A Real Time Green Enviro Solar Power Car

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Abstract---To encourage the use of clean and green environment, a vehicle energized by solar power is developed. Instead of diesel engine, a 500W/36V Permanent Magnet Brushless DC motor is used, solar energy is converted into electrical energy using 36V, 150W PV panel. To provide a continuous operation, the batteries are charged from solar power and EB supply. For economic reason, the 12V-20AH lead-acid batteries are used and they are connected in series to increase the voltage rating, capacity and the mileage of vehicle. The 3ϕ voltage source inverter is used for converting the battery output to 3ϕ ac voltage to energize the Permanent Magnet Brushless DC motor. The voltage source inverter comprises of 6-N channel MOSFET. The gating signal for MOSFET is given from the motor controller. The closed loop path is provided by motor controller by comparing the Hall Effect sensors signals on the accelerator and motor. This control the acceleration and deceleration of the motor.

Keywords--- *BLDC motor, Solar panel, SMPS, Motor controller.*

I. INTRODUCTION

SOLAR Powered Vehicle (SPV) gives good efficiency, better performance, simple and robust in construction and also without pollution which will make the world green and clean. The fossil fuel such as petrol and diesel have been extracted and used in an erratic and expensive way. The use of fossil fuel based vehicles is one of the major ways that has accelerated the extraction of these non-renewable resources in an unsustainable way. Further, transportation of these fuel to rural communities itself has become a major problem. Therefore, it is high time for researching and engineering new technology for replacing the current practice with the alternative energy such as solar power. Therefore, we have developed a research project to build a Solar- Powered Vehicle (SPV) which is expected to be economical than to the petrol running vehicles but here it will be emulated by 36Volt battery.

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panels that are electrically interconnected and installed on some type of support structure. Using a solar panel array allows you to generate greater voltage and current than is possible with a single solar panel. The panels are interconnected in such a way that the voltage generated is close to (but greater than) the level of voltage of the batteries, and that the current generated is sufficient to feed the equipment and to charge the batteries.

Solar Panels are connected series because, increase the generated voltages/Solar Panels are connected parallel because, and increase the current. The number of panels used should be increased until the amount of power generated slightly exceeds the demands of your load. It is very important that all of the panels in your array are as identical as possible. In an array, you should use panels of the same brand and characteristics because any difference in their operating conditions will have a big impact on the health and performance of your system.

The Solar powered vehicle will be a power generating and storing vehicle. It will use solar panels to extract the solar energy through photo voltaic cells. The generated energy will be stored in Lead-acid batteries and these batteries will be paired up in series to increase the capacity and thus the mileage of the Vehicle. These Vehicles are expected to ensure a mileage of 40 km with 36 Volts of battery with full capacity. The solar-powered Vehicle will include a solar panel, a hub motor, battery storage, charge controller, motor speed controller circuit and a power electronic circuit allowing different switching as well as an access to external AC power which would help the vehicle to charge during the night. In order to make it a commercial product it can also include a headlight, a mobile charging circuit, and other luxuries if possible.

The battery stores the energy produced by the panels that is not immediately consumed by the load. This stored energy can be

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used during periods of low solar irradiation. The battery component is also sometimes called the accumulator. Batteries store electricity in the form of chemical energy. The most common type of batteries used in solar applications are maintenance-free lead-acid batteries, also called recombinant or VRLA (valve regulated lead acid) batteries.

Choosing a good battery can be very challenging in developing regions. High capacity batteries are heavy, bulky and expensive to import. A 200 Ah battery weights around 50 kg (120 pounds) and it cannot be transported as hand luggage. If you want long-life (as in > 5 years) and maintenance free batteries are ready to pay the price. A good battery should always come with its technical specifications, including the capacity at different discharge rates (C20, C100), operating temperature, cut-off voltage points, and requirements for chargers. The batteries must be free of cracks, liquid spillage or any sign of damage, and battery terminals should be free of corrosion. As laboratory tests are necessary to obtain complete data about real capacity and aging, expect lots of low quality batteries (including fakes) in the local markets.

Life expectancy versus number of cycles Batteries are the only component of a solar system that should be amortized over a short period and regularly replaced. You can increase the useful lifetime of a battery by reducing the depth of discharge per cycle. Even deep cycle batteries will have an increased battery life if the the number of deep discharge (>30%) cycles is reduced. If you completely discharge the battery every day, you will typically need to change it after less than one year. If you use only 1/3 of the capacity the battery, it can last more than 3 years. It can be cheaper to buy a battery with 3 times the capacity than to change the battery every year.

