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Diminution of Harmonics in a Cascaded Multilevel Inverter using Third Harmonics Injection PWM Technique

S.Satish Kumar, M.Sasi Kumar

Abstract*: This paper is deals the Asymmetric cascaded three phase hybrid multilevel inverter for ac motor application. This proposed hybrid three phase inverter is used to diminishes the no of semiconductor device requirement and enhances the power distribution of each H-bridge cell. The Third Harmonics Injection (THIPWM) with sinusoidal pulse width modulation (SPWM) are used to regulate the output voltage of the inverter, further incorporate the Phase disposition (PD) and Alternative Phase Opposition disposition PWM (APOD) techniques. This control technique is applied to minimize the current harmonic and get the better recital of the system. The circuit is simulated using Mat-lab Simu-link. The circuit performance such as THD, line voltage and phase voltage are compared using two hybrid modulation techniques and verified with simulation results.

Keywords: Multi level inverter, Third harmonic injection, Harmonic, Hybrid inverter and Induction motor.

I. INTRODUCTION

Low voltage to high voltage conversion happens with help of Power electronics converters. These converters are used to develop efficient power supply due to advancement of semiconducting device. Many industries are required more efficient and low cost power supply for running the applications. This work is focused for reduction of harmonic and cost.

The Multi level inverters are used mainly to improve the power quality. [1-2]. Cascade multi level inverter is superior compare than other multi level inverter techniques such as diode clamped and capacitor clamped [3].Cascade multi level inverter is also further classified into symmetrical and asymmetrical type. The symmetrical topologies has equal and separate voltage source for each H-bridge [4]. Asymmetrical topology has unequal and separate voltage source and less no of dc source and H-bridge compare than symmetrical method [5-6]. The combination of two other inverter topologies is called as Hybrid topology. Hybrid topology was proposed further reduced the components count and harmonic [7]. Many modulation techniques are developed for control the inverter and reduced the harmonic [8-10]. Sinusoidal Pulse width modulation (SPWM) and Third harmonic injection Pulse width modulation (THIPWM) technique are applied for reduced the harmonic in five level inverter. The proposed hybrid MLI is used to improve the power distribution and power handling capacity. This inverter is controlled by using Sinusoidal Pulse width modulation (SPWM) and third harmonic injection Pulse width modulation (THIPWM) reference with comparison of Phase disposition (PD) and an Alternative phase opposite disposition carrier PWM signals (APOD). The circuit operation and simulation results will be discussed in the following section.

II. CIRCUIT DESCRIPTION

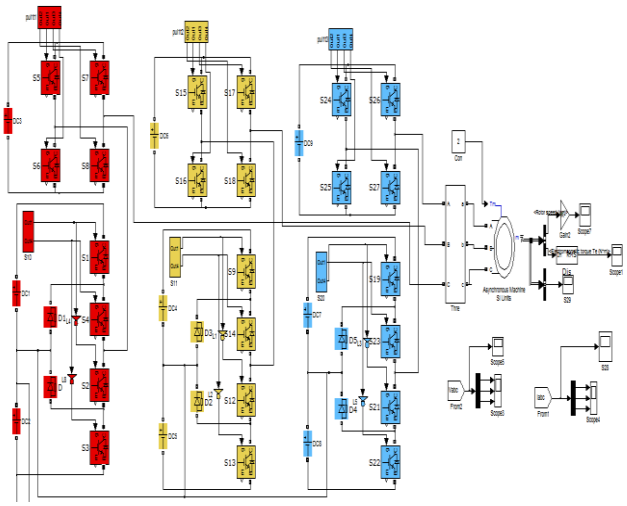

Fig 1.Proposed 3ph inverter circuit diagram

The proposed three phase asymmetrical neutral point diode clamped three level inverter with integrated h-bridge inverter fed induction motor circuit diagram is as shown in fig1. This proposed circuit has asymmetrical input source, three level and H-bridge combination and motor load. This inverter switches are controlled by multi carrier PWM technique. The table shows the switching sequence as shown in table-1 for single leg. Similarly other two legs switches are triggered with 120 degree Phase shift from each phase. Table 1 shows the fundamental switching frequency. In this method the output voltage level is produced based on the level of output voltage required. For generating +3VDC switch S1, S4, S5 and S8 are turned –ON. Similarly other voltage levels are also achieved.

