ANALYSIS APPROACH FOR THREE PHASE TWO-LEVEL VOLTAGE SOURCE INVERTER AND FIVE PHASE TWO-LEVEL VOLTAGE SOURCE INVERTER FOR INDUCTION MOTOR DRIVE

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Abstract

This paper gives idea of comparison of three phase two-level voltage source inverter (TPTLVSI) and five phase two-level voltage inverter (FPTLVSI) without filter circuit for induction motor drive. The paper demonstrates using mat lab simulations about comparison in term of harmonics analysis for different firing angles and find best angle suitable for output with minimum harmonics for FPTLVSI. This paper suggests simulation of comparison point of view three phase two-level voltage inverter (TPTLVSI) and five phase two-level voltage inverter (FPTLVSI) for induction motor drive.

Index Terms: *Modeling of Three phase two-level voltage inverter (TPTLVSI) and five phase two-level voltage inverter (FPTLVSI)*

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1. INTRODUCTION

RESEARCH interest in the area of multiphase machines has been steadily increasing over the past decade [1].The newest developments are application-driven (marine electric propulsion, electric vehicles (EVs) and hybrid electric vehicles (HEVs), more electric aircraft, locomotive traction, and high-power applications in general) and the consequence of the advantages offered by multiphase machines, when compared to the three-phase equivalents. These are predominantly related to the possibility of reduction of the converter per-phase rating for the given machine power and to significantly improved fault tolerance, since an n-phase machine can continue to operate with a rotating field as long as no more than (n−3) phases are faulted. A further advantage exists if the multiphase machine is designed with concentrated stator windings, since it then becomes possible to enhance the torque production by injection of the low-order stator current harmonics of an appropriate order. five phase induction machine drive.

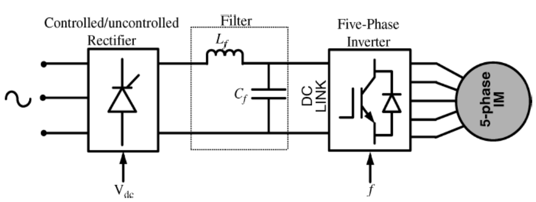


Fig.1 Block diagram of five phase induction motor drive

A simple open-loop five-phase drive structure is elaborated in **Error! Reference source not found.**. The dc link voltage is adjusted from the controlled rectifier by varying the conduction angles of the thyristors. The frequency of the fundamental output is controlled from the IGBT based voltage source inverter. The subsequent section describes the implantation issues of control of a five-phase voltage source inverter. The motivation behind choosing this structure lies in the fault tolerant nature of a five-phase drive system. It has been advantage of five phase induction motor drive like reduction in phase current, reliable in faulty conditions, reduction in current ripple.

2. BLOCK DIAGRAM FIVE PHASE TWO LEVEL VOLTAGE SOURCE INVERTER MODEL

As shown in fig.2 each switch in the circuit consists of two power semiconductor devices connected in anti-parallel. One of these is a fully controllable semiconductor, such as a bipolar transistor, MOSFET, or IGBT, while the second is a diode.

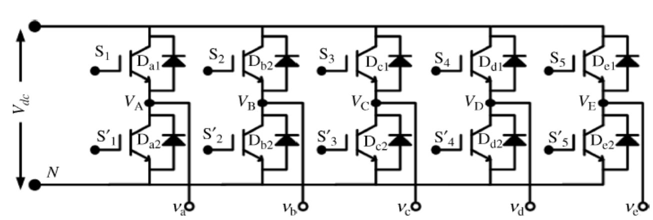


Fig.2 Power Circuit topology of a FPTLVSI

The upper and lower power switches of the same leg are complimentary in operation, i.e. if the upper switch is 'ON' the lower must be 'OFF,' and vice-versa. As shown in fig.3 Dead time is done to avoid shorting the DC supply.

