IMPLEMENTATION OF MULTICARRIER PULSE WIDTH MODULATION TECHNIQUE FOR FIVE LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER

[1]P. Siva Santosh, [2]A.Santhi, [3]B. Sesha Sai,
[1]PG Student, [2]Associate Professor & Head, [3]Assistant Professor,
[1,2,3]Dept of EEE, SSCE
[1]sivasantosh243@gmail.com, [2]santhi.dunna@gmail.com, [3]bseshasai211@gmail.com

Abstract

The cascaded H-bridge multilevel inverters utilization is increased since last few decades. These types of inverters are suitable for various high voltages, high power applications. The transformer less Photo voltaic inverter is very advantageous of simple structure, low weight and provides higher efficiency. This thesis presents five level cascaded H-bridge inverter using phase disposition multicarrier PWM technique. The simulation results presented to prove that THD is reduced with Phase disposition multicarrier PWM. From the results, the three phase cascaded H-bridge multilevel inverter provides higher output quality with relatively less power loss as compared to the single phase cascaded H-bridge inverter with the same output quality. Simulation of five level cascaded H-bridge inverter is done in MATLAB/Simulink environment.

I. INTRODUCTION

Compared to other prevalent energy resources, the complete power generation through the use of photovoltaic (PV) system is much lower owing to its elevated installation price. Because of the decreased price of the PV system and its enhanced effectiveness, the higher interest in studies is achieved. One of the interpretations to decrease the price of the PV energy scheme is to disconnect the transformer needed in the output of the PV inverter[1]-[3]. Using popular energy switches, multilevel inverters are suggested as a key to increase the energy in an inverter. There are several other benefits of multilevel converters. Because of this benefit and their many other merits such as reduced EMI issues and losses [1]-[2], multilevel inverters have attracted growing attention in latest years and have discovered extensive applications, even in single-phase systems. However, single-phase converters are frequently used in low-power applications such as housing and small industrial applications, due to their benefits, multi-level converters suggested as a high-power conversion alternative are used in single-phase applications.

1.1 Inverter

An inverter is an electrical unit that transforms direct present (DC) to alternating present (AC); with the use of suitable transformers, switching and control circuits, the converted AC can be at any voltage and frequency. Static inverters do not have moving components and are used in a broad variety of applications, ranging from tiny switching power supplies in PCS to big high-voltage electric utility direct current apps that carry bulk energy. Usually inverters are used to supply AC power from DC sources like solar panels or batteries.

II CASCADED H-BRIDGES INVERTER

Figure 1.1 illustrates a single phase structure of a cascaded inverter at m-level. A single-phase full-bridge, or H-bridge, inverter is linked to each distinct dc source (SDCS). Each level of the inverter can produce three distinct voltage outputs, + Vdc, 0, and –Vdc by linking the source dc to the ac output by combining the four switches, S1, S2, S3, and S4. To acquire + Vdc, switches S1 and S4 are switched on, while switches S2 and S3 can be switched on to acquire –Vdc. The output voltage is 0 by switching on S1 and S2 or S3 and S4. The ac outputs of each of the distinct stages of the full-bridge inverter are linked in sequence to make the synthesized voltage waveform the total of the inverter inputs.

M= 2s+1, where s is the number of distinct dc sources, defines the amount of output stage voltage concentrations m in a cascade inverter. For an11-level cascaded H-bridge inverter with 5 SDCSs and 5 complete bridges, the example phase voltage waveform is shown in Figure 1.1. The van= va1 + va2 + va3 + va4 + va5 stage voltage. The Fourier Transform for this waveform follows for a stepped waveform as shown in Figure 31.2 with s measures.

