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Elimination of Commutation Failure of VSC HVDC System with Controllable Capacitor

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Abstract: This system presents a totally unique hybrid converter configuration for traditional Line-Commutated converter (LCC) HVDC technology aiming to eliminate commutation failures at lower place serious faults. Dynamic series insertion of capacitors throughout commutation is employed to increase the effective commutation voltage. The operational principles are bestowed followed by elaborate mathematical analysis for every zero ohmic resistance single-phase and three-phase faults thus on choose the required capacitance size and its voltage level. The performance of the planned technique is valid by simulation leads to Real Time Digital machine (RTDS) and so the results show that the planned convertor con- figuration is during a position to eliminate commutation failures below every fault cases. Consequently partial power transferring capability throughout single-phase fault and quick fault recovery from three-phase fault can be achieved. Additional simulation results show that the harmonic content of electrical convertor AC voltage and current are not significantly accumulated and so the voltage stress of the thyristor valve is harking back to that of the primary benchmark system.

Keyword —Commutation failures, governable capacitance, HVDC transmission, LCC HVDC, series capacitance insertion.

1. INTRODUCTION

High Voltage electrical energy transmission supported Line-Commutated convertor (LCC) technology has been wide used around the world for power transmission since its first application sixty years past. Though the recent Voltage-Sourced-Converter (VSC) principally |primarily based} mostly HVDC technology is additionally the popular alternative for multi-terminal DC grid or wind energy facility integration, the LCC HVDC still out-performs the VSC in long distance bulk power transmission because of its higher efficiencies. But some well-known problems connected to LCC HVDC still exist these days that limits the extra application of this technology. The foremost notable one is commutation failure which could happen to a lower place 10%–14% of voltage depression at converter AC bus. The commutation failure will cause a temporary halt of power transfer and heating of the valves. An explosion of power transfer between adjacent AC transmissions lines conjointly will happen that may have a bearing on system transient stability.

The controller modification methods, it has been identified in literature that commutation failures can't be utterly avoided if the fault is electrically near the electrical converter. So the objectives of those modifications area unit either to scale back the chance of commutation failure or to extend the recovery speed of DC system when commutation failure. The most commonly used methodology is to advance the firing angle at electrical converter facet right away when detection of AC voltage disturbance so as to offer a bigger commutation margin. Another possibility is to scale back the commutated DC current by lowering the present order at rectifier facet upon detection of AC voltage disturbance. However the advancement of firing angle can lead to multiplied reactive power consumption, which can more depress the electrical converter AC bus voltage notably for weak AC systems. Also the modification of current order at rectifier facet may not be quick enough given the usually long distance of the DC link]. Among the methods with additions of electrical phenomenon components/power electronic devices, Capacitor-Commutated Converters (CCC) [16] was the most popular one which may operate at higher power issue and lower chance of commutation failures. However commutation failure still cannot be eliminated and important increase of voltage stress on thyristors which may be two p.u. to 3 p.u. has been identified. Besides CCC, some other researchers are tired the realm of active series compensation. A small-rated series VSC is added in addition to the fastened series condenser in three hundred. The small rated-VSC is

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employed to actively modification its output voltage to compensate the variations of AC voltage whereas the fastened series condenser still acts because the main commutation condenser. The level of AC voltage variation that the series VSC can address is proscribed as a result of its little rating.

Since the main contributions to commutation failure mitigation are still from the fastened series capacitors therefore the problems related to three hundred still exist during this topology, and commutation failure elimination is hard to realize. A similar method exploitation solely the series VSC to assist mitigate commutation failures is mentioned. The much higher rating of VSC considerably will increase the DC voltage harmonic content that will be seen from simulation ends up in the system. For commutation failure mitigation, a maximum of 100% AC voltage reduction is simulated thus it will be expected that even higher rating of VSC is needed for higher performance. Circuit configuration called Controlled Series condenser device (CSCC) is compared with ancient three hundred. CSCC has the series capacitors inserted between filter bus and AC system bus and its capacitor values will be adjusted in an exceedingly manner the same as that in Thyristor Controlled Series Compensation (TCSC) schemes. However the controllability of capacitors is solely wont to avoid ferroresonance drawback. Considering commutation failure mitigation, it has similar performance with CCC and has the potential risk of accelerating valve voltage stress. The Gate-Commuted Series Capacitor (GCSC) is used at rectifier facet for power issue correction. The proposed methodology will solely insert capacitors in one direction and no discussions with regard to commutation failure area unit bestowed.

