Design of Solar/Electric Powered Hybrid Vehicle (SEPHV) System with Charge Pattern Optimization for Energy Cost

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Abstract: **This paper proposes a Solar Electric Powered Hybrid Vehicle (SEPHV) system which solves the major problems of fuel and pollution. An electric vehicle usually uses a battery which has been charged by external electrical power supply. All recent electric vehicles present a drive on AC power supplied motor. An inverter set is required to be connected with the battery through which AC power is converted to DC power. During this conversion many losses take place and also the maintenance cost of the AC System is very high. The proposed topology has the most feasible solar/electric power generation system mounted on the vehicle to charge the battery during all durations. With a view of providing ignited us to develop this "Solar/Electric Powered Hybrid Vehicle" [SEPHV].This multi charging vehicle can charge itself from both solar and electric power. The vehicle is altered out of a Maruti Omni vehicle by replacing its engine with a 1.2HP, 24V Permanent Magnet DC [PMDC] Motor. The Supply to the motor is obtained from a battery set of 12V, 150AH. The household electric supply of 230V is reduced with a step-down transformer to 48V and then it is converted to the DC with a rectifying unit to charge the battery. Two solar panels each with a rating of 230watts are attached to the top of the Vehicle to grab the solar energy and is controlled with a help of charge controller. The SEPHV can be driven by 1.2 HP PMDC motor consisting of two 230 watts PV panel in the voltage rating of 24 V.**

***KEYWORDS*- Solar module, Batteries, PMDC motor, Charge Controller, Step-down Transformer Diode Rectifier.**

I INTRODUCTION

The fossil fuel such as petrol and diesel are very expensive way to be extracted and used. The use of fossil fuel based vehicles is one of the major reasons that has accelerated the extraction of these non-renewable resources in an unsustainable way. Further, transportation of these fuel to rural areas itself has become a problem. The major problem is green house effect caused due to this burning of fossil fuel where large amount of CO_2 will be emitted which causes lots of problem. Solar vehicles depend on PV cells to convert sunlight into electricity to drive the PMDC motors. Unlike solar thermal energy which converts solar energy to heat, PV cells directly convert sunlight into electricity. According to recent surveys the fossil fuels are depleting at a fast rate where in and around 50 years the whole fossil fuel in the world must be completely depleted. Therefore it is the need of the time to make a new exploration of natural resources of energy and power among the natural resources available sunlight is the most promising one. Sunlight is considered to be a source of energy which is implemented in various day to day applications.

Solar/Electric Powered Hybrid Vehicle (SEPHV) can charge itself from both solar and electric power. The vehicle is altered out of a 'Maruti Omni' by replacing its engine with a 1.2HP, 24V Permanent Magnet DC [PMDC] motor. The electric supply to the motor is obtained from a battery set of 12v, 150AH. Two solar panels each with a rating of 230Watts are attached to the top of the vehicle to grab the solar energy and then it is controlled with the help of charge controller. This is used as a main source of energy to charge the battery. The household electric supply of 230V is reduced with a step down transformer to 24V and then it is converted it to DC with a rectifying unit to charge the battery. This is used as a backup source or auxiliary of energy to charge the battery. The Vehicle can be controlled and can matchup a speed of 45km/hr. The PV/Electric Powered Hybrid Vehicle [SEPHV] is thus a boom to the present world by providing us with fuel free mode of transport.