II. SYSTEM OVERVIEW

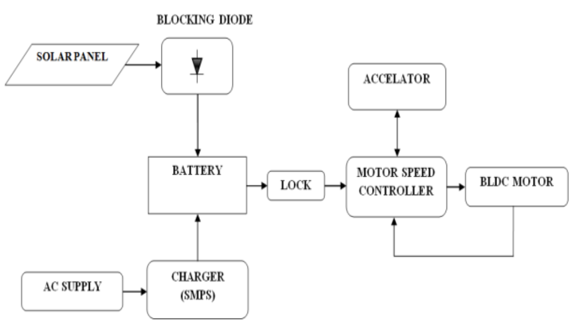

Fig 2.1 System Overview

We first time research on 'Solar Powered four wheeler' was conducted to encourage the use of clean and green energy. The performance of the vehicle is also studied. The fabricated vehicle uses a 500W/ 36V BLDC Hub motor that is powered by six 12 Volt, 25 W PV panels. A six-step motor controller controls the operation of the motor, braking and acceleration system are also associated with the motor controller which aids in the operation of the motor. The performance of the vehicle was found to be satisfactory for the load of three people in 10 degree gradient surfaces with the average speed of 40 km/h. The block diagram of solar vehicle consist of solar panel, blocking diode, battery, SMPS, Accelerator, Motor controller and BLDC Hub motor.

III. WORKING PRINCIPLE OF SOLAR CAR

Photovoltaic (PV) comprises the technology to convert sunlight directly into electricity. The PV panel output goes to blocking diode, the blocking diode allow current only forward direction. The Solar powered vehicle will be a power generating and storing vehicle. It will use solar panels to extract the solar energy through photo voltaic cells. The generated energy will be stored in Lead-acid batteries and these batteries will be paired up in series to increase the capacity and thus the mileage of the Vehicle. The solar-powered Vehicle will include a solar panel, a hub motor, battery storage, charge controller, motor speed controller circuit and a power electronic circuit allowing different switching as well as an access to external AC power which would help the vehicle to charge during the night. To drive and control the BLDC motor, the use of a motor controller was implemented. The motor controller is an essential device for any motor driven device. The motor controller is analogous to the human brain, processing information and feeding it back to the end user. Of course, the applications of a motor controller vary based on the task that it will be performing. One of the simplest applications is a basic switch to supply power to the motor, thus making the motor run.

IV. SOLAR ENERGY PHOTO VOLTAIC CELL

Photovoltaic (PV) comprises the technology to convert sunlight directly into electricity. The term "Photo" means light and "voltaic," electricity. A photovoltaic (PV) cell, also known as "Solar Cell," is a semiconductor device that generates electricity when light falls on it. As it silently generates electricity, PV produces no air pollution or hazardous waste. Doesn't require liquid or gaseous fuels to be transported or combusted. And because sunlight is free and abundant, PV systems, especially base load

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Space Solar Power, may eliminate uncertainties surrounding oil, gas, or other energy fuel supplies from politically unstable regions. Because PV systems burn no fuel and have no moving parts, they are clean and silent, producing no atmospheric emissions or greenhouse gases to cause detrimental effects on our water, air, and soil. Compared with electricity generated from fossil fuels, each PV-produced kilowatt eliminates up to 830 pounds of nitrogen oxides, 1,500 pounds of sulfur dioxide, and 217,000 pounds of carbon dioxide, every year, according to National Renewable Energy Laboratory (NREL) research.

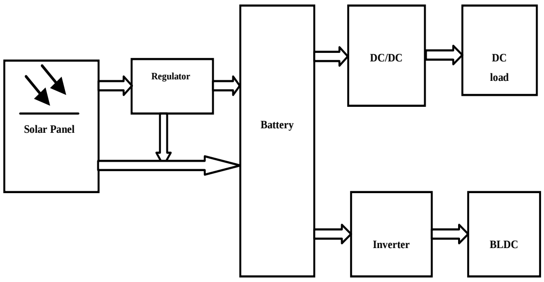

Fig 4.1 Block Diagram of Solar Energy

a) Arrangement of PV Cell

When sunlight strikes a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons then move through the cell, creating and filling in holes in the cell. It is this movement of electrons and holes that generates electricity. The physical process in which a PV cell converts sunlight into electricity is known as the photovoltaic effect.

