

High Efficiency, Low Cost, less Weight Material Design of Solar Powered Electric Vehicle

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Abstract

At present, solar powered vehicle is connected as one of the essential vitality sparing vehicle where the utilization of sustainable power source found practical vitality request with decline in fuel cost and purging of environment. One of the principle zones of sustainable power source assets today is solar power. P.V cells are utilized to change over sunlight based vitality in to valuable electrical vitality. The target of this paper is to develop a productive sun oriented vehicle, with the goal that the one can travel regularly on a solid and affordable vehicle that essentially keeps running on free sustainable sun powered vitality This paper clarifies how the charge created by a variety of solar panel is gotten and its stream all through a battery bank is to be controlled utilizing a charge controller to ensure proficient putting away of in a battery pack. The put away vitality would be sustained to a BLDC motor which would run the vehicle. The mechanical development of the frame alongside all essential mechanical frameworks is shown. Finally the wiring of the electrical structure on the mechanical body is represented

Keywords: BLDC Motor, Lead Acid Battery, PWM chopper controller, Solar Panel.

I. Introduction:

A solar powered vehicle is utilized for land transport fueled by an electric motor, other vehicle has an overwhelming clamor and furthermore dirties the air, electric vehicle is smooth and quiet. A portion of the choices are sustainable power sources which incorporate all fuel types and vitality bearers, not the same as the fossil ones, for example, the sun, wind, tides, hydropower and biomass. Among these components, solar powered vitality is favored since it could give the cleanest supportable vitality to the longest term of time. On account of fuel issue, acquainting electric vehicle is with decrease the weight on fuel and our condition will be sufficient. The segments of an electric vehicle are BLDC motor, charge controller, Lead corrosive batteries, Battery Charger.

Solar vehicles rely upon PV cells to change over daylight into power. Dissimilar to sun powered warm vitality which changes over sun-oriented vitality to warm for either family purposes, modern purposes or to be changed over to power,

PV cells straightforwardly convert daylight into power. Whenever daylight (photons) strikes PV cells, they energize electrons and enable them to stream, making an electrical flow. PV cells are made of semiconductor materials, for example, silicon and compounds of indium, gallium and nitrogen. Silicon is the most widely recognized material utilized and has a proficiency rate of 15- 20%.

To Fight against Fuel Problem:

Sustainable power source originates from normal assets, for example, daylight, wind, tides, rain and geothermal warmth, which are altogether inexhaustible. These energies are gotten from common procedures that are reestablished continually. Electrical vitality is gotten from sunlight based, wind, sea, hydropower, biomass, geothermal assets, bio-powers and hydrogen. In the event that we can utilize sustainable power source to deliver control for electric Vehicle then it has no awful effect on our capacity deficiency issue and just as we diminish the weight on utilizing fuel.

I. Survey work

Solar powered controlled vehicle is a three-wheel drive and has been utilized for shorter separations. The principle focus was made on enhancing the plan and making them financially savvy. Energy from Sun is caught by the solar panels and is changed over to electrical Energy. The electrical Energy consequently got is being bolstered to the batteries that get charged and is utilized to run BLDC motors. The pole of the motors is associated with the back wheel of the vehicle through chain sprocket. The batteries are at first completely charged and from there on they are charged by panels.

A) Paper objective

The principle goal of this undertaking is to build a solar powered electric vehicle with minimum cost to permit transport for individuals traveling a specific measure of separation each day, with essentially no expense as it will keep running off free inexhaustible solar energy. And additionally, in view of fuel issue, acquainting electric vehicle is with decrease the weight on fuel and our condition will be adequate.

II. System Overview

A solar power vehicle is an electric vehicle controlled by sun powered power. This is gotten from solar panels superficially (for the most part, the best or window) of the vehicle or utilizing a solar powered coat in electric bikes. Photovoltaic (PV) cells convert the sun's vitality straightforwardly into electrical vitality. Solar powered vehicles are not sold as down to earth everyday transportation gadgets at present, however are essentially showing vehicles and designing activities, regularly supported by government offices. Anyway, in a roundabout way solar powered charged vehicles are broad and solar water crafts are accessible industrially.

