Analysis and Comparison of APOD and PD PWM technique CHB Inverter to Three Phase Induction Machine

Mandapti Durga Lakshmi[1], R.V.R.N Pavan Kumar[2]

[1]M.Tech Scholar, Department of EEE, SAI ADITYA Institute of Engineering and Technology, Surampalem, AP, India

[2]Assistant Professor, Department of EEE, SAI ADITYA Institute of Engineering and Technology, Surampalem, AP, India

Abstract: ***The objective of this paper is to develop for improvement of induction machine performance for large industries applications with help of fifteen level*** *CHB* ***level shifted Phase Disposition (PD) and Alternate Phase Opposition Disposition (APOD) PWM technique*** *inverters****. Proposed configuration is analysis and comparison of APOD and PD PWM technique applied to three phase induction machine. It has been analyzed in point of THD of induction machine stator currents. THD of APOD is 4.18% and PD is 3.23%. The fifteen level inverter output voltages, harmonic performance of induction machine current, induction machine outputs and THD is available by using simulation of MATLAB/SIMULINK software.***

Keywords: Alternate Phase Opposition Disposition (APOD), Fifteen level, phase disposition (PD)

1. Introduction

In recent years, the basic concept of a multilevel converter is to use a series of power semiconductor switches that properly connected to several lower dc voltage sources to synthesize a near sinusoidal staircase voltage waveform. The small output voltage step results in high quality output voltage, reduction of voltage stresses on power switching devices, lower switching losses and higher efficiency.

Three topologies of multi-level inverters are Diode clamped, Flying capacitor inverter and cascaded multi-level inverter. The cascaded multilevel inverter uses several full bridges in series to synthesize waveforms. This topology is free from complicated connections and uses less number of components than diode clamped and flying capacitor multi-level inverter

In recent years the control of high-performance induction motor drives for general industry applications and production automation has received widespread research interests. Three phase induction motors are commonly used in many industries and they have three phase stator and rotor windings. Induction machine modeling has continuously attracted the attention of researchers not only because such machines are made and used in largest numbers but also due to their varied modes of operation both under steady and dynamic states. Traditionally, DC motors were the work horses for the Adjustable Speed Drives (ASDs) due to their excellent speed and torque response. But, they have the inherent disadvantage of commutator and mechanical brushes, which undergo wear and tear with the passage of time. In most cases, AC motors are preferred to DC motors, in particular, an induction motor due to its low cost, low maintenance, lower weight, higher efficiency, improved ruggedness and reliability. All these features make the use of induction motors a mandatory in many areas of industrial applications. The advancement in Power electronics and semiconductor technology has triggered the development of high power and high speed semiconductor devices in order to achieve a smooth, continuous and low total harmonics distortion (THD). Proposed configuration is analysis and comparison of APOD and PD PWM technique applied to three phase induction machine. It has been analyzed in point of THD of induction machine stator currents. The fifteen level inverter output voltages, harmonic performance of induction machine current, induction machine outputs and THD is available by using simulation of MATLAB/SIMULINK software.

2. Proposed Concept

This proposed 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. For each full bridge inverter the output voltage is given by

$$V_{oi} = V_{dc} (S_{1i} – S_{2i}) \quad (1)$$

And the input dc current is

$$I_{dci} = I_a (S_{1i} – S_{2i}) \quad (2)$$

Where,
(a) i =1. .. 3 (number of full bridge inverters employed) for the 11 level type.
(b) Ia is the output current of the cascaded inverter.
(c) SliandS2, are the upper switch of each full bridge inverter.

