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PERFORMANCE ANALYSIS OF INDIRECT ROTOR FIELD ORIENTATED CONTROL FOR FIVE PHASE INDUCTION MOTOR DRIVE

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ABSTRACT

This paper proposes a new topology of five-phase inverter with reduced number of switches fed coil with indirect rotor field oriented five-phase induction motor. It employs only eight IGBT switches performing a five-phase inverter. The reduction of the number of power switches from ten to eight reduces the cost, volume-compactness and reliability of five-phase induction motor drive systems. Simulation of the proposed drive system is developed using the Matlab/Simulink package and the results are analyzed to verify the effectiveness at different operating conditions. Comparison between performance of the five-phase induction motor under classical ten-switch inverter and the new topology, at the same operation conditions, has been illustrated. The proposed system gives similar operations as the classical ten-switch inverter for a certain range of motor speed and load torque. The DC voltage of the proposed inverter must be compensated to a higher value for achieving the same performance of classical ten-switch inverter in all ranges of motor speed and load torque.

الملخص العربي

يقدم هذا البحث نظام تسيير لمحرك حثى خماسى الاوجه . يعتمد هذا النظام على نظرية التوجيه الغير مباشر للمجال . يعتمد النظام على عاكس خماسى الاوجه يتكون من ثمانية مفاتيح لتغذية المحرك الخماسى الاوجه. ويقدم البحث التحليل الرياضي والمحاكاة للنظام المقترح المعتمد على التحكم ذي المسار المغلق للمحركات الحثيه خماسية الاوجه وذلك لبحث خصائص أدائها مقترنة بهذه العاكس، ويقدم البحث عرضا للنتائج عند حالات التشغيل المختلفة. وقد اثبتت النتائج قوة النظام المقترح كما انه يعطى خصائص اداء عاليه لتسيير المحركات الحثيه خماسية.الاوجه

Keyword: Five phase induction motor, Field oriented control, Ten-switch inverter, Eight-switch inverter

1. INTRODUCTION

Multiphase drives have several advantages over conventional three-phase drives such as: reducing motor phase current without increasing the phase voltage, increasing the frequency and reducing the amplitude of torque pulsations, increasing the torque / RMS ampere for the same machine volume [1-2]. With the advancement in power electronics, interest in multi-phase machine has been increased tremendously as high power electronic devices are used as a switch in voltage source inverter (VSI). To increase power system level, two approaches are used; the first one is the use of multilevel inverters supplying three-phase machines [3-4]. The second approach is multi-leg inverters fed multiphase machines [5-6]. It is noted that the similarity between two approaches ,in multilevel inverter the additional switching devices increase the number of voltage levels, while in the multi leg inverter, the additional number of switching devices increases the number of phases.

The performance under faulty conditions in voltage source inverter or in motor windings is one of advantages of multi phase motor [7-10]. Two techniques are used in five phase inverter, one, is the carrier based pulse width modulation (PWM) and the other is the space vector modulation (SVM) [11-14].

This paper study a new inverter topology to fed indirect rotor field oriented five phase induction motor drive system. This inverter topology consists of eight switches instead of ten switches, two switches used for every phase and the fifth phase connected to the midpoint of dc-link capacitor. This topology of the inverter introduces many advantages compared to traditional ten switch inverter, such as, compactness, simplicity, low cost, and more reliable. To ensure the validity of drive system with the proposed topology, a simulations of the system is made using Simulink/MATLAB. Simulation results are carried out at different operating conditions and show that the performance characteristics are similar in both cases of classical ten switch inverter and proposed eight switch inverter for a certain range of speed and load torque. To have the same performance for all range of speed and load torque the DC voltage of proposed inverter must be increased.

2. MATHEMATICAL MODEL of 5-PHASE INDUCTION MOTOR

Squirrel-cage five-phase induction motor is represented in its d-q synchronous reference frame. The winding axes of five-stator winding are displaced by 72 electrical degrees. In this analysis the air gap is uniform and the windings are sinusoidal distributed around the air gap magnetic saturation and core losses are neglected. As for the three-phase induction motor, where the well-known d-q rotating reference is used in analysis and control. A d-q reference frame is also used for the five-phase induction motor. The five-phase induction machine can be modeled with the following voltage equations in synchronous reference frame [15-16].

The q-d stator and referred rotor voltages are given by:

$$V_{qs} = R_s I_{qs} + \frac{d\,\psi_{qs}}{dt} + \omega_e \psi_{ds} \tag{1}$$

$$V_{ds} = R_s I_{ds} + \frac{d\,\psi_{ds}}{dt} - \omega_e \psi_{qs} \tag{2}$$

$$0 = R_r I_{qr} + \frac{d\,\psi_{qr}}{dt} + (\omega_e - \omega_r)\psi_{dr} \tag{3}$$

$$0 = R_r I_{dr} + \frac{d\,\psi_{dr}}{dt} - (\omega_e - \omega_r)\psi_{qr} \tag{4}$$

Where, V_{qs}, V_{ds}, ψ_{qs}, ψ_{ds} are the q and d components of stator voltage and flux. I_{qs}, I_{ds}, I_{qr} and I_{dr} are the q and d component of stator and referred rotor currents. R_s and R_r are stator and referred rotor windings resistance. ω_e is the speed of stator field in elec rad/s. ω_r is the rotor speed in elec rad/s.

