Z-Source Inverter with Vector Control Strategy for Ac Drive Applications

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Abstract-

This paper concentrated on the Z-source inverter applications with reduced inductor current ripples. In order to produce the requirement here in this suggested project implemented an advanced vector control technology for the induction machine applications. The existed PWM converters are designed by the single phase shoot mechanism, in this the time intervals are spitted into six equal parts for the three legs Z-source inverter. The firing pulse generation which is very flexible and simple but in this control algorithm the harmonic content cant minimized. Because the presence of inductor ripple contents increases this causes the necessity of filter. In the filters the utilization of components required more due to this the cost increases. In the proposed model which is operated with the help of vector control method. In this approachment we can control by direct speed control mechanism or the direct torque control mechanism for the production of ripple contents were demagnetized. The simulink models are tested and verified within the MATLAB/SIMULINK models with vector control mechanism with minimized ripple contents.

Keywords — *Current ripple, pulse width modulation (PWM), single-phase shoot-through (SPST), Z-source inverter (ZSI).*

I. INTRODUCTION

THE voltage-source inverter (VSI) performs just the voltage buck change, which restrains its application in the fields with wide information voltage, for example, the renewable vitality framework. To augment the suited info voltage extend, a support converter is normally embedded as the front stage. Such two-stage structure needs an extra dynamic switch either with isolated controller and drive framework for the two stages. By presenting an uninvolved system created two inductors and two capacitors into the voltage-source inverter, the Z-source inverter (ZSI) can buck and help its yield voltage in a solitary stage without extra dynamic switch [1][2][3].

The extra shoot-through state which is illegal in VSI is used to support the voltage in ZSI. Contrasted with the two-stage structure, the framework structure of ZSI is simplified. In the ZSI, the presented Z-source system influences the framework weight and volume incredibly. The framework power thickness can be enhanced by minimizing the measure of Z-source system. The span of the Z-source capacitors can be minimized by the change of ZSI topology. As of late, two enhanced ZSI topologies have been exhibited [4][5][6], called as the implanted and arrangement ZSI, separately.

The force source is arrangement joined with the Z-source inductor in inserted ZSI, demonstrates the benefits, for example, constant info present and diminished voltage crosswise over one capacitor. In arrangement ZSI, the force source is arrangement joined with the inverter scaffold and demonstrates the lessened voltage crosswise over both capacitors with delicate begin ability. Contrasted with customary ZSI, the enhanced ZSI topologies can diminish the size and cost of the capacitor in Z-source system with higher force thickness.

By minimizing the extent of the inductors in Z-source organize, the framework power thickness can be higher. As of late, this theme has not been examined yet. At the point when the upper and lower switches in the same stage legs are turned on at the same time, named the shoot-through state. All the ZSI topologies use the shoot-through state to support the voltage [7][8];[9] in this way, they can be tweaked with the same pulse width modulation (PWM) strategies. Various PWM strategies have been developed and can be classified as three-phase shoot-through (TPST) and single-phase shoot through (SPST). In the TPST type, the shoot-through state is embedded into the focal point of zero state.

It is basic in acknowledgment, however the exchanging times are multiplied, and the proportional working recurrence of the Z-source system is just double the bearer recurrence, which causes to utilize huge inductors. In the SPST sort, the shoot-through state is embedded into the travel time of exchanging while keeping up the same dynamic state time without presenting extra exchanging times.