Solar powered vehicle join innovation commonly utilized in the aviation, bike, elective vitality and car enterprises. The structure of a solar powered vehicle is seriously restricted by the measure of vitality contribution to the vehicle. Most solar autos have been worked with the end goal of sun powered vehicle races. Special cases incorporate sun powered controlled autos and utility vehicles. Solar vehicles are regularly fitted with checks as observed in traditional autos. So as to keep the vehicle running easily, the driver must watch out for these measures to spot conceivable issues. Vehicles without measures quite often highlight remote telemetry, which enables the driver's group to screen the vehicle's vitality utilization, solar vitality catch and different parameters and free the driver to focus on driving.

Solar vehicles rely upon PV cells to change over daylight into power. Indeed, 51% of daylight really enters the Earth's air. Not at all like sun based warm vitality which changes over sun-oriented vitality to warm for either family unit purposes, modern purposes or to be changed over to power; PV cells specifically convert daylight into power. Whenever daylight (photons) strikes

PV cells, they energize electrons and enable them to stream, making an electrical flow. PV cells are made of semiconductor materials, for example, silicon and combinations of indium, gallium and nitrogen. Silicon is the most well-known material utilized and has a proficiency rate of 15-20%. Recently, a few counseling organizations, for example, Phoenix Snider Power, have begun offering specialized and money related administrations to establishments and groups creating solar autos around the world.

There would be a great deal of segments in our vehicle, for example, Solar panel secured the entire body of the vehicle, Battery Charger, to capacity the solar power, there are 12V Lead acid batteries associated with the solar panels, additional 12V Lead corrosive battery for providing the advantageous power, Battery plate, BLDC motors, Voltage and Motor controller, The complete segments are appeared in the square chart.

A. Block Diagram

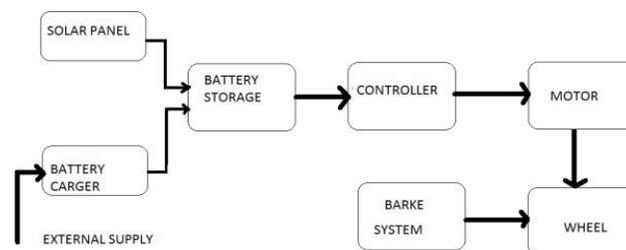


Fig1: Block Diagram

▪ Solar panel:

Solar panels have been around since the nineteenth century and from that point forward till today individuals have been utilizing them for an assortment of utilizations at home, business, for transportation and notwithstanding for farming use. Solar panels are still viewed as costly and their execution should be confirmed without totally depending on the gave evaluations by the organization delivering them. On account of a sun powered vehicle, the solar panels will be a definitive provider of vitality for the entire vehicle to work; in every practical sense it will be much the same as the heart that siphons blood around the human body.

▪ Solar system Batteries:

Solar system batteries are charged and discharged subjectively. Life time of battery is depends after charging and discharging of battery. Battery examinations are depended by cycle. In vehicle there is used shallow cycle battery which infers battery have cycles between 10% - 15% of batteries hard and fast limit. Regardless, in solar system batteries there is used significant cycle batteries which have up to half - 80% of hard and fast battery's capacity. This kind of battery is best for sun fueled errand.

Lead-Acid Battery

Lead corrosive batteries can be utilized in sun based vitality stockpiling. These kinds of batteries are profound cycled and possess long life energy for charging and releasing. Run of the mill life time of lead-corrosive batteries is 3-5 years. Life time of Battery really relies upon the charging and releasing cycle. Lead corrosive batteries discharges a few gas while charging. That is the reason these batteries are should have been kept outside or cross ventilated place, where air flow is adequate.

▪ Motor selection:

As our greatest concern on designing a cost-effective solar vehicle, among the two types of DC

motor Brushless DC motor is most suitable for us because of its long life span, almost zero maintenance cost and high efficiency.

