MODULAR MULTI-LEVEL CONVERTER: A COMPLETE REVIEW

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Abstract: This paper describes the concept of the modular multi-level converter and also explains its topologies in details and applications of the modular multi-level converter.
Keywords: multi-level converter, HVDC.

I. INTRODUCTION

As of late, expanding consideration has been attracted to the utilization of voltage source converter HVDC (VSC-HVDC) for association of substantial seaward wind power plants to the ashore framework. Moreover, between associations among far off and nonconcurrent systems look appealing so as to improve the monetary effectiveness and strength of power systems, in this manner offering more space for obliging vast offers of fluctuating sustainable power source. The conjugation of the two viewpoints may perhaps prompt the development of tremendous multi-terminal HVDC frameworks with a few seaward wind ranches. Late advances in VSC-HVDC innovation have moved the concentration from the traditional two-level configuration to the new modular multi-level converter (MMC) idea [1], which offers various specialized focal points, for example, exceptionally low characteristic symphonious voltage substance and low exchanging misfortunes. Such advantages seem to have as of late exceeded volume and cost downsides.

The primary composed impression over the modular multilevel converter hardware was presented in 1975 [1] dependent on arrangement association of full-connect cells, while in 2002, a topology with an elective module structure was presented by R. Marquardt [1], in which half-connect modules were used. The diminished number of switches, alongside advances in power electronic innovation, at that point encouraged the utilization of this topology in HVDC systems.

Wind turbine makers in this manner face the requirement for understanding the task of this new converter topology and, going past that, to research their conduct and capacities against variety of seaward voltage and recurrence, which may normally emerge as a result of the seaward matrix configuration or, then again, be used as real control signals [1]

High voltage direct current (HVDC) transmission was truly performed utilizing the thyristor-controlled Line Commutated Converter (LCC) [1]. In any case, it has a few restrictions: it utilizes semiconductors that can't be turned off, outer voltage must supply receptive power to create semiconductor exchanging, it just works with a postpone power factor and it can't be utilized in disconnected systems [2].

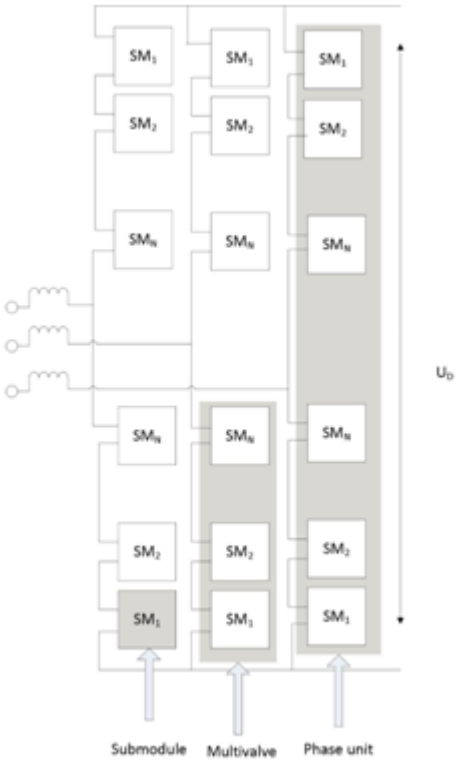

Fig 1. MMC

Afterward, the Voltage Source Converter (VSC) [2], made with protected door bipolar transistors (IGBT), was utilized. This has a few points of interest over LCC: it utilizes semiconductors that can be turned on and off, the converter can supply responsive power, it can work with a deferral and advance power factor and it very well may be utilized in secluded systems [2].

At the point when the two level VSC topology is utilized, it shows a few issues:

- Very high di/dt of the arms of the converter and the semiconductors.
- Great pressure and over-voltages in the semiconductors.
- Emission of electromagnetic radiation and troubles in the development of the converter.
- With pulse-width modulation (PWM): extraordinary loss of power in the semiconductors and utilization of voluminous and costly uninvolved channels.

