Besides, the lead acid battery chosen is fully discharge at 10.5V and fully charge at 12.7V.

All the data collection by hour per day of charging battery is shown in table 4.1 and Table 4.2 is the weather and temperature of that particular day.

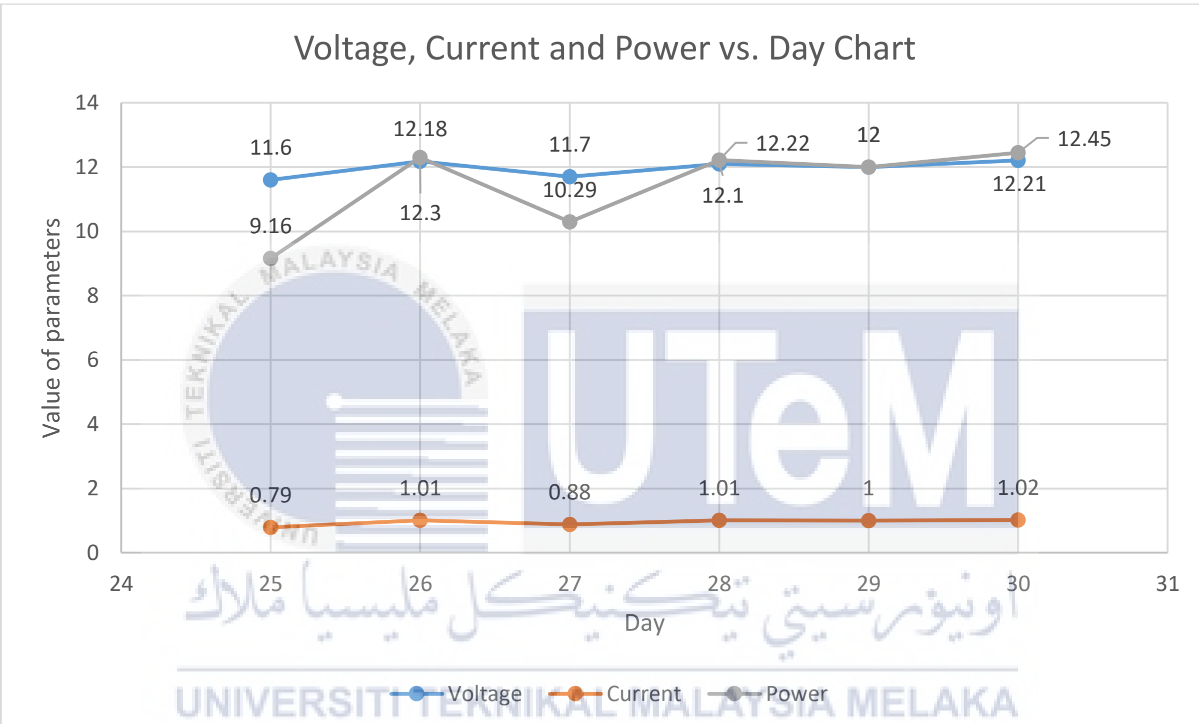
Table 4.1: Value of parameters of charge battery using PV panel

Hour (p.m)	Voltage (V)	Current (A)	Energy (W/h)
25 April			
12	10.6	0.23	2.44
1	10.9	0.43	4.69
2	11.2	0.58	6.49
3	11.3	0.6	6.78
4	11.6	0.79	9.16
26 April			
12	10.7	0.3	3.21
1	11.2	0.55	6.16
2	11.6	0.71	8.24
3	11.9	1	11.9
4	12.18	1.01	12.3
27 April			
12	10.7	0.23	2.46
1	11	0.45	4.95
2	11.3	0.61	6.89
3	11.5	0.7	8.05
4	11.7	0.88	10.29
28 April			
12	10.6	0.23	2.44
1	10.9	0.42	4.58
2	11.3	0.6	6.78
3	11.8	0.89	10.50
4	12.1	1.01	12.22
29 April			
12	10.6	0.22	2.33
1	10.8	0.4	4.32
2	11.5	0.7	8.05
3	11.8	0.9	10.62
4	12	1	12
30 April			
12	10.7	0.31	3.32
1	11.4	0.63	7.18
2	11.8	0.98	11.56
3	12	1	12
4	12.21	1.02	12.45

