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Research paper

A comparative analysis on six switch inverter and four switch inverter fed three phase induction motor

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Abstract

In small scale applications where the Induction motors are powered from dc supply, the inverter assumes an imperative part in changing over the dc voltage to the required ac voltage. This paper manages the correlation of three phase six switch inverter and three phase four switch inverter. Each voltage source inverter requires PWM system for their activity. Space vector pulse width modulation (SVPWM) procedure was utilized as a part of this work for setting off the inverter. This work is persuaded by the need of inverter with decreased segment cost and high effectiveness. Both the inverters were displayed in MATLAB Simulink and the outcomes were observed

Keywords: *Induction Motor; Pulse Width Modulation; Space Vector Modulation; Three-Phase Four Switch Inverter; Three-Phase Six Switch Inverter.*

1. Introduction

Induction motor (IM) has been used throughout the years as a workhorse in the business because of its reduced maintenance and less cost, and for the most part satisfactory effectiveness. With the innovation of fast power semiconductor gadgets, the three-stage inverters assume the key part for variable speed ac motor drives. Generally three stage six switch inverters have been comprehensively utilized for variable speed IM drives. This incorporates the mishaps of the six switches and furthermore the versatile nature of the control figuring and interface circuits to create six PWM logic signals [1]. Previously, researchers essentially centered on the change of the beneficial control computations for predominant variable speed IM drives. Nonetheless, the cost, effortlessness and adaptability of the general drive framework which turn out to be probably the most essential factors did not get that much consideration regarding the analysts [2]. That is the reason, despite immense research around there most of the made control system fail to attract the business. Thusly, the essential issue of this work is to develop a clever, clear and profitable first class IM drive. Three stage four switch inverter gives a superior answer for this issue. In this work space vector pulse width balance (SVPWM) is utilized for the replacement of voltage source inverter.

Space vector modulation (SVM) is an estimation for the control of pulse width modulation (PWM). It is used for the creation of alternating current (AC) waveforms; most usually to drive 3 phase AC fueled motors at various speeds from DC using multiple class-D intensifiers. There are assortments of SVM that result in different quality and computational requirements. One active region of change is in the diminishment of total harmonic distortion (THD) made by the fast changing natural for these calculations [3]. The conventional structure of a three stage voltage inverter includes three legs, six power switches (SSTPI), a necessary counterpart for each stage. The four-switch three-stage inverter (FSTPI) uses only four switches, a few essential switches. The utilization of the FSTPI structure reduces the measure of vitality semiconductors and accordingly the cost of the importance converter hardware at costs of an expansion in the total consonant turning of the yield wave-outline.

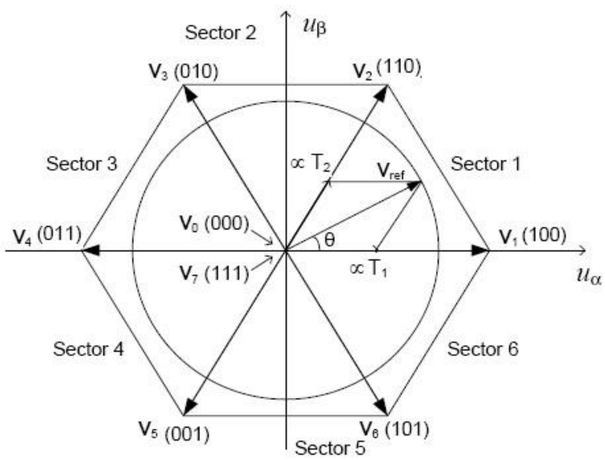

Fig. 1: Space Vector.

2. Three phase six switch inverter

If a three phase balanced voltage is related with the windings of a three-arrange machine, a turning voltage space vector might be inspected. The resultant voltage space-vector will pivot dependably at the synchronous speed and will have a degree proportionate to 1.5 times the pinnacle enormity of the stage voltage [4]. In the midst of each day and age of the stage voltages six discrete time minutes can be perceived, when one of the stage voltages have most prominent positive or negative snappy degree. The resultants of the three space-voltages at these minutes have been named V1 to V6 as showed up in Fig.2. At six discrete minutes, these vectors are balanced along the stage tomahawks having most noteworthy provoke voltage.

