UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electrical Technology and Engineering

Development of solar portable station using DC-AC inverter and Arduino for campers charging electronic device and power up lamp

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Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

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Development of solar portable station using DC-AC inverter and Arduino for campers charging electronic device and power up lamp

TAN WEI KHAWN

A project report submitted
in partial fulfillment of the requirements for the degree of
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Supervisor Name : DR. NUR AZURA BINTI NOOR AZHUAN

Date : 15 / 1 / 2024

DEDICATION

To my beloved mother, Bong Man Moi, and father, Tan Khoon Huat,
Your unflinching love and unending support have been my journey's beacons of hope. With each victory and hardship, your guidance and support formed me into exactly who I am today. This project is dedicated to the two amazing beings who have brought love, courage, and never-ending inspiration into my life. My dreams have their roots in your selfless dedication and sacrifices. I present this project as a sincere appreciation and homage to my amazing parents, whom have been my solid foundation.

ABSTRACT

This project is to create a portable solar station, sometimes known as a solar generator. The solar generator is designed for outdoor enthusiasts, especially campers. It uses renewable energy technology to effectively catch sunlight and transform it into power. This sustainable method offers a workable answer to the problems associated with obtaining electricity in isolated and off-grid areas. The project's major goal is to remove barriers associated with energy use, with an emphasis on proactive maintenance techniques and system operating efficiency. Modern parts are included into the solar portable station, such as an Arduino system for relay control and battery level monitoring, an inverter for converting DC to AC, and a solar charging system. Together, these elements fulfil the need for a dependable and adaptable power source that can meet the various requirements of outdoor activities. Throughout the project, successful solar charging under various weather circumstances has been proven, confirming the solar generator's effectiveness and efficiency. This creative method greatly reduces the carbon footprint associated with traditional power sources while simultaneously satisfying the power requirements of outdoor enthusiasts and adhering to ecologically friendly standards. All things considered, the solar portable station is an economical and environmentally friendly power source that may improve outdoor activities while encouraging energy conservation.

ABSTRAK

Projek ini adalah untuk mencipta sebuah stesen solar mudah alih, juga dikenali sebagai generator solar. Generator solar direka untuk penggiat luaran, terutamanya perkemah. Ia menggunakan teknologi tenaga boleh diperbaharui untuk menangkap sinar matahari dan mengubahnya menjadi tenaga. Kaedah lestari ini menawarkan penyelesaian yang berkesan terhadap masalah yang berkaitan dengan mendapatkan elektrik di kawasan terpencil dan luar grid. Matlamat utama projek ini adalah untuk menghapuskan sekatan yang berkaitan dengan penggunaan tenaga, dengan penekanan pada teknik penyelenggaraan proaktif dan kecekapan operasi sistem. Komponen moden disertakan dalam stesen mudah alih solar ini, seperti sistem Arduino untuk kawalan rele dan pemantauan aras bateri, inverter untuk menukar arus terus (DC) kepada arus ulang-alik (AC), dan sistem pengecasan solar. Bersama-sama, elemen-elemen ini memenuhi keperluan bagi sumber tenaga yang boleh diandalkan dan mudah diubahsuai yang boleh memenuhi pelbagai keperluan aktiviti luaran. Sepanjang projek ini, pengecasan solar yang berjaya di bawah pelbagai keadaan cuaca telah terbukti, mengesahkan keberkesanan dan kecekapan generator solar ini. Kaedah kreatif ini secara besar-besaran mengurangkan kesan karbon yang berkaitan dengan sumber tenaga tradisional sambil pada masa yang sama memenuhi keperluan tenaga penggiat luaran dan mematuhi piawaian mesra alam. Semua yang dipertimbangkan, stesen mudah alih solar ini adalah sumber tenaga yang ekonomikal dan mesra alam yang boleh meningkatkan aktiviti luaran sambil menggalakkan pemuliharaan tenaga.

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LIST OF SYMBOLS

℃	-	Degree Celcius
°F	-	Degree Fahrenheit

LIST OF ABBREVIATIONS

V	-	Voltage
%	-	Percentage
kW	-	KiloWatt
kWh	-	kiloWatthour
MW	-	MegaWatt
A	-	Ampere

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CHAPTER 1

INTRODUCTION

1.1 Background

Alternatives to the usage of non-renewable and toxins in fossil fuels must be researched in today's atmosphere of increasing energy needs and growing environmental concern. Solar energy is one such option.

According to The New England Journal of Medicine [1], the combustion of these fuels emits enormous amounts of airborne fine respirable particles with aerodynamic diameters of 2.5 m or less (PM2.5), sulfur dioxide, nitrogen oxides, polycyclic aromatic hydrocarbons (PAH), mercury, and volatile substances that form ground-level ozone. One billion children are exposed to extremely substantial amounts of air pollution worldwide. Fortunately, ways to significantly reduce, as well as in certain situations eliminate, these emissions are now available. Asthma attacks in children are caused by air pollution. It can also lead to respiratory infections, bronchitis, and decreased lung function and growth. A study found that children exposed to greater levels of air pollution had greater severity of asthma attacks and a lower percentage of regulator T cell components that play a vital role in managing allergic disorders like breathing difficulties than children from less polluted areas. Several definitions of sustainable development have been proposed, the most popular of which is development that satisfies the requirements of the present without jeopardizing future generations' ability to meet their own needs. According to recent World Energy Council (WEC) research, worldwide energy demand in 2020 would be 50-80% higher than in 1990 if nothing changes in our current practices [6].

According to a recent US Department of Energy (DoE) estimate, annual energy demand would increase from 363,000,000 kilowatts to more than 750 million kilowatts by 2020 [6]. Global energy consumption is expected to rise from 22 billion kWh per year today to 53 billion kWh by 2020. Such increased demand might put immense strain on the world's energy infrastructure while also endangering global environmental health via CO, CO_2, SO_2, and NO_x effluent gas emissions and global warming. Long-term solutions are required to address today's environmental issues prospective initiatives for sustainable development. Renewable energy resources appear to be one of the most efficient and effective alternatives in this regard, owing to the close association between renewable energy and environmental sustainability. More efficient energy consumption is a key step in transitioning from today's fossil-fuel-dominated world to one driven by non-polluting fuels and sophisticated technologies like photovoltaic (PV) and fuel cells (FC) [6].

Simply described, solar energy is energy generated completely by the rays of the sun and captured somewhere else, most commonly the Earth. The sun produces energy through a thermonuclear process that converts around 650,000,0010 tons of hydrogen into helium every second [2]. As a result of the process, heat and electromagnetic radiation are produced. The heat that stays in the sun will aid in the continuation of the thermonuclear process. Electromagnetic radiation (including visible light, infrared light, and ultraviolet radiation) is emitted into space in all directions. Because of the nature of solar, a successful solar energy generator necessitates the use of two components [3]. The two components are a collector and a storage unit. Simply put, the collector collects radiation and transforms a portion of it to other forms of electrical energy (either electricity as well as heat or heat alone). The storage unit is essential because solar energy is never constant; at certain times, only a small quantity of radiation is collected.

The amount of energy produced by the collector is quite minimal at night or during periods of thick cloud cover. To remedy this, the storage unit can save any excess energy produced during its peak performance and release it when efficiency falls. Additionally, a backup power source is frequently installed to guarantee sufficient energy supply if demand exceeds the amount generated and stored. Solar energies are widely accessible being a source of renewable energy, having the sun's radiation releasing radiation at an average rate of 3.81023 kW of power, of which the earth harvests roughly 1.81014 kW [4]. Solar energy arrives on Earth in a variety of forms, including heat and light. Unfortunately, because of cloud dispersion, reflection, and absorption, a considerable percentage of this energy is lost during its voyage. However, research indicates that solar energy has the potential to meet the world's energy needs. This is mostly because it is abundant in nature and is a free source of energy. Furthermore, solar energy has worldwide potential because it is an endless resource that provides consistent energy and higher production efficiency than other energy sources [4]. Two critical aspects determine the efficiency of the solar photovoltaic industry: the dispersion and intensity of solar radiation. These variables vary significantly across countries.

Inverters have played an important role as a vital interface for changing energy sources in power generating systems that use renewable resources such as wind and solar power in various situations including micro-grid power supplies [7]. However, because of the existence of asymmetrical and nonlinear demands in the microgrid system, the inverter's voltage output quality falls short of the needed standards. While incorporating a Y-isolation transformer and implementing a three-phase, four-leg topology can effectively handle the issue of supporting single-phase loads, this solution results in higher production costs. To address this issue and support single-phase loads, the present research employs a three-phase, three-leg inverter in conjunction using a z-type grounded transformer topology. To solve the issue of imbalanced inverter output voltage caused by uneven loads, a method was implemented that separates positive-sequence and negative-sequence voltages and controls them in separate rotating coordinate systems. This approach proved effective, but it required a complicated phase locking strategy for negative-sequence voltage. An alternative method involves using a PI+PR controller to regulate both types of voltage in a positive-sequence rotating coordinate system. However, adjusting the parameters of the PR controller can be challenging and may lead to system resonance [7].

The rise of environmental concerns has led to increased interest in natural energy sources [5]. Among these, photovoltaic (PV) generation systems are being extensively studied due to their suitability for use in urban areas. These systems involve connecting PV modules in series to generate sufficient DC voltage for the inverter to produce AC output voltage. However, in metropolitan areas, the presence of adjacent buildings often results in partial shading of the PV modules, leading to uneven generation. This issue reduces power generation capacity and cannot be resolved using conventional methods. The standard solution has been to connect bypass diodes in parallel to each PV module, but this approach has its own limitations, which will be discussed later. To overcome these challenges, a novel utility-interactive PV inverter system with a generation control circuit has been developed.

The difficulty of a camping routine is that it is very hard to get electricity in the forest. Without electricity, campers will face a lot of problems such as their electronic devices dying and campers having difficulties seeing during nighttime. Nowadays humans rely on electricity too much.

Therefore, the project aims to develop a versatile solar power supply that uses an inverter to convert DC to AC and an Arduino to control the relay and monitor battery percentage and solar battery charging. Ultimately, the goal is to create a reliable and efficient solar generator that can meet the needs of people who enjoy outdoor activities while reducing their carbon footprint.

