Performance and Comparative Evaluation of Improved Multicell Impedance Source Inverter for Drives

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ABSTRACT *:* Voltage-Source Inverter is limited by voltage step-down operation only. Their boosting capabilities are anyhow less with high component stresses and poorer spectral performances caused by low modulation index ratios.Their boosting gains are, therefore, restricted in practice.To overcome these we use the Improved Multicell switched-inductor Z-source inverter is proposed.In adding with extra boosting the flexibility is kept active for the number of semiconductors which is unchanged, Voltage-type Z-source inverter was earlier employed.Now,these new classes of inverter is generally less sensitive and Electromagnetic Interference are reduced.By comparing with SPWM technique and SVPWM technique for Induction Motor Drives, whose extra boosting abilities,THD other advantages have been verified in simulation analysis and experiment.

KEYWORDS*:* Multicell,SPWMTechnique,SVPWM Technique,Switched Inductor, Z-Source Inverter,

I. INTRODUCTION

Voltage and Current type can surely added by connecting appropriate DC- DC converters to the traditional inverters, which is the most commercial way of approach because of its simple structure, Z-Source inverters has actively progressed in terms of modulation, controlling and modelling [2]-[5],component size has been addressed with their applications[7]-[9]. The Z-Source inverters conversion gains are infinite theoretically with practical issues like high semiconductor stresses and spectral performances are poor and constraint are those which are in between modulation index and shoot through duration by the Z-source Inverters are experienced.

Each technique has its advantages and disadvantages that might applicable for specified applications The final decision on which to select is therefore dependent on problems under considerations and preferences. The various developments related to DC to AC inverters are found in the literature. Among this the noticeable is Multicell and Single cell Z-source inverter whose single cell type is shown in Fig.1[1], where it provides sinusoidal input and output waveform with minimum higher order harmonics and no sub harmonics. The new Z-source type networks consists of two inductors and two capacitors are connected to the three phase bridges as shown in Fig.1,
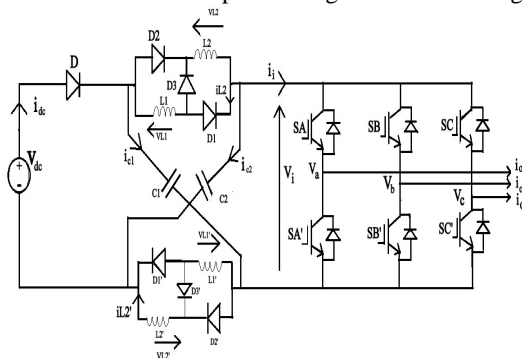

Fig 1. Single cell Impedance Source Inverter

The ZSI advantages uses the ST states to boost DC link voltage by gating on both the upper and lower switches of phase leg, where the Electromagnetic Interference will not destroy the circuit. However a more reliable single stage conversion for both buck and boost operation can obtained.

II. IMPROVED MULTICELL SL TOPOLOGY

The improved Multicell Switched Inductor Topology is shown in Fig 2. Where the cell structure is shown. It comprises of one inductor L_n and three diodes D_{3n-1}, D_{3n-2} and D_{3n} for the nth cell. This cell will be duplicated for 2N times (where N is an Integer) divided equally between the upper and lower sides, Note that the inductors L_{2N+1} and L_{2N+2} are not included in the cells , but rather shown as the original two inductors as shown in Fig.1. It thus appears that the style of forming the improved cells allows the Switched Inductor type to be viewed as adding extra cells to the original two inductors rather than to replace them[10].
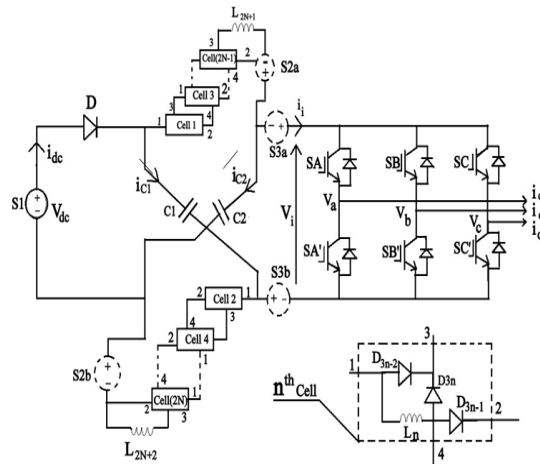

Fig 2. Voltage type Improved Multicell Z- Source Inverter

These cells must introduce additional inductors in parallel during shoot- through charging and more inductors in series during nonshoot- through discharging. Features and expressions for the two processes are summarized as follows.