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Table 1. switching sequence of HMLI topology

Level	S1	S2	S3	S4	S5	S6	S7	S8
-3V	0	1	1	0	0	1	1	0
-2V	0	1	0	1	0	1	1	0
-1V	0	1	1	0	1	0	1	0
0V	0	1	0	1	1	0	1	0
1V	1	0	0	1	1	0	1	0
2V	0	1	0	1	1	0	0	1
3V	1	0	0	1	1	0	0	1

III. CONTROL TECHNIQUE

The proposed hybrid inverter output is controlled using SPWM and THIPWM method. Sinusoidal reference signal is compared with phase disposition and alternative phase disposition carrier signal. This pulse pattern is known as SPWM. This pulse generation technique is as shown in fig 2a &2b. This method gives better voltage control and reduction of THD.

Third harmonic injection reference signal is compared with phase disposition and anti phase opposite disposition carrier signal. This pulse pattern is known as THIPWM. This pulse generation technique is as shown in fig 3a &3b. This technique is used to reduce the third and fifth order harmonic. This method gives better voltage control and reduction of lower order harmonic.

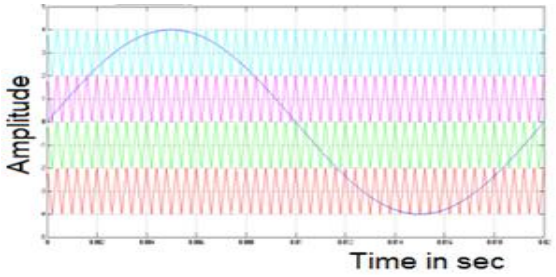


Fig 2a Hybrid PD PWM control Technique SPWM method

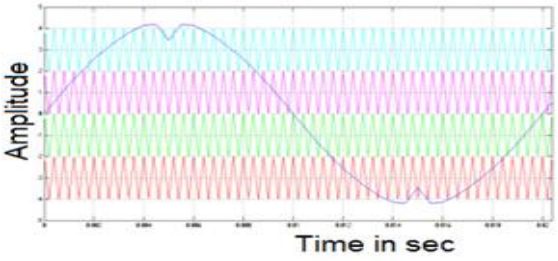


Fig 2 b Hybrid PD PWM control Technique THIPWM method

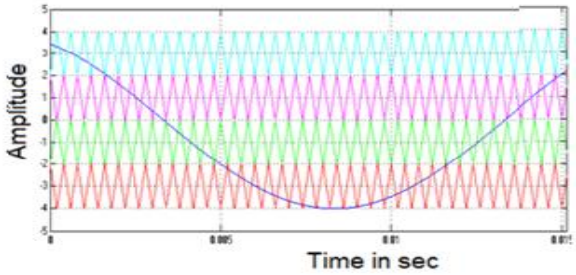


Fig 3a Hybrid APOD PWM control Technique SPWM method

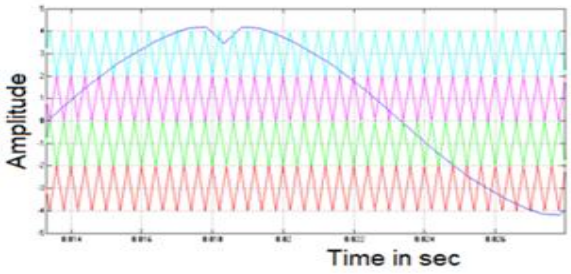


Fig 3b Hybrid APOD PWM control Technique THIPWM method

IV.SIMULATION RESULTS:

The Fig 1 shows the simu-link circuit for the proposed inverter. This inverter voltage is controlled by multi carrier PWM technique. The output voltage is controlled by using Sinusoidal PWM (SPWM) and Third harmonic injection PWM (THIPWM) reference signal with comparison of Phase disposition (PD) and alternative phase opposite disposition carrier PWM signals (APOD). The Fig 4a &4b shows the inverter phase voltage for PD and APOD method using SPWM. The Fig 5a & 5b shows the inverter phase voltage for PD and APOD method using THIPWM. The output voltage has seven levels so it is called as seven level multi-level inverter. Fig 6a & 6b shows the current output for PD and APOD technique using SPWM. Fig 7a &7b shows the current output for PD and APOD method using THIPWM. The current output has almost sinusoidal waveform as a result this current output has less current harmonic.

