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Investigation of Sst Pwm in qZSI

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ABSTRACT

This paper presents an analysis of single phase Quasi Z-Source (qZS) Inverter based grid connected system. Quasi Z-Source DC to DC converter consists of unique impedance network which consists of inductors and capacitors. To boost DC voltage, traditional boost converters were used. But it has many disadvantages like dual stage converter, complexity in control, losses are high. On the other side the quasi-Z-Source Inverter (qZSI) is an alternative converter that can boost the input voltage. It has many advantages like single stage conversion, lesser losses, reduced component rating as well as size of components and provides continuous input current. Quasi-ZSI provides boost capability with single stage conversion which ultimately reduces the switching losses. qZSI allow the shoot through state which is responsible for the boosting of the input voltage to the higher values and avoids the risk of damaging switches in converter circuit to make the circuit more reliable. Theoretical analysis of boosted voltage and control methods for the qZSI system are investigated in this paper. Both simulations and theoretical analysis will be presented to demonstrate the proposed concept.

Keywords: Quasi-Z-Source Inverter (qZSI), DC to DC converter, shoot through state, PWM

I. INTRODUCTION

With the increasing use of renewable source of energy, the fossil fuels are on edge of its extinction. Because of which the concern about the non-renewable energy sources, constant increase in fossil fuel prices, global warming damage to environment and ecosystem, and the renewable energy is becoming more popular and is gaining more attention as an alternative to non-renewable energy sources [2]. Among the renewable energy sources, the photovoltaic energy is considered to be the most promising energy resource as compared to other types of energy sources such as wind, tidal etc. The output obtained by the PV system is unregulated DC which is of small capacity power source at the customer site at distribution voltage levels. Therefore, DC converters are used for boosting up of unregulated DC voltage obtained by the PV module to a regulated suitably higher voltage levels to supply power to the load [3]. Conventional PWM inverters are of buck type inverters and require additional power stage to boost the voltage from the renewable source. Hence, complexity in control, losses are high, stresses on the switch increases which makes the system less efficient [4]. Therefore, there is a need to develop buck- boost type inverters for renewable energy based DG system. For applications requiring both buck and boost power conversions, z- source inverters based topology has been proposed earlier. But the control complexity is an issue when the ZSI is used in a back-to- back configuration due to the coupling of the inverter switching functions. Also the total harmonic distortion obtained is high [8]. Therefore, the advanced topology, quasi-z source based grid connected system is to be investigated over conventional methodologies.

In case of ZSI impedance source network, the sine PWM (SPWM) pattern, which is symmetrical by its nature, the symmetry is not preserved due to the addition of a shoot- through state, which generates lower order harmonics [5]. In this paper, the concept of Symmetrical Shoot-Through based PWM, in which sinusoidal shoot-through state is additionally inserted so as to preserve the sinusoidal nature of the SPWM which further reduces the THD, of the voltage waveform generated at the output [9]. Decoupled control ensures nearly independent control of the DC side controller and AC side controller. The DC side controller is used to track the maximum power point in Photovoltaic generation. The AC side controller is used to regulate and fed the necessary power to the grid. In this paper, using a symmetrical shoot through based PWM the Quasi Z-source based grid tied inverter is investigated [8].

II. PROPOSED QUASI-Z-SOURCE BASED CONVERTER BASED GRID TIED INVERTER SYSTEM

The given proposed scheme is qZS converter which is shown in Figure 1. It is similar to the VSI; the only difference is it consists of qZS impedance network connected after the DC source. The impedance network is the combination of capacitors (C_1, C_2), inductors (L_1, L_2) and diode D.

Unlike the traditional voltage source or current source inverter, the qZ-Source inverter has a unique impedance network. This LC impedance network is coupled with an inverter which boosts output capability of the qZSI. The single phase qZSI consists of five switching states given as follows:

1. Two active
2. Two zero and
3. One shoot through state.

Out of these, the shoot through is the unique state which is responsible for the buck-boost capability of qZSI.

The shoot-through zero state is not applicable in the traditional V-source inverter, because it would cause a short- circuit or damage the system. With the help of LC network, the qZ-Source Inverter is capable to use the shoot through state to boost the voltage. In addition, with the ability to handle the shoot through state, the inverter system becomes more reliable.

The impedance LC network helps the inverter from damage during the shoot-through state

or any fault occurs. During shoot-though state the input voltage gets boosted to the higher values and it is controlled through the shoot through signal.

