Faculty of Electrical Technology and Engineering

DEVELOPMENT OF SOLAR-MICRO HYDRO POWER GENERATION FOR BATTERY CHARGING SYSTEM

AHMAD FEIRDAOUS BIN MOHD SHAH

Bachelor of Electrical Engineering Technology with Honours

2024

DEVELOPMENT OF SOLAR-MICRO HYDRO POWER GENERATION FOR BATTERY CHARGING SYSTEM

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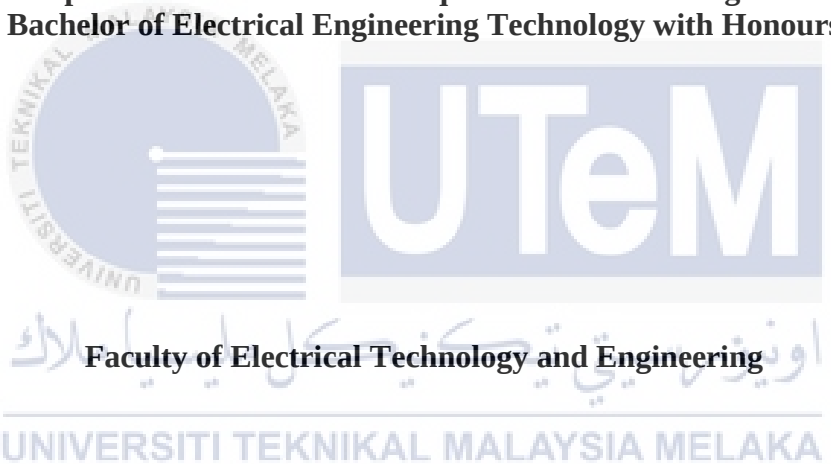
A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology with Honours



Faculty of Electrical Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

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APPROVAL

I approve that this Bachelor Degree Project 1 (PSM1) report entitled "Development of Solar-Micro Hydro Power Generation For Battery Charging System" is sufficient for submission.

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

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DEDICATION

To my beloved father and mother who always support me from the bottom to the top and able to create and run this project. Their supports, inspiration, and encouragement has brightened my path and made this journey not only possible but meaningful. I hope this project stand as a testament to the collective effort and dedication of all those who believe in the project.

ABSTRACT

This study aimed to determine two sources of renewable energy, solar and micro-hydro which will be used for power generation. Hybrid power generation system is a combination of two or more energy sources and used to produce electricity. Solar and hydro energy are the two sources of energy that are focused on this study where it is to evaluate the efficiency performance of solar and micro-hydro by using different type of loads. This study is motivated to decrease the uses of fuel cell power generation that leads to air pollution, global warming, and water pollution. Besides, power generation nowadays mostly uses fuel cell where it is expensively higher price while sustainable energy is free. However, solar energy works finely only on days but not on rainy days and cloudy days due to the shading factor. Solar energy is produced from sunlight using solar panel to convert light into electricity, while hydro energy is kinetic energy produced by conversion from potential energy via turbine. The hybrid solar-hydro system is more economical and sustainable compared to commercial power plant. It can be used to generate electricity without spending massive cost on infrastructure development. Portable power station design that are user friendly and mobile will reduce commercial electricity dependence in rural area. It is to design a small-scale prototype solar-micro hydro power generation for battery charging. The idea of incorporating hybrid system is to solve solar underperformance issue during rainy or cloudy season by adding hydro system into the power station. Hydro system are powered by kinetic energy produced from water movement via turbine. The energy produced by hydro system will be stored in a separate battery that act as a backup when there are less or no sunlight available. Hence, the design will involve water cycle, turbine, and solar system. On this study, the expected result is able to determine the efficiency of the system where we measure the voltage output, current output, and power output by using different types of loads and able to measure the effectiveness of the system itself. The system is used to measure each types of load current, voltage, and power. It is to determine power consumption of a load that use the system itself. Due to this, it is to develop Arduino based circuit by using proteus software and hardware.

ABSTRAK

Kajian ini bertujuan untuk menentukan dua sumber tenaga boleh diperbaharui iaitu solar dan mikrohidro yang akan digunakan untuk penjanaan kuasa. Sistem penjanaan kuasa hibrid ialah gabungan dua atau lebih sumber tenaga dan digunakan untuk menghasilkan tenaga elektrik. Tenaga suria dan hidro merupakan dua sumber tenaga yang difokuskan kepada kajian ini di mana ia adalah untuk menilai prestasi kecekapan solar dan mikro-hidro dengan menggunakan jenis beban yang berbeza. Kajian ini bermotivasi untuk mengurangkan penggunaan penjanaan kuasa sel bahan api yang membawa kepada pencemaran udara, pemanasan global, dan pencemaran air. Selain itu, penjanaan kuasa pada masa kini kebanyakannya menggunakan sel bahan api yang harganya lebih mahal manakala tenaga mampan adalah percuma. Walau bagaimanapun, tenaga suria berfungsi dengan baik hanya pada hari tetapi tidak pada hari hujan dan hari mendung kerana faktor teduhan. Tenaga suria dihasilkan daripada cahaya matahari menggunakan panel solar untuk menukar cahaya kepada elektrik, manakala tenaga hidro ialah tenaga kinetik yang dihasilkan melalui penukaran daripada tenaga berpotensi melalui turbin. Sistem solar-hidro hibrid adalah lebih menjimatkan dan mampan berbanding loji janakuasa komersial. Ia boleh digunakan untuk menjana elektrik tanpa membelanjakan kos besar untuk pembangunan infrastruktur. Reka bentuk stesen janakuasa mudah alih yang mesra pengguna dan mudah alih akan mengurangkan pergantungan elektrik komersial di kawasan luar bandar. Ia adalah untuk mereka bentuk prototaip kecil penjanaan tenaga solar-mikro hidro untuk pengecasan bateri. Idea untuk menggabungkan sistem hibrid adalah untuk menyelesaikan isu kurang prestasi solar semasa musim hujan atau mendung dengan menambah sistem hidro ke dalam stesen janakuasa. Sistem hidro dikuasakan oleh tenaga kinetik yang dihasilkan daripada pergerakan air melalui turbin. Tenaga yang dihasilkan oleh sistem hidro akan disimpan dalam bateri berasingan yang bertindak sebagai sandaran apabila cahaya matahari kurang atau tiada. Oleh itu, reka bentuk akan melibatkan kitaran air, turbin, dan sistem suria. Pada kajian ini, hasil yang diharapkan mampu menentukan kecekapan sistem di mana kita mengukur keluaran voltan, keluaran arus, dan keluaran kuasa dengan menggunakan pelbagai jenis beban dan mampu mengukur keberkesanan sistem itu sendiri. Sistem ini digunakan untuk mengukur setiap jenis arus beban, voltan, dan kuasa. Ia adalah untuk menentukan penggunaan kuasa

beban yang menggunakan sistem itu sendiri. Disebabkan ini, ia adalah untuk membangunkan litar berasaskan Arduino dengan menggunakan perisian dan perkakasan proteus.

ACKNOWLEDGEMENTS

First and foremost, Alhamdulillah grateful to Allah, I would like to express my gratitude to my supervisor, Dr. Nor Hafizah Binti Hussin for their precious guidance, words of wisdom and patient throughout this project.

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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 Mohd Shah for all the motivation and understanding.

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

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LIST OF SYMBOLS

Ω	-	Ohm
±	-	Tolerence of LCD measurement and Voltage-Current meter
V	-	Voltage
A	-	Current
W	-	Power
	-	
	-	
	-	

LIST OF ABBREVIATIONS

V	-	Voltage
I	-	Current
Vmpp	-	Voltage at maximum point
Vsc	-	Voltage short circuit
Voc	-	Voltage open circuit
Isc	-	Current short circuit
Ioc	-	Current open circuit
Impp	-	Current at maximum point
DC	-	Direct current
LED	-	Light-emitting diode
RTC	-	Real Time Clock

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CHAPTER 1

INTRODUCTION

1.1 Background

Solar-micro hydro power generation for battery charging system is a system that consist of two sustainable energy which is solar energy and hydro energy that generates power. The system is able to store the generated power. From the system itself, power is generated which produce voltage and current as an energy. By having the system, Arduino UNO device is used to control and display the generated voltage and current so that we are able to collect data. The data it self shows that system is more efficient than any individual system. Hydro energy is used to support by generate power continuously while solar system generate power on sunny days. The system itself is to evaluate DC loads such as, DC fan, DC waterpump, and DC LED lamp. It is to measure the power consumption for each types of load. Where it is able to determine the load can be use for how long it can takes by using the prototype system. Besides, the system itself generate power from solar and micro-hydro generator.

1.2 Problem Statement

Renewable energy is an energy that generate power freely. Unlike the commercial energy which is fuel cell that need to be produce costly. The different between renewable energy and commercial energy is that renewable energy can naturally replenish themselves while commercial energy cannot. This means that commercial energy is limited in supply and cannot be used sustainably when its rely only on the fuel cell which it can be no longer

in exist in future. Solar and hydro are the sustainable energy which is free and available in most country. By having sustainable energy, cost of power generation might be lower due to the source of energy are free.

Power generation by using fuel cell is called as combustion of fossil fuel such as coal or natural gas. The burning of coal release carbon dioxide (CO2) and methane (CH4) which knows to contribute to global warming and climate change. Besides, large quantities of water are needed to remove impurities from coal. This process is known as coal washing where it will reduce air pollution. Besides, as the water is removed after washing the coal it will leads to water pollution that affects fish and other aquatic life along with animals relying of water.

Sustainable energy such as solar energy generate power only in days while there is fewer amount of power on rainy days or cloudy. The efficiency of the solar system drops due to rainy or cloudy days. Solar panels are dependent on sunlight to have effectively gather solar energy. Besides, solar energy cannot be collected during the night. So, to make sure that the system is efficient, it is able to add other sustainable sources such as hydro which is free power source in rural area.

1.3 Project Objective

This project major purpose is to develop an efficient and structured mechanism for determining with tolerable accuracy, the effectiveness of the developed solar-micro hydro power generation for battery charging system prototype where it will be compared by individually type of loads.

Specifically, the objectives are as follows:

a) To develop Arduino based circuit by using proteus software and hardware.

b) To design a small-scale prototype solar-micro hydro power generation for battery charging.

c) To evaluate the efficiency performance of solar and micro hydro by using different types of load.

1.4 Scope of Project

The scope of this project are as follows:

a) Program Development

An integrated development environment (IDE) is a software that designed to help in the creative creation of software code by programmers. To use the Arduino IDE software to write a program for an Arduino UNO microcontroller to perform measurement of current and voltage load. This program development able to increase the purpose of creativity to design a program.

b) Software Development

To construct circuit connections, it is great to use a software that able to design well circuit connection without harming the component itself. By using PROTEUS software, it can display the output for the design circuit. It is to make sure that other components will run smoothly and well maintained.

c) Hardware

Battery charging system requires a sealed lead acid battery, solar charger controller and use 5V adapter to power up the Arduino board. It is also necessary to have voltage and current sensor to read the output of the system. A solar-hydro hybrid system needs solar photovoltaic (PV) and generator for

hydro power. To monitor the output differential of each load, both loads are connected to a voltage sensor and current sensor and can be displayed on liquid crystal Display (LCD). All the components are connected to microcontroller (Arduino UNO).

d) Performance Comparison

The system has two power sources which are solar system and hydro power generator where solar system is a battery based system while the hydro power generator system only act as a source. To compare each system, by measuring the output current, voltage, and power, it is able to observe which are efficiently working with different type of loads.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Renewable energy sources are now demand and urgent needs for sustainable power generation. This is because of sustainable power generation is able to produce freely and reduce pollutions such as air pollution and water pollution. By combining two or more sustainable energy sources it is possible to increase the efficiency of renewable energy systems especially for battery charging applications. The aim of this literature review is to study and extract existing research on the topic of development of solar hydro hybrid power generation for battery charging systems. For strategic planning and development of the solar hydro hybrid power generation system, it is vital for utilities to develop effective methodology to efficiently evaluate the stability of the system.

2.2 Renewable energy as source of Energy

According to International Energy Agency, over the projected period, their fraction of the power mix is expected to rise by 10 percentage points, reaching 38% in 2027[1]. With dropping shares for coal, natural gas, nuclear, and oil generation, renewable energy sources are the only ones whose proportion of global power production is predicted to increase. In the following five years, the amount of electricity produced by wind and solar PV more than doubles, making up about 20% of the world's energy production in 2027. Over the projection period, these variable technologies will raise worldwide renewable generation by 80%, necessitating new sources of power system flexibility. Dispatchable renewable energy sources including hydropower, biomass, geothermal, and concentrated solar power are still

growing slowly while playing a crucial part in integrating wind and solar PV into the world's electrical grids.

By 2027, solar PV is expected to have the greatest global installed electricity capacity, surpassing coal. In our prediction, total solar PV capacity nearly triples, increasing by approximately 1 500 GW over the timeframe, surpassing coal by 2027 and natural gas by 2026. Over the next five years, annual solar PV capacity additions will grow yearly. Utility-scale solar PV remains the least expensive choice for new energy generation in the vast majority of nations globally, notwithstanding current increased investment costs caused by heightened commodity prices. Due to rising retail power rates and expanding legislative assistance to help customers reduce their energy costs, distributed solar PV, such as rooftop solar on buildings, is also expected to increase more quickly in the future [2]. Figure 2.1 shows multiple renewable sources.

