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Comparison of Cascaded H-bridge Inverter and Switched DC Source Inverter

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ABSTRACT

A multilevel voltage-source inverters are the best solution for high power dc-to-ac conversion applications. A multilevel inverter is a linkage structure of multiple input dc levels and power semiconductor devices to get a quasisquare waveform. In addition, the multilevel waveform has a less harmonic contents as compared to a two-level waveform obtained from conventional inverters. The quality of the multilevel waveform is improved by increasing the number of levels. But ,If number of level increases, a large number of power semiconductor devices and gate driver circuits are also increased. So, it will increases system complexity and cost and tends to reduce the system reliability and efficiency. For a high-resolution waveform, therefore, practical considerations necessitate reduction in the number of switches and gate driver circuits. In this paper, the working principle of single phase five level switched DC sources inverter and single phase five level cascaded H-bridge inverter are explained. Performances of single phase five level switched DC sources inverter and single phase five level cascaded H-bridge inverter are compared on the basis of structure, working principle, number of power switches required and switching losses.

Keywords: **Classical topologies, multilevel inverter (MLI), reduced component count, reduced switching losses.**

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I. INTRODUCTION

Multilevel inverter technology has recently as a very important alternative in the area of high-power medium voltage applications. Researchers are going on to improve their capabilities further through optimized control techniques, and to minimize both component count and manufacturing cost. The multilevel inverter has been implemented in various applications, such as motor drives, power conditioning devices, renewable energy generation and distribution. PWM inverters can simultaneously control output voltage, frequency and it can reduce the amount of harmonics in output current which results in better THD content.

Several multilevel topologies have been developed, but increase in number of levels, it also increases the number of switches, number of independent dc sources, switching stresses, losses, voltage unbalancing across capacitors etc. Performances of switched DC sources inverter and cascaded H-bridge inverter are compared on the basis of structure, working principle, number of switches used and switching losses.

A multilevel inverter consists multiple input DC sources and/or capacitors and power semiconductor devices to produce a quasi square waveform. Quality of output voltage waveform of a MLI indicates how much close in shape the waveform to the required sine wave. Quality of output voltage waveform of a MLI can be improved by increasing the number of levels. However, it results in a large number of power semiconductor devices and gate driver circuits. Therefore, system complexity and cost will be increased. Also, system reliability and efficiency will be reduced. Therefore, for multilevel inverters having higher number of levels in output voltage waveform, practical considerations necessitate reduction in the number of switches and gate driver circuits.

The paper is organized as follows. Section II presents structure and modes of operations of Cascaded H-bridge Inverter. Section III presents structure and modes of operations of switched dc source Inverter. Section IV

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presents comparison in between cascaded H-bridge inverter and switched dc source inverter. In Section V conclusions are summarized.

II. STRUCTURE AND WORKING PRINCIPLE OF CASCADED H-BRIDGE INVERTER.

A single phase five level cascaded H-bridge inverter is is shown in Fig. 2.1. A single phase five level cascaded H-bridge inverter consists two isolated input DC sources E1 and E2. There are eight power switches(N-Channel MOSFETs) which are denoted by S1, S2, S3,S4, S5, S6, S7 and S8. vo1(t), vo2(t) and vo(t) denotes output voltages of H-bridge 1,H-bridge 2 and single phase five level cascaded H-bridge inverter respectively. Load current is indicated by io(t).

