Harmonics Reduction Using 5 Level Inverter

Nikhileshwar P Adhikari, Anurag Tiwari

Abstract: In this paper control the drive & reducing the Total Harmonic Distortion using the 5 Level 3 Lags Multilevel Inverter & to compare the THD using different filter. The proposed scheme for neutral point clamped multilevel inverter is Sinusoidal PWM control. The conventional two level inverter is not produce the high output voltage, but the high quality AC output voltage is obtained by the help of multi level inverter. The Multi level inverter consist series of power semiconductor switches, dc source & capacitor to get superior power. The simulation results shows that the proposed model increases the performance of drive by reducing the THD.

Keywords: Multilevel inverter, Total harmonic distortion, Neuteal point clamped inverter, Asynchronous motor, Filter, and Sinusoidal PWM.

I. INTRODUCTION

In the past Induction Motor mostly used for constant speed [1].Induction Motor Playa a vital role in Industry, they are low cost, reliable, rugged.But in the Industry there are so many application that required variable speed, in the early times, DC motor is widely used for variable speed application. In the last century Mechanical gear system was used to produce variable speed. But, recently with the help of control system & power electronics it is easy to obtain the variable speed & control of motor is became easy & replace the older method.

Now multilevel inverter is used to control the motor in place of Mechanical gear system. Inverter is a electronic appliance which converts dc to ac, but ac waveform is in the form of staircase & more harmonic distortion is present. With the help of multilevel inverter, it is possible to get the low THD.

There are 3 types of multilevel inverter are present

- Cascaded inverter with separate DC sources.
- Flying capacitors multilevel inverter.
- Diode clamped multilevel inverter or Neutral point clamped inverter.

This paper presents 5 level 3 lags multilevel inverter using Neutral point clamped inverter

Manuscript received March 16, 2016

Nikhileshwar P Adhikari, Research Scholar, Mewar University, Chittorgarh

Anurag Tiwari, Research Scholar, Mewar University, Chittorgarh

Neutral Point Clamped-The diagram of five level three lags Neutral Point Clamped Multilevel inverter as shown in figure 1.Each lag has eight MOSFET,four capacitors, six clamping diodes. To obtain a staircase output, firstly consider only one arm of multilevel inverter.

From the table 1 it is clear that at every stage only 4 MOSFET are ON STATE & others are OFF. Clamping diodes plays a very important role to maintain a voltage. In Neutral Point Clamped Multilevel inverter a load is taken from the middle. Induction motor is a load of the multilevel inverter.

Table (1) Operation of Neutral Point Clamped Multilevel inverter.

Output voltage= Va	MOSFET STATE							
	M 1	M 2	M 3	M 4	M ’1	M ’2	M’ 3	M’ 4
Va=4Vdc	1	1	1	1	0	0	0	0
Va=3Vdc	0	1	1	1	1	0	0	0
Va=2Vdc	0	0	1	1	1	1	0	0
Va=Vdc	0	0	0	1	1	1	1	0
Va=0	0	0	0	0	1	1	1	1

Table 1 shows the ON state & O show OFF state.

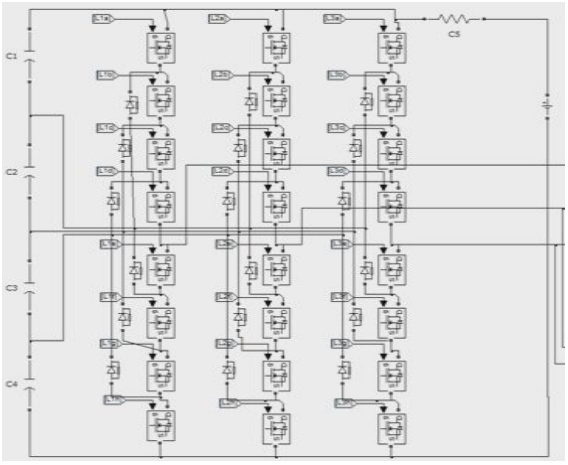

Fig (1) 5 level 3 lags multilevel inverter using Neutral point clamped inverter.