For the stationary reference frame $\omega_e = 0$, substitute into Eqs. (1) to (4) yields:

$$V_{qs} = R_s i_{qs} + \frac{d\,\psi_{qs}}{dt} \tag{5}$$

$$V_{ds} = R_s i_{ds} + \frac{d\,\psi_{ds}}{dt} \tag{6}$$

$$0 = R_r i_{qr} + \frac{d\,\psi_{qr}}{dt} - \omega_r \psi_{dr} \tag{7}$$

$$0 = R_r i_{dr} + \frac{d\,\psi_{dr}}{dt} + \omega_r \psi_{qr} \tag{8}$$

The q-d stator flux linkage are given by:

$$\psi_{qs} = (L_{ls} + L_m) i_{qs} + L_m i_{qr} \tag{9}$$

$$\psi_{ds} = (L_{ls} + L_m) i_{ds} + L_m i_{dr} \tag{10}$$

Where; L_{ls} and L_m are the stator leakage and mutual inductance.

The q-d referred rotor flux linkage are given by:

$$\psi_{qr} = (L_{lr} + L_m) i_{qr} + L_m i_{qs} \tag{11}$$

$$\psi_{dr} = (L_{lr} + L_m) i_{dr} + L_m i_{ds} \tag{12}$$

Where; L_{lr} is the rotor leakage inductance.

The electromagnetic torque is given by:

$$T_e = \frac{5}{2}\frac{P}{2}\frac{L_m}{L_r}(\psi_{dr} i_{qs} - \psi_{qr} i_{ds}) \tag{13}$$

The rotor dynamic equation is:

$$T_e - T_L = J\frac{d\omega_r}{dt} + B\,\omega \tag{14}$$

Where; P is the number of poles, J is the moment of inertia kg.m^2, B is the friction coefficient N.m.s/rad.

To achieve indirect rotor field oriented control of five phase induction motor the component ψ_{qr} must equals zero. In this case, the reference value of quadrature current component in synchronous rotating frame is given by:

$$I_{qs}^{e*} = \frac{2}{5}\frac{2}{P}\frac{L_r}{L_m}\frac{(\omega^* - \omega_r)(K_p + \frac{K_i}{S})}{\psi_{dr}^*} \tag{15}$$

The reference value of direct current component in synchronous rotating frame is given as:

$$I_{ds}^{e*} = \frac{1}{L_m}\left(1 + \frac{L_r}{R_r}p\right)\psi_{dr}^* \tag{16}$$

The angular slip frequency command (ω_{sl}^*) is:

$$\omega_{sl} = \frac{R_r\,L_m}{L_r}\frac{I_{qs}^{e*}}{\psi_{dr}^*} = \frac{L_m}{\tau_r}\frac{I_{qs}^{e*}}{\psi_{dr}^*} \tag{17}$$

Where; $\tau_r = \frac{L_r}{R_r}$ is the rotor time constant.

The angular frequency can be calculated as:

$$\omega_e = \omega_{sl} + \omega_r \tag{18}$$

$$\theta_e = \int \omega_e\,dt \tag{19}$$

The reference currents can be given as:

$$\left\{\begin{aligned} i_a^{s*} &= i_{qs}^* \cos(\theta_e) + i_{ds}^* \sin(\theta_e) \\ i_b^{s*} &= i_{qs}^* \cos\left(\theta_e - \frac{2\pi}{5}\right) + i_{ds}^* \sin\left(\theta_e - \frac{2\pi}{5}\right) \\ i_c^{s*} &= i_{qs}^* \cos\left(\theta_e - \frac{4\pi}{5}\right) + i_{ds}^* \sin\left(\theta_e - \frac{4\pi}{5}\right) \\ i_d^{s*} &= i_{qs}^* \cos\left(\theta_e + \frac{4\pi}{5}\right) + i_{ds}^* \sin\left(\theta_e + \frac{4\pi}{5}\right) \\ i_e^{s*} &= i_{qs}^* \cos\left(\theta_e + \frac{2\pi}{5}\right) + i_{ds}^* \sin\left(\theta_e + \frac{2\pi}{5}\right) \end{aligned}\right\} \tag{20}$$

With Field oriented control, the motor torque is given by:

$$T_e = \frac{5}{2}\frac{P}{2}\frac{L_m}{L_r}\psi_{dr} i_{qs} = k_t\ \psi_{dr}^e I_{qs}^e \tag{21}$$

Eq. (21) is similar to that of the separately excited dc motor and denotes that the torque is proportional to the quadrature component of the stator current (I_{qs}^{e}) if the flux direct axis component of rotor flux (ψ_{dr}^{e}) is kept constant. This is the principle of field oriented control technique.

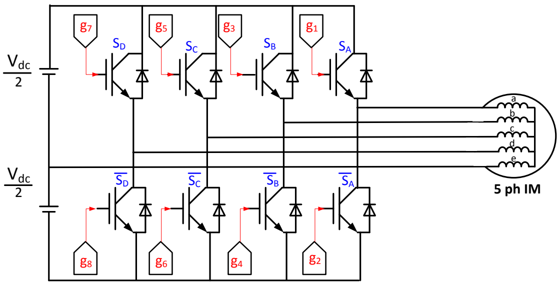

Fig. 1 Eight-switch proposed Inverter

The phase voltages of the classical ten-switch five-phase inverter fed five-phase induction motor are introduced as a function of switching logic NA, NB, NC,ND and NE of power switches by the following relation:

$$\begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix} = \frac{V_{dc}}{5} \begin{bmatrix} 4 & -1 & -1 & -1 & -1 \\ -1 & 4 & -1 & -1 & -1 \\ -1 & -1 & 4 & -1 & -1 \\ -1 & -1 & -1 & 4 & -1 \\ -1 & -1 & -1 & -1 & 4 \end{bmatrix} \begin{bmatrix} NA \\ NB \\ NC \\ ND \\ NE \end{bmatrix} \quad (22)$$

The switching logic state may be 0 or 1.Where, 1is for ON state and 0 is for OFF state.

The switching table of classical ten switches five-phase inverter is given in Tab. 1.