One single PV cell produces up to 2 watts of power, too small even for powering pocket calculators or wristwatches. To increase power output, many PV cells are connected together to form modules, which are further assembled into larger units called arrays.

b) Solar Panel

An individual solar panel is made of many solar cells. The cells are electrically connected to provide a particular value of current and voltage. The individual cells are properly encapsulated to provide isolation and protection from humidity and corrosion. There are different types of modules available on the market, depending on the power demands of your application. The most common modules are composed of 32 or 36 solar cells of crystalline silicon. These cells are all of equal size, wired in series, and encapsulated between glass and plastic material, using a polymer resin (EVA) as a thermal insulator. The surface area of the module is typically between 0.1 and 0.5 m^2. Solar panels usually have two electrical contacts, one positive and one negative. Some panels also include extra contacts to allow the installation of bypass diodes across individual cells. Bypass diodes protect the panel against a phenomenon known as "hot-spots". A hot-spot occurs when some of the cells are in shadow while the rest of the panel is in full

Fig 4.1 Solar Panel

Sun. Rather than producing energy, shaded cells behave as a load that dissipates energy. In this situation, shaded cells can see a significant increase in temperature (about 85 to100ºC.) Bypass diodes will prevent hot-spots on shaded cells, but reduce the maximum voltage of the panel. They should only be used when shading is unavoidable. It is a much better solution to expose the entire panel to full sun whenever possible.

c) Solar Array System

A solar panel array is a collection of solar panels that are electrically interconnected and installed on some type of support structure. Using a solar panel array allows you to generate greater voltage and current than is possible with a single solar panel. The panels are interconnected in such a way that the voltage generated is close to (but greater than) the level of voltage of the batteries, and that the current generated is sufficient to feed the equipment and to charge the batteries.

Solar Panels are connected series because, increases the generated voltages/Solar Panels are connected parallel because, increase the current. The number of panels used should be increased until the amount of power generated slightly exceeds the demands of your load. It is very important that all of the panels in your array are as identical as possible. In an array, you should use panels of the same brand

and characteristics because any difference in their operating conditions will have a big impact on the health and performance of your system. Even panels that have identical performance ratings will usually display some variance in their characteristics due to manufacturing processes. The actual operating characteristics of two panels from the same manufacturer can vary by as much as ±10%.Whenever possible, it is a good idea to test the real-world performance of individual panels to verify their operating characteristics before assembling them into an array.

d) Number of Panels

By combining solar panels in series and parallel, we can obtain the desired voltage and current. When panels are connected in series, the total voltage is equal to the sum of the individual voltages of each module, while the current remains unchanged. When connecting panels in parallel, the currents are summed together while the voltage remains unchanged. It is very important, to use panels of nearly identical characteristics when building an array.

We should try to acquire panels with V_{Pmax} a bit bigger than the nominal voltage of the system (12, 24 or 48 V). Remember that you need to provide few volts more than the nominal voltage of the battery in order to charge it. If it is not possible to find a single panel that satisfies your requirements, you need to connect several panels in series to reach your desired voltage. The number of panels in series N_{ps} is equal to the nominal voltage of the system divided by the voltage of a single panel, rounded up to the nearest integer.

$$N_{ps} = V_N / V_{Pmax} \quad \text{(2)}$$

In order to calculate the number of panels in parallel (N_{PP}), you need to divide the I_{pmax} by the current of a single panel at the point of maximum power I_{Pmax}, rounded up to the nearest integer.

$$N_{pp} = I_{pmax} / I_{pmax} \quad \text{(3)}$$

The total number of panels is the result of multiplying the number of panels in series (to set the voltage) by the number of panels in parallel (to set the current).

$$N_{TOTAL} = N_{ps} \times N_{pp} \quad \text{(4)}$$

V. CONSTRUCTION OF POWER DIODES

As mention in the introduction Power Diodes of largest power rating are required to conduct several kilo amps of current in the forward direction with very little power loss while blocking several kilo volts in the reverse direction. Large blocking voltage requires wide depletion layer in order to restrict the maximum electric field strength below the “impact ionization” level. Space charge density in the depletion layer should also be low in order to yield a wide depletion layer for a given maximum Electric fields strength. These two requirements will be satisfied in a lightly doped p-n junction diode of sufficient width to accommodate the required depletion layer. Such a construction, however, will result in a device with high resistively in the forward direction. Consequently, the power loss at the required rated current will be unacceptably high.

Fig 5.1 Power Diode

VI. BATTERY

The battery stores the energy produced by the panels that is not immediately consumed by the load. This stored energy can then be used during periods of low solar irradiation. The battery component is also sometimes called the accumulator. Batteries store electricity in the form of chemical energy. The most common type of batteries used in solar applications are maintenance-free lead-acid batteries, also called recombinant or VRLA (valve regulated lead acid) batteries.