II. OPERATIONAL CONCEPT OF MMC

In a three stage MMC, every one of the stage units comprises of two multivalves, and each multivalve comprises of N sub-modules associated in arrangement[3]. With a DC voltage of ±320 kV N=38 is commonly required [3]. The half-connect submodule comprises of two valves (T1 and T2) and a capacitor (Fig. 2). The valves are comprised of an IGBT and a freewheeling diode in anti-parallel. In ordinary activity, just a solitary one of the valves is exchanged on at a given moment in time. Contingent upon the present heading the capacitor can charge or release [3].

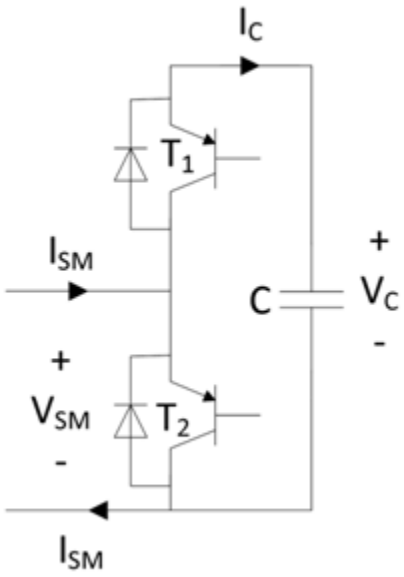

Fig. 2. The Sub module Circuit

At the point when one and only IBGT is exchanged on, either that IGBT or the freewheeling diode in a similar valve will lead, contingent upon the present heading, and consequently it bodes well to characterize a valve as on, demonstrating that either the IGBT or the diode is directing [3].

Three conceivable exchanging states can be characterized [4]:

- In the ON or embedded state T1 is on, and T2 is off. The sub-module output voltage, VS M , parallels the capacitor voltage, VC , and the capacitor charges if the multivalve current is certain and releases generally.
- In the OFF or circumvent state T2 is on, and T1 is off. The sub module output voltage, VS M , is zero and the capacitor voltage is steady, for example the capacitor won't charge nor release.
- In the blocked state, the two valves are off, and the current can just direct through the freewheeling diodes. The capacitor will charge if the current is certain, however in a perfect world it can't discharge.

The blocking voltage in each stage unit is double the DC voltage. This can be clarified from the circumstance when all the sub-modules in the upper multivalve are circumvent, giving a stage volt-age equivalent to the DC voltage. The lower multivalve must almost certainly obstruct the voltage crosswise over itself, for example the DC voltage. [4]

III. MMC TOPOLOGIES

For the most part, there are three entrenched and established topologies of multilevel inverter. These are as per the following:

1. Neutral point clamped (NPC) or diode clamped
2. Flying capacitor (FC) or capacitor clamped

1. Cascaded H-bridge (CHB)

Lately, researchers have beaten the multilevel inverter circuit's intricacy by switches game plan which helped underway of a totally new assortment of topologies: dynamic NPC (ANPC) multilevel inverter, hybridized cascaded H-bridge (HCHB) multilevel inverter, modular multilevel converter (MMC), switched arrangement/parallel sources (SSPS)- based multilevel inverter and H-bridge and two-level power modules (HBTPM)- based multilevel inverter. These topologies are examined in this paper.

A. Neutral Point Clamped Multilevel Inverter

Neutral point clamped (NPC) inverter was at first presented in 1981 by Nabae. It was considered as the primary kind of multilevel inverters, known as the 3-level NPC. [5]

It has been built by using two customary inverters of 2-level. One has been fixed over the other to stack. Additionally, two diodes of arrangement associated have been joined among lower and upper inverter between the neutral mid-points, N. Capacitors help with part the DC transport voltage in two indistinguishable phases. Thus, the necessity for having an additional source of DC is invalid for this situation. In the course of recent years, these inverters have generally been utilized in mechanical applications requiring roughly 6kV. For supporting a higher working and power voltage, NPC inverter could be stretched and reached out to higher levels of voltage. It is genuinely simple to stretch out the scheme to a typical n-level compliance and course of action. Alternately, the utilization of NPC topology in modern application is constrained to 3-level simply because of the arrangement associated capacitors require voltage adjusting control.

