An SL2CC Approach for Eliminating Commutation Failure in HVDC System

Kamaljeet Singh, Sukhmider Singh Gill

Research Scholar, Assistant Professor
Department of Electrical Engineering,
I.K. Gujral Punjab Technical University, IET Bhaddal Institution of Engineering and Technology, Mianpur Ropar-Punjab, India

Abstract— With the growing demand of electricity on a daily basis, we cannot rely on conventional electric authority systems like long-haul distributed power stations as well as complicated and heavy load distribution networks. Due to enlarged demand for power at the load center and concentration to distributed power generation, a lot of high capacity long distance HVDC systems are requisite and are intended to achieve various advantages. As growth in the power electronics field advances, HVDC systems are more consistent. So, this paper offers an overview to the work that has been done many authors.

Keywords—HVDC, Transmission, Thyristor Valves, Monopolar, Biopolar, Multi Thermal

I. INTRODUCTION

Significant amount of voltage with high amplitude can be transmitted over large distances by transmission systems referred as High Voltage Direct Current (HVDC) systems. For the purpose of transmitting power different versions of HVDC systems can be employed. On the basis of the requirement different methods such as Line Commutated Converter (LCC) dependent HVDC, Voltage-Source-Converter (VSC) methods can be used to implement such systems. The Voltage source convertor technique is implemented at multi-terminal DC grid and on the other hand the LCC HVDC technique produce optimum results as compare to Voltage Source Convertor while using it for distant locations and for ample amount of power transmission. Different obstacles were faced in Line commutated convertor HVDC system, for example when the voltage level was reduced to 10 to 15 percent and failure of commutate take place. HVDC system is shown in the Figure 1 below in which the AC-DC transmission is represented
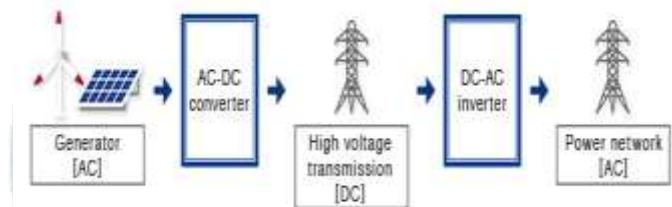

Figure 1: HVDC conversion block diagram

II. HVDC SYSTEM CONFIGURATION

In order to transfer the large amount of DC power for longer distance, different types of HVDC configurations are required. Different configuration is associated with the different pros and applications. Various types of HVDC configuration are discussed below.

2.1 Back-to-back HVDC system.

Under this HVDC configuration, two different energy stations are located at the same place and the transmission of energy will not occur by implementing DC connection over longer distance. In this type of HVDC configuration it is required to deal with the amount of power generated by the synchronous form of AC system and it is also required to stabilize weak AC links.
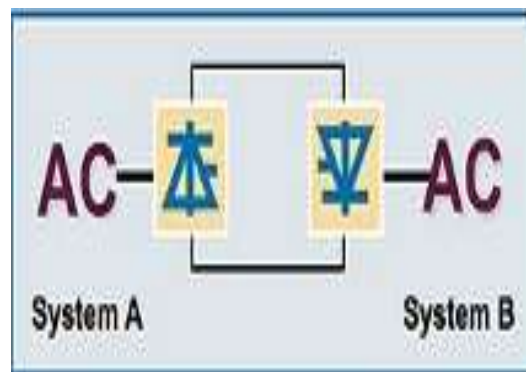

Figure 2: Diagram of Back-to-back HVDC system

2.2 Monopolar HVDC system.

In mono-polar HVDC configuration there is only one pole or it can be say that single conductor for transmission of power. In this configuration, conductor can attain any polarity i.e. it can be positive or negative. Mostly for better results, the negative polarity of conductor

is preferred. Monopolar HVDC system uses metal path and earth for current return path. This type of configuration is not widely used due to various problems associated with it.
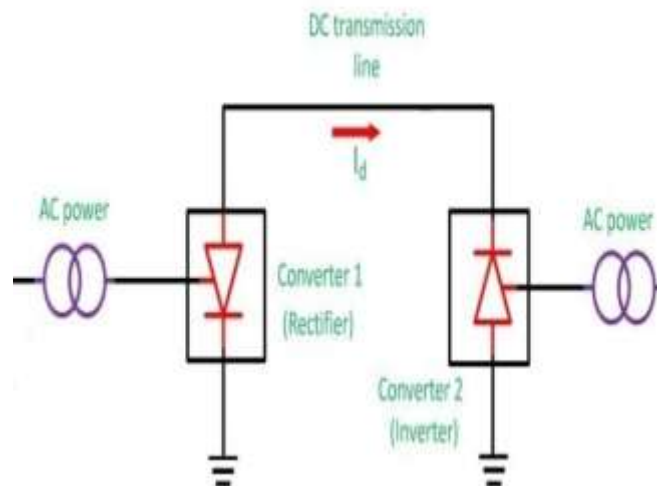