From the Table 4.1 the recorded data of energy in watt is by using formula below:

$$P = iv$$

Where: i = current ; v= voltage



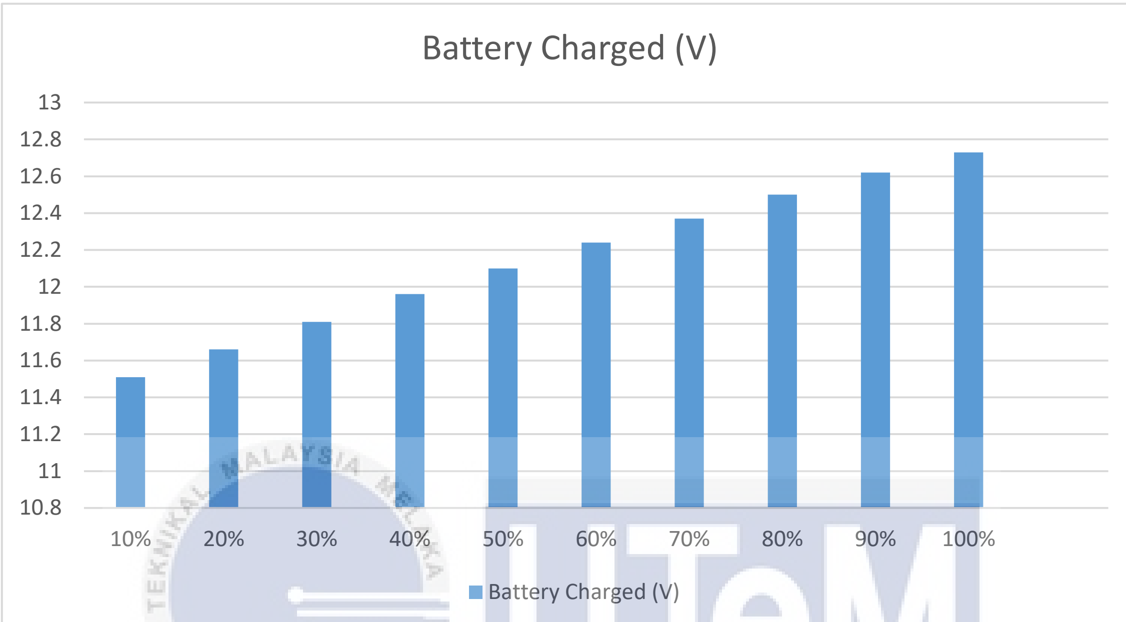
Graph 4.1: Voltage, Current and Power vs. Day graph

Table 4.2: The weather of Melaka area on 25-30 April 2017 by AccuWeather.com

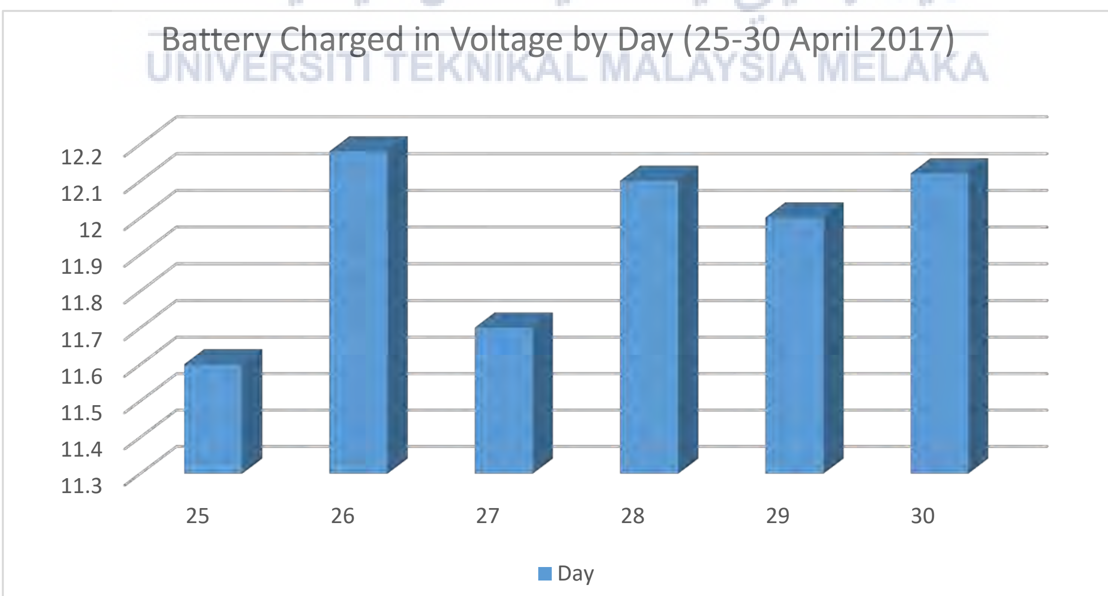
Day	Ave. Temp between 12-4 p.m	Rain	Ave.Temp per day
Tue 4/25	31°	132 MM	33°/25°
Wed 4/26	30°	0 MM	33°/25°
Thu 4/27	32°	120 MM	33°/25°
Fri 4/28	31°	25 MM	33°/25°
Sat 4/29	32°	27 MM	33°/25°
Sun 4/30	30°	0 MM	33°/25°

