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Drive Control & THD Reducing Using 5 Level 3 Legs Multilevel Inverter

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Abstract: **The object of this paper is to control the drive & reducing the Total Harmonic Distortion using the 5 Level 3 Legs 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 producing the high output voltage. The high quality AC output voltage is obtained by the help of multilevel inverter. The Multilevel 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, Neutral point clamped inverter, Asynchronous motor, Filter, Sinusoidal PWM.**

I. INTRODUCTION

In the past Induction Motor mostly used for constant speed. Induction Motor Play a vital role in Industry, they are low cost, reliable, rugged. In the Industry there are so many applications 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. Presently with the help of control system & power electronics it is easy to obtain the variable speed & control of motor is become 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:

(a) Cascaded inverter with separate DC sources.

(b) Flying capacitors multilevel inverter.

(c) Diode clamped multilevel inverter or Neutral point clamped inverter.

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

II. PROPOSED TOPOLOGY

Neutral Point Clamped MLI-The diagram of five level three legs Neutral Point Clamped Multilevel inverter as shown in Fig.(1).Each leg has eight MOSFET, four capacitors ,six clamping diodes. To obtain a staircase output, first 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							
	M1	M2	M3	M4	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

1 show the ON state & O show OFF state.

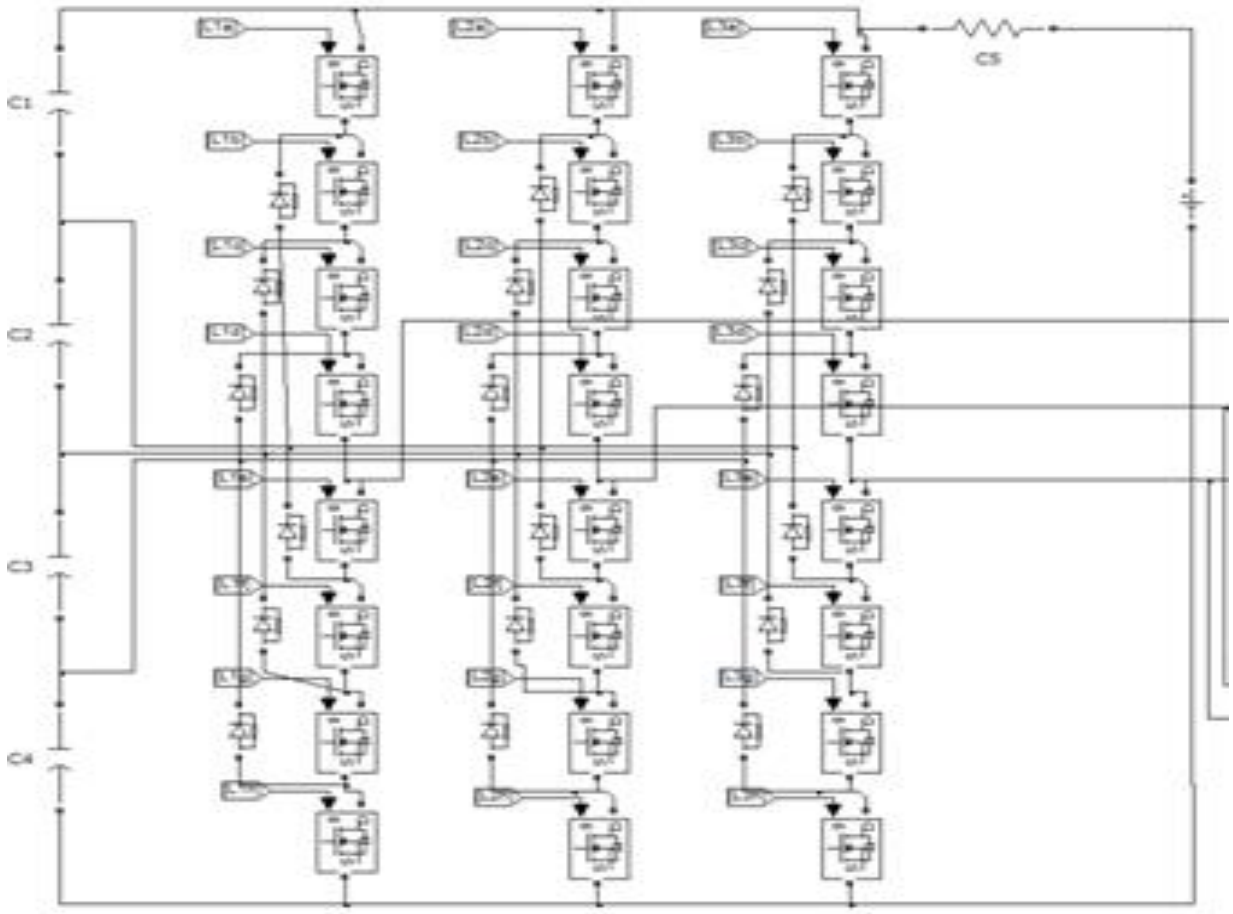

Fig.(1) 5 level 3 legs Multilevel inverter using Neutral point clamped inverter.

III. 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.

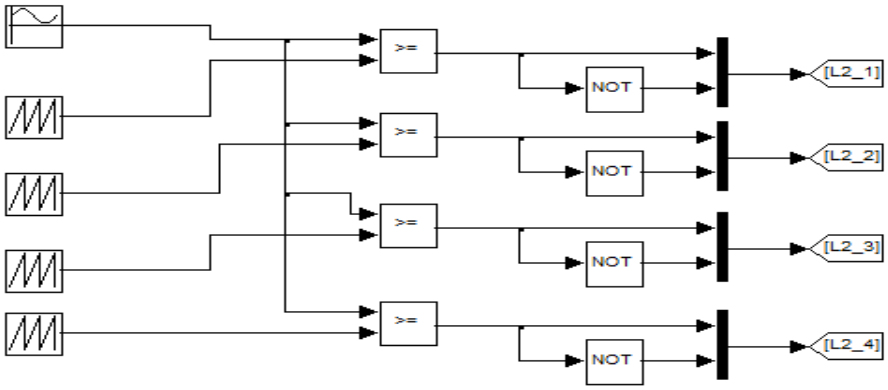

Fig.(2) Simulink model of Sinusoidal PWM for 5 level MLI.

IV. 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:

(1) Wound.

(2) 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 motor are widely used.

Table(2) Parameter of Induction motor.

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

V. FILTER

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

(1) Active filter.

(2) Passive filter.

(3) 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.

VI. SIMULINK MODEL

As per the proposed topology & proposed control method the Simulink model has been developed are shown below. Fig. (3) Represents the 5 level MLI with second order low pass filter & Fig. (4) Represents 5 level MLI with LC filter.

