

Introduction to Three Phase Three Leg Nine Switch AC/AC Converter

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Abstract - Here is a convertor having nine switches has been introduced. It has features such as sinusoidal output, unity power factor less switching states (minimize switch count). It costs reduced due to less number of switches. When it is compared with back-to-back voltage source convertor it results reduction in total harmonic distortion. It is ac-dc-ac-convertor

Keywords - AC-DC-AC converter, pulse width modulation (PWM), minimization of switch count.

1. Introduction

In industries most of the convertor application with variable frequency and variable voltage are found in a wide range. Most popular configurations are voltage source inverter (VSI), uninterrupter power supply (UPS) and adjustable speed drives (ASD's) etc. This devices costs low because they use diode rectifier but there input line currents are highly distorted and are also incapable of regenerative dynamic braking if back-to-back voltage source convertor is used with PWM this problem can overcome.

This back to back voltage source convertor involves 12 number of active switches and DC link capacitor, 6 switches for rectifier operation and 6 for inverter operation with separate PWM generator for their respective modes of operation i.e. rectifier or inverter operation. Presence of DC link capacitor introduced aging effect and also increases in cost of convertor. Reduction of device count and minimization of DC capacitor based convertors have been proposed here.

The first one is used of two DC capacitor in cascade and midpoint of them is used as input/output terminals in this way saving of entire phase leg for rectifier or inverter can be achieved. The second one is the reduction of total number of

switches by sharing a middle leg for both rectifier and inverter operation. The third one is, use of first and second together i.e. DC midpoint connection and shared phase leg between rectifier and inverter. Thus here only four legs are required to perform AC-DC-AC having bidirectional power flow and power factor control also. All this first second and third features with reduced number of switches hence reduced switching losses and thus economical but they involve complex control as structure is unbalanced in nature.

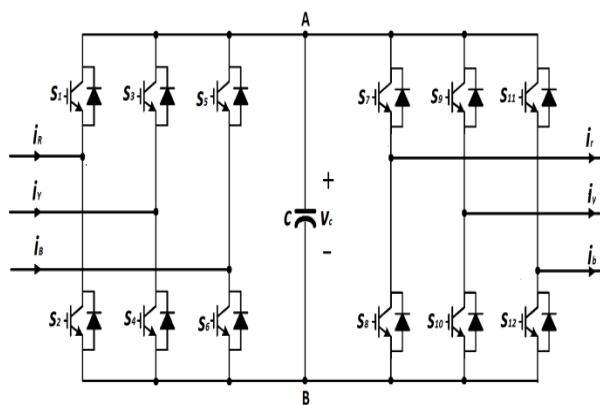


Fig1. B2B 2L VSC

Considering a matrix convertor it has no DC link capacitor and it directly converts fixed AC into adjustable AC. So this convertor has the entire required feature such as sinusoidal output power factor control and bidirectional energy transfer. Also reduction in cost due to absence of DC capacitor but it required 18 numbers of active switches and its switching scheme is complex one. Hence in complex matrix convertor (CMC). Semiconductor cost is high and its control is not simple which makes it less attractive similarly sparse matrix convertor (SMC) is also proposed and it has same functional properties as CMC but it required 16 switches this are also higher than back

to back converter. In this paper introduction to one stage three phase AC-DC-AC converter is introduced. Comparing to above mentioned convertors it has only three legs nine active switches and it has bidirectional power transfer.

