

Research Article

# Comparative Performance & Simulation Study of Single Phase Induction Motor using Multilevel Inverter

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## Abstract

*This paper deals with the analysis of induction motor supplied by multilevel inverter (MLI). Generally, the poor quality of voltage and current of a conventional inverter fed induction motor is obtained due to the presence of harmonics and hence there is a significant level of energy losses. These losses can be reduced using multilevel inverter. In inverters by increasing the number of steps it generates the very high quality of the output voltage and current. By increasing the number of steps in output voltage, harmonics is reduces and significant level of energy losses is also reduced. A constant frequency multicarrier phase disposition PWM technique is implemented for the Cascaded MLI. Phase Disposition Sinusoidal Pulse Width Modulation (SPWM) technique is used for controlling frequency and voltage of MLI. The simulation is carried out using MATLAB/SIMULINK.*

**Keyword:** SPWM, MLI, Induction motor, Total Harmonics Distortion (THD).

## 1. Introduction

All DC motors have been used during the last century in industries for variable speed applications, because its flux and torque can be controlled easily by means of changing the field and armature currents respectively. Furthermore, operation in the four quadrants of the torque speed plane including temporary standstill was achieved. Almost for a century, induction motor has been the workhorse of industry due to its robustness, low cost high efficiency and less maintenance. The induction motors were mainly used for essentially constant speed applications because of the unavailability of the variable- frequency voltage supply. The advancement of power electronics has made it possible to vary the frequency of the voltage supplies relatively easy, thus extending the use of the induction motor in variable speed drive applications. But due to the inherent coupling of flux and torque components in induction motor, it could not provide the torque performance as good as the DC motor (B. Biswas *et al*, 2009).

In recent years, industry has begun to demand higher power equipment, which now reaches as the megawatt level. Controlled Ac drives in the megawatt range are usually connected to the medium voltage grids (2.3, 3.3, 4.16, or 6.9kv). For these reasons, a new family of multilevel inverters as emerged as the solution for working with higher voltage levels (B.

Biswas *et al*, 2009). In a medium voltage and high power applications two level inverter have some limitations in operating at high frequency mainly due to switching losses and constraints of devices voltage\ power ratings (Alessandro Luiz *et al*, 2012) For a medium voltage grid it is troublesome to connect only one power semiconductor switches directly. As a result, multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations (K.Srinivas *et al*, 2012). The most attractive features of multilevel inverters are as follows. They can generate output voltage with extremely low distortion (K.Srinivas *et al*, 2012). They draw input current with very low distortion. The multi level inverters are mainly classified as Diode clamped, Flying capacitor inverter and cascaded multi level inverter. The cascaded multilevel control method is very easy when compare to other multilevel inverter because it doesn't require any clamping diode and flying capacitor (K.Srinivas *et al*, 2012).

## 2. Cascaded Multilevel Inverter Topology

A cascaded multilevel inverter made up of series connected single full H-bridge inverter, each with their own isolated dc bus. This multilevel inverter can generate almost sinusoidal waveform voltage from several separate dc sources, which may be obtained from solar cells, fuel cells, batteries, etc. This type of converter does not need any transformer or clamping diodes or flying capacitors. Each level can generate

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three different voltage outputs +Vdc, 0 and -Vdc by connecting the dc sources to the ac output side by different combinations of the four switches. The output voltage of an N-level inverter is the sum of all the individual H-bridge inverter outputs. Each of the H-bridge's active devices switches only at the fundamental frequency, and each H-bridge unit generates a quasi-square waveform by phase-shifting its positive and negative phase legs switching timings (Wei LI et al, 2012).

This topology of inverter is suitable for high voltage and high power inversion because of its ability of synthesize waveforms with better harmonic spectrum and low switching frequency. The number of output voltage levels m in a cascade inverter is defined by

$$N=2M+1 \tag{1}$$

where M is the number of separate DC sources required.

