IMPLEMENTATION OF SOLAR-POWERED E-VEHICLE

by

MEHATAJ KALAM

ABDUN NOOR PAVEL

ABU ZAHED

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical and Electronic Engineering
INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

APRIL 2022

IMPLEMENTATION OF SOLAR-POWERED E-VEHICLE

by

MEHATAJ KALAM

ABDUN NOOR PAVEL

ABU ZAHED

A project
Submitted as partial fulfilment of the requirement for the degree of

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical and Electronic Engineering

INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

APRIL 2022

CERTIFICATE OF APPROVAL

The project entitled as "**Implementation of Solar Powered E-Vehicle"** submitted by **Mehataj Kalam**, bearing Matric ID. **ET 153072**, **Abdun Noor Pavel**, bearing Matric ID. **ET 153061, Abu Zahed,** bearing Matric ID. **ET153065** of session **Spring 2021**, to the Department of Electrical and Electronic Engineering (EEE), International Islamic University Chittagong (IIUC), has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on April **2022**.

____

Supervisor
Engr. Md. Jalal Uddin
Assistant Professor
Department of Electrical and Electronic Engineering
International Islamic University Chittagong.

DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this project has been submitted elsewhere for the award of any degree or diploma.

Mehataj Kalam

Abdun Noor Pavel

Abu Zahed

ACKNOWLEDGMENT

In the name of Allah, the most gracious and the most merciful. First of all, we are grateful to almighty Allah for giving us strength and wisdom throughout our life. We thank our family for their love, the and moral and financial support they had given us. This helped us a lot. We would like to give our gratitude to our honourable supervisor Engr. Md. Jalal Uddin, Lecturer Dept. of EEE, IIUC has given us significant suggestions and inspections during the whole process of the work. His invaluable help of constructive comments and suggestions throughout the experiment and project work has contributed to the success of this project.

Last but not least we are grateful to our teachers, friends, classmates, seniors, and lab Assistants, who have given us their unlimited support and help in every aspect. We are fortunate to have nice human beings like them beside us.

Authors

ABSTRACT

Solar-powered vehicle (SPV) is one of the representatives of the future automobile industry. Since global warming is an alarming sign for the upcoming days, we need to minimize the usage of fossil fuels. SPV allows us to decrease pollution. In this project, we have designed and implemented a solar-powered car. Generally, these cars are not a common sight in Bangladesh and are in the experimental phase. But still, these can be a potential alternative for eco-conscious buyers. Solar power vehicle is powered by electricity through solar energy. Adjustable solar panels are added to the roof and body of the car. The solar charge controller is applied that works like the command centre of the Photovoltaic (PV) system and regulates the charge as well as the discharge of the battery storage. However, it also controls the power output of the solar cell module and storage according to the input demand of the load. Our used lead-acid battery vehicle can be charged from solar along with an AC source through a charger. The motor runs using the power of the lead-acid battery. Lastly, we finalized our project by extending our vision on near future expectancy in this field.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 Introduction

At present global warming is increasing day by day because of pollution. There are many ways that we pollute our world like air pollution, water pollution, sound pollution, etc. All of these are major problems for our environment. Air pollution is one of the major problems. We pollute the air by emitting toxic gas from vehicles, industry, factories, etc. That's why we need eco-friendly machinery that doesn't pollute our environment. That eco-friendly machinery is powered by electricity. Nowadays maximum vehicles are running with like diesel, petrol, and octane. This kind of fuel is coming from our natural liquid. One day this natural thing will end and we need another source for powering and running our vehicles. For this kind of problem, there is also a solution like solar power electric vehicle [1]. This vehicle is powered by a battery. The battery is charged with electricity. We can use renewable energy for charging our vehicle batteries.

1.2 Motivation

Day by day our technology is improving. Solar cars are electric vehicles that are completely powered or partially by direct solar energy. Solar vehicles are a happy union of solar power and electric vehicles and the two technologies magnify the effects of each other because the batteries in EVs can store the clean energy produced by the solar panels. Solar cars use an array of photovoltaic cells to convert sunlight into usable electric energy. Solar cell technology exhibits significant advantages over traditional fuel-based energy sources, such as free energy sources, zero-emission, no noise, and versatility.

1.3 Project Objective

The objective of our project is given below

- To design an eco-friendly vehicle.
- To design a system that can capable of solar power and e-power.

1.4 Report Outline

Six chapters have been covered in the course of the design and development of this project. The chapters and their contents are as follows:

- Chapter 1 is the introductory chapter that gives the overview, motivation, and objective of the project.
- Chapter 2 is a literature review. The previous work-relation edis project has been discussed in this chapter.
- Chapter 3 is a hardware description. In this chapter, all the components used in this project have been described elaborately.
- Chapter 4 deals with the system design of the project. In this chapter Block diagram, Circuit diagram, Flow chart, and Programming of the project have been discussed.
- Chapter5 deals with the system implementation and results, Objective verification, and system specification.
- Finally, the summary of this project has been discussed in detail in chapter 6. The limitation of the project t, advantage, and future development has been discussed on this topic.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Currently, one of the greatest engineering issues to tackle is the need for clean energy sources [2]. Much of the world is highly dependent on natural gases and coal to produce electricity. Although this power source is abundant, it is shown to assist in global warming. Global warming is the biggest problem facing the Earth. Furthermore, extraction methods such as fracking are shown to have a detrimental effect on the environment, namely earthquakes. One source of energy being heavily studied is solar energy [3]. Solar energy is the largest source of renewable energy in the world. Until recently, the efficiency of the solar panels, used in the collection of solar energy, was too low for it to be a viable option for replacing energy obtained from fossil fuels. This form of energy is created by us photo voltaic static, commonly known as solar cells to convert photons produced from the rays of the sun to electricity. These cells use the photons to knock electrons in atoms out of their place, thereby aiding in the flow of electricity.

2.2 Review of Previous Work

In this 21st century and recent development in electric cars and solar cars, the most famous and familiar name is “Tesla”. ‘TeslaRoadster’ was the first invented electric car of this company that used lithium-ion battery cells, introduced in 2008 [4].

In Bangladesh, a solar electric car manufactured by a local company, Advance Dynamics Limited fruitfully finished a historic 2000km journey across the country on July 15, 2019. The vehicle consumed 502.90Kwh of grid electricity and generated 31.62Kwh of solar power during the tour [5]. At the University of Michigan, a solar energy-based higher-scale hybrid car was developed by a group of students. It was a complex project and needed one year to accomplish [6].

Seth Leitman and Bob Brandt et. al. made a DIY electric vehicle [7]. The authors provide a cost list to make an EV conversion that provides several different scenarios for the buyer. Using an economy car with a combination of new and used components, the total cost is estimated at $5,200 [16]. The paper entitled “Design and Development of Solar Assisted

Bicycle" was written by Sankar M R. et al. A solar-assisted bicycle was driven by a DC motor fitted in the front or rear axle housing & operated by solar energy. The solar panels mounted on the carriage charged the battery which in turn drove the hub motor. When the bicycle was idle, the solar panel charged the battery. The solar-assisted bicycle had a power rating of 250 W and a traveling speed of around 25-30 km/h [8].

