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Comparative Analysis of Cascaded H- Bridge Inverter and RV Inverter Topology

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Abstract: ***This paper presents a comparative analysis of seven levels Cascaded-H-bridge inverter and RV topology based on SPWM control techniques. Three distinctive major multilevel inverter flying capacitor multilevel inverter, diode clamped multilevel inverter and cascaded multilevel inverter have been used in industrial application among them cascaded H-bridge multilevel inverter has more advantages compared to other two multilevel inverters as it requires less number of components and no voltage balancing problem. The main drawback of cascaded multilevel inverter is it requires isolated DC sources, increased number of components, complex firing method mainly used SPWM method which requires m-1 carrier signal for firing the power electronic switches which increases the complexity. In this paper, a new inverter topology with a reversing-voltage topology is compared with conventional cascaded H- bridge multilevel inverter to improve the multilevel performance. RV topology requires fewer components compared to existing inverter as RV topology requires less number of switches which reduce the number of gate drive circuit. Also a less number of the carrier signal is used in RV topology because this topology generates only positive cycle. Therefore, the overall cost and complexity are greatly reduced, particularly for higher output voltage levels.***

Keywords: Cascade Multi Level Inverter, New RV Topology, Total Harmonic Distortion, number of carriers.

1. Introduction

In today's era, most of equipment use in industrial, commercial, residential and utility application, require an AC supply as input. The inverter is a device that converts DC power to AC power at desired output voltage and frequency. Multilevel inverters have been widely accepted for high-power, high-voltage applications. Their performance is highly superior to that of conventional two-level inverters due to reduced harmonic distortion, lower electromagnetic interference, and higher DC link voltages [1]. The term Multilevel began with the three-level converter. The concept of multilevel converters has been introduced since 1975. Demerits of conventional two level inverter are less efficient, high cost, and high switching losses. To overcome these demerits, multilevel inverter is used.

Multilevel inverter produces a staircase output waveform, this waveform look like a sinusoidal waveform. The multilevel inverter output voltage having less number of harmonics compares to the conventional bipolar inverter output voltage.

Diode clamped multilevel inverter also known as Neutral Point Clamped (NPC) Inverter, the flying capacitors Multilevel Inverter (MLI) and cascaded multilevel inverter are various multilevel topologies use in industry. Among these multilevel topologies, cascaded multilevel inverter has preferred over FCMLI and DCMLI because it requires the least number of components and increases the number of levels in the inverter without requiring high ratings on individual devices and the power rating of the CCMLI is also increased [2]. The cascaded multilevel control method is very easy when compare to other multilevel inverter because it doesn't require any clamping diode and flying capacitor [2]. However, it has some disadvantages as complicated PWM controlling technique, increased number of components, complex power bus structure in approximate topologies, and voltage balancing problem. Each active semiconductor added requires associated gate drive circuits and adds further complexity to the converter. Another disadvantage of multilevel power converters is that the small voltage steps are typically produced by isolated voltage sources or a bank of series capacitors. Isolated voltage sources may not always be readily available, and series capacitors require voltage balancing [3]. Some new approaches have been recently suggested such as the topology utilizing low-switching-frequency, high-power devices [4]. Although the topology has some modification to reduce output voltage distortion, the general disadvantage of this method is that it has significant low-order current harmonics. It is also unable to exactly manipulate the magnitude of output voltage due to an adopted pulse width modulation (PWM) method. To overcome the disadvantage of cascaded multilevel inverter a new inverter topology has been proposed which has superior features over conventional topologies in terms of the required power switches and isolated DC supplies, number of carriers for PWM, complexity, cost, and reliability. In the RV topology, the switching operation is separated into high- and low-frequency parts.

2. Cascaded Multilevel Inverter

A cascaded multilevel inverter consist of a series connected single full bridge inverter, each full bridge inverter module required isolated DC source, So wind cell, fuel cells, solar cell and batteries etc. are used as an isolated DC source for cascaded multilevel inverter. The value of each isolated DC input is Vdc. Each full bridge inverter generates +Vdc, 0 and –Vdc output voltage level, by connecting the DC input to the output as terminal by using different switching combinations of the four semiconductor switches, at a time to switch is on to produce output voltage. The output voltage of cascaded multilevel inverter is equal to the summation of the output voltage of the each module connected in series [5,6]. The output voltage level for seven levels cascaded inverter are +3Vdc, +2Vdc, +Vdc, 0, –Vdc, – 2Vdc and -3Vdc by turning on the different combination of active switching devices. If M is the number of modules or number of DC source required and m is the number of output voltage level than the relation between the M and m is given by the equation. 1

$M = (m-1) /2$ (1)

The Fig. -1 shows the connecting diagram of single phase cascaded inverter and Table 1 shows the switching combination of active devices for various voltage levels.