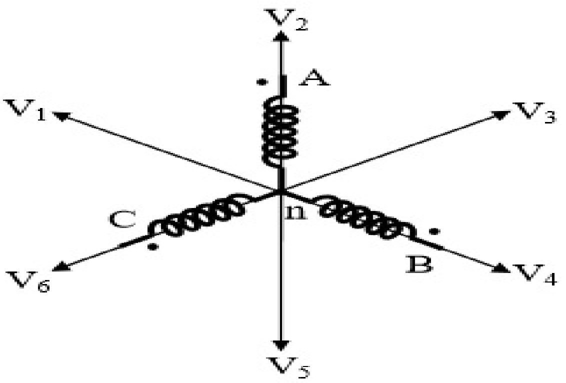

Fig. 2:.The Voltage Space-Vectors.

The space-vector PWM framework means to comprehend this bit by bit turning voltage space vector (contrasting with key portion of yield voltage) from the six active state voltage vectors and two invalid state vectors. The dynamic state voltage vectors have a size equivalents Edc and they point along settled headings however invalid state vectors have zero degree. Fig.3 shows the voltage space-vector plane formed by the dynamic state and invalid state voltage vectors. The invalid state voltage vectors V7 and V8 are each tended to by a spot at the origin of the voltage space plane. The trading word for V7 is 000, which implies all lower side switches are ON and for V8 is 111, identifying with all upper side switches ON.

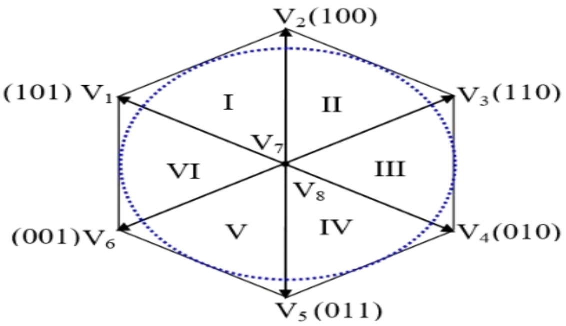

Fig. 3: The Voltage Space-Vectors Output by A 3-Phase Inverter.

A general hexagon is confined ensuing to joining the tips of the six active voltage vectors. The space-plane of Fig.3 can be segregated in six indistinct zones (I to VI). The yield voltage vector from the inverter (aside from high repeat agitating impacts) should turn with settled size and speed in the voltage plane. By and by it is possible to mastermind the resultant voltage space-vector along any course in the space plane using the six active vectors of the inverter. Accept one needs to comprehend a space voltage vector along a heading that misrepresentations exactly in the point of convergence of region I of the space-plane showed up in Fig.3.

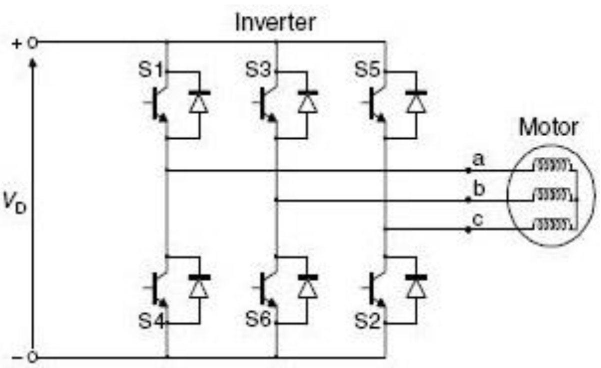

Fig. 4: Three Phase Six Switch Inverter.

Table 1: Sectors and Range of Angle of 6STP Inverter

Sectors	Range of Angle
1	0^0<a<60^0
2	60^0<a<120^0
3	120^0<a<180^0
4	180^0<a<240^0
5	240^0<a<300^0
6	300^0a<360^0

Table 2: Determine the Switching Time of Each Switch (S1, S3 & S5)

