Comparison of Cascaded H-bridge Multilevel Inverter Topologies with THD Analysis

Vidya M. Patil[2], Onkar A. Bhadule[3], Shubhangi S. Patil[4], Sujit S. Jadhav[5]

Department of Electrical Engineering, Annasaheb Dange College of Engineering and Technology Ashta,

Maharashtra, India [2,3,4,5]

ABSTRACT: The project mainly focuses on the comparison of cascade H-bridge multilevel inverter with THD analysis. The main objective of our project is to increase number of levels with a low THD and sources at the output without adding any complexity to the power circuit. The main advantage of this topology is to reduce the Total Harmonic Distortion (THD), lower electromagnetic interference generation and achieve high output voltage. The Pulse Width Modulation technique has proposed which can minimize the total harmonic distortion and enhances the output voltages from proposed work of seven level inverter. The operation of single-phase three level & seven level cascaded H-bridge multilevel inverters are being analysed in this project. The comparison of performances of these two topologies will be discussed on the basis of various parameters such as voltage levels, number of switches, THD level and output.In this project work hardware model of Seven-level single phase cascade H-Bridge inverter has been developed using MOSFET. Gating signals for these MOSFET have been generated by comparators. In order to maintain the different voltage levels at appropriate interval, the conduction time intervals of MOSFETS have been maintained by controlling the pulse width of gating pulses (by varying the reference signal magnitude by the comparator). The results of hardware are compared with simulation result. Simulation model (designed in SIULINK) have developed up to seven level and THD in all the cases have identified.

KEYWORDS: MLI-multi level inverter, THD-Total harmonic distortion.

I. INTRODUCTION

Basically Inverter is a device which converts DC power to AC power with desired voltage and frequency.The demerits of inverter are less efficiency, high cost and high switching losses [1]. To overcome this demerits multilevel inverter are preferred.

The concept of multilevel converters has beenintroduced since 1975.Some of the widely used multilevel inverters are diode clamped, flying capacitor and cascaded H-bridge. In diode clamped as number of levels increases diode required for inverter also increases. In flying capacitor topology as number of levels increases capacitor required also increases which makes this topology heavy and cumbersome. The cascaded multilevel control method is very easy as compared to other multilevel inverters because it doesn't require any clamping diodes and flying capacitor. The attractive features of multilevelinverter are, they can generate the output with very low THD, it is much suitable for high voltage, High power applications than that of conventional inverter, it can switch each device only once per cycle and generateMultistate stair case waveform approaching pure sinusoidal output voltage. It has more electromagnetic capability and higher voltage capability. The multilevel output voltage is having less number of harmonics as compared to conventional bipolar inverter output voltage. In case of multilevel inverters as output increases to N level, the harmonic reduces [2].

II. RELATED WORK

The different multilevel inverter topologies have explained in various articles with different control system with modifications. Sridhar R. Pulikanti, et al [1] have worked on hybrid 7 level cascaded active neutral point clamped based multilevel converter under selective harmonic elimination pulse with modulation (SHE-PWM) technique with minimum switching frequency with provided the elimination of low order harmonic and the results have validated through simulation results and low power laboratory prototype. Jose Rodriguez, et al [2] have reviewed a survey of topologies, with controls and applications of multilevel inverters. The soft switched multilevel inverters with sinusoidal pulse with modulation, multilevel selective harmonic elimination and space vector modulation have explained. Javier Chivite-Zabalza, et al [3] have demonstrated the applications of combining three level neutral point clamped power electronics building blocks for a large power voltage source converter for FACTS. The analysis of system has carried

out with elimination of third harmonic component by the modulation, high quality output which eliminated the need of filters and also the results have verified with experimental results for several modulation strategies. Jia-Min Shen, et at [4] have implemented five level inverter for a renewable power generation system. The five level inverter have developed and applied for injecting real power of the renewable power into the grid to reduce the switching power loss, harmonic distortion and electromagnetic interference caused by switching operation of power electronics devices. The system has analyzed with output current of five level inverter controlled to generate a sinusoidal current in phase with utility voltage inject into the grid and verified the results with hardware setup. Hossein Sepahvant, et al [5] have designed a single dc source cascaded H-bridge multilevel converters for capacitor voltage regulation using phase shift modulation control strategy. The issues of voltage balancing have solved with this modulation technique in which converter have fed with only one independent dc source. Thus, the constraints involved in selecting the voltage source level of auxiliary H-bridge cell have discussed. Mohammad Farhadi Kangarlu, et al [6] have proposed an application of cascaded multilevel for higher level purposes in industries due to its high quality output waveform as compared to two level inverter. It has provided a special attention to obtain optimal structure regarding different criteria such as number of switches, standing voltage, number of voltage sources etc. They have analysed multilevel inverter for both symmetric and asymmetric conditions and verified with both software and laboratory prototype implementation. J. M. Kharade et al. [7] have reviewed different multilevel converter topologies with current source converter, voltage source converter, hybrid converters for HVDC applications with its applications, advantages and disadvantages.