From Table 4.2, the recorded temperature and weather of Melaka from 25-30 April recorded by AccuWeather.com showed it was raining in 25, 27, 28, and 29 of April. There was no rain in 26 and 30 April. On the other hands, the weather data eventually indicate the rain and might be cloudy in term of cloud movement at that particular day from 12-4 p.m. The sunlight intensity stability based on weather that particular day. So, the relation of weather and average temperature in between 12-4p.m do affect the amount of energy charged for the battery from the solar system.

For state of charge of the battery, the voltage of battery charged towards the intensity of solar irradiance vs percent of battery charged could be consider in graph 4.1 below. The percentage of the state of charge for the battery is a standard for lead acid 12V battery.



Graph 4.2: The voltage of battery charged towards the intensity of solar irradiance vs percent of battery charged.



Graph 4.3: the battery charged in voltage by day (25-30 April 2017)

From data graph of standard percentage state of charge for the 12V battery, the calculation of the observation is made by dividing the voltage charged per fully charge of the 12V lead acid battery, then multiply by 100%.

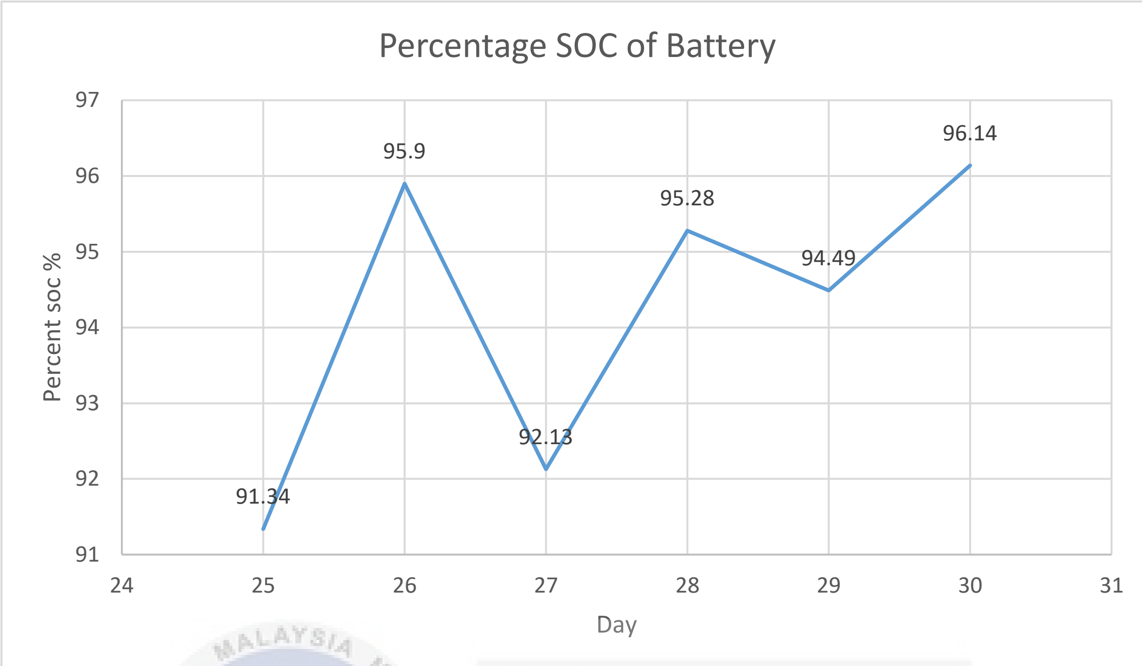
$$\frac{voltage\ charge\ of\ the\ battery}{12.7V} \times 100\%$$

Thus, the calculation been made for each day of the charged battery by the solar radiation of the PV panel from 12-4p.m. The calculated data written on table 4.3.

