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IMPROVED SEPIC-ZETA CONVERTERFOR PHOTOVOLTAIC SYSTEMS

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Abstract: A Bidirectional Single-Stage Grid-connected inverter (BSG inverter) for the battery energy storage system in EV applications using SEPIC-ZETA converter is proposed. The proposed BSG-inverter is composed of Bidirectional SEPIC- ZETA type DC–DC converters (BSZS) and a DC–AC unfolder. The circuit diagram of the proposed BSG-inverter which iscomposed of distributed SEPIC-ZETA type DC–DC converters and a DC–AC unfolder. BBC consists of two switches, twodiodes, and one inductor. It can convert the DC current generated by the battery module into a high frequency pulsating DC current. This high frequency pulsating output current of the BBCs will be converted into sinusoidal one with utility line frequency by the DC–AC unfolder of four active switches operated at low switching frequency and an LC filter. The proposed BSG-inverter will comply with the power commands which is coming from the central control unit of the BMS tocharge or discharge the battery modules. The power flow from each battery module is transferred to the AC mains by means of single-stage power conversion. Also the BBCs can be operated with interleaving to reduce the current ripple of the outputinductor. This proposed method is implemented using MATLAB simulation and hardware is developed with DSPIC30F4011controller.

Keywords: SEPIC-ZETA Converter, BSG inverter, AC grid, Photovoltaic.

I.INTRODUCTION

The fossil fuel exhaustion and global warming issue, renewable energies such as the Photo Voltaic (PV) power and wind turbines are more and more popular recently. However, the fluctuations of the high penetration renewable energy will cause the negative impact to the grid voltage and frequency stabilization. Battery energy storage system is a promising candidate to increase the penetration rate of the renewable energy. For the micro grid application the battery energy storage system isessential not only for controlling and managing the energy of distributed generation units such as photovoltaic, wind turbinesand micro-turbines for the stability of the power system but also for protecting loads from grid fault conditions. The conventional battery energy storage system consists of a battery array which is formed by many battery modules connected in series or parallel and a bidirectional grid-tied DC-AC inverter as a full-bridge inverter. Circuit simplicity is the main advantage of this type of battery energy storage system but the total power capacity may be easily reduced by a particular over charging/discharging battery module due to the battery tolerance, unequal battery losses and so on. In order to maximize energy storage the voltage of the individual battery module connected in series to form a DC bus as the input of the grid-tiedinverter must be equalized with each other. The general solution to solve the battery capacity reduction problem is to use extra balancing circuit to connect each battery module and balance the charge of all battery modules. However, the balancing circuit may result in the reduction of total efficiency and the increase of cost and circuit complexity.

The salient features of the reduction of the transformer and proposed power converter are only two power electronic switches of the power converter are operated at high switching frequency simultaneously (one is a DC–DC power converterand the other is a DC–AC inverter) and the negative terminal of the solar cell array is directly connected to the ground to solve the problems of TCO corrosion and leakage current for some types of thin-film solar cell array. The experimental results show that the proposed grid-connected power converter can trace the maximum power point of the solar cell array convert solar power to a high quality AC power to inject into the utility and reduce the leakage current of the solar cell array.

II. LITERATURE SURVEY

The Comparative Study on Buck and Buck-Boost DC-DC Converters for MPP Tracking for Photovoltaic Power Systems discussed in this method solar based Buck Boost converter with different MPPT algorithm is proposed such as hills clamping MPPT method. The Buck-Boost converter can track the MPP with a reasonably higher efficiency in all the subjected atmospheric conditions of insulation and temperature. It provides 93.82% efficiency at Boost mode. In

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Buck Boost converter the input current is discontinuous so that it will produce higher order ripple in output voltage. Also not discussed about Partial shading condition in PV panel side, it is the major drawback. The solar energy with this converter is not enough to maintain power for whole day.