III. CASCADED H- BRIDGE MULTILEVEL INVERTERS WITH THD ANALYSIS

The cascaded multilevel control method is very easy as compared to other multilevel inverter because it does not require any clamping diode and flying capacitor. A multilevel inverter has four main advantages over the conventional inverter. First, the voltage stress on each switch decreased due to series connection of the switches. Therefore, the rated voltage and consequently the total power of the inverter could be safely increased.Second, the rate of change of voltage (dv/dt) decreased due to lower the lower voltage swing of each switching cycle. Third, harmonic distortion reduced due to more output levels. Fourth, lower acoustic noise and electromagnetic interference(EMI) obtained.

A. CASCADED H-BRIDGE THREE LEVEL INVERTER:

The cascaded H-bridgethree level inverter consists of one H-bridge, DC source, R load. The DC source may be batteries, solar cells, etc. The H-bridge may having MOSFET, IGBT, Diode. The number of levels of output voltage wave depends on number of H-bridges. In cascaded H-bridge three level inverter, single H-bridge produces three levels of output voltage. The voltage levels are +V,0 and –V. The voltage output is in staircase form.

The simulation diagram and THD result of cascaded H-bridge three level inverter is shown in figures below:
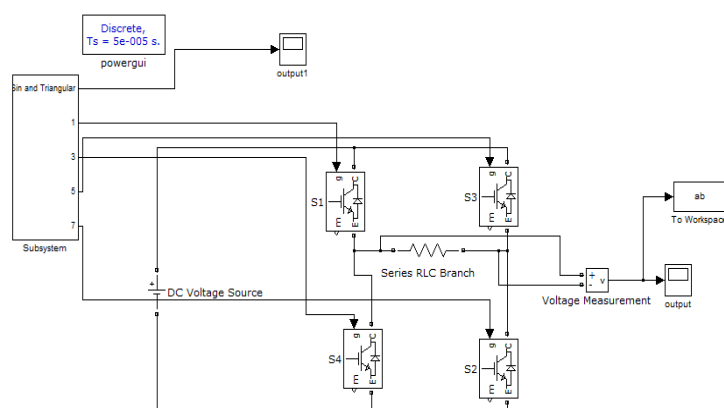

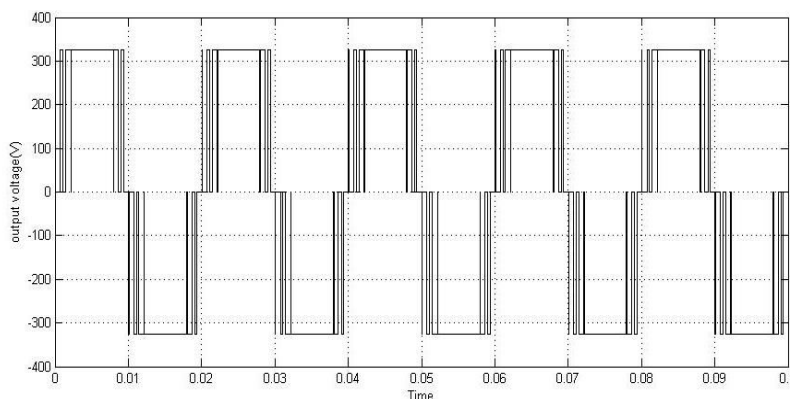Fig. 1(a) Simulation model of cascaded H-bridge three level inverter

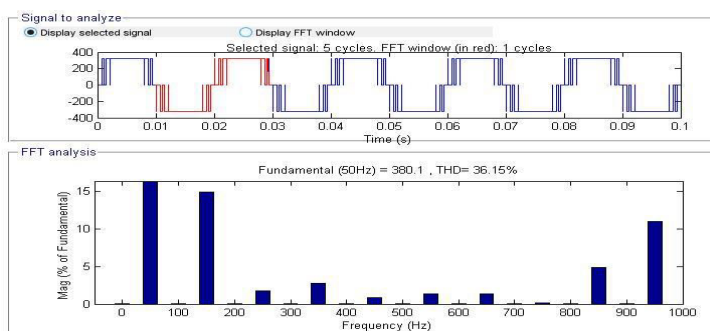Fig-1(b) Output voltage of cascaded H-bridge three level inverter

Fig. 1(c) THD level in output voltage of cascaded H-bridge three level inverter

The % of THD for three level inverter may be 36.15%. The % of THD is depends upon number of switches used in inverter circuit.

