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CMLI Based STATCOM Employing Single D.C input Source

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Abstract: 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 (like IEEE-519-1992, IEC-6100) 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 static compensator technique has been studied and developed in the recent years to solve the harmonic problems. The STATCOM is assumed to be connected to an equivalent three-phase star-connected power supply. inverter and a three-phase conventional pulse width modulation (PWM) based inverter in MATLAB (using power system simulink tools), finally they are compared and their simulation results verified for a distorted three-phase, 500 KVA, 440 V, 50 Hz power system utility. For Simulation we are using seven level inverters per phase. This paper proposes an isolated cascaded multilevel inverter employing low-frequency three-phase transformers and a single dc input power source.

Key words: Harmonics · Switching loss control and achieve high power requirement with modular structure and less cost using inverter and 3phase transformer

INTRODUCTION

The objective of the electric utility is to deliver sinusoidal voltage at fairly constant magnitude throughout their system. This objective is complicated by the fact that there are loads on the system that produce harmonic currents. These currents result in distorted voltages and currents that can adversely impact the system performance in different ways. As the number of harmonic producing loads has increased over the years, it has become increasingly necessary to address their influence when making any additions or changes to an Installation. To fully appreciate the impact of this phenomenon, there are two important concepts to bear in mind with regard to power system harmonics. The first is the nature of harmonic-current producing loads (non-linear loads) and the second is the way in which harmonic currents flow and how the resulting harmonic voltages develop. Each term in the series is referred to as a harmonic of the fundamental.

The third harmonic would have a frequency of three times 60 Hz or 180 Hz. Symmetrical waves contain only odd harmonics and un-symmetrical waves contain even and odd harmonics. A symmetrical wave is one in which the positive portion of the wave is identical to the negative portion of the wave. An un-symmetrical wave contains a DC component (or offset) or the load is such that the positive portion of the wave is different than the negative portion. An example of un-symmetrical wave would be a half wave rectifier. Most power system elements are symmetrical. They produce only odd harmonics and have no DC offset. There are exceptions, of course and normally-symmetrical devices may produce even harmonics due to component mismatches or failures. Arc furnaces are another common source of even harmonics but they are notorious for producing both even and odd harmonics at different stages of the process. When a non-linear load draws current that current passes through all of the impedance that is between the load and the system source (See Figure 4). As a result of the current flow, harmonic voltages are produced by impedance in the system for each harmonic. These voltages sum and when added to the nominal voltage produce voltage distortion.

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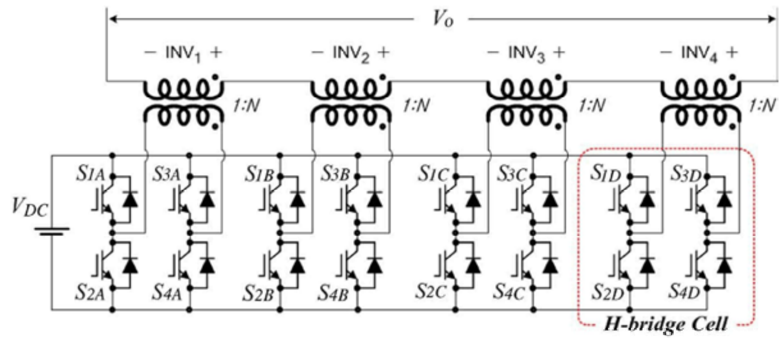

