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Multi Level Inverter Topologies for VSC based HVDC Transmission

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***Abstract*— In this paper a brief review on different multilevel inverter topologies are discussed. Inverter is a power electronic device that converts DC power into AC power at desired output voltage and frequency. Multilevel Converters nowadays have become an interesting area in the field of industrial applications. Conventional power electronic converters are able to produce an output voltage that switches between two voltage levels only. Multilevel Inverter generates a desired output voltage from several DC voltage levels at its input. The input side voltage levels are usually obtained from renewable energy sources, capacitor voltage sources, fuel cells etc. The different multilevel inverter topologies are: Cascaded H-bridges converter, Diode clamped inverter, Flying capacitor multilevel inverter, and Modular Multilevel Converter (MMC). The disadvantages of MLI are the need for isolated power supplies, design complexity and switching control circuits**

Keywords— Multi-Level Inverter topologies, MLI, PWM, sinusoidal pulse width modulation, phase opposition disposition, THD.

INTRODUCTION:

The development of new technologies and devices during the 20th century enhanced the interest in electric power systems. Modern civilization based his operation on an increasing energy demand and on the substitutions of human activities with complex and sophisticated machines; thus, studies on electric power generation and conversion devices become every day more and more important.

The recent attention in environment protection and preservation increased the interest in electrical power generation from renewable sources: wind power systems and solar systems are diffusing and are supposed to occupy an increasingly important role in world-wide energy production in coming years.

Not only house utilities, but industrial applications and even the electrical network requirements display the importance that energy supply and control will have in the future researches.

As a consequence, power conversion and secondly control is required to be reliable, safe and available in order to accomplish all requirements, both from users and legal regulations, and to reduce the environmental impact.

Voltage Source Converter (VSC) technology is becoming common in high-voltage direct current (HVDC) transmission systems (especially transmission of offshore wind power, among others). HVDC transmission technology is an important and efficient possibility to transmit high powers over long distances.

The vast majority of electric power transmissions were three-phase and this was the common technology widespread. Main advantages for choosing HVDC instead of AC to transmit power can be numerous but still in discussion, and each individual situation must be considered apart. Each project will display its own pro and con about HVDC transmission, but commonly these advantages can be summarized: lower losses, long distance water crossing, controllability, limitation short circuit currents, environmental reason and lower cost.

One of the most important advantages of HVDC on AC systems is related with the possibility to accurately control the active power transmitted, in contrast AC lines power flow can’t be controlled in the same direct way.

However conventional converters display problems into accomplishing requirements and operation of HVDC transmission. Compared to conventional VSC technology, Modular Multilevel topology instead offers advantages such as higher voltage levels, modular construction, longer maintenance intervals and improved reliability.

A multilevel approach guarantees a reduction of output harmonics due to sinusoidal output voltages: thus grid filters become negligible, leading to system cost and complexity reduction. Like in many other engineering fields, modular and distributed systems are becoming the suggested topology to achieve modern projects requirements: this configuration ensure a more reliable operation, facilitates, diagnosis, maintenance and reconfigurations of control system. Especially in fail safe situations, modular configuration allows control system to isolate the problem, drive the process in safe state easily, and in many cases allows one to reach an almost normal operation even if in faulty conditions.

In the case of MMC, the concept of a modular converter topology has the intrinsic capability to improve the reliability, as a fault module can be bypassed allowing the operation of the whole circuit without affecting significantly the performance.

Many multi-level converter topologies have been investigated in these last years, having advantages and disadvantages during operation or when assembling the converters. To solve the problems of conventional multi-level converter a new MMC topology was proposed in this

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work describing the operation principle and performance under different operating conditions.

Thus the attractive features can be summarized as follows

1. Reduced harmonic distortion
2. Higher no. of voltage level
3. Staircase waveform quality
4. Operates at both fundamental and high switching frequency pwm
5. Lower switching losses
6. Better electromagnetic compatibility
7. Higher power quality

One particular disadvantage is the need for large number of power semiconductor switches. Each switch have a related a gate driver circuit which adds complexity to the system. The overall system will be more expensive. Focuses are going on in present years to reduce the complexity of the circuit by decreasing the number of power electronic switches and gate driver circuits. This paper presents the different multilevel power converter topologies with related structures and the pros and cons of each circuit

CONCEPT OF MULTILEVEL INVERTERS:

As in Figure 1, Conventional two-level inverters normally generate an output AC voltage from an input DCvoltage. Pulse Width Modulation switching scheme is used to generate the AC output voltage (as shown in figure2). In the concept of Multilevel Inverter topology (MLI), several DC voltage levels are added together to create a smoother output waveform (as shown in figure3).The obtained output waveform have lower dv/dt and harmonic distortions. The circuit design is more complex with the increase in voltage levels. It needs a complicated switching controller circuit also.