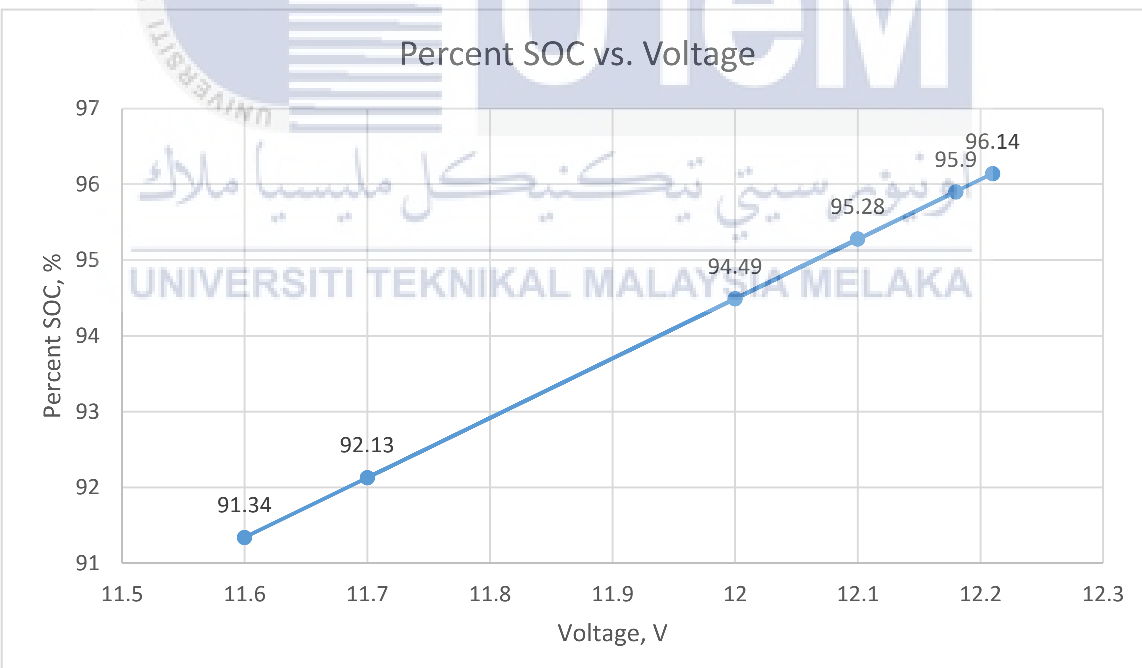
Table 4.3: the battery charged in voltage by day (25-30 April 2017)

Day	Voltage (V)	Percentage SOC Of the Battery (%)
25	11.6	91.34
26	12.18	95.9
27	11.7	92.13
28	12.1	95.28
29	12	94.49
30	12.21	96.14

The percentage graph of SOC vs. per Day from 25-30 April 2017 plotted on Graph 4.4. Graph of percent SOC vs. Voltage plotted in Graph 4.5.



Graph 4.4: Percent SOC vs. per Day



Graph 4.5: Percent SOC vs. Voltage

From all the data collection, the studied been made to relate the effect of solar irradiance form sunlight intensity towards state-of-charge of the battery. So, on 26 and 30 April 2017, the weather is clear with good sunlight intensity thus the battery charge at optimum percent with both highest value of voltage and percent SOC for the charged battery. The most heavy rain weather with high amount of rain drop between 12-4p.m recorded is on 25 April 2017, so that at the time the intensity of sunlight was not so good thus the percentage SOC and battery voltage charged is the lowest among all. The increasing volume of rain drop followed on 28, 29 and 27 April 2017, and studied been made shows that the increasing of percent SOC and voltage in sequence is 27, 29 and 28 April. All these data collection can be conclude that when the weather is rainy or condition is cloudy with low intensity of sunlight radiation do affect the SOC of the battery that supplied by harvested energy from PV panel.

This project also aim on developing a prototype for the solar monitoring system, thus the survey has been made for public to analyst and study the response of public user about the product development. The survey questionnaire listed below:

Solar Energy Monitoring System Based on IoT Technology

Thinking about simple, interactive and easy access monitoring system for solar charge.

