ISSN 2250-3153

Cascade H-bridge multilevel inverter at different Modulation index

Akanksha Dubey*, Dr.Ajay kumar Bansal**

*Poornima college of engineering
**Professor, Poornima College of Engineering

Abstract- An Alternative to conventional converter is a multilevel inverter. The objective is to reduce the harmonics generated by the converter while not increasing the switching losses in the power semiconductor devices. The purpose of multilevel inverter is to generate stair case sinusoidal pulse using DC Source. The Multilevel inverter suitable for high voltage and high power applications. Multilevel inverters are used for industrial drive directly, the THD contents in output voltage of inverters is very significant index as the performance of drive depends very much on the quality of voltage applied to drive. This paper Presents comparison on cascade H-bridge multilevel inverter at different modulation index. THD analysis is carried out using MATLAB simulation.

I. Introduction

Power electronics involves the study of electronic circuits intended to control the flow of electrical energy. These circuits handle power flow at levels much higher than the individual device ratings[4].

Power electronic have very broad area it has many converter like AC to DC and DC to AC. In conversion of DC to AC Multilevel inverter is replacing conventional Inverter because of it high power applications with good potential for further development. The most attractive feature of this inverter is in the medium-to-high-voltage range, motor drives, power distribution, and power conditioning applications. In present power sector is growing very fast, industry are demanding power in the megawatt level. It is not possible for convention inverter as the semiconductor devices must be connected in series to obtain the required high-voltage operation. This can be only possible when outputs of several conventional inverters are added with transformers or inductors, or direct series connection, or by more complex topologies [1]. For these reasons, a new family of multilevel inverters has emerged as the solution for working with higher voltage levels.

Ac loads may require constant or adjustable voltage at their input terminals. When such load fed by inverter, it is essential that output voltage of the inverter is so controlled as to fulfill the requirement of Ac load [2].

Multilevel inverter is replacing conventional inverter and step-up transformer because of its upgrading features like increment in output voltage and power does not require an increase in rating of individual device .The concept of multilevel inverter has been purposed on 1975.The purpose of multilevel inverter to generate desired multi-staircase single or three phase voltage by combining several DC voltage sources. Solar cells, fuel cells, batteries and ultra-capacitors are the most common independent sources used. One important application of multilevel converters is focused on medium and high-power [3]. In multilevel inverter the term level is referred to as the number of node to which the inverter can be accessible [2].

In this output voltage can be defined as voltage Across output terminal of the inverter and the ground point and input node voltage and Current is referred to input terminal of the inverter with reference to ground. The structural switches, be capable of withstanding very high input voltage for high power application and lower switching frequency for each switching device.

II. Multilevel Inverter PWM Modulation Strategies

A Modulation scheme can be used to create the variable frequency, variable voltage ac waveforms. The sinusoidal PWM compares a high frequency triangular carrier with three sinusoidal reference signal knows as modulating signals to generate the gating signals for inverter switches. The requirements of multilevel modulation technique are as follows.

1 .Voltage quality should be good

2. Modular design Simultaneous switching of multiple voltage levels is not allowed.

3. Switching frequency of power devices should be minimized.

4. Power modules should share the load equally.

5. Control algorithm should be simple.

6. Implementation cost should be low.

When it comes to a multilevel inverter modulation , there are basically categorized into two groups:

1. Modulation with fundamental switching frequency
2. High switching frequency PWM [4].

There are two different methods For fundamental switching modulation one is Space vector control and anther one is Selective Harmonic Elimination. High frequency switching also categorized in three different method of modulation ,Sinusoidal pulse width modulation , Space vector pulse width modulation, Selective Harmonic pulse width modulation .In both cases a stepped output waveform is achieved, but with the high switching frequency methods the steppes are modulated with some sort of PWM. Independent of switching frequency choice there are, however, Sinusoidal pulse width modulation to choose from it, and modulation index for any scheme is ratio of Amplitude of reference wave to carrier wave.

$$MI=\frac{vr}{vc}$$

2.1.1 PWM for multilevel inverters

Multilevel PWM methods uses high switching frequency carrier waves in comparison to the reference waves to generate a sinusoidal output wave, much like in the two-level PWM case. To reduce harmonic distortions in the output signal phase-shifting techniques are used [4]. There are several methods that change disposition of or shift multiple triangular carrier waves. The number of carrier waves used is dependent to the number of switches to be controlled in the inverter.

