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New Approaches for Harmonic Reduction Using Cascaded H-Bridge and Level Modules

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ABSTRACT

This paper analyzes and compares two approaches for dc to ac power conversion i.e. inverter. First method uses cascaded H-Bridge Inverter and second uses new Multi-level Scheme having Level Modules and H-Bridge. The simulation is done in MATLAB Software. Also the hardware can be done by taking the AC supply from the mains and converts it into DC supply by using rectifier. MOSFET can be used for switching purpose. The Total Harmonic Distortion in output load voltage, produced by both the approaches is compared. It is shown that THD produced in second scheme is better up to a certain stages of the first scheme. The Total Harmonic Distortion produced in output load voltage when cascaded H-Bridge is used is 12.64% while the Total Harmonic Distortion produced in output load voltage when Level Modules and H-Bridge are used is 7.94%.

Keywords: Simulation, CHB, Level Module, THD.

Introduction

Over the past two decades, multilevel inverters have attracted wide interest both in the scientific community and in the industry. The reason for the increased interest is that the multilevel inverters are a viable technology to implement controlled rotational movement in high-power applications. There are several types of multilevel inverter like Neutral-Point-Clamped inverters, flying capacitor inverters, Multilevel cascaded H-Bridge inverters etc. But also there are many disadvantages in these types of multilevel inverter like complexity of the system, switching losses, heating losses because of increased number of switches. The problems can be overcome by using another method for dc to ac power conversion. This paper compares two methods; first method uses cascaded H-bridge and second uses H-bridge along with level modules. Both methods are used to get the output voltage of 15 levels. In the second method numbers of switches used are comparatively less. So there is less complexity of the system and also switching losses and heating losses are reduced.

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A) Multilevel cascaded H-Bridge inverters

The multilevel cascaded H-bridge converter (usually called CHB converter) is formed by the series connection of several H-bridges with their corresponding independent voltage sources. In Figure 1, a conventional H-bridge VSI was shown. This circuit can be considered as the basic cell to develop multilevel CHB converters and its operating principles is same as a full bridge inverter. A CHB is easily built connecting several H-bridge cells in series, like the two-cell CHB shown in Figure 1. In this way, the CHB topology is able to reach higher voltage levels by just adding H-bridge cells in series. This high modularity feature is very attractive to reach medium voltages up to 10 or even 13 kV in some industrial applications. This is why the CHB is found in practical applications up to nine cells in series.