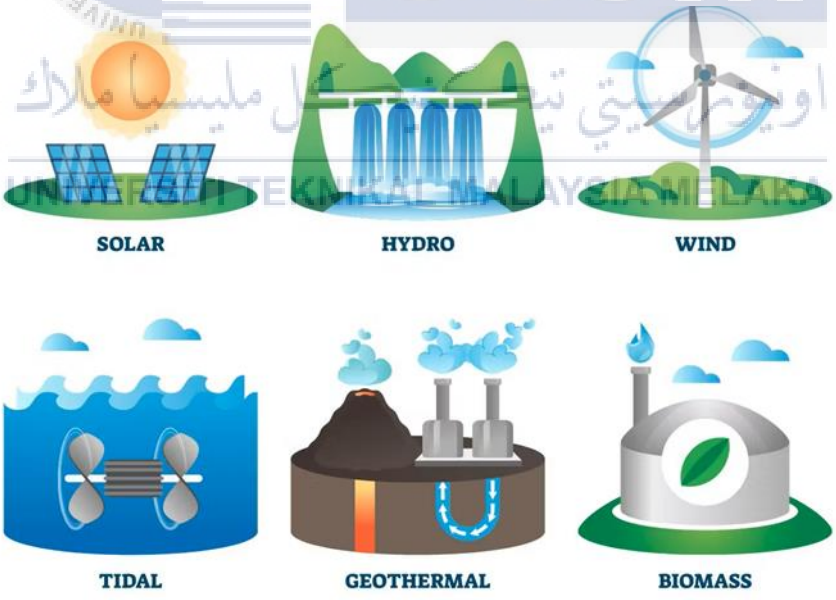
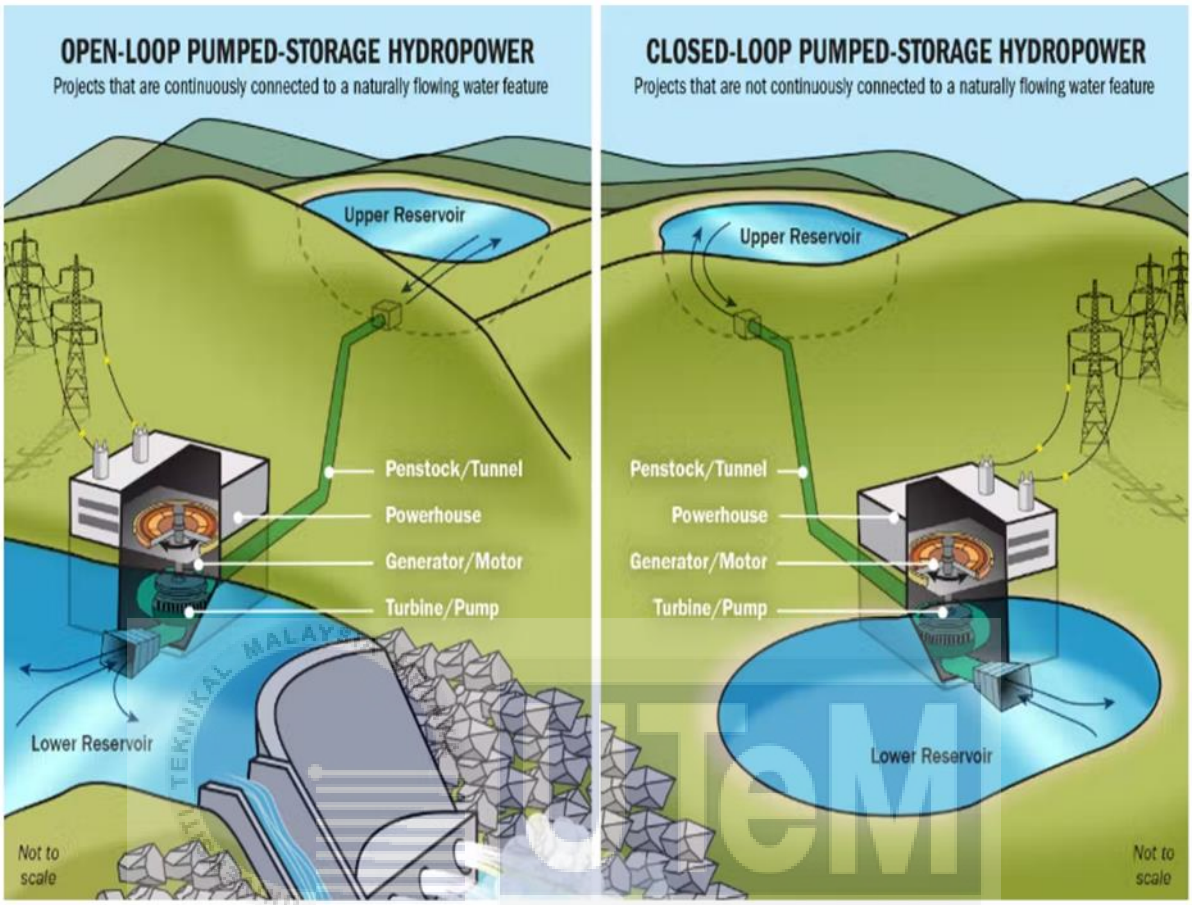


Figure 2.1 Renewable Sources

2.3 Water Storage for Hydropower

Hydropower systems use the energy in flowing water to produce electricity or mechanical energy[3]. There are several ways of producing energy from moving water. For instance, water that have been storage from hours to years are often used for micro-hydro or small-scale hydro projects. To run the mechanism of hydropower system where the water storage is placed on a higher position which known as higher reservoirs from the pipeline that delivers to a waterwheel or turbine. The water that moves from the pipeline will rotates the wheel or turbine, which spins a shaft of the turbine and generate mechanical energy to electrical energy. The first use of moving water to produce electricity was a waterwheel on the Fox River in Wisconsin in 1882. Besides, natural water river is natural storage of water where it will store the water when the day is raining. It can be a place to develop a hydropower system as a natural damp. There are two types of storage plant of hydropower system such as open-loop storage and closed-loop storage hydro-power system. As for the small scale, closed-loop water storage is suitable for the development of hydropower system due to the weather condition. Figure 2.2 shows the types of water storage.



Two types of pumped-storage hydropower; one doesn't require a river. NREL

Figure 2.2 Open-loop and Closed-loop Water Storage [4]

2.4 Energy source from solar power

Solar energy is a non-depleting renewable energy source that is widely distributed in the natural world. There are several ways to produce power, including burning fossil fuels, but doing so has a negative impact on the environment. Sustainable energy is able to be use which are being provided by nature, such as wind and solar energy, to at least partially overcome difficulties. A solar cell is used to convert light energy into electrical energy. The fundamental component for transforming light energy into electrical energy is a solar cell. There are three types of solar power system namely On-grid solar, Hybrid solar and Off-grid

for residential solar system. Figure 2.3 shows that the difference between the three types of solar power system.

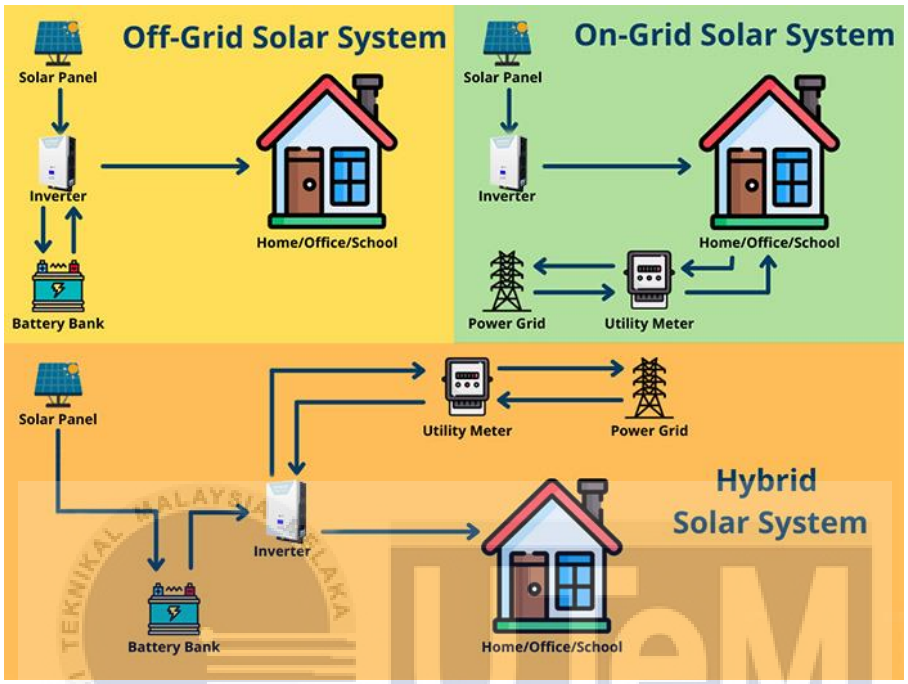


Figure 2.3 Types of Solar Power System [5]

The most widely used system for solar is On-grid solar power system which known as Grid-Connected System. The working principal of the system is it connects to the home electrical system and the local grid. It is an excellent method due to low maintenance. Besides, this system requires less equipment so the operational expenses are cheaper. In addition, it is efficiently for supplying electrical energy to the grid because the electrical energy produced can be used for the consumers and can be supplied to the grid since it only requires one conversion of DC to AC type of current where it is more efficiently.

Furthermore, Hybrid solar system often known as first form of solar system where it is connected to grid and battery bank. By comparing between Hybrid solar system and off-grid solar system, consumers are able to save money. This is because when the battery bank has stored energy, the grid's electricity will automatically cut-off and use the battery bank as a main source of power. However, this highly technology system is the most expensive

compare to the other system. This is because the battery bank is regularly replaced to protect it from wearing out.

Moreover, Off-grid solar power system is also known as stand-alone power system where it requires battery bank as a storage of energy instead of the connectivity to the electricity grid. This system consists of solar photovoltaic panel, inverter and a battery bank. It is the most reliable system when it is developed in rural area where the electricity cannot be supplied.

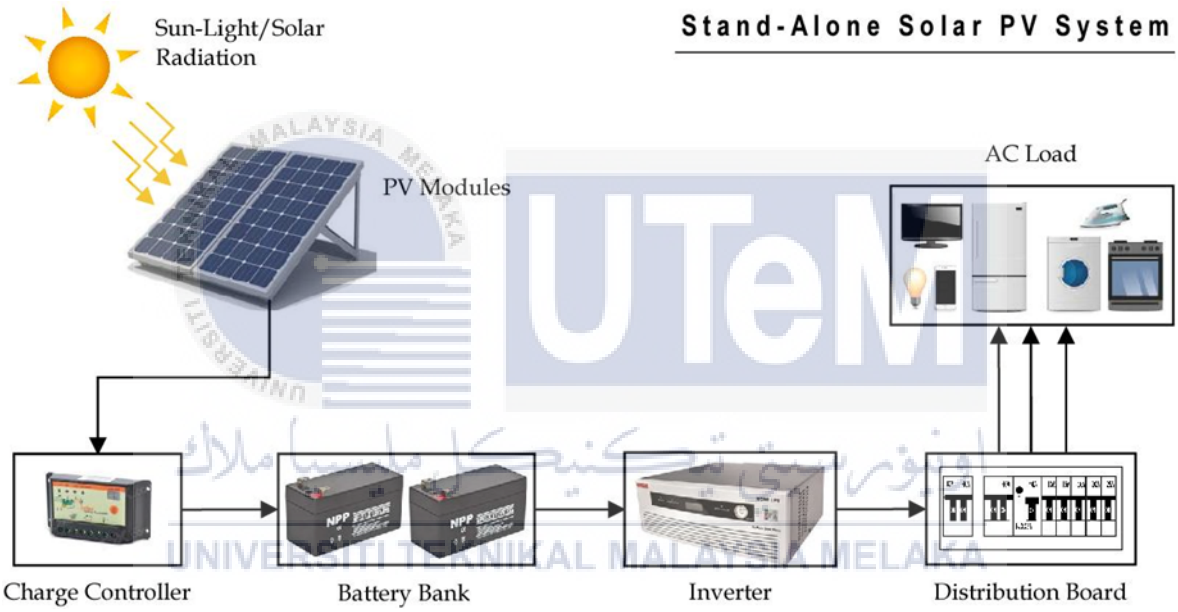


Figure 2.4 Off-grid Solar Power System

Figure 2.4 shows the Off-grid solar power system where it is suitable for combining the system itself with other renewable power generation for battery charging system. In smaller DC coupled system, solar charger controller is a must to regulate battery charging and inverter is used as a converter of DC to AC voltage to supply on the load used.

2.5 Type of Solar panel

According to M. Arun, solar photovoltaic (PV) is an electrical device that converts light energy directly into electricity by the photovoltaic effect. To generate electrical power from solar cell by rays the sunlight on the solar cell and produce current and voltage. The solar cells are divided by four types of cells which are monocrystalline, polycrystalline and thin film[6].

2.5.1 Monocrystalline PV

Most common types of solar PV are monocrystalline and polycrystalline[7]. Both of solar PV work using photovoltaic cells that made from silicon. The material itself is used in chips for electronic gadgets. The differences between monocrystalline and polycrystalline solar panel are the arrangement of the cell itself.

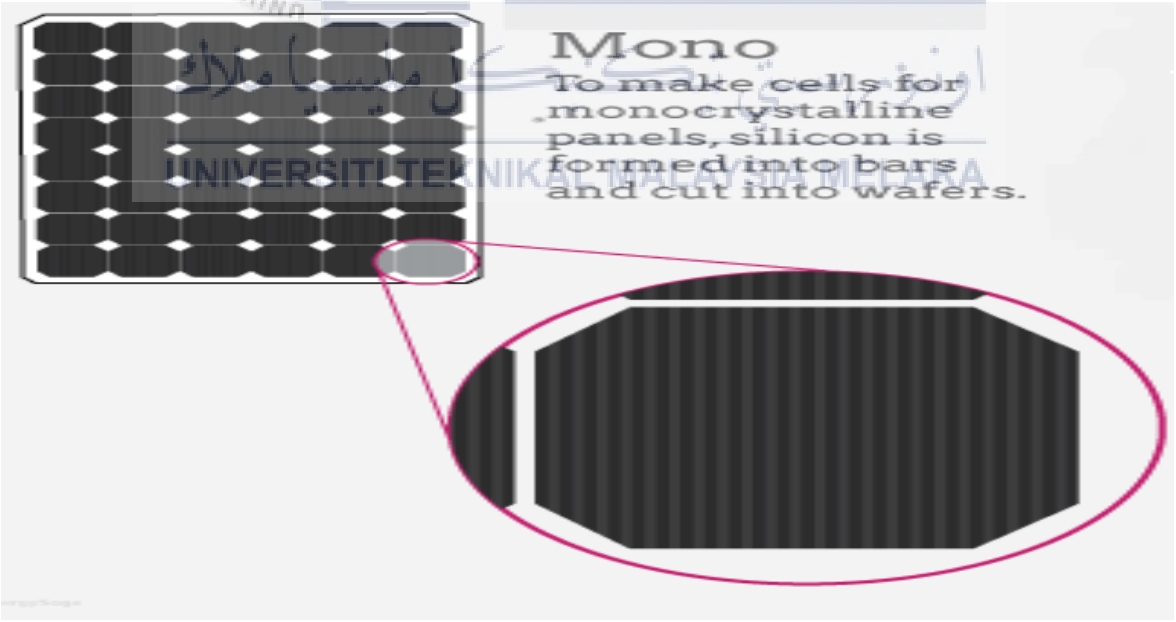


Figure 2.5 Monocrystalline Solar Panel Cell

Referring to Figure 2.5, monocrystalline solar panel are made from a single silicon crystal. Due to single silicon crystal, it has the highest efficiency and better power output than polycrystalline solar panel.

2.5.2 Polycrystalline Solar Panel

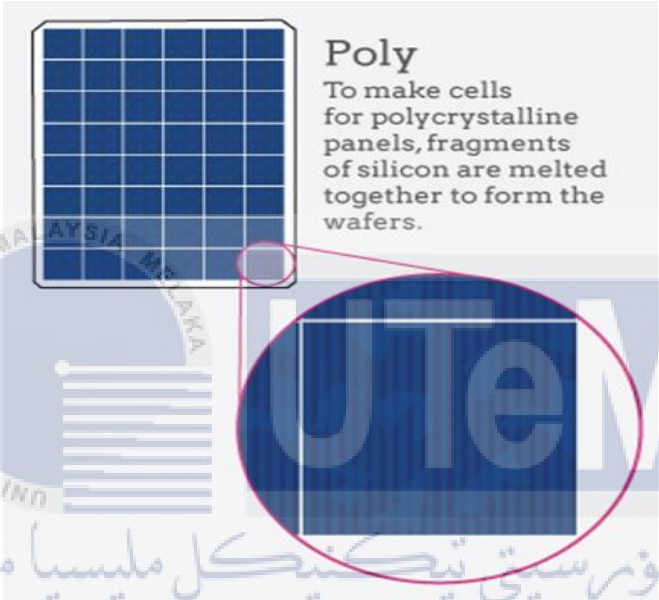


Figure 2.6 Polycrystalline Solar Panel Cell

Figure 2.6 shows polycrystalline solar panel where it can be called multi crystalline solar panels that consist of several crystal of silicon in a single PV cell[8]. The silicon is melted together to form the wafers of polycrystalline solar panels. Due to this, the molten vat of silicon used to create the cells is allowed to cool on the panel itself. Besides, polycrystalline solar panel is inexpensive than monocrystalline panels but the efficiency of polycrystalline solar panel slightly lower than monocrystalline solar panels due to purity of silicon.