2.3 Energy Perspective of Bangladesh

In Bangladesh, the power crisis is a common phenomenon that has become a serious problem nowadays. More than a quarter of the rural population still does not have access to electricity. Transmission loss, distribution loss, machinery loss, and unscrupulous management are the key factors for power shortage. Some plants are out of operation for maintenance, and rehabilitation, and the capacity of some plants is degraded due to aging. To get over the excess demand, it is necessary to construct a new power station while the electricity demand is increasing. The main source of generation of electricity in Bangladesh is natural gas. About 68% of the total electricity in the country is produced from natural gas according to a report by the Bangladesh Power Development Board (BPDB) [9]. **Fig 2.1** shows the fuel type contributions to electricity generation in Bangladesh

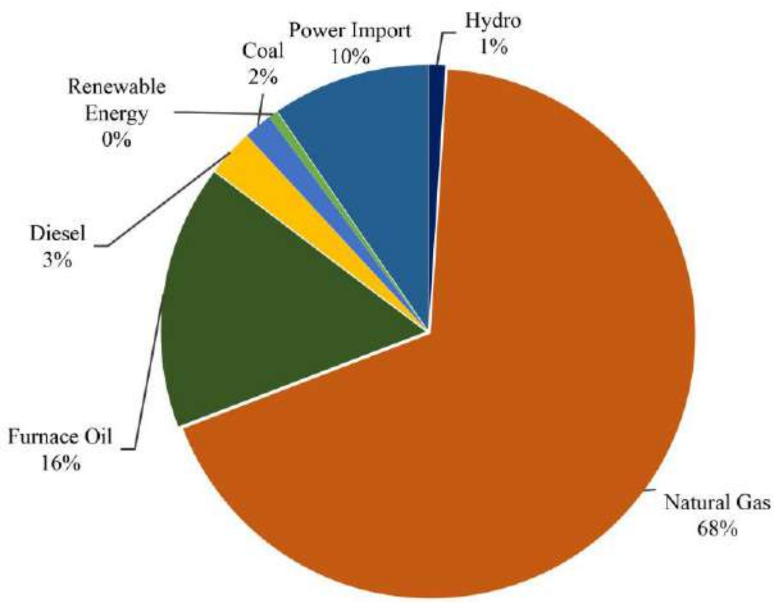

Fig 2.1: Fuel type contributions to electricity generation of Bangladesh [9]

For millions of people, daily activities like cooking, working, and studying are difficult, or even impossible, after sundown. But off-grid solar power is rapidly changing all this. However, it is quite implausible for our country to build up new power stations due to the shortage of huge funds. Besides, the lifetime of the old power stations is over. In that case, sometimes some of the units or whole station collapsed. Bangladesh is a subtropical country, which is situated between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east which is an ideal location for solar energy utilization [10].

CHAPTER 3
DESIGN METHODOLOGY

3.1 Introduction

This chapter includes the system design and simulation of this project. Block diagram, Circuit diagram and Flowchart of the system as discussed below.

3.2 System Architecture

A System Architecture is the calculated model that characterizes the structure and shows us the perspective of a system framework. The architecture which binds the whole system of our work is illustrated herein in **Fig. 3.1.**

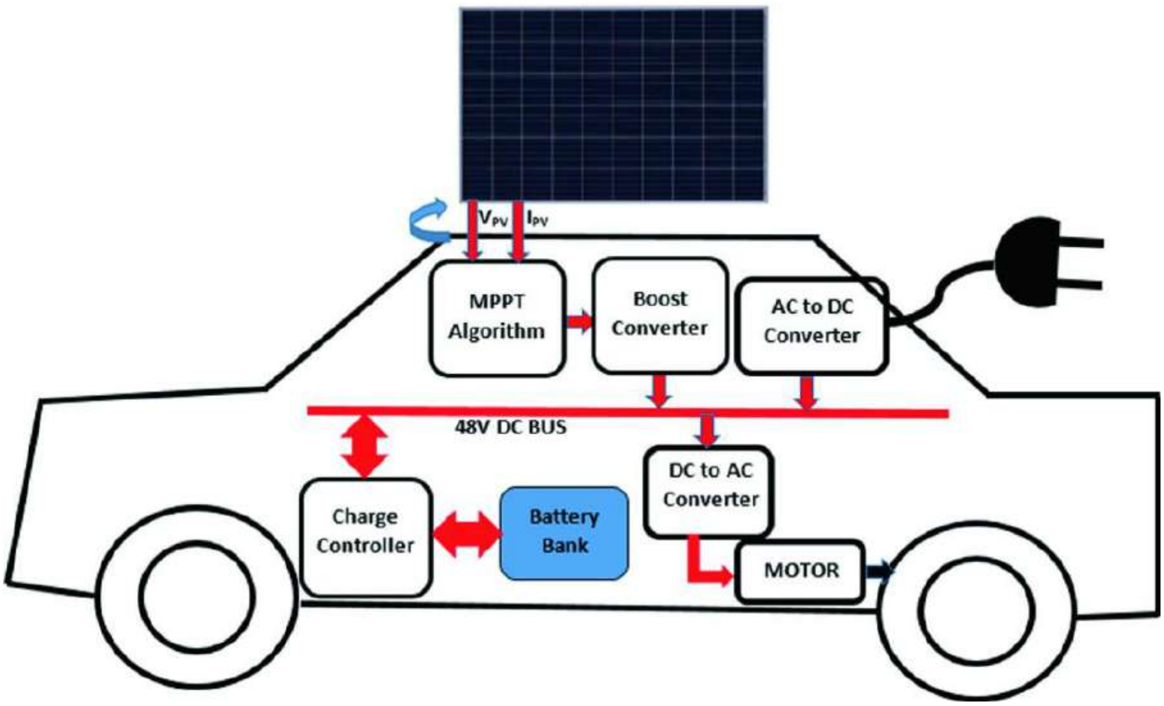

Fig. 3.1: Solar car basic design [11]

Here, from the above system architecture, we can gather basic knowledge about the system. Our solar car consists of a solar panel, motor, motor controller, battery, chassis, charger, charge controller, wheel, etc. Solar Panel is lined with PV cells that convert the solar energy into usable electricity through which our battery gets power. However, a major part of the energy to drive the vehicle is provided by grid electricity. The battery accumulates the energy needed to run the motor along with the controller. Electric energy is converted into mechanical energy by an electric motor to rotate the wheels. Speed controller assists to monitor the vehicle's speed and controlling the engine and wheels accordingly. Chassis is the backbone of the vehicle that holds the entire load and wheels support the whole system to run.

