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Performance Analysis of Dual Loop Z-Source Inverter

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Abstract: This paper presents a performance analysis of dual loop z-source inverter (ZSI). Z-source inverter is controlled by dual loop control strategy. Such as outer voltage loop and inner current loop are taken into consideration. The peak dc-link voltage is estimated by measuring both the input and capacitor voltages. Many Pulse Width Modulation (PWM) techniques are analyzed for the conversion among that it has been proven that Maximum Constant Boost Control PWM is a best method. Maximum constant boost control method is used to produce the shoot through states (ST).With this proposed method distortion in output voltage and stress in switch can be reduced. A high performance language for technical computing MATLAB is used here to implement the concept.

Index terms: *Z-source inverter, dual loop control, shoot-through, Pulse width modulation*

I. INTRODUCTION

The impedance (Z-source) source power converters and its control methods are developing technology for power electronics converters. The Z-source network (circuit) consists of two inductors and two capacitors connected in a special arrangement to form a two-port impedance network. Based on this unique Z-source network, several power converters/inverters have been presented to overcome the limitations and problems of the traditional voltage-source and current-source converters, to provide the advantageous buck and boost function, and to improve reliability and performance. The Z-source network proposed in Figure can be short- and open-circuited on either side. Therefore, the Z-source concept can be generalized as to provide a two-port network (or circuit) that can be short-and open-circuited at any time according to operation needs.

The ZSI topology has been greatly explored from various aspects, such as ST control methods designing of the Z-network elements. Various types of control methods are simple boost control (SBC), maximum boost control, and maximum constant boost control (MCBC), and modified space vector modulation boost control (MSVMBC). The MCBC method is the most suitable ST control methods for different ZSI topologies. The MCBC requires less inductor value and results in less switch voltage stress, less output current total harmonic distortion, better Z-network behavior, high obtainable ac output voltage and higher efficiency.

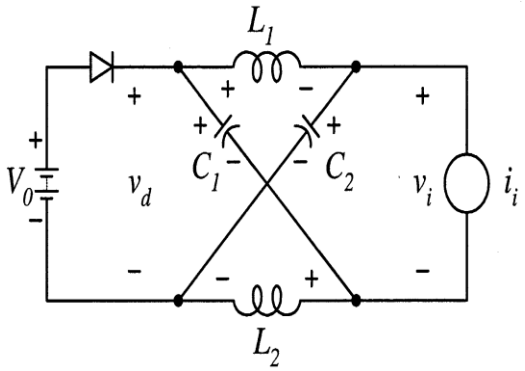

Fig 1 ZSI structure

The various control strategies for the control of the z-source inverter are single loop control and dual loop control. However the single loop control has the following disadvantages. By controlling the capacitor voltage, the peak dc-link voltage will increase when there is a step change in the input voltage. Therefore, the ac output voltage will be distorted and the voltage stress of the switches will increase. Furthermore, the indirect control of the dc-link voltage cannot bring high performance.. The problem is that the inductor current is not regulated and can be overloaded during transient events.

A dual-loop peak dc-link voltage control technique for controlling the peak dc-link voltage for a ZSI with inductive load, where the outer voltage loop provides the inductor current reference and the inner current loop produces the ST duty ratio and the modulation index is calculated based on the MCBC method, where, the peak dc-link voltage is estimated by measuring both the input and capacitor voltages.

II. Z-SOURCE OPERATION

The traditional three phase V-source inverter has eight permissible switching states or switching vectors, i.e. six active states where a DC voltage is applied to the load and two zero states where the load is open circuit (either through the upper or lower switches). The Z-source inverter has an extra state where both the upper and lower switch in a branch is conducting at the same time, i.e. the Z-source is in short circuit (ST). The ST state might be applied in seven different ways, i.e. ST by one branch which gives three combinations, ST by two branches which also gives three combinations and ST by all three branches at once. The ST state makes it possible to boost up the input voltage. In the traditional three phases V-source inverter the ST state would destroy the switches of the inverter bridge as all the stored energy of the system would be dissipated in the switches. In the Z-source inverter the ST state has no damaging effect as the energy stored in the capacitors is transferred to the two inductors of the Z-source during this state. The extra ST state is only applied when the input DC voltage is not high enough to generate the needed output voltage. The possibility of using the ST state may influence the triggering strategy of the switches in the inverter bridge.

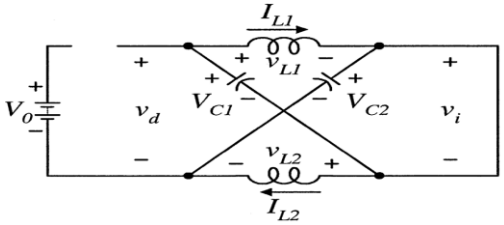

Fig 2 Z-Source inverter in Shoot-through mode

Fig 2 shows an equivalent diagram of the Z-source inverter when it is in the ST state. Fig. 3 shows the three-phase Z-source inverter switching waveform with the extra zero state (or vector) when the load terminals are shorted through both the upper and lower devices of any one phase leg (i.e., both devices are gated on), any two phase legs, or all three phase legs.