3. PROPOSED EIGHT SWITCH FIVE PHASE INVERTER

The proposed inverter has reduced switching devices compared with classical five-phase inverter which consists of ten switches. The proposed inverter consists of eight switches as shown in Fig. 1.

Table 1: The switching states of ten-switch five-phase inverter

NA	NB	NC	ND	NE	V_a	V_b	V_c	V_d	V_e
0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	-0.2V_{dc}	-0.2V_{dc}	-0.2V_{dc}	-0.2V_{dc}	0.8V_{dc}
0	0	0	1	0	-0.2V_{dc}	-0.2V_{dc}	-0.2V_{dc}	0.8V_{dc}	-0.2V_{dc}
0	0	0	1	1	-0.4V_{dc}	-0.4V_{dc}	-0.4V_{dc}	0.6V_{dc}	0.6V_{dc}
0	0	1	0	0	-0.2V_{dc}	-0.2V_{dc}	0.8V_{dc}	-0.2V_{dc}	-0.2V_{dc}
0	0	1	0	1	-0.4V_{dc}	-0.4V_{dc}	0.6V_{dc}	-0.4V_{dc}	0.6V_{dc}
0	0	1	1	0	-0.4V_{dc}	-0.4V_{dc}	0.6V_{dc}	0.6V_{dc}	-0.4V_{dc}
0	0	1	1	1	-0.6V_{dc}	-0.6V_{dc}	0.4V_{dc}	0.4V_{dc}	0.4V_{dc}
0	1	0	0	0	-0.2V_{dc}	0.8V_{dc}	-0.2V_{dc}	-0.2V_{dc}	-0.2V_{dc}
0	1	0	0	1	-0.4V_{dc}	0.6V_{dc}	-0.4V_{dc}	-0.4V_{dc}	0.6V_{dc}
0	1	0	1	0	-0.4V_{dc}	0.6V_{dc}	-0.4V_{dc}	0.6V_{dc}	-0.4V_{dc}
0	1	0	1	1	-0.6V_{dc}	0.4V_{dc}	-0.6V_{dc}	0.4V_{dc}	0.4V_{dc}
0	1	1	0	0	-0.4V_{dc}	0.6V_{dc}	0.6V_{dc}	-0.4V_{dc}	-0.4V_{dc}
0	1	1	0	1	-0.6V_{dc}	0.4V_{dc}	0.4V_{dc}	-0.6V_{dc}	0.4V_{dc}
0	1	1	1	0	-0.6V_{dc}	0.4V_{dc}	0.4V_{dc}	0.4V_{dc}	-0.6V_{dc}
0	1	1	1	1	-0.8V_{dc}	0.2V_{dc}	0.2V_{dc}	0.2V_{dc}	0.2V_{dc}
1	0	0	0	0	0.8V_{dc}	-0.2V_{dc}	-0.2V_{dc}	-0.2V_{dc}	-0.2V_{dc}
1	0	0	0	1	0.6V_{dc}	-0.4V_{dc}	-0.4V_{dc}	-0.4V_{dc}	0.6V_{dc}
1	0	0	1	0	0.6V_{dc}	-0.4V_{dc}	-0.4V_{dc}	0.6V_{dc}	-0.4V_{dc}
1	0	0	1	1	0.4V_{dc}	-0.6V_{dc}	-0.6V_{dc}	0.4V_{dc}	0.4V_{dc}
1	0	1	0	0	0.6V_{dc}	-0.4V_{dc}	0.6V_{dc}	-0.4V_{dc}	-0.4V_{dc}
1	0	1	0	1	0.4V_{dc}	-0.6V_{dc}	0.4V_{dc}	-0.6V_{dc}	0.4V_{dc}
1	0	1	1	0	0.4V_{dc}	-0.6V_{dc}	0.4V_{dc}	0.4V_{dc}	-0.6V_{dc}
1	0	1	1	1	0.2V_{dc}	-0.8V_{dc}	0.2V_{dc}	0.2V_{dc}	0.2V_{dc}
1	1	0	0	0	0.6V_{dc}	0.6V_{dc}	-0.4V_{dc}	-0.4V_{dc}	-0.4V_{dc}
1	1	0	0	1	0.4V_{dc}	0.4V_{dc}	-0.6V_{dc}	-0.6V_{dc}	0.4V_{dc}
1	1	0	1	0	0.4V_{dc}	0.4V_{dc}	-0.6V_{dc}	0.4V_{dc}	-0.6V_{dc}
1	1	0	1	1	0.2V_{dc}	0.2V_{dc}	-0.8V_{dc}	0.2V_{dc}	0.2V_{dc}
1	1	1	0	0	0.4V_{dc}	0.4V_{dc}	0.4V_{dc}	-0.6V_{dc}	-0.6V_{dc}
1	1	1	0	1	0.2V_{dc}	0.2V_{dc}	0.2V_{dc}	-0.8V_{dc}	0.2V_{dc}
1	1	1	1	0	0.2V_{dc}	0.2V_{dc}	0.2V_{dc}	0.2V_{dc}	-0.8V_{dc}
1	1	1	1	1	0	0	0	0	0

the modulated phase voltages of the proposed eight-switch five-phase inverter are introduced as a function of switching logic NA, NB, NC and ND can be defined as given in Eqs. (23) and (24).

$$\begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix} = \frac{0.5\,V_{dc}}{5} \begin{bmatrix} 8 & -2 & -2 & -2 & -1 \\ -2 & 8 & -2 & -2 & -1 \\ -2 & -2 & 8 & -2 & -1 \\ -2 & -2 & -2 & 8 & -1 \\ -2 & -2 & -2 & -2 & 4 \end{bmatrix} \begin{bmatrix} NA \\ NB \\ NC \\ ND \\ 1 \end{bmatrix} \quad (23)$$

$$\begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix} = \frac{V_{dc}}{5} \begin{bmatrix} 4 & -1 & -1 & -1 & -1 \\ -1 & 4 & -1 & -1 & -1 \\ -1 & -1 & 4 & -1 & -1 \\ -1 & -1 & -1 & 4 & -1 \\ -1 & -1 & -1 & -1 & 4 \end{bmatrix} \begin{bmatrix} NA \\ NB \\ NC \\ ND \\ 0.5 \end{bmatrix} \quad (24)$$

The switching table of eight-switch five-phase inverter is shown in Tab. 2.

