Energetic PV Cell Based Power Supply Management Using Modified Quasi-Z-Source Inverter

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Abstract— This paper presents a photo voltaic cell based power supply management using modified quasi-z-source inverter. The quasi-z-source inverter (qzsi) is a single stage power converter derived from the z-source inverter topology, employing an impedance network which couples the source and the inverter to achieve voltage boost and inversion in a single step. The main advantages of the inverter are it will minimizes switching ripples, reduced component count, lower component ratings and simplified control methods. From the PV panel, QZSI draws a continuous constant current. It controls the PV panel output power to maximize energy production; it can boost the input voltage by utilizing extra switching state the shoot through state technique. The system simulation confirms the performance of the proposed system.

Index Terms— Pv cell, Quasi-z-source inverter, z-source network, active state, shoot through state, simple boost control method,

1 INTRODUCTION

The usage of electric energy is increasing rapidly due to the global population growth and industrialization. This increase in the energy demand needs electric utilities to increase their generation. In order to cope up the increasing energy consumption, fossil fuels soaring costs and exhaustible nature and worsening global environment have created a booming interest in renewable energy generation systems, one of which is photovoltaic. Such a system directly converts the solar radiation into electric power without hampering the environment. The worldwide installed photovoltaic power capacity shows nearly an exponential increase due to decreasing costs and to improvements in solar energy technology [2].

. Z-source and its derived topologies could be applied in many application areas, such as fuel cell, photovoltaic and wind power generation system, hybrid electric vehicle, etc. [3]-[7]. The voltage of the pv cell varies widely with temperature and irradiation, but the traditional voltage Source Inverter (VSI) cannot deal with this wide range without over- rating of the inverter, Because the VSI is a buck converter whose input dc voltage must be greater than the peak ac output voltage. Due to this a transformer and/or a dc/dc converter is usually used in PV applications, in order to cope with PV voltage range, reduce inverter ratings and to produce a desired voltage for the load or connection to the utility. This leads to a higher component count and low efficiency, which opposes the goal of cost reduction. Recently four new topologies of the quasi-Z-Source Inverters (qzsi), have been derived from the original ZSI. By the implementation of the new quasi-Z-Source topology, the inverter draws a constant current from the PV array and is capable of handling a wide input voltage range and which in turn reduces the stress in the inverter switch.

The proposed topology has good load characteristics, which can be can suitable for wide range of load, from no-load, light load to heavy load, and more relevantly , it can not only power purely resistive, inductive or capacitive load, but also can remove inductive load during operation[1].

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2. SYSTEM DESCRIPTION

Fig. 1 shows the circuit structure of the proposed ac power supply which based on quasi-Z-source inverter topology. It splits in to three parts: pv module, quasi-Z-source network and single-phase inverter bridge. The DC source to the quasi z source inverter can be taken as from a PV array. The proposed circuit involves impedance network having inductances L_1, L_2 and capacitances C_1, C_2 and the inverter module contains IGBT switches with an anti parallel diodes.

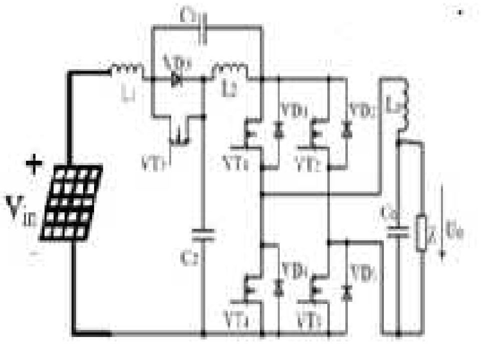

Fig 2.1 Circuit diagram for the proposed topology

Here the controllable device VT_5 is used to deal with light load for discontinuous operation, it could be an IGBT or a Power MOSFET, and we can take an IGBT module which composed of an IGBT and an anti-parallel diode to replace discrete components, the IGBT be in the on state when inverter were operating in the non-shoot through mode and traditional zero state, and power module will be in off state when the inverter operates in the shoot through state. Under light load condition, in a primary voltage-fed quasi-Z-source inverter which only have the diode, it will become inactive when current through it will reduces to zero, which results in the open circuit between Z-network and DC power supply. It leads to the output voltage to be not consistent. Due to the presence of the controllable device an opposite current will flows in the circuit, in turn makes the circuit active.

Because of the advantages of quazi-z source inverter, it is suitable for power conditioning in renewable energy systems. As the PV cell's voltage varies widely with temperature and irradiation, through proper control continuous dc voltage can be obtained as pv array output. By the quasi-Z-source topology, the inverter draws a constant current from the PV array and is capable of handling a wide input voltage range.

