



Comparative Study of Three level and Five level Inverter

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ABSTRACT: This paper analyses and compares the different cascaded H-Bridge multilevel inverter used for dc to ac power conversion. The simulation of multilevel inverters is done in MATLAB/SIMULINK software. The active power output, reactive power output and Total Harmonic Distortion (THD) in output voltage produced in 3-level and 5-level inverters are obtained and compared. It was observed that THD in 5-level inverter is less as compared to 3-level inverter & THD in 7-level inverter is less as compared to 3-level and 5-level inverter.

KEYWORDS: Cascaded H-Bridge Multilevel Inverter, Three level inverter, Five level inverter, Comparison.

I. INTRODUCTION

The use of renewable energy sources is increasing to supply the increasing demand of electricity due to urbanisation. Solar energy produces dc power which needs to be converted into ac for further applications. Conversion of dc power to ac is done using cascaded H bridge multilevel inverter with less THD. The high power cascaded H bridge multilevel inverter should be analysed with respect to its output active power, reactive power and THD in output voltage. This study will help the design engineer in selecting the appropriate multilevel inverter for required application. Multilevel inverters are classified as current source inverter and voltage source inverter. In case of multilevel current source inverter, it was observed that if there is short circuit in the circuit, the fault current will be very high further damaging the other equipment's connected in the circuit. Therefore multilevel voltage source inverters are more commonly used [3]. Multilevel voltage source inverters are classified into three main categories as (i) cascaded H-bridge multilevel inverter, (ii) Neutral point clamped multilevel inverter and (iii) Flying capacitor multilevel inverter. Cascaded H bridge multilevel inverter is more commonly used because it gives high output voltage, reliability, power levels and simplicity of control.

II. CASCADED H-BRIDGE MULTILEVEL INVERTER

The cascaded H-Bridge multilevel inverter are the most advanced and important method of power electronic converters that analyses output voltage with number of dc sources as inputs. As compared to neutral point clamped multilevel inverter and flying capacitor multilevel inverter, the cascaded H-Bridge multilevel inverters requires less number of components and it reaches high quality output voltage which is close to sinewave. By increasing the number of output levels the total harmonic distortion in output voltage can be reduced. In cascaded H-Bridge multilevel inverter required AC output voltage is obtained by synthesizing number of DC sources. The number of H-Bridge units with different DC sources is connected in series or cascade to produce cascaded H-Bridge multilevel inverter [4].

III. SINGLE PHASE 3-LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER

Fig 1 shows Single phase Three level Cascaded H-Bridge inverter consisting of single isolated DC source, four IGBT switches & R-L load. The result of output voltage waveform of three level multilevel inverter is shown in fig 3. It consists of three levels 0, +V_{dc}, -V_{dc} [1].

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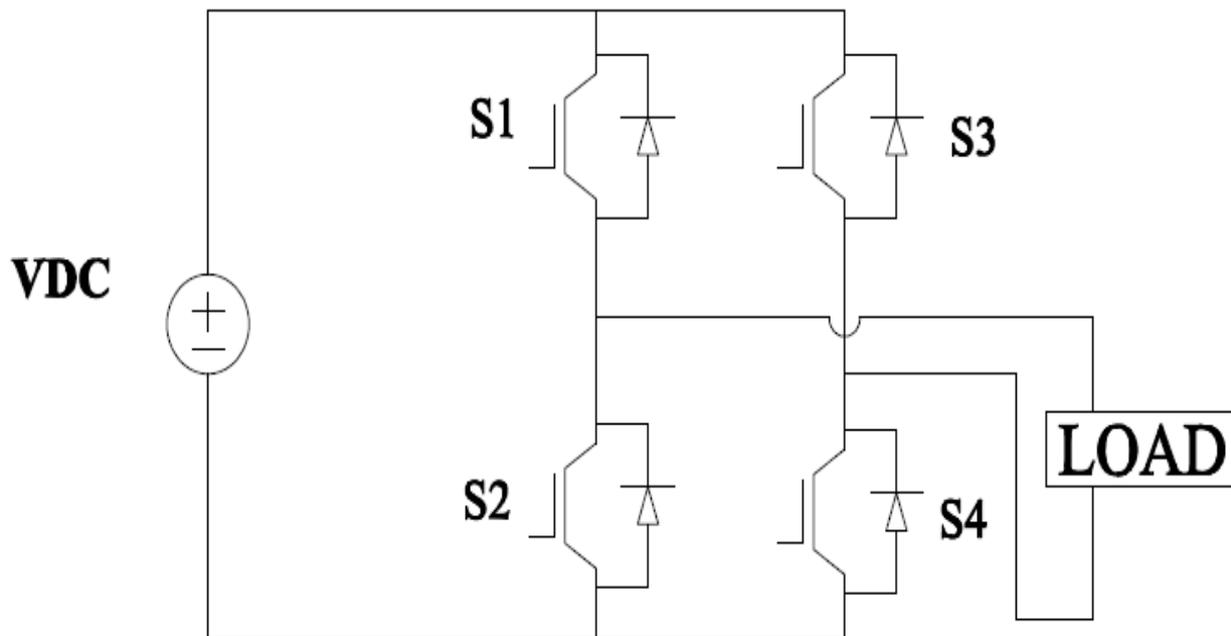