- Jinwei He et al [1] Introduce a Hybrid voltage and Current control Method (HCM) to improve the interfacing converters performance in distributed generation units. Nowadays Current Controlled Method (CCM) used in grid connected converters. Proposed method allows the coordinated closed –loop control of the DG unit fundamental voltage and harmonic currents. Overcome the disadvantages of fossil energy based centralized power generation was large numberof Renewable Energy Sources (RES) have been integrated into the power distribution system in the form of distributed generations. RESs are unregulated DC power or AC power at variable frequencies. The robust interconnection of theseRESs, the interfacing converter with LCL filter is normally placed between RESs and the main grid.

- Moon-Young Kim et al [2] Presented a Chain Structure of Switched Capacitor for Improved Cell Balancing Speed of Lithium-Ion Batteries. Nowadays many applications used for rechargeable batteries. And the lithium-ion battery is one of the most attractive batteries due to its high energy density low self-discharge rate. Existing method series connection of the lithium-ion batteries is required to meet the demanded voltage level. Proposed method chain structure of switchedcapacitor for improved cell balancing speed.

- Kyung Min Lee et al [3] Developed a active cell balancing of Li-ion batteries using LC series resonant circuit. Series connected li-ion batteries have high energy density, high cell voltage, long life cycle. All cell battery operated in a Safe Operating Area (SOA) and Charging Voltage Limit (CVL) Discharging Voltage Limit (DVL). Charging over CVL burns or burns the battery and discharging below DVL damages its chemical properties. Proposed a new active cell balancing method for Li-ion batteries.

- Wangxin Huang et al [4] Proposed a energy sharing State-of Charge (SOC) balancing control scheme based on a distributed battery energy storage system architecture where the cell balancing system and the DC bus voltage regulation system are combined into a single system. The small power converters are utilized to achieve both SOC balancing between the battery cells and DC bus voltage regulation at the same time. The battery cells' SOC imbalance issue is addressed from the root by using the energy sharing concept to automatically adjust the discharge/charge rate of each cell while maintaining a regulated DC bus voltage..
- Liang-Rui Chen et al [5] developed a improvement of Li-ion battery discharging performance by pulse and sinusoidal current strategies the AC impedance analysis is used to explore the optimal discharging frequency for a Li-ion battery connected li-ion batteries have high energy density, high cell voltage, long life cycle. All cell battery operated in a Safe Operating Area (SOA) and Charging Voltage Limit (CVL), Discharging Voltage Limit (DVL) Sinusoidal Current (SC) discharging strategy is also proposed to achieve better performances. This SC discharging strategy improves the discharging capacity, discharging efficiency, and rising temperature of the Li-ion battery compared with the traditionalconstant-current discharging.

- Michail Vasiladiotis et al [6] presented a power converter architecture for the implementation of an ultrafast charging station for Electric Vehicles (EVs). The versatile converter topology is based on the concept of the power electronic transformer. For the direct transformer less coupling to the medium-voltage grid a Cascaded H-Bridge (CHB) converteris utilized. On the level of each sub module integrated split battery energy storage elements play the role of power buffers reducing thus the influence of the charging station on the distribution grid. All possible charging station operating modes among with the designed necessary control functions are analyzed. The state-of-charge self-balancing mode of the delta-connected CHB converter is also introduced.

III. PROPOSED SYSTEM

In this proposed method the integration operation of two SEPIC and ZETA converters and a single phase bidirectional inverter is presented. The proposed MPPT algorithm used is PI controller. The duty cycle can be perturbed according to the PI controller and which is given as the gate input to the SEPIC converter. The bidirectional inverter is required for the purpose of power flow control between DC bus and AC grid. DC-DC converter operates with MPPT algorithm to maximizepower generation. DC-DC converter transfers photovoltaic energy to DC-link capacitor and increase DC-link voltage. DC- AC inverter controls DC-link voltage to certain level and transfer DC-link energy built up by DC-DC converter to grid.