1.2 Problem Statement

Campers enjoy spending time around the campfire with their families and friends. Campfires provide warmth throughout the frigid nights. Campfires can be harmful to the environment, even contributing to global warming. A campfire would necessitate the burning of wood. When wood is burned, a substantial amount of carbon monoxide, carbon dioxide, nitrogen oxides, benzene particulate matter, and other potentially harmful volatile organic compounds (VOCs) are released. Particulates of ash, liquid droplets, and partially burned fuel are expelled, as are the invisible gases. They have an impact on the air quality in a certain area. Such pollution, particularly smoke pollution, can be so intense that it impairs visibility, resulting in injuries.

The worldwide hunger for electricity is constantly increasing, whereas conventional energy resources are depleted or are on the verge of depletion. Furthermore, their rates are rising. Because of these factors, the demand for alternative sources of energy has grown, and solar energy has proven to be a very promising alternative due to its abundance and lack of pollution. A portable inverter powered by batteries should be designed where it can deliver stand-alone AC loads due to the increasing efficiencies and reduced cost of solar cells, as well as the advancement of the switching technology used for power conversion. When we connect solar panels to the power grid or use them in other industrial applications, we should have an AC output at a specific voltage level and frequency. The conversion from DC to AC is primarily achieved by the system's main component, the DC-AC inverter. However, the output of the solar panel is not constant and is affected by the immediate sunshine intensity and ambient temperature.

Campers would face difficulties in the woods. Campers would face difficulties such as their electronic device is dying. Campers will also have the difficulties of seeing during nighttime. Electronic devices such as smartphones are important because if there is a family emergency, campers can be notified. For lighting, it is important too because during nighttime in the woods, wildlife would approach the campers for food and if there is no light it is hard to identify where is the wildlife and the road to evacuate to a safer place.

1.3 Objectives

These objectives have been identified to meet the needs of this project. Among the objectives are:

i) To design a portable solar power station that integrates smartphone connectivity, priorities the campers by designing a system that is dependable, simple to operate, and flexible enough to accommodate a range of camping conditions.

ii) To develop an Arduino system and Arduino based relay that can control the on and off inverters and car smoke sockets with USB sockets and will shut them down when the battery is low.

iii) To analyze overall efficiency of the solar portable station and perform extensive testing to assess the battery's efficiency and the dependability of the remote-control features.

1.4 Scope of Project

The scope of the project are as follows:

a) The solar charging system can support voltages up to 20V, but its charging operation stop when the battery reaches 12.7V, as the solar controller identifies this voltage as indicating a fully charged battery.

b) The battery has the capability to charge two smartphones simultaneously by using a phone charger, USB connections, or car smoke socket usage.

c) The battery can support DC 5V 1A lamps for up to 20 hours.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The most frequently recognized definition of sustainable development is development that meets current demands while preserving the capacity of the next generations to fulfil their own needs. A recent report by the World Energy Council (WEC) reveals that if we continue with our current practices, the worldwide energy demand in 2020 could be 55-85% higher than that in 1990. Additionally, the US Department of Energy (DoE) has forecasted that the annual energy demand will increase from 363 million kilowatts to 750 million kilowatts by 2020. This surge in demand will cause global energy consumption to rise from 22-billion-kilowatt hour per year to 53-billion-kilowatt hour by 2020. Such a large rise in demand might put a tremendous amount of strain on the energy infrastructure now in place and may cause hazardous emissions of carbon dioxide, monoxide, sulfur dioxide, and NOx effluent gas as well as leading to global warming, all of which could possibly be damaging to the health of the planet's ecosystem. To tackle the environmental challenges of our time, we need sustainable development plans that have long-term objectives. Renewable energy resources are considered one of the most effective and successful solutions to achieve sustainable development, as they are directly linked to it. To make the switch from a world powered by fossil fuels to one powered by sophisticated technologies like photovoltaic (PV) and fuel cells (FC) and non-polluting fuels [6], it is crucial to improve energy efficiency. To achieve optimal building performance, it is essential to have a plan in place for integrating renewable energy sources. However, these sources of energy are unpredictable and spread out geographically, so meeting the demand for energy can be challenging. One way to address this issue is to either expand the area used to capture renewable energy to exceed the size of the community being supplied or to reduce the energy demands of the community to match the number of renewable resources available locally.

2.1.1 Renewable Energy

There has been tremendous global study and development in renewable energy resources and systems since the early 1970s oil crisis. Renewable energy technologies have emerged as the most appealing energy conversion systems. During this time period due to variables such as the expected high cost of oil, cost-effectiveness forecasts, and the ease with which renewable energy systems can be implemented. Furthermore, there is growing recognition that renewable energy sources and systems have the potential to address some of the world's most pressing technological, environmental, economic, and political challenges in a positive way [9]. As Hartley points out, renewable energy solutions provide marketable energy by harnessing natural phenomena. These technologies make use of the energy that comes from the sun's radiation, as well as its direct and indirect impacts on the planet (for example, photons, winds, water falling, heating effects, and plant development), gravitational forces (such tides), and the heat from the center of the Earth (geothermal). Renewable energy resources have an enormous energy potential that surpasses that of comparable fossil resources. Consequently, their magnitude is not a significant limitation on energy output. However, these resources are often dispersed and not fully accessible, some are intermittent, and each has different regional variations. These characteristics create challenging but solvable technical, institutional, and economic issues in the development and use of renewable energy supplies. Despite these challenges, research and development on renewable energy resources and technologies have advanced over the past two decades due to these reasons. Today, significant progress is being made in enhancing collection and conversion efficiencies, reducing startup and maintenance costs, increasing reliability and applicability, and understanding the phenomena of renewable energy systems [9].

Renewable energy technologies are becoming increasingly crucial due to growing environmental concerns, rising utility (hydro) costs, and increasing labor costs. The unstable global economy is another factor. To address this situation, it is necessary to increase research and development in high-tech areas, some of which are directly linked to renewable energy technology. This could lead to innovative products and job creation supported by governments. The development of other technologies, particularly in high-tech, has resulted in several new ideas for renewable energy system designs. Even before the engineer finalizes the design, the ubiquitous computer provides a means of optimizing system performance, costs and benefits, and environmental consequences. Renewable energy technologies have distinctive operating and financial characteristics, including modularity, flexibility, and low operating costs, which suggest relative cost certainty. These characteristics differ significantly from those of traditional fossil-based technologies, which require large capital investments, long implementation lead times, and operating cost uncertainties regarding future fuel costs. The total benefits of renewable energy technologies are often misunderstood, leading to the perception that they are less cost-effective than traditional technologies. However, to fully analyze renewable energy technologies, some of their overlooked benefits must be acknowledged. Renewable energy technologies are sometimes seen as simple replacements for existing technologies, with their benefits and costs evaluated using the assessment methodologies created for existing technologies. For instance, solar and other renewable energy technologies can add small incremental capacity to existing energy systems with minimal lead time. These power-generating units are often more flexible in terms of incremental supply than large, long-lead-time equipment such as nuclear power plants [9].

Renewable energy technologies that have been tested and proven effective in the field will continue to expand with improved designs in the 1990s. As developing nations strive for a higher standard of living, there will be an increase in market demand for these technologies. The global deployment of renewable energy systems will undoubtedly reduce pollution levels. Solar energy technology, particularly photovoltaics (PV), has made significant advances over the past two decades. The widespread use of silicon chip technology in the United States, Japan, and Germany, which led to the development of the world's electronic industries and communication superhighways, was the driving force behind the rapid advancement of solar photovoltaic energy, or the direct conversion of sunlight into electric power using a solid-state device, since the launch of the first satellite in the 1950s. In the United States, large terrestrial photovoltaic power plants with capacities of up to 100 MW now supply the AC grid network or operate independently. The development of advanced renewable energy technology can offer cost-effective and environmentally responsible alternatives to traditional energy generation. By the year 2000, there is technical and market potential to significantly increase the current contribution of renewable energy sources to the country's energy demands, resulting in employment and economic benefits that are many times greater than the investment in research and development. Several government energy institutions and agencies acknowledge the potential and endorse the renewable energy industry's efforts to take advantage of the short-term commercial potential by examining renewable energy opportunities and working together with the industry to determine research and development as well as market strategies to meet technological objectives. This involves conducting joint research and development efforts with the industry to create and commercialize technologies, as well as promoting the use of renewable energy technologies. To fully benefit from the energy, economic, and environmental advantages that renewable energy sources offer, the following comprehensive set of operations must be implemented:

- To align with the demands of the industry, research and development priorities should be established through close communication with them. The majority of research is carried out in the short- to medium-term through cost-sharing agreements. A variety of energy industry players, including private sector businesses, utilities throughout the country, provincial governments, and other federal departments, should be involved as partners in research and development.
- To evaluate technology, criteria such as cost benefit, reliability, environmental impact, safety, and potential for development should be gathered both in the laboratory and through field experiments. This data can also be used to generate technology status reports and research and development strategic plans.
- To encourage the market adoption of established technology, technical and safety standards need to be established. The development of standards should involve national and international organizations responsible for writing standards, as well as other regulatory authorities at the national and provincial levels.
- The results of R&D should be distributed via technical seminars, classes, and forums, as well as the development of instruction guides and design instruments and the release of technical reports. This is referred to as technological transfer.

Such events will also inspire potential consumers to think about the advantages of implementing renewable energy technologies. A significant technology transfer area in support of creating sustainable markets is to expedite the deployment of renewable energy technologies in a country's distant villages [9].