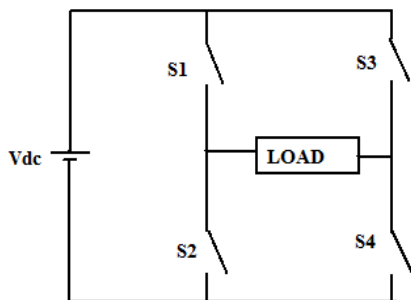


Fig.1 Power Circuit diagram of three Level inverter

Table 1: Switching Strategy for three level MLI

Switches	Load Voltage		
	+Vdc	0	-Vdc
S1	ON	OFF	OFF
S4	ON	ON	OFF
S2	OFF	ON	ON
S3	OFF	OFF	ON

### 3. SPWM Techniques

The gate pulses are generated by utilizing the simplicity of multi carrier sine PWM. In this technique sine wave is taken as reference wave of amplitude  $A_r$  and frequency  $f_r$  and it is continuously compared with triangular carrier wave of amplitude  $A_c$  and frequency  $f_c$ . If sine wave is greater than triangular wave, switch is turned on otherwise off. For N level N-1 carrier wave with same frequency  $f_c$  and same amplitude  $A_c$  are disposed such that the bands they occupy are continuous. The reference waveform has peak-to-peak amplitude  $A_r$ , the frequency  $f_r$  and it is zero centered in the middle of the carrier set. The reference is continuously compared with each of the carrier signals. If the reference is greater than a carrier signal, then the

device corresponding to that carrier is switched on otherwise off (D. Mohan et al, 2012). In multilevel inverters, the amplitude modulation index (M) is the ratio of reference amplitude ( $A_r$ ) to carrier amplitude ( $A_c$ ).

$$M = A_r / (N - 1)A_c$$

### 3.1 Phase Disposition Pulse Width Modulation Method (PDPWM)

In phase disposition method all the carriers have the same frequency and amplitude. Moreover all the N-1 carriers are in phase with each other. It is based on a comparison of a sinusoidal reference waveform with vertically shifted carrier waveform as shown in Fig. 2. This method uses N - 1 carrier signals to generate N level inverter output voltage. All the carrier signals have the same amplitude, same frequency and are in phase. In this method four triangular carrier waves have been compared with the one sinusoidal reference wave.

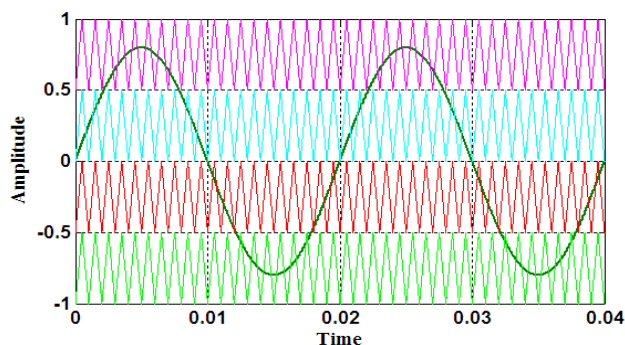


Fig.2 Phase Disposition PWM

### 4. Simulation Results

Under this topic, the simulation performance of induction motor has been carried out by using normal AC supply, conventional inverter supply and Three level Cascaded H-bridge Multilevel inverter. Simulation parameter of single phase induction motor is given below.

Table 2 Simulation Parameters

Parameters	Values
AC Bus Voltage	230 V
DC Bus Voltage	250 V
Carrier frequency	2.1 kHz
Fundamental frequency	50Hz
Load	Single Phase Asynchronous motor (split phase)