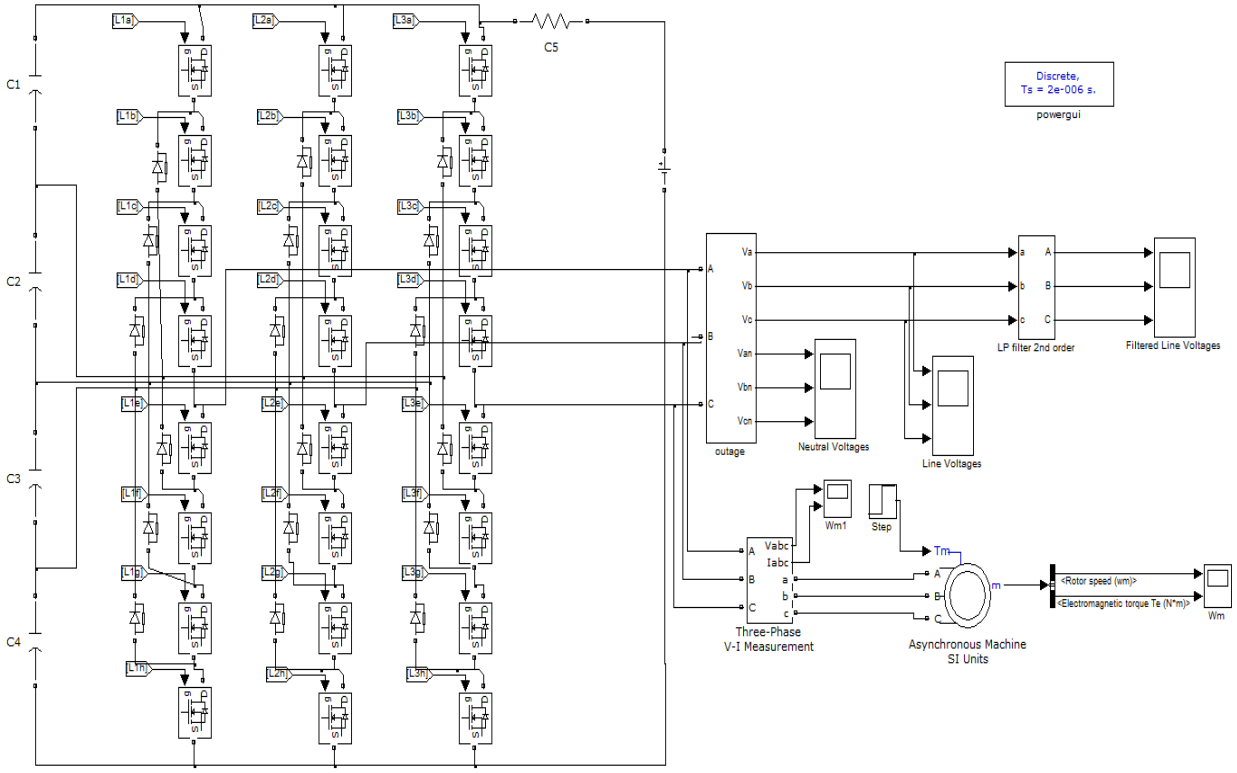

Fig.(3) 5 level Multilevel inverter with second order low pass filter.

