Controlling of Circulating Current in MMC- HVDC using SVPWM

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Abstract—The Particular Multilevel Converter is another plan in the field of medium and high power gadgets. The working activity of converter is relying upon secluded approach. The flowing current which influences both the arms are remunerated by the half and full extensions coordinated as a proposed approach in this work which involves modules, each one being a half-connect related in parallel to a capacitor. The central qualities behind this thought are that it is possible to develop the sinusoidal waveform of the voltage by incorporating a couple of modules in game plan in each stage leg of the converter. An arm inductance is related in course of action with the modules of each arm. Instead of the two level voltage source converter, where the yield stage voltage can be either plus or minus the half of the dc-interface voltage, the MMC with SVPWM can change its yield with steps comparable to each module capacitor's voltage level.

Keywords- *Modular Multilevel Converter, HVDC, Voltage Source Converter, Space Vector Pulse Width Modulation.*

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I. INTRODUCTION

AC has been the favored worldwide stage for electrical transmission to homes and organizations for as far back as 100 years. But high-voltage AC transmission has a few restrictions, beginning with transmission limit and separation imperatives, and the difficulty of straightforwardly associating two AC control networks of various frequencies. With the beginning of another energy time and the need to fabricate a more intelligent grid, HVDC is expected to grow far beyond its traditional position as a supplement to AC transmission [1]. High Voltage Direct Current (HVDC) is the electric power transmission decision used in substantial measure of control over long separations with insignificant misfortunes. Considering the way that in a regular three phase system the power conveyed is affirmed by its RMS esteem, HVDC permits transmitting dynamic power with higher voltage extend. Moreover, the impedance created in AC transmission systems are avoidable decreasing the power losses. Therefore, the initial installation cost of HVDC is higher than HVAC systems but due to lower losses it becomes cost effective over the time. For instance, control conveyed from remote seaward wind ranches can be effectively bolstered into power grids coastal by means of HVDC innovation. Also, HVDC systems are valuable to interconnect offbeat AC grids dependably. Using HVDC system allows the possibility of using underground and sub-sea cables. Hence, HVDC is considered as a profoundly proficient option for transmitting a lot of power over long separations and for extraordinary reason applications. As a key empowering influence later on energy system based on renewable, HVDC is really molding the grid without bounds.

This technology consists of a converter station in which the AC system is converted into DC then transmitted through a power transmission cable and then converted back into AC. The cable connection can be overhead or both underground or submarine under water. An HVDC transmission system is depicted in Figure 1.1

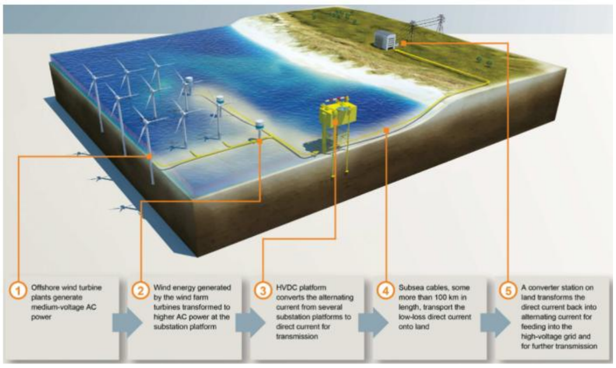

Figure: 1.1 HVDC transmission systems from an offshore to onshore grid.

Power electronics are fundamental components in consumer electronics and clean energy technologies [1], [2]. For today's high-power applications, multilevel converters are gaining a lot of attention, and are becoming one of the top clean power and emery conversion choices for new topologies and control in industry and academia [3]. Currently, multilevel converters are marketed in standard and altered items that power an extensive variety of uses, for example, compressors, extruders, pumps, fans, pounding factories, moving plants, transports, crushers, impact heater blowers, gas turbine starters, blenders, mine lifts, receptive power compensation, marine impetus, high-voltage coordinate current (HVDC) transmission, hydro pumped storage, wind energy conversion, and railway traction, to name a few. Several well-known companies offer multilevel converters commercially for these applications in the field. In

Figure 1.1.2, the applications of multilevel converters are shown. In spite of the fact that the innovation of multilevel converters is already grown to such an extent that they can be viewed as a developed and demonstrated innovation, despite everything they have many associated challenges. These challenges motivate researchers from all over the world to discover new ways to further energy efficiency, reliability, power density, simplicity for, and reduce costs of, multilevel converters, and broaden their application field as they turn out to be more alluring and aggressive than the great topologies.