Figure 3: Representation of Monopolar HVDC system

2.3 Bipolar HVDC system.

The Bipolar High Voltage Direct Current (HVDC) system is widely used for power transmission as compare to different configuration of HVDC systems. This configuration is implemented where energy is transferred by using overhead transmission lines. This system is comprised of two poles and each pole was associated with different polarities. It is beneficial in case of failures, if one pole stops operating then other starts working as the monopolar configuration of HVDC system. In this both systems can act as self governing composition and current return with the earth return. Value of ground signal is approximately zero and may be lies in between the range of 1 % in two different poles.
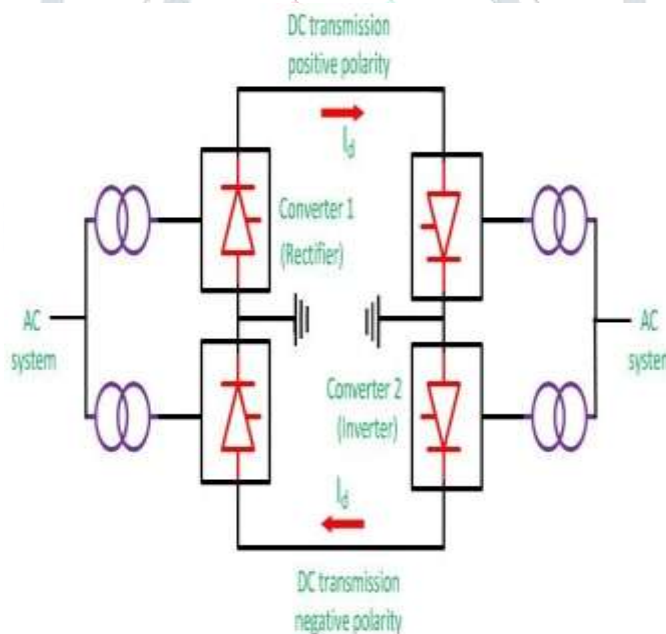

Figure 4: diagram of Bipolar HVDC systems

2.4 Multi-terminal HVDC systems

Under this HVDC configuration, more than two sets of convertor are used similar to the case of the Bipolar HVDC system. This type of HVDC configuration operates convertor 1 and 3 as rectifiers on the other hand the convertor 2 worked as the inverter unit. In the order s reversed the convertor 2 can work as a rectifier and convertors 1 and 3 can work as the inverter units. It is also possible to form various other combinations of inverter and rectifier by changing the connections of converter. The twelve pulse per pole converters are presented in the configuration of Multi-terminal HVDC configuration as demonstrated in the figure 5.
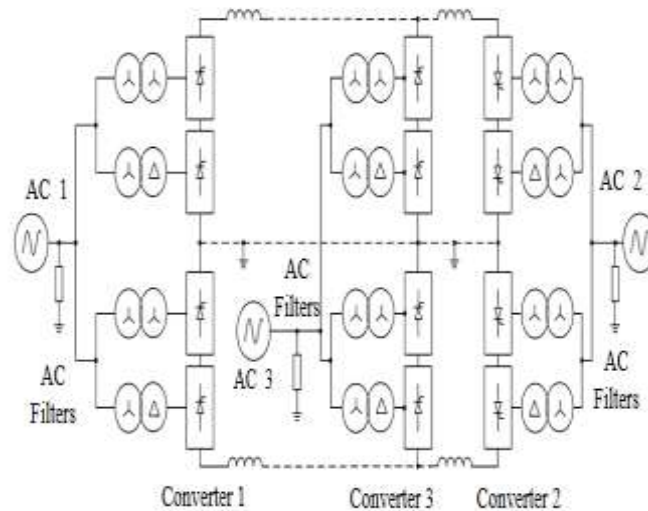
Figure 5: Multi-terminal HVDC system