2.1.2 Carrier based disposition PWM method

The natural sampling techniques for a multilevel inverter are categorized into two [6] and they are:

1. Single-Carrier (SCSPWM)
2. Multi carrier PWM (MC-PWM)

Sinusoidal PWM is an exclusive control strategy for multilevel inverters and has further classifications. They are

1. Carrier Disposition PWM methods
i. Phase Disposition (PD)
ii. Alternative Phase Opposition Disposition (APOD)
iii. Phase Opposition Disposition (POD)

2. Inverted Sine Wave PWM Method

Carrier based disposition PWM methods were first proposed by Carrara et al[7]For an *n*-level inverter, *n*-1 carriers with the same frequency fc and the same amplitude Ac are disposed such that the bands they occupy are contiguous. The reference waveform has maximum amplitude Am, a frequency fm, and its zero centered in the middle of the carrier set. The reference is continuously compared with each of the carrier signals. If the reference is greater than a carrier signal, then the IGBT corresponding to that carrier is switched on and if the reference is less than a carrier signal, then the IGBT corresponding to that carrier is switched off [9].

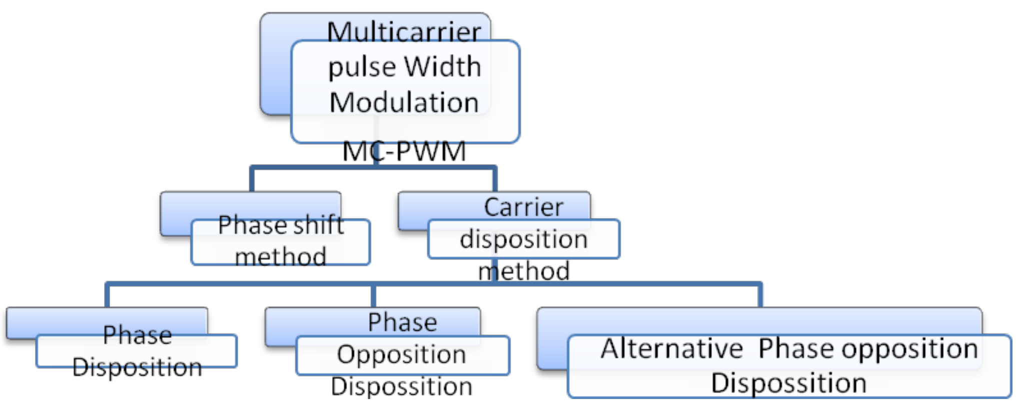


Fig 1.1 classification of Multi carrier pulse width Modulation

2.1.3Phase Disposition Modulation Method (PDPWM)

If all carriers are in same phase, then this method is known as Phase Disposition (PD) method. It is generally accepted that this method gives rise to the lowest harmonic distortion in higher modulation indices when compared to other disposition methods. This method is also well applicable to cascade inverters. 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 4.1. This method uses N – 1 carrier signals to generate N level inverter output voltage [2]. All the carrier signals have the same amplitude, same frequency and are in phase . In this method fourteen triangular carrier wave have compared with the one sinusoidal reference wave.