2.5.3 Thin Film Solar Panel

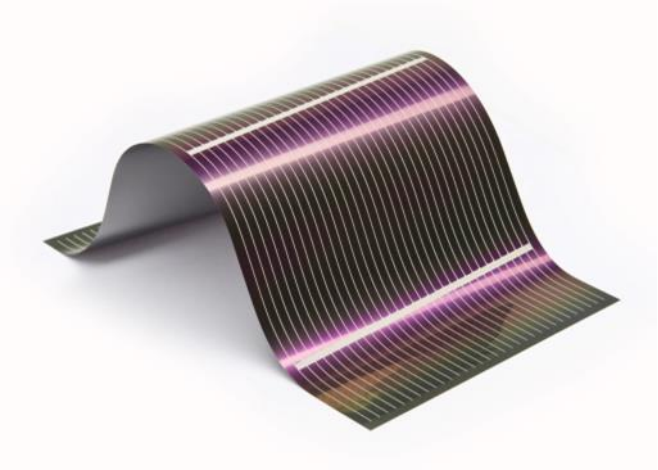


Figure 2.7 Thin Film Solar Panel

Figure 2.7 shows a thin film solar panel made of a variety of materials, including Copper Indium Gallium Selenide (CIGS), Cadmium telluride (CdTe), and Armorphous silicon (a-Si). These cells are thus 350 times thinner than panels made of monocrystalline and polycrystalline crystals. This panel is appliable and lightweight. It works with all types of roof designs.

2.6 Charging System for Solar

Today's R&D, enabling technologies, including smart consumer gadgets, electric cars, and smart grids, are motivated by the need for energy for a sustainable future[9]. Batteries are necessary for these technologies. Sunlight is a plentiful, healthy source of energy, while batteries can solve solar intermittency, can lessen the energy limitations of batteries. This viewpoint paper provides a critical evaluation, discussion, and outlook while developing principles in PV-battery system design. There is discussion of reports on both discrete and integrated PV-battery solutions. Energy density, efficiency, and stability are three major technological obstacles that need to be overcome before combined PV-battery

systems may go further. We offer an outlook on possibilities and potential future paths, stressing important tactics for creating such PV-battery systems. Figure 2.8 shows the sequence for solar charging controller.

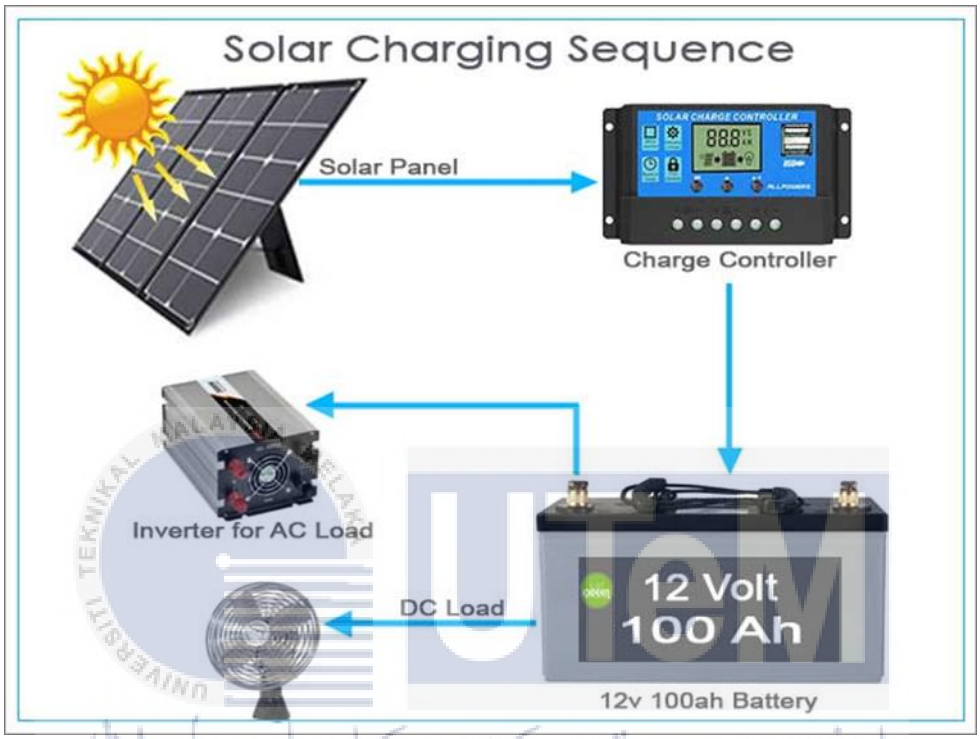


Figure 2.8 Sequence of Battery Charging for Solar [10]

2.7 Solar Irradiance in Malaysia

Due to its tropical location, high average daily solar radiation (4500 kWh/m2), and enough sunshine for roughly 10 hours each day, Malaysia has a significant potential to develop solar power plants. In several towns in Malaysia, Table 2 demonstrates that Kota Kinabalu has the maximum solar radiation at 1900 kWh/m2, followed by Bayan Lepas (1809 kWh/m2) and Georgetown (1785 kWh/m2)[11]. However, due to the high cost of installation and solar power tariff rate, solar energy appears to be so unpopular. In order to promote the expansion of solar energy, the government has implemented a variety of incentives, laws,

finances, investments, and initiatives (as stated under the 9th and 10th Malaysia Plans**).** Table 2.1 shows the annual average value radiation in Malaysia with different region.

Table 2.1 Annual Average Value Irradiance in Malaysia

Region /cities	Annual average value (kWh/m^2)
Kuching	1470
Bangi	1487
Kuala Lumpur	1571
Petaling Jaya	1571
Seremban	1572
Kuantan	1601
Johor Bahru	1625
Senai	1629
Kota Bahru	1705
Ipoh	1739
Taiping	1768
Georgetown	1785
Bayan Lepas	1809
Kota Kinabalu	1900

2.8 Battery as storage

In PV systems, batteries are frequently utilized to store the energy generated by the PV array during the day and provide it to electrical loads when needed (during the night and during overcast weather). Batteries are also used in PV systems to power electrical loads at stable voltages, run the PV array close to its maximum power point, and deliver peak currents to electrical loads and inverters. To prevent the battery from overcharging and over-discharging, a battery charge controller is typically employed in these systems.

In stand-alone systems, solar generate power usually stored the power into lead-acid battery by charging the battery using charger controller. There are other types of battery such as lithium ion and sodium ion battery can be used as primary battery, but the advantages

of sealed lead-acid battery ensure that it is still the most popular choice in many years. Most of the battery capacity are 12V, 24V, and 48V where the higher the value of capacity will become most expensive battery. The battery capacity is measured in Ampere-hours (Ah). Table 2.2 shows the comparison of rechargeable batteries.

Table 2.2 Comparison of Rechargeable batteries[12]

Parameters	Lead Acid Batteries	Lithium-ion Batteries	Sodium-ion Batteries
Cost	Low	High	Low
Energy Density	Low	High	Moderate/High
Safety	Moderate	Low	High
Materials	Toxic	Scarce	Earth-abundant
Cycling Stability	Moderate (high self-discharge)	High (negligible self-discharge)	High (negligible self-discharge)
Efficiency	Low (<75%)	High (>90%)	High (>90%)
Temperature Range	-40°C	-25°C to 40°C	-40°C to 60°C
Remarks	Mature technology; fast charging not possible	Transportation restrictions at discharge state	Less mature technology; easy transportation

2.9 Arduino Based for Solar System

Solar power generation will produce current and voltage where it can be called as power. Voltage open-circuit (Voc) and Current short-circuit (Isc) is an output from solar panel can be measured at the time of maximum power. On the solar panel, power maximum output (Pmax), the ACS712 current sensor and voltage sensor are used in this system's functioning to get the current and voltage values that are linked to the Arduino Uno microcontroller, which serves as the central processing unit[13]. The microcontroller instructs the stepper motor driver to operate the stepper motor that is attached to the rheostat resistor in order to prevent or delay the solar panel from generating its maximum power when the measurement reaches its maximum value. This method is used to achieve an

accurate measurement of PV output. Functions of limit switch is to re-measure and reset the rheostat resistor to initial condition.

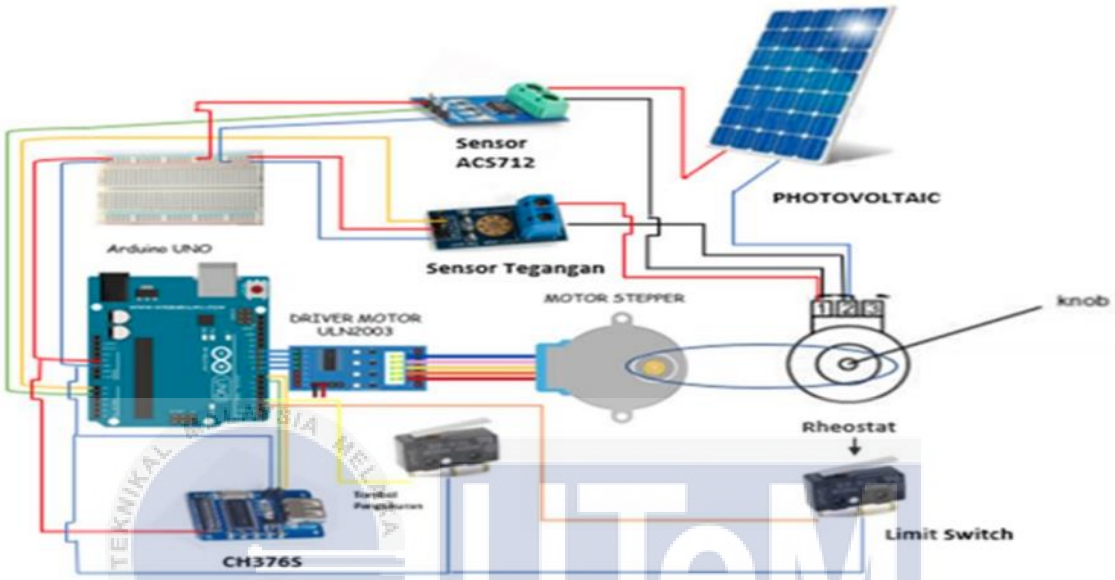


Figure 2.9 Hardware Design for Solar system with rheostate as a load [14]

The Figure 2.9 above shows, it is the design of all components into one system that can measure the output power, current and voltage from solar PV. To determine the outcomes of DC voltage measurements that the voltage sensor can read, voltage sensor testing is conducted. A SANWA CD711 multi-meter will be used to calibrate the voltage sensor in order to calculate the ratio of voltage difference to error. The output voltage (Vout) and the sensor are able to measure any specified output voltage by passing the voltage source supplied by the DC power supply through the two input pins. Table 2.3 shows the difference testing result by using different tools which is multimeter and voltage sensor.

Table 2.3 Voltage Sensor Test Result

Multimeter (V)	Voltage Sensor (V)	Difference	Error(%)
5.06	4.97	0.10	1.97%
10.02	9.84	0.18	1.79%
15.03	14.87	0.16	1.06%
20.04	19.85	0.19	0.95%
25.02	24.76	0.26	1.04%
Average value:		0.18	1.36%

By adjusting the resistor that in series connectivity, current will flow through and the value of current might be change. Table 2.4 shows the result of current value which using difference tools which is multimeter and ACS712 Sensor.

Table 2.4 Current Sensor Test Result

Multimeter (V)	Voltage Sensor (V)	Difference	Error(%)
0.39	0.37	0.02	5.12%
0.78	0.76	0.02	2.56%
1.06	1.05	0.01	0.94%
1.33	1.31	0.02	1.50%
1.52	1.50	0.02	1.31%
Average value:		0.02	2.28%

2.10 Sample formula

Solar power has its own formula where the formula is used to calculate the output of the solar PV panel. The formula requires current MPP (Impp), voltage MPP (Vmpp), short- circuit current (Isc), and open-circuit current (Isc). Where MPP is known as at its maximum point[15]. Besides, to measure the voltage and current can be calculated by using a formula of Ohm's Law[16] and derived to calculate power. Table 2.5 shows the formula.

Table 2.5 Sample of formula

Description	Formula
Fill Factor, Ff	$Fill\ factor, Ff = \frac{(Vmpp\ x\ Impp)}{(Voc\ x\ Isc)}$
Power output, Watt (W)	$Power = Current\ x\ Voltage$

2.11 Summary

To summarize, literature review is important due to the study of related project which can help increase the effectiveness of the project by comparing each of the literature studies. Each different study has different solution, how it works, how the system can be implemented and what are the component each system used. From the review, it helps the project to maximize the utilization of this project by comparing the method of other study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In general, this chapter will cover the methodologies and procedures that will be implement in this project. It is contained of hardware components and software needed to complete the project where it will be able to create a prototype of combination of solar and hydropower to generate power while it can be stored in a battery bank by using charger controller. This project will be used Arduino Uno microcontroller as well as software and it is suitable to ensure its success.

3.2 Methodology

In research, specialized processes or approaches, analyzing information and so on are such challenges that able to known as quantitative and qualitative type of data. This methodology is defined as to study reasoning or as a method of doing something. This is a small-scale prototype where it will analyze the efficiency output from two types of renewable sources which are solar-hydro hybrid power generation system by monitoring the reading of current load and voltage load.

3.3 Project architecture

A basic graphical reprenstation of the entire project or programming is known as flow chart. This form shows the steps in logical sequence. It is a progress of the project where it starts to the end of the project sequence. Besides, it also displays the progression of a project from start to finish. Pre-development include the phases of research and data

gathering, as well as understanding all programming languages and functional design. After the pre-development stage, the first stage of development is to include the data gathering procedure into the Arduino coding. In the post-development phase, the simulation results are exported into hardware and apps for the last time.

3.3.1 Project system flowchart

Figure 3.1 shows the project's working system in order to better comprehend the project constructure flow.

Figure 3.1 Flowchart of project structure

a) Design hardware prototype

The project consists of water tanks, DC mini hydro electric generator, water pump, solar panel, charger controller, battery, voltage sensor, current sensor, liquid crystal display (LCD), and Arduino UNO microcontroller.

b) Performance test

The solar panel will be exposed under the sun while the DC mini hydro electric generator is connected to low requirement of output such as LED (Light Emitting Diode).

c) Performance comparison

The project will be compared to battery-based solar system and the DC mini hydro electric generator with different types of load.

d) Performance analysis

The efficiency of the developed project is to analyze the output power and the efficiency of difference sources.

3.3.1.1 System architecture

The most vital principle for carrying out this process is the readings of measured current and voltage at each output load for the charge controller of solar power generation and DC mini hydro electric generator. In addition, energy that generated by solar and DC mini hydro electric generator is used as the main source to power up this system. Where the power that flows the charge controller will be split between Arduino UNO and battery. Figure 3.2 shown as project block diagram.