Multi-Terminal High Voltage Direct Current (HVDC) grids seem to be one of the most viable solutions for massive integration of renewable energy to the power grid, especially for societies with an already highly developed AC Grid. This purported Super Grid will fill in as a cross-country thruway for sustainable power source, [1], taking into account geological smoothing impacts which will limit the disadvantages innate to the irregular way of inexhaustible sources. The Modular Multilevel Converter (MMC) proposed by Prof. Marquardt [2] has emerged as the most suitable power converter for such an application, since it has several advantages with respect to its predecessors.

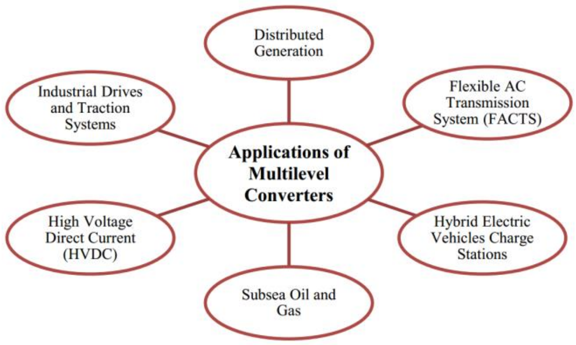

Figure: 1.1.2 Application of Multilevel Converter

The MMC topology allows a smooth and nearly ideal sinusoidal output voltage which requires little or no filtering, when many levels are used. It is able to operate at lower switching frequencies; hence the converter losses are more similar to those of the LCC technology [5]. It presents a modular design which may lead to a reduced production cost and easier maintenance. Moreover, it has high scalability allowing a simple adjustment to the maximum voltage by in-creasing or reducing the number of SMs; and finally it has the ability to continue its operation despite module failure.

MMC-HVDC

Modular Multilevel Converters (MMCs) have picked up specialist's consideration because of their capacity to deal with high voltage and power evaluations. VSC-HVDC is getting progressively imperative for coordinating sustainable power sources, for example, substantial seaward wind ranches, providing flexible interconnection between two weak AC grid network using back-to-back configuration, or simply transmitting power using underground cables. The VSC-HVDC also has fast and precise control over the active power-flow as well as it can independently control the reactive power injection at the local ac grid. There are numerous operational MMC-HVDC projects such as HVDC PLUS (Siemens) with an 88 km undersea transmission link between San Francisco's City Centre electrical power grid and a substation near Pittsburg. The main supporting functions HVDC PLUS provides are AC voltage Control, black-start capability, compact converter station space usage, four quadrant operation, compensation of asymmetrical loads, and flexible integration into HVDC multi terminal systems or future HVDC grids. Its basic operating principle and other advantages both on the technical as well as on the economical aspect can be described [4].

Another MMC-HVDC installation named HVDC Light by ABB is an adaptation of HVDC classic used to transmit electricity in power ranges (50-2500MW) transmit-ted using overhead lines and environmental friendly underground and sub-sea cables. It is used for grid interconnections and offshore links to wind farms. With HVDC Light, it is conceivable to transmit control in both headings and to bolster existing AC grids with a specific end goal to expand heartiness, solidness, dependability and controllability. HVDC Light offers many other advantages and can be used in different applications which are explained [5]. As outlined before, the main limitation of the two level converters is its high switching losses due to relatively high switching frequency which necessitates high insulation requirements of the transformer, as well as filters. The use of modular multilevel converters overcomes many of the aforementioned shortcomings, but at the expense of twice as many semi-conducting devices and a large distributed capacitor for each sub module. The principle idea of the hybrid VSC-HVDC, as used in HVDC Max Sine developed by Alstom, is to utilize a two level converter as the fundamental exchanging part with low exchanging frequency and a MMC to give a voltage wave molding capacity on the AC side keeping in mind the end goal to remove the harmonics.

