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A COMPARATIVE ANALYSIS OF SOLAR PV ARRAY FED MULTILEVEL INVERTER TOPOLOGIES

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Abstract—**In current power deficit era, the ever increasing global demand of energy during the last few decades had a significant impact on the climatic conditions such as pollution, global warming, and impact on ozone layer etc.Most reliable type of the renewable energy i.e. Solar Energy is utilized for powering utility in the proposed work of this paper.Many efforts has done to improve the performance of the system with minimum losses, distortion and as possible as the maximum efficiency by using different topologies of multilevel inverter and with different levels. All have their own benefits and limitations. Therefore in this paper comparative analysis and simulation of a various multilevel inverter fed by PV array based on Phase Opposition Disposition Pulse Width Modulation (PODPWM) technique is presented. The solar PV system used is modeled in SIMULINK library present in MATLAB.**

Keywords—**Photovoltic; Inverter ; PODPWM; Energy;**

I. INTRODUCTION

Renewable energy power has drawn extreme attention in today's world due to increasing fossil fuel prices, energy demands and clean environment hence studies on power generation and conversion devices become more necessary. The recent attention in environment protection and preservation increased the interest in electrical power generation from renewable source such as solar energy, wind energy and fuel cell. Apart from the rapidly decreasing reserves of fossil fuels in the world, another key factor working against fossil fuels is the pollution associated with their combustion. The main sources of world energy generation are the fossil fuels (gas, oil, coal) and nuclear power plants and due to the usage of those, greenhouse gases (CFC, CH_4, O_3, but mainly CO_2) emit into the atmosphere. Renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts. The renewable energy resources are sufficient enough to match the world energy requirement [1].The block diagram and detailed circuit diagram of the proposed work is shown in the fig 1.

Fig1. Block Diagram

II. MULTILEVEL INVERTERS; GENERAL IDEA

The concept of multilevel converters does not depend on just two levels of voltage to create an AC signal. Instead several voltage levels are added to each other to create a smoother stepped waveform, with lower dv/dt and lower harmonic distortions. With more voltage levels in the inverter the waveform it creates becomes smoother, but with many levels the design becomes more complicated, with more components and a more complicated controller for the inverter is needed. A three-level inverter design is similar to that of a conventional two-level inverter but there are twice as many valves in each phase leg. In between the upper and lower two valves there are diodes, called clamping diodes [2], connected to a neutral point. There are three basic level of topologies:

- Diode Clamped
- Flying Capacitor
- Cascade H-Bridge

A. Diode Clamped

The diode clamped converter provides multiple voltages through connecting the phases to a series capacitors banks shown in Fig.2. The concept can be increased to number of levels by increasing the number of capacitors. Earlier this methods was only limited to three levels in which two capacitors connected across the dc bus resulting in one additional level that is the neutral point, so the terminology neutral point clamped (NPC) inverter was introduced in the theories[3-10], [11], [12].

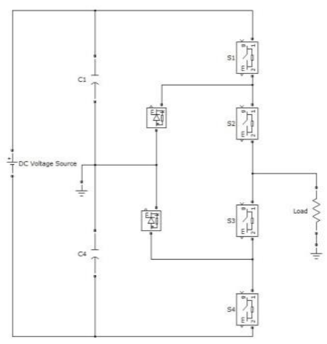

Fig.2 Three level diode clamped multilevel converter (NPC)

B. Flying Capacitor

This multilevel topology the flying capacitor involves series connection of capacitor clamped switching cells as shown in Fig.3. This has several advantages when compared to the diode clamped method. Like one feature is that added clamping diodes are not needed in this topology. Further, the flying capacitor converter has switching redundancy within the phase which can be used to balance the flying capacitors due to this only one dc source is required [3-10].

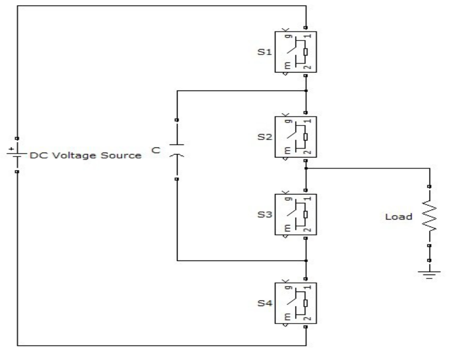

Fig 3 Three level flying capacitor multilevel converter

C. Flying Capacitor

In cascade H-bridge there are several different configurations as well. This topology consists of series power conversion units, the voltage and power level may be conveniently scaled. A noticeable disadvantage of this cascade H-Bridge topology is large number of isolated voltages are required to supply each cell unit separately [3-10]. In this study focus is on the increasing different levels in converters starting from basic three levels to the nine levels with their simulated results giving a comparison on using two different topologies neutral point (NCP) and cascade H-Bridge (CHB) type.

