Faculty of Electrical Technology and Engineering

DEVELOPMENT OF SOLAR POWERED HOME ENERGY MONITORING AND ALERT SYSTEM WITH IOT CONTROL

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Bachelor of Electrical Engineering Technology with Honours

2024

DEVELOPMENT OF SOLAR POWERED HOME ENERGY MONITORING AND ALERT SYSTEM WITH IOT CONTROL

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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

2025

DECLARATION

I declare that this project report entitled "Development of Solar Powered Home Energy Monitoring And Alert System With IOT Control" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I approve that this Bachelor Degree Project 1 (PSM 2) report entitled “Development of Solar Powered Home Energy Monitoring And Alert System With IOT Control” is sufficient for submission.

Signature :

Supervisor Name :

Date : 2 JANUARY 2025

APPROVAL

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

Signature :
....

Supervisor Name :
....

Date : 2 JANUARY 2025
....

Signature :
....

Co-Supervisor :

Name (if any)
....

Date :
....

DEDICATION

This report is dedicated to my loving parents, whose unwavering support, sacrifices, and encouragement have been my guiding light throughout my academic journey. Their belief in my abilities has inspired me to strive for excellence.

To my advisor and professors, who have shared their invaluable knowledge and wisdom, shaping my understanding of the world of electrical engineering.

Lastly, thanks to the Almighty God for guidance, energy, mind power, security, skills and giving us a safe life. Thank you all for all these and not forget, to my friends and peers, whose companionship and collaboration have made this journey memorable and fulfilling.

ABSTRACT

The increase of gas emission leading to the global warming and resulted to extreme climate change produced by coal to generate electricity. Nowadays, traditional Home Energy Monitoring system uses electricity from the power grid and is not applicable in rural area where there is no electricity supply. Additionally, the control and alert system that prevent accidents from happening is not equipped in the existing system. To overcome this issue, the project introduces the development of solar energy for home appliances power monitoring and control system in order to minimize the gas emission issue; that also integrates the IoT system to monitor and also able to control the load consumption of the home appliances. The control, alert and monitoring part in this system uses esp32 microcontroller and IoT system to firstly demonstrate the solar battery management system by displaying the simultaneous battery voltage level with the use of a voltage sensor. Besides that, the IoT system is designed to display an alert system that alerts the users whenever there is an over-use of some electrical appliances to avoid accidents from happening, especially when users are away from home. Furthermore, the IoT is interfaced with control switches so that users can also control the appliances' load usage based on the users' requirement. The installation of hardware circuit and ideal system is assembled using electronic components to validate the system on the energy consumption and the solar system workability. The project also has a motor driver to control the speed of motor. The data analysis on the power usage and IoT system test concluded that by using this system, users can control and monitor their home appliances usage remotely and can minimise accidents and environmental damage with the system.

ABSTRAK

Peningkatan pelepasan gas yang membawa kepada pemanasan global dan mengakibatkan perubahan iklim melampau yang dihasilkan oleh arang batu untuk menjana elektrik. Pada masa kini, sistem Pemantauan Tenaga untuk rumah tradisional menggunakan elektrik daripada grid kuasa dan tidak boleh digunakan di kawasan luar bandar yang tiada bekalan elektrik. Selain itu, sistem kawalan dan amaran yang menghalang kemalangan daripada berlaku tidak dilengkapi dalam sistem sedia ada. Bagi mengatasi isu ini, projek ini memperkenalkan pembangunan tenaga suria untuk sistem pemantauan dan kawalan kuasa perkakas rumah bagi meminimumkan isu pelepasan gas; yang juga menyepadukan sistem IoT untuk memantau dan juga dapat mengawal penggunaan perkakas rumah. Bahagian kawalan, amaran dan pemantauan dalam sistem ini menggunakan mikropengawal esp32 dan sistem IoT untuk mula-mula menunjukkan sistem pengurusan bateri solar dengan memaparkan paras voltan bateri serentak dengan penggunaan penderia voltan. Selain itu, sistem IoT direka untuk memaparkan sistem amaran yang memberi amaran kepada pengguna apabila terdapat penggunaan berlebihan untuk beberapa peralatan elektrik bagi mengelakkan kemalangan daripada berlaku, terutamanya apabila pengguna berada di luar rumah. Tambahan pula, IoT disambungkan dengan suis kawalan supaya pengguna juga boleh mengawal penggunaan beban perkakas berdasarkan keperluan pengguna. Pemasangan litar perkakasan dan sistem yang ideal dipasang menggunakan komponen elektronik untuk mengesahkan sistem mengenai penggunaan tenaga dan kebolehkerjaan sistem suria. Projek ini juga mempunyai pemandu motor untuk mengawal kelajuan motor. Analisis data mengenai penggunaan kuasa dan ujian sistem IoT menyimpulkan bahawa dengan menggunakan sistem ini, pengguna boleh mengawal dan memantau penggunaan peralatan rumah mereka dari jauh dan boleh meminimumkan kemalangan dan kerosakan alam sekitar dengan sistem suria.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to everyone who contributed to the completion of this report.

First and foremost, I am deeply thankful to my project advisor, Puan Intan Mastura Saadon, for her guidance, patience, and constructive feedback. Her expertise has been instrumental in the successful execution of this work.

I also extend my thanks to the faculty and staff of the Department of Electrical Engineering at Universiti Teknikal Malaysia Melaka (UTeM) for providing a conducive learning environment and resources essential for this project.

A special note of thanks to my family, who have always been my pillar of strength and motivation throughout this endeavor.

Lastly, I am grateful to my friends and colleagues, whose encouragement and valuable insights helped me navigate through challenges and achieve my goals.

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LIST OF ABBREVIATIONS

ADC	-	Analog to Digital converter
PV	-	Photovoltaic
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CHAPTER 1

INTRODUCTION

1.1 Background

Solar energy has emerged as a crucial RE in the global pursuit of sustainable and clean power sources. Solar energy signifies a shift towards harnessing the unlimited and boundless energy radiated by the sun to meet ever-growing energy demands while reducing reliance on finite fossil fuels.

Solar energy can be harvested in two ways first, solar energy is captured by photovoltaic (PV) cells, which directly convert sunlight into electrical current and second by solar thermal systems[1],which use solar radiation to heat a fluid, which in turn powers a turbine to produce electricity. Both ways provide reliable and flexible systems for a variety of uses, from large solar farms to residential rooftops.

In order to handle the inconsistent nature of renewable energy sources like solar, energy storage batteries are essential, by storing onto extra energy produced at peak production times and releasing it during times of high demand or when electricity is not being produced by renewable sources.

Energy storage batteries are mostly used in combination with solar photovoltaic systems. Combining batteries and solar panels allows for the storage of extra energy produced during the day for use at night or during times when there is little sunshine. This allows for Continuous usage of solar power and lessens depend on the grid.

Passive systems with programmed charging profiles and settings are used in the conventional method of charging solar batteries. These systems are somewhat successful, but they are not flexible, adaptive, or real-time responsive to changing energy demands and environmental circumstances. On the other hand, Internet of Things (IoT)-enabled solar battery charging systems make use of networked sensors, actuators, and communication technologies to allow for remote charging process monitoring, control, and improvement.

1.2 Problem Statement

As much as 85% of the power generated today is thought to come from the burning of fossil fuels, with the remaining 15% coming from renewable energy sources. Because of this, the government intends to lessen the environmental impact by increasing and supporting the widespread usage of renewable energy.Since it affordable and clean energy, it follows a Sustainable Development Goal (SDG) 7 which utilize solar panels to generate renewable energy, reducing dependency on non-renewable sources. Furthermore, it also sustainable and contribute to the communities which follows Sustainable Development Goal (SDG) 11 in enable smart home technologies that monitor and manage energy use, contributing to the development of sustainable and resilient urban living spaces. In order to assist the government's efforts to reduce global warming now, the usage of solar energy will rise from this point on. Furthermore, in recent years, home energy monitoring system has been developed and studied. However, most of the system are using power source from the power grid. As a result, the system is not able to be used at the rural areas with no electricity supply. Hence, this project proposes the use of solar power as the power supply for the home energy monitoring system, so that is can be applied in all areas including rural areas, and it can also help the planning sector when designing a home's energy-efficient features.

Conventional Home Energy Monitoring systems enable users to monitor the usage of electricity being used. However, the existing systems are lack of alert and control system, which are also the important elements that should be included in the systems. The critical aspect related to the biggest hazards that can result in loss of property, injuries, and fatalities is fire as shown in Figure 1-1.

Elektrik penyumbang utama kebakaran

Bomba rekodkan hampir 60 peratus kes kebakaran pada musim perayaan

PUTRAJAYA

Hampir 60 peratus kebakaran kediaman yang berlaku pada musim perayaan Hari Raya Aidilfitri di seluruh negara berpunca daripada elektrik.

Timbalan Ketua Pengarah (Operasi) Jabatan Bomba dan Penyelamat Malaysia (JBPM), Datuk Amer Yusof berkata, ...

... lu banyak alat pada satu soket, wayar rosak atau terpintal dan kecuaian mengendalikan perkakasan elektrik seperti seterika.

"Sentiasa peka terhadap barangan elektrik yang digunakan seperti peralatan yang berbau, bercap atau terlampau panas.

"Letakkan alat pemanas seperti seterika pada jarak satu meter daripada sebarang benda mudah terbakar sebab kadang-kadang kita lupa tutup dan apabila ia terlalu panas boleh me...

AMER

... sekadar menutup suis tetapi kadang-kadang walaupun suis itu tutup sepenuhnya, arus elektrik masih mengalir.

"Sebelum balik kampung beritahu jiran untuk tengok-tengokkan rumah supaya kalau berlaku kebakaran atau perkara tidak diingini, mereka boleh hubungi bomba dengan segera," katanya.

Selain elektrik, Amer berkata, hampir 20 peratus kebakaran musim perayaan berlaku akibat peralatan gas kerana kecuaian semasa memasak dengan 116 ...

... an termasuklah penggunaan pelita atau lilin, bunga api atau mercun dan bara api yang tidak dipadamkan sepenuhnya.

Justeru, beliau menggalakkan supaya setiap rumah mempunyai sekurang-kurangnya satu alat pemadam kebakaran yang boleh didapati dengan harga antara RM120 hingga RM130 bagi seunit sembilan kilogram.

"Dari segi peraturan memang tidak diwajibkan, tetapi ia merupakan satu alat yang sangat berkesan untuk padam kebakaran. Bagaimanapun, kesedaran dalam kalangan masyarakat masih lagi rendah," katanya.

Dalam pada itu, Amer ber...

Figure 1-1 : Newspapers related to house fires

One of the main factors that could cause fire is carelessness while using electrical appliances, including air conditioners, heaters, irons, and other kitchenware. Over-use of electrical appliances unnecassarily could also cause an increase in electricity bills, that be a waste of electrical energy and cost. Besides that, the existing system does not have a battery management system that shows the simultaneous battery level for the users to monitor. This is crucial because the system is dependent on the battery to operate and battery voltage needs to be at an optimum level at all times. As of right now, there is no technology that can assist users to constantly be reminded of the load consumption especially to prevent incidents like a burning house. Hence it is crucial to have a Home Energy Monitoring system that not only can monitor the energy, but also can alert and control the usage of electrical appliances.

1.3 Project Objectives

1. To determine the solar system sizing and battery capacity of a home energy monitoring system through calculation.

2. To design a battery monitoring system with control and alert system for home energy usage by interfacing esp32 to IoT control.

3. To analyze the home energy monitoring system reliability in terms of controlling, alert, monitoring and state of battery.

1.4 Scope of Project

1. To achieve the objective of solar system sizing, the calculation is simulated using PVsyst system according to power rating (kW) of the selected appliances that are normally used in domestic. From this, the solar panel rating, battery capacity and system circuit is designed and developed.
2. Secondly, to achieve the next objective, the IoT and esp32 is used to integrate data of the battery voltage using voltage sensor for the monitoring part. The control and alert part of the system manipulates a switch, relay and timer to be interfaced with IoT and esp32. The IoT system is being developed using IoT Blynk software.
3. For the third objective, the analysis will include the battery state of voltage, during charging and discharging for various load setup. The data is collected for 3 days from 8.00 am to 5.00 pm. The IoT functionality is being tested and the IoT interfacing is shown in the results.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The exploration of solar powered led using IOT control has garnered significant attention in recent years, reflecting its growing importance in reducing global warming. This literature review aims to synthesize existing research, identify key themes, and highlight gaps in the current understanding of solar powered system. By examining a broad spectrum of studies, this review provides a comprehensive overview of the methodologies, findings, and theoretical that have shaped the discourse around solar powered using IoT also a research about solar system design and energy storage.

2.2 Renewable Energy

Technology has improved to the point that renewable energy systems have the potential to displace traditional fossil fuel energy systems, which emit greenhouse gases. However, there are drawbacks to producing energy from renewable sources, like poor power quality. Because renewable energy sources are erratic in nature, for example, solar PV's fluctuating irradiance and wind energy's wind speed in a remote area. It may cause voltage changes on the source side and produce harmonic distortion as a result of the inverter switching process.[2]

2.2.1 Solar Energy

Solar energy is limitless and abundant. Unlike finite fossil fuels, solar energy will always be available as long as the sun remains. Solar energy is a sustainable energy source because it doesn't harm the environment over time or deplete natural resources.

