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A Novel SVM Proposed For Minimizing THD of Dual Output Nine Switch Inverter


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Abstract:
In this paper, the space vector modulation (SVM) of nine-switch inverter and nine-switch-z-source inverter is proposed. The extra voltage available for a given input dc-voltage, translates to a higher torque—a critical factor for defining the capacity of products in marketplace. Also, in order to further reduce the cost of power devices and also thermal heat effect, and to reduce the number of semiconductor switching, specific SVM switching pattern is presented. The performance of the proposed SVM for both nine-switch inverter and nine-switch-z-source inverter is verified by simulation. Simulations are performed using MATLAB-SIMULINK. Harmonics analysis and evaluation of performance measures for various modulation indices have been carried out and presented.

I. INTRODUCTION:
Today, it is hard to connect a single power Semiconductor switch directly to medium voltage grids. For these reasons, a new family of multilevel inverters has emerged as the solution for working with higher voltage levels. The inverters with voltage level 3 or more are referred as multi-level inverters. Multilevel inverters have become attractive recently particularly because of the increased power ratings, improved harmonic performance and reduced EMI emission that can be achieved with the multiple DC levels that are available for synthesis of the output voltage. Developed DC link capacitor voltage balancing in a three phase diode clamped inverter controlled by a direct space vector of line to line voltages. It can be generally classified into on-line, off-line, and line-interactive UPS. A UPS should be able to produce a regulated sinusoidal output voltage for its critical load, to have seamless transition between normal operation and power failure modes, and to draw sinusoidal currents from the utility supply with unity power factor.UPS mainly composed of a PWM rectifier, a PWM inverter, a battery and a static transfer switch.

During the normal operation, the load is powered by the inverter through the rectifier and the utility supply. In case of power interruption, the battery provides power to the load. The rectifier normally operates with a unity power factor and low line current distortion while the inverter provides a high-quality regulated voltage source to the critical load. However, this configuration requires two power conversion stages, which increases the cost and reduces the energy efficiency as well. A novel nine-switch converter topology for online UPS applications has been proposed to reduce the cost of UPS system as shown in Fig 1.

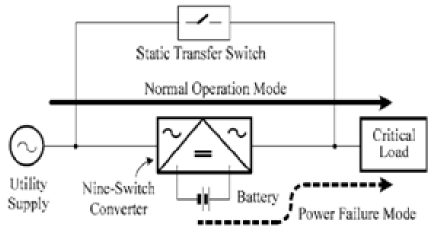

Fig 1: proposed nine switch converter topology for three-phase UPS

II. Nine-switch Converter Topology:

Fig. 2 shows the proposed three-phase nine-switch converter topology. This converter has three legs with three switches per leg. The novelty of this converter is that the middle switch in each of the converter legs is shared by the rectifier and inverter, thereby reducing the switch count by 33% in comparison to the PWM back-to-back converter. The utility power is delivered to the load partially through the middle switches (direct ac/ac conversion) and partially through a quasi dc link circuit. For the convenience of discussion, we can consider that the rectifier of the nine-switch converter is composed of top three and middle three switches whereas the inverter consists of middle three and bottom three switches.

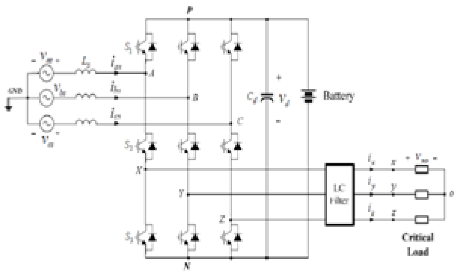

Fig 2: Proposed nine-switch converter for UPS applications

The converter has two modes of operation: 1) constant frequency (CF) mode, where the inverter output frequency is constant and also the same as that of the utility supply, and 2) variable frequency (VF) mode, where both magnitude and frequency of the inverter output voltage are adjustable The CF mode of operation is particularly suitable for UPS applications whereas the VF mode can be used in adjustable-speed drives.