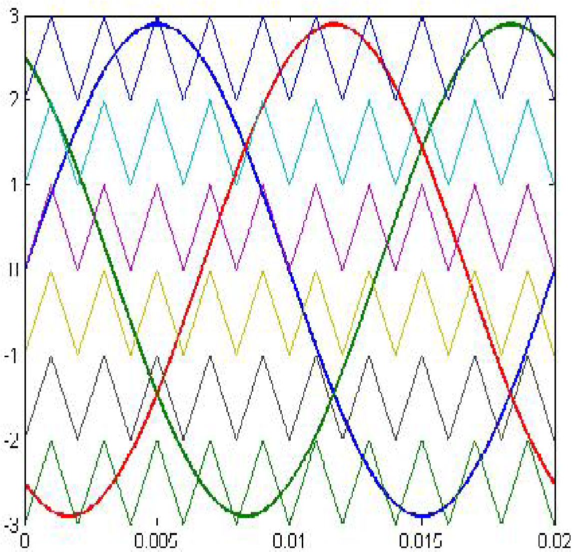


Fig 1.2Phase disposition pattern

2.1.4 Phase Opposition Disposition PWM (PODPWM)

In The Phase Opposition Disposition (POD) method, the carriers wave above the zero line of reference voltage out of phase with those of below this line by 180 degrees as shown in Fig. 4.2 is one another of the carriers' disposition group. Compared to the PD method, this method has better results from the viewpoint of harmonic performances in lower modulation indices. In POD method, there is no harmonic at the carrier frequency and its multiples and the dispersion of harmonics occurs around them.

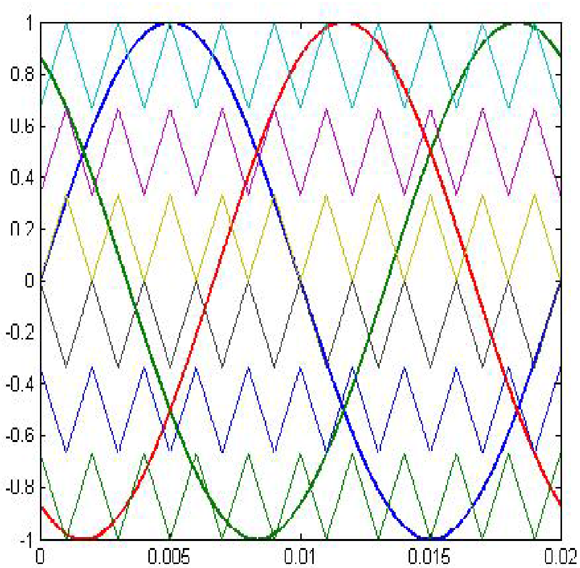


Fig 1.3 phase opposition disposition

2.1.5 Alternate Phase Opposition Disposition:

The third member of the carriers' disposition group is known as Alternative Phase Opposition Disposition (APOD) method. Each carrier of this method is phase shifted by 180 degrees from its adjacent one. It should be noted that POD and APOD methods are exactly the same for a 3-level Inverter. This method gives almost the same results as the POD method. The major differences are the larger amount of third order harmonics which is not important because of their cancellation in line voltages. Thus, this method results in a better THD for line voltages when comparing to the POD method. The carrier waveforms of this method are illustrated in Fig4.3