Section A: Tick any box that desired

	YES (AGREE)	NO (DISAGREE)
1. Energy empowered by solar is green energy		
2. Most of people believe the solar energy could be next important energy worldwide		
3. Solar energy is the alternative energy for daily use		
4. Solar energy could save your money?		
5. Implement of solar could reduce the ozone effect?		
6. Educate children on how important solar energy is		
7. Electrical appliances consume energy directly via plug at home?		
8. Electrical consumption need to be save		
9. High cost to develop green energy		
10. Internet influences your daily life		
11. Internet is important to you?		
12. Internet based application interested you?		
13. Internet is a must		
14. Did applied of internet make your life easier?		
15. Wi-Fi coverage important for you?		
16. Your house got Wi-Fi?		
17. Smartphone really useful?		
18. Smartphone make your live easier		
19. Smartphone need internet for fully function		
20. Smartphone apps easy to access		

Section B: Implementation of Energy Monitoring for Solar System by Using IoT Technology

	YES	NO
1. Agree to use IoT technology in daily life?		
2. New technology always add up new experiences?		
3. Internet application does give people more advance control?		
4. Product with internet based application is hot selling in market?		
5. People can access internet easily anywhere they want?		
6. Energy monitoring system from harvested PV panel with smartphone and internet application interest you?		
7. Do you interested at the system application that could cost you less investment?		

The survey been done to student in UTeM main campus. 30 people been given the questionnaire to complete the form. The survey data recorded in description below.

Section A

- Question 1-9 in section A is about green energy knowledge:
  - 30/30 person does agree with question 1-6 and all tick NO in question no 9. Thus from this survey all the people answered the questionnaire, could be conclude that the people does really understand the important of green energy implementation and to save the energy nowadays.
- Question 10-16 in section A is about internet usage for user.
  - Question 10; 2 out of 30 person disagreed, 28 agreed.
  - Question 11-15 record all the person does agreed.
  - Question 16; 5 out of 30 tick NO. 25 tick YES.
  - From these questions, majority of people been survey agreed that internet does influences their daily life. All of them agreed with question 11-15, thus it shows that how important internet in their daily life. Question 16, indicate majority of them do have Wi-Fi at their home.
- Question 17-20 in section A is about smartphone
  - All of the volunteer that been survey agreed that smartphone is useful, easy, need internet for fully function and the application is easy to access.

Section B

- All the data survey for section B been recorded in detail and analysis shows Pie chart 4.1.

  - Question 1; 25 out of 30 said YES, 5 person said NO

    $\frac{25}{30} \times 100\% = 83.33\%$ agreed to use the IoT technology.

  - Question 2; all volunteer said YES. Thus, the new technology does give new experience to them. 100%

  - Question 3; all volunteer said YES. Thus, internet application does give people advance control. 100%

  - Question 4; 16 out of 30 said YES, 14 said NO

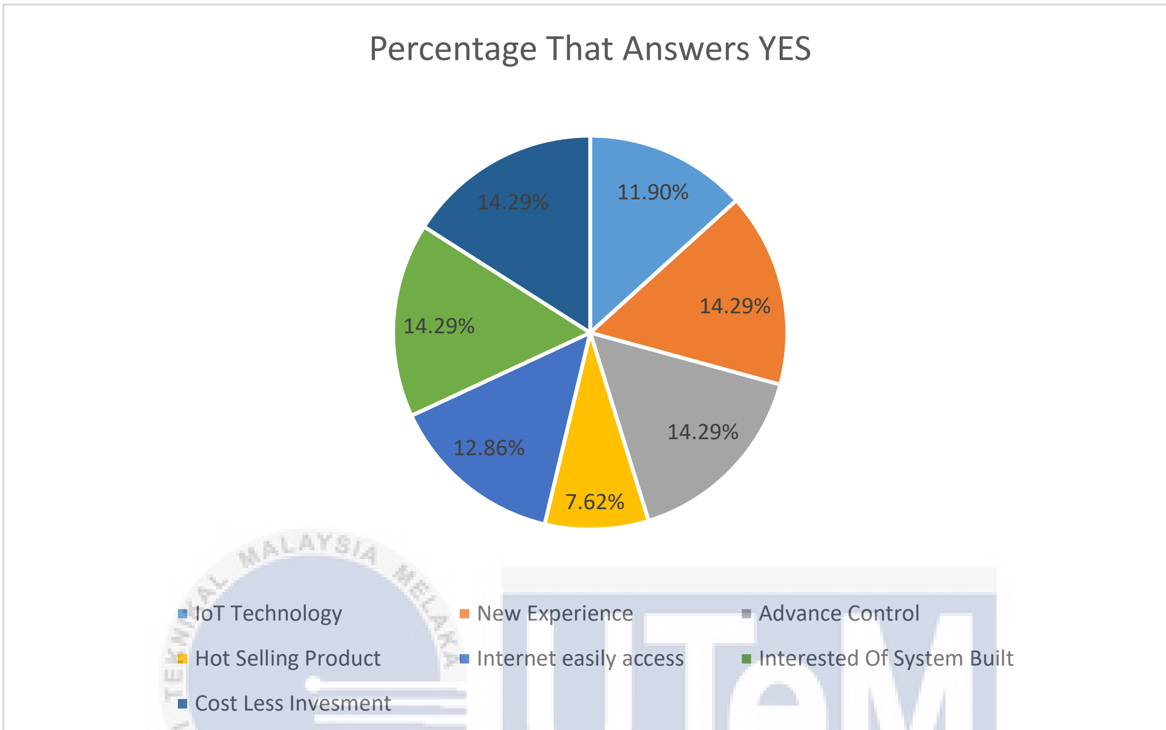
    $\frac{16}{30} \times 100\% = 53.33\%$ agreed, thus majority agreed the internet based application are hot selling product in market.