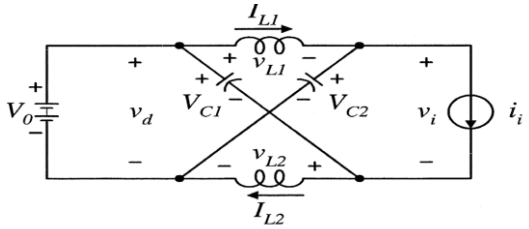

Fig 3Z-Source inverter in non-Shoot-through mode

III. CONTROL STRATEGIES

The various control strategies for the control of the z-source inverter are single loop control and dual loop control.

There are two ways to control the DC-link voltage of ZSI in single loop control

1. Indirect DC-link voltage control
2. Direct DC-link voltage control

IV. SINGLE LOOP CONTROL

A. Indirect dc-link voltage control

In the indirect control method, by controlling the capacitor voltage, the peak dc-link voltage will increase when there is a step change in the input voltage. Therefore, the ac output voltage will be

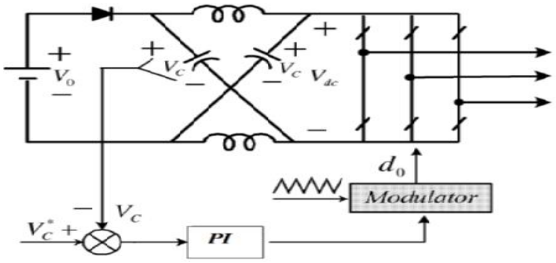

Fig4 In-Direct DC-link voltage control in z-source inverter

distorted and the voltage stress of the switches will increase. Furthermore, the indirect control of the dc-link voltage cannot bring high performance due to the nonlinear property of the Vi/VC relation.

B. Direct DC-link voltage control

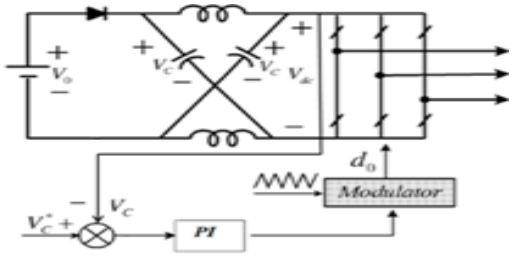

Fig5 Direct DC-link voltage controls in z-source inverter

In the direct peak dc-link voltage control method, either using an external sensing circuit with special design or simplify the inverter bridge by a single switch. In high-power converters, a single-loop voltage control has two problems. The first problem is that the inductor current is not regulated and can be overloaded during transient events and the limited stability margin is the second problem.

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V. DUAL LOOP CONTROL

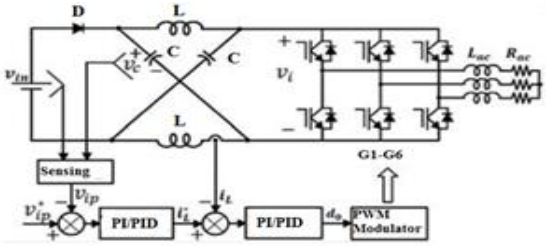

Fig 6 Block diagram for dual loop ZSI

A dual-loop peak dc-link voltage control technique for controlling the peak dc-link voltage for a ZSI with inductive load, where the outer voltage loop provides the inductor current reference and the inner current loop produces the ST duty ratio and the modulation index is calculated based on the MCBC method, where, the peak dc-link voltage is estimated by measuring both the input and capacitor voltages. PI and PID controllers are used for the voltage and current measurements.

VI. SIMULATION RESULTS

The dynamic performance of the ZSI with the proposed dual loop peak dc-link voltage control has been tested using MATLAB simulation. Two type of controllers are compared in this paper they are PI controller type and PID controller.

A. PI CONTROLLER

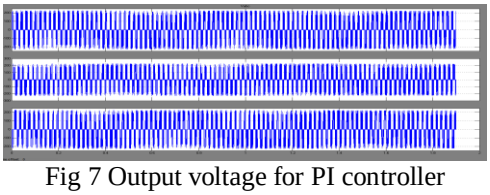

Fig 7 Output voltage for PI controller

B. PID CONTROL

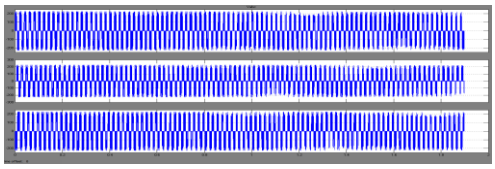

Fig 8 Output voltage for PID controller

By comparing PI and PID controller type at a particular time there is a small distortion in the PI controller. There is no distortion in the PID type controller

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VII. CONCLSION

This paper presents the performance analysis of dual loop Z-source inverter. By comparing the PI and PID controller the performance were analyzed. The outer voltage loop and inner current loop are taken into consideration. In the PID controller type distortion in output voltage and stress in switch is reduced. In a voltage and current control loop various controls are to be analyzed to get high performance.

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