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SV PWM Controlled ZSI Drive for Speed Control of 3 Phase Induction Motor using PID Controller

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***Abstract*— This paper proposes a SVPWM controlled Z-source inverter in its buck operation state, which is fed to the Induction motor which uses a PID controller for its speed control. Z-source concept is gaining popularity in modern times as it can be used in any of the three switching states that is active state, shoot-through state and zero state unlike the conventional inverters which either buck (VSI) or boost (CSI). Here ZSI works in its buck region using its zero states properly. Also instead of using the conventional PI controller, PID controller is used, which has a advantage of extra derivative part which leads to the anticipation of error in future and helps us to rectify it before it actually occurs. MATLAB/SIMULINK was used to simulate. .**

Keywords—Induction Motor,Z source Inverte, Shoot through state,Active state, Zero state, PID controller

I. INTRODUCTION

An asynchronous motor or an Induction motor is an AC motor where the rotor current needed to produce torque is induced by electromagnetic induction from the magnetic field of the stator winding. This eliminates the requirement of mechanical excitation or self excitation for all part of energy transferred fro stator or rotor. Thus Induction motor have benefits such as size, cost, life span and better maintainability as compared to the DC motors. The conventional speed drive of Induction motor is based on Voltage source inverter or current source inverter. Inverters are converters which convert dc input power to AC output power, which is then fed to the speed drive of induction motor.

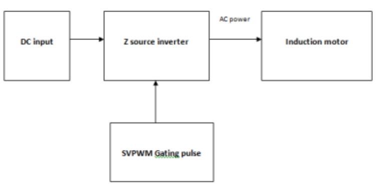

Fig.1: Block diagram of the proposed system

Proposed circuitry consists of a dc input from a PV cell. The block diagram of the proposed circuitry is shown above. In today's climate growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy Photovoltaic energy is the conservation of sunlight into electricity. A photovoltaic cell, commonly called a solar cell or PV cell, is the technology used to convert solar energy directly into electrical energy

Some advantages of photovoltaic system are:

1) Conversion of sunlight to electricity is direct, so bulky mechanical generator systems are unnecessary.
2) PV array environmental impact is minimal, requiring no water for system cooling and generating no by-products.

Output from PV Cell is DC power is fed to the Inverter as input. The inverter chosen here is a Z source inverter. The reason for choosing this inverter over the existing inverters i.e. Voltage source and current source inverters is that the former can be used for both buck and boost operation unlike the latter two inverters as only buck operation is possible for VSI and boost operation for CSI. Also insertion of shoot through sates for VSI and zero states for CSI is not permitted whereas they are permitted in ZSI. The operation of ZSI is discussed in detail. Taking various modes of operation into consideration. Also the concept of z source has been discussed. Every inverter has switches which need to be gated on and off as per requirement for specified time interval these can be done by different PWM methods, such as sinusoidal PWM can be used. Here we have used Space vector PWM technique. It is relatively the latest PWM method used for the control and modulation of ZSI. Its implementation is discussed further in this paper.

II. THE Z-SOURCE CONCEPT

The ZSI consists of a z source which is nothing but a simple 2 port network consisting of a slit inductor and 2 identical capacitors, in a zigzag manner, as shown in the figure below. This forms a unique impedance network when the devises are in shoot through model. Also a diode in series with the impedance network blocks reverse current to flow into the PV cell. Thus ZSI has 15 permissible switching states unlike VSI.

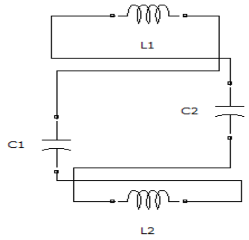

Fig2 .Z-Source Network

For traditional sources

$$V_{ac}=M\times\frac{Vo}{2} \qquad (1)$$

For Z source :

$$V_{ac}=B\times M\times\frac{Vo}{\sqrt{3}} \qquad (2)$$

$$\text{Where, } B=\frac{1}{1-\frac{Tst}{T}}$$

III. THE SVPWM TECHNQUE

The theory of SVPWM technique is relatively new and has been well established in the past few years. It is a concept of transforming a 3 phase system into 2 dimensional system.

