IMPLEMENTATION & SIMULATION OF MULTILEVEL INVETER

[1]AKSHAY A. SHINDE, [2]MANOJ R. HANS

[1]PG Student Electrical Power Systems, [2]Associate Professor, Electrical Department
Zeal College of Engineering and Research Narhe, Pune, India

Abstract- The main objective of this paper is to have high quality output with reduced number of harmonics i.e. total harmonics distortions (THD) by using the multicarrier based PWM method with a diode clamped multilevel inverter for resistive type of load and for the inductive i.e. the motor load. The control technique used is multicarrier PWM technique, also simple PWM technique can also be implemented for this scheme. The open loop speed control by using the V/f method can also be achieved in this scheme. The V/f control method can be done by changing the supply voltage and frequency which is applied to the three phase induction motor at a constant ratio.This scheme is therefore an effective replacement of the conventional technique. As in this paper scheme which is used gets the three phase output with the single phase power supply source. Therefore the conventional technique results in higher switching losses, harmonics, and THD and also poor drive performance of drive i.e. load. The simulation results prove that the proposed scheme produces a high quality output with resistive load. Thus a comparison can also be made for resistive load with filter and without filter, in order to see the THD performance with and without filter. So this can also be obtained from the simulation results. The effectiveness of this system can be verified by using the MATLAB simulink package R2010a

Keywords- Harmonics,THD,Multicarrier PWM Technique,V/f Method,Diode clamped multilevel inverter

I. INTRODUCTION

Most of the Industries are now using the induction motors because these are rugged, reliable and inexpensive relatively. The induction motors are mostly used for their constant speed applications and because of unavailability of the changing frequency supply voltage [2].But nowadays many applications need variable speed operations.Earlier mechanical gear systems were used to obtain the variable speed operation. Therefore now the electronics and the control systems have became progressive enough to have adjustable or variable output on the machine side or on the load side. Therefore previously some large classical three phase converters were used for the induction motor drives which are having the poor voltage and current qualities and also large switching losses. Thus by using some new techniques in combination with the electronics systems can overcome this.

The concept of multilevel inverter has been introduced to have controlled output for various loads such as resistive loads and inductive loads i.e. induction motors. The changes in the output with the resistive load can be achieved by using the proposed scheme; also the induction motor can be controlled to achieve the dynamic performance as equal to that of DC motors [2]. Many of the schemes are now been developed to have multi voltage profile, which are particularly suitable for induction motor drive applications and also resistive loads.

The diode clamped multilevel inverter method can be applied to higher number of converters. As in the number of levels increases the synthesized output waveforms adds more number of steps which produces a staircase output waveform. A zero harmonic output can be achieved by increasing the levels to a large number [4]. Therefore the number of which can be achieved is restricted to certain number of levels, only due to the voltage unbalancing problem and also due to voltage clamping requirement circuit layout and content.

In this paper a diode clamped multilevel inverter is implemented which can be fed to the resistive load and also to the induction motor i.e. inductive load. The diode clamped inverter provides multi voltage levels from a bank of series connected capacitors [2].These features effectively double the power rating of voltage source inverter for the given semiconductor devices [3].Generally as in conventional technique three phase power supply is used here the circuitry is using single phase power supply which can be made available easily and the output is achieved in three phase form. This inverter is generally a voltage source inverter for the given source. The proposed inverter scheme can reduce the harmonics i.e. THD contents by using the multicarrier PWM technique. This inverter scheme also provide the adjustable or variable output for the resistive loads i.e. lamps and also for the induction motors. The open loop V/f control is also can be obtained by using this scheme. The variable speed operation is also possible for induction motors by this scheme. Thus the speed control can be precisely done by the diode clamped multilevel inverters.

II. CONVENTIONAL METHOD

In the conventional method normal PWM technique is used, so the current quality and voltage quality found to be poor, also the switching losses are more [5].

