International Journal of Electrical Engineering & Emerging Technology, Vol. 02, No. 01, JUNE 2019, pp 6-10

Performance of Induction motor with multilevel Inverter

Tarique Mushtaque Koondhar [a*]
[a] Department of Electrical Engineering, Mehran University of Engineering and Technology Jamshoro
Corresponding author e-mail: Tarique.mushtaque@admin.muet.edu.pk
[**Received on: 19-03-2019 Accepted on: 24-05-2019 Published on: 05-06-2019]**

***Abstract*— Three-phase squirrel-cage induction motors are considered the backbone of any industry and are widely used in the industry due to the many advantages of low cost, high reliability, very simple rotor construction and no switch and carbon brush. In the recent past, multilevel inverter technology has become a very important alternative in the field of high voltage and medium voltage control applications in the energy industry. Multilevel inverters offer better harmonic profiles compared to conventional two-level inverters and are widely used in high power applications with medium voltage motors for better performance characteristics. In this document, a five-phase three-phase CHBMLI induction motor was modeled using the MATLAB SIMULINK software. Multi-carrier pulse width modulation (PD) phase alignment (PD) techniques were used to generate switching pulses. Extensive research is carried out to study various performance parameters of the induction motor, such as the FFT analysis and the load torque, the stator current where the motor speed, the rotor current, etc. were investigated. The results are verified by the MATLAB / SIMULINK environment.**

***Index Terms*— Cascade H Bridge Multilevel Inverter, Three phase squirrel cage Induction Motor, Multicarrier PWM techniques, Phase disposition (PD)**

I. INTRODUCTION

With the increasing demand for high power applications, power quality, and motor drive issues, the use of multilevel inverters is becoming increasingly important in the power industry. Multilevel inverters play an important role in the need for such power[1]. A multilevel inverter is a power electronic device that can provide the desired alternating voltage level at the output using multiple lower level DC voltages as inputs[2]. Multilevel inverters have many advantages over conventional inverters. The great benefits of multilevel inverters are summarized as low total harmonic distortion THD, negligible switching losses, improved power quality, and reduced electromagnetic interference EMI[3]. Multi-level PWM inverters have smaller dv / dt compared to normal PWM inverter drive. This reduction in dv / dt helps to prevent motor winding and bearing failure. Multilevel inverters have the feature of reducing voltage stress on each component[4]. Figure 1 shows the basic configuration of a two-level inverter and a multilevel inverter.

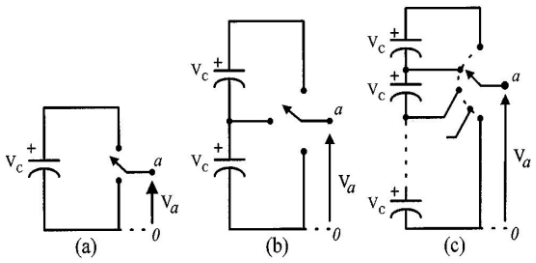

Fig. 1. Switching scheme of an inverter (a) two level (b) Two Level (c) N level

Multilevel inverters are basically classified into three main topologies according to the voltage source used in the inverter. Fig.2 indicates the main topologies of multilevel inverters.

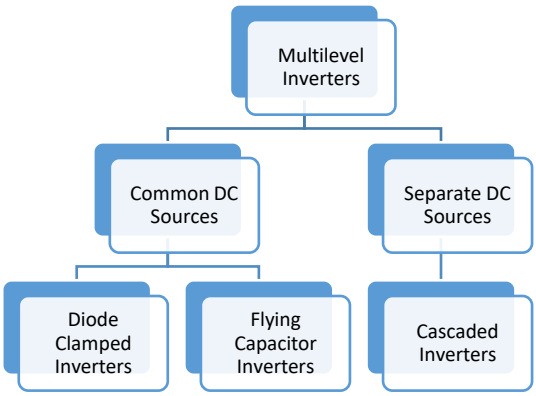

Fig 2. Different multilevel inverter topologies

II. CASCADE H BRIDGE MULTILEVEL INVERTER

For high power and medium voltage drives, from all other inverter topologies the cascade H bridge multilevel inverter is mostly used in industrial processes[5]. The CHBMLI comprises of many single phase H bridge connected power cells. For practical approaches, the working voltage and manufacturing cost determines the minimum amount of power cells in a CHBMLI. Comparing with other three types of multilevel inverter, the CHBMLI needs the small amount of components for the same voltage level[6] .The number of output phase voltage levels in a cascaded inverter is given in equation (1)