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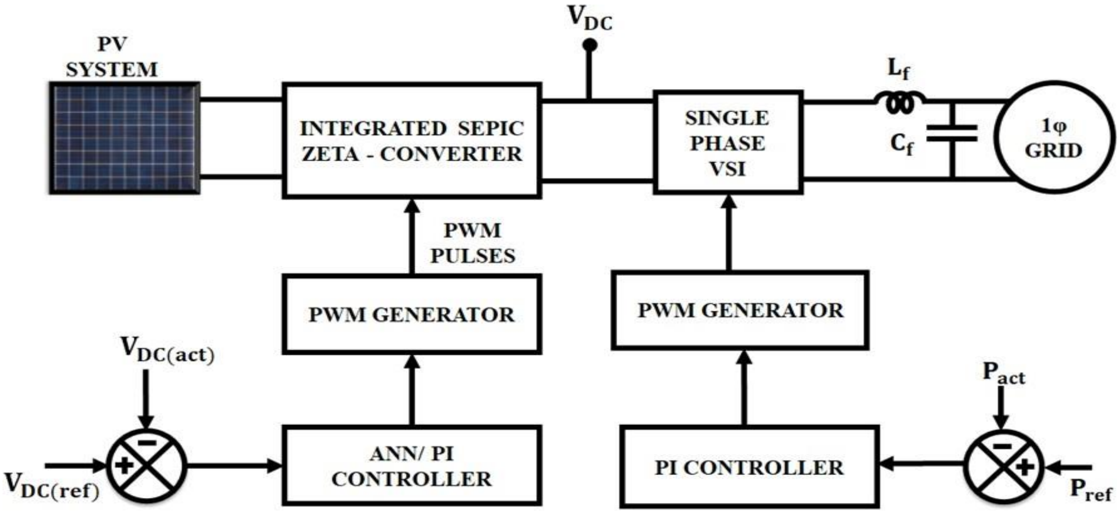

Fig:1 Block diagram of proposed system

Fig.1 shows the proposed system consists of has the integration of SEPIC and ZETA converters and a bidirectional inverter.The sun light is given to the solar panel as the input. The light intensity depends on the solar irradiation and the climate conditions. The SEPIC converter can be used for the DC-DC conversion and while comparing to buck-boost converter the SEPIC converter has ability that the output voltage is same polarity of input voltage. The bidirectional inverter will function as both inverter and rectifier charger mode. Bidirectional inverter is required to control the power flow between DC bus andAC grid and to regulate the DC bus to a certain range of voltages. The maximum power point tracking algorithm used is hill climbing method. This method deals with the perturbation of duty cycle.

