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Analysis of Sine Carrier PWM Strategy of Quasi Z Source inverter for High Gain Photovoltaic Application

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ABSTRACT: The world is being attracted towards the application of Photovoltaic, an eco-friendly energy source. Power converter is a crucial component in the photovoltaic system. Quasi Z source inverter (QZSI) is a unified power converter which uses shoot-through state for voltage boosting. Photovoltaic based system requires higher gain. Various modulation schemes are available for QZSI. Sine carrier Pulse Width Modulation control technique is employed in the proposed system for controlling inverter which compares output frequency sine wave reference with high frequency sine wave carrier. This method improves overall gain of the system without reducing modulation index.

KEYWORDS: Quasi Z source inverter (QZSI), Photovoltaic (PV), Sine carrier PWM, MPPT

I.INTRODUCTION

Renewable energy sources such as Solar, Wind, Fuel cell, tides are attractive alternatives of traditional energy sources and therefore becoming popular day by day. Due to the low cost, availability and improvement in technology Solar / Photovoltaic energy system is becoming dominant.

Inverter is the key component in such Photovoltaic based system. Traditional voltage source inverter (VSI) and current source inverter (CSI) can be used for such systems to step down and step up input voltage respectively; however, such converters cannot retain these two features together. To resolve this trouble Quasi Z source inverter (QZSI) was developed. It incorporates all the benefit as Z source Inverter with some more features such as constant current drawing from PV array, lower component rating, wider input voltage range capability, reduced stress compared to ZSI Because of such mentioned features, QZSI is becoming attractive choice to interface with renewable energy sources.

For proposed system, a sine carrier pulse width modulation (PWM) scheme is utilized in which instead of the conventional triangular carrier wave, a high frequency sine wave is used as carrier. Maximum power point tracking technique upgrades the performance of the Photovoltaic panel. By changing the duty cycle of the Quasi Z source inverter appropriately the source impedance is matched with that of the load impedance. Figure 1 presents basic block diagram of Proposed system.

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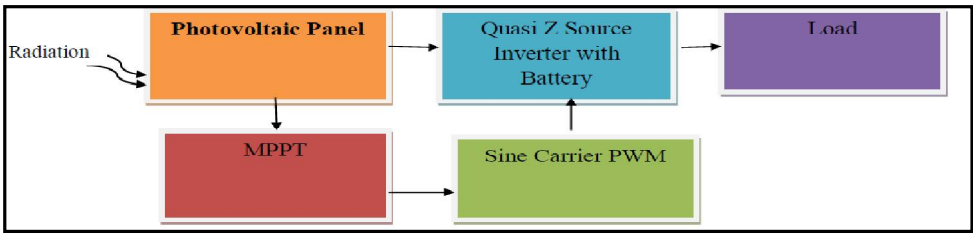

Fig 1 Basic Block diagram of Proposed system

II.PHOTOVOLTAIC PANEL AND MPPT

A photovoltaic cell converts sunlight energy into electricity using its Photoelectric effect. Single Photovoltaic cell can generate power around one watt. Therefore for obtaining higher output power, Photovoltaic cells are connected in series and parallel combination and encased in a tight package which is known as a solar module. These solar modules are then connected in serial and/or parallel with one another in a thousand of numbers which forms solar array. Hundreds of Solar array are combined to constitute large scale PV systems. The characteristics of PV cell changes with the solar radiation and temperature. The output power is directly proportional to the irradiance. As Solar irradiance increases, current value increases at that time voltage variation is minimal. Output current is affected by Irradiance and the terminal voltage is affected by temperature.

Maximum power point tracking is implemented to obtain Maximum power from PV panel. Maximum power point tracking, which is commonly known as MPPT upgrades the performance of the Photovoltaic panel. MPPT varies the electrical operating point of the PV module so that maximum available power can be obtained. There are the various MPPT methods available such as, Perturb and observe, Incremental conductance, Parasitic capacitance, Voltage based peak power tracking, and Current based peak power tracking. In this system Perturb and Observe (P&O) MPPT algorithm is interfaced with Photovoltaic panel.

