Australian Journal of Basic and Applied Sciences, 9(7) April 2015, Pages: 816-824

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Fuzzy Based Hybrid Asymmetric Cascaded Five level Inverter Based Induction Motor Drive.

[1]NandakumarS and [2]VijayanS

[1]*Department of Electrical and Electronics Engineering,Coimbatore Institute of Technology, Affiliated to Anna University Chennai.Coimbatore-641014., Tamil Nadu, India*
[2]*Department of Electrical and Electronics Engineering,Surya Engineering College, Affiliated to Anna University Chennai.Erode-638107, Tamil Nadu, India*

ARTICLE INFO

Article history:
Received 12 October 2014
Received in revised form 26 December 2014
Accepted 1 January 2015
Available online 27 February 2015

Keywords:
Phase disposition, Fuzzy logic, Induction motor, Multi level Inverter.

ABSTRACT

This paper proposed a closed loop modulation technique which operated by fuzzy controlled reference signal. This proposed technique applied tohybrid asymmetric multilevel inverter which controlssingle phase capacitor start induction motor drive. This new technique improves both inverter and motor performance.Phase disposition multicarrier PWM scheme used which compares constant triangular signal with fuzzy operated reference signal. Fuzzy logic mainly helps to adjust the reference signal to improve the drive performance. The proposed closed loop method can reduces the torque ripples, speed settling time, stator current variations, and harmonic distortions which improves the system dynamic performance. Finally results have compared with PID based closed loop system. To verify the proposed scheme, a simulation has been carried out by using MATLAB/SIMULINK

To Cite This Article: Nandakumar S and Vijayan S, Fuzzy Based Hybrid Asymmetric Cascaded Five level Inverter Based Induction Motor Drive. ***Aust. J. Basic & Appl. Sci.**, 9(7): 816-824, 2015*

INTRODUCTION

Variable speed drives are very commonly used for industrial applications in the different sectors. Several industrial applications require higher power drive system. Conventional inverters has not ready to meet the entire industrial requirement moreover it has more difficult to design at high power. Further the problem increases when we improve the efficiency with these drives system. Mainly it affects the quality of output due to introduce the harmonics, voltage unbalancing, switching stress, Electromagnetic interference etc. To reduce these effects of the system, proper inverter topologies and PWM techniques are required.so the multi-level inverter has been introduced in the year of 1975 as alternative in high power and medium voltage situations. Mainly the multilevel inverter can eliminate the need for the step up transformer and reduce the harmonics produced by inverter. Multilevel structure with more than three levels can significantly reduce the harmonic content. By using the proper voltage clamping techniques, the system voltage rating can be extended beyond the limits of an individual device. The output voltage and power increases with number of levels. Adding a voltage levels involves adding a main switching device to each phase.The Harmonic content decreases as the number of levels increases and filtering requirements are reduced. It is more suitable for high voltage and high current applications. It offers higher efficiency because the devices can be switched at a low frequency, Power factor also increase near to unity for multilevel inverters as rectifiers. Due to minimum stress on device,there is a less impact on Electromagnetic Interference. They do not have charge unbalances problems when the converters are in either rectification mode or inversion mode multilevel converters require balancing the voltage across the series connected dc bus capacitors.(D. G. Holmes and T. A. Lipo. *et al.*, 2003; Carrara, G., 1992; M.H. Rashid, 2004). There are numerous topologies of multilevel inverters available. But the differences in the switching techniques and input voltage sources to the multilevel inverters. Most commonly used multilevel inverter topologies are Diode Clamped multilevel inverters, Flying Capacitor multilevel inverters and Cascaded H-bridge multilevel inverters. Hybrid cascaded Multilevel inverters are gradually used in industrial applications because it has more advantages than

Corresponding Author: Nandakumar, S., Assistant Professor, Department of Electrical and Electronics Engineering, Coimbatore Institute of Technology, Affiliated to Anna University Chennai, Coimbatore-641014. Tamilnadu, India.
Tel:9994160342

diode clamped and flying capacitor multilevel inverter. (M. H. Rashid, 2004)

In Hybrid cascaded inverter many modulation techniques applied which can improve performance of induction motor drive. But performance of the harmonics in output voltage is poor, particularly under low modulation index region. Multilevel inverter is playing major role in drive applications specifically reduction harmonic effect, balancing the capacitor voltage. By applying the proper time internal of switching states, we can balance the charging and discharging intervals. This helps to improve capacitor utilization. Harmonics created lot of problems in an induction motor, Harmonics frequency will be the multiples of the fundamental frequency. Core loss is major issue at higher frequencies because core loss in an induction machine creates both hysteresis loss and eddy current loss. Hysteresis loss of the induction motor is proportional to the applied input frequency and eddy current loss is proportional to the square of the frequency. And also harmonic currents and voltages can be reduced the overall efficiency of the machine. Harmonics frequency will be generated torque in both forward and in reverse direction of the machine. It will reduce the net operating torque of the machine. This will create deviation in the induction motor torque- speed characteristics. Harmonics frequency increases in skin effect tending the current to flow on the surface of the conductor , further skin effect increases heat on machines. This will lead to insulation damage.[M. H. Rashid]For many of industrial drive applications, multilevel inverter operates at the low modulation index. When we operate at low modulation index, selection of PWM technique is very important part. Then only we can improve the efficiency of the drive in terms of speed settling time, current distortion, Torque pulsation, THD. (D.G. Holmes and T.A. Lipo. *et al*., 2003)