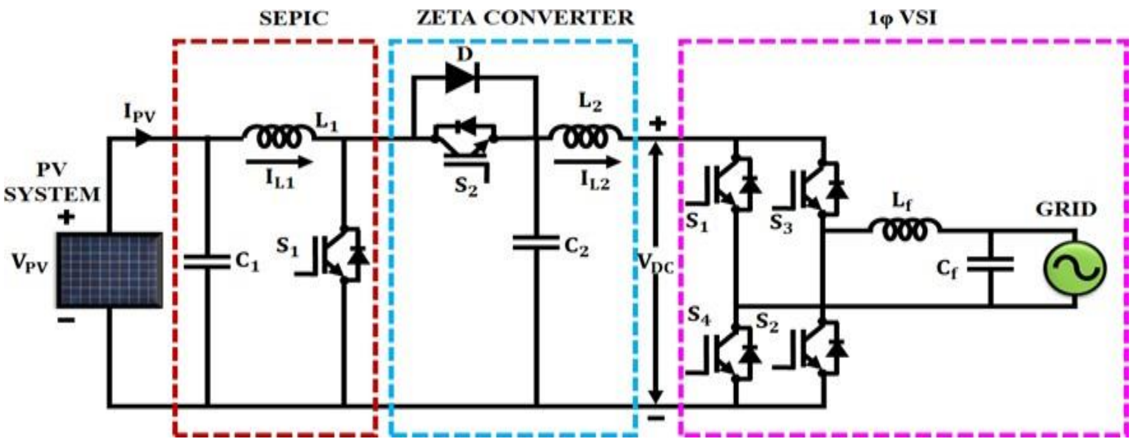

Fig:2 Circuit diagram

Fig:2 shows the circuit diagram of improved SEPIC-ZETA converter for photovoltaic systems. Single Ended Primary Inductor Converter (SEPIC-ZETA) is a type of DC-DC converter allowing the electrical potential at its output to be greater than or less than or equal to that at its input voltage. The output of the SEPIC-ZETA is controlled by the duty cycle of thecontrol switch. A SEPIC-ZETA converter is similar to a traditional Buck-Boost converter. It has advantages of having non-inverted output that is the output has the same voltage polarity as the input. By using a series capacitor to couple energy from the input to the output and thus can respond more gracefully to a short-circuit output and being capable of true shutdown. When the switch is turned off its output drops to 0 V SEPIC-ZETA are useful in applications in which a batteryvoltage can be above and below that of the regulator's intended output. For many power electronics applications especially PV systems the basic requirement for efficient control is that the circuit should be capable of handling bidirectional power flow. So that energy transfer should be possible from the grid to battery during charging mode and battery to grid in discharging mode. A bidirectional charger will need to function smoothly in both directions. While in discharge mode the charger should return current in a similar sinusoidal form that complies with regulations. An AC waveform is passed through the filter to remove unwanted harmonics. The AC waveform is then

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rectified into DC waveform as it passes through the bidirectional inverter.

The bidirectional DC-DC converter then steps up the voltage to that of the battery to ensure a proper charging voltage.In discharge mode the charging mode is reversed. The bidirectional DC-DC converter steps down the voltage to that of the rectified grid. The DC waveform is then passed through the inverter back into a unipolar modulated signal and out throughthe filter producing an AC waveform acceptable to the grid.

IV. SIMULATION RESULTS

The simulation of the integrated operation of SEPIC-ZETA converters and a bidirectional inverter is done by using MATLAB/Simulink. The various input and output waveforms are showed below. The input voltage of 12 V is fed to the SEPIC converter and three voltage outputs can be taken as per requirements. Hence the various output voltages and currentare shown with respect to the time. The final conclusion about the integration operation of the SEPIC converter and the bidirectional inverter can be clearly known from above showed figures. The output voltage of the SEPIC converter can beclassified as output voltage greater than or less than and equal to that of input voltage. Hence the greater than output voltagemay be coming around 36V and less than output voltage will be 20V. The input current is around 0.6A for a single PV panel. When compared to Buck-Boost converter the SEPIC converter has an extra option that it can provide an output voltage that is equal to the input voltage which is taken as 12V as same as the input voltage. The figure shows the simulationview of the proposed system.

