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Implementation of 5-Level H-Bridge Inverter with Multicarrier based Modulation Techniques

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***Abstract*: Paper Setup must be in A4 size with Margin: Top In the present paper multi carrier sinusoidal modulation technique which is an efficient method of producing control signals is used for a symmetrical inverter with several levels in cascade H Bridge is discussed. The Cascaded H-Bridge performance output levels depend on the DC voltage sources used at the input side. With the help of two DC voltage sources, five level output can be obtained whereas three sources gives levels of seven in output voltage. In this paper, multi-carrier SPWM switching is obtained for switching of multilevel inverter based switches. Two signals are used in this switching method, among which one of the signals is reference which is a low frequency sinusoidal signal and the one is a carrier signal. In case of sinusoidal PWM method of modulation technique, the reference signal is a sinusoidal one and triangular signal can be used as a carrier signal. These types of inverters have the ability to generate inverted output voltage with an efficient harmonic spectrum and reliable output results. This document provides switching signal for H-bridge inverter structure which can improve harmonic performance. The 5-level multilevel inverter is simulated for traditional carrier-based pulse-width modulation (PWM) phase change carrier techniques. The total harmonic performance of the output voltages is analyzed for the two PWM control methods. The performance of the symmetrical PWM CHB is simulated using MATLAB-SIMULINK model. Model results show that THD can be minimized to a limit with level shifted modulation method of the sinusoidal pulse width. The results from the simulations show that the quality of the waveform of the output voltage improves with less loss and with a lower THD*.

Keywords* : H- bridge cascaded multilevel inverter, level shift carrier sinusoidal PWM, phase shift carrier PWM, Phase Disposition PWM, THD.

I. INTRODUCTION

In recent decades, renewable energy sources based generation have become an important thing in the global concerns related to the production of clean energy. However, due to the non-constant nature of renewable energy sources based generation, the generated voltage and frequency parameters are the difficult problems for connecting these systems to electrical grids or for enabling different applications.

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conventional two-level investors. Traction motors are an application. And the static energy conditioning system is another application of multi-level inverters. A large number of switches are used to get multiple different voltage levels at the output. Because of the increased number of voltage Several methods electronic power inverters have been developed to meet the desired requirements of renewable energy systems. Multi-level investors receive more attention due to their advantages compared to levels, the switching losses of the power converters are reduced. Less filtering is also necessary, as the harmonic distortions in the output voltage decreases as considered. As the number in the output voltage steps increases, the THD of the output waveform decreases and becomes almost sinusoidal.

In response to the requirement for medium and high power applications, new inverter topologies and new semiconductor technologies have been launched to increase all the power required. The development of high-voltage and current semiconductors to drive high-power inverter systems continues. From a practical point of view, multi-level inverters can be based on suitable configurations for high power applications where a high output voltage can be generated using medium voltage devices. In addition to this focal characteristic, multilevel inverters have high quality performance due to the generation of a stepped output voltage closer to the sine waveform which reduces the harmonics in the output waveform and finally, the size of the output filter [1].

The types of multi-level inverters are listed mainly in three configurations. These are diodes, flying capacitors and multilevel H-bridge inverters in cascade. The design procedures for these types are different. In the subject, the diode uses many diodes. Capacitors connected in series which obtain different voltage levels are also used. Since the amount of voltage is limited, the use of diodes reduces the stress on other devices. Only half of the input voltage is obtained as maximum voltage which presents itself as the main drawback. While in the H bridge type, series of cascaded cells are used to obtain different voltage levels. But the applications are limited due to the presence of many sources. The use of capacitors is the main idea behind the design of flying capacitors.Several pulse width modulation (PWM) techniques and design problems for asymmetric DC link arrangements for multilevel inverters are taken into account to present an optimal design for maximum output resolution, with a minimum number of components and losses.

The application of multilevel inverters extends to the field of conditioning the application of the power line, adjustable electronic power variations and static VAR compensation. Although the multi-level voltage source inverter concept was introduced only and limited by the suitable practical applications. By using the multi-level voltage source inverter structure, the pressure in each switch can be minimized in proportion to the number of levels, as the PWM can withstand higher voltages. As the levels in the multi-level inverter increases, the output voltage increases more like the waveform as a scale.