Brushless DC motor

Brushless DC motor utilizes a pivoting perpetual magnet or delicate attractive center in the rotor, and stationary electrical magnets on the motor lodging. A motor controller changes over DC to AC. This plan is more straightforward than that of brushed motor since it takes out the intricacy of exchanging power from outside the motor to the turning rotor. Brushless DC equip motors from Oriental Motor can accomplish when joined with a standard equipped alternative. Their space sparing structure adds to a smaller and amazing arrangement extending from 15 W up to 400 W. Their level torque attributes can create the equivalent appraised torque at wide speed extend. Brushless DC Motors (BLDC Motors) likewise highlight a wide assortment of pre-massed equipped and electromechanical brake choices and are accessible with our industry driving stable lead times.

Construction:

Construction of BLDC motor as shown in fig.2 the brushless DC outfit motor includes a loop is star-wired (Y-wired) with three-stages: U, V, and W and is situated in the stator, and the rotor is made of magnets charged in a multi-post arrangement as appeared in fig 2.

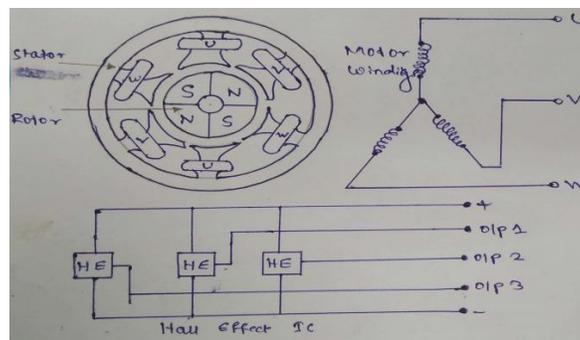


Fig2: Construction of BLDC Motor

Inside the stator, three porch ICs are organized as attractive components with the area that the stage distinction of the yield wave from every passage IC will be 120 degrees separated for each revolution of the rotor. Brushless DC Motors (BLDC Motors) are very compact and when mated with a gear head, can produce a large amount of torque. The Brushless DC Motors (BLDC Motors) do not use brushes, which frequently require swapping and/or maintenance, saving time and cost.

III. Problem identification

From the earliest starting point of our undertaking work we are centered around diminishing weight on oil just as not presenting electric vehicle since it will make an additional heap to our national network. To present solar powered vehicle we confront four noteworthy issues and these are providing power around evening time, charging sun based board in terrible climate condition, planning the controller and most huge isn't getting adequate measure of vitality from solar panel. These prime difficulties coming in our direction are portrayed quickly here.

A. Power supply at night

The best issue with solar panels is it can't supply control if there is no sun beam falling on the solar panels. So on the off chance that anybody needs control supply from solar panels when there is no daylight he should have capacity the additional energy to another gadget (battery) appended to the framework. Two batteries consistently store the electric vitality originating from the solar panels and supply that vitality to stack when required. So the framework should have two batteries associated with solar panels to guarantee steady power supply in the motor.

B. Charging at night and bad weather condition

At the point when there is overwhelming mists for a few back to back days in blustery seasons. This overcast condition may mischief to deliver adequate measure of vitality to run the vehicle. So that on that times both the batteries can't charge completely and supply vitality to motor.

C. Solar panel cannot supply whole day's energy

The motor utilized in the vehicle need high measure of intensity entire the day yet the space of the vehicle secured by solar panel isn't supply that measure of intensity always in light of the fact that it store energy to battery in a low rate and not all the time daylight hit the solar panel in same manner. So connecting both batteries with solar panel is ideal because when one battery is in full charge then other battery will store energy from solar panel.

IV. Methodology

A. Design Analysis

▪ Motor power rating:

Solar powered vehicle contrasted with interior burning motor vehicles are less difficult in that they have few noteworthy segments. Be that as it may, being an electrical framework makes exact computations of the appraisals of these significant segments of the vehicle basic at the plan arrange. The appraisals of the 3 noteworthy segments of the vehicle that will be resolved are

- 1) The motor control rating required to accomplish the fundamental speed and increasing speed.
- 2) The battery limit which can bolster the separation required to be voyage.
- 3) The solar panel details expected to keep the battery adequately charged for the voyage.