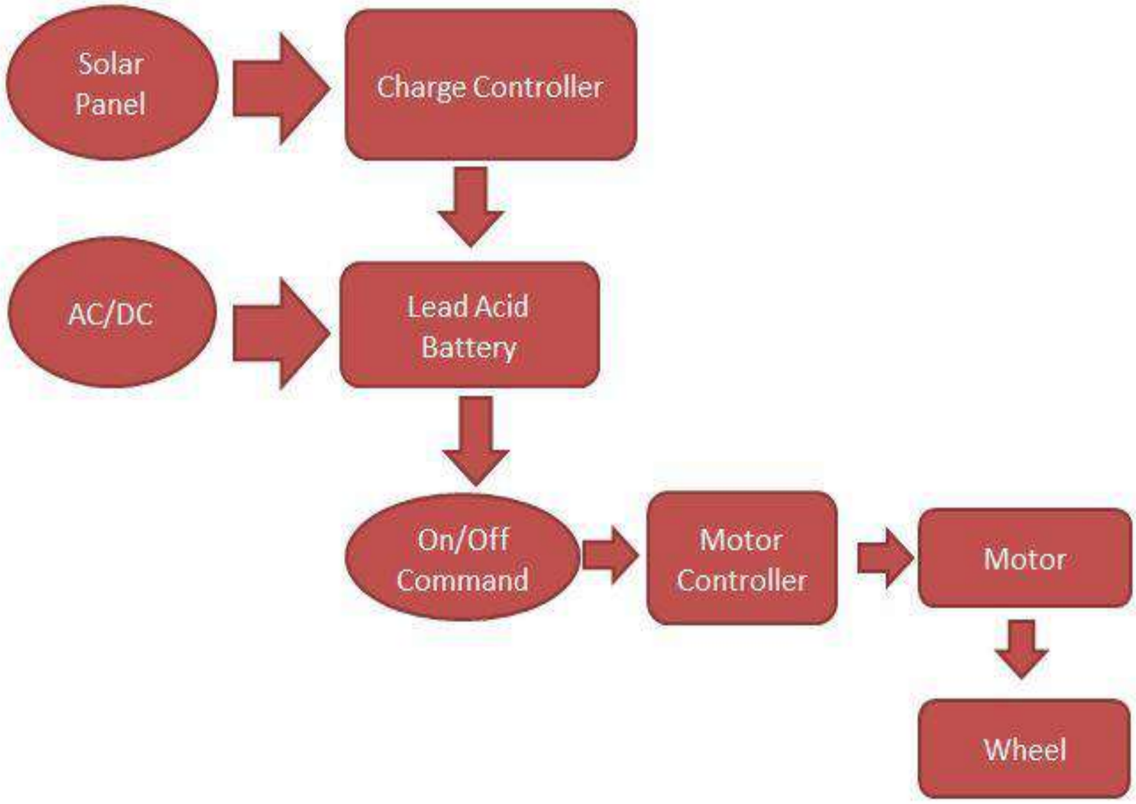

Fig. 3.2: Solar Car system block diagram

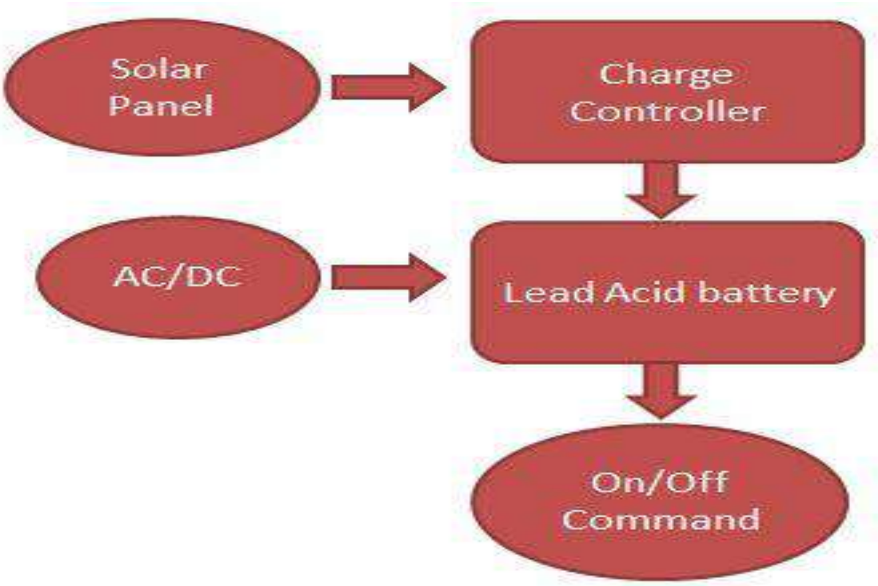

Fig. 3.3: Power System block diagram of designed solar car

3.3 Solar System

Solar PV arrays are associated in series and parallel to achieve the required voltage and current. Each photovoltaic cell is created by a PN junction semiconductor that with the presence of sunlight becomes an electrical current generated by the photovoltaic impact. The PV cell circuit model is shown in **Fig. 3.4**.

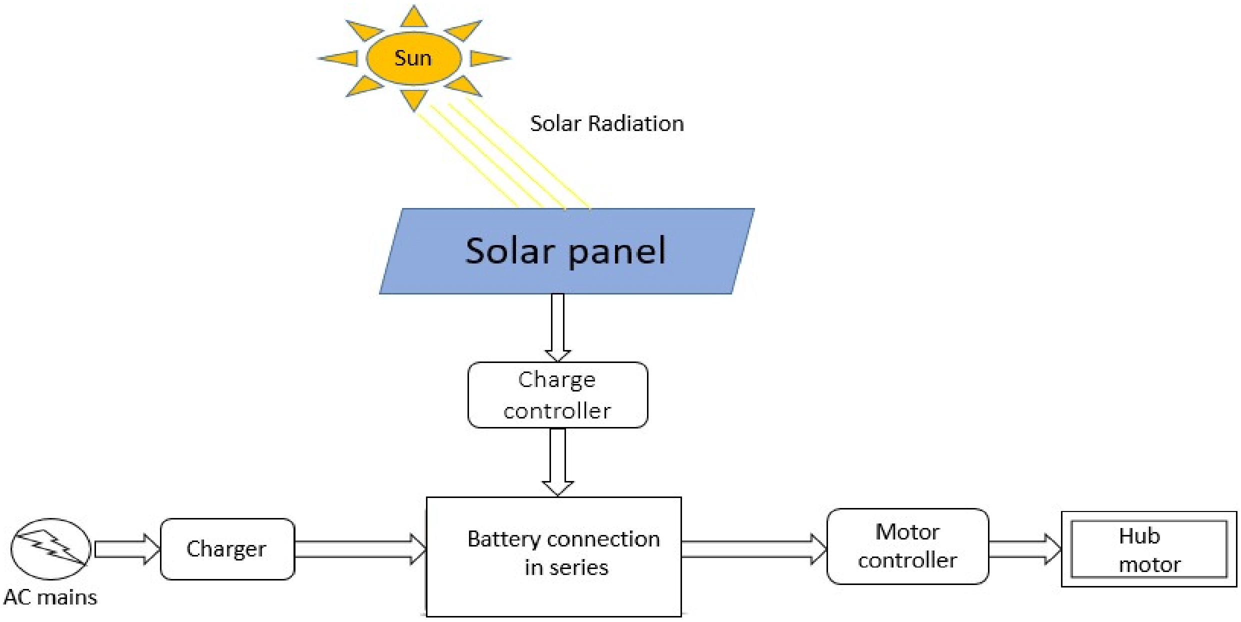

Fig. 3.4: Solar Cell Model [12]

3.4 Solar Charger

The proposed 48V solar battery charger circuit with a high/low cut-off feature can be witnessed in the following diagram f**ig. 3.5**. The IC 741 is configured as a comparator and is appropriately stabilized from the high 48V input using Zener diodes and potential divider networks across its supply and input pins. As requested, the input voltage which may be more than 50v is acquired from a solar panel and applied to the circuit. The 10kpresett is adjusted such that the power MOSFET cuts off when the connected battery reaches the full charge level. The 22k preset is the hysteresis control for the circuit and also serves as the lower threshold adjustment pre-set. It should adjust such that the MOSFET just initiates and switches ON at the preferred low battery voltage threshold. Once the discussed setup is implemented and power switched ON, the discharge level of the battery drags the supply to around 48V forcing pin2 of the IC to go below pin3 potential. This prompts the IC output pin6 to go high initiating the MOSFET connected in series with the ground rail so that the battery becomes integrated with the solar panel supply. The above also switches ON the BJT BC546 which in turn makes sure that the associated MOSFET and the load remains switched OFF.

As soon as the battery attains the full charge level, Pin 2 is pulled higher than Pin 3 rendering the output to a logic low. This instantly switches OFF the ground rail MOSFET and the BJT enforcing two things: cutting off supply to the battery and switching ON the load MOSFET such that the load now gets access to the supply voltages from the panel as well as the battery. The feedback hysteresis network formed by the 22k pre-set and the series 10k resistors ensures that the above action locks ON until the battery voltage reaches below the predetermined lower threshold.