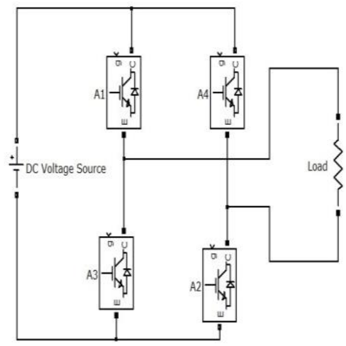

Fig4. Three level Cascade H-bridge multilevel converter

III. Phase opposition Deispostion Pulse Width modulation

In Phase Opposition Disposition (POD), the carrier signal above the zero axes is in phase with each other having same frequency and same amplitude. Consecutively below the zero axis the carrier wave have phase shifted 180 degree with the same frequency and same amplitude as the above zero axis. The figure demonstrates the PODPWM. The three level multilevel converter simulation sine wave and the triangular carrier shown in Figure 5.

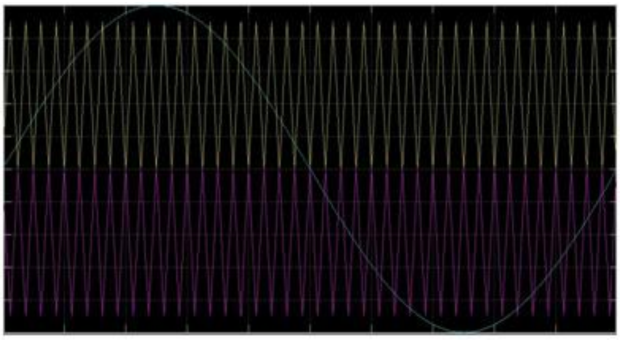

Fig 5.POD of three level Multilevel inverter

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IV. Solar PV System

The photovoltaic effect was discovered as early as 1839 by the French scientist Edmund Becquerel. When sunlight falls on the PV cell, it absorbs a part of this light through the semiconductor material. Photons with the energy greater than the band gap energy of the semiconductor are absorbed and dislodge the electrons from the atoms of the cell and create an electron-hole pair. These carriers are swept apart under the influence of internal electric fields of the p-n junction and create a current proportional to the incident radiation.

The physical process in which a PV cell converts sunlight into electricity is known as the photovoltaic effect.

An accurate PV cell electrical model is presented based on the Shockley diode equation. When light falls on the PV cell it generates current, hence PV cell acts like a current source rather than a voltage source. The current from PV cell is sensitive to the variation in the intensity of light or irradiance level.

Solar cells are photodiode (silicon diode) on a large scale & therefore some have some basic characteristics of p-n junction diode. Hence in the mathematical modeling of a PV cell diode is used along with current source.

An ideal Solar cell is modeled by a current source in parallel with a diode as shown in fig 6.

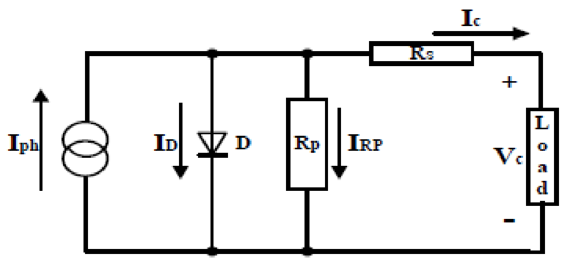

Fig 6. Equivalent model of solar cell

Solar photovoltaic energy system will have more influence in the future because of the development of eco-friendly power conversion. A solar panel which is consisting 36 cells in series is used in the study which produces approximately 21.6V in maximum sunlight condition. Solar cell has been simulated in SIMSCAPE library for different levels of multilevel converter [3], [10-11].