Proven capability	**Transition phase**	**Future potential**
Hydropower	**Wind**	**Advanced Turbines**
Geothermal	Geothermal	Geothermal
Hydrothermal	Hydrothermal	Hot dry rock
Geopressure		
Magma		
Biomass	Biofuels	Biofuels
Direct combustion	Ethanol from corn	Methane
Gasification	Municipal wastes	
Passive solar	Active solar	Solar thermal
Buildings	Buildings	Advanced electricity
Process heat	High-temperature processes	
Solar Thermal		
Thermal/gas hybrid		
Photovoltaics	Photovoltaics	Photovoltaics
Small remote	Remote power	Utility power
Specialty products	Diesel hybrids	
Ocean Thermal		

Figure 2.1 : Renewable Energy

2.1.2 Non-Renewable and Air Pollution

Millions of years ago, plants covered the earth and converted sunlight energy into living tissue, some of which was buried deep in the earth and eventually formed coal, oil, and natural gas deposits. These complex chemical molecules have since been used in a variety of important applications, including the production of plastics, textiles, fertilizers, and other petrochemical products. The use of these products has grown over time, but coal, oil, and gas are non-renewable resources that will be valuable to future generations. However, the increasing depletion of these fossil fuels must be addressed, as their use has been linked to global warming. When burned, coal, gas, and oil release toxic gases that trap heat in the atmosphere and contribute to climate change. Although there is ongoing debate among scientists regarding the extent to which human activity contributes to climate change, developed countries are responsible for most emissions and must take action to reduce them. The Kyoto Protocol acknowledges that emerging countries must also make efforts to limit future emissions as their economies and populations grow. However, measures to reduce carbon dioxide emissions could have significant negative impacts on economic growth, jobs, investment, trade, and people's standard of living worldwide [6].

Over the past 70 years, the amount of carbon dioxide released from burning fossil fuels has increased dramatically, reaching 35 billion metric tons in 2020 from just 5 billion metric tons in 1950. The emission of fossil fuels has caused the average surface temperature of the earth to increase by roughly 1.1°C (2°F) since preindustrial times. The Intergovernmental Panel on Climate Change has emphasized the need for immediate action to restrict global warming to 1.5°C (2.7°F) above preindustrial levels to prevent the most catastrophic outcomes. Current climate policies, however, are projected to exceed this limit over the next 20 years, resulting in a temperature increase of 2.5 to 2.9°C above preindustrial levels by the end of the century. Even though a temperature increases of more than 1.5°C is unavoidable during the next two decades, immediate intervention can still have an impact on the future trajectory. In a joint statement, 200 plus health journals, including the Journal, encouraged world leaders to take immediate action on climate change, citing the serious health consequences. The combustion of fossil fuels also contributes to air pollution by emitting large amounts of fine respirable particles, sulfur dioxide, nitrogen oxides, polycyclic aromatic hydrocarbons (PAH), mercury, and volatile compounds that contribute to ground-level ozone formation. Air pollution is another crisis that affects one billion children globally, but there are now strategies available to significantly decrease or eliminate these pollutants [1].

The fetus, newborn, and child are highly susceptible to climate-related environmental consequences, including air pollution, due to a physiological and behavioral characteristic. During these stages of development, rapid growth and sophisticated programming make them vulnerable to hazardous substances and other stressors. Additionally, their immature biologic defense mechanisms make them more susceptible to psychosocial stress and physical toxicants, as they are unable to detoxify toxins, repair DNA damage, and provide immunological protection effectively. Infants and children require greater nutrition and hydration than adults to maintain their rapid growth, making them more vulnerable to disruptions in food and water supply. They are also more exposed to air pollutants as they breathe more air per body weight than adults, and their narrower airways are more susceptible to constriction by air pollution and allergens. Toddlers and teenagers are more sensitive to intense heat than adults due to their reduced thermoregulatory function at extreme temperatures and their reliance on adults who may not be aware of the risks, such as when newborns are left in cars and suffer from heat exhaustion. Toddlers and teenagers also spend more time outdoors engaging in physical activity than adults, making them more susceptible to the effects of relocation caused by natural disasters, which can lead to physical injury and psychological distress. Given their extended lifespan, early diseases like respiratory illnesses or mental health concerns may also jeopardize both wellness and functioning in adulthood [1].

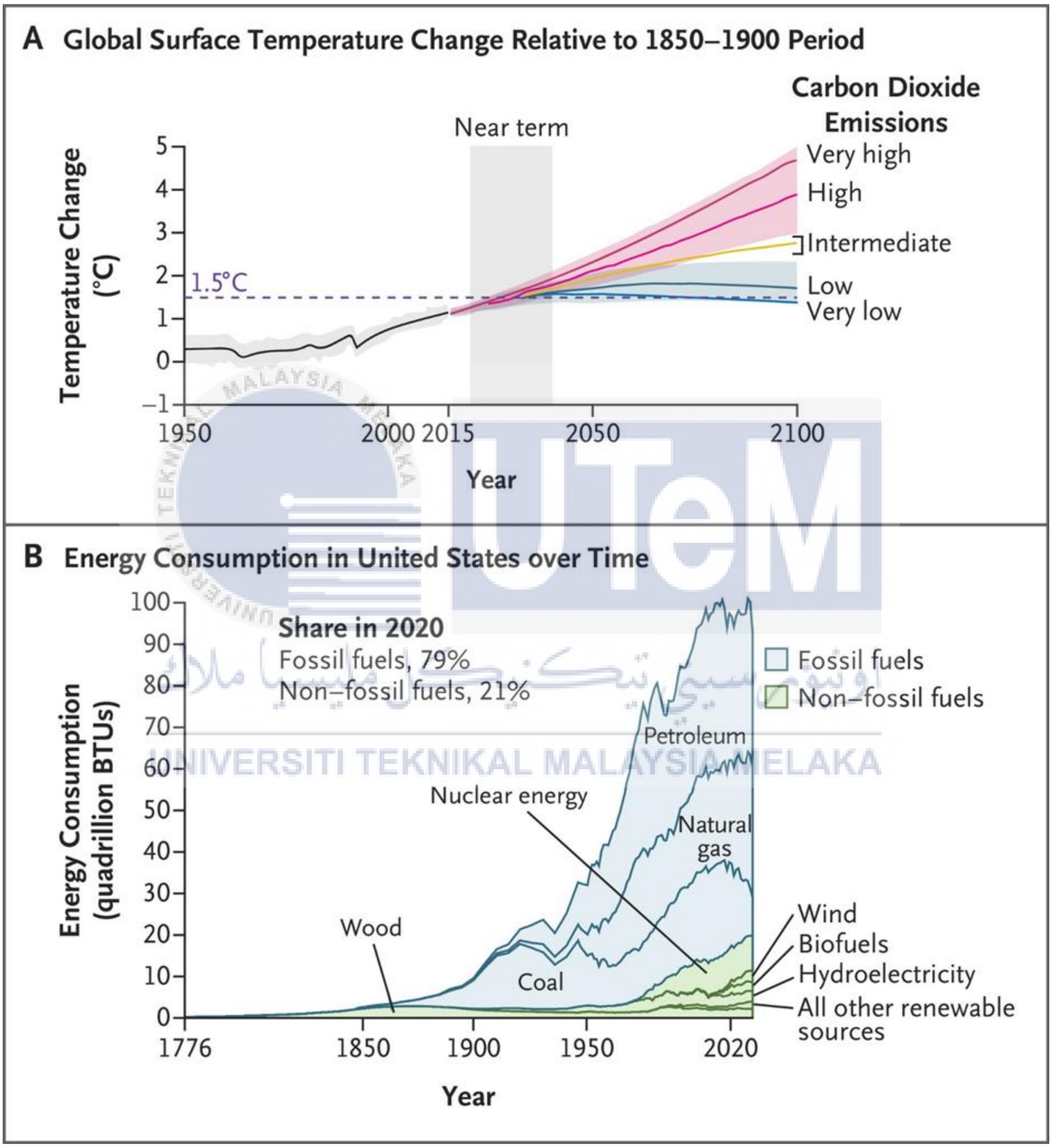

Figure 2.2: The change in global surface temperature compared to the period between 1850 and 1900 and the historical trend of energy consumption in the United States are being examined

2.2 Solar Energy

In simple terms, solar energy is the energy produced by the sun and collected elsewhere, typically on Earth. The sun generates energy through a thermonuclear process that converts around 650 million tons of hydrogen into helium every second, resulting in the production of heat and electromagnetic radiation. The heat remains in the sun and sustains the thermonuclear process, while the electromagnetic radiation, which includes visible light, infrared light, and ultraviolet radiation, is emitted in all directions into space. To generate solar energy effectively, two components are required: a collector and a storage unit. The collector captures the radiation that strikes it and converts it into other forms of energy such as electricity and heat, while a storage unit is necessary to store excess energy generated during peak productivity and release it when productivity declines. As solar energy is not continuous, a backup power supply is often included to ensure that energy demands are met. The methods for collecting and storing solar energy vary depending on the intended application of the solar generator. There are three types of collectors, including flat-plate collectors, focused collectors, and passive collectors, and several types of storage units [3].

In solar energy systems, a backup power supply is often included to ensure that energy demands can be met if the amount of energy required exceeds what is produced and stored in the container. There are three types of collectors available for collecting and storing solar energy, which are flat-plate collectors, focused collectors, and passive collectors. Focused collectors are essentially flat-plane collectors with optical components that maximize the radiation landing on the collector's focus, but they are now only used in a few isolated regions. While flat-plane panels can utilize reflected radiation from the ground, focusing collectors typically disregard it, except in snowy areas where the reflected radiation can be substantial. Focused collectors also face the challenge of high temperatures, which can cause the fragile silicon components that absorb incoming radiation to lose efficiency or even get permanently damaged. Therefore, they require additional protection to safeguard their silicon components. Solar furnaces are an example of a focusing collector that can generate more energy at a single point than flat-plane collectors but lose some of the radiation [3].

The capacity of passive collectors to naturally absorb radiation and transform it into heat without the necessity of special planning or equipment sets them apart from other forms of collectors. However, only a few objects, such as walls, can generate enough heat to be useful. Passive collectors are often enhanced by painting them black and adding a method for transferring the heat to another location. Solar energy can be utilized for various purposes, but transportation, heating, cooling, and electricity generation are the primary tasks that consume most of the energy. Solar energy is particularly efficient for the heating industry since it requires minimal energy conversion. Water or a bed of tightly packed materials, such stones and air space between them, may store heat energy. Phase-changer or heat-of-fusion devices, which employ a chemical that transforms condition from solid to liquid at a temperature which the solar collector can produce, are other ways to store heat energy. Swimming pools are frequently heated using solar energy, and the heat may be stored in a packed bed. Whether or not a bed that is packed is employed, a cover is frequently used to maintain the pool's temperature for extended periods of time while keeping the water warm [3].