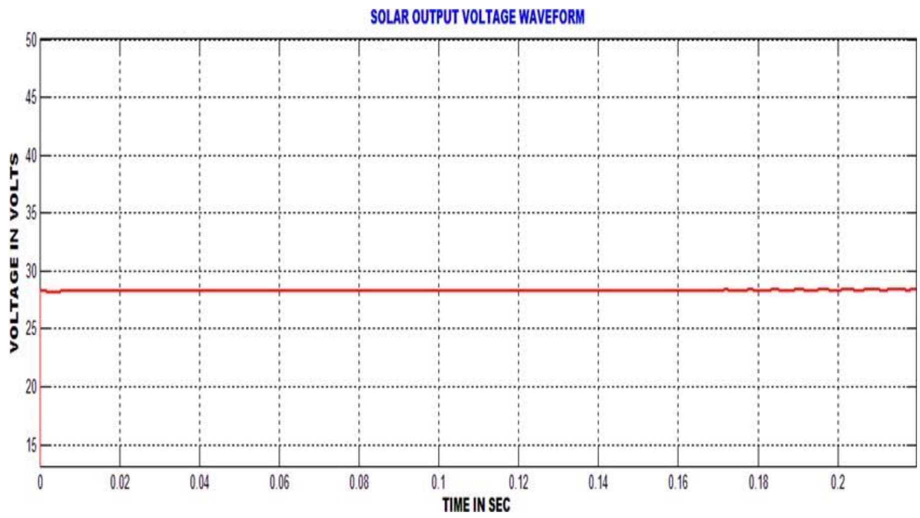

Fig:3 Output voltage from the PV system

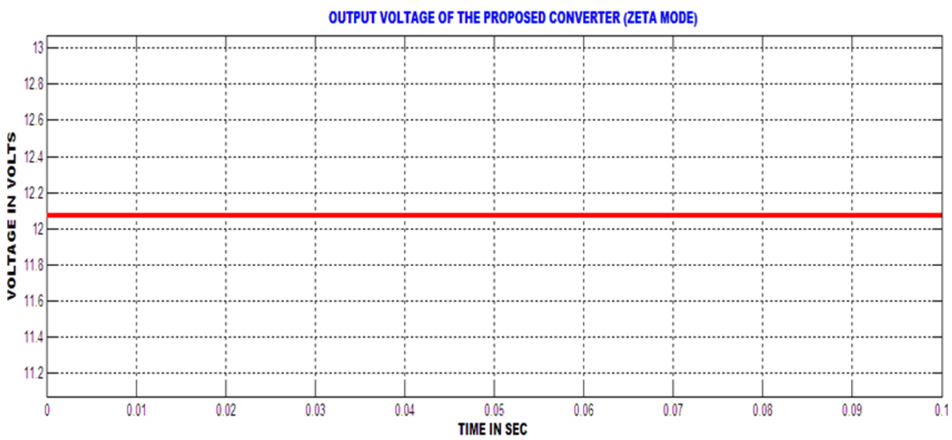

Fig:4 Battery operated voltage from ZETA converter

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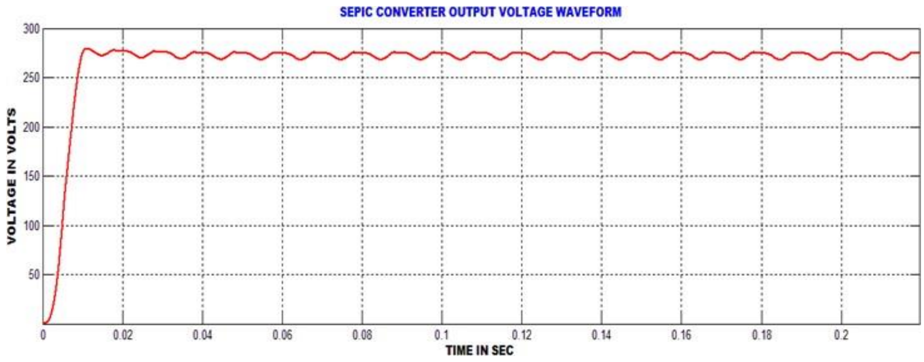