Nine-switch Converter Topology as AC-AC converter

Three-phase ac/dc/ac and ac/ac converters with variable frequency (VF) and variable voltage operation have found wide applications in the industry. The most popular configuration uses voltage source inverter (VSI) with a diode rectifier as the front end for adjustable speed drives (ASDs), uninterruptible power supplies (UPS), and other industrial applications [1]. This configuration features low cost and reliable operation due to the use of a diode rectifier, but it generates highly distorted input line currents and does not have regenerative or dynamic braking capability. These problems can be mitigated by using a back-to back two-level voltage source converter (B2B 2L-VSC), shown in Fig where a pulse width modulation (PWM) voltage source rectifier is used to replace the diode rectifier in [2].

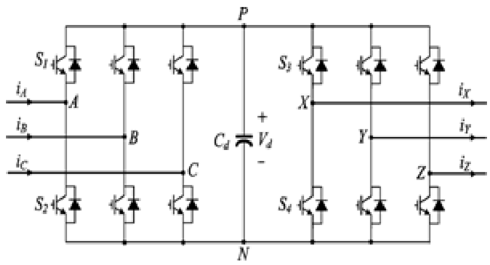

Fig 3: B2B 2L-VSC

Fig 4 shows the proposed three-phase nine-switch converter topology. This converter has only three legs with three switches installed on each of them. The novelty herein is that the middle switch in each individual leg is shared by both the rectifier and the inverter, thereby reducing the switch count by 33% and 50% in comparison to the B2B 2L-VSC and CMC, respectively The input power is delivered to the output partially through the middle three switches and partially through a quasi-dc-link circuit. For the convenience of discussion, we can consider that the rectifier of the nine-switch converter is composed of the top three and middle three switches, whereas the inverter consists of the middle three and bottom three switches The converter has two modes of operation: 1) constant frequency (CF) mode, where the output

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frequency of the inverter is constant and also the same as that of the utility supply, while the inverter output voltage is adjustable; and 2) VF mode, where both magnitude and frequency of the inverter output voltage are adjustable. The CF-mode operation is particularly suitable for applications in UPS, whereas the VF mode can be applied to variable-speed drives.

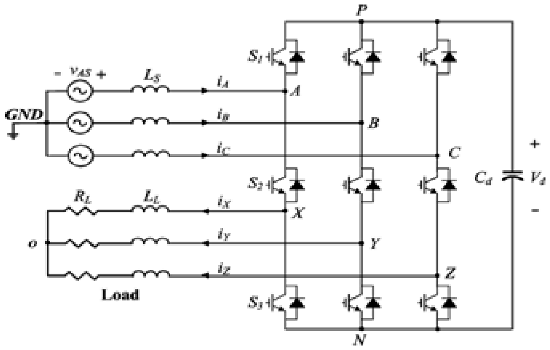

Fig 4: Proposed Nine-switch AC/AC converters with a quasi-dc link

III. SIMULINK RESULTS

Simulink Results of SPWM Method

The output results comprises of

1. Instantaneous values of line voltages
2.Phase voltages
3.Line voltage RMS waveforms
4.THD waveform

Instantaneous Values:

The instantaneous values of the output line voltages are always equal to the source voltage given irrespective of the modulation rate or voltage utilization factor. The results for load one and two are as shown.

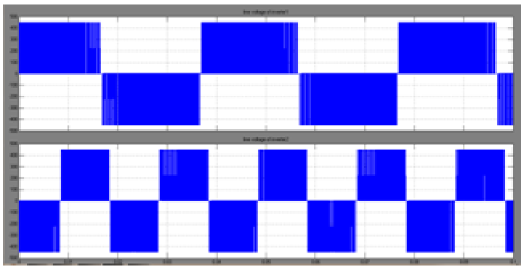

Fig 5: Line voltages inverter1 and inverter2

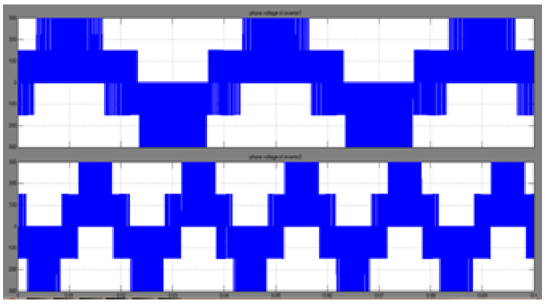

Fig 6: Phase voltages inverter1 and inverter2

Mat-Lab PARAMETERS:

DC Voltage	: 450 V
Resistance	: 50 Ω
Inductor	:15 mH
Carrier wave frequency	: 10 k H

RMS Values of Line Voltages:

The RMS values of the output line voltages are the values that differ with the variations in the modulation rate and the voltage utilization factors. The variation of RMS line voltage values are given along with the instantaneous line voltages for different ratios i.e. for 2.1, 1:2, 2:3 of A_1 and A_2. And line voltages and phase voltages Inverter1 with 25 Hz frequency and Inverter 2 with 50Hz.

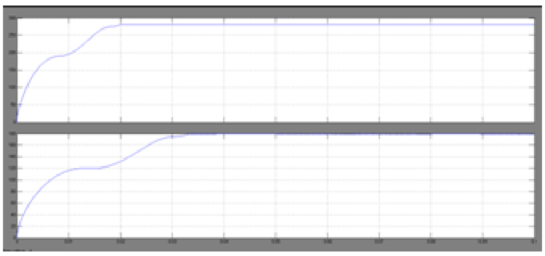

Fig 7: RMS line voltage 2:1 inverter 1 and 2

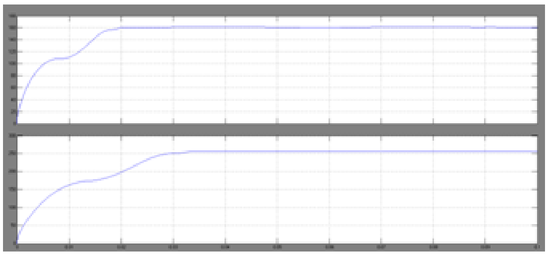

Fig 8: RMS line voltage 1:2 inverter 1 and 2

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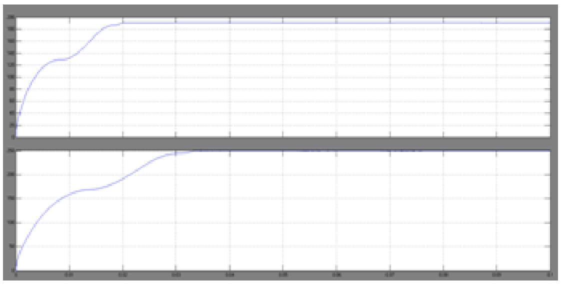
Fig 9: RMS line voltage 2:3 inverter 1 and 2

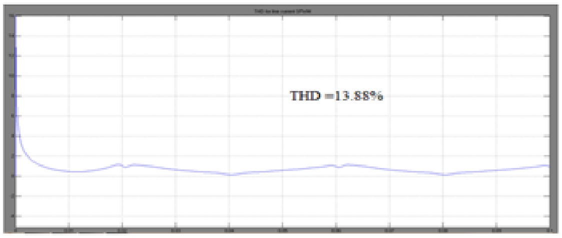

Fig 10: Total harmonic distortion wave form for SPWM Nine Switch Inverter

Simulink Results of SVPWM Method:

Space vector modulation based nine switches Inverter reduce the THD value of line compared to SPWM method and also reduces the number of switch count. Space vector modulation consists of two strategies namely

1. Minimum switching SVPWM
2.Reduced THD SVPWM

Each of the method consists of the following outputs:

1. Line voltages(Instantaneous)
2.Phase voltages and
3.Total harmonic waveforms

Minimum switching SVPWM

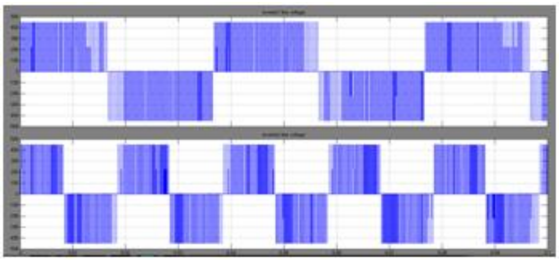
Fig 11: Line voltages of inverter1 and inverter2