The chemical is heated and then transformed into its state of liquid using the energy from the solar collector. Enabling the molecule to revert to its solid form will allow the heat to be recovered later. Swimming pools are frequently heated using solar energy; in some instances, the pool itself acts as a heat storage facility, while in others, a bed that is packed is employed. Whether or not the packed mattress is utilized, it's common practice to maintain the water warm while not in use by using a technology that extends the pool's heat retention, such a cover. Due to its location close to or around the building, the pond gathers solar energy during the day and transforms it into heat. This heat may be taken up by the structure or, if the structure is already overheated, transmitted to the pond.

Solar panels, which primarily consist of silicon, the second most abundant element on Earth, have little impact on the environment during production. The only time solar energy causes environmental harm is when it is produced on a large scale in centralized locations. However, solar energy can be produced on a massive scale, and it is the only energy source with the potential to generate more energy than it consumes. As an illustration, if we just capture 0.1 percent of the energy required by the planet for evaporating water from the seas, which is 4.5x1014 kWh out of 4.51017 kWh per year, the continuous yield would be 2.90x1010 kW when divided by the number of hours in a year. This amount of energy would provide 2.4 kW of power to 12 billion people, equivalent to the energy used by the average American today, and would be sufficient to supply the entire globe, regardless of population, as it exceeds the Earth's estimated carrying capacity [3].

2.3 Inverter

An inverter, also known as a power inverter or invertor, is a type of power electronics that transforms direct current (DC) into alternating current (AC), with the resulting AC frequency being determined by the equipment used. Unlike rectifiers that convert AC to DC, inverters perform the opposite function. Initially, rectifiers were massive electromechanical devices. However, inverters can be wholly electronic or a combination of mechanical and electronic circuitry, but they do not produce electricity; instead, they rely on the DC source provided. The frequency input voltage, output voltage and overall power handling are determined by the device or circuitry's design. Static inverters do not have moving parts in their conversion process, unlike oscillators that perform the same function for electronic signals with low currents and voltages. Power inverters are commonly used in electrical power applications with high currents and voltages, while rectifiers are circuits that convert AC to DC [10].

Environmental concerns have led to an increase of interest in natural energy resources. Photovoltaic (PV) generation systems, which are easy to use in urban areas, have been the subject of many studies. These systems involve connecting PV modules in series to generate sufficient DC voltage for the inverter to produce AC output voltage. However, in metropolitan areas, it is challenging to avoid shadows cast by neighboring buildings, which can partially obscure the PV modules. This is known as uneven generation of PV modules and results in decreased generation power, which cannot be resolved through standard solutions. The conventional approach to prevent power loss in partially shaded PV systems is to connect bypass diodes in parallel to each PV module. However, this method has several severe issues, which will be discussed below. To address these issues, a unique utility-interactive PV inverter system with a generation control circuit has been introduced.

The utilization of renewable energy resources in distributed power generation (DG) systems presents a significant opportunity [1]. The use of DG systems can benefit both consumers and power utilities by providing secure and diverse energy supply options, increasing generation and transmission efficiency, reducing GHG emissions, improving power quality and system stability, lowering energy costs and capital expenditures, and alleviating the bottleneck caused by distribution lines. DG systems are modular devices located near power customers, such as wind turbines, solar photovoltaic (PV) systems, fuel cells, and small hydro systems, along with their associated controlling and managing systems. In contrast to large and centralized grid utilities, DG systems are typically small and modular. Figure 2 illustrates that a renewable DG system utilizing solar energy requires inverters or dc-ac converters to serve as intermediaries between their single-phase loads and sources. DG inverters often encounter a wide range of input voltage variations due to the fluctuations in energy sources, which necessitates stringent requirements for inverter topologies and controls. Inverter functions for small DG systems can be summarized as follows: firstly, the conversion of variable DC voltage to a fixed AC voltage that can either be higher or lower than the DC voltage or produce an AC current that follows the grid voltage and frequency. Secondly, ensuring that the output power has minimal total harmonic distortion (THD), voltage or current flashing, and frequency deviation. Thirdly, protecting DG generators and electric power systems from abnormal voltage, current, frequency, and temperature conditions, including additional functions such as anti-islanding protections and electrical isolation if necessary. Furthermore, specific goals such as maximum wind energy extraction, maximum power point tracking (MPPT) of solar systems, optimal efficiency for fuel cell systems, and optimal energy flow controls in net-metering programs must be achieved. The delink voltage of DG system inverters can vary significantly, and they can be classified as buck, boost, or buck-boost inverters based on the input DC voltage ranges.

Boost or buck-boost inverters can be constructed using typical full-bridge buck inverters with large line-frequency transformers or with inductors or high-frequency transformers to create a more compact design and higher overall efficiency when used in DG systems [11].

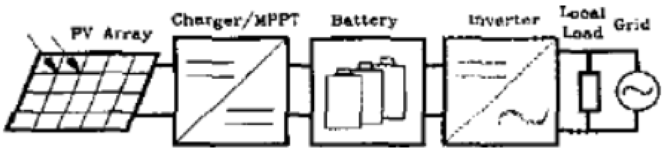

Figure 2.3 : Block Diagram of a solar PV system

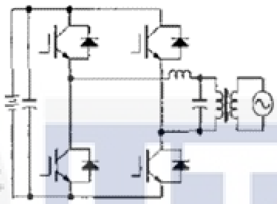

Figure 2.4 : Buck inverter and transformer.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is an engineering aspect that needs to be considered in producing a product. This methodology is equally defined as the methods of selection and analysis. In addition, with this methodology the products made can be completed perfectly and brilliantly.

Methodology is a technique or approach used to design, gather, and analyze data in order to produce evidence that can be used to support a study. It provides an explanation of how a problem is investigated and the reasoning behind the selection of specific methods and techniques.

Methodologies involve gathering philosophical theories, concepts, or ideas that are relevant to a particular field or area of study. The term "method" encompasses more than just a set of procedures; it also includes the logical and philosophical assumptions that underlie the study and are compared to the scientific method. This is why scientific literature often includes a section on the researchers involved in the study.

Every project is a step-by-step process that must be completed with careful attention to detail. If errors occur during any of the steps, it can lead to an ineffective or unnoticed project.