The power rating of the motor will decide the battery limit for example Ampere-hour charge and voltage expected to conquer the most extreme separation that the solar powered vehicle will go on sunlight based power alone. Therefore this thus will decide the board wattage required to support the battery charge.

▪ The rolling resistance:

The moving opposition compel is the power opposing the moving movement of the tires as they move over the street surface. Variables that add to moving opposition are the (measure of) misshaping of the wheels, the distortion of the roadbed surface, and development beneath the surface. Extra contributing elements incorporate wheel distance across, speed, load on wheels and so on. For instance, an elastic tire will have higher moving opposition on a cleared street than a steel railroad wheel on a steel rail. Thus, sand on the ground will give more moving opposition than cement. The moving obstruction power can be communicated as,

$$\text{Frolling} = \mu R * W \dots \dots \dots [1]$$

Where, W is the weight of the vehicle

μR is the coefficient of rolling resistance

What's more, is a consistent that relies upon the sort of feels worn out on the vehicle and the surface on which it will roll. Thicker tires with more extensive tracks, albeit useful for bond, anyway create additionally moving obstruction. To monitor control sun based autos need to utilize more slender tires. Likewise harder surfaces offer lower moving obstruction compel than milder ones. Some standard qualities are appeared as pursues:

0.0003 0.0004	to	Unadulterated moving hindrance Railroad steel wheel on steel rail.
0.0010 0.0024	to	Railroad steel wheel. Rail vehicle 0.0020
0.001 0.0015	to	Solidified steel metal rollers on steel
0.0022 0.005	to	Generation bike tires at 120 psi (8.3 bar) and 50 km/h (31 mph), estimated on rollers
0.0045 0.008	to	Huge truck (Semi) tires
0.010 0.0015	to	Normal vehicle tires on concrete
0.0385 0.073	to	Stage mentor (19 th century) on soil street. Delicate snow on street for most pessimistic scenario.
0.3		Common vehicle tires on sand

Table1: coefficient of rolling resistance μ_R

$$F_{\text{rolling}} = \mu_R * GVM$$

$$\mu_R = 0.005 \dots \dots \dots \text{(From above table)}$$

$$GVM = 500 \quad \text{(with load)}$$

$$F_{\text{rolling}} = 0.005 * 500 = 2.5 \text{ N}$$

▪ **Aerodynamic drag force:**

The streamlined drag force is just the power applied by the air to keep the vehicle from traveling through it. The streamlined drag power can be communicated.

$$F_{\text{drag}} = [(1/2) * c_D * A_{\text{cross}} * \rho * (V)^2 \dots \dots \dots [2]$$

Where, c_D is the coefficient of drag of car

A_{cross} is its frontal area in square feet

ρ is a constant that stands for the air mass density

V is the vehicle's speed

To minimize drag for any given c_D , the coefficient of drag, and across, and its frontal area must be minimized

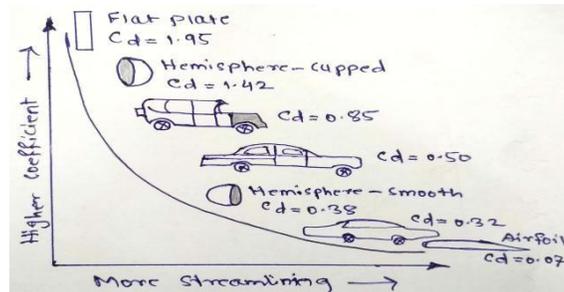


Fig3: Coefficient of drag of different vehicle shapes

$$F_{\text{drag}} = \left[\frac{1}{2} \right] \cdot c_D \cdot \text{across} \cdot \rho \cdot (V)^2$$

$$c_D = 0.85 \dots \dots \dots \text{(From fig 3)}$$

The frontal area side in inches is 40 inch & 31 inch. It converts in cm & m.