Domestic house nowdays have many electrical device such as hot water, air conditioning and heating account also it for the majority of a building's total energy consumption. Solar energy is a simple source of this thermal energy.[3] In addition to supplying the energy needed for human production and survival, clean energy systems can also successfully lower environmental pollutants.

Domestic hot water heating is the typical use for the solar combination system. Furthermore, a dynamic simulation for generating space heating and solar hot water in a solar combined system can benefit from data on household HWH usage.[4]

2.2.2 Wind Energy

Wind energy is one of the renewable energy source in earth, which is produced by harnessing the kinetic energy of the wind to produce electricity or mechanical power. Usually, wind turbines have big blades that harness wind movement and power a generator to create electricity. Two types of applications are possible which are offshore wind turbines and onshore wind turbines. The most prevalent kind of wind turbines are onshore ones, which are situated on land. In the meantime, Offshore wind turbines benefit from stronger and more regular winds since they are installed in bodies of water, typically on the continental shelf.

Turkey has looked into the production of electricity using wind energy. The data set for electrical energy production (GWh) covering the years 2010–2019 was utilised. These data have been used to assess trend analysis of electrical energy generation (using three distinct models). The linear, s-curve, and quadratic trend models. The model with the lowest MAPE, MAD, and MSD value result was selected. Ultimately, it was decided that the quadratic trend model is the best fit for producing electrical energy.[5]

In order to enhance the share of renewable energy sources in the country's energy supply. The deep research aim to examine the viability and possibility of developing an offshore wind farm inside the Gulf of Aqaba. With the help of the Weibull distribution function, the study of the planned farm shows adequate potential. As a result, the offshore wind speed was 6.47 m/s at 10 m height, whereas the onshore wind speed was 5.28 m/s. This made a proven that installing an offshore wind farm is the best course of action. [6]

2.2.3 Biomass

One type of renewable energy that comes from organic resources like plant and animal matter is biomass energy. This covers a broad range of materials, such as garbage, timber, crops, and even algae. Biomass can be burned directly to produce heat or processed to create biofuels and biogas for use in energy production. Biomass energy can be almost carbon neutral when it is managed responsibly. A balanced carbon cycle is maintained because the amount of carbon dioxide (CO_2) released during burning is about equal to the amount of CO_2 absorbed by the plants throughout their growth. Additionally, it makes use of waste materials that would otherwise be dumped in landfills, which lowers the amount of garbage and the related disposal issues. helps create a circular economy by converting garbage into useful energy.[7], [8]

Physical structure, volatile matter content, fixed carbon, chemical composition, and specific energy content were examined in conjunction with the type of conversion process to determine the relationship between the distribution of reaction products as intermediate materials for the production of biofuels and the process input data.[9]

2.3 Solar PV Panel

Solar photovoltaic (PV) power generation is becoming more popular due to the increased focus on renewable energy sources worldwide. The photovoltaic solar system's power-generating component is the PV panel. It is made up of many solar cells stacked in to raise the voltage and current levels, use series and parallel. Modelling is the first stage in researching a PV panel's characteristics and behaviour in a virtual setting. It is essential to have an accurate model of the PV system, considering its low power density and inefficient nature, in order to correctly analyse its performance. Moreover, the utilisation of a durable and accurate PV panel model facilitates the prediction of power plant energy production in the face of fluctuating environmental parameters.

Solar energy provides civilization with a clean, abundant, and sustainable energy source. Photovoltaic (PV) and concentrated solar power (CSP) systems are two distinct technologies that use solar radiation to create electricity. with the use of PV systems, which give the power network flexibility. The competitive cost of energy is the most significant issue in the energy sector. PV plants have lower energy costs than CSP systems. On the other hand, by optimising the energy generated, CSP systems with thermal energy storage capabilities may be utilised to efficiently overcome the intermittent problems of PV systems in order to balance the supply and demand of electricity within safe levels of reliability[10].

2.4 Types of Solar Photovoltaic (PV)

2.4.1 Monocrystalline Solar PV

Solar energy generating systems are a model example of clean energy, possessing features like low manufacturing costs, high efficiency, and a long development history. Perfect lattice structure, high material purity, low grain boundary energy, weak internal resistance, and high efficiency are among the benefits of monocrystalline silicon cells. In addition, the uniform colour and lack of spots give monocrystalline modules an excellent aesthetic value. With the same installed capacity, a monocrystalline module can generate power more efficiently and reasonably than a rooftop or piece of land.[11]

Monocrystalline silicon panel is the most appropriate option in terms of ratio between produced electricity and occupied area. Monocrystalline silicon panels usually offer better efficiency rates. Monocrystalline solar panels can have an efficiency of 15% to 22%; certain premium types can have an efficiency higher than this. From there, the panel may produce more electricity per square metre, requiring less surface area to produce the same amount of electricity. Because of this, it's especially suited for urban settings, rooftops in homes, and other spaces with limited space.[12]

2.4.2 Polycrystalline Solar PV

Polycrystalline solar panels provide several advantages, especially in warm climates. Despite being less effective than monocrystalline panels, they offer certain benefits that allow them to be used in hot climates. Polycrystalline semiconductors suffer a small decrease in efficiency with increasing temperatures, making them somewhat efficient in warm climes.

Because of the heat that the sun absorbs, solar panels are exposed to high temperatures, which has an adverse effect on their thermal management and causes a delay in the production of power. The solar cells' ability to produce energy is limited by the excessive heat they collect from the sun. Collapsing solar panels is a must, particularly for PV (concentrated photovoltaic) systems.[13]

Because the production method for polycrystalline panels is easier than that of monocrystalline panels, they are typically less expensive to make. They may be a more cost-effective option for large installations in hot areas where the initial investment cost is a major factor due to their cheaper price. Polycrystalline solar panels offer a cost-effective and efficient solution for projects with limited funds in warm climates.

2.4.3 Thin Film

The results of solar research highlight that thin film copper indium gallium selenide technology is the most suitable in terms of monthly average performance ratio. In comparison to other panels, thin film panels have a lower temperature coefficient. The rate at which the panel's efficiency drops as the temperature rises is shown by the temperature coefficient. The temperature coefficient for thin film is typically between -0.2% and -0.4% per degree Celsius, whereas other panels have larger values. It means that thin films are more effective in hotter regions since they lose less efficiency as temperatures rise. This makes them particularly fit for areas with high temperatures. The effectiveness of solar panels in hot areas can be greatly impacted by the surrounding temperature. Because of their reduced sensitivity to temperature changes, thin film panels continue to function well, resulting in a higher average monthly performance ratio [12]. Figure 2-1 shows that the thin film is the highest power generate and suitable for weather at Malaysia.

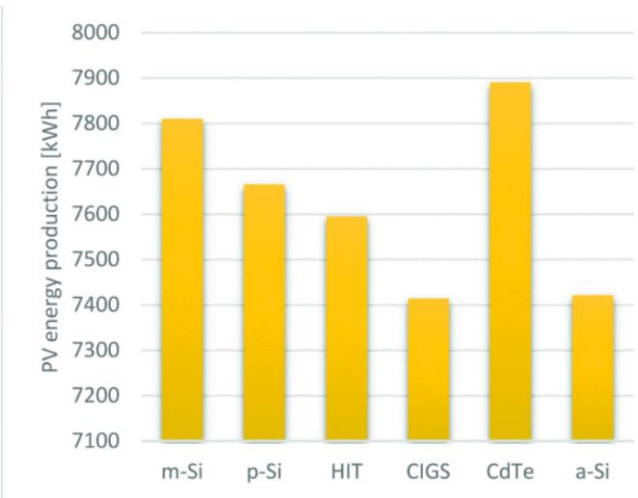

Figure 2-1 : Electric Energy Production

2.5 Battery Management System

Battery is a type of energy storage that uses electrochemical processes to convert chemical energy into electrical energy. A battery is made up of one or more electrochemical cells, each of which has a cathode (positive electrode), an anode (negative electrode), and an electrolyte (which manage the passage of ions between the electrodes to allow current to flow). Battery have 2 type which is non-rechargeable which made with a single use in mind, and discarded as the charge runs out. Zinc-carbon and alkaline batteries are typical examples. Next is rechargeableit may be used repeatedly after being fully charged. Example are lead-acid batteries, nickel-metal hydride (NiMH) batteries, and commonly use lithium-ion batteries.

An energy monitoring system must be effective, particularly in terms of allocating the captured energy as efficiently as possible. Furthermore, an effective system is required since the loads will originate from a variety of systems, including aquaponics, vision, irrigation, and communication systems. As a result, having an intelligent monitoring system that can gather all potential energy demands for each individual system load is important. Accurate energy distribution and monitoring are made achievable by smart farming technology.[14]

With the advancement of renewable energy, batteries are becoming more important in energy storage and electric cars. The battery management system (BMS) frequently comes with real-time battery cell monitoring capabilities to guarantee the battery system's safe operation in use.[15]

2.6 Types of Battery

2.6.1 Lithium-ion (Li-ion) Battery

Lithium ions go through the electrolyte from the cathode to the anode during charging as shown in Figure 2-2. They return to the cathode during discharging, producing an electric current. These days, lithium-ion rechargeable batteries are among the most popular energy-storage batteries found in a variety of portable electronic gadgets. Lithium-ion batteries can be damaged or have their lifespan shortened by careless charging. There are plenty of charging options.[16]

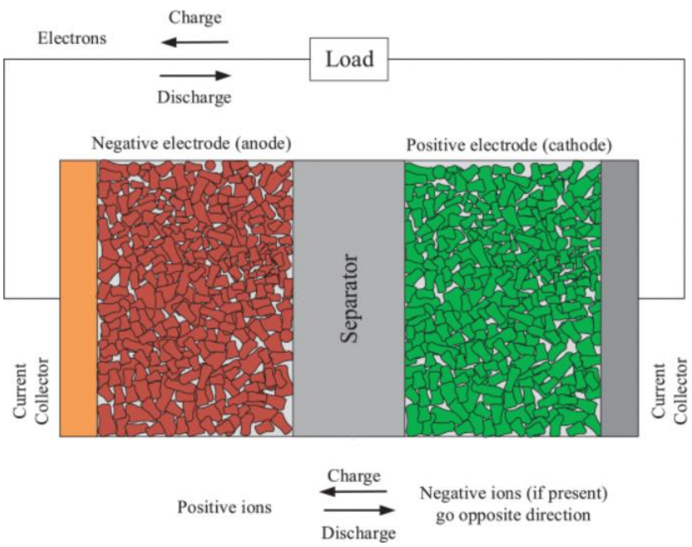

Figure 2-2 : Lithium-ion Battery Diagram

Li-ion batteries are perfect for electric cars and portable electronics because of their high energy density. Additionally, because of their low self-discharge, Li-ion batteries lose less charge when not in use. Furthermore, their lightweight design makes them simpler to install or carry.[16]

2.6.2 Nickel-Metal Hydride (NiMH)

NiMH batteries use nickel oxyhydroxide as the cathode and an alloy that absorbs hydrogen as the anode. Potassium hydroxide is typically used as the electrolyte. Energy is stored and released throughout the charge and discharge processes of nickel oxide hydroxide by reacting with the hydrogen ions in the electrolyte as depicted in Figure 2-3,.

NiMH batteries are among the several battery types used in electric vehicles.This approach is rarely used in real time and is dependent solely on computer software. In order to provide solutions that meet customer expectations, the project's focus is on discussing and determining how to implement the Particle Swarm Optimisation Algorithm on the charger controller in real time.[17]

In addition to having a higher energy density than other batteries, NiMH has fewer harmful elements than certain other batteries. NiMH is also less likely to experience temperature problems and leaks in terms of safety. Every component has a drawback. The NiMH's high self-discharge causes it to run out of power more quickly. In addition, if it is continually recharged after being just partially discharged, it will lose its maximum energy capacity.

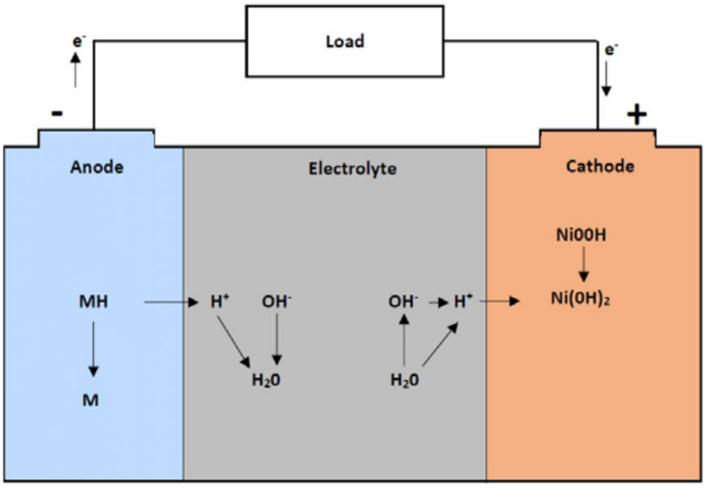

Figure 2-3 : Nickel-Metal (NiMH) Schematics Diagram

2.6.3 Lead-Acid

Lead dioxide serves as the cathode, sponge lead serves as the anode, and sulfuric acid serves as the electrolyte in lead-acid batteries. Lead sulphate and water are produced during discharge when lead dioxide and sulfuric acid combine. The charging process reverses this procedure as shown in Figure 2-4.

