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MULTILEVEL INVERTER EMPLOYED ON SHUNT ACTIVE POWER FILTER WITH SINGLE PHASE DISTRIBUTION SYSTEM

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ABSTRACT

The main aim of this project is modeling and simulation of ninelevel inverter based on shunt active power filter with single phase distribution system. To provide high power quality at the Point of Common Coupling (PCC) of power distribution systems, elimination of the harmonic is indispensably necessary. Most of the important international standards have defined the power quality and given some harmonic limits. Different methods are proposed in literature for solving the harmonic problems. One of these methods, the Active Power Filters (APFs) technique has been studied and developed in the recent years to solve the harmonic problems. The main objective of this paper is single phase multilevel cascaded H-Bridge inverters are used wherein the output waveform has several voltage levels leading to a better and more sinusoidal voltage waveform. As the number of voltage levels reach infinity, the output THD approaches zero. As a result, a lower total harmonic distortion (THD) is obtained. This is proposed, by using MATLAB simulation.

Key words: Shunt active filter, point of common coupling, THD, Multilevel inverter, Harmonics

I.INTRODUCTION

Pulse Width Modulated (PWM) inverters havebeen used for both harmonic compensation and staticVAR compensation. However, the high initial andrunning costs have been hindering their practical use inpower distribution systems. In addition, it is difficult forPWM-inverter-based active filters to comply with electromagnetic interference (EMI) requirements.A cascade multilevel inverter has been proposedfor both harmonics and static var compensation applications. The new cascade inverter eliminatesthe bulky transformers required by Static VAR Compensators (SVC's) that employ the multipulse inverter andcan respond much faster. This inverter generates almostsinusoidal staircase voltage with only one time switchingper line cycle. Its superior suitability has been demonstrated for VAR compensation. When the cascade inverter is applied to line conditioning and active power filtering of a distribution system, it is expected that the initial and running costs and the EMI will be dramatically reduced below that of the traditional PWM inverter. The new cascaded multilevel inverter, however, poses challenging problems for both harmonic filtering and reactive power (VAR) compensation, such as voltage control and balance of each dc capacitor.

A multilevel inverter is more recent and popular type of power electronic converter that synthesizes a desired output voltage from several levels of dc voltages as inputs. If sufficient number of dc sources is used, a nearly sinusoidal voltage waveform can be synthesized. In comparison with the hard-switched two-level pulse width modulation inverter, multilevel inverter offers several advantages such as, its capabilities to operate at high voltage with lower dv/dt per switching, high efficiency and low electromagnetic interference. The general concept involves utilizing a higher number of active semiconductor switches to perform the power conversion in small voltage steps. Nowadays, multilevel inverters have achieved increasing contribution in high performance applications. Recently, for high-performance power application, multilevel converters are widely used such as static var compensators, drives and active power filters. The advantages of multilevel inverters are good power quality, high voltage capability and low switching losses. The topologies of multilevel Inverters are classified into three types, that is, the flying capacitor, diode clamped and cascaded multilevel inverters. Among these inverter topologies, the cascaded H-bridge multilevel inverters require the least number of total main components.

The general function of this multilevel inverter is to synthesize a desired voltage from several separate dc sources (SDCSs), which may be obtained from batteries, fuel cells, or solar cells. These techniques take advantage of special properties available in multilevel inverter to minimize total harmonic distortion and increase output voltage. A multilevel converter has several advantages over a conventional two-level converter that uses high switching frequency pulse width modulation (PWM).

A cascaded multilevel inverter has several advantages they are, when compared with diode-clamped and flying capacitors inverters, it requires the least number of components to achieve the same number of voltage levels and optimized circuit layout and packaging are possible because each level has the same structure and there are no extra clamping diodes or voltage-balancing capacitor and Soft-switching techniques can be used to reduce switching losses.

III. PROPOSED SYSTEM

The basic function of the shunt active power filter isto eliminate harmonics and meet the reactive power requirements of the load locally so that the ac supply feedsonly the sinusoidal balanced unity power factor currents.The desired APF currents are estimated by sensing theload current, dc bus voltage, and source voltage . Inthis section a shunt active power filter is designed for a power distribution systems using a conventional PWM based inverter, which is used for both harmonics and reactive power compensation. The basic building block of the conventional shunt active power filter isshown in Fig. 1.