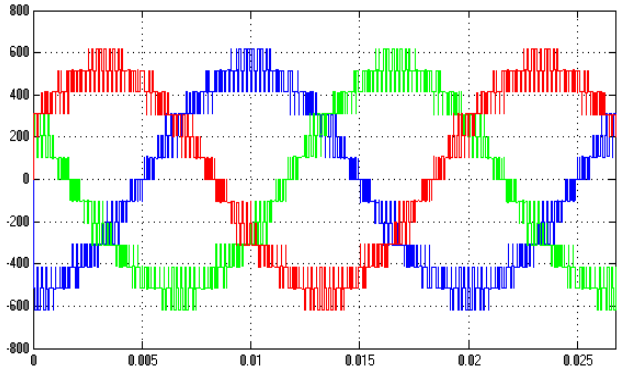


Fig 4a) Inverter phase output voltage for PD method (SPWM)

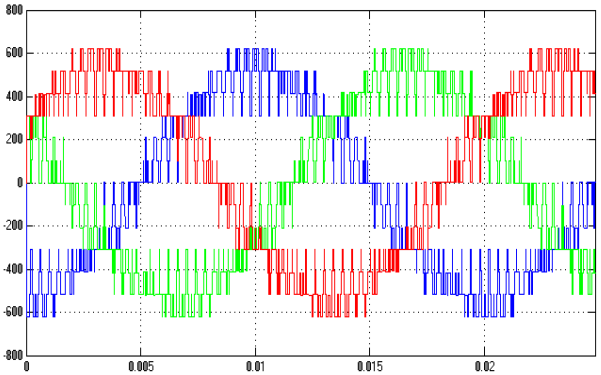


Fig 4b) Inverter phase output voltage for APOD method (SPWM)

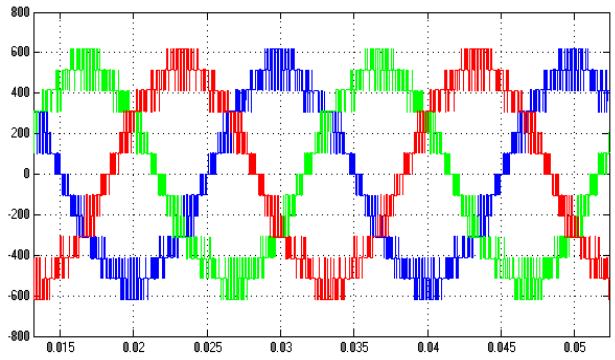


Fig 5a) Inverter phase output voltage for PD method (THIPWM)

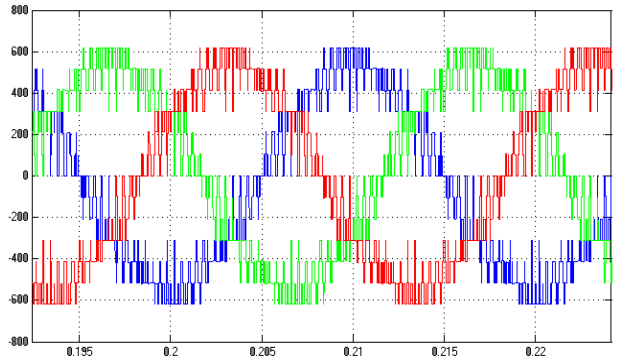


Fig 5b) Inverter phase output voltage for APOD method (THIPWM)