Over 95% of backup power supply sales are made up of lead-acid batteries, and the amount of lead-acid batteries that are disposed each year is astounding. One of the most important pieces in the "reduction and resource utilisation" of lead-acid batteries is the research on battery activation technology. Lead-acid battery activation requires charge and discharge technology, and disposed lead-acid batteries have significant consistency issues. Inconsistent charging and draining of a battery will almost certainly prevent the battery from being fully charged.[18]

Lead-acid batteries are cheap to produce and acquire. For more than a century, they have been dependable and strong in several applications. Additionally, they can deliver large surge currents, which qualifies them for uses where a high power-to-weight ratio is necessary. However, Lead-acid batteries are heavy and unwieldy due to their low energy density. When repeatedly charged and discharged, they decompose down more quickly and have a lower cycle life. It has an impact on the environment as well because contains sulfuric acid that corrodes and hazardous, if not disposed of correctly, poses a risk to the environment.

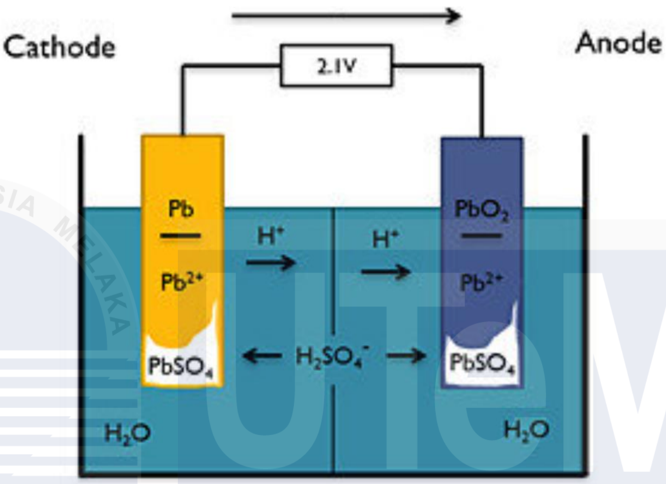

Figure 2-4 : Lead Acid Battery Schematics Diagram

2.7 Stand Alone Power System

An independent energy system that produces, stores, and distributes power independently of the public grid is called a Stand-Alone Power System (SAPS), sometimes referred to as an Off-Grid Power System. In remote places like rural areas, islands, and isolated industrial sites where grid connection is impracticable or impossible, SAPS are frequently employed. They are also becoming more and more common in emergency backup plans and sustainable living.

The benefits of employing real-time simulation technologies in the study and creation of SSC strategies have been shown through case studies. First, better stability in areas with high loads is achieved by optimised SSC techniques, which also lower the danger of voltage instability by using focused management measures. The next benefit is increased reliability thanks to real-time simulations, which offer a strong testing and improvement platform for SSC systems and guarantee dependable operation even in the face of faults and heavy load demands. Additionally, real-world situations involving the successful use of optimised SSC tactics have demonstrated the benefits of these strategies in a variety of settings, including industrial, residential, and distant communities.[19]

In remote and load-intensive areas, Stand-Alone Power Systems serve as crucial for guaranteeing dependable and sustainable energy access. For these systems to be optimised and their stability guaranteed, real-time simulation technology and SSC system integration are needed. The advantages of SAPS, such as energy independence, environmental sustainability, and resilience, make them a useful solution in the current energy landscape, despite obstacles such high initial prices and maintenance requirements. The effectiveness and dependability of SAPS will continue to be improved by additional study and technical developments, making them more useful in a variety of applications.

2.8 Internet of Things (IoT)

A network of physical items containing sensors, software, and other embedded technologies that communicate and share data with other systems and devices over the internet is known as the Internet of Things (IoT). These products might be anything from wearable technology and industrial gear to commonplace home appliances like refrigerators and thermostats.

Task automation makes possible by IoT minimises the need for manual intervention. Additionally, IoT can improve operations in industrial settings by keeping a check on machinery and anticipating maintenance requirements, which lowers downtime and boosts output. Secondly, real-time data from IoT devices can be used to make sensible choices. additionally Analytics for Predictive IoT systems may anticipate future conditions and events by analysing data trends, which enables protective measures. This is very helpful for supply chain management and maintenance. Furthermore, IoT can save operational costs through process optimisation and automation. IoT can also anticipate and avoid equipment breakdowns through preventive maintenance, which lowers the cost of unexpected repairs and downtime.

The world is using Internet of Things (IoT) technologies to monitor and control objects more quickly and accurately from a distance. IoT has many uses in the medical and healthcare sectors, including remote monitoring of vital signs, remote follow-up of chronic illnesses, emergency detection, diagnosis, and prognosis of patient status or disorders. IoT is clearly helpful when it comes to monitoring and providing healthcare for the elderly, which often involves duties that call for a carer or other medical personnel to be there full-time. This survey study aims to clarify the significance and categorization of elderly healthcare systems based on the Internet of Things.[20]

In this study, an Internet of things-based bridge safety monitoring system is designed using wireless networking. The outcome of recent advancements in sensor technology is the automated real-time bridge health monitoring system. Both the initial attempts at repair and the prevention of disasters will benefit from this technology. They are developing an IoT-based bridge safety monitoring system using wireless technology. Wireless sensor nodes can collect information regarding the weight of the Bridge, its vibration, and the water level. This information may also be used for monitoring and surveillance purposes. This study's main objective is to develop a system that can prevent structural mishaps on flyovers and bridges.[21]

This study demonstrates how Internet of Things technology can monitor local weather conditions and then share that data worldwide. Variations in the weather result in heavy rain. Using ultrasonic sensors and LEDs, a flood monitoring system use the NODEMCU ESP8266 to store and retrieve data and notify authorities of rising water levels. Crop growth is affected by soil moisture. Its sensor and microprocessor enhance the monitoring of soil moisture. Even the smallest vibrations before to a significant earthquake can be detected up by an earthquake warning system. The quality of the air is worsening because of industries and cars. Given how much has changed, IoT must be used to evaluate the chemical composition and air quality. Modern environmental monitoring has evolved into an advanced Smart Environment Monitoring System (SEMS) thanks to connected devices and improved sensor technologies.[22]

By linking devices and facilitating more informed decision-making based on data, the Internet of Things (IoT) is changing a number of industries. Its advantages include greater convenience, safety, cost savings, and efficiency. IoT applications and impact are predicted to increase as the technology develops, further combining the digital and physical environments for improved user experience and increased operational efficiency.

2.9 Literature Review on Previous Researches.

Table 2-1 shows a review table of the related researches being done on this system. From the review, it can be concluded that the existing researches have the benefits of IoT interfacing and embedded with microcontroller. However, current researches are found to lack of renewable energy source for rural areas application, monitoring of the battery management system, as well as control and alert system that are found to be a crucial aspect in a home energy monitoring system.This research aims to design and develop a system with all the gaps found from the previous researches.

Table 2-1 : Comparison of Previous Project

Name	Title	Renewable Energy	Battery	Microcontroller	System Benefits	Limitations
Y. Pal, et al	IoT based Weather, Soil, Earthquake, and Air Pollution Monitoring System’	N/A	N/A	Use of three different microcontroller which is inefficient. Arduino uno, ESP 8266, Raspberry pi	capable of acting quickly to avoid disasters like earthquakes and landslides	This project has monitoring only but do not have control and alert. Does not apply RE IoT monitoring – flood and send infromation, soil moisture, vibration.
G. Sudhamsu and M. C.R	IoT Based Bridge Monitoring System	N/A	N/A	ESP32	Monitor a real-time bridge condition to prepare for earthquake or flood.	This project hasonitoring only but not have controlling. Does not apply RE IoT-Monitoring data about vibration, smoke level, temperature and ultrasonic.

M. Elkahlout, et al	IoT-Based Healthcare and Monitoring Systems for the Elderly: A Literature Survey Study	N/A	N/A	Does not use a general microcontroller for many project. Circuit board which specific for healthcare monitoring.	to shed light on the importance and classification of IoT-based elderly healthcare systems	This project have Monitoring only but not have controlling. Does not apply RE IoT-Monitoring vital signs, ECG, EMG and patient status or illnesses
W. Zhu, et al	The Cloud-End Collaboration Battery Management System with Accurate State-of-Charge Estimation for Large-Scale Lithium-ion Battery System	SolarPV or Wind	Expensive Lithium-Ion Battery	Does not have online data. PCB board	To ensure the safe operation of the lithium-ion battery system in application.	This project has monitoring only but do not have control and alert. BMS- monitor the numerous battery cells using cloud platform
Jo-Ann V. et al	FLi-BMS: A Fuzzy Logic-based Intelligent Battery Management System for Smart Farm	Solar PV	Expensive lithium iron phosphate (LiFePO4)	Does not have online data fuzzy logic control (FLC)	to optimize the energy distribution to several loads in the smart farm.	This project has monitoring only but do not have control and alert. IoT- monitor SoC, solar irradiance, external cell temperature, load voltage and load power consumption
A. Sharma and M. Sharma	Power & energy optimization in solar photovoltaic and concentrated solar power systems	Solar PV	N/A	CSP System	To optimize power and energy produced by Solar Energy technologies to reduce Carbon footprint.	This project has monitoring only but do not have control and alert. Use Computer to monitor irradiance and power supply.
M.Mazelan	**Development Of Solar Powered Home Energy Monitoring And Alert System With Iot Control**	**Solar PV**	**Lead-Acid battery**	**Only use one microcontroller ESP32 to control the system and send the data to online platform.**	**Have a safety mechanism to guarantee that no mishaps happen and alert consumers in case of any unusual activity.**	**Besides monitoring system, it also has control system and alert system. Use Solar as RE. IoT-Monitoring voltage of the battery and control system load for lamp and motor**

CHAPTER 3
METHODOLOGY

3.1 Overview

This chapter is about the methodology of this study. The detailed explanation for the methodology is presented based on the Flow Chart diagram below also including the calculation to selecting a proper device. Furthermore, in this chapter it going to show a predicted circuit connection for better understanding and explaination.

3.2 Methodology

This project introduces an controlled battery managment system that can work much efficiency and stable. Various component will be combined in the development of the controlled battery managemnet system to complete its function and satisfaction result. The development of the system is carried out step by step in the aspects of researching, developing hardware, developing software, and then finally collecting the data as well as control the circuit. All the methods, equipment, and software used are listed in this chapter.

3.3 Project Flowchart

3.3.1 Flowchart System Overview

Figure 3-1 shows the overall system process. Firstly, system optimisation through project calculation, software, and hardware development is illustrated in the flowchart. The process officially starts here, indicating that a decision has been made on the title and that the following step will be taken. The project then moves on to a crucial phase when analysis of the required tools and compenent use is necessary to minimise errors made while allocating project money. Following analysis, calculation is necessary since the system needs to operate in accordance with expected behaviour for safety as well. There may be risks or malfunctioning equipment when the system is not calibrated and instead uses an arbitrary item specification. Based on the anticipated demand, calculations are used in this procedure to determine both the battery capacity and solar power required for this system design for a few hour to get a data for analysis. In order to ensure that the project will go without a hitch, calculations are made and then the project is simulated using software with identically to the hardware installation planning. This part should be considered as a warning or precaution before working with the hardware circuit design. The system's behaviour, system processing code, and component connections are all tested in the simulation. After the simulation is over, make a hardware draft to check that the connection is secure and to display an overview at the hardware simulation running in real time. The hardware component comes next, and it requires tools such as screw driver, multimeter to measure value of current and voltage and so on. In this phase also, safety and caution while handling the connections is a must because a bad connection might result in problems like burned components or short circuits worstof all the person will get shock or hurt. After the hardware is finished, it will operate, look into the behaviour of their processes, monitor the data that has been gathered, and use IoT to control the project either to turn it on or off. Should the process not function as anticipated, it will proceed to the troubleshooting phase. The hardware will be accessible in this part in order to look for the source of the issue espeacially the circuit connection. The project can be declared finished or successful if the hardware performs as desired and the value of data gain as expected.