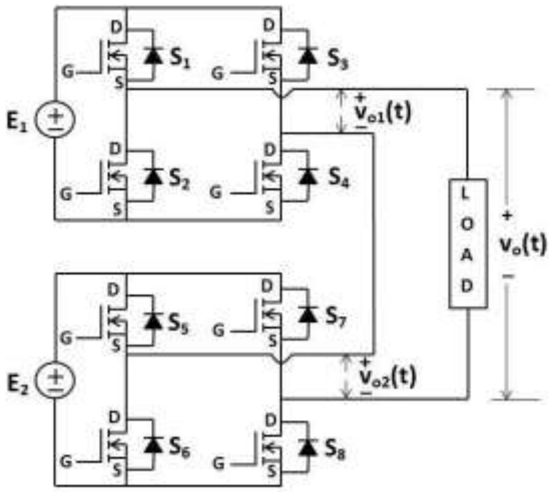

Fig. 2.1.: Single phase five level cascaded H-bridge inverter

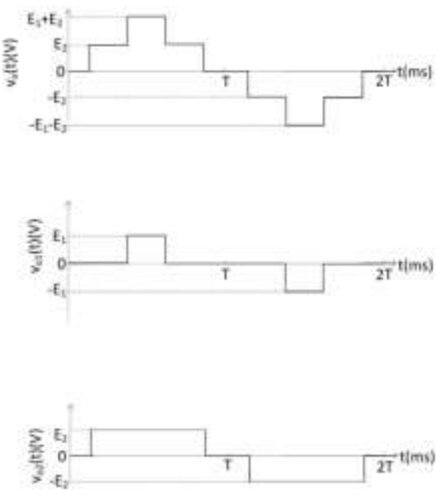

Fig. 2.2: Detailed output voltage waveform of single phase five level cascaded H-bridge inverter.

The detailed output voltage waveform of a single phase five level cascaded H-bridge inverter is shown in Fig. 2.2. The output voltage waveform consists of five levels 0, E2, E1 + E2, -E2, -E1-E2. Time period of output voltage is 2T .

There are six modes of operations for single phase five level cascaded H-bridge inverter Modes of operation are explained below:

Mode 1:
In mode 1, switches S1, S3, S5 and S7 are turned on. Source is not connected to the load. So, Output voltage across load is zero.

Mode 2:
In mode 2 , switches S2, S4, S6 and S8 are turned on. Source is not connected to the load. So,Output voltage across load is zero.

Mode 3:
In mode 3, switches S1, S3, S5 and S8 are turned on. So, Output voltage across load is E2.

Mode 4:
In mode 4 operation, switches S1, S4, S5 and S8 are turned on. So, Output voltage across load is E1 + E2.

Mode 5:
In mode 5, switches S2, S4, S7 and S6 are turned on. So, Output voltage across load is E2.

Mode 6:
In mode 6 , switches S3, S2, S7 and S6 are turned on. So, Output voltage across load is -E1-E2.

III. STRUCTURE AND WORKING PRINCIPLE OF SWITCHED DC SOURCE INVERTER

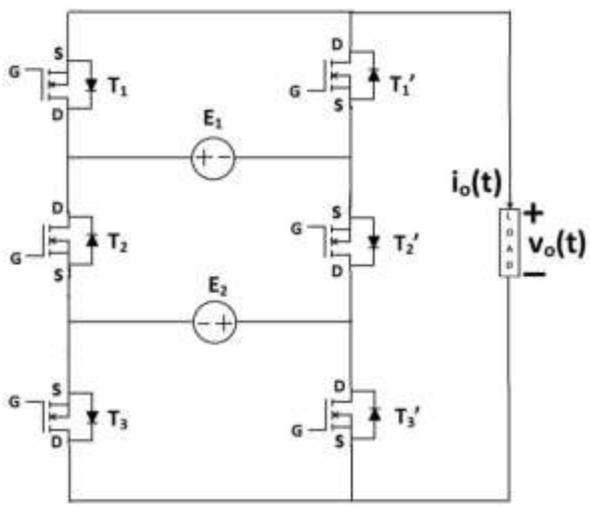

Fig. 3.1: Single phase five level switched DC sources inverter.

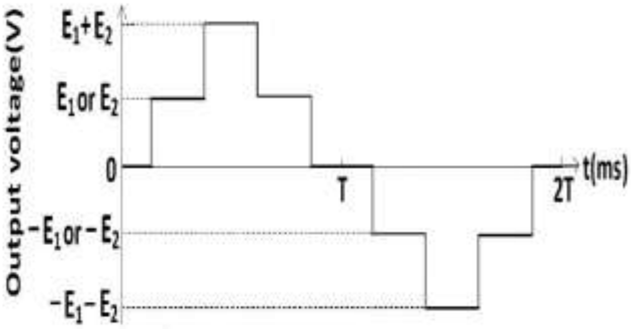

Fig. 3.2: Output voltage waveform of single phase five level switched DC sources inverter

A Single Phase Five Level Switched DC Sources Inverter is shown in Fig. 3.1. A Single Phase Five Level Switched DC Sources Inverter consist two isolated input DC sources E1and E2 (E1=E2). There are three complementary pairs of power switches(N-Channel MOSFETs) which are denoted by (T1, T1'), (T2, T2') and (T3, T3'). The output voltage across load and load current are denoted by vo(t) and io(t) respectively. The reference polarities of the output voltage vo(t) and reference direction of load current io(t) are shown. The output voltage waveform of a single phase five level switched DC sources inverter when E1=E2 is shown in Fig. 3.2. The output voltage waveform consists of five levels 0, E1 or E2, E1 + E2, -E1 or -E2, -E1-E2. Time period of output voltage is 2T .