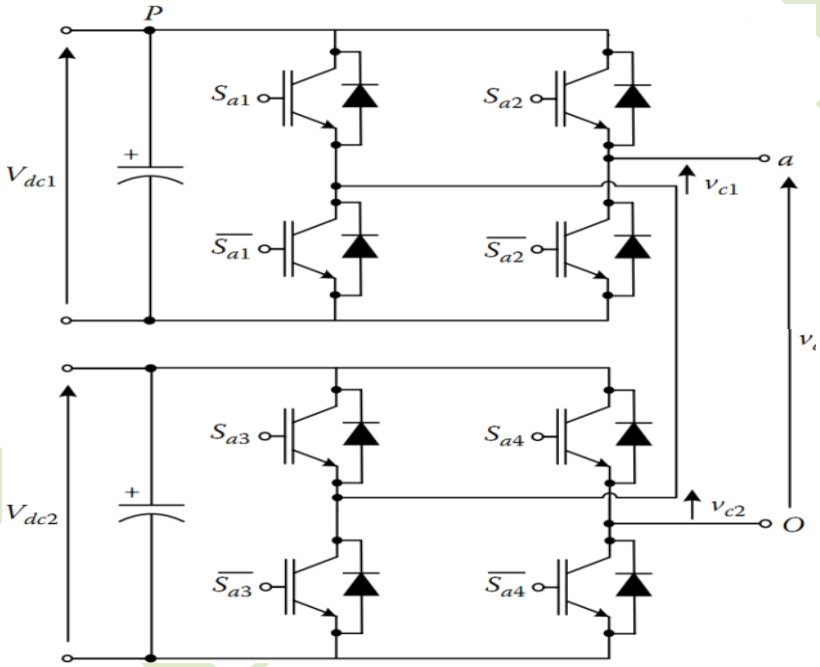

Fig.1Two – cell CHB converter

The conventional CHB assumes that all the dc voltage sources V_{dci} have exactly the same values; this corresponds to the CHB with equal dc sources. Assuming this conventional dc voltage ratio and considering a two-cell cascaded converter, like the one shown in Figure1. The two-cell achieves five possible output voltages and therefore it is a five-level converter. Many of the switching states generate the same output voltage level (voltage level redundancy), which increases over proportionally to the amount of cells. In general terms, the number of different voltage levels generated by a CHB with k cells is 2k + 1.

Different dc voltage source ratios can be applied in order to achieve more voltage levels in the output voltage. These converters are known as CHB with unequal dc sources or

asymmetric CHB. Depending on the dc voltage ratio, up to fifteen levels can be obtained using a two- cell CHB topology. In general terms, a voltage ratio in multiples of three between each cell of the CHB (V_{dc} (I+1) = $3V_{dci}$) eliminates all the voltage-level redundancies, maximizing the number of generated voltage levels. In this case, a k-cell CHB will generate 3k levels in the output voltage Compared to a CHB with equal dc sources, a 4-cell asymmetric converter will generate 34 = 81 levels compared to 2·4 + 1 = 9 levels of the symmetric CHB However, like with the FC, the modularity is lost since different blocking voltages appear among the semiconductors of the different cells.