Fig 1 Single phase Three level cascaded H-Bridge inverter

Operation:

Different modes of operation of three level cascaded H-Bridge multilevel inverter are explained below:

Mode 1:- In this mode of operation of three level cascaded H-Bridge inverter switches s1 & s2 are turned on & no source is connected to the load. Zero output voltage across the load is obtained.

Mode 2:- In this mode of operation of three level cascaded H-Bridge inverter switches s1 & s4 are turned on. Output voltage obtained across the load is +Vdc.

Mode 3:- In this mode of operation of three level cascaded H-Bridge inverters switches s2 & s3 are turned on. Output voltage obtained across the load is -Vdc.

Mode 4:- In this mode of operation of three level cascaded H-Bridge inverter switches s3 & s4 are turned on. Output voltage obtained across the load is zero.

The same operation is shown in tabular form below in table 1

Table 1 Modes of operation of single phase three level cascaded H-Bridge Inverter

| Mode | Switch1 | Switch2 | Switch3 | Switch4 |
|------|---------|---------|---------|---------|
| 1 | 1 | 1 | 0 | 0 |
| 2 | 1 | 0 | 0 | 1 |
| 3 | 0 | 1 | 1 | 0 |
| 4 | 0 | 0 | 1 | 1 |

IV.SINGLE PHASE 5-LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER

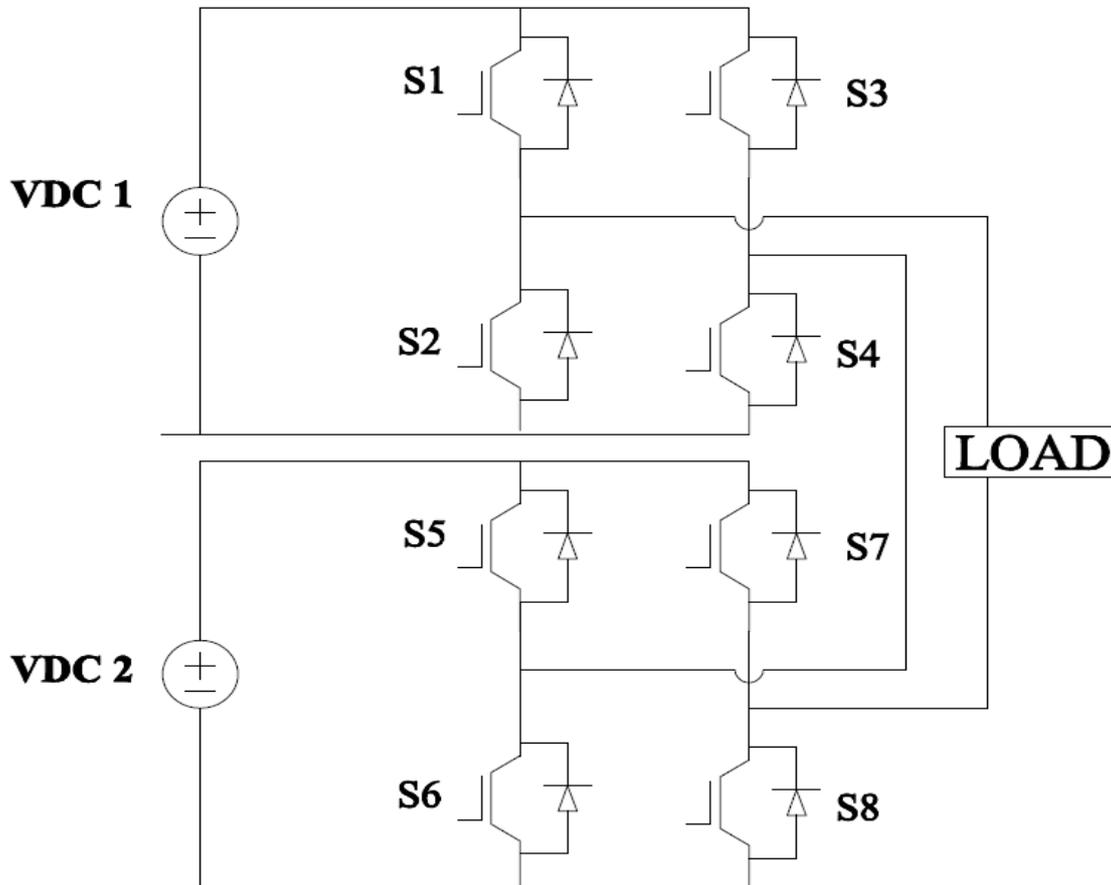


Fig 2 Single phase Five level cascaded H-Bridge inverter

Fig 2 shows single phase cascaded H-Bridge multilevel inverter consisting of two H-Bridges with 8 IGBT switches,two DC sources and ,R-L load.In this eight IGBT switches are (switch1,switch2,switch3,switch4,switch5,switch6,switch7,switch8) are used.Two H-Bridges are connected in series to generate five level output voltage.The output voltage of H-Bridge inverter 1 is V_1 and H-Bridge 2 is V_2 & total output voltage of 5 level inverter is V .i.s. $V=V_1+V_2$.

Working Operation of Five Level Inverter:

The working operation of cascaded H bridge five levels multilevel is explained below:

Mode1:-In this mode of operation single phase five level cascaded H-Bridge multilevel inverter switch1; switch3,switch5 and switch7 are turned on without connecting source to the load.The output voltage across the load obtained is zero.

Mode2:- In this mode of operation single phase five level cascaded H-Bridge multilevel inverter switch1,switch3, switch5 and switch8 are turned on.The output voltage across the load obtained is $+V_{dc2}$.

Mode3:-In this mode of operation single phase five level cascaded H-Bridge multilevel inverter switch1,switch4,switch5 and switch8 are turned on.The output voltage across the load obtained is $V_{dc1}+V_{dc2}$.

Mode4:-In this mode of operation single phase five level H-Bridge cascaded multilevel inverter switch2,switch4,switch6 and switch7 are turned on.The output voltage across the load obtained is $-V_{dc2}$.

Mode5:-In this mode of operation single phase five level H-Bridge cascaded multilevel inverter switch2,switch4,switch6 and switch8 are turned on.The output voltage across the load obtained is zero.

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 2, February 2016

Mode6:- In this mode of operation single phase five level H-Bridge cascaded multilevel inverter switch3,switch2,switch7 and switch6 are turned on.The output voltage across the load obtained is $-V_{dc1}-V_{dc2}$. The same operation is shown in tabular form below in table 2

Table 2 Modes of operation of single phase five level cascaded H-Bridge Inverter

| Mode | Switch1 | Switch2 | Switch3 | Switch4 | Switch5 | Switch6 | Switch7 | Switch8 |
|------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 3 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 4 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| 5 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 6 | | 1 | 1 | 0 | 0 | 1 | 1 | 0 |

V. RESULT AND DISCUSSION

Fig 3 shows the Output Voltage Waveform of Single phase three level Cascaded H-Bridge inverter consists of three level $+V_{dc}, 0, -V_{dc}$.

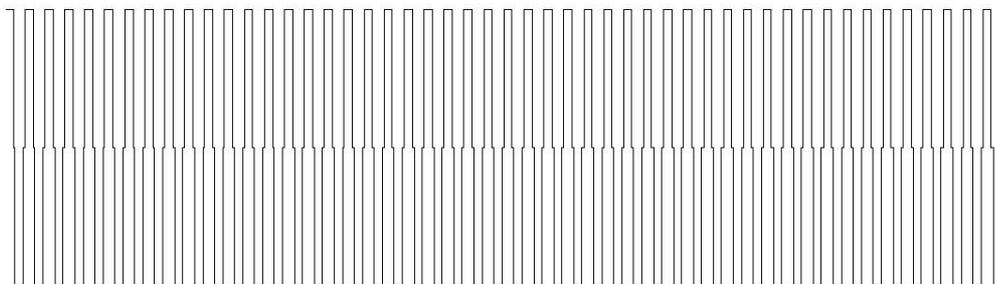


Fig.3 Output Voltage Waveform Of Single Phase Three Level Cascaded H-Bridge Inverter.