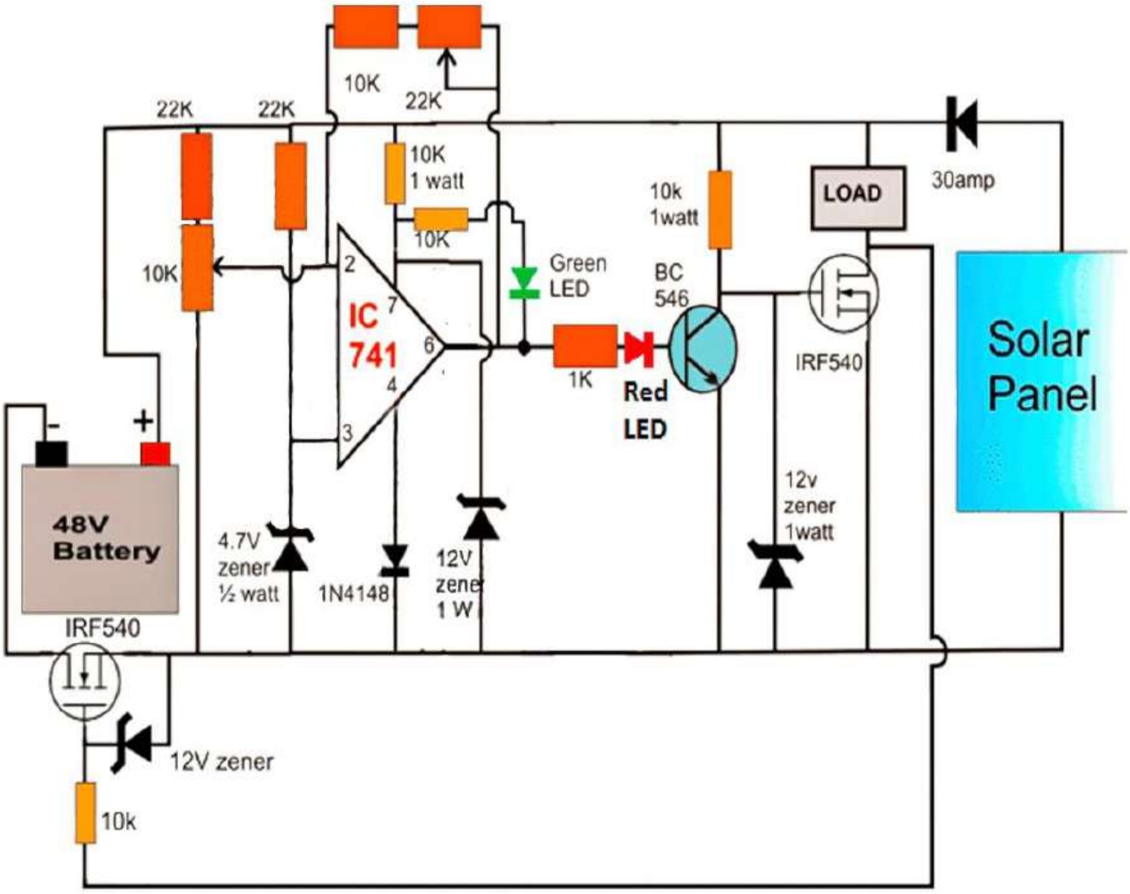

Fig 3.5: Solar Charger Circuit [13]

3.5 MPPT Charge Controller

The main component is the LT3562 power tracking IC. The circuit has two power sources one is from a DC jack connector and the other is from the solar panel. The DC jack connector to which we can connect an external DC adapter. The solar panel will be disconnected from any power source available if the DC connector is used. But we used external sources for better power to charge the battery. The 1n5819 diode reverses the voltage protection diode, so if the adapter of any polarity is connected the diode will protect our circuit. Moving on, we have an input filter capacitor of 10 microfarads used for filtering the noise and we also have a voltage divider in form of a potentiometer which can be used for setting the MPPT value on the other side three resistors are used to set the battery voltage based on the resistor value. Moving on, to the bug boost regulator section, there has 6 microhenries and two scotch diodes these resistors which are the current sense resistors, these resistors are used to set the battery charging current. We have a few more capacitors as a combination of electrolytic and ceramic capacitors for output noise filtering purposes.

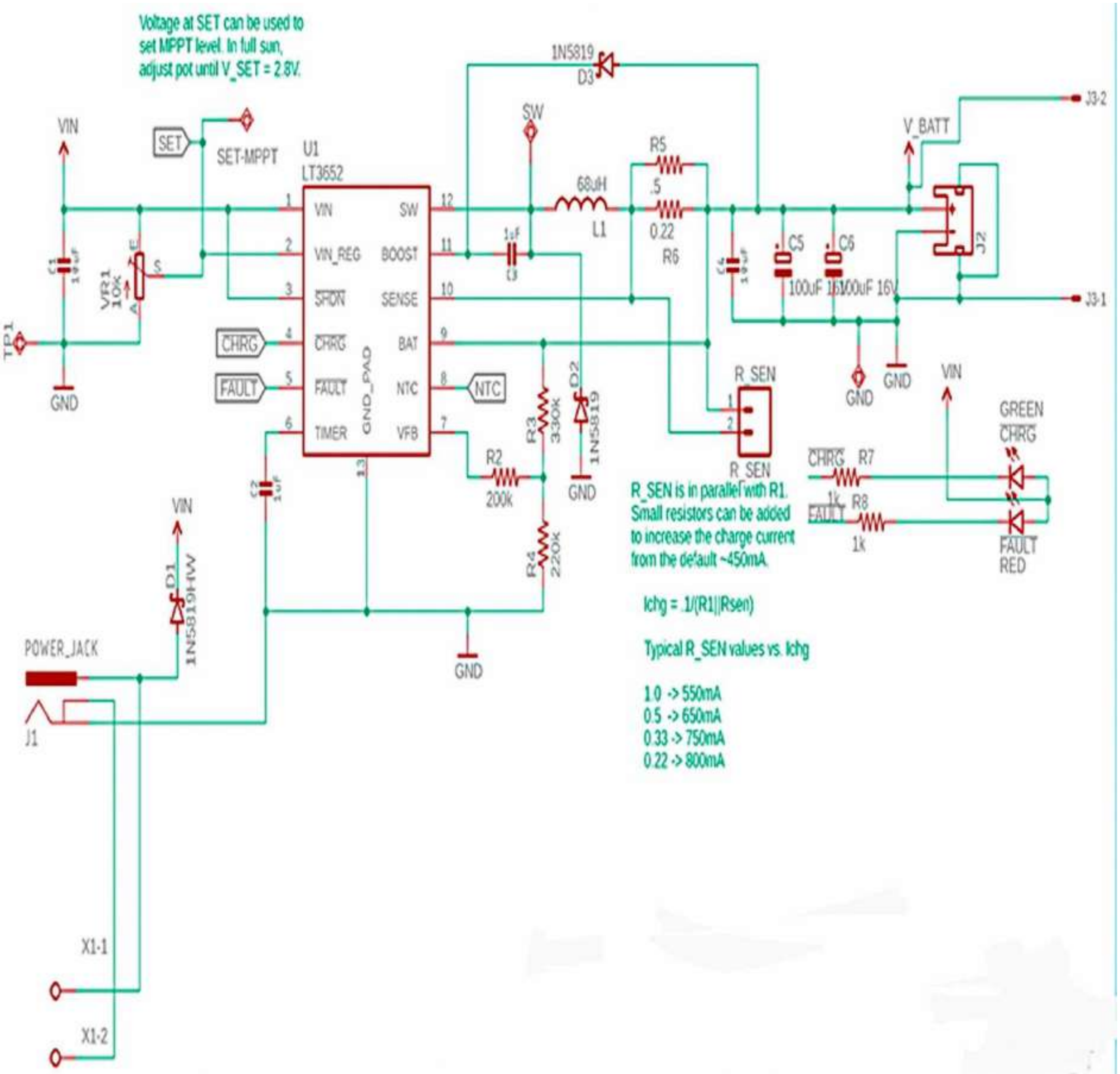

Fig: 3.6 MPPT Charger Controller Circuit Diagram

3.6 Experimental Site

Fig. **3.6** shows a mapping location of our experimental area “Agrabad” which is in the heart of Chattogram city. Solar resource data and location were obtained with Homer Pro software.

Fig. 3.7: Map location of Agrabad area [14]

3.7 Agrabad Area Solar Radiation Data

These data were obtained from the NASA Langley Research Centre Atmospheric Science Data Centre Surface Meteorological and Solar Energy (SSE) web portal supported by the NASA LARC POWER Project. The monthly averaged insolation incident on a horizontal surface is shown in **Table 3.1**

Table 3.1: Monthly Averaged Insolation Incident on a Horizontal Surface ($kWh/m^2/day$)

Months	**Averaged Insolation ($kWh/m^2/day$)**	**Monthly Averaged Clear Sky Days**	**Clearness Index**
January	4.42	17	0.618
February	4.98	19	0.606
March	5.44	24	0.572
April	5.51	25	0.524
May	5.11	23	0.465
June	4.16	18	0.375
July	4.04	12	0.367
August	4.18	13	0.395
September	4.02	22	0.413
October	4.28	25	0.503
November	4.25	22	0.579
December	4.28	19	0.629
Average	**4.56**	**20**	**0.504**

Monthly average global radiation data has been collected from NASA (National Aeronautics and Space Administration) satellite shown in **Fig. 3.shown**he average annual clearness index is 0.504 and the average daily solar radiation is 4.56 kWh/m2/day.