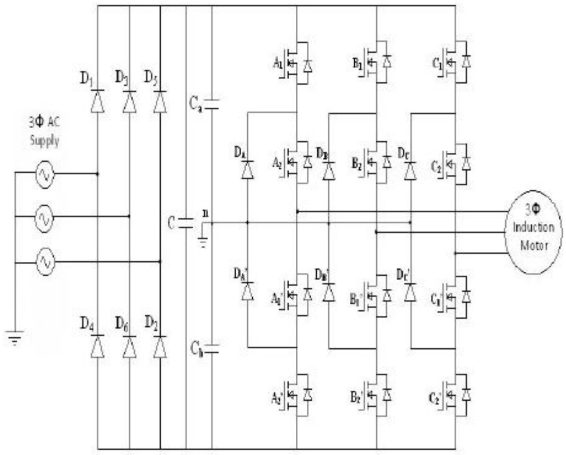

Fig.1 Multilevel inverter fed Induction motor drive (conventional)

III. PROPOSED (NEW) STRUCTURE OF THREE LEVEL DIODE CLAMPED MULTILEVEL INVERTER

The above drawbacks can be rectified by using a three level diode clamped multilevel inverter operated on single phase supply. The voltage and current qualities get improved and also the switching losses get reduced when compared with the conventional technique, also the THD i.e. harmonics is found to be reduced [6].

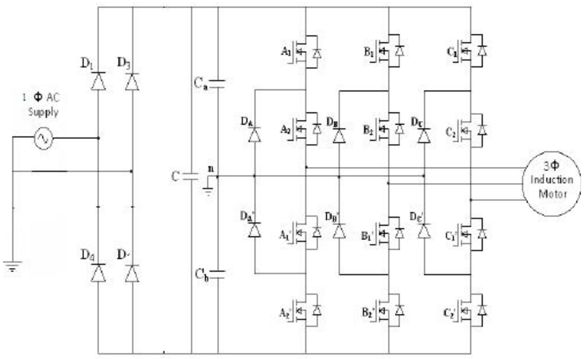

Fig.2 Multilevel inverter fed Induction motor drive with single phase supply source (new)

This structure basically contains single phase power supply source. As it is a voltage source inverter as shown in fig.2. It consists of twelve unidirectional active switches i.e. MOSFET's, six neutral point clamped diodes [4]. The middle point of the capacitors is given by term 'n' which can be defined as the neutral point. The benefit of this configuration is that each switch must block one half of the dc link voltages i.e. (Vdc/2). In order produce the three levels output it is essential that only two switches out of four switches should be turned on at any time. The dc bus voltage is divided into three levels by two series connected bulk capacitors i.e. 'Ca'and 'Cb' they are of same rating. The diodes are all of same type to provide equal voltage sharing to clamp the voltages across switch when switch is in off condition. Hence this structure provides less voltage stress across switch.

The diode clamped multilevel inverter provides following features:

a) These multilevel inverters can generate the output voltage with low distortion and low dv/dt.
b) They can have the input current with very low distortions [4].
c) These can be operated with low switching frequency [4].
d) They can generate lesser stress on motor bearings.

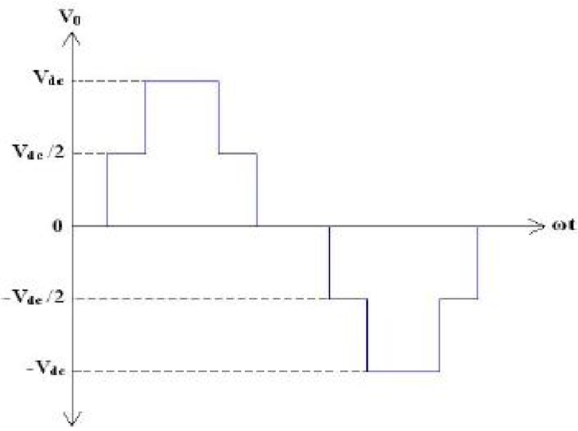

Fig.3 Three level inverter output voltage

IV. PROPOSED SCHEME

The block diagram of the scheme is as shown in fig.4. It is basically divided into two circuits. The first one is the power circuit and the second one is the control circuit. The power circuit consists of a single phase power supply, diode bridge rectifier, capacitor filter and the diode clamped MOSFET based inverter. An ac input voltage is provided to the diode bridge rectifier by using the power supply, this diode bridge rectifier then converts the ac supply to dc. This dc output consists of ripples content which is removed by using the capacitor filter, so as to produce the pure dc output voltage. The pure dc output voltage is applied to the input side of the MOSFET based multilevel inverter through the capacitor filter. This multilevel inverter has twelve MOSFET switches that are controlled in order to generate an ac output voltage from dc input voltage.

