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Bachelor of Electrical Engineering Technology with Honours

2022

A DEVELOPMENT OF CONTROL CHARGING SYSTEM BY SOLAR PANEL

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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



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this project report entitled "A Development of Control Charging System by Solar Panel" 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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DEDICATION

My dissertation honours my family and numerous friends. My dear parents, En. Mohd Nurudin bin Kadri and Pn. Rozila binti Abu Bakar, whose words of encouragement and push for perseverance continue to echo in my ears. My dear brothers and family who have never abandoned me.

This dissertation is also dedicated to my many friends and family members who have supported me throughout the process. I will be eternally thankful for everything they have done for me, especially my fellow classmates who have helped me build my technology skills, as well as the many hours of proofreading and technical expertise.



ABSTRACT

The need for clean power sources is growing since there is an ongoing need for electricity while individuals attempt to reduce the environmental impact of energy collecting. As a result, in the future, the use of renewable energy and control charging systems will become more frequent. As a result, this project is designed to be self-sufficient in solar energy rather than relying solely on electricity. Furthermore, the invention of the solar panel control charging system has further reduced the energy usage of the by only operating when necessary. This project requires the installation of a solar panel system, a solar control charge, and a microcontroller to control the system. For the system to be self-sufficient, the solar panels are expected to generate at least 12Wh. Meanwhile, when the system's controller detects that the battery is fully charged, it will immediately switch off the current. With the microcontroller that was created alongside the system, the functions and settings for the system may be readily altered. In addition, the output from the control charging system also can use for the AC and DC output equipments, usb interface 2.1A and international general socket but for now as a prototype it just allow for 220-240V and below 4000W only. As a result, the system will not only run independently, but it will also consume electrical energy.

ABSTRAK

Keperluan untuk sumber kuasa bersih semakin meningkat kerana terdapat keperluan berterusan untuk elektrik sementara individu cuba mengurangkan kesan alam sekitar daripada pengumpulan tenaga. Akibatnya, pada masa hadapan, penggunaan tenaga boleh diperbaharui dan sistem pengecasan kawalan akan menjadi lebih penting. Hasilnya, projek ini direka bentuk untuk berdikari dalam tenaga suria dan bukannya bergantung kepada tenaga elektrik semata-mata. Tambahan pula, penciptaan sistem pengecasan kawalan panel solar telah mengurangkan lagi penggunaan tenaga dengan hanya beroperasi apabila perlu. Projek ini memerlukan pemasangan sistem panel solar, cas kawalan suria, dan mikropengawal untuk mengawal sistem. Untuk sistem berdikari, panel solar dijangka menjana sekurang-kurangnya 12Wj. Sementara itu, apabila pengawal sistem mengesan bahawa bateri telah dicas sepenuhnya, ia akan segera mematikan arus. Dengan mikropengawal yang dicipta bersama sistem, fungsi dan tetapan untuk sistem mungkin mudah diubah. Tambahan lain, keluaran daripada sistem pengecasan kawalan juga boleh digunakan untuk peralatan keluaran AC dan DC, panel usb 2.1A dan soket am antarabangsa tetapi buat masa ini sebagai prototaip ia hanya membenarkan 220-240V dan di bawah 4000W sahaja.Akibatnya, sistem ini bukan sahaja akan berjalan secara bebas, tetapi ia juga akan menggunakan kurang tenaga elektrik.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Datin Dr. Fadzilah binti Salim and my co-supervisor, Puan Amalia binti Halim for their precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) for the financial support through provision which enables me to accomplish the project. Not forgetting my fellow colleague and family for the willingness of sharing his thoughts and ideas regarding the project.

My highest appreciation goes to my parents, and family members for their love and prayer during the period of my study. An honourable mention also goes to my parents for all the motivation and understanding. And to my supervisor, thanks for Datin Dr.Fadzilah binti Salim.

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

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LIST OF SYMBOLS

- Voltage angle

-

δ

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LIST OF ABBREVIATIONS

V - Voltage

- -
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CHAPTER 1

INTRODUCTION

1.1 Background

Concerns over the depletion of fossil energy supplies, as well as the negative environmental and economic repercussions of their overuse [1], have led academics to perform in-depth studies on renewable energy resources as alternatives [2]. For a variety of reasons, solar energy is a viable option for meeting a significant amount of the world's energy needs. This project enables a charging method that is controlled by a solar panel.

Solar energy is turned into electrical energy by photovoltaic cells using a solar panel. The technique is useful for storing energy for usage at night. It necessitates a collection of op-amps that constantly monitor parameters such as panel voltage and load current. When the battery is fully charged, a green LED illuminates, and when it is overcharged or undercharged, a red LED illuminate.

When the load is overcharged or undercharged, a MOSFET or Relay is used to cut it off, whereas a transistor is used to switch the load to another dummy one when it is fully charged, protecting it from damage. When the battery voltage reaches a certain level, thesimplest charge controller controls the device voltage and closes the circuit, thereby terminating the charging process. A mechanical relay was employed by more charge controllers to open or close the circuit, stopping or starting power to electric storage devices.

1.2 Problem Statement

In our daily lives, used a lot of battery-powered electrical equipment was used especially when people go on hiking, camping, road trips, and vacations. When the batteries in these electrical devices run out, frequently left scrambling to find a suitable power source to replenish the batteries. As a result, this battery is intended to be able to store energy for night-time use while also controlling the charging mechanism whether the battery is overcharged or undercharged. In this case, a solar-powered controlled charging system would be a more realistic approach to prevent the mechanism from overcharging.

1.3 Project Objective

This project's major goal is to present a systematic and effective methodology for estimating a system that can control solar panel charging. The following are the specific objectives:

a. To analyze the battery charging system.

nulo

- b. To study and develop a battery charging by solar panel.
- c. To evaluate the effectiveness of controls the charging system for the battery bank before getting overcharged or undercharged.

1.4 Scope of Project

The development and design of device that controlled charging method by solar panel is one of the project's goals.

- a. To use supply using Monocrystalline cell as a solar energy
- b. To use Mosfet and Timer as a micro controller in this system.

c. To use Solar Rechargeable Battery in this system

1.5 Project Outline

The organization of this report consists of 5 chapters. Chapter 1 describes the introduction of the project which includes the title background of the project, problem statements, objectives, and scopes of the project. In Chapter 2, the previous research related to the project will be carried out and studied. The research about previous journals and articles were made based on similar projects and the subjects included in this project. Meanwhile, all the methods and procedures in developing the project will be described in Chapter 3. A result and discussion of this project will be described in Chapter 4 . Lastly, Chapter 5 will conclude this project , the limitation for the project and also recommendation for future

features.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In today's modern society, electrical energy quite important for people to use their electrical mechanism, so this implement can be change by green energy for. reduce from wasting electrical energy. Green energy, also known as regeneration energy, has gotten a lot of attention recently. Sun, water, wind, biomass, terrestrial heat, marine temperature differential, sea waves, morning and evening tides, and other forms of green energy can all be recycled [1]. Solar energy only makes up around 12% of the world's power capacity, and it is still regarded as a low energy-efficient means of producing energy [2].

Consumers encounter difficulties with finances, technological issues, inadequate infrastructure compatibility, and a lack of local expertise, according to surveys. It is still apparent, nevertheless, that a solar energy system is a superior option for an energy source than a more conventional one like burning fuels. Consequently, research is required to make sure that a solar energy system can be constructed that is highly energy efficient by using the best possible components [3]. Additionally, there when it comes to using solar energy systems in homes, there are a few obstacles that are frequent. Solar energy is the most efficient source of electricity generation among these options [4]. Malaysia is located near the Earth's equator. According to research estimates of Malaysia's monthly average daily global solar radiation, this has resulted in Malaysia receiving a significant amount of solar radiation throughout the year [5]. • Low cost to operate and build.

- There is almost no effect on the environment
- Pleasant to the environment
- Modular and therefore flexible in terms of size and use
- Exceptionally dependable and low maintenance

2.2 Control Charging System

A charge controller also known as a charge regulator, is a voltage and/or current regulator that keeps batteries from overcharging. It keeps the voltage and current between the solar panels and the battery in check. A charge controller's principal job is to keep the battery charged to the maximum achievable amount [6]. The charge controller prevents deep. discharge by avoiding overcharging of the battery and eliminating the load. In theory, charge controllers have direct control over the status of the battery. The controller checks and changes the charge level of the battery in between pulses. The charging control system must separate the accumulators from the Solar cell arrays when a certain level of overcharge is reached, as shown. When charged at 0.1C (10% of the rated capacity in amps) , some manufacturers claim that nickel Cadmium accumulators can endure a continuous overcharge of 144 hours. This because the above-mentioned information is rarely available for Lead-Acid accumulators, it is widely thought that they behave similarly to those described above [6].

2.3 Type of Solar Controlled Charge

In today's solar power systems, charge controllers such as solar panels are frequently used. Pulse width modulation (PWM) and maximum power point tracking (MPPT) are two types of PWM (MPPT). Both charge at different rates depending on the battery's full capacity and monitor the battery's temperature to avoid overheating [7].

