

# Comparative Analysis Of Three Phase, Two Level And Three Level PWM Inverter Fed Induction Motor Drive Using Matlab/Simulink Model

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**Abstract:** This paper presents the comparative simulation analysis of three phase three level and two level PWM inverter fed three phase induction motor drive using MATLAB/Simulink software. Harmonic analysis of PWM inverter output voltage with different modulation index were analysed and a comparison table was given. THD of two level and three level inverter output voltage has been compared and it is concluded that three level inverter provides lesser Harmonic Distortion compared with two level inverter with modulation index 0.95.

**Keywords:** Induction motor, MATLAB/ Simulink, PWM inverter, Total Harmonic Distortion,

## I. INTRODUCTION

The ac induction motor is by far the most widely used motor in the industry. Traditionally, it has been in constant and variable –speed drive applications that do not cater for fast dynamic processes. Because of the recent development of several new control strategies, such as vector and direct torque controls, this situation is changing rapidly. The reason for this is that the cage induction motor is much cheaper and more rugged than its competitor, the dc motor in such applications. Single phase VSI s cover low range power applications and three phase VSIs cover the medium to high power applications. To control the induction motor drives, PWM inverter is the best choice. Using VSI it is possible to control the amplitude, phase and frequency applied the induction motor .As a result PWM inverter fed induction motor rives are more reliable and offer a wide speed range. It gives better performance when compared with fixed frequency induction motor drives. A survey of PWM techniques were studied[1]. Optimal pulse width modulation for three level inverter and for AC motor was given in [2],[3]. Space vector pulase width modulation techniques were also used[4],[5]. Various pulse width modulation techniques were given[6]. Spwm and Svpwm control is applied for three level inverter[7]. Space vector pulse width modulation for twolevel VSI was applied to induction motor[8]. This paper simulates the two and three level inverter fed induction motor .Total Harmonic Distortion of inverter output voltage was compared for various modulation indices and motor speed ,torque, currents were analysed for the above two types of Inverters .Inverter model was taken from MATLAB/Simulink software and three phase induction motor was connected to the output of the inverter and their

performance were studied. Modulation index of the PWM inverter was varied and the analysis made on the induction motor drive. FFT spectrums for the outputs are analysed to study the reduction in harmonics. This paper is organized as follows. In section II Block diagram of induction motor drive is presented. In section III simulation results of two level PWM inverter fed induction motor is given. In section IV simulation results of three level PWM inverter fed induction motor is given, In section V, comparative analysis was made. In section VI conclusion has been given.

## II. BLOCK DIAGRAM

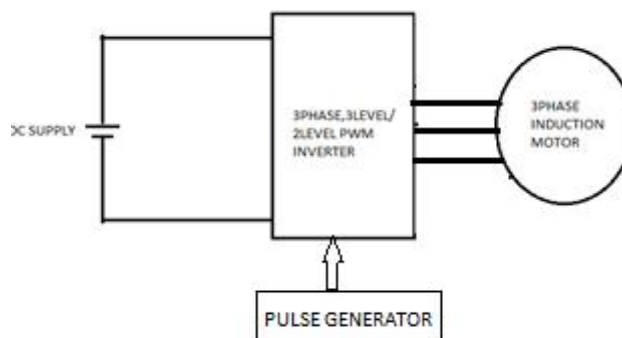


Fig1. Block Diagram

Block diagram of the model is shown in figure 1. DC supply of 400 volts is given to the 3 phase PWM 2 level/3 Level inverter and the AC output voltage is given to the three phase induction motor and the performance were studied. The inverter model is used from MATLAB7.6.0(R2008)/Simulink software .THD of the two inverter output voltages with different modulation index has been compared and simulation results were shown.