II. PROPOSED CONTROL METHOD

In Pulse Width Modulation, fixed dc is given as input to multilevel inverter and result obtained as controlled ac output. Sinusoidal Pulse Width Modulation: In sinusoidal pulse width modulation, a triangular carrier wave is compared with

a desired frequency of sinusoidal reference wave. Comparator is used to compare the carrier & reference waves. Comparator output is high when triangular wave magnitude is lower than the sinusoidal reference wave.

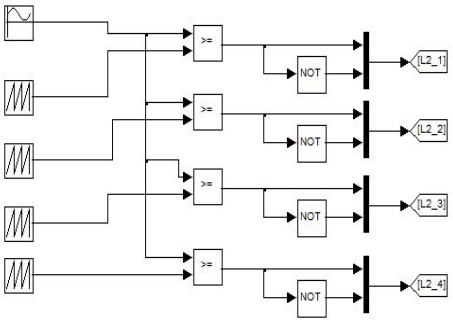

Fig. (2) Simulink model of Sinusoidal PWM for 5 level inverter.

III. Asynchronous Motor

An induction motor is also called as a asynchronous motor, it is a AC electric motor. In rotor there is a electric current, needed to obtained a torque which is produced by electromagnetic induction of the stator winding. An induction motor rotor classified in two types:

Wound and Squirrel cage.

Squirrel cage of three phase induction motor are rugged, reliable & economical that's why they are mostly used in industry. For house hold application that is for small loads like fans, Single phase induction motors are widely used.

Table (2) Parameter of Induction motor

Preset model	15:5.4HP (4KW), 400volt,50Hz,1430 Rpm
Mechanical input	Torque
Rotor type	Squirrel cage
Reference frame	Rotor

IV. Filter

Electronic filters are called as analog circuits & filters are used to remove unwanted components from the desired signals. There are different types of filter are present are as follow:

- Active filter.
- Passive filter.
- Hybrid filter.

Second order low pass filter-Two RC filters are connected in cascaded is called second order low pass filter.

Hybrid Filter-It is also called LC filter. Two conductive foil layers are present in hybrid filter. From these two layers, one layer is sandwiched between the multilevel inverter & induction motor is called the main foil. Another layer is linked to a neutral potential & capacitance is formed between the layers

V. SIMULINK MODEL

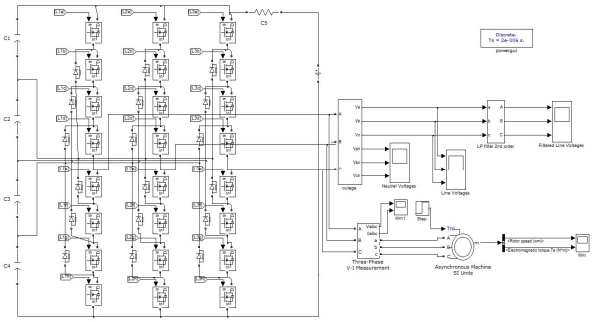

Fig. (3).5 level Multilevel inverter with second order low pass filter

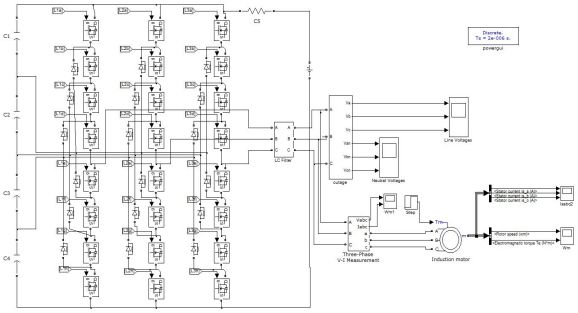

Fig. (4). 5 level Multilevel inverter with LC Filter

VI. Results

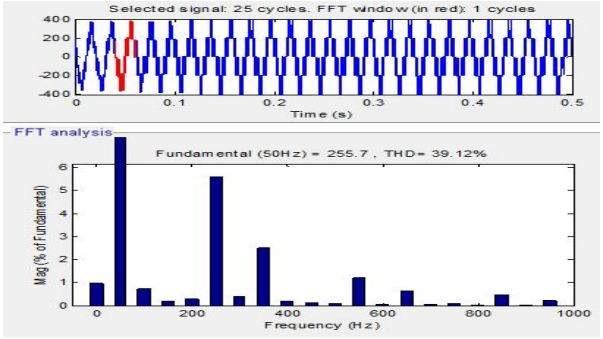

Fig. (5). FFT analysis of line voltage without filter.