$$V(\omega t) = \frac{4V_{dc}}{\pi}\sum_{n}[\cos(n\theta_1) + \cos(n\theta_2) + \cdots + \cos(n\theta_s)]\frac{\sin(n\omega t)}{n},$$

$$\text{Where } n = 1,3,5,7,\ldots \quad (1)$$

When normalized with regard to Vdc, the magnitudes of the Fourier coefficients are as follows:

$$H(n) = \frac{4}{\pi n}[\cos(n\theta_1) + \cos(n\theta_2) + \cdots + \cos(n\theta_s)],$$

$$\text{Where } n = 1,3,5,7,\ldots \quad (2)$$

The corners of conduction can be chosen to minimize the total harmonic distortion of the voltage. These angles are usually chosen to eliminate predominantly decreased harmonics of frequency, 5th, 7th, 11th, and 13th, [5]. More details will be provided in the next chapter on harmonic elimination methods.

Cascaded inverters are also suggested to use the Primary traction drive with several batteries in electric vehicles or ultra condensers are well adapted to serve as SDCS [8],[9]. As shown in Figure 1.1, the cascaded inverter can also be used as a charger for an electric vehicles batteries while the vehicle was on a supply of ac. In addition, in a car that utilizes regenerative braking, the cascade inverter can function as a rectifier.

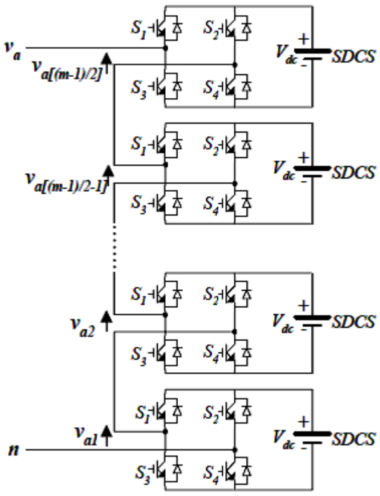

Fig 1. Cascaded H-bridge inverter single-phase structure.

III. MULTI CARRIER BASED PWM METHODS

There are two types of PWM techniques for Multilevel Inverter.

3.1 Level Shifted Carrier PWM

3.2 Phase shifted Carrier PWM

3.1. Level Shifted PWM

The module carriers have an offcar=1/Tsw frequency in all stage changed PWM techniques. Where the carrier signal frequency is inversely proportional to the device's switching time. On the other side, the reference voltage may have values between –MVdc and MVdc. The carriers are moved vertically to cover the entire voltage variety, so that the first module carrier covers the variety from Vdc to 2Vdc. The last module is from (M-1)Vdc to MVdc. There are three alternative modulation methods that have changed levels, namely; • phase disposition.

- Provision for opposition phase.
- Alternative provision for opposition stage
- Phase opposition disposition.

All carriers are in stage disposition (PD) across all bands. In greater modulation indices, this provides rise to the smallest harmonic compared to the other disposition method[3]. The level changed multi carrier modulation provides unequal operation of the device.

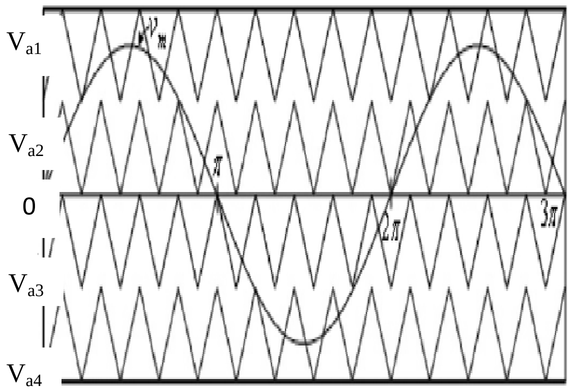

Fig. 2 Carrier Arrangements for PD.

In the alternative phase opposition disposition (APOD), the carriers of neighbours bands are phase shifted by 180[3].