MODES OF OPERATION

In QZSI, there are three modes of operations: a) active state mode. b) Traditional zero state mode and c) shoot through mode. Which has two active states, two traditional zero states and three shoot through states

A) ACTIVE STATE

In this mode, one of the upper switches and one of the lower switches of different legs are turned on and thus power will flows to the load. Here the capacitor voltage is equal to input voltage. There will be no voltage across the inductor since only pure DC current is flowing through inductor.

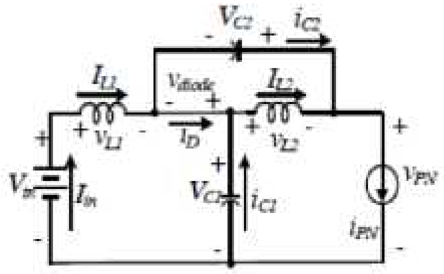

Fig 2.2 Active state

B) TRADITIONAL ZERO STATE

In this mode, Upper or lower two switches are turned on and power does not flow to load. During this mode, inductor current decreases linearly and voltage across the inductor is difference between input voltage and capacitor voltage.

C) SHOOT-THROUGH ZERO STATE

In this mode, the switches of same leg or total switches are turned on.

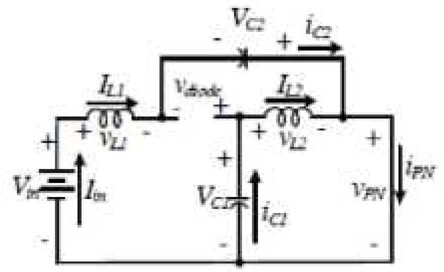

Fig 2.3 shoot through zero state

During this mode inductor current increases linearly and voltage across inductors is equal to voltage across capacitors. Thus these capacitors charge the inductors and current through the capacitor is equal to the current through the inductor. In this state, the switches of an inverter bridge leg or two inverter bridge legs are turned on simultaneously. In the traditional zero state, the upper or lower two switches are turned on simultaneously and the power does not flow to the load. In this case, the output is an open circuit and we can look it as a zero value current-source. Then we can integrate the active states and traditional zero states in to a single state-non-shoot-through state-and assuming that during one switching cycle, T, the interval of the shoot through state is T_0 ; the interval of non-shoot-through states is T_1 ; thus one has $T = T_0 + T_1$ and the shoot-through duty ratio, $D = T_0 / T_1$.

During the interval of the non-shoot-through states, T_1

$V_{L1} = V_{in} - V_{C1}$, $V_{L2} = -V_{C2}$ (2.1)

During the interval of the shoot-through states, T_0,

$V_{L1} = V_{C2} + V_{in}$, $V_{L2} = V_{C1}$ (2.2)

$V_{PN} = 0$, $V_{diode} = V_{C1} + V_{C2}$ (2.3)

At steady state, the average voltage of the inductors over one switching cycle is zero.

$V_{PN} = V_{C1} - V_{L2} = V_{C1} + V_{C2}$, $V_{diode} = 0$ (2.4)

To a same output voltage Vo, a larger m will correspond to a lower B, and this will decrease the voltage stress of the power switches. Due to the average voltage of the quasi-Z-network inductors L_1 and L_2 should be zero in a switching period, from the same deduct process, based on (1) and (2), we can obtain the average voltage of the quasi-Z-network capacitors C_1 and C_2,

$V_{C1} = -Vin*T0/(T1-T0) = -Vin*D/(1-2D)$. (2.5)

$V_{C2} = Vin*(1-T0)/(T1-T0) = Vin*(1-D)/(1-2D)$. (2.6)

The minus of V_{C1} indicates the actual polarity of the voltage of capacitor C1 is opposite to that of actual ,we can find that the voltage rating of one of the quasi-Z-network capacitors is decreased, compared to the case of voltage-fed Z-source inverter, this will make the whole system have less volume and weight. The value of shoot-through zero-state duty cycle D is related to the control method of the inverter.

CONTROL STRATEGY

SIMPLE BOOST CONTROL METHOD

There are many control methods to realize the control of quasi-Z source inverter, commonly such as simple boost control and maximum boost control that based on the traditional sinusoidal-PWM (SPWM) control, space vector PWM (SVPWM) control, etc. In simple boost control method, two constant voltage signals which are compared with the high frequency carrier wave. Whenever the magnitude of carrier wave becomes greater than or equal to positive constant signal or lesser than or equal to the negative constant signal, pulses are generated and they control the shoot through duty ratio.

