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A Comparison Study of Seven Level Inverter Using Cascaded H-Bridge and Reversing Voltage Topology

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ABSTRACT: Multilevel inverters have drawn tremendous interest in high power and high voltage applications. Multilevel inverters have unique structure which makes them possible to achieve high voltage with lesser harmonic distortion. As the number of output levels increases harmonic content of output waveform decreases. Multilevel inverters are classified as cascaded multilevel inverters, Diode clamped multilevel inverter and Flying capacitor inverter. The control of Cascaded H-bridge multilevel inverter is more convenient than other multilevel inverters because it doesn't have any clamping diodes and flying capacitor. Cascaded multilevel inverters are based on a series connection of several single phase inverters. In this paper a new topology called Reversing voltage is implemented to improve multilevel performance and comparing the results with cascaded multilevel inverter. This topology requires less number of components compared to conventional multilevel inverters. The control method based on SPWM and comparison with cascaded multilevel inverter is also presented. Finally simulation and experimental results are presented and discussed.

KEYWORDS: Seven level Inverter, Reversing Voltage Topology, Phase Disposition PWM, Level Generator, Polarity generator.

I. INTRODUCTION

Multilevel inverter is recognized as an important alternative to the two level inverter especially in high power applications[1]. Multilevel inverters are promising that they have nearly sinusoidal output voltage waveforms, less stress in the switching device, output current with better harmonic profile, switching losses are less compared to the conventional two-level inverters, smaller filter size, lower EMI, all of which make them cheaper, lighter and more compact[2]. Multilevel inverter circuit consists of a group of switching components and DC supplies, which makes output voltage in stepped waveforms. A conventional voltage source inverter can produce output voltage or current with levels 0, +Vdc, -Vdc[3]. In order to produce a quality output voltage or current waveform with less ripple content, they require high switching frequency. In high voltage applications two level inverters have some limitations in operating at high frequency mainly due to device constrains and switching losses. These limitations can be overcome using the multilevel inverters. The main function of multilevel inverter is to produce a high voltage from several levels of dc voltages that can be fuel cells, batteries etc. By increasing the number of levels, the output voltages have more steps with reduced harmonic distortion. As the number of levels increases the number of active switches also increases for cascaded multilevel inverters. In recent years, there has been a substantial increase in interest to multilevel power conversion. Some applications include industrial drives, flexible ac transmission systems and vehicle propulsion. One area where multilevel inverters are particularly suitable is that of renewable photovoltaic energy that efficiency and power quality are of great concerns for the researchers[3]. .

II. THE PROPOSED TOPOLOGY

In conventional multilevel inverters the switching components are combined to generate the output voltage in positive and negative half cycle[1].Fig. 1 shows the block diagram of reversing voltage topology. By the new reversing voltage topology there is no need to utilize all the switches in the bipolar levels. This is a hybrid multilevel inverter topology

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which separates the output voltage into two parts. One part is called the level generation part which is responsible for generating the levels in the positive polarity. This part requires high frequency switches. The switches in this part must require high switching frequency capability. The other part is called the polarity generation, which is responsible for generating the polarity of the output voltage. This part requires low frequency switches which is operating at the line frequency. This topology combines the two parts to generate multilevel output voltage. In order to obtain a complete multilevel output voltage, positive levels are generated by the high frequency part and this part is fed to a full bridge inverter which will generate required polarity of output voltage. This will eliminate many of the switches which are responsible to generate the output voltage levels in positive and negative polarity[4].