Proportional integrated Derivative (PID) controllers are widely used in control applications, but they have the poor performance when we applied to the nonlinear systems and also controller tuning is difficult due to inadequate knowledge of the system parameters. Fuzzy gives better performance with reduced number of oscillations and faster settling time. Fuzzy Logic controller has better stability, small overshoot, and faster response. Other advantages of the fuzzy controllers are, it can work with less precise inputs and naturally more robust and it does not require any fast processors. Fuzzy logic helps to tuning the reference wave in order to match the sine reference with minimum disturbance. (Krishnan, R *et al*., 2007)

The paper presents a multi carrier based PWM method with fuzzy operated reference waveformfor hybrid cascaded multilevel inverters fed single phase asynchronous capacitor start induction motor, which improves the harmonic performance of output voltage, especially under low modulation index region.

Proposed system:

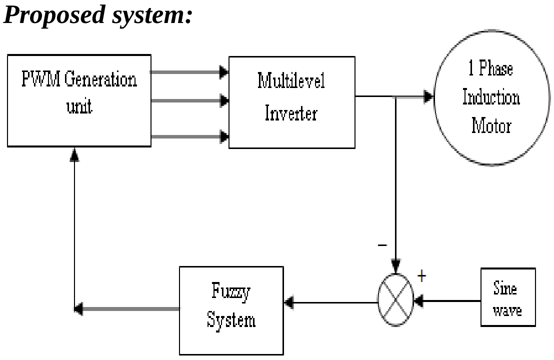

Fig. 1: Block diagram of the proposed system

In the proposed system, fuzzy logic used to generate the reference for multicarrier modulation. In the manner of modulation, all the carriers have the same frequency and amplitude. Quality of the inverter output affected by connecting load. Output voltage have compared with sinusoidal signal by using comparator. Fuzzy rules helps to adjust the error signal and It will act as areference of multicarrier modulation.

Multilevel Inverter:

There are numerous topologies of multilevel inverters available. But the differences in the switching techniques and input voltage sources to the multilevel inverters. Most commonly used multilevel inverter topologies are:

- Diode Clamped multilevel inverters
- Flying Capacitor multilevel inverters
- Cascaded H-bridge multilevel inverters

Diode Clamped multilevel inverters:

Diode clamped multilevel inverters designed by using clamping diodes in order to limit the voltage stress of power devices. This topology was first proposed in 1981 by Nabae, Takashi and Akagi and This is known as neutral point inverter. In this topology, DC voltage is subdivided into switches through capacitors, For *n*-level diode clamped inverter needs (*n-1*) switch pairs and (*n-1*) capacitors are required for clamping DC voltage. One of the switches from each couple must be turned ON and must be turned OFF. it has some advantages that are listed below:

1. At the fundamental frequency, it operates at higher efficiency.
2. The common dc bus can be shared by all the phases. So reduces the capacitance of capacitor.
3. Pre charging of capacitors is done in all the groups
4. High efficient for back to back inverter connections

It has some disadvantages, which are listed below,

1. Output voltage is limited.
2. Charging level affected when control of inverter is not an accurate.
3. When we increase the number of levels, it requires number of clamping diodes and difficult to calculate the relation between number of levels and number of diodes.
4. Charging level troubled for more number of levels.

This inverter can be used for high power medium speed motor drive application. High Power interfacing circuits in transmission line and Static VAR compensators. (Corzine *et al*., 2002; IlhamiColak *et al*., 2011; M.H. Rashid., 2004; J.Rodriguez *et al*., 2002; Mariusz Malinowski *et al*., 2010)

Flying Capacitor multilevel inverters:

This topology designed by using flying capacitors in order to limit the voltage stress of power device. The input DC voltages are divided by the capacitors. The voltage of each capacitor and each switch is V_{dc}. A n-level flying capacitor inverter requires ($2n - 2$) switches and ($n- 1$) number of capacitors in order to operate. Diode clamping topology has failed to maintain the balancing the voltage in the inverter. Unbalancing voltage causes excessive energy dissipation in the inverter load .Flying capacitor multilevel inverters has an important property which balances the capacitor voltage. The balancing of the capacitors is very important and it is driven by load current. The working principle is based on charging each capacitor to a different voltage level. The different in the magnitude of the voltage level between two capacitors will regulate the output voltage.

Advantages of Flying Capacitor Multilevel Inverters

1. For balancing capacitors voltage levels, phase redundancies are available.
2. We can control reactive and real power flow

Disadvantages of Flying Capacitor Multilevel Inverters are, An excessive number of storage capacitors are required when the number of converter levels is high. The inverter control will be very complicated, and the switching frequency and switching losses will be high for real power transmission.

1. Voltage control is more difficult for all the capacitors
2. Arrangement is Complex
3. Switching efficiency is poor
4. Capacitors are expansive than diodes.

