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Implementation of Bidirectional Converter in Electric Vehicle Charging

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ABSTRACT

This paper presents the implementation of a bidirectional converter for charging electric vehicles. This system includes a battery, bridgeless SEPIC converter, solar PV system, SEPIC converter, and bidirectional converter. To run the traction motor a Battery is implemented here. The Bridgeless SEPIC converter is provided here to convert AC source to DC source. The voltage from Solar PV is extracted, increased, and then stored in a battery using a SEPIC converter. The charge from the battery to the motor and the charge from the solar panel to the battery are charged and discharged using a bidirectional converter. Our Proposed system is used to charge the electric vehicle in hybrid mechanism, for example- Charging the vehicle by using Solar as well as AC-DC converter. This proposed system is analyzed by using Digital Storage Oscilloscope (DSO).

Keywords: Solar PV, MPPT, Bidirectional Converter, SEPIC Converter, Bridgeless SEPIC Converter, Battery, Digital Storage Oscilloscope.

1 Introduction

Nowadays, Electric Vehicles are plays a major role all over world. Because, EV using battery charge to run the motor instead of using polluting fuels to run ICE Vehicles. After 10 years, all ICE Vehicle owners switching their Vehicle to Electric Vehicles. At that time, we will face Power charging issues. So that, we designed one battery charger methodology to reduce the time domain issues. And also, increment of Electric Vehicle usage, there is a demand of energy to various sectors and fields. So that, many industries coming with various strategies to fulfilling this upcoming demands of energy requirements. Our proposed system will capable of applying this strategy to smart grid, micro grid, Electric Vehicle Charging and also in various industries which needs energy requirements. Our proposed system is more reliable, and also very economical and provide at low cost.

Our proposed Bidirectional Converter in Electric Vehicle Charging is demonstrated in given below Figure. The Solar PV panel, SEPIC Converter, bridgeless converter, bidirectional converter, traction motor and battery are presented in this block diagram, when receiving irradiance, Solar PV power is erratic by nature, therefore a bidirectional converter would be used to store any extra energy that was generated and transfer it to the battery. So battery would constantly produce the charge to run the motor efficiently and continuously. If the electric vehicle parked in home or any parking area, our designed system would AC – DC Converter to charge the vehicle. If the vehicle in run condition, solar panel will charge the vehicle. And if the battery charge become full, the current controller circuit will cut-off the current to charge the battery. Here, to extract Maximum power from solar by using perturbation and observation algorithm and here, we are implementing digital signal processor with Artificial Neural Network algorithm to process our system very reliable manner.

2 Components Explanation

2.1 Maximum Power Point Tracking (MPPT):

MPPT, is an algorithm to get the maximum available power from a Solar PV under specific circumstances. It is a charge controller device. The peak power voltage produced by solar PV is referred to as MPPT. Maximum strength is impacted by the cell temperature, ambient temperature, and sun irradiation. The MPPT is a digital gadget. It serves as a DC to DC converter to ensure the best possible compatibility between the battery pack, solar PV systems, and utility grid. In order to charge the batteries, they simply step down a higher voltage DC output from solar PV panels.

In this paper, a full power from the solar PV is extracted by proposing a charge controller with MPPT capability. In our proposed system SEPIC converter will act as MPPT and if MPPT requires, there we program P&O algorithm to extract available peak power at that particular solar irradiance.

2.2 DC-DC Converter:

The most used approach for converting voltage source which may or may not be controlled to a load applied that will or will not be constant is to operate a DC-DC converter. Additionally, Inductors, transformers, and capacitors are used in addition to high-frequency MOSFET switching in DC-DC converters to reduce switching noise and produce a regulated DC output voltage.

Here, we given brief explanation about our applied converters,

2.2.1 Bidirectional Converter:

In our proposed system, this converter is used in switching to charging and discharging at the same instant of time to run the system more reliable. This converter consists of inductors, diodes and MOSFET switching. This converter is a particular kind of buck-boost converter. For high speed switching application, two switch buck-boost converters are used here. And this converter used as step up and step down the voltage. In storage area, this converter used as step down and at load section – this converter used as boost or step up type. In a simple word, this bidirectional converter is key device to run the motor and charge the battery at the same time.

2.2.2 SEPIC Converter :(Single Ended Primary Inductive Converter)

A SEPIC converter is typically used as a boost converter followed by an MPPT charge controller, so it is similar to a buck-boost converter. In contrast to buck-boost converters, it has advantages like an output that is not inverted and has the same voltage polarity as the input, uses a series capacitor to couple energy from the input to the output so that it can respond to a short circuit output more accurately, and can achieve true shutdown when the switch S1 is sufficiently in off state.