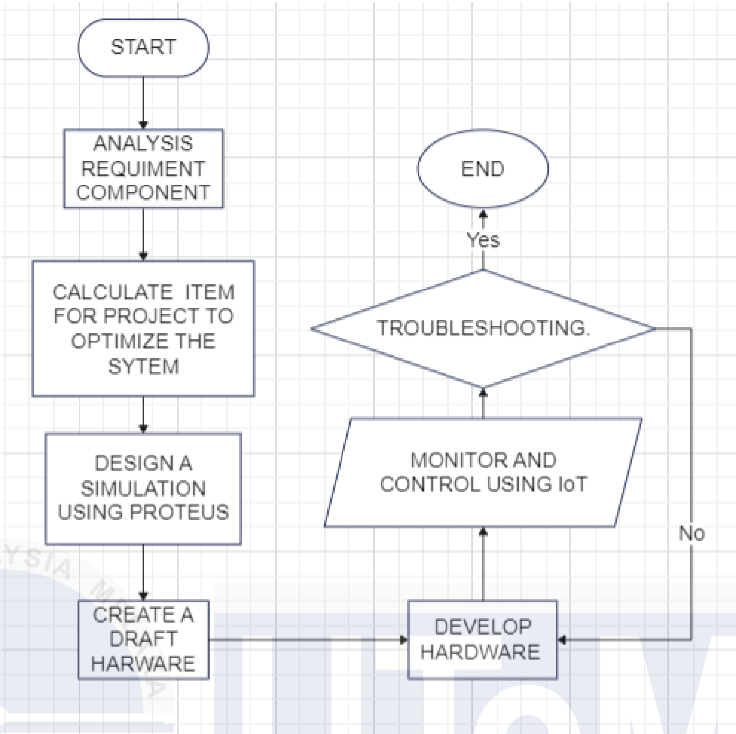

Figure 3-1 : Flowchart of the System

3.3.2 Flowchart of Simulation Software

The flowchart in Figure 3-2 illustrates a system that uses an Arduino Uno microprocessor based on a timer and push buttons to operate an LED and motor. The motor will start, the LED yellow will turn on, and the LCD will show the voltage, current, and status of the DC power supply—that is, whether it is on or off—when the simulation is executed or power is applied. LED red will turn on after 15 seconds, and it will stay like this until the power is turned off or the simulation is stopped. However, the LCD display will turn the DC supply from on to off if the PB 1 is pushed during the simulation. If nothing is done, it will stay that way until the power is turned off. The LCD display status returns to its initial state, in which the DC supply is on display, if PB 1 is pressed again. This state remains until further actions are taken. For PB2, the initial behavior remains till the power is turned off if it is not pushed. On the other hand, if the PB 2 is pushed, the motor will shut down immediately with the red LED. The situation will stay the same till the power is turned off if nothing changes. But if the PB 2 is pushed again, the motor will restart operating in the same manner as before.

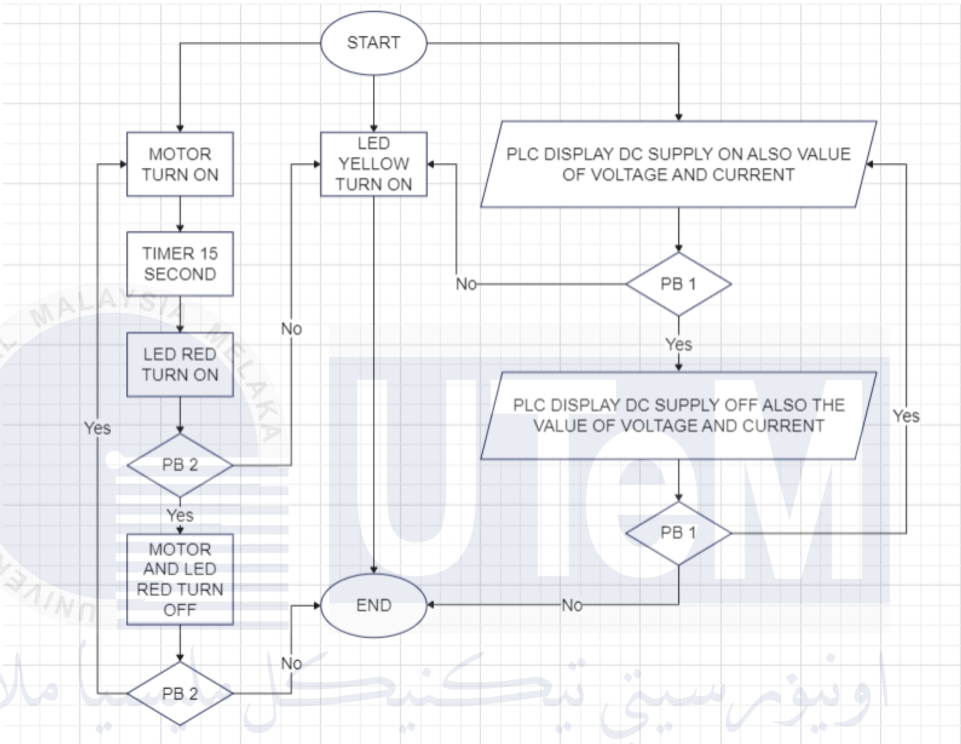

Figure 3-2 : Flowchart Software

3.4 Block Diagram

The block diagram from Figure 3-3 is about a system with consist of a solar panel, esp32 board, battery, relay, voltage sensor, loads including motor and lamps (12V and 5V), also a phone to interface the IoT system. For this system, the power source that supply energy for this system is from solar energy, consisting a solar panel (generate power), solar charge controller and a battery (store the power). Esp32 is the main microcontroller that integrates all the components to operate the system including monitor and control. All inputs including the voltage sensor, switch and timer are connected through the input pins of the Esp32. Output from Esp32 controls the relay for the loads control. The output also integrates to the IoT system that interfaces the display on the battery voltage level for battery management system, current state or conditions of the loads for control and alert system.

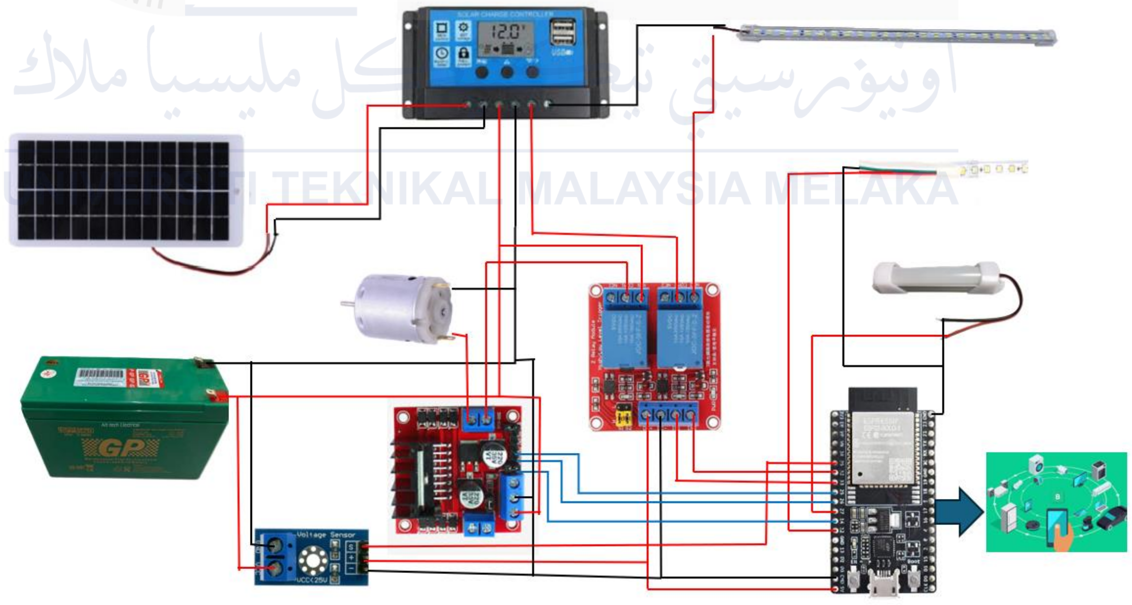

Figure 3-3 : Block Diagram of Home Energy Monitoring System

3.5 Solar PV System Design

One renewable energy source that offers an economical, ecologically friendly, and sustainable means of producing electricity is solar photovoltaic technology. Solar PV serves an important part in the shift to a cleaner and more reliable energy future due to its many uses and advantages.

3.5.1 Solar PV System Sizing

The solar PV system sizing is performed to determine the size of solar panel power rating and battery capacity. The sizing is done by simulating the required load in PVSyst while setting the Peak Sun Hour at 4 hours. In this system, the average daily power consumption considering a motor and 2 LED lights as the load is 74Wh. The figure 3-4 below shows an example of monocrystalline PV Panel being used in this project.

Figure 3-4 : Solar PV module monocrystalline

LED per unit watt = 2 watts

Motor power rating = 4 watts

Total power of LED and motor power = 2(2) + 4 = 8 watts

The average hour of LED usage per day = (24 + 10) ÷ 2 = 17 hours

The average hour of Motor usage per day = 10 hours

Average daily power consumption = (2 x 17) + (4 x 10) = 74Wh

Average monthly power consumption = 74Wh x 30 = 2220Wh

Average daily sunlight in Malaysia = 8 hours

Average monthly sunlight in Malaysia = 240 hours

Power required from solar panels = 2220Wh/240 hours = 9.25Wh a.k.a 10Wh

Threfore, the output power requirement for solar panels should be at least 10 watts per hour to ensure the efficiency of the system.

3.5.2 Types of Solar

There are several types of solar photovoltaic (PV) technologies such as Monocrystalline, Polycrystalline, Thin Film, Bifacial, Building-Integrated Photovoltaics. All choices are depends on efficiency, cost, application, and specific project requirements. In this project, the type of Solar PV selected is Mono crystalline because of balance of efficiency and cost. The efficiency of Monocrystalline are around 15% to 22% also have a long lifespan.

3.5.3 Solar Charge Controller

In solar power systems, a solar charge controller, sometimes referred to as a solar regulator, is a device that controls the flow of electricity from the solar panels to the battery bank and the load. Its main job is to control the voltage and current that the solar panels produce in order to make sure that the batteries are charged effectively and safely. This keeps the batteries safe from harm by preventing overcharging and excessive discharge. In this project, the use of solar charge controller is to control the power enter the battery and load in order to keep the other component work well since it can regulate power with efficience.

Any solar power system that includes battery storage must have a solar charge controller. It guarantees safe and effective battery charging, protects against overcharging and overdischarging, and improves the solar energy system's overall reliability and effectiveness. The type of the solar charge for this project is 30A and 12V as the Figure 3-5.

Figure 3-5 : Solar Charge Controller

3.5.4 Battery

An electrochemical device called a battery functions as a portable electrical power source by storing energy. It is made up from one or more electrochemical cells, each of which has an electrolyte, a negative electrode (anode), and a positive electrode (cathode). Electrons flow from the battery's chemical processes to produce an electric current that can power a variety of devices. Battery also have many type such as Li-ion, NiMH, Lead-Acid and many more. In this project, the type of battery use is Lead-Acid 12V &Ah as in figure 3-6, becasue of it easier to manage, lightweight, average life circle and also cheap which consider the budget of project. Hence, it make Lead-Acid a good selection.

Figure 3-6 : Rechargeable Lead Acid Battery

3.5.5 Capacity Battery Calculation

Total watts per hour required = 8W

Daily hours of power needed = 10 hours

Total daily power needed = 8W x 10h = 80Wh

Selected battery voltage = 12V

Minimum ampere hour of the battery = 80Wh/12V = 6.67Ah ~ 7Ah

Hence, the capacity of the battery is 12V and at least 7Ah capacity required.

3.6 Monitoring System Design

In this section, it talks about the item of making monitoring system to read value of voltage from battery and shows the alert indicator from the project. This system consists of Voltage sensor, IoT Blynk, Microcontroller ESP 32 and load indicator lamp 5V.

3.6.1 Voltage Sensor

Voltage sensor is an electronic device used to measure and monitor the voltage levels in electrical systems. In the context of a solar power system, voltage sensors play an essential role in ensuring the system operates efficiently and safely. In this project, the sensor is used to measure the voltage generated by the solar panels to assess their performance. This helps ensure the panels are producing the expected power under given sunlight conditions. Furthermore, it also used to monitor the battery's voltage to prevent overcharging or deep discharge. Overcharging can damage the battery, while deep discharge reduces its lifespan. The voltage sensor as in figure 3-7 model used is D25 which is the limit is 25V, this is because the maximum voltage produce from the system is 13V which make it ideal to used.

Figure 3-7 : Voltage Sensor

3.6.2 Internet of Things (IOT)

The network of physical items integrated with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet is known as the Internet of Things, or IoT for short. These ideal could be commonplace items, machinery used in industry, or specialty devices made to perform certain functions. IoT have varies type such as consumer IoT, Industrial IoT, Commercial IoT, Infrastructure IoT, Healthcare IoT and control IoT. Most of the use in IoT are just for monitoring. In this project, the type of IoT use is Control and monitoring IoT, which provided real-time data, graph and transfer signal to control the project process. In this system, IoT is used to monitoring the alert system from the load also the value of voltage produce by battery to keep it condition at safe point.

The IoT is developed using Blynk software as in figure 3-8. The monitoring system using the IoT can be observed through the users' phone.

Figure 3-8 : IoT Software Blynk

3.6.3 Microcontroller

A microcontroller is a single integrated circuit's (IC) central processing unit (CPU), intended to carry out calculations and provide control over electronic devices. To carry out operations like data manipulation, input/output (I/O) control, arithmetic operations, and decision-making, it performs out a set of instructions. Microcontroller, which process data and control system operations, are the brains behind computers, embedded systems, and other electronic gadgets.

3.6.3.1 ESP 32

ESP32 as in figure 3-9 working a 32-bit Tensilica Xtensa LX6. Clock speed ESP32 can run up to 240 MHz. In term of memory, ESP32 has much more memory which is 4 MB flash, 520 KB SRAM compared to Arduino Uno. Voltage supply for ESP32 3.3V. Furthermore, ESP32 has built-in Wi-Fi and Bluetooth connectivity, which make it wireless capabilities. ESP32 also have many ADC input which means it can run multiple sensor that produce analog signal. To conclude, ESP32 is more suited for this project simce it can resource-intensive applications involving IoT and wireless communication. In this system, the esp32 is used as receiving and process the data from voltage sensor and send the data to the IoT platform for the user.

