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PWM CONTROLLED FOUR SWITCH THREE PHASE INVERTER FED INDUCTION MOTOR DRIVE

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ABSTRACT

In this paper four switch three phase inverter (FSTPI) fed induction motor drive is studied and analysed using simulations based on MATLAB SIMULINK. The input voltage to the induction motor is in pulse width modulated form. A simple sine-pulse-width-modulation-based (SPWM) control strategy has been used. It is observed that the induction motor stator current is sinusoidal in nature. It is found that motor speed is attaining steady state speed satisfactorily. The FSTPI fed induction motor drive is found quite acceptable considering its performance, cost reduction due to reduced switch countthe switching losses, the complexity of the control algorithms and the interface circuits to generate six PWM logic signals. Both PWM and SPWM techniques are implemented for switching. The performance of the motor and the Total Harmonic Distortion (THD) are compared in both of these techniques. Finally a comparison between the performance of induction motor fed from three phase six-switch based inverter and three phase four-switch based inverter is carried out.

INDEX TERMS — Four-switch inverter, Induction motor drive, Pulse width modulation (PWM).Total Harmonic Distortion (THD)

INTRODUCTION

Over the years, traditionally, six-switch three-phase inverters (SSTPI) have been widely utilized for variable speed alternating current (ac) motor drives. Recently, some efforts have been made on the application of FSTPI for uninterruptible power supply and variable speed drives [1]–[5]. This is due to some advantages of the FSTPI inverter over the conventional (SSTPI) inverter. such as reduced price due to reduction in number of switches, reduced switching losses, reduced number of interface circuits to supply logic signals for the switches, simpler control algorithms to generate logic signals, less chances of destroying the switches due to lesser interaction among switches, and less real-time computational burden.

In this paper, a cost-effective, simple and efficient four switch three phase inverter (FSTPI) is developed. The four switches make the inverter less costly and also the switching losses are reduced. There are less chances of destroying the switches due to lesser interaction among switches and less complexity of Control algorithms and interface circuits as compared to the conventional SSTPI. Furthermore, the proposed control approach reduces the computation for real-time implementation, performance Comparison of the proposed four-switch three-phase inverter fed drive with a conventional six-switch three-phase inverter fed drive is also made in terms of total harmonic distortion (THD) of the stator current and speed response.

CONVERTER TOPOLOGY

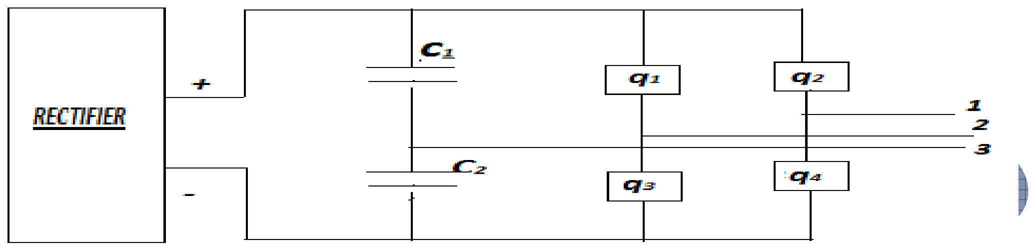

Figure.1.Power Circuit of Four switch invertors.

The power circuit of the FSTPI fed IM drive is shown in Fig. 1. The circuit consists of 4-switches q_1,q_2,$q_3$and $q_4$and split capacitors $C_1$and C_2. The three-phase AC input, which is of fixed frequency, is rectified by the rectifier switches. The power circuit is the three-phase four-switch inverter. Two phases '1' and '2' are connected to the two legs of the inverter, while the third phase '3' is connected to the centre point of the dc-link capacitors, $C_1$and C_2.

CONTROL TECHNIQUES

The control strategy is similar to the control of the six switch phase inverter, except that the reference signals does not obey the pattern as like to three phase inverter. Due to this phase shift, the odd triple harmonics of their reference waveform for each leg is eliminated from the line-to line output voltage.
The idea is same to SPWM for the six switch convertor (SSTPI) the carrier signals and the comparators are the same and the only modification to the conventional SPWM in order to control the four switch convertor.