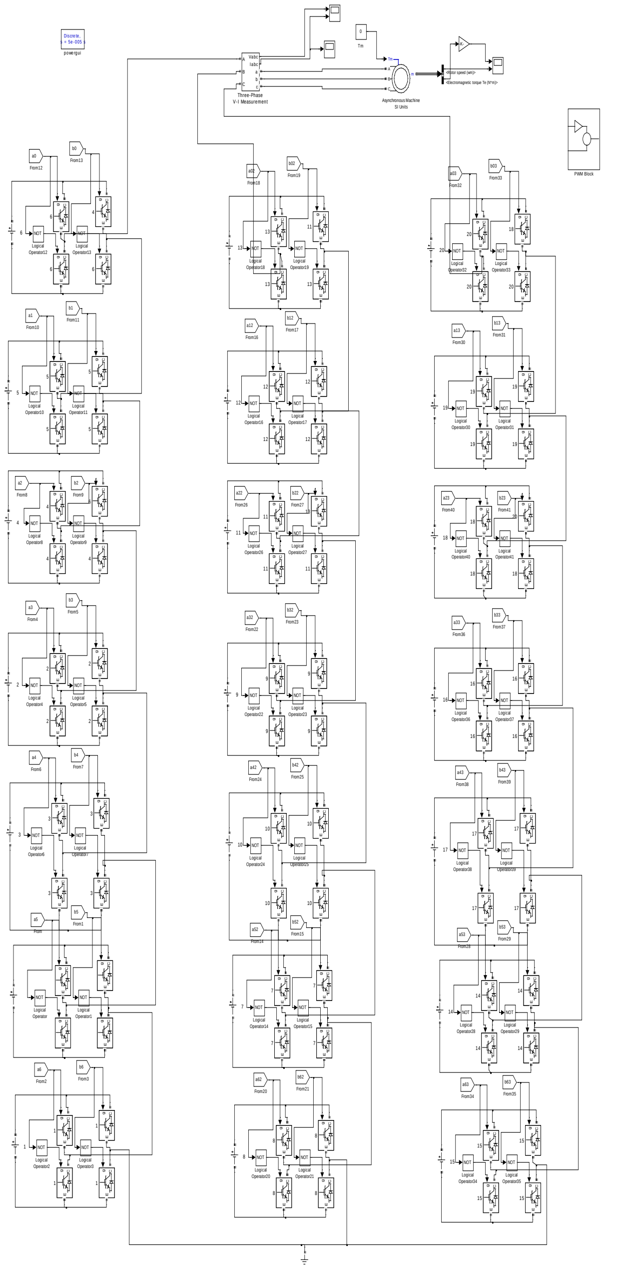

Figure 1: Proposed topology of fifteen level CHB inverter fed induction machine.

Now the output voltage of each phase of the multilevel cascaded inverter is given by:

$$V_{On} = \sum V_o; \; i = 1, 2 \ldots n \qquad (3)$$

2.1 Carrier Based Disposition PWM Method

2.1.1 Phase Disposition Technique (PD)

It is based on a comparison of a sinusoidal reference waveform with vertically shifted carrier waveform as shown in figure 2. This method uses N - 1 carrier signals to generate N level inverter output voltage [3]. All the carrier signals have the same amplitude, same frequency and are in phase [7]. In this method fourteen triangular carrier wave have compared with the one sinusoidal reference wave.

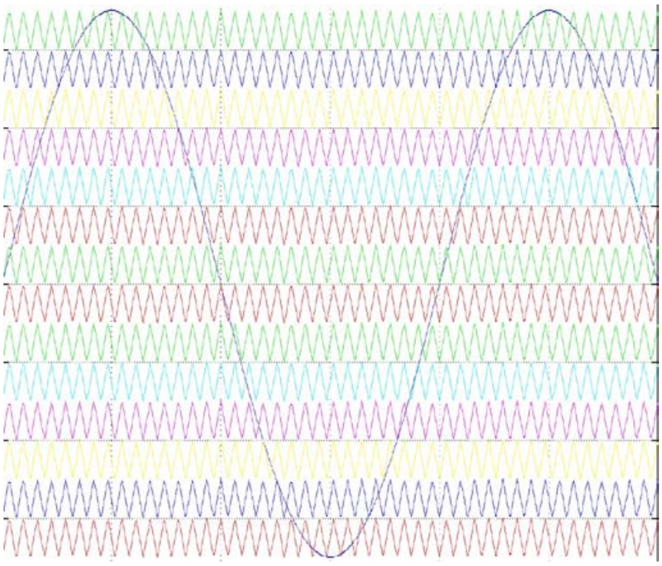

Figure 2: Phase Disposition Modulation.