Tabel 2: The switching states of eight switch five phase inverter

NA	NB	NC	ND	V_a	V_b	V_c	V_d	V_e
0	0	0	0	$-0.1V_{dc}$	$-0.1V_{dc}$	$-0.1V_{dc}$	$-0.1V_{dc}$	$0.4V_{dc}$
0	0	0	1	$-0.3V_{dc}$	$-0.3V_{dc}$	$-0.3V_{dc}$	$0.7V_{dc}$	$0.2V_{dc}$
0	0	1	0	$-0.3V_{dc}$	$-0.3V_{dc}$	$0.7V_{dc}$	$-0.3V_{dc}$	$0.2V_{dc}$
0	0	1	1	$-0.5V_{dc}$	$-0.5V_{dc}$	$0.5V_{dc}$	$0.5V_{dc}$	0
0	1	0	0	$-0.3V_{dc}$	$0.7V_{dc}$	$-0.3V_{dc}$	$-0.3V_{dc}$	$0.2V_{dc}$
0	1	0	1	$-0.5V_{dc}$	$0.5V_{dc}$	$-0.5V_{dc}$	$0.5V_{dc}$	0
0	1	1	0	$-0.5V_{dc}$	$0.5V_{dc}$	$0.5V_{dc}$	$-0.5V_{dc}$	0
0	1	1	1	$-0.7V_{dc}$	$0.3V_{dc}$	$0.3V_{dc}$	$0.3V_{dc}$	$-0.2V_{dc}$
1	0	0	0	$0.7V_{dc}$	$-0.3V_{dc}$	$-0.3V_{dc}$	$-0.3V_{dc}$	$0.2V_{dc}$
1	0	0	1	$0.5V_{dc}$	$-0.5V_{dc}$	$-0.5V_{dc}$	$0.5V_{dc}$	0
1	0	1	0	$0.5V_{dc}$	$-0.5V_{dc}$	$0.5V_{dc}$	$-0.5V_{dc}$	0
1	0	1	1	$0.3V_{dc}$	$-0.7V_{dc}$	$0.3V_{dc}$	$0.3V_{dc}$	$-0.2V_{dc}$
1	1	0	0	$0.5V_{dc}$	$0.5V_{dc}$	$-0.5V_{dc}$	$-0.5V_{dc}$	0
1	1	0	1	$0.3V_{dc}$	$0.3V_{dc}$	$-0.7V_{dc}$	$0.3V_{dc}$	$-0.2V_{dc}$
1	1	1	0	$0.3V_{dc}$	$0.3V_{dc}$	$0.3V_{dc}$	$-0.7V_{dc}$	$-0.2V_{dc}$
1	1	1	1	$0.1V_{dc}$	$0.1V_{dc}$	$0.1V_{dc}$	$0.1V_{dc}$	$-0.4V_{dc}$

4. PROPOSED INDIRECT ROTOR FIELD ORIENTED FIVE-PHASE INDUCTION MOTOR

The principle of indirect rotor field oriented control is applied to Five-phase induction motor. The application of the vector control scheme to such arrangement is simple, and can provide fast-decoupled control of torque and flux. The description of the complete system is illustrated in Fig. 2.

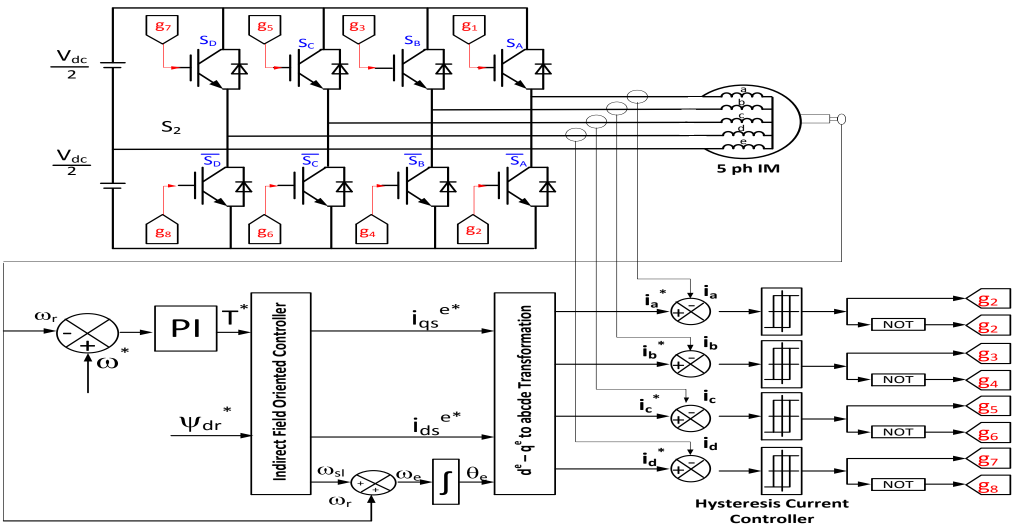

Fig. 2 Block diagram of speed control system

In Fig.2, the motor speed, ω_r is compared to a reference speed, ω^*, and the error signal is processed by the PI controller, to generate the torque-component current command $I_{qs}{}^{e*}$ as shown in Eq. (15). The flux- component of current command $I_{ds}{}^{e*}$is calculated according to adopted control strategy as given in Eq. (16). The two current command components are then transformed with the help of rotor position encoder (angleθ_e) to five current commands i_a, i_b, i_c, i_d and $i_e$in the stationary reference frame as define. in Eq. (20). These current commands are then compared to the actual motor currents by hysteresis current controller to generate the logic pulses for the inverter switches.