2.2.3 Bridgeless SEPIC Converter:

A device known as an AC-DC Converter transforms an AC voltage into a DC voltage with a controlled DC voltage output. In this paper, Bridgeless SEPIC Converter used as AC-DC Converter. In this proposed system, this converter is used to provide lower conduction losses with decrement of components. In our proposed system, control loop circuit is provided as simplified and no current loop is needed while the converter operates in discontinuous conduction mode.

3 Solar Panel

Solar energy is the one of useful renewable energy source. To generate direct current electricity solar panels use sunlight as a source of energy. Solar Panel absorbs Sunlight to convert that into the electricity.

The MPPT charge controller, battery, inverter, and other factors influence the choice of solar panel and. For instance, one can use a 12V battery if we decide to use a 12V solar PV. It is possible to utilize a 24V battery and a 24V solar panel. It's important to keep in mind that, despite the lack of 24V batteries on the marketplace right now, two 12V batteries connected in series can be used to create one. Therefore, Solar Cell Power rating is directly proportional to the battery power rating.

The buck mode of the bidirectional converter is used for charging. Additionally, the converter runs in boost mode whenever the battery discharges the charge to the load during a switching procedure.

4 Traction Motor

Traction Motor is powered by electrical energy and generating the power to rotate wheels of the vehicle. There is a few types of DC motor used in Electric Vehicle and today, various electric vehicle manufacturers choose BLDC and PMSM motors to run the vehicle. Because, this two motors are very good in torque and efficiency and there is no power dissipation. Electric Motor is a main icon or domain to dominate whole vehicle industry. By the development of Motors, after 10 years – all ICE vehicle users switch their vehicles to Electric Vehicle because of the development of DC Motors.

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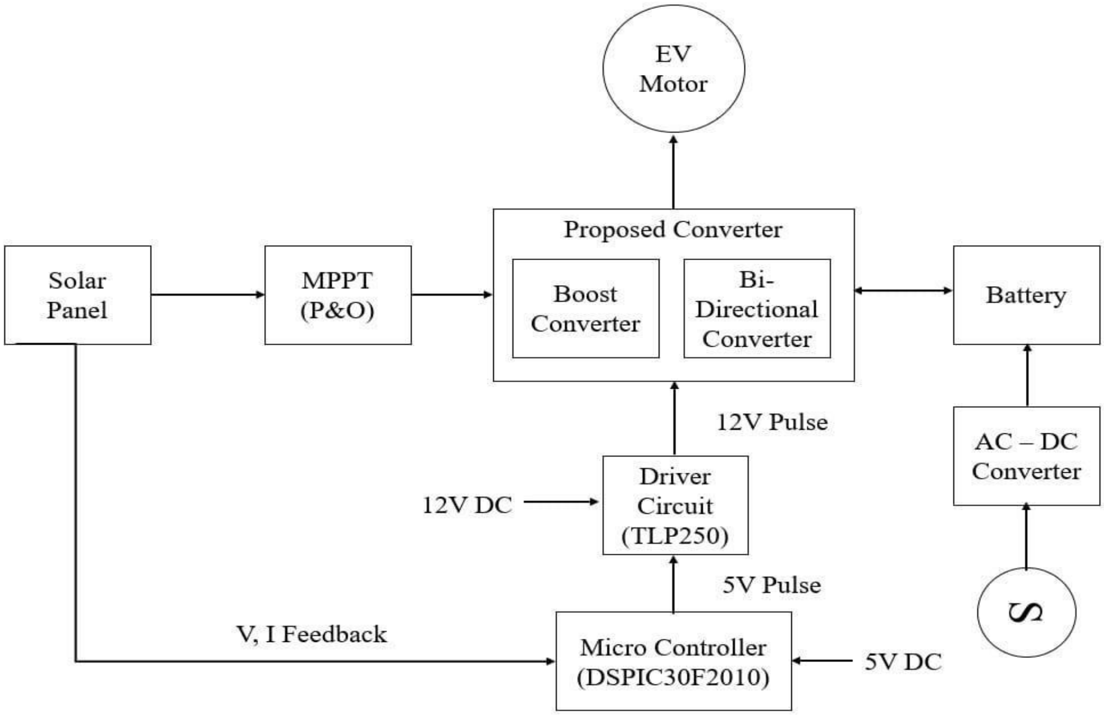