Solar panels are classified into two types: on-grid and off-grid systems. The off-grid system is a solar panel that operates independently of the electrical grid network, whereas the on-grid system is linked to the electrical grid network in order to distribute electrical energy to clients. The off-grid technique requires the installation of a battery to store the electrical energy generated by the solar panel during the day in order to maintain a consistent voltage. PWM signals are generally fixed in amplitude while variable in pulse width modulation. The pulse width of the PWM is proportional to the magnitude of the SCC output voltage.

The charge controller regulates the charge flow from the PV panels to the Dc supply. The controller has two modes of operation MPPT and VOC, and the operation mode is determined by the battery voltage. Whenever the inverter is turned on and provides the load requirements from the DC bus, there is a load demand. Based on the PV power and load requirements, the batteries may charge or discharge. The MPPT mode is used to collect the most power from the PV panels when the battery voltage falls below the reference limit. If the load is heavy enough to cause the battery to drain, the PV panel gives the maximum possible power to the load, with the battery providing the rest [8].

The Voltage Control mode is used to avoid overcharging of the battery whenever the battery voltage exceeds the reference limit. To provide a consistent output voltage at the battery terminals, the operating point of the PV panels is adjusted correspondingly. Because the voltage is held constant, the pace at which the battery absorbs charge or the current

flowing through the battery gradually slows. To avoid shuttling between the two modes, a voltage band is utilised [8].

2.3.1 Pulse Width Modulation (PWM)

A charge controller that uses pulse width modulation (PWM) to change the duty ratio of the switches is the most effective way to assure constant voltage battery charging (MOSFET). The current from the solar panel tapers in a PWM charge controller dependent on the battery's status and recharging demands. When a battery's voltage hits the regulation set point, the PWM algorithm progressively reduces the charging current to prevent overheating and gassing, while charging continues to return the maximum amount of energy to the battery in the quickest time possible. The array's voltage will be reduced to match that of the battery [9].

A DC-to-DC converter is not the same as a PWM controller. Through a switch, the PWM controller connects the solar panel to the battery. When the switch is closed, the panel and the battery will be close to the same voltage. The panel will be at =13.5V considering a voltage loss of 0.5V across cabling and controller, and the starting charge voltage will be about 13V assuming a drained battery. The voltage will progressively rise when the voltage is increased. the battery's current state of charge When the absorption voltage is achieved, the PWM controller will begin disconnecting and reconnecting the panel in order to prevent [9] Three types of PWM techniques are mainly used around the world. These are constant current techniques, constant current-constant voltage, and three-stage charging [10].Figure 2.1 shows the PWM Solar Charge Controller.



Figure 2.1 PWM Solar Charge Controller

2.3.2 Benefits of using Pulse Width Modulation (PWM)

The following are some of the benefits of using a PWM system:



2.3.3 Maximum Power Point Tracking (MPPT)

The most advanced solar charge controller available today is Maximum Power Point Tracking (MPPT). It is both more advanced and more expensive. There are a few advantages to it over a PWM charge controller. It is 30 to 40% more efficient at low temperatures. The MPPT is powered by a synchronous buck converter circuit. It translates the higher solar panel voltage to the charging voltage of the battery [11]. It will change its input voltage to capture the maximum amount of energy from the solar panel, then transform that energy to meet the varied voltage requirements of the battery and load. In a frigid temperate environment, PWM will function better, however in a subtropical to tropical climate, both controllers will operate identically. A DC-to-DC transformer, the MPPT charge controller can convert power from a higher voltage to a lower voltage. Because the quantity of power does not change, the output current will be greater than the input current if the output voltage is lower than the input voltage, resulting in a constant product P=VI. A charge controller should be able to choose the best current voltage point on the current-voltage curve: the Maximum Power Point, to get the most out of a solar panel [12]. That is precisely what an MPPT accomplishes.

2.3.4 Benefits of using Power Point Tracking (MPPT)

- With the MPPT controller, a panel array can get a higher voltage than a battery bank.
- Provide an increase in charging effiency up to 30% compared to PWM
- Greater Flexibility for system growth

•They typically come with higher warranty periods than the PWM type

UNIVERSITI TEKNIKAL MALAYSIA MELAKA 2.4 Comparison PWM and MPPT

To understand the differences between PWM and MPPT charge controllers and how they work, students must first become familiar with the usual I-V and power curves of a PV panel, as well as the effects of solar irradiation and ambient temperature on them. The short-circuit current of a PV module grows as solar irradiation increases, but the open circuit voltage falls as the module's temperature rises. As a result, MPPT is advised for PV arrays with rated power larger than several hundred watts or grid-connected installations [13] as shown in Figure 2.2 and Figure 2.3.



The PV array is linked in parallel to the battery when charging it, and the load and its operating point are governed by the battery voltage and the maximum current the PV array can generate at that voltage. To avoid overcharging the battery, the controller disconnects and reconnects the PV array at a predetermined frequency once the battery is fully charged. The frequency and duty ratio of the PWM are often determined by the current drawn by the load as well as the operating parameters of the PV panel [14].

The following is a comparison:

• Temperature conditions

In colder climates, an MPPT controller is more appropriate. The extra module voltage can be captured by the MPPT controller and used to charge the batteries. It can charge up to 20-25 % faster than a PWM controller [15]. This because pulse width modulation technology charges at the same voltage as the battery, the PWM type is unable to catch surplus voltage. However, when solar panels are installed in warm or hot climes, there is no excess voltage to be transferred, negating the MPPT's benefit over a PWM.

• Array Voltages

AALAYSI.

For PWM, the PV array and battery voltages should be the same, however for MPPT, the PV array voltage can be higher than the battery voltage.

• Battery Voltage

PWM operates at battery voltage, so it performs well in warm temperature and when battery is almost full while MPPT operates above the battery voltage, so it can provide "boost" in cold temperatures and when the battery is low.

• System Size

PWM is often advised for usage in smaller systems where the benefits of MPPT are minor, whereas MPPT is recommended for systems with a power rating of 150W-200W or greater.

• Cost

MPPT controllers are more expensive than PWM controllers, but they are more efficient under certain conditions, allowing them to produce more electricity with the same number of solar modules. This control system consisted of a solar energy transformation unit, an energy storage unit, and a control unit for day/night transition and time setting. To boost energy conversion efficiency and battery longevity, a Li-ion battery charging system and MPPT function were implemented. The solar energy conversion efficiency of the developed road traffic sign system is 90 % of the total, with a standby power of 8.8mW and a load power of 2W [14].

5	7	
Specification	Our System	Remark
Charging Mathod	PWM	Usually MPPT
Battery Type	تى تيكني Li-ion	اونيومرسي
Main Power Source	Panel / Battery EKNIKAL MALAYS	Only Battery
Day/Night Distinction	Able	Day -> Night : 5V Night -> Day : 6V
Load Time Setting	Able	
Charging Efficiency	93%	Input Panel Voltage : 17V
Discharging Efficiency	99.6%	Consume 8.8mW, when use 2W load

 Table 2.1 Comparison between PWM and MPPT

Based on Table 2.1 above, it was described a comparison between PWM and MPPT that can be determine which is more efficiency to use for long term usage. This PV charge controllers today include PWM and MPPT. PWM is often chosen to be utilised at low power since it is less expensive. MPPT, on the other hand, is favoured at medium and high powers due to its high cost. Many MPPT procedures are utilised around the world, but this study will focus on the most well-known technique, the P&O technique [15].

2.5 Charge Control Design

There are two ways to control or regulate the charge of a battery. Shunt and series regulation are the two. While both strategies are effective, they differ in a number of ways that affect their overall performance and application. The controller is called as Series Type when the MOSFET switch is linked in series with the PV Array and the battery. It is referred to as a Shunt Type when it is connected across the PV Array / Battery. When the batteries are fully charged, the MOSFET Switch of the Series Type remains open as example in Figure 2.4. The Photovoltaic Panel stops supplying current during this period [15].



Figure 2.4 Example Series Design

Figure 2.5 shows a controller that works in series with the array and the battery. The series type controller has various varieties, all of which use some form of control or regulation element in series. Relay or solid-state switch either closes the circuit between the array and the battery to stop charging or restricts the current in a series-linear fashion to keep the battery voltage high [15].



When the batteries are fully charged, a shunt charge controller directs extra current to

a "shunt" load, such as an electric water heater. The shunt controller controls the charging of a battery from the charge controller's PV array. To prevent the battery from shortcircuiting while the array is regulating, all shunt controllers must contain a blocking diode in series between the battery and the shunt element. In shunt controllers, the regulating element is usually a power transistor or a MOSFET, depending on the design[15].

2.6 Summary

This chapter discussed the research for the study of this project. Since this study is about control charging, the study includes whether a PWM control charge by solar power project is suitable to be carried out in Malaysia. The types of solar panels and type control charging that suitable for this project. In conclusion, this project is suitable to be carried out in Malaysia and the choice of the solar control charge is PWM.



CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter focuses the methods used to construct this project. The hardware and software components of this project will be separated. To ensure the success of a project, several components must be examined and organized properly to ensure the project's completion. In general, this chapter will explain and describe the project's development process briefly through flowcharts and block diagrams to ensure a better knowledge of the process.

3.2 Methodology

This project provides a controlling charging by solar panel that is self-contained and self-sustaining. To complete the function of control charging by solar, a variety of characteristics will be incorporated. The system is developed in stages, beginning with research, followed by hardware development, software development, and lastly data collection. This chapter details all the methodologies, equipment, and software used. Figure 3.1 shows the overview of the Flowchart for the project development .



3.3 Development of Software

Software development is required for this project to ensure that the system functions properly. The software required included circuit diagram sketching, microcontroller command scripting, and the creation of an application for controlling related software functions.

3.3.1 Proteus Software

Proteus 8 Professional simulates circuits before putting them into real-time circuits. The software runs on the Windows operating system and is available in English, French, Spanish, and Chinese. Proteus is a programme for simulating microprocessors, capturing schematics, and designing printed circuit boards (PCB). The circuit design environment, ISIS, and the circuit board designer, ARES, are two critical components. To create schemes and conduct real-time circuit simulations, ISIS (Smart Schematic Input System) is employed. Real-time simulation is achieved by allowing human interaction during the simulation's run period. The component library of ISIS contains a wide range of components. It includes signal generators, measuring and analysis tools like voltmeters and oscilloscopes, as well as samples to monitor.Figure 3.2 show the application Proteus



Figure 3.2 Application Proteus

3.3.2 Multisim

Multisims is an application that is commonly used for designing circuit diagrams and simulating them. Since it is commonly used among university projects and laboratory works, it is a suitable choice for designing the circuit diagrams for this project. This application is used in designing the circuit diagram of the PV system.

3.4 Development of Hardware

LAYS/

PV system is the input of this project and responsible for powering the whole system. Hence, to ensure the effectiveness and consistency of the system, the performance of the PV system developed should be prioritized. Several aspects should be paid attention to as they are the main factors that influencing the performance of the PV system.Figure 3.3 shows the diagram of PV system.



Figure 3.3 Example circuit diagram of PV system



3.4.1

Solar panels are employed as the power source in this project. Solar panels come in a variety of sizes, output power, costs, and other characteristics. Because the solar panel's design is so significant in the development of the project, it's crucial to find the solar panel with the best compatibility.Figure 3.4 shows the Monocrystalline Solar Panel.


Figure 3.4 Solar Panel

Among all the solar panels, the monocrystalline solar panel is selected as the type of solar panel used in this project. This selection is based on the consideration of the efficiency of the system. Monocrystalline solar panels have an average efficiency of 15% - 20% which is the highest among all the commonly used solar panels. Hence, the monocrystalline solar panel is selected to ensure the efficiency of the system.

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Here the following of solar panel output power :

LED per unit watt = 2 watts

Power bank power rating = 10 watts

Total power of LED and power bank = 12 watts

The average hour of LED and power bank usage per day = 8 hours

Average daily power consumption = $12 \times 8 = 96$ Wh

Average monthly power consumption = $96Wh \times 30 = 2880Wh$

Average daily sunlight in Malaysia = 8 hours

Average monthly sunlight in Malaysia = 240 hours

Power required from solar panels = 2880Wh/240 hours = 12Wh

Hence, the output power requirement for solar panels should be at least 12 watts per hour to ensure the efficiency of the system.

3.4.2 Solar Rechargeable Sealed Lead Acid Battery

The longest-used battery in solar power generation. The currently widely used solar storage batteries mainly include lead-acid maintenance-free batteries and gel batteries. These two types of lead acid battery solar are ideally suited for reliable solar power generation systems owing to their characteristics of inherent maintenance-free and less environmental impact.

3.5 Type of Microcontroller

A microcontroller is a semiconductor integrated circuit (IC) chip that has numerous functional blocks such as Bus Width, Memory, Instruction Set, and Memory Architecture. It's essentially for a tiny computer that includes all peripherals in one container. Figure 3.5 shows the type of microcontroller.



Figure 3.5 Type of Microcontroller

3.5.1 MosFet

The metal-oxide-semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a type of field-effect transistor (FET) that is most commonly made by controlled silicon oxidation. It has an insulated gate, the voltage of which determines the device's conductivity. This ability to change conductivity in response to voltage applied can be used to amplify or switch electronic signals. MOSFET is almost synonymous with metalinsulator-semiconductor field-effect transistor (MISFET). IGFET stands for insulated-gate field-effect transistor. RSITI TEKNIKAL MALAYSIA MELAKA

3.5.2 Timer 555

In bistable mode, the 555 timer acts as an SR flip-flop. The trigger and reset inputs are heldhigh via pull-up resistors while the threshold input is grounded. Thus configured, pulling the trigger momentarily to ground acts as a "set" and transitions the output pin to V_{CC} (highstate).Figure 3.6 shows Timer 555 for this project.



Figure 3.6 Timer 555

3.5.3 1N4007 Diode

The 1N4007-T is a Rectifier Diode with moulded plastic case. The rectifier diode has high current capability and low forward voltage drop. Diffused Junction. High Current Capability and Low Forward Voltage Drop. Low Reverse Leakage Current.

3.5.4 Variable Resistor

Variable resistors are widely used in electric circuits to adjust the value of current or voltage, since the resistance of variable resistors can be set to a certain value. Variable resistors allow you to adjust the value of voltage by changing the resistance and keeping current constant.

3.5.5 Voltage Sensor

The voltage sensors detect the voltage of the solar panel and the battery. It's done with the help of two voltage divider circuits. It has two resistors for sensing solar panel voltage, R1=100k and R2=20k, and R3=100k and R4=20k for sensing battery voltage. R1 and R2 outputs are connected to Arduino analogue pin A0, while R3 and R4 outputs are connected to Arduino analogue pin A1. The voltage sensor is depicted in Figure 3.6. The Voltage Control mode is used to avoid overcharging of the battery when the battery voltage exceeds the reference limit. To provide a consistent output voltage at the battery terminals, the operating point of the PV panels is adjusted correspondingly.

3.5.6 Current Sensor

The current sensor is used for measuring the load current. Later this current is used to calculate the load power and energy.Figure 3.7 shows the Current Sensor.



The temperature sensor is used to sense outdoor temperature . This project used the LM35 temperature sensor which is rated for -55° C to $+150^{\circ}$ C Range.Figure 3.8 shows the temperature sensor .



Figure 3.8 Temperature Sensor

3.5.8 Liquid Crystal Display (LCD)

LCD is a device commonly used calculators, massage chairs, radios, etc. It often shows information in words. A Liquid Crystal Display (LCD) is a display that uses Liquid Crystal as the reflex medium. A Liquid Crystal Display (LCD) is a display that uses Liquid Crystal as the reflex medium. There are tens of thousands of pixels on a colour LCD display, such as a monitor. Pixels are the smallest units in a liquid crystal display. The tens of thousands of pixels represent a picture 100 or words from an electric device's instructions. LCD contains 2 lines, and each line has 16 features that were used in this project, known as 16 x 2 LCD. Furthermore, the advantages of LCD such as being economically easily programmable enable the LCD to replace the LED in many projects successfully. This LCD features two registers: one for storing the LCD's command instructions, and another for storing the data to be displayed on the LCD. Figure 3.9 shows the liquid crystal display (LCD) module 16×2



Figure 3.9 Liquid Crystal Display (LCD) module

Features of 16x2 LCD module:

- Consumption current is 1mA without backlight
- The operating voltage range from 4v to 5v
- LCD display module alphanumeric, this enables of alphabets

3.6 Tools

There are a few tools used in this project to measure the input and output power in all the parts of the project. The measurement is done to achieve the precise data and reading of certain values to ensure the compatibility of the equipment of the system.

3.6.1 Voltmeter

The voltmeter is an instrument used for measuring the potential difference across an electric circuit. Voltmeter comes in both analog and digital. A voltmeter can be used to determine both DC voltage and sinusoidal AC voltages. The voltmeter has to be connected parallelly to the circuit or component which is needed to be measured. The voltmeter will connect two points across the circuit and the result shown is the measured voltage of the given circuit. For analog voltmeters, it is recommended to calibrate them before measuring although digital voltmeters are relatively more commonly used nowadays.

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3.6.2 Ammeter

The ammeter is an instrument used for measuring the amount of current flowing through an electric circuit. The ammeter can be used to measure both direct current and alternating current. Ammeter comes in both analog and digital. It can be used for measuring a wide range of current as the shunt mechanism in the ammeter will ensure that only a small portion of current will be directed through the meter even when measuring high-value currents. The ammeter must connect in series to the circuit or equipment that requires measuring. By connecting to the circuit, the current flowing through the circuit can then be measured and shown in Ampere by the ammeter.