$$m = 2H + 1 \quad (1)$$

Where H is the number of H-bridge and m is the inverter level

The cascaded H bridge MLI circuit consists of individual H-bridge cell which is fed by individual dc supply. Each H-bridge cell contains four switches. In this topology, IGBT is used as switch because of its low switching losses. Each H-Bridge generates three different output voltages, +Vdc, 0 and –Vdc using various combinations of switching with the four switches[7]. For five levels, each leg consists of two H-bridge cells as shown in Fig.3. In this research work, a three phase five level CHBMLI is modeled for the performance three phase squirrel cage induction motor drive. Fig3. shows the basic structure of three phase five level CHBMLI.

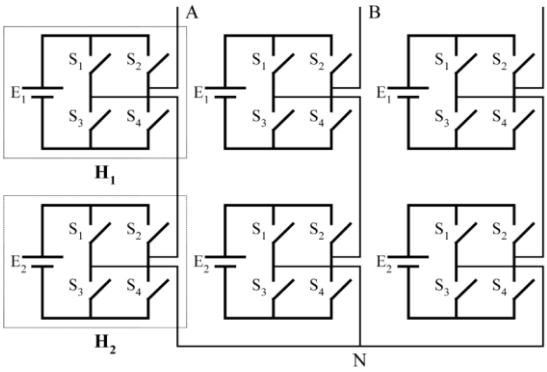

Fig. 3.Basic structure of three phase five level CHBMLI

The enormous use of MLI in power industries, renewable energies, motor drives causes the more attention of researchers towards the various modulation techniques. There are so many techniques used to control the output voltage of cascaded H Bridge MLI in order to synthesize the magnitude and spectral quality of multilevel voltages produced by inverter required for specific applications[8]. Of all these techniques, the multicarrier pulse width modulated control technique is widely accepted because it produces lesser total harmonic distortion (THD) values, which is desirable. The classification of multi carrier pulse width modulation strategies is done into phase disposition (PD), alternate phase opposition disposition (APOD), and phase opposition disposition (POD). Among all three modulation techniques, the Phase disposition (PD) scheme gives the better harmonic profile. The carrier signals in phase disposition technique are in phase but are level shifted[9]. In this research work, the multicarrier based pulse width modulated phase disposition control scheme is used.

III. LITERATURE REVIEW

T. Poompavai et al described the CHBMLI based induction motor. The matlab simulink has been used for developing the whole system and simulation results were obtained. From the results it is observed that CHBMLI is more proficient for Induction Motor [10]. A. Venkadesan et al described a cascade H bridge Multi level inverter drive .They used simple multi carrier SPWM technique phase disposition in order to generate pulses for Multilevel inverter [11]. Sayeda Farzana et al discussed the improvement in the performance of MLI based Induction Motor, and also compared the results with PWM inverter [12]. J. Swetha et al described strategy with minimum amount of switches for CHBMLI fed induction motor drive. This system consists of small single phase multilevel converter connected in cascade manner and one full bridge converter. The operation and performance of the given single phase multilevel convertor is verified by Matlab Simulink [13]. Prarthana Nagle et al described the FFT analysis of output voltage of CHBMLI by employing selective harmonic elimination method. In addition the elimination of 5^{th} and 7^{th} harmonic [14].

IV. CASCADE H BRIDGE MULTILEVEL INVERTER FED INDUCTION MOTOR DRIVE

The arrangement of cascaded H bridge multilevel inverter based induction motor drive is very simple. Fig.4. shows the basic block diagram of the drive system.