The convertor of fig.1. C1= C2. and the desired voltages are as bellow:

$$V_1 = Vm\ \sin \omega t \qquad (1)$$

$$V_2 = Vm \sin(\omega t - \tfrac{\pi}{2}) \qquad (2)$$

$$V_3 = Vm\ \sin(\omega t + \tfrac{\pi}{2}) \qquad (3)$$

Since , there is no control on third (3) phase, the DC link (point 0) is taken as the reference point, so

$$V_{10} = V_1 - V_3 = \sqrt{3}Vm\sin(\omega t - \tfrac{\pi}{6}) \qquad (4)$$

$$V_{20} = V_2 - V_3 = \sqrt{3}Vm\sin(\omega t - \tfrac{\pi}{2}) \qquad (5)$$

$$V_{30} = V_3 - V_3 = 0 \qquad (6)$$

From above equation it is clear that to achieve three-phase voltages, the reference wave of third phase is assumed zero and the first and second phases are sinusoidal waves with 60 degrees out of phase from each other[2]

PERFORMANCEANALYSIS OF INDUCTION MOTOR FED FROM FSTPI SIMULATION MODEL:-

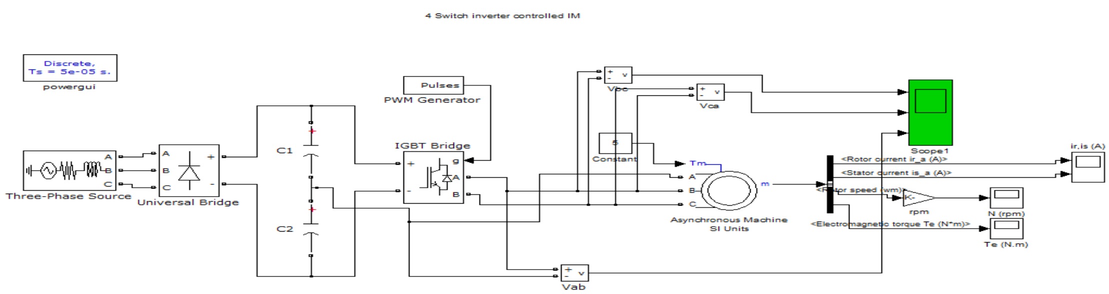

Figure 2

Digital computer simulation model using MATLAB-SIMULINK has been developed to test the proposed FSTPI fed IM drive. Simulation circuit diagram of the system is shown in Fig.2. The FSTPI fed drive system consists of a three-phase diode bridge rectifier, a split capacitor, four switch three phase inverter and three-phase Induction Motor. Input three-phase supply voltage: 400 V(rms), 50 Hz; Three-phase induction motor: 3 hp, 400 V, 50 Hz, 1500 rpm. The 3-phase output currents i_a,$i_b$and$i_c$of FSTPI with IM are shown in Figure. 2. The line voltage, line current, speed, torque and THD characteristic of the induction motor without load is shown in Fig.2a, Fig. 2b,Fig.2, Fig.2d and Fig. 2e respectively. The speed increases linearly and reaches the rated speed1500 rpm at steady state in 0.75 s. At starting, the torque increases and reduces to a minimum value when the speed reaches the rated value.the THD value is limited to 2.61% in stator current for 10 cycles (0.1µs) is obtained the rotor reaches the desired speed without any oscillations. The output voltage of the inverter is balanced which resulted in (29%) less THD.