$$40 \text{ inch} = 101.6 \text{ cm} = 1.016 \text{ m}$$

$$31 \text{ inch} = 78.74 \text{ cm} = 0.7874 \text{ m}$$

$$\text{Then, Across} = 1.016 \cdot 0.7874 = 0.8 \text{ m}^2$$

$$\rho = 1.225 \text{ Kg/m}^3$$

$$V = 6.94$$

$$F_{\text{drag}} = \left[\frac{1}{2} \right] \cdot 0.85 \cdot 0.8 \cdot 1.225 \cdot (6.94)^2$$

$$\mathbf{F_{\text{drag}} = 2.89 \text{ N}}$$

The drag constrains turns out to be progressively discernible at rates of over 40 km/h because of it being relative to the square of the speed. Since batteries give just 1% as much power per load as gas, enhancing for either fast or long-run execution objectives, necessitates that one remembers this basic execution factor first. As it is observable from figure the more streamlined the state of the vehicle the lower is c_D . It is assessed that for ordinary vehicle structures, the body's back zone contributes over 33% of c_D without anyone else's input, trailed by the wheel wells at 2%, the underbody zone at 14%, the front body territory at 12%, projections (minors, dribble rails, window breaks and so forth.) at 7%, and motor compartment and skin grating at 6% each.

Force of acceleration:

The power of increasing speed ought to be represented when the vehicle is quickening and is given by newton's second law of movement.

$$F_{\text{acceleration}} = [m \cdot a] \dots \dots \dots [3]$$

$$m = \text{GVM} / g \quad \text{GVM} = \text{Gross Vehicle Weight of the vehicle}$$

Where, a = required acceleration.

m = mass of the vehicle

g = acceleration due to gravity (9.81/sec)

$$F_{\text{acceleration}} = [m \cdot a]$$

$$m = 500 / 9.81 = 50.96$$

$$a = dv/dt = (v_f - v_i) / (t_f - t_i)$$

$$= (25-0) / (10-0) = 2.5 \text{ m/s}^2$$

$$\text{Facceleration} = [50.96 * 2.5] = 127.42$$

$$\begin{aligned} FT &= F_{rolling} + F_{drag} + F_{acce} \\ &= [\mu R * GVM] + [(1/2) * cD * A_{cross} * \rho * (V)^2] + [m * a] \\ &= [2.5 + 2.89 + 127.42] \\ &= 132.81 \text{ N/m.} \end{aligned}$$

$$\text{Torque} = R_f * FT * r$$

R_f = Friction factor that account for frictional losses between bearings, axles etc.

The frictional losses among the wheels and their axles and the effort on the motor bearings.

Classic values choice between 1.1 and 1.15 (or 10 to 15%). [8]

R = radius of drive wheel (m)

$$\text{Torque} = R_f * FT * r$$

$$= 1.1 * 132.81 * 0.20$$

$$\text{Torque} = 29.21 \text{ N/m.}$$

V. Project implementation

A. Controller

BLDC Controller Circuits have PWM chopper control which helps in controlling the PWM obligation cycle. It depends on simple information (8-bit ADC) and ensures the continuous execution of the circuit. Designed utilizing best accessible methods, this give exact planning which permits to precise speed and torque control, and furthermore ensure its pinnacle effectiveness. The application explicit plan and high practical productivity of these gadgets helps in beginning forward and turn around pivot and motor brake work for steady execution. These circuits bolster quicker powerful reaction with silent task and higher speed goes. Brushless DC motor frameworks are accessible with electronic-input control. The driver can be associated straightforwardly to a programmable controller. As the motor requires no power transfers, there is no requirement for occasional administration or substitution of transfers. This makes the machine exceedingly solid. In addition, the time required to set up the motor is incredibly diminished. Evacuating the transfers kills the start commotion amid opening and shutting of the hand-off contact focuses.

