CHAPTER 6

COMPARISION OF CHB AND CSD MULTILEVEL INVERTERS

6.1 Introduction

A recent study on the consumption of electrical energy shows that consumption is rapidly increasing due to the increase in energy demand. Therefore, resulting in the extinction of fossil fuels. So, the requirement for fossil fuels is increased largely. By using renewable energy sources, the control of the energy demand is possible. There are several multilevel inverter topologies are present for renewable energy integration. But the cascaded version of the multilevel inverters gives a lot of advantages over other topologies. There are three main types in the cascaded form of multilevel inverters. They are as follows:

1)cascaded H-bridge multilevel inverter.

2)cascaded half-bridge multilevel inverter.

3)cascaded switched diode multilevel inverter.

These three types have a lot of advantages over the diode clamped multilevel inverter and flying capacitor multilevel inverter. In renewable integration, the cascaded switched diode multilevel inverter can yield the best results out of the three multilevel inverters mainly because of the advantages it gets over the other two topologies of multilevel inverters. In today's modern world, a conventional two-level inverter is not very efficient when compared to the cascaded switched diode multilevel inverter. As the name suggests the conventional two-level inverter comes with only two levels which is a major drawback considering the levels required nowadays. The conventional inverters are replaced by the multilevel inverters because of the good power quality, low switching losses, and high voltage capability. The main aim of the multilevel inverters is to produce multiple output voltage levels with less power switching losses and less harmonic distortion losses. The cascaded H-bridge multilevel inverter has a major disadvantage that requires a greater number of switches which results in more switching losses. The cascaded H-bridge multilevel inverter is an expensive multilevel inverter and has a complex system. Then the cascaded half-bridge multilevel inverter is introduced which reduces the consumption of switches and reduces the switching losses very less when compared to the cascaded H-bridge. The cascaded half-bridge topology also produces more voltage levels than the CHB topology. Under the R-L load, there will be high voltage spikes occurring at the stepped output voltage but by using the cascaded half-bridge topology, there will be no path to flow these reverse currents resulting in deteriorated power quality which is considered as a major disadvantage in cascaded half-bridge topology. Therefore, the cascaded switched diode multilevel inverter is introduced which eliminates the disadvantage that occurs at the previous topology by adding a path for reverse currents to flow and also produce more voltage levels. By comparing the cascaded H-bridge multilevel inverter with the cascaded switched diode multilevel inverter gives the idea that why it's better to use cascaded switched diode topology for renewable energy integration.

6.2 Topology of the cascaded H-bridge multilevel inverter

By developing better power conversion converters, a lot of electrical energy can be saved and can be used efficiently in transmission, distribution, consumption sectors. The conventional inverter comes with the two levels generates the average voltage equal to the reference. But the losses in the conventional topology are very high. Therefore, multilevel inverters are introduced to eliminate these issues. The main theme of these multilevel inverters is to develop the desired output voltage from several input DC voltage sources. Several types of multilevel inverters are mentioned in the previous chapters i.e., diode clamped MLI, flying capacitor MLI, cascaded topologies. Cascaded H-bridge MLI topology is one of the most attractive topologies in MLI's. The cascaded H-bridge MLI has simple construction and control with many control techniques. The configuration of CHB MLI is a series-connected two-level H-bridge inverter with a separate DC source for each one. The topology of the cascaded H-bridge multilevel inverter is as follows:

The major disadvantages of CHB topology are as follows:

(a) increased number of isolated input DC voltage sources.

(b) increased number of switching devices which increase significantly MLI overall cost compared to conventional two levels inverters topology.

Resulting in developing of variety of techniques to reduce the number of utilized DC sources by selecting their values. Therefore, MLIs are classified based on the selection of utilized DC sources values. In the symmetric multilevel inverters, all DC sources have the same amplitude. Therefore, the MLI output voltage is generated by directly adding all the Vdcn sources, resulting in number DC sources equal to the number of required output levels. This method is not an efficient method to select and utilize the DC sources in MLI.

