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# A Multi-Function Conversion Technique for Electric Vehicle Charging Station

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**Abstract-** In this paper, a new method of integration between PV inverter system with utility grid for electric vehicle charging station based on the extended boost quasi-Z-source (q-ZSI) topology is proposed. The proposed system realizes a bidirectional power flow management between PV sources, energy storage unit and the utility grid. The extended boost q-ZSI is a most efficient topology that provides a single stage conversion for PV systems by providing low ratings for components, reduced number of components used, high input voltage gain, increased voltage boost property, reduced voltage stress across switches and simple control strategies. Its unique capability in single stage conversion with improved voltage gain is used for voltage buck and boost function. A simulation model of the grid connected q-ZSI for electric vehicle charging station has been built in MATLAB/ SIMULINK. The hardware setup was developed and the results are validated.

**Keywords-** electric vehicle charging station; battery storage; quasi ZSI; Shoot-through; extended boost

## I. INTRODUCTION

Electric vehicles are progressively replacing traditional automobiles equipped with internal combustion engines. The continuous development of outstanding performance batteries and high-efficiency motors also has spurred dramatic interest in EVs, which are regarded as representatives of new energy vehicles [1–2]. In addition, with the emergence and development of the concept of smart grid, the reliable, economic, efficient and clean performance of smart grid and its user-friendly interaction will give EVs brighter prospects and a new round of improvements [3].

In grid connected PV systems, the power electronic converters plays a vital role in conversion of DC current of PV panels into an AC current to supply the load, with the maximum efficiency, the lowest cost and superior performance. The two stages of DC-DC-AC power conversion may result in usage of more circuit components, lower efficiency, higher cost and larger size in comparison to single stage one.

The quasi Z source inverter has unique power conversion technology perfectly suitable for interfacing of renewable energy sources [4]. It has a single-stage boost-buck converter approach for the different renewable power applications. The efficiency and voltage gain of the q-ZSI are limited and comparable with the traditional system of a VSI inverter with the auxiliary step-up DC/DC converter in the input stage [5].

The use of photovoltaic (PV) energy for the charging operation has advantages, among others reducing the load demand on the utility grid, saving cost of energy usage to the utility provider especially for the business and contributing to the promotion of a cleaner technology. However as the harvested energy from PV is constrained by the factors such as sun irradiation availability and size and space of PV array installation, the charging station still normally need to be connected to the grid to maintain a stable power supply.

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In this paper multi function conversion technique for battery charging is done where DC power is directly injected to the vehicle n the off-board charger. The multi function conversion technique is done by using extended boost quasi ZSI technology which has unique single stage conversion of buck or boost function.

## II. Proposed Block Diagram

In order to investigate the feasibility of electric vehicle charging, a grid connected PV system with quasi Z source inverter and a three phase inverter is constructed. The proposed topology of grid connected q-ZSI for electric vehicle charging station was presented in Fig.1.and Fig.2.