The control circuit consists of two main blocks i.e. the opto-coupler, gate driver circuit. The gate driver circuit consists of a driver IC i.e. integrated circuit which will drive the induction motor directly without the requirement of microcontroller. The gate pulses are having a voltage magnitude of +5 volts. The gate driver circuit and the optocoupler circuit are needed so as to have the satisfactory performance of the power MOSFET switches. The MOSFET produces controlled ac output voltage which can be used for resistive load or induction motor purpose.

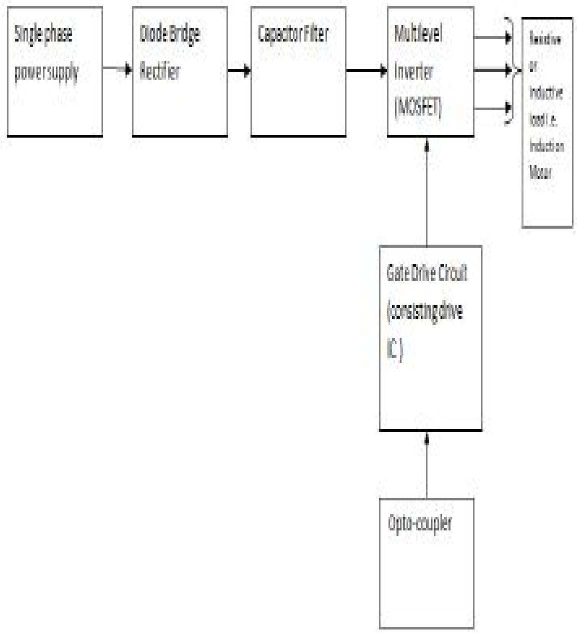

Fig.4 Block diagram of proposed scheme

V. MODULATION TECHNIQUE.

The paper mainly focuses on multicarrier PWM technique. As this method is simple and more flexible as compared to other methods such as SVM method, APOD methods etc. The multicarrier PWM method uses a number of triangular carrier signals, which keeps only one modulating sinusoidal signal. If n-level inverter is employed then n-1 carriers will be needed.

There are few advantages of multicarrier PWM technique:
a) The number levels can be easily increased.
b) Implementation is easy.
c) Switching losses can be minimized.
d) It compensates the unbalanced DC sources.

VI. SIMULATED CIRCUITS AND RESULTS

The fig.5 shows the PWM circuit for the generation of gating signals for multilevel inverter switches. The figure shows the single phase supply with bridge rectifier, capacitor filter and MOSFET based inverter is used for induction motor drive or resistive load.

The fig.6 shows the simulated circuit for resistive load with three lamps, each lamp of 25 W capacities. So as to get a total wattage of 75 W. This circuit is simulated for resistive load without filter, so as to observe the effect on harmonics.
Therefore the FFT plot can be seen for THD content of both current and voltage of resistive load without filter which is as shown in fig.7 and fig.8.

