ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 5, Issue 3 , March 2018

Simulation Analysis for Quasi Cascaded Multilevel Inverter using Solar PV Systems by Implementing APOD Technique

M.Chandravadhani, J.Indhu, B.Kaavery Priyadharshini' R.Sugeerthi Prabha, Lavanya Dhanesh

UG Scholar, Department of EEE, Panimalar Instiute of Technology, Chennai.
UG Scholar, Department of EEE, Panimalar Instiute of Technology, Chennai
UG Scholar, Department of EEE, Panimalar Instiute of Technology, Chennai
UG Scholar, Department of EEE, Panimalar Instiute of Technology, Chennai
Associate professor, Department of EEE, Panimalar Instiute of Technology, Chennai

ABSTRACT-Quasi Z-Source Inverter Cascaded Multilevel Inverters (QZS-CMI) are recently developed Inverters for application in PV systems. They have advantages like balanced DC-link voltage and voltage boost ability. However the QZS-CMI has passive component stress, limited boosting capability with higher component voltage stress and their low Modulation Index M. To overcome drawbacks in QZS-CMI a modified Quasi Cascaded Multilevel Inverter is proposed in this research work, with strong boost inversion capability than QZS-CMI.A Sine PWM method is used in Quasi Cascaded Multilevel Inverter, where still it faces a complexity in switching pulses, to overcome the drawbacks a new technique by name Alternative Phase Opposition Disposition (APOD) is proposed.

KEYWORDS: Quasi Cascaded Multilevel Inverter, Solar PV Systems, APOD Technique

I.INTRODUCTION

VSI can perform buck operation and CSI can perform boost operation. In case of ZSI/qZSI both buck and boost operation can be done. ZSI are used to shoot-through the inverter arms and boost voltage [1].

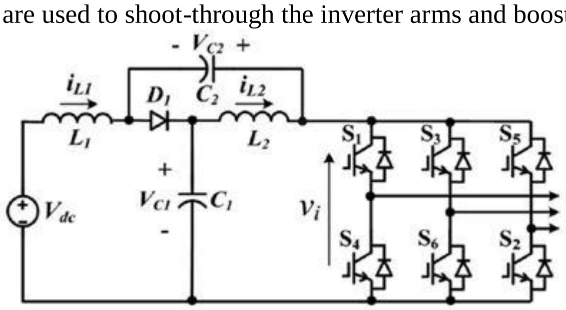

Fig.1. Basic Quasi Z-Source Inverter

In QZSI capacitor C_2 is very much less when compared to capacitor C_1 where this leads to low manufacturing cost [2]-[3]. Capacitor voltage can be made constant to avoid the disturbances in duty cycle and modulation index. In case of transformer based QZSI it gets higher boost voltage but it requires large turns ratio and isolation is more in between windings where it gives leakage in the inductance [4]-[6]. In PWM techniques like, Maximum boost control [7], Constant boost control [8] and Simple boost control has the drawback of high frequency and additional switching losses. QZSI is introduced because it has the advantages of continuous input current, lower component voltage stress. Alternate Phase Opposition Disposition (APOD) has mainly introduced to avoid the switching losses and better DC link voltage for better utilization. While being the simplest possible modulation technique, this produces low output voltage harmonics [9]-[11]. To increase the voltage gain in all topologies of QZSI either shoot-through duty ratio (D) or modulation index (M) should be increased. A quasi-switched boost network is used to replace the network. In comparison to the network, the network uses one less capacitor, one less inductor, one more diode, and one more switch in front of the main H-bridge circuit. An isolated high step-up dc–dc converter is proposed in based on the

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 5, Issue 3 , March 2018

network. In this paper, a new single-stage quasi-CHB five-level boost inverter is proposed. In the proposed, the network as presented is used in each module. The main features of the proposed are five-level output voltage with boost voltage ability, reduction in a number of passive components and ST immunity [12]-[14]

II. QUASI CASCADED MULTILEVEL INVERTER

The inverter consists of two separate dc sources, two quasi-boost inverter modules, and an inductor filter connected to the resistive load in series. Each module contains one capacitor, one boost inductor, four switches, and two diodes. The output voltage of the inverter has five level (Multilevel).