### III THREE PHASE TWO LEVEL INVERTER FED INDUCTION MOTOR

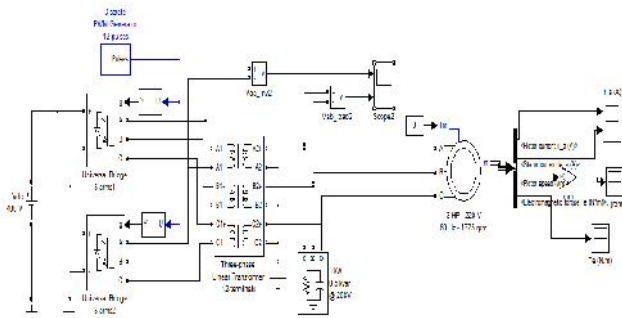


Fig.2. Matlab/Simulink Model of two level PWM inverter

#### A. Circuit Description

Fig.2 shows the Matlab/ Simulink model of two level PWM inverter. The system consists of three-phase two-level PWM voltage source inverter. Output of the inverter feeds 3 HP , 220 V, 60 Hz, 1725 rpm induction motor through a three-phase transformer. Inverter is controlled in open loop with the Discrete PWM Generator block available in the Extras/Discrete Control Blocks library. A dc voltage of 400V is given as the input to the inverter. Carrier frequency (1080 Hz), modulation index ( $m = 0.7, 0.85, 0.95$ ) and generated frequency ( $f = 60$  Hz). Harmonic filtering is performed by the transformer leakage inductance (8%) and load capacitance (500 var). Simulations are done and the output voltage of the inverter, THD, Speed, Torque of induction motor were analysed and the results were shown.

#### B. Simulation results:

The variation in speed is shown in Fig.3. The speed increases and settles at 1800rpm. Rotor and stator current is shown in Fig.4. The electromagnetic torque is shown in Fig.5. Two level inverter output voltage is shown in Fig.6. FFT analysis for voltage is done and the corresponding spectrum is shown in Fig.7. Fundamental voltage of the inverter is 340V. The total Harmonic Distortion is 70.32% for modulation index of 0.85. Modulation index values are varied and the corresponding THD values are analysed and given in Table.1