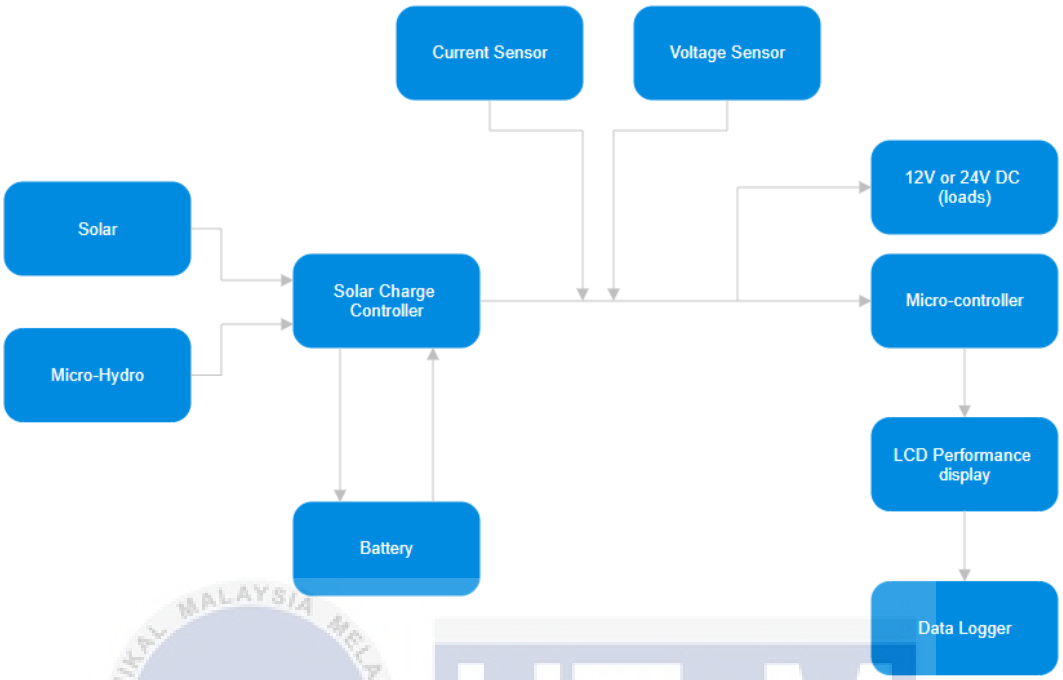


Figure 3.2 Project block diagram

a) Solar and DC mini hydro electric generator is the main power supply for this system where it can supply to the loads by using charger controller.

b) When the DC water pump is switched ON, the water will be supplied to the water tank and flows the water to the DC mini hydro electric generator and generate electricity for the uses of load.

c) At the same time, water will flow back to the water tank.

d) The current, voltage, and power can be measured by using Arduino UNO microcontroller and can be display on LCD for each load.

e) The readings of the current and voltage sensors are shown graphically in the flowchart as shown in Figure 3.3 and 3.4.

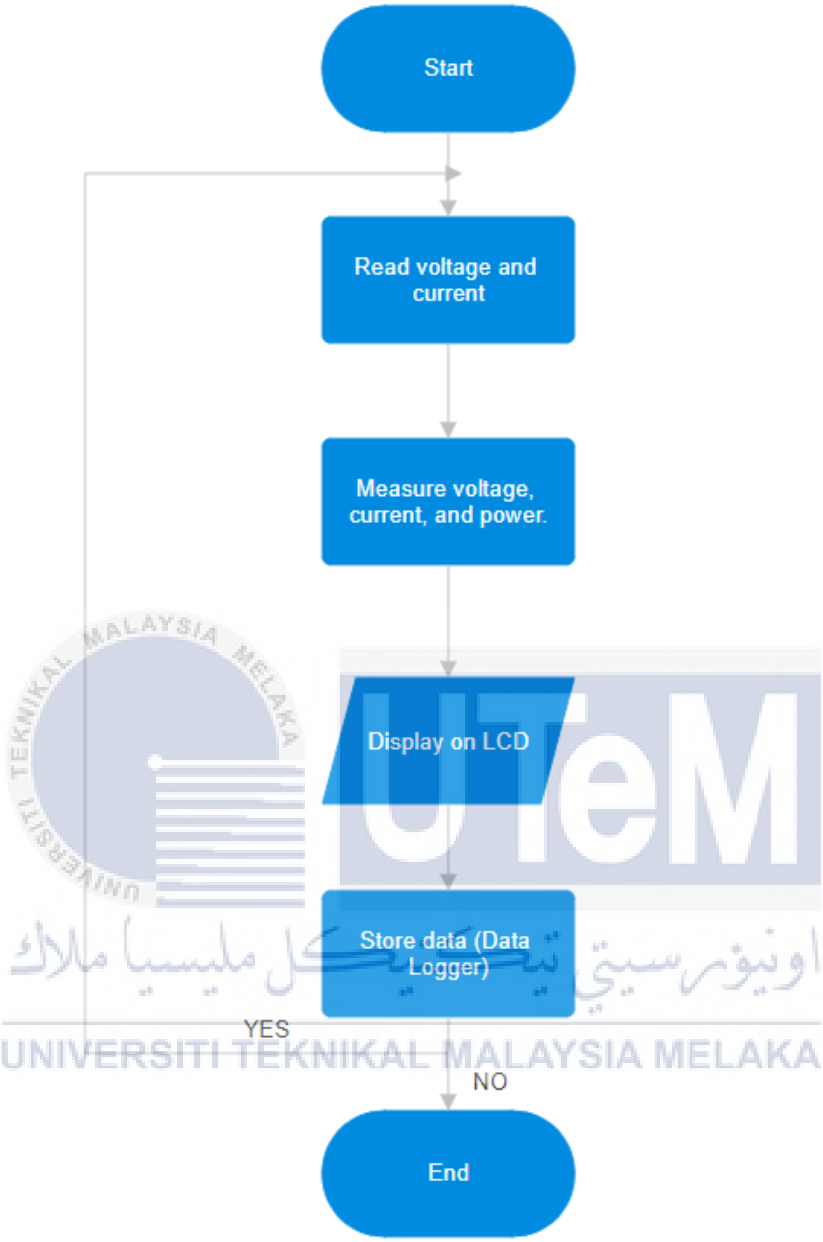


Figure 3.3 Flowchart of voltage, current, and power

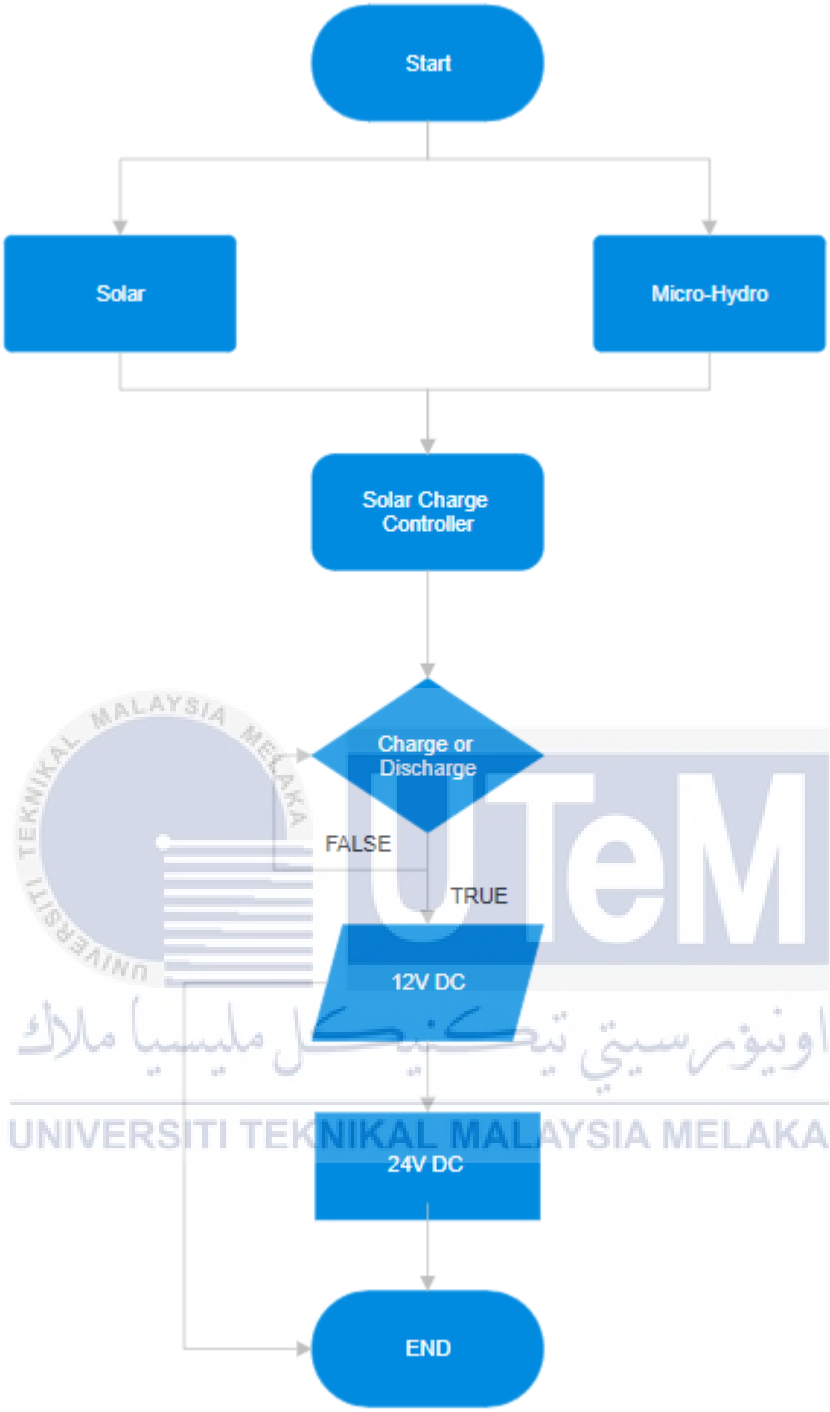


Figure 3.4 Flow chart of solar and micro hydro

3.3.2 Project Concept

Project concept is similar to the off-grid solar system where the project use charge contoller to charge the battery[17]. The battery used as a storage and source where it recharge and discharge the energy. When it is in discharge status, the energy will flow to supply the loads such as motor so the motor will act as the output. Using the formula of voltage which the existance of current and resistance, it is able to generate the voltage output. From the concept itself, the project is change from only solar as source to hydro power generator and solar PV.

3.4 Hardware

Hardware is an important part of any project that refer to physical components that make the project works better especially a prototype model. This is because it can provide us to represent all of our real data and work. This method is able to utilize the project output actual data or work where it is different from simulation by using software. Due to simulation, the output that obtained from simulation is not actual data but on hardware part it will measure the real time data where it depends on the factor such as environmental factors. These hardware components consist of solar panel, charge controller, DC mini hydro electric generator, Arduino microcontroller, DC water pump, current sensor module, voltage sensor module, and liquid crystal display (LCD). The best hardware allows us to study both software and hardware while improving our skills on designing and modelling a project.

3.4.1 Solar Panel

The solar panel is a device that convert sunlight into useable electrical energy. They are made up of silicon cell which are monocrystalline, polycrystalline and thin film. Basically, its absorb photons (particles of light) from the sun and convert them into an electrical current. This process is known as photovoltaic effect. Differents type of solar panel has a different efficiency where it depends on the solar module itself[18]. Table 3.1 shows the technical specifications of the PV panels.

Table 3.1 Technical specifications of the PV panels

Module Technology	Mono-crystalline	Poly-crystalline	Thin-film
Model	YL260C-30b	YL250P-29b	NA-E125L5
P_{max} (STC)	260W	250W	125W
Dimensions	1.65x0.99 m	1.65x0.99 m	1.40x1.00 m
Efficiency	15.9%	15.3%	8.9%
Temp. Coefficient for P_{max}	-0.42%/°C	-0.45%/°C	-0.25%/°C
Number of Modules installed	20	20	40

3.4.2 DC Micro Hydro Electrical Generator

DC mini hydro electrical generator is made of high-quality plastic that is both durable and long-lasting. The generator has newly developed, outstanding, waterproof all-metal technology that may be used in tiny water pumps and resists corrosion. The firm that produces the product is also ecologically responsible and offers a broad variety of this that may be used in several applications. Figure3.5 shows the design of the mini hydro electrical generator flow, and Table 3.2 lists the technical specifications. This generator will be use to generate voltage and current.

Figure 3.5 DC mini hydro electrical generator

Table 3.2 Features and specification of DC mini hydro electrical generator

Features	Specification
Weight	90g
Voltage	80V (1.2mpa)
Maximum Output Voltage	80V (1.2mpa)
Maximum Output Current	220mA
Line to line resistance	10.5 ± 0.5Ω
Insulation resistance	10mΩ
Maximum pressure of closed outlet	0.6 mpa
Maximum pressure of open outlet	1.2 mpa
Starting water pressure	0.05 mpa
Axial clearance	0.2 – 1.0mm
Mechanical noise	≤55 dB
Generator lifespan	≥3000h

3.4.3 Brushless motor water circulation pump

The brushless motor water circulation pump is constructed using superb wear-resistant shaft materials and contemporary electrical parts. This product's qualities include a simple idea, good efficiency, good performance, and a long service life. Additionally, it is feasible to work continuously for a long time while maintaning low noise levels, safety and environmental preservation. Table 3.3 shows the features and specification of the water pump and Figure 3.6 shows the water pump.

Table 3.3 Features and specifications of brushless DC water pump

Features	Specification
Material	ABS
Inlet / outlet port	4mm threaded port
Voltage	12V DC
Power	19W
Flow rate	800 L/h
Maximum Rated Current	1000mA
Maximum circulating water temperature	100°C

Figure 3.6 Brushless DC water pump

3.4.4 Charge Controller

Solar-powered system used a charge controller for charging battery. The charge controller provide simple use options, such as automatic battery voltage selection for 12V to 24V. Additionally, it incorporates a PWM charging technique with an automatic charge setpoint determined by battery voltage. Its display on LCD which has some idicators such as voltage,current, power, energy, and temperature. Figure 3.7 shows charge controller.

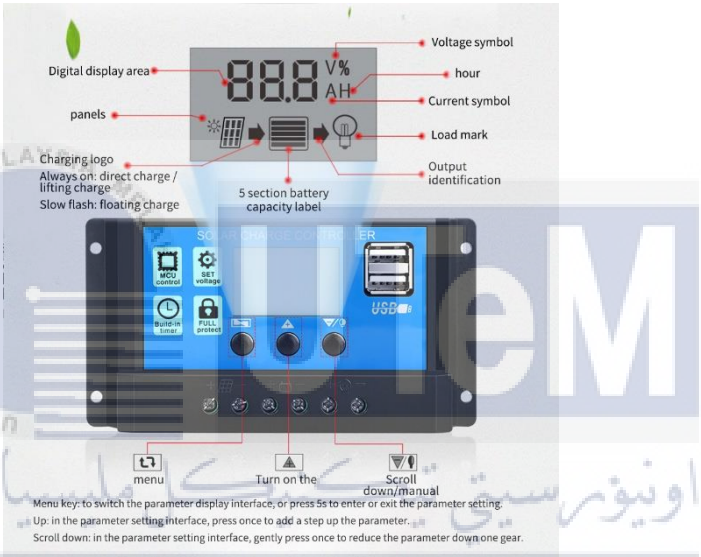


Figure 3.7 Charge Controller [19]

3.4.5 Current sensor module

The ACS712 20A rating current sensor module shown in Figure 3.8 was chosed to measure the current into the system. The sensing terminal of the current module may measure load current on medium voltage systems up to 230V AC supply even if the output detected voltage is isolated from the measuring section. In this application, the sensor was operated with a 5V supply voltage and the analog output is proportional to the current detected on the sensing terminals. The analog value is converted to a digital current

equivalent by the ADC on the microcontroller which will be displayed or recorded in data logger.