SIMULATION RESULTS
VOLTAGE (V_L):-

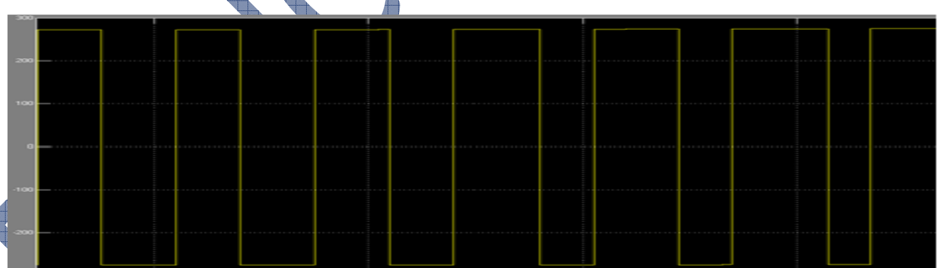

Figure.2.(a) voltage of fstpi invertor

CURRENT(IR IS):-

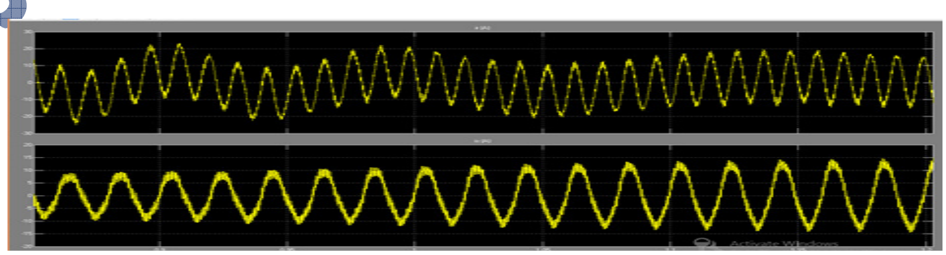

Figure.2.(b) stator current (is), Rotor current (ir) of Fstpi invertor

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SPEED:-

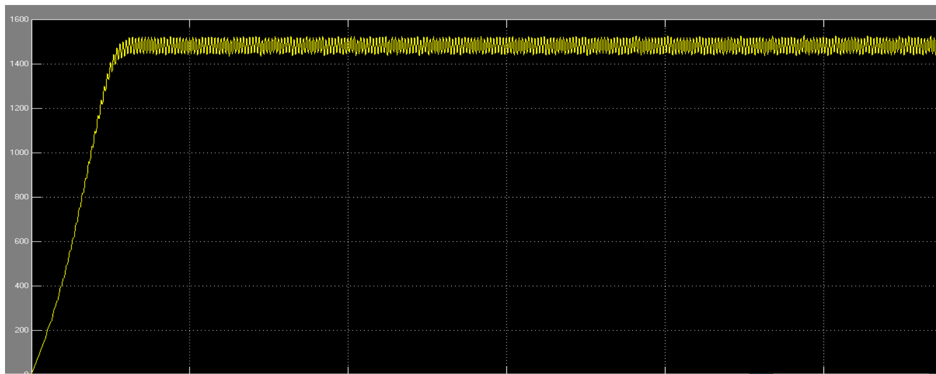

Figure.2.(c) Speed of Four switch Iinvertor fed induction motor

TORQUE:-

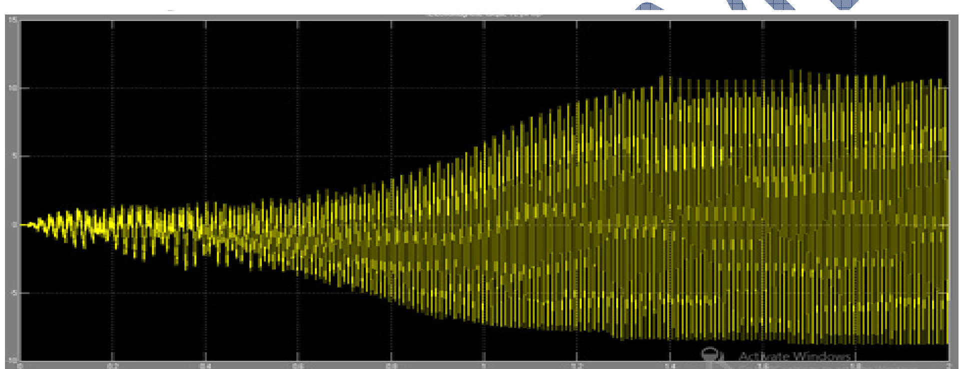

Figure.2.(d)Torque of Four switch Iinvertor

STATER CURRENT THD:-

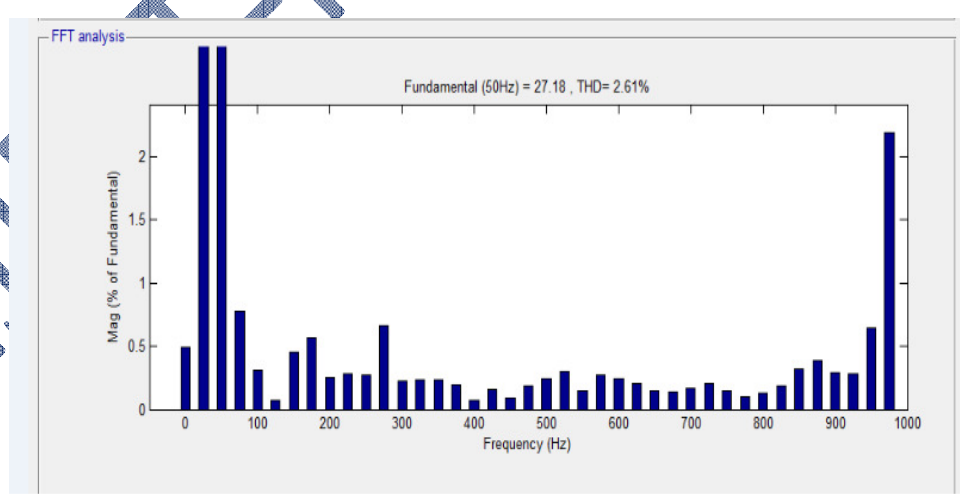

Figure. 2e.Stater Current THD of fsti invertor

PERFORMANCE ANALYSIS OF INDUCTION MOTOR FED FROM SIX SWITCH THREE PHASE INVERTOR (SSTPI)

SPEED

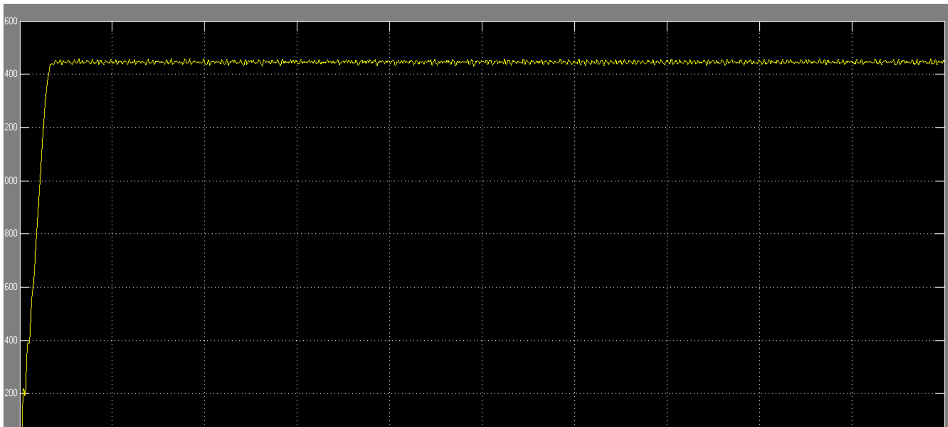

Figure.3.Speed of six switch inverter fed induction motor

STATERCURRENT THD:-

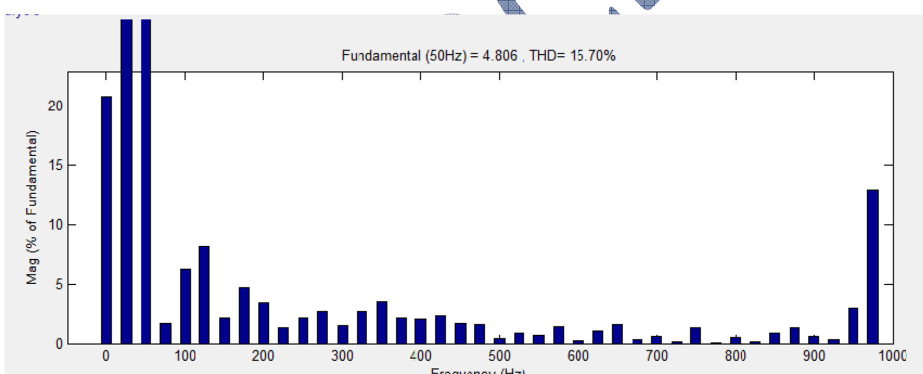

Figure 3.1 Stater Current THD of six switch invertors

RESULTS:-

Sr.No.	PERTICULARS	FSTPI	SSTPI
1	Number of switches	4	6
2	control	Easy	Complex
3	speed	Rated	Less than rated
4	THD (Stator Current)	2.64%	15.70%

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CONCLUSION

A cost effective FSTP inverter fed IM drive has been developed, simulated and successfully for a 3hp motor. The proposed control approach reduces the cost of the inverter, the switching losses, and the complexity of the control algorithms and interface circuits to generate 6 PWM logic signals.
The proposed FSTP inverter fed IM drive is found acceptable considering its cost reduction and other advantageous features. It was shown that it is economic to run light-load system, since it uses four switches instead of six and can be easily controlled by a low-cost.

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