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A New Model of H-Bridge Multilevel Inverter for Reduced Harmonics Distortion

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Abstract
In this paper the cascaded H Bridge multilevel inverter (CHB-MLI) is discussed and mainly focuses on the modified H-Bridge multilevel inverter in which the number of power devices is reduced. The analysis of five-level, seven-level and nine-level MLI are also done. The various control strategies are also introduced which effectively reduce the harmonics. The THD of five-level multilevel inverter is reduced to 16.91% which is much lower than the nine-level MLI.
Keywords: Multilevel inverter, five-level, seven-level, nine-level MLI, THD, control strategies.

I. Introduction

The preliminary studies on multilevel inverter (MLI) have been discussed using three level inverter that has been proposed by Nabae [15]. Multilevel inverters have more attention in the field of high voltage and medium power applications due to their many advantages, such as low voltage stress on power semiconductor devices, low harmonic distortions, good electromagnetic compatibility, reduced switching losses and improved reliability on fault tolerance. Comparing with the two or three level inverter multilevel inverter has the more harmonics reduction capability. Therefore, the multilevel inverters also have lower dv/dt ratios to prevent induction or discharge failures on the loads. The multilevel inverter topologies are classified into three categories up to now: Diode Clamped inverters, Flying Capacitor inverters, and Cascaded H Bridge inverters. Among three types of multi-level topology the cascaded H Bridge inverter has the least component for a given number of levels. A new model of H-Bridge MLI is introduced in which the number of switches is lower than the cascaded H-Bridge multilevel inverter which helps to reduce the overall cost of the inverter and circuit become less complicated.

This paper presents the model of H-Bridge for different levels and analysis of the THD with the resistive load with hardware waveform results. The THD of five-level MLI can be reduced up to 16.91% by using the various control strategies which is introduced in this paper.

II. General Cascaded H-Bridge Five-level MLI

This is the topology in which the two H-Bridges is connected in series by which the five-level output voltage is obtained. The circuit diagram of the three-phase CHB-MLI is shown in the fig 1 and the corresponding output waveform is shown in fig 2.

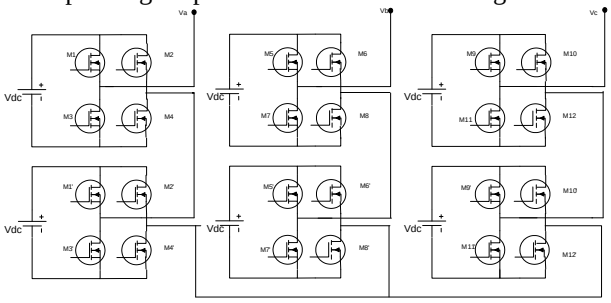


Fig.1 Three-phase five-level CHB-MLI

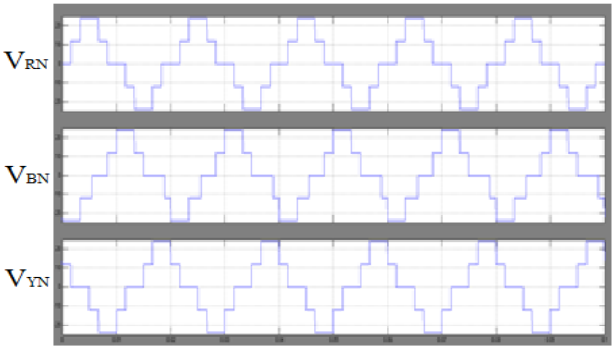


Fig. 2 Output Waveform of three-phase five-level CHB-MLI

The voltage THD with resistive load is calculated as 0.3192.