2.1.2 Alternate Phase Opposition Disposition Technique (APOD)

In Alternate Phase Opposition Disposition PWM (APOD), every carrier waveform is out phase with its neighboring carrier wave by 180 degree as shown in figure 3. All the carrier waveform have same frequency, same amplitude and but compare one carrier waveform to neighbor carrier waveform is phase shifted 180 degree. Odd carrier waveforms are in phase but compare to even carrier waveform are out of phase shift 180 degree in odd carrie waveform [3].

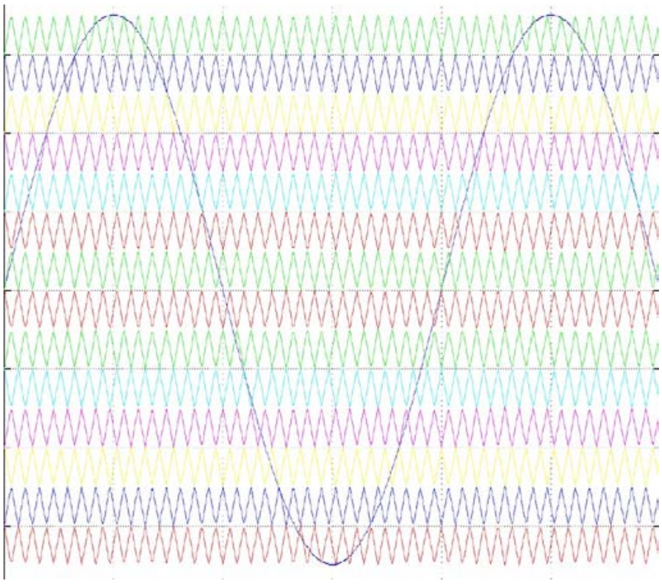

Figure 3: Alternate Phase Opposition Disposition PWM.

2.2 Induction Machine

In recent years the control of high-performance induction motor drives for general industry applications and production automation has received widespread research interests. Induction machine modeling has continuously attracted the attention of researchers not only because such machines are made and used in largest numbers but also due to their varied modes of operation both under steady and dynamic states.

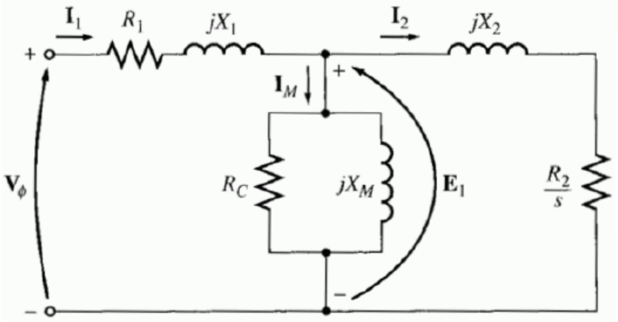

Figure 4: Equivalent circuit refers to stator of induction machine

The rotor current is

$$I_r = \frac{sE_r}{R_r + jX_r}$$

$$= \frac{E_r}{\frac{R_r}{s} + jX}$$

The complete circuit model with all parameters referred to the stator is in figure. Where Rs and Xs are the per phase resistance and leakage reactance of the stator winding. Xm represents the magnetizing reactance. R'r and X'r are the rotor resistance and reactance referred to the stator. I'r is the rotor current referred to the stator. There will be stator core loss, when the supply is connected and the rotor core loss depends on the slip.

3. MATLAB/SIMULINK Results

In this paper, the simulation model based on MATALB/SIMULINK is developed under level shifted APOD and PD PWM techniques. A 3- phase multilevel inverter has been developed using IGBT because IGBT is a very popular device among 11 high power semiconductor switches. This three phase inverter fed to three phase squirrel cage induction machine. The following are simulation results of APOD and PD PWM technique inverter fed induction motor.