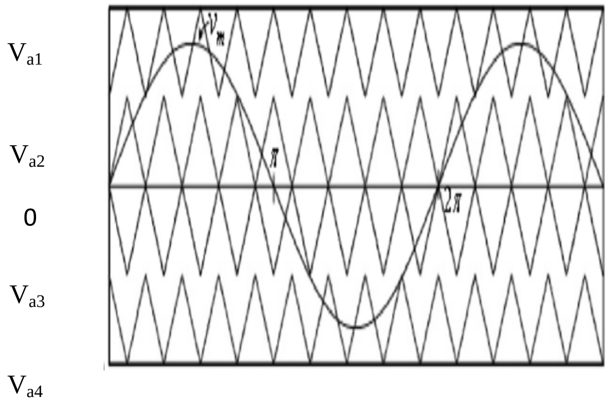

Fig. 3 Carrier Arrangements for APOD.

In the phase opposition disposition (POD) the carriers above the reference point, are out of phase with those zero, by 180[3].

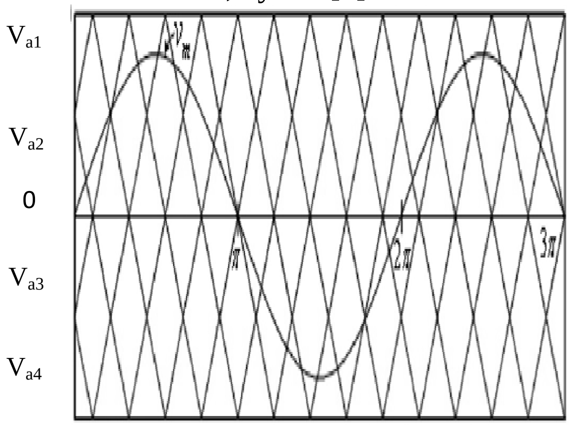

Fig. 4 Carrier Arrangement for POD.

3.2. Phase Shifted PWM

PSPWM's vital principle is the phase shift of each bridge's carriers to obtain extra harmonic sideband cancellation that occurs around various groups even carrier. Fig.5 demonstrates the carrier provisions in one of the phase legs of a seven-level cascaded system for the three H-bridge cells linked in sequence. Optimum harmonic cancelation is achieved by shifting each carrier phase to (k-1)/n, where k is the kth converter, n is the number of single-phase series-connected inverters per leg. For three cascaded H-bridges with a 60 ° shift in the carrier phase, harmonic cancelation up to side bands around multiples of 6fc will be achieved[3]. The cancelation does not depend on the carrier / fundamental frequency proportion.

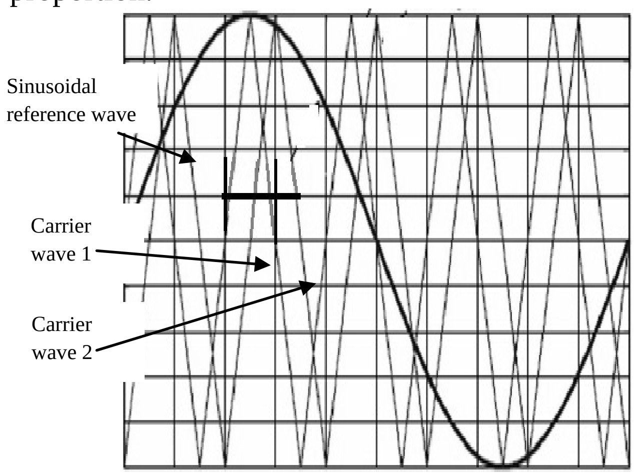

Fig. 5 PSPWM Technique.

IV SIMULATION RESULTS

Figure 6. demonstrates the model being checked by the simulated scheme in MATLAB / Simulink. The Simpower System toolbox library has been used to model each power device..