Any 3 phase system can be expressed as a rotating vector which has 2 components one real and the other imaginary. i.e a 3pahse vector V_A,V_B,V_C displaced at an angle $120^o$from each other can be expressed as a rotating vector V_s given by

$$V_s=\frac{2}{3}[V_A+\alpha V_{B+\alpha}{}^2V_C] \qquad (3)$$

$$\alpha = e^{j2\pi/3} \qquad (4)$$

$$\alpha^2=e^{j4\pi/3}. \qquad (5)$$

V_s, the rotating vector can be represented as the sum of a real component and imaginary component and can be written as

$$V_s= V_\alpha+jV_\beta \qquad (6)$$

Where V_α and V_β are given as

$$V_{\alpha}=\frac{2}{3}V_a-\frac{1}{3}V_b-\frac{1}{3}V_c \qquad (7)$$

$$V_\beta=\frac{1}{\sqrt{3}}(V_b-V_c) \qquad (8)$$

The voltage vector follows a hexagonal path as shown in the figure below:

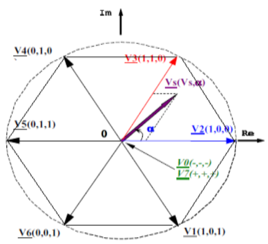

Fig3. Voltage vector

The MATLAB model for the generation of SVPWM pulses is shown in the figure below:

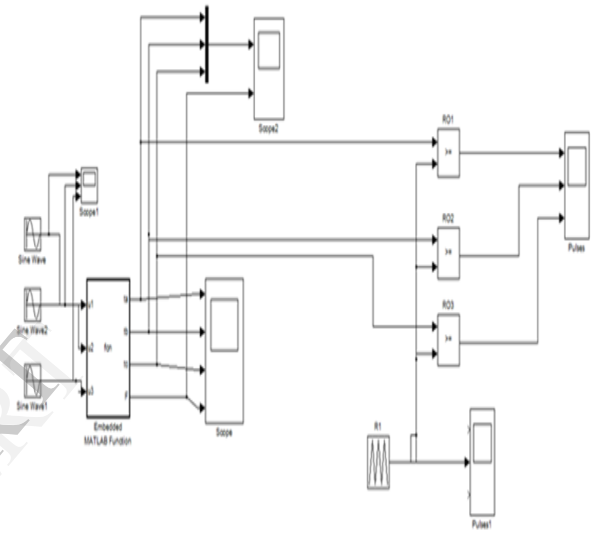

Fig4: SIMULINK model for generation of pulses

IV. USING THE TEMPLATE

The proposed electric drive system for induction motor is a z source inverter which uses dc input from PV cell and is controlled by SVPWM technique. The input capacitor is of very low value and is used to suppress the voltage spike that may occur during the shoot through state of the inverter. The phases with highest line voltage will only act at a given instant. The inverter works in 3 modes:

1) Active Mode
2) Shoot Through Mode
3) Zero Mode

Each of the modes have been discussed briefly below.

A. Mode 1: The Active Mode

Here in this mode the inverter works in its usual 6 switching states. Ie any one of the switch of each leg is switched on at an instant and there is a definite value for phase voltages. The equivalent circuit for this mode is given below:

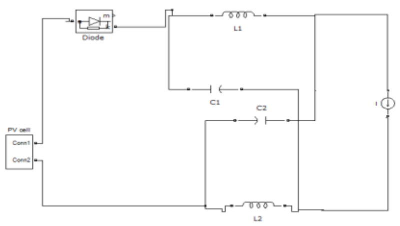

Fig.5: Equivalent circuit for mode 1 operation

A. Mode2: The shoot -through mode:

Here in this mode the inverter uses its one of the permissible 7 shoot through states. Shoot through means switching ON of switches of the same branch simultaneously. This is done for 2 branches at most and that is selected on the basis of the value of the line voltage that is the line to line voltage for which branches are highest that is shorted. The equivalent circuit for this Mode is as shown below:

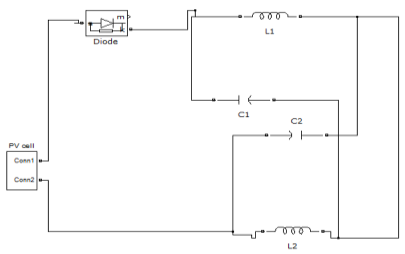

Fig6: Equivalent circuit for mode 2 operation

B. *Mode 3: The zero state mode:*

Here in this mode the inverter uses its zero switching states, i e both the switches of a leg are switched OFF and that branch acts as an open circuit as shown it the equivalent circuit below.

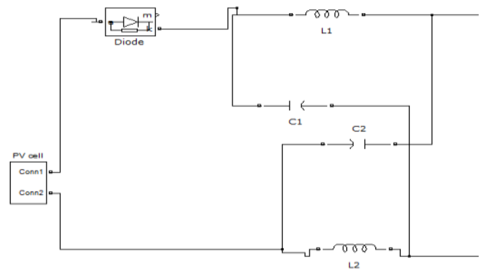

Fig.7: Equivalent circuit for mode 3 operation

V. PID CONTROLLER

Controller is nothing but get a nearest set value by calculating error value. Here we have used a PID controller instead of PI controller. The former has an advantage of having an extra derivative part which leads to the prediction of the disturbance and hence helps in anticipating the error and correcting them in advance. Also PI controller has a negative impact in terms speed of the response and the stability of the system, this can be corrected by using PID controller, the block diagram of which is given below:

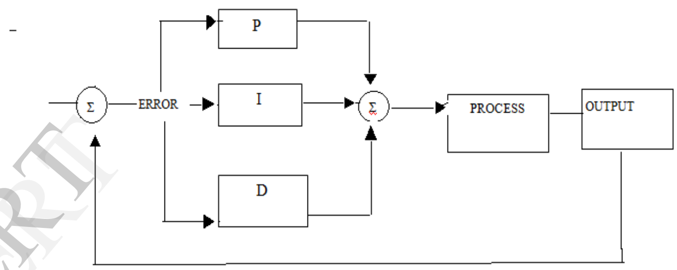

Fig.7:PID controller block diagram

VI. SIMULINK MODEL

The simulink model of the proposed system is shown below.

