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A Modified H-Bridge Eleven Level Inverter Using Single DC Source for the Elimination of Harmonics

* M. S. Sivagamasundari ** Dr. P. Melba Mary

* Assistant Professor , Department of EEE,V V College of Engineering,Tisaiyanvilai

** Principal , Department of EEE,V V College of Engineering,Tisaiyanvilai

ABSTRACT

Multilevel inverters are widely used in high voltage and high power applications especially in industrial drives. In these inverters, due to harmonic distortions the efficiency of the system is very much reduced and it is a major challenge to reduce the distortions in order to improve the efficiency. This research deals with a modified h-bridge eleven level inverter which employs eight switches only when compared to a conventional cascaded multilevel inverter which employs twenty switches. Multicarrier pwm technique is being used in this modified h-bridge eleven level inverter. The inverter is capable of producing eleven levels of output-voltage levels (Vdc , 4 Vdc /5, 3 Vdc /5, 2 Vdc /5, Vdc /5, 0, - Vdc /5,-2 Vdc /5, -3 Vdc /5, -4 Vdc /5 ,- Vdc) from the DC supply voltage. The performance has been studied by the MATLAB/Simulink. The output shows very low THD and high efficiency.

Keywords : Multilevel inverter, Cascaded multilevel inverter, Total Harmonic Distortion

I INTRODUCTION

A multilevel inverter is a power electronic converter that synthesizes a desired output voltage from several levels of dc voltages as inputs. With an increasing number of dc voltage sources, the converter output voltage waveform approaches a nearly sinusoidal waveform while using a fundamental frequency-switching scheme. The primary advantage of multilevel inverter is their small output voltage, results in higher output quality, lower harmonic component, better electromagnetic compatibility, and lower switching losses. [1] [2].They are of special interest in the distributed energy sources area because several batteries, fuel cell, solar cell and wind turbine can be connected through multilevel inverter to feed a load without voltage balance problems. The three common topologies for multilevel inverters are as follows: 1) Diode clamped (neutral clamped), 2) Capacitor clamped (flying capacitors), 3) Cascaded H-bridge inverter but the one considered in this paper is the modified h-bridge multilevel inverter.

This topology has many advantages not only in terms of its simple structure but also allows the use of a single dc source as the first dc source with the remaining (n-1) dc sources being capacitors[3]. The voltage regulation of the capacitor is the key issue and this is achieved by the switching state redundancy of the proposed modulation strategy. This scheme also provides the ability to produce higher voltages at higher speeds with low switching losses and high conversion efficiency.

A cascaded multilevel inverter may have more potential than others since input SDCS (Photovoltaic and Fuel cell) could be naturally interfaced to the multilevel inverter to provide higher output voltages: this may offer a high transformer less multilevel inverter in a grid connected application. Moreover, a cascaded configuration would provide a possibility to connect a higher SDCS (> 600 VDC) for getting higher output voltages which do not exceed the 600 VDC to ground as NEC limits. The cascaded multilevel control method is very easy when compared to other multilevel inverter because it doesn’t require any clamping diode and flying capacitor. [4]

The diode-clamped inverter (neutral-point clamped), capacitor-clamped (flying capacitor) requiring only one dc source and the cascaded bridge inverter requiring separate dc sources. The latter characteristic, which is a drawback when a single dc source is available, becomes a very attractive feature in the case of PV systems, because solar cells can be assembled in a number of separate generators. In this way, they satisfy the requirements of the CHB-MLI, obtaining additional advantages such as a possible elimination of the dc/dc booster (needed in order to adapt voltage levels), a significant reduction of the power drops caused by sun darkening (usually, it influences only a fraction of the overall PV field), and, therefore, a potential increase of efficiency and reliability.[5].

Performance of the multilevel inverter (such as THD) is mainly decided by the modulation strategies. For the cascaded multilevel inverter there are several well known pulse width modulation strategies. [6]. Compared to the conventional method, the proposed method is subjected to a new modulation scheme adopting the multicarrier pulse width modulation concept which uses multiple modulating signals with a single carrier reduces the total harmonic distortion.