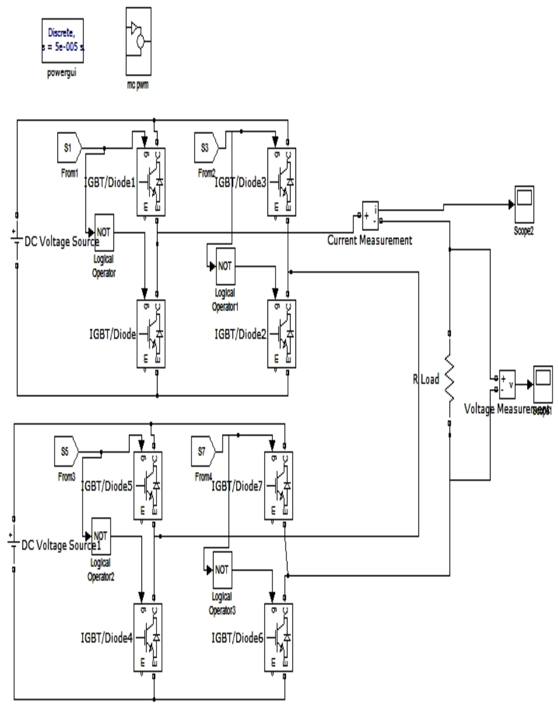

Fig. 6 Single Phase Five Level Cascaded H-Bridge Inverter Simulink Model.

Fig. 7 shows the phase disposition multi carrier pulse width modulation technique.

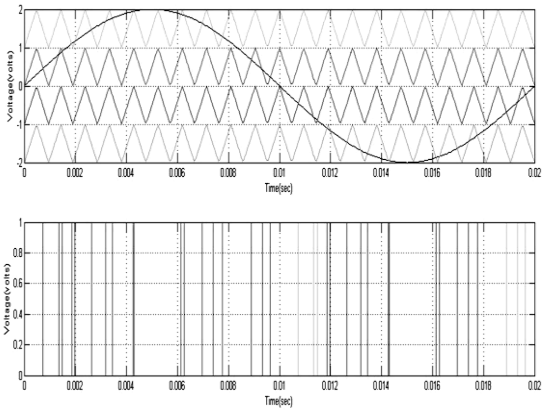

Fig. 7 Multi Carrier PWM with Phase Disposition Technique.

Figure 8 demonstrates the waveform inverter output waveform in five stage cascaded H-bridge with multi carrier PWM with phase disposition technology.

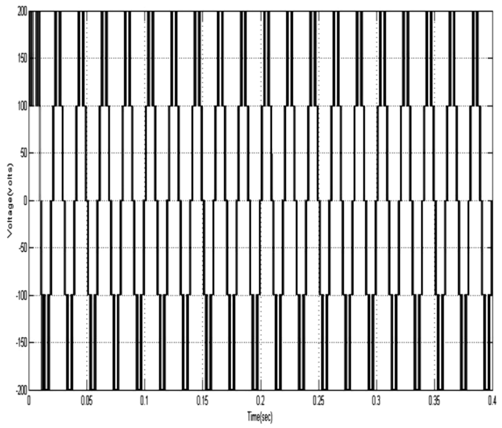

Fig. 9 Single Phase Five Level Inverter Output Voltage Waveform.

Figure 9 displays total harmonic distortion (THD=34.50 per cent) with PD multicarrier modulation on a single phase-five cascaded H-bridge inverter.

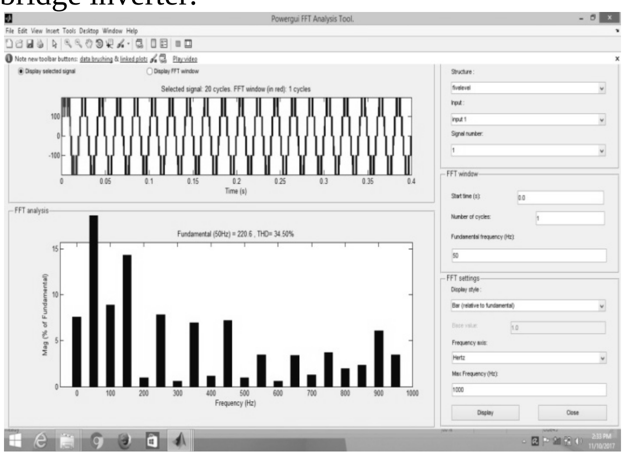

Fig. 10 THD of Single Phase Five Level Inverter.

