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Design of Three Level Modular Multilevel Converter with SPWM Technique

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Abstract: *Modular structured multilevel inverter is very attractive in high voltage and high power applications. The general function of this multilevel inverter is used to produce a desired sinusoidal voltage from several separate DC sources (SDCS).*

A new shunt compensator is presented based on modular multilevel converters(MMC) The transformer less MMC based STATCOM can be controlled for various purpose such as reactive power of STATCOM, simultaneous harmonics cancellation and load balancing procedure..A control strategy is proposed to ensure the source end three currents are sinusoidal and balanced.

Keywords: MMC-Modular Multilevel Converter.

I. INTRODUCTION

The multilevel inverters have drawn tremendous interest in the power industry. Modular structured multilevel inverter is very attractive in high voltage and high power application. It may easier to produce a high voltage, high power inverter with the multilevel structure because of the way in which device voltage stresses are controlled in the structure. By using multilevel structure, the stress on each switching device can be reduced proportional to the number of levels of the multilevel inverter. Thus, the inverter can handle higher voltage without using an expensive and bulky step-up transformer in various applications. As the number of inverter output voltage levels is increased, harmonics content of the output voltage waveform decreases significantly enough to avoid the need of bulky filters .The multilevel inverter has drawn tremendous interest in the power industry.

The topological structure of multilevel inverter must have less switching devices as far as possible, be capable of withstanding very high input voltage for high-power application and have lower switching frequency for each switching device. The topology of multilevel inverter can be classified into four types.

- Diode-clamped multilevel inverter (DCMI).
- Flying-capacitor multilevel inverter (FCMI).
- Cascaded multilevel inverter with separated DC sources (CISDCS).
- Modular multilevel converter(MMC)

II. MULTILEVEL INVERTER TOPOLOGIES

An inverter is an electrical or electromechanical device that converts direct current (DC) to alternating current (AC)"

Present problems with INVERTER:

Single devices can't handle the V&I

Device voltage rating required 8-10 not available

Poor power quality due to harmonic distortion

High switching losses

Solution to above problem is the modular multilevel converter

Numerous industrial applications have begun to require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel converter system for a high power application the concept of multilevel converters has been introduced by NABE- EL since 1975.

Multilevel inverters technology has emerged recently as very important alternative in the array of high power medium-voltage energy control. Multilevel inverter includes an array of power semiconductors and capacitor voltage sources, the output of which generates voltage with stepped waveform. The commutation of the switches permits the addition of the capacitor voltages, which reach the high voltage at the output.

III. MODULATION TECHNIQUES USED FOR SWITCHING INVERTER

Sinusoidal Pulse width Modulation (SPWM) :-

PWM applies a pulse train of fixed amplitude and frequency only the width is varied in proportion to an input voltage. In PWM technique the power semiconductor switches are turned ON and turn OFF several times during HALF cycles and output voltage is controlled by changing the width pulse.

N= number of carriers (n-1)

Modulation index=Am/N' Ac

Where

N= (n-1)/2, Where n= number of levels

Frequency of reference wave is 50 Hz and frequency of carrier is 2khz.We made comparing of reference wave and carrier wave its result is pure PWM for switching of switches. For 3 level no. carrier requires two and for 5 level no. of carrier requires 4 upper two and lower two. By using this technique we are giving the switching pulse to Swatches

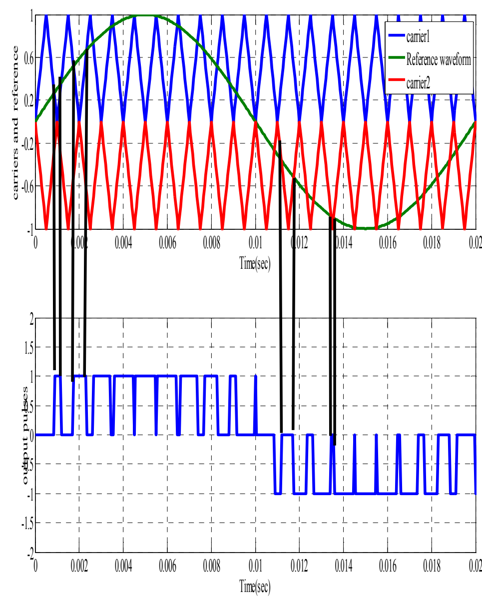

Fig.1:- Sinusoidal Pulse width Modulation (SPWM)