III. New model of H-Bridge MLI

In this proposed topology the CHB-MLI is modified with the objective to reduce the numbers of

power devices. As the number of power devices is reduced the cost of the circuit also reduces. As the levels of MLI are increased then in modified circuit only two power devices are to be added for increasing one level. Similarly for increasing the two-level just add four power devices. For example for five-level MLI six power devices are required, where as for seven-level eight power devices are required and for nine-level ten power devices are required. The power consumption of the circuit is also reduced and circuit become simple and less complicated as compared as conventional topology. The power circuit of five-level modified H-Bridge MLI is shown in fig 3.

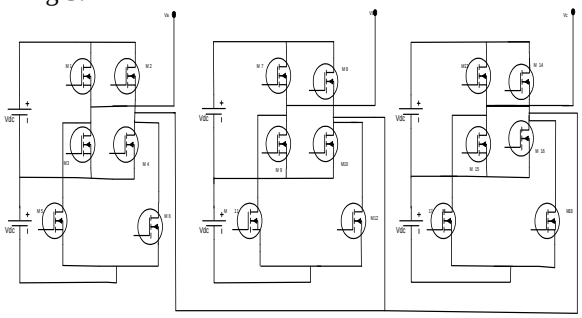


Fig. 3 Three-phase five level circuit of modified H-Bridge MLI

The percentage reduction in switching devices is shown in table 1.

Inverter type	5-level	7-level	9-level
Cascaded H-Bridge	8	12	16
Proposed topology	6	8	10
% Reduction	25%	33.33%	37.5%

Table1. The percentage reduction in switching devices

i. Five-level of new model H-Bridge MLI

In the five-level H-Bridge MLI six power devices are required for single phase and eighteen power devices for three-phase power circuit. The circuit diagram of single phase five-level modified H-Bridge MLI is shown in the fig 4.

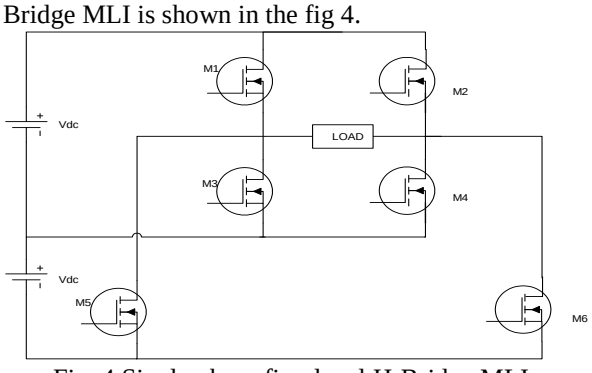


Fig. 4 Single phase five-level H-Bridge MLI

The voltage output waveforms are shown in fig 5. The control strategy which is used in this topology is termed as δ-δ-2δ-δ-δ where the value of δ is 30°.The circuit diagram of three-phase five-level new model H-Bridge MLI is shown in fig 6 and voltage output waveforms are shown in fig 7 respectively.

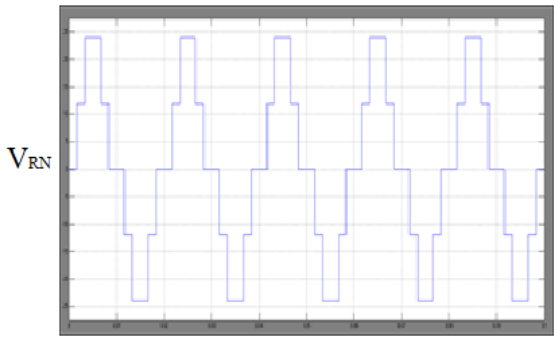


Fig. 5 Output voltage waveform for single phase five-level new model H-Bridge MLI