3.6.3 Watt Meter

The wattmeter is an instrument for measuring the electric active power (or the average of the rate of flow of electrical energy) in watts of any given circuit. Electromagnetic wattmeters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements.

3.7 Data Collection

To ensure that the Controlling Charge by solar panel is working as planned, collection of data should be carried out. The working of the system is separated into two parts which are the input and the output. The input of the system refers to the PV system which generates the energy required for the system to function, while the output is the effectiveness of control charge to cut off from overcharges. Data collection regarding both parts should be done to ensure the effectiveness and consistency of the system. For testing the efficiency of the system input, the system will be running for several days continuously. During this period, the energy generated and consumed by the system is recorded and compared to confirm if the system self-sufficient. Meanwhile, the output of the system will be tested in terms of its accuracy when functioning passively and also when being controlled by using the developed application.

3.8 Time Horizon

Table 3.1 show the Time Horizon during the development of solar control charging system.

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		2022									2023																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Project Title																																						
Problem Definition																																					_	
Identify project objective																																						
Procedure preparation					1		AR	Α.	Y S	4	1																											
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Smart meter logger production																																						
Experiment																																						
Data Analysis																																			_		_	
Discussion and Conclusion																																						

Table 3.1 Time Horizon durig Development of Solar Control Charging System

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter records and discusses the results obtained through the development of the project entitled 'Controlling Charge System by Solar Panel' and from this project will be focusing on the power generated by the PV system and the efficiency of the controlled charge system. In the first stage of project planning, the preliminary result will be obtained mostly based on theories and research. The results stated in this chapter will be explaining the performance of the PV system developed in this project, and whether the PV system can make the whole system self-sufficient. Besides, the accuracy of the controlled charge system with solar panel will be recorded. The results will then be further analysed to find out its performance in reducing the wastage of electricity

4.2 Implementation of Control Charging System

The Controlled Charge System with PV Solar is a self-sufficient solar powered controlling system. This system is targeted to be implemented for outdoor rooms. For the power generation, the PV system is expected to generate more energy than the consumption of the controlled charge system to keep the whole system self-sufficient.

Based on the calculation, the solar panels should be generating more than 12 WH to keep the system functioning. Since the controlled charging system functions most during the night-time, the power generated by the solar panels during daytime should be used to charge up the battery bank. Meanwhile, the charge controller connected to the battery will be controlling the amount of current flowing into the battery bank to prevent it from overcharging. When the controlled charge system functions, energy will be drained from the battery bank to power the system.

As there is no PWM in this bulk mode, a pre-set maximum constant amount of current (amps) is supplied into the battery. The voltage of the battery progressively increases while it is being charged. When the battery reaches the bulk charge voltage, the PWM starts holding the voltage constant. This is done to prevent the battery from overheating and over-gassing. As the battery charges more fully, the current will decrease to safe levels. This mode is known as absorption. Finally, when the battery has been entirely recharged, the charging voltage is decreased to prevent additional heating or gassing of the battery. This is the optimal charging method. The present charge cycle block of code is not implemented 3 stages charging. So can conclude use an easier logic in 2 stages.

The bulk charge starts when the solar panel voltage exceeds the battery voltage. When the battery voltage reaches 14.4V, an absorption charge will be applied. The PWM signal will control the charging current in order to maintain the battery voltage at 14.4V for one hour. The float fee will take effect after one hour. The float stage generates a trickle charge to maintain the battery voltage at 13.6V. If the battery voltage goes below 13.6V for 10 minutes, the charging cycle will be restarted. The benefits include automatic load connection and disconnection by monitoring dusk/dawn and battery voltage, as well as load control. When the PV voltage level goes below 5V and the battery voltage is higher than the LCD setting in the evening, the controller will turn on the load and the load green light will glow. The load will be shut off in the following two scenarios. When the PV voltage is greater than 5v in the morning. Seconds is when the battery voltage is lower than

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the LCD setting. The load red lit ON signifies that the load has been shut off. LCD is an abbreviation for Low Voltage Disconnect. Then, Figure 4.1 below shows a summary stages during the charging system from nightime to daytime.



Figure 4.1 Stages for Charging System

4.2.1 The Control Charging Signal Generator

The function of the controlled charging system by solar panel is designed and control the performance of changing to the battery bank with setup parameter to avoid overcome of overcharged and trace weak percentage of battery bank .

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A transmission signal data using a circuit that have been constuct in this project for generates a pulse width modulation signal by switching a power MOSFET transistor with a 555 timer as shown in Figure 4.2 below.



Figure 4.2 Schematic Circuit Signal of Controlled Charging System

A 555 timer is configured as an astable oscillator in the circuit above. At a specific duty cycle, the 555 timer will generate the pulse width modulation signal and switch the MOSFET transistor Q1. This circuit's MOSFET transistor is the IRF540 MOSFET transistor. D1 is an LED that will be brightened and dimmed as a result of signal. This, however, can be replaced by any other device that requires the signal and Diode D2 protects the MOSFET transistor from any back EMF caused by an inductive load (such as a motor). Resistors R1, R2, R4, and capacitor C3 keep the frequency at around 595 Hz. The frequency is fixed at about 595 Hz by resistors R1, R2, R4 and capacitor C3.



Figure 4.3 4.6% Duty Cycle

Figure 4.3 shows the ouput waveform for 4.6% of Duty Cycle .It can be seen that the voltage peak to peak is the smallest waveform.



Figure 4.4 50% Duty Cycle

Figure 4.4 shows the output waveform of 50% of Duty Cycle, that have the larger Voltage peak to peak than 46% Duty Cycle.



Figure 4.5 93.6% Duty Cycle

Lastly, Figure 4.5 shows the highest Duty Cycle that is 93.6%, also the largest Voltage peak to peak for the transmission signal PWM. If the frequency is too low, it will get visible flickering on the LED, and if too high, the control device or the load will not be able to turn on and off fast enough.

4.2.2 The PCB of Controlled Charging System

The connection PCB control charging system is shown in Figure 4.6, and the panel slot for connection from solar panel ,battery panel and the load panel at the right is shown in Figure 4.7.



Figure 4.7 The connection Panel

4.2.3 The LCD Display

Figure 4.8 shows the LCD Display based on the project setup below :



Figure 4.9 Interface Main Display

Figure 4.9 show the Interface Main Display on The LCD when the connection with solar panel to battery and load has been started.



Figure 4.10 Interface Float Voltage

Figure 4.10 shows the Interface Float Voltage. The voltage reach the maximum Voltage and the phase of control charging will occur to avoid battery bank from overcharged.



Figure 4.11 Interface Discharge Reconnect

Figure 4.11 shows the Interface Discharge Reconnect.It simplifies when the connection from the battery bank was used direct to the load.



Figure 4.12 Interface Discharge Stop

Figure 4.12 show the Interface Discharge Stop during using the load. The capacity for the battery bank is 0 or empty and cannot supply the load anymore.



Figure 4.13 Interface Work Mode

Figure 4.13 shows the work mode that can set for usage of load in 24 hours.



capacity of battery of 2/3 bar of capacity battery.

4.2.5 The System Connection with Output MALAYSIA MELAKA

Stages for prototype installation are as follows:

1. Firstly, charging the battery bank using photovoltaic module with connection to control charge board as shown in Figure 4.15.

2. After complete the phase of charging, connect the battery, control charger board, inverter and the load as shown in Figure 4.16.

3. Make a collection of data and comparison for the usage of the battery bank and the load that have been used.



Figure 4.15 Charging System



Figure 4.16 Prototype System Circuit of Discharged with Load

4.3 The Calculation

Charging time of battery bank = Ampere / Hours

Ampere

Solar panel power = Solar Panel Voltage x Solar Panel Ampere

Ampere / hours = Ampere x 0.17

Watt / hours = Solar Panel Voltage x Solar panel Ampere x 0.17

4.4 The Experiment Result

The experiment has been carried out from 27/12/2022 until 2/1/2023. The results obtained are tabulated as below wars and the second sec

4.4.1 The Charging Day 1

 Table 4.1 Reading Charging Day 1

	CHARGING DAY 1 (CLOUDY DAY)											
TIME	VOLTAGE	CURRENT	Ampere/Hour	Watt/Hour	HOURS							
1150	13.25	0.61	0	0								
1200	13.45	LI TEKNIKAL	MALAYSIA	MELAKA								
1210	14.05	0.57	0.19	2.5								
1220	13.31	0.69	0.21	2.8								
1230	13.33	0.62	0.22	3								
1240	14.43	0.59	0.24	3.2								
1250	13.38	0.68	0.25	3.4	1 hours							
1300	13.37	0.37	0.26	3.6								
1310	13.42	0.45	0.28	3.7								
1320	13.33	0.43	0.29	3.9								
1330	13.42	0.48	0.28	3.7								
1340	13.4	0.38	0.3	3.8								
1350	13.42	0.21	0.31	4.2	2 hours							
1400	13.4	0.14	0.33	4.4	3 hours							

