Faculty of Electrical and Electronic Engineering Technology



# SMART AIR PUMP USING SOLAR SYSTEM FOR SAVING

IZZUL FITRI BIN NORDIN

Bachelor of Electronics Engineering Technology with Honours

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# SMART AIR PUMP USING SOLAR SYSTEM FOR SAVING

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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**



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**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

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**PROJEK SARJANA MUDA II**

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# ABSTRACT

Solar energy is one of the renewable energy sources that is expanding widely as a result of technological advances today. The goal of this project is to reduce the use of electricity from the supply that must be paid for its use. Next, this project can prove that it is environmentally friendly because it only uses sunlight to be converted into electricity and belongs to an affordable project. Finally, this system will also evaluate the project's capabilities by using research resources and data collection. This project uses several types of sensors such as voltage sensors and current sensors. The results from the test show the feasibility, improve the functionality of the solar powered system, provide real-time monitoring and control to improve the reliability of the system.

## *ABSTRAK*

Tenaga solar adalah salah satu sumber tenaga boleh diperbaharui yang berkembang secara meluas hasil daripada kemajuan teknologi pada masa kini. Matlamat projek ini adalah untuk mengurangkan penggunaan tenaga elektrik daripada bekalan yang semestinya perlu dibayar atas kegunaannya. Seterusnya, projek ini mampu membuktikan bahawa ianya mesra alam kerana ia hanya menggunakan cahaya matahari untuk ditukarkan menjadi tenaga elektrik dan tergolong dalam projek yang mampu dimiliki. Akhir sekali, sistem ini juga akan menilai tentang keupayaan projek dengan menggunakan sumber kajian dan pengambilan data. Projek ini menggunakan beberapa jenis penderia seperti penderia voltan dan penderia arus. Keputusan daripada ujian memaparkan kebersanaan, meningkatkan kefungsian sistem berkuasa solar, menyediakan pemantauan masa ke semasa dan kawalan untuk meningkatkan kebolehpercayaan sistem.

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| | | |
|---|---|---|
| % | - | Percentage |
| < | - | Less than |

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| $V$ | - | Voltage |
| A | - | Current |
| Hz | - | Frequency |
| W | - | Power |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Nowadays, electricity is an important aspect of daily life and people are highly dependent on it. Solar energy, which is mostly derived from the sun's rays, is the form of energy that has the most positive impact on consumers and is environmentally friendly. The popularity of using solar energy systems as an alternative energy source has increased globally due to its easy installation and the need for minimal maintenance. Solar energy can be used to generate electricity using photovoltaics. As people continue to explore and advance with sustainable energy research and development, the advantages and benefits of photovoltaic power generation become more prominent and clearly more effective. Electricity is an important element that encompasses every aspect of daily life, from home lighting to powering refrigerators, heating, cooling systems and even vehicles. Over time, the demand for electricity has increased along with the need to generate more energy. However, the amount of electricity produced now is not enough to meet this demand, both in our country and in other developing countries, the increase in the cost of electricity makes it unaffordable for most people. As a sustainable and feasible solution, the use of solar energy has become increasingly popular in ancillary equipment such as aquarium pumps, alarms and others. The aquarium pump, which circulates and aerates the water, is the engine of the system. Usually, an impeller powered by an electric motor is what it consists of. The battery, which is charged by the solar panels, stores energy that powers the engine. The size and needs of the aquarium determine the flow rate and power consumption of the pump.

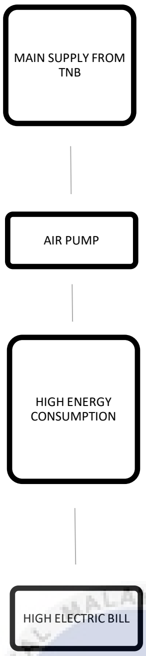
## 1.2 Problem Statement

Aquarium oxygen pumps use batteries and electricity to function full time. However, when solar panels are used to generate electricity and can be used as a supply. Unfortunately, sunlight does not emit light all the time. Because of this, a support battery needs to be provided so that it can be charged during the day when the solar panel receives sunlight and then this battery can be used as a supply for the aquarium's oxygen pump to function at night or in the absence of sunlight.

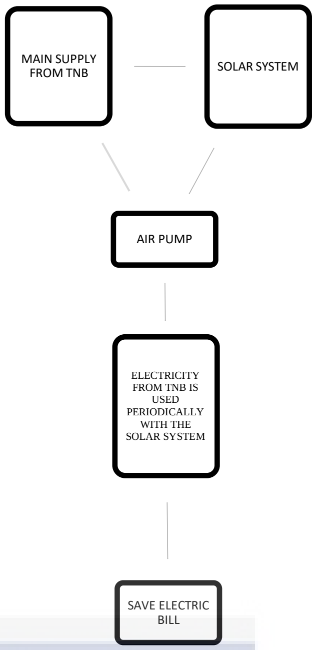
When charging devices are not properly managed, there is a danger of overcharging or undercharging which can result in reduced performance, shorter lifespan and safety risks. This risk can hinder the efficiency of the system and can cause more costs to be put into maintenance. Therefore, a good monitoring system can be a good solution to overcome this problem because it provides enough data so that the user can observe the data of the device and avoid incoming damage.

The presence of a solar charge controller is important to monitor the voltage and current value data produced by the solar charging system. As mentioned earlier, the danger of overcharging can occur but with a simple monitoring system, the charging system can operate smoothly without the risk and danger of overcharging or undercharging. Therefore, the fuse block can play an important role in ensuring efficient and reliable system operation by communicating with solar charge controller and measuring physical quantities such as voltage and current.

WITHOUT SYSTEM




WITH SYSTEM






## 1.3 Project Objective

1. To design a system using the Solar Charging Monitoring System using solar charge controller for aquarium air pump application.
2. To evaluate that everything functions properly while the aquarium pump receives solar energy and is powered by it.
3. To analyse the performance of Solar Charging Monitoring System using battery backup for supply power.

## 1.4 Scope of Project

This prototype consists of the following items;

a) This project uses a solar power as a main supply to the system.

b) The solar charge controller use for monitoring system for the charging detects amount of voltage and current supply from the solar panel.

c) To interface the load using ARDUINO UNO control

d) The battery will be a backup for the system.

e) Aquarium air pump is being the load for this project and its use to be a result.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

In several industries, including the aquarium business, there has been a substantial increase in interest in the usage of smart technologies and renewable energy sources. In recent years, increasing focus has been placed on developing environmentally friendly ways to power aquarium equipment. The use of smart air pumps powered by solar systems is one topic of study in this regard. The purpose of this literature review is to investigate the body of knowledge and research that already exists about smart air pumps that use solar power to reduce energy consumption in aquariums.

## 2.2 Solar PV

Electricity can be produced cleanly by solar photovoltaic (PV) technology by harnessing sun energy directly. Small to big isolated and connected grid applications have spread around the world. The process generates an electric current by absorbing photons from the sun and releasing electrons. Although solar photovoltaic technology has been around for a while, new advancements in materials and manufacturing methods have increased its effectiveness and reduced its cost. A photovoltaic array, then, is a group of solar panels that have been electrically linked together to form a much larger PV installation (PV system) known as an array. Typically, the entire surface area of the array determines how much solar electricity it will produce.

The cell temperature is another crucial factor that has a significant impact on how well solar PV systems work. PV panel power output tends to decrease as cell temperatures rise. The open-circuit voltage is specifically affected by temperature augmentation, which causes decreased efficiency at high temperatures. PV system performance can be significantly improved by using heat management and cooling strategies. An updated evaluation is essential for the PV research community because new methods for integrated cooling approaches have been studied in recent years.

As evidenced by rising production levels, expanding networks of solar installations, and expanding funding programmes globally, the PV industry has grown almost significantly in recent years. In 2018, almost 480 GW of installed PV capacity was realised, making up 2% of the world's electricity output. According to predictions, global capacity might reach 8500 GW by 2050 and 2840 GW by 2030. When all other factors are held constant and the average lifespan of a PV panel is assumed to be 25 years, the rapid development in PV deployment is predicted to cause an exponential rise in end-of-life (EOL) PV waste in the years to come. Additionally, several sizes of solar PV systems can be deployed, ranging from modest residential setups to enormous utility-scale installations. With less reliance on centralised power grids, solar PV can increase energy independence and resilience. In many regions of the world, solar PV technology is becoming more affordable and competitive with conventional power sources. As a result, the number of solar PV systems has rapidly increased, especially in regions with plenty of sunshine and favourable regulatory frameworks. Overall, the switch to a low-carbon and more sustainable energy system depends on solar photovoltaic technology.

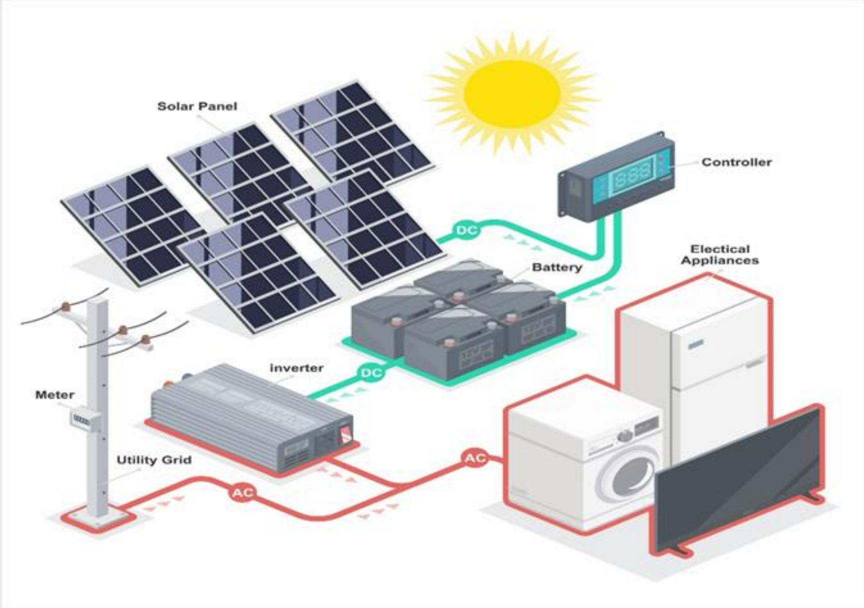



Figure 2.1 Inside photovoltaic system

## 2.3 Solar installation in Malaysia

Malaysia has a promising potential to establish solar power plant due to is located at equatorial zone, received great average daily solar radiation (4500 kWh/m2) and abundant sunshine for about 6-7 hours per day. The maximum solar radiation in Malaysian cities was recorded in Kota Kinabalu at 1900 (kWh/m2), followed by Bayan Lepas (1809 kWh/m2) and Georgetown (1785 kWh/m2). Solar energy, however, seems to be so unpopular because of the high cost of installation and solar electricity tariff rate. As highlighted under the 9th and 10th Malaysia Plans, the government has put in place a number of incentives, laws, funds, investments, and initiatives to stimulate the growth of solar energy.

Table 2.1 Annual solar radiation in different cities in Malaysia.

| Region / cities | Annual average value (kWh/$m^2$) |
|---|---|
| Kuching | 1470 |
| Bangi | 1478 |
| 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 |

Table 2.2 illustrates Solar energy production in Malaysia from 2008 to 2017. The amount of solar energy produced increased from nine to 362 megawatts in 2017. Malaysians have responded positively to government efforts to promote solar technology. Numerous governmental organisations, including Petronas, Tenaga Nasional Bhd, Malaysia Energy Centre (PTM), Sustainable Energy Development Authority of Malaysia (SEDA), and Tenaga Nasional Bhd, play a crucial part in determining the relevance of the country's energy development. In Malaysia, Tenaga Nasional Bhd will eventually construct the largest solar facility.