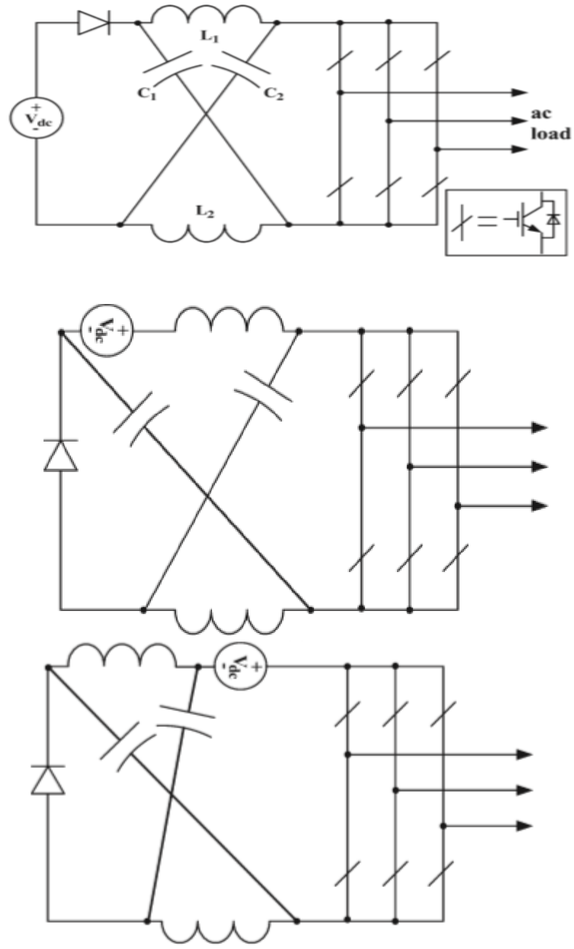

Fig 2: Derivation of Embedded and Series ZSI. (a) Embedded ZSI; (b) series ZSI

There are six shoot-through states in one bearer period, in this way the proportionate recurrence of Z-source system is higher analyzed in TPST sort, which is beneficial on minimizing the extent of inductors. In existing SPST way, the shoot-through time is appropriated to the three stages in equivalent time [10].

The computation and plan of the shoot-through time in stage legs is anything but difficult to acknowledge, however the inductor current swell is not advanced [11][15]. This paper uncovers the normal for the inductor current in customary SPST PWM technique and after that proposes another SPST PWM methodology with least inductor current swell. The operational standard of the proposed PWM procedure is examined in subtle element, and the correlation of current swell under conventional and proposed PWM system is given.

II. DERIVATION AND EQUIVALENCE OF ZSI TOPOLOGIES

For customary ZSI appeared in Fig 1, the dc source and the inverter scaffold is situated at two sides of the Z-source system. The implanted and arrangement ZSI can be gotten from the customary topology, as appeared in Fig. 2 [11] [15]

By embedding's the force source into the Z-source organize, this topology is the implanted ZSI in which the force source is arrangement joined with the inductor, appeared in Fig. 2(a). For arrangement ZSI topology, the force source is arrangement with the inverter scaffold, appeared in Fig. 2(b).

From the above deduction, we can see that the operational standard and regulation system of the three ZSI topologies is the same. The waveform of the inductor current in three topologies is precisely the same; the distinction is the capacitor voltage and has been talked about in point of interest in distributed papers.[4][6] The examination on inductor current swell can take the arrangement topology as a case.

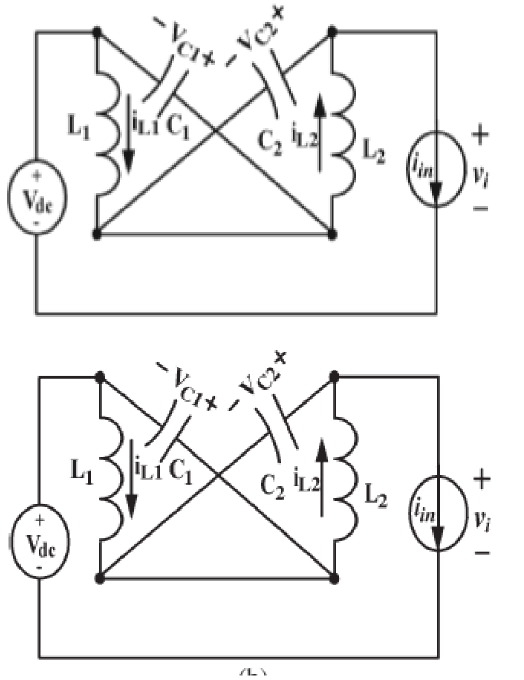

Fig 3: Equivalent Circuits of Series ZSI. (A) Shoot-Through State. (B) Non Shoot-Through State.