The multilevel based cascaded H bridge inverter requires more number of cascaded cells which increase the levels in output voltage waveform with independent DC voltage sources for each and every bridge [2]. It is a simple method to generate a waveform closer to the sine. The total harmonic distortion in the output voltage can be improved and then the output must be filtered to meet desired requirements related to THD. To meet the requirements related to this problem, an efficient sinusoidal PWM based on multicarrier modulation technique is proposed to generate controlled pulses for switches used in multilevel inverter. By providing this method of modulation, the results from the operation provides near sine waveform along with reduced THD.

The main purpose of the present paper is to implement H-bridge Cascaded Multilevel Inverter [3]. A 5-leveled inverter based on H-bridge Cascaded multilevel inverter model is proposed. The comparative results of the harmonic analysis for different modulation techniques have been obtained in MATLAB / SIMULINK.

II. MULTILEVEL CASCADED H- BRIDGE INVERTER

General blocks present in MLI have been represented in the diagram given in Fig. 1.

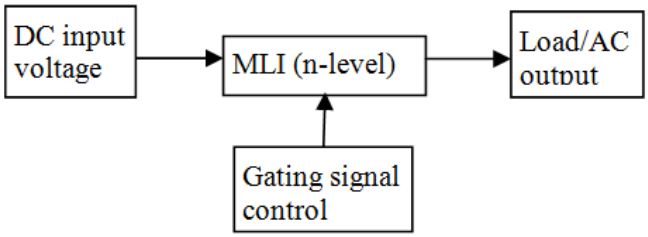
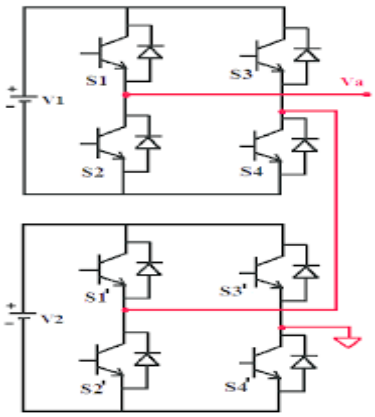


Fig. 1. Block diagram of MLI

Generally H-bridge MLI consists of two types of configurations. The configurations are namely asymmetrical and symmetrical types of CHB MLI.

In case of an asymmetrical based H-bridge multilevel inverter among the DC voltage sources present in the bridges of the CHB MLI, at least one of the DC power supplies has a different amplitude, that is to say that the H bridge cells are not supplied with all equal voltage and each cells in the inverter is going to have a different effect on the output voltage when compared with another cell with respect to steps to be present in the output voltage. The amplitude of the entire dc supply source to each H-bridge cells is equal in case of symmetrical cascaded H-bridge multilevel inverter [3].

Figure 5 shows the five stages of the inverter bridge are linked together in the 2 H-bridges. It embraces and operates by two different independent sources, even with the same voltage value that is, V1 and V2. Synthesizes the maximum voltage of the waveform, which is the sum of two voltages given by V1+V2. The first cell trips V1 and V2 are for another cell, which produces five levels given by number of levels, which is 2m + 1m. Where m is voltage sources present in the inverter. The output levels in voltage are in steps of 2V, V, 0, -V and -2V.



.Fig. 2. 5 level cascaded H-bridge inverter

H-bridge multi-level inverter emperor of the seven levels through the five stages can add a voltage source converter. In this case, when the source is added, which is necessary for the four switches to be required, that drives the fourth cell with other cells connected in series.

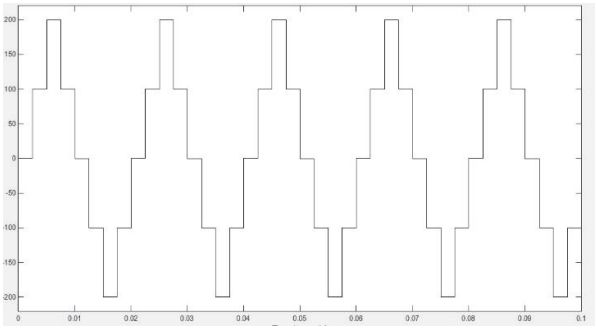


Fig. 3. 5 level per phase output voltage

Advantages and disadvantages of cascaded h bridge multilevel inverter over other types of multilevel inverters were discussed below:

Benefits of Cascaded H-bridge MLI configuration are given below [4]:

a) Stepped waveform with improved quality which reduced electromagnetic compatibility.

b) It results modularity of control.

c) The same number levels in output voltage with this configuration can be obtained with less switches when compared with the other type configurations of multi-level inverters.

d) This inverter can draw input current with reduced distortions.