Level Shifting Method

1) APOD (alternatively phase apposite disposition)
2) POD (phase opposite disposition)
3) PD (phase disposition)

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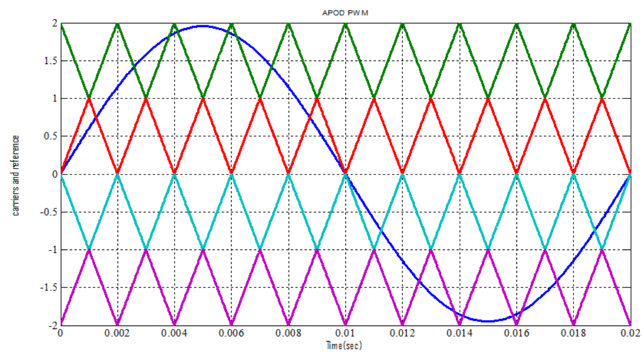
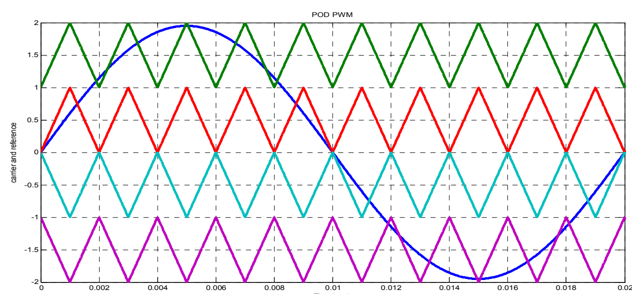
1) APOD*:* (alternatively phase apposite disposition)**:** All the carriers are alternatively in opposition, Where Each Carrier is phase shifted by 180^0 from its adjacent carrier.

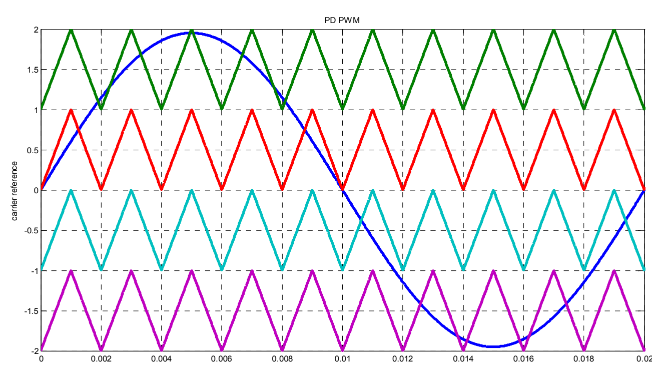


2) POD: All the carriers above the zero value reference are in phase among them but in opposition with those below



Carrier modulation index is
(1 2 1),(0 1 0),(-1 0 -1),(-2 -1 -2)

3) PD: All the carriers are in phase



Carrier modulation index is
(1 2 1),(0 1 0),(-1 0 -1),(-2 -1 -2)

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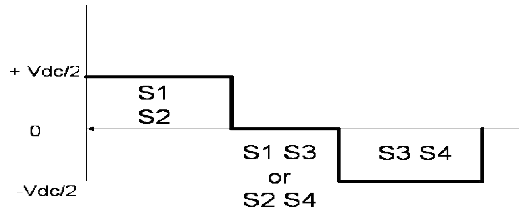
Circuit diagram of Diode clamping Three level Inverter

A 3-level inverter has 3 levels of switching namely $+V_{dc}/2$ (+state), 0 and $-V_{dc}/2$ (- state).
The switching states of NPC 3-level inverter is given below.