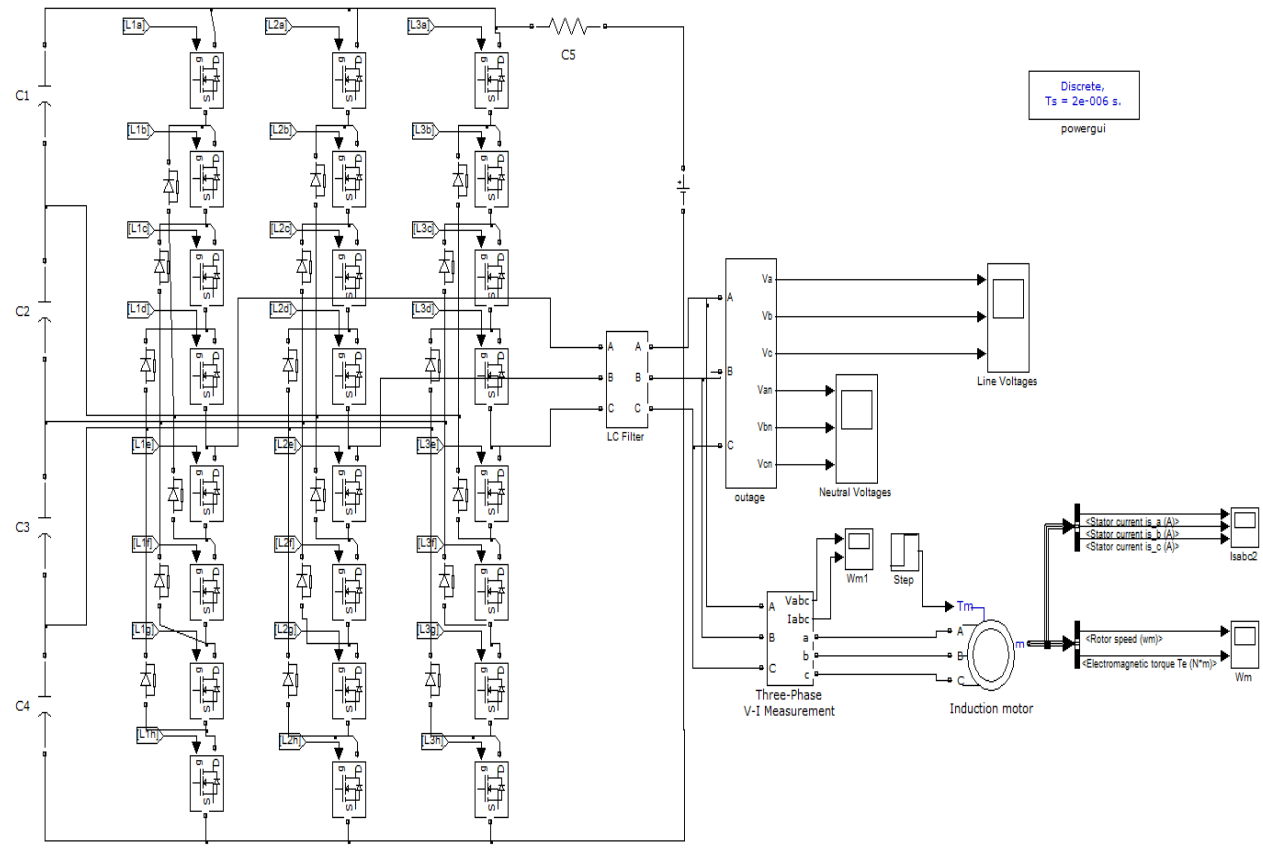

Fig.(4) 5 level Multilevel inverter with LC filter.

VII. RESULTS AND DISCUSSION (CASE STUDIES)

Case 1- FFT analysis of line voltage & THD without filter.

When 5 level 3 legs MLI has been used to control drive without filter, its THD is very high as shown below.

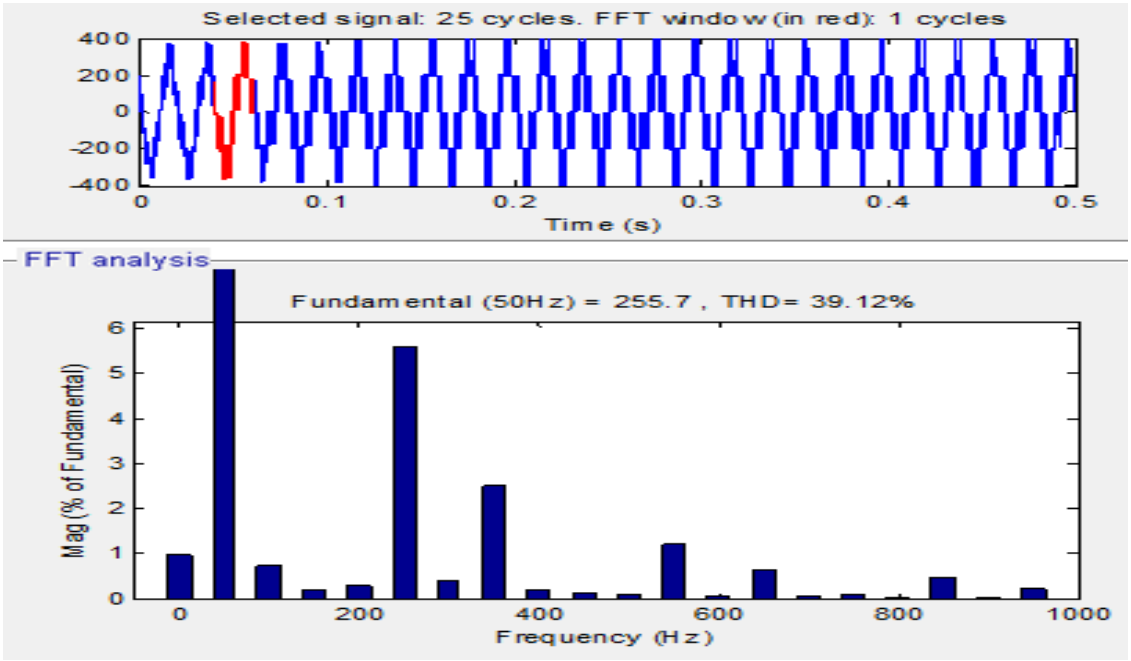

Fig.(5) FFT analysis of line voltage & THD without filter.

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

Case 2-FFT analysis of line voltage & THD for 5 level MLI with second order LPF.

When 5 level 3 legs MLI has been used to control drive with second order low pass filter & damping factor=0.707,its THD is decrease as shown below.