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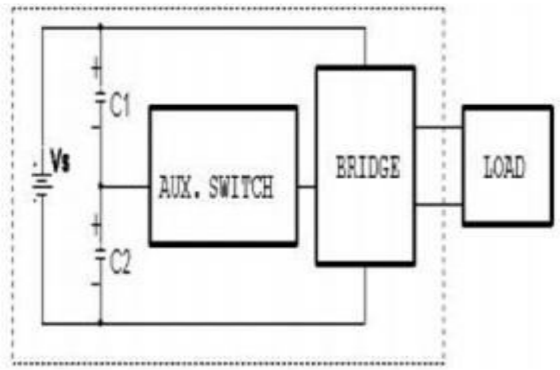

Figure1.Newtopologyblockdiagram

IV.CASCADEDE MULTILEVEL INVERTER

A cascaded multilevel inverter consists of a series of H-bridge single-phase, full-bridge inverter units. Figure 2 Shows the basic structure of a single-phase cascaded inverter with SDCSs. The ac terminal voltages of different level inverters are connected in series. Unlike the diode-clamp or anflying-capacitors inverters, the cascaded inverter does not require any voltage-clamping diodes or voltage-balancing capacitors. Each inverter level can generate three different voltage outputs, +Vdc, 0, and -Vdc , by connecting the dc source to the ac output side by different combinations of the four switches, S1, S2, S3, and S4. Using the top level as the example, turning on S1 and S4 yields $va4 = +Vd$. Turning on S2 and S3 yields $va4 = -Vd$. Turning off all switches yields $va4 = 0$. Similarly, the ac output voltage at each level can be obtained in the same manner. If NSis the number of dc sources, the output phase voltage level is m=NS+ 1. Thus, a five-level cascaded inverter needs four SDCSs and four full bridges. Controlling the conducting angles at different inverter levels can minimize the harmonic distortion of the output voltage The output voltage of the inverter is almost sinusoidal, and it has less than 5% total harmonic distribution (THD) with each of the H-bridges switching only at fundamental frequency. If the phase current ia , as shown in below Figure 6, is sinusoidal and leads or lags the phase voltage van by 90o , the average charge to each dc capacitor is equal to zero over one cycle. Therefore, all SDCS capacitor voltages can be balanced. By connecting the sufficient number of H-bridges incascade and using proper modulation scheme, nearly sinusoidal output voltage waveform. The number of levels in output phase voltage is 2s + 1, where s is the number of H-bridges used per phase. Figure 3 shows an 9-level output phase voltage waveform using four H-bridges. The magnitude of the ac output phase voltage is given by $van = va1 + va2 + va3 + va4$.

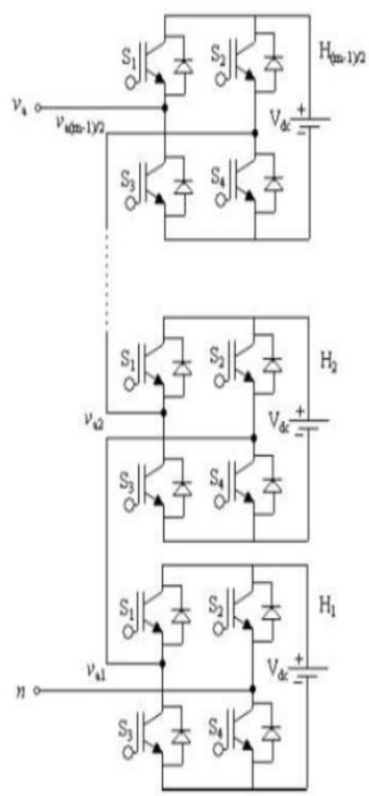
Figure 2: Single-Phase Multilevel Cascaded H-Bridge Inverter

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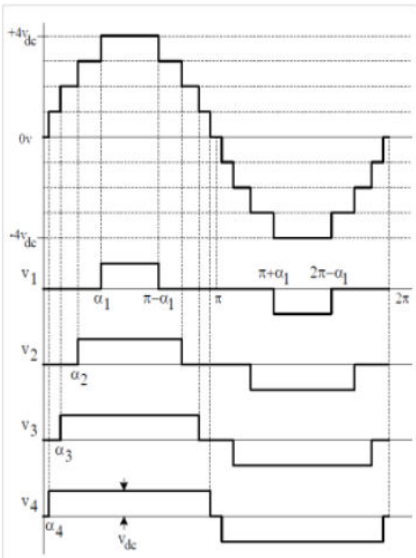

Figure 3: Output Waveform of 9-Level Phase Voltage

V.SIMULATION RESULTS

Figure 4 shows the Simulink Model of nine level CHB inverter with phase shifted carrier sinusoidal PWM technique.

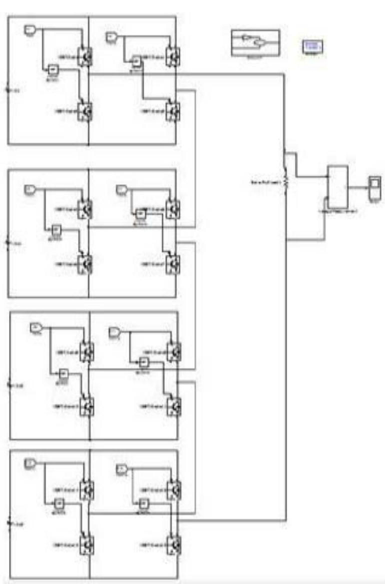

Figure 4: Simulink Model of Nine Level CHB Inverter with Phase Shifted Carrier Sinusoidal PWM

The nine level CHB inverter with phase shifted carrier sinusoidal PWM output voltage waveform is shown in Figure 5. From Figure 14 it is found that the dv/dtof nine level inverter is 200 V.