Hybrid cascaded multilevel inverter:

Diode-clamped multilevel Inverter, the charging time for each capacitor is different, such a capacitor charging profile repeats every half cycle, this result in un-balanced capacitor voltage between different levels. This can be solved by using proper control algorithm but system complexity and cost will be increased. For Flying-Capacitors Multilevel Inverter, when it involves real power conversions, the selection of a switch combination becomes very complicated in order to balance the capacitor charge and discharge. Each capacitor must be charged with different voltages as the voltage level increase. In both topologies have serial connection of low-voltage power semiconductors and switches shared the input voltage equally. When we compare two configurations, number of switches, Main diode and capacitors are same. In the first topology diode used to block the reverse voltage, Second topology uses capacitor to block the reverse voltage. But both topologies requires more number of components and design of control circuit is also complex. Hybrid cascaded Multilevel inverters are gradually used in industrial applications because it has more advantages than diode clamped and flying capacitor multilevel inverter. Cascaded H-Bridge configuration has recently become very popular in high-power AC supplies and adjustable-speed drive applications. The cascaded H-bridge multi-level inverter uses less number of devices. It requires only less number of components in each level. This topology consists of series of power conversion units and power can be easily scaled. The combination of capacitors and switches pair is called an H-bridge and gives the separate input DC voltage for each H-bridge. It consists of H-bridge unit and each unit can be delivered the three different voltages like zero, positive DC and negative DC voltages. The output waveform produced by summing up the inverter outputs. In general, the output voltage is produced by summing up the output voltage of each module with different duty cycle. The output voltage of the inverter is almost sinusoidal. Each H-bridge module generates a quasi-square waveform by phase shifting its positive and negative phase legs' switching timings. Hybrid inverter utilizes cascaded series inverter with different internal DC bus voltages and with different switching devices for the different DC levels. It is simplest configuration consist of two series- connected single phase inverters per phase with DC bus voltages sized in the ratio 2:1 (D.G. Holmes and T. A. Lipo. *et al*., 2003; Mariusz Malinowski *et al*., 2010; M.H. Rashid., 2004)

Advantages of Cascade H Bridge Multilevel Inverters

1. Output voltages levels are doubled the number of sources
2. Manufacturing can be done easily and quickly
3. Packaging and Layout is modularized.
4. Easily controllable
5. Economic because require less number of Components

But it requires large number of isolated voltages to supply the each unit.

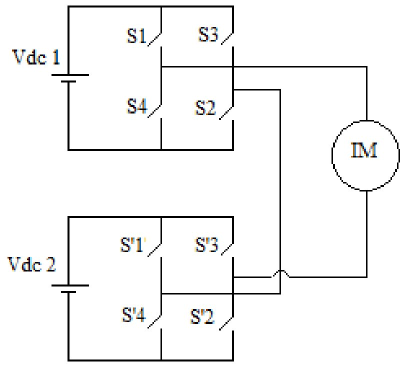

Fig. 2: Hybrid Cascaded MLI

This topology consists of series of two power conversion units. Different voltage applied to the units in the ratio of 2:1.This is called as asymmetric cascaded MLI. It produces five level voltage output to drive the single phase asynchronous induction motor with constant load by using phase disposition technique. (Corzine *et al*., 2002; IlhamiColak *et al*., 2011; M.H. Rashid., 2004; J. Rodriguez *et al*., 2002; Mariusz Malinowski *et al*., 2010)

Modulation:

The multilevel power inverter consist of large number of switches may lead to design a complex pulse width modulation algorithm. There are different types of switching techniques such as Sinusoidal PWM (SPWM), Third harmonic injection PWM (THPWM), Programming PWM and Space vector PWM (SVM).Among all those types SPWM is a very popular method in industrial applications. because It can be easily generated by comparing high frequency carrier with low frequency reference signals moreover it requires only less number of components. The most popular SPWM technique is carrier based PWM technique. Two level carrier based PWM technique can be extended into multiple levels to control the switches in a multilevel inverter. Number of carrier signals will be decided by number of output levels of the inverter. The performance of multilevel inverters mainly depends upon the type of the modulation technique preferred to control the semiconductor switches.

The principle of the multicarrier PWM is based on a comparison of a sinusoidal reference waveform with triangular carrier waveforms. m-1 carriers are required to generate m levels. The carriers are in continuous bands around the reference zero. They have the same amplitude A_c and the same frequency f_c. The sine reference waveform has a frequency f_r and A_r is the peak to peak value of the reference waveform. At each instant, the result of the comparison is 1 if the triangular carrier is greater than the reference signal and 0 otherwise. The output of the modulator is the sum of the different comparisons which represents the voltage level.

The two major classifications of fundamental frequency technique, with respect to carrier signal, are vertical arrangement and horizontal arrangement. According to adjustment of carrier phase angle we can classified the vertical carrier distribution techniques are: Phase disposition (PD), Phase opposition disposition (POD) and Alternate phase position disposition (APOD). Phase disposition modulation produces the lowest harmonic distortion for cascaded hybrid multilevel inverter by placing significant harmonic energy into common mode first carrier component which cancels between phase legs of the inverter. This leads to that an improvement in modulation performance. (Brendan Peter *et al*., 2002; Leon.M *et al*., 1999; Mcgrath, *et al*., 2002; P. Palanivel. *et al*., 2011

Phase Disposition technique: formulation:

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 figure. 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 (D.G. Holmes and T.A. Lipo. *et al*., 2003).