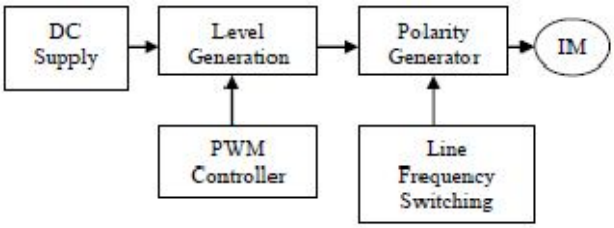

Fig. 1 Block diagram of proposed topology

RV topology in seven levels is shown in Fig.2. The circuit contains ten switches and three isolated power supplies. Here the left stage in fig.3 generates the required levels (without polarity) and the right circuit generates the polarity of the output voltage[6]. The polarity generation part transfers the output level to the output with same or opposite direction according to the required polarity. Cascaded seven level inverter is shown in Fig.3. Cascaded multilevel inverter consists of a series of H-bridge inverter units. Cascaded topology has no voltage sharing problem[12]. Cascaded seven level inverter consists of 12 switches. In the case of reversing voltage topology the total number of semiconductor switches are less compared to the cascaded inverters. The limitation of H-bridge is the requirement of isolated supply for each H-bridge. For applications without isolated power supplies, the requirement of capacitors and complexity of its control increases as the number of levels increases which restricts its application. In the reversing voltage topology, the switching sequences are simpler compared to the conventional topologies. Since there is no need to generate negative pulse for negative cycle control, there is no need for providing extra conditions for the negative cycle control[11].

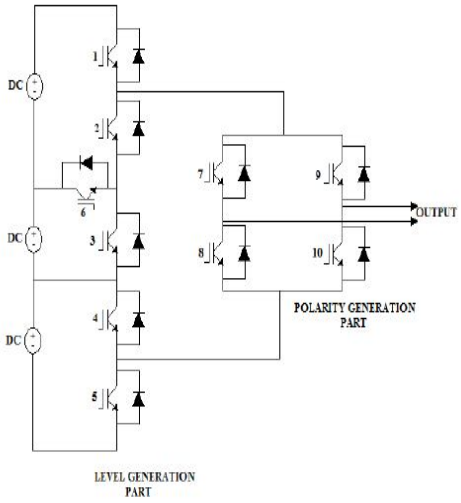

Fig. 2 Single phase seven level inverter using RV topology

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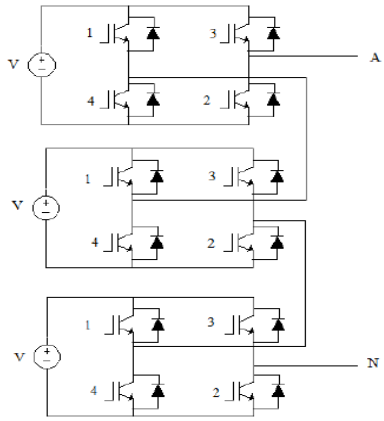

Fig. 3 Cascaded seven level inverter

III. PDPWM MODULATION STRATEGY

Multicarrier PWM techniques entail the neutral sampling of a single modulating or reference waveform typically being sinusoidal same as that of output frequency of the inversion system, through several carrier signals being triangular waveforms of higher frequencies of several KHz. In PDPWM, (m-1) carrier signals are compared with a single reference signal, where m is the number of levels[10]. Fig. 4 shows the PDPWM for a seven level inverter, 6 carrier triangular signals are compared with a single sinusoidal signal. The carrier signals have the same amplitude and frequency and are same. This technique involves a number of carriers (m-1) which are all in phase accordingly. According to that gate pulses are generated and are applied to each of the switching devices. By the reversing voltage topology, there is no need to generate pulse in the negative polarity. The polarity of output voltage is determined by the polarity generation part where low frequency switches are used. Carriers in this method do not have any coincidence, and they have definite offset from each other.

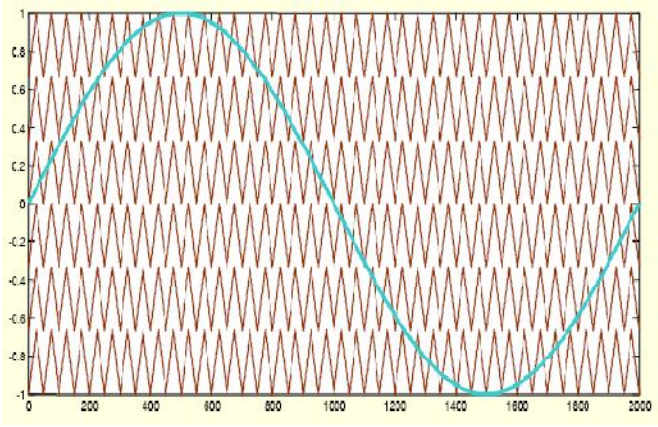

Fig. 4 Carrier and modulator for RV topology

Table. 1 shows the switching sequence for each level for seven level inverter. There are six possible switching patterns to control the inverter. In this topology there is isolated dc supplies are utilized so that ther is no voltage balancing problem. In order to avoid unwanted voltage levels during switching cycles, the switching modes should be selected so that the switching transitions become minimal during each mode transfer. This will help to decrease switching power dissipation. Compared to cascade multilevel inverters, it requires one third of dc supplies. Because of fixed voltage sources, there is no voltage balancing problem. Another advantage of this topology is that it requires half the carriers compared to conventional SPWM techniques. In conventional SPWM, a seven level inverter requires six carriers, but

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in this topology only three carriers are sufficient. The reason is that, the inverter works only in the positive polarity and does not generate negative pulses.