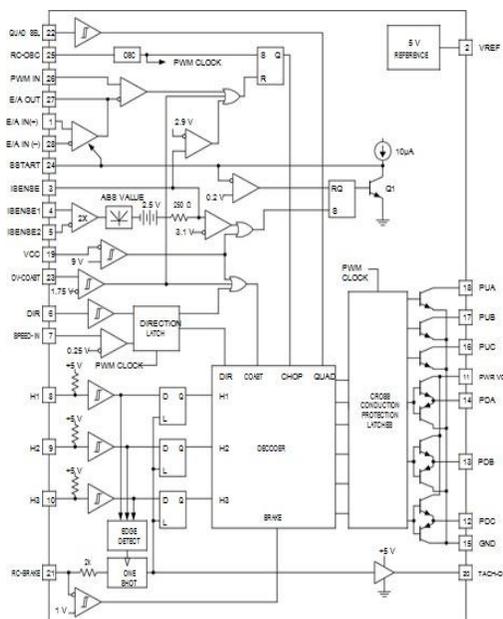


Fig4: Controller Layout

The motor controller incorporates the majority of the capacities required for elite brushless dc motor control into one bundle. At the point when combined with outer power MOSFETs or Darlingtons, this gadget performs settled recurrence PWM motor control in either voltage or current mode while executing shut circle speed control and braking with savvy clamor dismissal, safe heading inversion, and cross-conduction assurance. Albeit determined for task from power supplies between 10 V and 18 V, 26 V, 48 V the controller can control higher voltage control gadgets with outer dimension moving parts. The controller contains quick, high-ebb and flow push-pull drivers for low-side power gadgets and 50-V open-gatherer yields for high-side power gadgets or level moving hardware. The controller is described for task over the temperature scope of -55°C to 125°C .

Description

- i. Rated voltage: 48v DC
- ii. Current limit: 50A
- iii. Rated power: 900 w
- iv. Matching motor: dc brushless motor

B. Chassis and mechanical system:



Fig5: Screen Shot of Chassis

The state of the bodywork decides the streamlined drag, which over 25 mph can raise altogether. In the undertaking we are working by a fixed solar panel on the highest point of the vehicle. Another thought is weight and solidness. To make the vehicle light in weight the body material ought to be as light as could be allowed. Then again the material ought to be sufficient stiffer to convey the heap.

C. Steering



Fig6: Screen Shot of Steering Mechanism

Steering of a vehicle is utilized for controlling heading of the vehicle. It really moves both front wheels in an equivalent point when the vehicle alters its course. Controlling framework (manual directing framework) was utilized for this solar vehicle venture. Manual directing is an old guiding framework and today is as yet utilized as a result of its minimal effort. A level rack

adapts moves inside the rack body and it is driven by pinion. Pinion is a round rigging. The directing wheel is associated with the pole of the vehicle. The rack adapt is associated with a pole that is hanging inside and it is secured by an elastic cover beneath. The external piece of the inward attach pole is associated with the external piece of the external tie bar. These poles have some unique highlights state for instance these bar closures can move any straight way. At the very end the tie bar end is associated with the axle of the wheel.

D. Transmission system

The differential is a gadget that parts the motor torque two different ways, permitting each output to turn at an alternate speed. The differential is found on every cutting edge vehicle and trucks, and furthermore in some all-wheel-drive (full-time four-wheel-drive) vehicles.



Fig7: Screen Shot of Actual Differential

These all-wheel-drive vehicles require a differential between each arrangement of drive wheels, and they require one between the front and the back wheels also, in light of the fact that the front wheels travel an alternate separation through a turn than the back wheels.

E. Braking system

Drum braking mechanism was utilized for this undertaking. A drum brake is a brake that utilizes erosion brought about by a lot of shoes or cushions that press against a turning drum-formed part called a brake drum. The term drum brake as a rule implies a brake in which shoes push on the internal surface of the drum. At the point when shoes push outwardly of the drum, it is typically called a fasten brake. Where the drum is squeezed between two shoes, like a regular plate brake, it is here and there called a squeeze drum brake; however such brakes are moderately uncommon.