II SYSTEM CONFIGURATION AND OVERVIEW

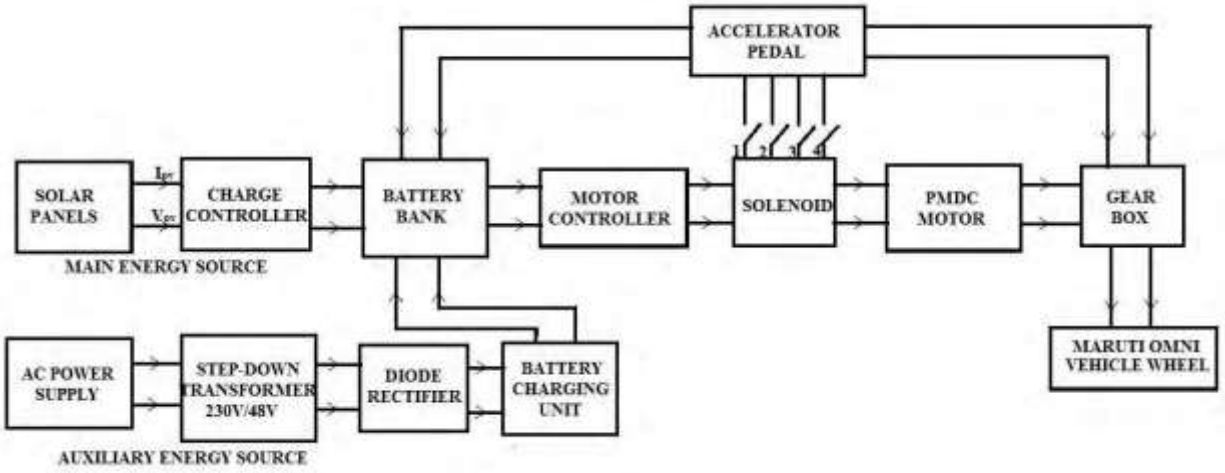

Fig.1. Overall View of the SEPHV

The Fig.1 represents an overall view of the Solar/Electric Powered Hybrid Vehicle (SEPHV) sun is the main source of energy for the vehicle and electric power supply is the auxiliary source of energy for the vehicle.

In this paper the configuration of the Solar/Electric Powered Hybrid Vehicle (SEPHV) system are composed by solar panels, charge controller, battery bank, PMDC motor, step down transformer, battery charging unit and altered 'Maruti Omni' vehicle. Hybrid vehicle carries the energy from the both the solar and normal ac supply. The output power from the solar panel is varied depending up on the light irradiation on the atmosphere conditions. Discrete power from the solar panel is connected to the charge controller circuit and fed to the battery bank circuit. At the same time the continuous power from the ac supply is connected to the step-down transformer (230V/48V) and battery charging unit to battery bank. The electric energy thus formed is being fed to the battery bank. The Vehicle combines the use of electric energy from the three different sources.

1) Photovoltaic solar energy
2) Rectified power supply
3) Batteries

The Solar cell collects a portion of Sun's energy and stores it in the batteries. Before that the charge controller convert the energy collected from the solar array to the proper system voltage. So, that the batteries and the motor can use it. Once the energy is utilized by the motor and the battery, an additional charging unit is implemented on the SEPHV to drive.

The additional charging unit is a rectifying unit of which will step down the 230V of normal electric AC Supply to 48V using a step-down Transformer and rectify it to DC supply to charge the batteries. The rotor shaft of the motor is directly coupled through the solenoid control a gear system. Solenoid control acts as a speed control switch. A Switch is designed with a 4 tapping, giving different values of resistance at each tapping, hence limiting the current that flows in the motor. The performance of the vehicle was found satisfactory for the load of four people with an average speed of 45km/hr.

The block diagram represents the overall representation of SEPHV. We altered a Maruti Omni Vehicle into Solar/Electric Powered Hybrid Vehicle (SEPHV) by first replacing its engine with a Permanent Magnet DC Motor [PMDC]. The Motor is made to run from a battery set which is charged from two methods. In the first method a series of Solar Panels are kept at the top of the SEPHV which produces a DC Voltage from the availability of solar radiation. The amount of DC Voltage developed is controlled using a charge controller.

III PMDC MOTOR AND CHARACTERISTIC

The stator is the fixed part of the motor, in which the rotor turns. The stator consists of a pair of permanent magnets aligned so that poles of opposite polarities forces each other. Thus one magnet has its North (N) pole close to the armature, while the other magnet has its South(S) pole close to the armature. Therefore, lines of magnetic field pass from one permanent magnet to other through the metallic armature. The rotor is the rotating part of the motor. It consists of a wire loop mounted on a rotary metallic armature [5]. The ends of the wire loop are connected to terminals located on the stator of the motor, via a commutator and a pair of brushes. The commutator has two segments isolated from one another.

The permanent magnet dc motor having four brushes, but in this paper we have added additional four brushes. For the increasing the efficiency of the running time of the vehicle. The brush Permanent Magnet DC motors have four general characteristics.

1) Desirable torque versus speed
2) Simple control of torque and speed
3) High electromagnetic power supply
4) Inverter set are not required.