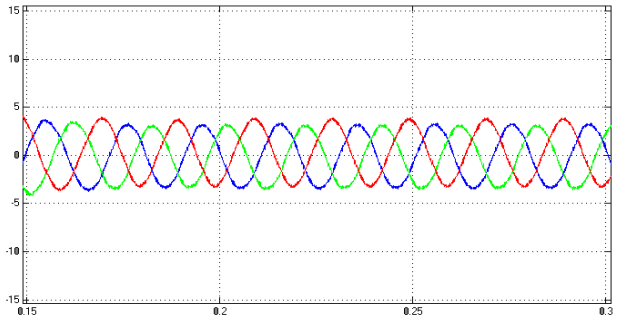


Fig 6a) Current output PD method (SPWM)

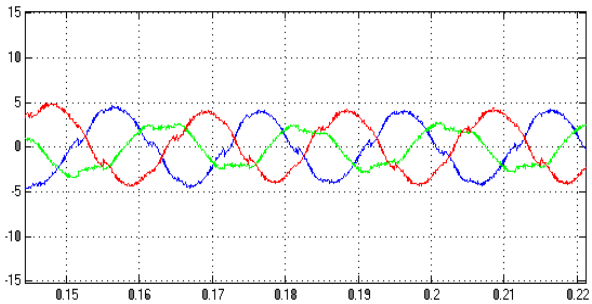
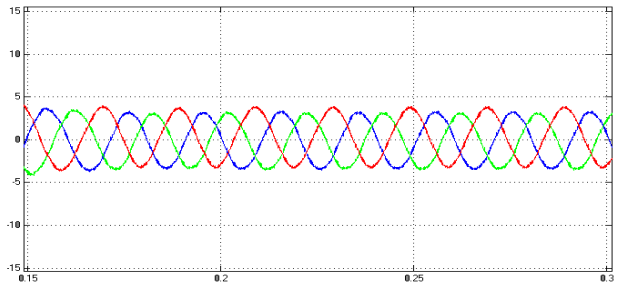


Fig 6b) Current output APOD method (SPWM)



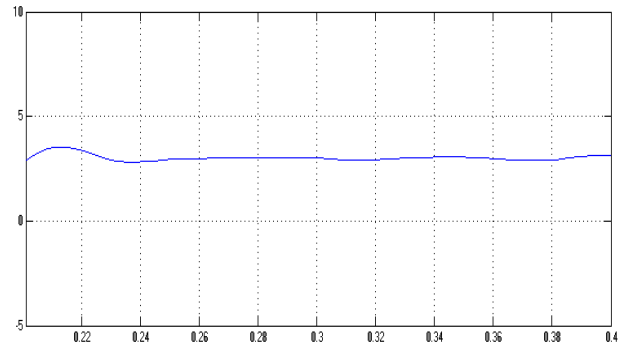


Fig 7a) Current output PD method (THIPWM)

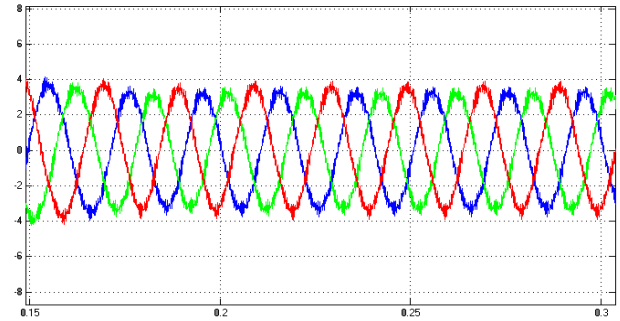


Fig 7b) Current output APOD method (THIPWM)

The Rotor speed as shows in Fig 8a &8b.the torque of the machine as shown in Fig 9a &9b.PD and APOD method