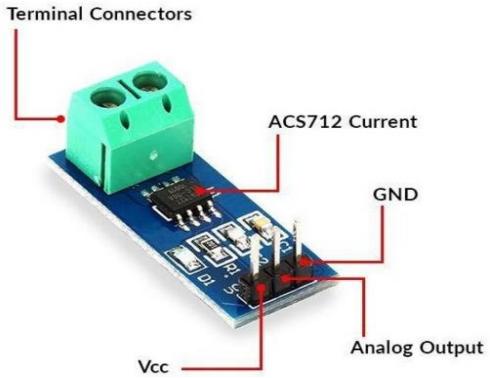


Figure 3.8 Current sensor module[20]

3.4.6 Voltage sensor module

The voltage of each load, including the load during solar-based battery charging and the generator is measured by the voltage sensor in Figure 3.9. Voltage greater than 5V will not be recognized by the voltage module's analog interface, which can only detect input voltages up to that level. The generator voltage and solar power battery charge were measured using a voltage divider. Two series resistors, R1 and R2 with corresponding values

of 30k ohm and 7.5k ohm and a resistance factor (RF), serve as the voltage sensor interface circuit.

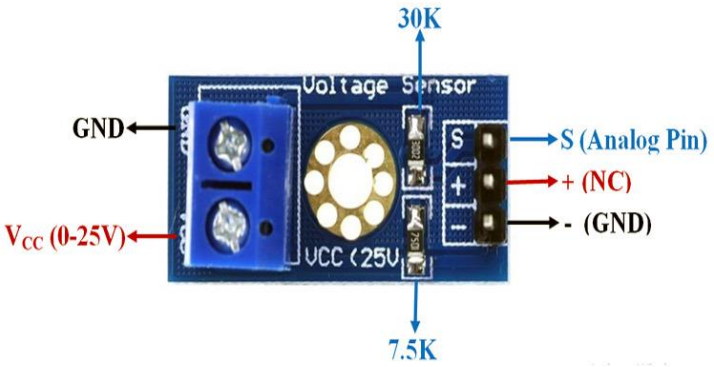


Figure 3.9 Voltage sensor module

3.4.7 Arduino Uno Board

A microcontroller board called the Arduino Uno is build around the Atmega328. The board with 14 digital input/output pins with a power connector, six analog input pins, a 16 MHz ceramic resonator, USB connection, reset button, and an ICSP header is shows in Figure 3.10. Additionally, the arduino board's microprocessor and other components need input supply which is 5V DC to function. To debug the coding and run it in real hardware where it is to measure current and voltage for each load will be use the Ardusino UNO board.

Figure 3.10 Arduino UNO board [21]

3.4.8 Liquid Crystal Display (LCD)

A flat panel display, electronic visual display (EVD), or video display that makes advantage of the light modulating properties of liquid crystal is known as a liquid-crystal display (LCD). Indirect light is produces by liquid crystals. Each of four rows of 20x4 LCD can show 20 characters, for a total of 80 characters, at any give time according to the LCD 20x4 designation. The current and voltage output of this project circuit are shown on the LCD. Figure 3.11 shows LCD module.

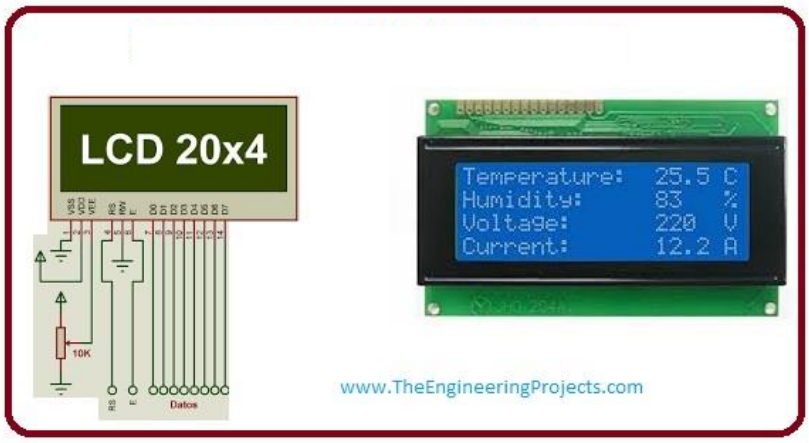


Figure 3.11 Liquid crystal display (LCD) [22]

3.4.9 Real time clock

Real time clock module is a component to determine real time. Which is it save the time zone that we save in the RTC modules. It keeps track of the time in terms of seconds, minutes, hours, days, months, and years. It often uses a quartz crystal oscillator for accurate timekeeping. Besides, it use battery backup to ensure continuous timekeeping even when the main power is off. RTC modulce includes a small battery. Before use the RTC, it is required calibration due to adjust the clock's accuracy based on external factors. Figure 3.12 shows RTC module.

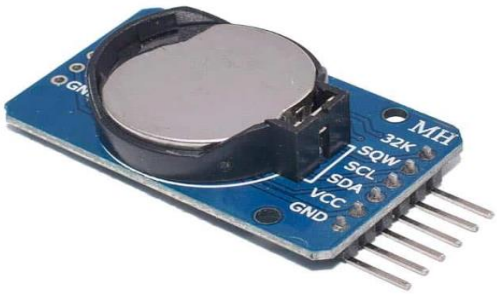


Figure 3.12 RTC module DS3231

3.4.10 SD card

SD card module for arduino is an external device that allows to interface an SD card with arduino board. This module simplifies the process of reading and writing data to SD card. It can be called as data logger. With an SD card module, it is able to log data from sensors, store configuration, or save any other kind of information to the SD card. For the project, SD card use to write data such as measurement of current, voltage, and power. Figure 3.13 shows SD card module.

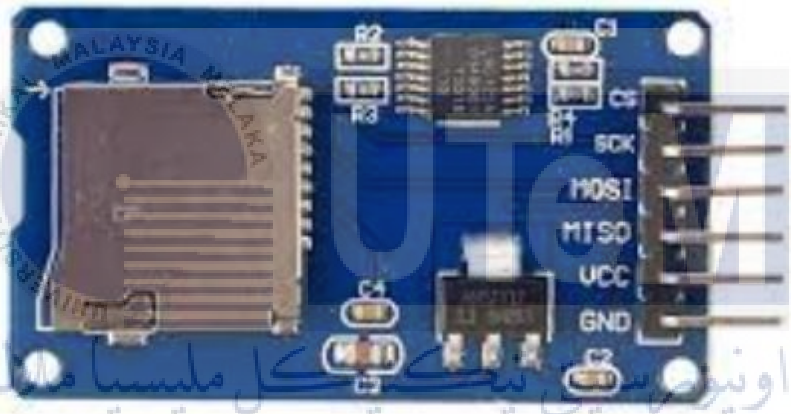


Figure 3.13 SD card module

3.4.11 Step-up boost converter module

A step-up (boost) converter from DC to DC voltage is a module for arduino that allows to increase the voltage from a lower level to a higher level. This can be particularly useful in electronic projects where it need to power components that require higher voltage than the power source provides. Figure 3.14 shows a module of step-up boost converter.

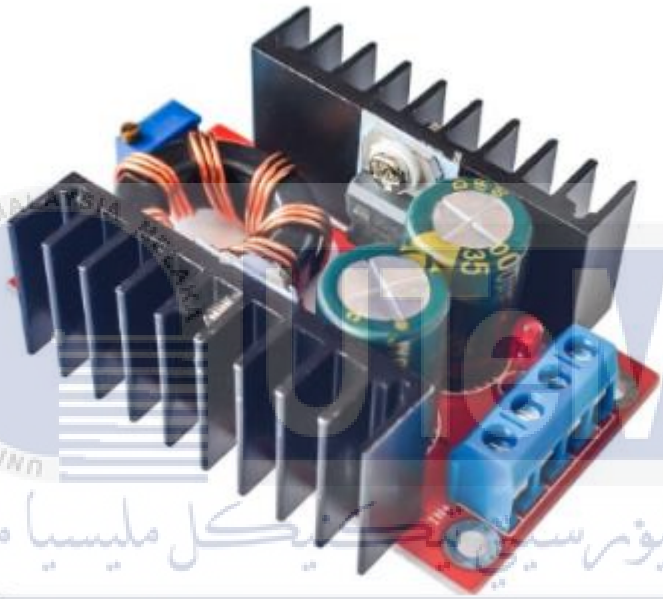


Figure 3.14 Module of step-up boost converter

3.5 Software Development

Software is an essential application program that helps to fulfill the entire project system due to the processes of microcontroller. Without this application, the project itself unable to be design the circuit connection and run the simulation of the build system.

3.5.1 Proteus 8 Version 8.13

Proteus 8 is a software development where it is able to simulate, designing, and sketch electrical circuits that requires our needs. By having various educational settings, this

software is compatible with a wide range of microcontrollers. Respectively, it is able to assist for the beginners in learning to build electronic circuits. Figure 3.15 shows the software.

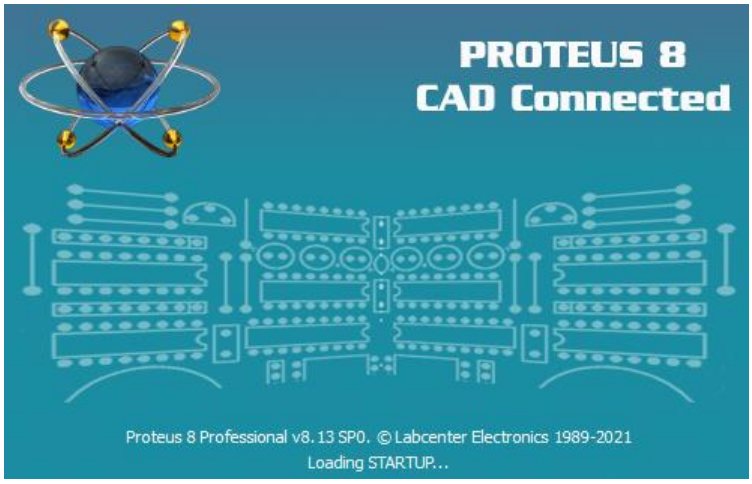


Figure 3.15 Proteus 8.13 [23]

3.5.2 Arduino IDE

The Arduino IDE is a software program that allows developers to build code in C and C++ using special code structure guidelines. The Arduino Ide comes with a software library called the wiring project which offers a variety of standard input and output functions. Additionally, it interfaces to Arduino and Genuino hardware so that the coding structure may be uploaded and communicated with it. Arduino may also be simulated in proteus because it is a simulation-based programme. Figure 3.16 shows Arduino IDE software.

Figure 3.16 Arduino IDE software [24]

3.6 Sustainable development

Solar energy is a sustainable source which offer a clean and eco-friendly of renewable source. The utilization of solar energy leads numerous opportunities to global challenges such as climate change, consumers of energy, and environmental degradation. By utilize the power of sun, solar technology leads to achieve a sustainable future for many generations. It is a great development for unlock the full potential of solar energy and brings to the brighter future for all.

3.7 Summary

To summarize, the project consist of software and hardware to develop the system itself. The uses of software is to conduct the calculation for the input and output to be measured such as voltage and current output. Hence, from the measured output, it is able to calculate for the power by using power formular where the software it self is decode by the code that have been upload to the microcontroller. Besides, the project used the battery as an energy storage and can be controlled by charge controller where it depends on the voltage

of the battery. Lastly, all the output will be displayed on LCD which is the data that have been measured by using different loads.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The result and discussion is a section where it is decisive part of any research paper where it represent the objectives and analysis of the project. This section allows to interpret the data collected and able to proof the project outcome. Within this section, it is also able to present the results of the project outcome and discuss the deficiency of the outcome.

4.2 Preliminary results

Figure 4.1 shows how the wiring connection of the simulation project system by using Proteus 8 software. Beside it use Arduino IDE software as a coding program and will be upload to the Arduino UNO package in the Proteus 8 software. The output of the simulation will be displayed on LCD. As the concept of the project, the source of the power is from the solar panel with 12V DC and the potential meter (RV1) is to control the output voltage.