Table.1 Switching sequences for each level

Level	0	1	2	3
1	2,3,4	2,3,5	1,4	1,5
2		2,4,6	2,6,5	

IV. SIMULATION RESULTS

Fig.5 shows the simulink model of a 300Vdc Cascaded single phase seven level inverter for R-L load in Matlab Simulink. From this simulink model the output voltage, THD observed as follows. In cascaded seven level inverter six carriers are compared with a single sinusoidal signal for pulse generation. As the number of levels increases the control method bcome more complex.

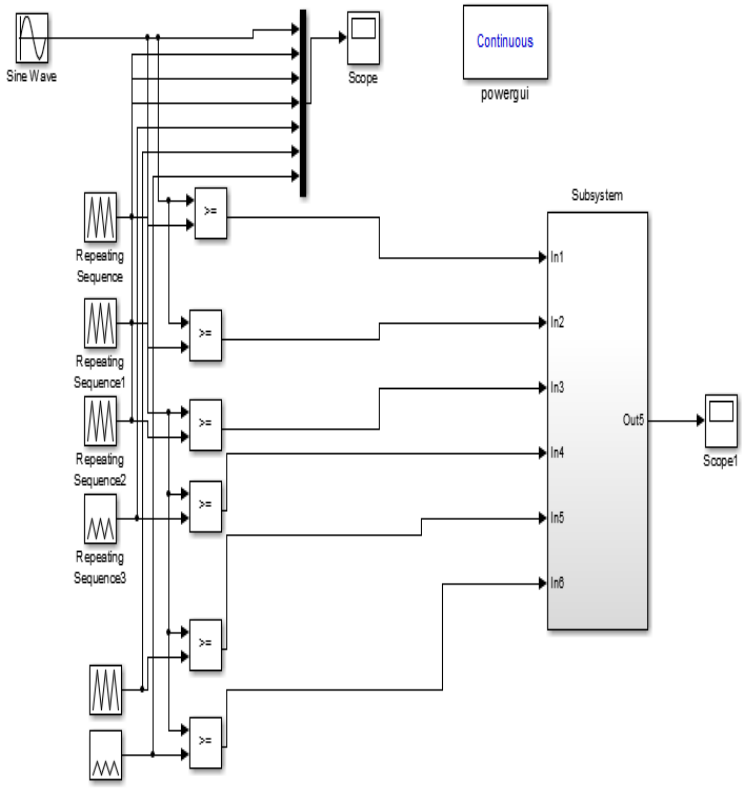

Fig. 5 Simulink model of Cascaded seven level inverter

Fig. 6 shows the output voltage of cascaded seven level inverter. Cascaded multilevel inverter consists of series of H bridges. For seven level inverter, three H bridges are considered consisting of four switches in each level. For seven levels, (N-1) carriers are required. Seven carrier triangular signals are compared with a single sinusoidal signal.

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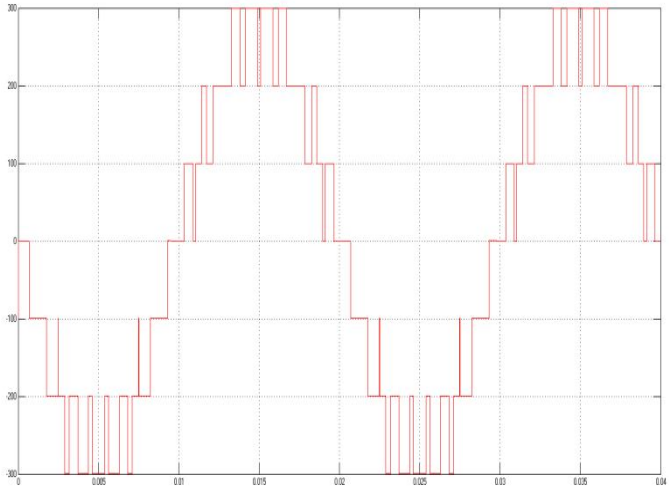

Fig. 6 Output voltage of cascaded seven level inverter for RL-load

In reversing voltage topology, the circuit consists of two parts level generation part and polarity generation part, shown in Fig.7. The level generatior generates the seven levels in positive polarity only and then the polarity generator determines the required polarity of output voltage.