III. RELATED WORK

Huang et al , in this paper the author had projected a grid dynamic segmentation process based on fault current limiter (FCL). The proposed technology involved the FCLs installation on appropriate ac lines. These installations were done in accordance to the architecture of network. The segmentation of multi-infeed HVDC systems was performed which decomposed it into number of distinct segments that were connected to each other via FCLs. Under normal environments, the equivalent impedance of the FCLs was zero and did not disturb power flow and bus voltage of the system. When short-circuit faults occurred in the ac system, the FCLs are triggered to limit the short-circuit current and impede the propagation of the faults among the sectors. As a consequence, for the dc systems, the commutation failure period of the dc links was decreased, and the retrieval of the dc systems was speeded. In case of ac system the concurrent occurrence of commutation failure in dc links resulted in power disparity and power flow transmission were determined. The transient steadiness of the whole ac/dc system was thus upgraded. The efficiency of the recommended grid dynamic segmentation method was demonstrated on two illustrative multi-infeed HVDC systems.

M Ramesh et al , For protected system's operation, a feasible technique was to monitor the signals so that precise and rapid classification of fault was probable for reaching appropriate control decisions. The application pure time domain or pure frequency domain based schemes construct the operation of HVDC fault identification quite complicated. For the time-varying transients the pure frequency domain based mechanisms were not suitable whereas the noise were easily control the pure time domain based methods. The detection of faults found in power system was facilitated by the use of High Voltage Direct Current transmission schemes for the purpose of enhancing power electronics technique. In oreder to investigate the faults in the HVDC transmission networks a case study was constructed to present the general idea of the artificial intelligence mechanisms.

Tao Gao et al, This research was based on the CIGRE HVDC Benchmark Model in PSCAD software, the test system served as standard system as it was frequently used for HVDC control analysis. As the system involved different DC equipment for controlling along with control schemes the analogous program and emulator were added to circuit model. This paper investigated the bus voltage and recent level in feeble AC system. By observing simulation results it was concluded that LCC was less constant than CCC. Both three-phase fault and signal-phase fault occurred in weak AC systems.CCC was considered to be less susceptible to commutation failure.

ChandupatlaChakradhar Reddy et al, proposed the improved version of Whitehead's theory for insulation restrictions by presenting a feasible theoretical study. The author addressed the issue of limited temperature values of insulation which were restricted by the evaluation of maximum power-carrying capacity for HVDC cables. This limited power-carrying capacity resulted in electro-thermal insulation failure. The external thermal resistance resulted from environmental interactions was regarded as a vital characteristics which was involved in formulations. The Lagrange multiplier methodology had been used to handle the resultant optimization problem. The theory on thermal breakdown in insulation provided for the basis for proposed theory which was regarded as its coherent extension.

Huang D, et al , presented the review study on advancements made in alternating current (AC), direct current (DC) and ultra-high voltage (UHV) transmissions. The paper discussed historical improvements in UHHV transmission that occurred oer the last two decades in China. Besides this, the paper analyzed results provided by different UHV main techniques which involved over-voltage, lightning performance, electromagnetic environment and live-line functioning. The proposals at the aspects of UHV transmission future design, construction, commercial operation and maintenance were basically introduced and deliberated. The evaluation and discussion were essential for the safe and reliable operation of UHV grid in China and can be a reference for other countries that urge to enhance the UHV AC and the DC transmission.

Bauman J et al , proposed the approach to improve efficiency offered by HVDC systems by employing fuzzy logic controllers in situations of different faults. Recent research had shown that the optimum membership function width in a fuzzy controller was distinct for several system events (such as current order change or fault). An adaptive method for developing fuzzy logic controllers required in HVDC systems was introduced in paper. The generation of look-up table was facilitated by simulation data for purpose of its utilization by fuzzy control system. On the basis of the operating point and the type and position of fault, the output of the table directed the membership function width to be used in the fuzzy controller to obtain the preffered outcomes. The finest controllers for nine faults at 27 operating points for the CIGRE benchmark HVDC method were projected in this paper as more effectively, utilized trends to originate a method for detecting these optimal controllers for other systems without the requirement for exhaustive simulation of each possibility.

Ch. Chakradhar Reddy et al, discussed different features of electrical and thermal failure that occurred in DC power cables. The closed form expressions were used for the purpose of computation of critical stress along with temperature in terms of steady current in conductor. Because of the occurrence of external heat source it was happened. The criticality here suggested an uneven state of the dielectric and was shown, more often than not, to be changed, from that corresponding to thermal decomposition boundaries. Formulation and clarification of

continuity equations under first and second kind limit conditions taking account of electric stress and temperature-dependent DC conductivity was enclosed. Stress and temperature distribution in the body of the insulation can be attained to a reasonable degree of accurateness by using the proposed model.