Demerits of Cascaded H-bridge MLI configuration are given below:

a) Communication between full bridges must achieve synchronization with the reference carrier waveforms.

b) This requires that the power source voltage for separate conversions, and thus to be somewhat limited applications.

III. DIFFERENT SINUSOIDAL PWM TECHNIQUES

The pulse width sinusoidal modulation technique (SPWM) is used to produce sinusoidal waveform to generate the output pulse waveform with a filtering by variable width [5]. A sinusoidal waveform output filtered chosen the better changes can be obtained by varying the amplitude and frequency and high frequency value to be considered or the reference voltage. The SPWM technique, which is the desired one to produce unequal widths without having equal widths which is possible with multi pulse width modulation method and can have modulation distortion and ordered lower harmonics much decreased significantly.

Sine wave PWM refers to the PWM output generation that uses a sine wave as a modulation signal which includes OFF and ON pulses to control the switching action of switches in inverter. In this case, the time of the PWM signal can be obtained by comparing the reference sine wave (modulated wave) with the high frequency triangular wave (carrier).

PWM sine wave technology is widely used in industrial applications and is abbreviated here as more P. The frequency of the modulating wave determines the frequency of the output voltage. The maximum amplitude of the modulating wave determines the modulation index and controls the RMS value of the output voltage. Changing the modulation index may change the RMS value of the output voltage. Compared to other poly phase modulation modes, this technique significantly improves the distortion factor and also removes lower order harmonics. Or equal to 2p-1. "P" is defined as the number of pulses in a half cycle of the specified sine wave. The output voltage of the inverter is not completely filtered and contains harmonics. Higher order harmonics can be easily filtered out.

More sinusoidal output voltages can be obtained with inverter changes that have been modified by multi-carrier SPWM technology. Modulation of cascaded multi-level H-bridge inverters can be divided into two categories. These are the fundamental changes in PWM and high frequency switching frequency called PWM based on multi-carrier and PWM space vector. Selective Harmonic Rejection and Multi-Level SPWM needs some career signals based on number of levels in the output of inverter. Multi-carrier SPWM technology requires unique support for each independent DC voltage source.

Modulation schemes require measurements to adjust the output voltage with high quality waveforms and minimal harmonics. Since the single carrier PWM can be used to generate only two voltage levels, it has more harmonic content and distorted output. To overcome this shortcoming, use a multi-carrier PWM to generate multiple output levels. Multicarrier modulation is available at power and at high switching frequencies. In this article, multi-carrier sinusoidal high frequency modulation is used due to the low distortion coefficient and the harmonics of the output.

Some of the PWM methods based on phase relation between carrier waves are given below:

1) APOD (Alternative Phase Opposition Disposition): Each and every high frequency carrier wave is out of phase with its next carrier wave (at 180 degrees).

2) POD (Phase Opposition Disposition): The high frequency carriers that are above the zero reference are in phase and in 180 degrees out of phase with carrier waves which are below the zero reference.

3) PD (Phase Disposition): All high frequency carrier waves are in phase.

4) PSC PWM: The changed phase PWM is the standard modulation strategy for multi-level cascading inverters because it can give a good result by reducing output harmonics and maintaining a balance of power distribution between power cells.

The researchers analyzed the fundamental theory of PS-PWM, which contains the law of phase change angle over the entire harmonic minimization range for a cascading H bridge [7]. Taking into account the operating conditions, an adaptive modulation method is proposed in [8] to improve the performance characteristics under various unbalanced conditions. The phase change angle of the method changes depending on the operating conditions. Currently, another research access point is based on the phase change of the voltage-controlled carrier of the capacitor and implements a balancing algorithm for the control signal of each carrier cycle in order to obtain balancing of voltage.

This paper presents a new modulation strategy that combines the advantages of PS-PWM and PD-PWM for three-phase CHB inverters. The new modulation methodology not only solves the problem of power distribution imbalance in PD-PWM due to the characteristics of PS-PWM, but also maintains the excellent output harmonic reduction performance in PD-PWM. The new modulation strategy is optimized to increase the use of the intermediate circuit voltage and further improve the output harmonics by injecting a common voltage into the reference [8]. To reduce switching time and switching losses, a simple and efficient discontinuous multi-level modulation scheme
has also been proposed based on a new modulation scheme for level N CHB inverters. Simulation and experimental results are provided to demonstrate the effectiveness of the new and discontinuous modulation strategies.Another thing to keep in mind is that reducing the switching frequency by removing the first state of each switching sequence is much less efficient than removing the last state. To eliminate the last state, simply maintain the state that occurred in the previous cycle. Equivalent media, no transition required. However, filtering the first state requires raising the output waveform by one level, thus introducing a switching transition [9]. Therefore, another switching transition is required to pass the output waveform to the first step.