II. PROPOSED STATEMENT AND PROPOSED METHODOLOGY

A problem that must be considered in the power stage design, especially in converters with chain- linked modules, is the failure of one or more modules. One possible reason for the module failure is the dc-link short-circuits. The use of the half bridge module at the MMC does not offer the possibility to limit dc-link fault currents due to the freewheeling diodes in parallel to the switches. The arm inductance plays the role of the current rise rate limiter but in high current applications, the inductance value is restricted because it causes large voltage drops and reactive power consumption.

The optimization problem is posed in a way such that power oscillations at the DC terminals of the converter will not take place, independently from the AC grid voltage conditions. The generation of the circulating current reference signals will therefore result from solving such an optimization problem using the Lagrange multipliers method once again. Furthermore, the power flow in the DC side of the MMC is most effectively decoupled from transients in the AC grid by establishing the primary power reference of the system at the DC terminals of the converter instead of at the point of common coupling.

A. PROPOSED METHODOLOGY

Proposed system of single cell converter has given in figure 4.1Demonstrated a MMC three phase structure. each phase as illustrated in figure 4.1 the upper arm is situated between two terminals positive DC and AC. both upper and lower arm consists of N number of half bridges or cells (N_{cell}) for circuit protection and smoothening of current it is noticeable that N_{cell} is different from the number of cell levels of converter. The arm inductor reduces the amount of circulating current in circuit at also reduces the effect of harmonics and potential faulty current either inside or outside the circuit. The DC is controlled by cells work as an on/off switch between the upper and lower arms.

B. SIMULATION IMPLEMENTATION

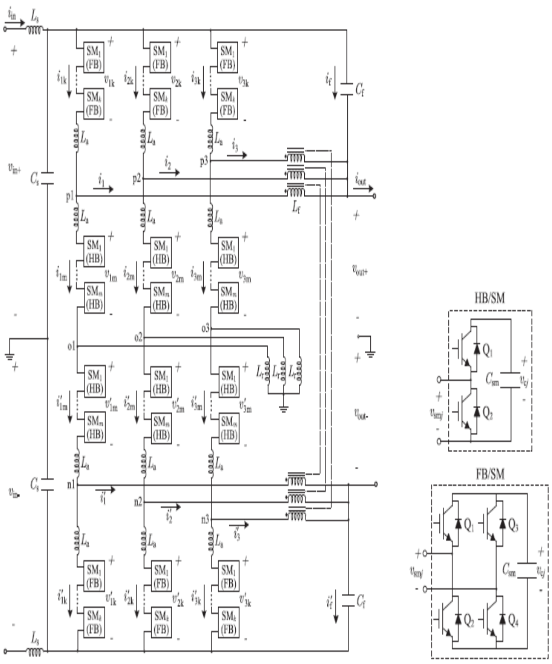

Figure: 1.3.1 proposed model 1 cell with half bridge & 1 cell with full bridge.

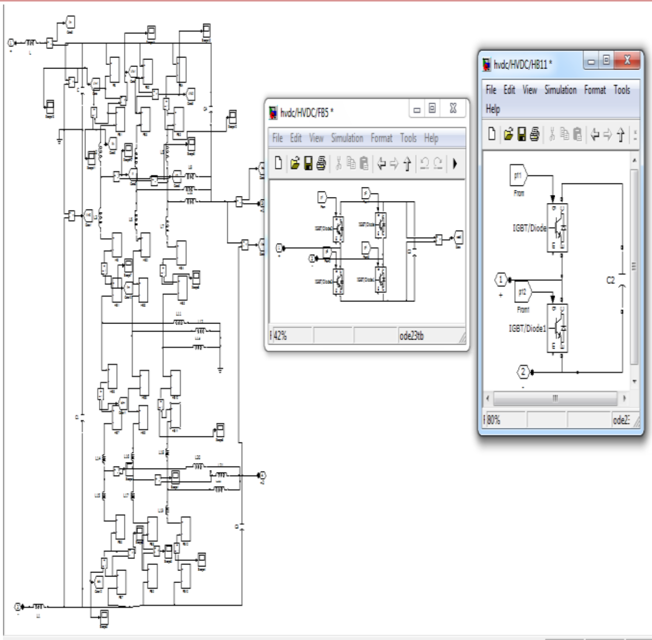
Figure: 1.3.2 Proposed model 1 cell with half bridge & 1 cell with full bridge.