5. SIMULATIONS AND DISCUSSIONS

In this section, it is assumed that per-phase parameters and ratings of the 5-phaseinduction motor are the same as for the three-phase motor due to the lack of data of 5-phase motor. The parameters of the motor are listed in the Appendix. The system is developed and simulated using MatLab R2014a. Various scenarios including speed and load torque variations are presented to study the performance of the system with proposed topology of eight switch inverter and classical ten switch inverter. The results of the proposed eight-switch inverter are compared with those of classical ten switch inverter.

5.1 SIMULATION RESULTS UNDER DIFFERENT REFERENCE SPEEDS

In this case of loading; the load torque is maintained constant at 5 N.m and the reference speed is changed from 50 rad/s (477.4648 rpm) to 100 rad/s (954.9297rpm) at t = 2s and then to 150 rad/s (1432.4 rpm) at t = 4s and to 120 rad/s (1145.9 rpm) at t=6s as shown in Fig. 3. It can be noticed that the motor response of eight switch inverter is similar to that to ten switch and the error between actual speed and motor speed is insignificant and the motor response is very fast to track reference speed. The motor phase currents are identical in both inverter techniques for lower range of speeds up to 100 rad/s as shown in Fig. 4. It has been shown that for higher speed, as shown in Fig. 5, at 150 rad/s the actual and reference current are the same for classical 10 switch inverter. But, in proposed 8 switch inverter the error between the reference and actual motor current is significant and the actual currents are non-sinusoidal and the motor peak current is higher than the one of 10 switch inverter. Therefore, the load torque of 8 switch inverter must be lower than one of 10 switch at this speed to avoid motor overheating. This a drawback of 8 switch inverter that at speeds near rated value the motor control fails to achieve field orientation as shown in Fig. 6 (ψ_{qr} has value at speed 150 and 120 rad/s) and motor current is higher than the 10 switch inverter. The reason of this disadvantage is that the motor voltage in 8 switch is insufficient to give rated reference flux (0.9 V/rad/s) as illustrated in Fig. 7 as ψ_{dr} has value lower than 0.9 at 150 and 120 rad/s. The solution of this problem will be presented in sec.(5.3) in this paper.

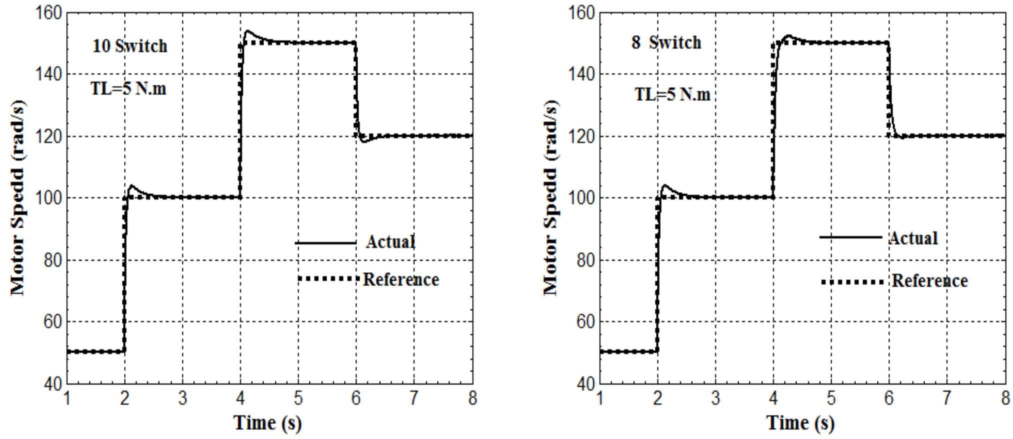

Fig. 3 Variation of motor speed with time at constant load torque of 5 N.m

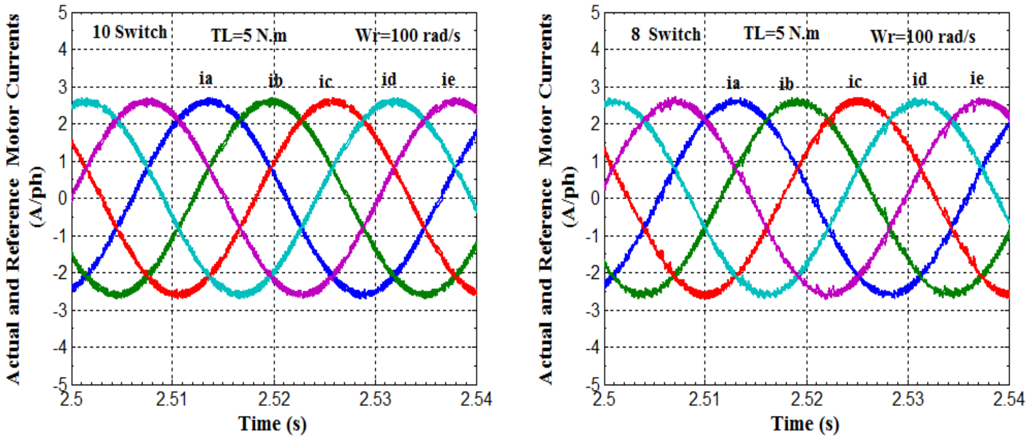

Fig. 4 Variation of actual and reference motor currents against time at $\omega_r = 100$ rad/s