Shoot-through: By turning on two switches from the same phase leg of the VSI bridge. That causes diodes D and D_{3n} to turn OFF, while diodes D_{3n-1} and D $_{3n-2}$ conduct. All inductors are then charged in parallel by the two Z-Source capacitors, giving rise to common inductive voltage $V_L = V_C$.

Nonshoot –through: By representing one of the traditional active VSI states. In this state, diodes D and D_{3n} conduct, while diodes D_{3n-1} and D_{3n-2} block. All inductors then discharge in series to the external AC load, whose common inductive voltage is written as $VL= (Vdc – Vc)/(N+1)$, where N+1 is the number of inductors in the upper or lower cascaded block. Averaging V_L over a switching period to zero then gives the following expression for governing the Improved multicell ZSI

$$V_C = \frac{1 - d_{ST}\ Vdc}{1 - (N + 2)d_{ST}} \quad (1)$$

$$V_i = \frac{1 + Nd_{ST}Vdc}{1 - (N + 2)d_{ST}}$$

(2)

$$V_{ac} = \frac{M(1 + Nd_{ST})Vdc}{1 - (N + 2)d_{ST}2}$$

$$(3)$$

The boost factor is given by B= $(1+Nd_{ST})/(1-(N+2)d_{ST})$, which will be made higher than the previous gains by adding more cells. The desired gain is also arrived at a reduced shoot-through duration whose limit is given as $d_{ST} <1/(N+2)$ is derived by setting the denominator of (3) to greater than zero. That allows a higher modulation ratio to be used since $M \leq 1.15(1- d_{ST})$Better utilization of DC- link, stress with lower components and better performance linked to a high M can be achieved[6]. With these characteristics, with this improved switched inductor topology is likely to find applications in renewable or other clean energy industry, where high boosting gain for grid interfacing is usually needed[11].

III.THREE PHASE VOLTAGE SOURCE INVERTER

The circuit diagram for three phase VSI is shown in Fig.3 and the eight valid switching states are given in Table.1. As in single phase the switches of same leg of the inverter(S_1 and S_4, S_3 and S_6,S_5 and S_2) cannot be switched on simultaneously because this will result in a short circuit across the DC link voltage supply. Similarly, In order to avoid undefined states in VSI, and thus undefined AC output line voltages, the switches of any leg of inverter cannot be switched off simultaneously as this will result in voltages that will depend upon the respective line current polarity.
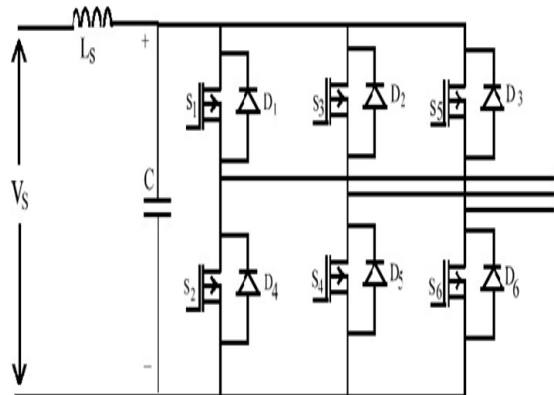

Fig 3. Three phase Voltage Source Inverter

During the switching states 7 & 8 the AC current freewheel through either the upper or lower component which produces zero AC line Voltage. The remaining states from 1 to 6 produces non zero AC output voltages. The inverter moves from one state to another to produce a required voltage waveform. Thus resulting AC output, line voltages consist of discrete values of voltages that are Vs,0 and –Vs .

