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Design, Implementation and Analysis of Cascaded H-bridge Multilevel Inverter for Wind Energy Conversion System

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Abstract:

This paper presents the cascaded H-bridge multilevel inverter with SPWM technique.Multilevel inverter act as a promising source in power applications, area of control and energy distribution systems.The comparison of 5-Level,7-Level & 9-Level cascaded H-bridge multilevel inverter is proposed to achieve that higher level inverter give high efficiency. The design of 9-Level cascaded H-bridge multilevel inverter is implemented and waveform pattern, total harmonic distortion is analysed with the help of MATLAB simulation.

Keywords **— SPWM technique, THD, MCPWM.**

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I. INTRODUCTION

Multilevel inverter has shown excellent profits in electrical based industries. Multilevel inverters are classified as flying capacitor, diode clamped and cascaded H-Bridge multilevel inverter.In this cascaded H-Bridge multilevel inverter is considered to be more advantageous as it uses less number of components.The cascaded H-Bridge multilevel inverter is used for both three phase and single phase system.The combination of switches and capacitors are known as H-Bridge.Each H-bridge has separate DC sources.In order to get required output that is minimum amount of ripple in output voltage,Multicarrier pulse width modulation is preferred. MCPWM is the simplest technique in eliminating complicated calculations necessary to control multilevel inverters above 5-Level.

II. CIRCUIT CONFIGURATION OF 9-LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER

For a single phase 9-Level cascaded H-bridge multilevel inverter four H-Bridges are required.

This four H-Bridges are connected in series which are fed by separate DC voltage sources as shown in Fig.1.

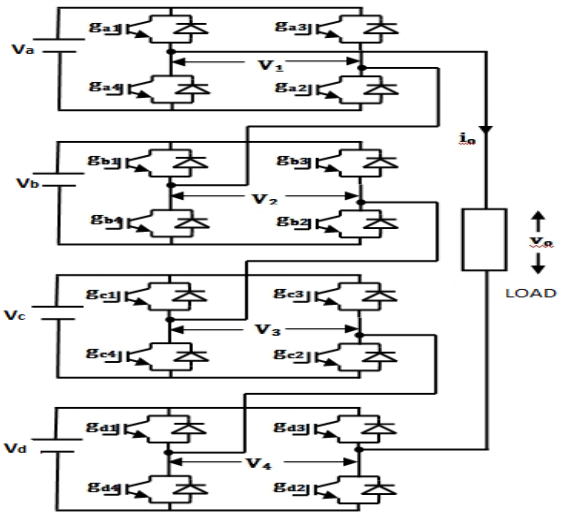

Fig.1.Nine level cascaded H-Bridge inverter

SWITCHING TABLE FOR 9-LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER																
S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	O/P
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1V
1	0	0	1	1	0	0	1	0	1	0	1	0	1	0	1	2V
1	0	0	1	1	0	0	1	1	0	0	1	0	1	0	1	3V
1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	4V
0	1	1	0	0	1	0	1	0	1	0	1	0	1	0	1	-1V
0	1	1	0	0	1	1	0	0	1	0	1	0	1	0	1	-2V
0	1	1	0	0	1	1	0	0	1	1	0	0	1	0	1	-3V
0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	-4V

In this circuit configuration sixteen power switches are required.The total output is the sum of all individual H-Bridge cell output.

$$Vo = Va + Vb + Vc + Vd$$

Where, Vo=Total output voltage
Va= Output voltage of first H-Bridge
Vb= Output voltage of second H-Bridge
Vc= Output voltage of third H-Bridge
Vd= Output voltage of fourth H-Bridge

III. MULTICARRIER SINUSOIDAL PULSE WIDTH MODULATION TECNIQUE

In this cascaded H-Bridge multilevel inverter multicarrier sinusoidal pulse width modulation is used.MCPWM is widely used because it is the simplest technique to generate multilevel pulses to control each power switches for any output level inverters by comparing reference signal with triangular signals.Here the reference signal is sinusoidal.

