Development of the Monitoring and the Lighting System of an Electric Vehicle

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CERTIFICATE OF APPROVAL

The thesis entitled **"Development of the Monitoring and the Lighting System of an Electric Vehicle"** submitted by **Dewan Nawshin Atiya, Rafia Islam, Ummay Honey Sara** and **Ahmad Tausif Choudhury** has been accepted satisfactorily in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on April, 2015.

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Declaration

We thus pronounce that this thesis titled "Development of monitoring and lighting system of an electric vehicle" and the work introduced in it and submitted to the Department of Electrical and Electronics Engineering of BRAC University is our own and has been created by us as the consequence of our own unique research. It was not submitted anywhere else for the award of any other degree or any other publication.

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Abstract

One of the major elements in the territory of renewable energy source today is solar power. Photovoltaic cells are utilized to convert solar energy into helpful electrical energy. The target of this paper is to build a proficient solar power oriented vehicle, for the everyday office suburbanites of Dhaka city with the goal that they can travel a certain distance that they need to travel regularly on a reliable and economic auto that basically runs on free renewable solar energy. The paper represents how the charge produced by an array of solar panels is received and its flow all through a battery pack is to be controlled utilizing a microcontroller based charge controller to guarantee efficientstorage of charge in a battery pack. The stored energy would be revealed to a DC engine which would run the automobile. The outline of a motor controller to control the car's speed and forward/reverse direction of movement is demonstrated. The mechanical construction from scratch to all essential mechanical systems is represented. At last the wiring of the electrical framework onto the mechanical body is illustrated.

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CHAPTER 1: INTRODUCTION

a. Solar Energy:

The radiant light and heat harnessed by sun reaches to the earth is called solar energy. Approximately, 172 Petawatt (pw) of energy is received by the earth toward that upper environment for imminent sun based radiation (insulation). Roughly 30% is reflected back to space while the rest is captivated by clouds, oceans and land masses. Those range about sun oriented light at the earth's surface will be basically spread over the noticeable furthermore near-infrared ranges for a little some piece in the near-ultraviolet. [1]

Solar energy is significant part of life and it has been helping the mankind since the beginning of time. It can be acknowledged as clean vitality source as it is completely natural. The way oil and some other energy sources disrupt the environment creating a threat to the Eco-systems, solar energy doesn't. It doesn't result in greenhouse gases, air or water contamination. Solar energy is versatile. This Energy could be used to power a number of things like calculator, cars, and watches and can also provide thermal heating for homes and businesses. The most important issues of all of the solar energy are it is renewable. Fossil Fuels like gas, coal and oil are non-renewable. For once this energy is used; it will take million of years to reform again. As these energies cannot be replenished, when these resources would run out mankind will need another acceptable path of energy which could be implemented.

In South-Asia, Bangladesh asserts the most reduced per-capita consumption of commercial energy having a significant gap between supply and demand. 40% of Bangladesh's Population had access to electricity. [2] With the rapid growth of industrialization and urbanization the demand of electricity has been increased 10%. On the other hand, the present gas production capacity in Bangladesh cannot hold up both domestic gas needs, as well as wider electricity production for the country. On September 15, 2009, the Power Division of the Ministry of Power, Energy and Mineral Resources of Bangladesh pushed for vital action to be taken to perk up the country's energy outlook. As the Bangladesh's gas reserves are quickly losing ground, Bangladesh needs to devote in finding alternative sources of energy. [3]

Therefore solar energy has noteworthy potential for Bangladesh. Solar power does not require sophisticated machinery. This energy is entirely eco-friendly as it doesn't involve fossil fuels to carry out its function and economically recommended. Many Researches have proposed that 10,000 mega watts of electricity can be created by solar in short and long run which is correspondent to twice the total amount of electricity produced and supplied on the national grid.

b. Solar Car Concept:

Transportation system has become a major concern to our country. As the sources of fossil fuels are running out and emissions from the fossil fuels are creating numerous problems including global warming a safe, clean and emission free vehicle is required by which mankind will be served by its benefits. Solar Car is a vehicle which is run by trapping the solar energy from the sun by the solar panels. This vehicle would not require any fossil fuels to drive the motors and thus it will be completely Carbon emission free. This was the main proposed idea of making our solar car which will be an alternative solution to conventional car. The work of our solar car was started in 2013 with the co-operation of the other group members and professors in BRAC University. The university authority has also been helpful and co-operative by giving us the well equipped lab, workshop and necessary fund to perform the research. Designing a vehicle considering all the pros and cons and developing a design according to the design was a challenging job but with the co-operation of the University faculties and the group members we finally proposed a design which can be implemented in real life. Our solar Car is designed in such a way so that it covers up 32 km distance when the batteries are fully charged. Our solar car is basically a two seated car with six panels on it.4 of them are placed on the top of a car and the other two on the bonnet of the car. There in total 6 batteries for the supply. The 5 batteries supplies altogether 60 volt to the motor and another battery is connected to support the lighting system of the car. The motor we used in the car is Dc brush carbon motor which speed is 1366 rpm. We have also developed an innovative lighting system in our car with the head and back lights, break lights along with the left and right indicators.

The innovation of the lighting system lies in the operation of the lights where the car driver can use the lights according to the need of that certain circumstances.

We have also developed a design of monitoring system which is different than the other conventional cars. Using multipurpose sensors we have developed two systems to measure the motor current, battery voltage, panel voltage and speed of the tyres. Our Car would be very efficient since its power source is the sun. We tried to give it out a aerodynamic shape to reduce wind -friction and made very light weight.

Our Solar is very important because it has many benefits. First of all, it produces no harmful emission in the air when it's running. Through the exchange of the electrons and the photons inside the solar cells the conversion of sun's energy to the electrical energy is done. There is no extra expense to maintain this car as it doesn't require any refueling. As there is no engine in the car so it is a very quiet vehicle and the electric motor is also much more efficient and usually produces no vibrations within it. Above, all the maintenance of the solar car is comparatively easy than the other conventional Cars.

CHAPTER 2: THE IDEA OF SOLAR CAR

a. Background:

The concept of the solar is not a new one. Many universities in different countries have been working on making a efficient solar car. The first solar car was made by William. G. Cobb which was a small 15 inch vehicle which was named Sunmobile. In august 31, 1955 this solar car was first showcased by cob at the Chicago Powerama Convention. This vehicle was made up with 12 selenium photovoltaic cells with a small pooley motor turning a pulley which in turn rotated the wheel shaft.

Though it was appreciable by everyone but it was too small to drive. Then in 1962, another solar car was invented that a person could drive which was demonstrated in front of public. In 1912 a vintage model was converted by The International Rectifier Company Baker electric car to run

on photovoltaic energy in 1958, but it was not shown by them until 4 years later. Around 10,640 individual solar cells were mounted to the rooftop of the Baker to help propel it.

Then Blue bird Solar was built in 1977 by Alabama University professor Ed Passereni which was a prototype full scale vehicle. This vehicle was thought to move from power created by the photovoltaic cells only without the use of a battery. In the Knoxville, TN 1982 World's Fair the BlueBird was showcased. Professor Masaharu Fujita first created a solar bicycle at Tokyo Denki University between 1977 and 1980,wheel solar car. Putting two bicycles together a complete solar car was made.Arye Braunstein and his colleagues developed a solar car in 1980 at the engineering department at Tel Aviv University in Israel. Solar panel was mounted on the motor and on the roof of the of the solar car consisted with 432 delivering 400 watts of peak power. Here 8 batteries were used 6 volts and the photovoltaic energy was stored by the each battery.Next a solar powered race car was built by Hans Tholstrup and Larry Perkins in 1981. They were the first people who crossed a continent in solar car by driving from perth to Sydney and became famous. Tholstrup is the creator of the World Solar Challenge in Australia.Greg Johanson and Joel Davidson invented the Sunrunner solar race car in 1984. The sunrunner set a world record of 24.7 mph officially in the Guinness in bellflower. 41 mph was officially recorded for a "Solely Solar Powered In the Mojave Desert of California and final top speed of in the 1986 Guinness Book of World Records for “Solely Solar powered car”. [4]

Researchers are still ongoing in the development of the solar car. America’s top solar car team and the top undergraduate team from The Stanford University began the Stanford Solar Car Project (SSCP) in 1989 which was basically a high efficient solar racing car.

On the other hand, The University of Texas Solar vehicle team also does various works regarding solar car. They point out new technologies and implement them into a vehicle which is entirely powered by solar them entered them into local and national competitions. Additionally, another team of the University of Michigun also runs an organization which builds solar electric vehicles and started working on solar car since 1990 building 12 vehicles from then and has won the American Solar Challenge 7 times.

There are some Companies that produces solar car one of them is SVEC which is owned by Lary Spartz Who is a businessman of Chicago. It was established in 2008 and the company focuses on making emission free transport in which 14 passengers can travel with the electric security. Hanergy Holding Group is another one of the largest thin filmed solar company which is doing work to implement its expertise to the solar car. Then the Ford Motor company also manufactures hybrid electric cars with solar panels on it and one of the model name is CMAX which can drive 21 miles by taking power from the sun. [5]

Above all, it can be said that Solar energy is feasible to utilize in the electric vehicle, as we have seen that many race cars and standard solar car is been produced by various countries and various students of different universities. When the non-renewable resources would run out it would be a great asset to the people of the world.

b. Economical Analysis:

As the way of generation of solar power is completely different from fossil fuel-based power, it creates a little complication to comparison of the price. As the Solar energy is raw form of energy, so it is free and infinite. On the Other hand Fossil fuels are non-renewable resources and using them in the electric vehicle involves high cost. Researches has been represented that the electric car driven by gasoline costs $3.50 per gallon and there has been an increase of 3% in the price in 50 years. Total fuel cost in a year is $275,000. In solar Car, Infrastructure and energy cost in are included in the price of Solar PV. The cost of 2Kwh solar PV cost $8000 in a year. [6]

The life time of the solar car depends on the maintenance of the vehicle. If the solar panels and other components of the car are taken care of properly its life time would increase. The batteries within the car should be placed in such a way so that the water doesn't go through it and notice the charge level regularly to monitor if charging and discharging conditions are good enough or not. In case of the solar panels, it is required to avoid the physical damage of the panels such as scratches created by the bushes and the trees while the wind is blowing. The more the surface is scratched; the more solar panel's performance will be degraded. For the furthermore efficiency of the solar car regular cleaning and maintenance is important. By taking good care of the components of the car, the car will remain safe and provide much more facility to the users.

The solar car no doubt is an efficient electric vehicle which doesn't emit any harmful carbon gases which pollutes the environment. It has low maintenance cost and it can provide better services than the traditional conventional cars. With the high efficient solar cells, Sun rays are absorbed to store the charge into batteries and run the vehicle more properly.

c. Zero Emission:

The term zero-emission refers to a system which does not emit any waste products that pollutes the environment or disrupts the climate. Solar Car is such a vehicle which fulfills the conditions of the Zero-emission that means it has no negative impact on the earth. As the non- renewable sources are being depleted, a huge change is taking place on the climate and environment. When the fossil fuels are burned it releases lot of heat and CFC gases which harmful to our environment. It is also responsible for the Global warming which factor arise the issue Zero-Emission. Possible responses to global warming include mitigation by emissions reduction, adaptation to its effects, building systems resilient to its effects, and possible future climate engineering. Solar Car can contribute to reduce these environmental problems. Other Conventional car releases huge CFC gases but solar car is entirely Emission free. If the Transport system is made dependent of solar energy, the environmental problem will be reduced gradually.

CHAPTER 3: DESIGN OF THE SOLAR CAR

a. Introduction

Designing is an important aspect before building the solar car. A proper designing facilitates the building process and also gives a vivid idea on how the planning needs to be executed.

b. Methodology

We were provided with the shell of a Maruti 800 car that was highly modified by us to meet up to our requirements. In order to achieve less weight the rear half of the car was cut off and a new chassis made of a lighter material had been built and welded with the front part. Exactly the same procedure had been followed while making the 3D model.

c. Software Implementation

The software used for the 3D modeling of the solar car is Sketchup 2014. The design of the car, the position of the lights, the placement of the batteries and the solar panels, and the colour to be used- all of these were perfo9rmed in the software before implementation. An actual 3D model of the Maruti 800 car was dismembered by parts in the software. The car was then given the design according to our ideas. The colour and the placement of the BRAC University logos were also determined afterwards.