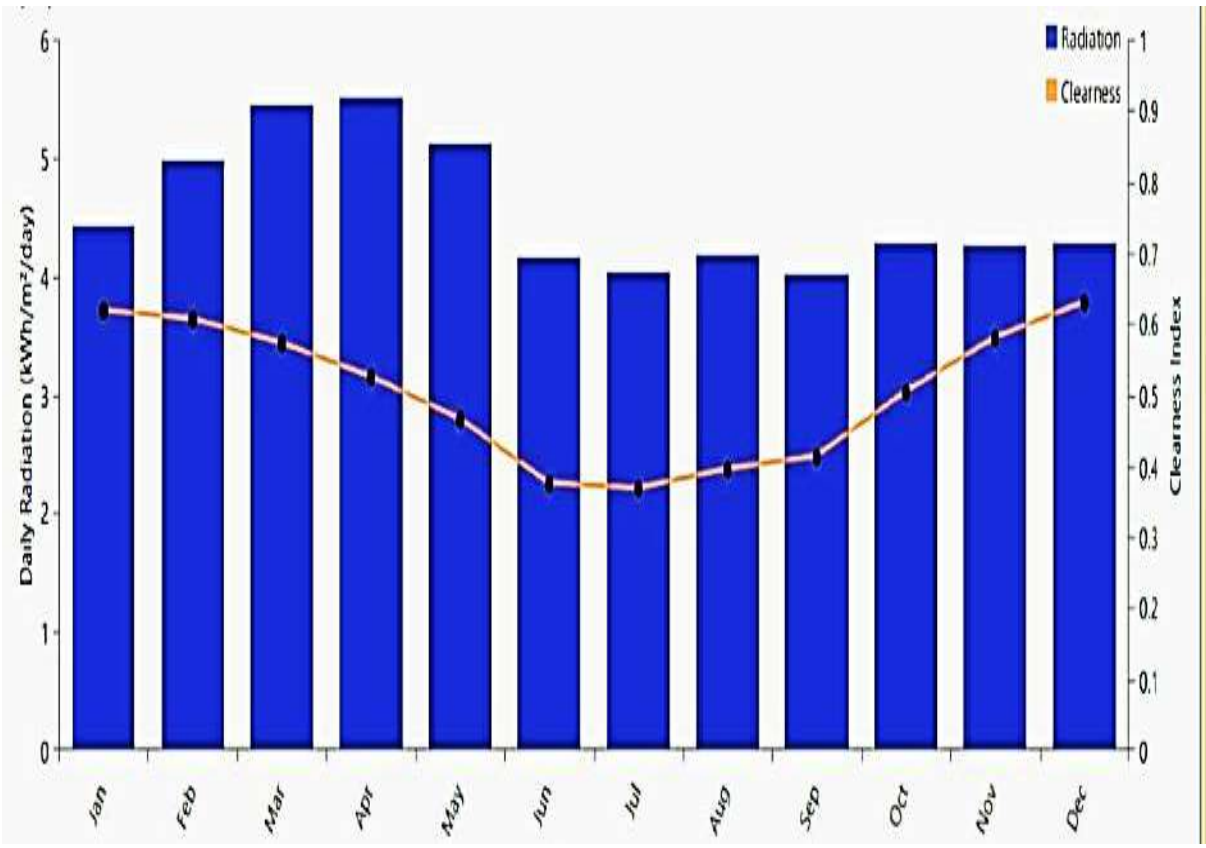

Fig. 3.8: Solar Radiation Data [14]

3.8 Monthly Averaged Daylight Hours

ITable**3.2** shows Monthly Averaged Daylight Hours are a combination of all direct and indirect sunlight during the daytime. This comprises direct sunlight, disseminated sky radiation, and, (often) both of these reflected by the earth and terrestrial objects. In our country, concerning seasonal change, monthly average daylight time is given in **Table 3.2**

Table 3.2: Monthly Averaged Daylight Hours (hours)

Month	**Daylight hour**
January	11.0
February	11.5
March	12.0
April	12.6
May	13.1
June	13.3
July	13.2
August	12.8
September	12.2
October	11.7
November	11.2
December	10.9

CHAPTER 4
HARDWARE DESCRIPTION

4.1 Introduction

Hardware is the most important fact for a project. Choosing the necessary hardware is also very difficult. In this chapter, we are going to describe the hardware used for this project. We will also discuss the function of the chosen parts. By the end of this chapter, one will understand the reason behind choosing the used components and their function for this project.

4.2 List of Components

- 48V-120A Battery Charger
- Solar Panel Mono Crystalline half cut
- 12V*4 Lead-acid Battery
- Charge Controller
- Chassis
- Steering
- Brake
- Wheels

4.3 Battery Charger

A battery works by converting its stored chemical energy into electrical power. Once the electrolyte of the battery is used up, it needs to be recharged. A battery charger is a device that provides Direct Current (DC) to the battery to restore the used-up electrolyte. So ideally, when all the electrolytes of the battery are restored, its current supply should stop. It consists of a rectifier circuit, power circuit, ripple monitoring, control circuit, regulator circuit,t, and a fault detection circuit. This charger can also be used as a DC source for a control and protection circuit of a substation during normal operation, or to charge the battery in floating mode. **Table 4.1** gives a solar battery specification and **Fig. 4.1** shows an image of a bathe battery charger.

Table 4.1: Product specification (Battery Charger)

Battery capacity	120AH
Voltage	48V
Charge current	18-20 A
Battery type	Lithium-Ion
Charger type	Analog
Working temperature	0-degreesree C

Fig. 4.1: 48V-120AH Battery Charger [15]

4.4 Solar Panel Mono Crystalline Half Cut

A monocrystalline solar panel is a solar panel comprising monocrystalline solar cells. These cells are made from a cylindrical silicon ingot grown from a single crystal of silicon of high purity in the same way as a semiconductor. The cylindrical ingot is sliced into wafers forming cells. A traditional solar panel is made up of several solar cells - usually 60 or 72. Aptly named, half-cell panels are made up of cells that have been cut in half (120 or 144 half cells). The cut cells can be polycrystalline but are usually monocrystalline PERC for the greatest results. When sunlight falls on the monocrystalline solar panel the cells absorb the energy and through a complicated process create an electric field. This electric field comprises voltage and current and generates power which is governed by the equation P = V*I. **Fig. 4.2:** shows a monocrystalline Solar Panel.

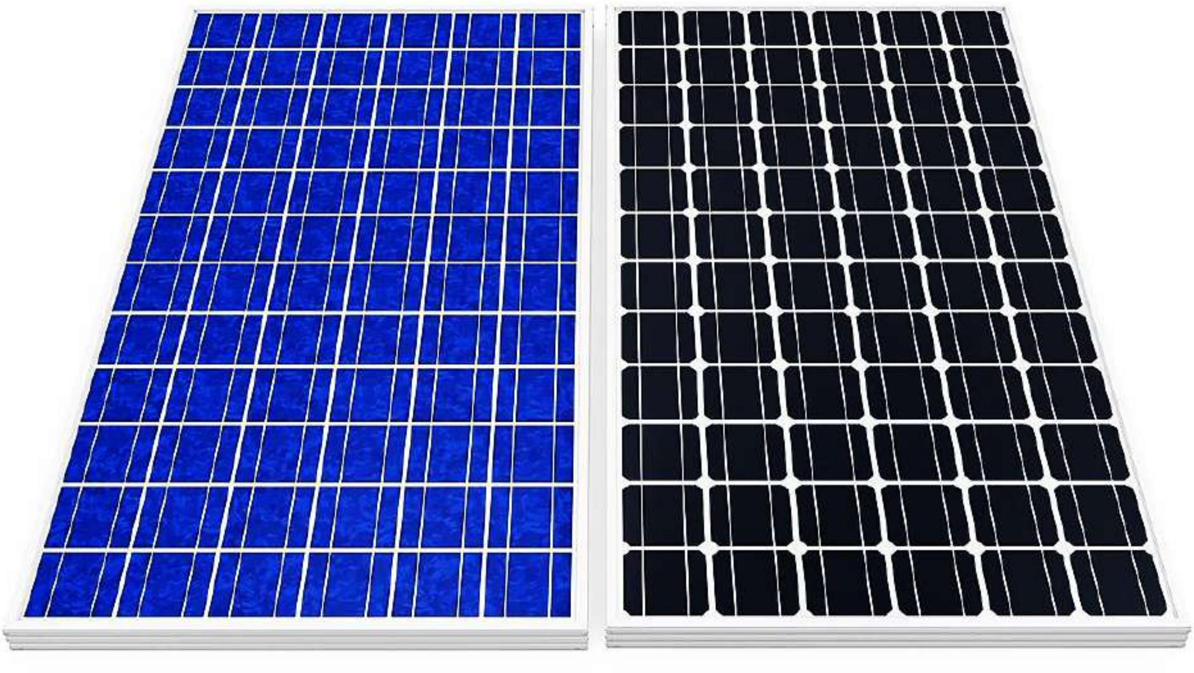

Fig. 4.2: Monocrystalline Solar Panel [16]

Advantages:

- Source of clean and renewable energy
- Saves money on electricity bills
- Easy installation
- Low-maintenance
- Potential to live completely grid-free

Disadvantages:

- They are the most expensive solar cells on the market, and so not in everyone's price range.
- The performance levels tend to suffer from an increase in temperature.
- There is a lot of waste material when the silicon is cut during manufacture.

