ENERGY TRANSFER FROM SOLAR TO VEHICLE AND VEHICLE TO HOME USING BIDIRECTIONAL DC-DC CONVERTER

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Abstract: This paper solves the problem of the requirement of energy. An idea has been portrayed keeping in mind the situations where there might be some issues with renewable energies. Taking into account the application of solar panel, battery and grid the energy transmit from solar to vehicle and vehicle to home using bidirectional converter is being designed. The basic concept of our paper is to transfer the electrical power from vehicle to grid and grid to vehicle with the help of a dc-dc bidirectional converter which is connected to a three-phase inverter in order to meet the grid’s energy. The purpose of the three-phase inverter is to yield the ac source for the home appliances and emergency power use. With the help of the bidirectional dc-dc converter the battery is charged and the energy is stored within the EVs. The path that allows the flow of electric current from scooter to power lines is known as vehicle to grid. Now in case of an emergency situation when solar power is not sufficient to charge the vehicle the path is reversed and power is taken from the grid to recharge the battery and is termed as grid to vehicle. This situation occurs when the inverter output voltage is higher than the voltage in the battery, then the supply is taken from the grid. A bridge rectifier is also there as an additional power supply if needed.

Keywords: Bidirectional DC-DC converter, AC-DC converter, Buck converter, Boost converter.

1. Introduction

Electric vehicles transportation is eventually a mode, but nowadays they are gaining their importance as backup power storage systems. Compared to the internal combustion engine and the gasoline powered vehicle the electric vehicles are considered to be ninety-six percent cleaner. Also one more problem with renewable energy resources is the unwanted weather conditions. The basic concept of this paper is to transmit the electrical power from electric vehicle to house and grid to electric vehicle with the help of a dc-dc bidirectional converter which is connected to a three-phase inverter in order to meet the grid’s energy. The purpose of the three-phase inverter is to submit the ac source for the home appliances and emergency power use. With the help of the bidirectional dc-dc converter the battery is charged and the energy is stored within the EVs. When connections are made with the help of an inverter capable of producing 50Hz ac voltage power is supplied to our homes and workplaces [1]. The path that allows the flow of electric current from scooter to power lines is known as vehicle to grid. Now in case of an emergency situation when solar power is not sufficient to charge the vehicle the path is reversed and power is taken from the grid to recharge the battery and this is how the charging of the battery takes place. The battery plays an important role and proper care must be taken. In order to maintain the battery efficiency proper charging and discharging is required [2] – [3].

Electric vehicle here acts as a storage substance which gets charged and this power is then extracted and supplied to various homes which can be used during peak hours. This transfer of energy does not require any tariff reading and hence the energy acquired produces free electricity [10]. This method causes less pollution and aids towards a sustainable environment. Moreover, as electric vehicles use energy from the grid so the cost for transportation of fuel gets eliminated. The charger and bidirectional converter are provided by wide range of inputs and outputs by the proposed converter in the aspect of flexibility [2]- [10].

2. System Configuration

The system is used to recharge a battery and transfer the energy of around 240V, 50Hz with a three phase inverter. The two main components are the bidirectional de-dc converter and also the three phase inverter. The three phase inverter is used to convert the DC-AC voltage and the DC-DC converter works in both buck and boost mode. It works in boost mode when energy is transferred to our home that is when the battery discharges and in the buck...
mode when the energy is transferred from grid to vehicle where the battery is again charged. The system includes a solar pv panel as the source which charges the battery of the electric vehicle. A three phase inverter is also used to supply the ac voltage to our house and workplaces. A two-way dc-dc converter provides a beneficial connection for the vehicle to home operations and grid to vehicle operations [7]. In order to maintain the maximum efficiency of the battery connected to the bidirectional converter a boost converter is involved. Basically MPPT is used to maximize the voltage when the solar voltage is low. This entire process is known as charging of the battery. The battery can send power to the utility grid [5]. Next comes the motoring and the charging of the USB. The dc-dc bidirectional converter acts as an intermediate for the transmission of power to the battery of the electric vehicle. The buck converter involved in this system minimizes the battery voltage of which is suitable for the USB. The storage bank is charged to 24 volts which drops down to 6 volts and the motoring and USB action is achieved. In this paper a normal permanent magnet dc motor is considered as an electric vehicle which runs at a speed of twenty-two radian per second. A two-way dc-dc converter acts as an intermediate device for the energy transfer. The buck converter used lowers the voltage to around 6V for the USB action.

![Fig.1 Block diagram of system configuration](image)

The maximum voltage of battery is around 24V which gets maximized to around 240V AC and again during the charging of the battery the 240V is reduced to around 24V. For the proper execution of this process the bilateral converter plays an important role. The block diagram is shown in Fig.1. The bidirectional converter works in two modes one is the boost mode when the energy transfer takes place from the battery to the home i.e vehicle to home. In this the charge from the battery is being boost up to 240V to supply the resistive load. The other mode is the buck mode this situation takes place when the inverter output voltage is higher than the stored battery voltage. The reverse process takes place and the voltage is brought down to 24V to keep the battery charged. So during the charging of the battery the converter is in the step-down mode and during discharging it works in the step-up[3]. The SPWM technique is employed to control the semiconductor switches and synchronizes the stages between inverter with the utility grid [2]. In this paper the converter is designed and operated in both forward and reverse direction[3]. From grid to vehicle operation it works as a rectifier and during vehicle to home it works as inverter.