Table. I. Switching states for Three phase inverter

	State No.	Switching States	V_{ab}	V_{bc}	V_{bc}
S1,S2, S3 on	1	100	Vs	0	-Vs
S2,S3, S1,on	2	110	0	Vs	-Vs
S3,S4, S2,on	3	010	-Vs	Vs	0
S4,S5, S3 on	4	011	-Vs	0	Vs
S5,S6, S4 on	5	001	0	-Vs	Vs

S6,S1, S5 on	6	101	Vs	-Vs	0
S1,S3, S5 on	7	111	0	0	0
S4,S6, S2 on	8	000	0	0	0

The line to neutral voltage must be determined to find the line (or phase) current. There are three modes of operation in a half-cycle and the expression for each mode will be given below,

During Mode I: $(0 \leq t \leq \pi/3)$

$$V_{an} = V_{cn} = \frac{\frac{R}{2}}{R + \frac{R}{2}} V = \frac{V}{3} \ \& \ V_{bn} = \frac{-R}{R + \frac{R}{2}} V = \frac{-2V}{3} \qquad (4)$$

During Mode II: $(\pi/3 \leq t \leq 2\pi/3)$

$$V_{bn} = V_{cn} = \frac{\frac{-R}{2}}{R + \frac{R}{2}} V = \frac{-V}{3} \ \& \ V_{an} = \frac{R}{R + \frac{R}{2}} V = \frac{2V}{3} \qquad (5)$$

During Mode III: $(2\pi/3 \leq t \leq \pi)$

$$V_{an} = V_{bn} = \frac{\frac{R}{2}}{R + \frac{R}{2}} V = \frac{V}{3} \ \& \ V_{cn} = \frac{-R}{R + \frac{R}{2}} V = \frac{-2V}{3} \qquad (6)$$

IV. SIUSOIDAL PULSE WIDTH MODULATION

The generation of gating signals with sinusoidal PWM is shown in Fig.4. There are three sinusoidal reference waves (V_{ra}, V_{rb} and V_{rc}) each shifted by 120°. A carrier wave is compared with the reference signal corresponding to a phase to generate the gating signals for that phase. Comparing the carrier signal V_{cr} with the reference phases V_{ra}, V_{rb} and V_{cr} will produce S1 and S3 respectively as shown in Fig.4b. The instantaneous line to line output voltage is $V_{ab} = V_{s}$(S1- S3).The output voltage as shown in Fig.4d is generated by eliminating the condition that two switching devices in the same arm cannot conduct at the same time. The normalized carrier frequency should be odd multiple of three. Thus all phase voltages (V_{an}, V_{bn}, V_{cn}) are identical but 120° out of phase without even harmonics, moreover harmonics at frequencies multiple of three are identical in amplitude and phase in all phases.
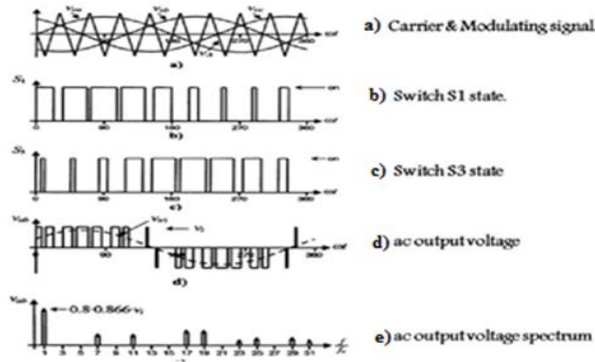
Fig.4 Waveform for SPWM Technique

For instance, if the ninth harmonic voltage in phase 'a' is,

$$V_{an} = v_9 Sin.9\omega t$$

The ninth harmonic in phase b_n will be,

$$V_{bn} = v_9 Sin(9(\omega t - 120°) = v_9 Sin(9\omega t - 1080°) = v_9 Sin9\omega t$$

The ideal waveform for SPWM Technique is shown in Fig.4

V. SPACE VECTOR PULSE WIDTH MODULATION TECHNIQUE

Space Vector Modulation(SVM) is an algorithm for the control of Pulse Width Modulation(PWM). It is used for the creation of alternating waveform (AC) .It is mostly used in inverters, Three phase AC powered motors. There are various types of SVM that result in different quality and computational requirements. One active area of development in the reduction of Total Harmonic Distortion(THD) created by the rapid switching inherent to these algorithms. With the increase of levels, traditional approaches of SVM based on five level or seven level inverters are hardly realized. Some modified methods have been proposed to approach the SVM of inverter with any levels. One of them is carrying out the SVM in 60° coordinates. This section will outline this SVM scheme. Any three phase system defined by $a_x(t)$, $a_y(t)$, $a_z(t)$ can be represented uniquely by rotating vector as,

$$a_s = \frac{2}{3}[a_x(t) + a.a_y(t) + a^2.a_z(t)] \quad (7)$$

Given a three phase system, the vector representation is achieved by the following 3/2 transformation:

$$\begin{bmatrix} A_\alpha \\ A_\beta \end{bmatrix} = \frac{2}{3} . \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} . \begin{bmatrix} a_X \\ a_Y \\ a_Z \end{bmatrix}$$