  - Question 5; 27 out of 30 said YES, 3 said NO.

    $\frac{27}{30} \times 100\% = 90\%$ agreed, thus majority said internet could be access easily anywhere they want.

  - Question 6; all volunteer said YES. Thus, all the volunteer interested for the energy monitoring system from harvested PV panel with smartphone and internet application. 100%

  - Question 7; all volunteer said YES. Thus, they are interested to application that could cost them less investment. 100%



Pie Chart 4.1: Percentage of survey who agreed based on questions in section B.

$$(14.29\% \times 4) + 11.90\% + 12.86\% + 7.62\% = 89.54\%$$

From Pie chart 4.1 based on questionnaire in section B, the percentage of 'agreed' from all volunteer involve indicate the total 89.54% agreed to implement the energy monitoring for solar system by using IoT technology. All these positive feedback give relevant reason for this technology implementation be commercialized as product development.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter consist of conclusion and recommendation based on the entire work and initial result achieved.

5.1 Conclusion

In previous semester (PSM 1), the system development related to the solar charging and current and voltage reading by using current sensor, ammeter voltmeter and Arduino component. Also implement of IoT device by using Espresso Lite 2.0 as wireless internet application for smartphone. The study about state of charge of a battery due to solar irradiance also been done in PSM 1. In this semester (PSM 2), the project focusing on finishing the hardware component. Also real time and save data from the prototype being done to study the energy consume by the load and energy used per hour, day, week and month. The enhance technology of IoT chosen in this project because it's simple and easy system that can be implement in any condition and important it is demanded by user as using internet for monitoring via Wi-Fi technology in every houses or places. The reading of the current and voltage plus the performance of the solar system in term of state of charge will make it easier to read and monitor by IoT implementation. In the resulting mechanism, the IoT will provide the sufficient application for the system to read all the data that being transferred in term of value of current and voltage from sensor that connected to Arduino Uno. The data can be transfer via email and sent it in excel format. The state-of-charge also could be affected by the solar irradiances of sunlight or solar radiation intensity that were not always constant due to weather condition. In the other hands, the solar irradiance do affected the state of charge of the battery due to high or low intensity of sunlight. If the intensity of solar is low as 40% light absorption by PV panel at the particular time, the state of charge for the battery is less than 30-20%. As the result, the battery is low in term of charging. The condition is vice versa as the sunlight intensity is high intensity as 80% and above, the state of charge of the battery should be at 94.5-97%. In conclusion, the weather affected the sunlight radiation intensity thus it also affected the SOC of the solar charged battery.

5.2 Recommendations

The overall hardware and data field been done in PSM1 and PSM2, the survey for product development from the prototype propose got positive response by user. But somehow, based on other previous project paperwork the implementation of using the IoT as part of monitoring that connected to Espresso Lite 2.0 had some limitation in term of analog input for sensors, this because the Espresso Lite 2.0 only got 1 analog input, so it is good to improve the project by using other device or component that can add up more analog input for other usage in term of sensor application. This project work indicates that's the IoT application could also control and analyst some of the data needed from the system connected. In term of state of charge could also be considerable as one of the real time reading devices, so it is recommended as a part of the project. Other recommendation is the PV panel should be install in the spaces with high intensity of sunlight. The solar irradiances does effect the performance of the battery state of charge, thus finding the best place with good weather condition is preferred for PV panel installation. Besides there were some limitation for IoT usage in daily life, it is still consider as a simplified method for monitoring the solar energy system for this project.