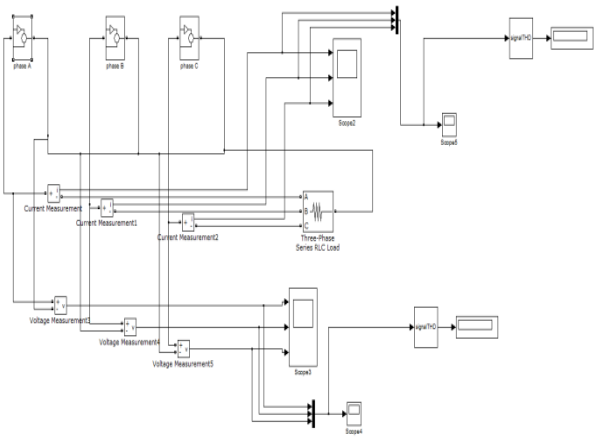


Fig. 6 Three-phase circuit for five-level New model H-Bridge MLI

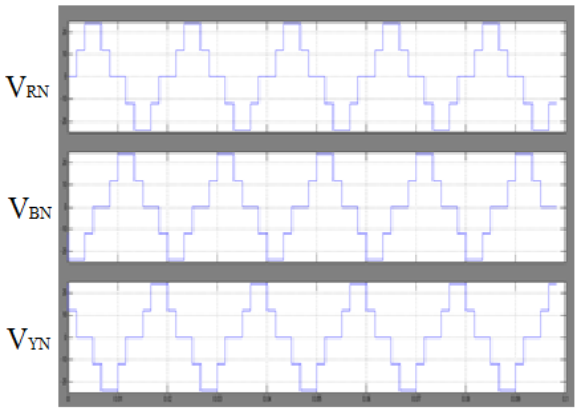


Fig. 7 The output voltage waveforms for three-phase five-level new model H-Bridge MLI

ii. Seven-level of new model H Bridge MLI

For the seven-level new model H-Bridge MLI eight power devices are required and for three-phase twenty four power devices are required. The power circuit is shown in fig 8. The three-phase power circuit is same as the power circuit of three-phase five-level modified H-Bridge MLI and the voltage output waveforms are shown in fig 9.

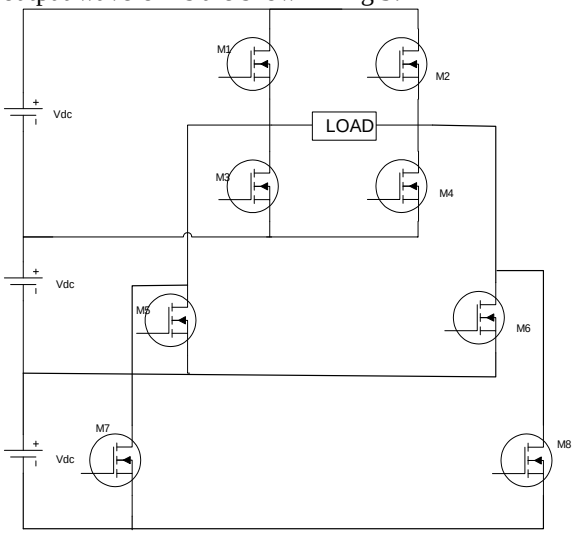


Fig. 8 Single phase seven-level H-Bridge MLI

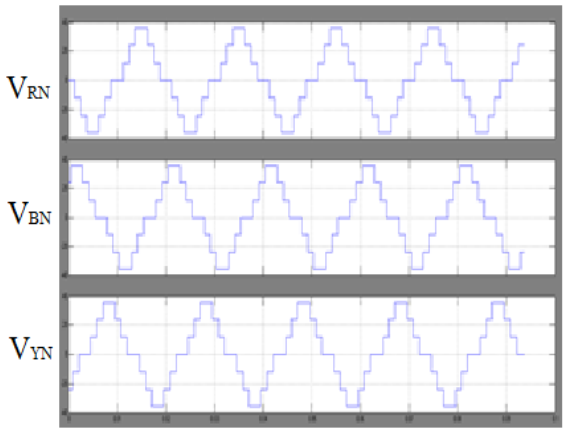


Fig. 9 The output voltage waveforms for three-phase seven-level new model H-Bridge MLI

iii. Nine-level modified H Bridge MLI

Similarly to the five-level and seven-level new model of H-bridge MLI the nine–level has required ten power devices for single-phase and thirty power devices for three-phase. The power circuit of nine-level modified H-Bridge MLI is shown in fig10. And the power circuit for three-phase is same as the five-level modified H Bridge MLI. The output voltage waveforms of nine-level three-phase modified H-Bridge MLI are shown in fig 11.