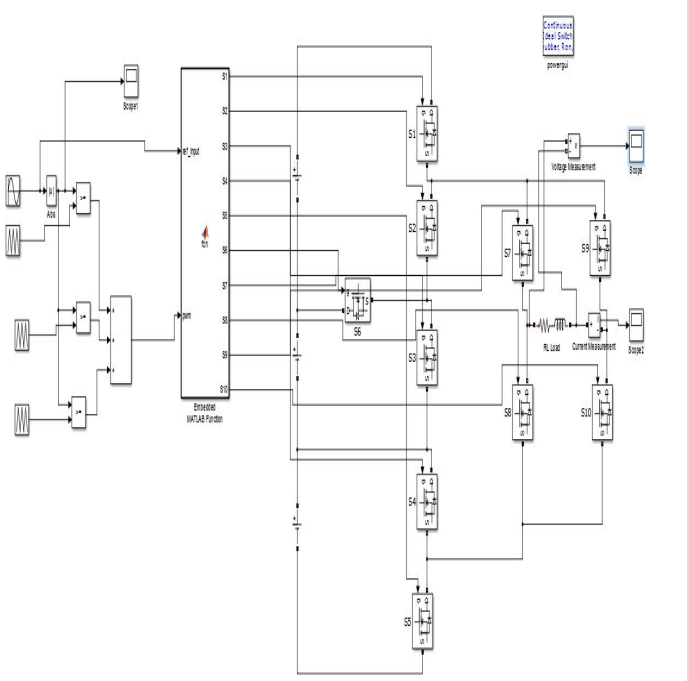

Fig. 7 Simulink model of seven level inverter using RV topology

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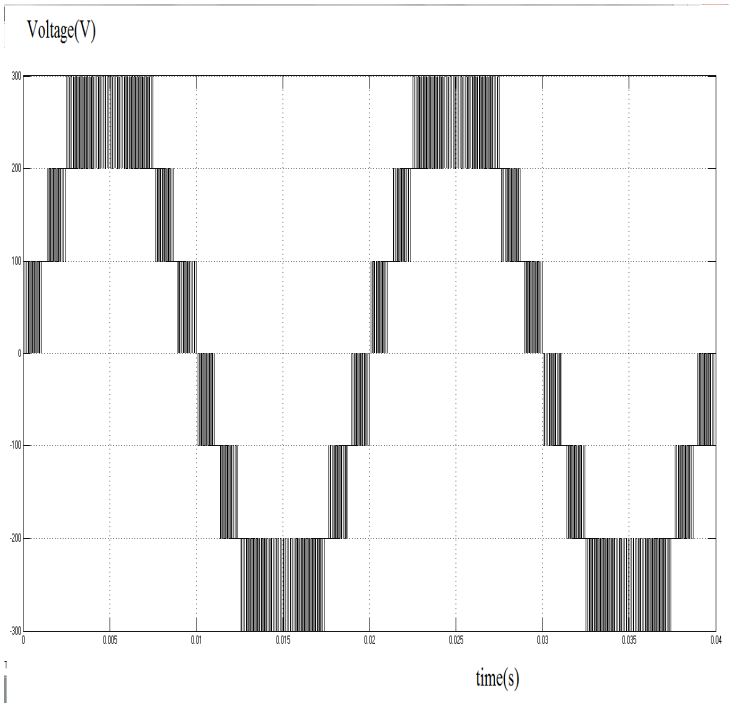

Fig. 8 Output voltage of seven level inverter for RL load

Fig. 8 shows the output voltage of seven level inverter using RV topology. Fig. 9 shows the output current of seven level inverter for RL load, R=100Ω and L=25Mh. From the current output it is clear that inverter can provide perfect sinusoidal current without any filter circuit. RV topology can provide perfect sinusoidal current compared to cascaded inverter.