B. CASCADED H-BRIDGE FIVE LEVEL INVERTER:

The cascaded H-bridge five level inverter consists of two H-bridge, two equipotential DC sources, R load. The DC source may be batteries, solar cells, etc. The H-bridge may have MOSFET, IGBT, Diode. The number of levels of output voltage wave depends on number of H-bridges. In cascaded H-bridge five level inverter, two H-bridges produces five levels of output voltage. The voltage levels are +2V, +V, 0 and –V,-2V. The voltage output is in staircase form.

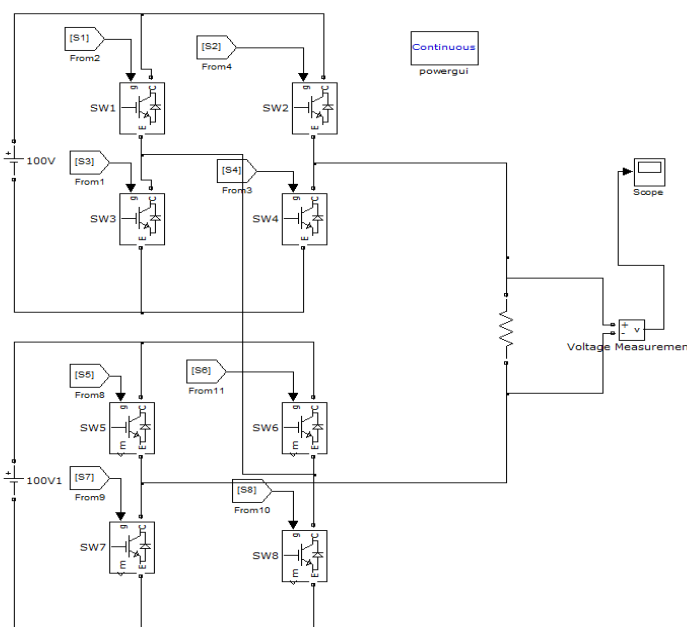The simulation diagram and THD result of cascaded H-bridge five level inverter is shown in below:

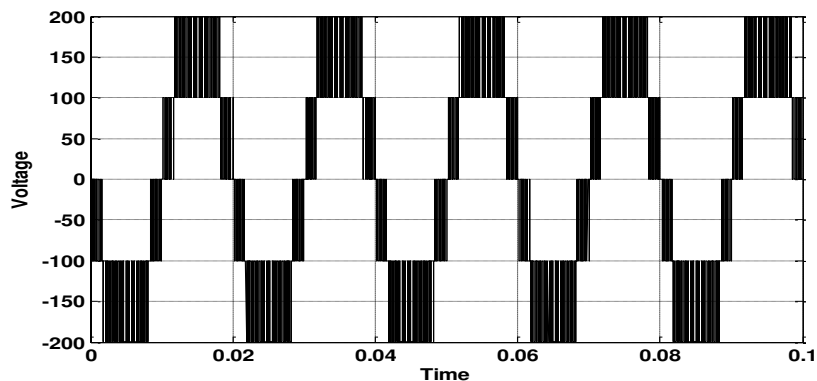Fig.2 (a) simulation model for five level inverter