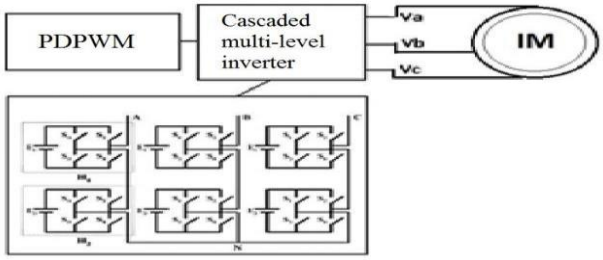

Fig .4. Block Diagram of CHBMLI based induction motor.

V. SIMULATION AND RESULTS

CHBMLI gives the near sinusoidal voltage waveforms to drive the induction motor. The parameters of three phase five level CHBMLI are given in table I.

TABLE I: Parameters of three phase CHBMLI

Input voltage	380 V
Input current	48 A
Input power	18240 W
Reference frequency	50 Hz
Carrier frequency	5 kHz
Resistance	8Ω

The parameters of three phase squirrel cage induction motor are given in Table II.

TABLE II: Parameters Of Three Phase Squirrel Cage Induction Motor

Rated Power	5.4 H.P (4kW)
Rated Voltage	400V
Phases	3
Frequency	50
Speed	1430 R.P.M
Stator resistance	1.405ohms
Rotor resistance	1.395

Fig.5 shows the Simulink circuit of a three phase five levels CHBMLI fed induction motor drive, which consists of 24 switches (IGBTs), 6 DC sources and a three phase squirrel cage induction motor.

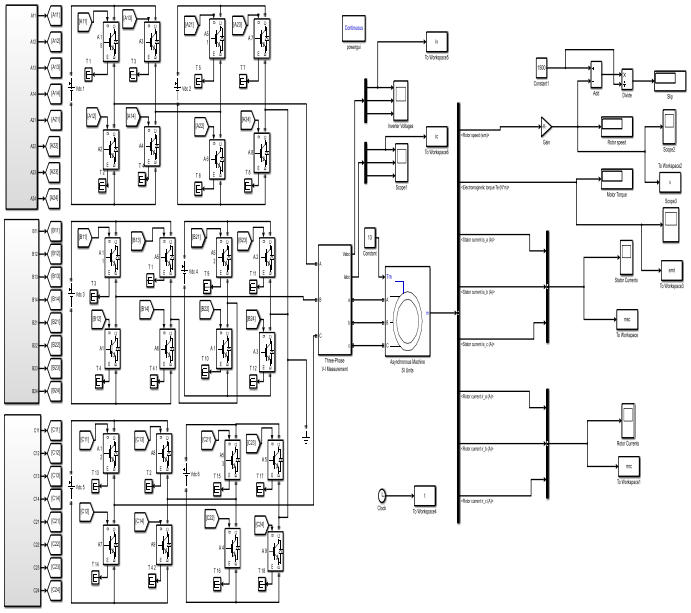

Fig.5. Simulink circuit of a three phase five level CHBMLI fed induction motor drive

The cascaded H bridge multilevel inverter is trigged by applying phase disposition (PD) multicarrier PWM technique and the output of inverter is fed to the three phase squirrel cage induction motor.

In these technique four triangular waves according to (m-1) formula where m is the level of inverter, and one reference sine wave is generated in MATLAB SIMULINK model. Two of them are applied across the positive half of the modulating signal duty cycle, remaining two is applied across the negative half of the modulating signal duty cycle. The Simulink model for multicarrier based pulse width modulated (PWM) phase disposition (PD) technique is shown in Fig.6.

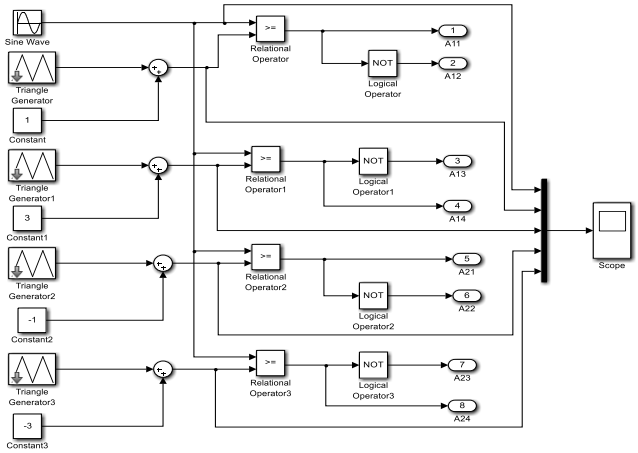

Fig.6. Simulink model for multicarrier based pulse width modulated (PWM) phase disposition (PD) technique

The carrier arrangement for multicarrier based pulse width modulated (PWM) phase disposition (PD) technique is shown in Fig.7.

