Performance of a Novel Multi Level Inverter based on Modulation Techniques

K. Aravinda Shilpa, K. RamaSudha

Abstract*: *The aim of the paper is to introduce a symmetrical multilevel inverter (MLI) with a basic module. This novel MLI have a group of components containing H-bridge which results in reduced device count thereby lowering the losses in the devices when related with other regular and recent MLI. Various control methods are employed to the novel inverter and a comparative study is made. FFT analysis is used and harmonic spectrum is analyzed. The evaluation and functioning of the novel inverter is verified through simulation using MATLAB/Simulink software.

Index Terms: Cascaded Multilevel inverter, Sinusoidal pulse width modulation, Total harmonic distortion. Trapezoidal pulse width modulation

I. INTRODUCTION

Now a day, present industries are increasing the power level to megawatt usually for high applications in power and voltage. So, it is compulsory to have numerous semiconductor switches that can be linked to the grid of average voltages. In addition, it will improve power quality if we are using high-level power and average voltage devices. Standard inverter of two level voltage source cannot be used for the applications of high power. The name multilevel inverter (MLI) is initiated with the three-level inverter by Nabae et al (1981). In general the types of MLI are;flying capacitor (FC), cascaded H-bridge (CHB) and neutral point clamped (NPC). Many researchers are more interested in CHB MLI since it has many advantages when related with others types of MLI. Usually CHB inverters are not new in developed area because of easy switching pattern on the other hand harmonic distortion and losses in the power electronics devices are more. To get a more precise waveform with smallest amount of losses, the level number ought to be more with lesser switch count.There are many different arrangements on basis of the fundamental rule of CHB MLI which has been seen in the literature. S. Inoue and H. Akagi used a high rated transformer-based unit to get CHB MLI [1] without the necessity of separate dc links. M.Glinkaand R.Marquardt, developed the modular multilevel converter (MMC) [2], where many modules of dc/dc which are floating are series connected to attain single-phase or three-phase output voltage. P. E. Melin, J. R. Espinoza [3] recently developed a CHB MLI on basis of single-phase current source inverters This arrangement has two voltage-sources but uses an inductor as a dc link. The inductors of the three output phases are magnetically joined, lowering the lower order harmonics that come out on the link of dc. Thus, the ripple in the input current and in the dc inductor is reduced in a high rate. Berrezzek. F & Berrezzek. F [4] studied on the many methods for controlling PWM. D. Carrara et al [5] evaluated three PWM schemes with distinct horizontal and perpendicular arrangement which has finally increased output harmonics. M.Calasis et al [6] spoke about PWM method with many carriers for CHB MLI. Urmila and subbarayaudu [7] also discussed on the relative study on various PWM methods. Wu et al [8] proposed new PWM methods on bases of carriers for MLI based on the arrangement of control degree of freedom.

Therefore for any new topology of MLI must cope up with the points below

- It should have less power electronic devices to the extent possible.
- It should be able to withstand the input voltage which is high for high power applications.
- Losses in the MLI should be minimal.

In this paper a new symmetrical MLI with less component count for eleven level inverter been simulated through different PWM techniques. Comparative analysis was done for total harmonic distortion (THD) between sinusoidal pulse width modulation (SPWM) and trapezoidal pulse width modulation (TRPWM).

II. NOVEL TOPOLOGY

The generalized configuration of the novel CHB MLI is shown in Figure 1. It comprises of isolated dc sources and unidirectional switches with a fast recovery diode. Current passes through the diode when the power electronic devices are turn-off. The dc values are same for all units therefore it is called as symmetrical inverter. For any state utmost three switches should be turn on at any time.