III.QUASI Z SOURCE INVERTER

In the proposed system the topology of QZSI is chosen in which an energy storage device is added to it without any auxiliary components by employing its exclusive input impedance network. QZSI with energy storage topology provides continues input current. The topology of Battery assisted QZSI which is used in this proposed system is presented in [1] as shown in Figure 2.
Similar to ZSI, QZSI topology has Short-circuit (shoot-through) and Non-short-circuit (non-shoot through) / Active modes of operation.

Shoot-through / Short circuit mode takes place when both the power switches being ‘ON’ simultaneously in one or more leg which leads voltage increment in the system. Equivalent circuit of this mode is shown in Figure 3. During this mode, voltage at the input of the inverter or Output DC from impedance network increases while output voltage at load terminal is zero. DC link voltage which appears across inverter input terminal is raised by a boost factor. The value of Boost factor depends on the shoot through duty ratio for a given modulation index. To obtain voltage boost, shoot-through state should always be followed by an active state.

In Active mode inverter will be operated as conventional Voltage source inverter and therefore any of six active states and two traditional zero states will take place which is called as the non-shoot-through/active state. A continuous current flows through the diode Dz, and its equivalent circuit is shown in Figure 4.

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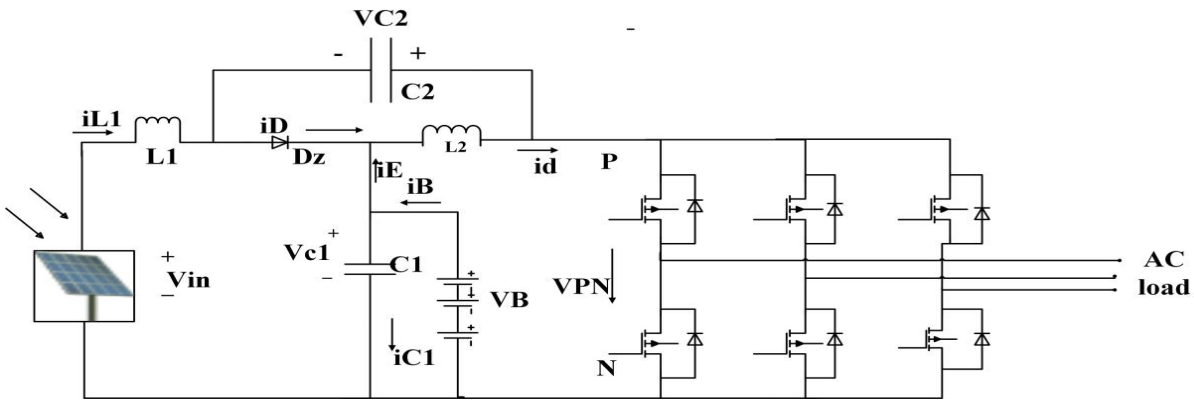