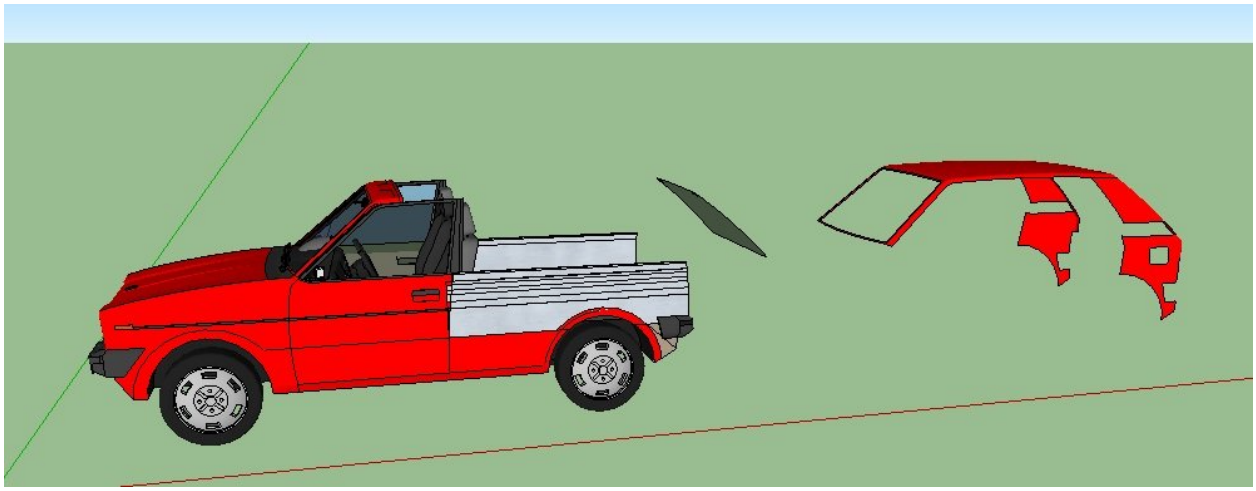

Figure (a): Dismembering the rear portion and building with modification.

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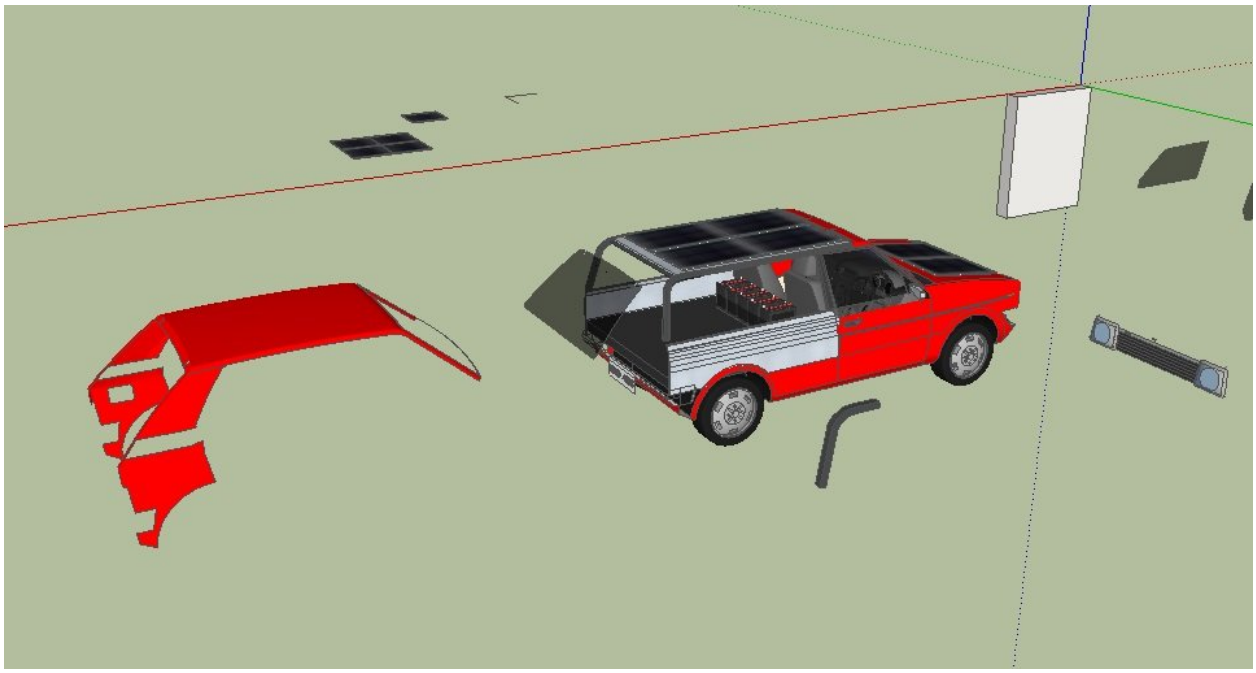


Figure (b): Placement of the solar panels and the batteries.

Figure (c): The final design of the solar car

CHAPTER 4: MECHANICAL PARTS

4.1 BRAKING SYSTEM

4.1.1 INTRODUCTION

Proper braking of the solar car is extremely crucial to avoid accidents and injuries, and also to keep the car stationary on a steep surface. Two types of brakes have been implemented in the solar car. Disk brakes are applied on the front wheels and are activated via the brake pedals by the driver of the vehicle. The handbrake works on the rear wheels and they are carried out by the drum braking system.

4.1.2 MASTER CYLINDER

4.1.2.1 INTRODUCTION

The master cylinder is the heart of the disk breaking system on the front wheels. It is comprised of the following components:

- Master cylinder.
- Piston.
- Spring.
- Valve stem.
- Plunger.
- Brake oil reservoir.
- Line towards the brake piston on the wheels.
- Brake pedal.

4.1.2.2 METHODOLOGY

Initially the master cylinder it is filled with brake oil from the reservoir. When the brake pedal is pressed it moves forward towards the inside and pushes on to the plunger. The plunger with the piston on the other end closes the portal connecting the reservoir via the valve system, and at the same time the spring compresses and the oil is sent towards the brake piston on the wheels. When the brake pedal is removed, the spring relaxes and the valve system allows the plunger to return to its original state and the connection to the reservoir is restored. [7]

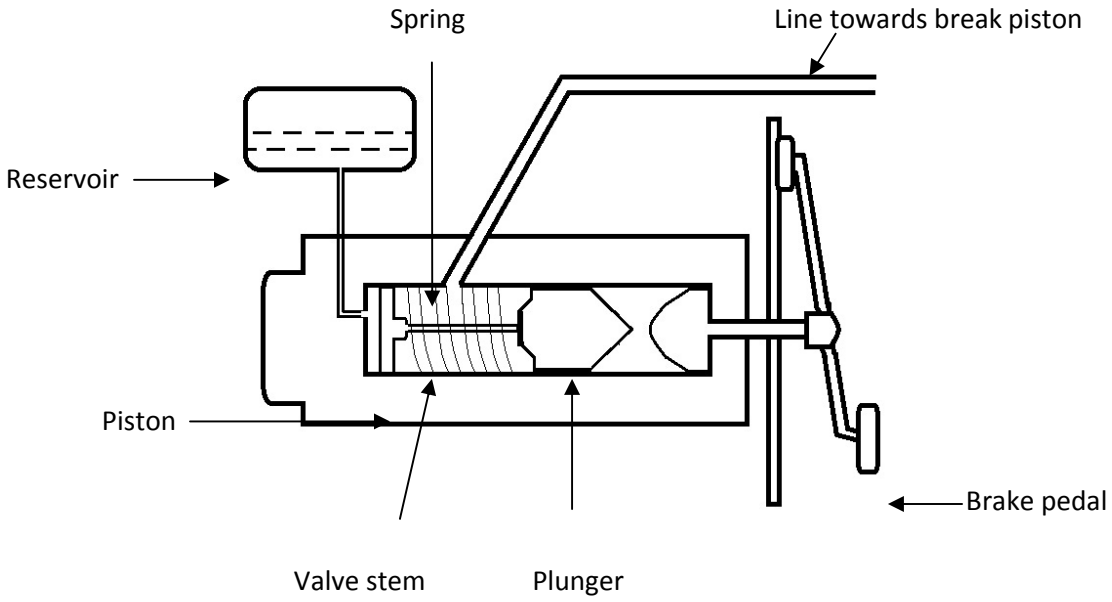


Figure 4.1.2.2 (a): The layout of the inside of a master cylinder.

Figure 4.1.2.2 (b): Master cylinder used in the solar car.

4.1.3 DISK BRAKING SYSTEM

4.1.3.1 INTRODUCTION

The disk braking system has been implemented on the front wheels of the vehicle and is initiated via the brake pedals. The system consists of the following components:

- Caliper.
- Rotor.
- Hub.
- Piston.
- Line from the master cylinder.
- Brake pads.

4.1.3.2 METHODOLOGY

The most important part of the disk brake system is the caliper which has the piston and brake pads attached to it. When the brake pedal is pressed the oil from the master cylinder comes through the line and presses on to the piston. The piston moves and the brake pads attached to it pressurizes on to the rotor, which is connected to the wheel via the hub. Hence, when the rotor is halted, the wheels are also stopped and the car comes to rest. [8]

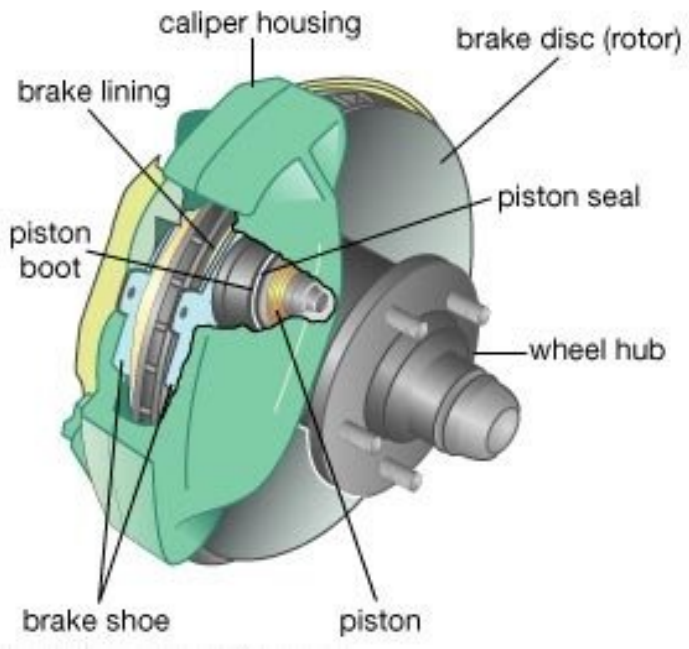


Figure 4.1.3.2: Diagram of a disk brake. [9]

4.1.4 DRUM BRAKING SYSTEM

4.1.4.1 INTRODUCTION

The drum braking system has been implemented on the rear wheels of the vehicle. The mechanism works with the pull of the handbrake in between the car seats. The system consists of the following components:

- Wheel/slave cylinder
- Brake drum.
- Brake shoes.
- Brake pads.
- Springs.
- Self adjusters.

4.1.4.2 METHODOLOGY

The rare wheels are attached to the brake drum. When the handbrake is pulled, the spring in the wheel cylinder pushes the brake shoes onto the brake drum. With the help of the brake pads joined with the brake shoes creates friction to stop the brake drums from moving. As a result the wheels are firmed. When the handbrake is released, the springs help the brake shoes to return to its original place and the wheels are free to move. As the brake pads wear off, the self adjusters control the distance of the brake shoes to travel to stop the drum. [10]

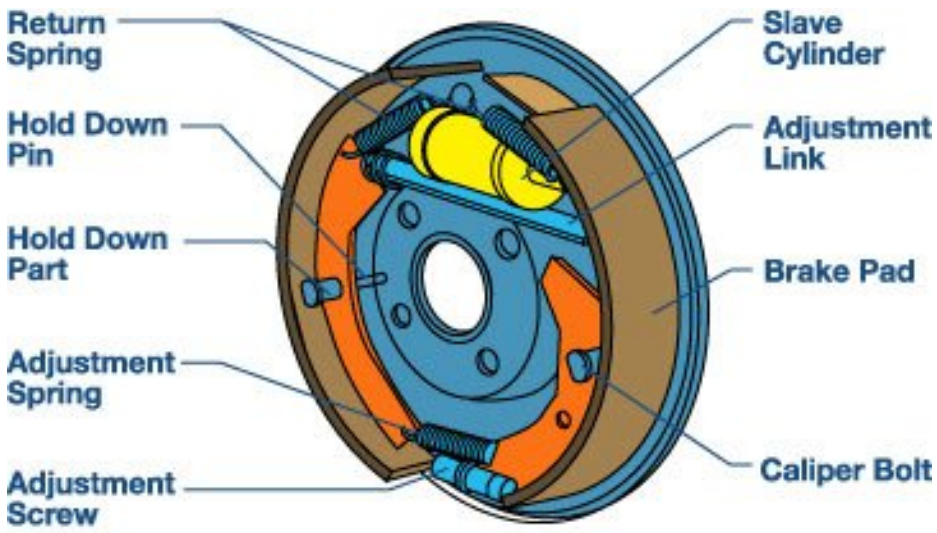


Figure 4.1.4.2: Diagram of a drum brake. [11]

4.2 DIFFERENTIAL

4.2.1 INTRODUCTION

The differential gear is connected with the two back wheels of the solar car. The major function of the differential is to allow the wheels to rotate at different speeds while receiving power from the motor. When the car takes a turn the inside wheel rotates at a lesser speed than the outside wheel. For instance, if the car takes a right turn, the radius of curvature of the left wheel is larger than that of the right wheel. In order to cover the distance at the same time the left wheel requires rotating faster than the right wheel. If the two wheels were connected by a plain pole, the right wheel would then have to slip in order to achieve the turn.