In this novel MLI switches count required are (K_s) to obtain total voltage levels (M_l)

$$K_S=n+3 \quad (1)$$

$$M_l=2\,K_s-5 \quad (2)$$

Where n denotes the dc sources in total .The highest voltage obtained is

$$V_{max}= n\,V_{dc} \quad (3)$$

Revised Manuscript Received on 30 July 2019.
* Correspondence Author

K. Aravinda Shilpa*, Dept of electrical engineering, Andhra University/ Visakhapatnam, India.

Prof.K. RamaSudha, Dept of electrical engineering, Andhra University/ Visakhapatnam, India

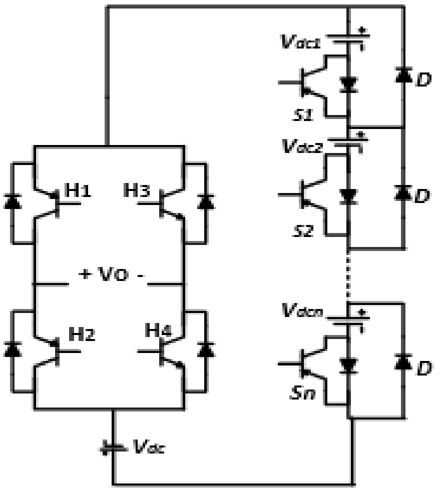

Figure 1: Generalized Topology

Table 1: Comparison of CHB MLI & Proposed MLI

	CHB MLI	Modified /Proposed CHBMLI
Total DC Sources	N	N
Total Switches	4n	**n+3**
Total output Levels	2n+3	2n+3

III. MODULATION SCHEMES

Here, SPWM and TRPWM techniques are employed. In SPWM, triangular signals are evaluated with sinusoidal altering signal. The control scheme for the semiconductor devices are determined by the meeting point of the carrier signal with the altering wave. For the novel inverter, one altering signal and ten carrier signals are required .The frequency of a sine wave should be same as that of the frequency of the preferred output voltage. The controlling frequency of carrier signal must be very much more than altering signal frequency .When two signals are modulated, it will produce pulses for the switching devices in the inverter .In TRPWM top most part of the triangular signal is flattened and it is referred as the modulating signal and the carrier signals are the triangular waveforms. The switching method is analogous to SPWM.

IV. ANALYSIS USING SPWD AND TRPWM

A. CASE I: SPWM-Phase Opposition Disposition (POD)

Figure 2 shows SPWM-POD,the frequency and amplitude for every carrier wave is constant and all carriers on top of zero level are equal within phase and under the zero level carriers also within phase but are 180 degree out of phase with respect to the top of zero level The altering signal having equal frequency as output waveform