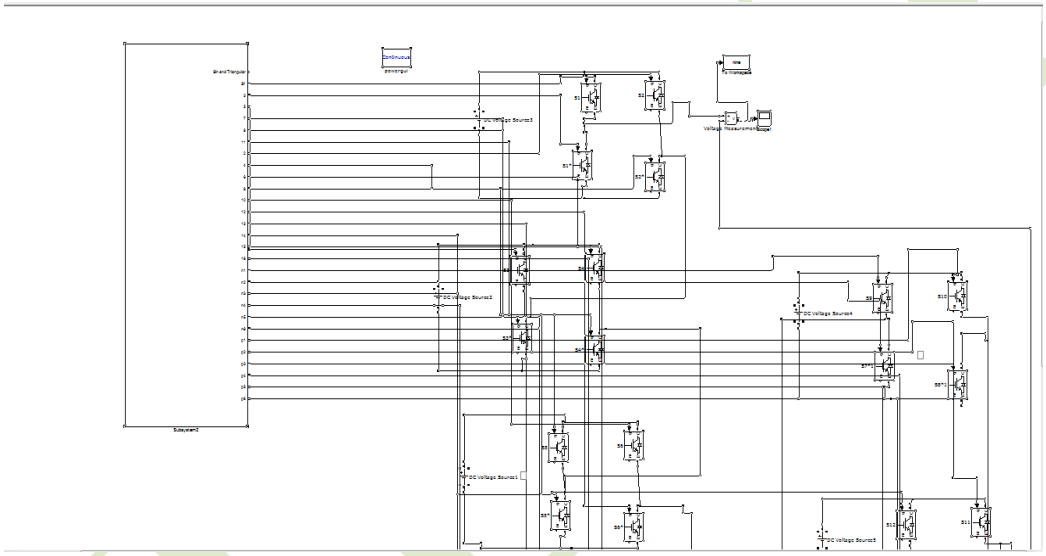

Fig.2 Matlab Simulation of cascaded H-bridge 15-level Inverter

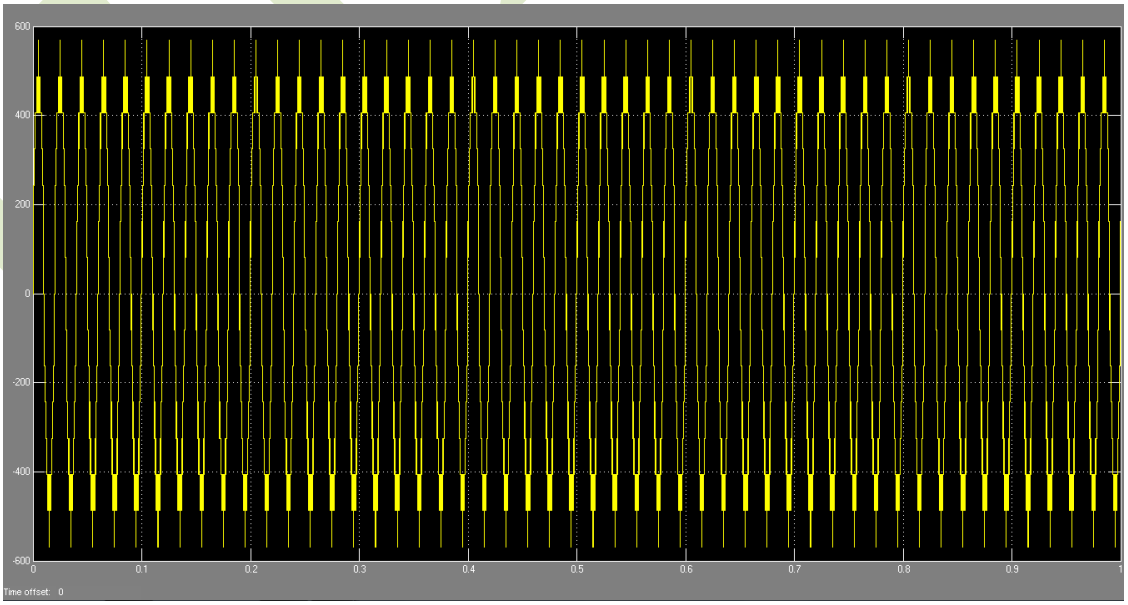

Fig.3 15-Level output voltage wave of cascaded H-bridge model

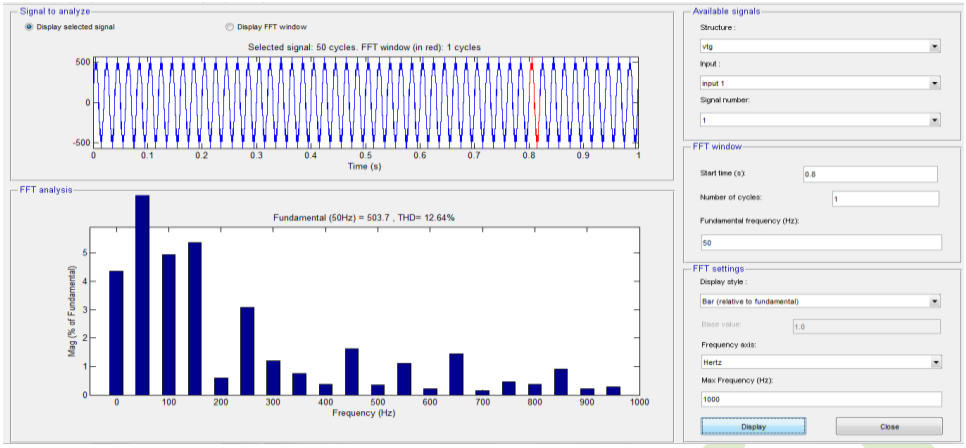

Fig.4 THD of cascaded H-bridge 15-level Inverter

B) New H-Bridge and level modules Inverter

In the proposed circuit, 3 Level modules, 1 H-Bridge inverter, and 3 dc voltage sources of Vd, 2Vd and 4Vd are used. Output wave has 15 level and the total no. of switches used are 10.Total dc voltage used in the circuit is 7Vd. The gate pulse for first LM switch Qo is a SPWM pulse having 7 pulses in each half cycle. To find the gate pulse for second LM switch Q1, this Qo is given to the clock of a negative edge triggered JK flip flop with J=K=1. Further this Q1 is given to the clock of another JK flip-flop to get gate pulse for third LM switch Q2.