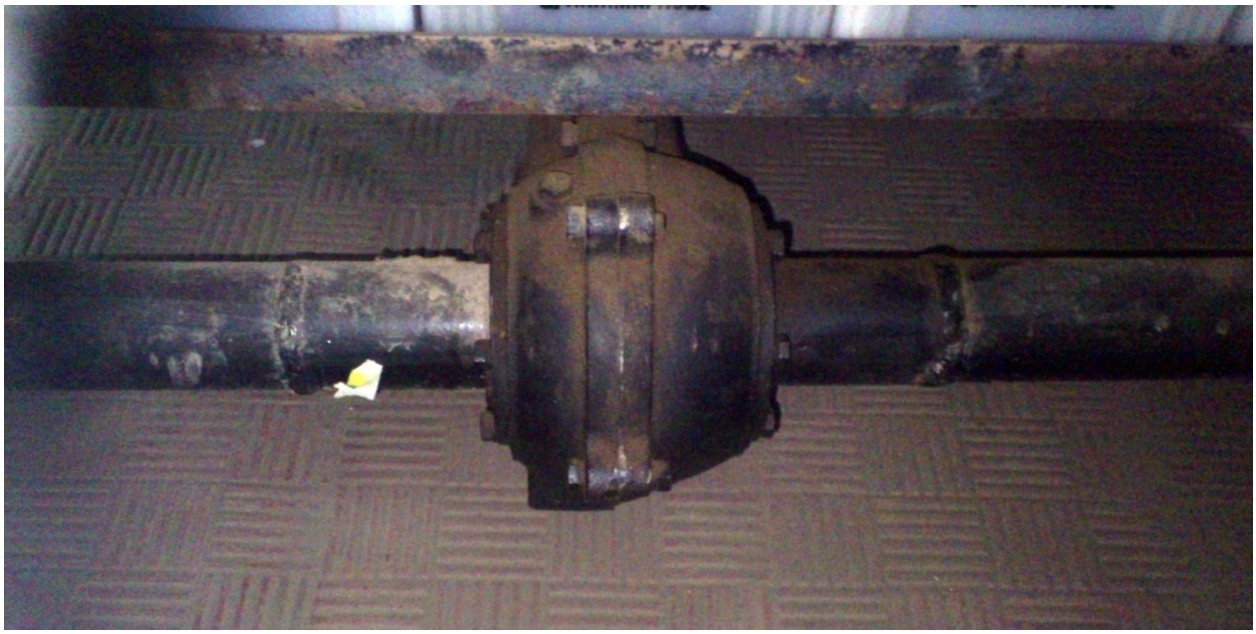


Figure 4.2.1: The differential at the rear of the solar car.

4.2.2 METHODOLOGY

In order to allow the two wheels to rotate separately, three types of gears are needed. They are as follows:

- Pinion gear.
- Ring gear.
- Side gear.

When the motor rotates, the pinion gear carries power from the shaft attached to the motor to the ring gear. The ring gear is joined with the axle and is responsible for the rotation of the wheels. The side gears allow the wheels to rotate freely during a turn. [12]

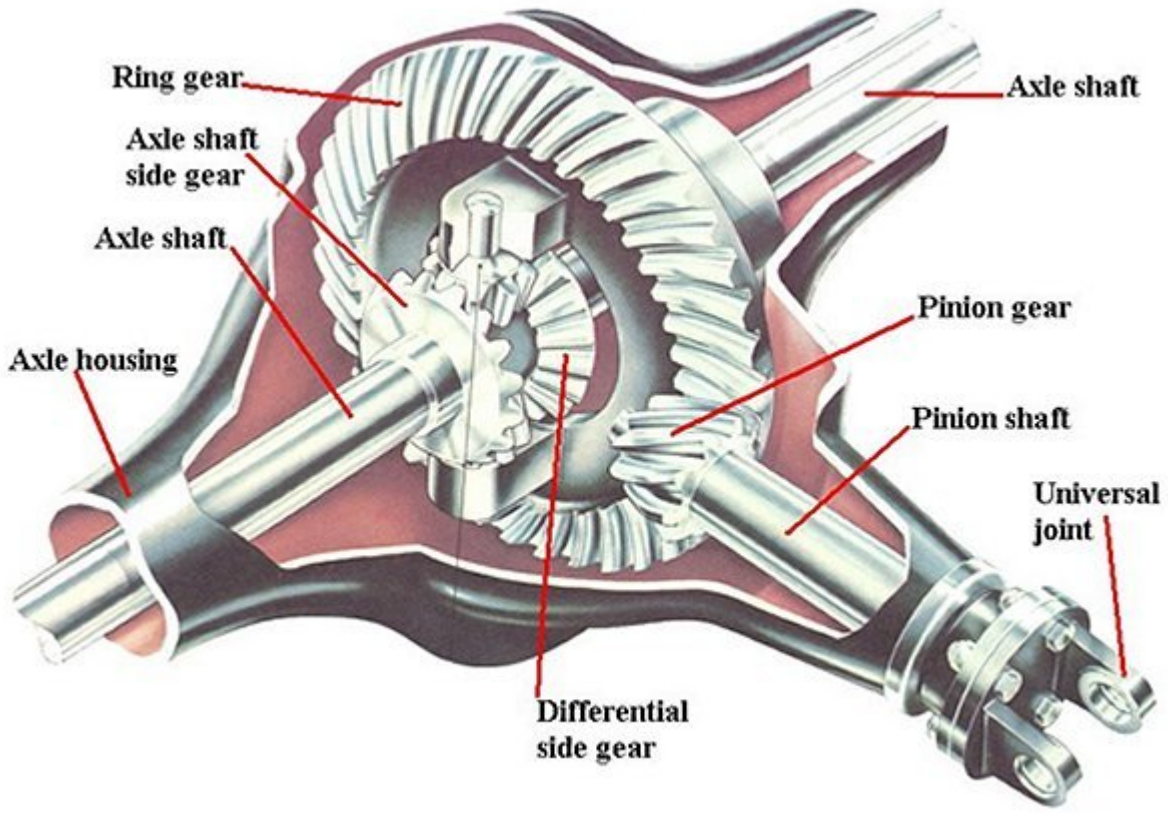


Figure 4.2.2: Inside a differential. [13]

4.3 PEDAL ACCELERATOR

4.3.1 INTRODUCTION

The accelerator allows the solar car to attain higher speed. The firmer the accelerator pedal is pressed the faster the vehicle travels.

Figure 4.3.1: The accelerator pedal (on the right) with the brake pedal (on the left).

4.3.1 METHODOLOGY

An innovative way of using the accelerator has been implemented in the solar car. The accelerator pedal is apparently attached with a hand throttle by a cable in such a way that while the accelerator is pressed, the throttle turns accordingly as shown in **Figure 4.3.1.** This turning of the throttle determines the rotation of the motor and hence the speed can be varied.

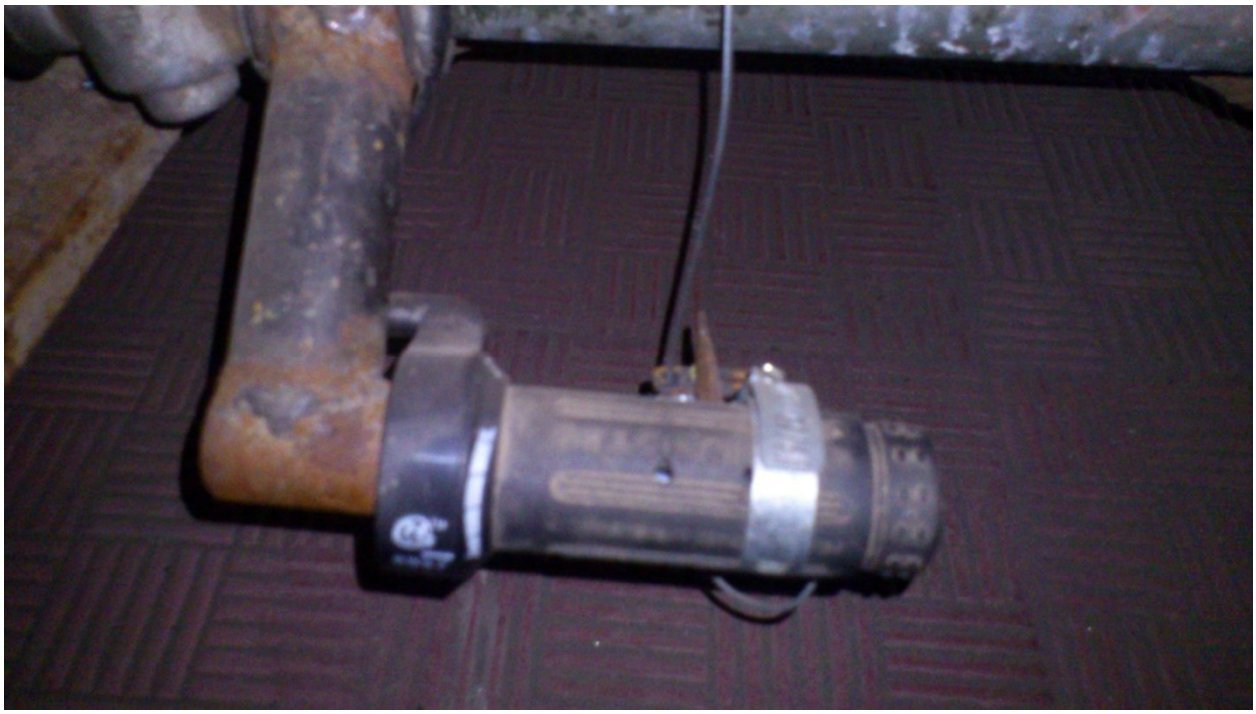


Figure 4.3.1: Hand throttle connected to the pedal accelerator via a cable.

CHAPTER 5. ELECTRICAL PARTS

1.LIGHTS :

a. Introduction :

The lighting arrangement of an engine vehicle comprises of lighting and signaling gadgets mounted or coordinated to different parts of an engine vehicle. These may incorporate the front, sides and back side of the vehicle. The motivation behind this framework is to give light to the driver. This empowers safe vehicle operation during night and gloomy weather. The lighting framework permits different drivers and walkers to watch the vehicle's position, size, course of travel, and the driver's propositions with respect to heading and velocity of travel. In a crutial moment or emergency travel, vehicles may contain some special arrangement to alert others about the necessary movement.

b. Importance:

Engine vehicle lighting is about security and signaling. Headlights and tail lights are to make certain drivers are seen by others even in the most constrained perceivable conditions. This is imperative to reduce road accident and save lives.

Early street vehicles utilized fuel lights, before the accessibility of electric lighting. Since the development of the auto, lighting has been a critical subsystem on all vehicles. Car lighting is crucial to traveler security, vehicle decoration and signal directions of movement of the transport. The innovation utilized as a part of auto lighting has quickly extended to make the lighting more esteem included, more secure and satisfying to clients. [14]

c. Different car lights

Side Lights:

These lights are not generally in side of the auto. They are faint lights which cause other street people and drivers to see your auto, however may not help for the own view to see others. They ought to be utilized for no less than 1 hour after dawn, and one hour before dusk. At the point when your side lights are on, tail lights are additionally on.

Dipped Headlights:

Plunged Headlights must be utilized during the evening, and when view is truly diminished because of substantial rain, mist, or snow. The level of plunge ought to be balanced by weight in the back of the auto. Plunged headlights ought not bring about other street clients to be stunned. Utilize these headlights on the off chance that one have the windscreen wipers on continually.

Main Beam Headlights:

These are otherwise called Full Beam, or High Beam. They ought to be utilized on dark streets during the evening which might likewise be utilized as a method for illuminating others of the vehicles vicinity.

Fog Lights:

The auto in just fitted with a back haze light. Numerous autos likewise have front mist lights. They ought not to be utilized if view is better than 100m .

Parking Lights:

Lights are fitted to most autos as they must be utilized when parking on a street where as far as possible surpasses 30mph. This principle may appear to be unusual, as leaving lights on throughout the night may deplete the battery. Be that as it may, it is very irregular to stop on a street where as far as possible surpasses 30mph in any case.

Brake Lights

lights are enacted by the footbrake. Numerous autos now have three lights at the back, so that it is more hard to mistake them for tail-lights. Utilization the brake delicately and right on time to caution taking after movement of your expectations.