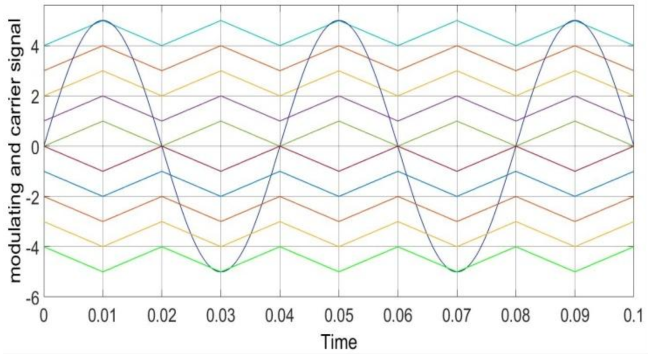

Figure 2: SPWM-POD Carrier Signal Arrangement

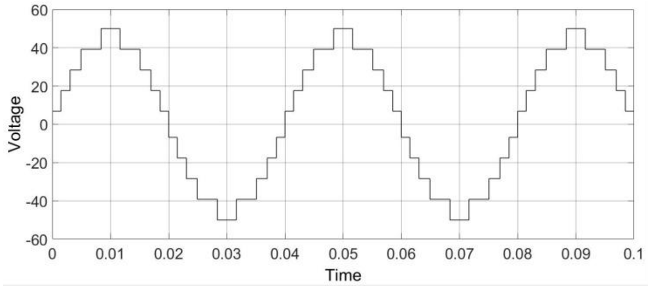

Figure 3: Output Waveform of SPWM-POD

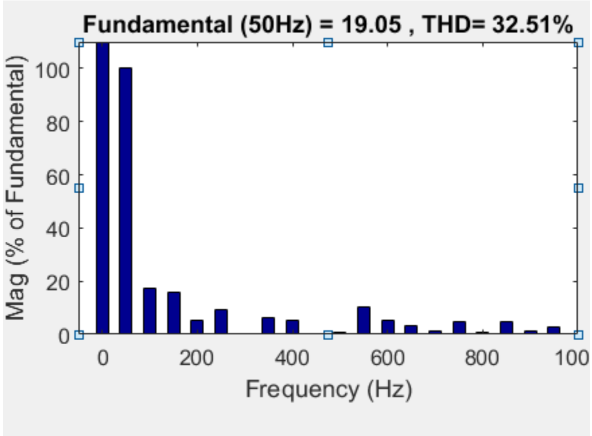

Figure 4: FFT Analysis of SPWM-POD

Figure 3 & 4 shows a staircase wave with eleven levels and in the FFT analysis the resultant THD value is 32.51% for SPWM-POD technique.

B. CASE II: SPWM-Alternate Phase Opposition Disposition (APOD)

Figure 5 shows SPWM-APOD, every carrier wave is shifted by 180° alternately. All the carriers have fixed frequency and amplitude.

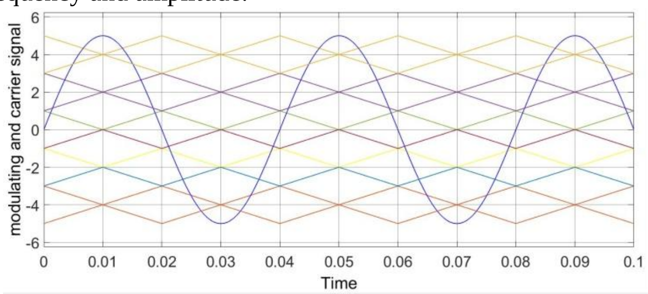

Figure 5: SPWM-APOD Carrier Signal Arrangement

Retrieval Number: A2198058119/19©BEIESP
DOI: 10.35940/ijrte.A2198.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

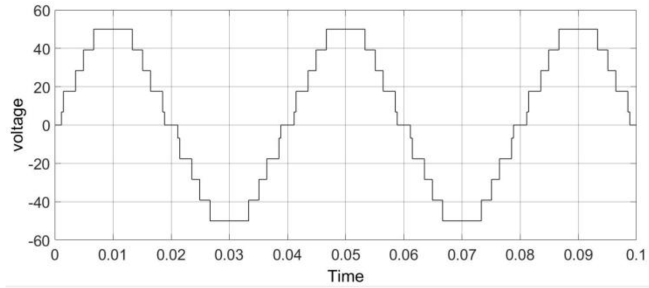

Figure 6: Output Waveform of SPWM-APOD

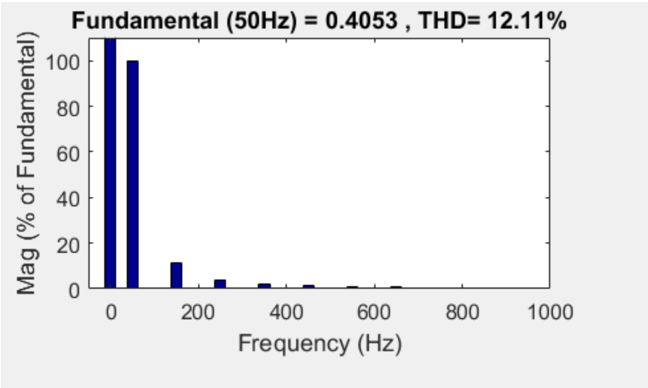

Figure 7: FFT Analysis of SPWM-APOD

C. Figure 6 & 7 shows a staircase wave with eleven levels and in the FFT analysis the resultant THD value is 12.11% for SPWM-APOD technique

D. CASE III: SPWM-Phase Disposition (PD)

Figure 8 shows,SPWM-PD each and every carrier is in phase with unchanged frequency and amplitude, however every carrier on top and bottom of zero level are same in phase.