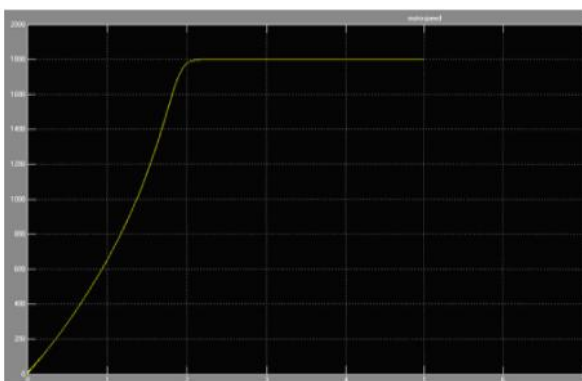


Fig.3 Motor Speed

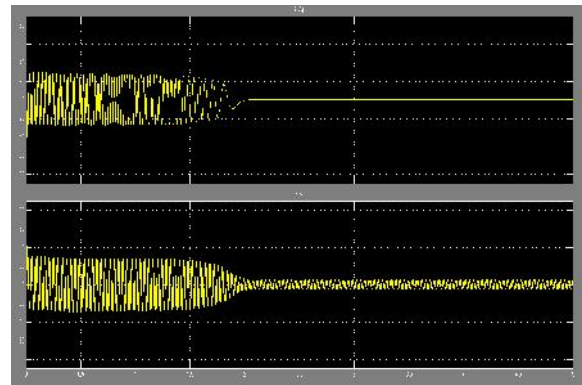


Fig.4 Rotor current and stator current

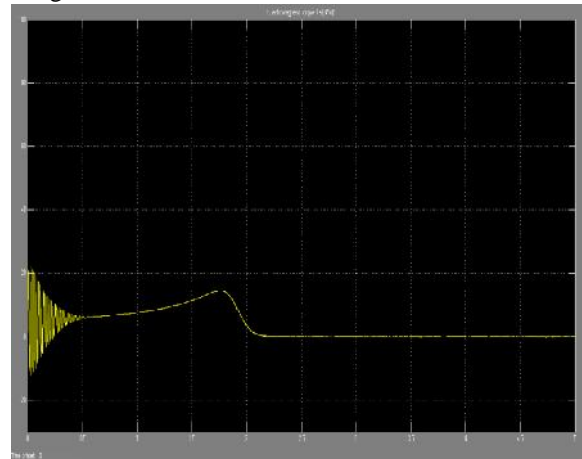


Fig.5 Electromagnetic Torque

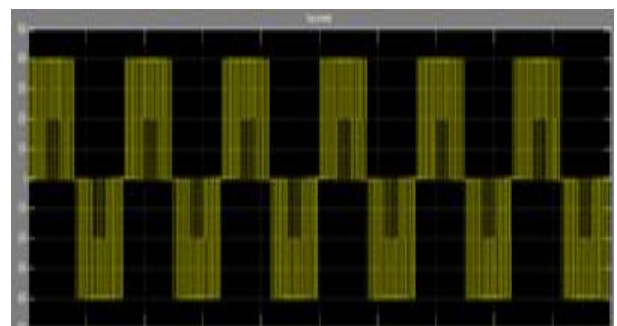


Fig. 6 Inverter output voltage

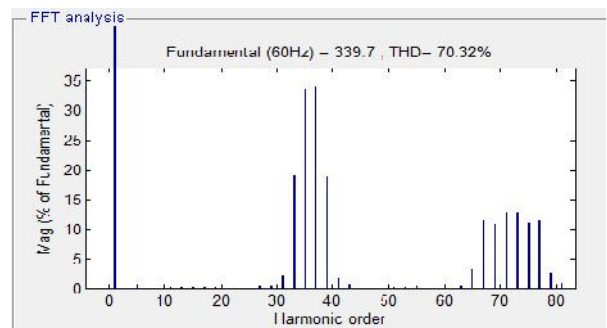


Fig.7 FFT analysis of two level inverter output voltage

#### IV. THREE PHASE THREE LEVEL INVERTER FED INDUCTION MOTOR

##### A. Matlab/Simulink Model of three phase three level inverter fed induction

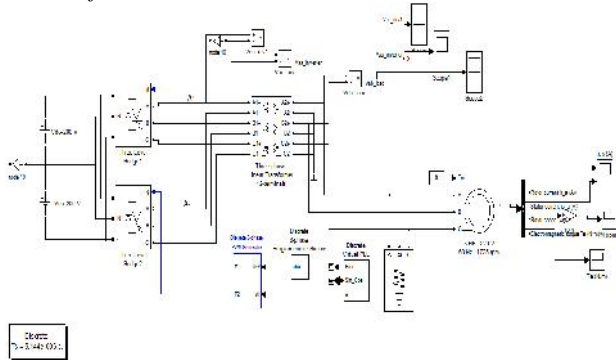


Fig.8 Matlab/Simulink Model of three level PWM inverter fed Induction motor

##### B. Circuit Description

The system consists of two three-phase three-level PWM voltage source converters connected in twin configuration. The inverter feeds three phase induction motor through a three-phase transformer. Harmonic filtering is performed by the transformer leakage inductance (8%) and load capacitance (500 var).

Each of the two inverters uses the Three-Level Bridge block where the specified power electronic devices are IGBT/Diode pairs. Each arm consists of 4 IGBTs, 4 antiparallel diodes, and 2 neutral clamping diodes. The inverter is controlled in open loop. Pulses are generated by the Discrete 3-Phase Discrete PWM Generator block. This PWM generator can be used to generate pulses for 3-phase, 2-level, or 3-level converters using one bridge or two bridges (twin configuration). In this paper, the PWM modulator generates two sets of 12 pulses (1 set per inverter) at P1 and P2 outputs. The generator can operate either in synchronized or un-synchronized mode. When operating in synchronized mode, the carrier triangular signal is synchronized on a PLL reference angle connected to input 'wt'. In synchronized mode, the carrier chopping frequency is specified by the switching ratio as a multiple of the output frequency.

Three sinusoidal 0.85 pu modulating signals are provided by the 'Discrete 3-phase Programmable Source' to obtain a modulation index of 0.7, 0.85, 0.95.

The DC bus voltage is 400V (+/- 200 V), chopping frequency is 1080 Hz (18\*60 Hz), magnitude of the three modulating signals is 0.85 (corresponding to a modulation index  $m = 0.85$ ) and the frequency of the three generated signals is 60 Hz.