Figure 3-9 : ESP 32 Model

3.6.4 Lamp 5V

A lamp in fugure 3-10 is a device that emits light when powered by electricity. Its primary function is illumination, but it also serves aesthetic, functional, or signaling purposes. In this system, the lamp is used for an indicator to alert the user that the equipment turn on more than it supposed.

Figure 3-10 : Lamp 5V

3.7 Control System Design

In this section, it talks about the item used to control the load. Most of the items are the same as monitoring system design which are IoT platforms to control the relay either to turn on and off for the load, ESP 32 to control and send data of the system. Overall, this system consists of IoT Blynk, Microcontroller ESP 32, Relays, Motor Driver, and load Motor and lamp 12V.

3.7.1 Relay

Relays as in figure 3-11 are solid-state or electromechanical switches that regulate the amount of electricity that flows across a circuit. It acts like a bridge between two circuits, allowing a low-power signal to regulate a higher-power one. In this project, the use of relay is like a switch to control the load either on and off for motor and lamp. Furthermore, it can work by receiving the signal to change the switching by using IoT control.

Figure 3-11 : Relay with 5V power

3.7.2 Motor

Motor have a two type which is AC motor and DC motor. DC motor use direct current (DC) power to operate either it brushed or brushless. It also offers exact direction and speed control, making it appropriate for small to medium-sized loads. While AC motor use electricity supplied by alternating current (AC), include both induction and synchronous motors. AC motor usually used for continuous operation and higher loads In this project, DC motor is selected since the project does not need high power. Furthermore, motor in project serve as a load, it is an electrical device that converts electrical energy to mechanical energy to perform work and to show a varies output in the project. In this system, the motor as in figure 3-12 is used as the load, representing high power loads such as air conditioner, clothes iron, or any appliances with heater.

Figure 3-12 : DC motor with 12V

3.7.3 Motor Driver

Motor driver as in figure 3-13 is an electrical circuit or device used to regulate and control the operation of electric motors mostly speed of motor and direction. It serves as a conduit between the motor and a microcontroller, guaranteeing that the motor receives the proper voltage and current to carry out its intended functions. In this system, the motor driver is used to control the motor speed in order to limit the current usage of the system which the ratio is 60% of the maximum speed of motor.

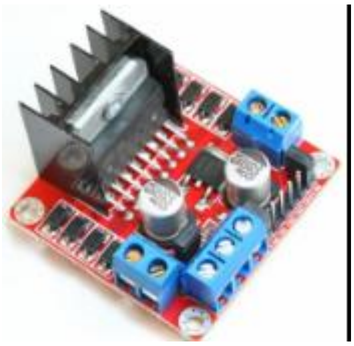

Figure 3-13 : Motor Driver L298N

3.8 Simulation Software

A type of computer programme known as simulation software simulates the functioning of systems, processes, or phenomena in the actual world in order to examine how they behave under various circumstances. With the aid of this programme, users can carry out investigations, analyses, and predictions also in decision-making, efficiency gains, cost reduction, and effective risk management without requiring actual prototypes or field testing. Several fields of study, including engineering, physics, economics, biology, and social sciences, employ simulation software to gather information, optimise procedures, and reach defensible conclusions.

There is many type of software simulation which is MATLAB, Solidwork simulation, COMSOL multiphysics, AnyLogic, PSpice, Arena simulation and Proteus. In this project, the software use is Proteus since it easier that MATLAB in performing a simple diagram without needed much specification in the component circuit. It also easy to learn and fast at executing a simulation which make it a great choice for a beginner. But it havesome changes,since proteus cannot connect the internet, so the push button is added to indicate control system and LCD to display the value of voltage.

Figure 3-14 : Proteus simulation software logo

3.9 Project design and installation

Building a house for a prototype to exhibit the Home Energy Monitoring System is a multifaceted process that requires meticulous planning, the right materials, and adherence to structural principles. It encompasses numerous stages, each critical to ensuring the safety, functionality, and aesthetic appeal of the final structure. The structural design forms the backbone of any house. It involves creating a framework that supports the building and withstands external forces. The foundation is the base of the house, distributing the building's weight evenly and preventing settling or shifting. So, the material used is plywood for its strength and durability. The size is considered by the installation of item project. The angle, cutting and illustrated in Figure 3-15.

Figure 3-15 House structure and building prototype

Building a house project is an intricate and rewarding process that combines technical, creative design, and practical considerations. By focusing on structural integrity, selecting appropriate materials such as plywood, which is strong, cost efficient and adhering to key principles.

3.10 Experiment setup for solar collecting data

The initial of the experiment is aimed to investigate the working of solar system energy in generating power from the sun. The power from solar flow to the solar charge controller to charge the battery and collect the data. Then the battery will be used to supply the load which consists of DC motor and LED lamp.

Figure 3-16 : Solar PV Data Collection Setup

3.11 Experiment setup for load Case A, Case B, Case C

In this section, it shows all the type of load setup for each case. It make it easier to obtain and conduct the data from the experiment throught the procedur setup.

Table 3-1 : Load Type Setup Variation

Case	Type of Load
A	Only use lamp
B	Only use Motor
C	Use both Motor and Lamp

3.11.1 Experiment setup for Case A

The experiment for Case A is about running a lamp 12V until the battery drain, the lamp will on, and the status of battery will be taken frequently every hour. This is to make sure how long the lamp with turn on for 1 period of battery lifecycle (From full to empty). The configuration for case A is illustrated in Figure 3-17.

Figure 3-17 : Load Lamp only

3.11.2 Experiment setup for Case B

The experiment for Case B is about running a Motor 12V until the battery drain, the Motor will on, and the status of battery will be taken frequently every 30 minutes. This is to make sure how long the motor with turn on for 1 period of battery lifecycle (From full to empty). The configuration for case B is illustrated in Figure 3-18.

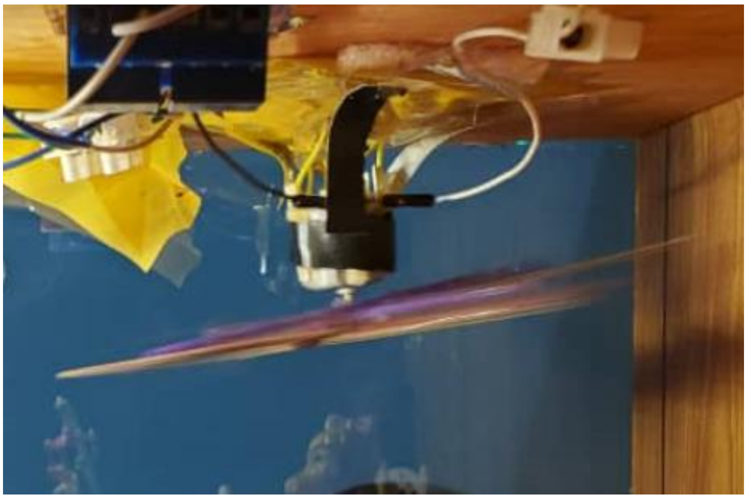

Figure 3-18 : Load Motor only

3.11.3 Experiment setup for Case C

The experiment for Case C is about running a lamp 12V and Motor 12V until the battery drain, the lamp and motor will on, and the status of battery will be taken frequently every 30 minutes. This is to make sure how long the lamp and motor turn on for 1 period of battery lifecycle (From full to empty). The configuration for case C is illustrated in Figure 3-19.

Figure 3-19 : Load Lamp and Motor

3.12 IoT System Display Setup

From the figure 3-20 , it shows that the project uses 2 switch button to control the load which is motor and lamp, also indicator at the middle of the switch is the signal for alert system, lastly, the graph and value display about voltage measurement for battery.

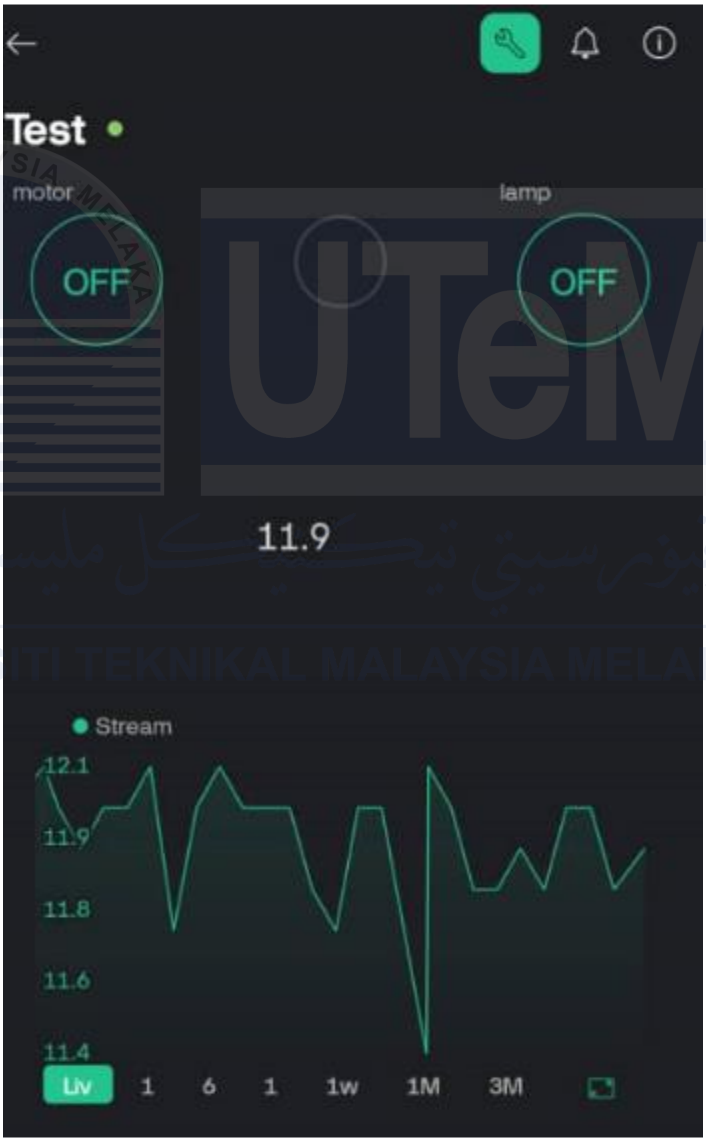

Figure 3-20 : IoT Blynk Initial condition

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Overview

In this part, it have 2 part which is the first part about the preliminaty result obtain from the sotfware proteus simulation where the circuit is mimic to the the actual hardware application and the second part about present the result and analysis data on hardware in term of power generate from solar, load consumption from motor and lamp also the behavior of battery.

4.2 Result from software (Part 1)

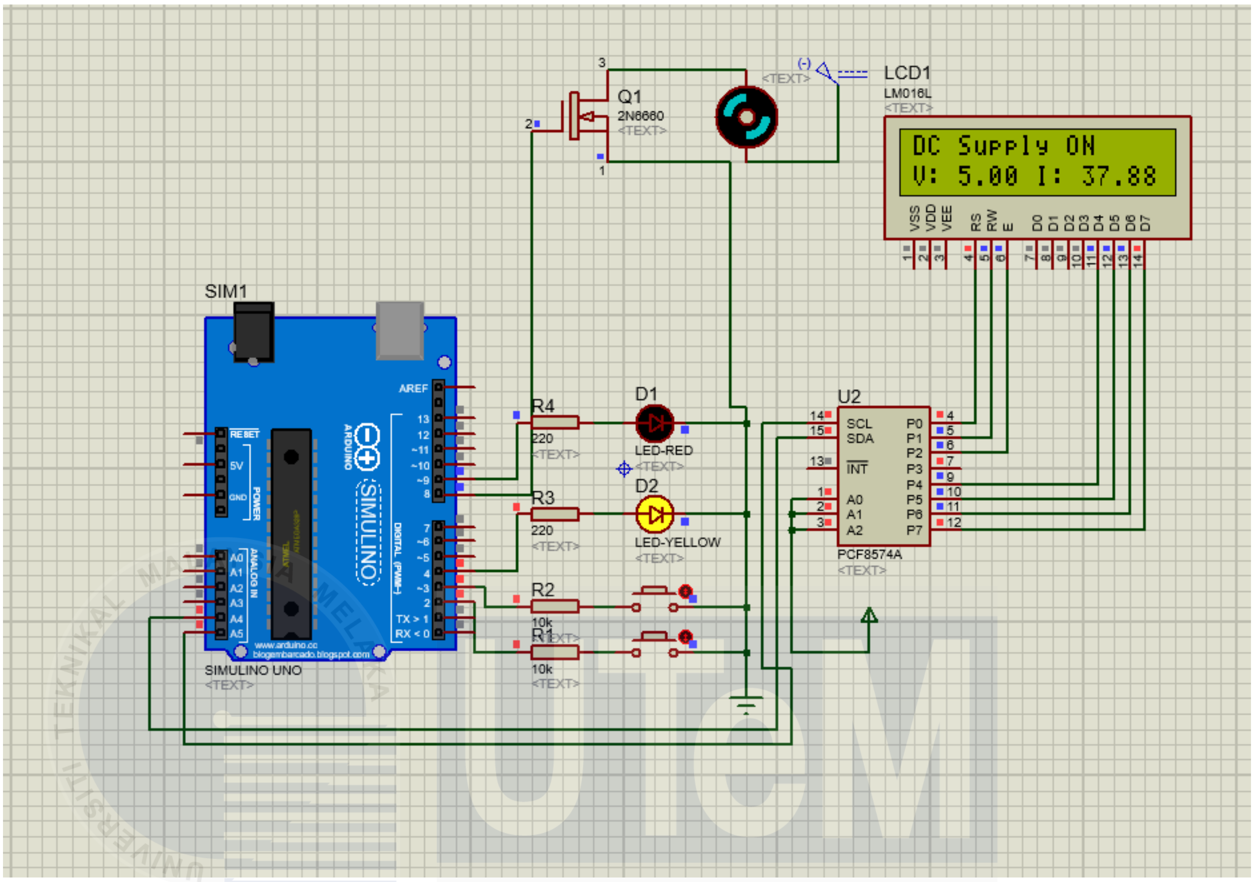

Figure 4-1 : Initial condition Circuit Diagram

From the figure above, it shows the circuit in initial condition when power is supply throw the circuit. The yellow led will turn on until the power cut off which indicate the load which use 24 hours working like refrigerator . Next, the motor also will turn on which indicate a load that working not in 24 hours like aircond since the motor can be controlled using push button or switch(when using IoT) to turn on and off. Furthermore, the LCD which indicate as monitor in device connected to IoT to view the data about the battery capacity, current and voltage value, the status of DC supply. For LCD initial condition, it shows the DC supply is on.