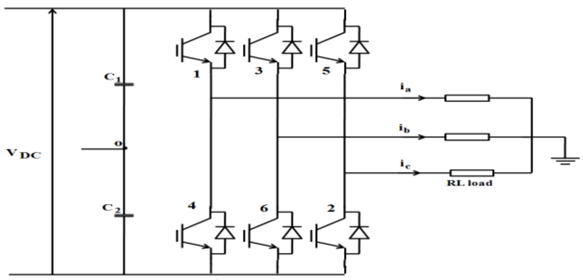

Figure1. One phase leg of a two-level inverter, two level output waveform without PWM

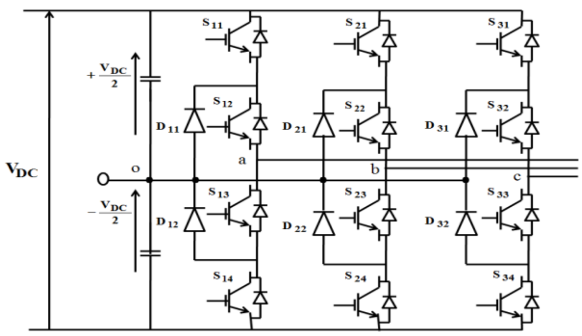

Figure2. Single leg of a three-level inverter

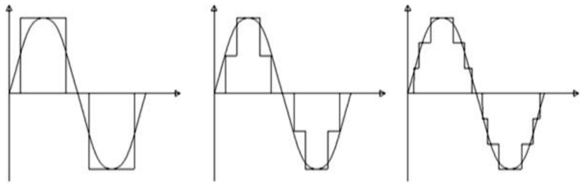

Figure 3. A three-level,five-level and seven-level output waveform at fundamental switching frequency

Figure2 shows the circuit of a conventional threelevel inverter. In a three level inverter each phase leg generate the three voltage levels (Vdc/2, 0, –Vdc/2). Three-level inverter is similar to a conventional two-level inverter, but with clamping diodes in between the two valves and are connected to the neutral between two capacitors. The capacitors act as DC bus voltage sources, each one is charged with the voltage Vdc/2. The number of levels can be increased by connecting another phase leg. Zero voltage level can be created by switching closer to the midpoint. Clamping diodes hold the voltage to zero with the neutral point. When valve pairs are more, capacitors and clamping diodes are added to generate more voltage levels in the inverter output. This results into a new topology of multilevel inverter with clamping diodes.

Table 1: The difference between a 2-level and a 3- level inverter

Sl. No	Conventional Inverter	Multilevel Inverter
1	THD is high in the output waveform	THD is Low in the output waveform
2	High Switching stresses	Low Switching stresses
3	Not used for high Used for high voltage Voltage applications	Used for high voltage applications
4	High voltage levels cannot be produced	High voltage levels can be produced
5	High dv/dt and EMI	Low dv/dt and EMI
6	High switching frequency, increased switching losses	Lower switching frequency, reduced switching losses

In a 2-level inverter the output voltage waveform is obtained by Pulse Width Modulation scheme with two levels of voltage. This results in lower THD because of the distorted output waveform. Due to the sinusoidal nature of the output in a three level inverter, THD obtained is far better than a 2 level inverter.

DIODE-CLAMPED MULTILEVEL INVERTER TOPOLOGY:

Neutral-point-clamped(NPC) PWM topologies the first practical multilevel topology. Diode clamped multilevel inverters use clamping diodes. It helps to limit the voltage stress of power electronic devices. It was first proposed by Nabae, Takashi and Akagiin 1981. It is also known as neutral point converter. An m level diode clamped inverter needs Switching devices :(2m – 2), Input voltage source :(m – 1) No of diodes: (m – 1) (m – 2). Voltage present

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across each diode and the switch is Vdc . A five level diode clamped inverter is shown in figure 4.