4.5 12V*4 Lead-acid Battery

A twelve-volt battery has six single cells in series producing a fully charged output voltage of 12.6 volts. Each cell is capable of storing 2.1 volts. For a lead-acid cell to produce a voltage, it must first receive a (forming) charge voltage of at least 2.1-volts/cell from a charger. Most car batteries have six cells, and therefore a 12-volt battery. The plates are submerged in sulphuric acid which triggers a reaction between the two plates. The result is a chemical reaction that produces electrons. The electrons race around the plates and generate electricity.

Table 4.2 Product specification (Lead Acid Battery)

Nominal voltage	12V
Type	Lead-acid battery
Capacity	30AH
Electrolyte	Acid
Model Number	6-Dm-30

Fig. 4.3: 12V*4 Lead-acid Battery [17]

4.6 Charge Controller (48-V, 60A)

Our charge controller is a high-end 60 Amp MPPT solar charge controller that supports 12V, 24V, 36Vand, 48V system voltage automatically identification and auto-switch. also supporting a wide solar voltage input range from 18-150V. The controller's MPPT conversion efficiency is up to 99%. The internal structure, adopting the MPPT control algorithm can quickly track the maximum power point of the PV array, and improve the utilization of solar energy. This controller has a wide application range and can be installed and used in multiple scenes.

Fig. 4.4: LCD Display of Charge Controller

4.7 Steering

A steering system is a group of parts that transmit the movement of the steering wheel to the front and rear wheels. The primary purpose of the steering is to allow the driver to guide the vehicle. It converts the rotation of the steering wheel into a swiveling movement of the road wheels in such a way that the steering-wheel rim turns a long way to move the road wheels a short way.

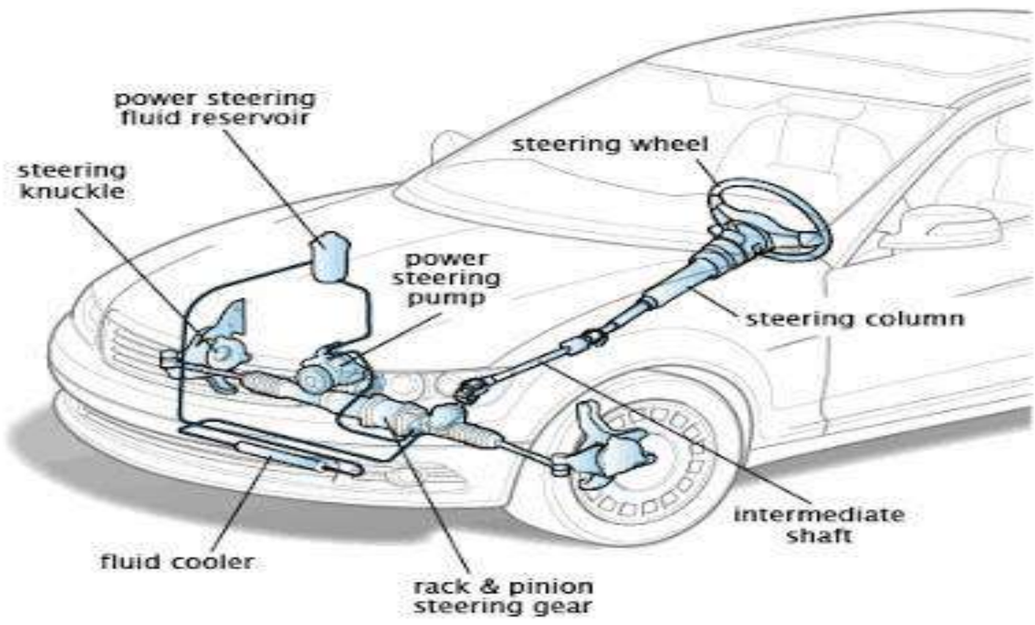

Fig. 4.5: Car Steering System [18]

4.8 Chassis

The chassis metal frame is the most essential component of the car on which the complete car body stands. It consists of the engine, transmission system, brakes, axles, ti, reset, and tc.

Fig. 4.6: Car basic Chassis design [18]

4.9 Brake

It is another crucial part of an automobile. The chassis frame holds the braking system of the car as well. A brake is a mechanical device designed to restrain motion by absorbing energy from a moving system usually by the means of friction. It is used to slow or stop a moving vehicle, wheels, axle, etc. The braking system is a complicated device with a lot of parts, but its working seems very easy. After all, pressing a single pedal will activate all brakes on the four wheels. The slowing down is achieved by hydraulic fluid, which is often bled to get the best performance of the breaking. Air is not allowed in the system else the component won't work well.

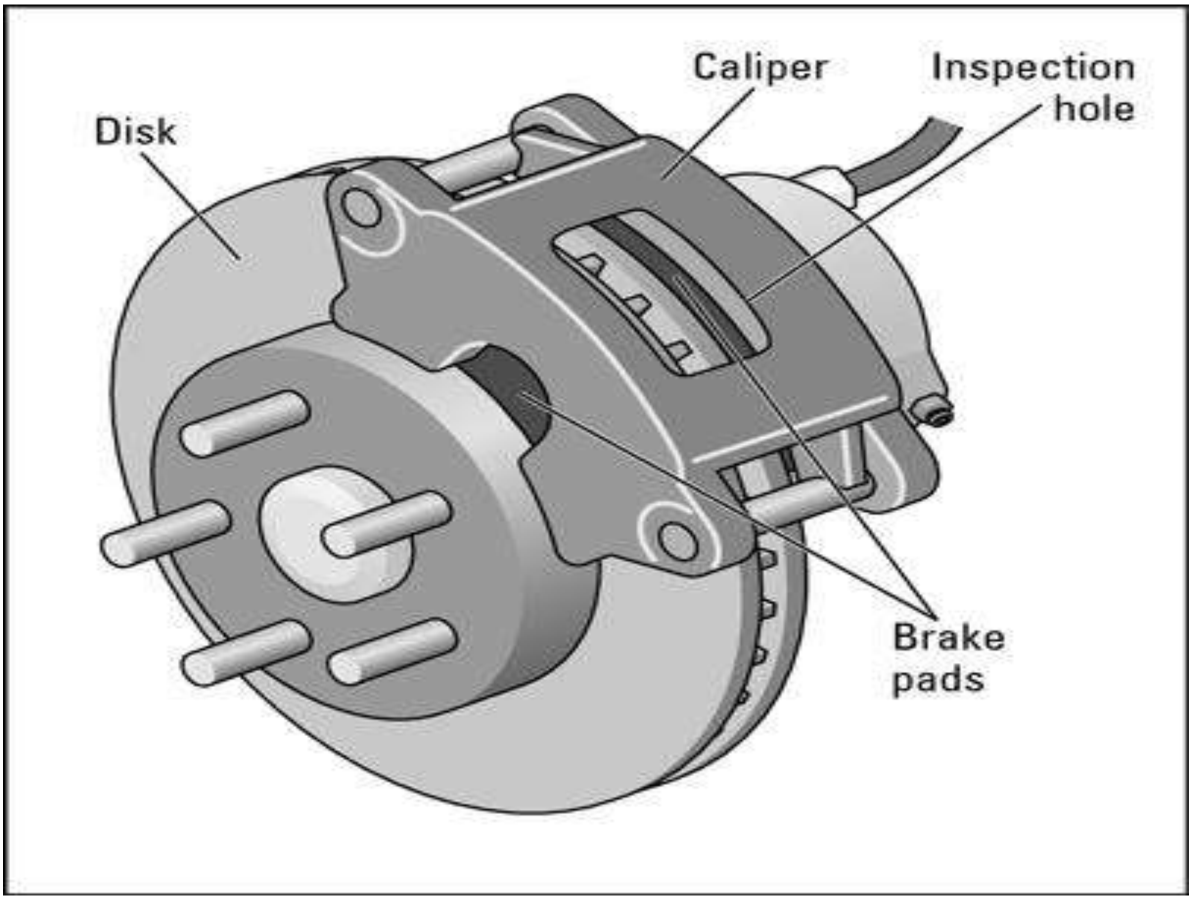

Fig. 4.7: Car Brake [18]

4.10 Wheel

Wheels are those primitive circular blocks that rotate for the car to move. They are placed vertically under the vehicle which doesn't only allow movements but also provides support for the vehicle and heavy loads.