Fig. 1: Cascaded H-bridge Multilevel Inverters Employing Single Dc Input Source

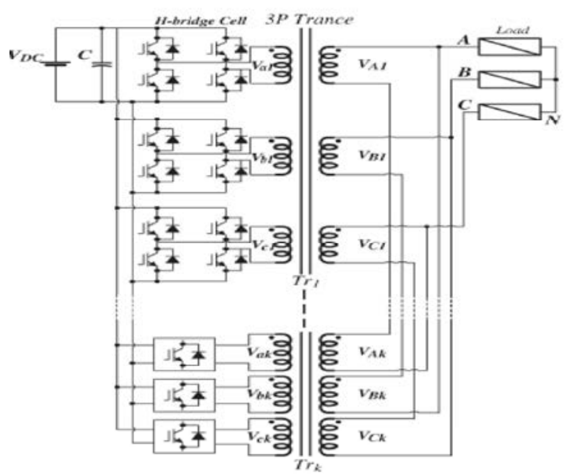

Fig. 2: Circuit Configuration of Proposed Multilevel inverter

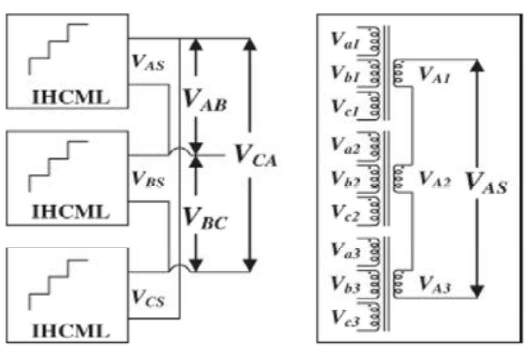

Fig. 3: Simplified Structure of the Proposed Multilevel Inverter

Figure 1 shows a configuration of a boost-type H-bridge multilevel inverter employing a cascade transformer. Four H-bridge modules are connected to the same dc input source in parallel and each secondary of the four transformers is connected in series. In this configuration, the output voltage becomes the sum of the terminal voltages of each H-bridge module. The amplitude of the output voltage is determined by the input voltage and turn ratio of the transformer. Usually, a traditional cascaded-bridge converter employs a multiples isolation transformer to obtain the input dc source. When the traditional cascaded-bridge converter needs to isolate from the ac output, it requires a three-phase transformer between the inverter and the ac outputs. On the other hand, the proposed inverter has an advantage of galvanic isolation between the source and the output voltages, which comes from being combined with transformers [1, 2]. However, when the circuit, shown in Fig3.6 needs to modify its configuration for use in three-phase applications, there is a drawback, which is the requirement of more transformers, considering that the same number of transformers needs to be used in each phase.

Proposed Cascaded H-Bridge Multilevel Inverter: Fig. 2 shows a predigested representation of Fig.3 when item ploys three three-phase transformers. As shown in Fig.3.7, the primary of each transformer is a three-phase one and each secondary is a single-phase terminal. Three terminal outputs are series connected to generate the voltage VAS. In the second transformer, the switching angle $\alpha 2$ is 43.1° and the extinction angle is 136.9°,as shown in $VA2$ of Fig.3.7 The switching angle $\alpha 3$ of the third transformer is 64.1° and the extinction angle is 115.9°, as shown in $VA3$ of Fig3.7 We can find that the switching angle of each transformer, at the modulation index of 0.9, completely satisfies cases 1, 2 and 3 shown in Fig. 3.8.At modulation index 1.0, the switching angle $\alpha 1$ of the first transformer is 11.7° and the extinction angle is 168.3°,as shown in $VA1$ of Fig. In the second transformer, the switching angle $\alpha 2$ is 31.2° and the extinction angle is 148.8°, as shown in $VA2$ of Fig.

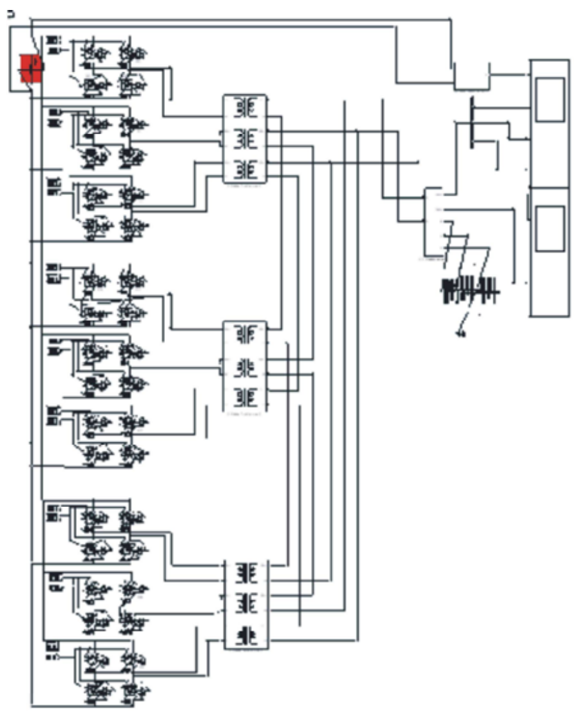

Fig. 4: Simulink Model of inverter with RL Load

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Simulink Model of Inverter with Load: Fig.4 shows a circuit configuration of the proposed multilevel inverter for three-phase applications. It consists of one single dc input source and several low-frequency three-phase transformers. By using the three-phase transformers, the number of transformers and the volume of system can be reduced. As a result, the price of the system is deservedly down. Each primary terminal of the transformer is connected to an H-bridge module so as to synthesize *V*DC, zero and-*V*DC. Every secondary of the transformer is connected in series to pile the output level up. Moreover, each phase terminal is delta connected to restrain the third harmonic component.

Simulink Model of Inverter Without Load: As shown in Fig. 4.4, the primary of each transformer is a three-phase one and each secondary is a single-phase terminal.