Indicators/Signals

Use directional pointers to give a clear message to other drivers. On the off chance that another driver has not enrolled the sign, turn it off, and after that on once more. On numerous autos the sign is consequently scratched off after turns. On the other hand, it might naturally cross out too early.

d. The type used in Solar Car:

The glowing light was long the light source utilized as a part of all auto lighting gadgets. Numerous sorts of globules have been utilized. Institutionalized sort numbers are utilized by

makers to distinguish knobs with the same determinations. Bases may be blade sort with maybe a couple contacts, plastic or glass wedge, or double wire circles or ferrules utilized on tubular "trim" lights. Screw-base lights are never utilized as a part of auto applications because of their releasing under vibration. Signal lights with inside or outside hued lenses use dismal globules; on the other hand, lights with lackluster lenses may utilize red or golden knobs to give light of the obliged hues for the different capacities. Including indicators and other all kind of lights are added to solar car for better driving and safety purpose. Thus for testing electrically the lighting system is implemented and tested in lab as well.

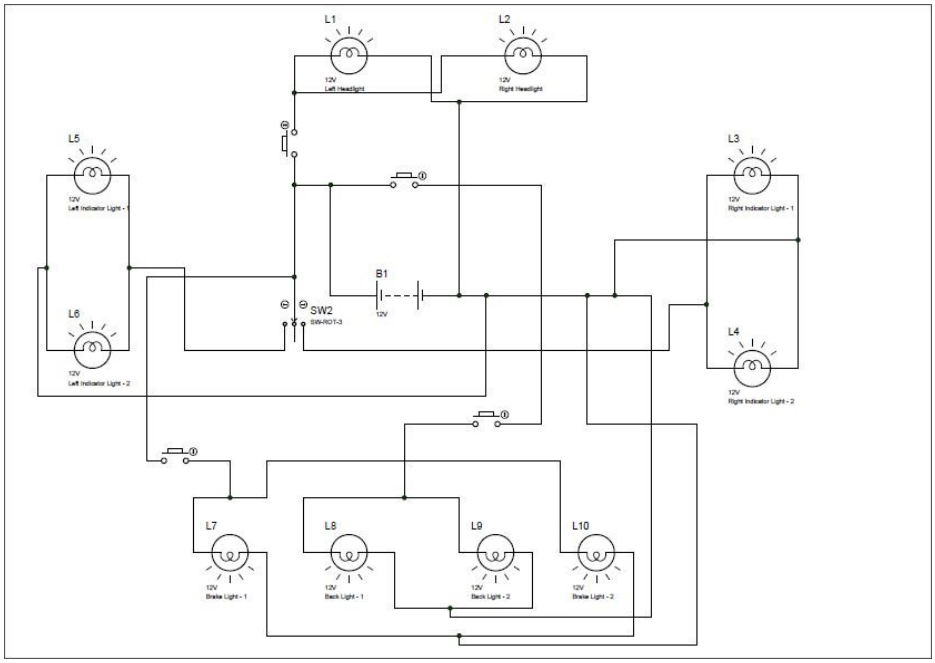


Figure: Testing diagram of the lighting system .

2. MOTOR

a. Introduction

A motor is a mechanical or electrical gadget that makes rotation by changing the form of supplied energy. In typical motoring mode, most electric engines work through the collaboration between an electric engine's attractive field and twisting streams to create constrain inside the engine. In specific applications, for example, in the transportation with footing engines, electric engines can work in both motoring and producing or braking modes to additionally create electrical vitality from mechanical vitality.

b.Types

The fundamental sorts are DC motor and AC motors, the previous progressively being dislodged by the recent. Air conditioning electric engines are either asynchronous or synchronous. Once began, a synchronous engine obliges synchronism with the moving attractive field's synchronous pace for all ordinary torque conditions.

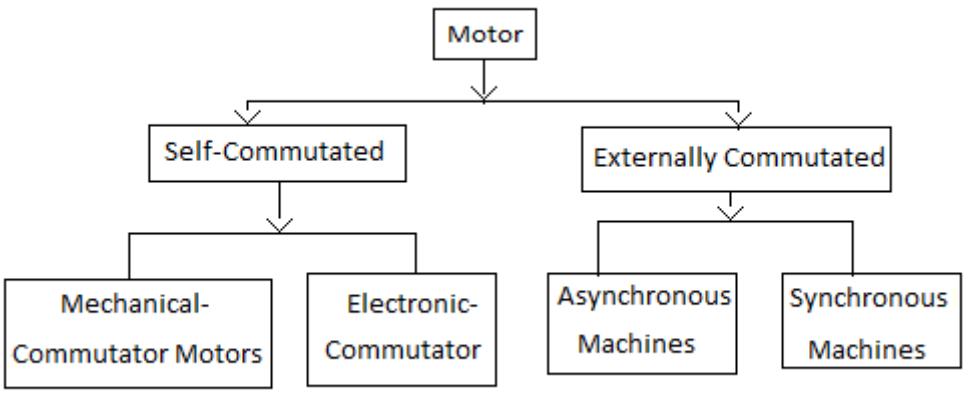
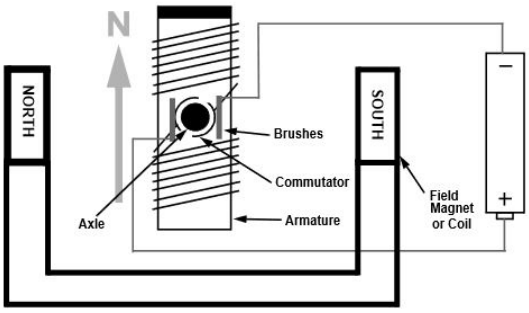


Figure: Classification of motor.

Self-commutated motors are:

1. *Brushed DC motor:*

   Brushed DC motors (BDC) are mainly used in various materials like toys to push button adjustable car seats. Brushed DC motors are cheap, easy to drive and available in all size and shape. The construction of a simple BDC motor is shown below:



2. *Permanent magnet DC motor:*

   Permanent magnet DC motors are much more efficient, lighter and compact than comparably sized wound DC motors because the permanent magnets replace the field winding of wound DC motors PM DC motors are constructed in two broad categories: brushed/commutator and brushless. The PM DC commutator motor uses a rotating armature winding with a stationary field of permanent magnets; a PM DC brushless motor has a reverse construction: a rotating field of permanent magnets and a stationary armature winding that is externally commutated by an electronic control.

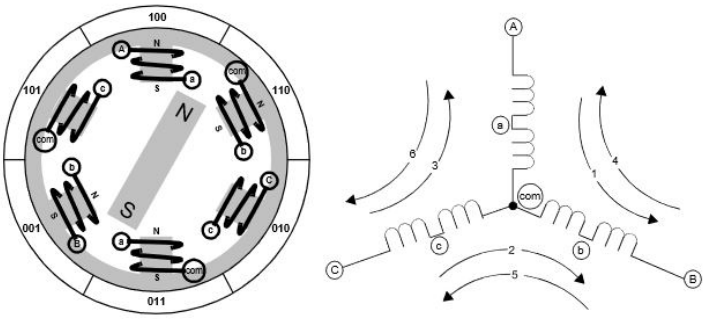
Electronic commutator (EC) motor :

1.Brushless DC motor:

This application note discusses the steps of developing

Several controllers for brushless motors. We cover sensored, sensor less, open loop, and closed loop design. There is even a controller with independent voltage and speed controls so you can discover your motor's characteristics empirically.

Figure below is a simplified illustration of BLDC motor construction. A brushless motor is constructed with a permanent magnet rotor and wire wound stator poles.



2.Switched reluctance motor.

A. Torque and speed of a DC motor:

A DC motor's speed and torque qualities fluctuate as indicated by three diverse charge sources, independently energized field, self-excited field or permanent field, which are utilized specifically to control the motor over the mechanical load's extent. Self-excited field motors can be series, shunt, or compound wound associated with the armature.

c. Equations

Basic DC motor equations

Let

- E_b = induced or counter emf (V)
- I_a = armature current (A)
- k_b = counter emf equation constant
- k_n = speed equation constant
- k_T = torque equation constant
- n = armature speed (rpm)
- R_m = motor resistance (Ω)
- T = motor torque (Nm)
- V_m = motor input voltage (V)
- $Ø$ = machine's total flux (Wb)

Counter emf equation

The DC motor's counter emf is proportional to the product of the machine's total flux strength and armature speed:

$$E_b = k_b * Ø * n$$

Voltage balance equation

The DC motor's input voltage must overcome the counter emf as well as the voltage drop created by the armature current across the motor resistance, that is, the combined resistance across the brushes, armature winding and series field winding, if any:

$$V_m = E_b + R_m * I_a$$

Torque equation

The DC motor's torque is proportional to the product of the armature current and the machine's total flux strength:

$T = k_b * I_a * Ø / (2π)$

$T = k_T * I_a * Ø$

Where

$k_T = k_b / (2π)$

Speed equation

Since

$n = E_b / (k_b * Ø)$ and $V_m = E_b + R_m * I_a$

we have

$n = (V_m - R_m * I_a) / (k_b * Ø)$

$n = k_n * (V_m - R_m * I_a) / Ø$

Where

$k_n = 1 / k_b$

3. RELAY

a. Startup: A relay is used for the complete electrical connection to be controlled by a key. Only when the key is placed and rotated, the contacts are made with the battery and the car will be ready to move. This ensures security as well as it a safety precaution.

b. Charging: The external charging system via the DC charger is always kept off. Only when the plug is connected from an AC source, the charging is on. This system is done with the help of a 220V relay. This acts as a safety precaution and also prevents the batteries from discharging.

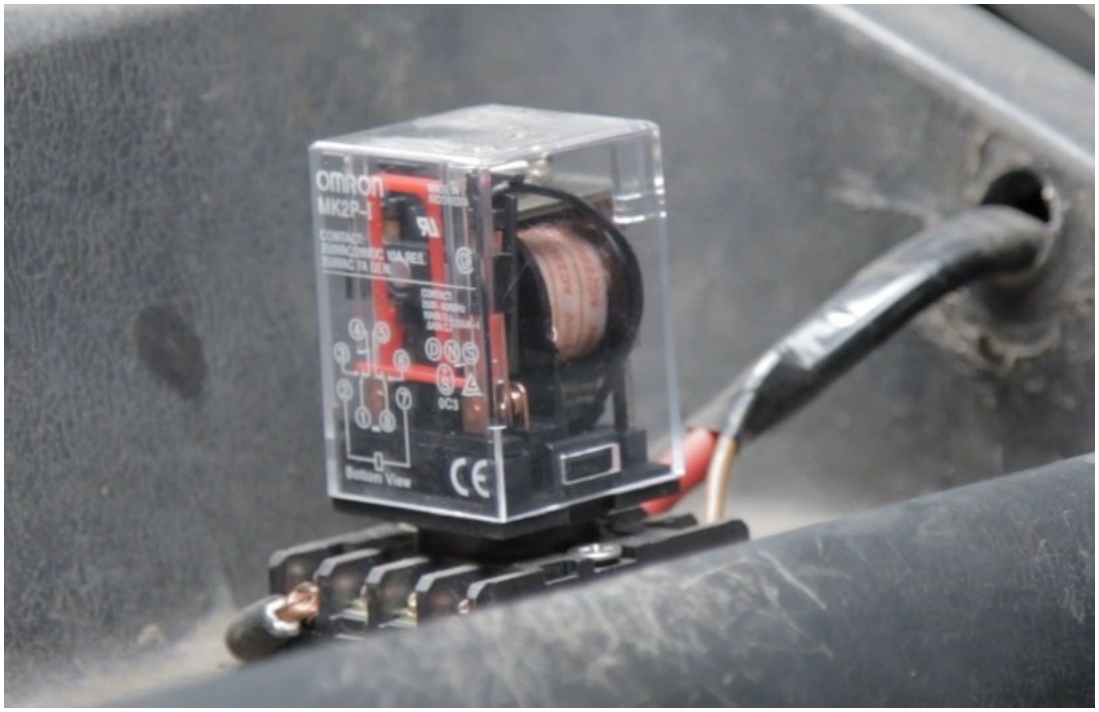


Figure: Relay used for charging via the DC charger.

CHAPTER 6. SOLAR CAR POWER SYSTEM

1. Solar panel

Solar panels are introduced in the nineteenth century and since then till now people are using them for a wide range of purposes regarding home, office, transportation system etc. They are also used in agricultural sector. They are still a little expensive. The company produces them provides the rating required but they not completely reliable. So a performance check is necessary. In case of a solar car, solar panels are the ultimate supplier of energy for the entire car to function properly. Therefore it was absolutely necessary to verify the performance of the solar panels that were used in the car.

a. Functional methodology

A solar panel works by allowing photons, or particles of light, to knock electrons free from atoms and generating a flow of electricity. Solar panels actually comprise many, smaller units called photovoltaic cells. Many cells linked together make up a solar panel.

