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Lead-acid Battery Charging with a Buck-Boost Power Converter for a Solar Powered Battery Management System

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***Abstract*: This article provides an overview of the photo voltaic (PV) system in order to replace the conventional energy sources like coal, nuclear, gas etc. BLDC motor as a load is replaced with the commercial DC motor to achieve better performance which has less maintenance and also less costly . A buck-boost converter is used for converting DC-to-DC and the output voltage magnitude are either greater than or less than the magnitude of the input voltage. A filter design is used to reduce the harmonics and to smoothen the output of the buck-boost converter. An inverter is used to convert boost output dc voltage into an ac voltage. By using MPPT algorithm ms, The Power converters that are operating from solar photovoltaic array are operated in max power extraction mode. Besides MPPT, buffering needs between PV and loads which requires battery storage as well. With respect to daily solar irradiation changes, Hardware implementation is carried out to determine the actual operation of the system. Based on the experimental results it is seen as an energy efficient operation of the BLDC motor drive, compared to the fan that uses single phase AC motor drive, the achievement scheme is simple and cost low.**

***Keywords:* Solar Radiation, Solar PV, BLDC Motor, MPPT, Buck-Boost convertor, Fan.**

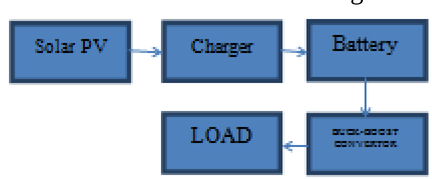
I. INTRODUCTION

The Renewable energy resources that exist over a wide geographical area, whereas in contrast to other energy sources like coal, uranium, Petroleum, which are concentrated in a limited number of countries. The growth of renewable energy is increasing day-by-day and for utilizing the energy from the resources, the government has implemented various renewable energy centers. Power generation from renewable sources in India is in great rise, with the share of renewable energy in the country's total energy mix is rising from 7.8% in FY08 to 12.3% in FY13. Based on Renewable energy policy network for 21st century reports that renewable energy contributing about 19% of our global energy consumption and contributing about 22% to total electricity generation in 2012 and 2013 respectively. In the energy consumption, India is the 4th biggest after China, USA, Russia. India's total consumption is about 3752.48 kWh , per day is 90,059kW and per year is about 3,28,71549 kW. According to Commissioning Status of Grid Connected Solar Power Projects under various schemes, Tamilnadu has a total capacity of 147.98 MW dated on 29/05/2015. Solar PV can be implemented for commercial fan application in Coimbatore (11.0183^{o}N, 76.9725^{o}E). The annual average high and low temperature is about 35^{o}C and 23^{o}C respectively, which has sufficient radiation to produce electricity for commercial fan applications. The Solar Photo Voltaic (SPV) is used to convert radiation of sunlight into electricity and radiation

varies from time to time in between sun rise and sun set. The amount radiation is not constant in a day, but constant DC voltage will be achieved in solar PV by incorporating buck-boost converter.

II. SOLAR PV

The main idea of the article is given as block diagram,



Solar cells plays the major role in the basic components of photovoltaic panels. Mostly they are made from silicon, though the other materials are also used. Solar cells take the great advantage of the photoelectric effect: The ability of some semiconductors is to convert electromagnetic radiation directly into electrical current. The charged particles that are generated by the incident radiation are separated conveniently to create an electric current by an appropriate design based on the structure of the solar cell, as will be explained in brief below. A solar cell, which is basically a p-n junction made from two different layers of silicon doped with a less quantity of impurity atoms- In the case of the n-layer, the atoms with one or more valence electron are called donors, and in the case of p-layer, the atom with one less valence electron is known as acceptors. When the two layers are joined together, the free electrons of the n-layer are diffused in the p-side, leaving behind an area which are positively charged by the donors. Similarly, the free holes that are in the p-layer are diffused in the n-side, leaving behind a region which are negatively charged by acceptors. An electrical field is produced between the two sides which acts as a potential barrier for further flow. The equilibrium is reached in the junction where the electrons and holes cannot exceed that potential barrier and thus consequently they cannot move. The electric field pulls the electrons and holes in the opposite direction so the current flow takes place as an unidirected flow- so, the electrons can move from the p-side to the n-side where as the holes in the opposite direction. A diagram of the p-n junction showing the effect of the mentioned electric field is illustrated in Figure 1.