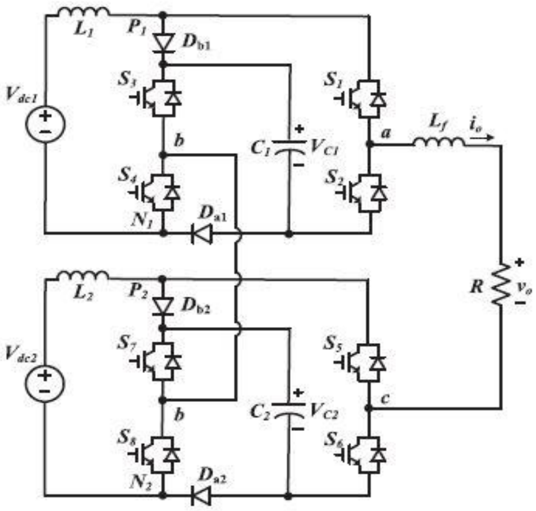

Fig.2.Quasi Cascaded Multilevel Inverter

It operates in shoot through and non-shoot through state, In the ST state 1, both S_1 and S_2 are turned ON. D_{a1} is conducting, while D_{b1} is blocking. If $_{S3}$ is turned ON, the output voltage of the module 1 is $-V_{C1}$. Else, it equals zero. The inductor L_1 is charged from the source.

In the ST state 2, S_3 and S_4 are turned ON as D_{a1} is blocking, while D_{b1} is conducting. If S_2 are turned ON, the output voltage of the qBI module 1 is $-V_{C1}$. Else, it equals zero. The inductor L_1 is also charged in this state. In the nonshoot-through (NST) state 1 both S_1 and S_3 are turned ON. In the NST state 4 both S_2 and S_4 are turned ON. The output voltage of the module 1 in both NST states 1 and 4 is zero. In the NST state 2, as shown, both S_2 and S_3 are turned ON. The output voltage of the module 1 is $-V_{C1}$. In the NST state 3, as shown both S_1 and S_4 are turned ON. The output voltage of the module 1 is V_{C1} .During the NST states as shown in D_{a1} and D_{b1} are conducting. The capacitor C_1 is charged from V_{dc}, while the inductor L_1 transfers energy from the DC voltage source to the main circuit. The H-bridge circuit is equivalent as current source, i_{PN1} .

III. LITERATURE SURVEY

This paper mainly focus on the advantages of Quasi Z-Source inverter and Cascaded Multilevel Inverter. In the past years the authors were used to work on particular inverter. Due to vast literature survey on single inverter or converter, In the present years the authors have started working on the combination of inverters, these are few papers given below for the work.

ChakkarapaniManickam, Guru Raghav Raman, Guru Praanesh Raman, SaravanaIlangoGanesan, and ChilakapatiNagamani.Maximum power point tracking (MPPT) isessential for photovoltaic (PV) string inverter systems. Partially shaded PV strings with bypass diodes exhibit multiple peaks in the power–voltage characteristic. Under partial shading conditions, conventional algorithms get trapped in a local maximum power point, and fail to track the globalMPP (GMPP). To overcome this problem, global search algorithms such as particle swarm optimization (PSO) have been proposed.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 5, Issue 3 , March 2018

Minh-Khai Nguyen, Tan-Tai Tran. The proposed five-level inverter has the advantages over the CHB quasi-Z-source inverter in cutting down passive components. Consequently, size, cost, and weight of the proposed inverter are reduced. Additionally, the proposed qCHB-FLBI can work in the shoot-though state.