3.2 Project Flow Chart

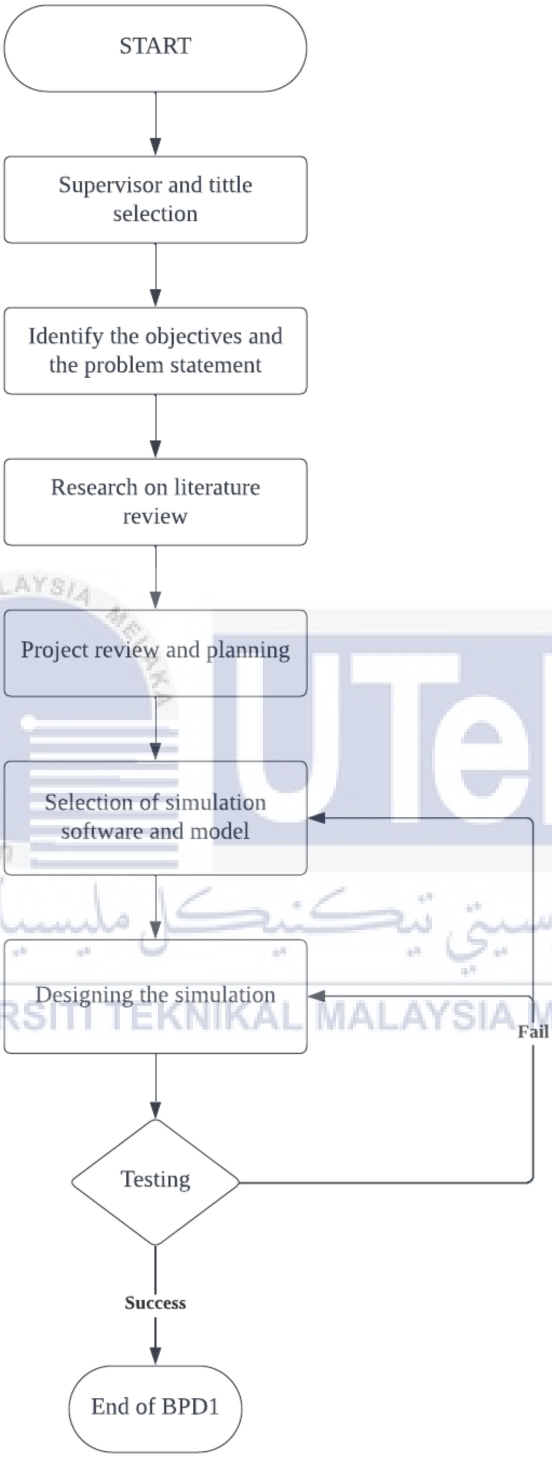

Figure 3.1 : Project Flow Chart

3.3 Block Diagram

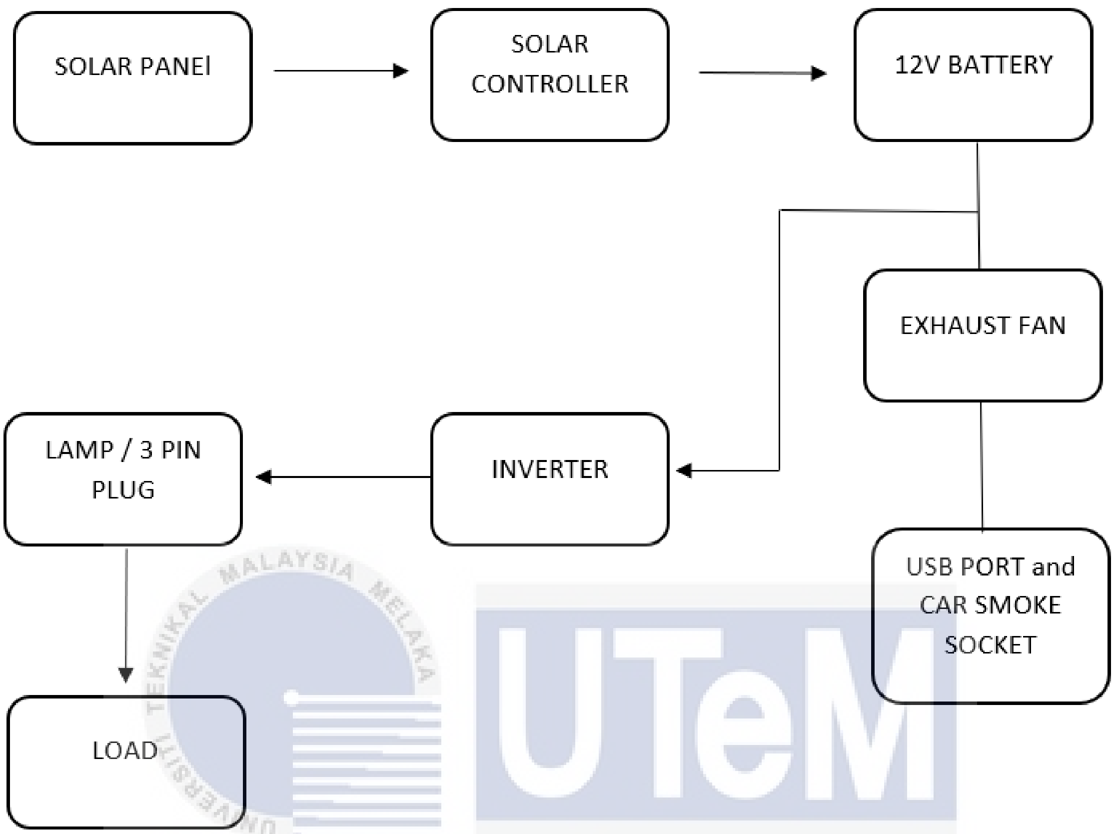

Figure 3.2 : Block Diagram

Circuit in this project used the direct current (dc) to alternate current (ac) by using an inverter that use energy from the battery through the solar panel. Next for this inverter we place an exhaust fan to prevent it from overheating. Moreover, we added a solar controller, the function of this device is to protect the battery for overcharge, the solar controller will automatically cut-off the charging when the battery is fully charge. Furthermore, USB and Car Smoke Socket are added which gets energy directly from battery (DC). Lastly, 3pins plug (AC) and LED light is added for consumers.

3.4 Flowchart

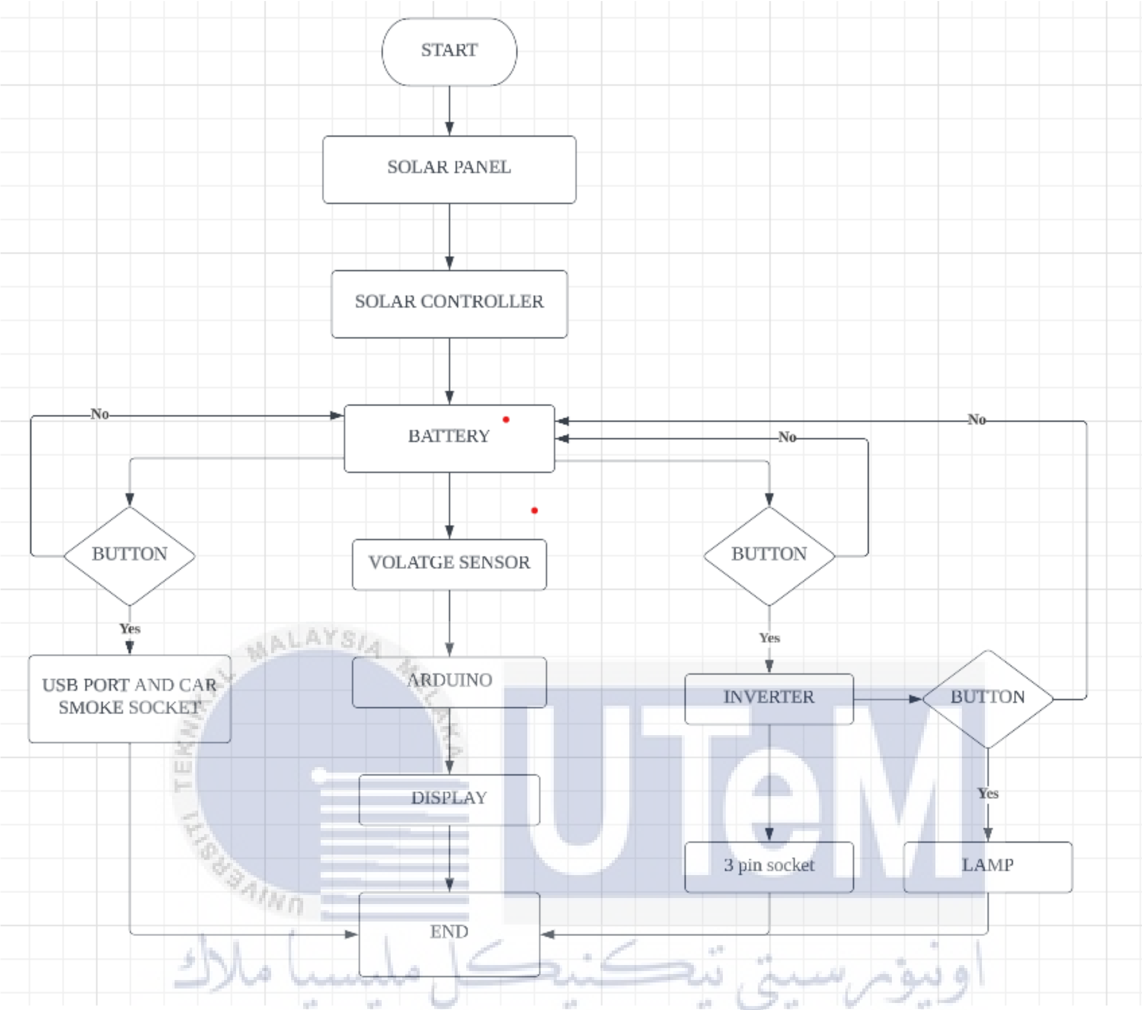

Figure 3.3 Flowchart

3.5 Proteus Software

Proteus 8 Professional

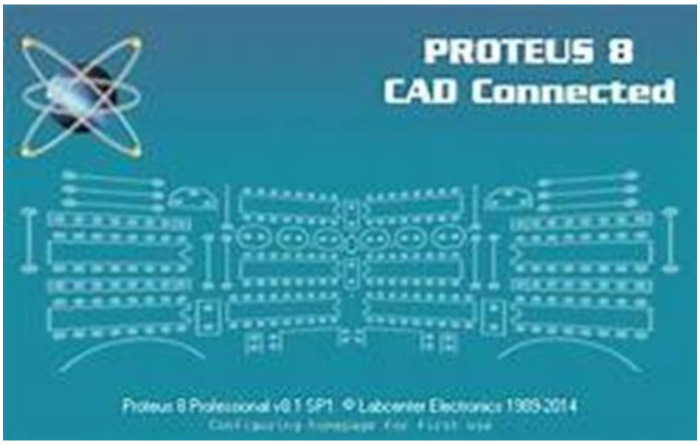

Figure 3.4: Inro Page to Proteus 8 Software

Figure 3.5: Proteus 8 Professional Software

Proteus 8 Software combines Schematic Capture and PCB Layout modules to provide an affordable, powerful, and easy to use suite of tools for professional PCB design. Virtual System Modelling (VSM).

3.6 Project Hardware

3.6.1 Arduino Uno

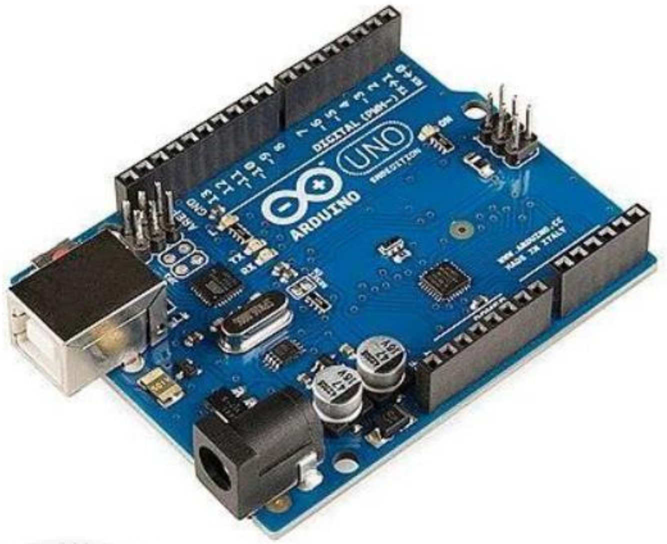

Figure 3.6: Arduino Uno

The Arduino UNO is a microcontroller board that is open-source and was created by Arduino.cc. It is based on the Microchip ATmega328P microcontroller and has both digital and analog input/output (I/O) pins that can be connected to various expansion boards (shields) and circuits. The board has 14 Digital pins and 6 Analog pins and can be programmed using the Arduino IDE (Integrated Development Environment) through a type B USB cable. It can be powered by either a USB cable or an external 9-volt battery and can accept voltages between 7 and 20 volts.

3.6.2 LCD (Liquid Crystal Display)

Figure 3.7 : LCD Display

LCD (liquid crystal display) is a display technology commonly used in smaller computers and notebooks. It allows for much thinner displays compared to older cathode ray tube (CRT) technology, as well as other modern display technologies like light-emitting diode (LED) and gas-plasma.

To connect to an LCD, the LiquidCrystal() function is used to set the pins on the Arduino. Any of the digital pins on the Arduino can be used to control the LCD. The Arduino pin numbers should be placed inside the parentheses in the following order: LiquidCrystal(RS, E, D4, D5, D6, D7).

3.6.3 Voltage Sensor Module for Arduino

Figure 3.8: Voltage Sensor

The voltage sensor module is a small device that can sense DC voltages between 0-25 volts. Its design is based on a resistive voltage divider circuit that multiplies the input voltage by 5 and provides an analog output voltage relative to the step-down voltage factor. This circuit is compact and portable, and it can detect under-voltage and over-voltage issues in electrical circuits.

The voltage sensor module features two header blocks. One block with screws is connected to the power source whose voltage needs to be measured, while the other connector is used to interface with microcontrollers like Arduino.