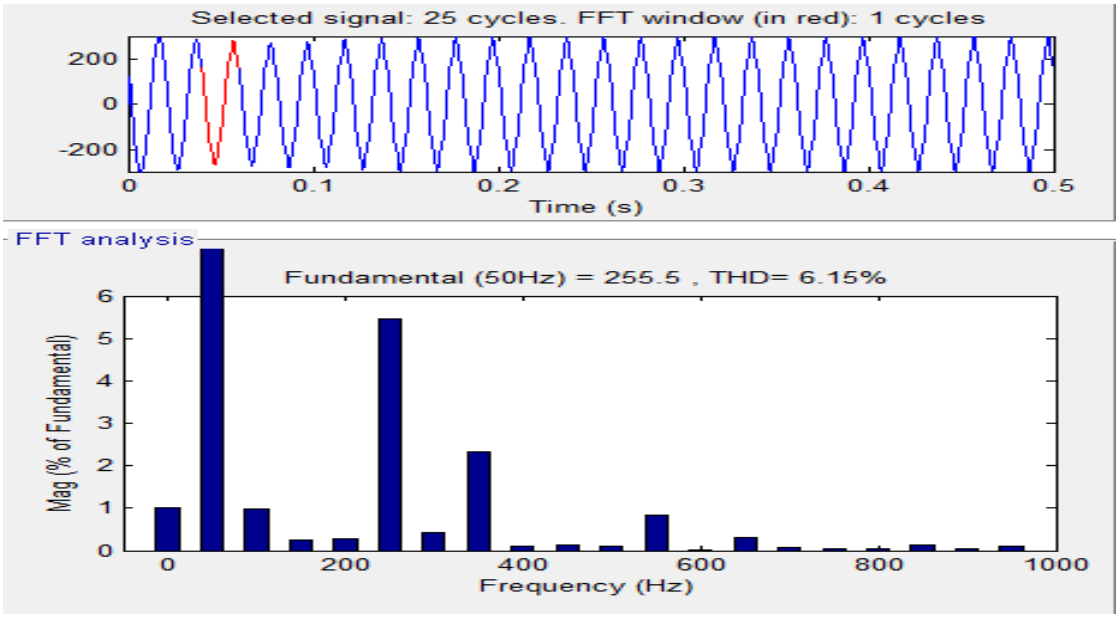

Fig. (6) FFT analysis of line voltage & THD with Second order LPF & damping factor=0.707

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.

For damping factor=0.85,gradually THD of line voltage is decrease & efficiency is also improved as shown below.

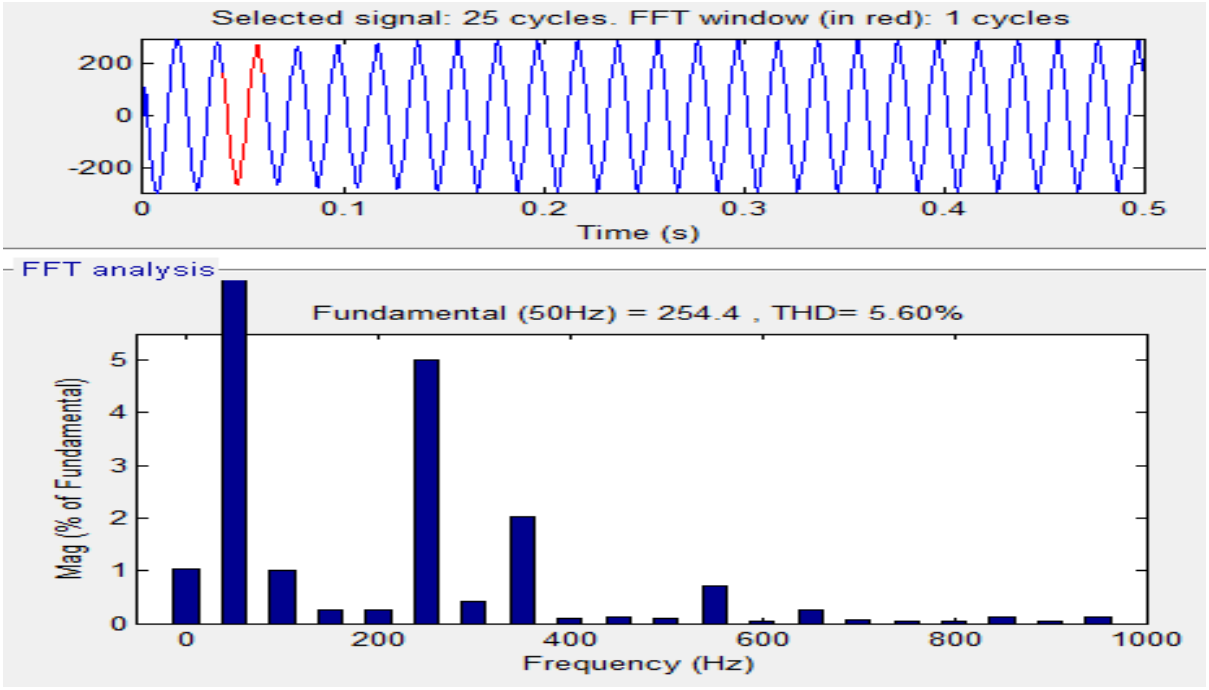

Fig.(7) FFT analysis of line voltage & THD with Second order LPF & damping factor=0.85.