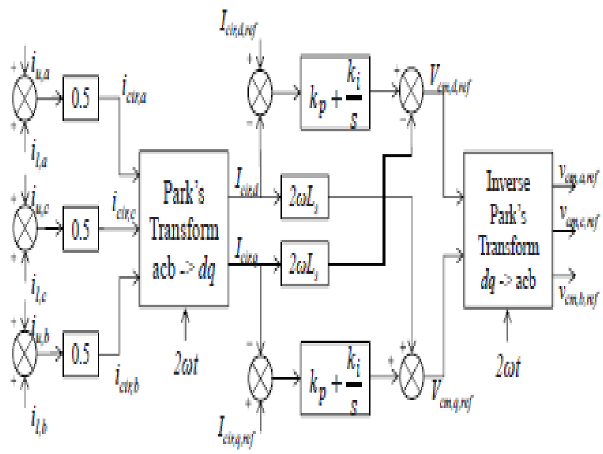

Figure: 1.3.3 Existing control loop only P – Q compensation.

Figure 1.3.3 illustrated the control loop of proposed system only with P-Q compensation in the proposed system parks transformation in inverse parks transformation has utilized.

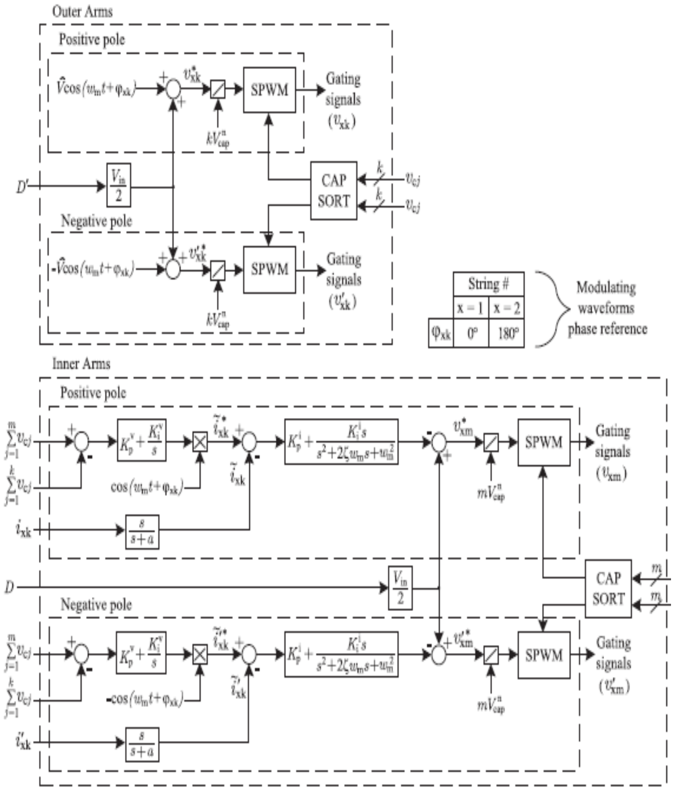

Figure: 1.3.4 Proposed control loop each string is compensated by SVPWM.

