COMPARISON ANALYSIS OF DIFFERENT MULTILEVEL INVERTER TOPOLOGIES

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Abstract : Multilevel inverters recommend several advantages over conventional inverters such as lower dv/dt stress, lower electromagnetic compatibility, better THD features, high-quality output and high efficiency. Also, they have different applications that are medium voltage and high power photovoltaic applications, modern variable speed drives and utilized in the power electronic circuit. For different applications, different topology of multilevel inverter may be used. This paper presents a review on the comparative study of dissimilar multilevel inverter topologies on the basis of applications which include diode clamped inverter, capacitor clamped inverter, cascaded H-bridge inverter, Z-source inverter, quasi-z source inverter. We have discussed a number of topologies and applications, more can be found. An additional target is to bring concepts related to the number of levels in an inverter. This can be important in analysis and attracts the topology of an inverter.

IndexTerms **- Diode clamped inverter, capacitor clamped inverter, cascade-H bridge inverter, z-source multilevel inverter, quasi-z source inverter**

I. INTRODUCTION

In recent years, high power equipment required for various industrial applications. Development of multilevel converter is to perform power conversions with few low DC voltage sources via synthesizing a staircase voltage waveform. Multiple DC voltage sources are capacitors, batteries and renewable energy sources (photovoltaic power plants, wind turbines). Due to high demand, an inverter is an interesting challenge in the field of power electronics. High-quality output voltage waveform can be generated with the high number of steps by better approximation of sinusoidal waveform. Multilevel inverters not only provide high-quality output waveform but also provide low dv/dt stress, low switching losses and weight. However, reliability, modularity, scalability and functionality of an inverter are the important issue. To increase more reliability, use high number of voltage levels, number of switching devices. With adding or subtracting full bridge cells in configuration, the number of output voltage levels can be changed. With an increased number of voltage levels THD will decrease and improved quality of staircase voltage waveform. On the other hand, cost and weight increased as well [1]. For switches, switching angles are not the same; the drive circuit for each switch is separate from other switches. Cost per watt can be decreased by increasing the power rating of an inverter. Therefore, inverters power rating offered up to a few megawatts in the market [2, 3,4]. Whereas the cost of wire and power losses can be reduced that uses high nominal voltage for both DC and AC side of an inverter. Therefore, many different topologies for different applications are proposed by researchers and compared with each other. Comparison analysis is to be done to find more suitable topology of an inverter in the application. For example, in PV applications quasi-z source converter has been a good performance on the basis of qualitative and quantitative analysis [5]. Most familiar topologies are cascaded-H Bridge [6], diode clamped inverter [7], capacitor clamped inverter [8], Z-source inverter [9], quasi-z source inverter [10] and commonly used in industrial applications. To evaluate or select more suitable multilevel topology, key parameters are THD, line current and voltage, losses, efficiency, cost and output specification of the converter. This paper presents a review on the comparison of different topologies such as neutral point converter, flying capacitor topology, cascaded-H Bridge, Z-source and quasi-z source. Different topology has different advantages and disadvantages and therefore one of the topologies not best suitable for all applications. Moreover, it depends on the selection of the number of voltage levels.

II. MULTILEVEL TOPOLOGY REVIEW

In this section short-lived review on most common topologies are discussed on the basis of applications. Unlike topologies are shown in figure 1-6. In every topology insulated gate bipolar transistors (IGBT's) act as the main switch. IGBT's provide great switching characteristics and high power handling capacity. It improves overall efficiency, performance and reliability of a system.

2.1 Diode Clamped Inverter/ Neutral Point Converter (NPC)

In [7], diode clamped inverter was proposed. In a n-level diode clamped inverter, (n-1) voltage sources, 2(n-1) switching devices and (n-1)(n-2) diodes required. The output of the 3-phase inverter is connected to a common dc voltage divided into three levels by two dc bus capacitors. To reduce capacitance requirements, each phase connected to a common dc voltage. The capacitor voltage is Vdc and Clamping diodes limits the voltage stress Vdc across the switching device. As shown in Figure 1, each phase has two complementary switch pairs if one of the switch is turn on then complementary switch turned off. With different advantages and disadvantages in [1], practical diode clamped inverters are limited to lower than 5 levels. It can be used for static var compensation, induction motor drives, high voltage interconnections system, high voltage AC and DC transmission lines [1].

