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Implementation of Solar based Electric Vehicle

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***Abstract*: -- The renewable energy is vital for today's world as in near future the non renewable sources that we are using are going to get exhausted. The solar vehicle is a step in saving these non renewable sources of energy. This paper discusses about the application of solar energy to power up the vehicle .The basic principle of solar based electric vehicle is to use energy that is stored in a battery during and after charging it from a solar panel. The charged batteries are used to drive the motor which serves here as an engine and moves the vehicle in reverse or forward direction. The Photo Voltaic (PV) Module may be connected either in parallel or series, but it's costlier. Thus to make it cost effective; power converters and batteries are been used. The electrical charge is consolidated from the PV panel and directed to the output terminals to produce low voltage (Direct Current). The charge controllers direct this power acquired from the solar panel to the batteries. According to the state of the battery, the charging is done, so as to avoid overcharging and deep discharge. The voltage is then boosted up using the boost DC-DC power converter, and then an inverter through which DC power is converted to AC power ultimately running the BLDC motor which is used as the drive motor for our vehicle application. This paper focuses on the design, simulation and implementation of the various components namely: solar panel, charge controller, battery, DC-DC boost converter, DC-AC power converter (Inverter circuit) and BLDC motor required for the vehicle application. All these components are studied in real time and also modeled individually using MATLAB/SIMULINK and the complete hardware integration of the system is tested to meet up the application's requirement.**

***Index Terms* — Photo Voltaic, Brushless DC motor, Field Programmable Gate Array, Active Neutral Point Clamped Multilevel Inverter**

I. INTRODUCTION

The major motivation and benefit from Wireless LANs is This paper discusses about the usage of solar energy to power up the vehicle. In order to achieve the required voltage, the Photo Voltaic (PV) Module may be connected either in parallel or series, but its costlier. Thus to make it cost effective, power converters and batteries are used. The electrical charge is consolidated from the PV panel and directed to the output terminals to produce low voltage (Direct Current)[1-3]. The charge controllers direct this power acquired from the solar panel to the batteries. According to the state of the battery, the charging is done, so as to avoid overcharging and deep discharge. The voltage is then fed to the motor controller, which ultimately runs the BLDC motor for vehicle application. The characteristic features of the components: solar panel, charge controller, battery and BLDC motor required for the vehicle application were studied in real time and also modeled separately and the hardware integration of the system is tested to verify the simulation results.

This project focuses on a novel multilevel inverter proposed for BLDC drive. Multilevel inverters have drawn tremendous interest in the electrical drive applications. It is easier to produce a high power inverter with the multilevel structure because of the way in which device voltages stresses are controlled[4-6]. Three-phase BLDC motors are mostly preferred for electric vehicles as it provides high efficiency, low maintenance, long life, low weight and compact construction . In conventional DC motors with brushes, field winding is on the stator and armature winding is on the rotor. The DC motor is relatively more expensive and needs maintenance due to the brushes and commutator surface wear. This could be solved by replacing the mechanical switching components I_e commutator and brushes by power electronic switches. BLDC motor has a rotor and stator, which is connected to a power electronic switching circuit.[7-10] This project presents the implementation of sensored control of three-phase active neutral point clamped multilevel inverter with brushless DC motor using FPGA. The commutation is implemented using FPGA and it receives hall sensor output from BLDC motor (3KW) and generates the gate pulses which drive the IGBT switches of the three-phase active neutral point clamped multilevel inverter. A model of the ANPCMLI with BLDC drive is simulated in MATLAB and the sensored control is implemented on a FPGA platform. The simulation results are verified experimentally.