The rules for phase opposition disposition method for a five level inverter are:

1. Four carrier waveforms are arranged in phase disposition.
2. The converter is switched to + $V_{dc}$when the sine wave is greater than both upper carriers.
3. The converter is switched to + $2V_{dc}$ when the sine wave is greater than first upper carrier.
4. The converter is switched to zero when sine wave is lower than upper carrier but higher than the lower carrier.
5. The converter is switched to – $2V_{dc}$ when the sine wave is less than first lower carrier.
6. The converter is switched to - V_{dc} when the sine wave is less than both lower carriers.

Multilevel cascaded inverter topologies uses series connected single phase H-Bridge inverters to achieve an increased voltage range and reduced output harmonics. The analytical solution for three level naturally sampled modulation of one single phase H-bridge was developed.

$$V_{ab}\ (t) = V_{dc}M\ \cos(\omega_o\ t) + \frac{4V_{dc}}{\pi}\sum_{m=1}^{\infty}\sum_{m=1}^{\infty}\frac{1}{2m}J_{2n-1}\,(m\pi M)\cos([m+n-1]\pi)\ X\cos(2m\omega_c t\ +[2n-1]\omega_o\ t)$$

By scaling $2V_{dc}$ to $V_{dc}$to suit the more usual bus voltage definition for single phase bridge cascaded into multilevel inverter. The above equation developed by subtracting two expressions corresponding to the switched voltages of phase legs a and b with respect to the DC neutral point. It can be recalled that around each odd carrier multiple group (ω_c, $3\omega_c$, $5\omega_c$, $7\omega_c$ etc..,) These expressions contain only even side band harmonics and these sidebands cancel despite the 180° phase shift of the fundamental of phase leg b with respect to phase leg a. Hence sideband harmonics of line output voltage of a single phase H-bridge only exist at even carrier multiple groups (ω_c, $3\omega_c$, $5\omega_c$, $7\omega_c$ etc..,). In five level PD PWM technique for the evaluation of the double Fourier coefficients C_{mn} can be readily extended to higher odd levels. [D. G. Holmes and T. A. Lipo. et.al]

A side band harmonic from the first carrier group which intrudes a long way below the first carrier frequency. This low –order intrudes of the first carrier group side band harmonics for PD modulation is an issue which is intrinsic to the modulation strategy and must be appreciated and allowed for when low carrier or fundamental ratios are implemented.[D. G. Holmes and T. A. Lipo. et.al]

Fuzzy Logic Controller:

The Fuzzy Logic tool was introduced by LotfiZadeh in 1965. It is a mathematical tool for dealing with uncertainty. The fuzzy theory provides a mechanism to represent the linguistic constructs like many,low, medium,often,few. In general, the fuzzy logic provides an inference structure which enables suitable human reasoning capabilities. The fuzzy logic controller (FLC) based on fuzzy logic which provides to convert a linguistic strategy based on expert knowledge into an automatic control strategy. Fuzzy logic systems have faster and smoother response than conventional systems and simplicity of control. Fuzzy system consists of Fuzzifier, De-fuzzifier and fuzzy rule knowledge base. Fuzzy Logic Controller (FLC) is an attractive choice when precise mathematical formulations are not possible. Fuzzy concept is merely a representation of the human cognitive and decision making process hence developing and tuning of the FIS is more intuitive than the PID controller. Fuzzy system which adjusts the control parameters depending upon the error. Fuzzy Logic Controller (FLC) is an attractive choice when precise mathematical formulations are not possible. Proportional integrated Derivative (PID) controllers are widely used in control applications, but they have the poor performance when we applied to the nonlinear systems and also controller tuning is difficult due to inadequate knowledge of the system parameters. Fuzzy gives better performance with reduced number of oscillations and faster settling time. Fuzzy Logic controller has better stability, small overshoot, and faster response. Other advantages of the fuzzy controllers are, it can work with less precise inputs and naturally more robust and it does not require any fast processors.
(Jan Jantzen, 1998)

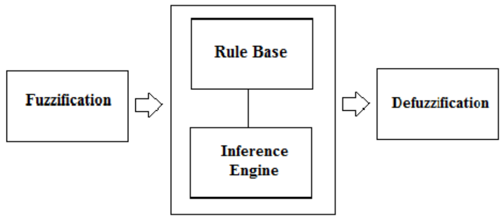

Fig. 3: Fuzzy controller

The first block inside the controller is fuzzification, which converts each piece of input data to degrees of membership by a lookup in one or several membership functions. The fuzzification block thus matches the input data with the conditions of the rules to determine how well the condition of each rule matches that particular input instance. There is a degree of membership for each linguistic term that applies to that input variable. The rules may use several variables both in the condition and the conclusion of the rules. The controllers can therefore be applied to both multi-input-multi-output (MIMO) problems and single-input-single-output (SISO) problems. The typical SISO problem is to regulate a control signal based on an error signal. The controller may actually need both the error, the change in error, and the accumulated error as inputs, but we will call it single-loop control, because in principle all three are formed from the error measurement.The resulting fuzzy set must be converted to a number that can be sent to the process as a control signal. This operation is called defuzzification. The resulting fuzzy set is thus defuzzified into a crisp control signal.(Jan Jantzen,1998et..al) (Timothy J. Ross, 2004)