For series ZSI the Z-source capacitor voltage V_c and the peak dc-link voltage v is calculated by

$$V_c = \frac{D_{sh}}{1-2D_{sh}} V_{dc} \quad \hat{v}_i = 2V_c + V_{dc} = \frac{1}{1-2D_{sh}} V_{dc}$$

Where Vdc is the dc source voltage, Dsh is the shoot-through job ratio. Fig. 3 gives the equivalent circuits. When in the shoot-through state given in Fig. 3 (a), the inductors are charged and the capacitors are discharged, the energy is distributed from the power source to the inductor the inductor current can be explained as

$$\frac{di_L}{dt} = \frac{V_{dc} + V_c}{L} = \frac{(1 - D_{sh})\hat{v_i}}{L}$$

Where i_L is the inductor current, L is the inductance. When in the non-shoot-through the inductors are discharged and the capacitors are charged, the energy is transferred from the power source to the load, the inductor current is

$$\frac{di_L}{dt} = \frac{-V_c}{L} = \frac{-D_{sh}\hat{v_i}}{L}$$

III. PROPOSED PWM STRATEGY WITH MINIMUM INDUCTOR CURRENT RIPPLE

A PWM system with least inductor current swell is proposed. For ZSI, the help element is dictated by the aggregate shoot-through time; consequently, the support capacity and air conditioning yield voltage of ZSI keeps the same while keeping up the same aggregate shoot-through time. The course of action of the shoot-through impacts the inductor current clearly; in this manner, via watchful apportioning of the shoot-through time in three stage legs, the inductor current swell can be improved.

The exchanging succession of the proposed PWM methodology is appeared. The shoot-through time of the stages is reassigned as Ta, Tb, Tc, individually, while keeping the aggregate of the three unaltered to get the same voltage support.

Ta, Tb, Tc is outlined by dynamic state time and zero state time to minimize the inductor current swell. The dynamic state time, the aggregate shoot-through time, and zero state time can be figured immediately and is distinct; thusly, the diminished estimation of inductor current in dynamic state and zero state is likewise clear.

The inductor current swell is appeared. The quick estimation of inductor current meets the accompanying guidelines:

The quick estimation of inductor current meets the accompanying standards:

$$|i(t2) - IL| + |i(t3) - IL| = a$$

$$|i(t4) - IL| + |i(t5) - IL| = b$$

$$|i(t1) - IL| = |i(t6) - IL| = c/2$$

where a, b, c is the diminished estimation of the inductor current in dynamic state 1, dynamic state 2, and zero state, individually. The inductor current swell can be communicated as

$$\Delta iL = 2\max(|i(t1) - IL|$$
$$|i(t2) - IL|, |i(t3) - IL|$$
$$i(t4) - IL|, i(t5) - IL|, i(t6) - IL|,$$

Consolidating (6) and (7), we can acquire

$$\Delta iL \geq 2max(a/2, b/2, c/2).$$

Whenever

$$|i(t2) - IL| = |i(t3) - IL| = a/2 \text{ and}$$

$$|i(t4) - IL| = |i(t5) - IL| = b/2.$$

The present swell achieves its base worth

$$\Delta iL\_min = \max(a,b,c).$$

In this manner, to get the base inductor current swell, the shoot-through time of the three stages Ta, Tb, Tc is intended to ensure that The expanded estimation of the inductor current in shoot-through time Ta, Tb, Tc is

$$\Delta iL_{Ta} = \frac{c}{2} + \frac{a}{2},$$

$$\Delta iL_{Tb} = \frac{a}{2} + \frac{b}{2}$$

$$\Delta iL\_Tc = b/2 + c/2.$$

The expanded worth is equivalent to the diminished quality; accordingly, the shoot-through time of the three stages Ta, Tb, Tc can be ascertained as

$$Ta = \frac{\left(\left(\frac{c}{2} + \frac{a}{2}\right)Tsh\right)}{2(a + b + c)}$$

$$Tb = (\frac{\left(\frac{a}{2} + \frac{b}{2}\right)Tsh}{2(a + b + c)}$$

$$Tc = ((b/2 + c/2)Tsh) / 2(a + b + c)$$

where a, b, c is corresponding to the time interim of dynamic state 1, dynamic state 2, and zero state, portrayed as

$$a : b : c = T1/2 : T2/2 : (T0 - Tsh)/2$$

By consolidating the above two mathematical statements, Ta, Tb, Tc can be determined as