DESCRIPTION OF PROBLEM:

The concerns about the petrol reserves and prices as well as pollution issues have increased the interest on electric vehicles. Both the government and private sector have concentrated on the design of electric vehicle powered by renewable energy. The renewable energy is vital for today's world as in near future the non renewable sources that we are using are going to get exhausted. This project focuses on the usage of solar energy to power up the vehicle .In order to achieve the required voltage, the Photo Voltaic (PV) Module may be connected either in parallel or series, but it's costlier[11-13]. Thus to make it cost effective; power converters and batteries are used. The electrical charge is

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consolidated from the PV panel and directed to the output terminals to produce low voltage (Direct Current). The charge controllers direct this power acquired from the solar panel to the batteries. According to the state of the battery, the charging is done, so as to avoid overcharging and deep discharge. The voltage is then boosted up using the boost power converter, ultimately running the BLDC motor which is used as the drive motor for our vehicle application[14-19]. In the course work, the characteristic features of the components; solar panel, charge controller, battery, power converter and BLDC motor required for the vehicle application will be studied in real time and also modeled individually using MATLAB/SIMULINK and the complete hardware integration of the system will be tested to meet up the application's requirement.

II. REVIEW OF LITERATURE

Researchers from Istanbul University, Turkey have presented the design and application of a hub drive system for hybrid electric vehicle and all electric vehicles. Initially, the MATLAB model of a hub driven hybrid electric vehicle is developed and the performance values are calculated. Two 15kW BLDC are designed and manufactured to be located inside the rim of the wheels. The performance tests of these wheels are conducted in laboratory environment. ACAN bus communication is established between the control system of electric drive and electronic control unit of the vehicle. The concerted action between electrically driven rear wheels and ICE driven front axle is achieved. Finally, some preliminary road tests are executed and encouraging test results are obtained.

A.Tashakori from Swinburne University of Technology, Melbourne, Australia the sensor less commutation technique of brushless DC motor based on zero crossing detection for electric vehicle application has been optimized and improved. In this method only the line voltage of one phase of BLDC motor has been measured instead of voltage of all three phases, causing a remarkable reduction in cost, sensing circuit components and wiring of the BLDC motor drive.

PWM switching technique has been implemented to control speed of BLDC motor. Stability of PWM digital speed controller has been investigated through Lyapunov stability criterion. A new condition has been derived to check stability of BLDC motor drive. Simplicity, low noise, low cost and ease of implementation of proposed technique along with speed control of BLDC motor in a single microcontroller or digital signal processor makes it suitable for the drive train of high performance electric vehicles. Proposed technique has been modeled in Simulink and verified through experiment. Simulation and experimental results are satisfactory and prove correct performance of proposed sensor less drive and PWM speed controller of BLDC motor.

University of Malaysia proposed a drive range improvement for electric vehicle using solar energy. First, power consumption modeling based on Proton Savvy using torque analysis to achieve 45mph vehicle top speed when converted to electric vehicle. Second, for continuous battery charger three solar panel (each panel with 125W) controllers had been developed. Finally, calculation, analysis and various tests are performed based on Savvy technical specifications, energy consumption requirement and vehicle movement using this proposed method.

C. C. CHAN, FELLOW, IEEE provide an overview of the present status of electric and hybrid vehicles worldwide and their state of the art, with emphasis on the engineering philosophy and key technologies. The importance of the integration of technologies of automobile, electric motor drive, electronics, energy storage, and controls and also the importance of the integration of society strength from government, industry, research institutions, electric power utilities, and transportation authorities are addressed. The challenge of EV commercialization is discussed.

H.Fu of Massachusetts Institute of Technology, USA has provided a comprehensive analysis of batteries for electric vehicles. Five key factors including power density, energy density, safety, reliability, and cost are employed for comparing lithium ion batteries.

John Connors of California University has discussed about the hybrid technologies for electric vehicles. The development of a telemetry system for a solar powered car aids in better understanding of the energy usage of a vehicle and the aspects of a electric vehicle as a whole. This paper has surveyed the history and developments in solar powered car.