Sector	Switches
1	s1=(Ts-(Ta+Tb+To./2))./Ts s3=(Ts-(Tb+To./2))./Ts s5=(Ts-(To./2))./Ts
2	s1=(Ts-(Ta+To./2))./Ts s3=(Ts-(Ta+Tb+To./2))./Ts s5=(Ts-(To./2))./Ts
3	s1=(Ts-(To./2))./Ts s3=(Ts-(Ta+Tb+To./2))./Ts s5=(Ts-(Tb+To./2))./Ts
4	s1=(Ts-(To./2))./Ts s3=(Ts-(Ta+To./2))./Ts s5=(Ts-(Ta+Tb+To./2))./Ts
5	s1=(Ts-(Tb+To./2))./Ts s3=(Ts-(To./2))./Ts s5=(Ts-(Ta+Tb+To./2))./Ts
6	s1=(Ts-(Ta+Tb+To./2))./Ts s3=(Ts-(To./2))./Ts s5=(Ts-(Ta+To./2))./Ts

For this the inverter may be reliably traded (at high repeat) among V1 and V2 active states, with unclear withstand time along these two states. The resultant vector so acknowledged will include the mean daring position of V1 and V2 and the measure of the resultant vector can be seen to be 0.866 times the enormity of V1 or V2 (being the vector total of 0.5 V1 and 0.5 V2). Further, the degree of the resultant voltage vector can be controlled by imbuing fitting terms of invalid state [5]. Fig.4 exhibits the schematic of a three stage six switch inverter (6STP).

The sectors and their range for a three phase four switch inverter is given in Table. [1] And Table. [2] shows how to determine the switching time of each switches.

Where,

$$s = (\sqrt{3}\ (V/Vd)\ Ts \quad (1)$$

$$Ta = s*\sin((n.*pi./3)-a) \quad (2)$$

$$Tb = s*\sin(a-(n-1).*pi./3 \quad (3)$$

$$To = Ts-Ta-Tb \quad (4)$$

3. Three phase four switch inverter

The circuit layout of a 4S3P inverter is showed up in Fig.4. The four switch three stage inverter topology incorporates four switches that give two inverter yield stages: B and C [6]. The third yield arrange, organize An, is connected with the midpoint of the two split capacitors. The zero potential point is portrayed as point 0 in Fig.5.

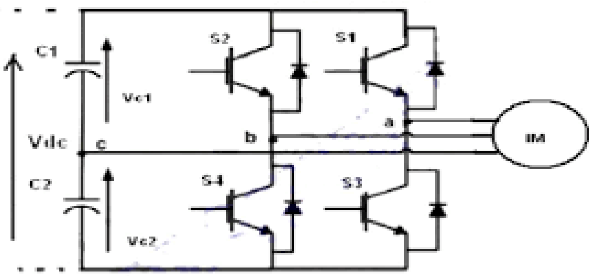

Fig. 5: Three-Phase Four-Switch Inverter.

The stage to-zero voltages VA0, VB0 and VC0 rely upon the exchanging conditions of S1, S2, S3 and S4, and two dc-interface voltages (Vdc1, Vdc2). The stage to-zero voltages are resolved as takes after:

$$V_{AO} = Vdc2 \quad (5)$$

$$VBO = S1\,(Vdc1+Vdc2) \quad (6)$$

$$VCO = S2\,(Vdc1+Vdc2) \quad (7)$$

Where Vdc is the total dc-link voltage. Voltages across two capacitors C1 and C2 are given by Vdc1 and Vdc2, respectively.

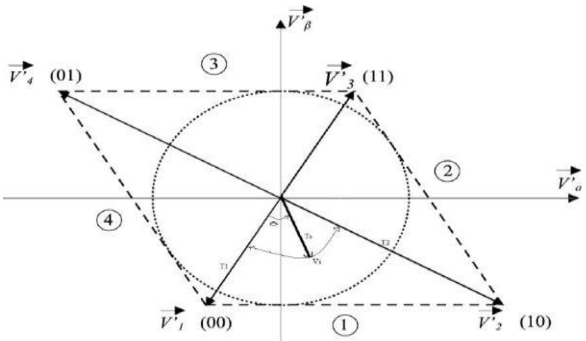

Fig. 6: Time Durationts, T1 & T0.

The sectors and their range for a three phase four switch inverter is given in Table. [3] and Table. [4] shows how to determine the switching time of each switches.