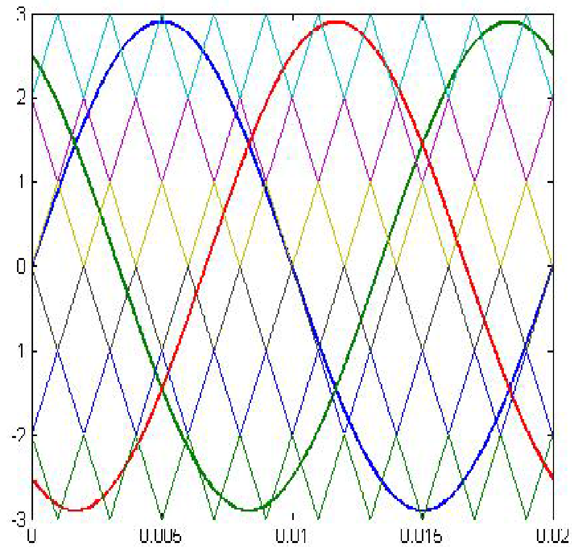


Fig 1.4 Alternate Phase Opposition Disposition

2.1.3 Inverted Sine Wave:

The inverted sine carrier PWM (ISPWM) method uses the conventional sinusoidal reference signal and an inverted sine carrier. The control strategy uses the same reference synchronized sinusoidal signal) as the conventional SPWM while the carrier triangle is a modified one. The control scheme uses an inverted (high frequency) sine carrier that helps to maximize the output voltage for a given modulation . For an 'n' level inverter, (n-1) carrier waves are required. when the amplitude of the modulating signal is greater than that of the carrier signal. The proposed control strategy has a better spectral quality and a higher fundamental output voltage without any pulse dropping. Fig4.4

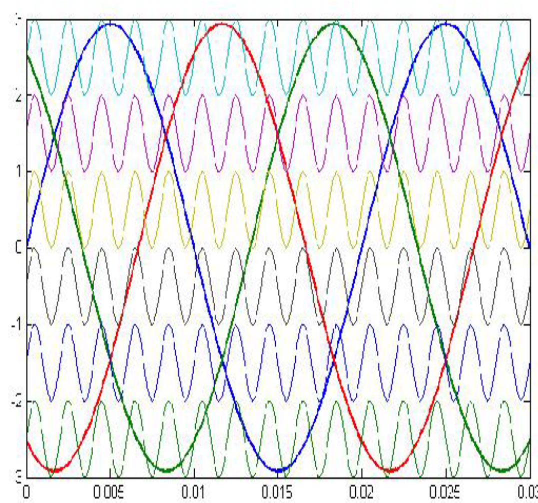
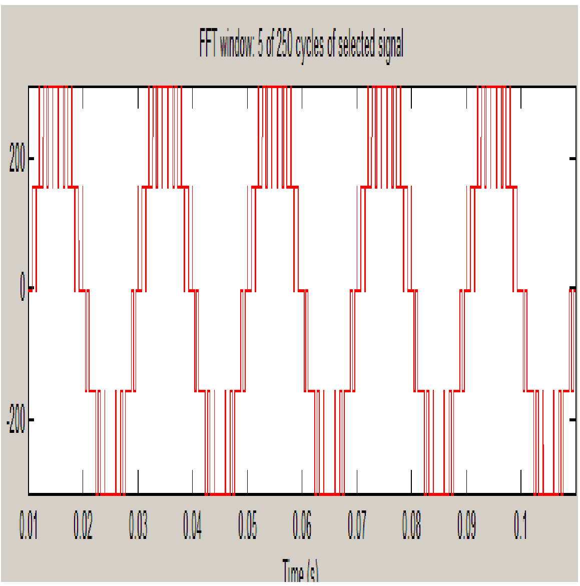