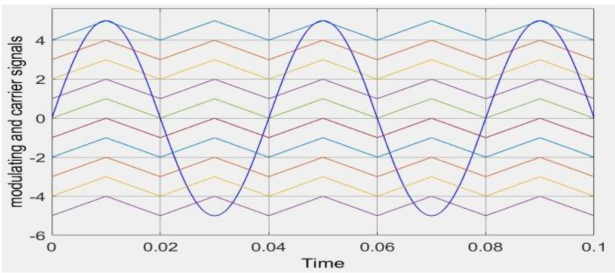

Figure 8: SPWM-PD Carrier Signal Arrangement

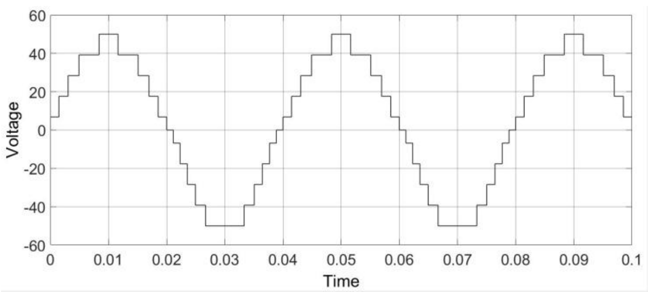

Figure 9: Output Waveform of SPWM-PD

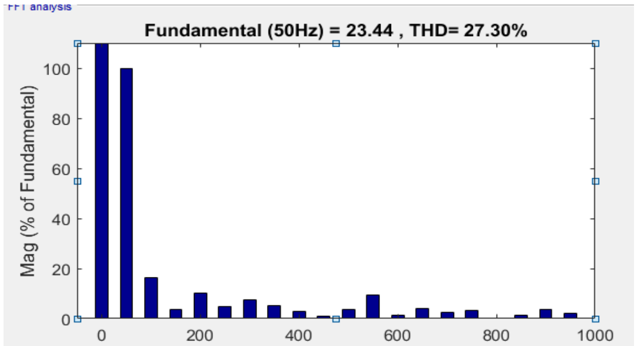

Figure 10: FFT Analysis of SPWM-PD

Figure 9 & 10 shows a staircase wave with eleven levels and in the FFT analysis the resultant THD value is 27.30% for SPWM-PD technique.

E. CASE IV: TRPWM-Phase Opposition Disposition (POD)

Figure 11 shows, TRPWM-POD, the altering signal is a trapezoidal wave and the carriers are similar to SPWM-POD