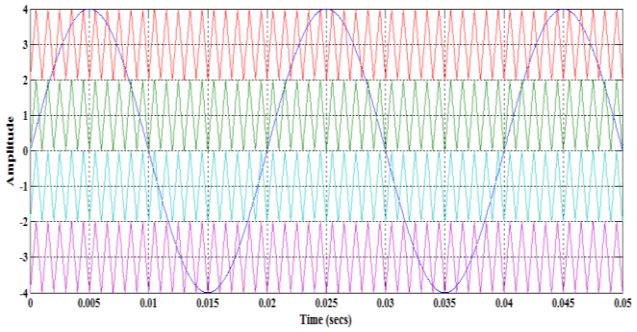

Fig 7 .Carrier arrangement for pulse width modulated phase disiposition (PD) scheme

The phase voltage waveforms of three phase five level CHBMLI are shown in Fig 8.

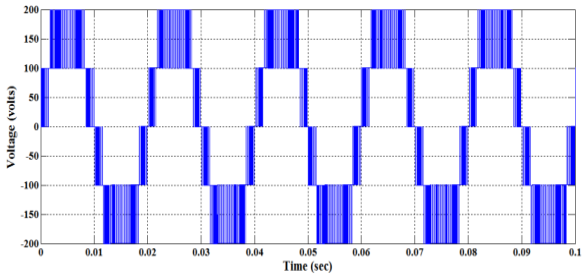

Fig. 8 .Phase voltages waveforms

The corresponding FFT analysis of phase voltages of inverter is shown in Fig.9. So the fundamental value at the output is 199 and THD is 26.97%.

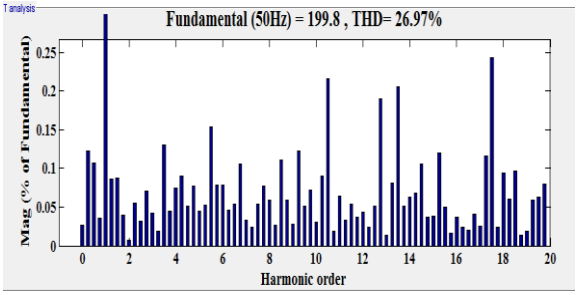

Fig. 9 .FFT analysis for phase voltage

The three phase five level CHBMLI's line voltage is shown in Fig.10.

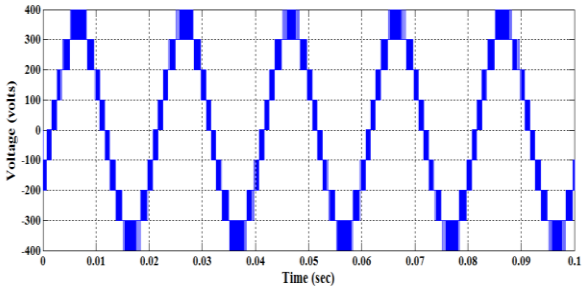

Fig. 10 .Line voltages waveforms

The FFT analysis of line voltage is done at output of 346.4 and THD formed is 17.07% are shown in Fig11.

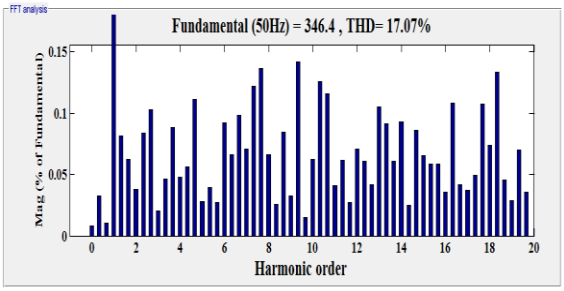

Fig 11 .FFT analysis for Line voltage

The stator currents of three phase five level CHBMLI fed induction motor drive are shown in Fig.12.