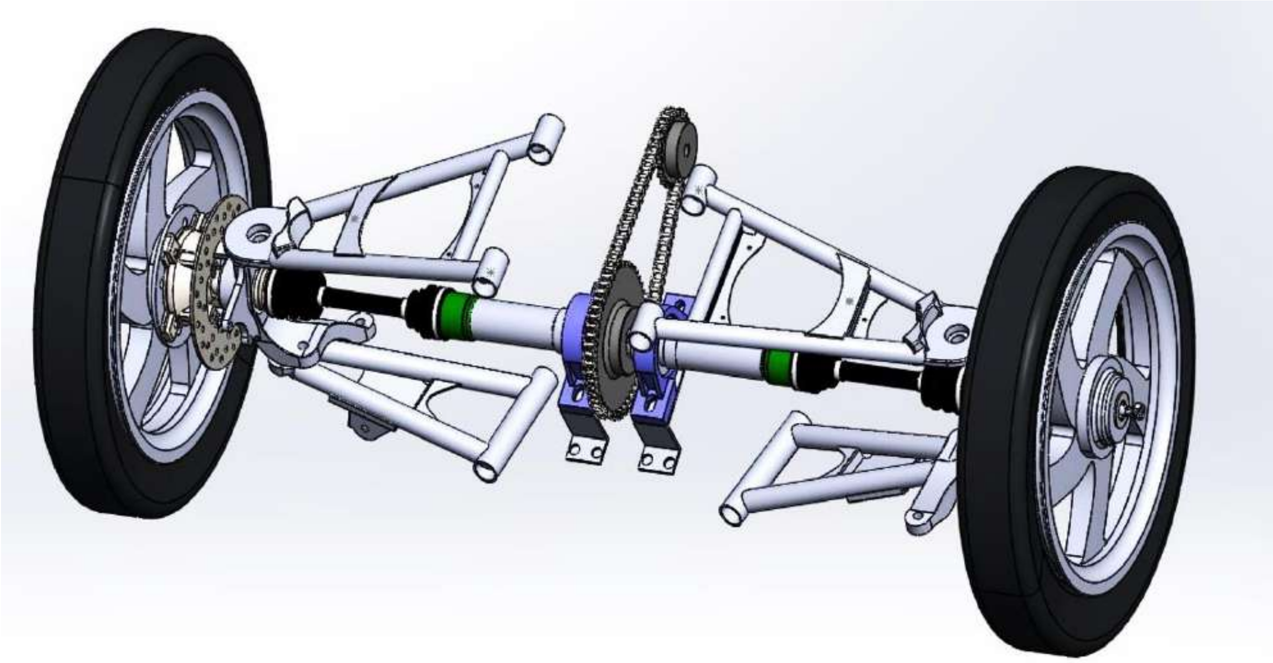

Fig. 4.8: Car Wheel [18]

CHAPTER 5

SYSTEM IMPLEMENTATION AND RESULT

5.1 Introduction

In this chapter, the complete implementation and objective justification have been discussed with proper demonstration.

5.2 Driving System Working Principle

The drive system consists of BLDC Motor which is powered by a 48V 60Ah battery bank through a dedicated motor speed controller. The motor has a built-in Rotor position sensor to sense the position of the rotor using the Hall Effect. The controller has a controlled inverter that converts DC voltage from the battery bank into AC voltage that is supplied to the stator of the motor. The thyristors in the inverter on appropriate phases are switched on and off concerning the rotor position sensor. The Throttle which works on the Hall Effect principle modulates the gate pulse width by giving a reference voltage of 0V to 4V and thus controlling the voltage amplitude supplied to the motor, hence the speed of the motor is varied by pressing and releasing the throttle.

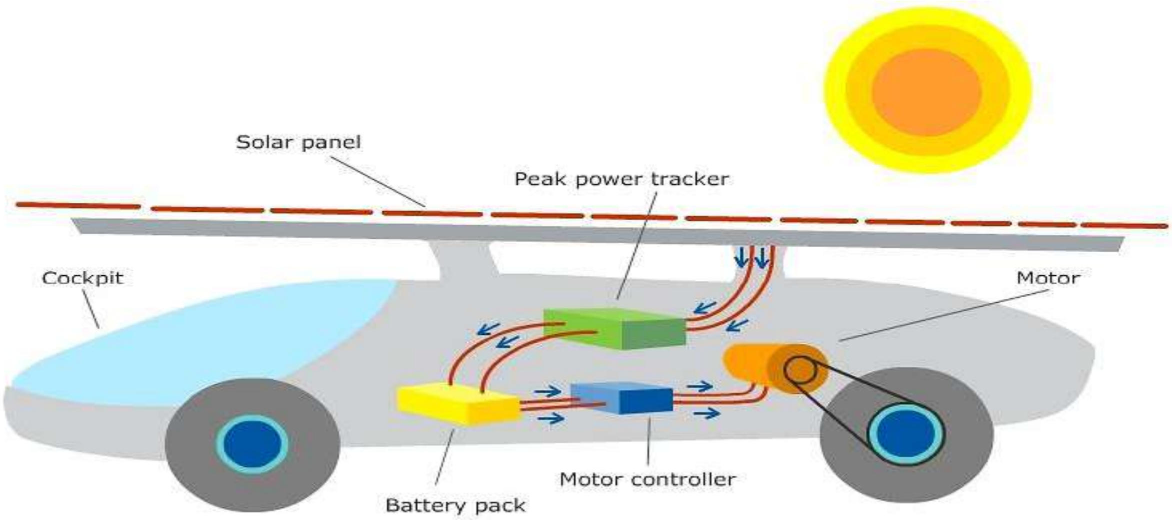

Fig. 5.1: Solar-powered e-vehicle System Design [19]

The charge level in the battery bank is monitored by the charge controller which is connected to solar panels installed. When the charge in the battery goes below rated voltage the charge controller transfers the charge generated by the solar panels to the battery until it regains rated voltage. A fully charged battery can power the vehicle for 2 hours and can cover a distance of 30 km/h. It needs 8 hours to charge the battery fully by-charger from the source and the solar panels can provide 15% back up to the vehicle for an extra hour.