Fig 2 Quasi Z source inverter with Battery topology

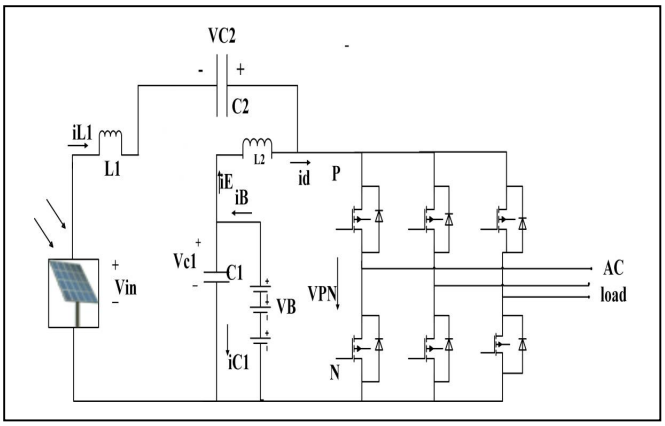

Fig 3 Shoot-through state

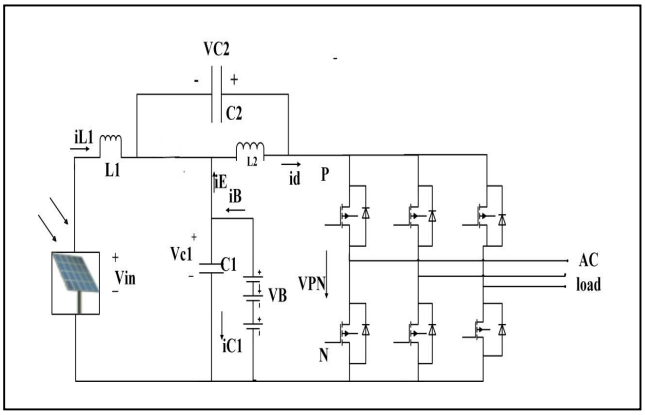

Fig 4 Active state

IV. SINE CARRIER PWM

Pulse width modulation (PWM) strategies of inverters regulate output voltage and frequency. QZSIs have additional shoot-through switching states which is not present in traditional VSI. Therefore, PWM techniques used for controlling ZSI and QZSI are slightly different compared to the techniques used for traditional VSI.

PWM methods of ZSI / QZSI are further classified in three strategies based on the Shoot-through state value.

1) Simple Boost Control

Shoot-through state is implemented as two straight lines. The amplitude value of the shoot-through line should be higher than or equal to the reference sine wave.

2) Maximum Boost Control

In the Maximum boost control method all classical zero states are changed into shoot-through state.

3) Maximum constant Boost control

The shoot through duty cycle should be preserved constant in this strategy. The upper and lower shoot-through values should be regular so that duty cycle will be constant.

In the proposed system, Simple Boost Control method is taken up.

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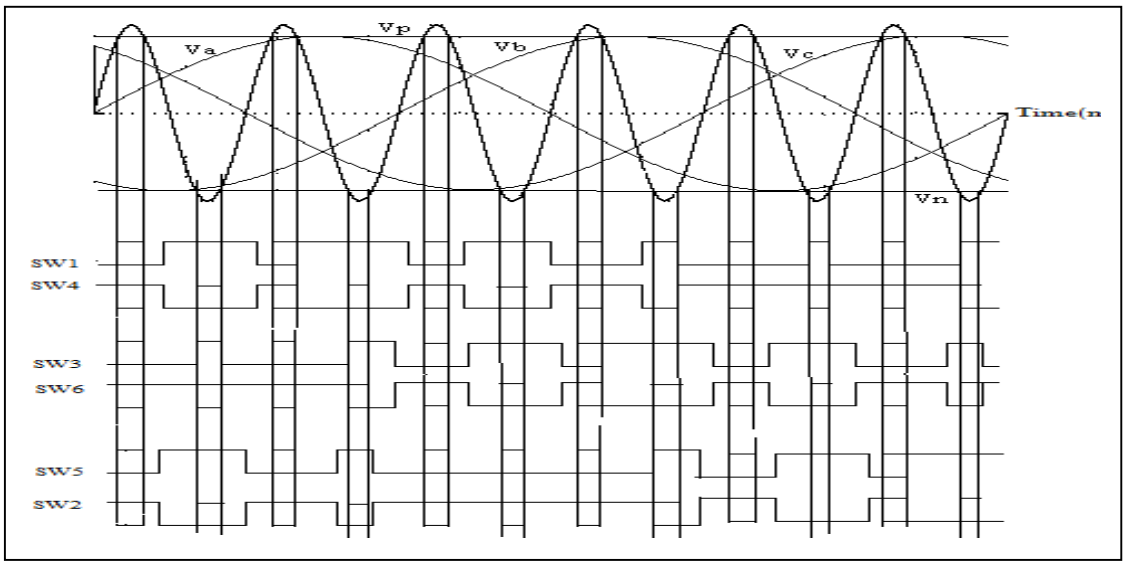