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 with second order low pass filter for damping factor=0.707.

Case 3- FFT analysis of line voltage & THD with LC filter.

When 5 level 3 legs MLI has been used to control drive with LC filter its THD is decrease & less than THD without filter but more than THD with second order LPF as shown below.

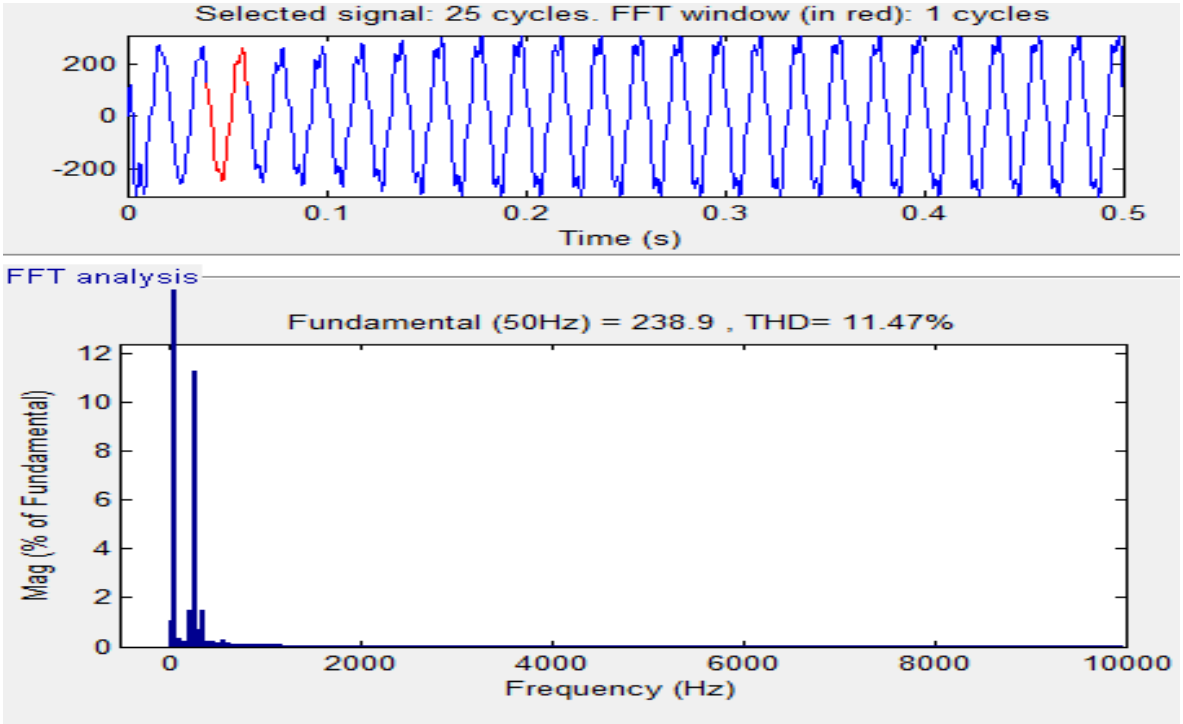

Fig.(8.)FFT analysis of line voltage & THD with LC filter.

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.	THD of line voltage without filter in 5 level multi level inverter.	THD of line voltage with LC filter in 5 level MLI.	Damping factor	THD of line voltage with Second Order Low Pass Filter in 5 level MLI.
1	39.12%	11.47%	ζ (zeta)=0.1	9.82 %
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 %

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.

Case 4- Settling time of rotor speed & torque with LC filter.

When 5 level MLI with LC filter has been used to control rotor speed & torque of Asynchronous motor its settling time is shown below.