3. Modes of Operation

The basic concept behind this process is to charge the battery to its maximum efficiency using a pv panel. A dc-dc converter is used to re-charge the battery. Often there are unwanted weather conditions where the pv panel does not work at its maximum efficiency. As a solution to this problem a MPPT is use to maximize the voltage. There is only one specific point of operation where the power obtained is maximum and which mainly lies on the knee of I-V curve of the solar panel. The MPPT controller is used for the proper execution of the algorithm and the inputs are the voltage and current of the solar panel [3]. The calculations are done by the algorithm and the output is adjusted and fed to the dc chopper (dc-dc converter) where the voltage is maximized to around 24V.

In this motoring and usb mode the charge from the battery goes to the bidirectional converter, the mosfets transfers the charge to the dc machine i.e the motor starts rotating. The converter is capable of utilizing the energy and drive the on-board electrical appliances [1]. The buck converter involved in this system is to lower the voltage of the battery to charge the USB. Battery is charged to 24 volts which drops down to 6 volts and the motoring and
usb action is achieved. In this vehicle to home mode connections are made with the help of an inverter capable of producing 50Hz ac voltage power is supplied to our homes and workplaces. Since the battery is fully charged there is no need for the pv panel in this mode and the battery acts as a storage [8]. No motor will be there and the bidirectional converter is used in boost mode. Before this mode the bidirectional converter was not giving high voltage but now it will increase the battery output voltage to a higher value from 24V to around 240V. In this grid to vehicle mode, the battery is charged by the grid. Under difficult circumstances or in an emergency situation when there is no solar power available to charge the battery we can take the power from the grid. The bidirectional converter is used in buck mode to maintain the control on voltage and current [2]. Since the maximum capacity of the battery is 24V so the grid voltage is lowered to the desired value. The input of the converter is the ac source and the dc output is fed to the bidirectional converter to charge the battery. This reverse process of transferring the energy from home to the vehicle is known as grid to vehicle.

4. Simulations and Results

All the simulations were done and the results were noted which contains the simulations for different modes of operations. These results show the different values that are being taken at each step. The graphs were plotted in a x-y plane. Fig. 2 shows the solar input voltage 24V during normal conditions. Fig. 3 shows the solar input voltage 8V during unfavorable weather conditions. Fig. 4 shows the DC-DC converter output voltage that is the maximized output voltage of the solar panel. Fig. 5 shows the charging voltage of the battery. For all the figures the X axis is the Time and Y axis is the voltage.

![Fig. 2 Solar input for normal conditions 24V](image1)

![Fig. 3 Solar input for unfavorable conditions 8V](image2)

![Fig. 4 Converter voltage waveform](image3)

![Fig. 5 Charging voltage of battery 25V](image4)

Fig. 6 shows the maximum voltage of the battery during motoring. Fig. 7 shows the motor running speed in rad/sec where X axis is the time in seconds and Y axis is the speed in radian. The output voltage and current for the USB mode of operation where the voltage is lowered to around 6V. Fig. 9 shows the maximum voltage of the battery which is charged by the panel. Fig. 8 shows the bidirectional DC-DC output voltage where the voltage is boosted from 24V to the voltage which is sufficient for the home applications. Fig. 10 shows the output voltage of the three phase inverter. In all the figures the X axis is the time and the Y axis is the voltage. Fig. 11 shows the grid voltage of around 240V which is used to charge the battery. Fig. 12 shows the output of AC-DC converter.
that is 240V DC. Fig. 13 shows the charging voltage of the battery which is lowered by the bidirectional DC-DC converter to the preferred voltage.
5. Conclusions

With the help of the converter the ac current at very low harmonics to and from the grid is delivered which eventually prolongs the life of the battery and converter and reduces the possibility of distorted grid voltage. The paper is based on an electric vehicle in which energy is transferred from the main power supply to the vehicle and then it also goes to the resistive load. The output of the two-way dc-dc converter is given to the permanent magnet dc motor which increases efficiency of EV storage system. The converter is made to work in buck-boost mode. During the energy transfer from vehicle to home it works in boost mode and during the reverse process of energy transfer from grid to vehicle the converter works in the buck mode. For increasing the sustainability of the paper a buck converter is also attached with the battery which charges an appliance with the USB source at 6 volts. All the operations are successfully verified using MATLAB. In real time the electric vehicle acts as a source for home appliances and also meets the emergency situations. Keeping in mind the growing pollution and the importance to save excessive usage of nonrenewable resources most countries are now finding technologies to shift to renewable resources so that the livelihood of the people is not hampered and this paper aids towards solving these problem and can be used to grow up in a sustainable environment with ample resources and latest technologies for mankind.

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