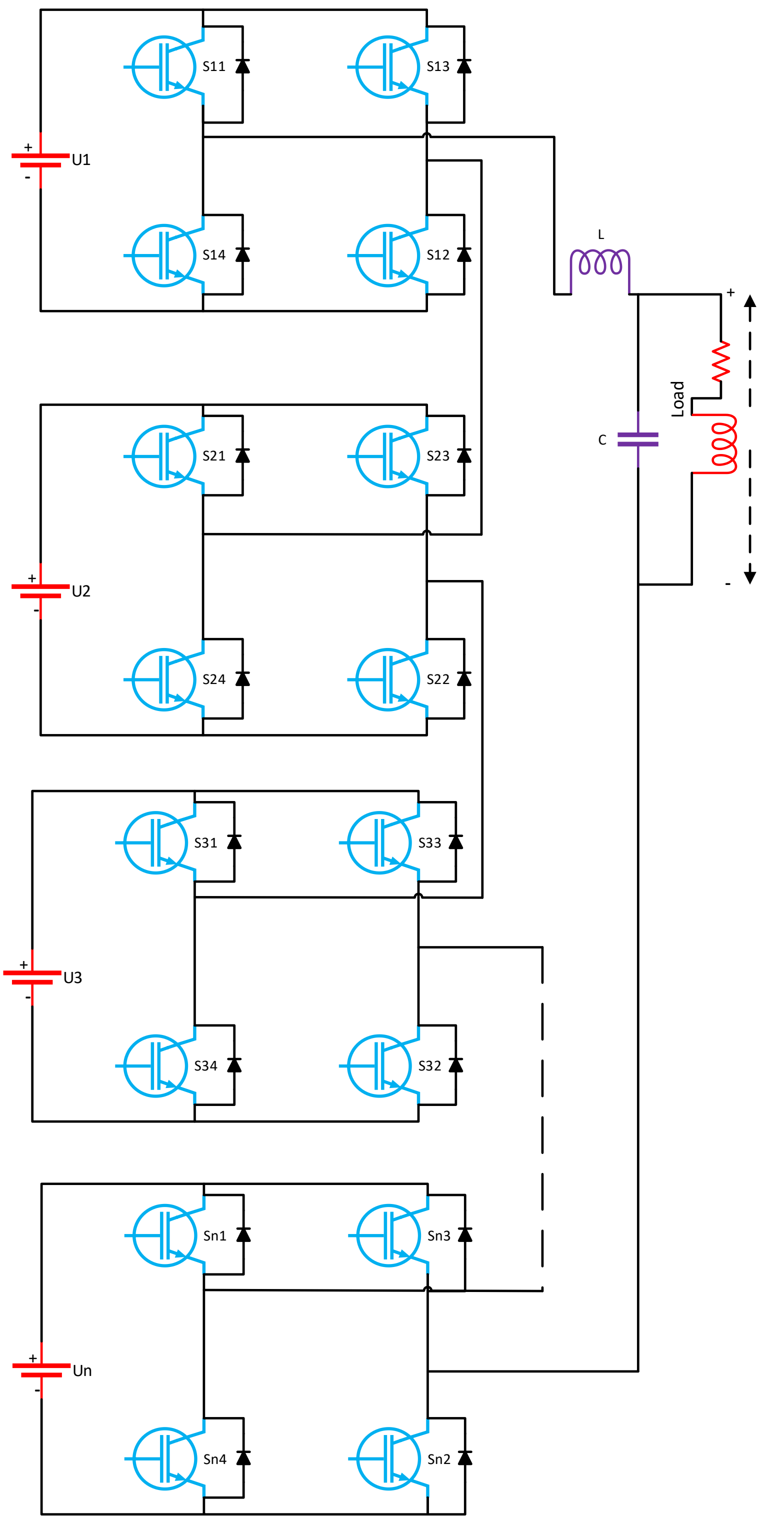

Fig.6.1 Topology of the cascaded H-bridge multilevel inverter

There are n DC sources present at the CHB topology each connected to an inverter called H-bridge inverter, as shown in Fig.6.1. Three levels of the output voltage can be generated from each H-bridge i.e., u_{dc}, 0, $-u_{dc}$. In the case of symmetric, the number of required switches for a N_{level} output voltage is obtained as follows:

$$N_{IGBT} = 2N_{Level} - 2 \tag{6.1}$$

6.3 Topology of Cascaded Switched Diode

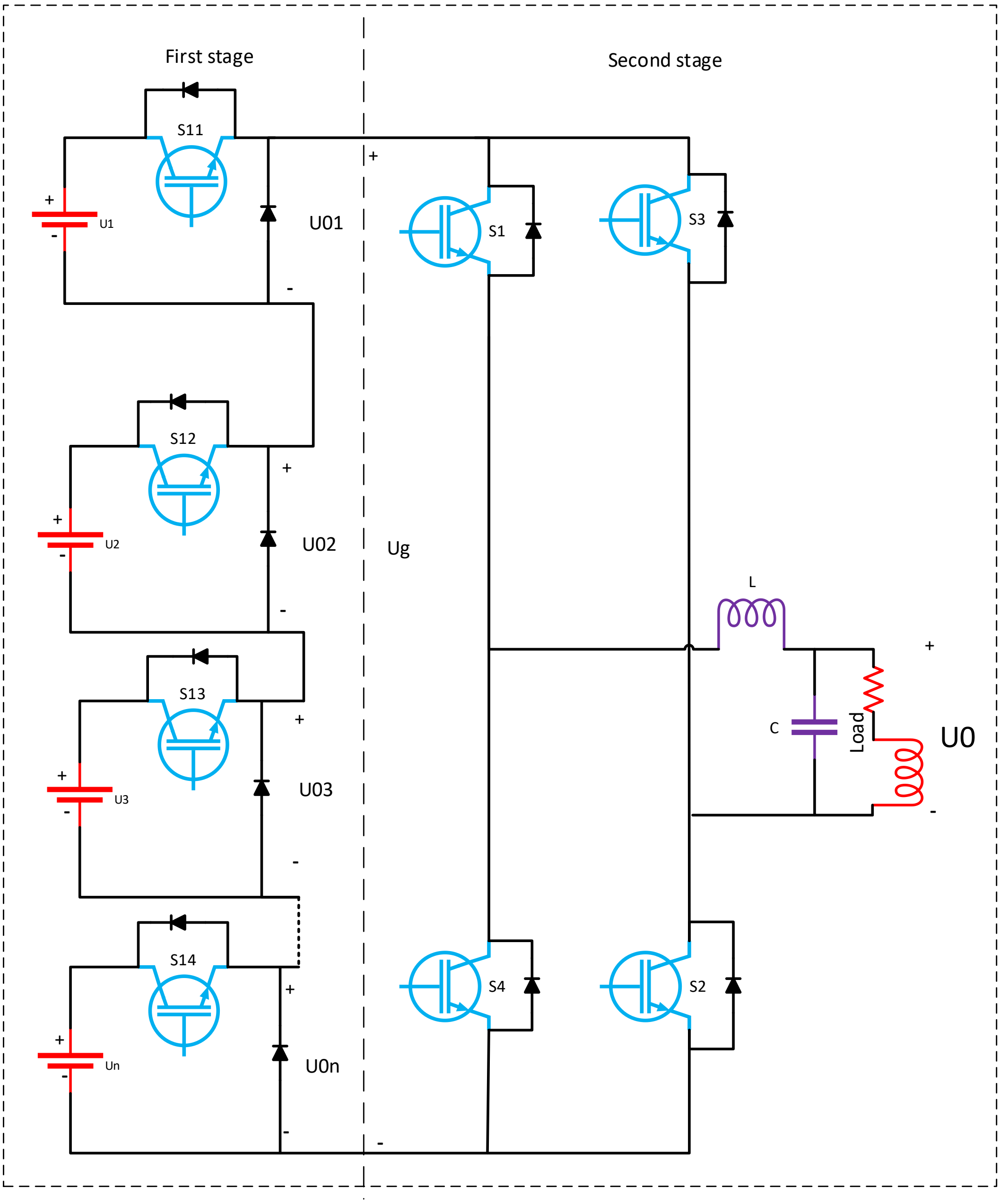

Fig.6.2 The structure of the proposed two-staged CSD topology

The cascaded switched diode topology which is shown in fig 6.2 overcomes all the disadvantages obtained during the cascaded H-bridge and cascade half-bridge multilevel inverters. The CSD topology has a switch Sg is connected between unit 2 and unit n which blocks the high voltage. This switch is considered a spike removal switch in CSD topology. The voltage and current ratings are very important in designing the inverters. Also, the proposed CSD topology has the highest voltage rating. The number of the required switches for a N_{level} output voltage is derived as follows:

$$N_{IGBT} = (N_{level} + 7)/ 2 \tag{6.2}$$

So, as the levels started to increase, the required number of switches started to decrease a lot when compared to the CHB topology. The main aim of this proposed CSD topology is to reduce the number of required switches and produce more voltage levels. The reliability, cost, circuit size, and control complexity are always based on the switches. The important factor in designing a multilevel converter is the rating of switches. In the above-mentioned topologies, the currents of all devices are equal to the rated currents of the loads. Therefore, the power component requirements among the CHB and the proposed CSD topologies are listed in Table 6.1 concerning the number of required switches and voltage rating of all the devices. And the fig.6.3 showing the difference between the CHB topology and cascaded switched diode topology is as follows:

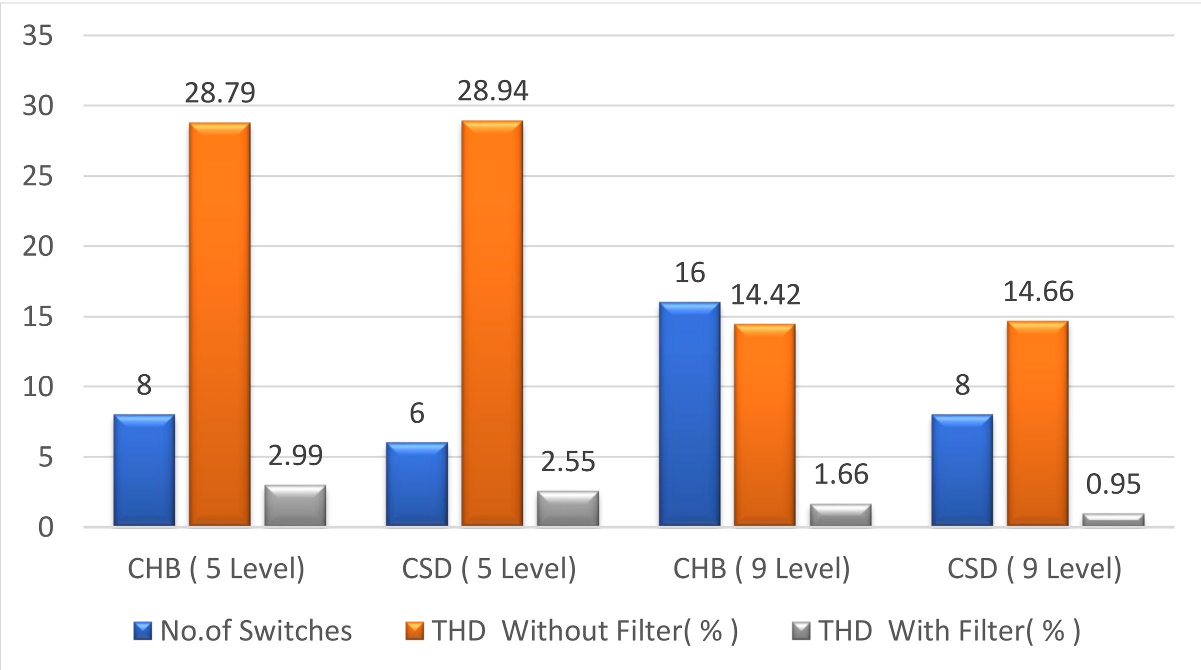

Fig.6.3 Comparison of CHB and CSD Topologies.

In the case of the 5-level, the number of switches required by CHB topology is 8 but in CSD topology the number is reduced to 6 and in the case of 9-level, the number is greatly reduced from 16 to 8. The THD levels with and without filters are relatively high in CHB topology when compared to CSD topology. The harmonic distortions produced in the process are very less in CSD topology which makes it more suitable for renewable energy integration. The mathematical equations of the maximum output voltage, no. of required switches, voltage rating of Sg and all the switches and diodes are presented below.

Therefore, by comparing these two topologies of cascaded multilevel inverters in different sectors, the CSD topology is more efficient than the CHB topology which makes it more suitable for renewable energy integration.

Therefore, the power component requirements are listed in table 6.1 as follows:

Table 6.1 comparison of CHB and CSD

	CHB	CSD
Maximum output Voltage	$U_{dc}((N_{level} -1)/2)$	$U_{dc}((N_{level} -1)/2)$
No. of required switches	$2(N_{level}-1)$	$(N_{level}+7)/2$
Voltage rating of Sg (CSD)	N/A	$u_{dc}((N_{level}-3)/ 2)$
Voltage rating of all the switches and diodes	$2u_{dc} (N_{level}-1)$	$3u_{dc}(N_{level}-3)+(u_{dc} (N_{level}-1)/2)$