During non-shoot through state, the inverter operates normally as a traditional voltage source inverter (VSI). Where the two opposite switches of an inverter operates simultaneously. Total time period (T) will be the sum of both shoot through state time (T_1) and non-shoot through state time (T_2). Shoot-through duty ratio D can be given as D = T_1 T . For qZS network, let assuming identical values of inductances L_1, L_2 and identical values of capacitances C1 and C_2.

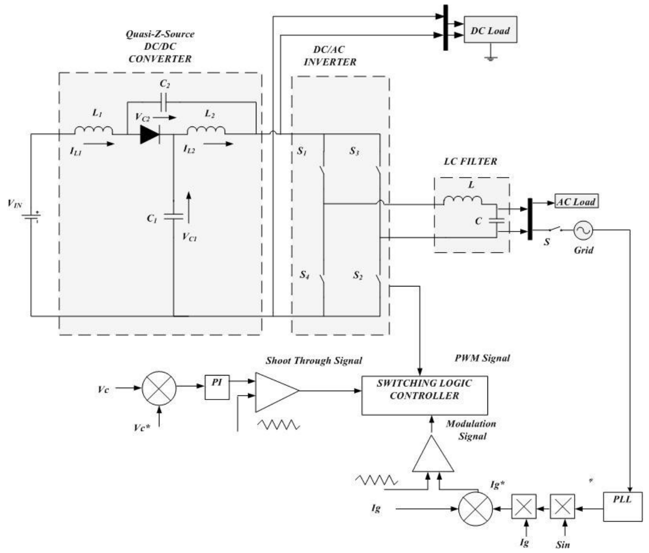

Figure 1. Block Diagram of AC and DC Hybrid System Using qZSI

As the input DC voltage is not constant in nature, the DC side control loop consists compared with a reference value, and this error quantity is given to the PI controller, which eventually, generates the modulation signal for inserting the shoot-through in, the zero states. Thus, the DC link voltage is controlled effectively, by modulation of the shoot-through duty ratio. The AC side control loop involves the control of AC side voltage with reference generation for generating the modulating signal. This control employs a comparison of the output voltage with, a reference voltage, and this compared output is given to a PI controller which will generate the modulating signal and with the help this modulating signals, we can generate the PWM signals. of a DC link voltage in order to maintain a constant voltage across the inverter. The qZ-source capacitor voltage which is input to the inverter needs to be regulated in order to regulate the DC link voltage. The variations in load voltage is happened because there is variations in DC link voltage, these variations in the DC link voltage will occur due to change in input DC voltage. Thus, the DC link voltage must be regulated. For this, the qZ-source capacitor voltage is taken as the controlling quantity. This voltage is Figure 4: Waveform of SST The logic diagram for the generation of a modulating signal pulses is shown in Figure 4. The shift h in a carrier wave is given by DC side controller and the modulating signal M is given by the AC side controller. The two carrier signal is in upward direction and downward direction which is shifted by h/2 value using the summing amplifier. Upward shifted carrier is compared with modulating signal to produce a PWM signal of first leg upper switching device S1 and the complement of this signal provide the PWM signal of second leg upper switching device S3 . Similarly, downward shifted carrier waveform is compared with a M (modulating signal) to produce PWM signals of lower switching devices S2 and S4 . Hence necessary shoot-through states are produced by using this shifted carrier approach logically.