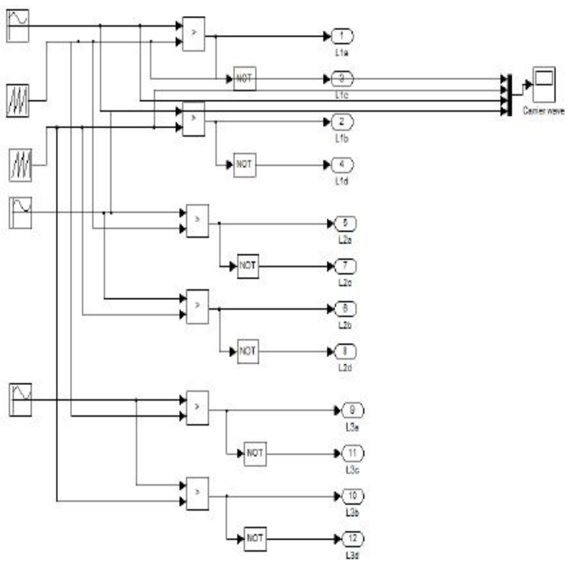

Fig.5 PWM simulation circuit

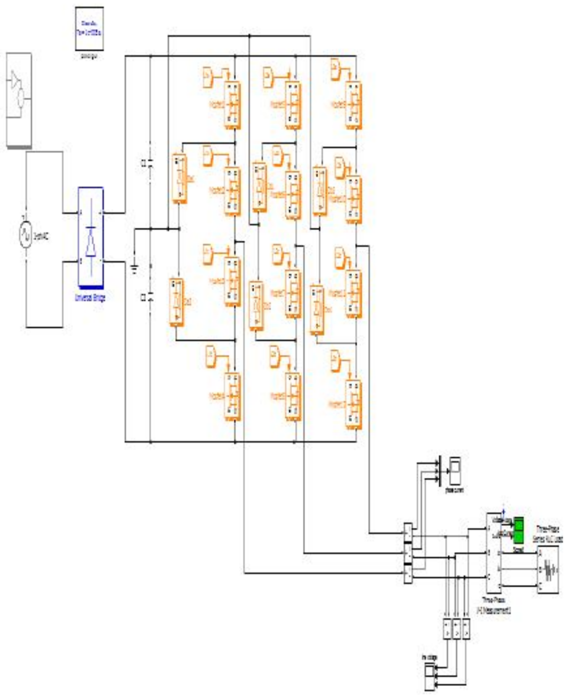

Fig.6 Simulated circuit for resistive load without filter

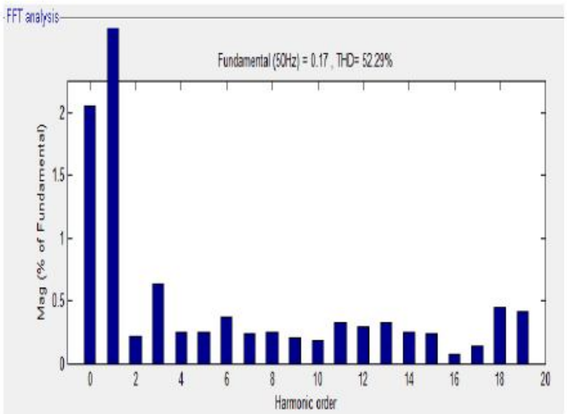

Fig.7 FFT plot for current THD for Resistive load without filter

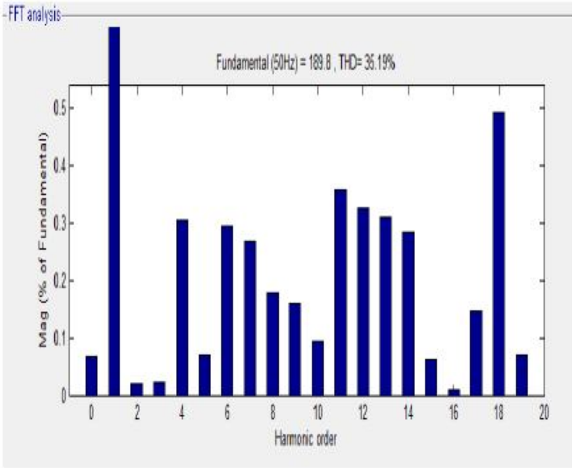

Fig.8 FFT plot for voltage THD for Resistive load without filter

The output i.e. load voltage and current waveforms for resistive loads without filter are shown in fig.8