Forward connection:

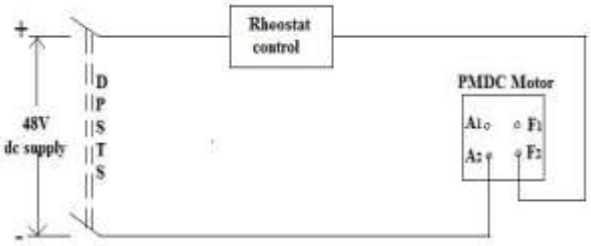

Fig.2. Circuit diagram for the movement of the vehicle – Forward Connection Connection

Reverse Connection:

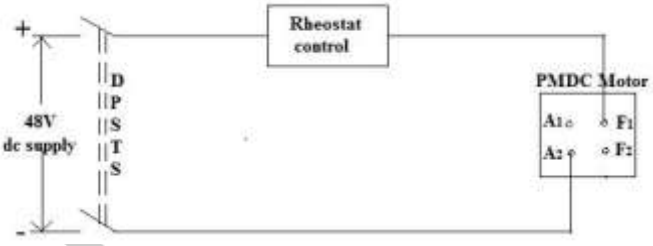

Fig.3. Circuit diagram for the movement of the vehicle - Reverse

The Fig.2.& Fig.3. Shown below represents the connections of the motor for forward and backward direction motions. There are four terminals on the motor, namely A_1, A_2, F_1, F_2 as A_1, A_2 are the armature terminals and they are internally shorted. All the connections are made keeping the DPDT switch at the centre. The either connections on DPDT switch are made for forward direction motion of motor and the next side of DPDT switch is made for reverse direction of the motor. The A_2 is directly taken from battery to the positive side of DPDT switch and F_2 is taken via controller unit to the negative terminal of the switch. For the DPDT the centre terminals are given the upper side as positive from the battery and lower as the negative from the battery. Now the A_1, A_2 are the internally shorted terminals of the motor. Thus either of the one is the main and another one is the dummy. In case of our motor the A_1 terminal is dummy and A_2 is the main terminal. Thus all connections are made keeping A_2 as the main terminal. In the switch the A_2 and F_1 are the terminals that are responsible for the reverse motion of motor. All are connected directly to the switch, A_2 is connected to the positive and F_1 is connected to the negative of the switch.

IV Design Procedure of Solar/Electric Powered Hybrid Vehicle (SEPHV)

Design of the proposed SEPHV system involves the design of the altered PMDC motor and altered Maruti Omni vehicle.

a) Solar panel specifications

Solar cells are solid state semiconductor devices which convert light energy directly into electrical energy. A solar cell contains a low voltage typically about 0.45 volts per cell; cells are connected in series to increase voltage. The model of solar cell can be categorized as P-N semiconductor junction, when exposed to light, the DC current is generated. The generated current depends on the solar irradiance, temperature and load current. The typical equivalent circuit of PV cell is shown in Fig.5. The energy produced by solar panel obtained from two types of energy contribution as shown in equation 1 and equation 2.

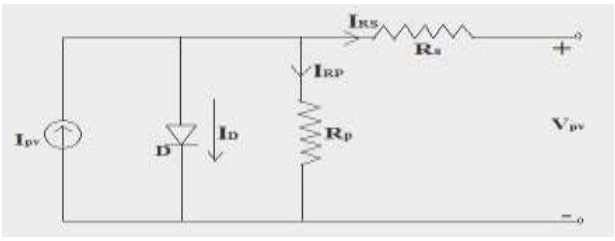

Fig.4. Equivalent Circuit of PV Cell

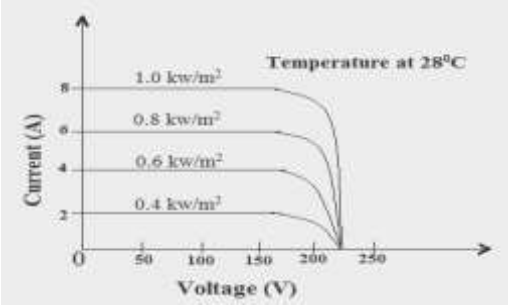

Fig.5. V-I Curve of the 230 watts Solar Module

b) Charge controller and battery specifications

Charge controller limits the rate at which electric current is added to or drawn from the electric batteries. The prime purpose of using the charge controller is to prevent against overcharging and deep charging of a battery. In the SEPHV design we will be taking a depth of discharge to be 85%.Temperature correction is needed because at low temperature battery efficiency decreases. Charge controller consists of a circuitry that controls the DOD of the battery. The DOD and the battery life have inverse relationship. The battery that is discharged more has lesser life than that which is discharged less. The charge controller prevents the battery to be overcharged (or) over discharged.

c) Integration setup observations of SEPHV

The Complete integrated setup consists of the solar panel, solar charge controller, batteries, step down transformer, charging circuit, PMDC motor and altered Maruti Omni vehicle. The complete integration setup of solar/electric powered hybrid vehicle is shown as in Fig.6.