Figure 1: *Block Diagram of Proposed System*

From below figure 2: It displays the proposed circuit for an E-Vehicle bidirectional converter powered by solar energy The PV panel is made up of the following components: S1, C1, L1, C2, D1, and L2 on the left side of the load in figure 2. The left sideways of the load, etc. L – C –S2– battery acts as the buck converter which is in the load's right side and the battery – S2 – C – S3 – L– Load works as battery side boost circuit. The supply voltage is generated from PV panel whenever the irradiance occurs. As long as switch S2 is activated, it bucks the voltage to charge the battery while switch S1 boosts the voltage transmitted to the load. The AC to DC Converter Circuit as L4 - D3 - S5 - S4 - D2 - C5 may switch on to charge the battery if there is no sunlight or if the system is at rest. The MPPT controller is connected to the PV panel from the load to determine its optimal output. The P & O algorithm is used by the MPPT to derive at most available power possible from the panel.

Here, SEPIC converter circuit act as MPPT charge controller and charge the battery continuously, and cut the charge when the battery gets fully charged.

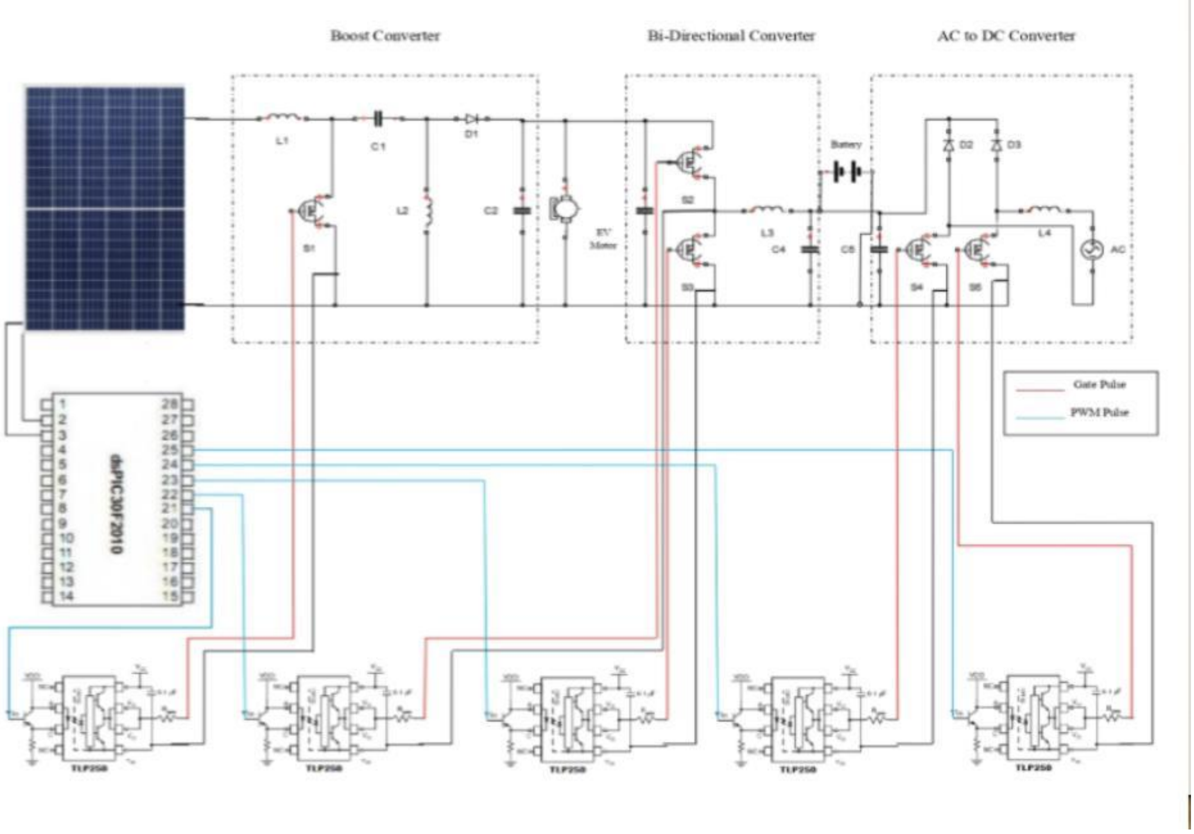

Figure 2: *Circuit Diagram of Electric Vehicle Charging using Bidirectional Converter*