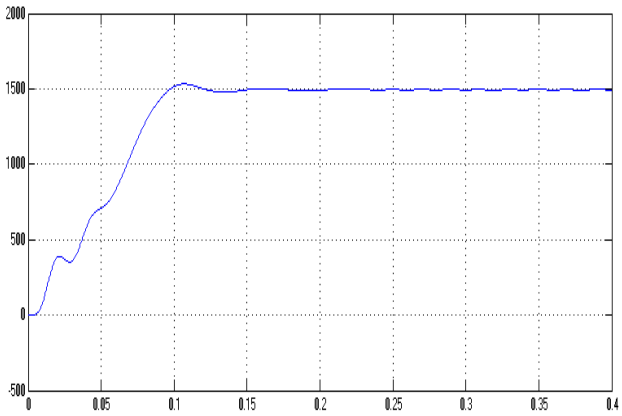


Fig 8a) Rotor Speed in PD method

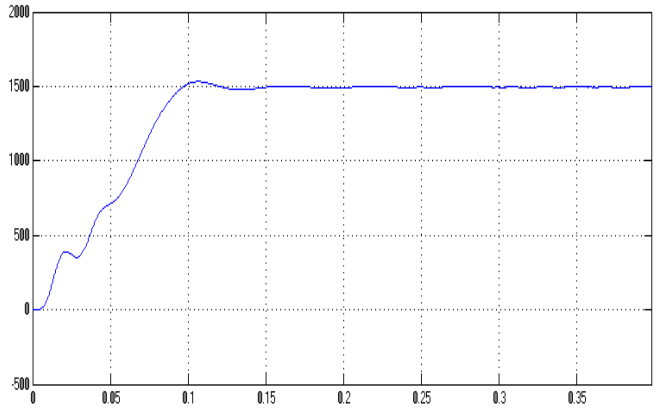


Fig 8b) Rotor speed in APOD method

Fig 9a) Torque in N-M PD method

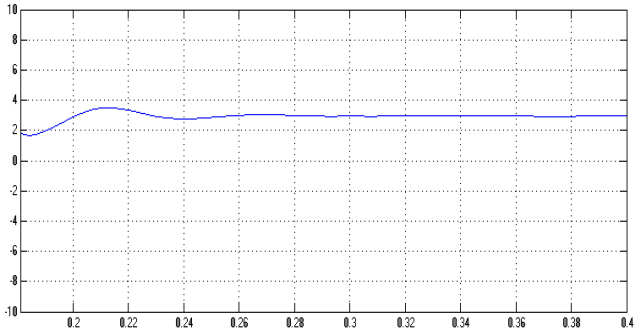


Fig 9 b) Torque in APOD methods

The FFT analysis of 3 phases inverter as shown in Fig 10a &10b for SPWM method. The output current FFT analysis foe THIPWM method as shown in fie 11 a &11b.

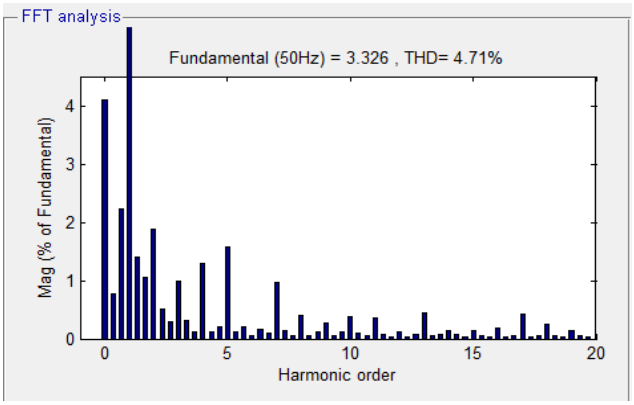


Fig 10a) FFT Analysis for current output (m=1) PD method (SPWM)

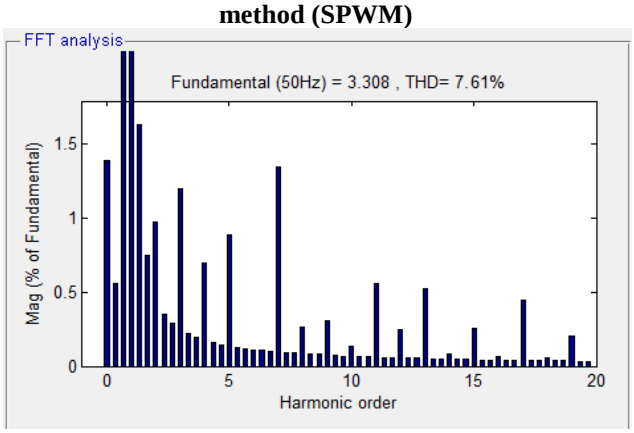


Fig 10b) FFT Analysis for current output (m=1) APOD method (SPWM)