Umesh K. Shinde, Sumant G. Kadwane, S. P. Gawande, M. Jaya Bharata Reddy and D. K. Mohanta.Quasi-Z-source inverters (qZSIs) are nowadays increasingly used owing to advantages such as single-stage operation, lower component rating, and continuous input current and common dc rail. These benefits lead to investigate this converter for grid-connected applications. This paper presents a grid- connected qZSI with both ac and dc side control. Sliding mode control (SMC)-based controller for capacitor voltage regulation has been proposed to ensure a fast and dynamic response for wide variations in input voltage, output load, and reference controlled quantity

III.APOD TECHNIQUE FOR QUASI CASCADED MULTILEVEL INVERTER

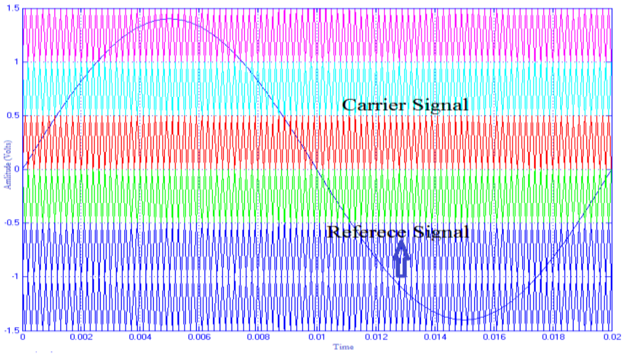

Fig.2.Generation of pulses for APOD Technique

To generate pulses for large number of switches APOD technique is most preferred, by using APOD technique for Quasi-CMI the complexity of switching action will be reduced

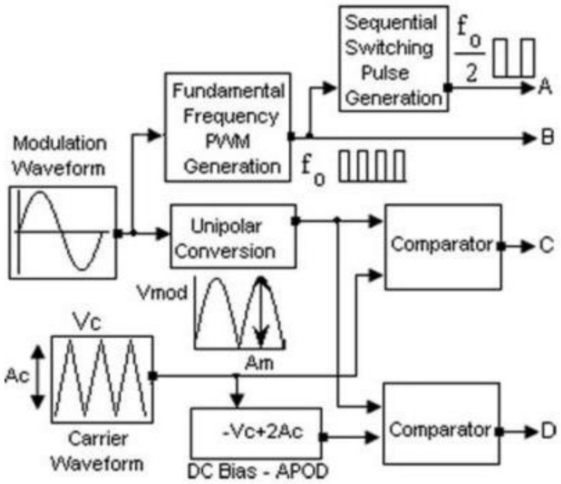

Fig.4. APOD Technique

APOD modulator scheme is used for switching purpose for the H-Bridge in Multilevel inverter, the switching sequence of APOD for any H-Bridge will be as follows.

$$S_{11} = ABC' + \bar{A}B$$
$$S_{12} = \bar{A}BC' + \bar{A}\bar{B}$$
$$S_{13} = \bar{A}\bar{B}C' + A\bar{B}$$
$$S_{14} = \bar{A}BC' + AB$$

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 5, Issue 3 , March 2018

The above 4 equation is common for any 1st H-Bridge of Cascaded Multilevel, whereas from 2nd H-Bridge it will be changing depending upon the level.

In case of alternate phase disposition (APOD) modulation every carrier waveform is in out of phase with its neighbour carrier by 180 degree. Since APOD and POD schemes in case of seven-level inverter are the same, a seven level inverter is considered to discuss about the APOD scheme. The rules for APOD method, when the number of level m = 7, are The m – 1 = 6 carrier waveforms are arranged so that every carrier waveform is in out of phase with its neighbour carrier by 180degree. The converter switches to + V_{dc} / 2 when the reference is greater than all the carrier waveforms. The converter switches to +V_{dc} / 4 when the reference is less than the uppermost carrier waveform and greater than all other carriers. The converter switches to 0 when the reference is less than the two uppermost carrier waveform and greater than two lowermost carriers. The converter switches to - V_{dc} / 4 when the reference is greater than the lowermost carrier waveform and lesser than all other carriers. The converter switches to -V_{dc}/ 2 when the reference is lesser than all the carrier waveforms.

