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Analysis of Three and Five Level Half-Bridge Modular Multilevel Inverter

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ABSTRACT
The multi level inverters are mainly classified as Diode clamped, Flying capacitor inverter and cascaded multi level inverter. The cascaded H-bridge multilevel control method is very easy when compare to other multilevel inverter because it doesn't require any clamping diode and flying capacitor. The simulation had been carried for single leg of three phase three and five level Half-bridge modular multilevel converter (MMC) by using submodules. The main objective of this paper is to analyse operation of Half-bridge MMC for different level of voltage by using SPWM technique which reduces total harmonic distortion and enhances output voltage and current closer to sinewave without adding any complexity to the power circuit.
Keywords **-** Cascaded H-bridge MLI, half- bridge MMC, SPWM techniques, THD.

I. INTRODUCTION

Basically Inverter is a device that converts DC power to AC power at desired output voltage and frequency. Demerits of inverter are less efficiency, high THD, and high switching losses. To overcome these demerits, we are going to use multilevel inverter. The term Multilevel began with the three-level converter. The concept of multilevel converters has been introduced since 1975. The cascade multilevel inverter was first proposed in 1975 [1]. In recent years multilevel inverters are used for high power and high voltage applications .Multilevel inverter output voltage produce a staircase output waveform, this waveform is closer to sinusoidal waveform. The multilevel inverter output voltage having less number of harmonics compare to the conventional two level inverter output voltage. If the multilevel inverter output increase to N level, the harmonics reduced to the output voltage value to zero. The multi level inverters are mainly classified as Diode clamped, Flying capacitor inverter and cascaded multi level inverter. The cascaded multilevel control method is simple when compare to other multilevel inverter because it doesn't require any clamping diode and flying capacitor [2]. Cascaded H-Bridge (CHB) converters employ dc-side isolated series connected full-bridge modules at each phase allowing high modularity and the lower total number of components when compared to NPC, FC. These characteristics make them widely employed in industrial applications.

Cascaded half-Bridge (C1/2B) converters employ half-bridge modules connected in series instead of the full bridge ones. These converters are an alternative to the conventional cascaded full-bridge converters. The modular multilevel converter (MMC or M2C) employ series connections of pairs of half-Bridge modules (known as submodules). The topology has some advantages like; modular design, simple voltage scaling by a series connection of submodules, filterless configuration for standard machines or grid converters,etc[10].

The single phase three level half-bridge MMC power Circuit consist of two submodules for obtaining three level output voltage. Circuit diagram for three level half-bridge MMC is shown in fig. 1. Fig. 1 shows one-phase leg of an N-level two switch modular converter, where $M = N - 1$ and M is number of submodules per arm.

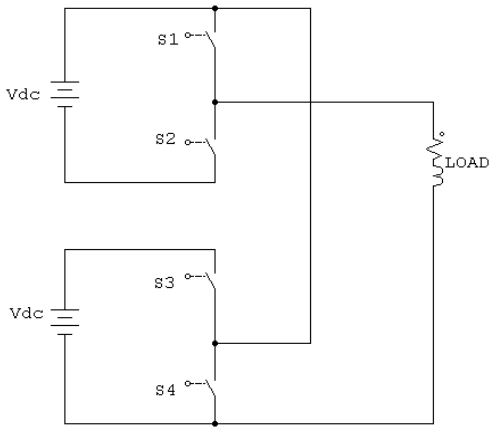

Fig. 1 circuit diagram for three level half-bridge MMC

The switching pattern to achieve three level output voltage for half-bridge MMC is given below.

Table 1: Switching strategy for three level

SWITCHES	+VDC	0	-VDC
S1	ON	OFF	OFF
S2	OFF	ON	ON
S3	ON	ON	OFF
S4	OFF	OFF	ON

II. SPWM TECHNIQUE

The The gate pulses are generated by utilizing the simplicity of multi carrier sine PWM. In this technique sine wave is taken as reference wave of amplitude Ar and frequency fr and it is continuously compared with triangular carrier wave of amplitude Ac and frequency fc. If sine wave is greater than triangular wave, the IGBTs is turned on otherwise off. For N level N-1 carrier wave with same frequency fc and same amplitude Ac are disposed such that the bands they occupy are contiguous. The reference waveform has peak-to-peak amplitude Ar, the frequency fr and it is zero centered in the middle of the carrier set. The reference is continuously compared with each of the carrier signals. If the reference is greater than a carrier signal, then thedevice corresponding to that carrier is switched on otherwise off[3].