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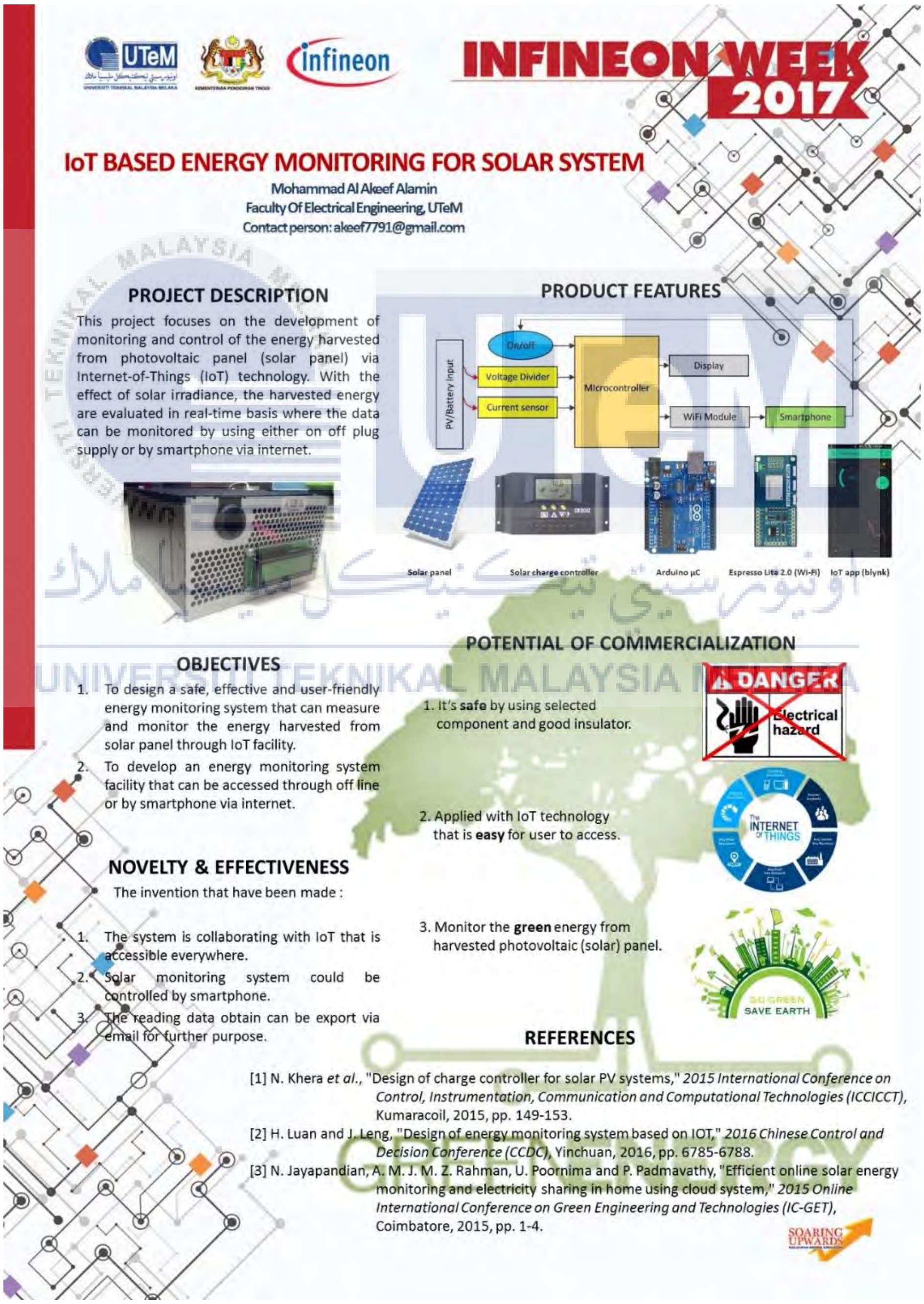
APPENDICES