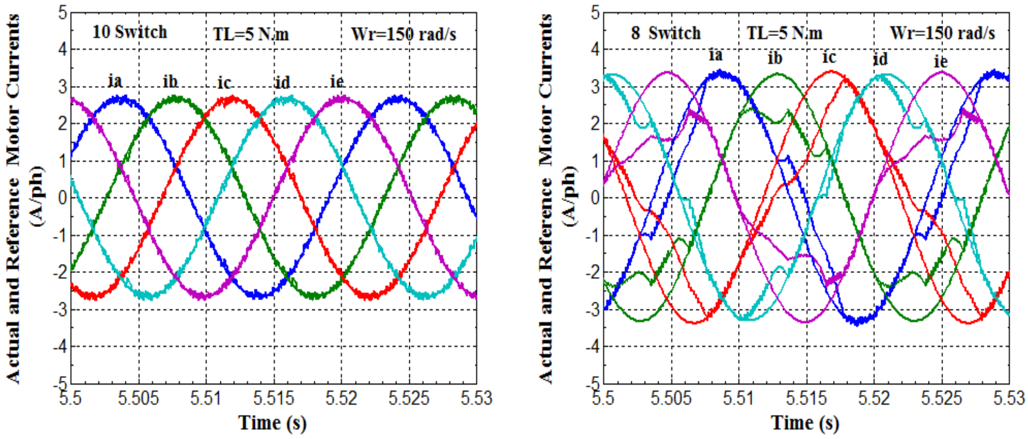

Fig. 5 Variation of actual and reference motor currents against time at $\omega_r = 150$ rad/s

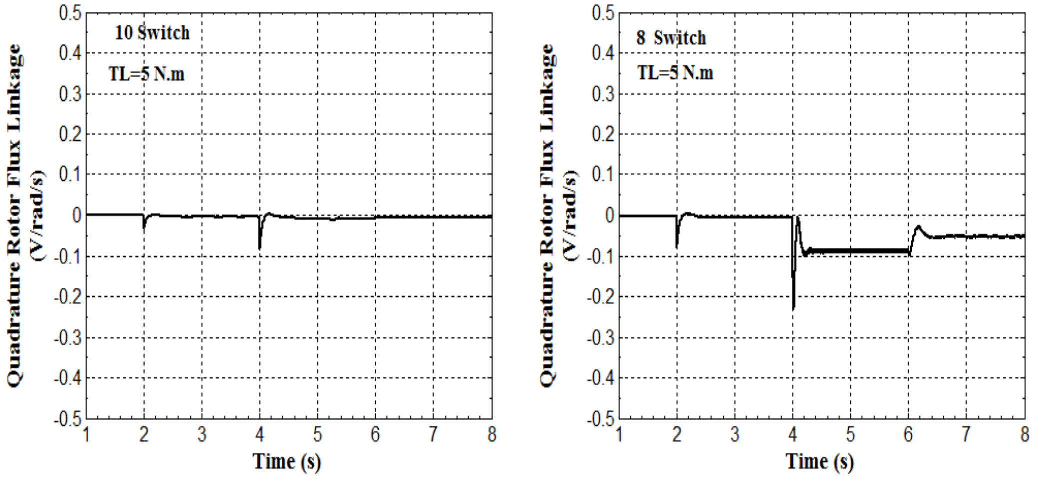

Fig. 6 Variation of quadrature rotor flux versus time at constant load torque of 5 N.m

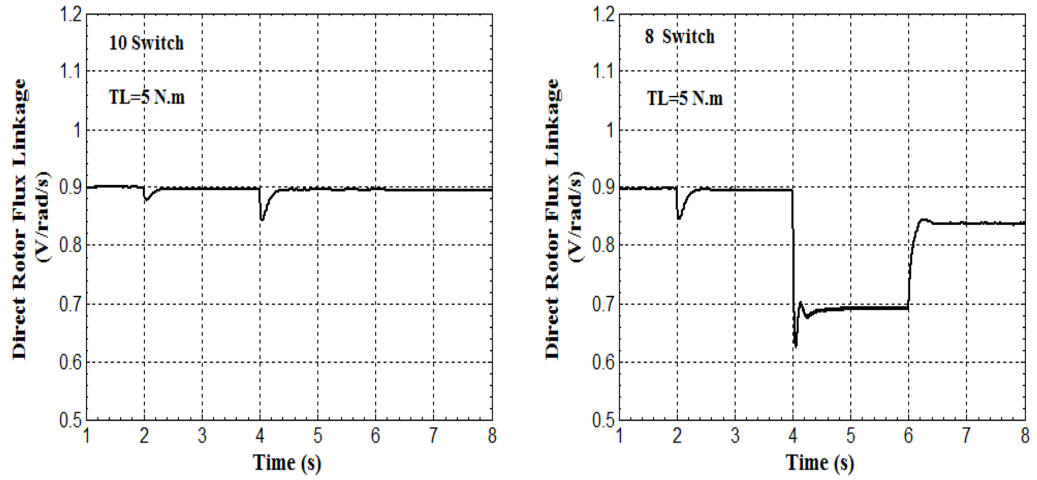

Fig. 7 Variation of direct rotor flux versus time at constant load torque of 5 N.m

5.2 RESPONSE WITH DIFFERENT LOAD TORQUES

In this scenario of loading; the reference speed is constant at 100 rad/s (954.9297 rpm) and load torque is changed from 1 N.m to 3 N.m at t = 2s and then to 7 N.m at t = 4s and to 5 N.m at t= 6s as shown in Fig. 8.