Fig.4 shows the Total Harmonic Distortion (THD) result for 3 level cascaded H-bridge inverter

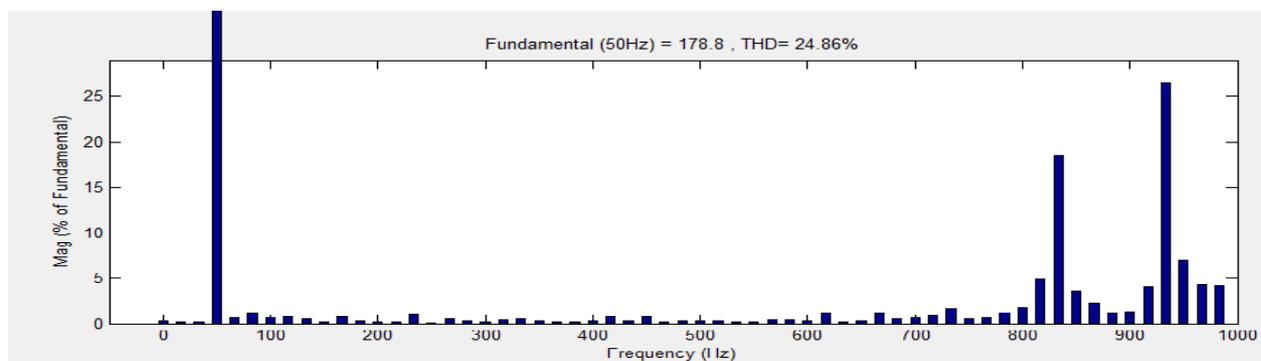


Fig 4 THD for 3 level cascaded H-bridge inverter

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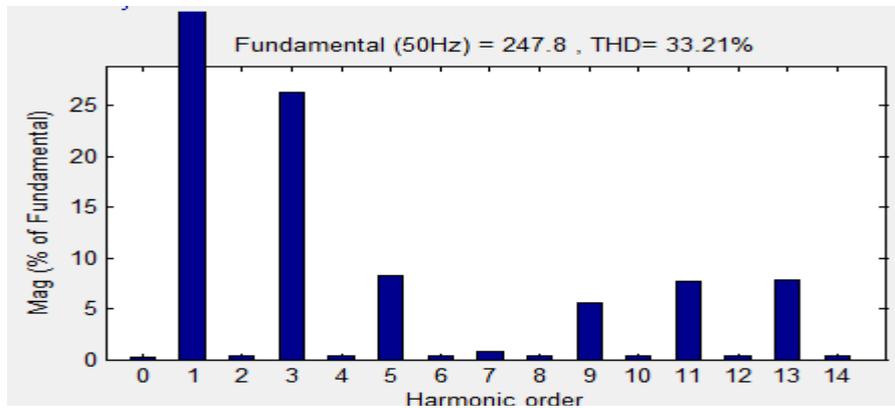


Fig 5 THD of 3 level cascaded H-Bridge Inverter with RL load

In the fig 5 shows the Output Voltage Waveform of Single phase Five level Cascaded H-Bridge inverter consists of five level $V_{dc1}, V_{dc1}+V_{dc2}, 0, -V_{dc2}, -V_{dc1}-V_{dc2}$.

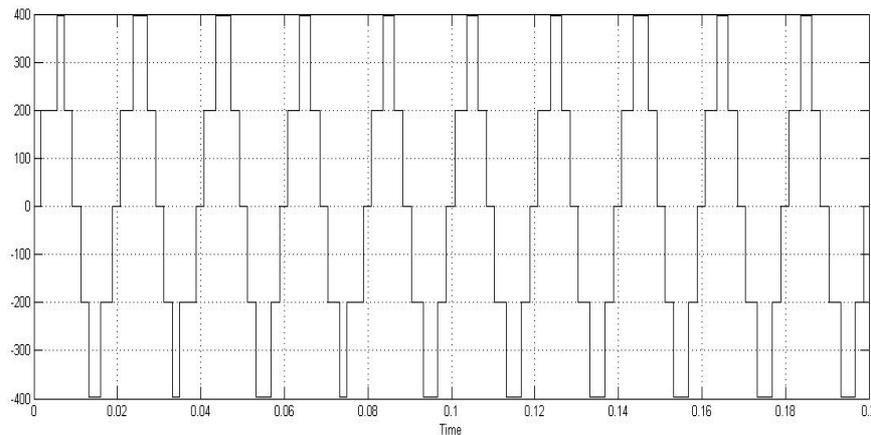


Fig.6 Output Voltage Waveform Of Single Phase 5 Level Cascaded H-Bridge Inverter.