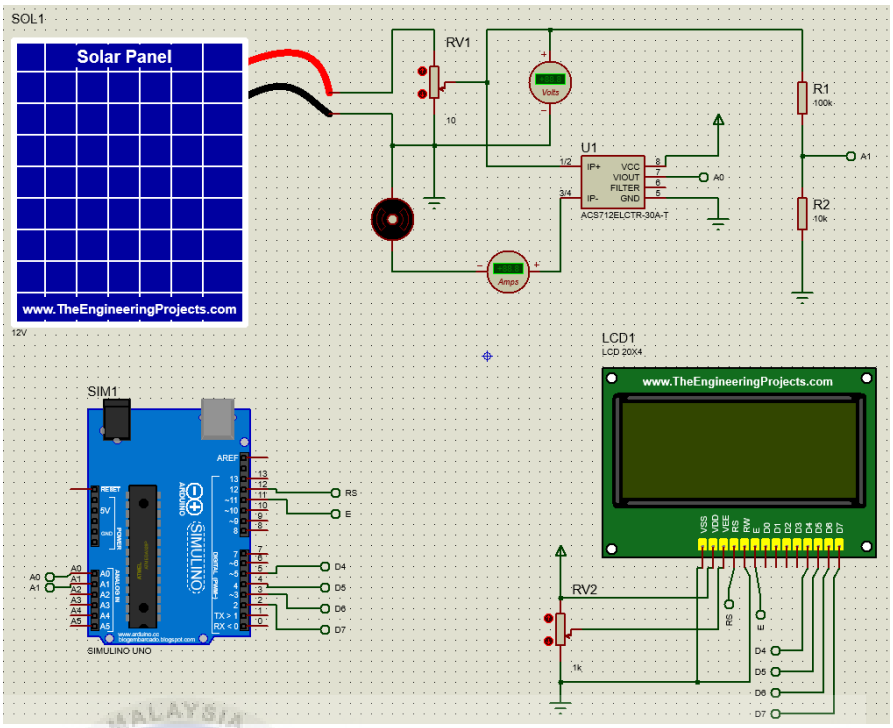
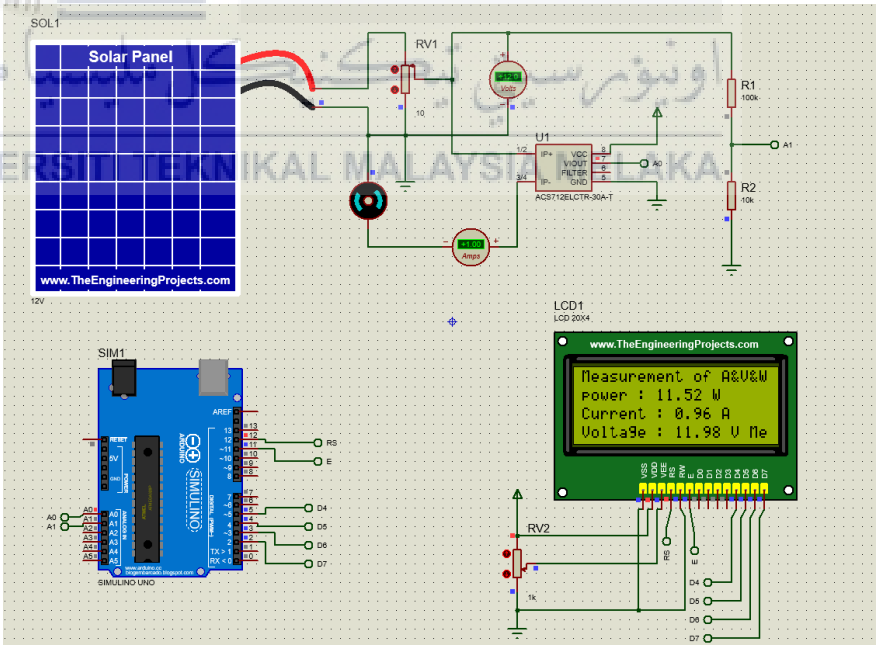
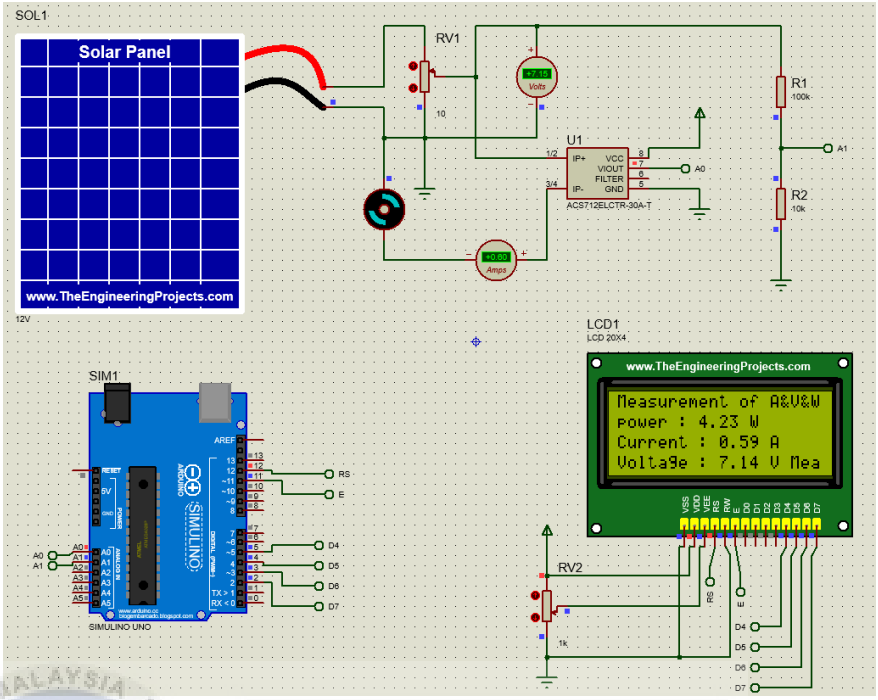
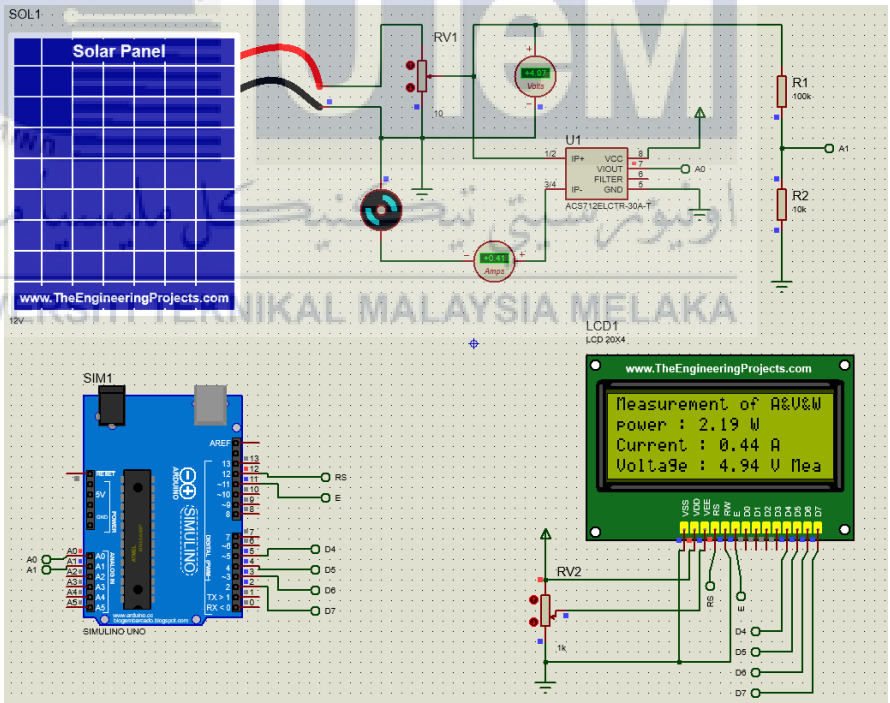


Figure 4.1 Designation of project simulation

Table 4.1 Result of simulation

Condition	Result
Potential meter value (%): 0% Current output: 0.96A Voltage output: 11.98V Power output: 11.52W	

Potential meter value (%): 25% Current output: 0.59A Voltage output: 7.14V Power output: 4.23W	
Potential meter value (%):50% Current output: 0.44A Voltage output: 4.94V Power output: 2.19W	

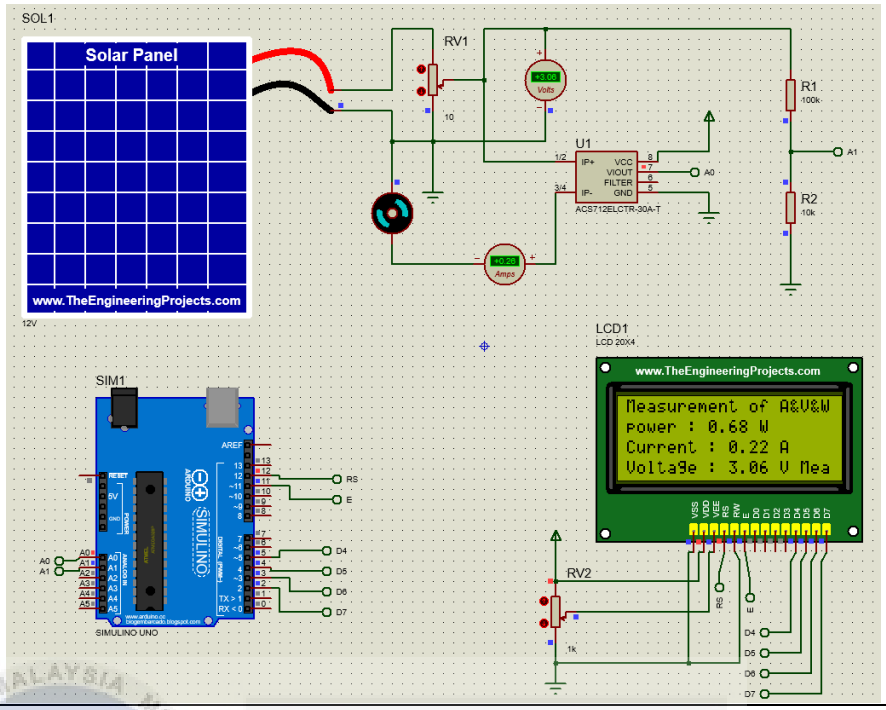
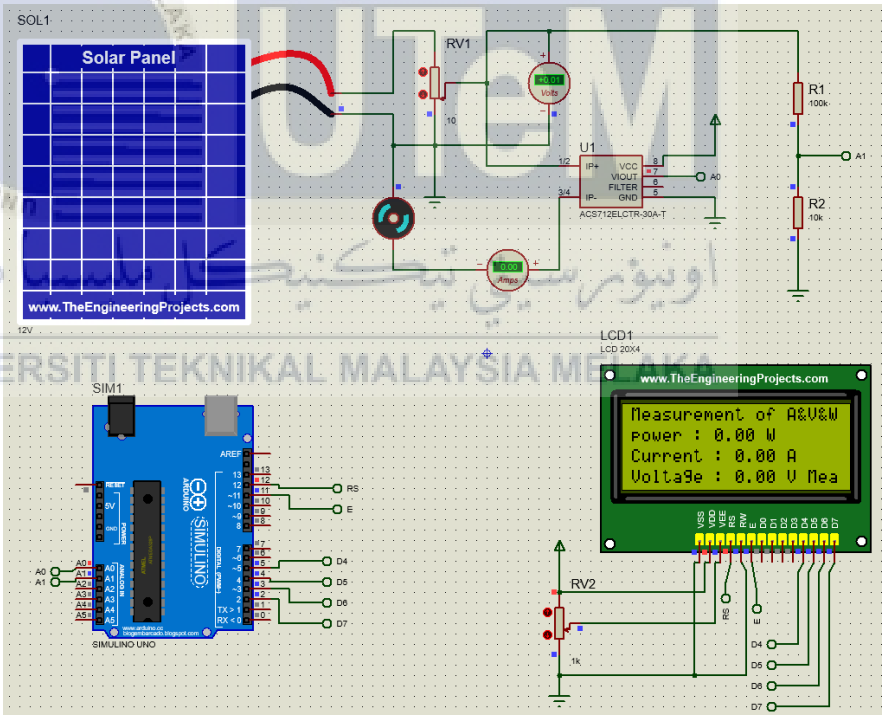
Potential meter value (%):75% Current output: 0.22A Voltage output: 3.06V Power output: 0.68W	
Potential meter value (%):100% Current output: 0.00A Voltage output:0V Power output: 0.00W	

Table 4.1 shows each result with different percentage of potential meter has different output of voltage, current, and power where it is being controlled by the potential meter which are 0%, 25%, 50%, 75%, and 100%. From the result it is slightly different from the actual measurement within the measurement on LCD. Due to this, the measurement in the LCD is being calculated by microcontrollers where it has formula that has sensitivity of the current sensor module. The output from LCD and the measurement has difference of ±0.03V. Appendix B shows the coding of the Arduino IDE software that uploaded to the Proteus software.

4.3 Results and Analysis

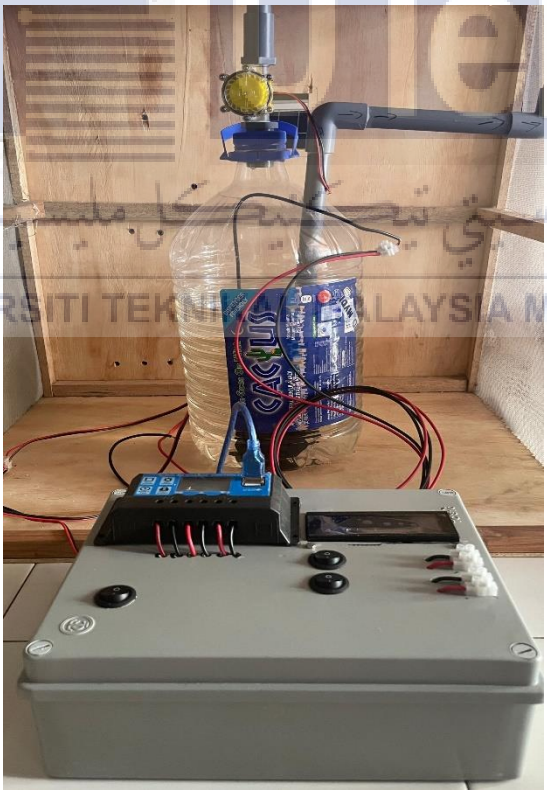


Figure 4.2 Prototype with micro-hydro system

Based on the Figure 4.2, it is a prototype for a complete system where it has solar charge controller, liquid crystal display (LCD), main switch, switch for 12V and 24V DC supply, solar panel, and micro-hydro system. The liquid crystal display (LCD) will display the measurement of current, voltage, and power. It is also displayed an opening for the system. For 24V DC supply, the system itself used step-up boost converter which is increasing the voltage for DC-DC voltage. The solar panel that has been used is 30W polycrystalline solar panel. Figure 4.3 shows step-up boots converter used in the prototype.

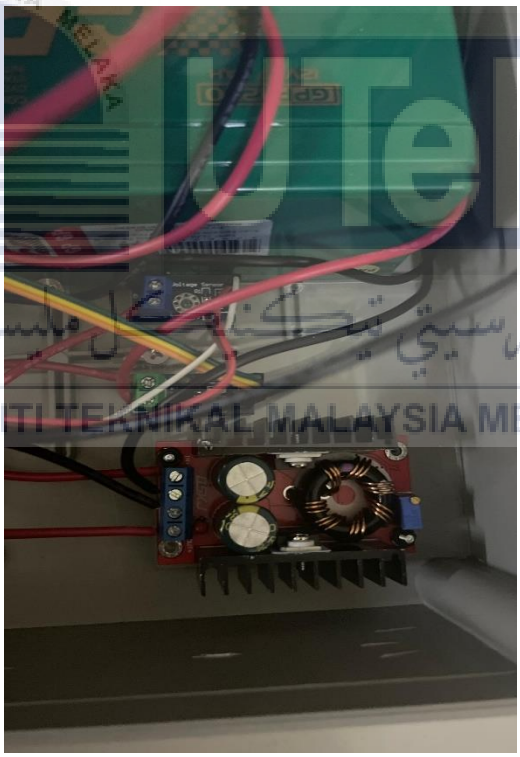


Figure 4.3 Step-up boost converter

4.3.1 View of inside Prototype

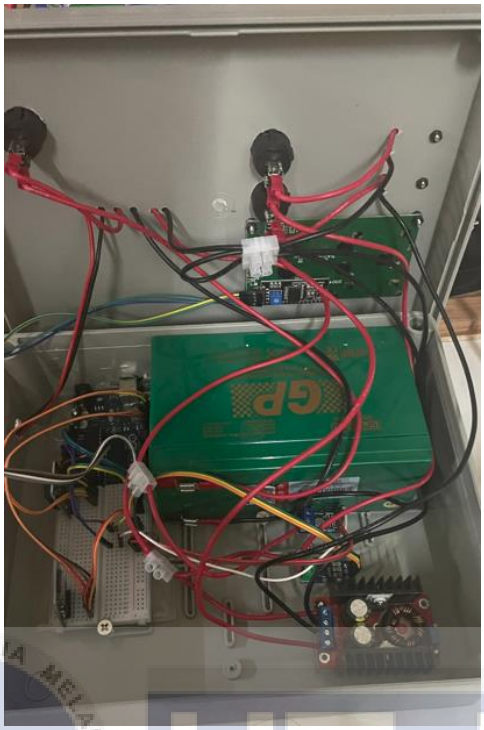


Figure 4.4 Inside view of prototype

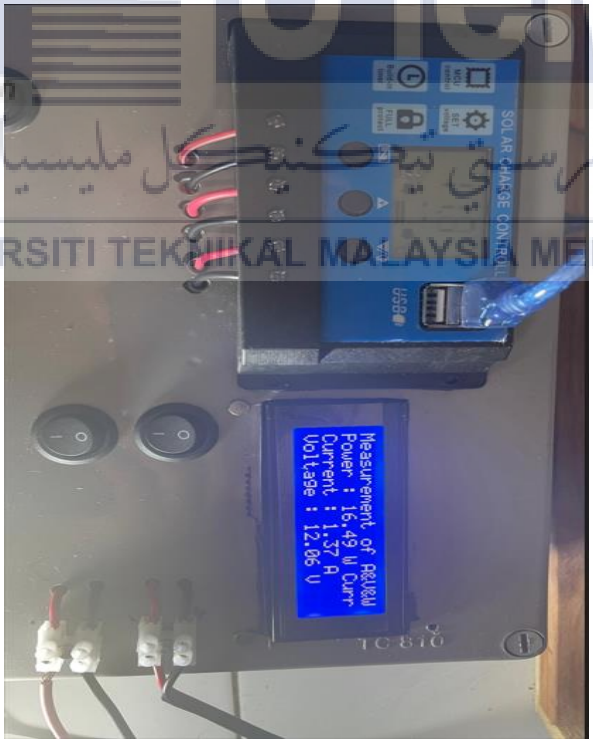


Figure 4.5 Top view of prototype with display

4.3.2 System functionality

The system of the prototype is used to generate power from micro-hydro generator and solar panel to charge the battery. The battery is to store the power that being generated. Since the purpose of the prototype is to generate power in rural area where it has solar power and river for the hydro system being function.