Figure 10 demonstrates the three-phase five-level cascaded H-bridge inverter described in Simulink with PD multi carrier modulation. The Simpower System toolbox library has been used to model each power device..

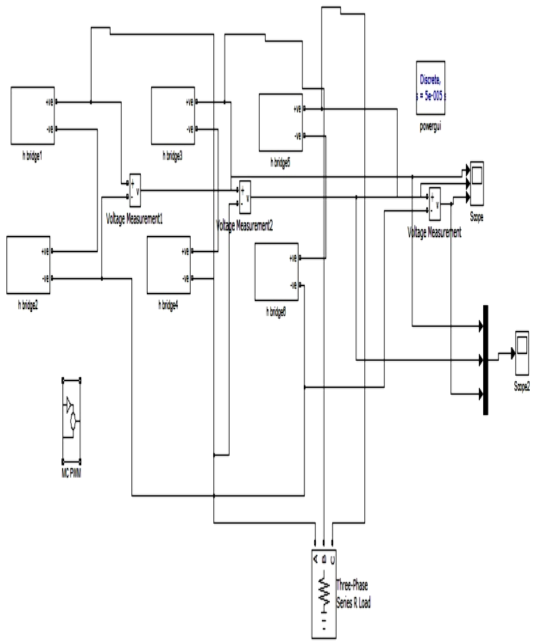

Fig. 11 Three Phase Five Level Cascaded H-Bridge Inverter Simulink Model.

Fig 12 and Fig. 13 show three phase five level cascaded H-bridge inverter output voltage waveform of each phase and combined output voltage waveform respectively.

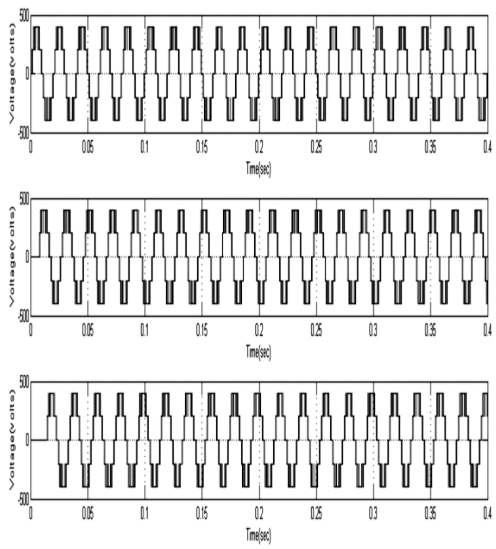

Fig. 12 Three Phase Five Level Inverter Output Voltage Waveform.

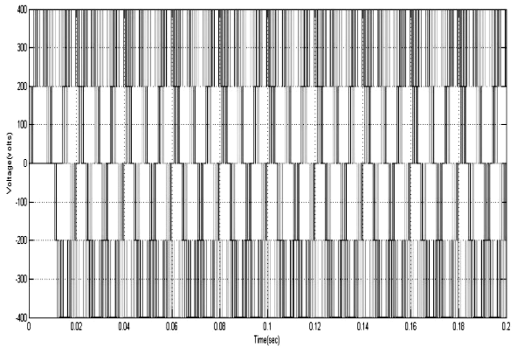

Fig. 13 Three Phase Five Level Inverter Output Voltages Waveform.

Figure 14 displays complete harmonic distortion (THD=26.91%) of the three-phase five-level cascaded H-bridge inverter using multi-carrier PD modulation.