B.Kennedy form Northern Territory University has outlined the design, construction and testing of a 20kW DC brushless motor controller for use in a light electric vehicle. Specific attention was paid to the layout of the motor controller to ensure high reliability, ease of manufacture and lightweight construction without compromising efficiency. This can be achieved by the correct choice of component packages, a laminated bus bar structure and integration of the control electronics into a 'Eurocard' rack for reliability and ease of servicing

III. MATERIALS AND METHODS

Select a polycrystalline solar panel and model the PV panel in MATLAB to obtain the current voltage relationship. Investigate the different types of battery for the proposed solar car and model the battery to obtain the state of charge characteristics. Design a solar battery charger with a novel

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Vol 3, Issue 11, November 2017

PWM charging which prevents against overcharging and deep discharging of a battery. Design a SPWM inverter (DC-AC Converter) using SiC based power module and analyze the various modulation strategies to get a better spectral quality of the output of the inverter. Model a Brush less DC (BLDC) motor for the proposed electric vehicle and design a digital PWM controller. To develop a 3kW prototype of the proposed solar powered four seated electric vehicle using BLDC drive.

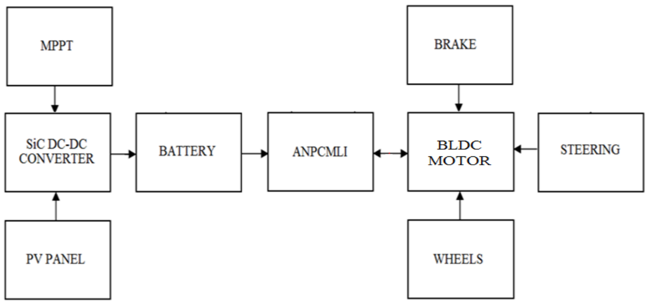

Figure.1: Black diagram of Solar powered Electric Vehicle

The block diagram of solar power electric vehicle system is shown in Figure 1.PV and VI characteristics of solar panel - 250 W is shown in Figure 2.

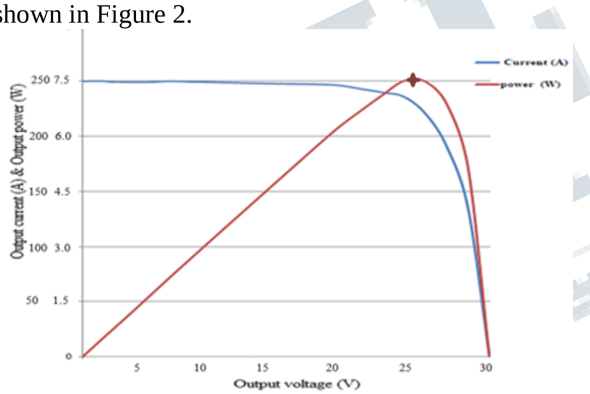

Figure.2:Experimental VI &PV characteristics of solar panel

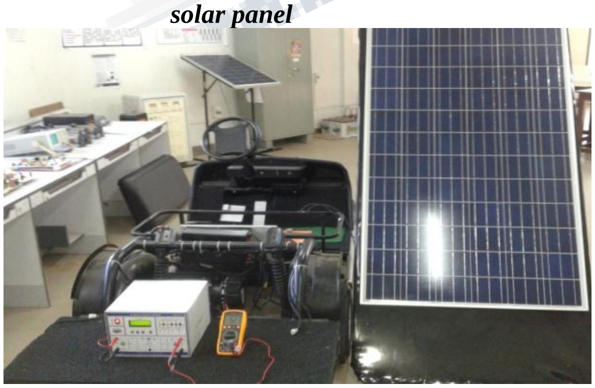

Figure.3: SiC Boost converter & 250 W Solar panel Battery charging setup

A battery charging method of solar power electric vehicle system is shown in Figure 3.BLDC motor for electric vehicle is shown in Figure 4 and Table 1 shows that specification of BLDC motor.