The level at which the corresponding reference does not initially exceed common support. Furthermore, in multi-level applications, the state that is the first or last fast transit of a public carrier is rotated between the three phases after the phase reference has been fitted to the common carrier band, so the additional transitions resulting from the removal of the first state of the transition Switching significantly reduces the ability to reduce the switching frequency.

For 5 levels that is for 5 voltage levels, the required number of carrier waveforms is 5-1 = 4. These four high-frequency carrier signals are in phase with zero upper and lower references. Two carriers above the zero reference and two lower carriers.

1. Multi-level inverter goes + 2V in a few seconds. Positive high frequency carriers are lower than the norm.
2. If the first positive carrier is lower than the reference, the inverter will be + V.
3. When the two positive high frequency carriers are older than the reference, then the inverter gives 0V.
4. When the first high frequency negative carrier is higher as a reference, provide -V.
5. When the reference is lower than the second highest negative carrier frequency then inverter gives -2V.

When the number of levels is seven: as the number of voltage levels there are seven, so the required carriers are 7-1 = 6. By providing switching to a multilevel inverter such as discussed above, will give results as shown in the simulation results.

IV. SIMULATION AND RESULTS

The cascaded three phase 5-level inverter are modeled in MATLAB/SIMULINK. The switching signal for each and every switch in inverter is generated from the different multicarrier based Sinusoidal PWM technique like level shift, phase shift SPWM and analyzed by FFT analysis.

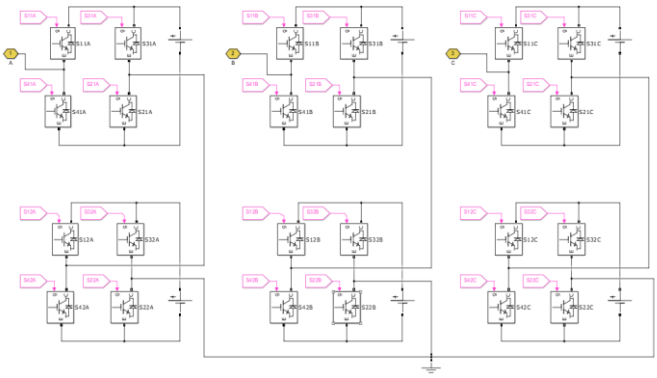
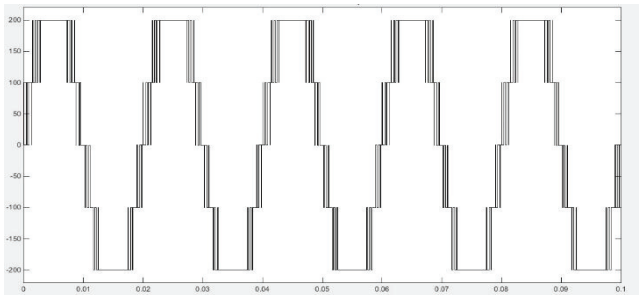
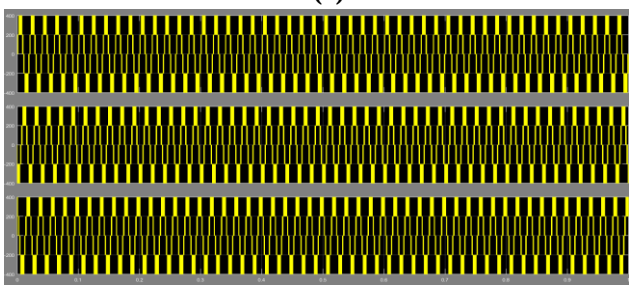


Fig. 4. Simulation model for three-phase 5 level CHBI

Five level cascaded H-bridge multilevel inverter modelling in MATLAB/SIMULINK was shown in Fig. 4 which includes 2 bridges in each phase which produces five level voltage in each phase.Simulation of the different modulation techniques to compare a CHB MLI are carried out using MATLAB / SIMULINK and the following parameters were used: Vdc = 200V, fc = 5 kHz and fm = 50 Hz, Ma = 0.9. Simulated control techniques, output Voltage and FFT waveform analysis for the 5-level CHB-MLI using PD-PWM, POD-PWM, APOD-PWM and phase shifted PWM proposals are presented.