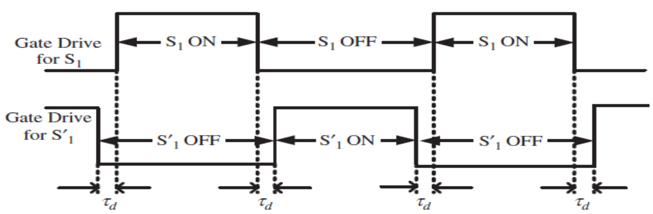


Fig.3 Illustration for dead time

3. HARMONICS ANALYSIS OF TPTLVSI AND FPTLVSI

This section presents the comprehensive analysis of simulation results. The performance of two different conduction modes are elaborated in terms of the harmonic content in the phase voltages, line voltages and the distortion in the ac side line current. The Fourier series of the phase-to-neutral voltage for 180° conduction mode is obtained as;

$$V(t) = \frac{2}{\pi} V_{dc} \left[\begin{array}{l} \sin \omega t + \frac{1}{3} \sin 3\omega t + \\ \frac{1}{7} \sin 7\omega t + \frac{1}{9} \sin 9\omega t + \\ \frac{1}{11} \sin 11\omega t + ... \end{array} \right] \quad (1)$$

From above equation (1) it follows that the fundamental component of the output phase-to-neutral voltage has an RMS value equal to

$$V_1 = \frac{\sqrt{2}}{\pi} V_{dc} = 0.45 V_{dc} \quad (2)$$

The Fourier series of the phase-to-neutral voltage for 120° conduction mode is obtained as;

$$V(t) = \frac{2V_{dc}}{\pi} \sum_{n=1,2,3,..}^{\infty} \left[\frac{\cos\left((2n-1)\frac{\pi}{10} \right) \sin\left((2n-1)\omega t \right)}{2n-1} \right] \quad (3)$$

From above equation (3) it follows that the fundamental component of the output phase-to-neutral voltage has an RMS value equal to

$$V_1 = \frac{\sqrt{2}}{\pi} V_{dc} \cos\left(\frac{\pi}{10} \right) = 0.428 V_{dc} \quad (4)$$

As per the equation of (4) loss in fundamental voltage in 120° conduction mode is of the order of 4.89% compared to 180° conduction mode. This loss will affect the loss of torque in the driven machine and subsequently the load will be affected. However, the drop in the torque is not very significant compared to the benefits obtained due to better harmonic performance.

Performance comparison in terms of harmonic content in output phase voltage, for different conduction modes are presented in fig.10 to 11**Error! Reference source not found.**. It is clearly seen that the harmonic content reduces significantly with reduction in conduction angle. The harmonic content is largest in 180 degree conduction mode and it is least in 120 degree conduction mode. However, the best utilization of available dc link voltage is possible with conventional ten step mode (180 degree conduction mode). It can thus be concluded that a trade-off exist between the loss in fundamental and corresponding gain in terms of lower harmonic content in output waveform is obtained by using 120 degree conduction mode.

A comparison of total harmonic distortion in the output phase voltages of five-phase voltage source inverter for different conduction angle is presented. The conduction angles considered are 180°, 162°, 144°, 126°, and 108°. Thus two more conduction states are included when compared to further prove the superiority of control at 120° conduction mode. It is observed that the lowest THD is obtained for 120° conduction mode.