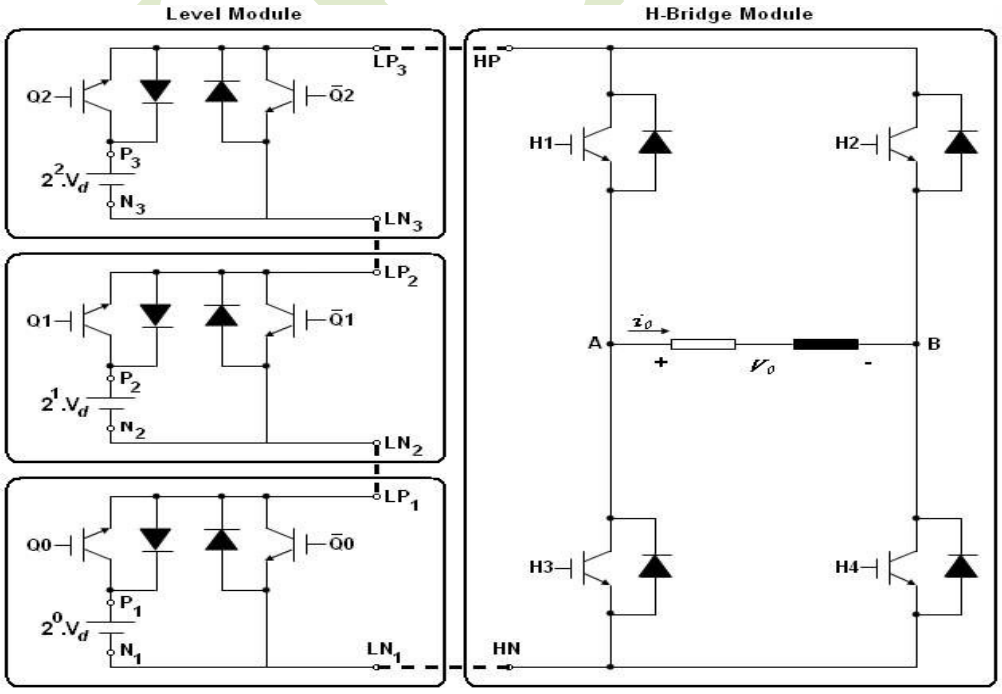

Fig.5 Proposed multilevel circuit

The level of output voltage shape depends on the level module used in the circuit.

Output Level

$$n = 2^{(m+1)} - 1$$

Where m is the no. of Level Module used.