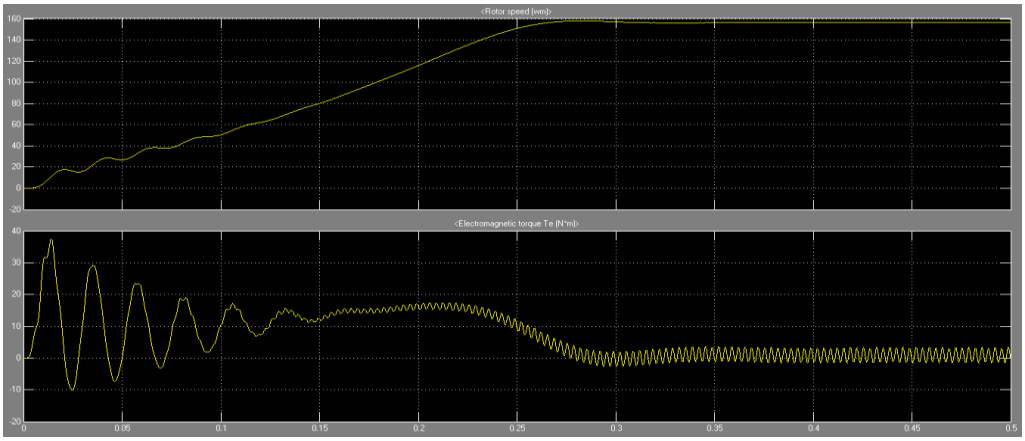

Fig.(9)Settling time of rotor speed & torque of Asynchronous motor using LC filter.

From the Fig.(9) it is seen that the settling time of rotor speed & torque of Asynchronous motor is approx 0.3 using 5 level MLI with LC filter.

Case 5- Settling time of rotor speed & torque without LC filter.

When 5 level MLI has been used to control rotor speed & torque of Asynchronous motor without LC filter, its settling time is shown below.

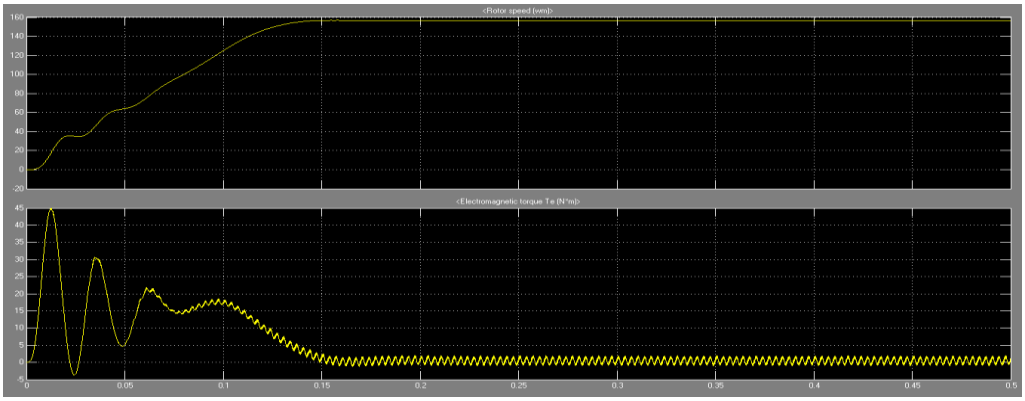

Fig.(10) Settling time of rotor speed & torque of Asynchronous motor without LC filter.

From the Fig (10) it is seen that the settling time of rotor speed & torque of Asynchronous motor is 0.15.

Table (4) Comparison Between Settling time of Rotor Speed & Torque of Asynchronous Motor.

S.No.	Settling time of rotor speed & torque of Asynchronous motor using 5 level inverter with LC filter.	Settling time of rotor speed & torque of Asynchronous motor using 5 level inverter without LC filter.
1	0.3(approx)	0.15

From the Table (4) it is seen that Settling time of rotor speed & torque of Asynchronous motor using 5 level inverter without LC filter is 0.15 is less compare to Settling time of rotor speed & torque using 5 level inverter with LC filter that is 0.3.

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

VIII. CONCLUSION

In this paper,5-level 3 legs MLI using neutral point clamped topology has been presented. The sinusoidal PWM control method is used for reducing THD. The high quality AC output & low THD is produced. The simulation results shows that as the value of damping factor increases the efficiency of the system is also increases. From the Table (3) it is seen that the THD using Second Order Low Pass Filter is gives the best result. Settling time of Rotor speed & Torque of Asynchronous motor is less without LC filter.

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