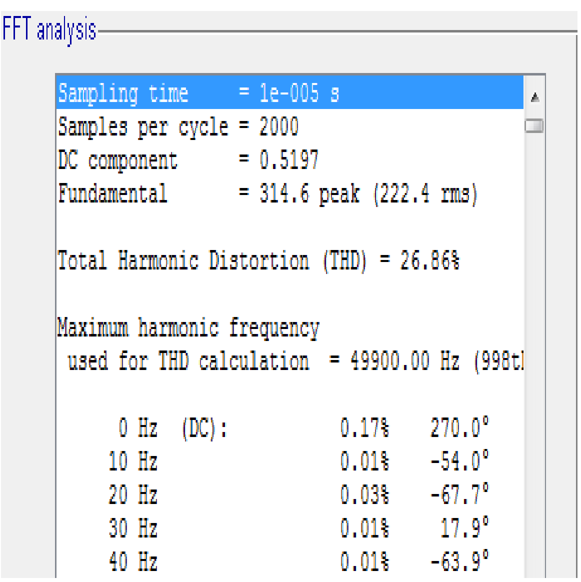
Fig1.5 inverted sine wave

III. FFT ANALYSIS FIVE LEVEL CASCADED H-BRIDGE

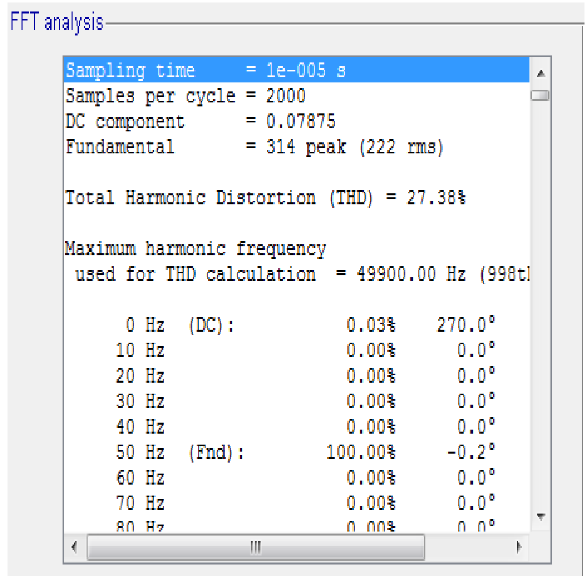
THD Analysis is done with help of FFT using Matlab tool/version 2010. Performance of five level cascaded H-bridge inverter at no load is analyzed on various carrier disposition modulation PD,POD, APOD . The FFT analysis is done for five cycle for maximum frequency of 5000 Hz and cycle started from 0.01second.The purpose behind FFT analysis to find out the total harmonic distortion at different carrier disposition techniques.

3.1.1 FFT Analysis for Phase Disposition Modulation at 0.25 modulation Index

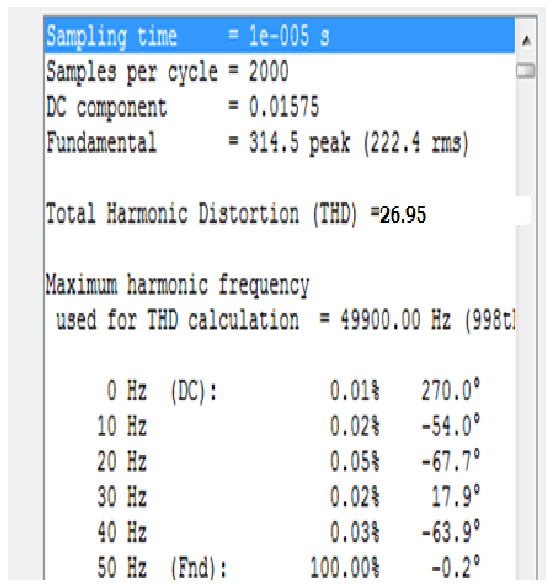




3.1.2FFT Analysis for Phase Opposition Disposition Modulation at 0.25 modulation Index