Each photovoltaic cell is basically a sandwich made up of two slices of semi-conducting material, usually silicon and they convert the sunlight into electricity.

b. Types of solar panel

There are mainly three types of solar panels available in the market. They are: Monocrystalline silicon, Polycrystalline silicon and Amorphous silicon ‘thin film’ module.

Monocrystalline silicon:

Monocrstalline photovoltaic electric solar panels have been the go to choice for many years. They are among the oldest, most efficient and most dependable ways to produce electricity from the sun. Each module is made from a single silicon crystal and is more efficient which comes with the expensiveness than newer and cheaper polycrystalline and thin film PV panel technologies. Monocrystalline panels are typically black in color and square shaped cells. They are typically used in areas where high reliability is needed like telecommunication.

PolyCrystalline silicon:

Polycrystalline silicon Solar panels utilize less silicon, which makes them to a degree less productive. In any case, the remarkable outline, which highlights pieces of silicon wrapped around rectangular course wires, permits them to capacity all the more proficiently. Certain incidental utilization of polycrystalline siliconsolar panels, for example, when utilized on housetops can yield proficiency as near to as those of monocrystalline silicon solar panels.

Amorphous thin film

Thin film solar panels are one of the least expensive sorts of boards, but at the same time are the minimum effective. The effectiveness of formless modules to change over daylight to power is a large portion of polycrystalline or mono crystalline boards. These are not suitable for dependable home or business utilization. However when the attention is on amount instead of value i.e. where huge quantities of sun based boards are obliged to create a lot of venergy (e.g. in substantial show sun based homesteads), because of their cheap large scale manufacturing expense they get to be important.

Monocrystalline silicon Solar panels

Polycrystalline silicon solar panels

Amorphous thin film

Car with solar panels placed on the roof and bonnet

c. Power calculation

Solar car require less energy to run the car compared to the conventional car with internal combustion engines. Therefore it is very important to utilize this energy as efficiently as possible. Also we had less space for the panels to place on the car body as the car is not very big. So judging carefully and going thoroughly through all the facts it was wide to choose the monocrystalline solar panels as they have the most efficiency among three. Considering solar panel cost, durability, longevity, warranty, size and wattage, five monocrystalline flexible solar panels, bought from Chinese based company "Shenzhen Shine Solar Co. Ltd" was used in the construction of the car.It is very important to note that each of the panels are semi flexible which allows them to be places in a curved manner on the roof of the car which is said to have a more curved and aerodynamic shape rather being flat. The ratings of the 5 Solar Panels given by the company is given below:

50 Watt Monocrystalline Bendable Photovoltaic Module

Made with high efficiency back-contact solar cells

Electrical Characteristics

Max Power	Pmax	50W
Max Power Voltage	Vmp	17.6V
Max Power Current	Imp	2.84A
Open Circuit Voltage	Voc	21.2V
Short Circuit Current	Isc	3.05A
Maximum System Voltage		600V
Series Fuse Rating		10A
Temperature Co-efficients		
	Power	-0.38%/℃
	Voltage	-60.8mV/℃
	Current	2.2mA/℃
Cell Efficiency		21.5%
Number of Cells in Series		32
Max Power tolerance		±5%

Mechanical Characteristics

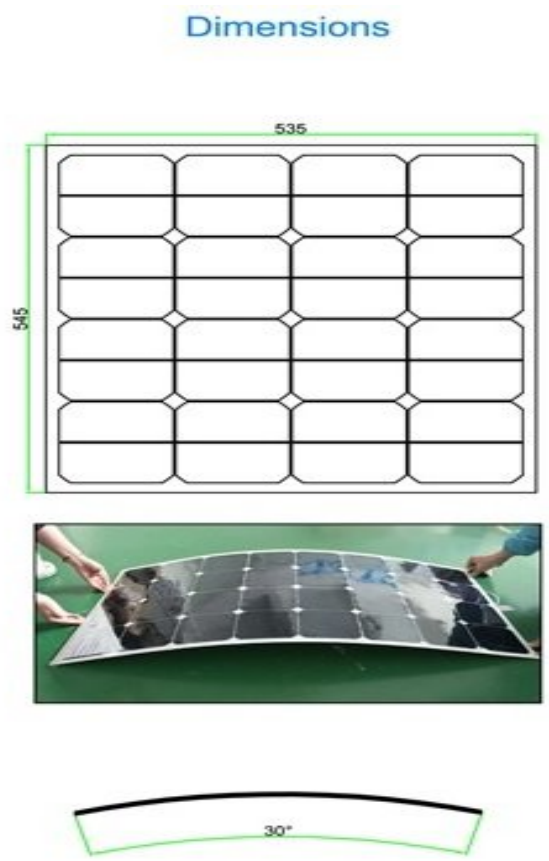
Weight	0.7KG
Dimension	545*535*3

d. Solar panel frames

Difficulties were faced during the fixation of solar panels on the roof of the car as the roof is curved. We had make an external frame on which the solar panels were placed rather than being placed on the car body directly. The panel frame was made with aluminum and flat iron bar to give it more stability and rigidity. It was fixed on the roof of the car with screws. The shape of the frame is made curved to match with the roof shape. Solar panels were screwed with the frame.

e. Dimension

The dimension of the panels is 545*535*3. Weight of the each of the panel is about 0.7 kg. The panels are not entirely rigid rather they slightly flexible. Maximum recommended banding of the panels is 30 degree. Bending at a higher angle can cause damage to the panels.



Maximum bending angle recommended is 30 degree

2. Batteries

a. Introduction

The battery to be utilized is a 12 V unlocked lead-acid re-chargeable battery. Lead–acid battery was invented in 1859 by French physicist Gaston Planté. Among the rechargeable kind, they are the oldest type. In spite of having a low energy-to-weight proportion and a low energy-to-volume proportion, their capacity to supply high surge current implies that the cells keep up a generally high power-to-weight proportion. These highlights, alongside their ease, make them appealing for utilization in engine vehicles to give the high current needed via automobile motors.

Because of the internal electro-chemical component of a lead-acid battery, charging is done in 3 particular stages as opposed to through a persistent settled voltage/current supply to the battery. Each of these stages is changed in the measure of voltage/current that needs to be supplied to the battery. The charge controller will recognize voltage from the battery before charging. In the wake of perusing the battery the charge controller will figures out which stage to legitimately charge at. The 3 stages are of charging are:

b. Types/selected types

There are many types of batteries that are used for various purposes. Basically we can line up the batteries into two major categories. They are:

i) Primary cells or non-rechargeable battery
ii) Secondary cells or rechargeable batteries.

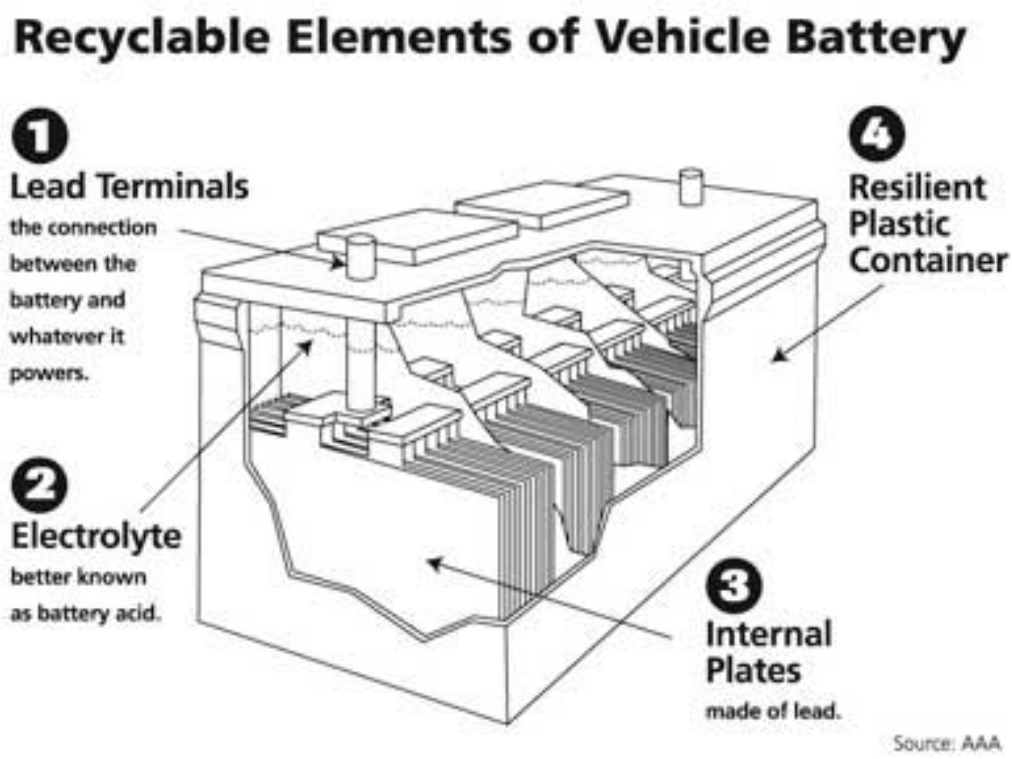
Alkaline battery, lithium battery, galvanic cell, daniell cell, dry cell, atomic battery etc. are primary or non-rechargeable type of battery. They cannot be recharged and thus reproduce electricity.

Secondary cells or rechargeable batteries include lithium ion batteries, fuel cell, lead acid battery, nickel-cadmium battery, super ion battery etc. These batteries can be recharged and reproduce current as long as they are not fully decayed.

For the solar car, we could only use the rechargeable batteries and after considering all the options, we chose lead-acid battery considering its inexpensiveness and its availability in Bangladesh. The size of the battery is not very big which was also in our favor. Also lead-acid battery is safer than other batteries we considered and has less chance to explode or any other damage. It is easy to recharge the batteries as well.

c. Short chemical description

A lead acid battery is made up of a number of lead-acid galvanic (voltaic) cells connected up is series. It converts chemical energy into electric energy.



Discharge

Fully discharged: two identical lead sulfate plates in the discharged state both the positive and negative plates become lead(II) sulfate ($PbSO_4$), and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water. The discharge process is driven by the conduction of electrons from the negative plate back into the cell at the positive plate in the external circuit.

Negative plate reaction:

$$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$$

Positive plate reaction:

$$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$

The total reaction can be written as

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

The sum of the molecular masses of the reactants is 642.6 g/mol, so theoretically a cell can produce two faradays of charge (192,971coulombs) from 642.6 g of reactants, or 83.4 ampere-hours per kilogram (or 13.9 ampere-hours per kilogram for a 12-volt battery). For a 2 volts cell, this comes to 167 watt-hours per kilogram of reactants, but a lead-acid cell in practice gives only 30–40 watt-hours per kilogram of battery, due to the mass of the water and other constituent parts.

Charging

Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which is lost to the cell. Periodic maintenance of lead-acid batteries requires inspection of the electrolyte level and replacement of any water that has been lost.

Due to the freezing-point depression of the electrolyte, as the battery discharges and the concentration of sulfuric acid decreases, the electrolyte is more likely to freeze during winter weather when discharged.

Ion motion

During discharge, H+ produced at the negative plates moves into the electrolyte solution and then is consumed into the positive plates, while HSO−4 is consumed at both plates. The reverse occurs during charge. This motion can be by electrically driven proton flow or Grotthuss mechanism, or by diffusion through the medium, or by flow of a liquid electrolyte medium. Since the density is greater when the sulfuric acid concentration is higher, the liquid will tend to circulate by convection. Therefore a liquid-medium cell tends to rapidly discharge and rapidly charge more efficiently than an otherwise similar gel cell.

d. Stages of battery charge

The three important phases of battery charge are-

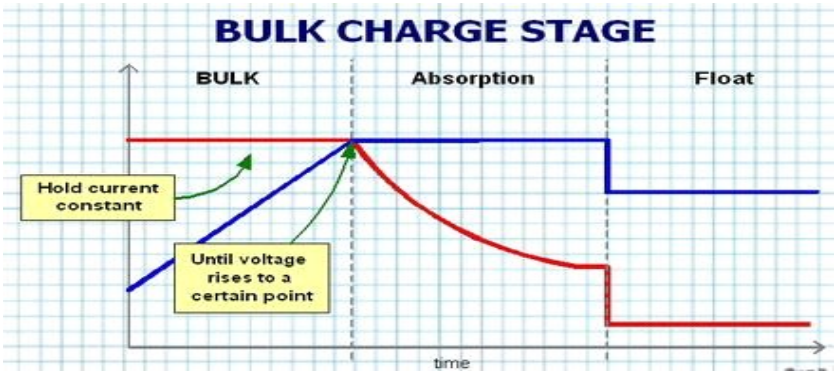
- **The bulk charge**
- **The absorption charge**
- **The float charge**

The Bulk charge:

The first stage in a three stage charge cycle is known as the bulk charge. In this stage, the battery charger will rapidly return the battery to an 80 to 90 percent state of charge.