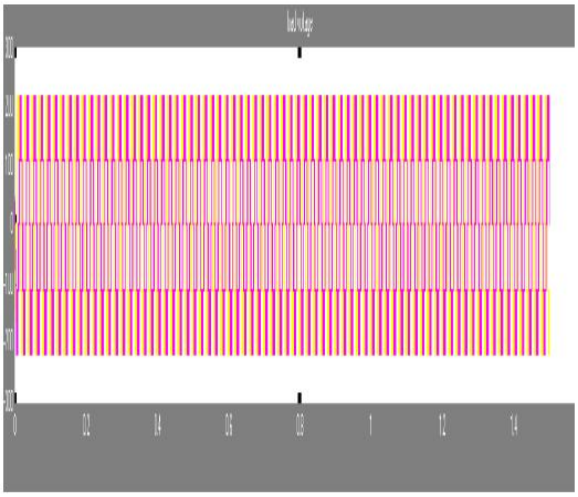

Fig.9 load current for resistive load without filter

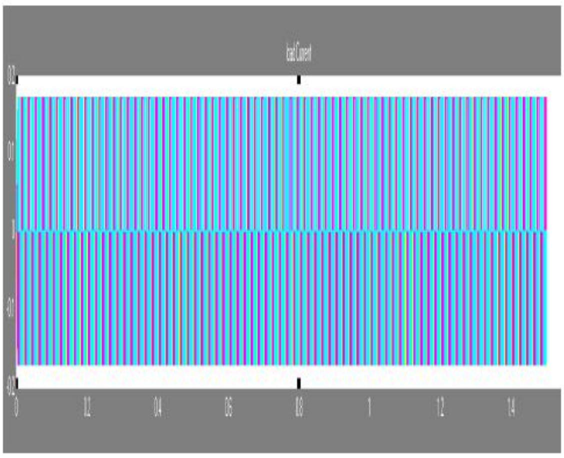

Fig.10 load voltage for resistive load without filter

The fig.11 shows the simulated circuit for resistive load with three lamps of total 75 W capacity and having a LC filter connected before them. So as to see the effect of harmonics i.e.THD by using a LC filter.

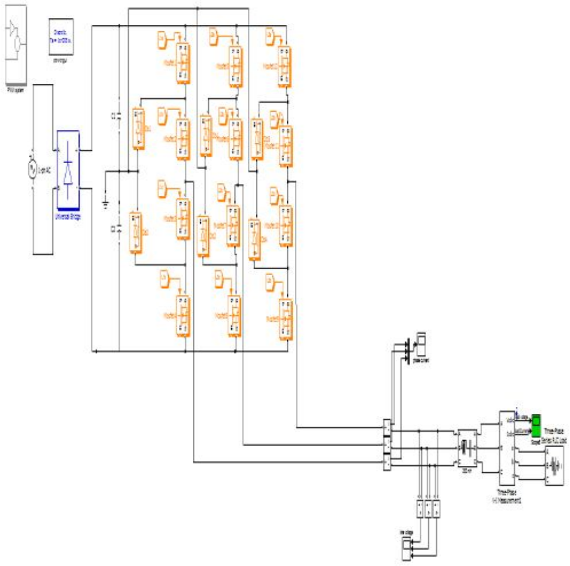

Fig.11 Simulated circuit for resistive load with filter

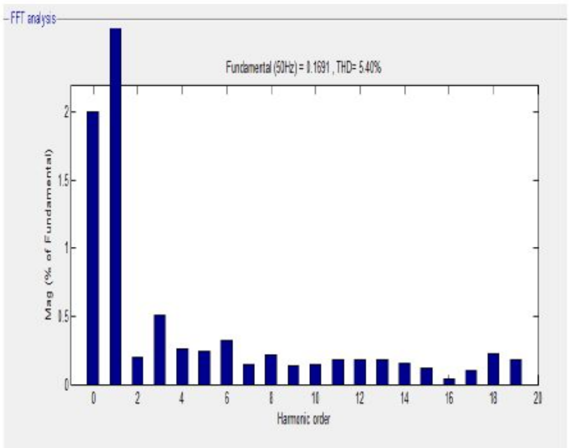

Fig.12 FFT plot for current THD for Resistive load with filter

By referring the fig.12 it is been observed that theTHD is been decreased by using the filter. Also the FFT plot for voltage THD shows the lower harmonic content by using a filter with resistive load which is as shown in fig.13.