3.1.3 FFT Analysis for Alternative Phase Opposition Disposition Modulation at 0.25

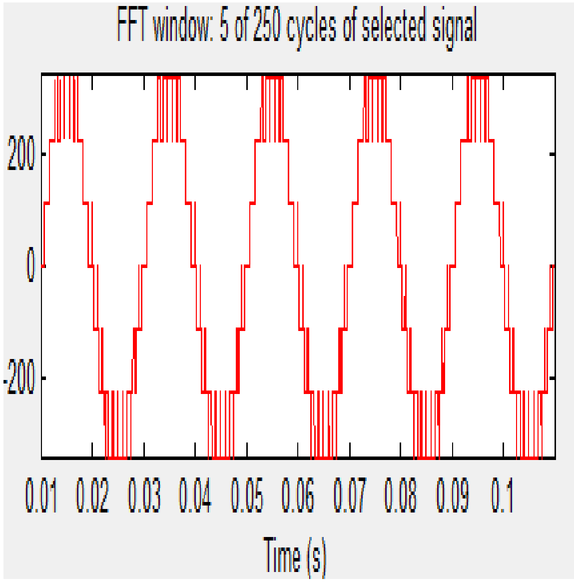


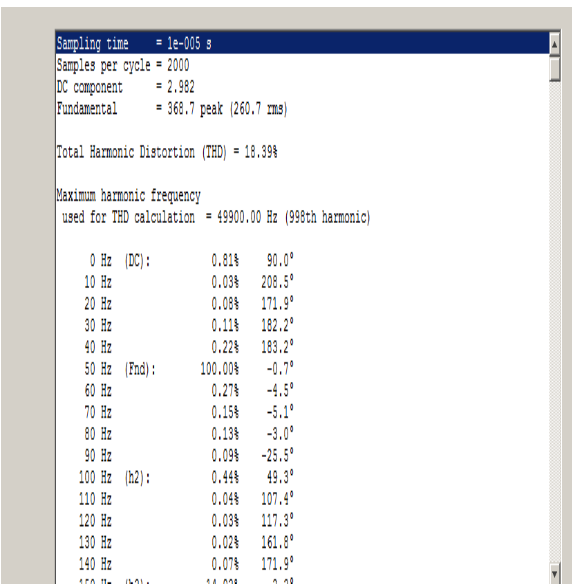
IV. FFT ANALYSIS FIVE LEVEL CASCADED H-BRIDGE

THD Analysis is done with help of FFT using Matlab tool/version 2010. Performance of Seven level cascaded H-bridge inverter at no load is analyzed on various carrier disposition modulation PD,POD, APOD. The FFT analysis is done for five cycle for maximum frequency of 5000 Hz and cycle started from 0.01second.The purpose behind FFT analysis to find out the total harmonic distortion at different carrier disposition techniques.