The motor developed required reference torque at reference speed in both two inverter technique as

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shown in Fig. 8 and Fig. 9 respectively. The motor currents in both inverter techniques are approximately similar as illustrated in Fig. 10. This similarity in motor currents is due to the motor in both inverters achieves field orientation($\psi_{qr} = 0$) with reference flux ($\psi_{dr} =$ 0.9 V/rad/s) as shown in Figs. 11 and 12 respectively

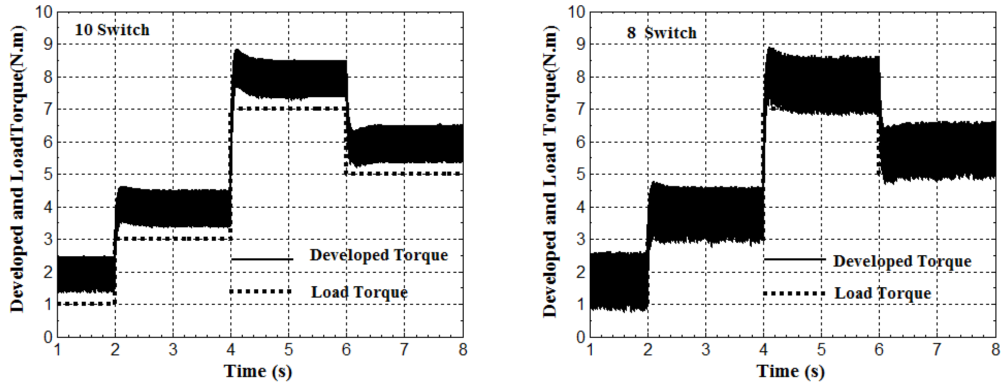

Fig. 8 Variation of developed and load torques with time at constant reference speed of 100 rad/s

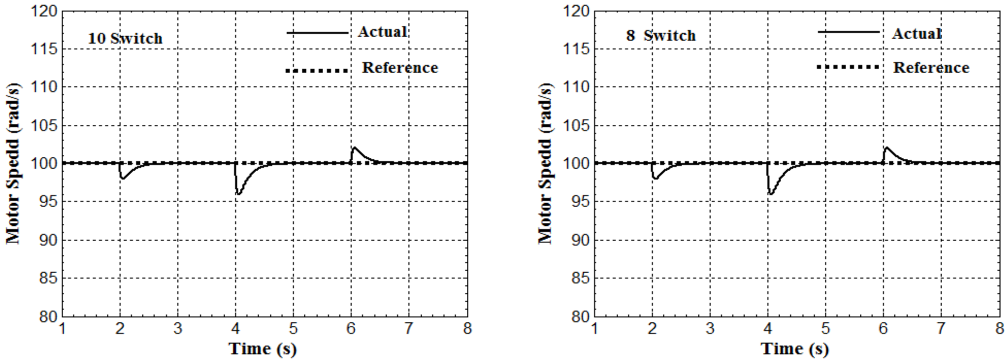

Fig. 9 Variation of motor speed versus time

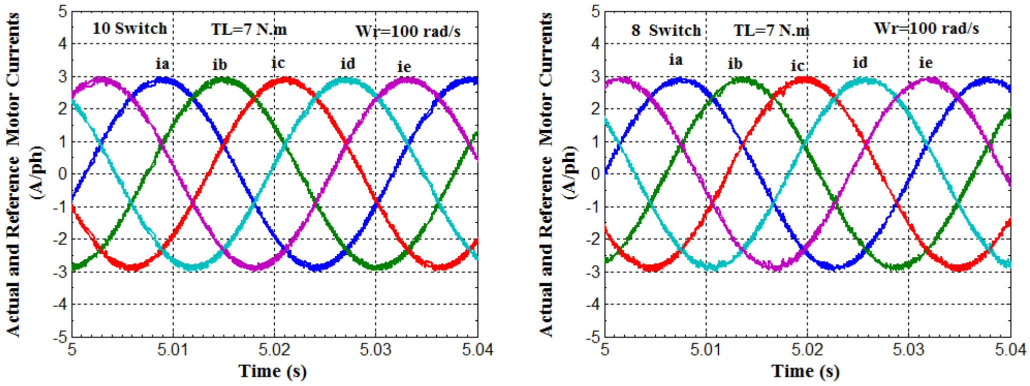

Fig. 10 Variation of actual and reference motor current against time with $T_L = 7$ N.m