Fuzzification:

Fuzzy logic uses linguistic variables instead of Numerical variables. In the real world, measured quantities are crisp or real values. The process of converting a numerical variable (real number) into a linguistic variable (Fuzzy number) is called fuzzification. In the proposed scheme, we have used MAMDANI typefuzzification. It is the most commonly used implication method. In this method, the output MF is truncated to the degree of membership obtained from the IF-THEN rule. Output of each rule obtained by using AND (min) operator or using OR (max) operator. Hence it is called Min-Max implication.

List of rules:

1. If (L is NB) then (T is NB) (1)
2. If (L is NB) then (T is NB) (1)
3. If (L is NB) then (T is NB) (1)
4. If (L is NB) then (T is NS) (1)
5. If (L is NB) then (T is ZO) (1)

6. If (L is NS) then (T is NB) (1)
7. If (L is NS) then (T is NB) (1)
8. If (L is NS) then (T is NS) (1)
9. If (L is NS) then (T is ZO) (1)
10. If (L is NS) then (T is PS) (1)
11. If (L is ZO) then (T is NB) (1)
12. If (L is ZO) then (T is NS) (1)
13. If (L is ZO) then (T is ZO) (1)
14. If (L is ZO) then (T is PS) (1)
15. If (L is ZO) then (T is PB) (1)
16. If (L is PS) then (T is NS) (1)
17. If (L is PS) then (T is ZO) (1)
18. If (L is PS) then (T is PS) (1)
19. If (L is PS) then (T is PB) (1)
20. If (L is PS) then (T is PB) (1)
21. If (L is PB) then (T is ZO) (1)
22. If (L is PB) then (T is PS) (1)
23. If (L is PB) then (T is PB) (1)
24. If (L is PB) then (T is PB) (1)
25. If (L is PB) then (T is PB) (1)

Defuzzification:

This is the conversion of the inferred fuzzy control action to a crisp or non-fuzzy control action. Centroid defuzzification used in proposed technique. In this method of defuzzification, the crispy output Z_{out} is taken as geometric center of the fuzzy area $\mu_{out}(Z)$ obtained after aggregation.(Timothy J. Ross, 2004)

RESULTS AND DISCUSSION

To test and analysis the proposed topology, by usingMATLAB/SIMULINK software. The multicarrier phase disposition PWM technique hasbeen implemented for single phasefive levelasymmetrical multilevelinverter fed induction motor drive.Fuzzy rules designed and implemented by using dedicated fuzzy tool box. Simulation results also compared with PID controller.

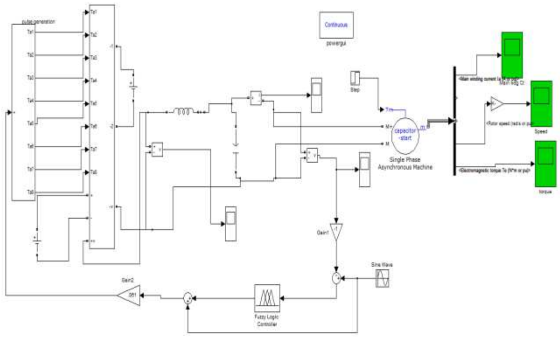

Fig. 4: Simulation circuit

Reference switching frequency, f_m =50Hz
Carrier switching frequency, f_c =2 kHz

Table 1: Load parameters

Induction motor parameters	Values
Type, No. of Phases	Capacitor Start , 1Φ
Nominal power, voltage and frequency	0.25 HP, 230V, 50Hz
Speed (RPM)	1500
Main winding stator resistance R_m (Ω)	2.02
Main winding stator inductance L_m (mH)	7.54
Rotor resistance $R_{r'}$(Ω)	4.12
Mutual inductance (H)	0.177
Auxiliary winding stator resistance R_s (Ω)	7.14
Auxiliary winding stator inductance L_s (mH)	8.54
Capacitor value (μF)	255
Inertia coefficient J (kg.m^2)	0.0146
Number of poles (P)	4
Turns ratio (Aux/Main)	1.18