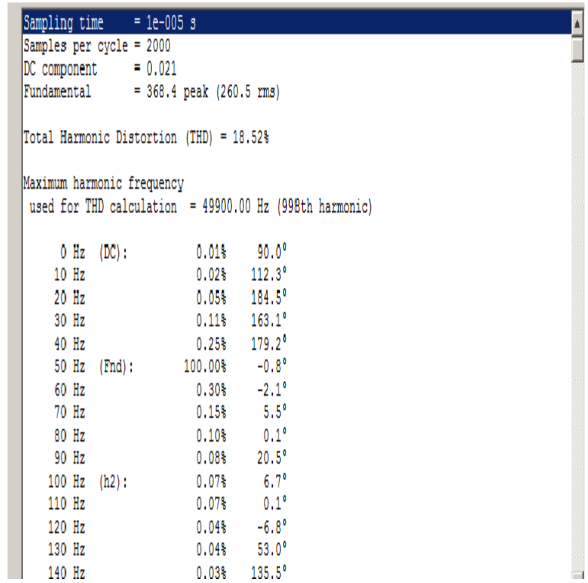
ISSN 2250-3153

4.1.1 Phase Disposition Modulation at 0.25 modulation Index

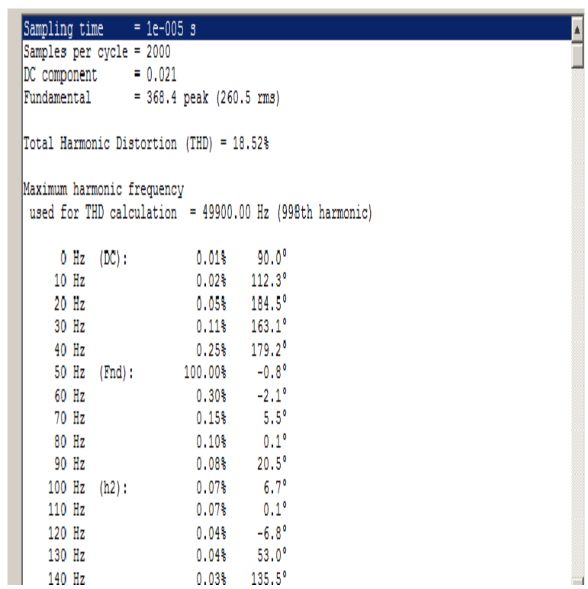




4.1.2 Opposition Disposition Modulation at 0.25 modulation Index



4.1.3 Alternative Phase Disposition Modulation at 0.25 modulation Index



V. Comparative Analysis Result for THD

In the comparative analysis comparison of five level and seven cascaded H-bridge is done at different modulation index and also carrier disposition method. For finding out which carrier disposition method more appropriate for lower THD.

Modulation Index	No of Level	PD	POD	APOD
0.2	Five Level	38.03	39.02	38.09
	Seven Level	14.97	15.65	15.65
0.25	Five	26.86	27.38	26.95

	Level			
	Seven Level	18.39	18.52	18.52

Table no 5.3 Comparative analysis of five level and seven level THD at different carrier disposition method and different modulation index

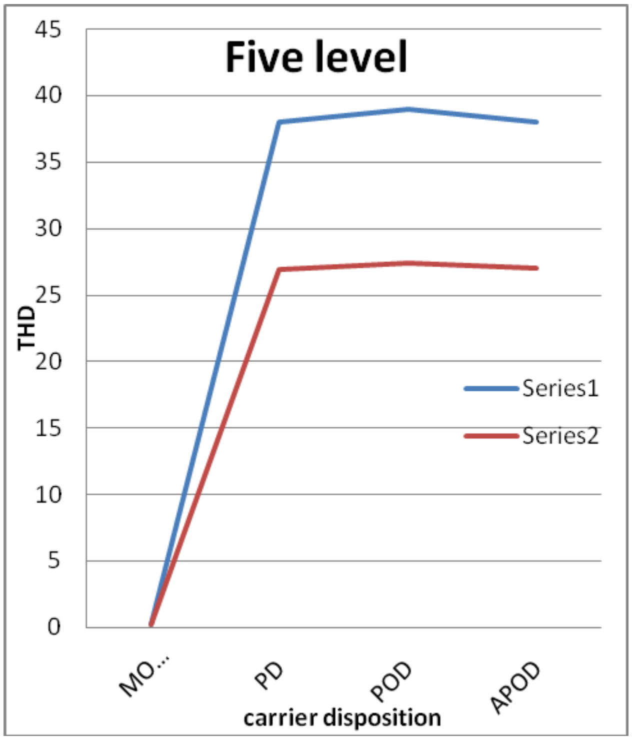


Fig no1.6Graphical representations of five levels THD at 0.2 and 0.25 modulation Index

Graph no 5.1 Relate the table no 5.3, this graph show the THD of five level inverter at different modulation index. This graph clearly represent on increasing the modulation index THD is decreases in five level cascaded.