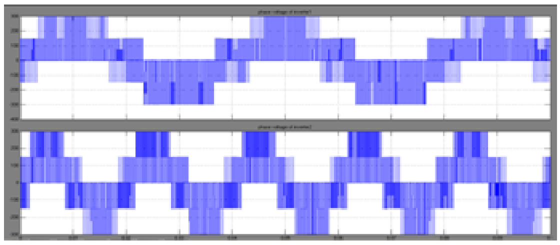
Fig12: Phase voltages of inverter1 and inverter2

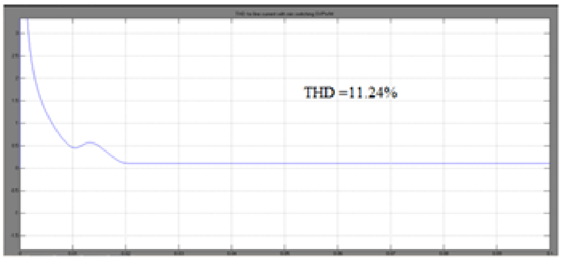

Fig 13: THD waveform

Reduced THD SVPWM

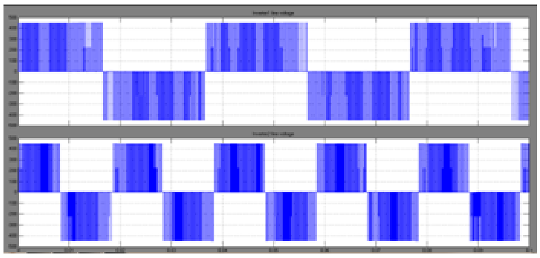
Fig 14: Line voltages of inverter1 and inverter2

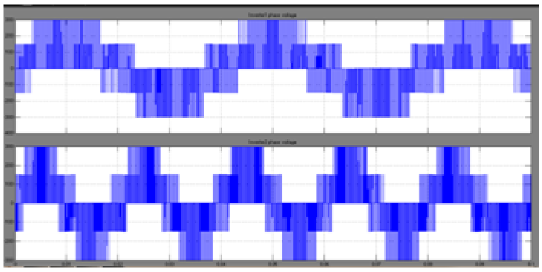
Fig 15: Phase voltages of inverter1 and inverter2

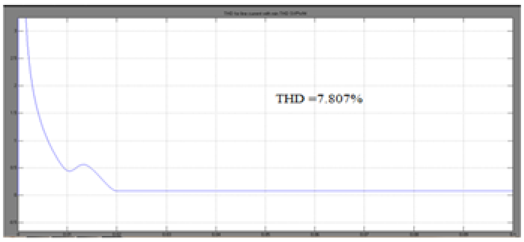

Fig 16: THD waveform

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Following table 1 shows the values of number of switch count in SPWM method and SVPWM method

	SPWM	SVM(Min switching)	SVM(Min THD)
9-switch inverter	3600	2450	3400

Table 1.Number of switch count

IV. CONCLUSION:

Space Vector Modulation for Nine Switch inverter verified through simulation model, and the results confirmed that Nine switch inverter can control independently amplitude and frequency the two three phase loads. above results shows SVPWM reduces the total harmonic distortion and number of switch count compared with sinusoidal pulse width modulation (SPWM) method .space vector modulation method also improves the sum of modulation indices of outputs up to 15%.reduced number of switch count corresponds to less switching loss, and reduced THD helps to higher order harmonic content in the outputs of the inverter which can be easily eliminated. However there is a problem with the RMS output voltage values are not divided in the ratio specified by the user and there is a need for improvement of Voltage division, and also Z-source network (Impedance network) has to be connect at the input terminal of Nine Switch inverter, which acts as DC-DC converter so, Nine Switch inverter can get variable DC voltage as input.

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