$$Ta = \frac{Tsh}{4(Ts - Tsh)} * (T0 + T1 - Tsh) =$$

$$k(T0 + T1 - Tsh)Tb = \frac{Tsh}{4(Ts - Tsh)}(T1 + T2)$$

$$k(T1 + T2)Tc = Tsh/4(Ts - Tsh)$$

$$* \ (T0 + T2 - Tsh) = k(T0 + T2 - Tsh$$

Where k is corresponding to the proportion of the shoot-through time to non-shoot-through time, expressed as

$$K = \frac{Tsh}{4(Ts - Tsh)}$$

IV. PROPOSED SIMULINK MODEL

The proposed Simulink model consisted three phase z-source inverter is presented for the constant speed applications. In this project we are proposed z-source inverter which is controlled by the vector control methodology. The z-source converter utilized to maintain the resonant condition such as total inductive reactance plus total capacitive reactance which is equal to zero.

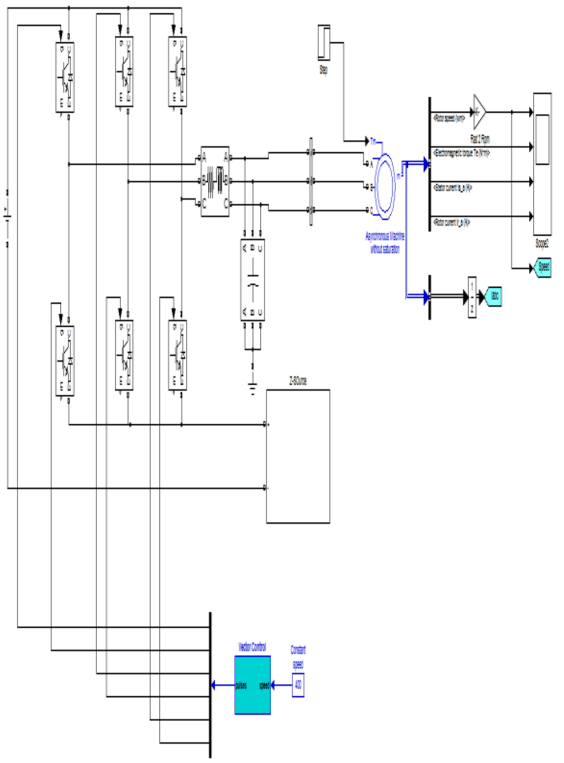

Fig 4: Proposed Three Phase Z-Source Inverter With Vector Control Technique

This is performed by presence of two inductances and two capacitances with one diode these are interconnected anti parallel to system, for the purpose of to reduce the ripple contents from the system. The three phase voltage source inverter consisted six-IGBT switches with diodes. The switches regulated by the vector control methodology. The diodes are provided in parallel to switches to control the circulating current from the conversion. The developed Simulink model shown in figure 4.

The controller collects the references from the induction machine such as stator current and speed. The reference speed and measured speeds are given to the speed controller. The speed controller consisted proportional gains integral gains and torque limits to improve the stability of the system and delivered the equivalent torque.

The speed from the machine and the rotor pitch current from the induction machine and quadrature axis current they are produced teeta value by utilizing transfer functions with gain mechanisms. By utilizing the flux calculator from stator we can control direct axis current and generated pitch current.