1410	13.48	0.18	0.5	4.8	
1420	13.32	0.82	0.5	6.6	
1430	13.32	0.26	0.54	7.18	
1440	13.4	0.3	0.57	7.9	
1450	13.35	0.4	0.61	8.07	
1500	13.37	0.8	0.74	12.07	
1510	13.38	0.8	0.87	13.85	
1520	13.59	0.23	0.91	14.37	
1530	13.67	0.33	0.96	15.12	
1540	13.55	0.35	1.02	15.91	
1550	13.33	0.36	1.08	16.71	4 hours
1600	13.18	0.28	1.13	16.78	
1610	13.44	0.3	1.18	17.45	
1620	13.49 AY S	0.27	1.23	18.55	
1630	13.21	0.18	1.26	18.94	
1640	13.36	0.2	1.29	19.39	
1650	13.42	0.21	1.33	19.86	5 hours
1700	13.4	0.18	1.36	20.25	
1710	13.38	0.2	1.39	20.7	
1720	13.36	0.17	1.41	21.08	
1730	13.28	0.18	1.44	21.48	
1740	13.2	0.19	1.47	21.89	
1750	13.1	0.18	1.5	22.28	6 hours



Table 4.1 and Figure 4.17 show the experimental result on 27/12/2022. The power generated at 11.50 am is higher while 2.20 pm has the highest power generated. Meanwhile, there is a drop in power after 2.20 pm to 5 pm as the weather during that time has changed from sunny to cloudy .

4.4.2 The Charging of Day 2

Cable 4.2 Readin	g Charging Day 2
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CHARGING DAY 2										
TIME	VOLTAGE	CURRENT	AMPERE/HOUR	WATT/HOUR	HOURS					
1100	12.53	0.83	0.01	0.2						
1110	12.64	0.85	0.1	1.3						
1120	12.72	0.93	0.27	3.4						
1130	12.45	0.96	0.4	5	1 HOURS					

1140	12.8	0.94	0.56	7.1	
1150	12.84	0.93	0.71	9.1	
1200	12.87	0.93	0.86	11	
1210	12.9	0.86	1.03	13.1	
1220	12.95	0.9	1.17	14.9	
1230	12.98	0.85	1.32	16.8	
1240	13.03	0.87	1.46	18.7	
1250	13.08	0.87	1.61	20.6	
1300	13.11	0.85	1.76	22.6	2 HOURS
1310	13.16	0.85	1.89	24.3	
1320	13.16	0.77	2.04	26.3	
1330	13.18	0.74	2.15	27.6	
1340	13.18	0.66	2.28	29.4	
1350	13.16 AY 5	0.58	2.42	31.2	
1400	13.23	0.64	2.51	32.32	3 HOURS
1410	13.23	0.64	2.57	33.1	
1420	13.32	0.71	2.66	34.3	
1430	13.32	0.6	2.77	35.9	
1440	13.3	0.58	2.85	36.8	
1450	13.3	0.53	2.93	37.9	
1500	13.35	0.54	3.03	39.3	4 HOURS
1510	13.38	0.52	3.14	40.7	
1520	13.37	0.31	3.23	41.8	
1530	13.32	0.38	3.26	42.2	
1540	13.2	0.23	3.31	42.9	
1550	13.16	0.2	3.34	43.9	
1600	13.18	0.2	3.38	43.8	5 HOURS
1610	13.21	0.23	3.42	44.31	
1620	13.18	0.17	3.45	44.68	
1630	13.18	0.17	3.48	45.05	
1640	13.16	0.15	3.51	45.13	
1650	13.15	0.13	3.53	45.2	
1700	13.11	0.1	3.55	45.42	6 HOURS



Figure 4.18 Graph Charging Day 2

Table 4.2 and Figure 4.18 show the experimental result on 28/12/2022. The power generated at 5 pm is the lowest while 11.30 pm has the highest power generated. The power generated from 2.30 pm to 4 pm is lower as the weather during that time was cloudy.

4.4.3 The Charging of Day 3 UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Table 4.3 Reading Charging Day 3

CHARGING DAY 3											
TIME	VOLTAGE	CURRENT	AH	WH	HOURS						
1100	12.73	0.9	0	0							
1110	12.69	0.85	0.14	1.8							
1120	12.7	0.91	0.3	3.73							
1130	12.41	0.87	0.45	5.53							
1140	12.51	0.89	0.6	7.4							
1150	12.64	0.92	0.75	9.34							
1200	12.68	0.93	0.91	11.31	1 JAM						
1210	12.71	0.86	1.1	13.13							
1220	12.75	0.9	1.25	15.04	2 JAM						

1230	12.81	0.95	1.41	17.01	
1240	12.85	0.89	1.55	18.91	
1250	12.91	0.87	1.7	20.71	
1300	12.95	0.85	1.8	22.54	
1310	13.11	0.89	1.9	24.48	
1320	13.16	0.74	1.9	26.1	
1330	13.18	0.78	2.03	27.81	
1340	13.21	0.72	2.15	29.4	
1350	13.16	0.7	2.27	30.9	
1400	13.18	0.64	2.38	32.3	3 JAM
1410	13.21	0.64	2.48	33.71	
1420	13.25	0.62	2.58	35.08	
1430	13.32	0.6	2.68	36.41	
1440	13.3 AYS	0.58	2.77	37.69	
1450	13.4	0.61	2.87	39.05	
1500	13.35	0.6	2.97	40.39	4 JAM
1510	13.38	0.58	3.06	41.68	
1520	13.35	0.45	3.13	42.68	
1530	13.41	0.38	3.19	43.53	
1540	13.2	0.35	3.24	44.3	
1550	13.16	0.3	3.29	44.95	
1600	13.18	0.32	3.34	45.65	5 JAM
1610	13.21	0.23	3.37	46.15	
1620	13.27	0.17	3.39	46.52	
1630	13.2	0.17	3.41	46.89	
1640	13.16	0.15	3.43	47.21	
1650	13.15	0.13	3.45	47.49	
1700	13.1	0.11	3.47	47.73	6 JAM



Figure 4.19 Graph Charging Day 3

Table 4.3 and Figure 4.19 show the experimental result on 29/12/2022. The power generated at 5 pm is the lowest while 12.30 pm has the highest power generated. Meanwhile, there is a drop of power at 1.10 pm as it was raining during that time.

4.4.4 The Charging of Day 4 UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Table 4.4 Reading Charging Day 4

	CHARGING DAY 4											
TIME	VOLTAGE	CURRENT	AMPERE/HOUR	WATT/HOUR	HOURS							
1100	13.1	0.33	0.03	0.73								
1110	13.19	0.39	0.09	1.6								
1120	13.15	0.41	0.17	2.53								
1130	12.92	0.53	0.26	3.69								
1140	13.1	0.67	0.36	5.18								
1150	13.15	0.78	0.49	6.92								
1200	13.1	0.91	0.64	8.94	1 HOURS							
1210	13.19	0.93	0.79	11.02								
1220	13.15	0.97	0.95	13.19	2 HOURS							

1					
1230	12.97	0.96	1.12	15.3	
1240	13.15	0.95	1.28	17.42	
1250	12.97	0.97	1.44	19.56	
1300	12.97	1.01	1.61	21.78	
1310	13.19	0.97	1.77	23.95	
1320	13.19	0.87	1.93	25.9	
1330	13.1	0.93	2.08	27.97	
1340	12.98	0.79	2.22	29.71	
1350	13.15	0.79	2.36	31.47	
1400	12.97	0.66	2.48	32.93	3 HOURS
1410	13.15	0.65	2.59	34.38	
1420	12.97	0.59	2.69	35.68	
1430	12.97	0.55	2.78	36.89	
1440	13.1 AYS	0.56	2.88	38.13	
1450	12.98	0.56	2.97	39.36	
1500	13.15	0.53	3.06	40.54	4 HOURS
1510	12.97	0.53	3.15	41.7	
1520	13.09	0.49	3.24	42.79	
1530	12.97	0.48	3.32	43.84	
1540	13.15	0.47	3.4	44.89	
1550	13.19	0.4	3.46	45.78	
1600	13.12	0.42	3.54	46.72	5 HOURS
1610	12.97	0.4	3.6	47.6	
1620	13.12	0.37	3.67	48.43	
1630	13.15	0.27	3.71	49.03	
1640	12.92	0.31	3.76	49.71	
1650	13.1	0.29	3.82	50.36	
1700	13.19	0.29	3.86	51.01	6 HOURS



Figure 4.20 Graph Charging Day 4

Table 4.4 and Figure 4.20 shows the experimental result on 30/12/2022. The power generated at 5 pm is the lowest while 1 pm has the highest power generated. Meanwhile, there is a drop of power at 1.30 pm because the weather turned cloudy.