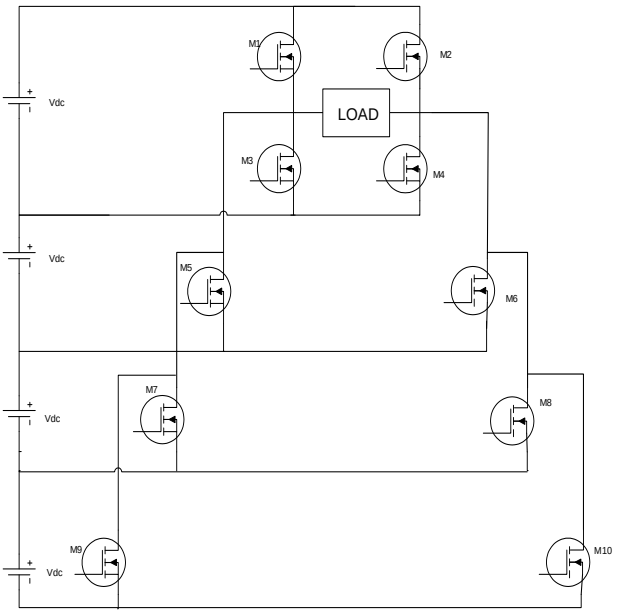


Fig. 10 Single phase nine-level H-Bridge MLI

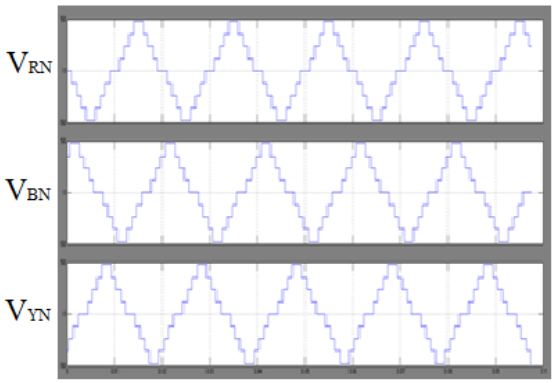


Fig. 11 The output waveform three-phase nine-level modified H Bridge MLI

IV. THD of new model H-Bridge MLI

The THD of five-level, seven-level and nine-level of mew model H-Bridge MLI is shown in the table 2.

Levels	THD
Five-level	0.3192
Seven-level	0.2546
Nine-level	0.2203

Table 2. Comparing THD of new model H-Bridge MLI for different levels.

V. Control strategies

By properly controlling the switching of the MOSFETs, the THD of output voltage waveforms can be reduced to substantial level. The various control schemes for five-level new model H-Bridge MLI are discussed in detail below.

i. δ-δ-4δ-δ-δ scheme

In this scheme the switching of the MOSFETs is done in the pattern δ-δ-4δ-δ-δ, where the value of δ is 22.5°. The output voltage waveform for three-phase is shown in fig 12. It is observed that the THD is reduced to 0.286.

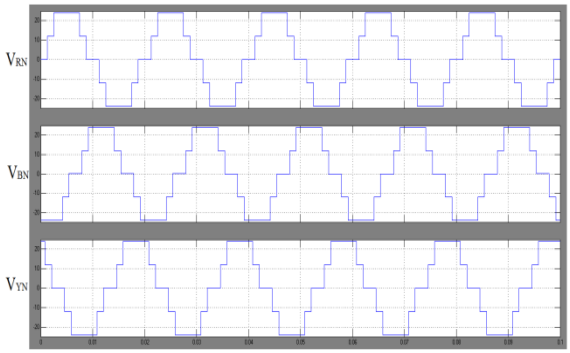


Fig 12.Output waveform of δ-δ-4δ-δ-δ

ii. δ-2δ-4δ-2δ-δscheme

In this scheme the switching of MOSFETs has changed as δ-2δ-4δ- 2δ- δ, where the value of δ is 18°. It is analyzed the THD is reduced 0.2049. The output waveform of three-phase is shown in fig 13.