IV. SOLAR PV MODELLING

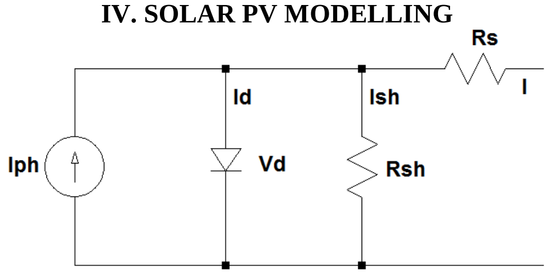

Fig.5. Basic diagram of Solar PV Cell

A PV system directly converts sunlight into electricity. The main device of a PV system is a solar cell. Cells may be grouped to form panels or arrays. Power electronic converters are usually required to process the electricity from the PV device. These converters may be used to regulate the voltage and current at the load, to control the power flow in grid-connected systems, and for the maximum power point tracking (MPPT) of the device.

The solar cell is basically a semiconductor diode exposed to light. Solar cells are made of several types of semiconductors using different manufacturing processes [15]. The electrical energy produced by a solar cell at any time instant depends on its intrinsic properties and the incoming solar radiation [16]. The solar radiation is composed of photons of different energies, and some are absorbed at the p-n junction. Photons with energies lower than the band gap of the solar cell are useless and generate no voltage or electric current. Photons with energy superior to the band gap generate electricity, but only the energy corresponding to the band gap is used. The remainder of energy is dissipated as heat in the body of the solar cell [17]-[18]. A single-diode PV cell model is considered in this paper, including the effect of the series resistance. The paper uses the equivalent circuit of a solar cell with its parameters as a tool to simulate in order to consider the irradiance and temperature change, the I-V characteristics of PV cell.

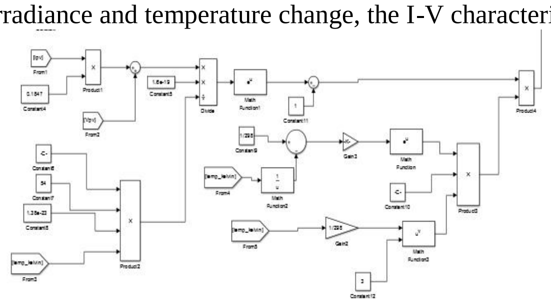

Fig.6. Modelling of PV Cell

As mentioned previously, the solar cells are semiconductor with a p-n junction fabricated in a thin wafer or layer of semiconductors. When exposed to light a photo current proportional to the solar radiation is generated, if the photon energy is greater than the band gap. In the dark, the I-V characteristics of a solar cell have an exponential characteristic similar to that of a diode. In order to maximize the extracted output power from a PV power plant with

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 5, Issue 3 , March 2018

the help of MPPT control, the understanding and modelling of PV cell is necessary. The following equations are used for modelling Solar PV cell;

$$I_{ph} = I_{sch}\left(\frac{G}{Go}\right)(1 + \alpha_1(T - T_0))$$

$$I_{PV} = I_{ph} - I_0\left[\left(\frac{V_{pv} + R_s I_{pv}}{\eta(\eta KT / q)}\right) - 1\right] - \left[\frac{V_{pv} + R_s I_{pv}}{R_{sh}}\right]$$

$$I_0 = I_{0\,ref}\left(\frac{T}{T_0}\right)^3 exp\left[\left(\frac{qE_g}{\eta K_B}\right)\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]$$

IV. SIMULATION RESULTS AND ANALYSIS

The simulation results of Quasi Cascaded Multilevel Inverter by applying the APOD technique to the three level inverter are presented. In above section-III APOD technique is explained and as explained in section-I the reason for choosing the APOD, has no switching losses mainly. Previously the three techniques which mentioned n section-I has high frequency and additional switching losses.