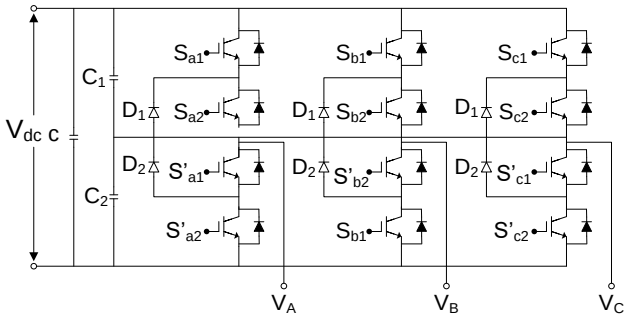

Fig.1. diode clamped inverter [7]

2.2 Capacitor Clamped Multilevel Inverter/ Flying Capacitor Inverter

It is similar to the diode clamped inverter. Instead of using clamping diodes, it used capacitors to keep the voltages to the favored values [8]. An m-level multilevel inverter involves 2(m-1) main switches and main diodes per phase leg and (m-1) dc bus capacitors, (m-1)(m-2)/2 balancing capacitors. Figure 2 shows 3-level inverter with the voltage across the main device is Vdc/2. In support of balance the voltage levels of capacitors, control active and reactive power, phase redundancies are present. This type of topology can be applicable for sinusoidal current rectifiers, static var generation, power electronic conversion (AC-DC and DC-AC).

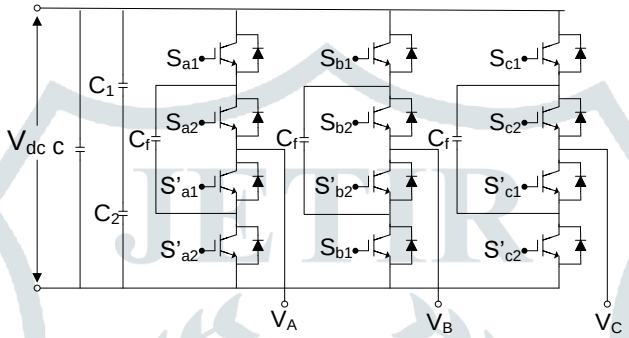

Fig.2. capacitor clamped multilevel inverter [8]

2.3 Cascaded H-Bridge Multilevel Inverter

In [6], Cascaded-H multilevel inverter had been proposed and shows the configuration of multilevel step voltage waveform with separate dc voltage sources (Figure 3). Each one dc voltage source connected in cascade with other sources related to special H-bridge. That type of inverter has less number of switching components(2(n-1)). This topology has more and more applications like induction motor drives, active filters, vehicular applications, power factor compensators and so on. But this will bound the usage in those products that already have multiple SDCS's.

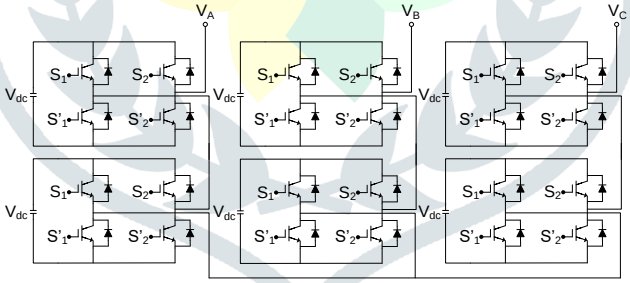

Fig.3. cascaded-h bridge inverter [6]

2.4 Z-source Inverter/ Impedance Multilevel Inverter(ZSI)

In [9], ZSI proposed that used six switching devices and shown in figure 4. ZSI provided voltage boost capability and overcome the deficiency in the general configuration of the multilevel inverter. In general configuration, the upper and lower power switch cannot conduct all together in such a way dc source will short circuit and therefore, a dead band is provided between switching on and switching off. It has high efficiency than other types [5]. ZSI is most suitable for automotive applications [11] and also for feedback control methods, motor control algorithms.