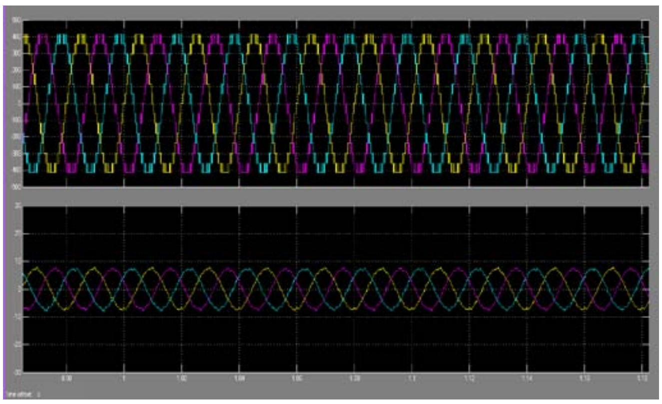

Figure.5: Stator Voltages and Currents of induction motor under APOD PWM technique.

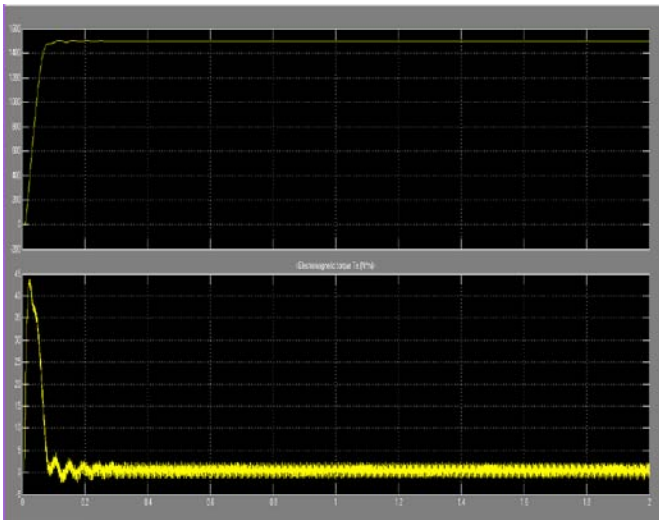

Figure 6: Speed and Electromagnetic torque of induction motor under APOD PWM technique.

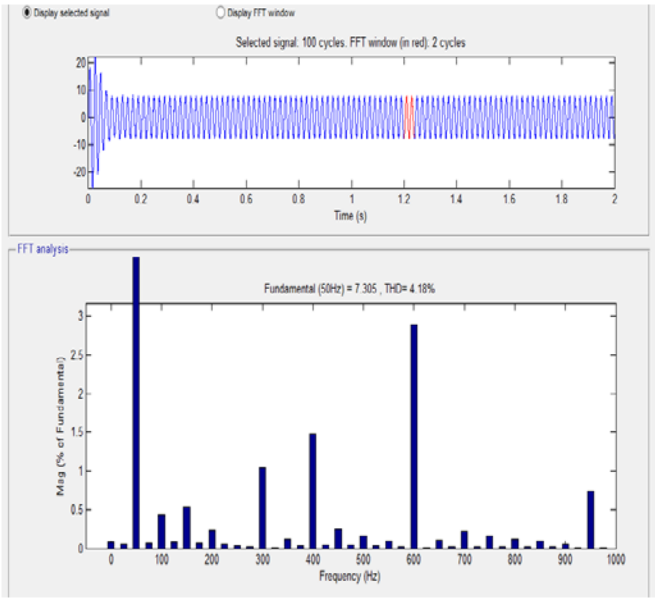

Figure 7: THD % of stator current under APOD PWM technique.

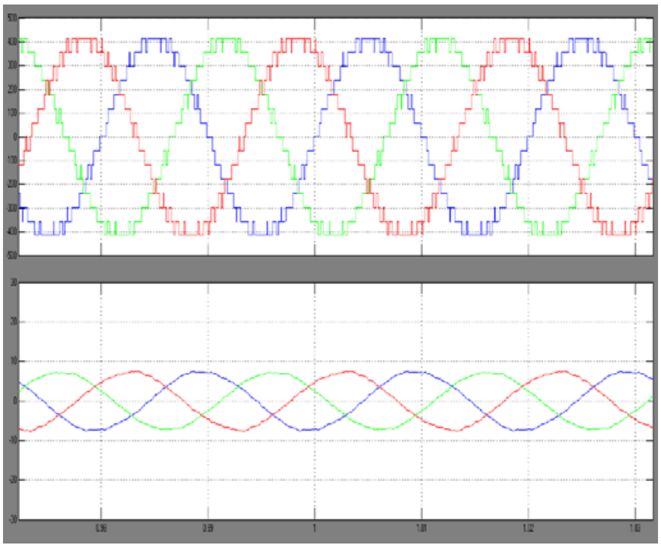

Figure 8: Stator voltages and currents of induction motor under PD PWM technique.