Where (Aα, Aβ) are forming an orthogonal 2-phase system $a_s = A_\alpha + jA_\beta$. A vector can be uniquely defined in the complex plane by these components. The reverse transformation (2/3 transformation) is given by,

$$a_x(t) = Re[a_s] + a_0(t)$$

$$a_y(t) = Re[a^2.a_s] + a_n(t)$$

$$a_z(t) = Re[a.a_s] + a_n(t)$$
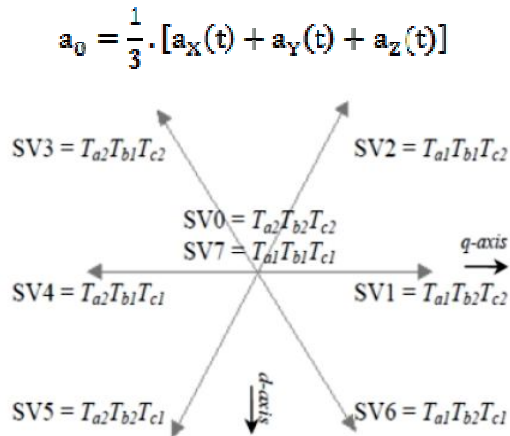
$$a_0 = \frac{1}{3}.[a_X(t) + a_Y(t) + a_Z(t)]$$

Fig.5 Space Vector d,q axis locations and their corresponding closed switches

The Space Vector Modulation treats the sinusoidal voltage as a constant amplitude vector rotating at constant frequency. It approximates reference voltage V_{ref} by a combination of eight switching patterns (V_0 to V_7)[12].

VI.SIMULATION AND RESULTS

The MATLAB/ Simulink model of the Multicell Z-Source inverter based SPWM technique with DC to AC inverter is shown in Fig.6
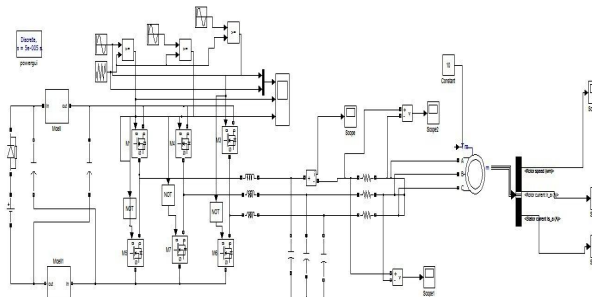
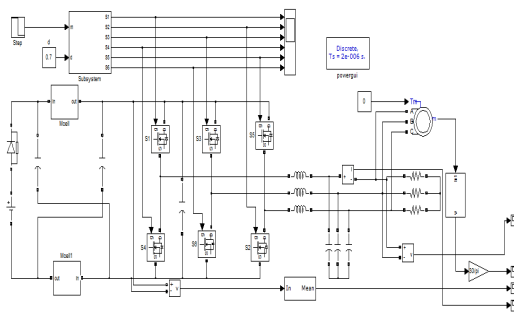Fig.6. Simulink model of SPWM Technique

Fig.7.Simulink model of SVM Technique

The above Fig..6 and Fig.7 shown for the SPWM Technique and SVM Technique.The values of Z- Source components are L=150μH and C = 1500μF.
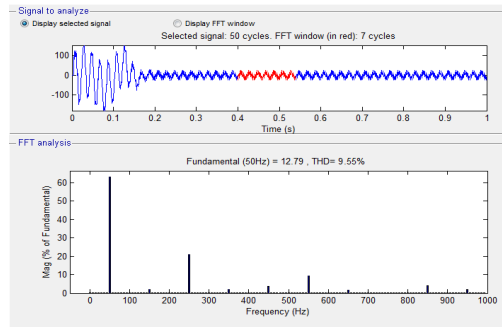
Fig.8.THD for SPWM Technique
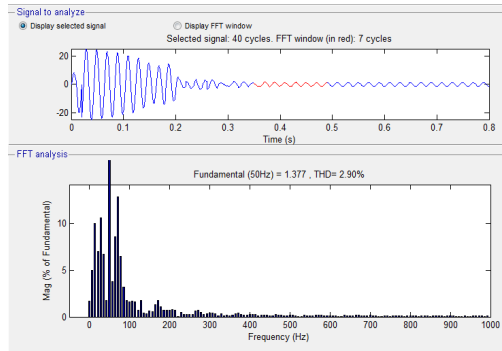