There are eight modes of operations for single phase five level switched DC source .Modes of operation are explained below:

Mode 1:
In mode 1, The switches T1', T2' and T3' are turned on. No source is connected to the load. So, Output voltage across load is zero.

Mode 2:
In mode 2, The switches T1, T2 and T3 are turned on. No source is connected to the load. So, Output voltage across load is zero.

Mode 3:
In mode 3,The switches T1, T2' and T3' are turned on. So, Output voltage across load is +E1.

Mode 4:
In mode 4, The switches T1', T2' and T3 are turned on. So, Output voltage across load is +E2.

Mode 5:
In mode 5, switches T1, T2' and T3 are turned on. So, Output voltage across load is E1 + E2.

Mode 6:
In mode 6, switches T1', T2 and T3 are turned on. So, Output voltage across load is -E1.

Mode 7:
In mode 7,The switches T1, T2 and T3' are turned on. So, Output voltage across load is -E2.

Mode 8:
In mode 8, switches T1', T2 and T3' are turned on. So, Output voltage across load is -E1-E2.

IV. COMPARISON OF SWITCHED DC SOURCE INVERTER WITH CASCADED H-BRIDGE INVERTER

A comparison between the switched dc source inverter and CHB inverter is carried out in terms of component requirements and switching losses.

a) Power Switch Requirements: If CHB Inverter consist n number of dc sources, then total 4n switches are required, while the dc switched source inverter requires "2n + 2" switches. If the comparison is made for three-phase inverters, the difference in the numbers of switches required becomes significantly large. For example, In case of a three-phase 11-level voltage, a CHB inverter requires 60 switches and the dc switched source inverter needs only 36 switches.So, number of switches required for switched dc source inverter is less than CHB inverter with increase in number of levels.

b) Switching Losses: The dc switched source inverter has less switching losses as compared to cascaded H-bridge inverter. By considering the case of a five-level inverter with two equal input dc sources of voltage Vdc, the average switching power loss ρs in the switch caused by switching operations can be defined using as,

$$\rho s = (1/6) Vo.Io\ (ton + toff) \cdot f \qquad (1)$$

where ton and toff are the turn-on and turn-off intervals respectively, Vo is the voltage blocked by the switch, Io is the switch current, and f is the switching frequency. For simplification, it is assumed that switches operate with the same ton and toff values while they carry the same current Io. Thus, ρs can be expressed as

$$\rho s = \zeta Vo.f \qquad (2)$$

where ζ [= (1/6)Io(ton + toff)] is a constant. Thus, switching power losses in the CHB five-level inverter in which all eight switches operate at high switching frequency fs, while blocking the same voltage Vdc can be averaged as ρs,

$$\rho s, CHB/5L = 8\zeta Vdc.fs \qquad (3)$$

Similarly, the switching power loss of switched source five-level inverter with six switches can be obtained as ρs,

$$\rho s, SDCSI/5L = \zeta\ \{4Vdc.fs + 2(2Vdc).fo\} \qquad (4)$$

This is so because four switches which block voltage Vdc operate at high switching frequency fs and two switches

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which block voltage 2Vdc operate at fundamental frequency fo. Hence,

$$\rho s,\ SDCSI/5L = 4\zeta Vdc(fs + fo). \quad (5)$$

But,fo is too much small as compared to fs,so the switching losses can be approximated as,

$$\rho s,\ SDCSI/5L = 4\zeta Vdc.fs. \quad (6)$$

From (3) and (6), It is clear that the switching losses in switched dc source inverter is half of the switching losses in CHB inverter.

V. **CONCLUSION**

In this paper performances of single phase five level switched DC source inverter is compared with single phase five level cascaded H bridge inverter on the basis of structure, working principle, number of power switches required and Switching losses. Single phase five level switched DC source inverter is more competitive than single phase five level cascaded H- bridge inverter .So, switched dc source inverter is can be effectively employed for applications where isolated dc sources are available.

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