4. MATLAB/SIMULINK MODELING OF TPTLVSI AND FPTLVSI

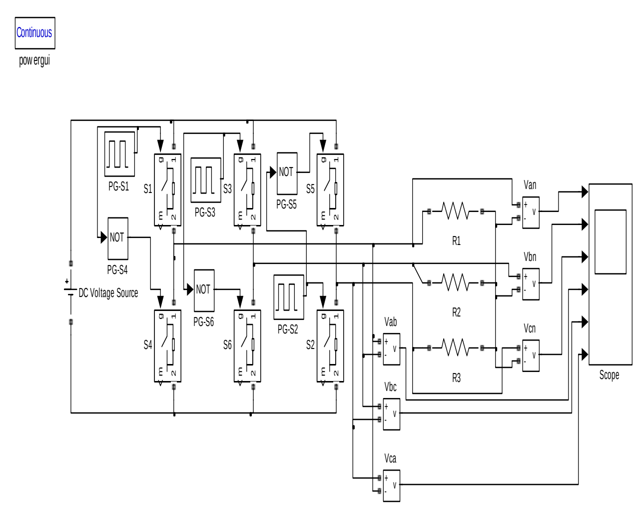


Fig.4 Matlab/simulink of model of TPTLVSI

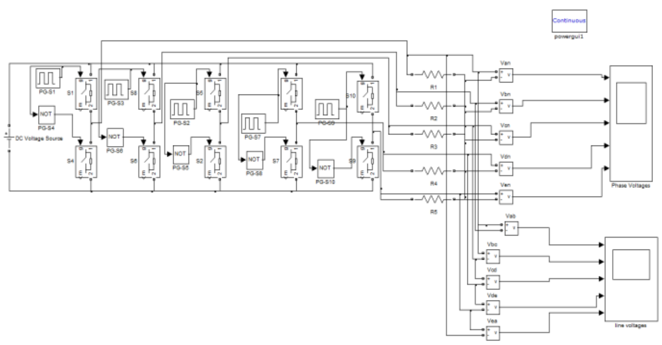


Fig.5 Matlab/simulink of FPTLVSI

Above fig.4 is mat lab simulation of TPTLVSI with balance resistive load. It can be simulated as different firing angles of power electronics switches. Similarly Fig.5 is also mat lab simulation of FPTLVSI with balance resistive load. It can be simulated and analysis for different firing angles and takes measurement of harmonics behavior.

Following Table1 shows THD Vs different firing angles for FPTLVSI without any filter circuit.

Table: 1 Different firing angles and related THD for harmonic analysis of FPTLVSI

Firing angles	THD(Total Harmonics Distortion)
108	53.63
110	49.96
115	47.3
118	36.99
120	27.03
125	36.28
126	35.68
130	38.51
144	42.98
180	46.68

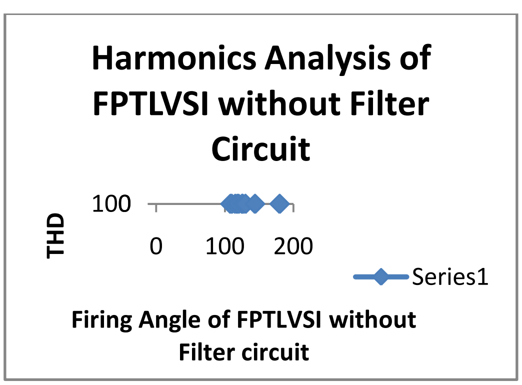


Fig.6 curve of different firing angles and related THD for harmonic analysis of FPTLVSI

5. RESULTS

Matlab/simulation results of three phase two-level voltage source inverter and five phase two-level voltage source
Simulation results of for TPTLVSI and FPTLVSI the operating conditions given below are shown in Fig.7 to fig.11. Simulation results show output phase voltages, line voltage currents, gate triggering, load current, harmonics analysis for three phase two-level inverter and five phase two level voltage inverter.

Operating condition:

Simulation time: 0.02 sec
DC Link Voltage Vdc=200 V before running simulation given in command prompt.
Freq=50 Hz running simulation given in command prompt.

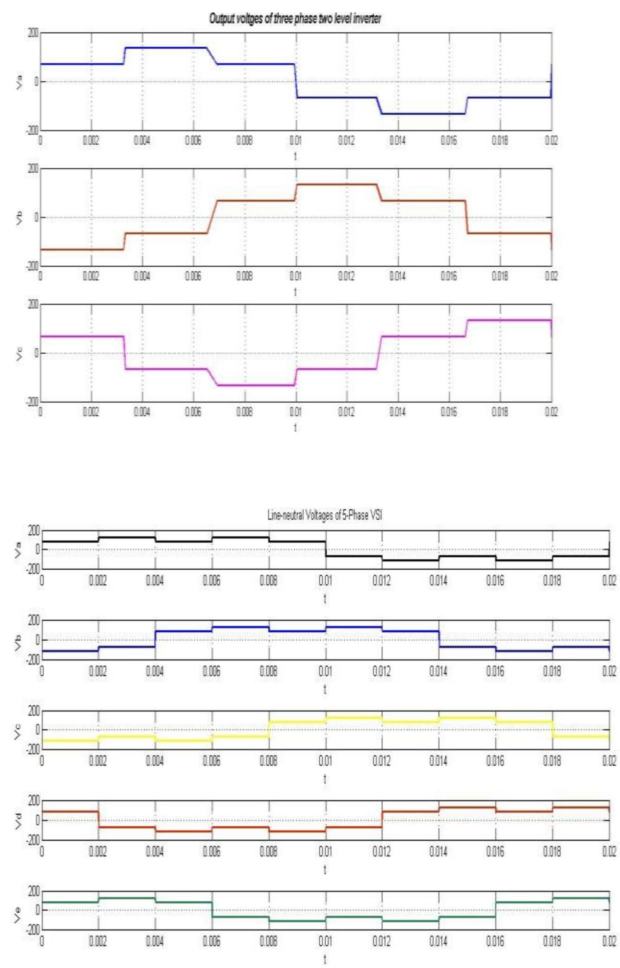


Fig.7 Matlab/simulation results for output phase voltages of Three phase two-level voltage source inverter and five phase two-level voltage source