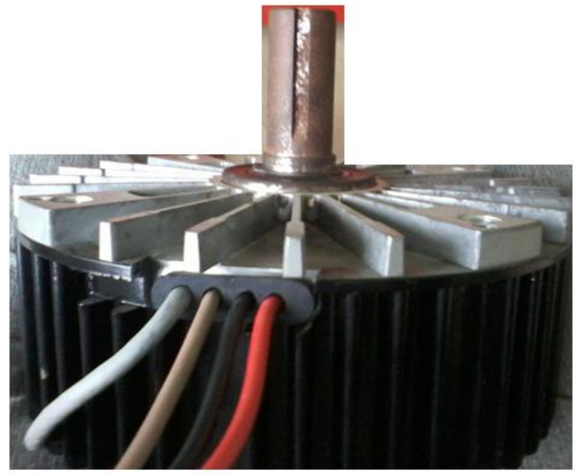

Figure 4:BLDC motor for Electric vehicle

Table 1:Specification of BLDC motor

Type of motor	Three phase BLDC Motor
Stator voltage	48 V
Power rating	4 KW
Speed	3000rpm
No. of poles	16
Degree	60 Discrete degrees

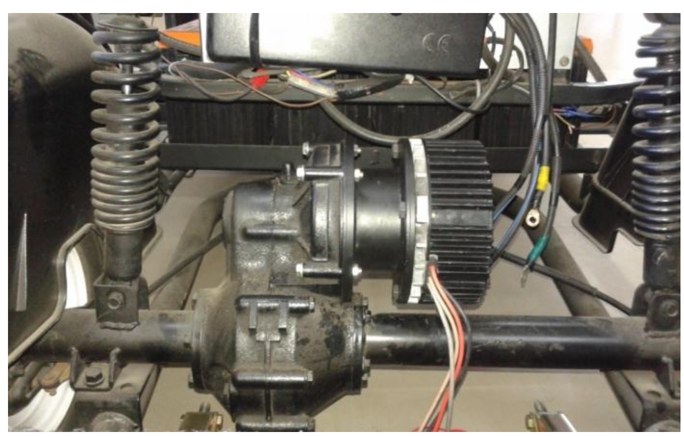

Figure.5:Differential gear and 3KW BLDC coupling setup

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The Differential gear and BLDC motor coupling of solar power electric vehicle system is shown in Figure 5.Overall test setup for electric vehicle is shown in Figure 6.

Figure.6.:Overall Test setup for Solar powered Electric vehicle

Figure.7:Final build up Solar powered Electric vehicle

Table 1:Specification of Electric Vehicle

Passenger Capacity	4
Overall Dimensions (mm)	3350*1220*1900
Range KM(full loading at 50km/h on flat road)	250km
Max Speed (Km/h)	60km
Minimum Turning Radius(m)	3.7m
Max Climbing Ability (loaded)	20%
Charge Time(h)	3-4h
Wheelbase (mm)	2430mm
Thread(F/R)	860/975
System voltage (V)	48V
Motor Power (KW)	4KW/48V
Brake Distance (at 50km/h on flat road)	4.5m

Table 2:Specification of Electric system for Vehicle

Solar Output	*Output parameters :31.5 V, 5.5 A, 250 W*
Solar Controller	*Fuzzy MPPT Controller*
Battery Charger	*Li –ion 48 V, 200 Ah*
Accelerator	*Resistive Type*
Power Converter	*SiC MOSFET DC-DC Boost Converter (32V to 48V)* *DC-AC Converter ANPCMLI*
Motor	*Three Phase BLDC 4KW/48V*
Lighting System	*2 Heaf lights / 2 Turn Signal* *2 Tail lights (1 brake with 1 turn signal)*
Others	*Electric Meter/Horn/Reserving Alarm/FR Switch*