Table 2.2 Solar energy capacity in Malaysia from 2008 to 2017

| Year | Megawatts |
|---|---|
| 2008 | 9 |
| 2009 | 11 |
| 2010 | 13 |

| | |
|---|---|
| 2011 | 14 |
| 2012 | 32 |
| 2013 | 138 |
| 2014 | 203 |
| 2015 | 263 |
| 2016 | 340 |
| 2017 | 262 |

Malaysia lay along the equator, providing enough potential for solar energy with an average daily shine of 6-7 hours. As a result, the government has committed to constructing solar power plants for a number of purposes. We must realise that we can no longer rely solely on fossil fuels as the demand for electricity rises along with the economy and population expansion.

## 2.4 Types of solar panel in Malaysia

The number of solar energy installations has increased significantly in recent years in Malaysia, a country renowned for its profusion of sunlight and dedication to renewable energy. Malaysia has developed into a favourable climate for using solar energy because it is a tropical nation with abundant sun resources. This introduction gives a summary of the many types of solar panels frequently used in Malaysia while highlighting their features, advantages, and uses.

### 2.4.1 Polycrystalline panel

PV cells in polycrystalline or multicrystalline solar panels may have several silicon grains.Tiny silicon granules are melted together to create the polycrystalline solar panels' plates. The molten silicon pot used to create the polycrystalline solar cells is placed on the panel itself and allowed to cool. These solar cells have what appears to be a pattern on their surface. Because they are composed of numerous tiny polycrystalline silicon bits, they are square and blue. In a polycrystalline panel, each cell has several silicon crystals, limiting the amount of movement that electrons can make within the cells. These solar panels generate electricity using the sun's energy. There are several photovoltaic cells in these solar panels. Each cell contains silicon crystals, so it can work as a semiconductor device. Solar photons give electrons energy and allow them to travel as an electric current when they strike the PN junction (the point where N-type and P-type semiconductor materials converge). In this situation, P-type materials lack electrons while N-type materials are electron-rich. The PV cells are attached to two electrodes. The electrode on the top surface is composed of tiny wires, and the electrode on the bottom is a conductor that resembles foil.



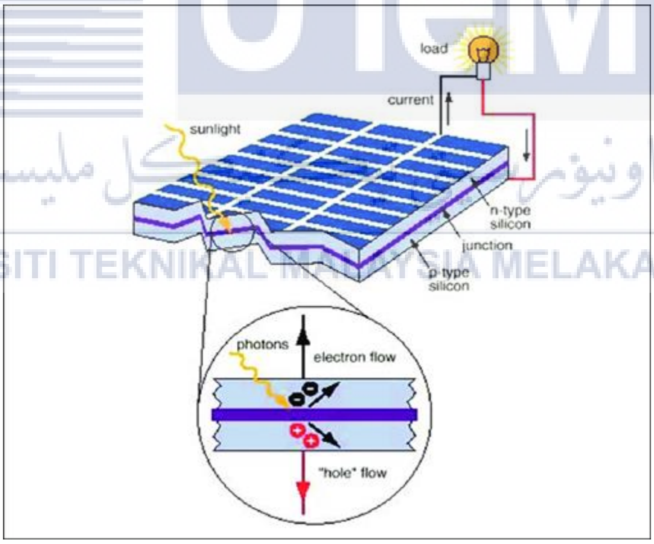



Figure 2.2 Schematic polycrystalline panel diagram

### 2.4.2 Monocrystalline panel

A solar panel made up of monocrystalline solar cells is referred to as a monocrystalline solar panel. The cylindrical silicon ingot used in the panel, which was made from highly pure single crystal silicon, is where the name of the product comes from. The cell's single crystal construction gives the electrons greater room to move, resulting in a better electricity flow.  Wafers are cut from the cylindrical ingot to create cells. The circular wafers are wire cut into an octagonal shape to maximise the use of the cells. The octagonal shape of these chambers gives them a distinctive appearance. They also have the same colouring. These solar panels' construction material is referred to as "monocrystalline" in the name. Each solar cell contains a silicon wafer, which is made up of a single silicon crystal. The single crystal is made using the Czochralski technique, which involves lowering a "seed" crystal into a pot of molten, pure silicon at a high temperature. The seed is then raised, and a crystal is formed around it by molten silicon. The large crystal, also known as an ingot, is divided into thin wafers and used to make solar cells.

Monocrystalline solar panels typically offer the best efficiency and power output out of all solar panel types. Monocrystalline solar panels may have an efficiency range of 17% to 20%. Because monocrystalline solar cells are formed of a single silicon crystal, electrons can travel through them more easily than through other forms of solar panels, increasing their efficiency.

Due to their higher efficiency, monocrystalline solar panels use less space to generate the same quantity of power. Therefore, monocrystalline solar panels will often have a greater power output rating than polycrystalline or thin-film modules.. The monocrystalline solar panel absorbs solar energy from the sun, and through a complex process, the cells produce an electric field. The power produced by this electric field, which consists of voltage and current, is determined by the equation P = V x I.

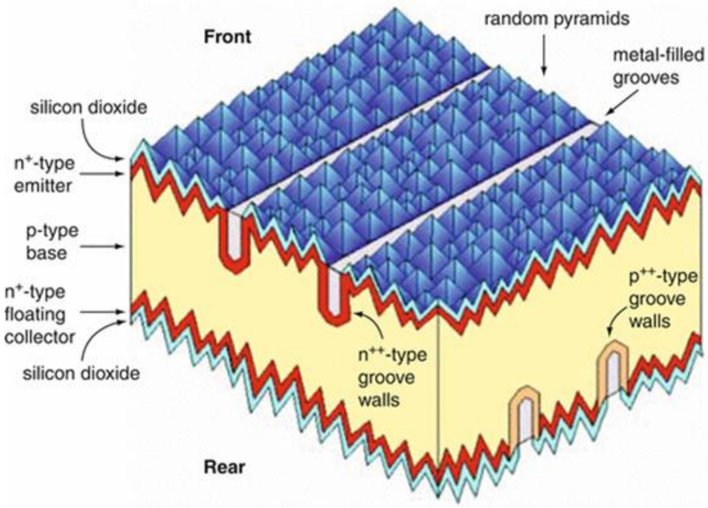



Figure 2.3 Schematic of Monocrystalline panel

### 2.4.3 Thin film panel

Thin films are less efficient than conventional, rigid photovoltaics, such traditional crystalline silicon panels. Nonflexible solar cells, except for cadmium telluride thin films, offer quicker payback times and more robust construction, which has advantages in many applications. Thin-film solar cells are expected to surpass the traditional rigid photovoltaic technologies that have been in use since the middle of the 20th century as their efficiency keeps rising. Thin-film sheets may be used to generate electricity in more locations that are inaccessible to traditional solar cells, including as curved surfaces of buildings or automobiles, or even on clothing to power portable gadgets. Such applications might assist in achieving a sustainable energy future.

Due to their thin construction, thin-film solar cells are lighter and more flexible than first-generation silicon solar cells. This qualifies them for usage in solar systems that are incorporated into buildings and as semi-transparent photovoltaic glass that may be laminated onto windows. Some of the biggest photovoltaic power plants in the world use rigid thin film solar panels (interleaved between two panes of glass) for other commercial uses. Additionally, compared to first-generation cells, the materials used in thin-film solar cells are often made utilising straightforward, scalable processes that are more affordable, and this often results in lesser environmental impacts like greenhouse gas (GHG) emissions. In terms of human toxicity and heavy metal emissions, thin-film cells frequently outperform both renewable and non-renewable sources of energy to produce power.

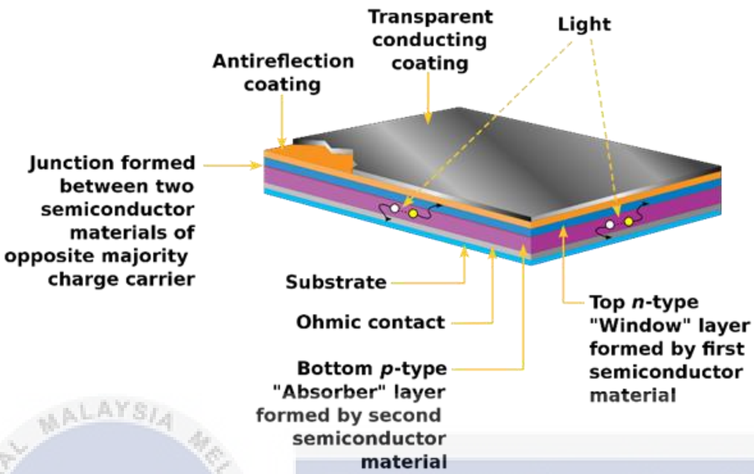



Figure 2.4 Cross-section thin film cell

Technologies using thin films lessen the amount of active material in a cell. The cell can be constructed using a flexible substrate like fabric or a stiff substrate comprised of glass, plastic, or metal. According to life cycle analyses, thin-film solar cells have a lower ecological impact and are typically less expensive than crystalline silicon solar cells. They are also perfect for uses like photovoltaic systems that are integrated into buildings because of how thin and flexible they are. Though some thin-film materials exceed crystalline silicon panels in terms of efficiency, most film panels have conversion efficiencies that are 2-3 percentage points lower than crystalline silicon. Three of the most well-known thin-film technologies are amorphous silicon (a-Si), copper indium gallium selenide (CIGS), and cadmium telluride (CdTe).



### 2.4.4 Advantages and Disadvantages of Solar Panel

The table below show the advantages and disadvantages of solar panel. There are three types of solar panel that is commonly use in Malaysia.

Table 2.3 Advantages and disadvantages of solar panel

| Type | Advantages | Disadvantages |
|---|---|---|
| Polycrystalline | 1. Less costly compared to Mono.<br>2. Less production wastage | A. Less efficient compared to Mono.<br>B. Less power yield per square foot<br>C. High temperatures and low light conditions impair performance. |
| Monocrystalline | 1. More efficient<br>2. High power yield per square foot<br>3. Perform better even in low light | A. Costly<br>B. More production wastage<br>C. Poor performance at high temperature |
| Thin Film | 1. Less costly compared to Mono and Poly<br>2. Flexible panel can be made out.<br>3. Visually appealing<br>4. Good performance at high temperature or at low light condition | A. Less efficient compared to Mono and Poly<br>B. Less power yield per square foot compared to Mono and Poly<br>C. Doesn't last long compared to Mono and Poly |



## 2.5 Working Principle and Construction of Solar Panel

The photovoltaic effect, which enables the conversion of sunlight into usable electrical energy, is the basis for the operation of a solar panel. A solar panel is made up of various layers and parts that work together to capture solar energy.

### 2.5.1 Working Principle of Solar Panel

The p-type layer at the p-n junction is so thin that light photons can readily travel through it. The connection receives enough energy from the photons from the light source to create several electron-hole pairs. The incoming light disturbs the thermal equilibrium state of the connection. Free electrons in the depletion zone have a high mobility to the n-type side of the junction. The p-type side of the junction may be easily accessed by the holes, just as the depletion. Once they reach the n-type side of the junction, newly created free electrons cannot continue to cross it due to its barrier potential.