Consider ohm's law where voltage, V= I(current in Amps) X R(resistance in Ohms)

A quick survey of this equation shows that if we want to maintain a constant current in a circuit with rising resistance, we must raise the voltage. The bulk charge continues until the voltage output by the charger reaches a specific level. At that point, it switches to the absorption charge.



The Absorption charge:

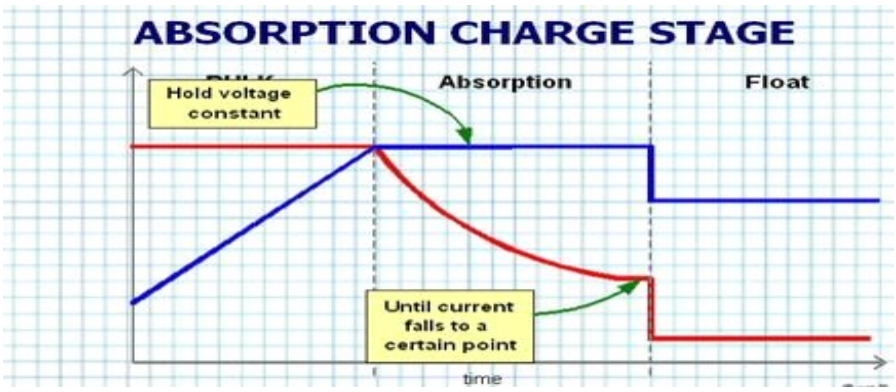
In this stage, the voltage applied to the battery by one charger is held at a constant level. As the charger holds the level, it is also monitoring the current being supplied.As the battery becomes increasing charged, it's opposition or resistance to a charged current increases. This will the current flow to tail off.

Let us consider the Ohm's law again where

Voltage, V= I (current in amps) X R (resistance in ohms)

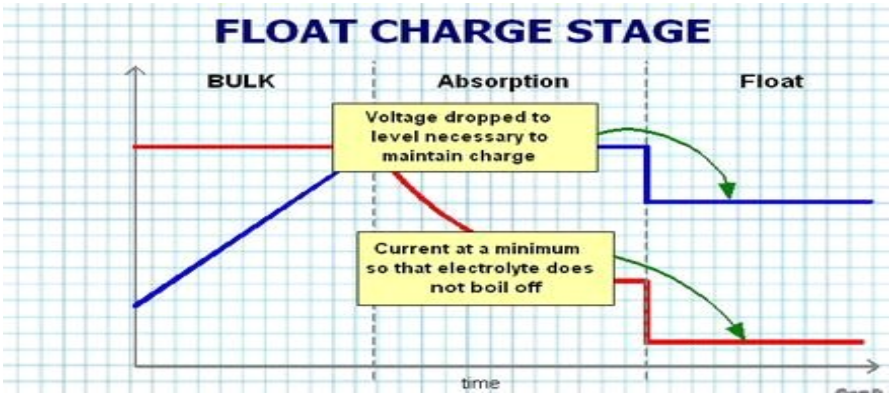
If voltage is held constant and resistance increases, current must decrease.

During the absorption charge, the three stage charger monitors the falling current until a specified point is reached that indicates that the battery is about ninety eight percent charged. When this specified level of current is reached, the three stage battery charge will switch to the float charge state.



The float charge:

In this stage, the voltage is dropped to a level lower than what was applied during the absorption charge. The float charge serves two purposes. First, it brings the battery from a 98 percent state of charge to a 100 percent state of charge. Second, it maintains the battery in a 100 percent state of charge condition.



e. Cost

Batteries available in Bangladesh have a wide range of cost. We had to select one which would fulfill our purpose properly and would cost less. After surveying the market, we finally bought Lucas AP70 Lead Acid battery in the amount of five from Rahimafrooz Batteries Ltd. (RBL). These five batteries have been used to run the motor of the car.

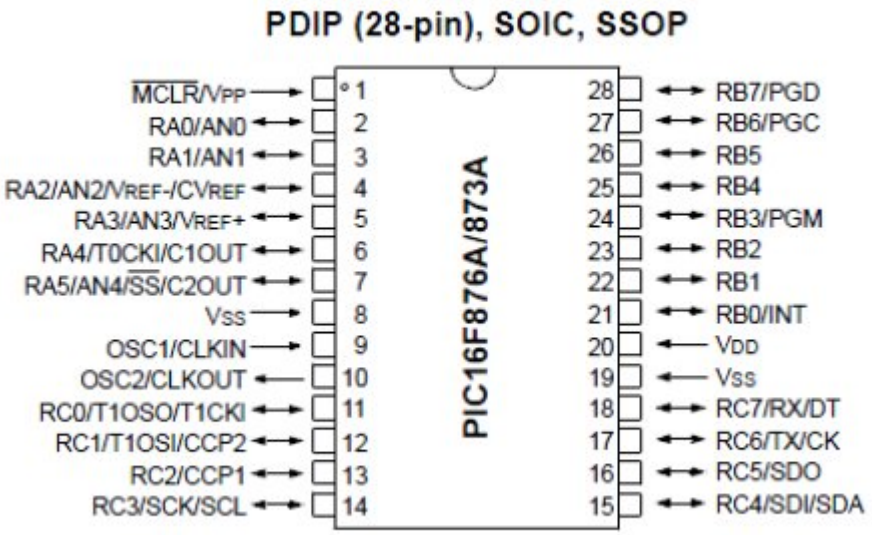
Model	Voltage	Plate/cell	AHC@20Hrs	Total Taka	Dimension(mm)approximate
AP70	12	9	70	7,500	L 410 W 175 H 240

We needed another battery to provide voltage to the entire lighting system of the car. Another AP70 battery manufactured by Hamko Group has been bought. While the other batteries gives 70 AHC@20 Hrs, it provides 45 AHC@20 Hrs. it was bought in a reconditioned state and the price was 2,700 Taka. Each of the batteries has a weight of around 15 kilograms.

Batteries placed in the back of the car

3. Charge Controller

The goal of the charge controller is to work as a battery management system (BMS) where it manages the charging and discharging of the battery. The undertaking is completed utilizing a PIC 16F876A microcontroller chip.



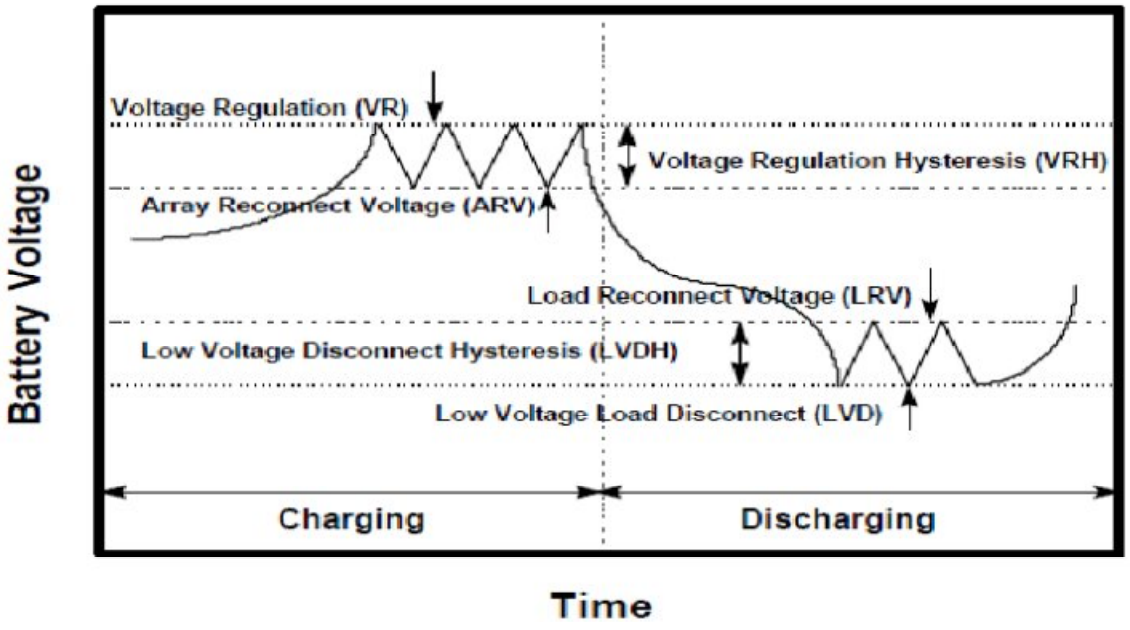
a. Description:

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into a 28-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F876A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 5 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port which can be configured as either 3-wire Serial Peripheral

Interface (SPI) or the 2-wire Inter-Integrated Circuit (I2C) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications. The power up voltage of the PIC16F876A is rated at 5 V. In the circuit design the microcontroller is to be powered by the battery itself. Since the battery voltage will most likely be over the voltage specification of 5 V, a voltage regulator (LM 7805) would be used to convert the battery's voltage into a 5 V constant DC supply at the microcontrollers power pin.

b. Charge controller set points:

Whenever the battery is going to be charged above 100% state of charge it is said to be over charged. Whenever the battery is discharged below 20% it is said to be over-discharged. To prolong battery life the charge controller must ensure the battery remains within the range of 100% to 20% of state of charge. The charge controller would then protect the battery from over-charge if the battery voltage goes beyond its upper set point by disconnecting the solar panel charger from the battery. It would protect the battery from over-discharge if the battery voltage goes beyond its lower set point by disconnecting the load from the battery.



Charge controller set points

c. Charge controller parameters:

At last the accompanying parameters and set points were settled on for the charge controller as gathered from the battery test:

AC (3 steps, due to high charging current):

- Stage 1: 0-14V : 90% PWM charging
- Stage 2: 14-14.2V : 50% PWM charging
- Stage 3: 14.2-14.3V : 10% PWM charging

0% PWM above 14.3V

Solar panel (2 steps, due to high charging current):

• Stage 1: 0-13.4V : 90% PWM charging

• Stage 2: 13.4-13.7V : 10% PWM charging

0% PWM above 13.7V

- Low voltage disconnect at 10.8V and reconnect at 12.4V.
- Max charging currents:
  - 4A for charging via solar panel
  - 8A for charging via AC.
- Charge controller input voltage and current range for

• Solar panel charging are 75V and 10 A respectively

- AC line charging are 90V and 10 A respectively

CHAPTER 7: SOLAR BODY CONSTRUCTION

A car's body is exclusively designed to minimize air circular drag force and to maximize smooth movement on road. The opposite drag force by air decelerates car's speed since it has direct impact on the front side of car. To minimize the contrasting drag force of car due to air flow, the frontal car glass is aligned with a 45^{o} angle fixed with the body of solar car. For this reason, air can flow slickly without creating any opposite net force and car can be driven forward without any air relating disturbance. On the other hand, for a low powered car in which payload is insignificant, the orientation of frontal glass is essential rather than of high powered vehicle like Buses, Lorries. On those highly powered vehicles, the air drag force is considered negligible

because for high torque generating engines behind them. Moreover, the cars which should have a high speed carrying low payload, like solar cars or other electric vehicles, the frontal glass dimension is obviously an important issue that was considered while constructing our designed solar car. Not only the frontal glass but also the bonnet design was also important for minimizing air resistance while running on road. The design of bonnet is similar to conventional car but the modification of it was done fixing two 50W solar panels using non rusty screw bolts on it.

Figure (d): the bonnet of the solar car

The panels that were fixed on it were not kept so high from bonnet because it might create an additional air resistance for the car. So, the panels were kept as low as possible just by keeping a plastic that is surely less heat sensitive sheet below it. The bonnet and frontal glass are fixed with cast iron and air ventilation system is kept also to flow air through it. Since, the panel efficiency is lessened because of external car body temperature, so the plastic sheet works as a barrier to transfer heat from body to the panel easily. Additionally, from an external frontal view our solar car looks like conventional car design but every aspect including frontal glass and attached panel of bonnet are done to increase swift movement of it. Here the bonnet is made of cast iron which has an estimate weight of 15 KG excluding solar panels. The solar panels that are fixed to the bonnet, their respective wires are taken within two rectangular shaped holes that are not visible from outside. Among the limitations of solar car's bonnet design, the frontal glass cleaning mechanism is not yet brought to the car, because of our fixed panels on it. But wipers are also

attached to the bonnet which is run by a 12V DC motor. A grill having air moving capability is fixed with the chassis of car and also the bonnet is fixed with a manual lock system.