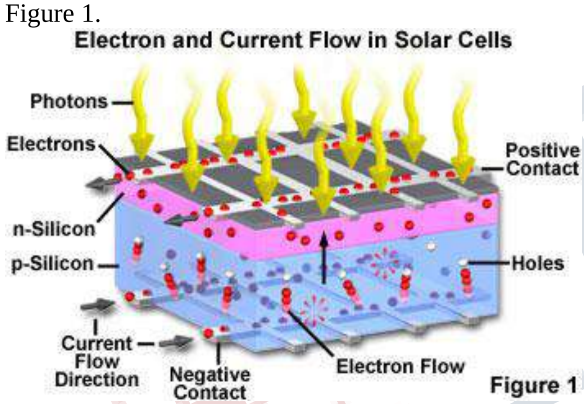


Figure 1: Solar cell

Metallic contacts are added at the both sides of the atom to collect the electrons and holes so the current can flow. In the case of the n-layer, which is facing the high solar irradiance , contacts are several metallic strips, as they must allow the light to pass to the solar cell is called fingers. The photons of the solar radiation directly from the sun would shine on the cell. There are some different cases that can happen: some of the photons(the rays that gets reflected back to the atmosphere) are reflected from the top surface of the cells and metal fingers. Those that are not reflected penetrate in the substrate. Some of them, usually the ones with less energy will pass through the cell without causing any effect. Only those with energy level above the band gap of the silicon has the chance of creating an electron-hole pair. These pairs are generated at both sides of the p-n junction. The minority charges (electrons in the p-side, holes in the n-side) are diffused to the junction and swept away in opposite directions (electrons towards the n-side, holes towards the p-side) by the electric field, generating a current in the cell, which is collected by the metal contacts at both sides. This can be seen in the figure above, Figure 2. This is the light-generated current which depends directly on the irradiation: if it is higher, then it contains more photons with enough energy to create more electron-hole pairs and consequently more current is generated by the solar cell. Photo voltaic's are used for generating electric power by using solar cells to convert energy from the sun radiation. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. Solar cells produce direct current electricity from sun light which can be used to power equipment or to recharge a battery. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photo voltaics include mono crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide.

III. PV ARRAY MODELING

Solar PV cells are made with P-type and N-type semiconductor materials. A solar cell is basically a light-emitting diode which activates when exposed to sunlight and generates the voltage. It contains a current generator shunted by a diode, one series resistor and a shunt resistor. The shunt resistor specifies the leakage currents through the ground and generally the significance of shunt resistor is high, around 1000 ohms. Series resistor specifies the internal resistance of leads which are connected to the solar cell and the significance of series resistance is low around 0.001 ohms. A single solar cell will generate low voltages (typically 0.5V-0.7V), as a result these cells are connected either in series or in parallel to meet our requirement. Number of solar PV modules stacked together to make a solar array. Figure 2 shows the model of Solar PV,

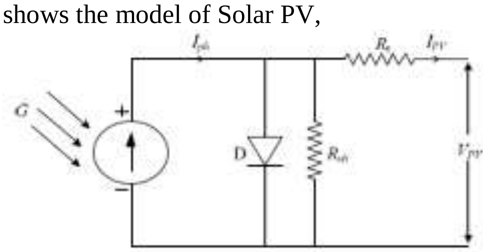


Figure 2. Practical model of solar cell

The PV array is considered to be having two12V, 10Wp PV modules connected in series to provide 24V,20W to operate the motor drive and for experimental study,24V, 20W and 24V, 40W were used and compared

IV.CHARGER

In a solar charging system the major role is played by the charge controller and a system without a charge controller is not possible. The charge controller takes the energy from the solar panels or wind turbine and converts the voltage to a level that is suitable to charge the battery. A charge controller, or charge regulator is basically a voltage and/or current regulator which is to keep the batteries from overcharging. It regulates the voltage and current coming from the solar panels which are fed to the battery through this unit. Most "12 volt" panels put out about 16 to 20 volts, so if there is no regulation then the batteries will be damaged due to overcharging. Most batteries need around 14 to 14.5 volts to get fully charged.

V.BATTEY.