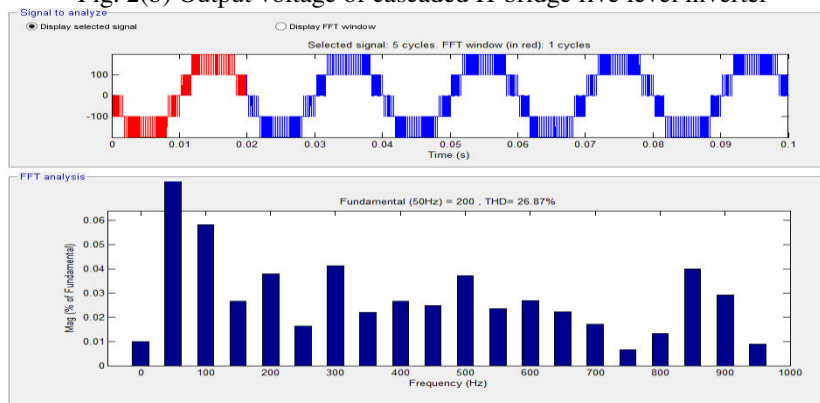Fig. 2(b) Output voltage of cascaded H-bridge five level inverter

Fig. 2(c) THD level in output voltage of cascaded H-bridge five level inverter

C. CASCADED H-BRIDGE SEVEN LEVEL INVERTER:

The cascaded H-bridge seven level inverter consists of three H-bridge, three equipotential DC sources, R load. The DC source may be batteries, solar cells, etc. The H-bridge may having MOSFET, IGBT, Diode. The number of levels of output voltage wave depends on number of H-bridges. In cascaded H-bridge seven level inverter, three H-bridges produces seven levels of output voltage. The voltage levels are +2V, +V, 0 and –V,-2V. The voltage output is in staircase form.

The simulation diagram and THD result of cascaded H-bridge seven level inverter is shown in figures below:
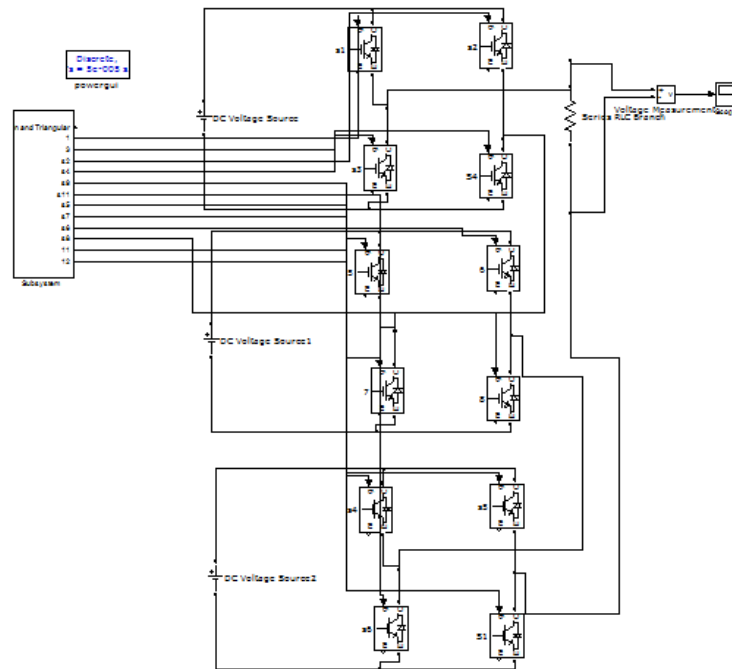
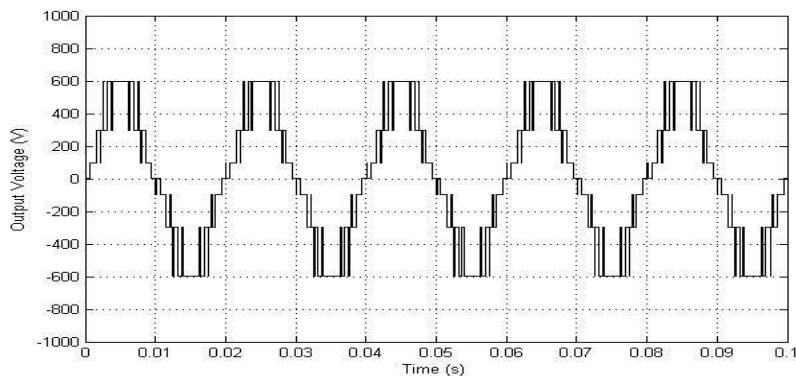Fig. 3(a) Simulation model of cascaded H-bridge seven level inverter