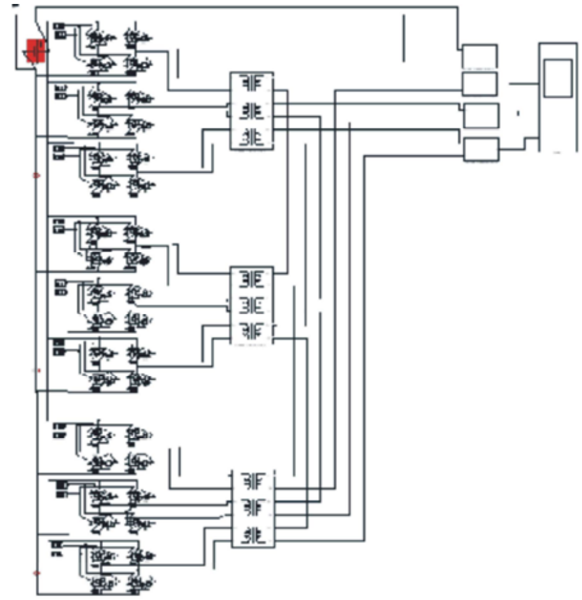

Fig. 5: Output Model without Load

Simulated Output Wave form with RL Load

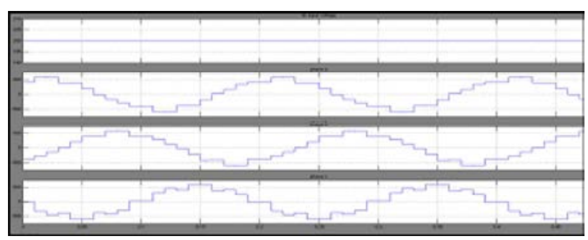

Fig. 5: Simulated Output WaveformWind Generator AC to DC Converter Model:

Three terminal outputs are series connected to generate the voltage *V*AS. In this configuration, each phase can be expressed independently and we call each phase multilevel inverter as isolated H-bridge cascaded multilevel inverter. In Fig. 4.4, *Vak*, *Vbk* and *Vck* mean the output voltages of the H-bridge inverter connected to the *k*th transformer. Here, *VAk*, *VBk* and *VCk* are the output voltages of the transformers in each phase.

Output Waveforms: Figure 4.5 shows the output voltage of the *A* phase and switching signals of each phase when the modulation index is 1.0. Here, the switching frequency is equal to the fundamental. Figure shows the output voltage, phase voltage to a Y-connected load and the FFT result at the modulation index of 1.0. Fig.4.5 shows the result waveform to a pure resistive load (200 Ù) at modulation indexes of 1.0 and 0.9, respectively.

Wind Generator Ac to Dc Converter Model

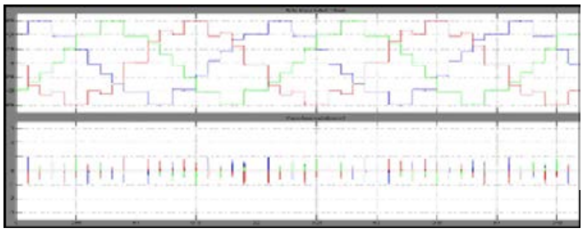

Fig. 6: Simulated Output Waveform with RL Load for three phase Load

Simulated Output Waveform Without Load

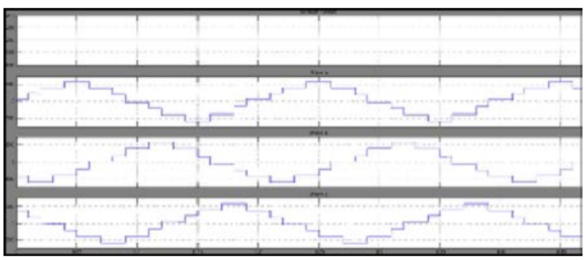

Fig. 7: Output Waveform without Load

Fig. 4.5 shows the result waveforms of parallel-connected resistive and inductive loads (200 Ù +800 mH) at the modulation indexes of 1.0 and 0.9, respectively. The proposed multilevel inverter was designed for the use of grid connected photovoltaic/wind power generator, flexible alternating-current systems and other similar applications. The output frequency of these systems is usually fixed to a grid frequency. Therefore, there is no problem when using the low frequency transformers. However, for motor drive applications with a variable frequency control scheme, the proposed topology has some problems because of the transformers on the ac side. In the experiment, the proposed multilevel inverter was designed to synthesize 13 output levels. If we want to generate the same number of output levels with conventional multilevel inverters, we can find that they need many components compared with the proposed. In addition, usually, these traditional multilevel inverters employ a three-phase low-frequency transformer at the output.

RESULTS AND DISCUSSION

In addition, usually, these traditional multilevel inverters employ a three-phase low-frequency transformer at the output terminal for a high-power grid connection. In this point, the proposed circuit topology has a valuable merit. Considering that the output voltage is synthesized by an accumulation of each transformer output, it does not require an additional transformer for galvanic isolation. Although the proposed scheme needs three three-phase transformers, the cost and size will be slightly increased because the capacity of the transformer is 1/3 of the transformer which is applied to the conventional method.

Summary of Valuable Advantages: Efficient and Economical Circuit Configuration to synthesize multilevel outputs by using three-phase transformers;

Increase of Utilization Rate and Decrease of Volume by using three-phase transformers;

Possibility of using a Single DC source by using isolate Transformers;

Little Transition Loss of switch due to low switching frequency and reduced electromagnetic interference, which is suitable for high-voltage applications [3-15].

Removing High-Order Harmonics by using the liberalization relay angle control in each area on the basis of the Newton-Raphson method [16-21].

CONCLUSION

The proposed circuit configuration can reduce a number of transformers compared with conventional three-phase multilevel inverters using single-phase transformers.

Table 4.1 Components comparison with traditional multilevel inverters [2]

Components	Diode Clamped	Flying Capacitors	Cascaded H-bridge	Proposed
Switch	36	36	72	36
Diode	396	0	0	0
Capactor	4	210	18	1
Input de Source	1	1	18	1
Output Transformer	1	1	1	3

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