Based on battery renewable energy systems vary greatly in size and design based on the purpose and location of the installation. Unlike many other battery applications, our battery-based renewable energy applications are unique, the batteries in the following systems can be discharged and charged in an unpredictable manner due to variations in the sunshine. They are also subjected to seasonal variations due to the presence of self-resealing pressure valve and this will result in that the batteries are to be operated in a partial state of charge for considerable lengths of time. As a result, these factors can cause the batteries to frequent deep discharges and lack of charge. Consequently, the most important requirement for batteries that are used in renewable energy systems should be long cycle life. **Deep-Cycle Valve-Regulated Lead-Acid Batteries (VRLA) or sealed battery** is the best choice for renewable energy applications, but we also recognized that there are different types which are having strengths and weaknesses which influence their suitability and life.

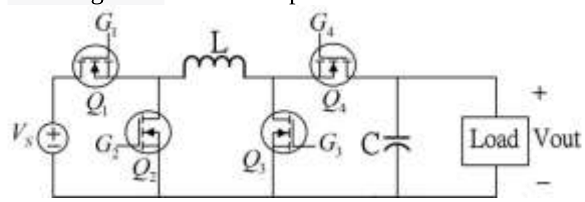
What does deep cycle means ?

Deep cycle refers to the fact that in a solar power system, it is likely that the battery will get charged during a sunny day, then they may become almost fully discharged with use, before they are again fully charged.
It has various advantages like maintenance is low that is no need of periodic adding of chemicals, less expensive than the deep-cycle Gel batteries, wider temperature tolerance range slowest self-discharge rate, best shock/vibration resistance, maintains a constant voltage throughout the discharge cycle.

VI. BUCK-BOOST CONVERTOR

The non-inverting buck-boost converter, is able to convert the source supply voltage to higher and lower voltages to the load terminal, without changing the voltage polarity. Figure 3 shows a diagram of the synchronous buck-boost circuit. Four high speed power MOSFETs (Q1-Q4) are used to control energy flow from the supply to load terminals.

Figure 3.buck-boost power converter



Due to the supply voltage variations, the power converter is operating as buck, buck-boost, or boost modes through proper control of the power MOSFETs. When supply voltage is higher than the desired load voltage, the converter is set to buck operation. In buck mode operation, transistor *Q4* is always on and *Q3* is always off. Buck mode operation is achieved by controlling power switches *Q1* and *Q2* . When transistor *Q1* is closed and *Q2* is open, thus the inductor is charged by the power source. In the inductor charging cycle, the inductor current increases almost linearly and the capacitor supplies output current tothe load. For inductor discharging, transistor *Q2* is closed and transistor *Q1* is open. In this mode, energy stored in the inductor is delivered to the capacitor (charging the capacitor) and the load. Current from the inductor decreases linearly during the inductor discharge period. If the duty cycle for charging the inductor is d , average load voltage *Vout* equals *dVs* for buck operation. Duty cycle $d < 1$,thus, controlling duty cycle d regulates output voltage *Vout* at a voltage less than supplied voltage *Vs* .

When the supply voltage is less than the desired load voltage, the converter is set to boost operation. In boost mode operation, transistor *Q1* is on and *Q2* is off. To charge the inductor, transistor *Q3* is closed and *Q4* is open. The operation of *Q3* and *Q4* are reversed during the inductor discharge cycle. In boost mode, average load voltage *Vout* equals $1/(1 - d)Vs$. Thus, the output voltage can be higher than the input supply voltage. When supply voltage is close to the desired load voltage, the converter isset to buck-boost operation. In this mode, transistors *Q1* and *Q3* work as a group and *Q2* and *Q4* work as another group. To charge the inductor, switches *Q1* and *Q3* are closed and *Q2* and *Q4* are open. Transistors *Q2* and *Q4* are closed and *Q1* and *Q3* are opened to engage the inductor discharge cycle. In this mode, average load voltage *Vout* equals $d/(1 - d)Vs$. This implies that output voltage can be changedto more or less than the supplied voltage.

VII. CONCLUSION

This paper presents an analysis of the Lead-acid battery charging process for a solar powered battery management system. Based on the supply voltage conditions of solar panels, the system operates in buck, buck-boost, or boost modes. Depends on the output voltage from the buck-boost converter , it is given to the applications with the help of an inverter. This paper briefs the importance of the renewable energy sources.

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