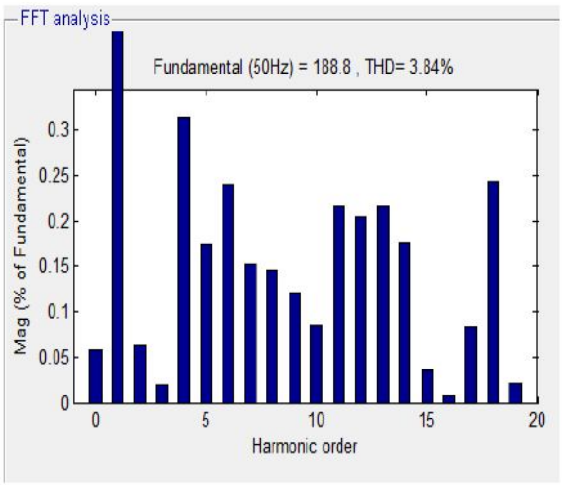

Fig.13 FFT plot for current THD for Resistive load with filter

The load current and voltage waveforms are as shown in fig.14 and fig.15 for resistive load with filter.

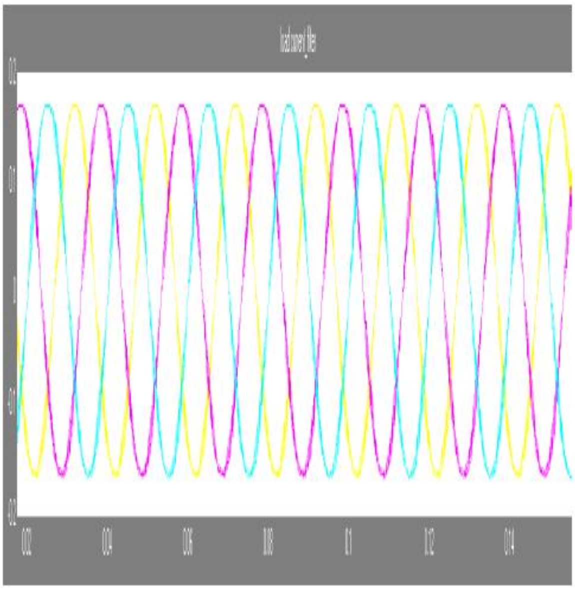

Fig.14 load current for resistive load with filter

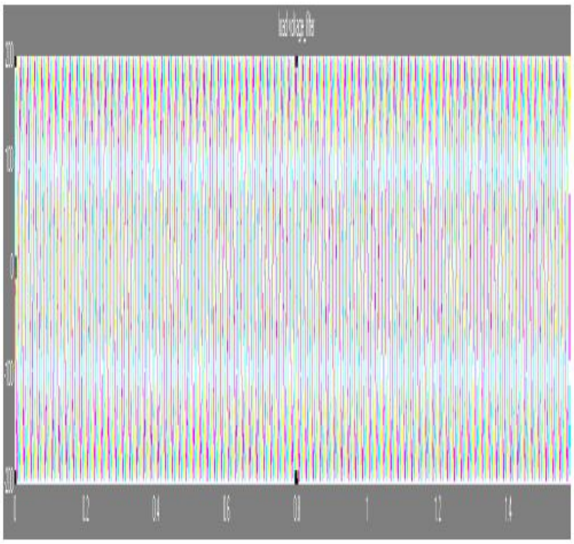

Fig.15 load voltage for resistive load with filter

VII. HARDWARE CIRCUIT

As discussed earlier also that the circuit consists of two sections i.e. the power circuit and the control circuit section.

In the on or working condition the pot has to be kept in the minimum position and then slowly it has to be varied from minimum to maximum position. The output of this condition can be observed on the Lamps i.e. on the resistive load. Therefore in the minimum position the intensity of lamps is low and as the pot is varied it goes on increasing i.e. the lamps will get the full intensity and will get brighter. The same phenomenon can be applied to vary the speed of the induction motor for speed control of induction motor.