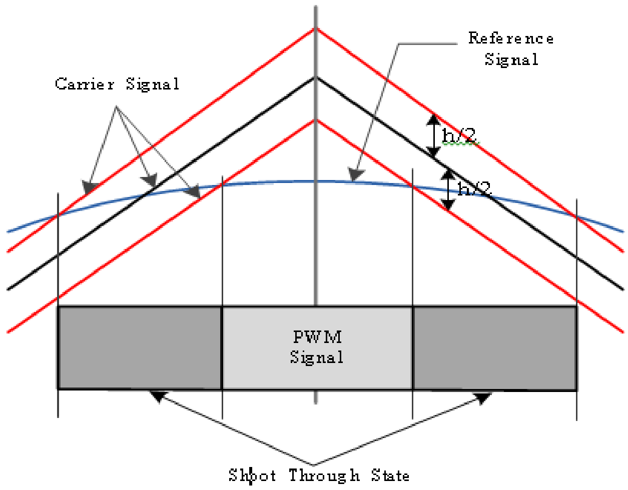

Figure 2

III. Simulation results

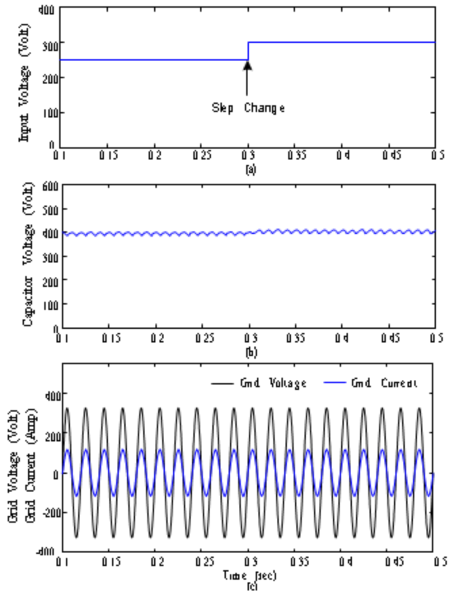

Figure 3. Simulation result for step change in voltage from 250V to 200V (a) Input voltage (b) Capacitor voltage (c) Grid voltage and current (scaled by x 10)

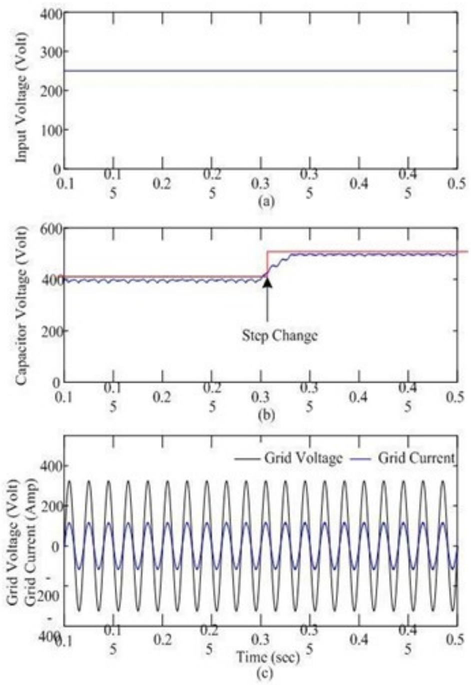

Figure 4. Simulation result for step change in capacitor voltage from 400V to 500V (a) Input voltage (b) Capacitor voltage (c) Grid voltage and current (scaled by x 10).

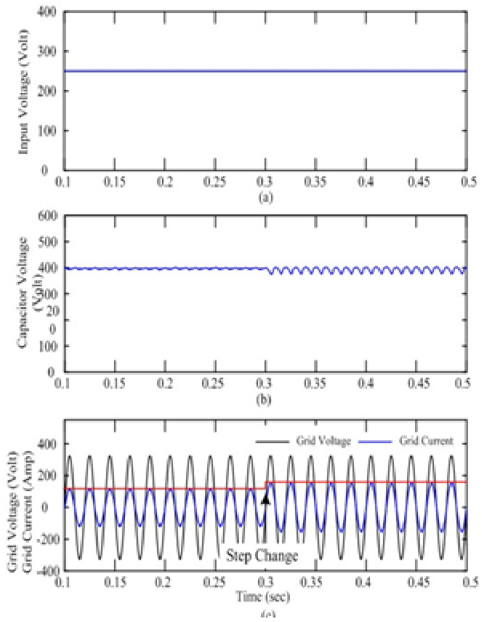

Figure 5. Simulation result for step change in current from 5A to 10A (a) Input voltage (b) Capacitor voltage (c) Grid voltage and current

IV. Conclusion and Future scope

A symmetrical shoot through based PWM method for a Quasi-Z-Source Inverter has been investigated experimentally and presented in this paper. From simulation results it is found that by inserting a symmetrical shoot through state using PWM the total harmonic distortion has been reduced as compared to the existing PWM methods. This paper also demonstrates, a simple carrier shifting method for the implementation of this symmetrical shoot through PWM. The Quasi-z source based inverter topology presented in this paper provides several advantages when compared to the traditional ZSI. These advantages include reduction of passive component ratings, reduced component count, and improved input efficiency of the system. Both, the simulation and experimental results are compared and analyzed which confirm the theoretical analysis. The dynamic response of the DC as well as AC side controllers with the proposed

PWM is validated over different operating conditions.

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