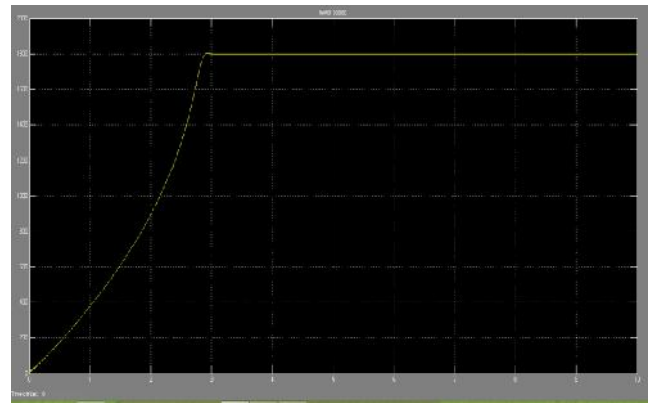


Fig.9 Motor speed

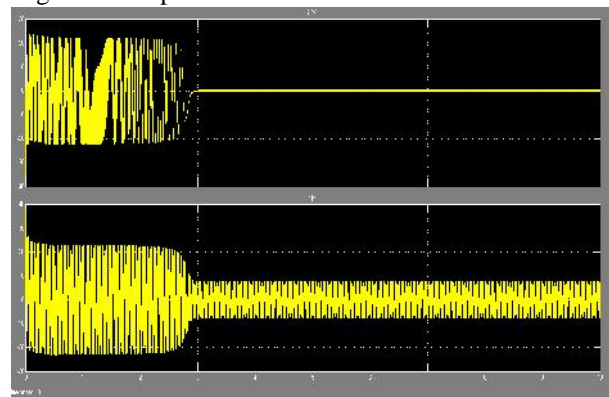


Fig.10.Rotor current and stator current

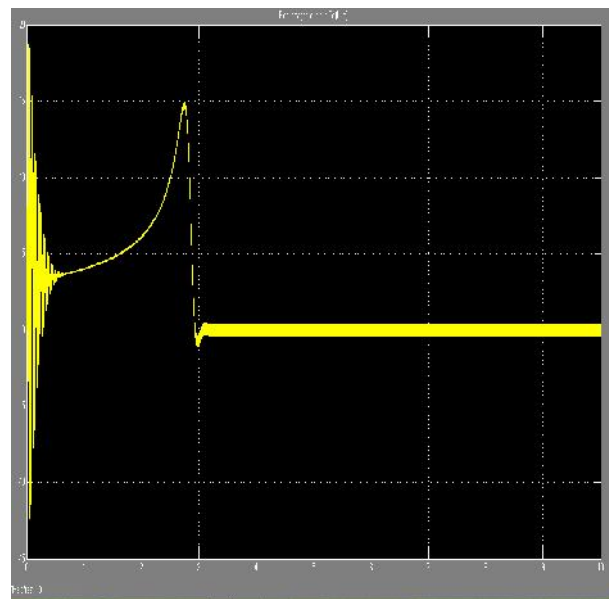


Fig.11 Electromagnetic Torque



Fig.12 Inverter Output Voltage

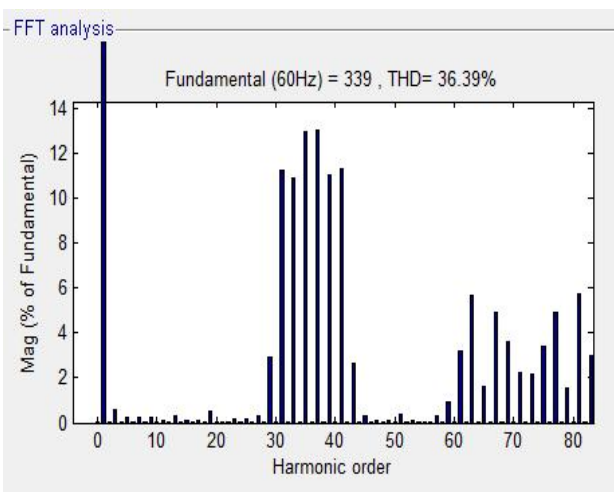


Fig.13 FFT analysis of three level inverter output voltage

**V COMPARATIVE ANALYSIS**

Table 1. shows the THD analysis of two level and three level inverter fed induction motor .Compared to two level pwm inverter ,three level has reduced harmonic distortion .Also as the modulation index increases ,THD level decreases. For three level pwm inverter with modulation index 0.7 ,THD is 42.4%,for 0.85 ,THD is 36.3% and it is decreased to 30% for m=0.95.Inverter output voltage is given in Fig.12.FFT spectrum of three level inverter output voltage is given in Fig.13.Fundamental voltage of the inverter is 339V.TH D is 36.39for m=0.85.modulation index is varied and the corresponding THD is given in Table.1

Table 1. THD Analysis of two level and three level pwm inverter fed Induction motor drive.

Parameters	3phase 2 level Inverter fed Induction motor			3 phase 3 level Inverter fed Induction motor		
	0.7	0.85	0.95	0.7	0.85	0.95
Modulation Index	0.7	0.85	0.95	0.7	0.85	0.95
Total Harmonic Disortion	0.9	0.703	0.58	0.424	0.363	0.304

**VI CONCLUSION**

Two level and three level PWM inverter fed induction motor drive are simulated using the blocks of simulink.The results of two level and three level systems are compared.It is observed that the THD produced by the three level inverter system is less than that of the two level inverter fed drive system. Due to this the heat produced in the system get reduced .The simulation results of voltage,current,speed, torque are presented.This system can be used in industries where adjustable speed drives are required with lesser harmonic content. In future this can be implemented in hardware so that experimental investigations can also be made and used in adjustable speed drive system

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