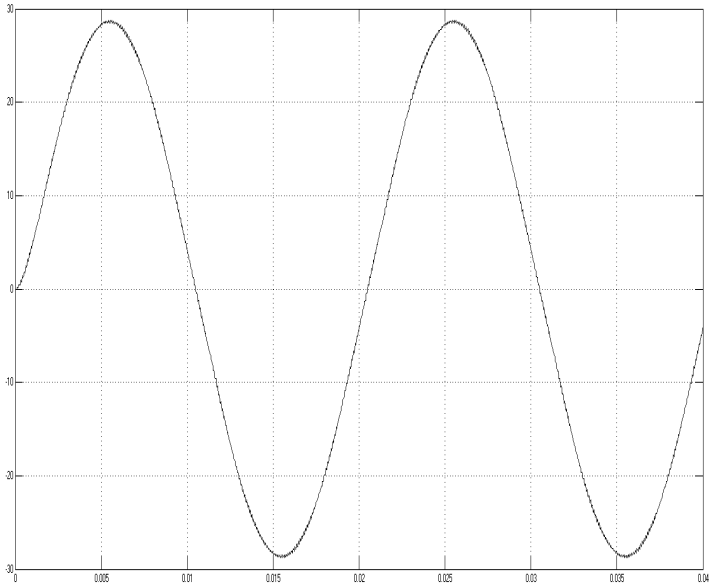

Fig. 9 Output current of seven level inverter for R-L load

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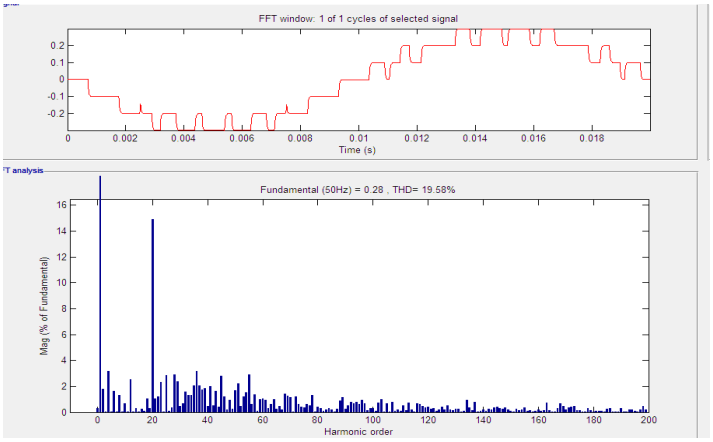

Fig. 10 THD of cascaded seven level inverter

Fig.10 shows the THD analysis of cascaded seven level inverter. THD of seven level output voltage is obtained as 19.58%.

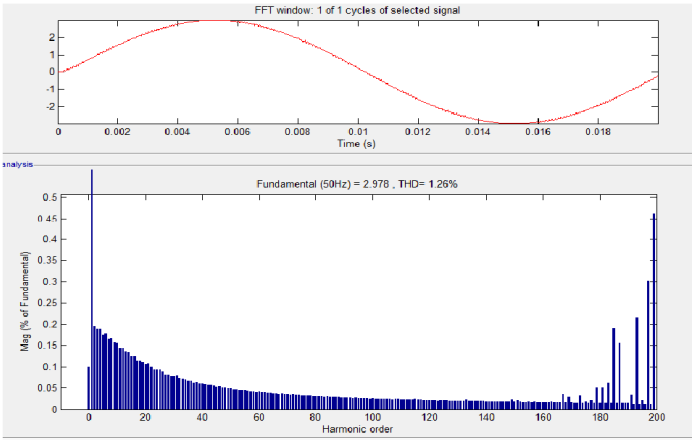

Fig. 11 THD of seven level inverter using RV topology

Fig. 11 shows THD of seven level inverter using RV topology.From the THD waveforms it is found that the proposed topology possess better improvement in THD compared to the cascaded topology. For RV topology the THD of output curent is 1.26% and for the conventional cascaded inverter it is 19.58%.

V.CONCLUSION

In this paper, a new inverter topology is proposed having advantages over the conventional topologies and compared the results with conventional cascaded inverter. The proposed topology requires lesser number of components compared to the conventional inverters. The proposed topology is better for all applications because it has less control complexities and cost is also less. The PWM for this topology is less complex because it generates gate pulses for positive cycle only. This will improve the efficiency of the inverter as well as size and cost of the whole set up. The results clearly show that the proposed topology can be efficiently work as a multilevel inverter with reduced number of switches. Simulation results show the performance of cascaded seven level inverter and seven level inverter using reversing voltage topology.

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