Similar to this, as they reach the p-type side of the junction, the freshly generated holes become subject to the same barrier potential as the junction. The p-n junction will act like a miniature battery cell as one side of the junction, the n-type side, experiences higher electron concentrations and the other side, the p-type side, experiences higher hole concentrations. A voltage known as the photovoltage is put up. A minor current will flow across the junction if we attach a small load across it.

### 2.5.2 Construction of Solar Panel



Although it has a somewhat different design from standard p-n junction diodes, a solar cell is fundamentally a junction diode. On top of a somewhat thicker n-type semiconductor, a very thin layer of p-type semiconductor is formed. Next, we add a few smaller electrodes to the p-type semiconductor layer's top.

These electrodes don't prevent light from passing through to the p-type layer. A p-n junction is located just beneath the p-type layer. A current-collecting electrode is additionally provided at the base of the n-type layer. To shield the solar cell from any mechanical disturbance, we encase the complete device in a thin glass shell.

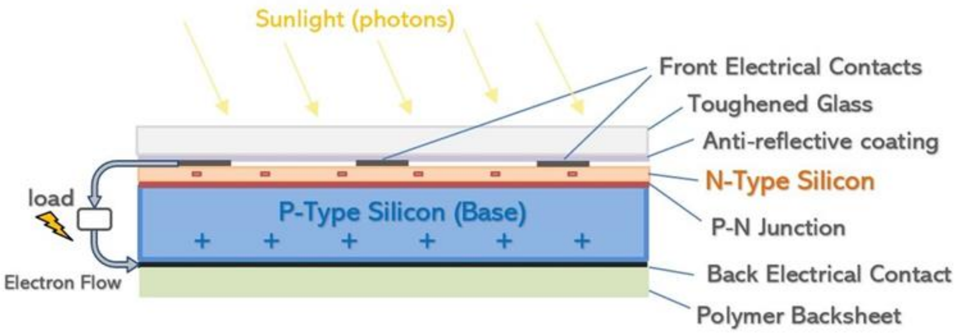



Figure 2.5 P-Type base solar panel

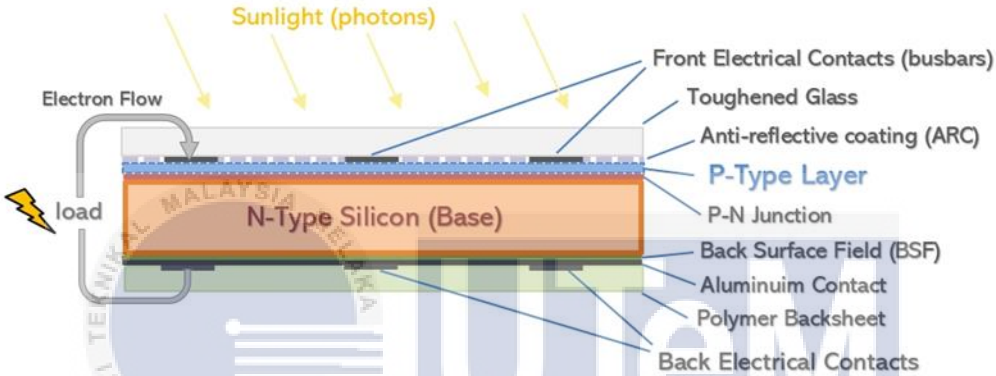



Figure 2.6 N-Type base solar panel



## 2.6 PV Module Characteristics

The important performance module and details of a photovoltaic (PV), sometimes referred to as a solar panel, are referred to as PV module characteristics. Standard test conditions (STC) and nominal operating cell temperature (NOCT) are provided by these features.

### 2.6.1 Standart Test Condition (STC)

Standard Test Conditions (STC) are the industry benchmark that all PV modules are evaluated and compared against. STC is a predetermined set of lab testing settings that simulate real-world usage scenarios for solar panels or PV modules. STC offers the most universal standard, despite the fact that other standards offer closer approximations to the real world. The same criteria are used to evaluate potential installation sites because they serve as the basis for values. STC consists of three elements:

1. Irradiance is the amount of sunlight falling on a flat surface, measured in Watts per square metre. The unit of measurement is 1 kW per square metre (1,000 Watts/m2).
2. The term "air mass" refers to the "thickness" and "clarity" of the air that allows light to enter the modules (the sun angle impacts this value). The requirement is 1.5.
3. Cell temperature will be different from the temperature of the surrounding air. STC specifies a maximum temperature of 25 degree Celsius for cell testing.

### 2.6.2 Nominal Operating Cell Temperature (NOCT)

A solar panel converts some of the solar energy (irradiance) it absorbs into thermal energy and some of it into electrical energy. This implies that while generating power, the temperature of the cell and the module will rise. Other external factors also have an impact on the PV module's temperature, though. It is challenging to determine a PV module's temperature given all the weather variations. Scientists developed Nominal Operating Cell Temperature (NOCT) to simplify the calculation. The nominal operating cell temperature (NOCT) is the temperature reached by open circuited cells in a module under the following conditions::



1. Irradiance on cell surface = 800 W/m2
2. Air Temperature = 20°C
3. Wind Velocity = 1 m/s

## 2.7 Solar Charging System

A solar charging system directly powers gadgets or recharges batteries using solar energy. It typically consists of solar panels that take in light from the sun and convert it into electricity that is either given right away to devices or stored in batteries for later use. Solar charging systems offer a sustainable and environmentally responsible alternative because people use renewable energy and produce no emissions. The energy is especially useful in remote areas with little access to traditional electrical infrastructure. As the efficiency and durability of solar charging systems have improved over time, they are becoming a more desirable option for a range of uses, including off-grid living, outdoor activities, and emergency power backup. Solar power systems provide a dependable and available source of electricity that could reduce reliance on

One or more electrochemical cells in the battery-powered gadget transform chemical energy that has been stored into electrical energy. The overall chemical reaction in a battery is split into two physically and electrically distinct processes, such as an oxidation process at the battery negative electrode where at least one species' valence becomes more positive and a reduction process at the battery positive electrode where at least one species' valence becomes more negative. The battery must offer two different routes for electrons and ions to flow between the sites of oxidation and reduction. The electrons will move through the external circuit, where they can perform beneficial tasks, such as producing power a transportable object, such a mobile or an electric car. While moving through the electrolyte that sits between the battery's two electrodes, which is both electrically insulating and ionically conducting. As a result, the electronic current, which may be readily controlled by a switch or a load in the external circuit, is isolated from the ionic current.

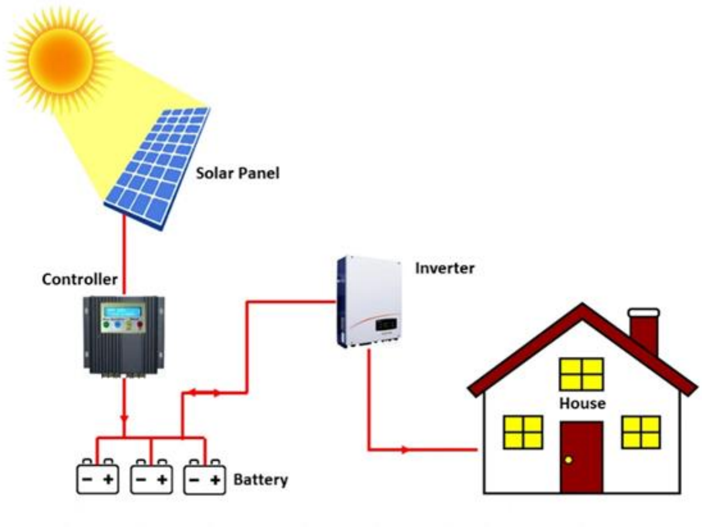



Figure 2.7 Solar power system for home

## 2.8 Typical of Grid-Tied System

Grid-tied solar power systems are connected to the electrical grid. As seen in figure 2.8 below, a grid-connected or grid-interconnected system is referred to. A bidirectional metre, an inverter, and solar panels make up the device. electricity produced by sunlight from the inverter converts the solar panels' DC power into usable AC power. Grid-tie systems, as opposed to off-grid systems, which only rely on energy that has been stored in batteries, transmit any excess electricity generated by the solar panels back into the power grid. This enables the system owner to receive credits or payment for the electricity they deliver to the grid through net metering contracts. Grid-tie systems can be used in areas with solid electrical infrastructure and policies that favour renewable energy. The system has the advantage of supplying extra electricity to the grid when solar production exceeds demand and allows energy to be pulled from it when solar output is insufficient. Grid-tie systems offer people and businesses the chance to reduce their environmental impact, offset their energy expenses, and enhance the overall sustainability and dependability of the electrical grid.

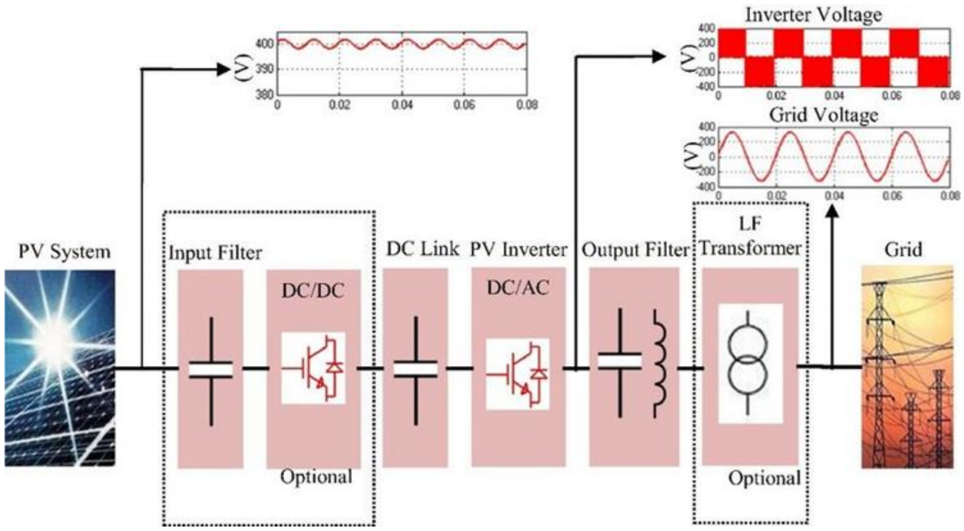



Figure 2.8 Grid interface solar photovoltaic system

### 2.8.1 Advantages of Grid-Tied System

As a result, grid-tied solar systems are typically less expensive and easier to install. Frequently, your solar panels will produce more electricity than you can use. Instead of storing the extra power themselves in batteries, householders can use net metering to send it onto the electrical grid. Real-time electricity consumption is required. It can, however, be momentarily stored as different types of energy (for instance, chemical energy in batteries). Typically, energy storage results in large losses. The electric power grid resembles a battery in many ways, except that it is significantly more efficient and doesn't require any upkeep or repairs. In other words, typical battery systems lose more electricity (and more money). Due to this simplicity, which not only lowers upfront costs but also streamlines the installation and maintenance processes, grid-tied solar systems are an affordable and practical option for people primarily focused on balancing the energy use and gaining access to net metering agreements.