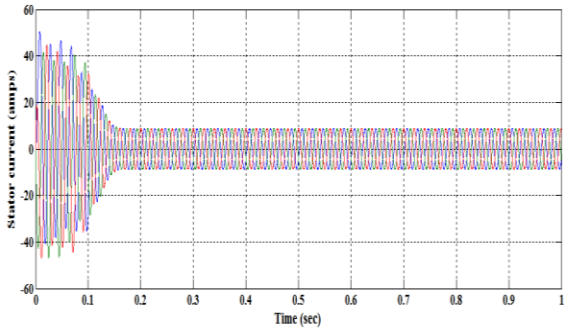

Fig 12 .Stator current waveforms

The harmonic spectrum of stator currents is shown in Fig.13. by FFT analysis the THD for stator currents is 16.98% at fundamental output of 43.99.

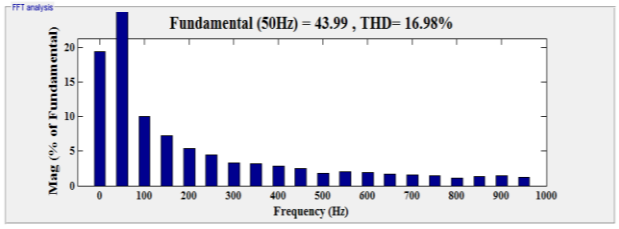

Fig 13 .FFT analysis for stator currents

Similarly the rotor current waveforms of three phase five level CHBMLI fed induction motor drive are shown in Fig.

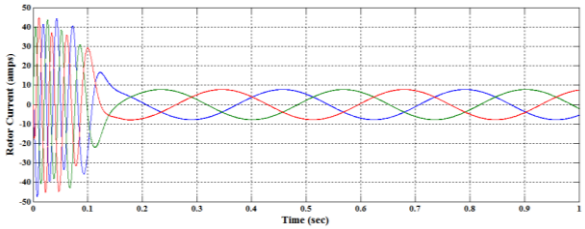

Fig. 14 .Rotor current waveforms

The FFT analysis for rotor currents is shown in Fig.15. From FFT analysis it is clear that THD formed is 19.80% at fundamental of 42.48.

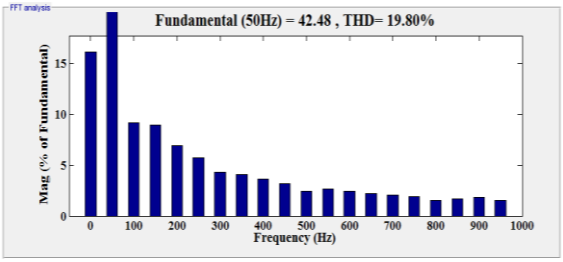

Fig 15 .FFT analysis for rotor currents

Variation in torque of three phase five level CHBLI induction motor is shown in Fig.16.

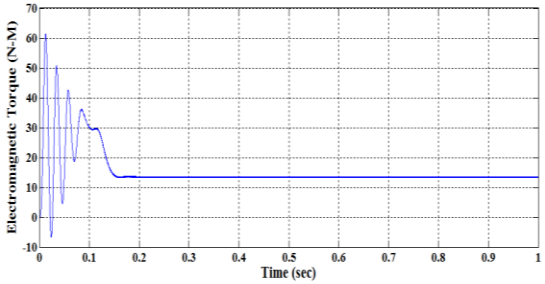

Fig.16.Electromagnetic Torque of CHBMLI based Induction Motor.

Hence rotor speed increases and settles to1408 rpm at same period, it is shown in Fig.17.

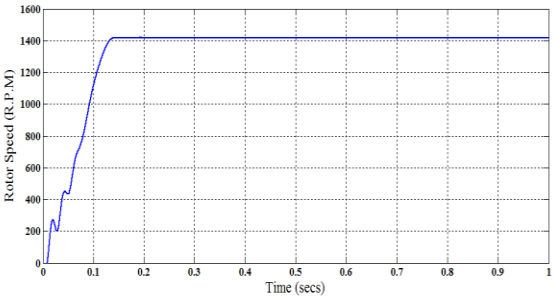

Fig 17 .Rotor speed of CHBMLI based Induction Motor.