(a)



(b)

Fig. 4. 5 level SPWM output voltage (a) per phase, (b) three phase

Total harmonic deviation for the developed five level SPWM output is as shown in Fig 5. THD for Five level output voltage with SPWM is 17.51%.

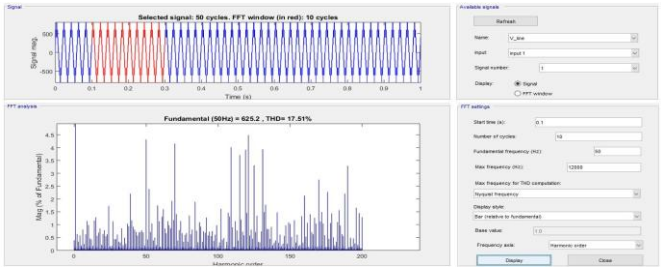


Fig. 5. THD for 5-level CHB inverter-SPWM output.

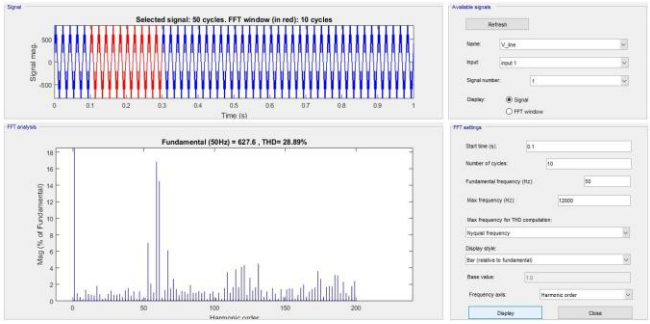


Fig. 6. THD for 5-level CHB inverter-PODSPWM output.

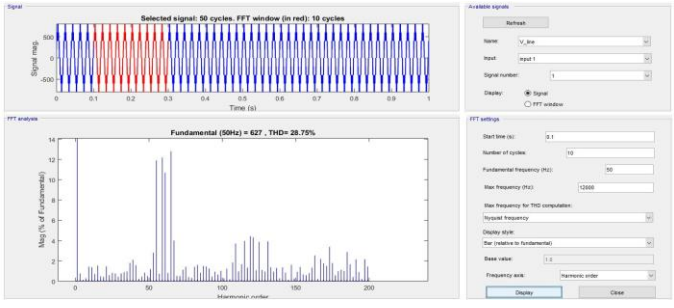


Fig. 6. THD for 5-level CHB inverter-APODSPWM output.

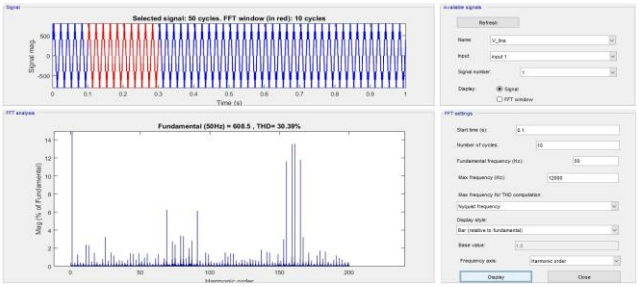


Fig. 7. THD for 5-level CHB inverter-phase shift SPWM output.

Multi Carrier waveforms for different modulation techniques were given below:

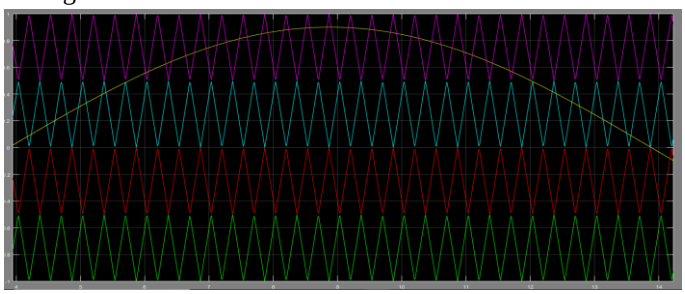


Fig. 8. Multicarrier APOD - SPWM.