3.6.4 Inverter

Figure 3.9: Inverter

The main purpose of an inverter is to convert direct current (DC) power into alternating current (AC) power. This is commonly needed in households, businesses, and factories that require AC power.

Inverters are primarily used to enable the use of DC power sources, such as batteries, solar panels, or wind turbines, to power AC devices and appliances. The DC electricity is fed into the inverter, which then converts it into AC power at the appropriate voltage and frequency.

Inverters are commonly used in renewable energy systems, such as solar photovoltaic (PV) installations. They convert the DC electricity produced by solar panels into AC electricity that can be used to power homes or fed back into the electrical grid.

Aside from renewable energy systems, inverters are also used in uninterruptible power supply (UPS) systems, which provide backup power during power outages or voltage fluctuations. They are also used in electric vehicles to convert DC power from the battery into AC power to run the electric motor.

Overall, the main function of an inverter is to bridge the gap between DC power sources and AC power devices, allowing for efficient and convenient use of electricity in various applications.

3.6.5 15W LED Lamp

Figure 3.10: LED Lamp

A LED lamp, often known as an LED light bulb, is a form of lighting appliance that illuminates with light-emitting diodes (LEDs). When an electric current runs through LEDs, they emit light.

LED lamps are more energy-efficient and last longer than standard incandescent or fluorescent bulbs. They have grown in popularity because of several benefits including energy efficiency, durability, and color possibilities.

LED lights are commonly used for indoor and outdoor lighting in residential, commercial, and industrial environments. They are used in homes, workplaces, retail establishments, streetlights, automobile illumination, and a variety of other applications that require effective and long-lasting lighting.

3.6.6 USB Port and Car Smoke Socket

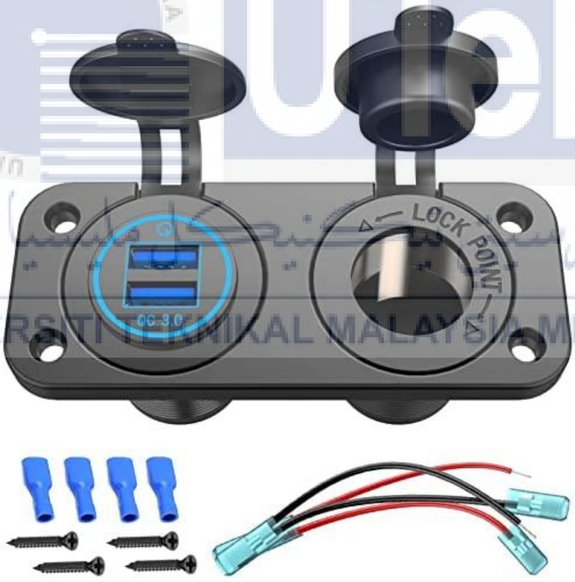

Figure 3.11: USB Port and Car Smoke Socket

A USB (Universal Serial Bus) port's function is to provide a standardized interface between electronic devices as well as a means of connecting to and communicating with peripheral devices. USB ports can be used to charge electronic devices.

A car socket function to power up some appliances that comes with a car smoke adapter such as a mini fan.

3.7 Previous Research

Solar power supply is an existing product thus we modify it by giving some additional features and it has become a multi-usage portable power supply. The main features that we made are converting the direct current (dc) to alternating current (ac) by using an inverter that uses energy from the battery through the solar panel. Next for this inverter we place an exhaust fan to prevent it from overheating. Moreover, solar controller is added, the function of this device is to protect the battery from overcharging, the solar controller will automatically cut-off the charging when the battery is fully charged. Besides that, a 16*2 LCD is provided to make it easier for the consumer to know the capacity of the battery. Furthermore, for consumers this project will provide USB port and car smoke socket. Moreover, this project is equipped with 3pins plug (AC) and LED light for consumers. Lastly, this project is made in portable size but compact with power and reliable when it comes to outdoor activities.

Organize the need into hierarchy:

a) Converting alternating current(ac) to direct current(dc) effectively.

- Solar panel will charge the battery with (dc) current.
- The battery will flow to the inverter and step-up transformer from 12V(dc) to 220-240V(ac).

b) Versatile use:

- Can be used as an emergency power supply.
- It can be used for outdoor and indoor activities.

c) Long life cycle and durable:

- Solar panels are manufactured in such a way that long durability is ensured.
- Have a large capacity battery that will last long after fully charged.

d) Spare Parts:

- Parts are available in the market at reasonable prices.
- Easy to repair.

e) Green energy product

- Do not cause any pollution to the environment.
- Save energy and money on electrical usage

3.8 Summary of Chapter

The conclusions that can be drawn in this chapter are that, after conducting a review of this chapter and getting knowledge and ways to make the project clearer, more detailed, and easier. This will make it easier for the project to be done. Design studies have helped facilitate the process of determining how appropriate designs are without costing much in materials, and the materials used are easily obtained. In addition, in this chapter, I also find out the specifications of the materials on the market as well as the different prices according to different stores. Material selection factors are also very important in the production of this project. This is because the selection of unsuitable items will harm the resulting project. Failure in the appropriate selection also does not only brings harm to the project, but it will also result in higher costs to purchase new material because of the damage caused by the misbehavior in material selection.

After conducting this chapter, I will study and acquire theoretical knowledge related to the software and components used during the study. In addition, I am also able to know the function of every piece of software and component that has been used. This review of the literature has helped facilitate the process of determining the components to be used. The use of component factors is also very important in the production of this project. This is because the use of inappropriate components will cause the project to not function properly.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The main purpose of this chapter is to explain the findings and analysis of the study based on the objective of the project. In the first part, we develop coding and design using software. The discussion on solar charging is highlighted followed by an overall view of hardware. After that, we test the battery that is connected to the inverter with the phone charger and see how long the battery lasts. Furthermore, hands-on experiments with USB car smoke socket charging for cellphones are carried out. These experiments emphasize the solar generator's practical value by demonstrating its capacity to power typical outdoor electronic gadgets.

4.2 Software Design

sketch_jun7a.ino

```
#include<LiquidCrystal.h>
const char rs=8, en=9, d4=10, d5=11, d6=12, d7=13;
LiquidCrystal lcd(rs,en,d4,d5,d6,d7);


const int analogInput = A0;
float vOUT = 0;
float vIN = 0;
float R1 = 7500.0;
float R2 = 5357.143;
int value = 0;


void setup(){
  Serial.begin(9600);
  lcd.begin(16,2);
  lcd.setCursor(0,0);
  lcd.print("WELCOME TO");
  lcd.setCursor(0,1);
  lcd.print("MY PROJECCT");
  delay(5000);
  lcd.setCursor(0,0);
  lcd.print("                ");
  lcd.setCursor(0,1);
  lcd.print("BATTERY : ");
  lcd.clear();

}

void loop()
{
  value = analogRead(analogInput);
  vOUT = (value * 5.0) / 1023.0;
  vIN = vOUT / (R2/ (R1 + R2));

  lcd.setCursor(0,0);
  lcd.print("BATTERY : ");
  lcd.print(vIN);
  lcd.print("V");

}
```