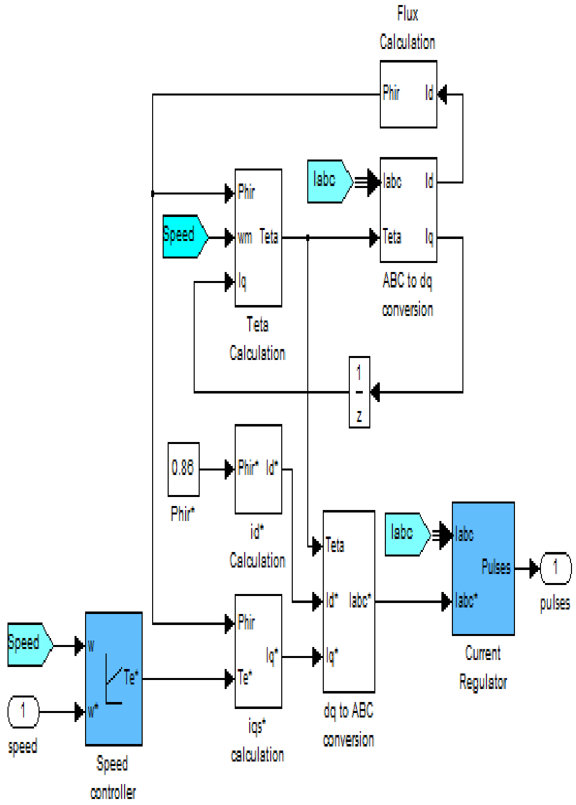

Fig 5: Vector Control Technology for the Three Phase Z-Source Inverter

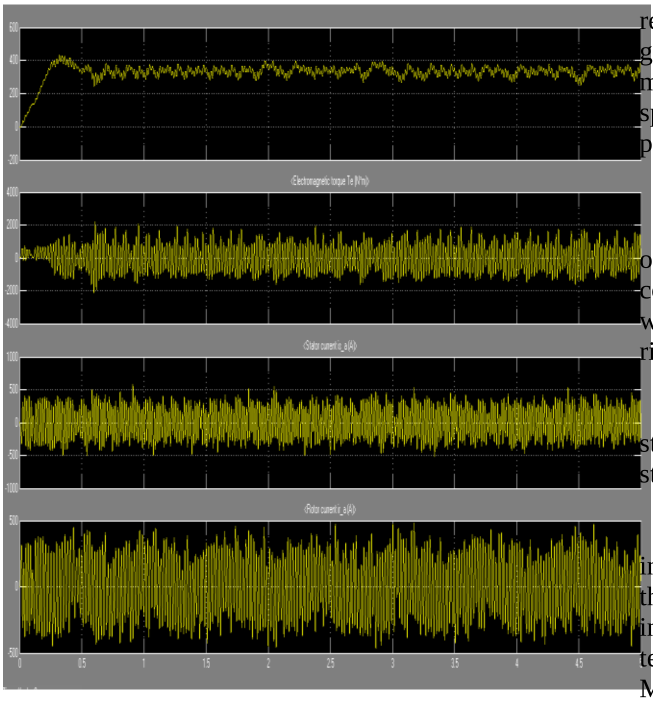

Fig 6: Output Results from the Induction Machine Such As Speed, Electromagnetic Torque, Stator Current And Rotor Current

Here abc-dq transformations are provided to convert three phase stator current into two phase system such as direct axis current and quadrature axis current. The reference quadrature axis current generated from pitch current and reference torque from speed controllers. Here the dq-abc conversion provided to convert two phase stator current system to three phase stator reference current. Here the reference current and stator current controlled by current controller and it will produce the firing pulses for the three phase inverter.

The Three phase Z- source VSI triggered by the generated firing pulses from the vector controller and it produce three phase voltage and current from system. Z source parameters are provided to control the impedances in the network. Filter elements are presented to eliminate the unwanted ripple contents from the inverter. The three phase power is delivered to induction machine and it is operated with generated voltages from the inverter. Finally induction machine produces constant amount of required reference speeds.

The proposed ZSI is operate with the vector control Strategy when we compare this model with the SPWM technique. In this I taken the voltage of two techniques were same then the generated voltage levels of proposed technique which improves more as compare to existed model and the proposed model can achieve better speed controllability because of the high voltage generations from the converter in case of SPWM model it can't achieve required speed levels as our requirement. In this analysis the load current generation is somewhat higher than the existed model. The proposed model can achieve better speed response from the improved voltage production.

V. CONCLUSION

This paper concentrated on the generation of speed which is constant by utilizing the vector control methodology. In this Z-source inverter (ZSI) which is implemented with reduced inductor current ripple contents from the proposed scheme.

The generation harmonic ripple content was studied and analysed under the traditional control strategy with the vector control strategy.

The generated speed levels from the induction machine which can work effectively with the three phase z-source inverter with minimum inductor current ripple. The Simulink models are tested and verified within the MATLAB/SIMULINK.

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