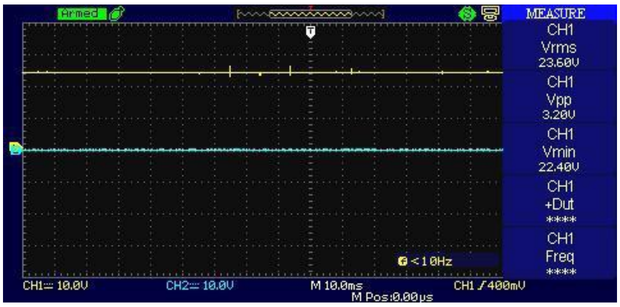

Figure 3 :
Output Waveform : Bidirectional DC-DC Converter

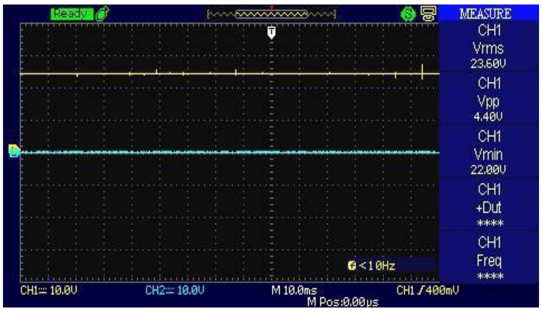

Figure 4 :
Output Waveform : SEPIC Converter

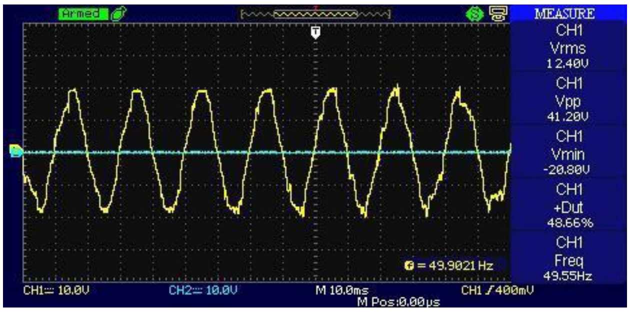

Figure 5 :
Output Waveform : Step-Down Transformer (230-12)V

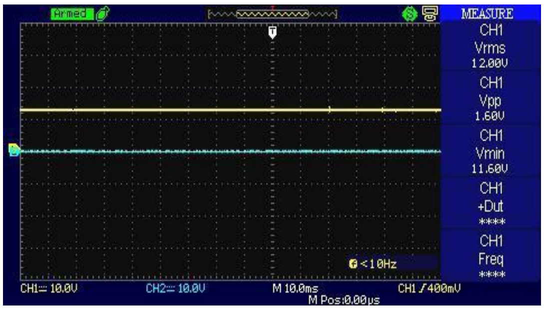

Figure 6 :
Output Waveform : Bridgeless SEPIC Converter

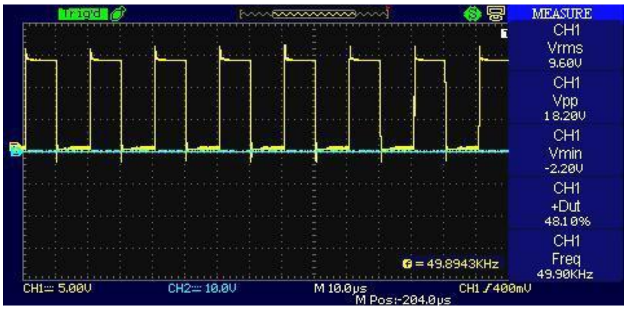

Figure 7 :
Output Waveform : MOSFET Switching

5 Result Discussion

From figure 3 to figure 7, the resultant waveforms are recorded by using digital storage oscilloscope. In figure 3, bi directional converter is the output of the recorded waveform, figure 4 illustrations the output waveform of SEPIC converter which act as MPPT charge controller, figure 5 shows the stepping down voltage using step down transformer, figure 6 shows the AC to DC Converter by using PFC converter and figure 7 shows about MOSFET switching. These are resultant waveforms got as outcome of our proposed system.

6 Conclusion

Bidirectional converters are implemented in a hardware environment for electric vehicle charging. The present work mainly includes the Bridgeless SEPIC converter and Battery system, Bidirectional Converter, and SEPIC converter, to keep the system stable under a variety of load conditions, models are constructed for all the converters. And also the control mechanism are studied under real time application. The MPPT P&O algorithm is used to coordinate power exchange between EV Motor and Battery and to maximize the solar panels' output of power. When a DC motor is used with solar PV and batteries, under various generation of solar energy conditions, its effectiveness is tested as well as the battery power requirements. We find that the solar panel's ability to generate power depends on the load placed on it at a given temperature and radiance. Our Proposed system provides a high quality, reliable and more capable electric vehicles to the owner.

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