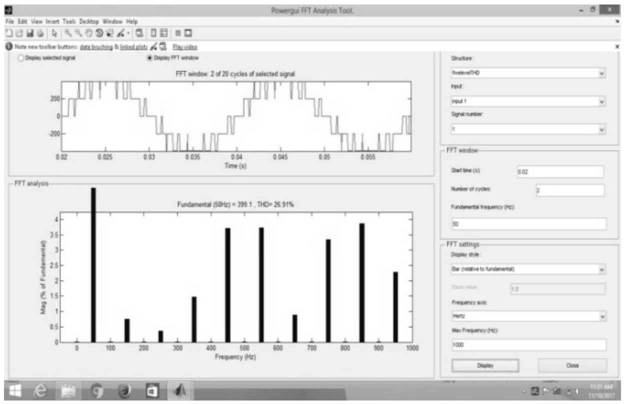

Fig. 14 THD of Three Phase Five Level Cascaded H-Bridge Inverter.

V CONCLUSION

This thesis gave a short account of a five-level cascaded H-bridge inverter with modulation of PD multicarrier pulse width and MATLAB / simulink model integrated. The findings of the simulation indicate that the total harmonic distortion for multi-carrier modulation is small.Using the MATLAB / simulink model, both single phase and five-level cascaded H-bridge inverters are simulated.The results of both methods are compared and observed that the total harmonic distortion in the output voltage of the three phase five level cascaded H-bridge inverter (26.91%) using PD multicarrier PWM is less compared to the single phase five level cascaded H-bridge inverter (34.50%).it is also observed that modulation level increases THD reduces very significantly and also increases system efficiency. This can be extended to higher levels so that harmonics are reduced further. It is also noted that, compared to standard modulation techniques, the suggested MCPWM provides less total harmonic distortion.

VI REFERENCES

[1] R. Gonzalez, J. Lopez, P. Sanchis and L. Marroyo, “Transformerless inverter for single-phase photovoltaic systems,” *IEEE Trans. Power Electron.*, vol. 22, no. 2, pp. 693–697, Mar. 2007.

[2] Y. Wensong, L. Jih-Sheng, H. Qian and C. Hutchens, “High-efficiency MOSFET inverter with H6-type configuration for photovoltaic non-isolated AC-module applications,” *IEEE Trans. Power Electron.*, vol. 26, no. 4, pp. 1253–1260, Apr. 2011.

[3] Y. Zhou, W. Huang, P. Zhao and J. Zhao, “A transformerless grid-connected photovoltaic system based on the coupled inductor single-stage boost three-phase inverter,” *IEEE Trans. Power Electron.*, vol. 29, no. 3, pp. 1041–1046, Mar. 2014.

[4] L. Zhang, K. Sun, Y. Xing and M. Xing, “H6 transformerless full-bridge PV grid-tied inverters,” *IEEE Trans. Power Electron.*, vol. 29, no. 3, pp. 1229–1238, Mar. 2014.

[5] T. Kerekes, R. Teodorescu, P. Rodriguez, G. Vazquez and E. Aldabas, “A new high-efficiency single-phase transformerless PV inverter topology,” *IEEE Trans. Ind. Electron.*, vol. 58, no. 1, pp. 184–191, Jan. 2011.

[6] E. Koutroulis and F. Blaabjerg, “Design optimization of transformerless grid-connected PV inverters including reliability,” *IEEE Trans. Power Electron.*, vol. 28, no. 1, pp. 325–335, Jan. 2013.

[7] L. June-Seok and L. Kyo-Beum, “New modulation techniques for a leak-age current reduction and a neutral-point voltage balance in transformer-less photovoltaic systems using a three-level inverter,” *IEEE Trans. Power Electron.*, vol. 29, no. 4, pp. 1720–1732, Apr. 2014.

[8] Z. Li, S. Kai Sun, F. Lanlan, W. Hongfei and X. Yan, “A family of neutral point clamped full-bridge topologies for transformerless photovoltaic grid-tied inverters,” IEEE Trans. Power Electron., vol. 28, no. 2, pp. 730–739, Feb. 2013.