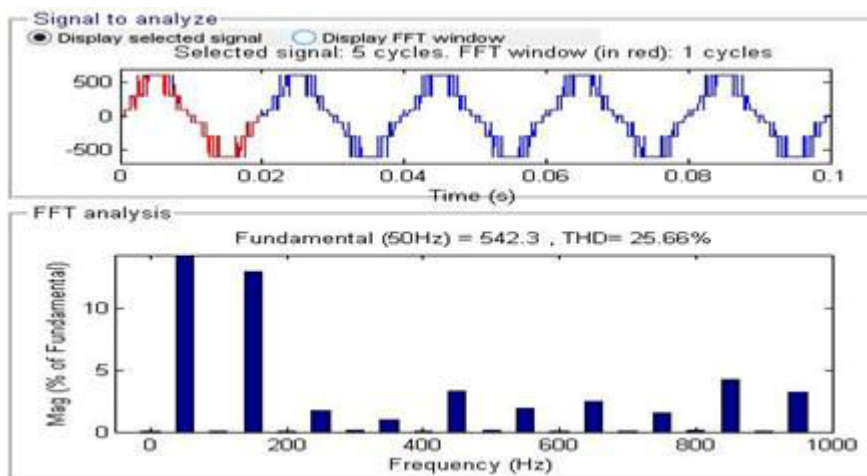Fig. 3(b) Output voltage of cascaded H-bridge seven level inverter.

Fig. 3(c)THD level in output voltage of cascaded H-bridge seven level inverter.

The % of THD for seven level inverter may be 25.66%. The % of THD is depends upon number of switches used in inverter circuit.The THD level of seven level inverter is less as compared to the three level and five level inverter. This is major advantage of seven level cascaded H-bridge inverter over three level and five level inverter.

IV. COMPARISON OF CASCADED H- BRIDGE MULTILEVEL INVERTERS

The table 1 illustrates the comparison of Cascaded H inverters with three level five level and seven level.

Table No. 1

Sr. No.	Parameters	Three level CHBI	Five level CHBI	Seven level CHBI
1	No. of bridges	1 H-bridge	2 H-bridge	3 H-bridge
2	No. of switches	4	8	12
3	Output levels	3	5	7
4	No. of DC sources	1	2	3
5	%THD	36.15	26.87	25.66

The performance of proposed cascaded multilevel inverter is evaluated by using MATLAB/SIMULINK software. From this simulation we can observe that as the number of levels are increased the %THD decreased. The above table shows the comparison between different level cascaded H-bridge inverters with the help of different parameters.

V. CONCLUSION

In this paper, three level, five level and seven level cascaded H-bridge inverters have been simulated by using MATLAB/SIMULINK. The results of simulated system of multilevel Cascaded H- Bridge inverter have been compared on the basis of different parameters such as number of switches, number of DC sources required for operation and THD levels. According to the comparison, the seven level inverter has less THD level as compared to the three level and seven level inverter. From this comparison, we can conclude that as the number of level increases the THD level decreases. As the H-bridges increases the harmonic content in the output of inverter decreases.

REFERENCES

[1]. Sridhar R.Pulikanti, "Hybrid Seven Level Cascaded Active Neutral-Point-Clamped-Based Multilevel Converter under SHE-PWM" IEEE Transaction on industrial electronics, vol. 60, no.11, Nov 2013.
[2]. José Rodríguez, "Multilevel Inverters: A Survey of Topologies, Controls, and Applications" IEEE Transaction on industrial electronics, vol. 49, no.4, August 2002.
[3]. Javier Chivite-Zabalza, "A Large-Power Voltage Source Converter for FACT Applications Combining Three-Level Neutral-Point-Clamped Power Electronic.Building Blocks" IEEE Transaction on industrial electronics, vol. 60, no.11, Nov 2013.
[4]. Jia-Min Shen, "Five-Level Inverter for Renewable Power Generation System." IEEE Transaction on industrial electronics, vol. 28, no.2, June 2013.
[5]. Hossein Sepahvand, "Capacitor Voltage Regulation in Single-DC-Source Cascaded H-Bridge Multilevel Converters Using Phase-Shift Modulation." IEEE Transaction on industrial electronics, vol. 60, no.9, Sept. 2013.
[6]. Mohammad Farhadi Kangarlu, "A Generalized Cascaded Multilevel Inverter UsingSeries Connection of Submultilevel Inverters." IEEE Transaction on industrial electronics, vol. 28, no.02, Feb. 2013.
[7]. Miss. Jyoti M. Kharade, Dr. Niteen G. Savagave, "A review of HVDC converter topologies", International Journal of Innovative Research in Science, Engineering and Technology, vol 6, Issue 2, Feb. 2017, pp.1822-1830.