The switching of active device of CCMLI depends upon the output voltage requirement, for example for seven levels cascaded inverter if we want output voltage +3Vdc Switch S1, S4, S5, S8, S9 and S12 are ON other switches are Off. The switching combination of active devices for various voltage levels is given in Table-1

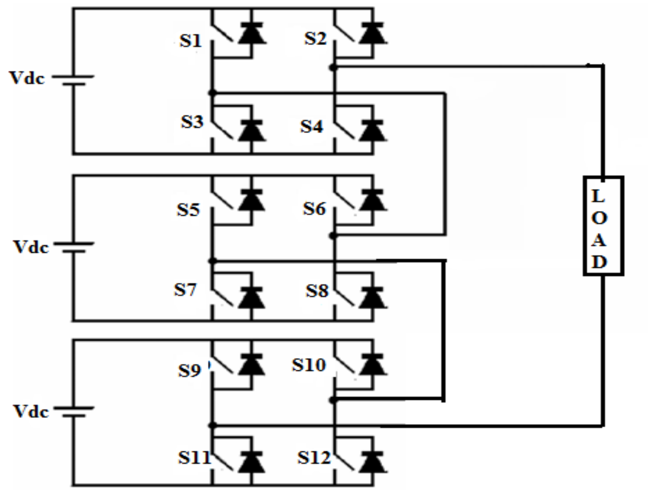

Figure 1: Single phase Seven level Cascaded Inverter

Table-1. Switching states

Vo	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
3Vdc	1	0	0	1	1	0	0	1	1	0	0	1
2Vdc	1	0	0	1	1	0	0	1	0	0	1	1
Vdc	1	0	0	1	0	0	1	1	0	0	1	1
0	1	0	1	0	1	0	1	0	1	0	1	0
-Vdc	0	1	1	0	1	1	0	0	1	1	0	0
-2Vdc	0	1	1	0	0	1	1	0	1	1	0	0
-3Vdc	0	1	1	0	0	1	1	0	0	1	1	0

Various types of control scheme are used to turn on the switches of multilevel inverter.

The most popular control technique for inverters is the Carrier based sinusoidal pulse width modulation techniques. Carrier based SPWM methods have more than one carrier that can be triangular waves, sawtooth wave shape and so on and one sinusoidal reference signal. If an m-level inverter is employed, m - 1 carrier will be needed. Phase disposition, alternative phase opposition disposition and phase opposition disposition method are used for Cascaded H bridge Inverter out of which PD method is preferred due to the lower value of THD but all these methods required six carriers and one modulating signal for seven levels cascaded inverter.

All these carrier disposition methods used the intersection of a sine wave with a triangular wave to generate firing pulses. When sine wave is greater than the triangular signal, then the corresponding switch is on [7].

For example, for seven level inverter:

- The inverter gives the output voltage +3Vdc when the sine wave is greater than all the six carriers (Three carriers above the zero line and three carriers below the zero line).
- The inverter gives the output voltage +2Vdc when the sine wave is less than the uppermost carrier and greater than the other carriers.
- The inverter gives the output voltage +Vdc when the sine wave is less than the two upper most carriers and greater than the other carrier
- The inverter gives the output voltage zero when a sine wave is lower than the all three carriers above the zero, but greater than all three carrier below the zero.
- The inverter gives the output voltage –Vdc when the sine wave is greater than the two lowest carriers and less than the other carriers
- The inverter gives the output voltage –2Vdc when the sine wave is greater than the lowest carrier and less than the other carriers.
- The inverter gives the output voltage –3Vdc when the sine wave is less than all the carriers.

3. RV Topology

This paper presents an overview of a multilevel inverter topology named reversing voltage (RV). This topology requires less number of components and requires easy control techniques compared to conventional topologies. RV Topology is also more efficient since the inverter has a component which operates at a low switching frequency (line frequency). So in this topology no need for all switches to work on high frequency which leads to simpler and more reliable control of the inverter [8,9].