A. GENERATION OF MULTICARRIER SIGNALS

The train of pulses can be generated by comparing the modulating signal and carrier signal at each instant.These pulses can be used to control the switches of an inverter.If A_m is the peak to peak amplitude of modulating signal and A_c is the peak to peak amplitude of carrier signal,the amplitude modulation index,m_a is

$$ma = Am/nAc$$

If f_c is the frequency of carrier signal and f_m is the frequency of modulating signal,then frequency modulation index,m_f is

$$mf = fc/fm$$

If modulating signal is greater than zero with +ve carrier then it will generate '1' otherwise '0' and if modulating signal is greater than zero with –ve carrier,it will generate '-1' otherwise '0'.

B. SIMULATION RESULTS

Simulation results of 9-Level cascaded H-Bridge multilevel inverter is obtained with R load and analysis is done with respect to number of switches, output voltage, total harmonic distortion and input voltage by using MATLAB/SIMULINK.

1) Number of switches

For 5-Level cascaded H-Bridge multilevel inverter 2 H-Bridges and 8 power switches are used, for 7-Level cascaded H-Bridge multilevel inverter 3 H-Bridges and 12 power switches are used, for 9-Level cascaded H-Bridge multilevel inverter 4 H-Bridges and 16 power switches are used.

2) Output voltage waveform

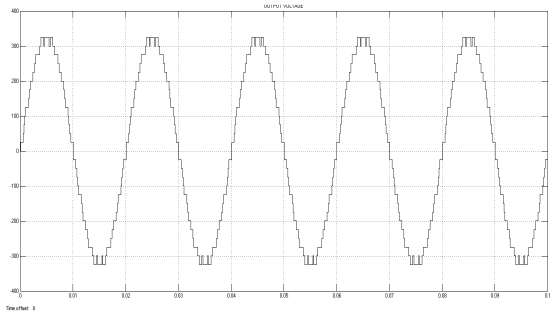

Fig.2.Output voltage waveform of single phase 9-Level cascaded H-Bridge multilevel inverter

3) Output current waveform

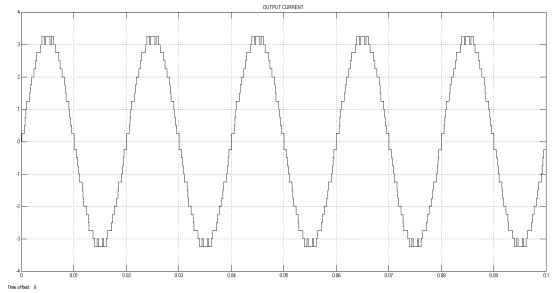

Fig.3.Output current waveform of single phase 9-Level cascaded H-Bridge multilevel inverter

4) Total harmonic distortion

If the number of level increases, total harmonic distortion decreases as shown in Fig.4.

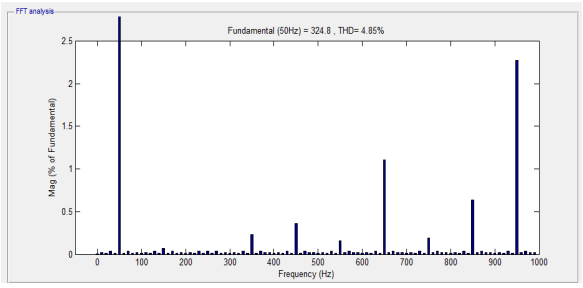

Fig.4.Total harmonic distortion of 9-Level cascaded H-Bridge multilevel inverter

C. COMPARISON BETWEEN DIFFERENT LEVELS OF CASCADED H-BRIDGE MULTILEVEL INVETER

PARAMETER	5-LEVEL	7-LEVEL	9-LEVEL
No. of H-Bridge	2 H-Bridges	3 H-Bridges	4 H-Bridges
No. of switches	8	12	16
Output levels	5	7	9
Input voltages	200	300	400
THD	17.12%	12.15%	4.85%

IV. CONCLUSION

In this paper, nine level cascaded H-Bridge multilevel inverter for wind energy conversion system using multicarrier PWM method is proposed. This unique structure uses less number of switches with reduced cost. This paper proves that by increasing the level of the inverter, %THD can be reduced and pure sinusoidal output waveform can be obtained. The comparison of 5-Level,7-Level and 9-Level inverter with respect to output voltage, input voltage and total harmonic distortion is also simulated.

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