Fig:5 SEPIC converter mode output voltage waveform

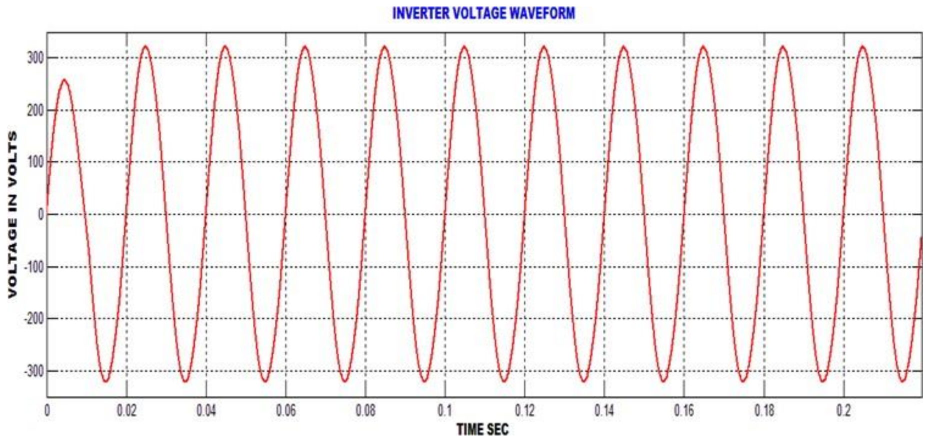

Fig:6 Single phase voltage source inverter output waveform

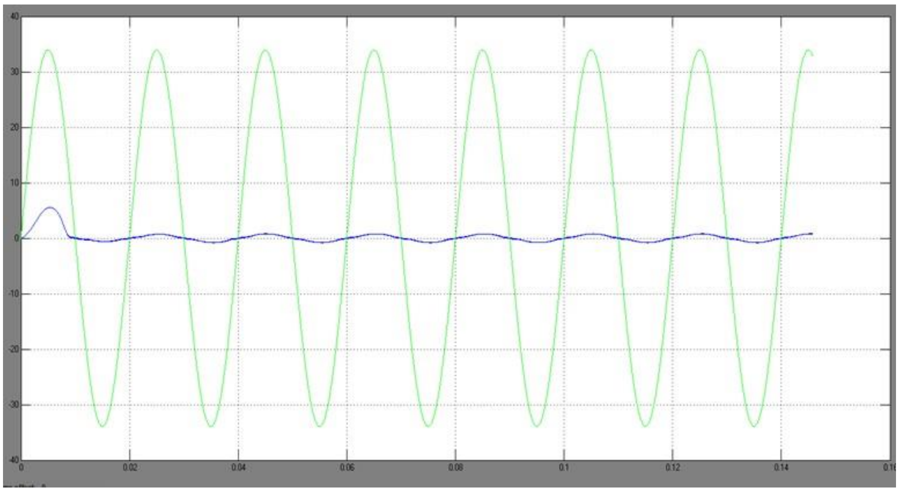

Fig:7 Grid connected inverter output voltage and current waveform

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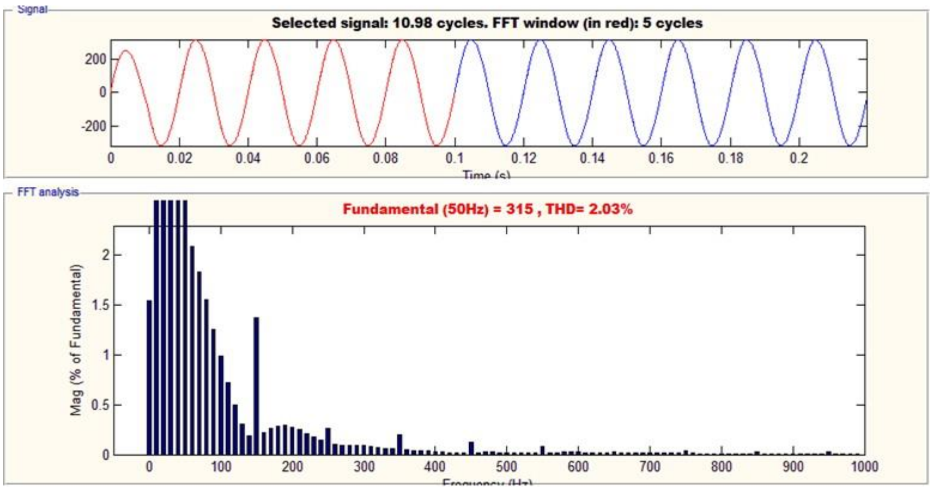

Fig:8 THD result of the grid voltage.

V. CONCLUSION

This proposed method deals with the integrated operation of SEPIC-ZETA converters and a single phase bidirectional inverter. The SEPIC converter is a DC-DC converter in which the output voltage may be greater than or lesser than or equal to that of input voltage. The DC voltage is converted into AC voltage by means of a single phase bidirectional inverter. During the grid connection operation the bidirectional inverter will convert the DC into AC voltages by using PWM signals. During the rectification operation the inverter act as converter and convert the AC voltage into DC voltage. The maximum power point tracking algorithm used is PI Controller method which deals with perturbing the duty cycle and maximum poweris obtained. The operation of DC loads are quiet easier than an AC loads since the integration of AC loads requires frequency matching AC-AC converters along with grid synchronization power, factor problems, grid stability issues and so on. Hence in future work rectification of these operating problems and a reliable grid connected solar operation should be done.

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