A Quasi Z-Source Inverter with Battery for PV Power Generation System

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Abstract-**The Demand of renewable energy sources for power production is rising from the period of time. Solar power plants are play vital role in supplying increased power challenge. PV array with battery based quasi z source inverter makes more reliable under PV fluctuations. The energy storage device is integrated to ZSI topology with no requirement for an extra charging circuit. This modified system obtains the operating characteristics from the conventional ZSI, with ability of operating under low renewable (PV) power conditions. In order to work below this circumstance, an energy storage device capable of managing the load demand for a period of time is required. A way to add the energy storage device is to install a charger circuit that integrates it to the DC voltage rail of inverter. However, this proposed system presents another way to integrate the energy storage device without an extra charger circuit.**

Index terms: PV array, quasi z source inverter, energy storage, shoot-through, power conversion.

I. INTRODUCTION

The z-source inverter (ZSI) has been reportable fit for residential PV module because of the capacity of voltage raise and variation in a single stage [7] .Alternate energy sources such as solar, fuel cell and wind have a large voltage difference due to the nature of the sources. Photovoltaic cells voltage different with temperature and irradiation. Fuel cell stack voltage decline greatly with current and wind generator voltage varies with wind speed and control .The traditional voltage source inverter that has been the power transformation technology for these energy sources cannot cope with wide voltage change nature and often requires an additional voltage boost by additional dc/dc converter .the z-source inverter can solve this problem. This individual power conversion technology gives a great choice with lower cost, higher reliability, and higher efficiency [8]. Recently, the quasi z-source inverter derived from the original ZSI, by using new quasi ZSI topology, the inverter draws a constant current from PV array and it's able to dealing a large input voltage range. It also has the characteristic of lower component rating and reduced source stress in contrast with the traditional ZSI.

II. Existing system

Without need of any additional dc/dc converter or section, the QZSI was first introducing for PV power generation system. The existing quasi z-source inverter has following properties [4]

- It is a single stage buck (or) boost (DC/AC) converter
- It consist of two split inductors and capacitors equal in magnitude
- This impedance network itself acts as a filter so the additional filter is not required
- The inductors are connected in series arms and capacitors are coupled in diagonal arms
- The impedance network used to buck or boost the input voltage depend upon the buck or boost factor
- It has one extra zero state when the load terminals shorted. This shoot through state provided buck-boost functions by single stage conversion
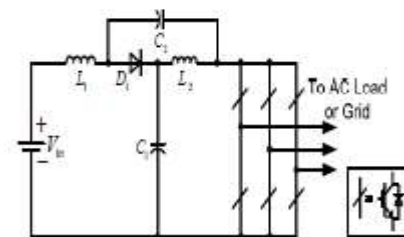

Fig.1.Existing QZSI without battery for PV power generation

Currently several control system for the traditional ZSI and QZSI in the literature, where they primarily concentrate on achieving a constant dc-link voltage, or constant capacitor voltage, and maximum power point (MPP) tracking (MPPT) by using the shoot through duty cycle and the modulation index. They are definitely very good reference for control of the energy-stored qzsi circuit. However, the batteries paralleled with the capacitor engage the circuit quite different. For example, the inductor currents are no longer level during battery charging and discharging and the capacitor voltage is clamped by parallel battery. It limits the conventional control methods ability to achieve a constant dc-link peak voltage [4, 10].

Disadvantage

The solar irradiation and the PV panel's temperature varies at random, the dc link peak voltage will change accordingly

.so, the additional alternate is required like battery is to provide the continuous power to the load.

III. PROPOSED WORK

Fig.1. shows the just one of the QZSI topologies, the proposed topology has the energy stored quasi z-source inverter. Where the battery is connected in parallel with capacitor c1 it has power limitation due to the power limitation there is a wide range of discontinuous conduction mode during battery discharge [5]. As a counterpart, to connect the battery in parallel to the capacitor c2, leading a new topology in Fig.2. They have common points:

1) It has three power sources/consumers,i.e.,PV panels, battery, and the grid/load.
2) As long as controlling two power flows, the third one automatically matches the power differences, according to power equation

$$P_{in} - P_{out} + P_B = 0$$

Where P_{in}, P_{out} and P_B are the PV panel power, the output power of the inverter, and the battery power respectively. The power P_{in} is always positive because the PV panel is unidirectional power supply, P_B is positive when the battery delivers energy and negative when absorbing energy, and P_{out} is positive when inverter injects power to grid