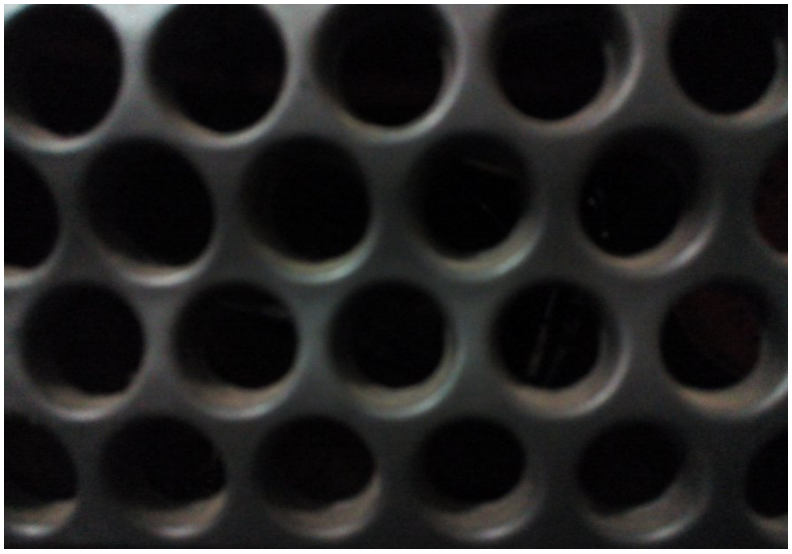


Figure (e): the Grill used for our solar car

The above grill is used to hold frontal lights and indicators. Actually the fixed grill is a plastic made approximately rectangular shaped mesh like sheets that is fixed between bonnet and bumper of solar car. It has a utility to increase exquisiteness of car and also to work efficiently for bonnet lock system. The structure of solar car's grill is modified using heating cutter machine, so that it can be fixed in that particular place and increase car looking scheme. The grill which is used has a dimension of 34 inch length and 7 inch height. In total it took a 238 square inch between two lights of solar car. It was made like mesh shaped because of decreasing air resistance and increasing air flow through the car.

Figure (f): The side view of the solar Car

Two indicator lights are attached on the two sides of car having a dimension of 2 inch by 1 inch. The functions of indicators are controlled from combinational switch attached with the steering of solar car. Though the weight of cast iron is high but also the right and left portion below bonnet are made of iron because it can absorb any bump creating by other cars on road. As a matter of fact, the floor skillet of auto is the biggest body segment to which a large number of boards and supports are accordingly either welded or darted. Here the shell of the vehicle is manufactured utilizing Galvanized Steel (GS) Sheets. The front and back door jambs, rooftop, and body side boards are collected in the comparable manner. The important items which are utilized to set up the body are: (a) Galvanized Steel Sheets, (b) Iron flat bars, (c) Transparent acrylic sheets, (d) Gas tungsten arc welding.

The Sheets that are utilized to get ready shell of the auto are Galvanized Sheets. Particular casings made of irons are likewise built which is utilized to append those sheets by gas welding machine. It is experienced by a compound methodology to keep it from rusting. The steel accompanies covered in layers of zinc oxide (ZnO) in light of the fact that this defensive metal does not get corroded as effortlessly. The covering additionally gives the steel a more tough,

difficult to scratch complete that is suitable for our auto body structure.

Figure (g) : the inside view of the solar car

A solar car is to run in an exceptionally corroded or intense climate, so the materials deciding to build car must be stressed. In GS steel sheets, Zinc ensures the auto in two ways. First and

foremost, it is exceedingly impervious to rust; press, a real segment of steel, responds effectively with oxygen and dampness and will in the long run deteriorate. It additionally builds up a patina — a layer of zinc oxides, salts, and different mixes — that offers further assurance.

In the above picture, the interior perspective of Solar Car is depicted. Here, the rear side frame is constructed as per our chosen GS sheet and the frames are constructed by iron metals. For choosing the wheels of solar car, we have chosen 5 inch width and 18 inch diameter wheels. These wheels are capable enough to take a payload about 500 kg including passengers of the solar car. The nuts and bolts which are used to construct solar car, is made of stainless steel and it is chosen to bear entire load of solar car on its axle connected to wheels. Zinc is likewise to a great degree tough and scratch safe, and has a smooth appearance that is much fitting for auto body development. For the wielding reason, a propelled most recent innovation is gotten our workshop that is GTAW technology.Gas tungsten arc welding (GTAW), also known as tungsten

inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. It is used to weld different sheets like GS Sheets and Iron flat bars to the body of car. In fact the weld area of GTWA is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used.

Figure (h): the back side of the Solar car

The rear side of car is constructed by transparent acrylic sheet that is bended by GTAW wielding heat. A frame is used to attach that sheet with solar car. Rotating mechanism was also introduced to open rear side of car. Two high quality rotating components are also used with acrylic sheets. The opening mechanism was required to enter into car for changing car batteries and also for maintaining car's interior system. Moreover high qualities of wires are also used to avoid any excessive heat generated by huge current flowing from batteries to motor. Besides to reduce viscous drag force generated by air flow, an aerodynamic shape was required. Thus to bring aerodynamic shape, appropriate bending of different parts of car's body is done by bending machine in robotics workshop of BRAC University. After that, those sheets are attached with frame.

Figure (i): The final solar car

Chapter 8: SOLAR CAR MONITORING SYSTEM

1. External monitoring feature

To monitor the state of the whole system continuous observation of the devices is essential for every parameters working in the system.

a. Panel Temperature:

Panels can be utilized as a segment of a bigger photovoltaic framework to create and supply power in business and private applications. Solar panel temperature is the vital parameter which affects the electricity producing rate of the Photovoltaic or solar panel. Usually the panel temperature is the air temperature and additionally the intensity of the sunlight which specifies panel's power production efficiency. Other environmental issues such as extreme sunny, gloomy , snow or cloudy weather may also increase or reduce performance of the panels. The energy generation effectiveness of these drops when the board spans hot temperatures. Photovoltaic power generation lives up to expectations most effectively in chilly temperatures.

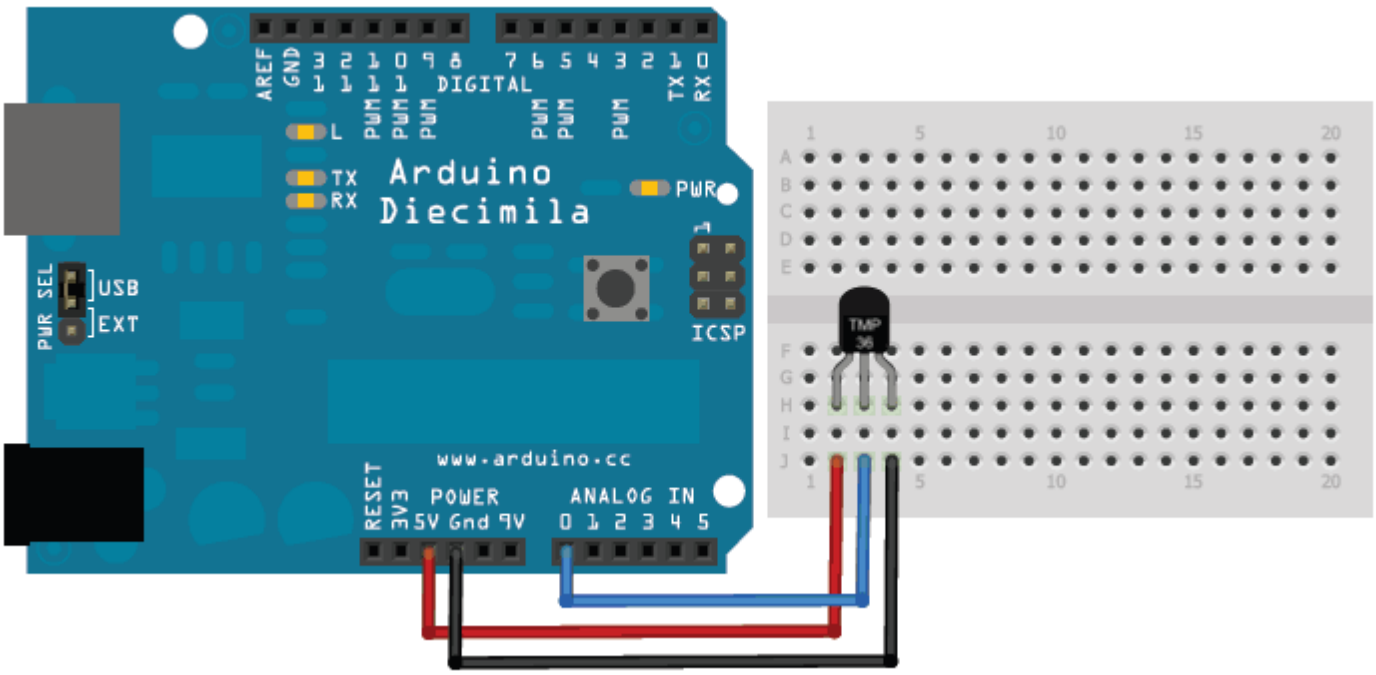


Figure: Arduino with temperature sensor LM35.

b. Speed:

The speedometer implemented on the vehicle is based on a very simple but effective mechanical mechanism. A metal cap containing pinion gears is connected to the wheel. One end of a mechanical cable, with a moveable wire inside, is connected to the pinion, and the other end to the speedometer. The mechanism inside the speedometer is set up as such that with the rotation of the wheel the speed pointer deflects and displays the speed.

Figure: Cable with a moveable wire inside.

Figure: Metal cap containing pinions.

Figure: Speedometer used

c. Battery temperature:

Room temperature is the best condition to run the battery efficiently. Moreover according to the inverse relationship of temperature and the internal resistance with the increasing temperature of the battery internal resistance decreases which may show up better performance for the time being. Besides low temperature is a drawback for battery capacity. As a result observation of the system regulations over time is significant. Furthermore battery temperature is monitored by *LM35* Precision Centigrade Temperature Sensor through Arduino Mega 2560 microcontrolling board with the help of Liquid Crysta Display(LCD) in the span of 1second.

d .Motor temperature :

The thermoelectric impact is the direct transformation of temperature contrasts to electric voltage and the other way around. Engine execution changes with temperature. Understanding the impacts of warmth and temperature changes will help in selecting the right engine for an application. At the point when applying DC engines to any sort of use, temperature impacts need to be considered keeping in mind the end goal to appropriately apply the engine. Execution will change as the engine temperature increments. Depending on the temperature and the obliged working point on the engine curve, the execution distinction in the middle of "cool" and "hot" conditions can be huge. Due to the importance of this parameter and effectiveness we included motor temperature monitoring system by LM35 to observe the motor conditions.

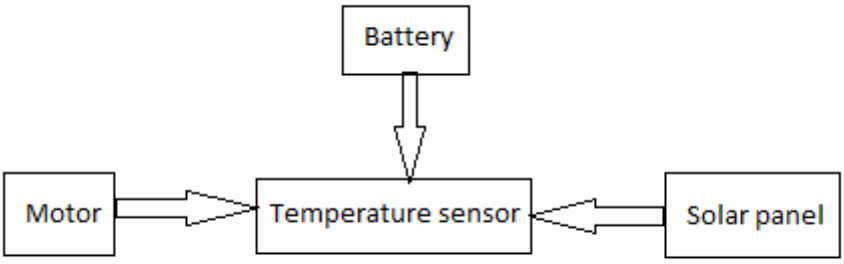


Figure: block diagram of temperature sense.

2.Internal monitoring feature

a. Current Measuring:

1.Importance:

An electric current is a stream of electric charge. In electric circuits this charge is regularly conveyed by moving electrons in a wire. DC current is unidirectional flow of stream of electric charge. Electric streams cause Joule heating, which makes light in radiant lights. They likewise make attractive fields, which are utilized as a part of engines, inductors and generators. As excessive current flow may generate enough heat to burn out the whole system. For internal monitoring purpose current measuring with full monitoring system is essential.

2.Battery-Motor:

Current measuring is the essential part of the whole monitoring system including Battery to motor current. Through the current sensor current flows from the battery to the Motor. through the slip rings the motor is supplied with DC current which describes the condition of the motor. By ACS 758 the battery to motor current is measured and showed in LCD display in this solar car.

3.Panel-Battery:

With respect to the intensity of sunlight the current and generated power varies. For general idea and overview about the charging situation of battery panel current is obligatory to measure and analyze.Using the same IC ACS 758 Panel to battery current is measured.