The no. of switches used in the circuit

$$r = 2m+4$$

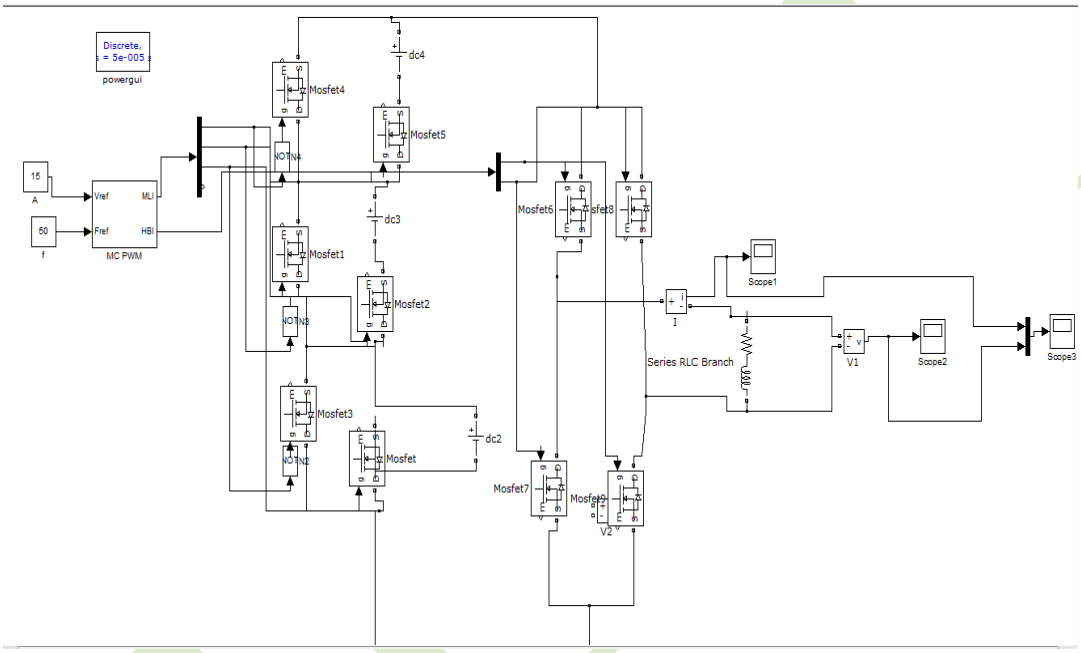

Fig.6 Simulation of Proposed Model

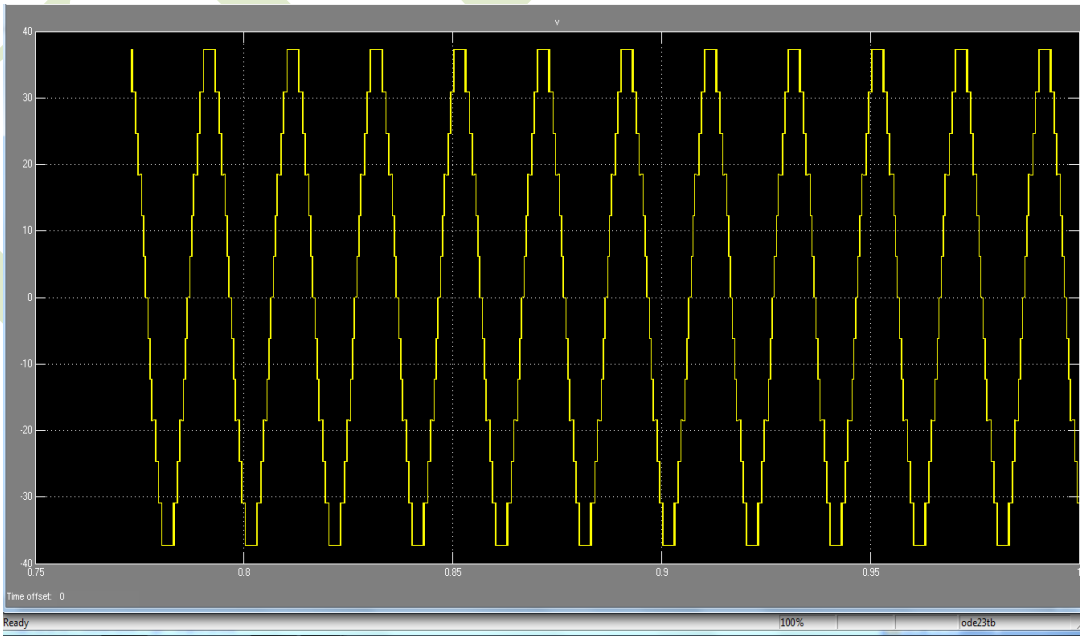

Fig.7 15-Level output voltage wave of proposed model

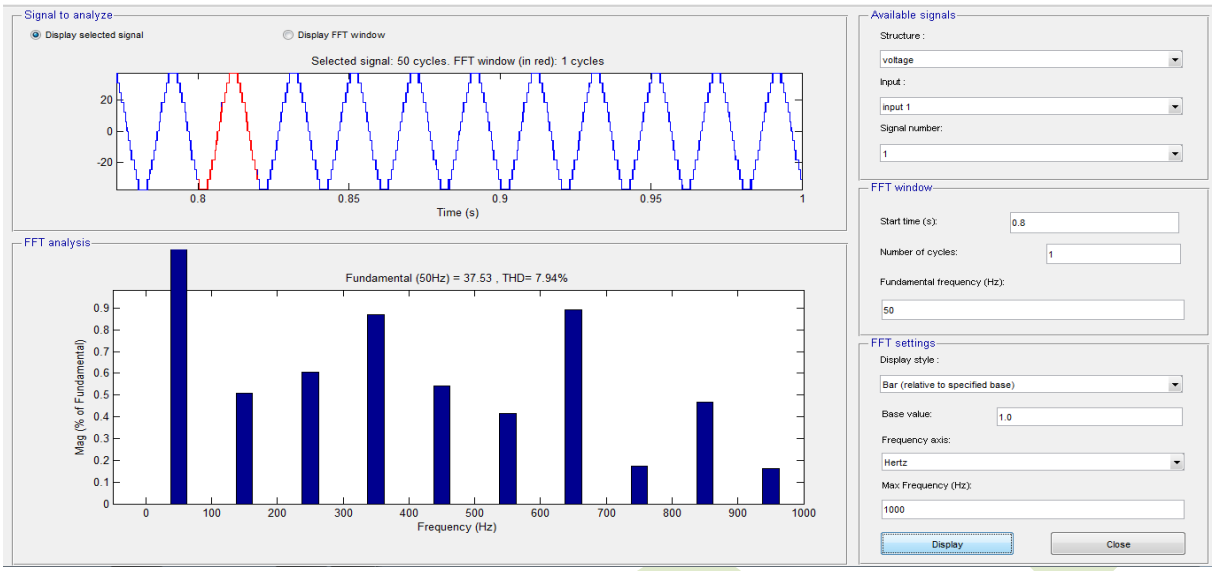

Fig.8 THD of proposed model

Comparison

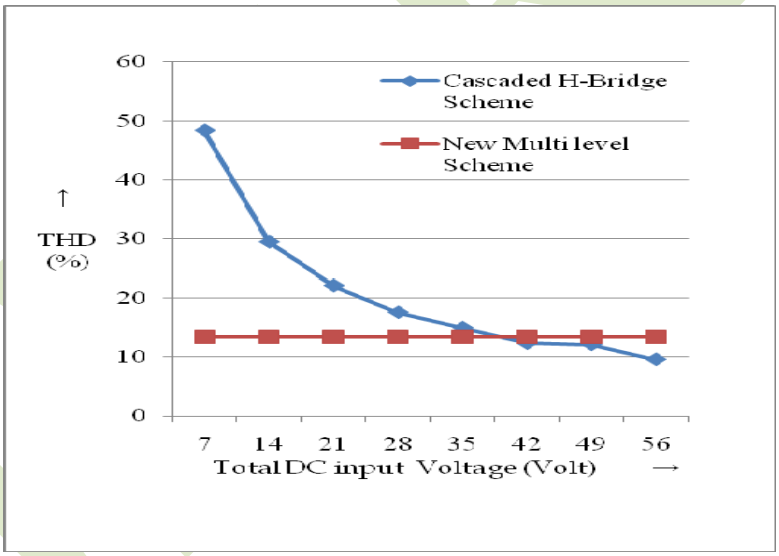

Fig.9 THD Vs DC Input Voltage for Cascaded H-Bridge and New Proposed Multilevel Schemes.

If comparison is made between cascaded H-bridge and new multilevel scheme, it is found that the new multilevel scheme produces a good quality output voltage waveform as compare to the cascaded H-bridge for different dc input voltages and the THD found is to be comparatively better in the new multilevel scheme as shown in fig.9.

Conclusion

The THD in output voltage obtained in second scheme is 7.94% while for cascaded H-Bridge inverter the minimum THD found is 12.64%. This shows that the power quality of the first scheme is poor as compare to second scheme. Also the switches used in the first scheme are 28, while the switches used in the second scheme are 10.

This paper shows only the comparison of two schemes without the use of filter. The THD obtained in output load voltage may always be reduced below 5% by using filter in both schemes.

In this paper, THD in load voltage are evaluated for the two schemes using MATLAB software and then compared for the same dc input voltage and same RL load without using the filter. It is found that the THD obtained in the proposed multilevel inverter with level module gives approximately 5% less THD as compare to the conventional cascaded H-bridge inverter.

The THD is better as well as cost is less for the second scheme. This means that if the Solar Panels having same power rating and same characteristics are connected in both the scheme, the Power Quality will be better and cost is less for second scheme.

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