Table 4.5 Reading Charging Day 5

CHARGING DAY 5											
TIME	VOLTAGE	CURRENT	AMPERE/HOUR	WATT/HOUR	HOURS						
1100	13.15	0.37	0.03	0.82							
1110	12.97	0.49	0.1	1.88							
1120	12.97	0.51	0.18	3							
1130	13.1	0.43	0.26	3.95							
1140	12.98	0.67	0.37	5.42							
1150	13.15	0.78	0.5	7.16							
1200	12.97	0.91	0.64	9.16	1 HOURS						
1210	13.09	0.93	0.8	11.23							
1220	12.97	0.97	0.96	13.36	2 HOURS						

1230	13.15	0.96	1.12	15.6	
1240	12.92	0.95	1.28	17.58	
1250	13.1	0.97	1.45	19.74	
1300	13.15	1.01	1.61	21.99	
1310	13.1	0.95	1.78	24.1	
1320	12.97	0.88	1.93	26.04	
1330	12.97	0.93	2.08	28.09	
1340	13.12	0.79	2.22	29.85	
1350	13.15	0.79	2.36	31.61	
1400	12.92	0.66	2.48	33.06	3 HOURS
1410	13.09	0.65	2.59	34.51	
1420	13.1	0.59	2.69	35.82	
1430	12.98	0.55	2.78	37.03	
1440	13.15 AY S	0.56	2.88	38.28	
1450	12.97	0.56	2.97	39.51	
1500	12.97	0.53	3.06	40.67	4 HOURS
1510	13.1	0.53	3.15	41.85	
1520	12.98	0.49	3.24	42.93	
1530	13.15	0.48	3.32	44	
1540	12.97	0.47	340	45.05	
1550	13.1	0.39	3.46	45.91	
1600	13.19	0.42	3.54	46.85	5 HOURS
1610	12.98	0.4	3.6	47.73	
1620	13.09	0.37	3.67	48.55	
1630	13.12	0.27	3.71	49.15	
1640	13.15	0.31	3.76	49.84	
1650	12.98	0.29	3.82	50.48	
1700	13.09	0.29	3.86	51.13	6 HOURS



Figure 4.21 Graph Charging Day 5

Table 4.5 and Figure 4.21 shows the experimental result on 31/12/2022. The power generated at 5 pm is the lowest while 1 pm has the highest power generated. The power generated has dropped and remained low during the whole afternoon.

4.4.6 The Charging of Day 6 EKNIKAL MALAYSIA MELAKA

CHARGING DAY 6 (HEAVY RAIN)					
TIME	VOLTAGE	CURRENT	AMPERE/HOUR	WATT/HOUR	HOURS
1100	13.1	0.26	0.02	0.57	
1110	12.98	0.18	0.06	0.96	
1120	13.15	0.26	0.11	1.54	
1130	12.97	0.27	0.15	2.13	
1140	12.97	0.26	0.19	2.7	
1150	13.1	0.12	0.21	2.97	
1200	12.98	0.17	0.24	3.35	1 HOURS
1210	13.15	0.16	0.26	3.71	2 HOURS

Table 4.6 Reading Charging Day 6

1220	12.97	0.16	0.29	4.06	
1230	13.1	0.12	0.31	4.32	
1240	13.19	0.12	0.35	4.58	
1250	12.98	0.13	0.37	4.86	
1300	13.15	0.1	0.38	5.08	
1310	12.97	0.08	0.4	5.25	
1320	13.1	0.09	0.41	5.45	
1330	12.92	0.06	0.42	5.58	
1340	13.1	0.06	0.43	5.71	
1350	12.97	0.06	0.45	5.84	
1400	13.1	0.06	0.46	5.97	3 HOURS
1410	13.19	0.06	0.47	6.1	
1420	12.92	0.06	0.48	6.23	
1430	13.1 AYS	0	0.48	6.23	
1440	13.09	0	0.48	6.23	
1450	13.12	×0	0.48	6.23	
1500	13.12	0	0.48	6.23	4 HOURS
1510	13.15	0	0.48	6.23	
1520	12.92	0	0.48	6.23	
1530	13.1	0	0.48	6.23	
1540	12.97	ىيە ق	0.48	6.23	
1550	12.98		0.48	6.23	
1600	12.97		0.48	6.23	5 HOURS
1610	13.09	0	0.48	6.23	
1620	13.09	0	0.48	6.23	
1630	13.15	0.12	0.5	6.5	
1640	12.92	0.13	0.52	6.79	
1650	13.15	0.14	0.54	7.1	
1700	12.92	0.04	0.55	7.19	6 HOURS



Figure 4.22 Graph Charging Day 6

Table 4.6 and Figure 4.22 show the experimental result on 1/1/2023. The power generated during 2.30 pm to 4.20 is the lowest because heavy rain was occured , and the power generated in lower performance because it was rainy for the whole day .

4.4.7 The Charging of Day 7 EKNIKAL MALAYSIA MELAKA

CHARGING DAY 7					
TIME	VOLTAGE	CURRENT	AMPERE/HOUR	WATT/HOUR	HOURS
1100	12.97	0.3	0.03	0.66	
1110	13.1	0.49	0.09	1.75	
1120	13.19	0.53	0.17	2.94	
1130	12.92	0.43	0.25	3.88	
1140	13.1	0.67	0.36	5.37	
1150	13.09	0.78	0.49	7.11	
1200	13.12	0.91	0.63	9.13	1 HOURS
1210	13.15	0.93	0.79	11.21	
1220	12.97	0.97	0.95	13.35	2 HOURS

1230	13.15	0.96	1.11	15.49	
1240	12.92	0.95	1.27	17.58	
1250	13.1	0.97	1.43	19.74	
1300	13.1	1.01	1.6	21.99	
1310	12.98	0.97	1.77	24.13	
1320	13.15	0.91	1.85	26.16	
1330	13.19	0.88	2.07	28.13	
1340	12.98	0.79	2.21	29.87	
1350	13.15	0.79	2.35	31.63	
1400	12.97	0.66	2.47	33.09	3 HOURS
1410	13.1	0.65	2.58	34.53	
1420	12.98	0.59	2.68	35.83	
1430	13.15	0.55	2.77	37.05	
1440	12.98 AY 5	0.56	2.87	38.29	
1450	13.15	0.56	2.96	39.54	
1500	12.97	0.53	3.05	40.7	4 HOURS
1510	12.97	0.53	3.04	41.86	
1520	13.1	0.49	3.23	42.95	
1530	12.97	0.48	3.31	44	
1540	13.1	0.45	3.39	45	
1550	13.15	0.4	3.45	45.89	
1600	12.92	0.42	3.52	46.81	5 HOURS
1610	13.1	0.4	3.59	47.7	
1620	13.09	0.37	3.65	48.52	
1630	13.12	0.27	3.7	49.12	
1640	13.15	0.31	3.75	49.81	
1650	12.92	0.29	3.8	50.44	
1700	13.1	0.29	3.85	51.09	6 HOURS



Figure 4.23 Graph Charging Day 7

Table 4.7 and Figure 4.23 shows the experimental result on 2/1/2022. The power generated at 5 pm is the lowest while 1 am has the highest power generated. Meanwhile, there is a little difference power generated between 11 am and 5 pm because the weather during the whole day is sunny.

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4.5 Analysis of the experiment

Table 4.7	Average	Reading fo	or Voltage vs	Current in	7 days

Average Charging				
Voltage	Current			
13.25	0.61			
13.45	0.58			
14.05	0.57			
13.31	0.69			
13.33	0.62			
14.43	0.59			
13.38	0.68			
13.37	0.37			
13.42	0.45			
13.33	0.43			
-------------------------------------	-------------------			
13.42	0.48			
13.4	0.38			
13.42	0.21			
13.4	0.14			
13.48	0.18			
13.32	0.82			
13.32	0.26			
13.4	0.3			
13.35	0.4			
13.37	0.8			
13.38	0.8			
13.59	0.23			
13.67	0.33			
13.55	0.35			
13.33	0.36			
13.18	0.28			
13.44	0.3			
13.49	0.27			
13.21	0.18			
13.36 🖕	0.2			
13.42	0.21			
13.4	0.18			
13.38	0.2			
13.36	0.17			
13.28	0.18			
13.2	او يونون سيني بيه			
13.1	0.18			
UNIVERSI ^{12.53} KNIKAL MA	LAYSIA M 0.83 KA			
12.64	0.85			
12.72	0.93			
12.45	0.96			
12.8	0.94			
12.84	0.93			
12.87	0.93			
12.9	0.86			
12.95	0.9			
12.98	0.85			
13.03	0.87			
13.08	0.87			
13.11	0.85			
13.16	0.85			
13.16	0.77			
13.18	0.74			
13.18	0.66			
13.16	0.58			