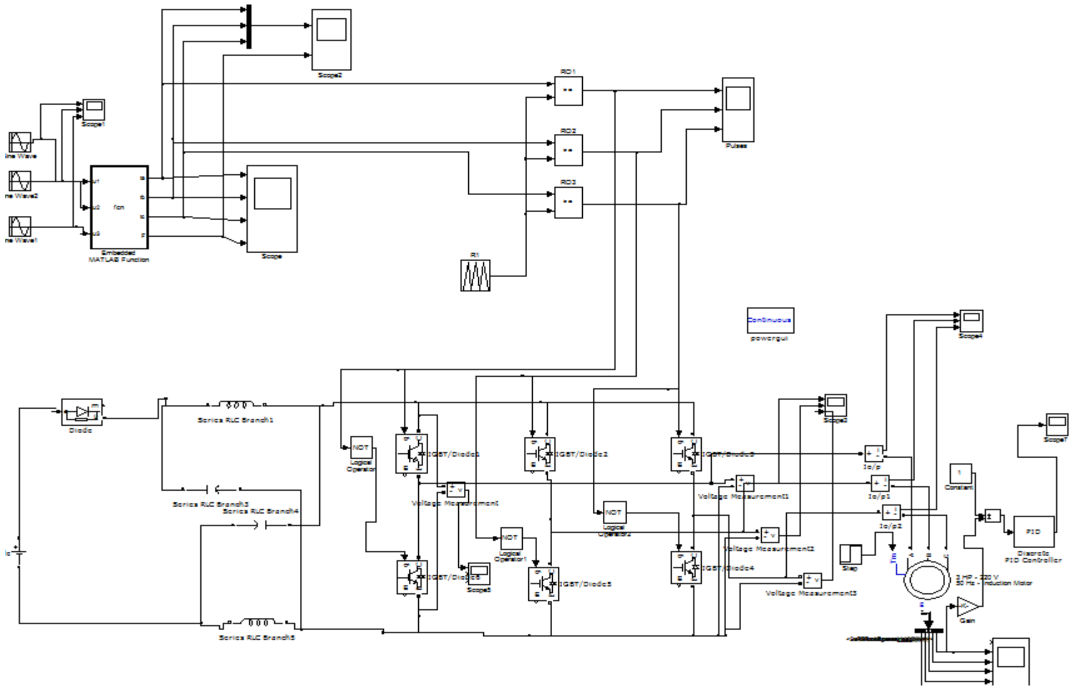

Fig.8 SIMULINK model for the circuit with PID controller

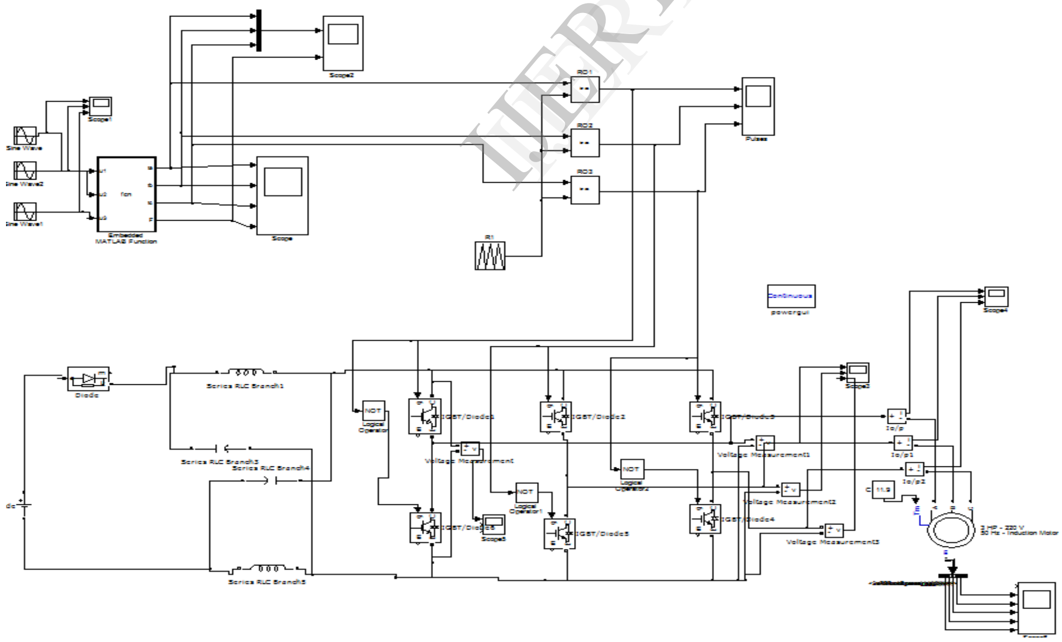

Fig9:SIMULINK model for the proposed circuit without PID

VII. SIMULATION RESULTS

For simulation first the SVPWM pulses were generated in order to work the proposed ZSI as buck converter and its simulation output for each phase branch is shown. Also the components used are split inductor having inductances LI=L2=0.1 H and two identical capacitors C1=C2=0.2F

Input voltage is the dc produced by the PV cell.