The power that being generated is controlled by a charge controller to charge the battery. The battery that being charged is sealed-lead acid battery 12V 7Ah. The prototype itself can supply 12V DC and 24V DC power supply. It is because the system used step-up boost converter to increase the voltage of the power supply.

Since the system used Arduino as a micro-controller, they can measure the power, current, and voltage to evaluate the power being used. Liquid crystal display (LCD) as a display for the system. Different types of load can be evaluate through the prototype.

There are several types of load which are LED lamp 12-24V DC, 12V DC waterpump, 12V DC fan is used as load. To evaluate the system, all of the load is being applied to the prototype per load. It will measure the power usage of each load for several time.

4.3.3 LED Lamp 12-24V DC applied as a load

LED lamp 24V DC 22W is used to evaluate the system. The system supply is 24V DC and 12V DC where both of the supply can be used for the load. By applying the load, the prototype is able to measure the current, voltage, and power. Basically, for LED lamp it has small value of current due to advanced technology.

Table 4.2 Summary of current measurement (LED lamp)

Current Summary	
Mean	0.24A
Minimum	0.05A
Maximum	0.29A
Total Data	432 Sample

Table 4.2 shows the summary of current measurement of LED 12-24V DC lamp where the average current is 0.24A that have been taken by 432 samples. This evaluation is to measure the current of LED lamp to differentiate the measurement between different types of load.

Table 4.3 Summary of voltage measurement (LED lamp)

Voltage Summary	
Mean	12.27V
Minimum	12.16V
Maximum	12.55V
Total Data	432 Sample

Table 4.3 shows the summary of voltage measurement where the voltage is being supplied for 12V DC to LED lamp. The average voltage is 12.27V that have been taken by 432 samples. To evaluate the system which the voltage supply is 12V, it can be measured by applying the load and the load will be function as well.

Table 4.4 Summary of power measurement (LED lamp)

Power Summary	
Mean	2.94W
Minimum	0.66W
Maximum	3.57W
Total Data	432 Sample

Table 4.4 shows the summary of power measurement for LED lamp where the average power is 2.94W. The power consumption of the LED lamp is small due to small value of current usage for the LED lamp. Since power is a multiplication of voltage and current, the system is able to measure the power that have been used for a sample of 432 within 9 minutes which is 2.94W.

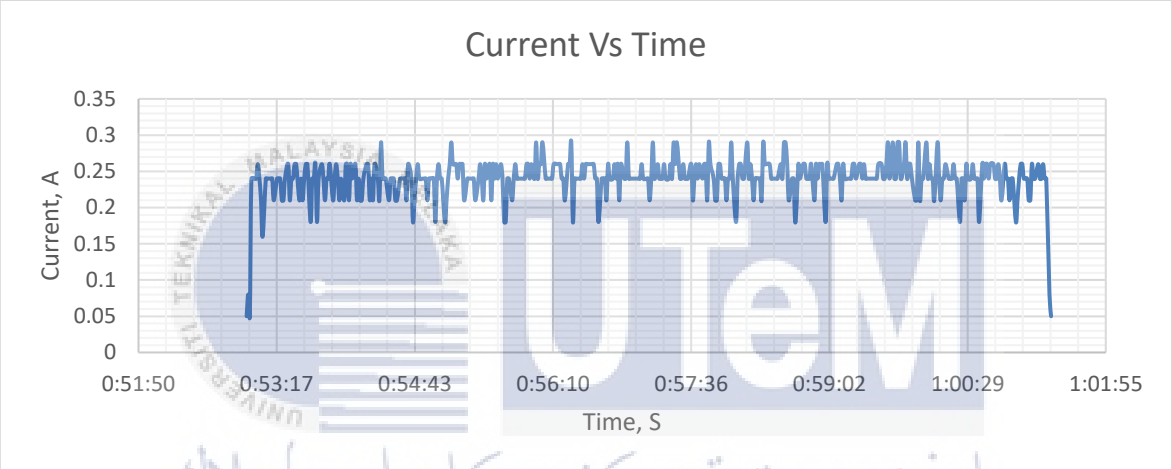


Figure 4.6 Graph of Current vs Time (LED lamp)

Figure 4.6 shows the graph of the 432 sample of current for LED lamp. The data is taken for 9 minutes. It shows the lowest current for LED lamp is 0.05A and the highest is 0.29A. The lowest current is taken where the system is off while when the system is switch on for the LED lamp the current will increase due to load as a resistance.

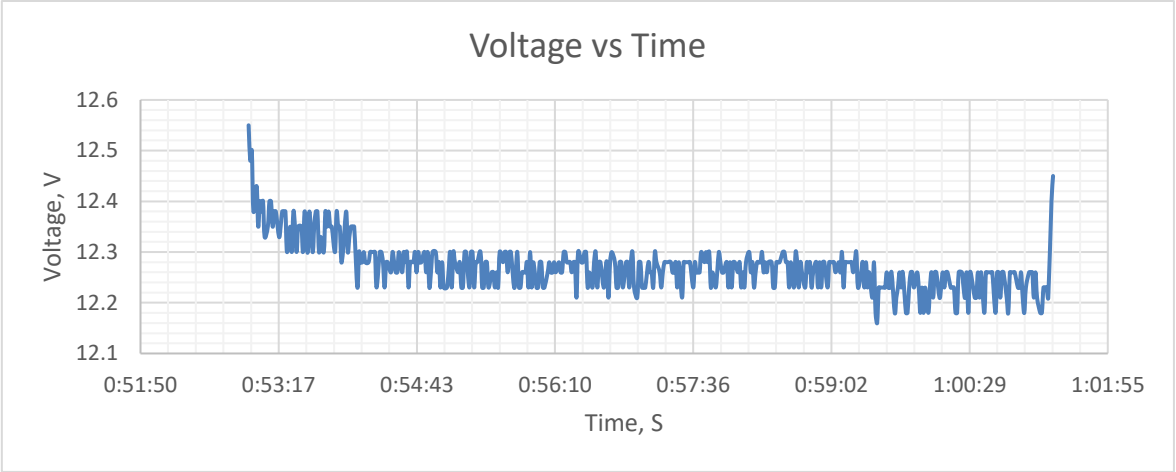


Figure 4.7 Graph of Voltage vs Time (LED lamp)

Figure 4.7 shows the graph of voltage vs time which it shows the voltage supply is 12V. The highest voltage is 12.55V and the minimum voltage is 12.16V where the average voltage of 432 sample data is 12.16V.

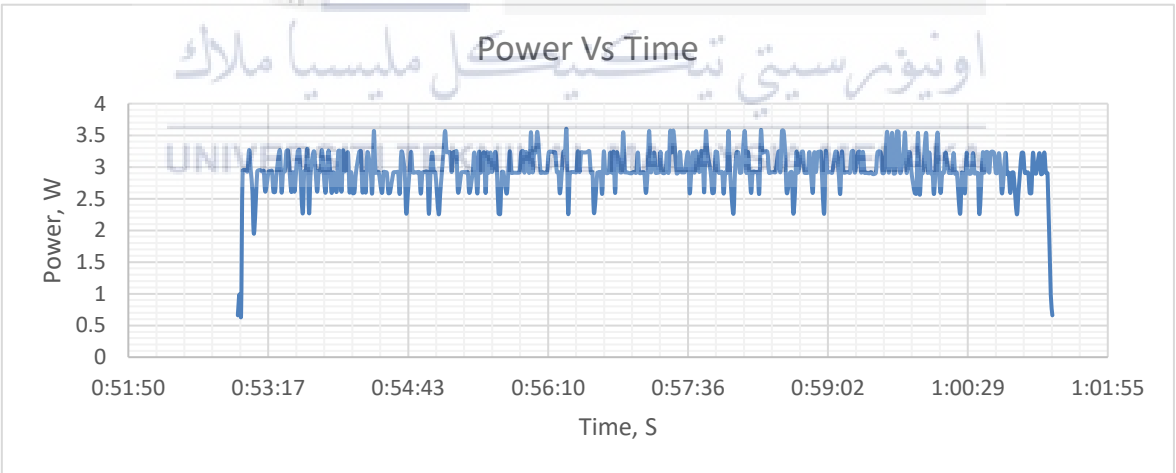


Figure 4.8 Graph of Power vs Time (LED lamp)

Figure 4.8 shows the graph of power vs time where the power is being used by the load from the system. The average power is 2.94W within 9 minutes.

4.3.4 Waterpump 12V DC applied as a load

Waterpump 12V DC is being used to flow water through the micro-hydro generator to generate power for battery charging. It is the same concept of solar system but to help the battery charging on night days since solar system can be used only in sunny days. Based on the problem where the system is will be used at rural area where it has river to able the micro-hydro system function to generate power.

Table 4.5 Summary of current (Waterpump)

Current Summary	
Mean	0.54A
Minimum	-0.7A
Maximum	1.61A
Total Data	269 Sample

Table 4.5 shows the summary of current for waterpump as a load where it being supplied by the system on 12V DC. Total sample of data that has been taken is 269 sample where the average current is 0.54A.

Table 4.6 Summary of voltage (waterpump)

Voltage Summary	
Mean	12.21V
Minimum	12.01V
Maximum	12.7V
Total Data	269 Sample

Table 4.6 shows the voltage summary of waterpump as a load. The average voltage of the load is 12.21V where it is the same as the system supply 12V to function the waterpump and act as support for micro-hydro generator. The average voltage is being taken by 269 samples of data.

Table 4.7 Summary of power (waterpump)

Power Summary	
Mean	6.54W
Minimum	-12.2W
Maximum	19.8W
Total Data	269 Sample

Table 4.7 shows the power summary of waterpump which is minimum power being used is 12.2W and the maximum power being used is 19.8W. The average power is 6.54W that taken by 269 samples.

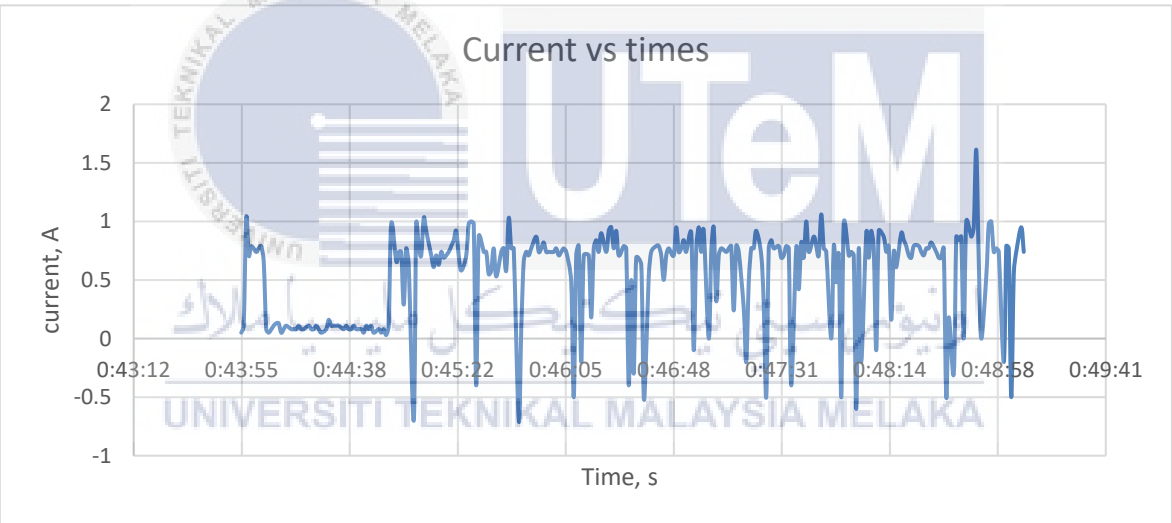


Figure 4.9 Graph of Current vs Time (waterpump)

Figure 4.9 shows the graph of current vs time where the current value has positive and negative value due to motor in waterpump generate positive and negative current. The graph shows of a sample of 269 within 5 minutes.

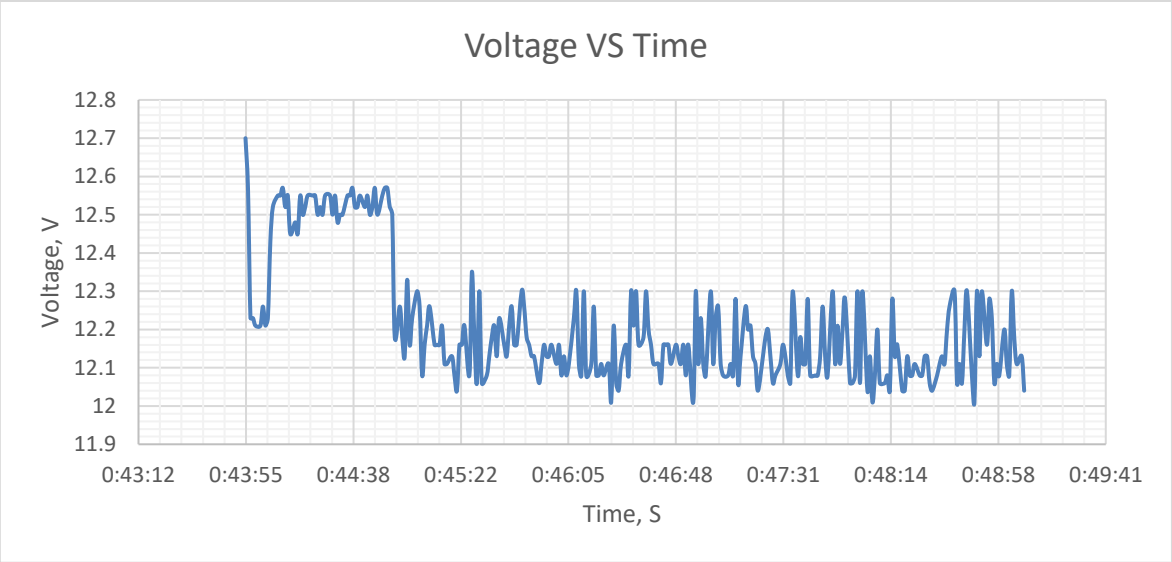


Figure 4.10 Graph of Voltage vs Time (waterpump)

Figure 4.10 shows the graph of voltage vs time where it has high starting voltage to power up the waterpump itself. It is because motor in waterpump require higher torque. Since the waterpump is required 12V DC voltage where the protoype is able to supply 12V DC so that the waterpump is function as well.