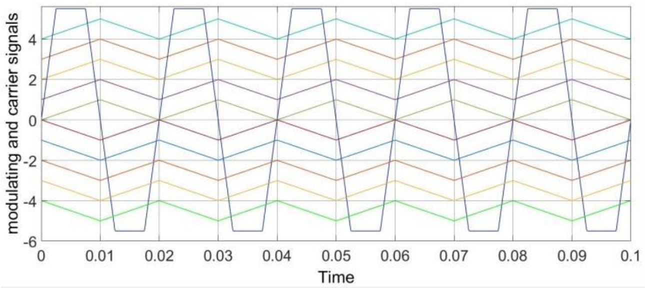

Figure 11: TRPWM-POD Carrier Signal Arrangement

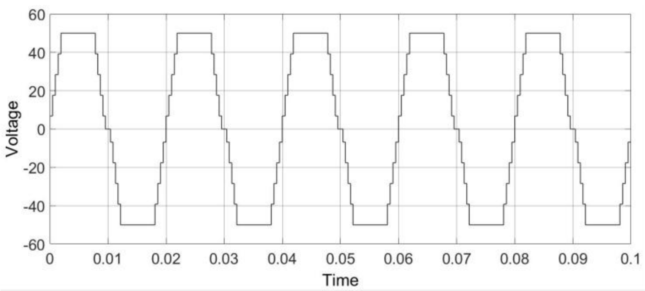

Figure 12: Output Waveform of TRPWM-POD

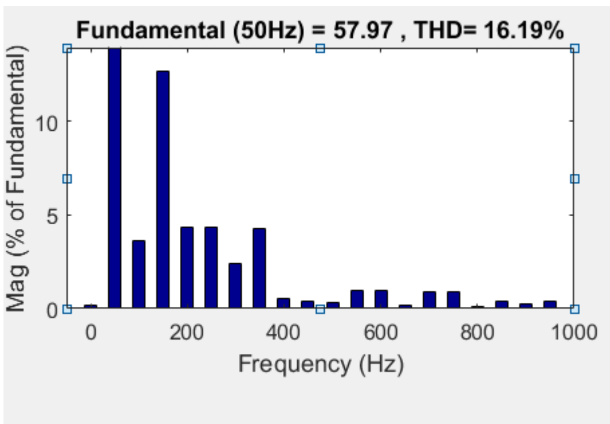

Figure 13: FFT Analysis of TRPWM-POD

Figure 12 & 13 shows a staircase wave with eleven levels and in the FFT analysis the resultant THD value is 16.19% for TRPWM-POD technique.

F. CASE V: TRPWM-Alternate Phase Opposition Disposition (APOD)

In TRPWM-APOD technique shown in Figure 14 the altering signal is a trapezoidal wave and the carriers are similar to SPWM-APOD.