Fig 6.1 Battery

Lead-acid batteries also serve two important functions: They are able to provide an instantaneous power superior to what the array of panels can generate. This instantaneous power is needed to start some appliances, such as the motor of a refrigerator or a pump.

They determine the operating voltage of your installation. For a small power installation and where space constraints are important, other type of batteries (such as NiCd, NiMh, or Li-ion) can be used. These types of batteries need a specialized charger/regulator and cannot directly replace lead-acid batteries.

VII. BLDC MOTOR

Brushless Direct Current (BLDC) motors are one of the motor types rapidly gaining popularity. BLDC motors are used in industries such as Appliances, Automotive, Aerospace, Consumer, Medical, Industrial Automation Equipment and Instrumentation.

As the name implies, BLDC motors do not use brushes for commutation; instead, they are electronically commutated. BLDC motors have many advantages over brushed DC motors and induction motors. A few of these are:

- Better speed versus torque characteristics
- High dynamic response
- High efficiency
- Long operating life
- Noiseless operation
- Higher speed ranges

In addition, the ratio of torque delivered to the size of the motor is higher, making it useful in applications where space and weight are critical factors. In this application note, we will discuss in detail the construction, working principle, characteristics and typical applications of BLDC motors.

BLDC motors are a type of synchronous motor. This means the magnetic field generated by the stator and the magnetic field generated by the rotor rotates at the same frequency. BLDC motors do not experience the "slip" that is normally seen in induction motors.

Fig 7.1 BLDC Hub Motor

BLDC motors come in single-phase, 2-phase and 3-phase configurations. Corresponding to its type, the stator has the same number of windings. Out of these, 3-phase motors are the most popular and widely used. This application note focuses on 3-phase motors.

VIII. SWITCHED MODE POWER SUPPLY

The linear power supply contains a mains transformer and a dissipative series regulator. This means the supply has extremely large and heavy 50/60 Hz transformers, and also very poor power conversion efficiencies, both serious drawbacks. Typical efficiencies of 30% are standard for a linear. This compares with efficiencies of between 70 and 80%, currently available using SMPS designs. Furthermore, by employing high switching frequencies, the sizes of the power transformer and associated filtering components in the SMPS are dramatically reduced in comparison to the linear. For example, an SMPS operating at 20 kHz produces a 4 times reduction in component size, and this increases to about 8 times at 100 kHz and above. This means an SMPS design can produce very compact and lightweight supplies. This is now an essential requirement for the majority of electronic systems. The supply must slot into an ever shrinking space left for it by electronic system designers.

An SMPS is based on DC chopper with a rectified and possibly transformed output. By operating the on/off switch vary rapidly, AC ripple frequency rises which can be easily filtered by L and C filter. This filter size also reduces. Due to this, SMPS is very popular in all applications.

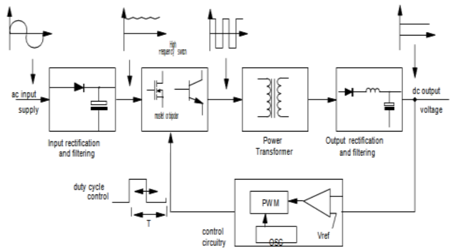

Fig 8.1 Basic Switched Mode Power Supply Block Diagram.

IX. MOTOR CONTROLLER

To drive and control the BLDC motor, the use of a motor controller was implemented. The motor controller is an essential device for any motor driven device. The motor controller is analogous to the human brain, processing information and feeding it back to the end user. Of course, the applications of a motor controller vary based on the task that it will be performing. One of the simplest applications is a basic switch to supply power to the motor, thus making the motor run. As one utilizes more features in the motor, the complexity of the motor controller increases. To drive the BLDC motor, the motor controller sends rectangular/trapezoidal voltage stokes that are coupled with the position of the rotor. Figure 9.1 shows the timing diagram of the voltage stokes applied with respect to the rotor position dictated by the Hall Effect sensor.

The voltage stokes of the BLDC motor need to be applied to the two phases of the 3-phase winding system so that the angle between the stator, flux and the rotor flux is kept close to 90 degrees in order to generate maximum torque from the motor. In order to do that, the motor controller is used to electronically control when the voltage strokes are applied.

The power stage of the BLDC motor uses six transistors in order to switch on and off the signals that are being delivered to each individual phase of the motor. Any timing offset will ruin the timing of the voltage strokes, thus running the motor less than the maximum efficiency. Figure 9.1 below shows the six transistors as well as the other circuitry in the motor controller.