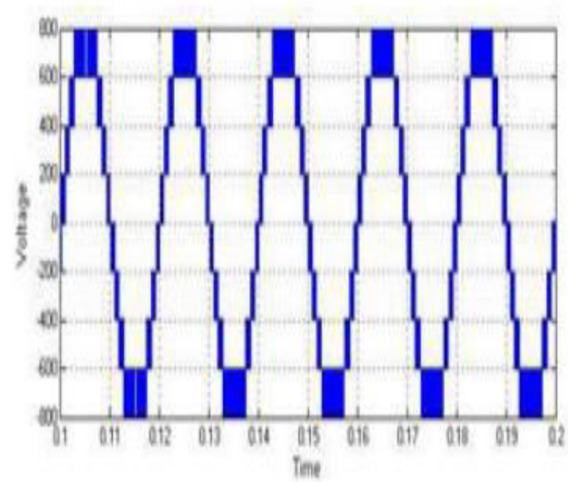

Figure 5.Output Voltage Waveform of Ninelevel CHB Inverter

The FFT analysis of output voltage wave form is shown in Figure 6.In this figure it is observed that the dominantharmonic is shifted to further high frequency zone and its frequency is 23850 and 24550 Hz.

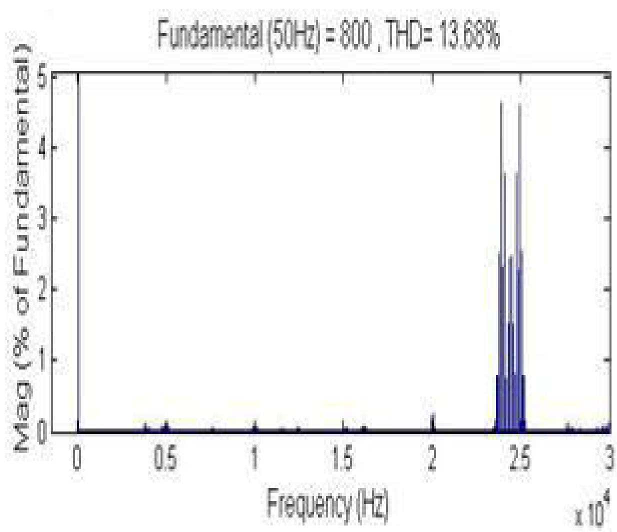

Figure 6: Spectrum Analysis of Output Voltage of Nine Level CHB Inverter

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Table 2. Content of harmonics in source voltage (V_{AN}) (from th simulated results).

S No	Order of Harmonics	with shunt APF using PWM based inverter (in %)	with Shunt APF using proposed cascaded-inverter (in %)
1	Fundamental	100	100
2	2^{nd}	10.92	10.00
3	3^{rd}	9.71	7.12
4	4^{th}	7.01	3.91
5	5^{th}	1.05	1.6
6	6^{th}	4.06	0.17
7	7^{th}	4.19	1.14
8	8^{th}	2.92	0.79
9	9^{th}	1.77	0.77
10	11^{th}	1.54	0.44
11	13^{th}	2.29	0.11
12	15^{th}	0.47	0.23
13	17^{th}	1.45	0.57
14	19^{th}	0.45	0.45
15	21^{st}	0.93	0.31
16	23^{rd}	0.76	0.41
17	25^{th}	0.41	0.12
	THD	17.82%	13.36%

The following results give the comparison betweenPWM and Multilevel Inverter methodologies of shuntAPF. These results have been obtained using a FFT toolin MATLAB called 'Power-GUI editor'.Tables 2 and3 give the comparison of the voltage and current quality interms of individual and total harmonic distortion (THD) obtained with a shunt APF implemented by boththe conventional PWM based inverter.

Table 3. Content of harmonics in supply current (IA) (from the simulated results).

S No	Order of Harmonics	with shunt APF using PWM based inverter (in %)	with Shunt APF using proposed cascaded-inverter (in %)
1	Fundamental	100	100
2	2^{nd}	3.57	2.2
3	3^{rd}	2.55	1.38
4	4^{th}	1.91	1.07
5	5^{th}	1.52	0.83
6	6^{th}	1.25	0.7
7	7^{th}	1.08	0.62
8	8^{th}	0.94	0.54
9	9^{th}	0.85	0.48
10	11^{th}	0.69	0.39
11	13^{th}	0.59	0.33
12	15^{th}	0.51	0.29
13	17^{th}	0.45	0.25
14	19^{th}	0.40	0.23
15	21^{st}	0.36	0.20
16	23^{rd}	0.33	0.19
17	25^{th}	0.3	0.17
	THD	5.87%	3.15%

CONCLUSION

This paper takes up the commonly used multilevel inverters and proposes a control scheme. Here, we are reducingTHD values for different levels of inverter. the proposed multilevel inverter provides higherperformance, less EMI, and higher efficiency than the traditional PWM inverter. Because the switching frequencyis the line frequency, switching losses and related EMI arenegligible. A simple control scheme has been presented forboth reactive power (VAR) and harmonic compensation,which ensures dc voltage balance.

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