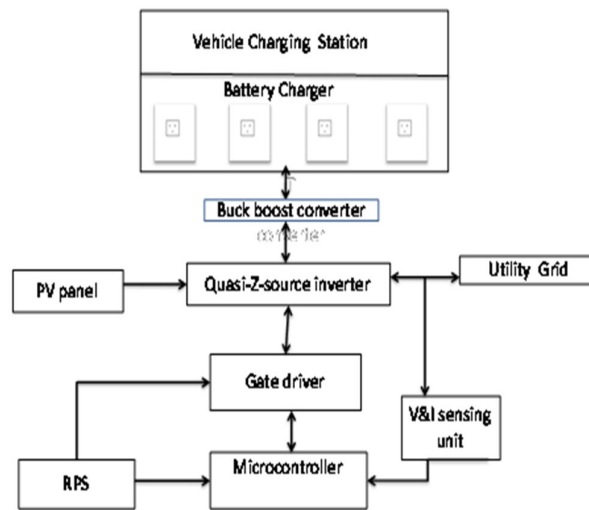


Fig.1. Proposed Block Diagram

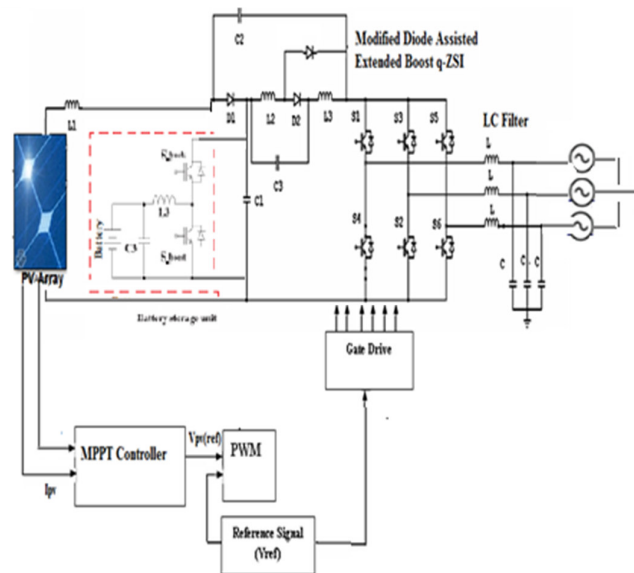


Fig.2. Grid-connected q-ZSI PV inverter system with bidirectional DCDC converter for battery storage

### 2.1 Steady State Analysis of q-ZSI

The extended boost q-ZSI has two operational states at the dc side, non-shoot-through states and the shoot-through state. [7-9].



$$\begin{aligned} V_{dc} &= V_{c1} + V_{c2} \\ &= V_{in} \frac{1}{(D_s^2 - 3D_s + 1)} \end{aligned} \quad (12)$$

The boost ratio of the input voltage is

$$B = \frac{V_{dc}}{V_{in}} = \frac{1}{(D_s^2 - 3D_s + 1)} \quad (13)$$

## 2.2 Battery Storage Unit

Energy storage capability is used in the charging station infrastructure especially when PV source is used as an alternative source. Extra energy from the PV can be stored and used to reduce the reliance to the energy from the utility grid. The battery is connected directly in parallel to one of the capacitor at the impedance network as shown in Fig. 1. Direct connection to the capacitor however causes the battery terminal voltage need to be designed at higher voltage in series to match with the range of operation for the PV terminal voltage and the dc link voltage across the inverter switches.

Inside the storage unit a bidirectional DC-DC converter with the terminals across the switches are connected in parallel to capacitor C1 at point A and B. The bidirectional DC-DC converter enables the circuit to operate either as a buck converter to charge the storage battery with input voltage of 680V across C1 down to 300 V which is the optimal voltage value of the battery, or as a boost converter to supply current from the storage battery to the charging station. Value of L3 and C3 is designed based on the voltage and current ripple requirement.

## 2.3. Vehicle Charging Station

The EV charging station consists of DC rail connected in parallel to the battery storage unit, and a charger 1 to 4, consists of DC-DC buck converter which are used to deliver the energy to the EV during charging process. Inside the DC-DC buck converter, controller is used to regulate the amount of current delivered to the car battery which can be varied depending on the time required to achieve certain level of SoC.

## 2.4. Modes of Operation

There are 3 factors used to determine mode of operation for the system; power received from the PV array ( $P_{pv}$ ), charging power demand ( $P_{charge}$ ) and the SoC level of battery storage unit. Fig. 5 shows the flowchart of power management of the system which can be briefly summarized as follow.

**Mode 1:** obtained PV energy is high sufficient to supply the charging demand. Energy from PV is directly used for charging and the remaining energy is stored/deliver to the grid.

**Mode 2:** obtained PV energy is low insufficient to supply the charging demand. Battery SoC in range. Battery goes to discharging operation to back up the low energy from PV.

**Mode 3:** obtained PV energy is low insufficient to supply the charging demand. Battery SoC is low. Power is drawn from the grid to support the low energy from PV.

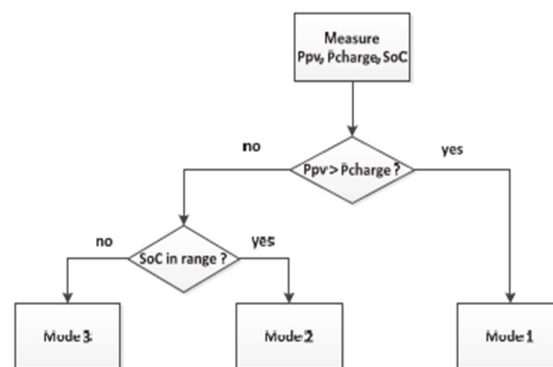


Fig.4.Flowchart of the charging management system

### III. Simulation Results

Fig.5. shows the Matlab/ Simulink circuit of grid connected q-ZSI for electric vehicle charging station. Fig.6. shows the subsystem with battery arrangement.