13.23	0.64	
13.23	0.64	
13.32	0.71	
13.32	0.6	
13.3	0.58	
13.3	0.53	
13.35	0.54	
13.38	0.52	
13.37	0.31	
13.32	0.38	
13.2	0.23	
13.16	0.2	
13.18	0.2	
13.21	0.23	
13.18	0.17	
13.18	0.17	
13.16	0.15	
13.15	0.13	
13.11	0.1	
12.73	0.9	
12.69 🖕	0.85	
12.7	0.91	
12.41	0.87	
12.51	0.89	
12.64	0.92	
12.68	0.93	
12.71	او د.86 سيبي بيه	
12.75	0.9	
UNIVERSI ^{12.81} EKNIKAL MA	LAYSIA ME0.95 KA	
12.85	0.89	
12.91	0.87	
12.95	0.85	
13.11	0.89	
13.16	0.74	
13.18	0.78	
13.21	0.72	
13.16	0.7	
13.18	0.64	
13.21	0.64	
13.25	0.62	
13.32	0.6	
13.3	0.58	
13.4	0.61	
13.35	0.6	
13.38	0.58	
13.35	0.45	

13.41	0.38
13.2	0.35
13.16	0.3
13.18	0.32
13.21	0.23
13.27	0.17
13.2	0.17
13.16	0.15
13.15	0.13
13.1	0.11
13.1	0.33
13.19	0.39
13.15	0.41
12.92	0.53
13.1	0.67
13.15	0.78
13.1	0.91
13.19	0.93
13.15	0.97
12.97	0.96
13.15	0.95
12.97	0.97
12.97	1.01
13.19	0.97
13.19	0.87
13.1	0.93
<u>المارك (12.98</u> مالاك	او دو.0.7 سىپتى بىچ
13.15	0.79
UNIVERSIT12.97=KNIKAL MA	LAYSIA ME0.66 KA
13.15	0.65
12.97	0.59
12.97	0.55
13.1	0.56
12.98	0.56
13.15	0.53
12.97	0.53
13.09	0.49
12.97	0.48
13.15	0.47
13.19	0.4
13.12	0.42
12.97	0.4
13.12	0.37
13.15	0.27
12.92	0.31
13.1	0.29

13.19	0.29
13.15	0.37
12.97	0.49
12.97	0.51
13.1	0.43
12.98	0.67
13.15	0.78
12.97	0.91
13.09	0.93
12.97	0.97
13.15	0.96
12.92	0.95
13.1	0.97
13.15	1.01
13.1	0.95
12.97	0.88
12.97	0.93
13.12	0.79
13.15	0.79
12.92	0.66
13.09	0.65
- 13.1	0.59
12.98	0.55
13.15	0.56
12.97	0.56
12.97	0.53
	0.53
12.98	0.49
UNIVERSI13.15EKNIKAL MA	LAYSIA ME0.48 KA
12.97	0.47
13.1	0.39
13.19	0.42
12.98	0.4
13.09	0.37
13.12	0.27
13.15	0.31
12.98	0.29
13.09	0.29
13.1	0.26
12.98	0.18
13.15	0.26
12.97	0.27
12.97	0.26
13.1	0.12
12.98	0.17
13.15	0.16

12.97	0.16	
13.1	0.12	
13.19	0.12	
12.98	0.13	
13.15	0.1	
12.97	0.08	
13.1	0.09	
12.92	0.06	
13.1	0.06	
12.97	0.06	
13.1	0.06	
13.19	0.06	
12.92	0.06	
13.1	0	
13.09	0	
13.12	0	
13.12	0	
13.15	0	
12.92	0	
13.1	0	
12.97	0	
12.98	0	
12.97	0	
13.09	0	
13.09	0	
13.15	0.12	
12.92	اوىيە:، سىپى بېھ	
13.15	0.14	
UNIVERSI ^{12.92} KNIKAL MA	LAYSIA ME0.04 KA	
12.97	0.3	
13.1	0.49	
13.19	0.53	
12.92	0.43	
13.1	0.67	
13.09	0.78	
13.12	0.91	
13.15	0.93	
12.97	0.97	
13.15	0.96	
12.92	0.95	
13.1	0.97	
13.1	1.01	
12.98	0.97	
13.15	0.91	
13.19	0.88	
12.98	0.79	

	13.15		0.79	
	12.97		0.66	
	13.1		0.65	
	12.98		0.59	
	13.15		0.55	
	12.98		0.56	
	13.15		0.56	
	12.97		0.53	
	12.97		0.53	
	13.1		0.49	
	12.97		0.48	
	13.1		0.45	
	13.15		0.4	
	12.92		0.42	
	13.1		0.4	
	13.09		0.37	
	13.12		0.27	
	13.15		0.31	
	12.92		0.29	
	13.1		0.29	
Average	TEKN	13.11622		0.508919
	4			



Figure 4.24 Graph for Voltage vs Current

According to the data collected in Table 4.7 and Figure 4.24 from 7 continuous days with 6 hours each day, the data for voltage generated by solar panels and the current (ampere) during charging time for the battery has been recorded. With the solar panel receiving sunlight for 6 hours per day for 7 consecutive days, the average voltage generated is 13.12V, and the average current during charging time for the battery bank is 0.51A. The system will be activated for approximately 8 hours each night beginning at 6 p.m., allowing the battery bank to charge without load during the day. When the battery bank is fully charged during the day, the system will run completely on the battery bank at night. The battery endurance of the battery bank is the maximum time for the load to be supplied solely by the battery bank.

Table 4.8 Average Ampere/Hours VS watt/Hours			
Average Charging			
AH AH	WH/		
0	0		
0.09	1.3		
0.19 C	2.5		
0.21	2.8		
0.22	3		
UNIVERSI10.24 EKNIKAL MA	LAT SIA ME3.2		
0.25	3.4		
0.26	3.6		
0.28	3.7		
0.29	3.9		
0.28	3.7		
0.3	3.8		
0.31	4.2		
0.33	4.4		
0.5	4.8		
0.5	6.6		
0.54	7.18		
0.57	7.9		
0.61	8.07		
0.74	12.07		
0.87	13.85		

Table 4.8 Average Ampere/Hours VS Watt/Hours

0.91	14.37	
0.96	15.12	
1.02	15.91	
1.08	16.71	
1.13	16.78	
1.18	17.45	
1.23	18.55	
1.26	18.94	
1.29	19.39	
1.33	19.86	
1.36	20.25	
1.39	20.7	
1.41	21.08	
1.44	21.48	
1.47	21.89	
1.5	22.28	
0.01	0.2	
0.1	1.3	
0.27	3.4	
0.4	5	
0.56	7.1	
0.71	9.1	
0.86	11	
1.03	13.1	
كنيك الليسيا ملاك	2	
1.32	16.8	
UNIVERSIT ^{1.46} EKNIKAL MA	LAYSIA ME ^{18.7} KA	
1.61	20.6	
1.76	22.6	
1.89	24.3	
2.04	26.3	
2.15	27.6	
2.28	29.4	
2.42	31.2	
2.51	32.32	
2.57	33.1	
2.66	34.3	
2.77	35.9	
2.85	36.8	
2.93	37.9	
3.03	39.3	
3.14	40.7	
3.23	41.8	

3.26	42.2	
3.31	42.9	
3.34	43.9	
3.38	43.8	
3.42	44.31	
3.45	44.68	
3.48	45.05	
3.51	45.13	
3.53	45.2	
3.55	45.42	
0	0	
0.14	1.8	
0.3	3.73	
0.45	5.53	
0.6	7.4	
0.75	9.34	
0.91	11.31	
1.1	13.13	
1.25	15.04	
1.41	17.01	
1.55	18.91	
1.7	20.71	
1.8	22.54	
1.9	24.48	
كنيك فليسبأ ملاك	26.1	
2.03	27.81	
UNIVERSIT ^{2.15} EKNIKAL MA	LAVSIA ME ^{29.4} KA	
2.27	30.9	
2.38	32.3	
2.48	33.71	
2.58	35.08	
2.68	36.41	
2.77	37.69	
2.87	39.05	
2.97	40.39	
3.06	41.68	
3.13	42.68	
3.19	43.53	
3.24	44.3	
3.29	44.95	
3.34	45.65	
3.37	46.15	
3.39	46.52	

3.41	46.89	
3.43	47.21	
3.45	47.49	
3.47	47.73	
0.03	0.73	
0.09	1.6	
0.17	2.53	
0.26	3.69	
0.36	5.18	
0.49	6.92	
0.64	8.94	
0.79	11.02	
0.95	13.19	
1.12	15.3	
1.28	17.42	
1.44	19.56	
1.61	21.78	
1.77	23.95	
1.93	25.9	
2.08 >	27.97	
2.22	29.71	
2.36	31.47	
2.48	32.93	
2.59	34.38	
کنیک (2.69 میں مالالے	35.68	
2.78	36.89	
UNIVERSIT ^{2.88} EKNIKAL MA	LAYSIA M ^{28.13} KA	
2.97	39.36	
3.06	40.54	
3.15	41.7	
3.24	42.79	
3.32	43.84	
3.4	44.89	
3.46	45.78	
3.54	46.72	
3.6	47.6	
3.67	48.43	
3.71	49.03	
3.70	49.71	
3.82	50.36	
3.86	51.01	
0.03	0.82	
0.1	1.88	