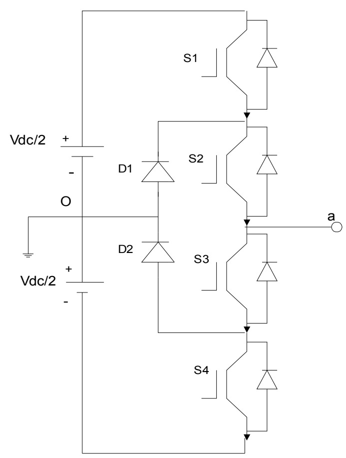


Fig.2 Structure of Diaode Clamping NPC

PWM applies a pulse train of fixed amplitude and frequency. only the width is varied in proportion to an input voltage. In PWM technique the power semiconductor switches are turned ON and turn OFF several times during HALF cycles and out put voltage is controlled by changing the width pulse

Switching State	**S1 S2 S3 S4**	
+1	**1 1 0 0**	**+ Vdc/2**
	1 0 1 0	**0**
-1	**0 0 1 1**	**- Vdc/2**

n-1=2 , no. of DC bus capacitors
2(n-1)=4 , switches
Vdc/n-1, = Vdc/2
Where 'n' means number of levels.
Clamping diodes=(n-1)*(n-2)= **2**

Simulation of three level diode clamping inverter with SPWM technique

Matlab Model for NPC and its output is shown in fig.3 & fig.4

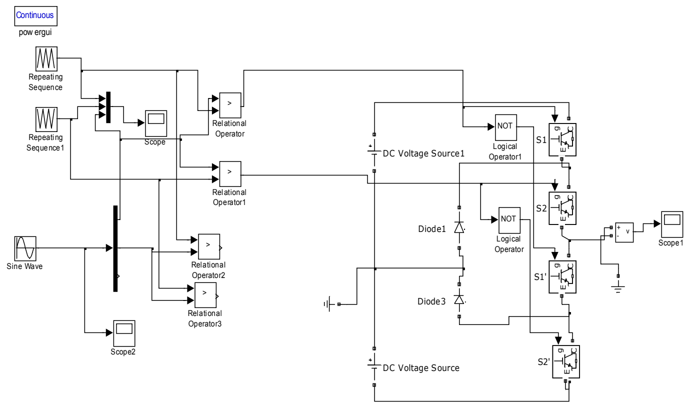


Fig.3 MatLab Model for NPC

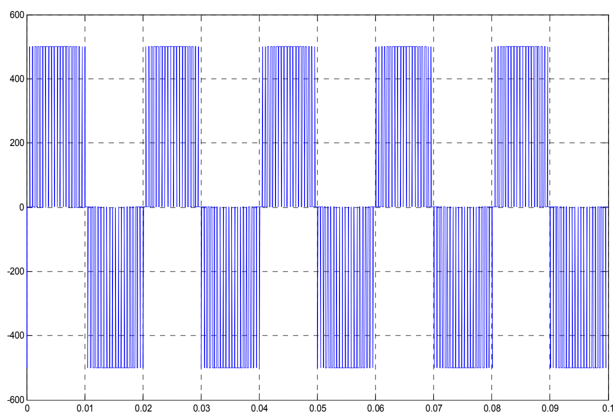


Fig.4 Output Voltage of NPC

Modular Multilevel Converter(MMC)

Modular multilevel inverter is high/medium-voltage inverter for achieving high power conversion without line frequency transformer. Modular multilevel inverter has advantages of easy assembling &flexible converter design. it requires rigid voltage control of the floating DC capacitors

It is also called as half of the cascaded H-bridge converter. For DC bus capacitor =2Vdc/(m-1). For three levels, DC bus capacitor =2

Total number of capacitor required is (2m-2, per phase)

Number of switches (IGBT) is 4(m-1).

Number of Levels =Vdc /(m-1)

SM' is OFF when S1=0, S2=1,

'SM' is ON when S1=1, S2=0.