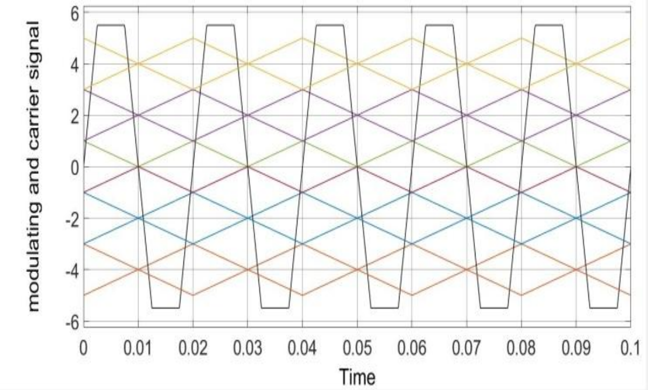

Figure 14: TRPWM-APOD Carrier Signal Arrangement

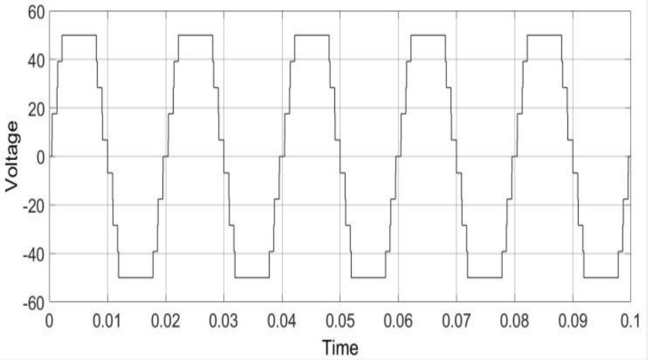

Figure 15: Output Waveform of TRPWM-APOD

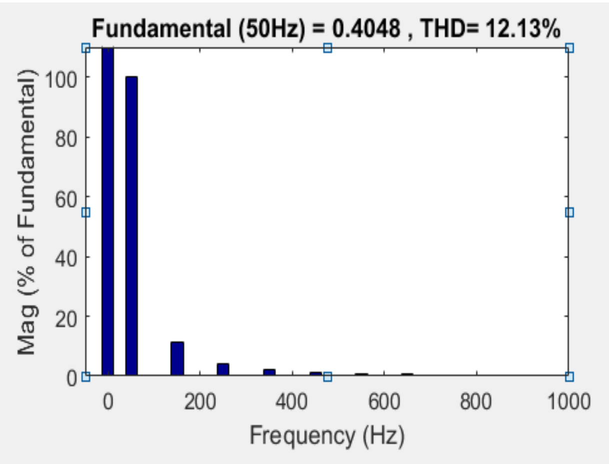

Figure 16: FFT Analysis of TRPWM-APOD

Figure 15 & 16 shows a staircase wave with eleven levels and
in the FFT analysis the resultant THD value is 12.13% for TRPWM-APOD technique..

G. CASE VI: TRPWM-Phase Disposition (PD)

Figure17shows,TRPWM-PD technique the altering signal is a trapezoidal wave and the carriers are similar to SPWM-PD

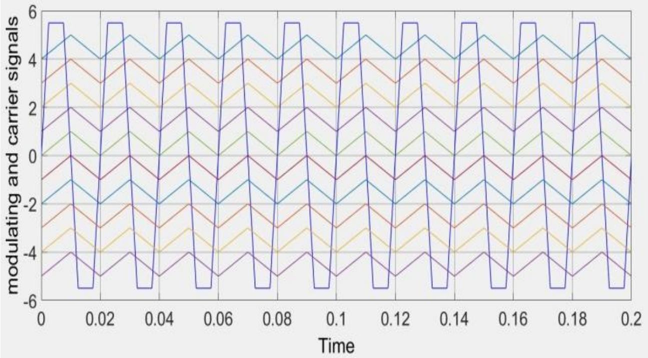

Figure 17: TRPWM-PD Carrier Signal Arrangement

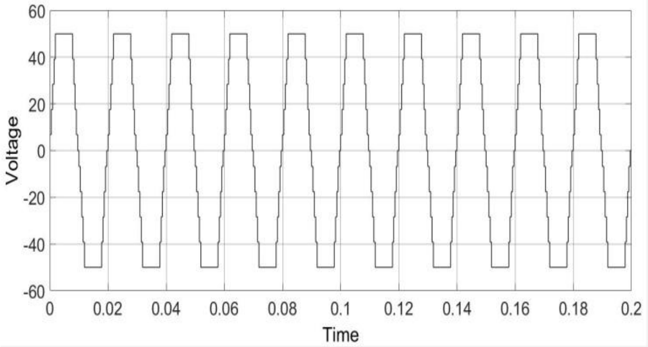

Figure 18: Output Waveform of TRPWM-PD

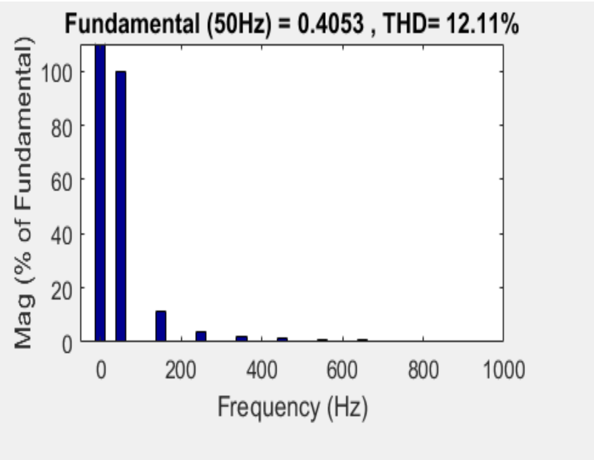

Figure 19: FFT Analysis of TRPWM-PD

Figure 18 & 19 shows a staircase wave with eleven levels and in the FFT analysis the resultant THD value is 12.11% for TRPWM-PD technique.
Comparison of THD is presented in Figure 20.