From the Fig (5) it is seen that the Total Harmonic Distortion of line voltage without filter is 39.12% that is very high.

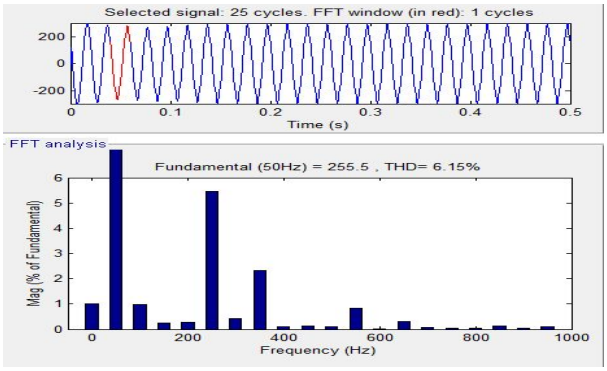

Fig. (6). FFT analysis of line voltage with LPF filter & damping factor=0.707

From the Fig (6) it is seen that the Total Harmonic Distortion of line voltage with second order low pass filter & damping factor=0.707 is 6.15 % that is less compare to THD without filter.

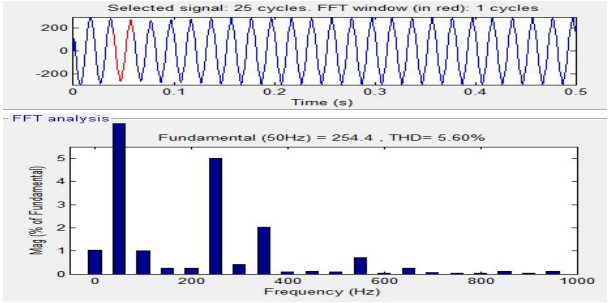

Fig.(7.)FFT analysis of line voltage with LPF filter & damping factor=0.85

From the Fig (7) it is seen that the Total Harmonic Distortion of line voltage with second order low pass filter & damping factor=0.85 is 5.60% that is less compare to THD without filter.

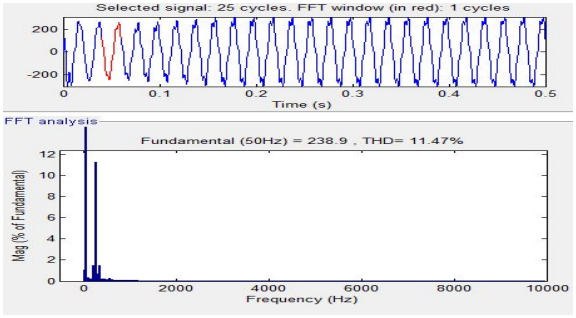

Fig.(8.)FFT analysis of line voltage with LC filter

From the Fig (8) it is seen that the Total Harmonic Distortion of line voltage with LC filter is 11.47%

TABLE (3) COMPARISON BETWEEN THD OF LINE VOLTAGE

S.No.	Damping factor	THD of line voltage using second order LOW PASS FILTER	THD of line voltage with out filter in 5 level multi level inverter	THD of line voltage in 5 level MLI using LC filter
1	ζ (zeta)=0.1	9.82 %	39.12%	11.47%
2	ζ (zeta)=0.2	8.92 %		
3	ζ (zeta)=0.3	8.24 %		
4	ζ (zeta)=0.4	7.65 %		
5	ζ (zeta)=0.5	7.11%		
6	ζ (zeta)=0.6	6.62 %		
7	ζ (zeta)=0.707	6.15%		
8	ζ (zeta)=0.85	5.60 %		
9	ζ (zeta)=0.9	5.43 %		
10	ζ (zeta)=1	5.12 %		
11	ζ (zeta)=1.2	4.59 %		

From the Table(3) it is seen that THD using SECOND ORDER LOW PASS FILTER very less as compare to THD without filter & with LC filter.