There is a switch associated with the stack agent in the back haggie the brake pedal. Break paddle is associated with another switch and a spring. At the point when the brake pedal is squeezed the switch appended to it is pulled and it endeavors to push ahead and subsequently the switch associated with the stack agent attempts to move in forward. At the point when the switch pushes ahead the stack agent spring gets a weight from it and it endeavors to move the clockwise way. Subsequently it puts weight on the break shoe. Because of this weight break shoe attempts to extend the outward way and as it is associated with the back wheel center point, the vehicle in the long run stops. This is fundamentally how the slowing mechanism functions.

VI. Conclusion

Request of fuel is expanding step by step. To satisfy the interest of this expanding fuel request it's a great opportunity to search for exchange sources. Solar energy is by a long shot the best decision since it is modest, condition well-disposed and in particular it is provided by an everlasting wellspring of energy. The extent of the task includes structuring and building a proto-

type sun powered fueled clean vehicle that would be conservative, dependable and ecologically well disposed.

The skeleton of the vehicle is built with key parts, for example, suspension framework, drum slowing mechanism, Steering, all set up. At long last a streamlined external body shape is proposed. Obviously it is particularly cost effective and the plan of body of this vehicle is finished by less weight material as contrast with the other vehicle accessible before this vehicle. This is only the start of another innovation venture began and it is ensured that future advancements will make sun powered vehicles the dominating method of transportation over vehicles with interior ignition motors.

REFERENCES

1. Md. Muntashir Bin Mahfuz, Md Tahsin-ul-Islam, “Design a solar powered clean car” BRAC UNIVERSITY.
2. U. S Department of Energy, “*A Consumer's Guide: Get your Power from the Sun Energy Efficiency and Renewable Energy*”, U.S Department of Energy.
3. Md. Jobair Bin Alam “*Traffic induced noise pollution in Dhaka city*” published on Journal of Civil Engineering, The Institution of Engineers, Bangladesh, Vol. CE 29, no. 1, 2001
4. Vasilis M. Fthenakis, Hyung Chul Kim, and Erik Alsema. *Emissions from Photovoltaic Life Cycles Environ. Sci. Technol*
5. Adinolfi G., Arsie I., Di Martino R., Giustiniani A, Petrone G., Rizzo Sorrentino M.(2008) , “*A Prototype of Hybrid Solar Vehicle: Simulations and On-Board Measurements*”, *Proc. of Advanced Vehicle Control Symposium AVEC 2008, October 6-9, 2008, Kobe, (Japan) 917-922 Society of Automotive Engineers of Japan - ISBN: 978-z 904056-21-9*
6. *Design and Fabrication of a Solar Powered Car Conference Paper · April 2014 DOI:10.1109/ICEEICT.2014.6919041*
7. Mubarak W. Al-Grafi , Mostafa K. Mohamed and Farhan A. Salem “*Analysis of Vehicle Friction Coefficient by Simulink/Matlab*” Taibah University, College of Engineering, Al-Madinah Al-Mounwara, Saudi Arabia ** Taif University, Faculty of Engineering, Mechanical Engineering., Saudi Arabia *INTERNATIONAL JOURNAL OF CONTROL, AUTOMATION AND SYSTEMS VOL.2 NO.2 July 2013*
8. “*EML2322L – MAE Design and Manufacturing Laboratory Drive Wheel Motor Torque Calculations*” *Reference Citation: White Hydraulics Drive Products*
9. Daniels M W and Kumar P R (2005), *The Optimal Use of the Solar Power Automobile, Control Systems Magazine, IEEE, Vol. 19, No. 3.*
10. John Connors *Solar Vehicles and Benefits of the Technology, ICCEP Paper(2007)*
Gianfranco Rizzo, Ivan Arsie, and Marco Sorrentino, *Solar energy for cars: perspectives, opportunities and problems, GTAA Meeting, Mulhouse, 26-27 May, 2010*