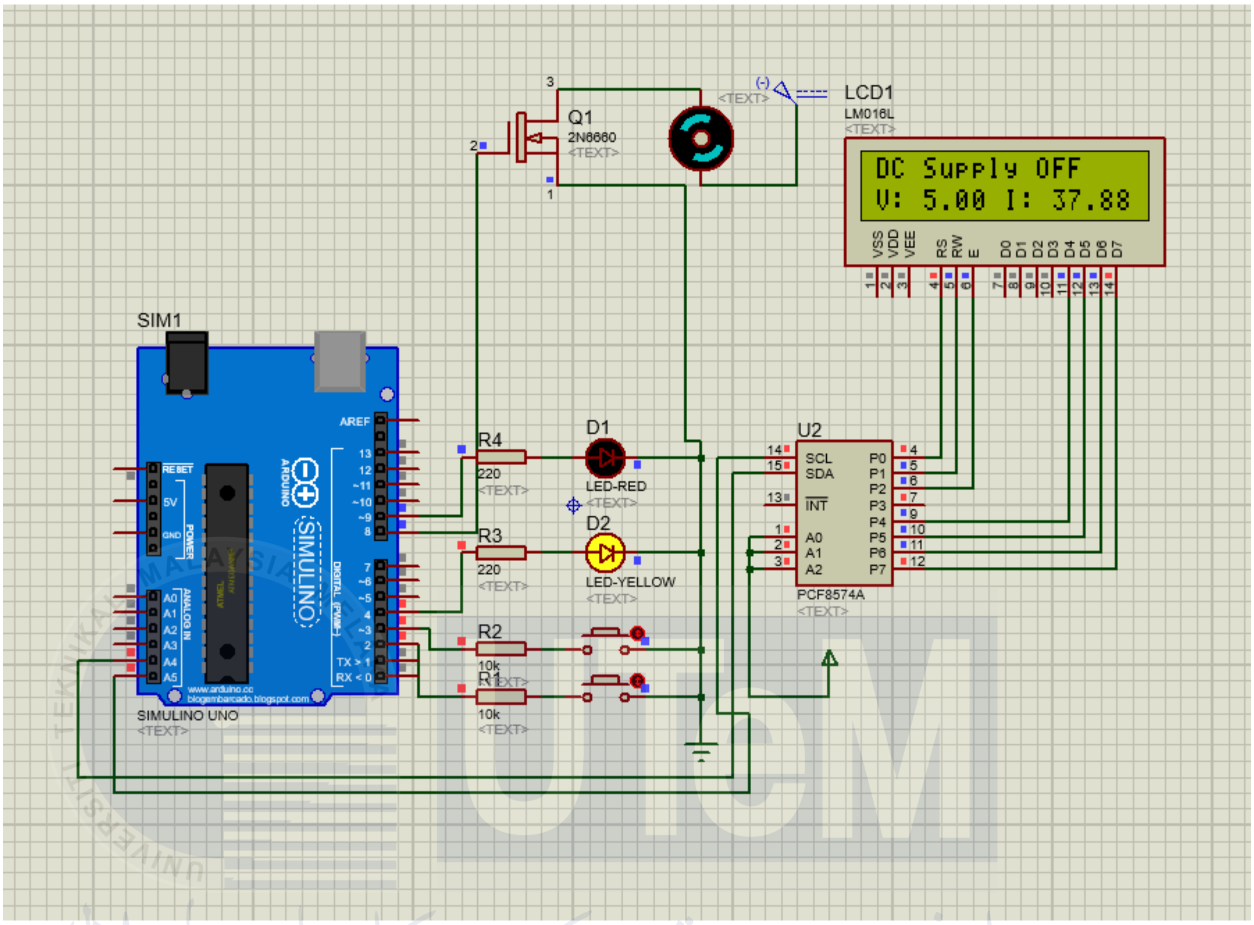

Figure 4-2 : Circuit Diagram PB 1 push

From the figure above, it shows the DC power supply is off when the push button was being press which means the power supply from solar are cut off in order to control the system. This action will remain until the power is cut off or the push button are being press again to back as an initial condition.

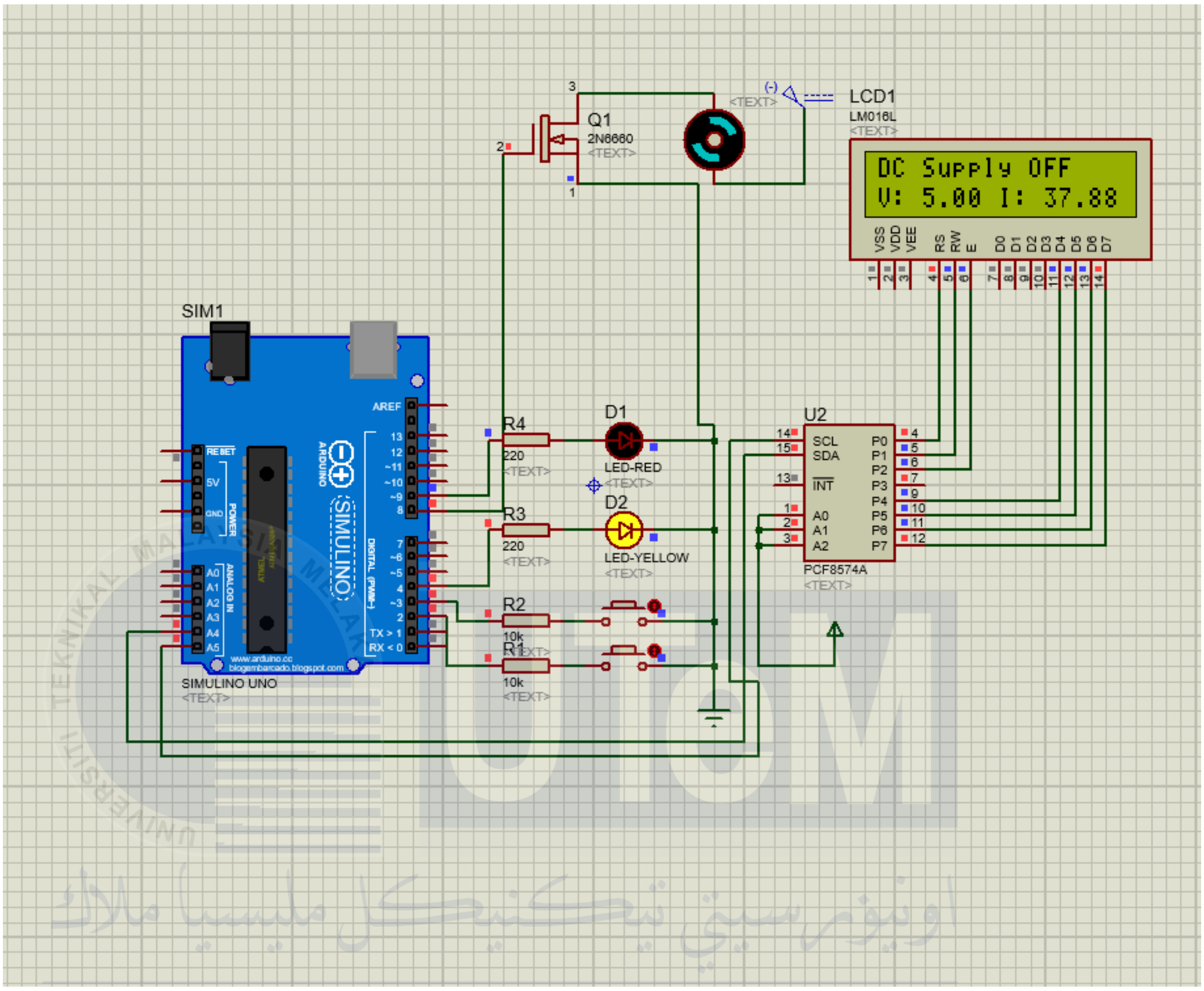

Figure 4-3 : Circuit Diagram PB 2 push

From the figure above, it shows about the motor turn of when the push button 2 was being press. This action indicate the load can be control throw the IoT for it on and off. The action will remain until the power it cut off or the push button are being press again to back as an initial condition.

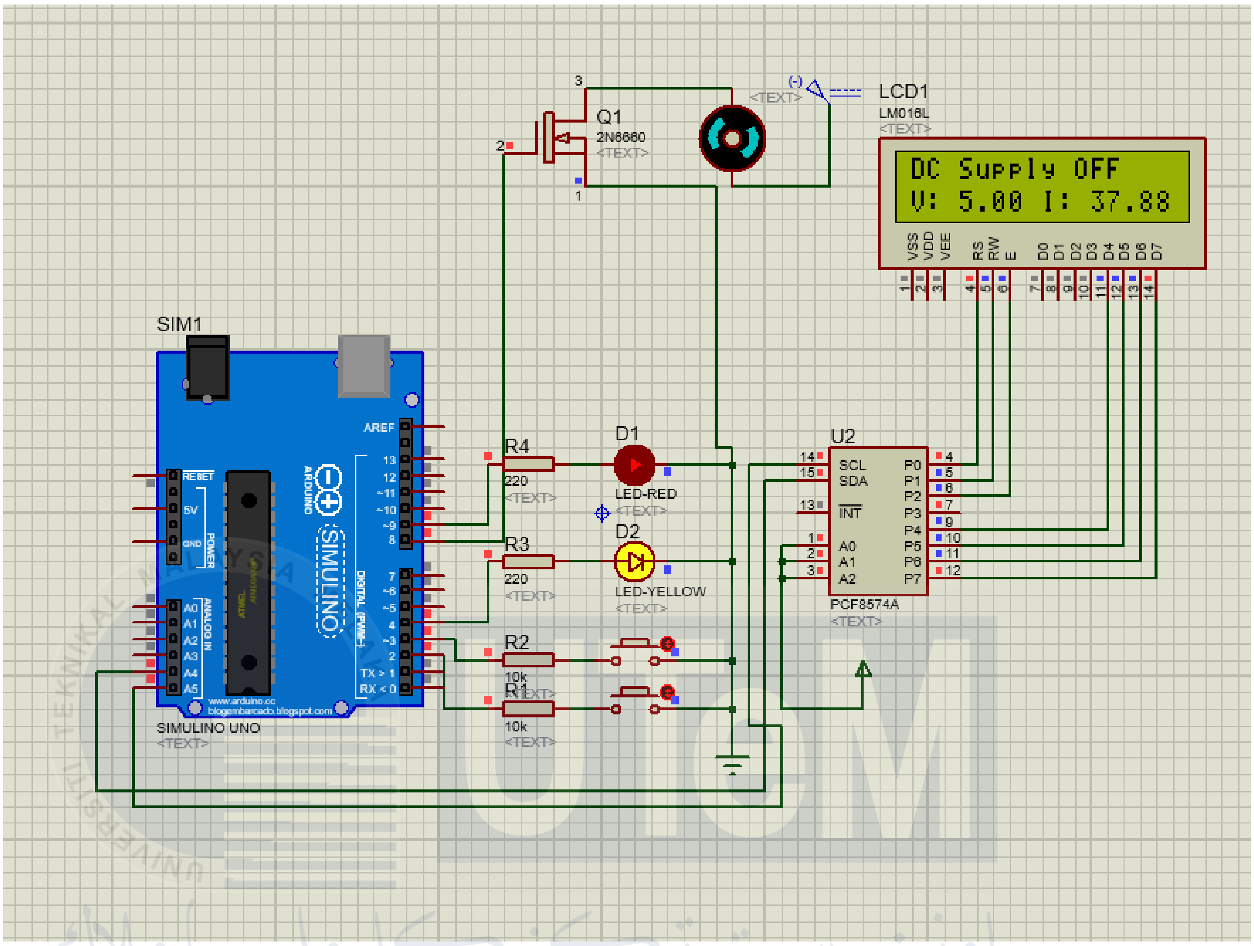

Figure 4-4 : Circuit Diagram after 15 Second Motor Running

From the figure above, it shows the LED red turn on after the motor was turn on after 15 second. This action indicate to shows a warning to the user, the warning is needed in order to alert the user which remind them that the load was running more than it should, like when the is on more than 12 hours then it will give a warning which remain them to turn off when not in use.