### 2.8.2 Disadvantages of Grid-Tied System

Grid-tied solar systems lack battery storage, which prevents them from providing backup power, in contrast to off-grid or hybrid systems. Grid-tied systems cannot provide electricity during grid disruptions or outages because they exclusively depend on the electrical grid to supply electricity. This suggests that when the grid goes down, grid-tied solar systems are instantly turned off for safety reasons, limiting the use of the solar-generated power within the building. Households and businesses using grid-tied systems must rely on the grid's stability and dependability to guarantee a steady supply of electricity. The lack of battery storage makes the system simpler and more affordable overall, but it also highlights how important it is to consider other backup power choices, like grid-independent battery backup systems or freestanding generators.

## 2.9 Solar PV DC to AC

DC electricity can be used by most appliances, therefore solar PV and battery storage are linked to them directly. Other devices that cannot accept DC nevertheless have a conversion problem. It is important to step-up the low-level solar PV voltage to the standard voltage level (220 V) before continuing with the AC conversion while converting power from lower-level DC voltage to higher-level AC voltage. These solar PV arrays are connected to the local grid using various inverters with conversion losses because solar PV generates a DC supply, and the current utility only accepts AC.

Battery banks are required for energy storage in standalone systems that are not connected to the utility grid, but energy that is produced in excess of what is needed by the end user is transferred back to the utility grid and used where there is a shortage. Community power grids are also employed as energy stores in grid-connected systems.

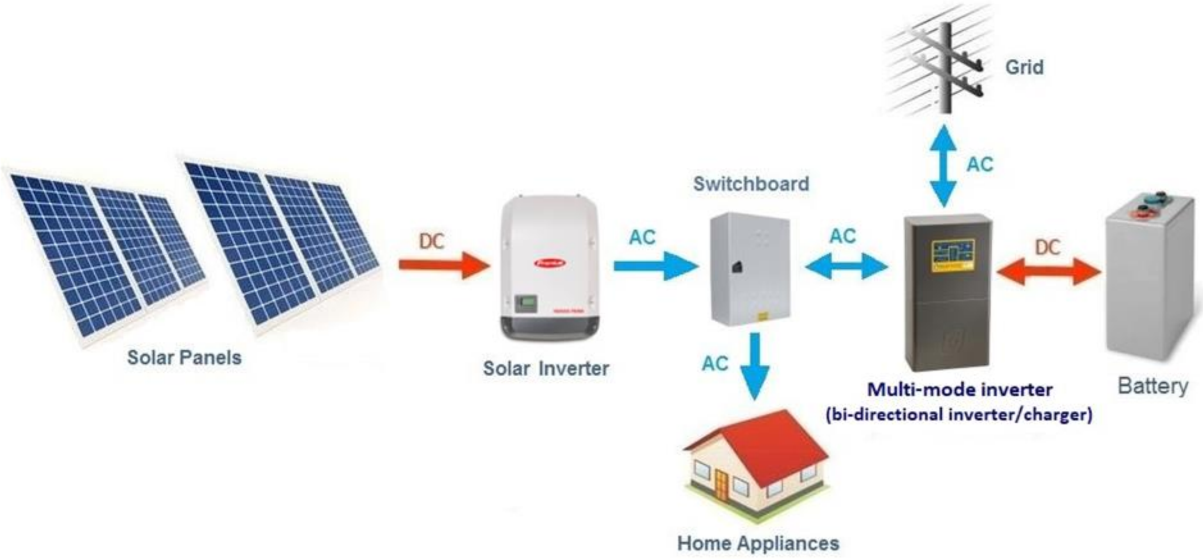



Figure 2.9 Solar PV DC to AC converter

Additional inverters than ever before are being connected to the grid as a result of the addition of additional solar systems. Because there is no turbine involved, inverter-based generating can produce energy at any frequency and does not share the same inertial characteristics as steam-based power. Building smarter inverters that can react to frequency shifts and other grid disruptions and assist stabilise the system against them is therefore necessary to make the switch to an electrical grid with more inverters.

## 2.10 Project Comparison

| PROJECT NAME | SUPPLY | LOAD | ADVANTAGE | DISADVANTAGE |
|---|---|---|---|---|
| THE DEVELOPMENT OF SOLAR-BASED FLOOD WARNING SYSTEM | SOLAR | BUZZER LED | SAVING ELECTRICITY BILL BECAUSE OF USING SOLAR | ONLY DEPENDS ON SOLAR ENERGY |
| DESIGN AND DEVELOPMENT OF AN EFFICIENT WATER SPRINKLER SYSTEM FOR PHOTOVOLTAIC PAN ELS | SOLAR | WATER PUMP | SAVING ELECTRICITY BILL BECAUSE OF USING SOLAR | ONLY DEPENDS ON SOLAR ENERGY |
| DEVELOPMENT OF THE SOLAR CHARGING MONITORING SYSTEM USING ARDUINO UNO FOR LIGHTING APPLICATION | SOLAR | LED SYSTEM CONTRO LLER | SAVING ELECTRICITY BILL BECAUSE OF USING SOLAR | ONLY DEPENDS ON SOLAR ENERGY |
| DUAL AXIS SOLAR TRACKER | SOLAR | DUAL AXIS MOTOR | SAVING ELECTRICITY BILL BECAUSE OF USING SOLAR | ONLY DEPENDS ON SOLAR ENERGY |
| **SMART AIR PUMP USING SOLAR SYSTEM FOR SAVING** | SOLAR TNB SUPPLY | AIR PUMP | THE SYSTEM CAN BE USED DURING THE DAY AND NIGHT WITHOUT EXPECTING ONLY SOLAR ENERGY | STILL USING ENERGY FROM TNB |

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter will describe the operation of every part of the system, including how to activate the air pump. To ensure that all the major objectives are accomplished, guidelines and flowcharts will be given in the approach as a reference. The use of all parts and tools will also be explained.

## 3.2 Justification for Sustainable Development on The Project

A renewable energy source that harnesses the power of the sun is solar energy. The smart air pump is powered by solar panels, which lessens the project's dependency on fossil fuels and its emissions of greenhouse gases. This promotes a cleaner and more sustainable energy system while assisting in the fight against climate change. Traditional air pumps frequently use electricity produced by fossil fuel-based power plants, which can worsen the environment and contribute to air pollution. The smart air pump lessens its environmental impact overall, including air and water pollution, by utilising solar energy. Systems that run on solar energy promote energy efficiency because of these features. Transmission losses associated with conventional power sources are eliminated by solar panels since they convert sunlight directly into energy. The smart air pump can further improve its energy efficiency by incorporating energy-efficient components and optimising power usage, resulting in the least amount of resource waste possible. Once the infrastructure is in place, solar energy offers a long-term cost advantage over conventional energy sources. Although the initial investment may be larger, solar-powered systems often have lower operating expenses because there is no need for fuel and less maintenance is required. The smart air pump is an economically effective and environmentally friendly option because users may reduce their operating costs and electricity bills.

### 3.3 Methodology

To learn more and gain insights, conduct research on solar energy systems and smart air pump technologies that are already in use. The system is totally solar powered and utilises an aquarium air pump. This system will create data that may be used by the solar charge controller to determine the voltage and current values that the solar panel can generate to ensure that the air pump has access to sufficient power. The battery will receive electricity from the solar charge controller while it is being charged so that it may power the aquarium air pump at day and when the night turn out the air pump will relate to a Power Supply to convert the DC connection to AC so that it operates effectively. The flow chart will serve as an overview of this project to aid in better comprehension.

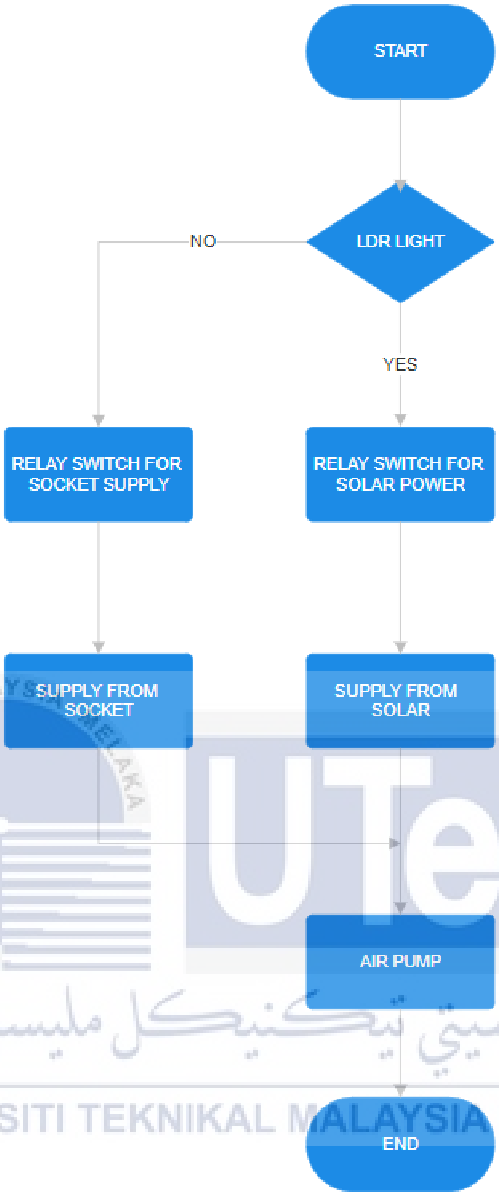



Figure 3.1 Flowchart of project

## 3.4 Component

A larger system or entity's constituent parts or elements are referred to as components. Within the wider framework or system, specific tasks or responsibilities are carried out by various entities. Each of these parts is intended to work in harmony with the others and adds to the system's overall functionality, effectiveness, or purpose. Understanding the components is crucial for comprehending the operation of the system, outlining each role and relationship, and assessing the contribution of each component to the success or failure of the system.

### 3.4.1 Polycrystalline Solar Panel

A polycrystalline solar panel is a type of photovoltaic panel that uses polycrystalline silicon solar cells, as seen in figure 3.1 below. Since these solar cells are made by melting many silicon chips together, they have a less uniform crystal structure than monocrystalline ones. Polycrystalline solar panels can be distinguished from monocrystalline ones by their multiple grain boundaries and distinctive blue tint. These solar panels are a popular choice in the solar industry due to their accessibility and comparably high efficiency. Using polycrystalline solar panels, which are well known for their ability to produce electricity from sunshine, solar energy may be transformed into useful electrical power. These panels are suitable for a range of applications, including industrial-scale solar power installations and both domestic and industrial systems. Polycrystalline solar panels are an intriguing solution for those wishing to harness solar energy and reduce their reliance on conventional power sources despite having slightly lower efficiency than monocrystalline panels due to their lower cost.



Figure 3.2 Polycrystalline solar panel

Table 3.1 Technical specification

| Type | Polycrystalline |
|---|---|
| Power Maximum | 10W |
| Tolerance | +- 5% |
| Vmp | 12V |
| Imp | 0.42A |
| Voc | 14.5V |
| Isc | 0.45A |
| Maximum System Voltage | 750v |
| Size | 500mm x 400mm x 22mm |

This is a 10W polycrystalline solar panel with a tolerance of ±5% that is intended forflexible energy collection. This panel performs dependably while operating at a maximum power voltage (Vmp) of 12V and a matching current (Imp) of 0.42A. It has a short-circuit current (Isc) of 0.45A and an open-circuit voltage (Voc) of 14.5V. It guarantees system compatibility with a maximum system voltage of 750V. The solar panel's small size (275 x 180 x 17 mm) allows it to be used in a variety of ways while combining efficiency and flexibility in the use of solar energy.