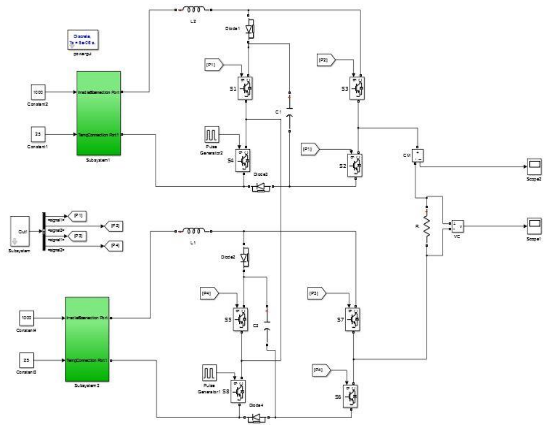

Fig.7. Simulink of Quasi Cascaded Multilevel Inverter using Solar PV System

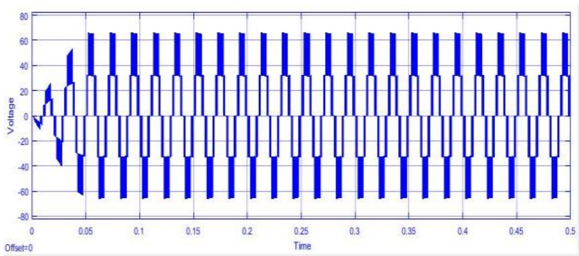

Fig.8. Output voltage of Quasi Cascaded Multilevel Inverter

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 5, Issue 3 , March 2018

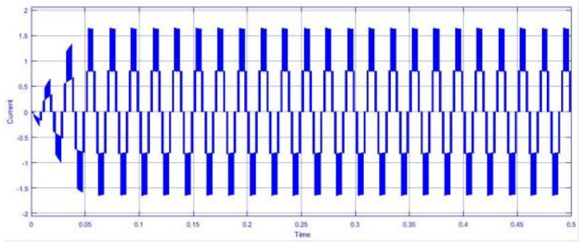

Fig. 9. Output current of Quasi Cascaded MLI

Fig.8 and Fig.9 shows the output voltage and output current waveform. The output voltage of the Quasi Cascaded MLI is 60.2 volts and current is 1.2 Amps.

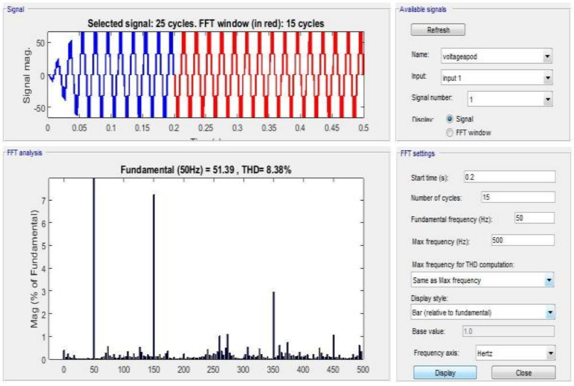

Fig.10. Voltage THD(%) with APOD

Table-I Harmonics description for Voltage

S.No	Type	THD(%)
1.	Without APOD	12.04%
2.	With APOD	8.39%

Table-I gives the detail explanation of voltage harmonics in the Quasi Cascaded Multilevel Inverter by comparing without APOD technique and with APOD technique.

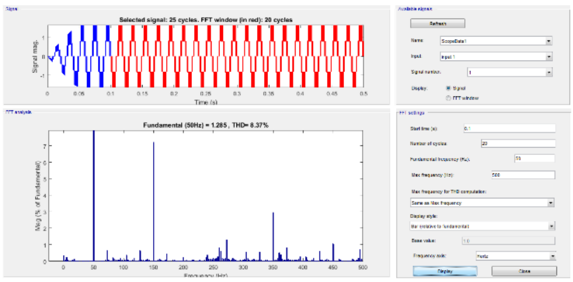

Fig.11. Current THD(%) with APOD

Table-2 Harmonics description for Current

S.No	Type	THD(%)
1.	Without APOD	12.04%
2.	With APOD	8.39%

Table-I gives the detail explanation of voltage harmonics in the Quasi Cascaded Multilevel Inverter by comparing without APOD technique and with APOD technique.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 5, Issue 3 , March 2018

V.CONCLUSION

The Quasi Cascaded Multilevel inverter has the following main features as: reduction in number of passive components, and shoot through immunity, a constant capacitor voltage can be achieved with an excellent transient performance which enhances the rejection of disturbance, including the input voltage and load current variations. By implementing APOD technique the stability in output voltage waveform is increased, whereas the Total Harmonic Distortion (THD) is reduced in compare with normal PWM technique. Hence in future by designing the filter we can reduce the THD as per IEEE standards.