4.1 Simulation performance of induction motor through AC supply

Output Voltage and Current of motor is given below

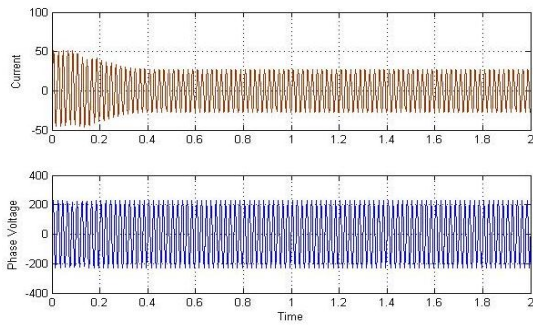


Fig.3 Phase Voltage and Current of IM through AC supply

Speed and Torque output of IM

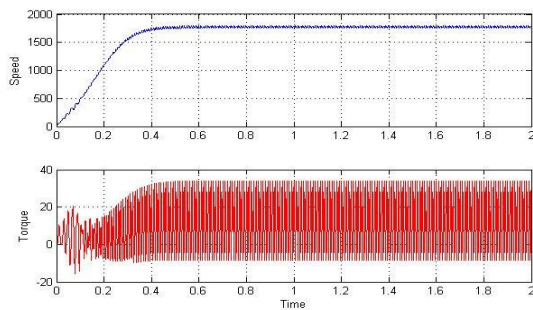


Fig.4 Speed and torque output of IM through AC supply

FFT analysis of output current of IM

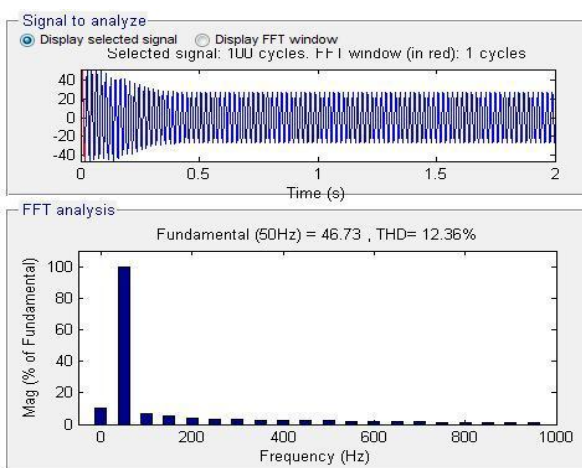


Fig.5 FFT analysis of output current of IM through AC supply

4.2 Simulation performance of induction motor through Conventional two level inverter supply

Output Voltage and Current of motor is given below.

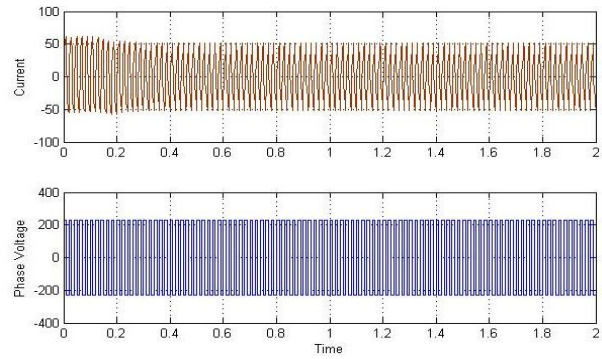


Fig.6: Phase Voltage and Current of IM through Conventional two level inverter supply

Speed and Torque output of IM

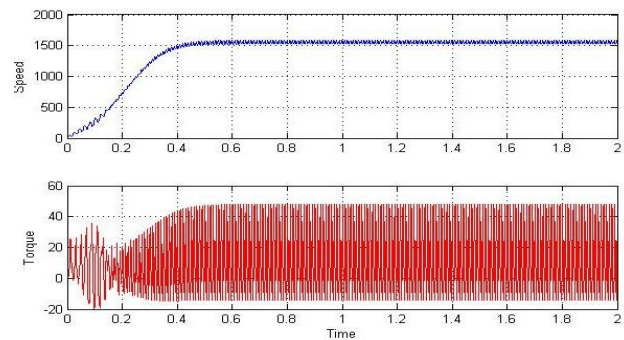


Fig.7 Speed and torque output of IM through Conventional two level inverter supply