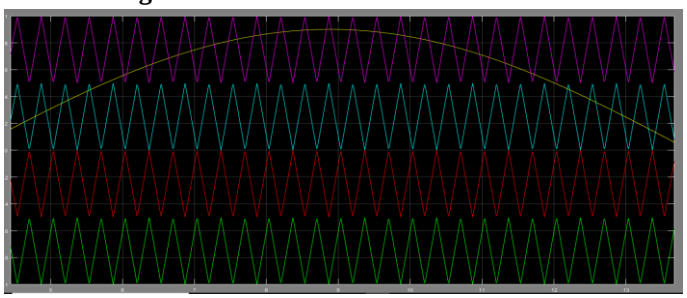


Fig. 9. Multicarrier phase opposition disposition SPWM.

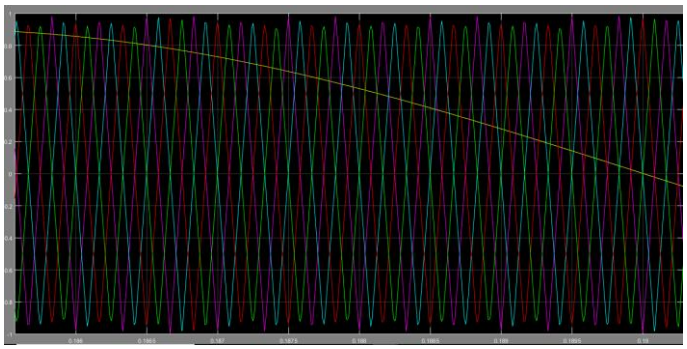


Fig. 10. Multicarrier phase shift SPWM.

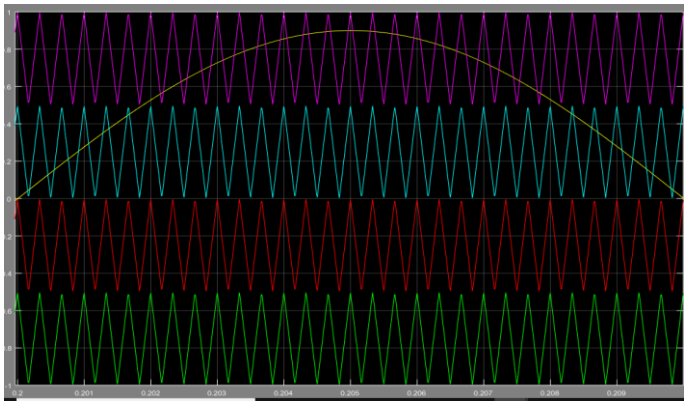


Fig. 11. Multicarrier phase disposition SPWM.

Table.I. Comparison of THD

Modulation Technique	Vline-line THD (%)
Level shift SPWM	17.51%
Phase Shift SPWM	30.39%
POD - SPWM	28.89%
APOD - SPWM	28.75%

V. CONCLUSION

The work carried out and described in this article aims to contribute to the improvement of the performance of multilevel inverters of H-bridge cascaded multilevel inverter, the control for the given topology generates a higher complexity in the control algorithms since the maintenance of the voltages through the capacitors is an additional constraint to be satisfied to ensure correct conversion and good quality. The solution presented uses the use of auxiliary circuits dedicated to balancing the voltages. The inverter is therefore very interesting for renewable energy conversion systems, because it increases the efficiency, while maintaining stable dynamics under the effect of a non-linear or unbalanced load. The results of the different modulation techniques were given and compared with those of the simulation results. It is found that the total harmonic distortion is reduced with increasing voltage level. This paper proposes a PWM technique which uses PD, POD, APOD and phase-shifted PWM to generate the desired multi-level voltage while switching the pulses of a 5-level cascade multi-level inverter with two H Bridges. Simulations using MATLAB / SIMULINK software were carried out to show that the technique recommended for PWM-PD at 17.51% THD is more effective compared to the traditional PWM APOD with 28.75% THD It was done. Pulse width modulation (phase layout) for 5-level inverter. An equivalent FFT analysis has created its own phase. The THD of the 5-level POD is 28.89%. With the SPWM phase layout strategy, the THD percentage is 17.51%.

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Chapala Shravani, M. Tech, Research scholar at JNTUK, Kakinada. Presently working as Asst. Prof. in EEE Dept. at CVR college of engineering, Hyderabad. She has 11 years of experiene in teaching. Her research areas are Power Quality, Drives and Smart Grid. She is an IEEE member since 6 years. She publisheb few papers on her research area.