**Load details for size of solar panel:**

1 unit of 1W ultrasonic sensor use for 24 hour/day

Total load = (1 x 1W x 24) = 24W

**System specific requirement:**

Energy usage (per day) = 24Wh

Depth of Discharge (DoD) = 50%

Days of Autonomy (DoA) = 2 day

Battery Bank Temperature Multiplier (BBTM) = 1

Peak Sun Hour (PSH) = 4 hours

**Solar panel size:**

The output power of solar panel

= Energy usage (per day) ÷ PSH ÷ system efficiency

= 24Wh ÷ 4 hours ÷ 0.85

= 7.06W

Polycrystalline silicon panel size = 12V, 10W

Therefore, 7.06W ÷ 10W = 1 solar panel

Hence, 1 polycrystalline silicon solar panel is needed for the system to operate.



### 3.4.2 Solar Charge Controller PWM

A solar charge controller that uses pulse width modulation (PMW) can be used to regulate and optimise the charging of batteries in solar energy systems, as shown in Figure 3.3 below. PWM is a method that swiftly switches the solar panel's output on and off to control the power supplied to the battery. In order to maintain a steady charging voltage, the charge controller adjusts the switching frequency based on the battery's level of charge. A smooth and efficient charging process is achieved by the charge controller's effective pulse width regulation of the amount of electricity supplied to the battery. By avoiding overcharging, which can degrade the battery, this helps maintain the battery's general health and durability.


Figure 3.3 PWM Solar Charge Controller

Table 3.2 Technical Specification

| Model | W88-B |
|---|---|
| Rated Voltage | 12V / 24V |
| Rated Current | 20A |
| Max. PV Voltage | 50V |
| Max. PV Input Power | 260W (12V), 520W (24V) |



The W88-B solar charge controller is a multifunctional model intended for effective photovoltaic (PV) system management. It can support moderate-sized solar setups with a rated voltage of 12V or 24V and a rated current of 20A. The controller is compatible with a variety of solar panel designs and can manage a maximum PV power of 50V. It is noteworthy for its capacity to control and optimize solar energy harvesting, as seen by its ability to manage a maximum PV input power of 260W for 12V systems and 520W for 24V systems, indicating versatility. With its efficient voltage and current control characteristics, the W88-B is an essential part of keeping solar power systems operating at peak health.

### 3.4.3 Sealed Lead Acid Battery

A sealed lead acid (SLA) battery with a 12V and 4.5AH rating is a specific type of rechargeable battery that is often used in many applications. The battery's nominal voltage, shown by the 12V sign, is about 12 volts of electrical potential when fully charged. The battery's 4.5AH (Ampere-Hour) capacity rating tells you how much charge it can hold for a specific period. This SLA battery, which has a 4.5AH capacity, is widely used in low-power applications such as small-scale electronics, alarm systems, emergency lighting, and others. The battery is safer to use and requires no maintenance because to its sealed design, which prevents electrolyte leakage. The 4.5AH capacity allows for significant energy savings, making it suitable for applications with lower power requirements. It's essential to adhere to the recommended charging and usage procedures to enhance the battery's performance and longevity.

Table 3.3 Technical Specification

| Type | Sealed Lead Acid |
|---|---|
| Cycle Use | 14.5 – 14.9 V |
| Standby Use | 13.4 – 13.8 V |
| Initial Current | <1.35A |


Figure 3.4 Sealed lead acid battery 12V, 4.5 AH

What makes the Sealed Lead Acid (SLA) battery described here suitable for a wide range of applications is that it provides different voltage ranges for different use cases. The suggested voltage range for cyclic usage is 14.5–14.9 V, which guarantees peak performance over repeated cycles of discharge and recharge. When not actively cycling, the battery operates in the range of 13.6 to 13.8 V for standby use, which offers stability during idle times. Furthermore, a maximum current of 1.35A is allowed during the first charging phase, highlighting the need of regulated current input when the battery is first connected to a charging source. Together, these requirements provide essential principles that support the safe and effective functioning of sealed lead acid batteries in a range of real-world applications.

### 3.4.4 Air Pump

The oxygen content of the aquarium water is increased with the aid of the air pump. The air pump creates bubbles that rise to the water's top and break there, releasing oxygen into the liquid below. This is especially advantageous for aquatic creatures like fish who need dissolved oxygen to breathe. Water circulation and movement in the aquarium are caused by the air bubbles produced by the air pump. This motion prevents stagnant areas and fosters a better environment for the residents by distributing heat, nutrients, and oxygen equally throughout the tank. The air pump also helps the aquarium's substrate breathe. It aids in preventing the accumulation of anaerobic pockets, which can release toxic gases, by releasing air bubbles close to the substrate. An environment that is favourable for beneficial microorganisms and plant root systems is promoted by proper substrate aeration. These filters use an air pump to provide suction or flow, which draws water through the filter material and offers mechanical and biological filtration. It's crucial to remember that not every aquarium layout calls for an air pump. In some circumstances, water circulation and oxygenation may be adequately provided by the filtration system or water movement from other sources, such as powerheads or wave generators. The aquarium's and its inhabitants' unique needs determine if an air pump is necessary.

Figure 3.5 Air Pump

Table 3.4 Technical Specification

| | |
|---|---|
| Model | 1100L/H Submersible Air Pump |
| Input voltage | 12V |
| Power | 1W |
| Weight | 0.5 kg |
| Performance | Automatic |



### 3.4.5 Arduino Uno R3

ATmega328P is the microcontroller used in Arduino Uno. It features 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB port, a power jack, an ICSP header and a reset button. It includes everything necessary to support the microcontroller, simply connect it to a computer through USB or power it with an AC-to-DC adapter or battery to get started. The name "Uno" was chosen to commemorate the debut of Arduino Software (IDE) version 1.0. The Uno board and version 1.0 of the Arduino Software (IDE) were the original versions of Arduino, which newer version have since replaced. The Uno board is the first of a series of USB Arduino boards and the reference model for the Arduino platform. The Arduino UNO R3 are shown in Figure 3.6 and the technical specification for the board are shown in Table 3.5.


Figure 3.6 Arduino Uno R3

Table 3.5 Technical Specification

| **Microcontroller** | **ATmega328P** |
|---|---|
| Operating Voltage | 5V |
| Input Voltage (Recommended) | 7-12V |
| Input Voltage (Limit) | 6-20V |
| Digital I/O Pins | 14 (of which 6 provide PWM output) |
| Pwm Digital I/O Pins | 6 |
| Analog Input Pins | 6 |
| Dc Current Per I/O Pin | 20mA |
| Dc Current For 3.3v Pin | 50mA |
| Flash Memory | 3 KB (ATmega328P) of which 0.5 KB used by bootloader |
| SRAM | 2 KB (ATmega328P) |
| Eeprom | 1 KB (ATmega328P) |

The adaptable integrated solution with an operating voltage of 5V and a suggested input voltage range of 7V to 12V, with a limit of 6V to 20V, is displayed in the above table. It has versatile interface capabilities with 14 digital I/O pins, including 6 with PWM output and 6 analogue input pins. A DC current of 20 mA per I/O pin and 50 mA for the 3.3V pin may be supported by the microcontroller. With its 3 KB of flash memory (ATmega328P), 2 KB of SRAM (ATmega328P), and 1 KB of EEPROM (ATmega328P), it provides several embedded applications with both processing power and memory resources. This ATmega328P microcontroller is a versatile and feature-rich platform that may be used for many different electrical systems and applications.

### 3.4.6 Relay Module

Relay modules as shown in figure below are an essential part of the electronics world. They are multipurpose switches that allow low-power microcontrollers or digital circuits to operate high-power devices. Relays are essentially electromechanical devices that mechanically switch electrical circuits by activating an electromagnetic coil. The relay module improves and streamlines the interface between high-power appliances or equipment and low-voltage electronic systems, such microcontrollers or Arduino boards. This gives a microcontroller the ability to command and isolate power circuits, which facilitates smooth automation and control in a variety of applications, including as robots, industrial operations, and home automation. The relay module adds a layer of flexibility to electronic systems and is a vital tool for projects requiring safe and effective management of electrical loads due to its versatility and dependability.




Figure 3.7 Relay Module

### 3.4.7 LDR Sensor Module

One important aspect of many electrical applications is the Light Dependent Resistor (LDR) sensor module as shown in figure below, especially those that need to sense light intensity. The LDR sensor, sometimes referred to as a photoresistor, is a useful tool for developing systems that react to changing lighting conditions since it displays a change in resistance dependent on ambient light levels. The LDR sensor module is a basic component of light detecting technology that is used in security devices, dusk-to-dawn controllers, and automated lighting systems. This module is a crucial component of projects that aim to improve energy efficiency, promote automation, and guarantee optimal performance in response to ambient lighting conditions because of its adaptability and ease of use in sensing light changes.

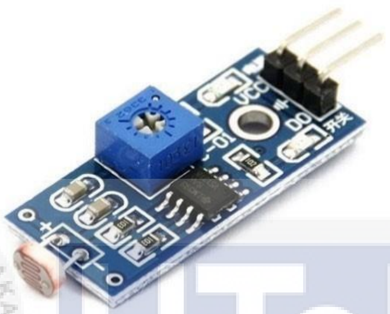


Figure 3.8 LDR Sensor Module

## 3.5 Experimental setup and Data Measurement



The foundation of all scientific studies and research projects is the Experimental Setup and Data Measurement system, which offers a controlled setting for carrying out experiments and collecting accurate data. Several instruments, sensors, and measuring devices are integrated into this painstakingly built system to enable precise data collection and processing. Researchers may control variables, observe events, and gather trustworthy data for well-informed conclusions by using the Experimental Setup and Data Measurement system, whether they are working in physics, chemistry, engineering, or other scientific fields. This approach, which emphasises repeatability and accuracy, is essential to the advancement of science, creativity, and the creation of novel technology in a variety of sectors.

### 3.5.1 Open Circuit Voltage (VOC) and Short Circuit Current (ISC) values

The Experimental Setup, which measures Open Circuit Voltage (OCV) and Short Circuit Current (ISC) using a multimeter and solar panel in figure below, is an important investigation into the performance features of solar photovoltaic systems. This arrangement combines the accuracy of a multimeter with the renewable energy potential of a solar panel to examine important elements impacting power generation. Researchers and amateurs can learn more about the electrical behaviour of solar cells and get a greater comprehension of their functionality and efficiency by using this experimental setup. This practical technique bridges the gap between theoretical knowledge and real-world application in the field of solar energy research and technology, while also yielding insightful data on OCV and ISC.