This paper describes the general seven level RV inverter which can be extended to any number of voltage levels by duplicating the middle circled stage as shown in fig. 2

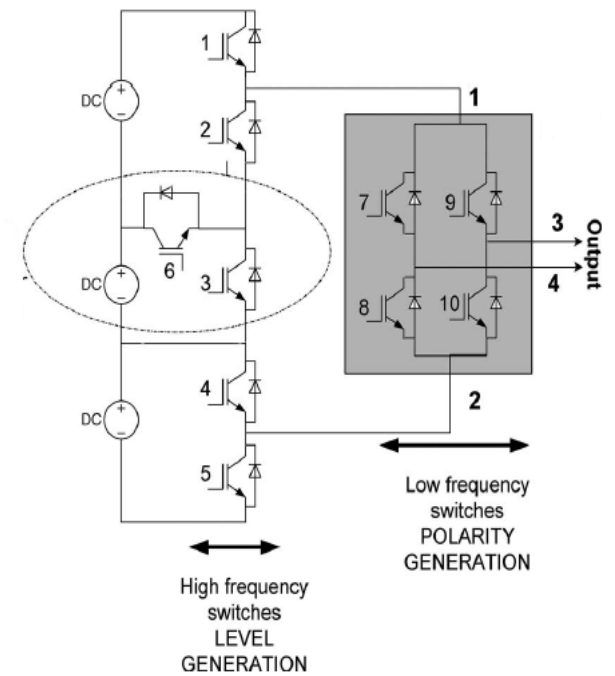

Figure 2: Schematic of a seven-level inverter in single phase.

In conventional multilevel inverters, a combination of power semiconductor switches are use to produce a high-frequency output voltage level in positive and negative polarities, but in RV topology all the switches are not used for generating bipolar levels. This topology is a hybrid multilevel topology which separates the output voltage into two parts. One part is named as level generation part and it is responsible for level generating in positive polarity. This part requires high-frequency switches to generate the required levels. The other part is called polarity generation part and it is responsible for generating the polarity of the output voltage, which is the low-frequency part operating at line frequency [8,9].The block diagram for RV topology is shown in fig. 3

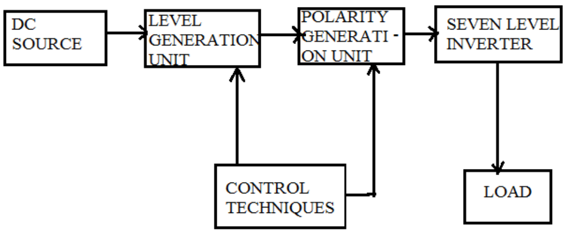

Figure 3: Block Diagram of RV Topology

The RV topology as shown in fig. 2 requires ten switches and three isolated sources for seven level output. The principal idea of this topology as a multilevel inverter is that the left stage in Fig. 2 generates the required output levels (without polarity) and the right circuit (full-bridge converter) decides about the polarity of the output voltage. This part, which is named polarity generation, transfers the required output level to the output with the same direction or opposite direction according to the required output polarity. It reverses the voltage direction when the voltage polarity requires to be changed for negative polarity. This topology requires fewer components in comparison to conventional inverters. Another advantage of the topology is that it just requires half of the conventional carriers for SPWM controller. SPWM for seven-level conventional converters consists of six carriers, but in this topology, three carriers and one modulating signal are sufficient as shown in fig. 4. The reason is that, according to Fig. 2, the multilevel converter works only in positive polarity and does not generate negative polarities. Full bridge inverter is used to generate the polarity.

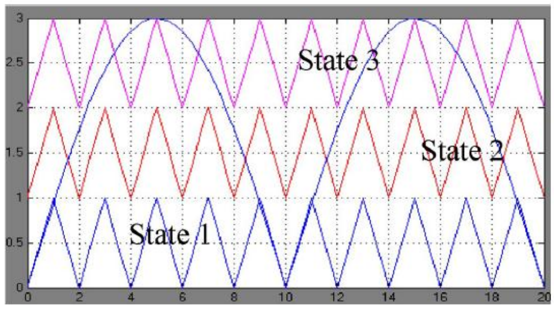

Figure 4: Phase disposition Carriers and Modulating signal

- The RV Inverter Topology gives output voltage + 3Vdc when the absolute sine wave is greater than all the three carriers.
- The RV Inverter Topology gives output voltage + 2Vdc when the absolute sine wave is greater than two carriers but less than the highest carrier.
- The RV Inverter Topology gives output voltage +Vdc when the absolute sine wave is less than the two upper carrier and greater than the lowest carrier.
- The RV Inverter gives output voltage 0 when the absolute sine wave is less than the all three carriers.