This research deals with a modified h-bridge eleven level inverter which employs eight switches only when compared to a conventional cascaded multilevel inverter which employs twenty switches. Multicarrier pwm is being used in this modified h-bridge eleven level inverter. The inverter is capable of producing eleven levels of output-voltage levels (Vdc , 4 Vdc /5, 3 Vdc /5, 2 Vdc /5, Vdc /5, 0, - Vdc /5,-2 Vdc /5, -3 Vdc /5, -4 Vdc /5 ,- Vdc) from the DC supply voltage. The performance has been studied by the MATLAB/Simulink. The output shows very low THD and high efficiency.

II MODIFIED H-BRIDGE ELEVEN LEVEL INVERTER

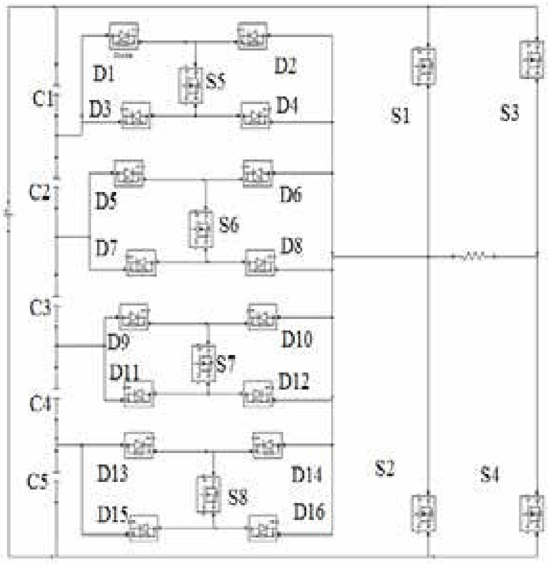

Fig.1.Modified H-bridge eleven level inverter

The new topology consists of eight controlled power switches ,sixteen diodes and five split source capacitors and achieves 40% reduction in the number of main switches required, using only eight controlled power switches instead of twenty required in the conventional cascaded h-bridge inverter. The auxiliary switch voltage and current rating are lower than the once required by the main controlled switches. Additionally, five capacitors are connected in parallel with the main dc power supply, no significant capacitor voltage swing is produced during normal operation, avoiding a problem that can limit operating range in some other multilevel configuration.

III OPERATION OF MODIFIED H-BRIDGE ELEVEN LEVEL INVERTER

The operating modes are as follows.

1. Zero output level(0):
The two main switches S2 and S4 are ON, short circuiting the load. All other control switches are OFF; the voltage applied to the load terminal is zero.

2. Positive output level (Vdc/5):
The auxiliary switch S8 is ON, connecting the load positive terminal, through diodes D13 and D16 and S4 is ON, connecting the load negative terminal to ground. All other control switches are OFF; the voltage applied to the load terminal is Vdc/5.

3. Positive output level (2Vdc/5):
The auxiliary switch S7 is ON Connecting to the load positive terminal, through diodes D9 and D12, and S4 is ON, connecting the load negative terminal to ground. All other control switches are OFF, the voltage applied to load terminal is 2Vdc/5.

4. Positive output level (3Vdc/5):
The auxiliary switch S6 is ON Connecting to the load positive terminal, through diodes D5 and D8, and S4 is ON, connecting the load negative terminal to ground. All other control switches are OFF, the voltage applied to load terminal is 3Vdc/5.

5. Positive output level (4Vdc/5):
The auxiliary switch S5 is ON Connecting to the load positive terminal, through diodes D1 and D4, and S4 is ON, connecting the load negative terminal to ground. All other control switches are OFF, the voltage applied to load terminal is 4Vdc/5.

6. Maximum Positive output level (Vdc):
S1 is ON, connecting the load positive terminal to Vdc and S4 is on, connecting the load negative terminal to ground. All other control switches are OFF. The voltage applied to load terminal is Vdc.

7. Negative output level (-Vdc/5):
The auxiliary switch S5 is ON Connecting to the load positive terminal, through diodes D3 and D2, and S3 is ON, connecting the load negative terminal. All other control switches are OFF, the voltage applied to load terminal is -Vdc/5.