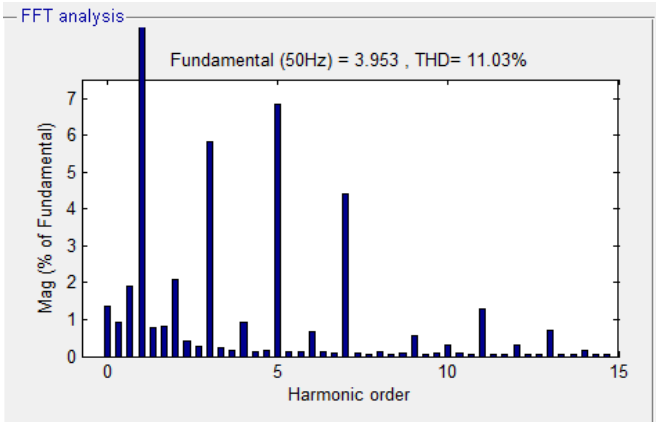


Fig 11a) FFT Analysis for current output (m=1) PD method (THIPWM)

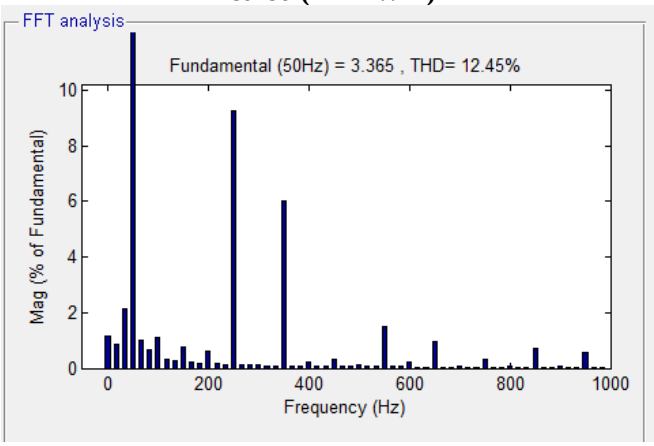


Fig 11b) FFT Analysis for current output (m=1) APOD method (THIPWM)

V. COMPARATIVE ANALYSIS

The output voltage is controlled by using Sinusoidal Pulse Width Modulation (SPWM) and Third harmonic injection PWM (THIPWM) reference with comparison of Phase disposition (PD) and anti phase opposite disposition carrier PWM signals. Both PDPWM and APODPWM methods are used to determine the inverter performance such as THD, line voltage and speed. PD method has less harmonic of 4.71% compare than APOD technique harmonic of 12.29% it is shown from Table 2 and Fig 12 and fig 13. Inverter output voltage has more distortion in APOD PWM method compare than PDPWM method. SPWM has less harmonic of 4.71% compare than THIPWM technique. It is shown from fig 24,

Table 2: The Modulation Index vs % of THD

m	% of THD in PD technique (SPWM)	% of THD in PD technique (THIPWM)	% of THD in APOD technique (SPWM)	% of THD in APOD technique (THIPWM)
0.7	5.32	12.29	8.77	13.87
0.8	5.05	11.65	9.59	13.78
0.9	4.96	11.38	9.06	13.59

1.0	4.71	11.03	7.61	12.45

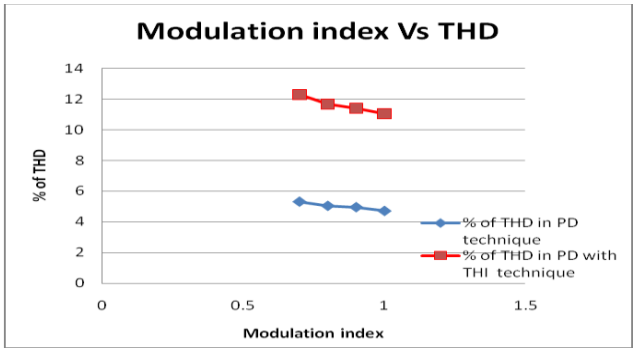


Fig 12 Graph between modulation index and Total Harmonic Distortion (SPWM)