Table 3: Sectors and Range of Angle of 4STP Inverter

Sectors	Range of Angle
1	$-120^0<a<-30^0$
2	$-30^0<a<-60^0$
3	$-60^0<a<150^0$
4	$150^0<a<180^0$
4	$-180^0<a<-120^0$

Table 4: Determine the Switching Time of Each Switch (S1 & S3)

Sector	Switches
1	To=(1-(T1+T2)) s1=(To./2) s3=(T2+To./2)
2	To=(1-(T1+T2)) s1=(T1+T2+(To./2)) s3=(T2+(To./2))
3	To=(1-(T1+T2)) s1=(T1+T2+(To./2)) s3=(T1+To./2)
4	To=(1-(T1+T2)) s1=(To./2) s3=(T1+To./2)

Where,

$$T1 = m\,(3/2)\cos(a)$$

$$T2 = m\,(\sqrt{3}/2)\sin(a)$$

M = modulation index

4. Simulation and results

In order to verify the results, the simulation was done on MATLAB software and the results are studied for both three phase six switch inverter and three phase four switch inverter.

4.1. Three phase six-switch inverter

Fig. 7 displays the MATLAB simulation of three phase six switch inverter. The pulse from the space vector modulation signal is used to drive the switches.

The inverter was conditioned to drive a 0.5 HP, 415V, 50Hz. 1500 rpm Induction motor. At beginning the torque rises and lessens to a smallest rate when the speed touches the rated value. The inverter output waveform is shown in Fig.8.

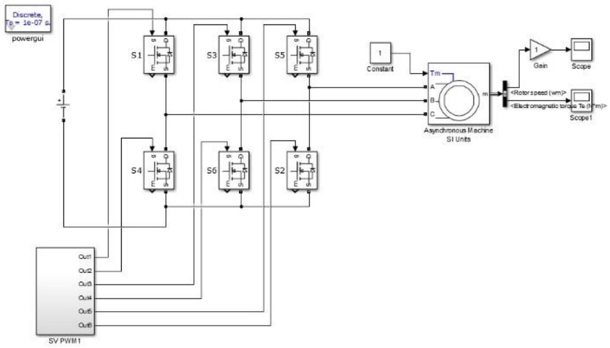

Fig. 7: Simulation of Three Phase Six Switch Inverter.

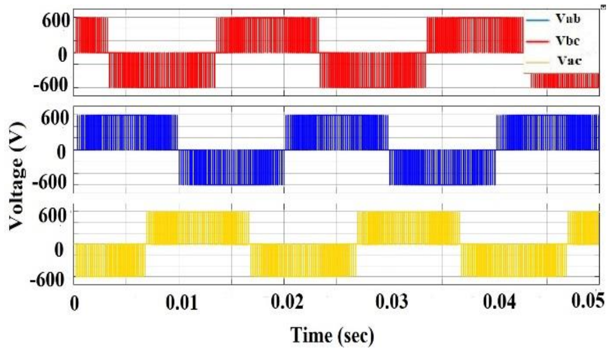

Fig. 8: Inverter Output Voltage.

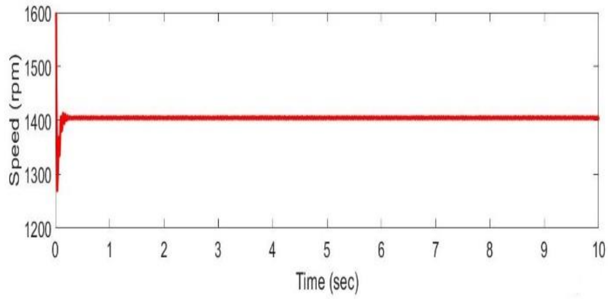

Fig. 9: Speed Characteristic of Induction Motor with 6STP.

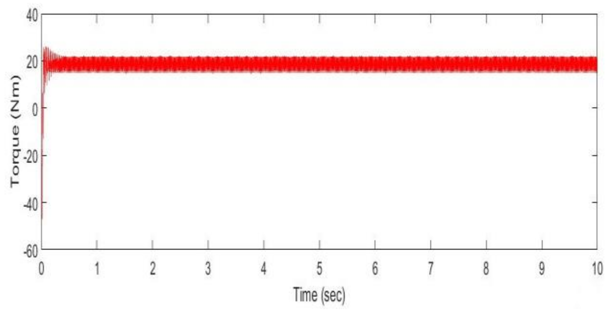

Fig. 10: Torque Characteristics of Induction Motor with 6STP.