This topology however faces technical difficulties for high power converters. It requires high speed clamping diodes that will subject to reverse recovery stress. The design complexity is a major concern due to the series connection of diodes.

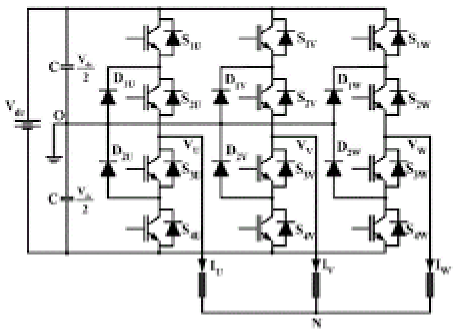

Figure 4. A Five level diode clamped MLI

FLYING CAPACITOR MULTILEVEL INVERTER TOPOLOGY:

It is an alternative to the diode-clamped MLI topology. Here capacitors are used to limit the voltage. The presence of capacitors makes it different from that of diode clamped MLI where diodes are used. Capacitors divide the input DC voltages. The voltage across each capacitor and switch is *Vdc*. An *m* level flying capacitor inverter needs Switches: $(2m - 2)$ Number of capacitors: $(m - 1)$ The capacitor clamped switching cells are connected in series. The switching states are same as that of diode clamped inverter. No Clamping diodes are required in this inverter. The output voltage is just half of the input DC voltage. A five level topology is shown below in figure 5.

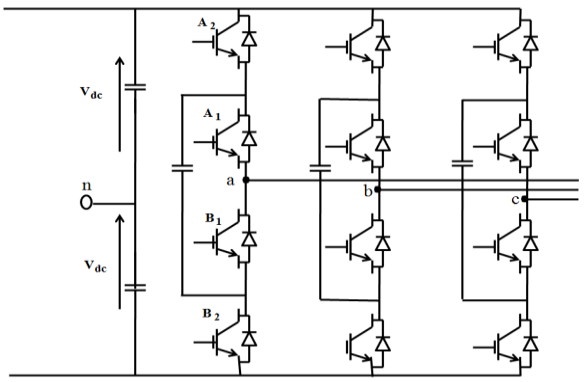

Figure 5. A flying capacitor clamped MLI

CASCADED VOLTAGE H BRIDGE MULTILEVEL INVERTER TOPOLOGY:

The cascaded H-bridge inverter uses separate Dc sources or capacitors (as shown in figure 8.).It requires only less number of components in each level. There is a series connection of power conversion cells. The H-bridge consists of capacitors and switches pair combination. For each H Bridge, separate input DC voltage is obtained. It generates a sinusoidal output voltage. The inverter uses series connected H-bridge cells, each providing three different levels of Dc voltages (zero, positive DC and negative DC voltages).The output voltage is the sum of all the generated voltages from each H Bridge cell. If m cells are present, the numbers of output voltage levels will be2m+1.A five level H bridge Inverter is shown in figure 6.

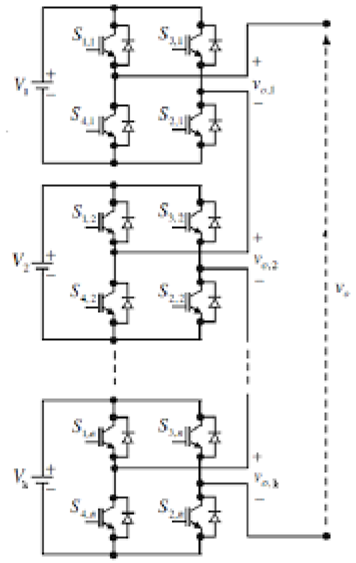

Figure 6. A 5 level H-bridge inverter

PROPOSED MODULAR MULTILEVEL CONVERTER TOPOLOGY:

An MMC is a circuit that can be used to convert AC to DC voltage and convert DC to AC voltage. The MMC is made up of two multi-valves, one for the positive voltages called the upper multi-valve and the other for the negative voltages called the lower multi-valve. These two multi-valves as shown in Figure 7 are connected together through two inductors to control the power flow. Each multi-valve contains multiple submodules that are cascaded together. The more submodules in each multi-valve the higher the voltage it can convert and the smoother the AC waveform will be. Figure 8 shows one leg of three phase MMC. A submodule contains two switches in series that will be fired in a complementary fashion, connected to a capacitor that will charge and discharge when the switches open and close (Figure 9). The capacitor voltages will be added together from the submodules to obtain the required voltage at the output of the system. Across each switch is a reverse diode that is used to control the current flow in the submodule. The switches need to be fired with a large enough dead time between them to ensure that one switch is able to fully turn off before the second switch turns on.