Whenever both the switches of inverter bridge leg conducts circuit is getting short circuited and there by huge amount of current flows, by connecting a z source or quasi z source the current flow can be reduced by the impedance network. Especially L2 and C2 play a key role. The circuit also operates in two states: the non-shoot-through state and the shoot through state
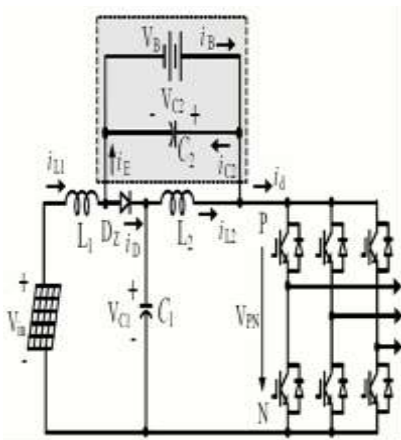

Fig.2. proposed QZSI with battery for PV power generation

Circuit operation

It is one of the energy stored QZSI topologies, where the battery is connected in parallel with the capacitor C2.It consists of PV panels or battery and the grid or load. Without need of any additional dc/dc converters or components, the QZSI with energy storage is proposed for PV power generation system by connecting the battery in parallel with capacitor C2 of the QZSI this system is able to (1) produce the desired output AC voltage to the grid/load

(2) regulate battery SOC (state of charge) and (3) control the PV panel output power (or voltage) to increase energy production. The battery parallel with the capacitor makes the circuit quite different.

These type of inverter are operated in two states or modes, the active state which is denoted as (T1).and shoot through state denoted as (T0).during one switching cycle both the state occur and the total period time is given as T=T1+T0.during active state the inverter operated using normal sinusoidal pulse width modulation (SPWM) and during the shoot –through state an intentional short circuit between P and N is created. The unique QZSI LC network acts as step up DC-DC converter controlled by shoot through state [6].

The average voltage across VL1 during each switching cycle is given

$$V_{L1} = \frac{T_1(V_{in} - V_{c1}) + T_0(V_{in} + V_{battery})}{T} = 0 \ (1)$$

The average voltage across VL1 during each switching cycle is given as

$$V_{L2} = \frac{T_1(-V_{battery}) + T_0(V_{c1})}{T} = 0 \ (2)$$

CIRCUIT ANALYSIS
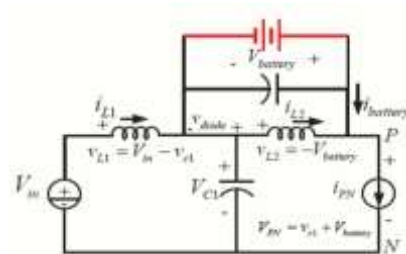MODE A-ACTIVE STATE (or) NON-SHOOT THROUGH STATE

Fig.3. equivalent circuit of active state

This mode will make the inverter operate in one of the six active states and two traditional zero states, which are referred to as non-shoot through state. Continuous current flows through the diode DZ and its equivalent circuit as shown in fig.3. During the interval of no-shoot through state, according to KCL, KVL the circuit equations are,

$$L_1 \frac{di_{L1}}{dt} = V_{pv} - V_{c1}$$

$$L_2 \frac{di_{L2}}{dt} = -V_{c2}$$

$$C_1 \frac{du_{C1}}{dt} = i_{L1} - i_{PN}$$

$$C_2 \frac{du_{C2}}{dt} = i_{L2} - i_{PN} - I_b$$
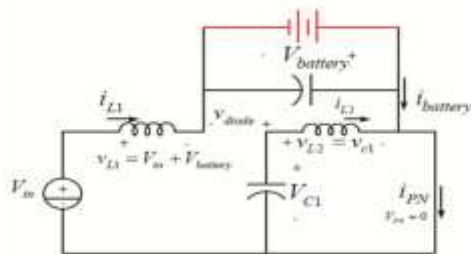
(1)

MODE B - SHOOT- THROUGH STATE

Fig.4. equivalent circuit of shoot-through state

This mode will make the inverter short circuit via any one phase leg, combinations of any two phase's legs, and all three phase which is referred to as the shoot-through state. As a result, the diode DZ is turned off due to the reverse – bias voltage .its equivalent circuit is shown in fig.4.