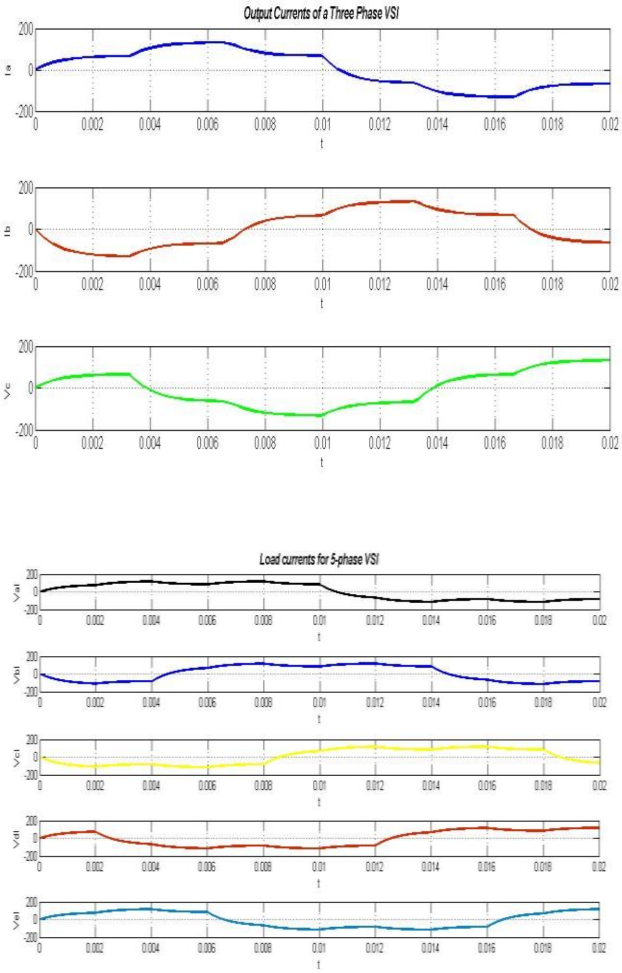
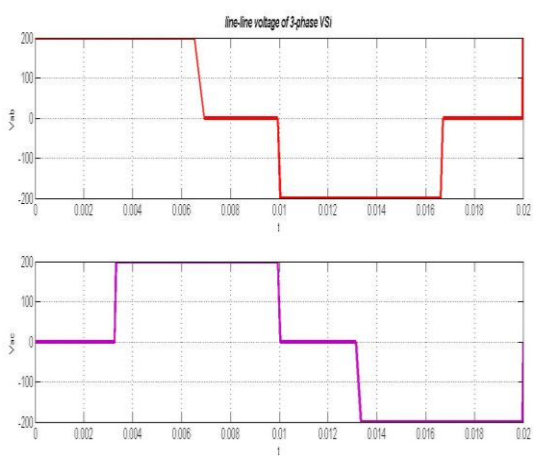


Fig.8 Matlab/simulation results for output load currents of Three phase two-level voltage source inverter and five phase two-level voltage source



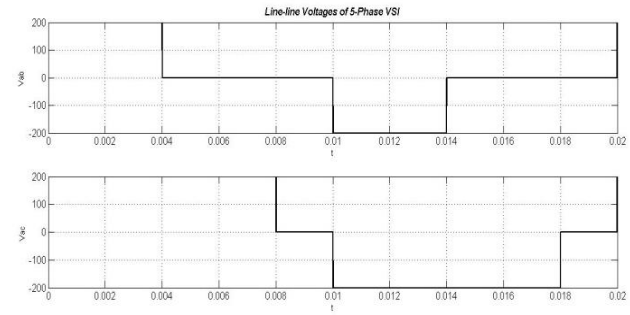


Fig.9 Matlab/simulation results for output line voltages of Three phase two-level voltage source inverter and five phase two-level voltage source