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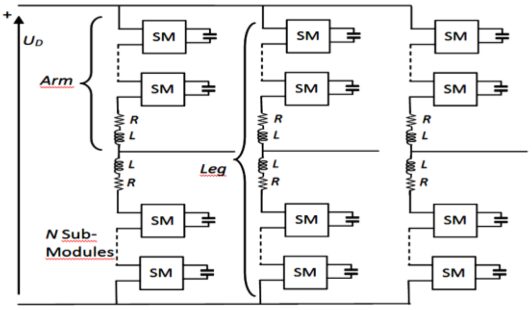

Figure 7 - Schematic of a three-phase Modular Multi-level Converter

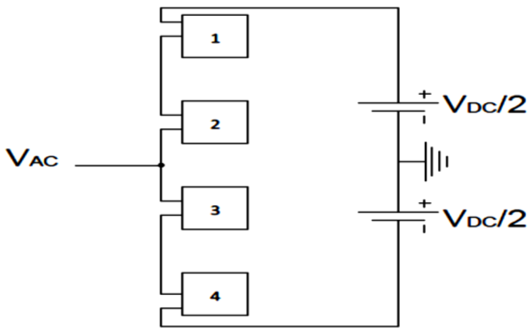

Figure 8 - Schematic of one phase of MMC

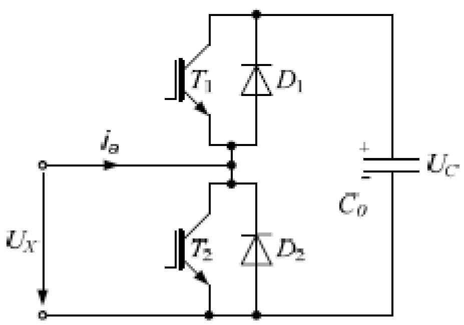

Figure 9 - Schematic of Sub Module of MMC

CONCLUSION:

The paper presents a brief discussion on basic multi-level inverter topologies. Fundamental multilevel converter structures including the advantages and disadvantages of each technique have been discussed. The main advantage of MLI family is that it finds a solution to the problems of total harmonics distortion, EMI, and dv/dt stress on switch. In industrial and commercial market areas, more and more product are available that depends on the multi-level inverter topologies. Research works are in progress considering the structure complexity and control circuits. This helps to reduce the power electronics components and improve total harmonics profile and total cost of the system.

REFERENCES:

[1] Mario Marchesoni, Diode-Clamped Multilevel Converters: A PracticableWay to Balance DC-Link Voltages, IEEE transactions on industrial electronics, vol. 49, no. 4, august 2002

[2] Liangzong He, Chen Cheng, Flying-Capacitor-Clamped Five-Level Inverter Based on Bridge Modular Switched-Capacitor Topology, IEEE transactions on industrial electronics, 2016.

[3] Dr. Asha Gaikwad, Study of Cascaded H-Bridge Multilevel Inverter, IEEE *2016* International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT) International Institute of Information Technology (I²IT), Pune.

[4] Anjali Krishna R, A Brief Review on Multi Level Inverter Topologies, IEEE 2016 International Conference on Circuit, Power and Computing Technologies [ICCPCT].

[5] S.Shalini, Voltage Balancing in Diode Clamped Multilevel inverter Using Sinusoidal PWM, International Journal of Engineering Trends and Technology (IJETT) – Volume 6 Number 2 - Dec 2013

[6] Kazunori Hasegawa, Low-Modulation-Index Operation of a Five-LevelDiode-Clamped PWM Inverter Witha DC-Voltage-Balancing Circuit for a Motor Drive, IEEE transactions on power electronics, vol. 27, no. 8, august 2012