TABLE 1 Parameter used for solar cell

Parameter	Value
Voc	0.6 V
Isc	5 A
Irradiance used for measurements Ir0 (Standard)	1000 W/m2
Operating Irradiance Ir	1000 W/m2
Quality factor, N	1.5
Series resistance, Rs	0
Energy gap, Eg	1.12
No of cell connected in series,Ns	36
Cell reference Temp,Tr0	250C
Cell operating Temp, Tr	250C
Voc for module	0.6*36 = 21.6 V
Isc for module	5 A

V. SIMULATION AND ANALYSIS

MATLAB environment is used for the simulation purpose for inverter topologies. The solar PV system output is considered as 21.6 V. For Cascade H-bridge topology shown below when interfaced with solar panel of 0.6 V of cell each connected in series for 36 cells, if considering three level inverter solar panels of 21.6 V can give three level i.e. +21.6, 0, - 21.6 and as shown in figure 7. The output voltage waveform is shown in Figure 8, similarly the FFT analysis for the THD is displayed in figure 9.

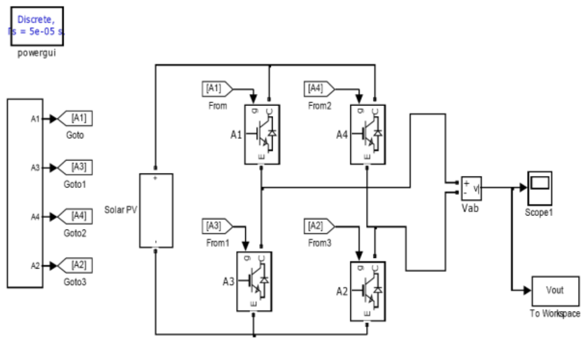

Figure 7 Three level cascade H-bridge multilevel converters interfaced with solar PV system

The total harmonics distortion using three level cascade H-bridge multilevel converters interfaced with solar PV system is 53.41%. Considering five level inverter two solar panels of 21.6 V each can produce five level i.e. +43.2V, +21.6V, 0, -21.6V and -43.2V, as shown in figure 4.9. The output-voltage waveform is shown in Figure 8. The output-voltage waveform is shown in Figure 8. Similarly the FFT analysis for the THD is displayed in figure 9.

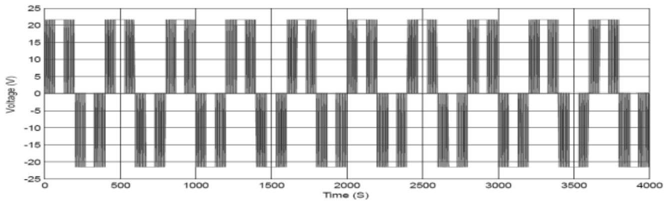

Fig 8. Output voltage waveform with respect to time of three level cascade H-bridge multilevel converter interfaced with solar PV

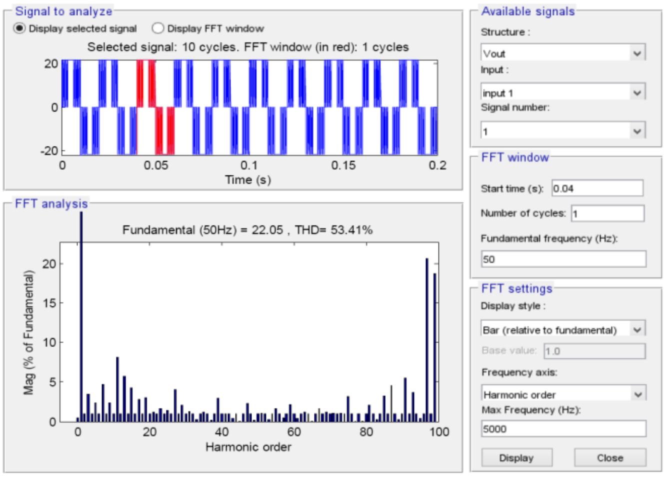

Fig 9. FFT Analysis of three level cascade H-bridge multilevel converters interfaced with solar PV System

Similar to the above presented cascade 3-level Bridgeinverter. Neutral point clamped inverters are also analyzed using FFT analysis up to eleven-levels and their corresponding harmonic distortion values are recorded which are presented in table 2.

Table II. Comparative analysis NPC and CHB topology of multilevel converter fed by solar PV supply in terms of Total Harmonic Distortion

Levels of Multi Level Inverters	THD %	
	Cascade H Bridge	Netural point Clamped
3	53.41	41.21
5	25.69	19.67
7	15.09	12.67
9	11.56	9.75
11	9.248	8.12

VI. CONCLUSION

This paper presents simulation of cascade H-bridge and Neutral point clamped multilevel converters up to eleven-level with their control strategies when interfaced with the solar PV system. As there is increase in the voltage levels through Neutral point clamped and Cascade H-bridge it reduces total harmonics distortion. The performance gets better dimensions in the sense it gives more or less a sinusoidal output voltage. Increasing the number of levels by these topologies is easily possible to large extends which is a new direction in this field. This study was to analyze the multilevel converter for different levels using Neutral point clamped and Cascade H-bridge solar PV system and to analyze their Total harmonics distortion. CHB is better in terms of switches count but it generates more THD than NPC. So in terms of no. of switches count CHB topology is better but in terms of THD the NPC is superior to CHB.