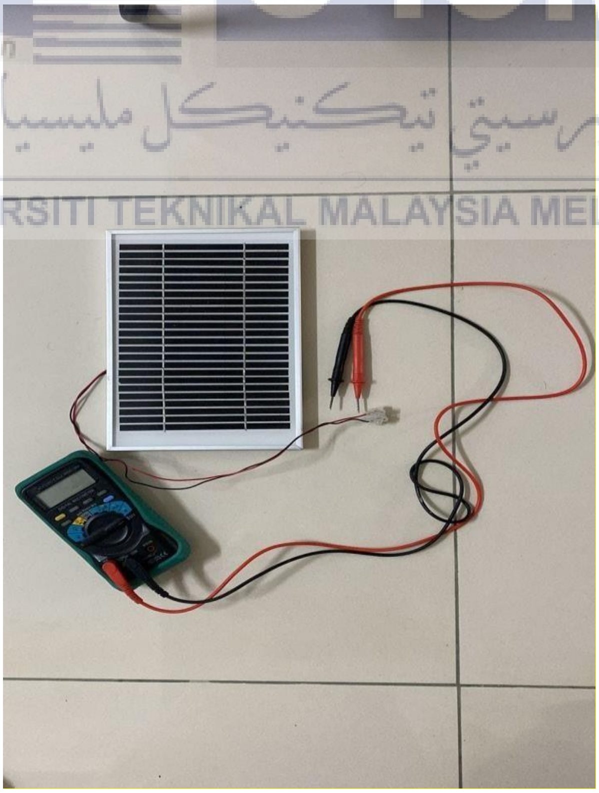


Figure 3.9 Hardware Setup

### 3.5.2 Arduino IDE

A vital resource for makers, amateurs, and experts exploring the realm of embedded electronics and microcontroller programming is the Arduino Integrated Development Environment (IDE). An easy-to-use platform for creating, developing, and uploading code to Arduino microcontroller boards is offered by this open-source software, which was developed by the Arduino team. Particularly well-known for being user-friendly for novices and providing robust functionality for more experienced users is the Arduino IDE. Its user-friendly interface allows it to handle both C and C++ programming languages. It also offers a large library of pre-written code, or sketches, which makes it easier to construct a variety of projects. From simple blinking LED projects to complex Internet of Things applications, the Arduino IDE has become the go-to environment for realising a wide range of electronic breakthroughs thanks to its real-time feedback through the Serial Monitor and easy connection with a number of Arduino-compatible boards. Figure below show the picture of the software.



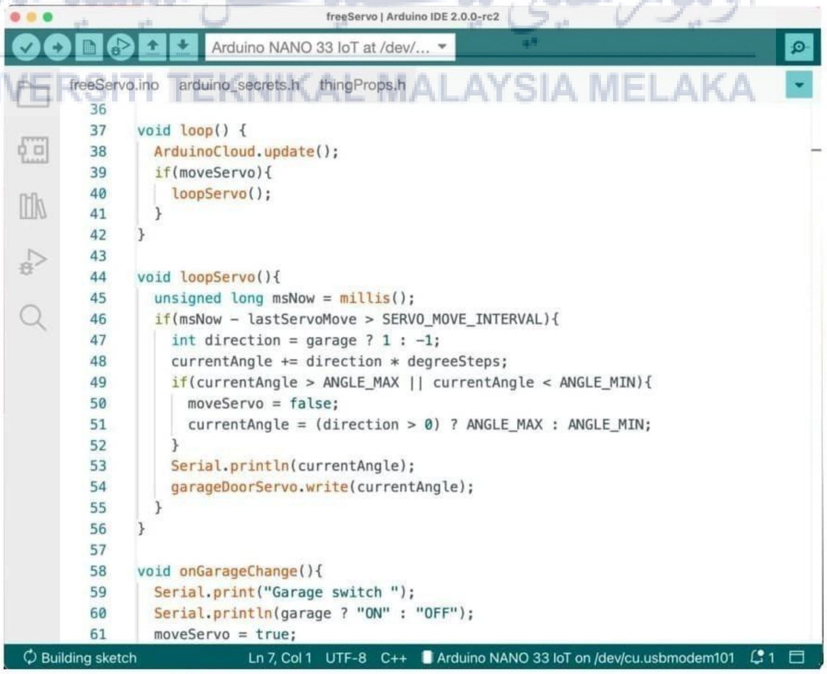



Figure 3.10 Arduino IDE

# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

In the result and discussion part, the effectiveness and performance of the solar charge monitoring system for AC applications are assessed and analysed. Among the parts that are integrated into this system are a solar charge controller and an inverter. Fuse blocks were utilised to prevent overcharging or undercharging of the battery, and the operation of the solar charge controller was evaluated for accuracy and dependability. Additionally, the feedback on the charge solar controller will come from the energy source, such as the voltage and current that pass through the inverter.

## 4.2 Results and Analysis



The Arduino Uno enables accurate monitoring of solar charging parameters and assesses efficiency in different climatic situations when combined with current and voltage sensors. The ESP8266 Wi-Fi module enables smooth wireless connectivity, enabling real-time data transfer to the Blynk application for control and monitoring from a distance. The system's ability to collect solar energy, maintain dependable charging performance, and maximise energy use for lighting applications is demonstrated by the results.

Figure 4.0 Project Hardware

### 4.2.1 The Open Circuit Voltage (VOC) and Short Current Circuit (ISC) results and graph

The Open Circuit Voltage (VOC), Short Circuit Current (ISC) and Power values of the solar panel for a single data collection day are displayed in the table and figure below.

Table 4.1 Data collected for VOC and ISC value

| TIME | VOLTAGE (V) | CURRENT (A) | POWER (W) |
|---|---|---|---|
| 8.00 a.m | 13.16 | 0.04 | 0.53 |
| 10.00 a.m | 13.17 | 0.05 | 0.66 |
| 12.00 p.m | 13.73 | 0.26 | 3.57 |
| 1.00 p.m | 14.02 | 0.33 | 4.63 |
| 2.00 p.m | 13.97 | 0.42 | 5.87 |
| 3.00 p.m | 13.82 | 0.39 | 5.39 |
| 4.00 p.m | 13.98 | 0.18 | 2.52 |
| 5.00 p.m | 13.42 | 0.08 | 1.07 |
| 6.00 p.m | 13.08 | 0.05 | 0.65 |

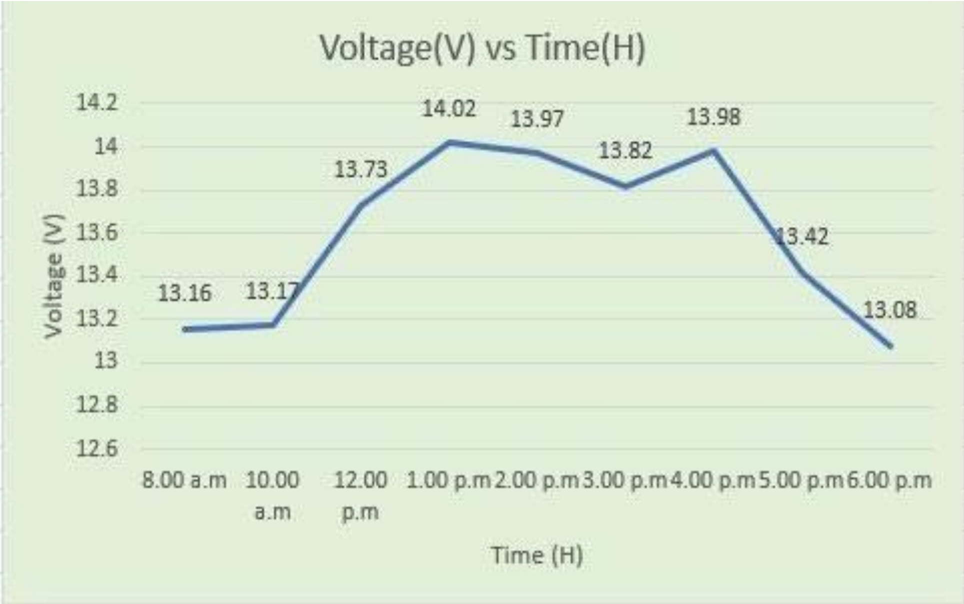



Figure 4.1 Voltage vs Time

The voltage variation over a certain period is succinctly shown in the preceding graph in Figure 4.2 Throughout the day, the voltage is mostly constant, ranging from 13.08 V to 14.02 V.

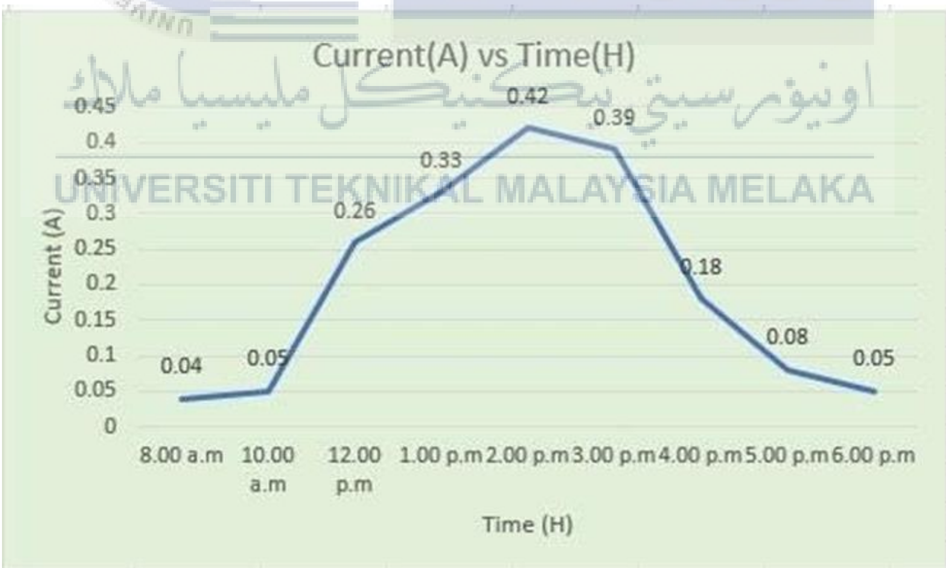



Figure 4.2 Current vs Time

The horizontal axis of the current–time graph above shows the values of time, while the vertical axis shows values of current.


Figure 4.3 Power vs Time

A power vs. time graph shows the variation in a system's or device's power usage over a certain time span. Time is represented by the horizontal axis in hours, while power is represented by the vertical axis in watts.

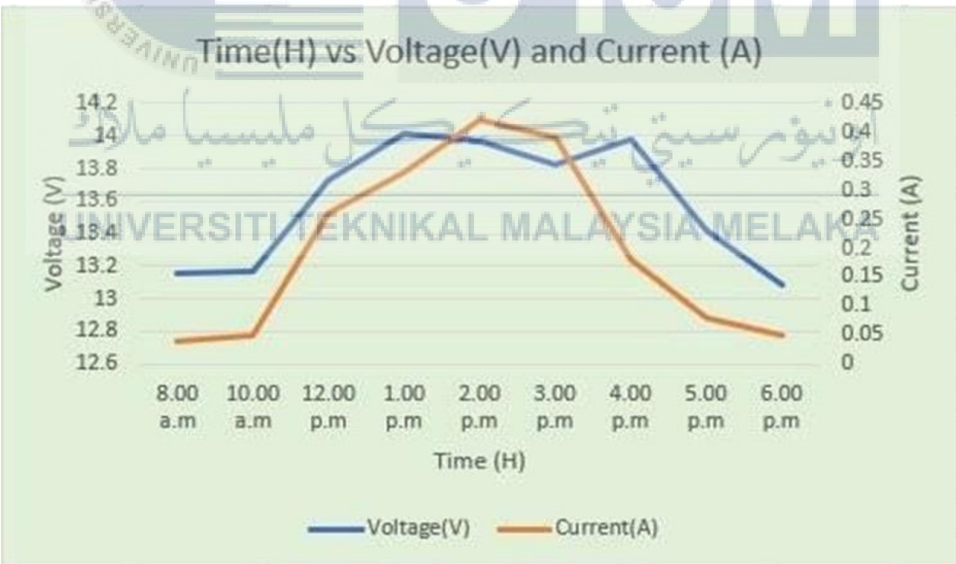





Figure 4.4 Time vs Voltage and Current

The voltage and current changes over a certain time period are shown on a time vs. voltage and current graph. The vertical axes display voltage and current, while the horizontal axis represents time. This graph, which shows variations, maximum values, and general trends in voltage and current over time, sheds light on the dynamic behaviour of an electrical system.