B. Flying Capacitor Multilevel Inverter

In mid-1990s, Meynard and Foch and Lavieville introduced flying capacitor (FC) inverter which is considered as another change of multilevel inverter topology. The premise of this inverter was the use of capacitors. It is developed by interfacing a progression of capacitors clamped switching cell. Restricted voltages are exchanged to electrical gadgets through capacitors.

The switching states in FC inverter are like the NPC inverter. However, bracing diodes are not required for this topology of multilevel inverter. The benefits of these inverters are have repetition of switching within the phase for adjusting the FC.The principle disadvantage of the half-bridge of FC inverter is that its output voltages are practically half of the input DC voltage.

C. Cascaded H-Bridge Multilevel Inverter

In the mid of 1970s, Baker and Banister [5] depicted the primary patent of converter topology which had the capacity to deliver multilevel voltages through the source of different DC voltage. In this topology, a progression of single phase inverters were connected and associated together. The circuit of CHB multilevel inverters has been structured with eight switches comprising of five levels of inverter. Each source of DC is connected with the relating H-bridge creating five remarkable voltage outputs. These outputs fluctuate from - 2Vdc, - Vdc, 0, +Vdc, and +2Vdc by usage of switching blends of four switches [5]. The arrangement of H-bridge associations synthesize the multilevel inverter output. In cascaded inverter, the quantity of voltage levels for output phase are determined through n = 2s + 1, where, s is the quantity of DC sources and n is the inverter output levels. [5]

IV. APPLICATIONS

A. HVDC Systems

The MMC, at first proposed for HVDC applications, has turned into the most encouraging sort of VSC for HVDC systems. One of the significant difficulties related with the MMC– HVDC system with the regular half - bridge SMs is the absence of dc - side short out blame taking care of ability. This issue is of serious concern, especially for HVDC transmission systems with overhead lines.[6]

B. Variable-Speed Drives

Use of the MMC to medium-voltage variable - speed drives has been appeared to be worthwhile over other multilevel converters, for example, the NPC and arrangement associated H-bridge converter, as for the introduced silicon territory and dc-interface energy [6]. Be that as it may, this application has its very own novel control difficulties. The fundamental test is the vast swell greatness of the SM capacitor voltages at low frequencies.

C. Dynamic Braking Chopper

In numerous applications, a dc braking chopper is required to retain and disseminate the energy. One model is the MMC based HVDC transmission system of a seaward wind ranch. If there should be an occurrence of failure of the less than desirable end (inland station) of the MMC– HVDC system to acknowledge the power in-feed from the breeze ranch, e.g., a non lasting deficiency on the coastal lattice, the framework code does not endure any impact on the task of the seaward station.

D. Different Applications

Advantages and notable highlights of the MMC for HVDC systems settle on it an unmistakable decision for adaptable air conditioning transmission system (FACTS) applications. The examination and establishment of the MMC - based STATCOM have been accounted for , in which, in view of the half-bridge SMs, the MMC– STATCOM performs dynamic filtering also.

One of the other potential utilizations of the MMC is in railroad electric footing systems, in which the MMC, as a medium voltage transformer less converter, is utilized to supply the footing engines [6].

V. CONCLUSION

Modular multi-level converter (MMC) innovation is quickly rising for voltage source converter. In spite of the fact that, till now, it has been essentially executed in high voltage dc transmission just yet the huge measure of work being done, over the globe, for its application in a few different fields including PV framework, wind vitality transformation, adaptable air conditioning transmission frameworks, medium/low voltage drives, and so on. This paper reviews the overall conceptual study of Modular multi-level converter.

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