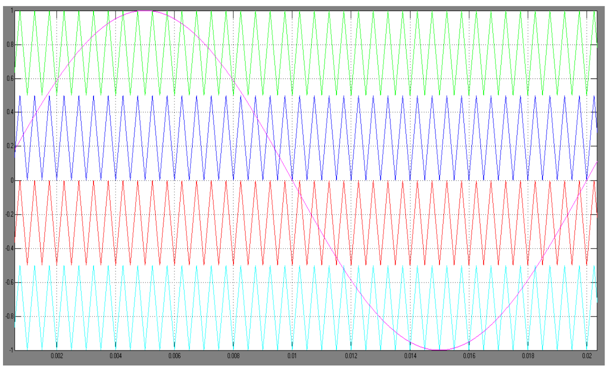

Fig. 5: Phase Disposition multicarrier technique

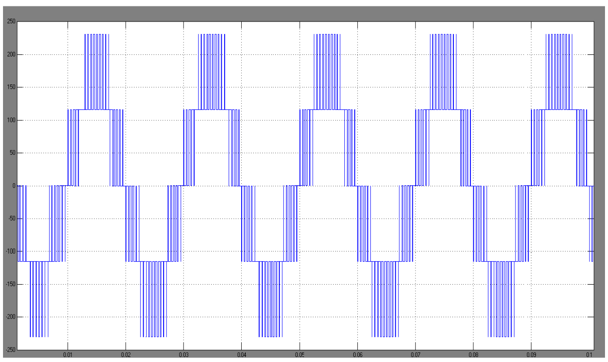

Fig. 6: Output Voltage

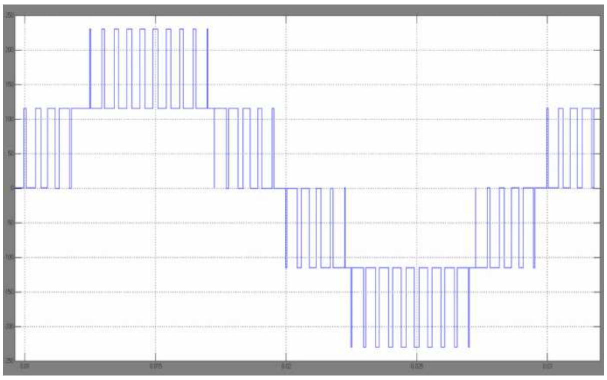

Fig. 7: Detailed Output Voltage

In PDPWM technique has shown in Fig 4, it consist four triangular carrier signal with operated fuzzy output reference signal. It is similar to sine waveform. All the carriers are arranged in phase. The five level output voltage waveforms of the asymmetrical MLI are shown in Fig.5 and Fig.6.

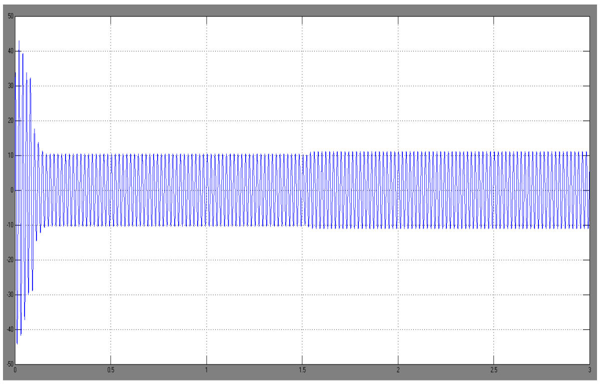

Fig. 8: Stator Current Responsefor fuzzy based MLI

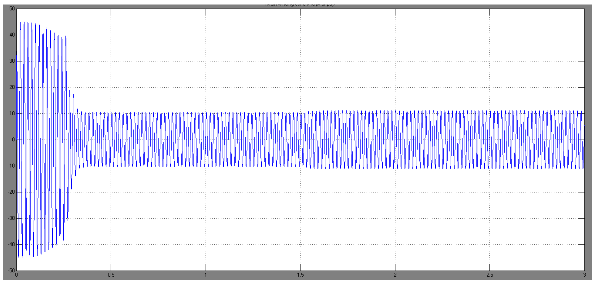

Fig. 9: Stator Current Responsefor PID based MLI

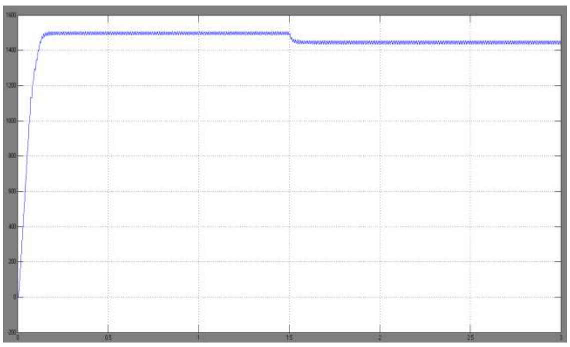

Fig. 10: Speed response for fuzzy based MLI

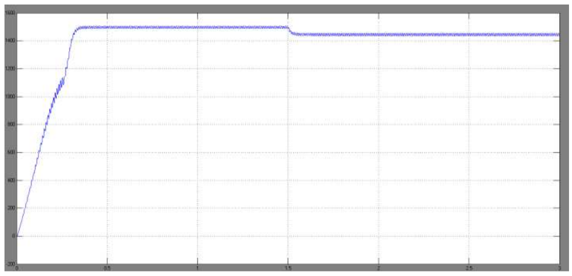

Fig. 11: Speed response for PID based MLI

From Fig. 8 to Fig 9 Stator current response compared. In PID based MLI, Current distortions present upto 0.25 sec. But fuzzy based MLI, current distortions present till 0.12 sec.