Figure 4.2.1 Coding for Arduino

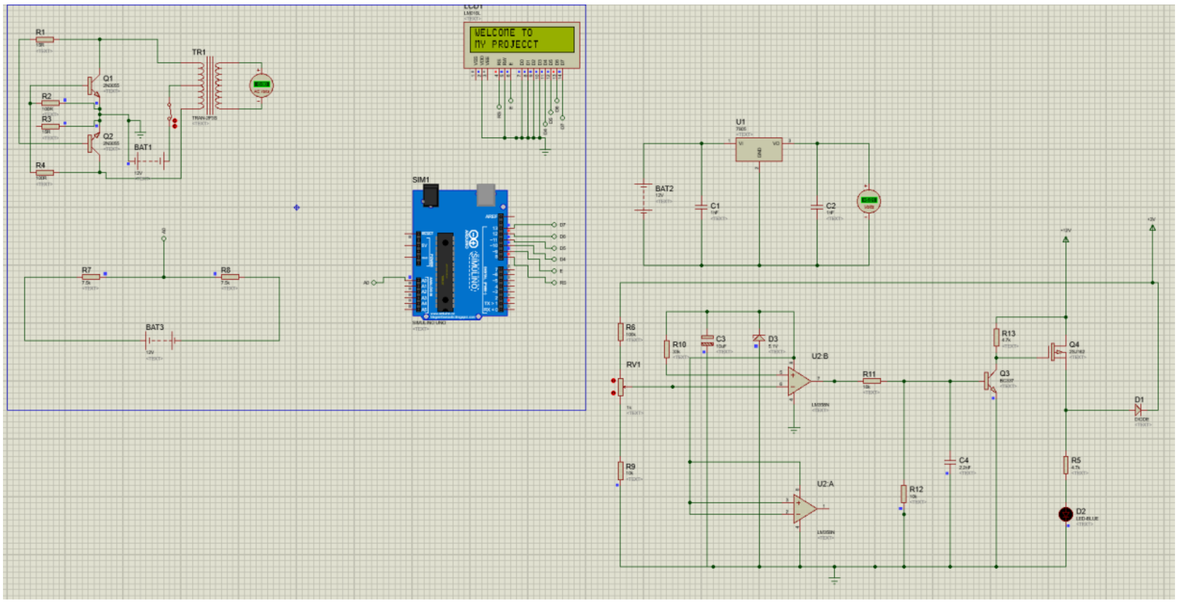

Figure 4.2.2 Starting of Simulation

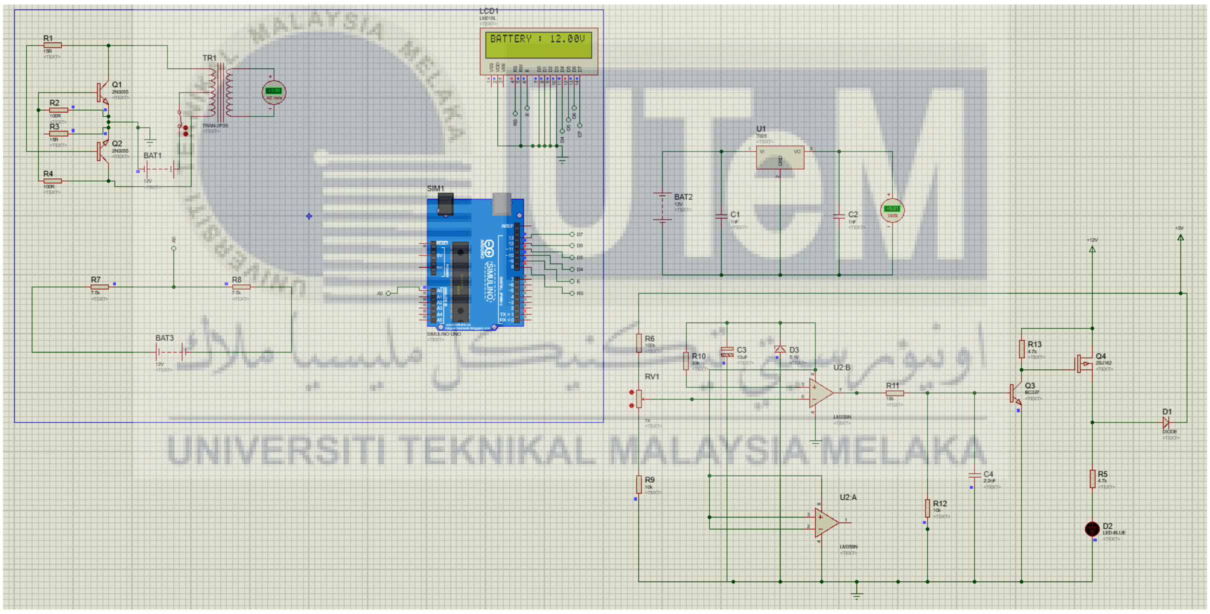

Figure 4.2.3 After 5 seconds

The Arduino coding is designed as shown in Figure 4.2.1 above. Then, LCD is connected to Arduino pin 8, 9, 10, 11, 12 and 13. The coding for Arduino will tell Arduino what to display on the LCD. The voltage sensor is connected to Arduino pin A0. Firstly, it will display “WELCOME TO” on the first row and it will display “MY PROJECT” as shown in Figure 4.2.2. After 5 sec, the LCD will be cleared and display battery voltage on the first row as shown in Figure 4.2.3.

4.3 DISCUSSION

4.3.1 Solar panel charging

Figure 4.3.1 a : Start Charging

Figure 4.3.1 b : After 30 minutes

10/11/2023 [12:11 PM]

Table 4.3.1 : Solar Charging

Starting	12.1 V
After 30 minutes	12.2 V

Based on the result on Solar Charging Table 1, the initial battery voltage is 12.1V as shown in Figure 4.3.1 a. After 30 minutes of charging using 10W solar panel with the help of solar charge controller, the battery voltage increases to 12.2V as shown in Figure

4.3.1 b. This is because the solar panel is peak hour of the day. So, the charging process takes less time.

Figure 4.3.1 c : Starting Charging

Figure 4.3.1 d : After 1 hour

11/11/2023 [12.39 PM]

Table 4.3.2 : Solar Charging

Starting	12.2 V
After 1 hour	12.2 V

Based on the result on Solar Charging Table 2, the initial battery voltage is 12.2V as shown in Figure 4.3.1 a. After 1 hour of charging using a 10W solar panel with the help of solar charge controller, the battery voltage remains the same as shown in Figure 4.3.1 d. This is because the weather on that day is mostly cloudy. So, the charging process takes more time.

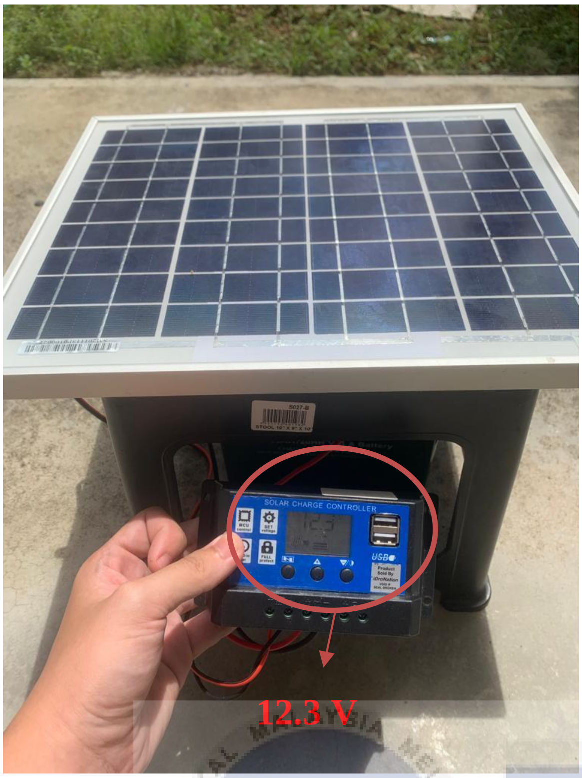

Figure 4.3.1 e : Start Chraging

Figure 4.3.1 f : After 1 hour

12/11/2023 [1:21 PM]

Table 4.3.3: Solar Charging

Starting	12.3 V
After 1 hour	12.3 V

Based on the result on Solar Charging Table 3, the initial battery voltage is 12.3V as shown in Figure 4.3.1 f. After 1 hour of charging using a 10W solar panel with the help of solar charge controller, the battery voltage remains the same as shown in Figure 4.3.1 e. This is because the weather on that day is cloudy. So, the charging process takes more time.

Figure 4.3.1 g : Start Charging

Figure 4.3.1 h : After 3 hours

18/11/2023 [1.02 PM]

Table 4.3.4: Solar Charging

Strating	12.4V
After 30 minutes	12.4V
After 1 hour	12.6V
After 1 hours and 30 minutes	12.6V
After 2 hours	12.6V
After 2 hour and 30 minutes	12.6V
After 3 hours	12.6V

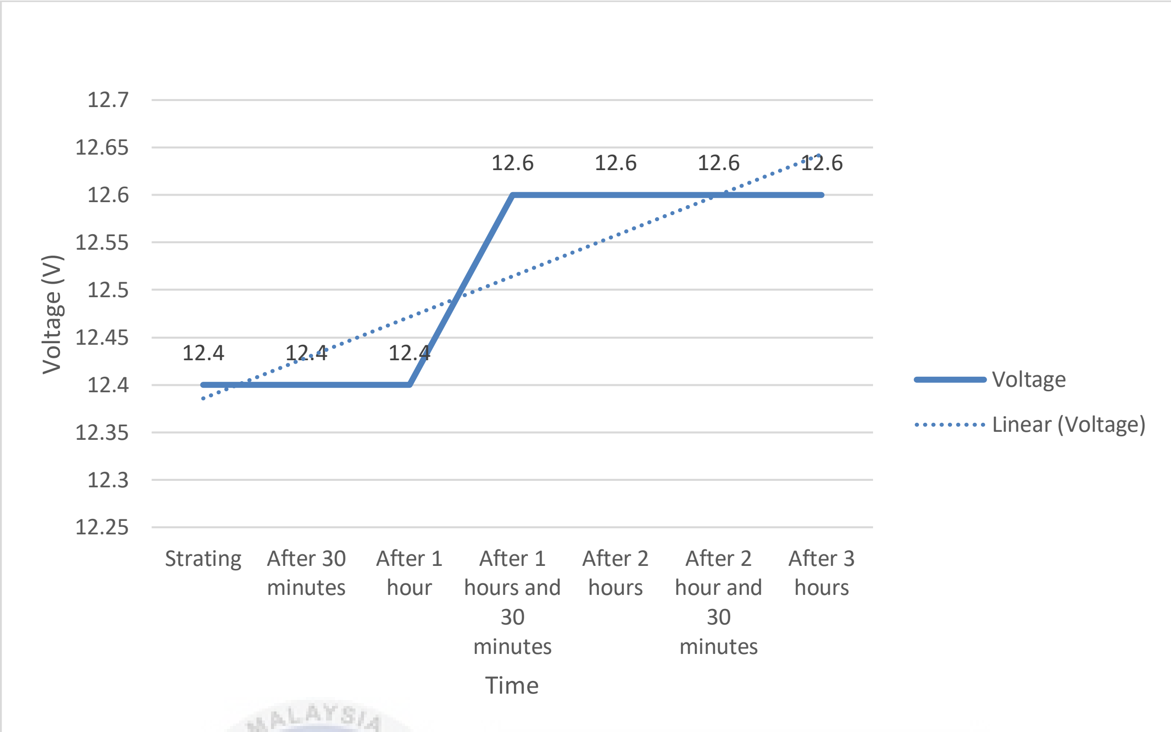

Figure 4.3.1 i : Voltage VS Time

Based on the data in Solar Charging Table 4 and figure 4.3.1 i, the initial battery voltage is 12.4V. After 1 hour of charging the battery voltage is 12.6V and this is because the weather is in sunny condition. Besides that, the voltage of the battery remains the same for 2 hours and this indicates that the battery is fully charged as shown in the table and figure 4.3.1 i above. From figure 4.3.1 i, can see that the trendline is directly proportional.

4.3.2 Overall View and Finished up

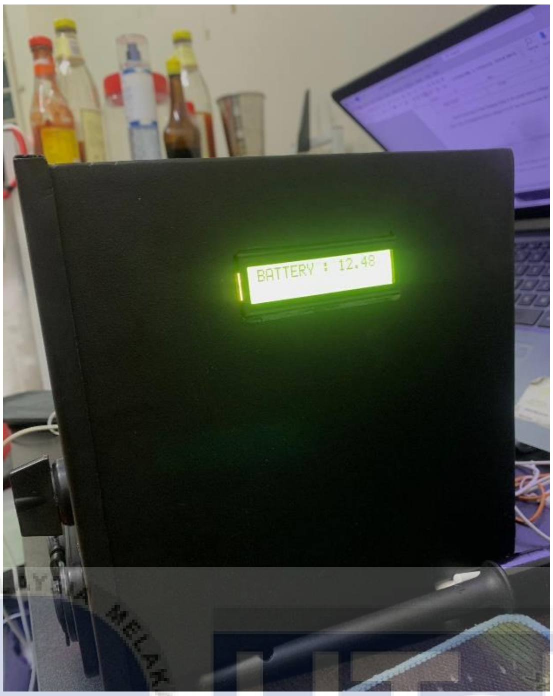

Figure 4.3.2 a : Front View

Figure 4.3.2 b : Left Side View

Figure 4.3.2 c : Back View

Figure 4.3.2 d: Right Side View

Figure 4.3.2 e : Internal View

Figure 4.3.2 (a-e) visualized the design of hardware. In the front view display the battery level. In the left side there are car smoke socket and USB port. At the back side there are solar charger controller and exhaust fan outlet. The exhaust fan outlet is designed so that it can suck the air from the internal of the hardware and release it so that the components that are inside of the hardware do get overheated if the weather or the surrounding is hot. In the right side there is 3 pin sockets for camper to charge their electronic devices. At the internal view there is inverter, Arduino, and relay on the top. At the internal view there is also battery in the bottom. The top and bottom are separated by a piece of perspex.