4. Circuit Diagram:

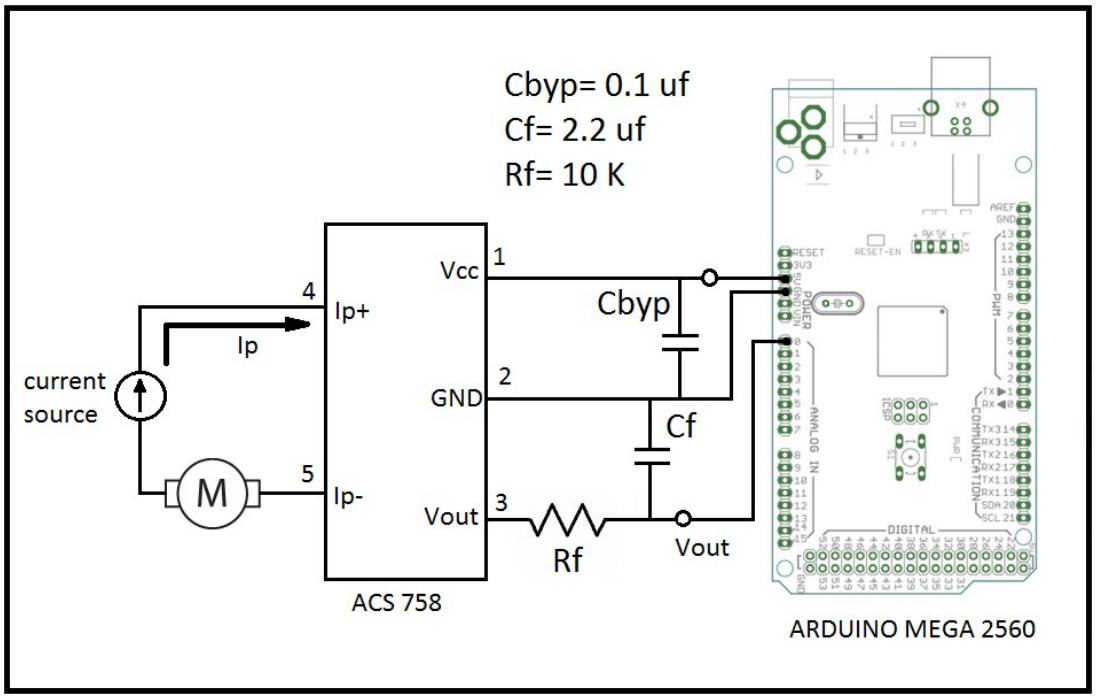


Figure: circuit diagram of current sensor ACS758 with arduino.

Block diagram:

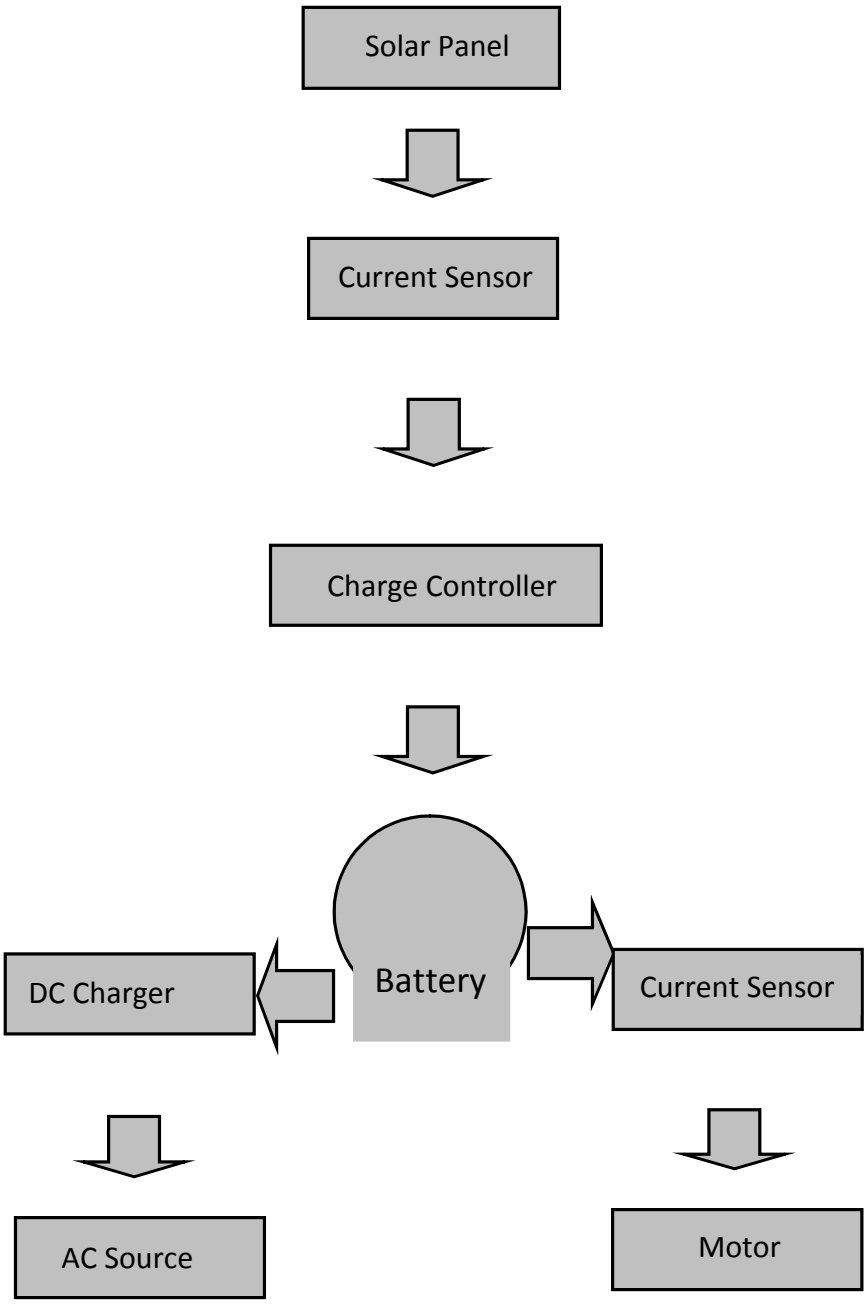


Figure: Block Diagram of the internal system and current sense system.

b. Voltage measuring:

In hardware, a voltage divider (otherwise called a potential divider) is a uninvolved direct circuit that creates a yield voltage (Vout) that is a small amount of its information voltage (Vin). Voltage division is the consequence of appropriating the info voltage among the segments of the divider. A straightforward illustration of a voltage divider is two resistors joined in arrangement, with the data voltage connected over the resistor pair and the yield voltage rising up out of the association between them. Experimentally by the voltage divider rule voltage can be sensed. A charge controller is used monitor and control charging as well as show up the battery voltage level by sensing the voltage of the batteries in total.

Chapter 9: PCB design.

a. Introduction:

A printed circuit board (PCB) mechanically backings and electrically interfaces electronic segments utilizing conductive tracks, cushions and different highlights scratched from copper sheets covered onto a non-conductive substrate. PCBs can be single sided (one copper layer), twofold sided (two copper layers) or multi-layer (external and inward layers). Multi-layer PCBs consider much higher part thickness. Conductors on diverse layers are associated with plated-through gaps called vias.

b. Proteus software:

All Proteus PCB outline items incorporate an incorporated shape based autorouter and an essential SPICE reenactment capacity as standard. More propelled directing modes are incorporated in Proteus PCB Design Level 2 and higher whilst recreation abilities can be

upgraded by acquiring the Advanced Simulation choice and/or smaller scale controller reenactment capacities.

c. PCB design in ISIS:

Progressed PCBs may contain segments - capacitors, resistors or dynamic gadgets - implanted in the substrate. Printed circuit sheets are utilized as a part of everything except the easiest electronic items. Different options for PCBs incorporate wire wrap and point-to-point development. PCBs require the extra plan push to lay out the circuit, yet assembling and gathering can be computerized.

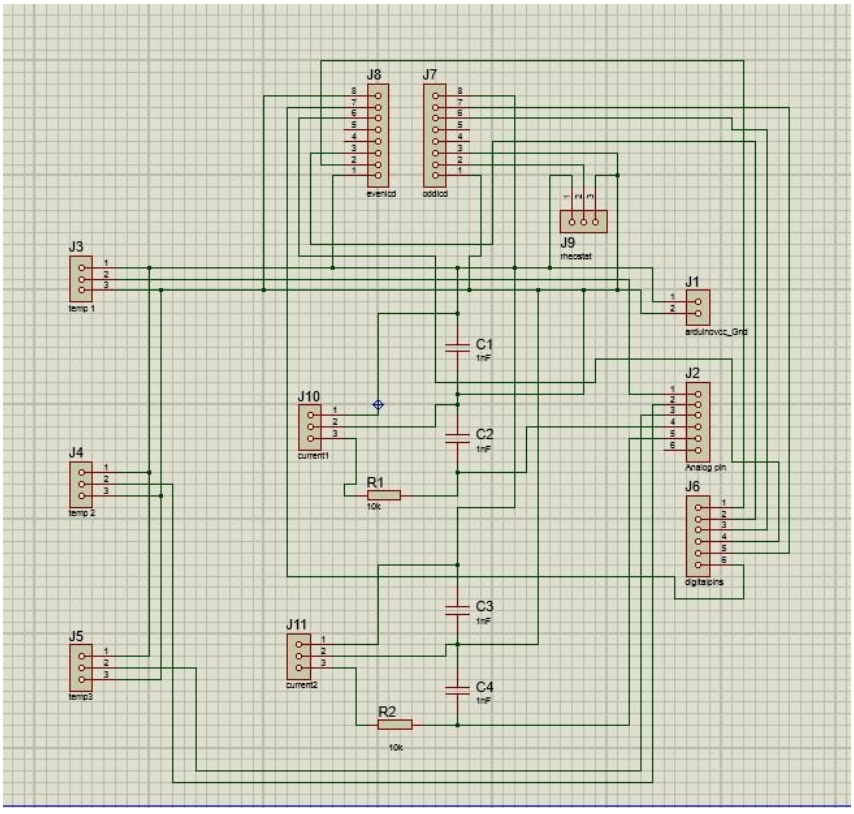


Figure: Simulated capture of the PCB.

d. Implementation:

Assembling circuits with PCBs is less expensive and quicker than with other wiring routines as parts are mounted and set up with one single part. Moreover, administrator wiring lapses are dispensed with. The monitoring components are added into a PCB to operate it form a single circuit board by proteus 8 professional.

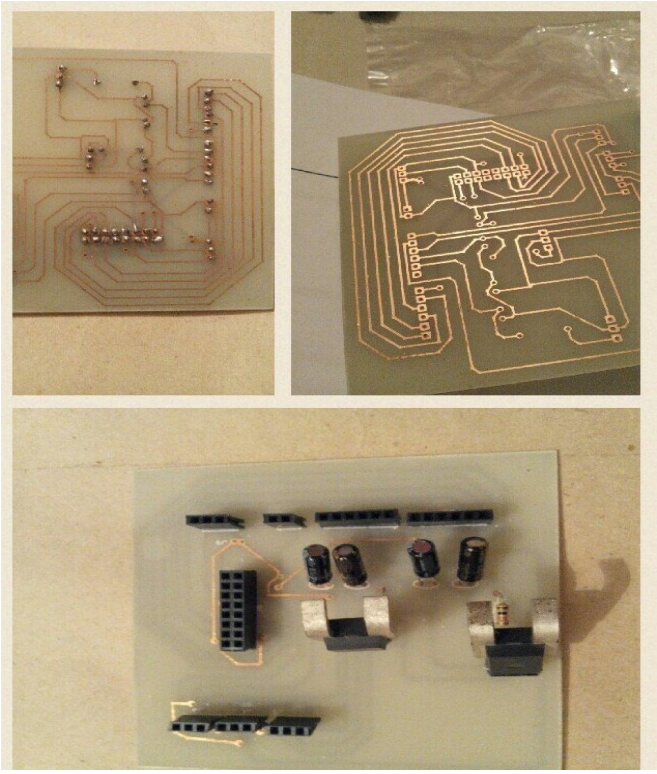


Figure: PCB of the monitoring system.

CHAPTER 10: CONCLUSION AND FUTURE WORK

In order to cope with the increasing demands for fuel and the disastrous environment pollution due to driving carbon-based vehicles, it is quite necessary to switch to a new source of energy, i.e. the solar power which would be a cheap, efficient, limitless and of course an eco-friendly alternative. Solar-powered electric vehicles are safe with no volatile fuel or hot exhaust systems. They are zero emission vehicles, odorless, smokeless and noiseless. They require minimal maintenance, are more reliable with little or no moving parts and can be efficiently charged nearly anywhere. Needless to say it is very much cost efficient. Since solar cars can easily incorporate future technology, we hope that it would not be long before the majority of the worlds' people would switch to driving this modern vehicle and thereby bring about a positive change in their lives and the environment. This is just the beginning of a new technology and it is guaranteed that future developments will make solar cars the predominant mode of transportation over vehicles with internal combustion engines.

With a specific goal to adapt with the expanding demand for fuel and the shocking environment pollution because of driving carbon-based vehicles, it is very important to change to new and reliable source of energy, i.e. the solar energy which would be a modest, effective, boundless and obviously an eco-friendly option.

Solar powered electric vehicles are safe with no unstable fuel or hot exhaust system. They are zero emission vehicles, scentless, smokeless and quiet. They require negligible support, are more dependable with almost no moving parts and can be proficiently charged about anyplace. Evidently it is very much cost efficient.

Solar powered car is compatible with today's and as well as future technology and we sincerely hope that it would not be much long before most of the people would change to driving this advanced vehicle and accordingly realize a positive change in their lives and the earth. This is simply the start of another innovation and it is ensured that future improvements will make solar powered cars the overwhelming method of transportation over vehicles with internal combustion engines.

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