VII. FUTURE SCOPE

Future research scope should be focused on developing optimal control for such topologies. A multilevel technique for converters ensures a reduction of output harmonics as a result of sinusoidal output voltages so ends up in reduce grid filters, system cost and complexity reduction.

REFERENCES

[1] Giampaolo Buticchi, Member, IEEE, Davide Barater, Student Member, IEEE, Emilio Lorenzani, Member, IEEE, Carlo Concari, Member, IEEE, and Giovanni Franceschini "A Nine-Level Grid-Connected Converter Topology for Single-Phase Transformerless PV Systems" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 61, NO. 8, AUGUST 2014J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[2] Mohan Ned, UndelandTore M. and Robbins William P." Power Electronics Converters Applications and Design", John Wiley & Son, Inc. , Book, 1995.K. Elissa, "Title of paper if known," unpublished.

[3] J. Chavarria, D. Biel, F. Guinjoan, C. Meza, and J. Negroni, "Energy balance control of PV cascaded multilevel grid-connected inverters under level-shifted and phase-shifted PWMS," IEEE Trans. Ind. Electron., vol. 60, no. 1, pp. 98–111, Jan. 2013.[9] Surin Khomfoi and Leon M. Tolbert ,The University of Tennessee "Multilevel Power Converters".

[4] Nikhil Kumar, Suresh K Gawre, Deepak Verma, "Harmonics Mitigation of P&O MPPT Based Solar Powered Neutral Point Clamped Multilevel Inverter", International Journal of Applied Control, Electrical and Electronics Engineering (IJACEEE),Wireilla Publication, Australia, Vol. 2., No. 3., june, 2014.

[5] Dash, S.K.; Verma, D.; Nema, S.; Nema, R.K., "Comparative analysis of maximum power point (MPP) tracking techniques for solar PV application using MATLAB simulink," IEEE- Recent Advances and Innovations in Engineering (ICRAIE), 2014 , vol., no., pp.1,7, 9-11 May 2014

[6] S. B . Kjaer ,J .K.Pedersen,andF.Blaabjerg, "A review of single-phase grid-connected inverters forphotovoltaicmodules",IEEE Transactions on IndustrialApplications.,2005,41(5):1292–1306.

[7] S. Daher, J. Schmid, and F. Antunes, "Multilevel inverter topologies for stand-alone PV systems," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2703–2712, Jul. 2008.

[8] [14] S. Kouro, M. Malinowski, K. Gopakumar, J. Pou, L. Franquelo, B. Wu, J. Rodriguez, M. P. Andrez, and J. Leon, "Recent advances and industrial applications of multilevel converters," IEEE Trans.Ind.Electron.,vol.57, no. 8, pp. 2553–2580, Aug. 2010.

[9] Nikhil Kumar, Suresh K Gawre, Deepak Verma, "Physical Design and Modeling of 24v/48v dc-dc boost converter for solar PV application by using SIMSCAPE library in MATLAB", International Journal of Applied Control, Electrical and Electronics Engineering (IJACEEE), Wireilla Publication, Australia, Vol. 2., No. 2., May, 2014

[10] S. Kouro, M. Malinowski, K. Gopakumar, J. Pou, L. Franquelo, B. Wu, J. Rodriguez, and J. Leon, "Recent advances and industrial applications of multilevel converters," IEEE Trans.Ind.Electron.,vol.57, no. 8, pp. 2553–2580, Aug. 2010.

[11] Nikhil Kumar, Suresh K Gawre, Deepak Verma , "Modeling and Simulation of Solar Photovoltaic System and Interfacing withNeutral Point clamped MultilevelInverter", International Conference in Electrical, Electronics and Computer Science (ICEECS-2014), Chennai, Tamil Nadu, 30 March

[12] S. Kouro, M. Malinowski, K. Gopakumar, J. Pou, L. Franquelo, B. Wu, J. Rodriguez, and J. Leon, "Recent advances and industrial applications of multilevel converters," IEEE Trans.Ind.Electron.,vol.57, no. 8, pp. 2553–2580, Aug. 2010