Table:I shows the simulation parameters of grid connected q-ZSI for electric vehicle charging station.

Input Voltage $V_{in}$	12V
Inductors L1,L2, L3 & r L	$65\mu\text{H}$ , $0.005\mu\text{H}$
Capacitors C1,C2, C3 &	$185\mu\text{F}$ , $0.0005\mu\text{F}$
Grid Voltage Source	230V,5Watts
Transformer Ratings	230V, 1A
DC Motor Ratings	12V,30watts
Battery	24V
Filter Inductance	20mH
Filter Capacitance	$220\mu\text{F}$

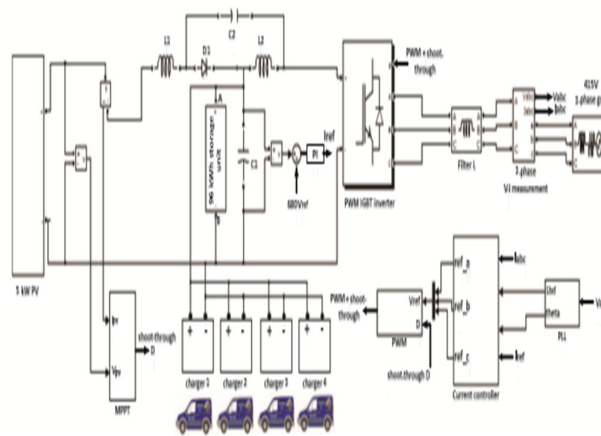


Fig.5. Matlab/Simulink circuit of proposed system

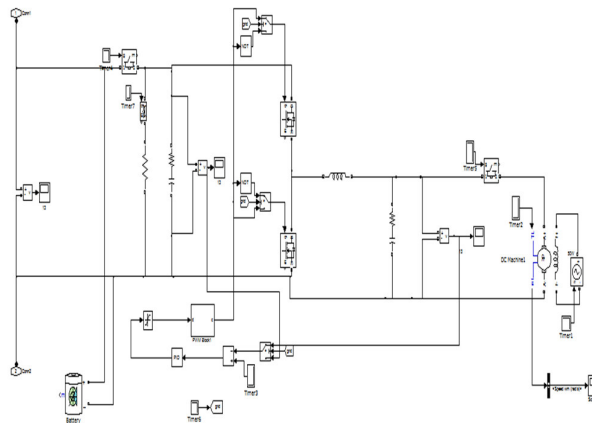


Fig.6. Matlab/ Simulink Circuit of battery storage

#### 3.1. Gating Pattern

The gating pattern of the pulse generation using the simple boost control technique is shown in Fig.7.

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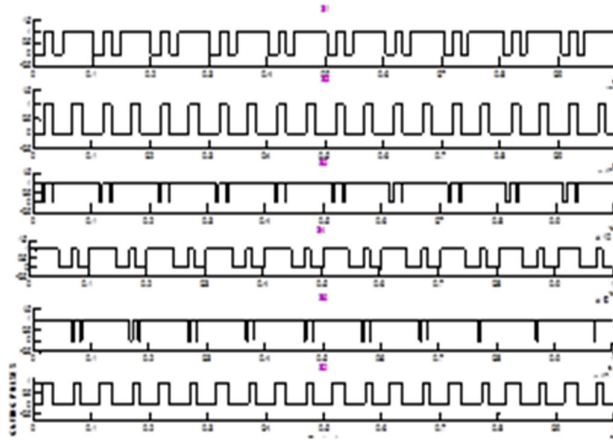


Fig.7. Gating Pattern for Simple Boost Control

Fig.7. shows the active state and shoot through pulse generation for simple boost control technique.

### 3.2. Input Power Waveform

The input power waveform is shown in Fig.8.

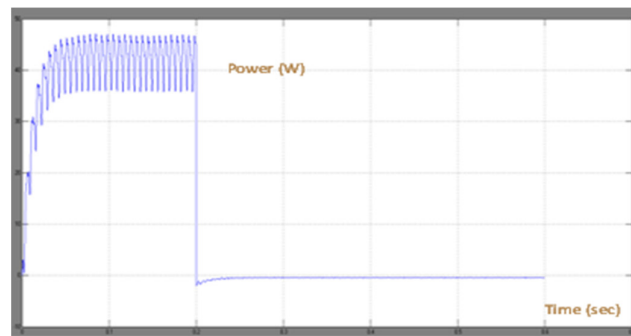


Fig.8. Input Power Waveform

### 3.3 Electric Vehicle Motor Speed Waveform

The motor speed waveform is shown in Fig.9.