4.3 Hardware Result

The base area of the house is 67cm × 42cm as the figure 4-5, the house has a motor as a fan, lamp and the system to control the load (lamp and motor using IoT. The reason for the control is to monitor and adjust the power consumptions base on the user on phone.

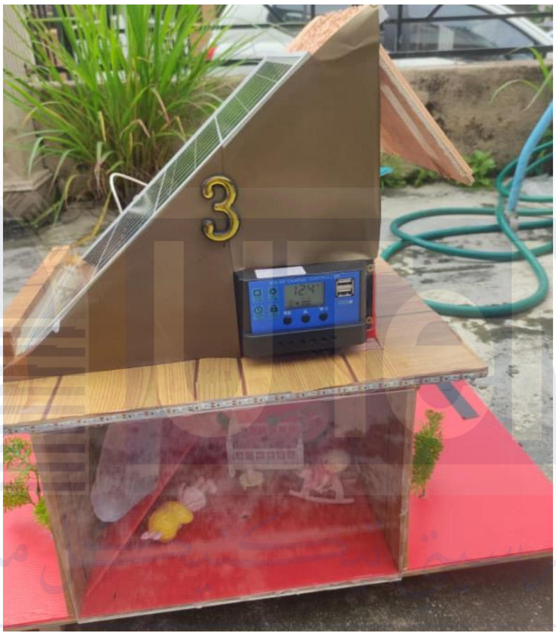

Figure 4-5 : Development of the Prototype of Home Energy Monitoring System

4.4 Data Collection

4.4.1 Data Collection and Analysis for Solar PV Panel Charging Rate

The overall performance of the system indicates a strong day, characterized by consistent sunlight throughout . Voltage and current showed a steady rise in the morning, peaked around midday, and then tapered off as the day progressed as in figure 4-6. Power output mirrored these trends, reaching a significant peak during the sunniest hours as in figure 4-7. This resulted in the highest power output observed, highlighting the day as one of the best performers due to stable and favorable sunlight conditions.

Table 4-1 : Solar Charge Day 1

Charge day 1				
Time	Weather	Voltage (V)	Current (A)	Power (W)
8.00am	Sunny	12.6	0.2	2.52
9.00am	Sunny	12.5	0.29	3.625
10.00am	Sunny	13.2	0.42	5.544
11.00am	Sunny	13.1	0.49	6.419
12.00am	Sunny	13.04	0.43	5.6072
1.00pm	Cloudy	12.56	0.34	4.2704
2.00pm	Rainy	12.54	0.2	2.508
3.00pm	Cloudy	12.74	0.08	1.0192
4.00pm	Rainy	12.56	0.04	0.5024
5.00pm	Cloudy	12.74	0.08	1.0192

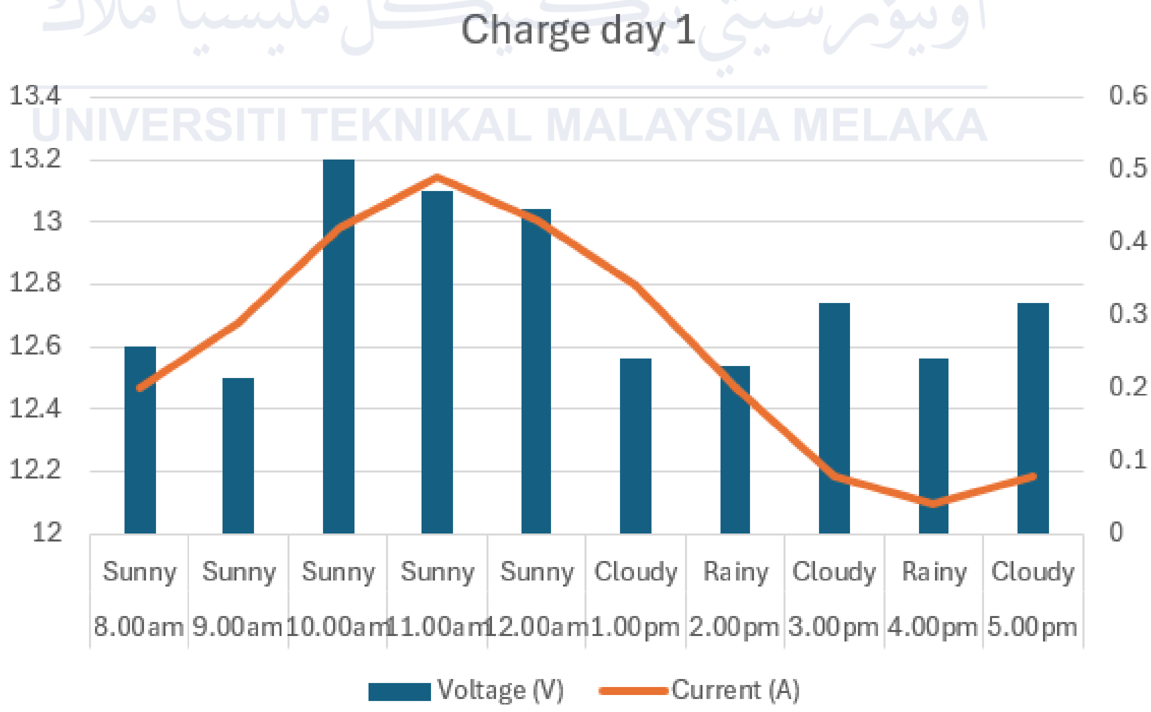

Figure 4-6 : Voltage and Current graph for Day 1

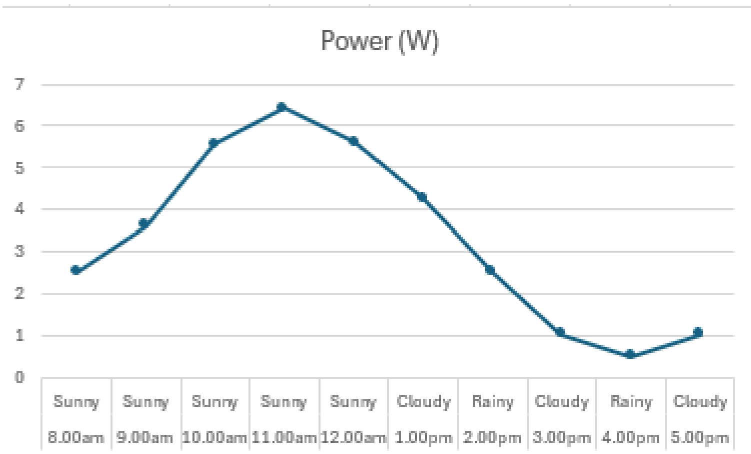

Figure 4-7 : Power graph for Day 1

The overall performance suggests the system experienced variable weather conditions, with periods of inconsistent sunlight. Voltage and current displayed noticeable fluctuations throughout the day as in figure 4-8, with dips during cloudy intervals. Power output mirrored these variations, peaking during sunny periods and dropping during cloud cover as in figure 4-9. Performance ranked between Day 1 and Day 3, indicating moderate sunlight conditions interrupted by occasional clouds.

Table 4-2 : Solar Charge Day 2

Charge day 2				
Time	Weather	Voltage (V)	Current (A)	Power (W)
8.00am	Cloudy	12.64	0.02	0.2528
9.00am	Sunny	12.76	0.28	3.5728
10.00am	Cloudy	12.72	0.15	1.908
11.00am	Cloudy	12.77	0.14	1.7878
12.00am	Sunny	13.1	0.48	6.288
1.00pm	Sunny	13.03	0.42	5.4726
2.00pm	Cloudy	12.7	0.1	1.27
3.00pm	Sunny	13.01	0.34	4.4234
4.00pm	Cloudy	12.7	0.05	0.635
5.00pm	Cloudy	12.7	0.06	0.762

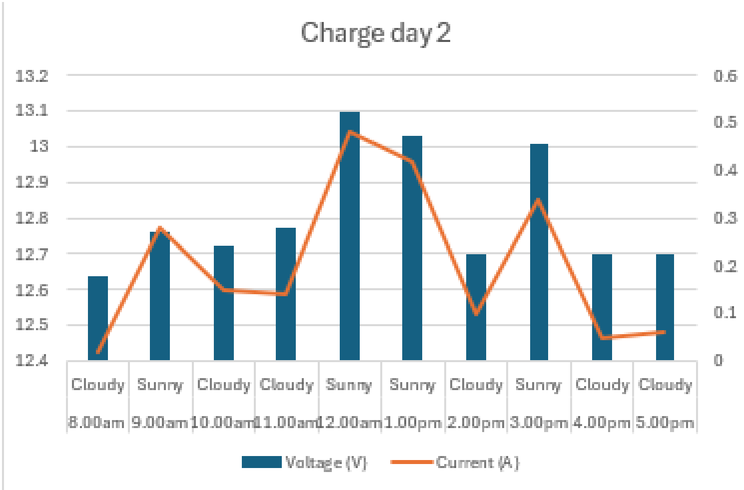

Figure 4-8 : Voltage and Current graph for Day 2

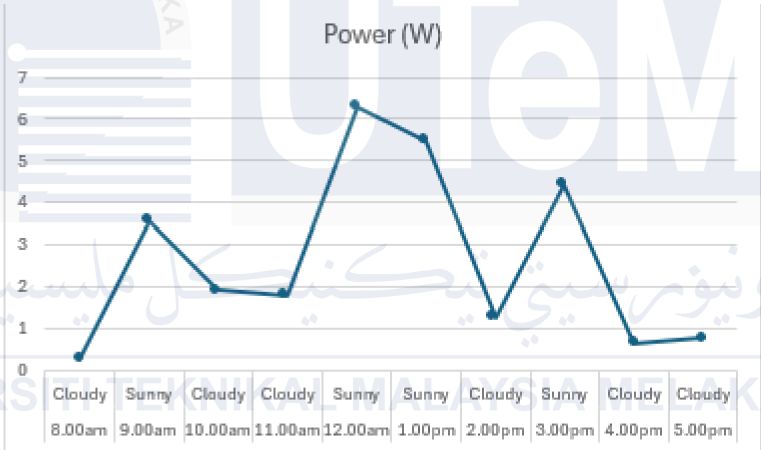

Figure 4-9 : Power graph for Day 2

The overall performance indicates a more consistent yet lower level of sunlight compared to Day 1. Voltage and current exhibited a less pronounced morning rise and a quicker decline in the evening as in figure 4-10. Power output followed this trend, with noticeably lower peak values as in figure 4-11. This marked the lowest-performing day, likely due to increased cloud cover or reduced sunlight intensity throughout the day.

Table 4-3 : Solar Charge for Day 3

Charge day 3

Time	Weather	Voltage (V)	Current (A)	Power (W)
8.00am	Sunny	12.4	0.24	2.976
9.00am	Sunny	12.6	0.33	4.158
10.00am	Cloudy	12.5	0.11	1.375
11.00am	Sunny	12.7	0.42	5.334
12.00am	Cloudy	12.83	0.42	5.3886
1.00pm	Cloudy	12.73	0.21	2.6733
2.00pm	Cloudy	12.6	0.12	1.512
3.00pm	Cloudy	12.72	0.15	1.908
4.00pm	Rainy	12.4	0.01	0.124
5.00pm	Rainy	12.39	0.01	0.1239

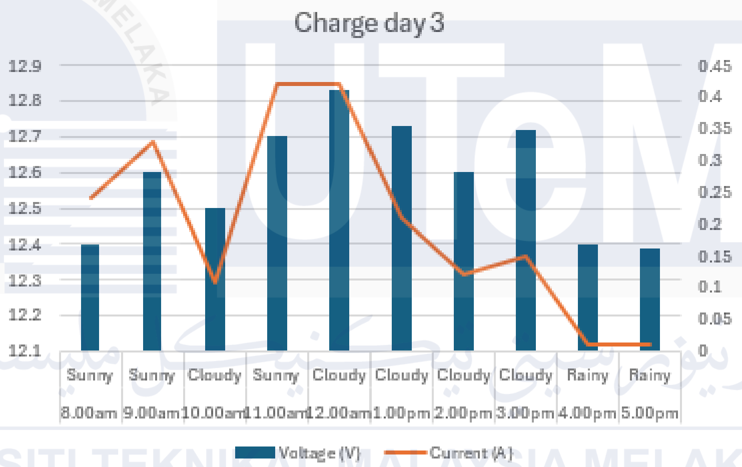

Figure 4-10 : Voltage and Current graph for Day 3

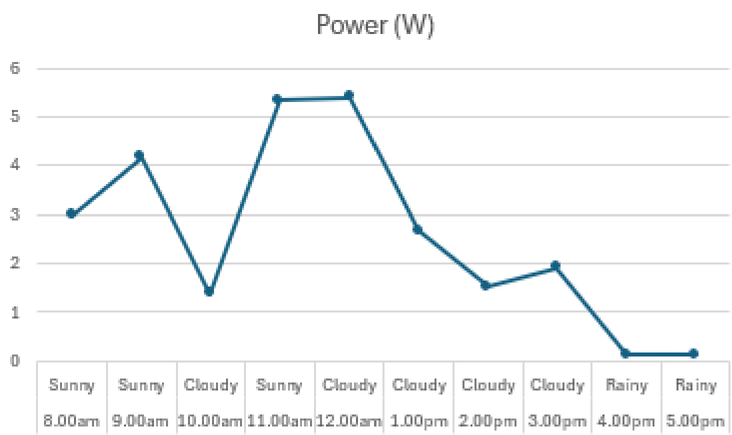

Figure 4-11 : Power graph for Day 3

In summary, the system's performance is highly sensitive to weather conditions. Sunny days result in higher power output, while cloudy periods significantly reduce generation. The general trend of increasing power output in the morning and decreasing in the afternoon is consistent across all days. The voltage fluctuates throughout the day, with peaks during sunny periods and dips during cloudy and rainy conditions. This is expected as solar panel output is directly influenced by sunlight intensity.