2. Basic Operating Principles

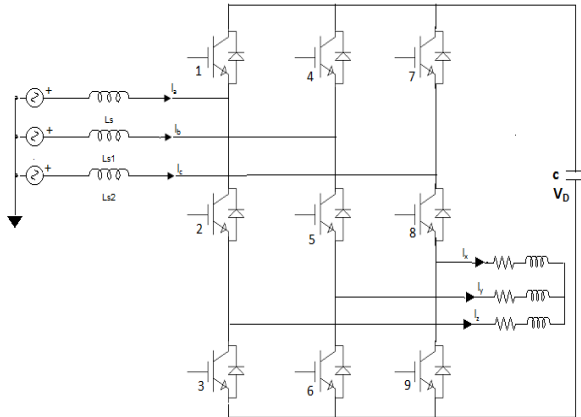


Fig2. Proposed Nine Switch Converter

These three leg AC-AC converter is comprised with nine IGBT switches. We have employed IGBT switches for fast switching purpose to overcome the switching losses. As we are using less number of switches than the back to back VSC, thereby reduction in switching losses and manufacturing cost. In back to back VSC there were 6 switches for rectifier and inverter operation each. So it include 4 switching state per phase. In nine switch converter middle switches are commonly used as a rectifier as well as inverter i.e. there is a common leg for inverter & rectifier operation. Thereby reduces the fourth operating state in back to back VSC i.e. it is reducing the operating states.

Table 1: Switching State for Back To Back Converter

On	Off	Rectifier Voltage	Inverter Voltage
S1, S3	S2,S4	Vd	Vd
S2, S4	S1,S3	0	0
S1,S4	S2,S3	Vd	0
S2, S3	S1,S4	0	Vd

Table 2: Switching States for 3 Leg 9 Switch Converter

On	Off	Rectifier Voltage	Inverter Voltage
S1, S2	S3	Vd	Vd
S2, S3	S1	0	0
S1, S3	S2	Vd	0
No Fourth State			

Here it is consider the rectifier is composed of top three and middle switches and inverter consists of middle three and bottom switches. Converter operation is carried out in two mode first one is constant frequency another one is variable frequency mode. In back to back converter the rectifier and inverter voltages are get control separately. In nine switch converter the inverter leg voltage is always lower than rectifier voltage at any instant on these constraints the switching scheme of nine switch converter is design. Modulation of voltage source converter uses Sinusoidal Pulse Width Modulation (SPWM), Space Vector Pulse Width Modulation (SVPWM) and Third Harmonic Injection Pulse width Modulation (THIPWM). In this paper SPWM scheme is described briefly. The modulation scheme with little modification can be applied to nine switch converter because it should match the switching constraints mentioned above. Carrier based modulation scheme is as follows, two modulating waves, rectifier and inverter modulating waves are arranged in a manner such that rectifier modulating voltage is more than inverter modulating voltage at any instant. These two waveforms are then compared with reference wave taken as triangular wave which in turn controls the switching operation of converter.

3. Control Structure

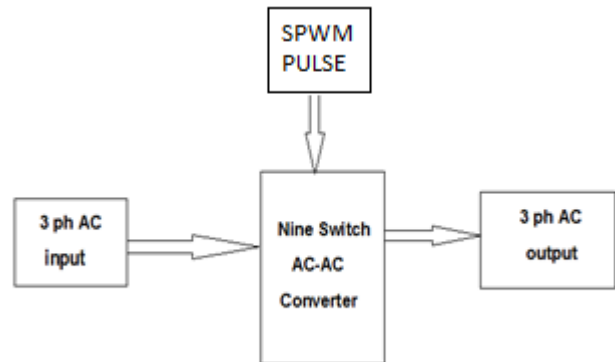


Fig3. Functional Block Diagram of Proposed Converter

3.1 In constant frequency mode- To match the required switching constraints of nine switch converters the modulating wave of rectifier is shifted towards top whereas modulating wave of inverter is shifted towards bottom with respect to DC plane. If modulating waves of inverter and rectifier are in phase with each other modulation indexes reaches to unity simultaneously.

3.2 In variable frequency mode- To match the required switching constraints of nine switch converter addition of rectifier modulation index and inverter modulation index must not be greater than 1.

4. Conclusions

A 3phase nine-switch AC-AC converter scheme is proposed in this paper. The nine IGBT switches are used for the ac to ac conversion. In compared with the number of switches in the proposed converter is reduced by 33% and 50%, back-to-back PWM VSC and the matrix converter respectively. This proposed converter has features like sinusoidal inputs and outputs, unity input power factor and low manufacturing cost. The operating principle of the converter was elaborated, and modulation schemes for constant and VF operations were developed. While working in CF mode, it has an overall higher efficiency than the B2B 2L-VSC at the expense of uneven loss distribution.

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