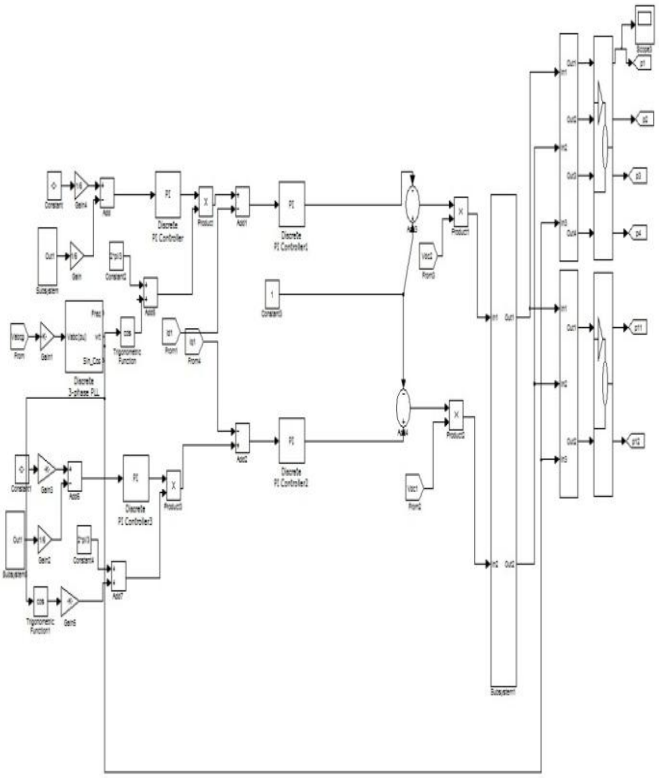

Figure: 1.3.5 Screen Shot of proposed DC Controller

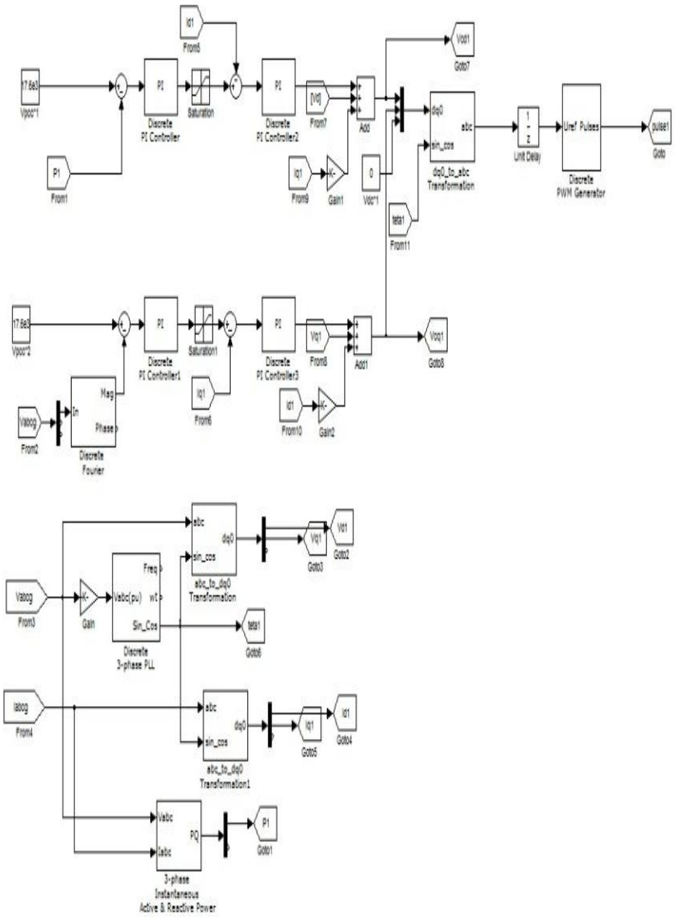

Figure: 1.3.6 Screen Shot of SVPWM in Proposed Model

III. RESULT

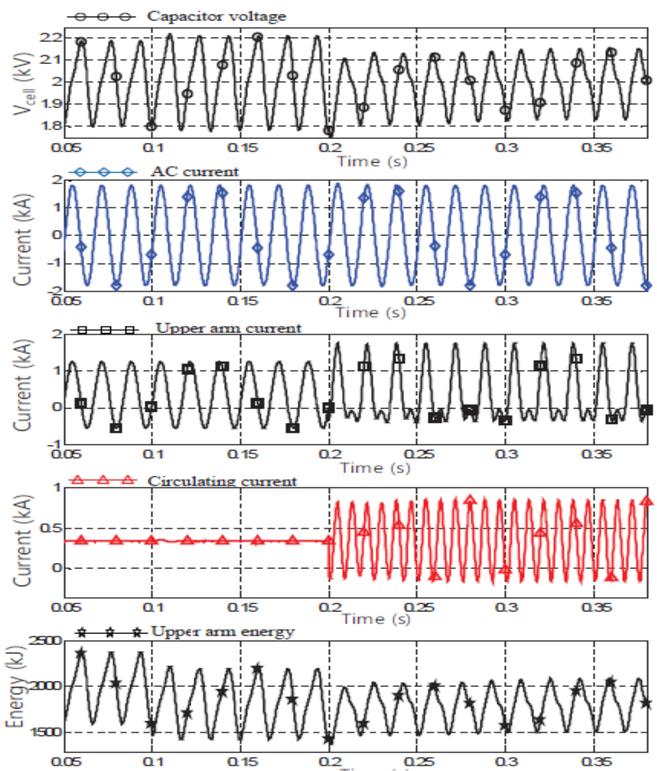

Fig: 1.4.1 Proposed Output with harmonics

Figure 1.4.2 illustrate the outcome of different component in circuit the top most waveform illustrate capacitor voltage where as respectively from top second is AC current waveform in kA ,upper arm current, circulating current , and upper arm energy.