VI. CONCLUSION

The research work shows the operation of a simulation model and harmonic analysis of the three phase five level CHBMLI induction motor drive. A multicarrier pulse width modulated phase disposition (PD) technique with switching frequency of 5 kHz has been used for generating pulses for the inverter. The harmonic analysis of three phase five level CHBMLI using phase disposition technique has been done for both phase and line voltages. From FFT analysis it is found that the THD are

26.97% and 17.07% respectively. From the results it is concluded that CHBMLI fed induction motor produced the 16.98 % total harmonic distortion in Stator currents. The THD of rotor current is 19.8 %, which are quite small without using the filters. Thus the designed MLI is found to be a promising alternative for induction motor drive.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support provided by the authority of Mehran University of Engineering and Technology.

REFERENCES

[1] Choudhury, S., et al. A comparative analysis of five level diode clamped and cascaded H-bridge multilevel inverter for harmonics reduction. in 2018 Technologies for Smart-City Energy Security and Power (ICSESP). 2018. IEEE.

[2] Sabah, V., K.P. Lall, and A. Chitra. Multilevel inverter fed induction motor drive for pumping application. in 2015 International Conference on Technological Advancements in Power and Energy (TAP Energy). 2015. IEEE.

[3] Palanivel, P. and S.S. Dash. Implementation of THD and output voltage of three phase cascaded multilevel inverter using multicarrier pulse width modulation techniques. in 2010 IEEE International Conference on Sustainable Energy Technologies (ICSET). 2010. IEEE.

[4] Gupta, K.K., et al., Multilevel inverter topologies with reduced device count: a review. IEEE Transactions on Power Electronics, 2016. **31**(1): p. 135-151.

[5] Farzana, S., Y. Sumith, and K. Ravisankar. Performance enhancement of three phase induction motor by using multi level inverter. in 2017 International Conference on Innovative Mechanisms for Industry Applications (ICIMIA). 2017. IEEE.

[6] McGrath, B.P. and D.G. Holmes, Multicarrier PWM strategies for multilevel inverters. IEEE Transactions on industrial electronics, 2002. **49**(4): p. 858-867.

[7] Rodríguez, J., et al., Multilevel voltage-source-converter topologies for industrial medium-voltage drives. IEEE Transactions on industrial electronics, 2007. **54**(6): p. 2930-2945.

[8] Patangia, H. and D. Gregory. A novel multilevel strategy in spwm design. in 2007 IEEE International Symposium on Industrial Electronics. 2007. IEEE.

[9] Verma, N.K., P. Gupta, and A. Shrivastava, THD Reduction in Performance of Cascaded Multi-Level Inverter Fed Induction Motor Drive. International Journal of Advanced Computer Research, 2013. **3**(4): p. 198-204.

[10] T. Poompavai ,A. Chitraet al "A meticulous analysis of Induction Motor fed from a nine level cascade H bridge inverter with level shifted multi carrier PWM ", IEEE 2013.

[11] A.Venkadesan, Priyatosh Panda et al, "Cascaded H Bridge Multi level Inverter for Induction Motor Drive", International Journal of Research in Engineering and Technology (IJRET) ,Volume: 03 Issue: 05 May-2014.

[12] Sayeeda Farzana, Y.Sumithetal "Performance enhancement of three phase Induction Motor by using multilevel inverter", IEEE, 2017.

[13] J. Swetha, S. Zubedaetal "A three phase cascaded H bridge Multi level inverter fed Induction Motor drive with reduced switches.", International Journal of Electrical and Electronics Engineering (ICEEMST), March 2017.

[14] Prarthana Nagle, C.S Sharma et al"Cascaded H Bridge Multi level Inverter for Induction Motor Drive" International Journal of Innovative Research in Electrical ,Electronics ,Instrumentation and Control Engg.(IJIREEICE) Volume 5, January 2017.

[15] Amaize Aigboviosa Peter et al "Influence of Power Quality Problems on the Performance of an Induction Motor", American Journal of Electrical Power and Energy Systems, 4(4): 39-44, 2015.