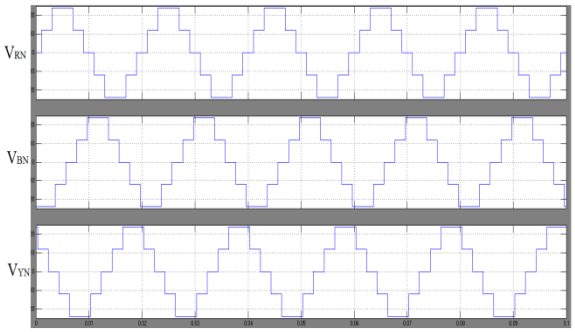


Fig 13.Output waveform of δ-2δ-4δ-2δ-δ

iii. δ-2δ-6δ-2δ-δscheme

In this scheme the switching of the MOSFETs is done in the pattern of δ-2δ-6δ-2δ-δ, where the value of δ is 15°. The output voltage waveform for three-phase is shown in fig 14. It is observed that the THD is reduced to 0.1697.

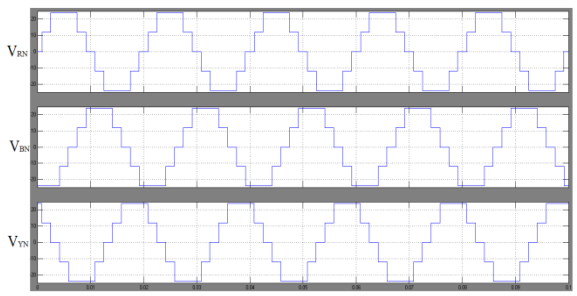


Fig 14.Output waveform of δ-2δ-6δ-2δ-δ

The comparison of THD of five-level modified H-Bridge MLI for various control strategies is shown in table 3.

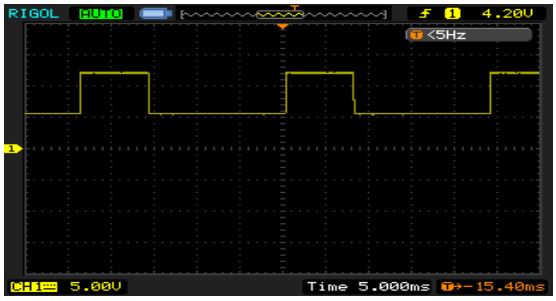
Schemes	THD
δ, δ, 2δ	0.3192
δ, δ, 4δ	0.2086
δ, 2δ, 4δ	0.2049
δ, 2δ, 6δ	0.1697

Table 3 Comparison of THD for various control strategies

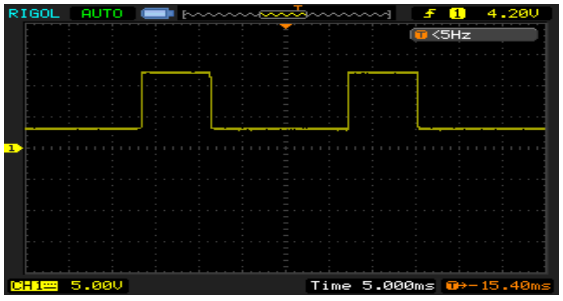
VI. Hardware results

The hardware result of a new model H-Bridge five-level Multilevel inverter is shown in the following figures.