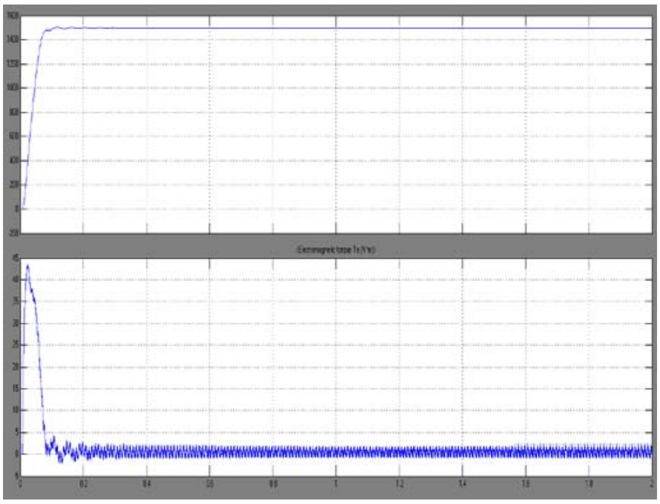

Figure 9: Speed and Electromagnetic torque of induction motor under PD PWM technique.

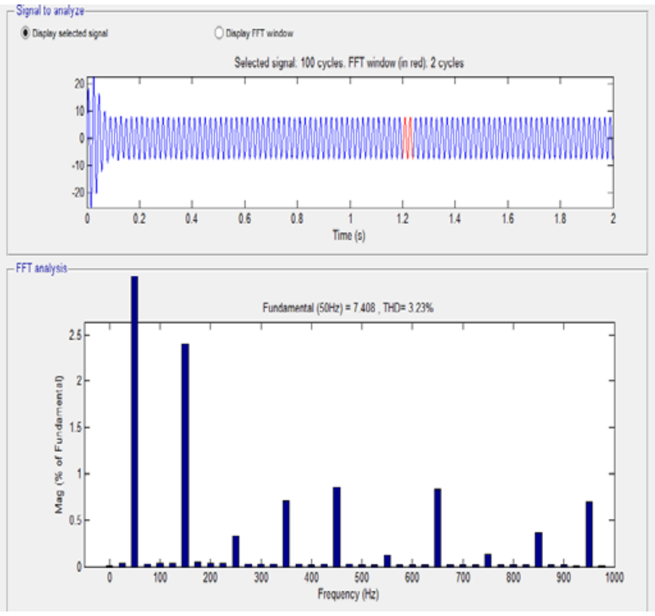

Figure 10: THD % of stator current under PD PWM technique.

Figure 7 and 10 shows the THD % of stator current under APOD and PD PWM technique of induction motor. It is clear about THD % is low in PD technique, but 3rd harmonic is high. Now THD % is high in APOD technique compare to PD, but 3rd harmonic low.

Table 1: Comparison of APOD and PD PWM technique current THD% and Harmonic

Technique	THD%	3rd Harmonic	5th Harmonic	7th Harmonic
APOD	4.18%	0.54%	0.03%	0.11%
PD	3.23%	2.40%	0.33%	0.71%

4. Conclusion

The SPWM control strategy method for three phase fifteen level cascaded H bridge multilevel inverter fed induction motor has been presented in this paper. The carrier based disposition of PDPWM and APODPWM method have simulated and results have been tabulated. The PDPWM method has given the better THD% than APODPWM, but 3rd, 5th and 7th harmonics content is low in APODPWM technique. APODPWM technique is better for induction motor under speed and torque. The simulation of fifteen level cascaded H bridge multi level has been designed and simulated as MA TLAB / Simulink environment.

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