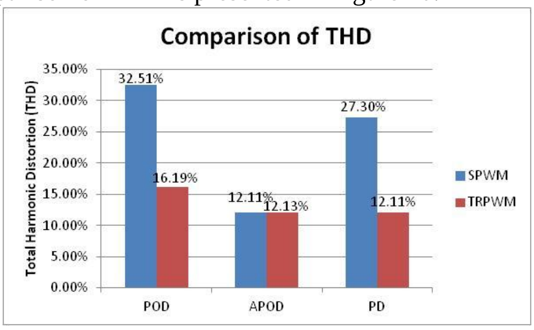

Figure 20: Comparison of THD

V. CONCLUSION

Thus, a novel MLI with reduced component count is proposed and its performance is analyzed with SPWM and TRPWM. The graph, clearly show that TRPWM-APOD control scheme which has THD 12.11% is the best control technique.TRPWM is better than SPWM control method as the peak of the signal is flattened by which use of dc link increases.

REFERENCES

1. S. Inoue and H. Akagi, "A bidirectional isolated DC–DC converter as a core circuit of the next-generation medium-voltage power conversion system," IEEE Trans. Power Electron., vol. 22, no. 2, pp. 535–542, Mar. 2007.
2. M.GlinkaandR.Marquardt,"AnewAC/ACmultilevelconverterfamily ," IEEE Trans. Ind. Electron., vol. 52, no. 3, pp. 662–669, Jun. 2005.
3. M. Hagiwara and H. Akagi, "PWM control and experiment of modular multilevel converters," in Proc. IEEE Power Electron. Spec. Conf., Jun. 2008, pp. 154–161.
4. Berrezzek Farid and Berrezzek Farid, "A Study of New Techniques of Controlled PWM Inverters", European Journal of Scientific Research, ISSN 1450-216X, Vol.32, No.1, pp.77-87., 2009
5. G.Carrara, S.Gardella, M.Marchesoni, R.Salutari and G.Seiutto: "A New Multilevel inverter PWM method: A theoretical analysis", IEEE Transaction on Power Electronics vol 7, pp 497-505, July 1992.
6. Martina Calais, Lawrence J. Borle and Vassilios G. Agelidis., "Analysis of multicarrier PWM methods for a single phase five level inverter", in IEEE Conf. Rec.: 0-7803-7067-8/01, 2001, pp.1351-1356
7. Urmila, B., and Subbarayudu, D., "Multilevel Inverters: A Comparative Study of Pulse Width Modulation Techniques", Journal of Scientific and Engineering Research, vol.1, no.13, pp.1-5,2010.
8. H. Wu, Y. Deng, Y. Liu, and X. He, "A New Clew For Research on PWM Methods of Multilevel Inverters: Principle and Applications," vol. 2, no. 1, 4-12 IEEE Trans. Industry Applications, pp. 12511256, 2002.

AUTHORS PROFILE

K. Aravinda Shilpa Research Scholar in Department of Electrical Engineering, Andhra University College of Engineering (Autonomous). She has completed B.E in the year 2005 from AU & M.Tech in 2012 from JNTUK. Her research area is Power Electronics. Presently, She is working as an Assistant Professor (C) in Andhra University College for Engineering for Women.

Dr.K.RamaSudha Professor in the Department of of Electrical Engineering,, Andhra University, College of Engineering, (Autonomous).She has completed her BE in 1991 and ME in 1994 in Andhra university. She has completed her PhD in 2006.She has more than 20 years of teaching experience in .She is the founder Head in Andhra university college of engineering for women She has published over 20 technical papers in national and international conferences proceedings / journals. Her research area is on multilevel invertes, fuzzgy controller ,induction motor drives