In multilevel inverters, the amplitude modulation index (Ma) is the ratio of reference amplitude (Ar) to carrier amplitude (Ac).

$$Ma = Ar/(N-1)Ac \quad (3)$$

Phase Disposition Modulation Method (PDPWM)

In phase disposition method all the carriers have the same frequency and amplitude. Moreover all the N-1 carriers are in phase with each other. It is based on a comparison of a sinusoidal reference waveform with vertically shifted carrier waveform as shown in Fig. 2. This method uses N – 1 carrier signals to generate N level inverter output voltage. All the carrier signals have the same amplitude, same frequency and are in phase. In this method four triangular carrier wave have compared with the one sinusoidal reference wave.

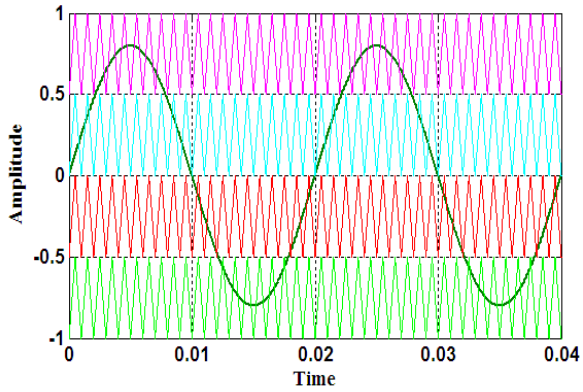

Fig 2: Phase Disposition PWM

III. SIMULATION

The Under this topic, the simulation of Cascaded H-bridge Multilevel Converter topology has been carried out. Simulation parameter single leg for five level are given below:

Table 2: Simulation paramerter

DC Bus Voltage	100 V
Carrier frequency	2.1 kHz
Fundamental frequency	50Hz
Load	R=10Ω

Simulation model of power circuit for single phase three level half-bridge MMC.

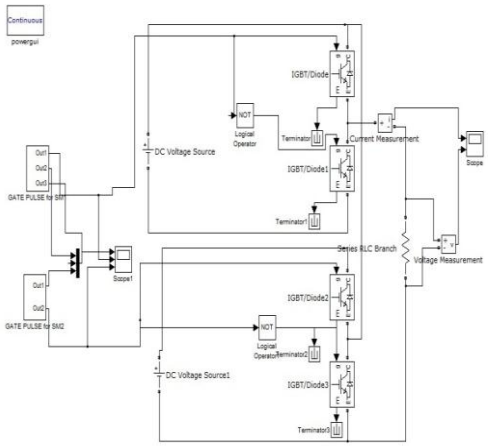

Fig. 3: Simulation model of single phase three level half-bridge MMC

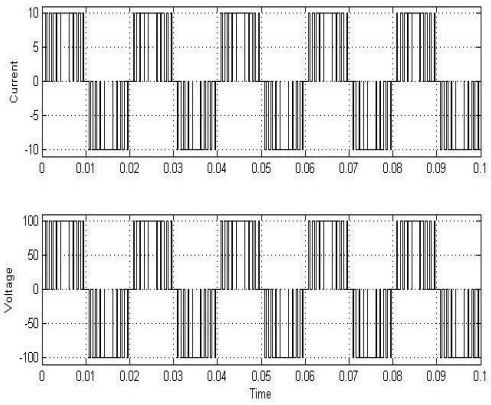

Fig 4: Output phase voltage and line current for three level half-bridge MMC

Harmonics Analysis for single phase three level half-bridge MMC

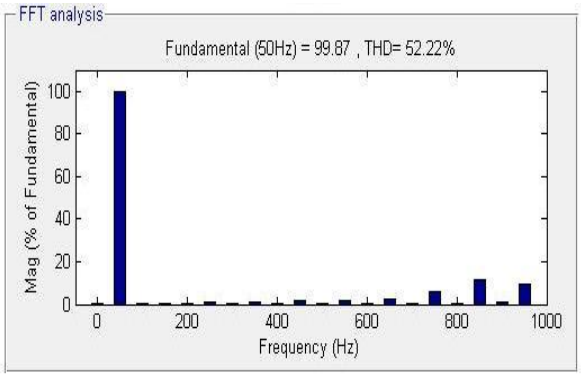

Fig. 5: Harmonic Spectrum for single phase Line Voltage of 3-Level Inverter using PDPWM

Simulation model of power circuit for single phase three level half-bridge MMC.