The voltage generally increases from morning to midday and then decreases towards the evening, mirroring the sun's path. The current follows a similar trend to the voltage, with higher values during sunny intervals and lower values during cloudy or rainy periods. The current is generally lower than the voltage, which is typical for solar panel systems. The power graph shows the product of voltage and current, representing the actual electrical power generated by the system. The power peaks during the sunniest periods, aligning with the peaks in both voltage and current. The power drops significantly during cloudy and rainy conditions, reflecting the reduced solar energy available.

4.4.2 Data Collection and Analysis for Monitoring and Control System

4.4.2.1 Data Case A

The graph from figure 4-12 illustrates the relationship between battery voltage and the percentage of remaining charge as a lamp is discharged over time, with measurements taken hourly. As the lamp discharges, the battery voltage steadily decreases. This is expected behavior as the battery loses energy to power the lamp. The discharge rate in the "Discharge Lamp / Hour" graph appears to be slower compared to the "Discharge Motor / Half Hour" graph, likely due to the lower power consumption of the lamp. The discharge rate in the

"Discharge Lamp / Hour" graph appears to be slower compared to the "Discharge Motor / Half Hour" graph, likely due to the lower power consumption of the lamp. The IoT Blynk application as in figure 4-13 shows that the switch turn green as it on for lamp and dark as it off for motor and indicator.

Table 4-4 : Discharge for Lamp

Discharge Lamp		
Run Hour	Voltage Battery (V)	Percentage (%)
0	12.6	80
1	12.3	60
2	12.2	50
3	12.2	50
4	12.1	40
5	12.1	30
6	12.1	30
7	12.1	30
8	12.1	30
9	12	20
10	12	20
11	12	20

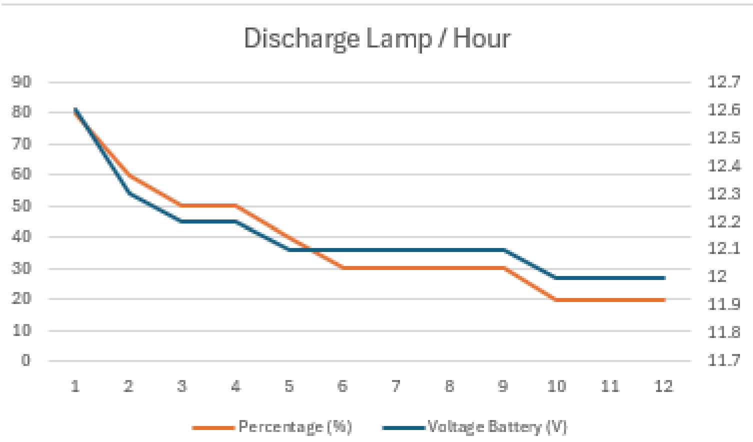

Figure 4-12 : Graph For Discharge Load (Lamp)

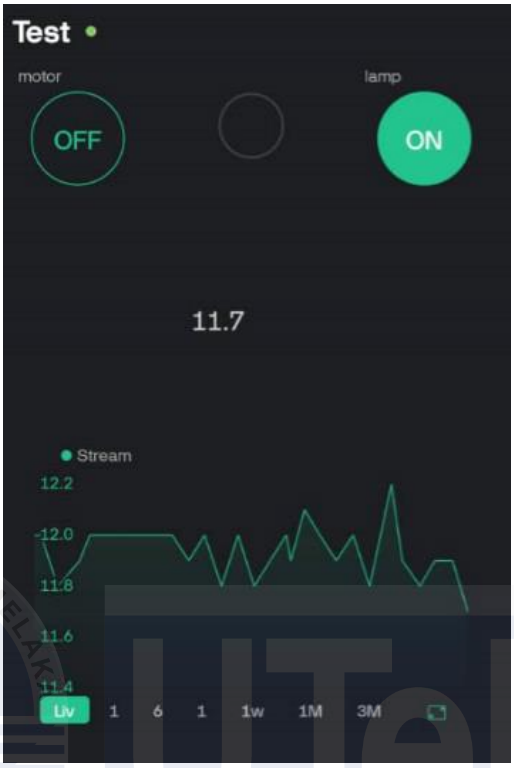

Figure 4-13 : IoT Blynk for Case A

4.4.2.2 Data Case B

The graph from figure 4-14 illustrates the relationship between battery voltage and the percentage of remaining charge as a motor is discharged over time, with measurements taken every half hour. As the motor discharges, the battery voltage steadily decreases. This is expected behavior as the battery loses energy to power the motor. The motor, being a high-power device, draws a significant amount of current from the battery. The voltage and percentage drop rapidly due to the high power consumption of the motor. The IoT Blynk application as in figure 4-15 shows that the switch turn green as it on for motor and dark as it off for lamp and indicator. As for figure 4-16 shows that the indicator lamps turn red after the 5 second to indicate the load has on more than supposed.

Table 4-5 : Discharge for Motor

Discharge Motor (60% from full speed)		
Run Hour	Voltage Battery (V)	Percentage (%)
0	12.6	80
0.5	12.4	60
1	12.4	60
1.5	12.3	50
2	12.3	50
2.5	12.2	40
3	12.2	40
3.5	12.1	30
4	12.1	30
4.5	12.1	30
5	12	20

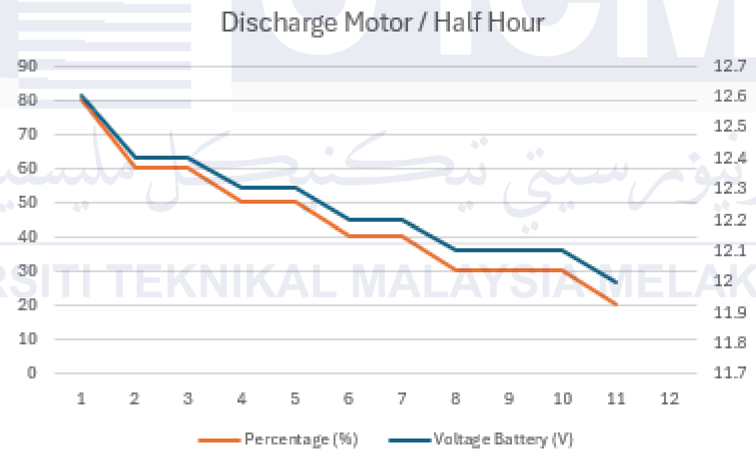

Figure 4-14 : Graph for Discharge Load (Motor)

Figure 4-15 : IoT Blynk for Case B

4.4.2.3 Data Case C

The graph from figure 4-16 illustrates the relationship between battery voltage and the percentage of remaining charge as both the motor and the lamp are discharged simultaneously, with measurements taken every half hour. Both the motor and lamp are drawing power from the battery, leading to a faster voltage drop and percentage decrease compared to either device discharging individually. The combined discharge of the motor and lamp results in a faster depletion of battery charge compared to either device alone. As for figure 4-17, it shows that the condition if the both load is on, the switch for motor and lamp turn green and indicator turn red.

Table 4-6 : Discharger for Motor and Lamp

Discharge Motor and Lamp		
Run Hour	Voltage Battery (V)	Percentage (%)
0	12.6	80
0.5	12.5	70
1	12.4	60
1.5	12.3	50
2	12.2	40
2.5	12.2	40
3	12.2	40
3.5	12.1	30
4	12.1	30
4.5	12	20

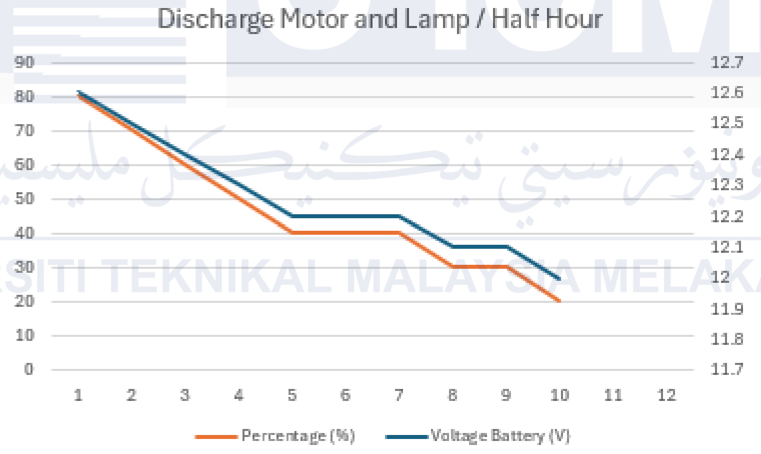

Figure 4-16 : Graph for Discharge Load (Motor and Lamp)

Figure 4-17 : IoT Blynk for Case C

In summary, the three graphs, "Discharge Motor / Half Hour," "Discharge Lamp / Hour," and "Discharge Motor and Lamp / Half Hour," illustrate the relationship between battery voltage and the percentage of remaining charge as different loads (motor, lamp, and both combined) are discharged from the battery. The motor, being a high-power device, draws a significant amount of current, leading to a rapid voltage drop and a fast discharge rate while the lamp consumes less power compared to the motor, resulting in a slower discharge rate and a less pronounced voltage drop. When the motor and lamp are discharged simultaneously, the combined load increases, leading to a discharge rate that is faster than the lamp and the motor discharged alone.

4.4.3 Data IoT Interfacing for Alert System

As for figure 4-18 shows that the indicator lamps is not on to shows that the alert in not turn on, after the 5 second indicate lamp turn red as in fugure 4-19 to shows that the load(Motor) has turn on more than supposed. From there it can conclude that the system for alert is working as expected.

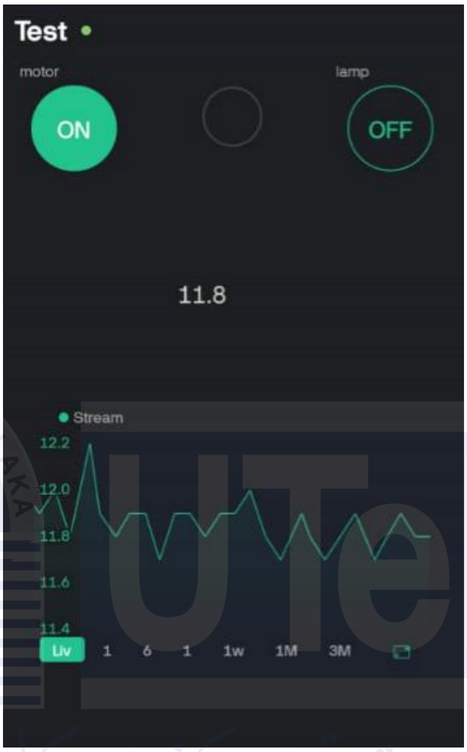

Figure 4-18 : Initial Condition

Figure 4-19 : After 5 Second the Load Turn On

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the preliminary result just a simulation works base on planned hardware installation. The circuit design is conducted by idea finding and component finding. The specification of these system design are being able to achieve by carefully analyzing the functionality component for the upcoming work on the projectinvestment to reduce TL in distribution network. It therefore lays a basis on which the suggested future research can be built.

For the hardware, the result of charging and discharging can be control by customize the component or controlling the load base on the user using the technologies which is IOT. The main component which is solar panels have been introduced in the project which make the system work well as planned. Positive result for this project have been obtained by conducted the experiment. In entirely, the project was complished successfully at BDP PSM 2.

5.2 Potential of commercialization

Market Trends and Opportunities by growing demand for smart homes. The global smart home market is projected to grow significantly, driven by advancements in IoT, AI, and cloud computing. Consumers seek integrated Home Energy Monitoring systems for convenience, security, and energy efficiency. Furthermore, it make renewable energy adoption by rising awareness of climate change and government incentives promote solar power adoption. A solar-powered IoT system aligns with the push for renewable energy solutions and off-grid independence. Lastly, it provide security and monitoring needs by increasing urbanization and safety concerns make Home Energy Monitoring systems highly desirable. The features like real-time alerts, remote control, and data storage are key selling points.

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APPENDICES

Appendix A Example of Appendix A

No.	Parameters	No.	Parameters
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3.		27.	
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24.			

Appendix B Example of Appendix B

Time	Residential	Industrial	Commercial