Number of level depends upon

Vo/p=(Vdc/(m-1))-Vupper=(Vdc/(m-1))+Vlower

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Vtjo=(Vdc/2)-Vupj=(-Vdc/2)+Vlowj

S1	S2	Vo	Current direction	Power path	Battery state
ON	OFF	0	$I_o>0$	S1	Unchanged
ON	OFF	0	$I_o<0$	D1	Unchanged
OFF	ON	V_{dc}	$I_o>0$	D2	charging
OFF	ON	V_{dc}	$I_o<0$	S2	Discharging

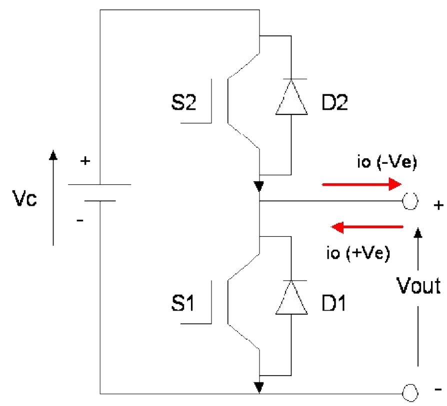

Fig.5 Direction of current in Modular Multilevel Inverter

Concept of Modular Multilevel converter (MMC)Three level

Number of bridges =2(m-1)

where 'm' is the number of levels

For three levels , s=4, where 's' is the no. bridges

For DC bus capacitor =Vdc/(m-1)

For three levels, DC bus capacitor =4

Total number of capacitor required is (2m-2,

Per phase)=**4**

Number of switches (IGBT) is 4(m-1)= 8

Number of Levels =Vdc /(m-1)

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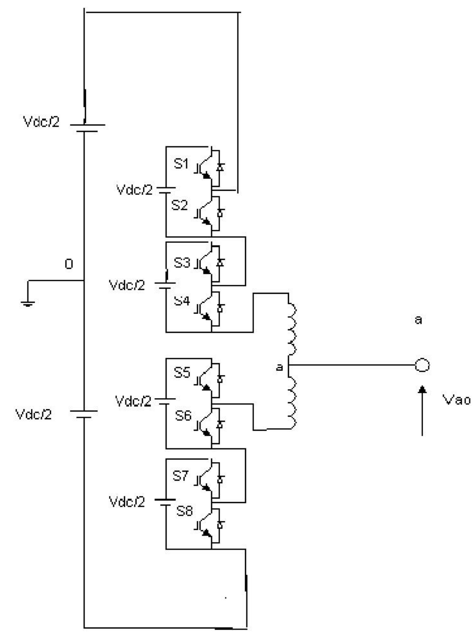

Fig.6 Structure of Modular Multilevel converter

Switching states	Output voltages	S1	S2	S3	S4	S5	S6	S7	S8
+1	Vdc/2	1	1	1	1	0	0	0	0
0	0	0	0	1	1	1	1	0	0
-1	-Vdc/2	0	0	0	0	1	1		

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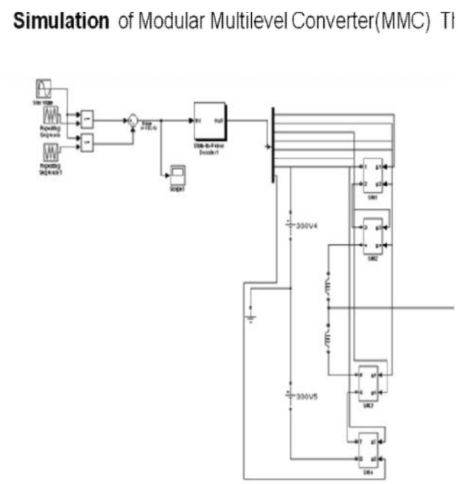
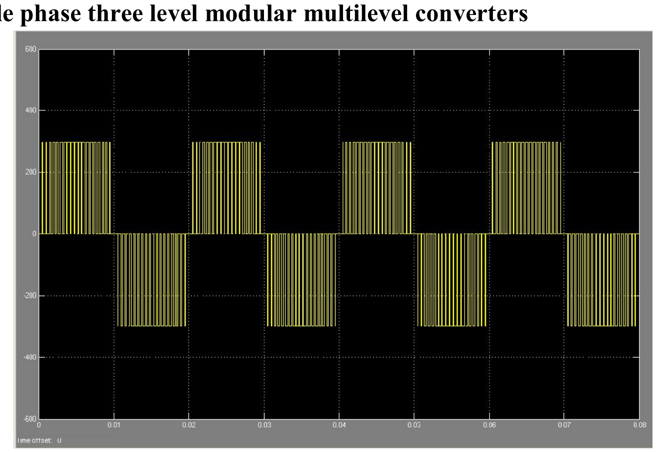
IV. RESULTS AND DISCUSSIONS