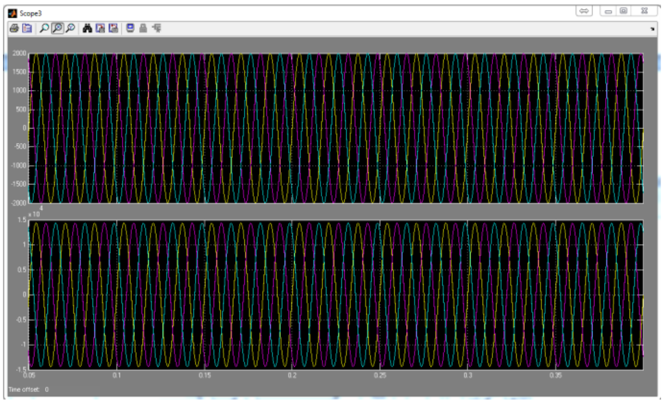

Figure: 1.4.2 Proposed system waveform after controlling of harmonics

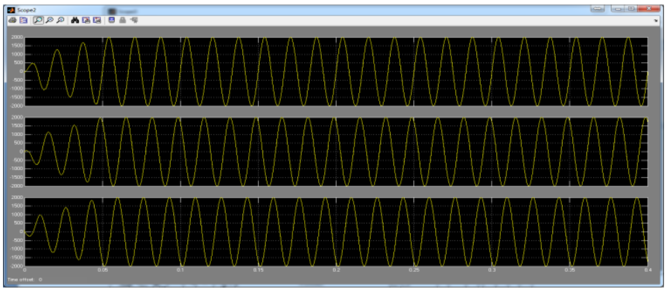

Figure: 1.4.3 proposed system Current waveform after controlling of harmonics

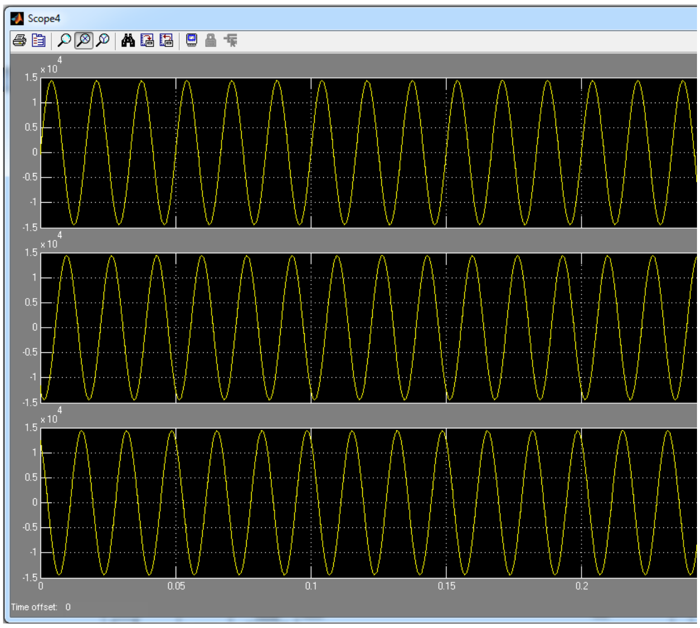

Figure: 1.4.4 proposed system Voltage waveform after controlling of harmonics

IV. CONCLUSION:

- In this work efficient method for high voltage direct current (HVDC) modular multilevel converter has explored and presented an efficient method foe HVDC application for reduced harmonics and power distortions.
- The proposed approach utilizes the full and half bridge hybrid multi level structure to control the circulating current harmonics and SVPWM controlling mechanism in upper and lower arm for remaining distortions presents in the system.
- The half and full bridge efficiently reduce the effect of injected second order harmonics by circulating and compensates the reactive power capability of MMC system.

In future the system can be integrated with the different controllers like PI Controller with Fuzzy logic controller to achieve desirable system requirements in various HVDC applications.