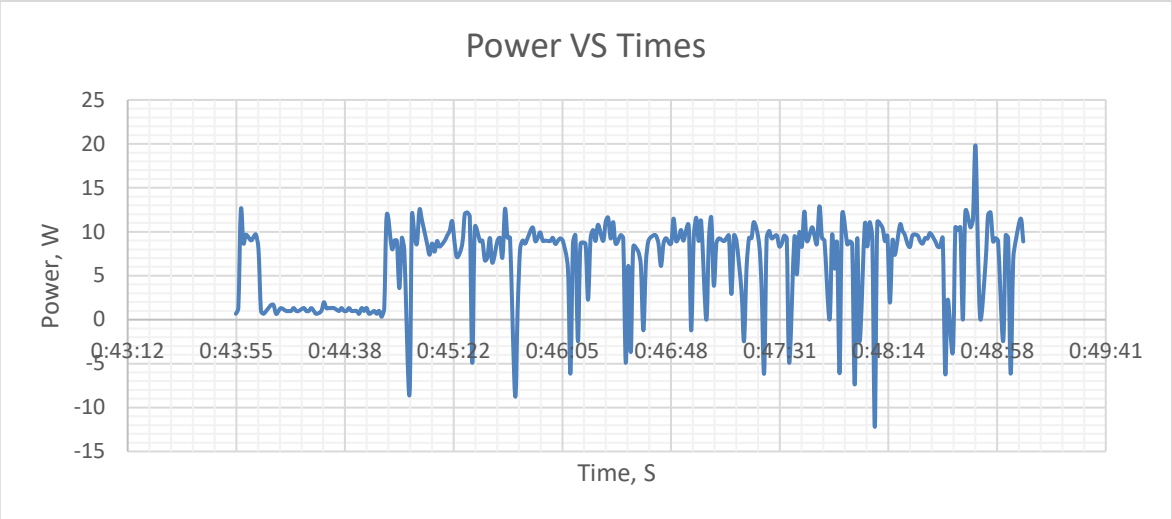


Figure 4.11 Graph of Power vs Time (waterpump)

Figure 4.11 shows the graph of power vs time where the waterpump used the average power of 6.54W within 5 minutes. Power is a multiplication of voltage and current where the graph shows negative value of power which is being affected by the negative current value.

4.3.5 Analysis of battery charging (Polycrystalline Solar 30W)

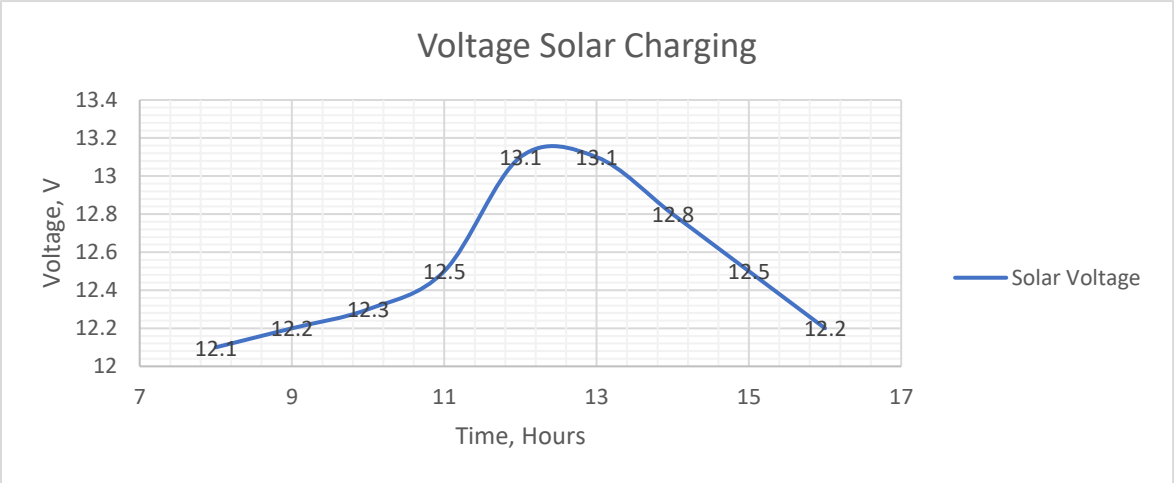


Figure 4.12 Graph of Voltage Solar Charging

Figure 4.12 shows the battery is being charge by using Polycrystalline solar panel 30W. It shows the peak sun hour where the generated voltage on peak at 12pm and 13pm is 13.1V. Lowest voltage generated is on 8am and 4pm where it is also can be affected by shaded region where the solar is not use optimizely.

4.3.6 Analysis of battery charging (micro-hydro)

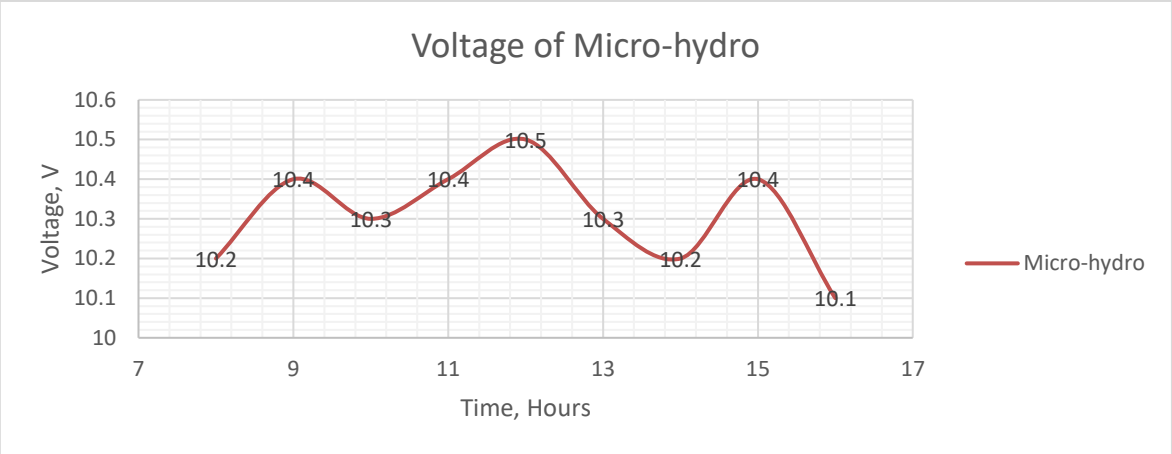


Figure 4.13 Graph of Voltage Micro-hydro generator

Figure 4.13 shows the voltage that being generate by micro-hydro generator which is to charge the battery. From the graph, the generated power is depends on the flow of water through the micro-hydro generator. If the flow water pressure is decrease, voltage generated is low while if the flow water pressure is increase, voltage generated is high. The peak voltage generated of the micro-hydro generator is 10.5V. In this case, the waterflow is being supplied by waterpump that act as load.

4.4 Summary

To summarize, the actual calculation and the measured output has a bit different of actual output and the measured output. This is due to the simulation has a perfect outcome where it does not depends on power losses or heat losses from the component. However, the result from LCD shows that the calculation by adding the sensitivity of sensor ACS712 which is current sensor module. The result came from LCD is the actual calculation and data output from the system where it depends on sensitivity of the current sensor. From the result, it is able to accomplish the project by simulating the project simulation. Components that used on simulation such as solar can be act as hydro power generator where it has the same voltage output which is 12V DC. The simulation itself can be use for both solar or hydro system. The prototype shows the measurement that been calculated by micro-controller which is Arduino Uno and able to display the power consumption, voltage, and current of each loads. Also, the data analysis of charging the battery where solar will depends on irradiance or peak sun hour while micro-hydro depends on the pressure of water flow. All data can be save by using data logger which is save on SD card and read real time clock (RTC) module. It saves real time data where it is interfacing with the micro-controller.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, Solar-micro hydro power generation is a system where it is environmental friendly. From the solar-micro hydro power generation it produce power where the power is store in battery. At the same time, the main problem is to know which are more efficient either single source power generation system or hybrid source power generation system. However, this study is able to evaluate which system works efficiently and how the system works. By evaluate the systems, it has a method on how to define the each system power produced on different loads. Each of the comparison will be held in different time. As an example, solar system will be experimented on days, rainy days, and cloudy. For the micro-hydro power system, the experiment can be held on all days since it is not being affected to weather condition compare to solar system. At the end of the project, to be expected for the project of solar-micro hydro power generation can demonstrate that both sources is able to charge the battery where it should be has different measurement result of voltage, current and power for solar system and micro-hydro power system. From the project it is able to observe the efficiency of the system where both solar and micro hydro generator is able to charge the battery while it also can power up 12-24V DC load.

5.2 Future Works

Future work of the project is to run the prototype by using higher capacity of battery bank with higher size of solar panel and micro-hydro generator to increase the production of energy.

- Increase solar size panel to generate more power.
- Increase battery bank capacity.
- Increase micro-hydro capacity to higher power.

5.3 Project potential for commercialization

Based on the project, the prototype might be able to be commercialize due to a system of solar and micro-hydro power generation for battery charging. For this purpose, the prototype is able to help people in need of power supply by store sustainable energy to the prototype.

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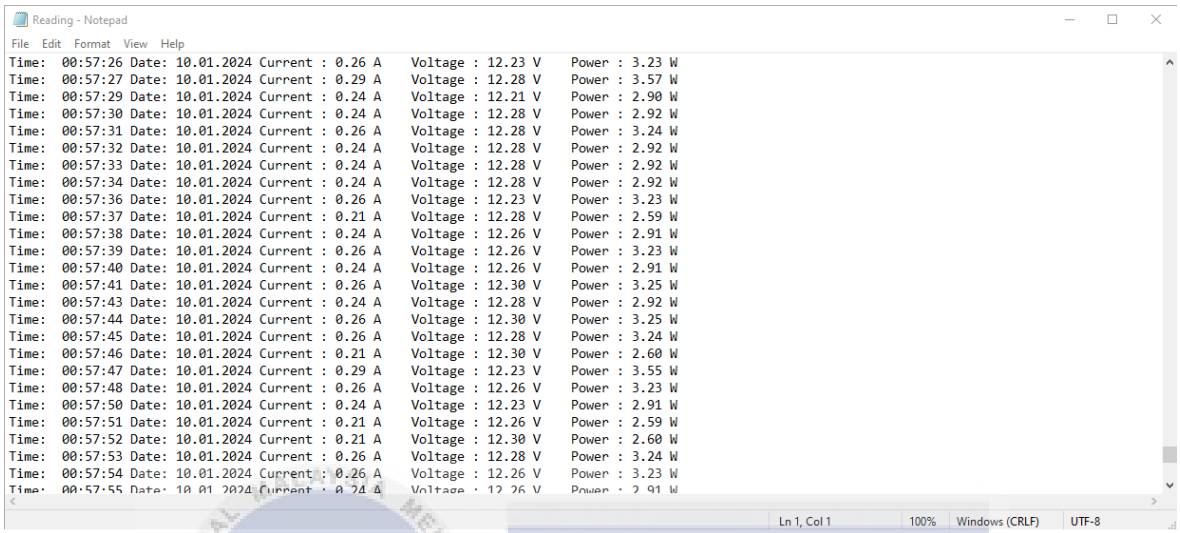
APPENDICES

Appendix A



```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#define ANALOG_IN_PIN A1
#include <SPI.h>
#include <SD.h>
#include <DS3231.h>
LiquidCrystal_I2C lcd(0x27, 20, 4);
File myFile;
DS3231  rtc(SDA, SCL);



int sensitivity = 100;
int adcValue = 0; int
offsetVoltage = 2500;
float adc_voltage = 0.0;
float in_voltage = 0.0;
double adcVoltage = 0;
double currentValue = 0;
float vout= 0.0; float
vin = 0.0; float R1 =
30000.0; float R2 =
7500.0; int volt = 0;
float power = 0.0; float
powerOut = 0.0; float
ref_voltage = 5.0; int
adc_value = 0;

void setup()
{

  Serial.begin(9600);
  rtc.begin(); // Initialize the rtc object
Serial.println("DC Voltage Test");
lcd.begin();   lcd.backlight();
lcd.clear();   lcd.setCursor(0,0);
lcd.print("Solar-Hydro Charging");
lcd.setCursor(7,1);   lcd.print("System");
lcd.setCursor(9,2);   lcd.print("By");
lcd.setCursor(0,3);   lcd.print("AHMAD
FEIRDAOUS SHAH");  delay(5000);
lcd.clear();
  Serial.begin(9600);
  Serial.println("Voltage:");
Serial.print(vin);
  Serial.println("Current:");
  Serial.print(currentValue);
```

```
  Serial.print("Initializing SD card...");

  if (!SD.begin(4)) {
    Serial.println("initialization failed!");
return;
  }
  Serial.println("initialization done.");

  // open the file. note that only one file can be open at a time,
  // so you have to close this one before opening another.
myFile = SD.open("test.txt", FILE_WRITE);

  // if the file opened okay, write to it:
  if (myFile) {
    Serial.print("Writing to test.txt...");
myFile.println("New Reading");
    // close the file:
myFile.close();
    Serial.println("done.");
  } else {
```

```
    // if the file didn't open, print an error:
Serial.println("error opening test.txt");   }

} void
loop()
{
  int adc = analogRead(A0);   float voltage
= adc * 5 / 1024.0;   float current = (2.5
- voltage) / 0.185;
  //if (current <= 0.02) {
   // current = 0;
//}



  // Read the Analog Input
   adc_value = analogRead(ANALOG_IN_PIN);

   // Determine voltage at ADC input
   adc_voltage  = (adc_value * ref_voltage) / 1024.0;

   // Calculate voltage at divider input
in_voltage = adc_voltage / (R2/(R1+R2)) ;


   power =  (in_voltage * current);
powerOut = power;
   // Print results to Serial Monitor to 2 decimal places
  Serial.print("Time:  ");
  Serial.print(rtc.getTimeStr());
  Serial.print("Date: ");
  Serial.print(rtc.getDateStr());
  Serial.print("Input Voltage = ");
Serial.print(in_voltage, 2);
  Serial.print("Input current = ");
  Serial.print(current, 2);
  Serial.print("Power = ");
Serial.println(powerOut, 2);
    lcd.clear();
lcd.setCursor(0,0);
lcd.print("Measurement of A&V&W");
lcd.setCursor(0,3);
lcd.print("Power : ");
lcd.print(powerOut,2);   lcd.print("
W ");
  //lcd.print("Current & Voltage");
lcd.setCursor(0,2 );   lcd.print
("Current : ");
lcd.print(current,2);   lcd.print("
A ");   lcd.setCursor(0,1);
lcd.print("Voltage : ");
lcd.print(in_voltage,2);
lcd.print(" V ");
```

```
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
}
  Serial.print("Initializing SD card...");

  if (!SD.begin(4)) {
    Serial.println("initialization failed!");
while (1);
  }
  Serial.println("initialization done.");


  // open the file. note that only one file can be open at a time,
// so you have to close this one before opening another.

  myFile = SD.open("test.txt", FILE_WRITE);
// if the file opened okay, write to it:   if
(myFile) {
    Serial.print("Writing  to  test.txt...");
myFile.print("Time:                          ");
myFile.print(rtc.getTimeStr                 ());
myFile.print("              Date:             ");
myFile.print(rtc.getDateStr                 ());
myFile.print     ("     Current     :     ");
myFile.print(current,2);       myFile.print("
A ");       myFile.print("     Voltage  :  ");
myFile.print(in_voltage,2);
myFile.print("  V  ");          myFile.print("
Power  :  ");           myFile.print(power,2);
myFile.println(" W ");

    // close the file:
myFile.close();
    Serial.println("done.");



    }

      delay(1000);
}
```

Appendix B

No.	Task	PSM1														PSM2													
	Weeks	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Create project title																												
2	Project Title Conformation and Registeration																												
3	Briefing with Supervisor																												
4	Study the Project Background																												
5	Drafting Chapter 1: Introduction																												
6	Task progress evaluation 1																												
7	Drafting Chapter 2: Literature Review																												
8	Table of Summary Literature Review																												
9	Drafting Chapter 3: Methodology																												
10	Work on the Software/Hardware																												
11	First Draft submission to Supervisor																												
12	Task progress evaluation 2																												
13	Submisiion Report to the Panel																												
14	Presentation of BDP1																												
15	Drafting Chapter 4: Analyse Data and Result																												
16	Data Analyse and Result																												
17	Record the Result																												
18	Drafting Chapter 5: Conclusion and Recommendation																												
19	Compiling Chapter 4 and Chapter 5																												
20	Submit Latest Report to Supervisor																												
21	Finalizze the Report																												
22	Presentation of BDP2																												