Fig.9.THD for SVM Technique

The THD result obtained for stator current with SPWM Technique is shown in Fig.8 and for SVM Technique is shown in Fig.9.It is observed that the THD is 9.55%, The THD level for SVM Technique is 2.90%, which is lower than the SPWM Technique.
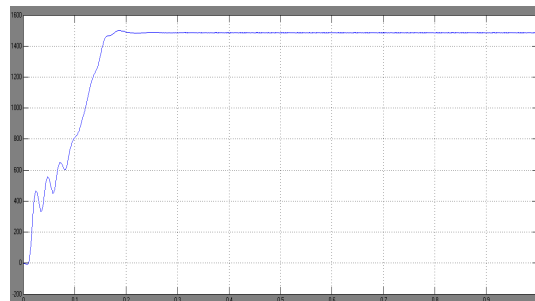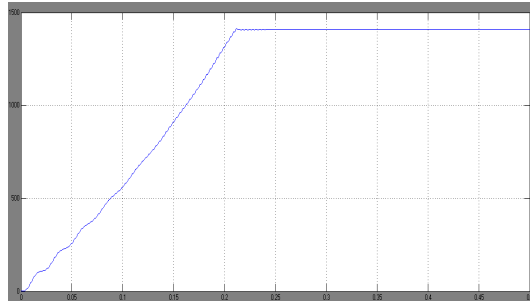

Fig.10.IM Speed for SPWM Technique

Fig.11.IM .Speed for SVM Technique

The achieved speed characteristics of the induction motor for both the technique is shown in the Fig.10 and Fig.11. The dynamic response of the speed is found to be improved in SVPWM technique when compared to SPWM technique with 1500rpm.
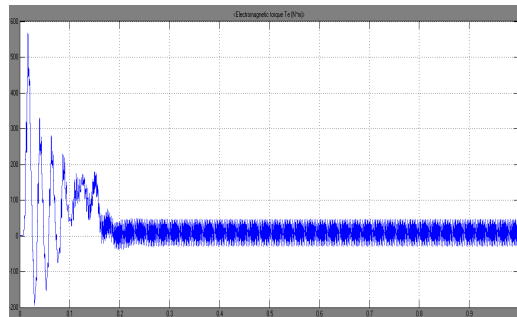

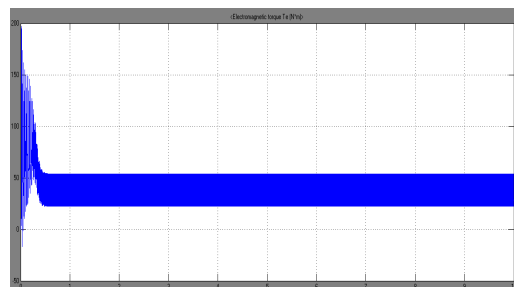Fig.12.Electromagnetictorque for SPWM Technique

Fig.13.Electromagnetic torque for SVM Technique

The electromagnetic torque obtained in induction motor is shown in Fig.12 and Fig.13. The torque ripple is observed to be much reduced when SVM technique is used due to reduced harmonic content in the stator current when compare to SPWM.

VII. CONCLUSION

In is paper Multicell Z-Source Inverter solution for three phase Induction Motor with . The proposed system is compared with SPWM technique. By using SPWM harmonics are more. To overcome this disadvantage SVM Technique is used by using his switching losses are also controlled because of selected switching and harmonics are also controlled and reduced compared to SVM Technique. Finally SPWM and SVM controlled Multicell Z-Source inverter is analyzed by Simulation results are obtained and resulting in stability improvement.

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BIOGRAPHY

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