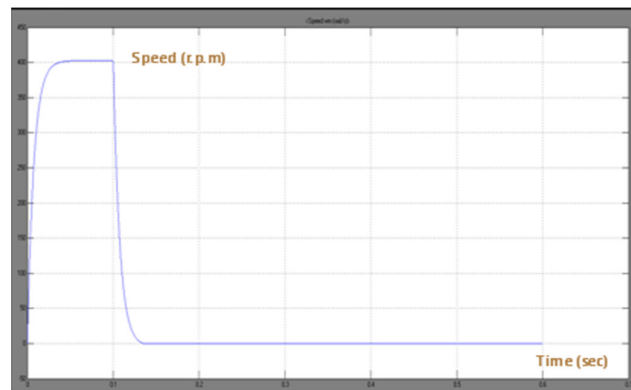


Fig.9. Motor Speed Waveform

### 3.4. Regenerative Mode Voltage Waveform

The regenerative mode voltage waveform is shown in Fig.10.

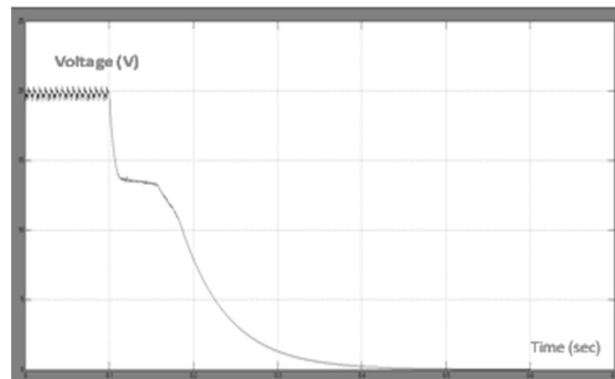


Fig.10.Regenerative Mode Voltage Waveform

### 3.5. Voltage and Current Waveform

The output load voltage and load current are shown in Fig.11.

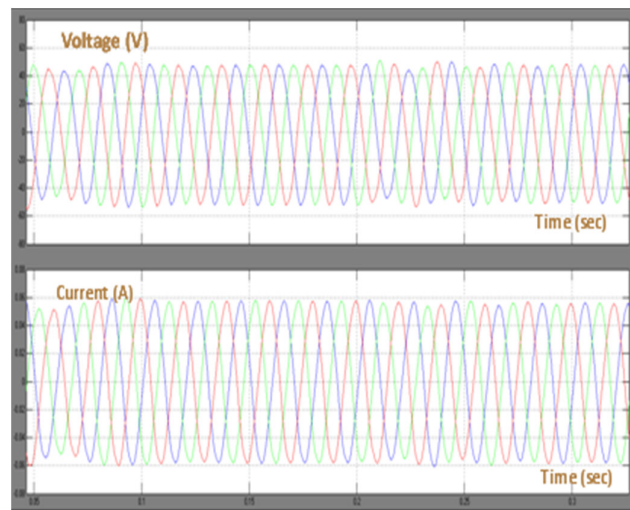


Fig.11.V & I Measurement waveform

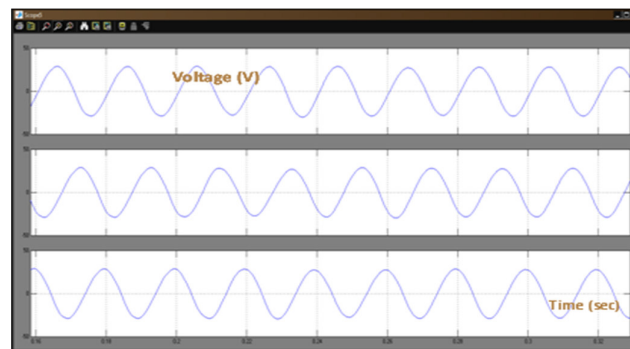


Fig.12.Load Voltage Waveform

#### IV. Conclusion

In this paper, the novel topology of modified diode assisted extended boost quasi ZSI is used in EV charging station based on grid connected PV system. The proposed topology of q-ZSI ensures the continuous input current and have increased boost factor of the input voltage and bidirectional power flow management system. From the simulation results, it is observed that the bidirectional power flow management between the PV source, charging station and the grid works well with the q-ZSI.

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