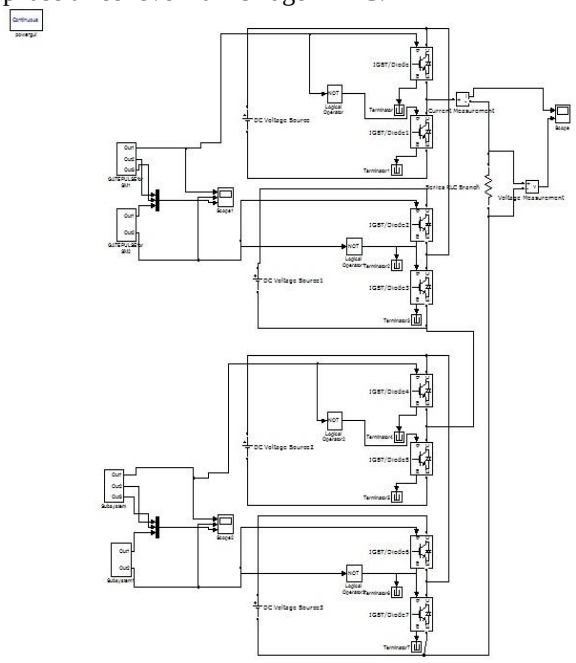

Fig. 6: Simulation model of single phase three level half-bridge MMC

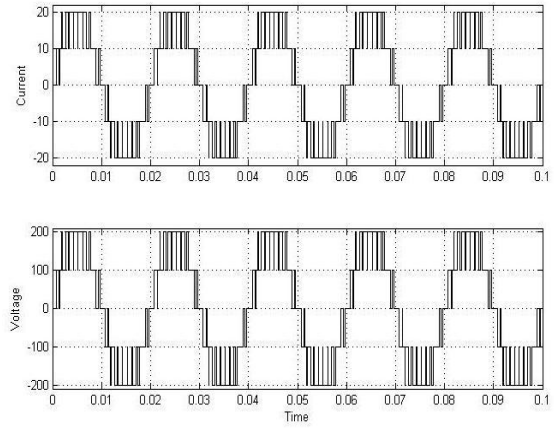

Fig. 7: Output phase voltage and line current for five level half-bridge MMC

Harmonics Analysis for single phase five level half-bridge MMC

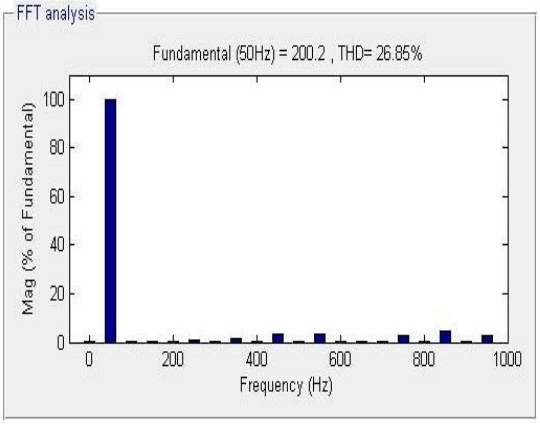

Fig. 8: Harmonic Spectrum for single phase Line Voltage of 5-Level Inverter using PDPWM

Table 2. Comparison of Harmonics analysis for three and five level half-bridge MMC

LEVEL	THD
THREE	52.22%
FIVE	26.85%

IV. CONCLUSION

Simulation of three and five level half-bridge MMC was carried out by using MATLAB/Simulink. The gate pulses have been generated by using PDSPWM techniques. The result of harmonic analysis shows that, Total Harmonics Distortion(THD) gets reduced by increasing level of voltage.

V. ACKNOWLEDGEMENTS

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