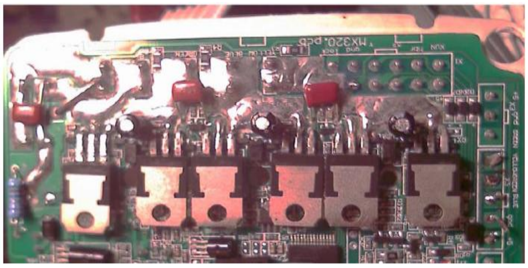

Fig 9.1 Inside view of the Motor Controller

The overall system of a BLDC with the motor controller is represented in Figure 9.2 the inputs to the controller include the speed and current signals that are supplied by the throttle. The DC power supply feeds power to the motor controller, which then distributes the voltage and current necessary to drive the BLDC motor. The Hall Effect sensors provide the feedback needed for the motor to know the position of the rotor and to tell it when to supply the voltage stoke to the different phases of the BLDC motor.

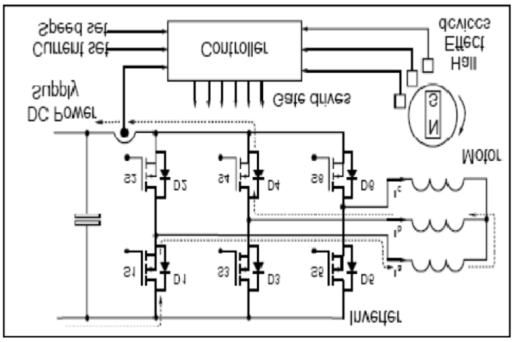

Fig 9.2 Overall Systems of the BLDC Motor and Motor Controller

The simple motor-drive model of a BLDC motor-header consists of a three-phase power stage plus a brushless DC motor as shown in Fig 9.3 The power for the system is provided by a voltage source (Ud). Six semiconductor switches (SA/B/C t/b) allow the rectangular voltage waveforms to be applied. The semiconductor switches and diodes are simulated as ideal devices. The trapezoidal control of the BLDC motor is based on energizing only two phases at a time. This means that one top and one bottom semiconductor switch are turned on, each in a different phase. Thus the last phase has both top and bottom switches switched off and is disconnected from the voltage source. Considering all possibilities, it will provide six possible combinations to energize two phases in the three-phase system. Therefore this technique is also called a six-step control. The most common way to control a BLDC motor is to use hall sensors to determine the rotor position. The control system senses the rotor position and the proper voltage pattern are applied to the motor.

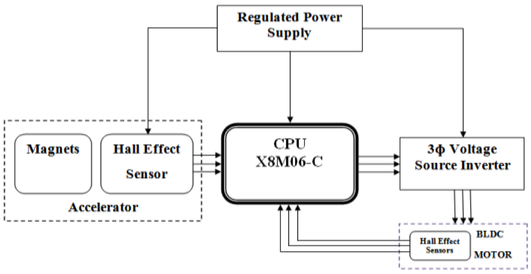

Fig 9.3 Block Diagram of Motor Controller

A DC power supply which maintains a constant output voltage irrespective of the changing AC main supply or varying load is known as a regulated DC power supply. In other words, an ideal regulated power supply is an electronic circuit designed to provide predetermined DC voltage as output, which is independent of the current drawn by the load, any variations in the input AC line voltage, and any changes in the temperature of its different parts etc the basic power supply for a regulated power is the linear power supply.

X. HARDWARE RESULTS

Fig 10.1 Solar Panel Assembly

Fig 10.2 Structure of Solar Power Vehicle

CONCLUSION

The environmental pollution is destroying the earth's beauty as each day progress. It has been a high time to go Green and save our earth. On behalf of an eco-friendly project of "GREEN ENVIRO SOLAR POWER CAR", we are proud to be a part in saving our world from pollution and energy crisis. In our project we use 36V, 500W BLDC motor which is energized by 36V, 150W solar PV panel through series connected 12V-20AH batteries. The components & parts used for completion of this project is non-pollutive and reusable. We have used high life time PV panel, lead-acid battery & the Galvanized Iron (GI) for robust construction. The implemented real time based solar vehicle gives the simple in operation and free from all types of pollution. The performance of the vehicle was found to be satisfactory for the load of three people in 10 degree gradient surfaces with the average speed of 40 km/h. In this project the implementation of solar vehicle gives good efficiency, better performance, simple and robust in construction and also without pollution which will make the world green and clean. However, it still needs modifications and improvements for make it challengeable with competitors. In our project the implementation of solar vehicle gives good efficiency, better performance, simple and robust in construction and also without pollution which will make the world green and clean.

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