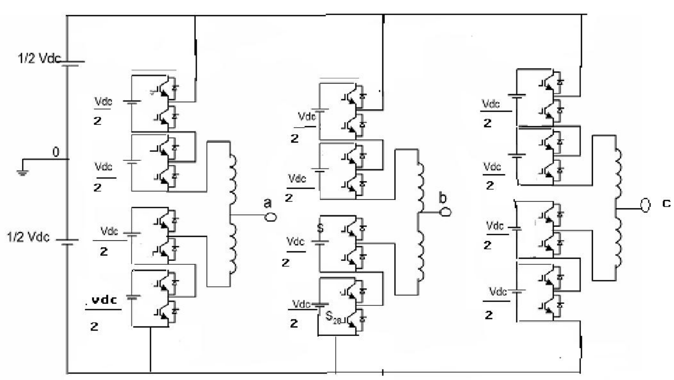
Mat Lab Model



2. Output voltage of Single phase three level modular multilevel converters



3. Structure of Three Phase Three Level Modular Multilevel Converter



Three phase Modular Multilevel Inverter

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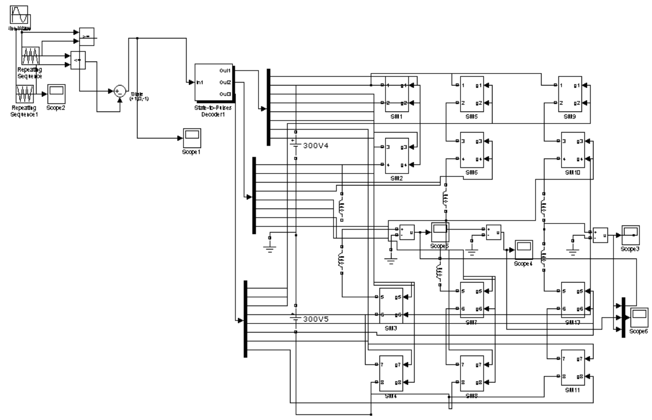
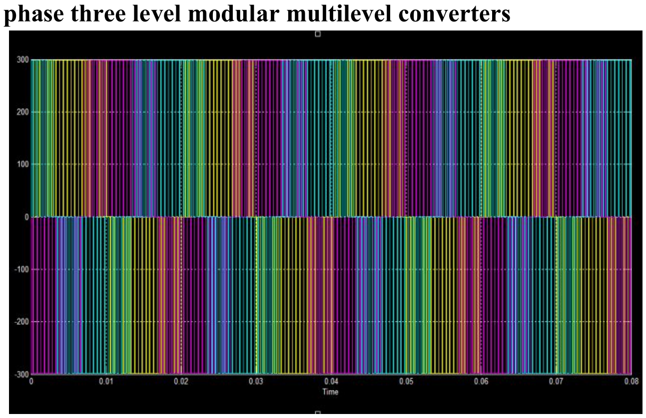
4. Simulation of three phase three level Modular Multilevel Converter (MMC)



5. Output voltage of three phase three level modular multilevel converters



V. CONCLUSION

This paper presents the topology of the new modular multilevel converter & its relevant operating characteristics. Three level modular multilevel converters is simulated in MATLAB/Simulink and simultaneously voltage and current is measured. Also this modular concept allows for wide range of power application. In further studies, improvement in the harmonics reduction in the converter voltage using SPWM technique will be investigated which will shows higher performance in a distorted & unbalanced medium-voltage large current system.

This project describe the operational principal of three level modular multilevel converter.

This project provided a brief summary of multilevel inverter circuit topology & their control strategies different inverter circuits were also discussed.

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