Fig. 5.2: Solar Panel Setup

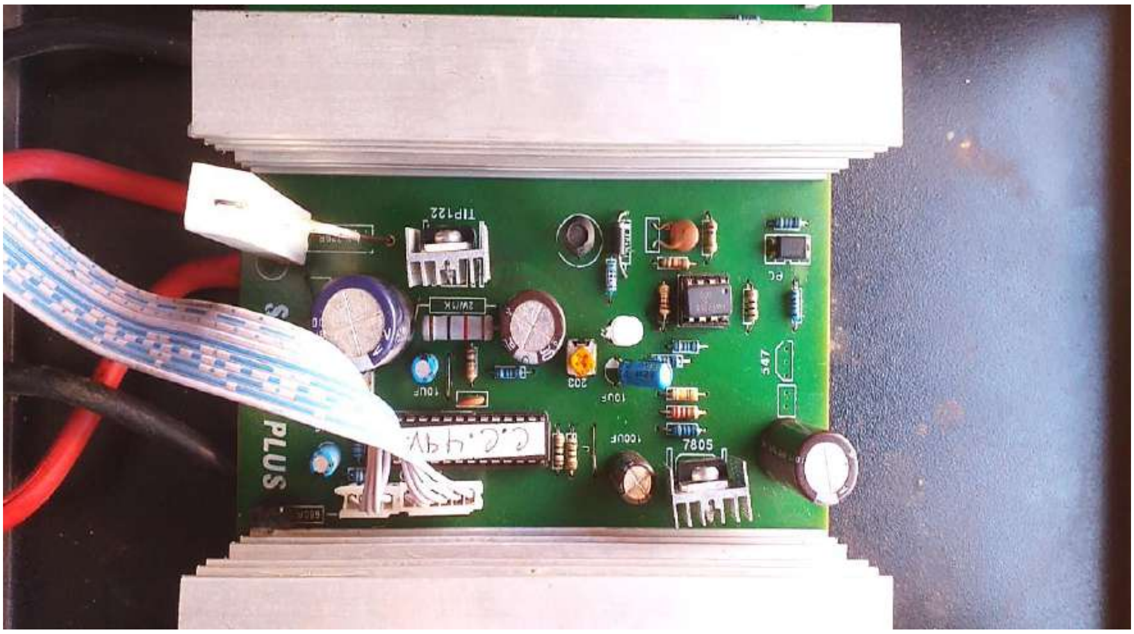

Fig. 5.3: Solar Charge Controller of the Vehicle

Fig 5.4: Back Side View of the Project

Fig 5.5: Overview of the project

Fig: 5.6 Front Side view of the project

We have used a solar panel to charge the battery has used to run the vehicle. The solar panel has mounted on the top side of the system.

5.3 Objective Justification

In this segment, we have shown all results that we have got from our project.

Calculation:

Full charging time (AC):

Battery (Ah) =120Ah

Charging current (A) =18A

T=Ah/A

=120/18

= 6.7 hours

Losses occurred during the battery charging 50%, take 18-20A for

Charging purpose. We take 20A instead of 18A.

Charging time for 120Ah, 48v battery=120Ah*(50/120)

=50 (120Ah*50% losses)

Battery rating (120Ah+50Ah) =170Ah (120Ah+losses)

Required charging time for battery =170Ah/20A

Full charging Time =8.5 hours

Charging per hours=100/8.5

=11.7 %

Full Charging Time (DC):

If we are using a MPPT controller the maximum efficiency can achieve is 90%. So with 220 watt of solar panels and 7 sun hours the most energy we can generate =

Watts * Hours * .90 = 220watt*7hours*.90

= 1386 WH

Total Battery Current = Battery voltage*amp hours

= 48v*120Ah

= 5760Wh

So if this batteries have 50% charge, I need to replace 5760 watt-hours. My panels can generate 1386 WH with a 7 sun hour day or 1386 WH / 7 hours = 198 watts. So factor out the Sun Hours 5760 WH / 198 watts = **29.1 hours.**

Charging per hour = (100/29.1) %

= 3.44%

Charge time for both:

Per hour charging time = battery time rate + solar time rate

= (11.7+3.44) %

=15.2%

Full charging time =100/15.2

= 6.57 hours

CHAPTER 6
CONCLUSION

6.1 Introduction

In this chapter, we will discuss the conclusion of the overall thesis. Also, discuss the application, advantage, limitation, and future improvement of the system.

6.2 Conclusion

The use of technological innovation in the Industrial world becomes extremely important for scientific advancement. In this sense, our project is very much innovative and will be helpful to humankind. It will create a new era in-vehicle system.

6.3 Advantage

- Powering cars using solar energy has some great benefits.
- It reduces the use of fossil fuels which is limited.
- Doesn’t cause environmental pollution.
- Solar energy is free that will never run out.

6.4 Limitation of Our Project

The limitation of this project has discussed below.

- Solar panels used being less efficient may result in longer charging time, which can be improved.
- In the rainy season, there might be a slight problem due to having less radiation.

6.5 Future Improvement

Some future work can be implemented later by further research proposed below.

- More efficient solar panels can be used.
- Charging time by both solar and AC power can be improved.
- The vehicle's structure can be made more feasible and developed.

REFERENCES

[1] Solar vehicles for business perspective in Bangladesh, Access Date: 14-06-2021, Retrieved from: www.tbsnews.net / feature /panorama /solar- electric-vehicles -business-prospect-Bangladesh- 121810

[2] Electrical engineering renewable energy, Access Date: 14-06-2021, Retrieved from: engineeringmasters.online.gwu.edu/electrical-engineering-renewable-energy/

[3] Solar Energy, Access Date: 17-6-2021, Retrieved from: www.britannica.com/science/solar-energy

[4] Tesla Roadster (first generation), Access Date: 17-06-2021, Retrieved from: www.en.wikipedia.org/wiki/Tesla Roadster (first generation)

[5] Country's first solar electric vehicle, Access Date: 25-06-2021, Retrieved from: www.thedailystar.net /science/innovation/news/ countrys-first-solar-electric-vehicle-completes-historic-tour-1792498

[6] Building of an Electric Car, Senior Projects of 2012, University of Ohio, USA, Access Date: 03-07-2021, Retrieved from: https://www.ohio.edu/engineering/eecs/

[7] Build Your Own Electric Vehicle by Seth Leitman and Bob Brandt Format: Paperback, 329 pp. ISBN: 978-0-07-154373-6 Publisher: McGraw Hill https://core.ac.uk/download/pdf/48842509.pdf

[8] Sankar M R. Design and Development of Solar Assisted Bicycle [J]. International Journal of Scientific and Research Publications, 2013 http://www.ijsrp.org/research-paper-0313/ijsrp-p15150.pdf

[9] Bangladesh Power Development Board (BPDB) (2019) Annual Report 2018-2019. Access Date: 06-12-2021, Retrieved from: https://www.bpdb.gov.bd/bpdb

[10] Geography of Bangladesh, Access Date: 27-09-2021, Retrieved from: https://en.wikipedia.org/wiki/Geography_of_Bangladesh

[11] Priya Ranjan Satpathy, Ali Mahmoud, Suraj Kumar Panigarhi, Renu Sharma, "Partial Shading Effect on the Performance of Electric Vehicle-Integrated Solar PV System", In Mahapatra S., Shahbaz M., Vaccaro A., Emilia Balas V. (eds) Advances in Energy Technology. Advances in Sustainability Science and Technology. Springer, Singapore. https://doi.org/10.1007/978-981-15-8700-9_16

[12] Solar cell model, Access Date: 06-12-2021, Retrieved from: https://jreda.com/programme-detail/14/Solar%20Tree

[13] Solar charger circuit, Access Date: 06-12-2021, Retrieved from: http://circuitdiagramcentre.blogspot.com/2017/01/48v-solar-battery-charger-circuit-with.html

[14] Homer Pro Software https://www.homerenergy.com/products/pro/index.html

[15] Solar battery charger, Access Date: 07-12-2021, Retrieved from: 83158629796374c5.en. made-in-china.com/ product/ZwIaucDEhnrs/China-12V-24V- 36V-48V-60V-72V-120ah-150ah- Battery-Charger-E-Bike- Rickshaw-Scooter-Tricycle-Battery-Charger- Best-Selling-Charger-Color-Shell-Charger.html

[16] Monocrystalline solar panel, Access Date: 09-12-2021, Retrieved from: https://www.kfsolar.com/product/monocrystalline-solar-panel-360w//

[17] Lead-acid battery, Access Date: 09-12-2021, Retrieved from: https://dongjinbattery.en.made-in-china.com/product/pjtEOqzCCPhL/China-12V40ah-Man-Logo-E-Bike-Storage-Battery-E-Rickshaw-Lead-Acid-Battery.html

[18] Solar cell model, Access Date: 10-12-2021, Retrieved from: https://jreda.com/programme-detail/14/Solar%20Tree

[19] Solar car sketch, Access Date: 10-12-2021, Retrieved from: www.sciencelearn.org.nz/images/ 2182-solar-car-sketch