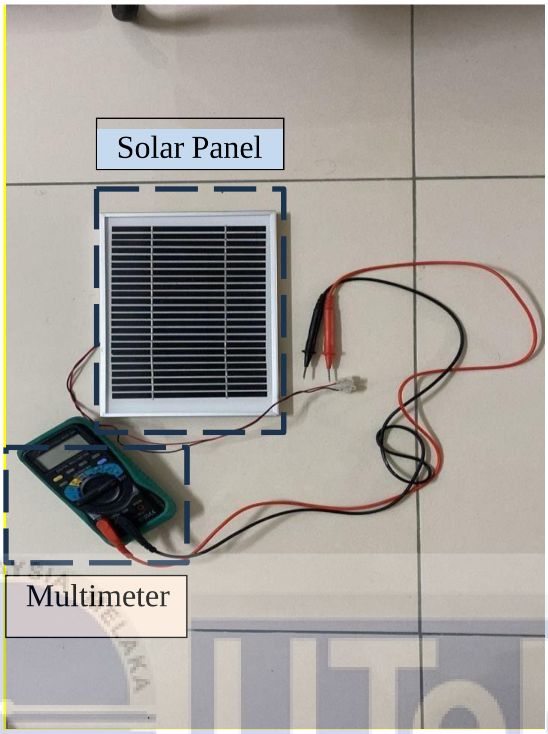



Figure 4.5 Data measured setup



### 4.2.2 Collecting data over three days across the entire system

Table and figure below show that the system was tested and measured throughout a period of three days, from 8 a.m. to 6 p.m.

Table 4.2 Data Collection for Day 1

| TIME | VOLTAGE (V) | CURRENT (A) | POWER (W) |
|---|---|---|---|
| 8.00 a.m | 12.10 | 0.02 | 0.24 |
| 10.00 a.m | 12.70 | 0.11 | 1.40 |
| 12.00 p.m | 12.68 | 0.15 | 1.90 |
| 2.00 p.m | 12.92 | 0.12 | 1.55 |
| 4.00 p.m | 12.78 | 0.02 | 0.26 |
| 6.00 p.m | 12.30 | 0.01 | 0.12 |


Figure 4.6 Voltage vs Time

Based on the data presented, a voltage vs. time graph shows a rather stable electrical system with slight voltage swings. Throughout the day, the voltage stays constant, ranging from 12.10 V to 12.92 V. The data exhibits a discernible maximum around 12:00 p.m., which is probably indicative of heightened power use, followed by a decline at 4:00 p.m. Overall, the graph shows a steady and constant voltage profile that provides information on the behaviour of the system over time.



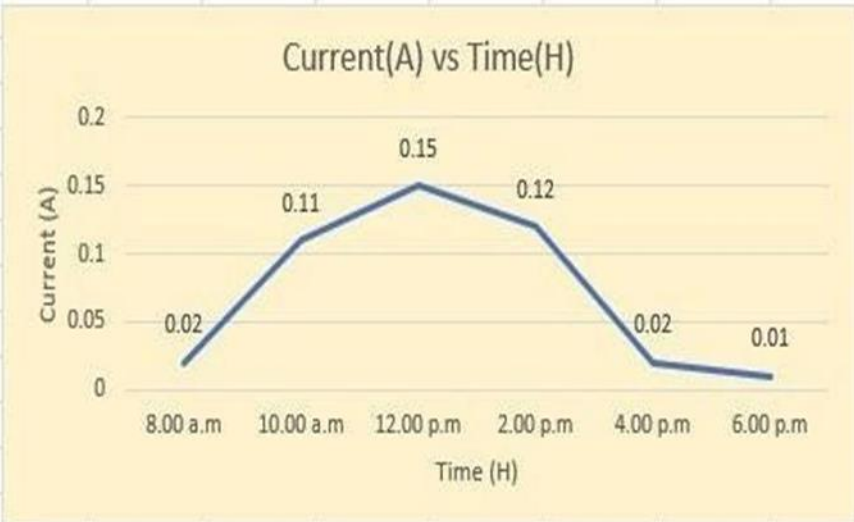



Figure 4.7 Current vs Time

Based on the above data, a current vs. time graph shows variations in current throughout the day. The current values fluctuate and peak at 0.15 A at 12:00 p.m., suggesting that noon is when there is a greater demand for electricity. The graph indicates a decrease in current at 6:00 p.m., indicating a decrease in energy use throughout the evening. In general, the current vs. time graph helps to analyse patterns of energy use throughout the day by offering insights into dynamic variations in electrical current.

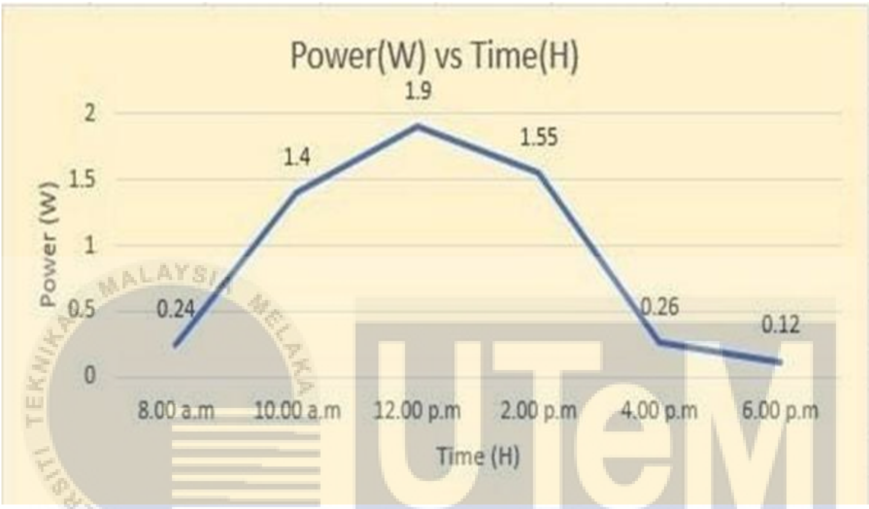



Figure 4.8 Power vs Time

The data supplied was used to create a power vs. time graph that shows daily fluctuations in power use. The power values exhibit a peak-trough pattern, with the maximum consumption of 1.55 W around 2:00 p.m. and the lowest consumption in the early morning and evening. This graph gives an overview of the dynamic power use trends and sheds light on times throughout the reported time frame when energy demand was higher and lower.

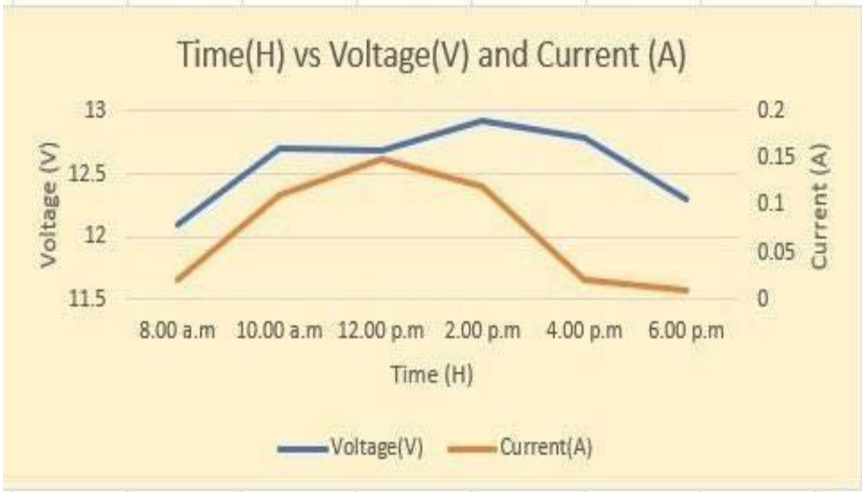



Figure 4.9 Time vs Voltage and Current

A voltage and current vs. time graph shows the changes in voltage and current over a certain time interval. The horizontal axis displays time, and the vertical axes display voltage and current. With its displays of voltage and current variations, peak values, and general trends over time, this graph sheds light on the dynamic behaviour of an electrical system.



Table 4.3 Data Collection for Day 2

| TIME | VOLTAGE (V) | CURRENT (A) | POWER (W) |
|---|---|---|---|
| 08:00 | 11.50 | 0.03 | 0.36 |
| 10:00 | 11.80 | 0.07 | 0.87 |
| 12:00 | 12.20 | 0.25 | 3.05 |
| 14:00 | 12.10 | 0.12 | 1.45 |
| 16:00 | 12.00 | 0.04 | 0.48 |
| 18:00 | 10.90 | 0.07 | 0.78 |

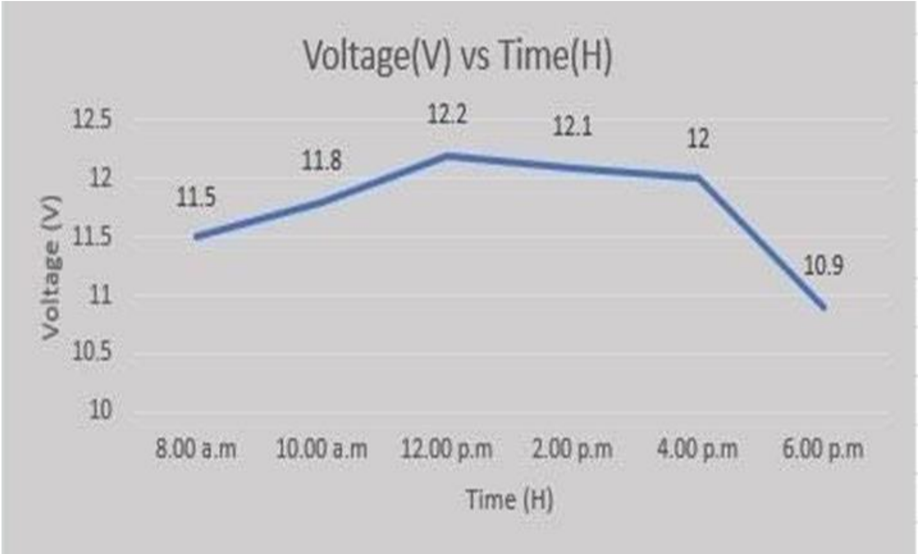



Figure 4.10 Voltage vs Time

Based on the above data, a voltage vs. time graph shows dynamic variations in voltage throughout the day. The voltage rises to a peak of 12.20 V at 12:00 p.m. from 11.50 V at 8:00 a.m., then drops to 10.90 V at 6:00 p.m. The graph, which shows a discernible noon peak and an evening power fall, depicts the shifting electrical circumstances. All in all, it offers a moment in time view of the voltage behaviour of the system.




Figure 4.11 Current vs Time

The current vs. time graph that was created using the provided data shows how the current changes during the course of the day. The current readings exhibit fluctuations, with a high of 0.25 A recorded around 12:00 p.m., suggesting a rise in power use at noon. At 4:00 p.m., the graph also displays a decrease in current (0.04 A). All things considered, the current vs. time graph offers a visual depiction of the system's behaviour over time and sheds light on the dynamic variations in electrical current.