Voltage	S1	S2	S3	S4	S5	S6	S7	S8
Vdc	1	0	0	1	0	0	0	0
4Vdc/5	0	0	0	1	1	0	0	0
3Vdc/5	0	0	0	1	0	1	0	0
2Vdc/5	0	0	0	1	0	0	1	0
Vdc/5	0	0	0	1	0	0	0	1
0	0	1	0	1	0	0	0	0
-Vdc/5	0	0	1	0	1	0	0	0
-2Vdc/5	0	0	1	0	0	1	0	0
-3Vdc/5	0	0	1	0	0	0	1	0
-4Vdc/5	0	0	1	0	0	0	0	1
-5Vdc/5	0	1	1	0	0	0	0	0

Table.1.Switching strategy

Table.1 shows the switching states of eleven level inverter

8. Negative output level (-2Vdc/5):
The auxiliary switch S6 is ON Connecting to the load positive terminal, through diodes D7 and D6, and S3 is ON, connecting the load negative terminal. All other control switches are OFF, the voltage applied to load terminal is -2Vdc/5.

9. Negative output level (-3Vdc/5):
The auxiliary switch S7 is ON Connecting to the load positive terminal, through diodes D11 and D10, and S3 is ON, connecting the load negative terminal. All other control switches are OFF, the voltage applied to load terminal is -3Vdc/5.

10. Negative output level (-4Vdc/5):
The auxiliary switch S8 is ON Connecting to the load positive terminal, through diodes D15 and D14, and S3 is ON, connecting the load negative terminal. All other control switches are OFF, the voltage applied to load terminal is -4Vdc/5.

11. Maximum Negative output level (-Vdc):
S2 is ON, connecting the load positive terminal and S3 is ON, connecting the load negative terminal. All other control switches are OFF, load voltage applied to the load terminal is –Vdc.

IV MULTICARRIER PWM TECHNIQUE

The Multicarrier PWM uses several triangular carrier signals and only one modulating sinusoidal signal as reference wave. If an 'n' level inverter is employed , 'n-1' carriers will be needed. At every instant each carrier is compared with the modulating signal. Each comparison gives one if the modulating signal is greater than the triangular carrier , zero otherwise. The results are added to give the voltage level, which is required at the output terminal of the inverter.[7].

Frequency modulation ratio is defined as the ratio of carrier frequency and modulating frequency.

Amplitude modulation ratio is defined as the ratio of amplitude of modulating signal and amplitude of carrier signal.

Using this technique THD value can be reduced with reduction in output voltage.

IV SIMULATION RESULTS

In this paper, the simulation model is developed with MAT-

LAB/SIMULINK. The simulation results of the proposed modified h-bridge eleven level inverter is shown in Fig.2 and the corresponding FFT analysis is shown in fig 3.

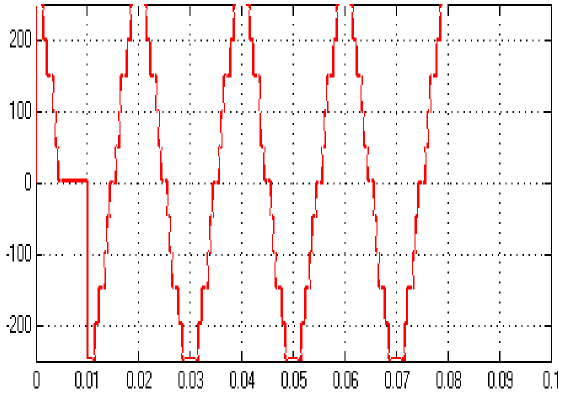

Fig.2.Output voltage waveform

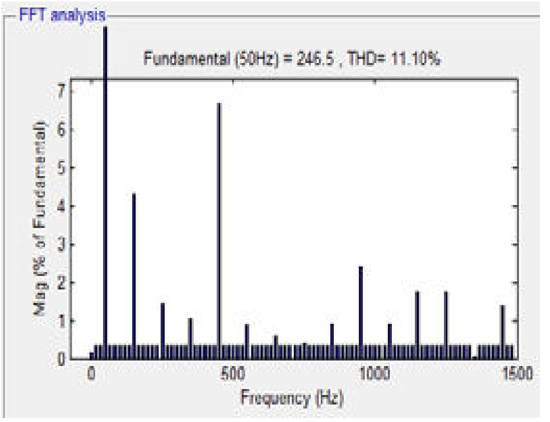

Fig.3.Harmonic Spectrum

V CONCLUSION

In the present work , modified h-bridge eleven level inverter which employs eight switches only when compared to a conventional cascaded multilevel inverter which employs twenty switches. Multicarrier pwm technique is being used in this modified h-bridge eleven level inverter. The performance has been studied by the MATLAB/Simulink. The output shows very low total harmonic distortion and is 11.10% .Hence we could achieve improved efficiency of the system.

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