A. Infineon Week 2017 (Competition involved for this project)



B. Arduino code

```
#include <LiquidCrystal.h>
LiquidCrystal lcd (8, 7, 6, 5, 4, 3, 2 );
void setup()
{
  Serial.begin(9600);
delay(2000);
 {
pinMode(backLight, OUTPUT);
analogWrite(backLight, 150);
lcd.begin(16,2);
lcd.clear();
}
}
void loop()
{
  Serial.print("VOLTAGE : ");
Serial.print(voltage);
Serial.println("Volt");
Serial.print("CURRENT :");
Serial.print(amps);
Serial.println("Amps");
Serial.print("POWER :");
Serial.print(watt);
Serial.println("Watt");
Serial.print("ENERGY CONSUMED :");
Serial.print(energy);
Serial.println("Watt-Hour");
Serial.println("");
```

```
 for(int i=0;i<150;i++)
 {
  sample1+=analogRead(0);  //read the voltage from the sensor
  delay(2);
 }
 sample1=sample1/150;
 voltage=6*2*sample1/1000;
 Serial.print("Battery voltage :");
 Serial.print(voltage);
 Serial.println(" Volt");
 delay(1000);
 {
sample1=sample1+analogRead(A2); //read the voltage from the divider circuit
delay (2);
}
sample1=sample1/150;
voltage=6*2*sample1/1000;
for(int i=0;i<150;i++)
{ sample2+=analogRead(A3);
delay(2);
sample2=sample2/150;
val =(5.0*sample2)/1024.0;
actualval =val-6;
amps =actualval*10;
long milisec = millis();
long time=milisec/1000;
totamps=totamps+amps;
avgamps=totamps/time;
amphr=(avgamps*time)
watt =voltage*amps; energy=(watt*time }}
```

C. Espresso Lite 2.0 Code

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
char auth[] = "fa9638d6b65d427786f11a0879751641";
char ssid[] = "DaunPisangBerbungaBunga";
char pass[] = "87654321";

float sample1=0.0;
float voltage=0.0;
//float sample1=0.0;
float sample2=0.0;
float val=0.0;
//float voltage=0.0;
float actualval=0.0;
float amps=0.0;
float totamps=0.0;
float avgamps=0.0;
float amphr=0.0;
float watt=0.0;
float energy=0.0;
void setup()
{
 Serial.begin(9600);
 pinMode(13,OUTPUT);
 Blynk.begin(auth, ssid, pass);
}
void loop()
{
```

```
 Blynk.run();
 char button = digitalRead(13);
  if (button == 13 )
 Blynk.notify("System is ON");
 for(int i=0;i<150;i++)
 {
   sample1+=analogRead(0);  //read the voltage from the sensor
   delay(2);
 }
 /* From voltage divider Vout =4.5V (see the multimeter reading)
CALIBRATION ::
 When  run Serial.println(sample1);
 get sample1= 927 in serial moniter which is equivalent to 4.5V
     So 4.5V = 927 ADC value
     => 1V = 4.5/927=4.854
sample1=sample1/150;
/* 2 is multiplied to get the actual battery voltage
   as Vout is half of the battery voltage */
 voltage=6*2*sample1/1000;
 Serial.print("Battery voltage :");
 Serial.print(voltage);
 Serial.println(" Volt");
 Blynk.virtualWrite(V0, sample1);
 Blynk.virtualWrite(V0, sample2);
 Blynk.virtualWrite(V2, watt);
 delay(1000);
//calibration
// taking 150 samples from voltage divider with a interval of 2sec and then average the samples data collected for(int i=0;i<150;i++)
{
```

```
sample1=sample1+analogRead(0); //read the voltage from the divider circuit
delay (2);
}
sample1=sample1/150;
voltage=6*2*sample1/1000;
// taking 150 samples from sensors with a interval of 2sec and then average the samples data collected
for(int i=0;i<150;i++)
{
sample2+=analogRead(A0); //read the current from sensor
delay(2);
}
sample2=sample2/150;
val =(5.0*sample2)/1024.0;
actualval =val-6; // offset voltage is 2.5v
amps =actualval*10;
long milisec = millis(); // calculate time in milliseconds
long time=milisec/1000; // convert milliseconds to seconds
totamps=totamps+amps; // calculate total amps
avgamps=totamps/time; // average amps
amphr=(avgamps*time)/3600; // amp-hour
watt =voltage*amps; // power=voltage*current
energy=(watt*time)/3600; //Watt-sec is again convert to Watt-Hr by dividing 1hr(3600sec)
// energy=(watt*time)/(1000*3600); for reading in kWh
}
}
```

D. Plagiarism (Turnitin) Result

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by Al Akeef

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