Figure 4.12 Power vs Time

The power consumption of a system or device is shown changing over a given time period in a power vs. time graph. Power is shown in watts on the vertical axis, and time is represented in hours on the horizontal axis.



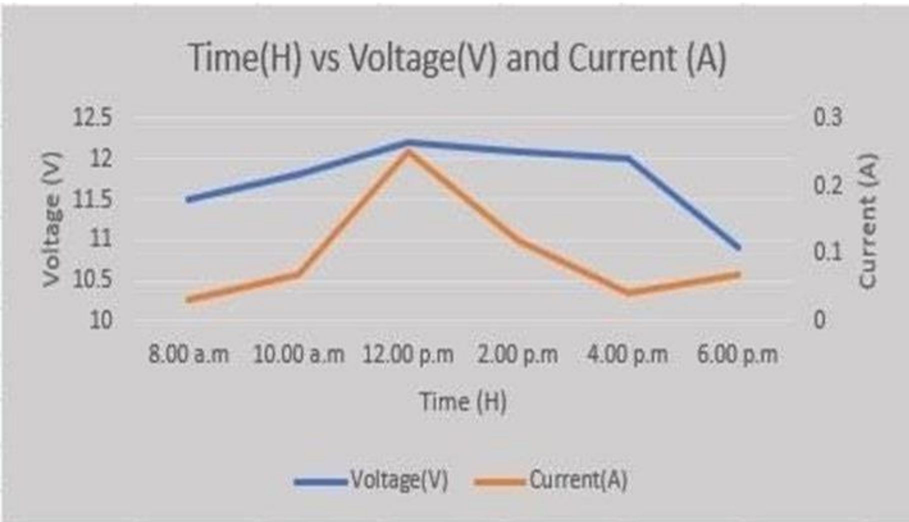



Figure 4.13 Time vs Voltage and Current

Based on the above data, a time versus voltage and current graph shows the dynamic electrical behaviour throughout the day. At eight in the morning, the voltage is 11.50 V. It peaks at 12.20 V at noon and then drops to 10.90 V at six in the evening. Present readings vary, reaching a maximum of 0.25 A at 12:00 p.m. and a minimum of 0.04 A at 4:00 p.m. The graph shows peak times and changes in the electrical system over time, giving a thorough understanding of both voltage and current trends.

Table 4.4 Data Collection for Day 3

| TIME | VOLTAGE (V) | CURRENT (A) | POWER (W) |
|---|---|---|---|
| 08:00 | 11.90 | 0.05 | 0.60 |
| 10:00 | 12.00 | 0.04 | 0.48 |
| 12:00 | 12.30 | 0.12 | 1.48 |
| 14:00 | 12.20 | 0.05 | 0.61 |
| 16:00 | 12.10 | 0.01 | 0.12 |
| 18:00 | 12.10 | 0.02 | 0.24 |




Figure 4.14 Voltage vs Time

Based on the above data, a stable electrical system with few variations is depicted in the voltage vs. time graph. From 11.90 V at 8:00 a.m. until 12.30 V at 12:00 p.m., the voltage is almost steady. It then gradually drops to 12.10 V in the evening. With a possible midday peak around 12:00 p.m., the graph shows a constant voltage profile throughout the day. All in all, it points to a consistent and constant voltage supply within the time frame that was observed.

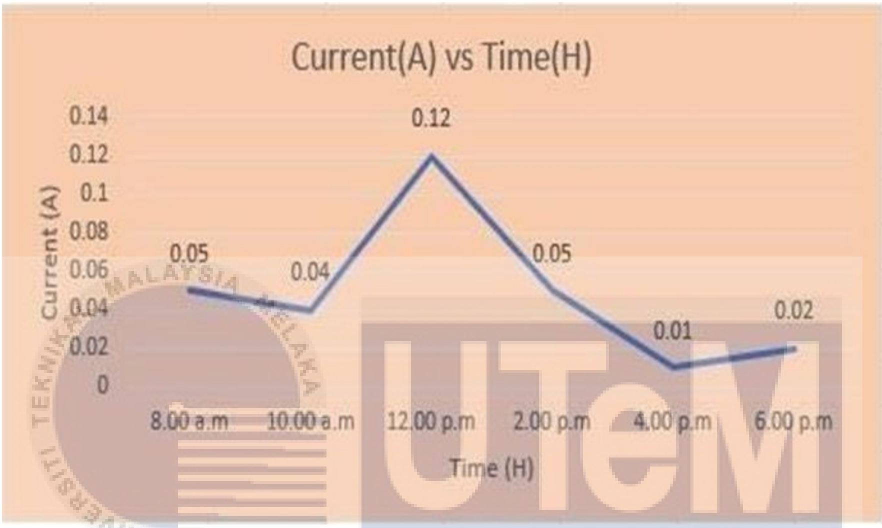



Figure 4.15 Current vs Time



The given data was used to create a current vs. time graph, which displays fluctuations in current throughout the day. The current measurements show a high of 0.12 A at 12:00 p.m. and then normally stay at lower levels at other times. A rather constant current profile across the observed time period is suggested by the graph's low oscillations. With a possible noon peak in electricity consumption, it offers insights into the present dynamics overall.


Figure 4.16 Power vs Time

A power vs. time graph shows the variation in a system's or device's power usage over a certain time frame. Time is shown on the horizontal axis in hours, while power is shown on the vertical axis in watts.

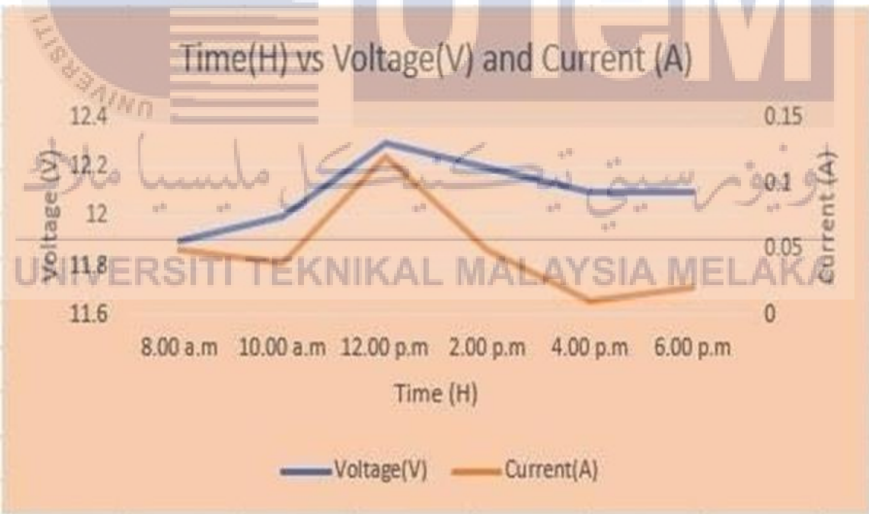



Figure 4.17 Time vs Voltage and Current

### 4.2.3 Data on a battery's State of Charge (SOC)

The "State Of Charge" (SOC) of a battery shows the proportion of energy left in the battery while no load is connected to it. The data obtained from the display of the solar charge controller is displayed in the table below.

Table 4.5 State of Charge at no load

| **State of Charge (%)** | **Open Circuit Voltage (OCV)** | |
|---|---|---|
| | **12V (Lead Acid)** | **9V (GP Supercell)** |
| 100 | 12.93 | 9.48 |
| 75 | 12.47 | 9.22 |
| 50 | 12.20 | 9.07 |
| 25 | 11.97 | 8.83 |
| 0 | 11.52 | 8.58 |


Figure 4.18 Data obtained for the OCV value

The methods for gathering data for a battery's state of charge based on voltage parameter and an indicator within the solar charge controller are depicted in the above image.

### 4.2.4 Functionality test results

Through the complete inspection of the system's overall performance, these tests seek to guarantee the correctness and appropriate operation of each component inside the system.

Table 4.6 Functionality test

| Test Step | Description | Expected Result | Actual Result | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Solar Charge Controller | Simulate fully charged battery and confirm the system cuts off charging | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| 2 | Voltage and Current Sensor | Check if the system accurately measures charging / discharging current and voltage from the supply | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# CHAPTER 5

# CONCLUSION

## 5.1 Conclusion

Finally, using a smart air pump powered by solar energy in aquariums offers a creative and environmentally beneficial way to improve the performance and effectiveness of aquarium systems while utilising less energy. The solar-powered air pump reduces reliance on fossil fuels and reduces overall energy usage by replacing traditional electrical sources with solar energy.

The capabilities of the air pump are further improved by the incorporation of smart technology. The smart air pump can regulate airflow, alter oxygen levels, and monitor water parameters in real-time through intelligent control systems, ensuring the best possible conditions for aquatic life. By adjusting the operation of the air pump to actual needs, this intelligent feature not only encourages a healthier and more vibrant aquarium ecology, but also maximises energy efficiency.

Aquarists can benefit from increased oxygenation, water movement, and aesthetic appeal in their aquariums while actively contributing to resource conservation by selecting a solar-powered smart air pump. This novel approach demonstrates how technology and sustainability may coexist peacefully while providing an appealing substitute for energy-conscious aquarium hobbyists looking for effective and responsible use of energy.

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# APPENDICES

## APPENDIX A Coding

```
// Define pin numbers
const int SocketRelay = 9;
const int SolarRelay = 8;// LED connected to digital pin 8
const int ldrPin = 2;      // LDR connected to analog pin A0

void setup()
{
  pinMode(SocketRelay, OUTPUT); // Set the RELAY FOR SOCKET pin as output
  pinMode(SolarRelay, OUTPUT); // Set the RELAY FOR SOLAR pin as output

}

void loop()
{
  int ldrValue = digitalRead(ldrPin);  // Read the value from the LDR
             // Print the value to the serial monitor

  // Assuming a lower value means more light
  if (ldrValue == LOW)
  {
    digitalWrite(SocketRelay, HIGH);
    digitalWrite(SolarRelay, HIGH);// Switch Supply To Socket
  }
  else
  {
    digitalWrite(SocketRelay, LOW);
    digitalWrite(SolarRelay, LOW);// Switch Supply To Solar
  }

  delay(500);  // Wait for half a second
}
```

APPENDIX B Gantt Chart

| Gant Chart for PSM 1 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Task project | Plan/Actual | Week | | | | | | | | | | | | | |
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | Registration of PSM title | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 2 | Briefing of PSM and project explanation by supervisor | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 3 | Drafting and writing of Chapter 2 Literature Review | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 4 | Presentation of draft Chapter 2 with supervisor | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 5 | Submission of Chapter 2 | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 6 | Briefing of Chapter 3 with supervisor | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 7 | Writing of Chapter 3 | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 8 | Submission of Chapter 3 | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 9 | Discussion of Chapter 1 with supervisor | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 10 | Draft and writing of Chapter 1 | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 11 | Submission of Chapter 1 | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Writing Chapter 4 expected result and conclusion, abstract | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 13 | Submission of report PSM 1 first draft | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 14 | Last correction of the report | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 15 | Submission of report to supervisor and panels | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |
| 16 | Preparation slide and presentation PSM 1 | Plan | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | |

APPENDIX C Turnitin Report

PSM JUN

ORIGINALITY REPORT

| 28% | 13% | 4% | 22% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

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| 4 | www.ijrer-net.ijrer.org | Internet Source | 2% |
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