Fig 5 Sine carrier PWM

A Sine carrier PWM control strategy for proposed system has been selected in which carrier is taken as high frequency sine wave instead of high frequency triangular wave as in case of classical Sinusoidal PWM method. For maintaining the shape of output voltage waveform, shoot-through states are put in place of zero modes of conventional VSI and the active states should continue to be unchanged.

The simple boost control method is taken here as controlling technique which constitutes two constant voltage envelopes as shoot-through levels which are then compared with the sine carrier wave. For the generation of Active states sine carrier waves are compared with sine wave modulating signal. These pulses fire the switching devices of the inverter. Figure 5 represents sine carrier PWM. The amplitude value of the shoot-through line should be higher than or equal to the reference sine wave. Whenever the carrier signal value is greater than the
positive straight line or lower than the negative straight line, the shoot-through pulses will be generated.

Voltage Gain (G) of QZSI can be mathematically represented as,

$$G = \text{Output AC voltage} / \text{Input DC link voltage} \quad (1)$$

$$\text{Output AC Voltage} = Vac = M * B * (Vs/2) \quad (2)$$

$$\text{Input DC link Voltage} = Vlink = Vs / 2 \quad (3)$$

Where, V link = DC link voltage
V ac = Output AC voltage
M = Modulation Index
B = Boost Factor

When a triangular wave is utilized as carrier, the shoot- through duty ratio, boost factor and voltage gain are described as,

$$D0 = 1- M \quad (4)$$

$$B = 1 / (2M-1) \quad (5)$$

$$G = M / (2M-1) \quad (6)$$

From above equations it is concluded that by reducing modulation index M duty ratio can be improved; however, it increases voltage stress on the switch and restricts the gain.

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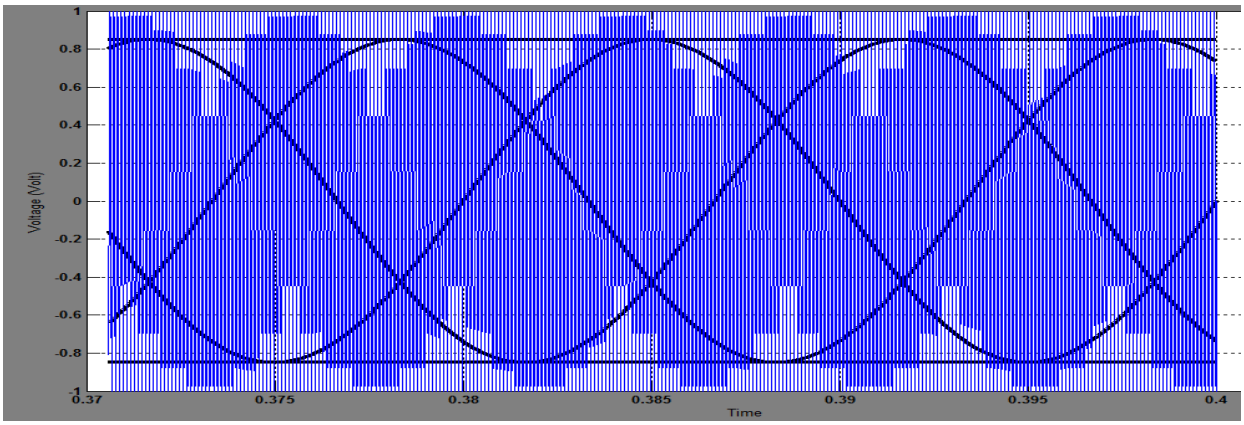