Rahimi E, et al, introduced an advance index for the purpose of estimating the susceptibility of an HVDC system to commutation failure which explored two distinct techniques to solve the purpose. In the first approach, the several runs (MR) of an electromagnetic transient simulation program (PSCAD/EMTDC) were directed through a focused algorithm whose sequential iterations among the arbitrary correctness resolved the trouble. In case of second method, the problem of finding the suggested index was formulated as an optimization problem and with the help of results of the first method, the paper presented that the optimization surface in this problem had some closely situated local minima. The multi-modality associated with optimization surface was resolved by employing dedicated algorithm. The transient simulation program was essentially combined with genetic algorithm (GA) process to overcome the issue. The paper showed that both approaches were successful in recognizing the critical value of the index.

Zhou, C et al, The uncertainty concurrent occurrence of commutation failures in all the inverters served as another challenge in multi-infeed HDVC system that were the constant dynamic events in the HVDC mechanism. The paper discussed electromagnetic transient simulation involved in commutation failures that were entirely based on dynamic dual-infeed HVDC test model for the purpose of addressing different conflicts occurring in AC system. The investigation of the causes leading to commutation failures in a multi-infeed HVDC system, explicitly of the voltage reduction and phase shift was specified. The outcome of the coupling impedance in the dual-infeed test model on the concurrent commutation failures was also discussed.

Thio, C.V et al, addressed onset or initiation process involved in commutation failures associated with line-commutated thyristor power converters. In this number of AC systems approaching to infinity were considered i.e. zero impedance. The theoretical designing along with critically analyzed parameters were elaborated.

John Reeve et al , Transient valve currents were derived for rectifier short circuits with respect of transient control behavior, and filter and ac system demonstration. Comparative analysis was performed by comparing filter connection present on ac side against tertiary of converter transformer. The valve currents were also examined for distinct types of singly-occurring and repetitive commutation failures. In each case, the analysis had been processed by dynamic digital computation and was considered to be of specific relevance to the existing surge ratings of thyristor valves within HVDC converter installations.

IV. CONCLUSION

This study covers the basic review to the HVDC systems and also provides a brief information corresponding to the past work that had been don in this field. This paper can be proved as a guide paper for those scholars who are working or will be work in this field. Since it provides a deep knowledge to the types of HVDC systems and the role of the thyristor in HVDC. It can be concluded that the innovations can be introduced in this field to improve the performance of the HVDC transmission system.

REFERENCES

[1]   Huang et al, "Improving performance of multi-infeedHVDCsystems using grid dynamic segmentation technique based on fault current limiters", IEEE, Vol 27, Issue 3, PP 1664-1672, 2012

[2]   M Ramesh et al, "Fault identification in HVDC using artificial intelligence — Recent trends and perspective", IEEE, April 2012.

[3]   Tao Gao et al, "Comparison of CCC and LCC in HVDC System", Energy Procedia, Vol. 16, Part B, Pp. 842-848, 2012

[4]   ChandupatlaChakradhar Reddy et al, "Theoretical Maximum Limits on Power-Handling Capacity of HVDC Cables", IEEE, Vol 24, Issue 3, PP 980-987, June 2009

[5]   Huang D,et al , "Ultra high voltage transmission in china:developments, current status and future prospects ",   IEEE Vol 97, Issue 3, PP 555-583, 2009,

[6]   Bauman J et al, "Commutation failure reduction in HVDC systems using adaptive fuzzy", IEEE, Vol 22, Issue 4, PP 1995-2002, 2007

[7]   Ch. Chakradhar Reddy et al, "On the computation of electric field and temperature distribution in HVDC cable insulation", IEEE,Vol 13, Issue 6, Dec 2006

[8]   RahimiE, et al, "communication failure in single and multifeed HVDC system", IEEE,PP 182-186, 2006

[9]   Zhou, C et al, "Study on commutation failure of multi-infeed HVDC system ", IEEE Power System Technology Conf., PP. 2462–2466, 2002

[10]   Thio, C.V et al, "Commutation failures in HVDC transmissionsystems", IEEE Trans. Power Deliv., Vol 11, Issue 2,PP. 946–957, 1996

[11]   John Reeve et al, "Dynamic Fault Analysis for HVDC Systems with ac System Representation", IEEE, Vol. 91, Issue 2, PP 668-696, March 1972