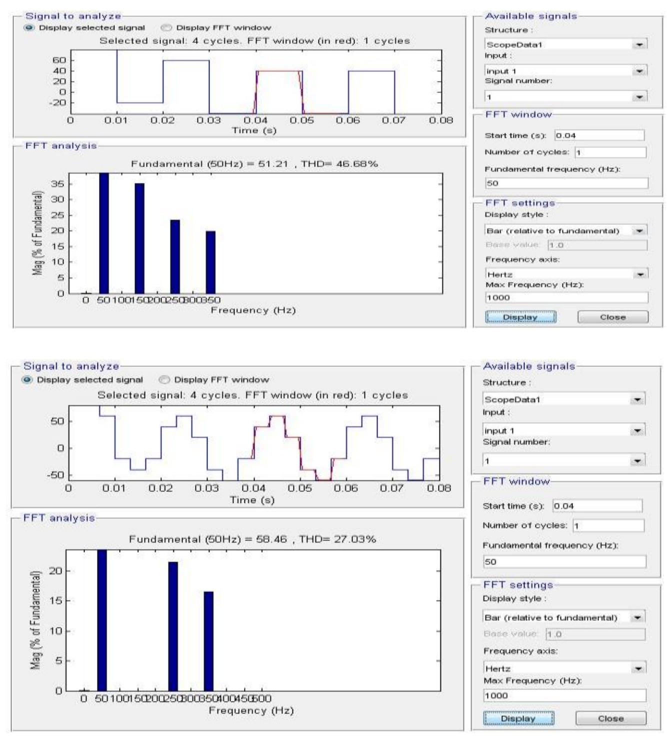
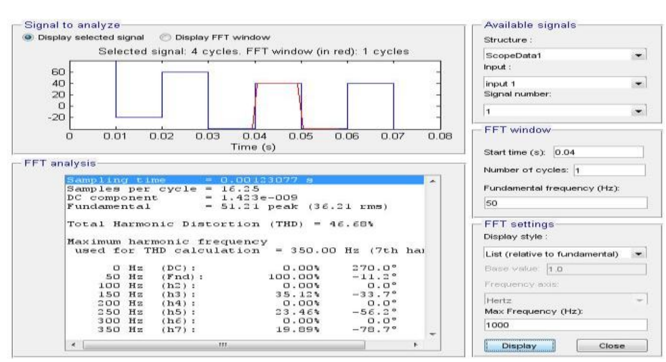


Fig.10 Matlab/simulation results for FFT analysis of five phase two level voltage source inverter with 1800 and 1200 conduction angles.



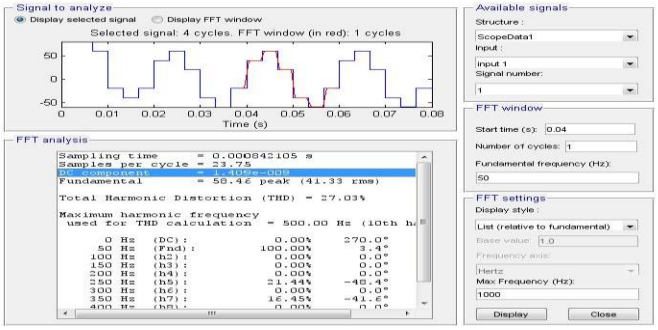


Fig.11 Matlab/simulation results for FFT analysis with different harmonic orders of five phase two level voltage source inverter with 1800 and 1200 conduction angles.

CONCLUSIONS

It has been advantages of like reduction in phase current, reliable in faulty conditions, reduction in current ripple as comparison between TPTLVSI and FPTLVSI. It can encourage of reduction of current rating of switches like IGBTS/MOSFET used in Voltage source inverters.

A comparison of total harmonic distortion in the output phase voltages of five-phase voltage source inverter for different conduction angle is presented. The conduction angles considered are 180°, 162°, 144°, 126°, and 108°. Thus two more conduction states are included when compared to further prove the superiority of control at 120° conduction mode. It is observed that the lowest THD is obtained for 120° conduction mode.

This paper has reviewed analytical approach for five phase two level voltage inverter used in application of induction motor drive.

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