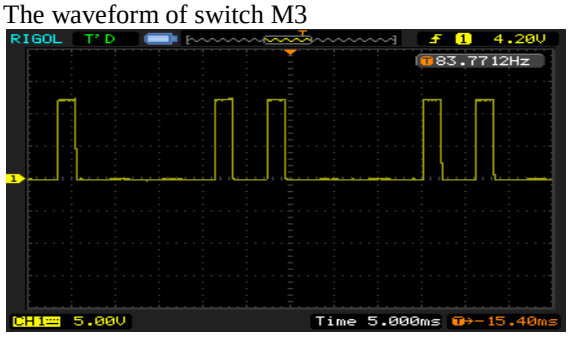
The waveforms of the switch M1



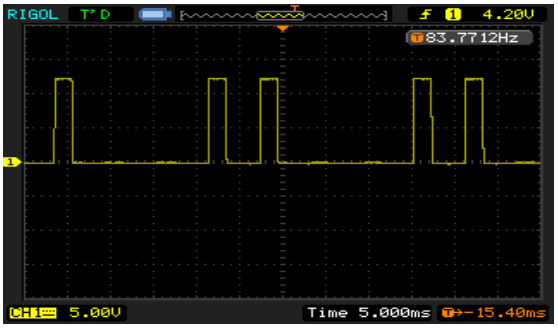
The waveform of switch M2



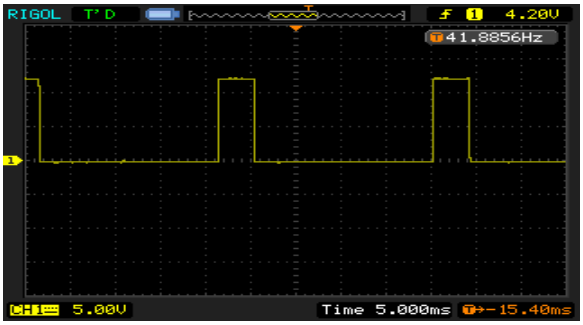
The waveform of switch M3



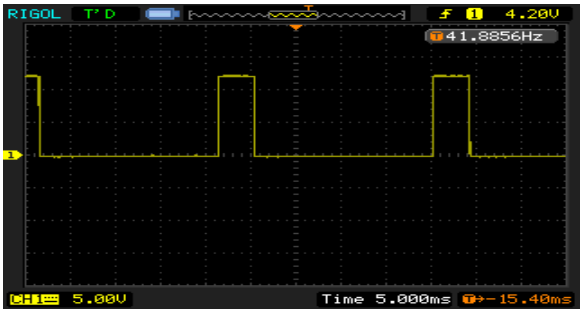
The waveform of switch M4 is



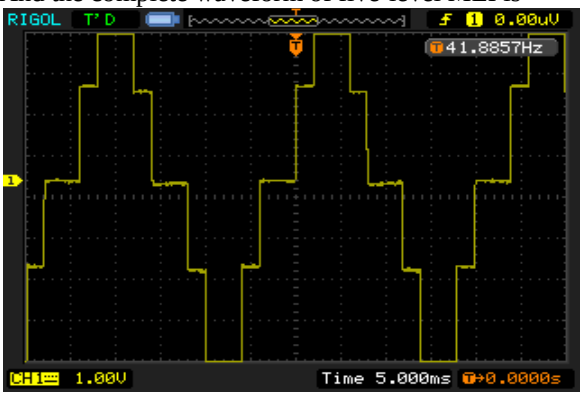
The waveform of switch M5 is



The waveform of switch M6



And the complete waveform of five-level MLI is



VII. Conclusions

In this paper modified H-Bridge MLI topology has been presented using reduced number of devices as compared to conventional H-Bridge cascaded MLI. The reduction in the number of devices goes on increasing as we increase the number of levels. A suitable and simple control strategy is proposed for three phase five-level MLI in which the THD is reduced to 16.97%, which is much lower than conventional nine-level MLI.

VIII. Acknowledgements

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