The speed and toque characteristics of Induction motor with 6STP is displayed in Fig.9 and Fig.10 respectively. The motor runs just below 1500rpm.

4.2. Three phase four-switch inverter

Fig.11 shows the MATLAB simulation of three phase six switch inverter. The pulse from the space vector modulation signal is used to drive the switches. The motor of same specification as in three phase six switch inverter was used to study three phase four switch inverter.
The three phase four switch inverter output waveform is displayed in Fig.12. The speed and torque characteristic of Induction motor when driven by three phase four switch inverter is shown in Fig.13 and Fig.14 respectively.

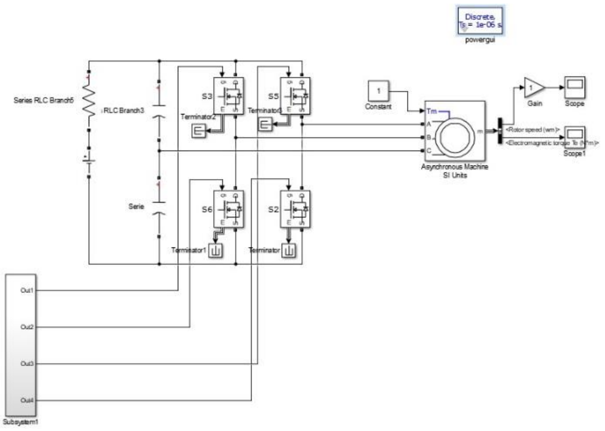

Fig. 11: Simulation of Three Phase Four Switch Inverter.

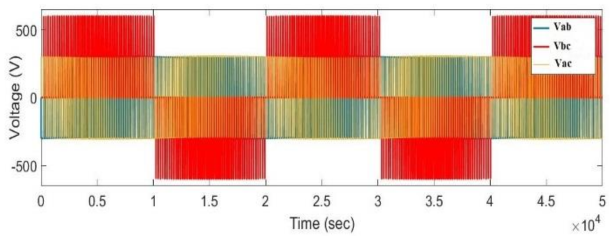

Fig. 12: Inverter Output Voltage.

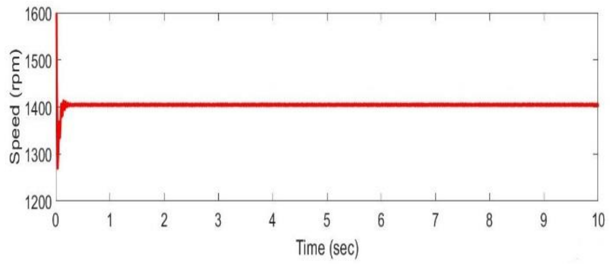

Fig. 10: Speed Characteristic of Induction Motor with 4STP.

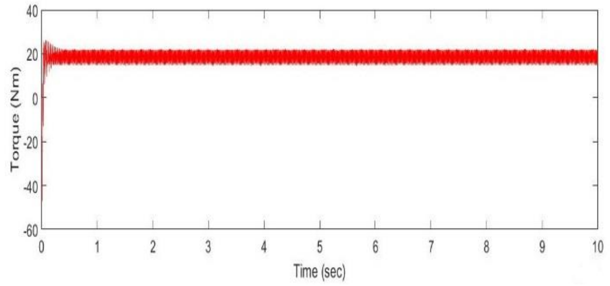

Fig. 11: Torque Characteristics of Induction Motor with 6STP.

5. Conclusion

A comparative study on three phase six switch inverter and three phase four switch inverter was done. Both the inverters are simulated in MATLAB software and the performance of Induction motor with each inverter was studied. The studies proves that both the inverter runs the machine in same manner without any disturbances. So the three phase four switch inverter can easily replace the three phase six switch inverter in applications where cost plays a vital role. The three phase four switch inverter have reduced cost when compared to three phase six switch inverter because of the compact amount of components. As the number of switches were reduced in the 4STP inverter the switching loss can also be reduced, thereby the total efficiency of the system can be improved.

Acknowledgement

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