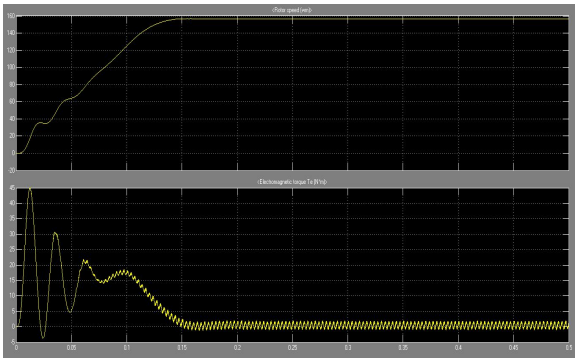

Fig. (8) settling time of rotor speed & torque.

From the Fig (8) it is seen that the settling time of rotor speed & torque is 0.15.

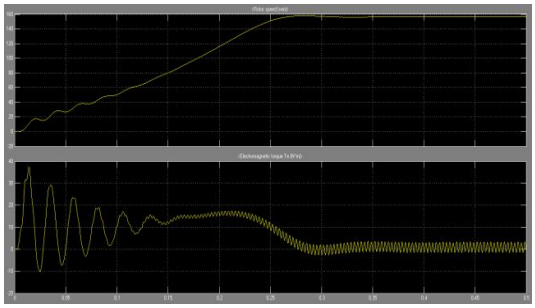

Fig. (9). settling time of rotor speed & torque using Lc filter.

From the Fig (8) it is seen that the settling time of rotor speed & torque is approx 0.3 using 5 level inverter with LC filter.

Table (4) Comparison between Rotor Speed & Torque of Induction Motor.

S.No.	Settling time of rotorspeed & torque using 5 level inverter	Settling time of rotor speed & torque using 5 level inverter with LC filter
1	0.15	0.3(approx)

From the Table(4) it is seen that Settling time of rotor speed & torque using 5 level inverter is 0.15 is less compare to Settling time of rotor speed & torque using 5 level inverter with LC filter that is 0.3.

Settling time of rotor speed & torque using 5 level inverter with LC filter is 0.3(approx) that is approx 2 times of Settling time of rotor speed & torque using 5 level inverter that is 0.15.

The Neutral Point Clamped Multilevel inverter scheme was simulated by the help of Matlab/simulink.Parameter used in this Model are as follow=50Hz, fs=4000Hz.Load is induction motor. Analysis of THD has done for line voltage using 5 level inverter.

Settling time of Speed & Torque is also control by Neutral Point Clamped Multilevel inverter.

CONCLUSION

In this paper,5-level 3 lags MLI using neutral point clamped topology has been presented. The sinusoidal PWM control method is used for reducing THD, control drives & high quality voltage is produced. From the table (3) it is seen that

the THD using Second ‘Order Low Pass Filter is less compare to THD without filter & with i]It is observed that THD in second order LPF is less than LC FILTER & without filter LC filter. Settling time of Rotor speed & Torque of induction motor is less without LC filter. Settling time of rotor speed & torque using 5 level inverter with LC filter is 0.3(approx) that is approx 2 times of Settling time of rotor speed & torque using 5 level inverter that is 0.15.

REFERENCES

[1] Jose, Steffen Sernet, Bin Wu, Jorge and SamirKouro,“Multilevel Voltage Source Converter Topologies for Industrial Medium Voltage Drives”,IEEE Trans Industrial Electronics, vol.54, no.6, Dec 2007.

[2] H. Natchpong, Y. Kondo, and H. Akagi, “Five-level diode clamped PWM converters connected back-to-back for motor drives,” IEEE Trans. Ind. Appl., vol. 44, no. 4, pp. 1268–1276, Jul./Aug. 2008.

[3] T. S.Key and J. S. Lai, “IEEE and international harmonic standards impact on power electronic equipment design,” in Conf. Rec. IEEE IECON, Nov.2005, vol. 2, pp. 430–436

[4] F. DeWinter, N. Zargari, S. Rizzo, and X. Yuan, “Medium voltage drives: Are isolation transformers required?,” in Conf. Rec. IEEE IAS Petroleum Chem. Ind. Conf., 2002, pp. 191–196.

[5] L.M.Tolbert,F.Z.Peng,andT. G. Habetler, “Multilevel converters for large electric drives,” IEEE Trans. Ind. Appl., vol. 35, no. 1, pp. 36–44,Jan./Feb. 2003

[6] B.Wu, High-Power Converters and AC Drives. Piscataway, NJ: IEEE Press, 2006.