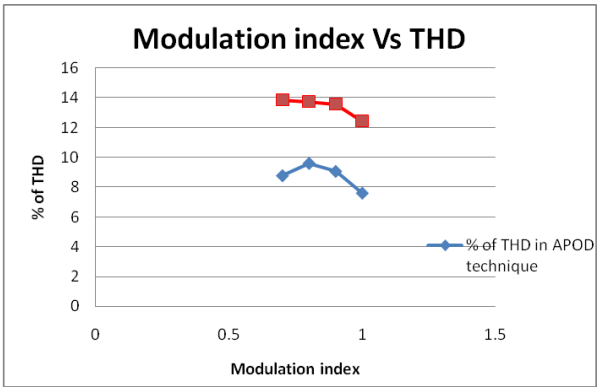


Fig 13 Graph between modulation index and Total Harmonic Distortion (THIPWM)

VI. CONCLUSION

The asymmetric cascade three phase multilevel inverter based power supply was proposed for ac motor application. This circuit is simulated using PDPWM and APODPWM method for compare the system performance. PD method has less current harmonic of 4.71% compare than APOD technique current harmonic of 1.79% by modulation index 1. Inverter output voltage has more distortion in APODPWM method compare than PDPWM method. PD-SPWM method gives better performance compare than APOD THIPWM method. It is proved from simulation results. This proposed hybrid multilevel inverter has less components count compare than other multilevel inverter topology.

REFERENCES

1. Pharne I.D. and Bhosale Y.N., "A Review on Multilevel Inverter Topology," IEEE Conference on Power,Control and Embedded Systems, pp.700-703, Feb 2013.
2. Jos Rodrguez, Jih-Sheng Lai, "Multilevel Inverters: A Survey of Topologies, Controls, and Applications", IEEE Transactions on Industrial Electronics, vol. 49., no.4, pp.2703-2712, August 2002.
3. J. Rodriguez, S. Bernet, B. Wu, J. O. Pontt, and S. Kouro, "Multilevel voltage-source-converter topologies for industrial medium-voltage drives," IEEE Trans. Ind. Electron., vol. 54, no. 6, pp. 2930–2945, Dec. 2007.
4. M.Malinowski, K. Gopakumar, J. Rodr´ıguez, andM. A. Perez, "A survey on cascaded multilevel inverters," IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2197–2206, Jul. 2010.
5. S. M. Dehnavi, M. Mohamadian, A. Yazdian, and F. Ashrafzadeh, Space vectors modulation for nine-switch converters IEEE Trans. Power Electron., vol. 25, no. 6, pp. 1488 1496, June 2010.
6. S. Mariéthoz and A. Rufer, "Design and Control of Asymmetrical Multi- Level Inverters", in Proceedings of the IEEE Industrial Electronics Society Conference (IECON 2002), 2002.
7. P. Steimer and M. Manjrekar, "Practical Medium Voltage Converter Topologies for High Power Applications", in Proceedings of the IEEE Industry Applications Society Annual Meeting (IAS), Vol. 3, 2001, pp. 1723–1730.
8. B. P. McGrath and D. G. Holmes, "Multicarrier PWM strategies for multilevel inverters," IEEE Trans. Ind. Electron., vol. 49, no. 4, pp. 858–867, Aug. 2002.
9. N Sujitha, S Satish Kumar, M Sasikumar (2014), " Design And Implementation Of Hybrid Spwm Control For Cascaded H-Bridge Multi Level Inverter For Motor Drives, "IU-Journal Of Electrical & Electronics Engineering, vol. 14, no.1, pp. 1721-1727. Impact Factor:- 0.14.
10. .Satish kumar and Dr M. Sasikumar "An Approach of Hybrid Modulation in Fusion seven-level Cascaded Multilevel Inverter accomplishment to IM drive system"2016 Second International Conference On Science Technology Engineering and Management(ICONSTEM) 978-1-5090-1706-5, 2016 IEEE pp 384-387

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