FFT analysis of output current of IM

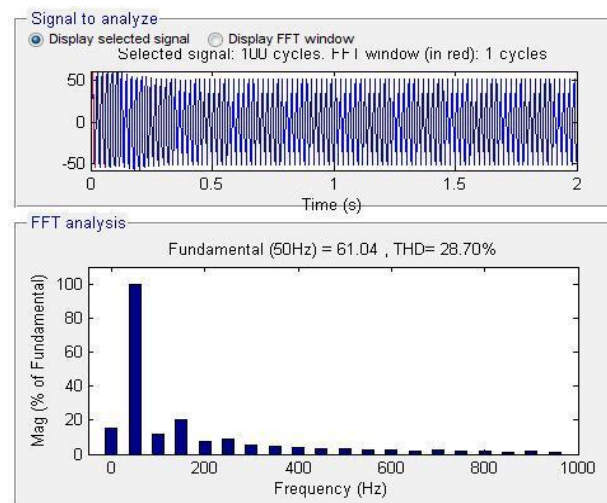
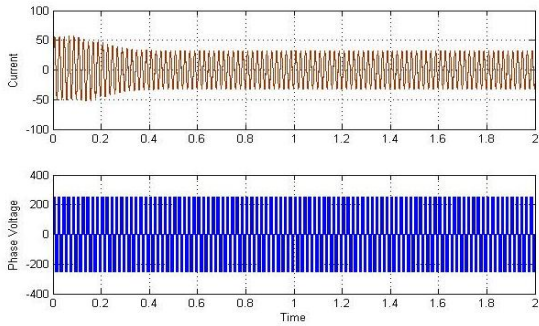


Fig.8 FFT analysis of output current of IM through Conventional two level inverter supply

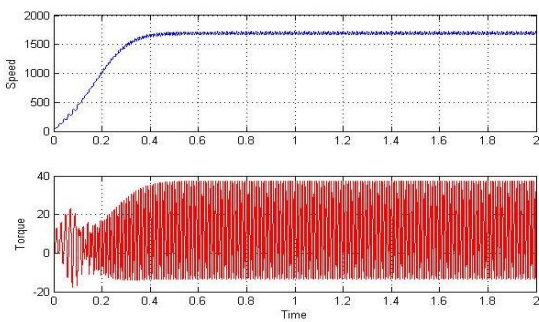
4.3 Simulation performance of induction motor through three level Cascaded H-Bridge Multilevel Inverter two level inverter supply

Output Voltage and Current of motor is given below.



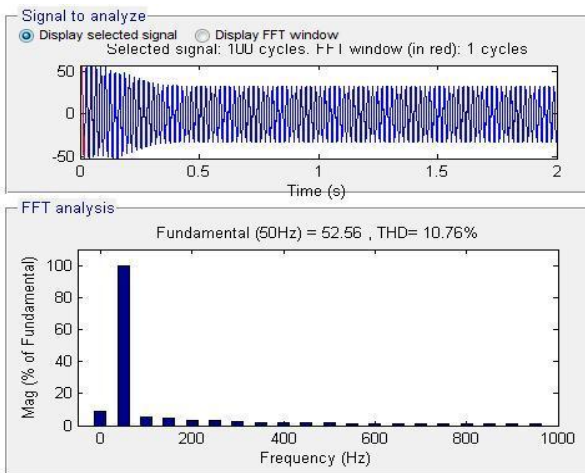
**Fig.9** Phase Voltage and Current of IM through Three level Cascaded H-bridge Multilevel inverter supply

Speed and Torque output of IM



**Fig.10** Speed and torque output of IM through Three level Cascaded H-bridge Multilevel inverter supply.

FFT analysis of output current of IM



**Fig.11** FFT analysis of output current of IM through Three level Cascaded H-bridge Multilevel inverter supply

**Table 3:** Comparison of all three techniques output

Parameters	Speed	Current THD
AC	1775	12.36%
Conventional two level Inverter	1557	28.7%
Three level Cascaded H-bridge Multilevel Inverter	1696	10.76%

**Conclusion**

The main aim of this paper was to study the performance of induction motor through AC supply, conventional two level inverter supply and three level multilevel supply. The simulation was carried out successfully using all three supply for induction motor, and it was observed that maximum speed was achieved by using AC supply and minimum THD was achieved by using Multilevel inverter. From simulation analysis we conclude that Multilevel Inverter gives better performance than conventional inverter in terms of speed as well as THD. By varying frequency and voltage of multilevel inverter V/F speed control method will be easily achieved.

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