4.3.3 Inverter Testing Using Phone Charger

Figure 4.3.3 a : Smartphone A with 11 % battery start charging

Figure 4.3.3 b : Smartphone A with 91% battery percentage

Figure 4.3.3 c : Smartphone B with 17% battery start charging

Figure 4.3.3 d : Smartphone B fully charged

Table 4.3.5: Smartphone A and B Chraging

Battery Level Before Charging Smartphone	Battery Level After Smartphone are fully charged
12.6V	12.3V
12.3V	12.1V

The system can support charging of two smartphones. One smartphone with only 11% battery can be charged up to 91% as shown in Figure 4.3.2 a and figure 4.3.2 b. Another smartphone with only 17% battery left can charged until it is max which is 100% as shown in Figure 4.3.2 c and 4.3.2 d.

4.3.4 Car smoke socket and USB testing

Figure 4.3.4 a : Smartphone A with 10% battery start charging

Figure 4.3.4 b : Smartphone A fully charged

Figure 4.3.4 c : Battery level when start charging

Figure 4.3.4 d : Start charging smartphone B

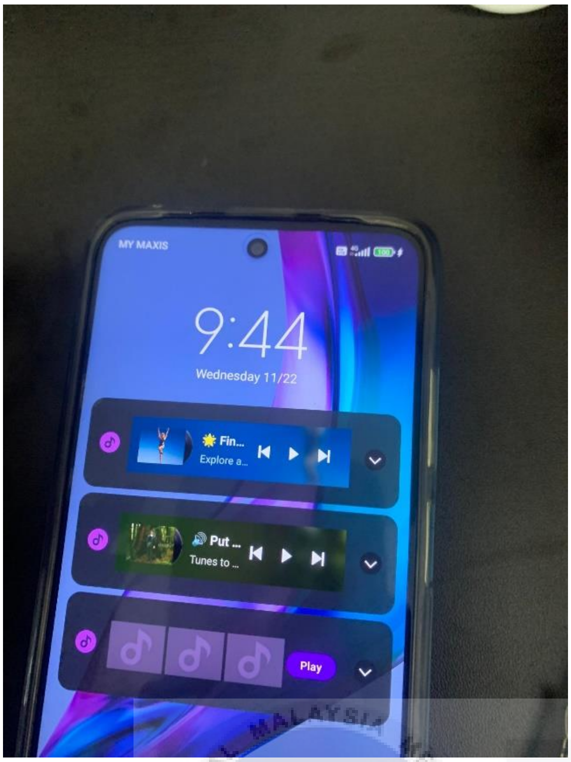

Figure 4.3.4 e : Smartphone B fully charged

Figure 4.3.4 f : Battery level left

Table 4.3.6 : Smartphone A Charging using USB Socket

Battery Level Before Charging Smartphone	Battery Level After Smartphone are fully charged
12.5V	12.5V

Table 4.3.7 : Smartphone B Charging using Car Smoke Socket

Battery Level Before Charging Smartphone	Battery Level After Smartphone are fully charged
12.5V	12.2V

Based on the result shown in Figure 4.3.3 a, the battery with 12.5V manages to charge a smartphone A using USB. After 2 hours and 11 minutes, the smartphone is fully charged with 100% battery and the battery's voltage remains the same as shown in Figure 4.3.3 b. This is because USB socket consume less power. On the other hand, another smartphone B is charged using car smoke socket with car charger adapter as shown in Figure 4.3.3 c. After approximately 2 hours and 45 minutes the smartphone is fully charged with 100% battery. The battery is left with 12.2V as shown in Figure 4.3.3 d and this is because car charger adapter consume more power .

4.4 Summary of Chapter

After completing the testing and troubleshooting, this project achieves the expected outcome that is targeted in the beginning of this project.

The main objectives are to build a portable solar station for campers, use a photovoltaic (PV) solar system to produce sustainable solar energy, and monitor solar battery charging with a solar charger controller. Monitoring the battery voltage level with an Arduino and a voltage sensor is also part of the goal.

This all-inclusive strategy includes using solar charger controllers to maximize charging efficiency, utilizing photovoltaic technology to capture clean and sustainable energy, and offering an easy-to-use solar solution designed specifically for campers. Real-time battery level monitoring is made possible by the combination of Arduino and voltage sensors, guaranteeing effective and dependable power management.

Through the accomplishment of these goals, the project hopes to improve camping experiences with dependable portable power stations, advance environmentally sustainable methods in off-grid circumstances, and contribute to eco-friendly energy solutions. The integration of solar power generation, sophisticated charging management, and efficient monitoring is in line with the increasing need for energy solutions that are both adaptable and ecologically friendly.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this project effectively addresses the important demand for dependable and sustainable power solutions, particularly in outdoor and off-grid circumstances, by developing a solar portable station. The main goal of developing a flexible solar power source has been accomplished, and it has been successful to integrate cutting-edge technology like an inverter, an Arduino system, and a solar charging mechanism.

The solar charging setup performed admirably in a variety of weather scenarios when paired with an Arduino-based monitoring system. The project's overall objective of giving outdoor enthusiasts an eco-friendly option is aligned with its effectiveness in efficiently using solar energy. The solar generator is a very useful tool for campers since it can power several applications and charge electronic gadgets in an environmentally friendly manner.

The generator's dependability is enhanced by the project's emphasis on preventive maintenance and efficient system operation. Features like an exhaust fan outlet and a thoughtfully planned internal structure guarantee that the parts function at their best, even in demanding environmental circumstances.

The outcomes of tests conducted on smartphone charging via USB and automobile smoke socket further confirm the solar generator's usefulness and dependability in satisfying a range of user requirements. The generator's versatility is further demonstrated by its capacity to charge numerous devices at once, providing it a complete solution for outdoor power needs.

This project successfully produced a solar portable station that not only satisfies its goals but also supports the worldwide movement towards environmentally friendly and sustainable technology. The solar generator is positioned as a dependable and effective power source for outdoor enthusiasts because of technological breakthroughs, successful testing, and a dedication to environmental responsibility.

5.2 Potential for Commercialization

The portable solar-powered station that is discussed in the conclusion has a lot of promise for the business market. As more people look for off-grid experiences, consumer's demand for eco-friendly items is expanding, especially regarding the campers and outdoor recreation sector. The device's distinctive selling point is its ability to combine renewable energy with ease, catering to the demands of campers who are concerned about the environment. A voltage sensor, an LCD display, and Arduino technology offer a technical edge that improves real-time user interaction. The device has an edge over competitors because of its adaptability in powering electrical devices and performing a variety of purposes outside of camping. Consumer values are aligned with its concentration on environmental sustainability, and IT aficionados are drawn to its instructional components. The product's brand image might be enhanced by strategically planned marketing of these attributes and its commitment to corporate responsibility. In conclusion, the unique qualities of the solar-powered portable station, along with its market demand and adaptability, make it an appealing and financially feasible option for the camping and outdoor leisure industries.

5.3 Future Works

For future improvements, solar portable station could be enhanced as follows:

i) Enhancing Product Quality and Adding New Features: To raise the solar panel's overall power output and improve its efficiency, carry out further research and development. Examine other features that may be included, such enhanced connection for a wider variety of devices, intelligent power monitoring systems, or energy storage alternatives.

ii) Weather resistance and durability: To make the portable station a dependable option in a range of climates and terrains, concentrate on enhancing its weather resistance and durability to endure severe outdoor circumstances.

iii) Small and Adaptable Architecture: Create a small, modular design for the portable station, removing any extraneous parts and making sure that each one has a distinct function.

iv) Light weight: Select materials for the portable station's structure and casing that are both sturdy and lightweight. Materials such as carbon fiber, high-strength polymers, and lightweight metals can be considered.

v) Modern Battery Technologies: Make an investment in energy-dense and high-capacity battery technology. For instance, lithium-ion batteries frequently offer an excellent balance between weight and energy density. Examine new battery technologies that provide longer cycle life and increased energy storage capacity.

vi) Battery Management System (BMS): Utilize an advanced Battery Management System (BMS) to track and balance each battery cell in the pack. This lessens the chance of imbalance problems, overcharging, and undercharging, which can shorten battery life.

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APPENDICES

Appendix A

```
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);

#define ANALOG_IN_PIN A0

float adc_voltage = 0.0;
float in_voltage = 0.0;
float R1 = 30000.0;
float R2 = 7500.0;
float ref_voltage = 5.0;
int adc_value = 0;

const char relay1=3;
const char relay2=5;
String receive;

void setup()
{
  Serial.begin(9600);
  lcd.init();
  lcd.backlight();
  lcd.begin(16,2);
  lcd.setCursor(0,0);
  lcd.print("WELCOME TO");
  lcd.setCursor(0,1);
  lcd.print("MY PROJECT");
  delay(1000);
  lcd.clear();
  pinMode (relay1,OUTPUT);
  pinMode (relay2,OUTPUT);
}

void loop()
{
adc_value = analogRead(ANALOG_IN_PIN);

adc_voltage  = (adc_value * ref_voltage) / 1024.0;
in_voltage = adc_voltage / (R2/(R1+R2)) ;
lcd.setCursor(0,0);
lcd.print("BATTERY : ");
lcd.print(in_voltage,2);
lcd.print(" V ");
delay(1000);
```