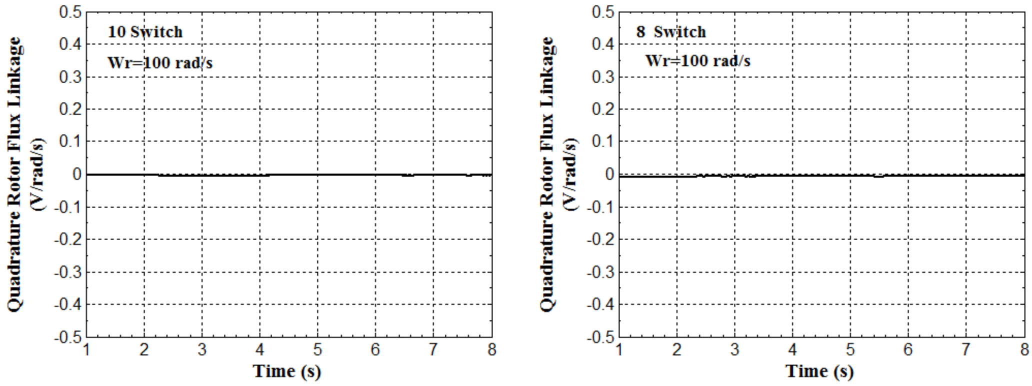

Fig. 11 Variation of quadrature rotor flux versus time

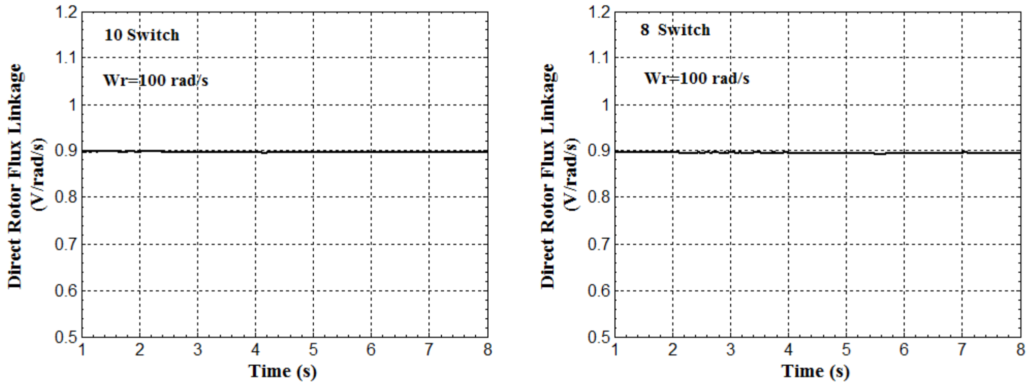

Fig. 12 Variation of direct rotor flux versus time

5.3 RESPONSE AT A HIGHER DC VALUE

It noticed that from above results that two techniques of inverters are similar for certain range of motor speed and load torque. But the difference between two inverters appears when the motor voltage in eight switch inverter is insufficient to develop required speed and load torque. This diversity can be eliminated by increasing the DC voltage of 8 switch inverter to 700 V instead of 512 V in 10 switch inverter. The motor currents in both inverters are similar at reference speed of 150 rad/s and load torque of 1N.m and 7 N.m as shown in Figs. 13 and 14 respectively.

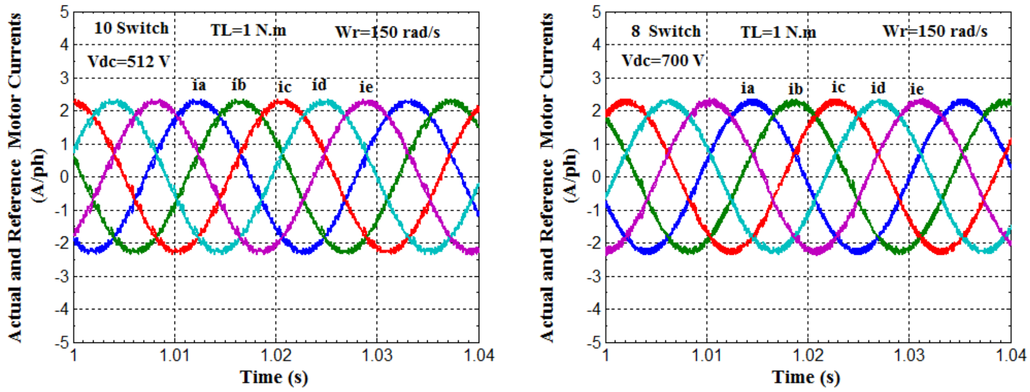

Fig. 13 Variation of motor current against time and $V_{dc} = 700\ V$ in 8 switch inverter at $\mathrm{T_L} = 1\ \mathrm{N.m}$

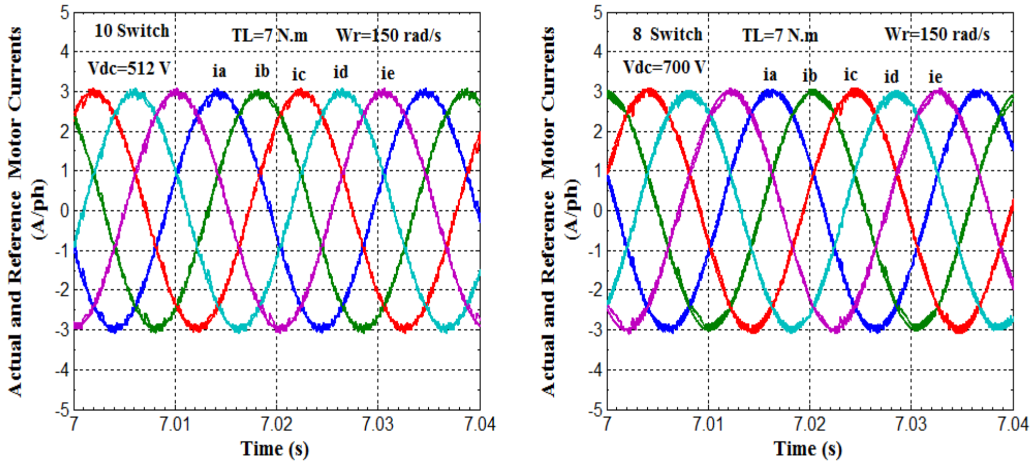

Fig. 14 Variation of motor current against time and $V_{dc} = 700\ V$ in 8 switch inverter at $\mathrm{T_L} = 7\ \mathrm{N.m}$

6. CONCLUSION

In this paper, the performance characteristics of vector control for five phase induction motor with eight switch five phase inverter have been presented The proposed inverter reduces the number of power switches from ten to eight ,and this improves the cost and reliability of the system. The system is simulated with sudden change in speed and load torque and the results ensure that the motor performance with proposed eight switch inverter is similar to those of ten-switch inverter for certain range of motor speed and load torque. The DC voltage of the proposed eight-switch inverter must be compensated to a higher value to achieve the same performance of the classical-ten switch inverter in all ranges of motor speed and load torque.

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APPENDIX

Motor parameters:

Rated power	1.1 kW
Rated Voltage	220/380 V
Rated frequency	50 Hz
Poles	4
Rated voltage	220/380 V
Stator resistance	7.4826 Ω
Referred rotor resistance	3.6840 Ω
Stator leakage inductance	0.0221 H
Referred rotor leakage inductance	0.0221 H
mutual inductance	0.4114 H
Moment of inertia	0.02 Kg.m^2