SOCIAL RELEVANCE & USEFULNESS OF THE PROJECT

With the oil price shocks of the past few decades, as well as an increasing awareness of the emissions of air pollutants and greenhouse gases from cars and trucks, the interest to investigate alternative vehicle propulsion systems has grown. With the continuous rapid economic development and the approaching of cars entering families, an increasing possession quantity of mobile vehicles are being achieved rapidly in our country. Electric vehicles (EV) have such prominent advantages as high efficiency, lower energy, low noise, zero emissions, so EV have become the human energy and environmental pressures to solve the most effective way. However, the electric vehicle suffers from relatively short range and long charging times and consequently has not become an acceptable solution to the automotive consumer. In this project, we planned to replace the combustion engine with a motor based operated system and solar cell and its controller. First, select suitable motor and its controller. Second, develop solar panel controller. Choosing suitable motor and controller as in-wheel motor is vital. Different types of electric motors have been used in electric vehicles so far. Brushed DC, induction, switched reluctance and BLDC motors have been compared as in-wheel motors and BLDC motor has been recommended as suitable drive train for high performance electric vehicles. This research will give a first-hand experience to the new and young researchers who are interested in this kind of project. With this opportunity they would be able to expand and sharpen their technical knowledge especially on electrical vehicle (EV) system as well as improving their hands on skill on wide range of electrical works.

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 11, November 2017

IV. CONCLUSION

The importance of making shift in the source of energy which is made cost effective was put forth, and utilization of solar power in vehicle application was implemented. The objective of selecting the appropriate components for the application was studied, and the various components for the same is subjected to various tests which was cross checked with simulation results .The designing of the whole system depends on the application for which it shall be used, and accordingly the components are been chosen starting from the motor to the solar modules. It was observed that according to the application, the motor was chosen first. From the rating of the motor, the battery which could satisfy its starting current and full load current was been selected, and then according to the rating of the battery, the solar charge controllers and the solar modules were selected. Finally the BLDC motor mounted upon the frame realized the prototype of the vehicle which was tested. The proposed solar powered electric vehicle becomes a solution to transportation where automotive traffic overcrowding is severe and can provide a pollution free environment. Maintenance cost is reduced compared to IC engines. Proper battery station for charging the batteries reduces the time compared to filling up petrol/diesel. By the usage of electric vehicles, the economy of the country can be improved by reducing the import of petroleum.

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Dr. R. Seyezhai2, Associate Professor in the Department of Electrical and Electronics Engineering, SSN College of Engineering, India has 15 years of teaching and research experience including 7 years of research experience in Power Electronics and Renewable Energy Systems. She received her B.E. from Manonmaniam Sundaranar University in 1996 and M.E in Power Electronics & Drives from Bharathidasan University in 1998 and Ph.D from Anna University, Chennai. During her Ph.D she developed a prototype of SiC based hybrid cascaded multilevel inverter employing a novel modulation technique for fuel cell Power Conditioning System (PCS). She has published over 70 research publications in referred International Journals and 95 in International and National Conferences. She has completed AICTE research project titled, "Design of silicon carbide based hard switched DC-AC Power Converter", during 2007-2010. She is the recognized supervisor of Anna University, Chennai. She is currently guiding 12 Ph.D scholars working on Multilevel Inverters, Interleaved Boost Converter for Renewable Energy sources, SiC based DC-DC Converter for Photovoltaic applications, Luo Converters, Active power factor correction circuits, Z-source inverter for PV, Hybrid Electric Vehicles and Power converters for Telecommunications. She has received Best paper awards in various conferences, Best teacher award and CTS – SSN Best Faculty Award – 2013 for the outstanding performance. She is a member of IEEE and Life member of ISTE. She is the editorial board member of various referred international journals.
Research Interest:
Dr. R. Seyezhai's research interests include: Multilevel Inverters, Interleaved Boost Converter for Renewable Energy sources, SiC based DC-DC Converter for Photovoltaic applications, Luo Converters, Active power factor correction circuits, Z-source inverter for PV, Hybrid Electric Vehicles and Power converters for Telecommunications.