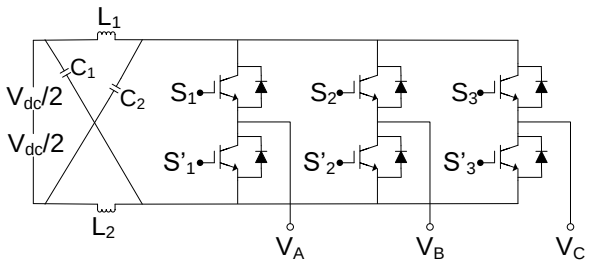

Fig.4. z-source multilevel inverter [9]

2.5 Quasi-Z Source Inverter(QZSI)

In [10], QZSI is derivative of original ZSI. QZSI used 6 power switches and presents the figure 5. [12, 13] ZSI has some limitations such as discontinuous input current during boost mode, high voltage across capacitors and higher stress on power switches. These limitations are overcome by QZSI [13, 14] and QZSI has major advantages over ZSI. In industrial applications, QZSI more applicable than other types and applications are wind power generation, fuel cell stack system, adjustable frequency drives, variable speed drives, speed control of induction motor and so on.

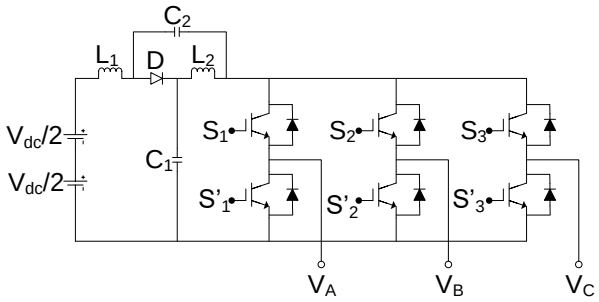

Fig.5. quasi-z source multilevel inverter [10]

III. Discussion

In this section, we discussed most common topology used for induction motor drive and suitable for use in photovoltaic applications with the focus on achieving low total harmonic distortion and better efficiency. M.E. Kathar et al [1] analyze the comparison of multilevel inverter topologies with implementation on induction motor drive and used to manage the speed of induction motor. It reduces cost and increased reliability. At same input voltage, the output voltage of Cascaded-H bridge inverter is double of the output voltage with diode clamped inverter or capacitor clamped inverters [15]. For multilevel inverters-fed induction motor drive, Cascaded-H bridge inverter has some advantages. As this topology can implement easily with the high number of levels and reduced harmonic distortion to enhance the fundamental output voltage. And the disadvantage is the requirement of separate dc voltage sources. Whereas diode clamped inverter used many clamping diodes and results in disturbing of charge balance and output voltage gets limited. In the case of capacitor clamped inverter, pre-charging capacitors required which is to be difficult to provide.

For PV applications, comparing different topologies with different perspectives are proposed by researchers. In a quantitative study, diode clamped inverter give better performance than other types [16]. By investigating more suitable topology in both qualitative and quantitative study, quasi-z source inverters give superior performance compared to other configuration. In [17] author shows that the efficiency of quasi-z source inverter lesser than that of as z-source inverter. But it has many advantages over z-source inverter such as high reliability, low voltage stress on the power switch and less number of elements. Also, quasi-z source inverters overcome the problems of Z-source inverter and that was dc link voltage unbalance problem.

In different type of configuration of a multilevel inverter require different number of switching components, capacitors, inductors and diodes. Cascaded-H Bridge topology needs less number of switching components. Except NPC, capacitor clamped inverters other inverters are suitable to implement high level voltage and also they have high reliability.

IV. Conclusion

Multilevel inverters are more economical than the conventional three-phase inverters. In this paper, we set up most suitable inverter by comparing characteristics of unlike topology configuration in an identical situation and on the basis of the application. We cannot perform or evaluate by using MATLAB/Simulink. With different advantages and disadvantages of each topology, we conclude that quasi-impedance source inverter (QZSI) is more suitable than other types.

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