Fig 7 Three modulating signals and shoot-through level comparison with carrier

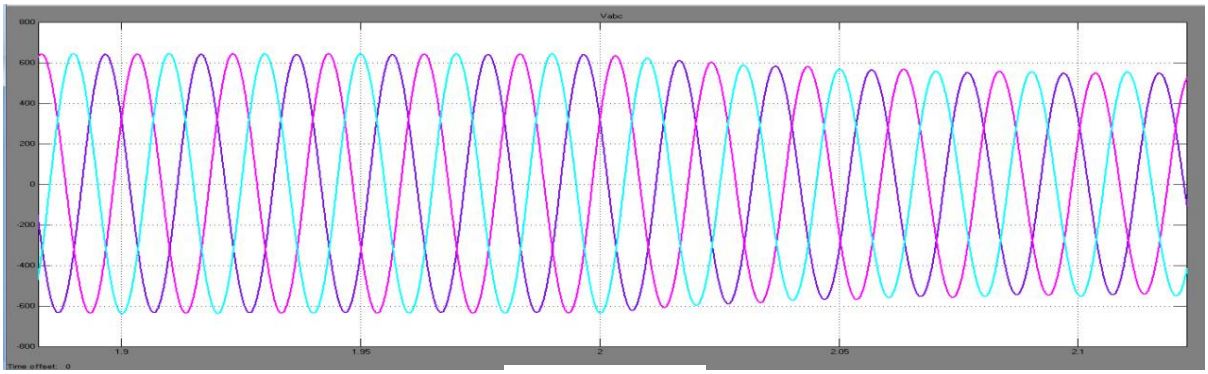

Fig 8 Three phase voltage for Triangular carrier Method

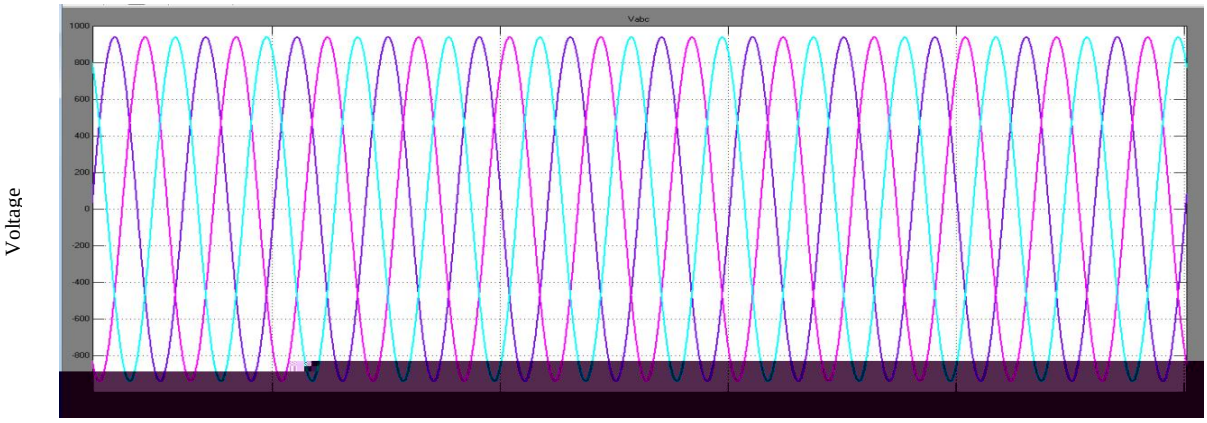

Fig 8 Three phase voltage for Sine carrier Method

VI.CONCLUSION

QZSI is becoming attractive choice in Photovoltaic based system due to its exclusive benefits over other inverters. PV array has been simulated and applied as a source of input to the QZSI. Maximum power point tracking system using

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perturb and observe method is integrated in the system which generates shoot-through duty ratio. Energy storage device is connected across capacitor C1 which maintains output voltage constant when variation occurs in Solar irradiance. PWM generation method employed here is Sine carrier PWM method which employs sine wave as carrier and modulating signals produces higher gain compared to traditional PWM method.

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