Fig.16 Hardware circuit in Off condition

Fig.17 Hardware circuit in working condition

Fig.18 CRO outputs

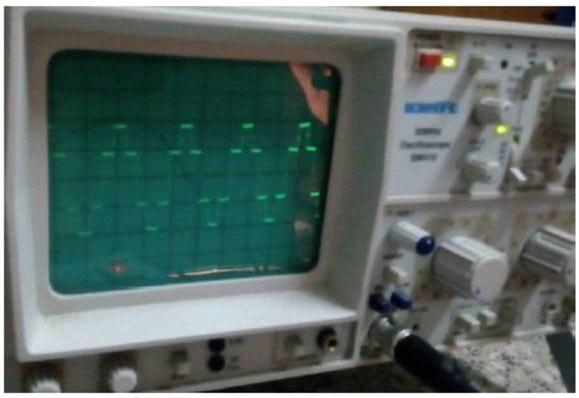

Fig.18 CRO outputs

I. TABLE
THD Results for Resistive load

Parameters/Load	THD %	
	Current	Voltage
Resistive Load without filter	52.29%	35.19%
Resistive Load with filter	5.40%	3.84%

CONCLUSION

Thus a Three level diode clamped multilevel inverter can be implemented for producing high quality output with reduced harmonic content by using the multicarrier PWM technique. The simulation result shows the reduced THD for resistive load with filter. Therefore this type system can be used for variable speed applications such as conveyors, rolling mills, printing machines etc.

REFERENCES

[1] Jose, Steffen Sernet, Bin Wu, Jorge and Samir Kouro, “Multilevel Voltage – Source -Converter Topologies for Industrial Medium -Voltage Drives,” *IEEE Trans on IndustrialElectronics*, vol.54, no.6, Dec 2007.

[2] Dr.Rama Reddy and G.Pandian,“Implementation of Multilevel inverter fed Induction motor Drive,” *Journal of IndustrialTechnology*, vol 24, no. 1, April 2008.

[3] N.Celanovic and D.Boroyevich, “ A Comprehensive study of neutral-pointvoltage balancing problem in three-level neutral - pointclamped voltage source PWM inverters,” *IEEE Trans on Power Electronics*, vol.15, no. 2, pp.242 – 249, March 2000.

[4] J. Rodriguez, J.S. Lai, Fang Z. Peng, “Multilevel Inverters: A Survey of Topologies, Controls and Applications,” *IEEE Trans on Industrial Electronics*, vol.49, no.4, pp 724-738 Aug 2002.

[5] Jae Hyeong Seo, Chang Choi and Dong Seok,“A New Simplified Space-Vector PWM Method For Three- Level Inverters,” *IEEE Trans on Power Electronics*, vol.16,no. 4, July 2000.

[6] Zhang, A.V. Jouanne, Shaoan Dai, A.K.Wallace and F.Wang, “Multilevel Inverter Modulation Schemes to Eliminate Common-Mode Voltages,”*IEEE Trans on Ind. Appl*, vol. 36, no 6, pp 1645-1653 Nov/Dec 2000.

[7] Brendan Peter McGrath, and Donald Grahame Holmes,“Multicarrier PWM Strategies for Multilevel Inverters” *IEEE Transactions on Industrial Electronics*, VOL. 49, NO. 4, August 2002,pp.858-867.

[8] Mariusz Malinowski,K.Gopakumar,Jose Rodriguez,and Marcelo A. Pérez,“A Survey on Cascaded Multilevel Inverters” *IEEE Transactions on Industrial Electronics*, VOL. 57, NO. 7, July 2010,pp.2197-2206.

[9] Mohammad Farhadi Kangarlu and Ebrahim Babaei,“A Generalized Cascaded Multilevel Inverter Using Series Connection of Submultilevel Inverters” *IEEE Transactions on Power Electronics*, VOL. 28, NO. 2, February 2013, pp.625-636.

★★★