Where i_{L1}, i_{L2} and IB denotes the currents of inductors L_1 and L_2 and the battery respectively. V_{c1}, V_{c2} and V_{in} denote the voltages of capacitors C_1, and C_2 and the PV panel respectively denotes the capacitance of capacitors C_1 and C_2, and L denotes the inductances of inductors L_1 and L_2.

$$L_1 \frac{diL1}{dt} = V_{pv} + V_{c2}$$

$$L_2 \frac{di_{L2}}{dt} = V_{c1}$$

$$C_1 \frac{du_{C1}}{dt} = -i_{L2} \qquad (2)$$

$$C_2 \frac{du_{C2}}{dt} = -i_{L1} - I_b$$

The PV panel output power is calculated as,

$$P_{pv} = V_{pv}.I_{pv}.I_{L1}.V_{pv} \ (3)$$

Assuming the voltage of battery is constant, the power of the battery is calculated as,

$$P_{battery} = I_{b.}V_b = I_b.V_{c2} = \frac{D}{1-2D} V_{pv}.I_b \ (4)$$

Neglecting the loss of inverter, the load power is equal to power flow on DC side of inverter, which can expressed as,

$$P_{load} = V_{PN}.i_{PN} = (1-D).V_{PN}.i_{PN} = \frac{1-D}{1-2D} V_{pv}.i_{PN} \ (5)$$

From above equations, we can get power relationship in the system is

$$P_{pv} - Pl_{oad} = P_{battery} \ (6)$$

There are three power modes in this system ,when input power is larger than output power, the battery is charged ,thus is $i_{L2}>i_{L1}$, when the input power is less than output power, the battery discharged, thus $i_{L2}<i_{l1}$, when input power is equal to output power, there is no power flow in the battery (i.e.). $i_{L2}=i_{L1}$.

IV.RESULTS

The proposed structure is simulated for Z-source inverter using MATLAB/Simulink 7.10 and sim power system toolbox the inductances value is L=10mH and capacitance value is c=10000uF.

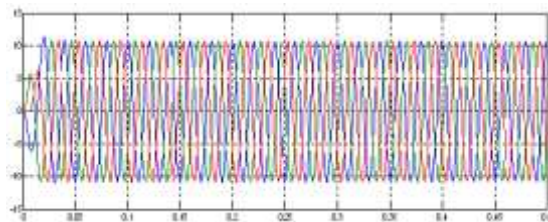In case for higher DC input voltage L & C value has to be changed as per output voltage requirement.
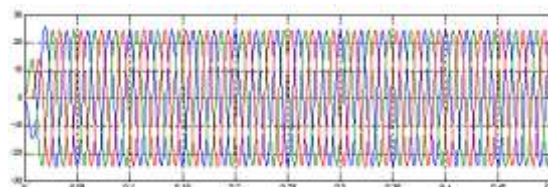

Fig.5(a).output voltage without battery

Fig.5(b). output voltage with battery

From this result,
DC input voltage(Vdc)=12V
AC output voltage(WITHOUT BATTERY)=12V ; AC output voltage(WITH BATTERY)=24 V
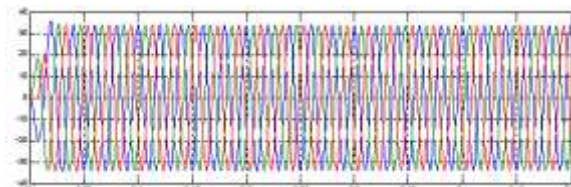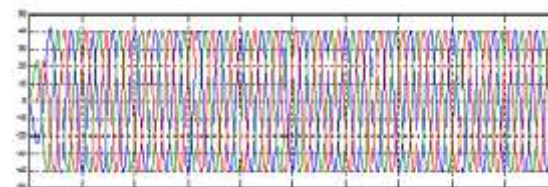

Fig.6(a).output voltage without battery

Fig.6(b).output voltage with battery

From this result,
DC input voltage(vdc)=36V
AC output voltage(WITHOUT BATTERY)=36V ; AC output voltage (WITH BATTERY)=42V

From above results, the DC input voltage from panel is converter in to AC by means of inverter and boosted with help of battery to get desired AC voltage and it delivers in to a grid/load

From the simulation, it is observed that the Z source network with battery maximize the output voltage.

Tab.1 Comparison of output voltage with and without battery

input DC voltage	WITHOUT BATTERY		WITH BATTERY	
	Input voltage 1 scope	Output 3 phase voltage	Input voltage 1 scope	Output 3 phase voltage
12v	16	12	36	24
24 v	34	24	46	32
36 v	52	36	60	42

V.CONCLUSION

In this research work, a new methodology for energy –stored QZSI has been proposed to conquer the drawback of existing solutions in PV power system. The theoretical analysis and simulation results show in this work clearly express the proposed energy- stored QZSI the battery operation can balance fluctuation from PV panel and supply the continuous power to the grid/load whenever PV panel cannot produce the power due to some low irradiation. There are three power sources/consumers, i.e., PV panels, battery and the grid/load. As long as dominant two power flows, the third one automatically meets the power differences. So, these proposed energy stored quasi z-source inverters (qzsi) have some new entrancing advantages more suited for applications in PV system. This will create PV system simpler and lower cost.

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