The switching of active device for level generation depends upon the output voltage requirement, for example for seven level RV Topology if we want output voltage +3Vdc Switch 1 and 5 is ON other switches are Off. The switching combination of active devices for various voltage levels is given in Table-2

Table-2. Switching states

Level / Mode	0	Vdc	2Vdc	3 Vdc
1	2,3,4	2,3,5	1,4	1.5
2		2,4,6	2,6,5	

4. Comparison of these Two Topology

- Number of Carriers: Cascaded H Bridge inverter required N-1 carriers and RV topology required (N-1) /2 carriers, where N is the number of output voltage levels.
- Even Harmonic is present in Cascaded H bridge inverter but not in RV topology for Phase Disposition SPWM techniques.
- One of the advantages of RV topology is, it requires less number of high-switching-frequency components. High-frequency switches are expensive and more prone to damage compared to low frequency switches.
- Number of components: For single phase inverter Cascaded H-bridge Inverter required 2 (N-1) main switches, (N-1) /2 isolated power supply. RV topology

requires (N-1) +4 main switches and (N-1) /2 isolated power supply.

- Due to less number of carrier and component cost and complexity of RV topology is reduced.
- Due to less number of high frequency switches output voltage THD reduces in RV Inverter Topology [10,11].

5. Conclusion

In this paper comparative analysis of cascaded H bridge inverter and reverse voltage inverter topology is presented and found that a reverse voltage balancing topology is superior over the conventional cascaded H bridge inverter in terms of number of carriers, cost, complexity, control requirement, no of component and output voltage THD. Output voltage THD has reduced in reverse voltage balancing Topology because less high frequency switches are used. High frequency switches only use for level generation.

References

[1] D.Mohan, Sreejith B.Kurub, "A Comparative Analysis of Multi Carrier SPWM Control Strategies using Fifteen Level Cascaded H – bridge Multilevel Inverter", International Journal of Computer Applications, Vol. 41, No.21, PP.7-11 March 2012.

[2] A.Mahendran, K.Muthulakshmi, R.Nagarajan, "Triangular Multicarrier SPWM Technique for Nine Level Cascaded Inverter", International Journal of Scientific & Engineering Research, Vol. 4, Issue 5, PP.269-275, May 2013.

[3] K.VEENA , K.ROOPA, "A New Rv Multilevel Inverter For Induction Motor Drive Applications", The International Journal Of Engineering And Science, pp.69-77, 2014.

[4] A. Jidin, N. R. N. Idris, A. H. M. Yatim, T. Sutikno, and M. E. Elbuluk,"An optimized switching strategy for quick dynamic torque control in DTC-hysteresis-based induction machines", *IEEE Trans. Ind. Electron.*,vol. 58, no. 8, pp. 3391–3400, Aug. 2011.

[5] P. Vinod Kumar, Ch. Santosh Kumar and K. Ramesh Reddy, "Single Phase Cascaded Multilevel Inverter using Multicarrier PWM Techniques", ARPN Journal of Engineering and Applied Sciences, Vol.8, No.10, PP. 796-799, October 2013.

[6] M. S. Sivagamasundari and Dr. P. Melba Mary, "Multicarrier PWM Technique for the Performance Improvement of Single Phase Five Level Inverter with Coupled Inductors", International Global Research Analysis, Vol. 5, PP. 76-78, May 2013.

[7] K. Gopalakrishnan, M. Sundar Raj and T. Saravanan, "Harmonic Evaluation of Multicarrier Pwm Techniques for Cascaded Multilevel Inverter", Middle-East Journal of Scientific Research, Vol.7, No.20, PP. 819-824, July 2014

[8] Ehsan Najafi and Abdul Halim Mohamed Yatim, "Design and Implementation of a New Multilevel Inverter Topology" , IEEE Trans.on Ind. Electronic, Vol.59, no.11, pp. 4148-4154, November 2012.

[9] Dileep.K and B.Satish, "A New Reverse Voltage (RV) Topology for Multi Level Inverters Fed to Induction Motor Drive, International Journal of Engineering Research & Technology (IJERT), Vol. 3, Issue 1, pp. 2621-2627, January - 2014.

[10] P.Himabindu and S.Mallikarjunaiah, "Multilevel Inverter for Induction Motor Drives Using Reversing Voltage Topology", IJAREEIE, Vol.3, Issue 12, PP. 14078-14081, December 2014.

[11] Saipadhma.S Sangeetha.S Kannabiran.A, "Comparison of Modulation Techniques for Cascaded and Reverse Voltage Multilevel Inverter Topologies", International Journal of Advanced Trends in Computer Science and Engineering, Vol.2, No. 2, PP. 261-266, 2013