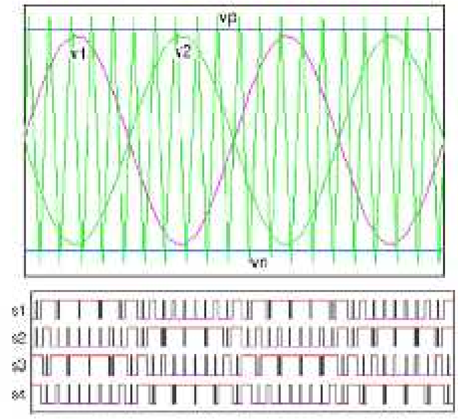

Fig 2.4 control signals for inverter

Whenever the triangular carrier signals is higher than the positive straight line or lower than the negative straight line, the inverter will be operated in shoot-through, otherwise, it works as a traditional PWM inverter. Simple boost control method used to control the shoot through duty ratio. The shoot through duty ratio is given by D.

$D = (T_o/T_o+T_1)$ (2.7)

From equation 4.1, duty ratio is the ratio of on time to the total time. For simple boost control, the obtainable shoot through duty ratio decreases with the increase of modulation index. The maximum shoot through duty ratio of simple boost control is limited to (1-m), where m is the modulation index. Voltage gain is given as:

$V_0/V_i = mB = m / 2m-1$ (2.8)

To simplify the control circuit and decrease switch voltage stress, the DC voltage value often chosen should be equal to the peak value of the ac modulation wave; in this case, it is easy to find that m + D =1, and the shoot-through zero- state duty cycle D is a constant value.

3 SIMULATION RESULTS

In the fig 5.1, it shows the simulink model for quazi-z source inverter based PV system. The proposed system is verified with MATLAB/SIMULINK version 2013. The simulation results conforms the boost function and characteristics of the presented quasi Z-source inverter-based ac power supply. The parameters taken are given in the below table.

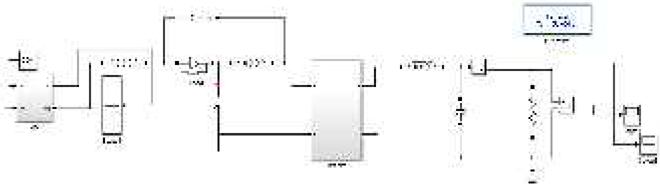

Fig 3.1 simulink model

TABLE.2

PARAMETERS FOR SIMULINK MODEL

SI NO	PARAMETER	PARAMETER VALUE
1	Input voltage	80 V
2	Z network components	$C_1 = C_2 = 10uF$ $L_1 = L_2 = 3mH$
3	Output filter components	L = 60mH C = 300uF

PV voltage, control signal for the inverter and output voltage has been shown below,

Fig 3.2 pv output voltage

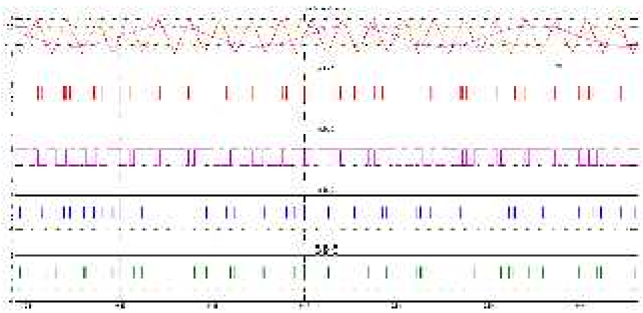

Fig 3.3 control signals for the inverter

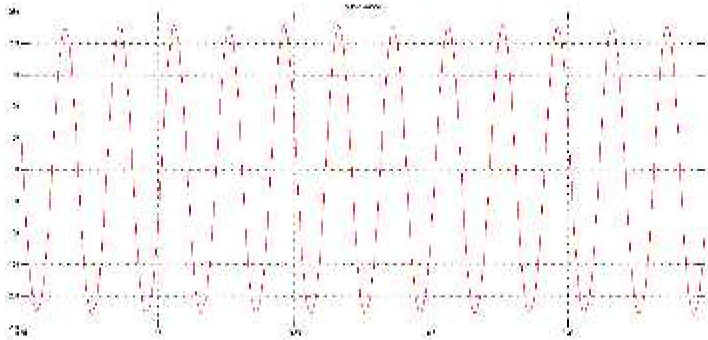

Fig 3.4 output voltage

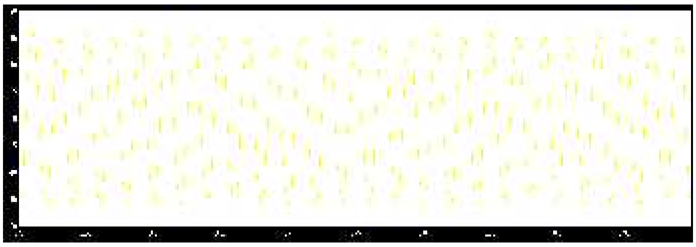

Fig 3.5 output current

4 CONCLUSION

In this proposed system, Energetic PV Cell Based Power Supply Management Using Modified Quasi-Z-Source Inverter has been implemented, which has been most suitable for light and heavy load conditions. The proposed system with minimum voltage stress of power switches is being investigated.

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