From Fig. 10 to Fig 11 Speed response compared. In PID based MLI, motor speed settled at 0.2 sec. But fuzzy based MLI, motor speed settled at 0.1 sec.

From Fig. 12 to Fig 13 Torque response compared in both techniques. In PID based MLI, torque ripples continued till0.35 sec. But fuzzy based MLI, torque ripples continued till 0.2 sec.

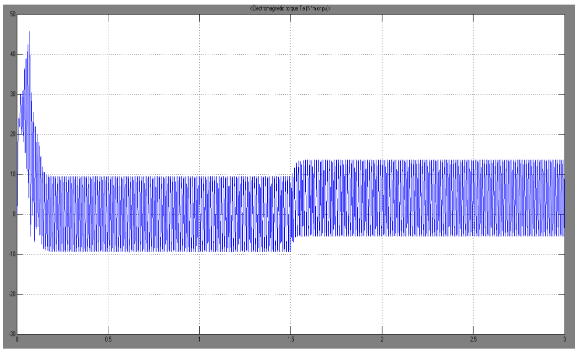

Fig. 12: Torque Responsefor fuzzy based MLI

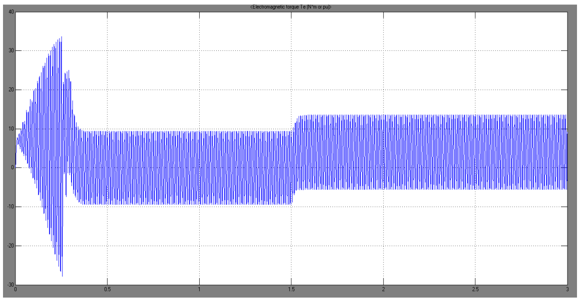

Fig. 13: Torque Responsefor PID based MLI

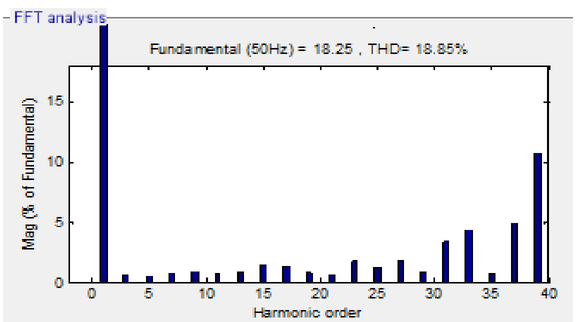

Fig. 14: THD for fuzzy based MLI

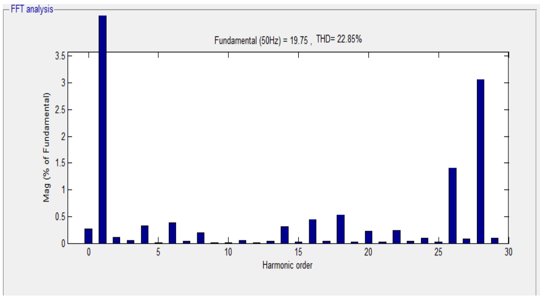

Fig. 15: THD for PID based MLI

From Fig. 14 to Fig 15 Harmonics distortion compared in both techniques. In PID based MLI, THD is 22% . But fuzzy based MLI, THD is 18%

Hardware Results:

Hardware prototype is developed to validate the experimental results.control logic is implemented using C2000 DSP controller.