0.18	3	
0.26	3.95	
0.37	5.42	
0.5	7.16	
0.64	9.16	
0.8	11.23	
0.96	13.36	
1.12	15.6	
1.28	17.58	
1.45	19.74	
1.61	21.99	
1.78	24.1	
1.93	26.04	
2.08	28.09	
2.22	29.85	
2.36	31.61	
2.48	33.06	
2.59	34.51	
2.69	35.82	
2.78	37.03	
2.88	38.28	
2.97	39.51	
3.06	40.67	
3.15	41.85	
<u>ڪنيڪ</u> 3.24 سيبا ملاك	42.93	
	44	
UNIVERSIT ³⁴⁰ EKNIKAL MA	LAYSIA M ^{45.05} KA	
3.46	45.91	
3.54	46.85	
3.6	47.73	
3.67	48.55	
3.71	49.15	
3.76	49.84	
3.82	50.48	
3.86	51.13	
0.02	0.57	
0.06	0.96	
0.11	1.54	
0.15	2.13	
0.19	2.7	
0.21	2.97	
0.24	3.35	
0.26	3.71	

0.29	4.06	
0.31	4.32	
0.35	4.58	
0.37	4.86	
0.38	5.08	
0.4	5.25	
0.41	5.45	
0.42	5.58	
0.43	5.71	
0.45	5.84	
0.46	5.97	
0.47	6.1	
0.48	6.23	
0.48	6.23	
0.48	6.23	
0.48	6.23	
0.48	6.23	
0.48	6.23	
0.48	6.23	
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0.48	6.23	
0.48	6.23	
كنيكم الملاك	و د6.23 سيخ ش	
0.5	6.5	
UNIVERSIT ^{0.52} EKNIKAL MA	LAYSIA ME ^{6.79} KA	
0.54	7.1	
0.55	7.19	
0.03	0.66	
0.09	1.75	
0.17	2.94	
0.25	3.88	
0.36	5.37	
0.49	7.11	
0.63	9.13	
0.79	11.21	
0.95	13.35	
1.11	15.49	
1.27	17.58	
1.43	19.74	
1.6	21.99	
1.77	24.13	

1.85	26.16
2.07	28.13
2.21	29.87
2.35	31.63
2.47	33.09
2.58	34.53
2.68	35.83
2.77	37.05
2.87	38.29
2.96	39.54
3.05	40.7
3.04	41.86
3.23	42.95
3.31	44
3.39	45
3.45	45.89
3.52	46.81
3.59	47.7
3.65	48.52
3.7 🖻	49.12
3.75	49.81
3.8	50.44
3.85	51.09
1.522317	23.1961



Figure 4.25 Graph AH vs WH

According to the data collected in Table 4.8 and Figure 4.25 from 7 continuous days with 6 hours each day, the data for ampere per hours and the watt (power) per hours during charging time for the battery has been recorded. With the solar panel receiving sunlight for 6 hours per day for 7 consecutive days, the average ampere generated is 1.522A, and the average watt per hours during charging time for the battery bank is 23.19A.

4.6 The Discharging Battery with Load

DISCHARGING OUTPUT (POWERBANK 10000mah)						
TIME	VOLTAGE	CURRENT	AH	WH	HOURS	
1730	12.15	0.14	0	0		
1740	12.02	0.14	0.02	0.2		
1750	12.02	0.13	0.04	0.5		
1800	11.95	0.16	0.06	0.7		
1810	11.89	0.16	0.09	1.1		
1820	11.84	ulo, 0.15	0.12	او 4.4 مر بس		
1830	11.79	0.16	0.14	1.7	1 JAM	
1840	UNI 11.73 SI	I TE _{0:16} IKAL	MAI0.17YSIA	MELĄKA		
1850	11.67	0.16	0.2	2.2		
1900	11.66	0.16	0.22	2.6		
1910	11.53	0.16	0.25	2.9		
1920	11.43	0.15	0.28	3.2		
1930	11.22	0.16	0.3	3.5	2 JAM	
1940	10.89	0.16	0.33	3.8		
1950	10.59	0.16	0.36	4		
2000	10.3	0.16	0.38	4.3		
2010	9.86	0.17	0.41	4.6		
2020	9.58	0.16	0.44	4.5		
2030	9.13	0.16	0.48	4.8	3 JAM	

Table 4.9 Discharging Output



Table 4.9 and Figure 4.26, the supply from battery bank generated power highest in the 3 hours usage on 8.30 pm.At that time, the percentage battery of powerbank has already 100% .It can be concluded that for every 1 hour charging can generated power untill 32-33% of percentage battery. It also can convert sources supply from DC to AC output using the inverter regulator that change the transmission signal going smoothly.

4.7 Summary

This chapter has laid out the development and implementation of the project. The prototypehas been developed and the experiment have been carried out. The readings from solar panel for seven consecutive days have been analysed. The control charging system by solarpanel are able to monitoring and cut off the voltage to the battery bank from overcharged or undercharged depends on the value that have set to the battery bank .

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

For a brief description, the Controlling Charge System with PV Solar is an automatic cut off charge system that combined the features of generating self-sufficient solar power and developing application software for easy control. The system is separated into two categories which are the PV system and the controlled charging system. The PV system is functions to generate solar power during the daytime, and the energy generated will be stored by controlled charge system for later use. Meanwhile, the controlled charge will be powered by the battery and functions when charging port is needed by the user. The controlled charge system functions automatically by providing PV system and battery to the users when they need it and switching the load by automatically cut off when the maximum charge achieved. The settings of the controlled charge system can be easily adjusted through the software application developed alongside the system.

5.2 **Project Objectives**

This project entails the design and development of a PV solar charging system. The systemis designed to run automatically and completely self-sufficiently, relying solely on solar power. The three objectives stated in Chapter I have been met as follows:

5.2.1 Analyze the battery charging system

As highlighted in Chapter 2, the battery charging system can be known as made up of thealternator, battery, wiring and electronic control unit (ECU), your vehicle's charging system keeps your battery charged. It also delivers the energy necessary to run the lights, radio and other electrical components while the engine is running . In addition , my project is an upgraded version of existing battery charging system to solar version . Solar trickle chargers perform similarly to, if not better than, standard trickle chargers. They are especially useful if you live in the country and do not have access to a standard power outlet. As long as they are exposed to sunlight, these devices will steadily charge the battery to which they are connected.

5.2.2 Development battery charging by solar panel

A charger design that efficiently extracts power from a solar panel must be able to steer the panel's output voltage to the point of maximum power. The proposed hardwares have been laid out in Chapter 3. The development for battery charging system by solar panel have beenachieved and constructed in successfully, as stated in Chapter 4.

5.2.3 Evaluate the effectiveness of controls the charging system for the battery before gets overcharged or undercharged.

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The experiment , have been done successfully stated in Chapter 4. The effectiveness of controls the charging system for the battery before gets overcharged or undercharged can be determine by the stage charging system that have been successly achieved . The temperature sensor was operate so effectively to make sure the battery in situation overcharged or undercharged . Undercharging will occur if alternator voltage is low (13.6-13.8volts), the alternator belt is loose or battery cables are worn and causing high resistance. A battery will gradually heat up when overcharged at high rates. As it heats up, it will accept more current, causing it to heat up even more. This is known as thermal runaway, and it can destroy a battery in a matter of hours. The control charging system which has been developed in

Chapter 4 is able to set the parameter of battery voltage that can cut off the charging system before it sets overchanged.

5.3 **Project Limitation**

Several limitations and challenges were encountered during the project's development, which influenced the results obtained. The factors limiting the development of this project are documented so that they can be avoided in the future. The period chosen to experiment for data collection should be carefully chosen as the most significant limitation. The experiment on the performance of solar panels is carried out at the end of the year during the data collection phase of this project. Due to Malaysia's rainy seasons at the end of the year, the weather is mostly cloudy or rainy during this time. As a result, the intensity of sunlight during this period is lower than the Malaysian average of 71. As a result, solar panel performance will appear to be lower during this time.

In this project, the other limitation is sources for supplying that use is only 12V 7AH so the performance as a bank capacitor can't be a use for the usage of 2 or 3 output for the whole day. If the output load that use is electronic load such as lamp or powerbank that can supply only 220V-240V, it just can be used only in range 2 - 3 hours only. Otherwise, the output for the USB port on the PCB control charging system also can be used for 5V/3A.

5.4 **Project Recommendation**

The efficiency of the solar panel, the capacity and endurance of the battery bank, and the sensitivity of the sensor are the focal points of this project. First, the solar panel's efficiency should be high enough to provide enough power to charge the battery bank quickly. The solar panel is sufficient for the current project only because the load is small. Therefore, the solar panel should be upgraded to supply a larger load.

5.5 **Project Potential**

A control charger system maybe can be upgrade in term of big LCD display and all the parameters can be adjustable. To following the modern technology, this control charging system can build in industrial micro controller, even the cost quite high but it will more easily to setting and adjustable. In addition, this circuit also can be upgrade in dual Mosfet Reverse current protection to make sure low heat will be produce, so it safer for long term usage. Lastly, although this project quite high cost in starting installment but it also can reduce cost for long term usage and energy for charging system.

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APPENDICES