The induction motor parameters are as given below:

i) Rated power:2238VA

ii) Rated voltage: 220V

iii)Stator resistance: 0.435Ω
iv) Rotor resistance:0.846Ω
v) stator inductance: 4mH
vi)Rotor inductance :4mH
vii)mutual inductance: 69.31mH

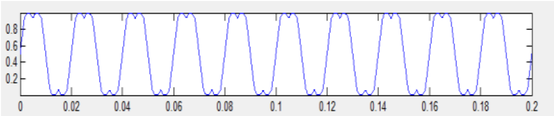
Fig.10: Reference pulses for phase A

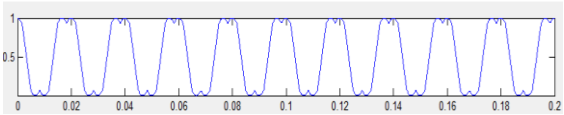
Fig.11: Reference pulses for phase B

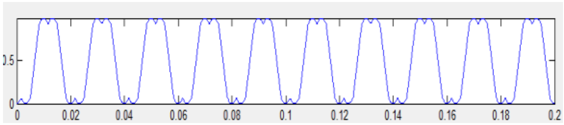
Fig.12: Reference pulses for phase C

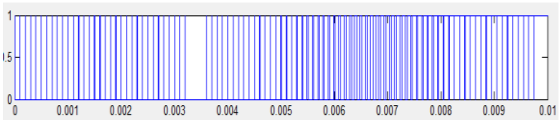
Fig13: SVPWM Pulses for phase A

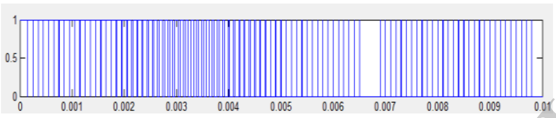
Fig14: SVPWM Pulses for phase B

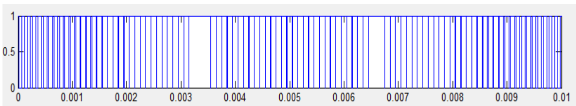
Fig.15: SVPW Pulses for phase C

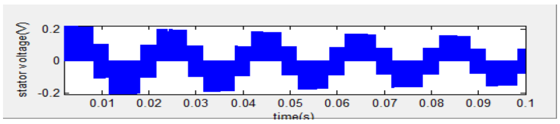

Fig.16: stator voltage

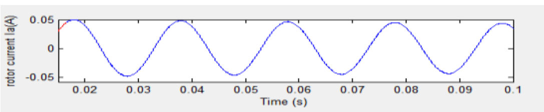

Fig17: rotor current, Ia

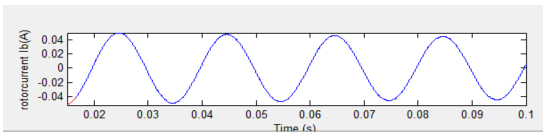

Fig18: Rotor current ,Ib

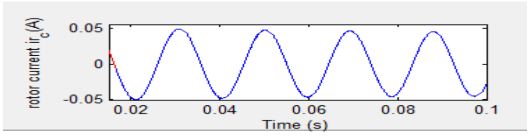

Fig19: rotor current ,Ic

VIII. CONCLUSION

The proposed system is simulated and waveforms are observed. SVPWM pulses generate low harmonic distortion and hence better option than Sine wave pwm. The use of z source inverter to feed speed drive of Induction motor is studied. The SVPWM controlled pulses is fed to the ZSI switches in each leg and stator voltage of IM is obtained . We see that distortion is lesser when a ZSI is used to feed the IM, than when a VSI is used. Also with the use of PID controller the anticipation of future errors becomes easy and hence lesser chances of error is there. Hence we can conclude that the use of ZSI and PID is preferable. Also the THD was much lesser when ZSI was used instead of VSI about 4.34%, which again justifies use of ZSI over VSI.

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