In the fig7 shows the total harmonic distortion (THD) of Five level Cascaded H-Bridge inverter

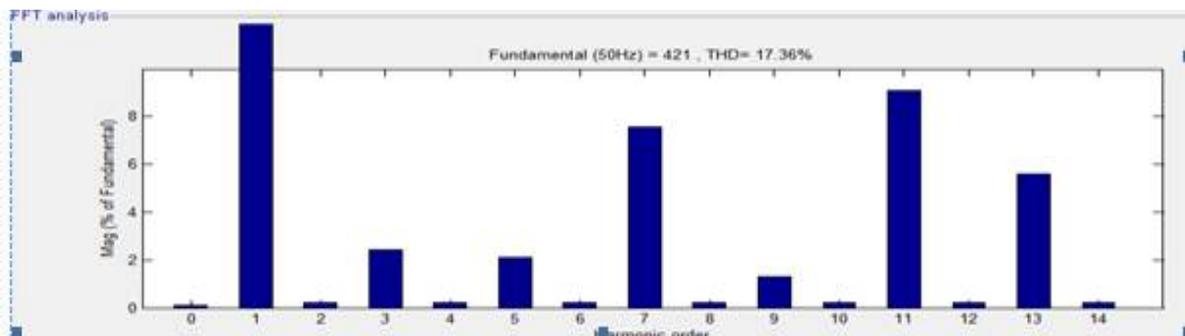


Fig.7 THD Result For 5 Level Cascaded H- Bridge Inverter

In the fig8 shows the total harmonic distortion (THD) of Five level Cascaded H-Bridge inverter with R-L load.

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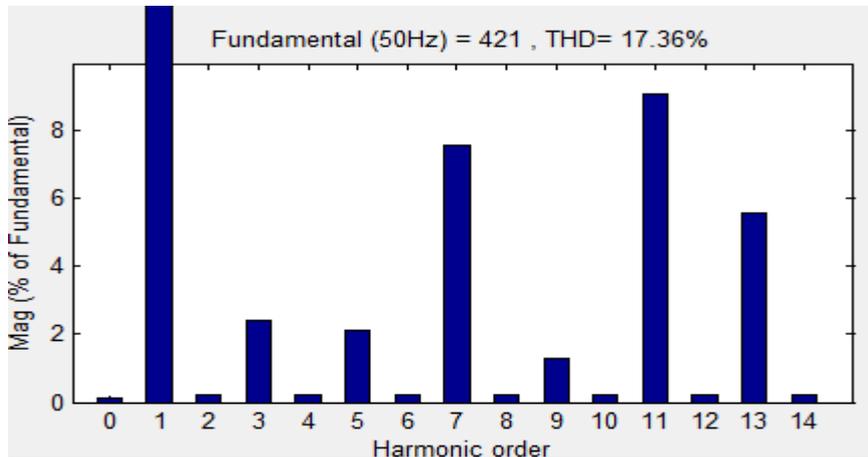


Fig 8 THD Result For 5 Level Cascaded H- Bridge Inverter with RL load

Table 3 Comparison Between Three level & Five level Inverter:

| Parameter | Single phase 3-Level Cascaded H-Bridge Inverter | Single phase 5-Level Cascaded H-Bridge Inverter |
|-----------------------------------|---|---|
| Number of switches | 4 | 8 |
| THD of Load voltage with R-load | 24.86% | 17.36% |
| THD of Load voltage with R-L load | 33.21% | 17.36% |
| ActivePower with R- load | 30.48 | 77.22 |
| Reactive Power with R- load | 0 | 0 |
| ActivePower with R-L load | 819.9W | 343.1 |
| Reactive Power with R-L load | 146.3W | 5.872 |

VI.CONCLUSION

Thus the single phase three level cascaded H-Bridge inverter is compared with single phase five level cascaded H-Bridge inverter using MATLAB simulation on the basis of switches, THD , Active power and reactive power with R-load and RL load .The total harmonic distortion in three level inverter is more as compared to five level inverter.As the number of level increases, THD decreases and active power increases. This study will help the design engineer for selection of appropriate multilevel inverter for further applications.

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