REFERENCES

[1] Fang ZhengPeng ,"Z-Source Inverter," IEEE Transactions on Industry Application, Vol.39, no.2,pp.504-510, March/April 2003.
[2] Yaun Li, Fang ZhengPeng, et.al, "Modelling and Control of Quasi Z-Source inverter for Distributed Generation Applications.
[3] Y. Liu, B. Ge, H. Abu-Rub, and F. Z. Peng, "Modelling and controller design of quasi-Z-source inverter with battery-based photovoltaic power system," IET Power Electron., Vol. 7, no. 7, pp. 1665–1674, Jul. 2014.
[4] Ding Li et.al., "Cascaded Multicell Trans-Z-Source Inverters", IEEE Transactions on Power Electronics, vol. 28, no. 2, Feb.2013.
[5] Minh-Khai Nguyen et.al., "Cascaded TZ-source inverters", IET Power Electron., Vol. 7, Iss. 8, pp. 2069–2080, 2014.
[6]W.Qian, F.Z.Peng, and H.Cha, "Trans-Z-source inverters," In Proc. IEEE IPEC-Sapporo2010, pp. 1874–1881, Jun. 2010.
[7] Fang ZhengPeng, MiaosenShen, et.al, " Maximum Boost control of the Z-Source inverter," IEEE Transactions on Power Electronics,Vol.20, No.4, pp.833-838, July 2005.
[8] MiaosenShen, Jin Wang, et.al "Constant Boost Control of the Z-Source inverter to minimize current ripple and voltage stress" IEEE Transactions on Industry Applications, pp. no.770-778, May/June 2006.
[9] Das, A; Lahiri, D.; Kar, et.al , "Space vector PWM based AC output voltage control of Z - source inverter," Control, Automation, Communication and Energy Conservation,. 2009 International Conference on INACEC , pp.1-4, June 2009.
[10] Vafakhah, B.; Sahnon, 1.; Knight, AM.; , "A New Space-Vector PWM With Optimal Switching Selection for Multilevel Coupled Inductor Inverters," IEEE Transactions on industrial Electronics ,Vo1.57, No.7, pp.2354-2364, July 2010.
[11] Mirafzal, B.; Saghaleini, M.; Kaviani, AK., "An SVM-Based Switching Pattern for Stand-Alone and Grid-Connected Three-Phase Single-Stage Boost Inverters," IEEE Transactions on Power Electronics, Vo1.26, no.4, pp.1102-1111, April 2011.
[12] Hafiz Furqan Ahmed et.al, "Switched-Coupled-Inductor Quasi-Z-Source Inverter", IEEE Transactions on Power Electronics, Vol. 31, No. 2, Feb.2016.
[13]M. Nguyen and T. Tran, "Quasi Cascaded H-Bridge Five-Level Boost Inverter," vol. 64, no. 11, pp. 8525–8533, 2017.
[14] V. R. Rajan and L. Premalatha, "Quasi-Z-Source Inverter Topologies with Reduced Device Rating : a Review," vol. 8, no. 1, pp. 325–334, 2017.
[15] M. G. Villalva, J. R. Gazoli, and E. R. Filho, "Comprehensive approach to modeling and simulation of photovoltaic arrays", IEEE Transactions on Power Electronics, Vol. 24, No. 5, pp. 1198-1208, May 2009.
[16] A. S. Sedra and K. C. Smith, Microelectronic Circuits. London, U.K.: Oxford Univ. Press, 2006.
[17] M.A. Eltawil, Z. Zhao, "Grid-connected photovoltaic power systems: Technical and potential problems—A review", Renewable and Sustainable Energy Reviews, Vol. 14, No. 1, pp. 112–129, Jan. 2010.
[18]Photovoltaic systems technology," Universitat Kassel, Kassel, Germany, 2003.