REFERENCES

[1] Heejin Kim, Sangmin Kim, Yong-Ho Chung, Dong-Wook Yoo, Chan-Ki Kim and Kyeon Hur, "Operating region of modular multilevel converter for HVDC with controlled second-order harmonic circulating current: Elaborating P-Q capability," 2016 IEEE Power and Energy Society General Meeting (PESGM), Boston, MA, 2016, pp. 1-1.

[2] A. Nami, J. Liang, F. Dijkhuizen and G. D. Demetriades, "Modular Multilevel Converters for HVDC Applications: Review on Converter Cells and Functionalities," in IEEE Transactions on Power Electronics, vol. 30, no. 1, pp. 18-36, Jan. 2015.

[3] S. Debnath, J. Qin, B. Bahrani, M. Saeedifard and P. Barbosa, "Operation, Control, and Applications of the Modular Multilevel Converter: A Review," in IEEE Transactions on Power Electronics, vol. 30, no. 1, pp. 37-53, Jan. 2015.

[4] S. Li, X. Wang, Z. Yao, T. Li and Z. Peng, "Circulating Current Suppressing Strategy for MMC-HVDC Based on Non ideal Proportional Resonant Controllers Under Unbalanced Grid Conditions," in IEEE Transactions on Power Electronics, vol. 30, no. 1, pp. 387-397, Jan. 2015.

[5] M. K. Bucher, R. Wiget, G. Andersson and C. M. Franck, "Multi terminal HVDC Networks—What is the Preferred Topology?," in IEEE Transactions on Power Delivery, vol. 29, no. 1, pp. 406-413, Feb. 2014.

[6] V. Akhmatov et al., "Technical Guidelines and Prestandardization Work for First HVDC Grids," in IEEE Transactions on Power Delivery, vol. 29, no. 1, pp. 327-335, Feb. 2014.

[7] N. Flourentzou, V. G. Agelidis, and G. Demetriades, "VSC-based HVDC power transmission systems: An overview," IEEE Trans. Power Electron., vol. 24, no. 3, pp. 592-602, 2009.

[8] R. Adapa, "High-wire act: HVDC Technology: The State of the Art," IEEE Power Energy Mag., vol. 10, no. 6, pp. 18-29, Nov./Dec. 2012.

[9] A. Lesnicar, J. Hildinger, and R. Marquardt, "Modular's strom-richterkonzept fur netzkupplungsanwendung bei hohen spannungen," in ETG-Fachtagung, pp. 155-161, Bad Nauheim, Germany, 2002(in German).

[10] R. Marquardt and A. Lesnicar, "A new modular voltage source inverter topology," in EPE Conf., Toulouse, France, 2003.

[11] J. Dorn, H. Huang, and D. Retzmann, "A new multilevel voltage sourced converter topology for HVDC applications," in Cigre, Paris, France, 2008, pp. B4-304.

[12] B. Gemmell, J. Dorn, D. Retzmann, and D. Soerangr, "Prospects of multilevel VSC technologies for power transmission," in Proc. IEEE Transmission and Distribution Conf. and Expo., pp.1-16, 2008.

[13] G. Ding, G. Tang, Z. He, and M. Ding, "New technologies of voltage source converter (VSC) for HVDC transmission system based on VSC," in Proc. IEEE Power Energy Soc. Gen. Meet., pp. 1-8, 2008.

[14] S. Allebrod, R. Hamerski, and R. Marquardt, "New transformer less, scalable modular multilevel converters for HVDC-transmission," in Proc. IEEE Power Electronics Specialists Conf., (PESC), pp. 1762-1768, 2008.

[15] J. Qin and M. Saeedifard, "Predictive Control of a Modular Multilevel Converter for a Back-to-Back HVDC System," IEEE Trans. Power Del., vol. 27, no. 3, pp. 1538-1547, 2012.

[16] C. Du, M. H. J. Bollen, E. Agneholm, and A. Sannino, "A New Control Strategy of a VSCHVDC System for High-Quality Supply of Industrial Plants," IEEE Trans. Power Del., vol. 22, no. 4, pp. 2386-2394, 2007.

[17] L. Xu and V. G. Agelidis, "VSC Transmission System Using Flying Capacitor Multilevel Converters and Hybrid PWM Control," IEEE Trans. Power Del. , vol. 22, no. 1, pp. 693-702, 2007.