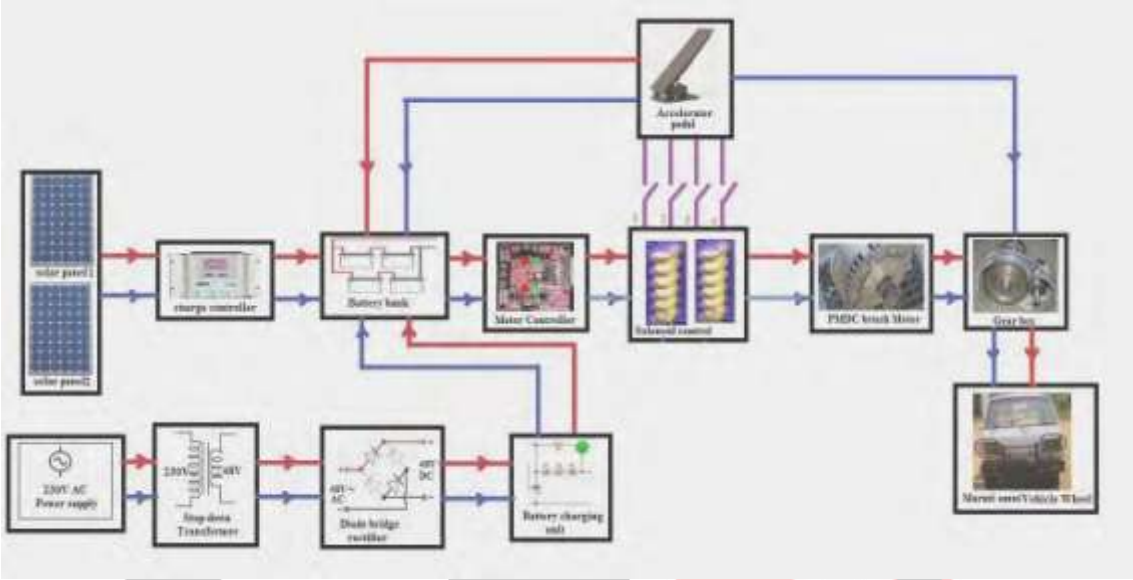

Fig.8. Integration setup of SEPHV

V CONCLUSION

The Solar/Electric Powered Hybrid Vehicle (SEPHV) solves many problems related to the environment and is the best pollution free method. Solar vehicles do have some disadvantages like small speed range, continuous running depending upon the climatic conditions. But these disadvantages can be easily overcome by SEPHV. This multi charging vehicle can charge itself from both solar and electric power. During sunless condition, the household electric supply of 230V is reduced with a step-down transformer to 48V and then it is converted it to DC with a rectifying unit to charge the battery. This is the back-up source of energy to charge the battery. The batteries are directly connected to the motor through a Solenoid control circuit. The Solenoids are acting as the speed control switch. Initially, First accelerator contact is pressed, solenoid-I activates and single battery is connected to the motor. When the second accelerator contact is pressed, solenoid-II activates and the two set of batteries are connected to the motor. When the third accelerator contact is pressed, solenoid-III activates and the three set of batteries are connected to the motor. When the fourth accelerator contact is pressed, solenoid-IV activates and the four set of batteries are connected to the motor. In this method it acts as a voltage control method. The SEPHV has been satisfactorily completed the prototype that vehicle can run in normal surface with a total weight of 730kg. When the battery of the vehicle is fully charged it can run continuously at an average speed of 45km/h. If the price is compared to petrol driven Omni Vehicle, the cost per KM travelled will be Rs. 3.90. Here the distance covered by the SEPHV in a single day is 45 KM when the batteries are fully charged, then cost per KM travelled in a single day for 45 KM will be 50 paisa per KM. A good feature of the proposed configuration is making a Solar/Electric Powered Hybrid Vehicle (SEPHV) prototype as our research work and the Maruti Omni vehicle is running successfully on solar /electric power. The efficiency and running time of the Solar/Electric Powered Hybrid Vehicle [SEPHV] was verified by experimental results.

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