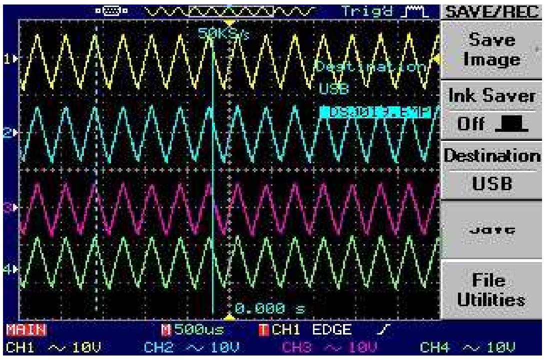

Fig. 16: Carrier signal

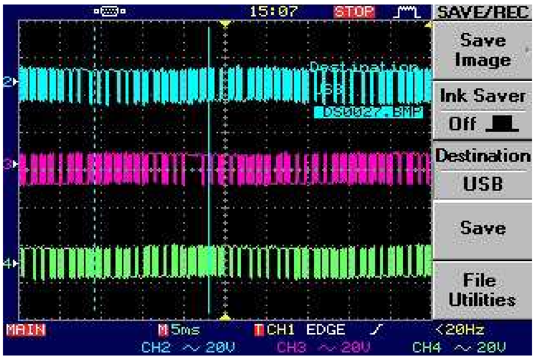

Fig. 17: Pulse output

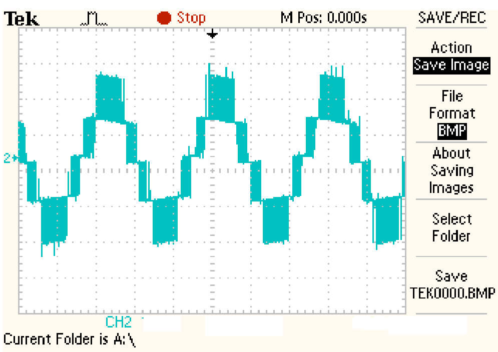

Fig. 18: Output voltage

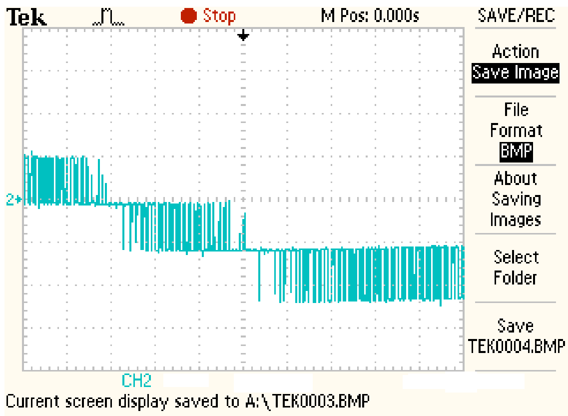

Fig. 19: Detailed output signal

Conclusion:

The conventional closed loop system uses PID controller in feedback path. It is very simple But, it gives a ripples in torque, current distortions. Moreover it has the poor performance when we applied to the nonlinear systems and also controller tuning is very difficult due to inadequate knowledge of the system parameters. In this paper proposed scheme uses fuzzy logic in feedback path to adjust the reference signal. This modified reference signal minimizes the torque ripples, stator current variations and settling time in drive system. Moreover this switching mechanism improves the dynamic performance of the drive under transient conditions

REFERENCES

Brendan Peter McGrath and Donald Grahame Holmes, 2002. “Multicarrier PWM Strategies for Multilevel Inverters”, IEEE Trans on Industrial Electronics, 49: 4.

Carrara, G., 1992. A New Multilevel PWM Method: A Theoretical Analysis, IEEE Transactions on Power Electronics, 7(3): 497-505.

Corzine, K.A., Y.L. Familiant, 2002, A new cascaded multi-level H-bridge drive‟, IEEE Trans. Power Electronics, 17: 125-131.

Holmes, D.G. and T.A. Lipo, 2003. Pulse Width Modulation for Power Converters.IEEE Press.

Dr.Shailendra Jain, 2012. Modeling and simulation using Matlab-simulink,Wileyindia

Krishnan, R., 2007. Electric Motor Drives-Modelling,Analysis And Control, Prentice Hall Of India(PHI).

Ilhami Colak, Ersan Kabalci and Ramazan Bayindir, 2011. Review of Multilevel Voltage Source Inverter Topologies and Control Schemes. Energy Conversion and Management., 52(2): 1114-1128.

Jan Jantzen, 1998. Design of Fuzzy Controllers, Technical design report, Technical University of Denmark.

Jose Rodriguez, 2007. Multilevel Voltage-Source-Converter Topologies for Industrial Medium-

Voltage Drives.IEEE Transactions on Industrial Electronics, 54: 6.

Rodriguez, J., J.S. Lai, an F.Z. peng, 2002."Multilevel inverter: A survey of topologies, controls, and applications," IEEE Trans. Ind. Electron., 49(4): 724-738.

Leon, M., Tolbert and G. Thomas, 1999. Habetler, Novel Multilevel Inverter Carrier Based PWM Method. IEEE Transaction on Industry Application. 35(5): 1098-1107.

Rashid, M.H., 2004. Power Electronics: Circuits, Devices and Applications,Prentice Hall, New York, NY, USA, 3rd edition.

Mariusz Malinowski, K. Gopakumar, Jose Rodriguezand Marcelo A. Pérez, 2010. "A Survey onCascaded Multilevel Inverters", IEEE Trans on Industrial Electronics, 57: 7.

Mcgrath, B.P. and D.G. Holmes, 2002. Multicarrier PWM Strategies for Multilevel Inverter. IEEE Transaction on Industrial Electronics, 49: 858-867.

Miao Chang-xin,Shi Li-ping, Wang Tai-xu and Cui Cheng-bao, 2009. "Flying capacitor multilevel inverters with novel PWM method" ,Proceedings on 6th International Conference on Mining Science & Technology, Science direct, pp: 1554-1560.

Mohan, D., Sreejith B. Kurub, 2012. A Comparative Analysis of Multicarrier SPWM Control Strategies using Fifteen Level Cascaded H-Bridge Multilevel Inverter, International Journal of Computer Applications. 41(21): 7-11.

Palanivel, P. and S.S. Dash, 2011. "Analysis of THD and output voltageperformance for cascaded multilevel inverter using carrierpulse width modulation techniques," IET Power Electronics, 4(8): 951-958.

Bhagwat, P.M. and V.R. Stefanovic, 1983. "Generalized structure of a multilevel PWM inverter," IEEE Trans. Ind. Applicat., IA-19: 1057-1069.

Ishida, T., K. Matsuse, T. Miyamoto, K. Sasagawa and L. Huang, 2002. Fundamental characteristics of five-level double converters with adjustable DC voltages for induction motor drives," IEEE Trans. Ind. Electron., 49(4): 775-782.