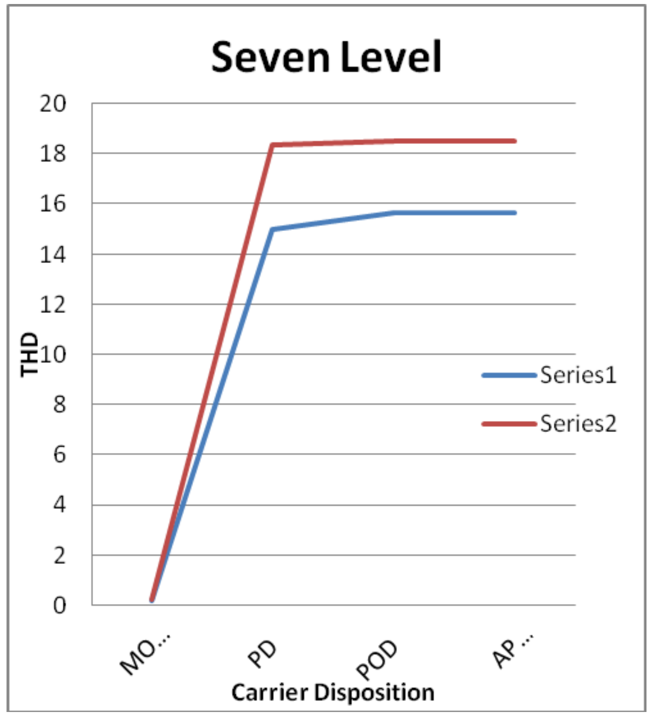


Fig no 1.7 Graphical representations of seven levels THD at 0.2 and 0.25 modulation Index

Graph no 5.2 Relate the table no 5.3, this graph show the THD of seven level inverter at different modulation index. This graph clearly represent on increasing the modulation index THD is increasing in seven level cascaded. Hence it can be concluded modulation index have assorted effect on THD.

VI. Conclusion

In this paper analysis of five level and seven level cascaded H-bridge is done at modulation index 0.2 and 0.25 modulation index. It has been observed that on decreasing the modulation index five level cascaded H-bridge inverter THD decreases and in seven level on decreasing the modulation index THD increasing. So it can be concluded that modulation index have assorted effect on THD.

VII. Future Scope

In future scope real time implementation of cascaded H-bridge inverter can be done according to analyze effect of modulation index for finding less THD.

References

[1] M.D Sing,K.B Khan chandani,power electronics TATA MC GRAW HILL Publication New Delhi Edition pp535-537,Eleventh print 2011.

[2] Dr M H. Rashid" Power Electronic circuit, device and application.

[3] J. Rodriguez, L. G. Franquelo, S. Kouro, J. I. Leon, R. C. Portillo, M. A. M. Prats, M. A. Perez, Multilevel inverters: an enabling technology for high power applications, Proc. IEEE 97(11), 2009, 1786–1817 .

[4] T.A. Meynard, H. Foch, "Multi-level Conversion: High Voltage Choppers and Voltage-source Inverters," Proceedings of the IEEE Power Electronics Specialist Conference, pages 397-403, 1992.

[5] Anshuman Shukla e thesis al 2008.

[6] McGrath, B.P.; Holmes, D.G.; , "A comparison of multicarrier PWM strategies for cascaded and neutral point clamped multilevel inverters," Power Electronics Specialists Conference, 2000. PESC 00. 2000 IEEE 31st Annual , vol.2, no., pp.674- 679 vol.2, 2000 doi: 10.1109/PESC.2000.879898]

[7] Cascaded H-Bridge Multilevel Inverter Using Inverted Sine Wave PWM Technique International Journal of Emerging Trends in Electrical and Electronics (IJETEE – ISSN: 2320-9569) Vol. 6, Issue. 1, Aug-2013]

[8] G. Carrara, S. Gardella, M. Marchesoni,R. Salutari, G. Sciutto, “A New MultilevelPWM Method: A Theoretical Analysis,” IEEETransactions on Power Electronics, vol. 7, no. 3,July 1992, pp. 497-505

[9] Multilevel Inverters: A Survey of Topologies, Controls, and Applications José Rodríguez, Senior Member, IEEE, Jih-Sheng Lai, Senior Member, IEEE, and Fang Zheng Peng, Senior Member, IEEE Transactions on Industrial Electronics, vol. 49, no. 4, August 2002

AUTHORS

First Author – Akanksha Dubey, Poornima college of engineering, a.eksha@gmail.com
Second Author – Dr.Ajay kumar Bansal, Professor, Poornima College of Engineering, ajaykumarbansal@poornima.org