2. EXISTING SYSTEM

Rectification or inversion for HVDC converters is accomplished through a process familiar as line or natural commutation. The valves act as switches so that the a.c. voltage is sequentially switched to continually give a d.c. voltage. With line commutation, the a.c. voltage at both the rectifier and electrical converter should be provided by the a.c. networks at each finish and ought to be 3 part and comparatively freed from harmonics as pictured in Figure eight. As each valve switches on, it will begin to conduct current whereas the present begins to fall to zero within the next valve to show off any 2 device valves with each valves carrying current at the same time throughout this method. Consider the rectification method. Each valve can switch on once it receives a firing pulse to its gate and its forward bias voltage becomes a lot of positive than the forward bias voltage of the conducting valve. The current flow through a conducting valve doesn't change outright because it commutates to a different valve as a result of the transfer is thru electrical device windings. The leakage electrical phenomenon of the electrical device windings is conjointly the commutation electrical phenomenon farewell because the a.c. filters are set on the primary or a.c. side of the device electrical device.

At the inverter, the three section a.c. voltage supplied by the a.c. system provides the forward and reverse bias conditions of each valve within the device bridge to permit commutation of current between valves a similar as within the rectifier. The inverter valve will solely flip on and conduct once the positive direct voltage from the d.c. line is greater than the rear negative voltage derived from the a.c. commutation voltage of the a.c. system at the inverter. Due to the road commutation valve switching method, a non-sinusoidal current is taken from the a.c. system at the rectifier and is delivered to the a.c. system at the inverter. Both Ivr and Ivi area unit insulant to the alternating voltage.

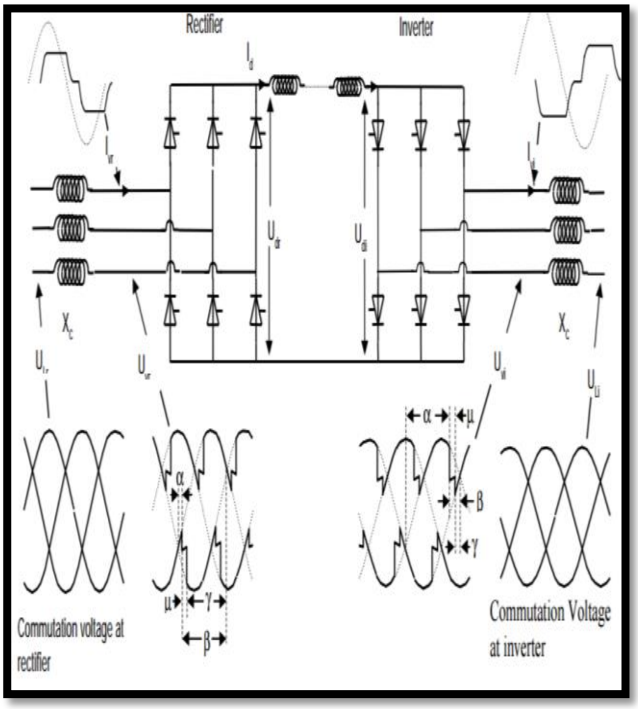

Figure 1. Voltage and current wave shapes associated with d.c. converter bridges.

This non-sinusoidal current waveform consists of the elementary frequency a.c. component and higher harmonics being taken from, and injected into, each a.c. system. The a.c. filters divert the harmonics from entering the a.c. system by offering a low electrical phenomenon bypass path permitting the commutation voltage to be comparatively harmonic free. Reversal of power flow in a line commutated d.c. link is not possible by reversing the direction of the DC. The valves will enable conductivity in one direction solely. Power flow can solely be reversed in line commutated d.c. converter bridges by ever-changing the polarity of the direct voltage. The dual operation of the device bridges as either a rectifier or electrical converter is achieved through firing management of the grid pulses.

2.1 Commutation failure

When a convertor bridge is in operation as AN electrical converter as pictured at the receiving finish of the d.c. a valve will flip off once its forward current commutates to zero and therefore the voltage across the valve remains negative. The period that the valve stays negatively biased is that the angle γ, the duration on the far side that the valve then becomes forward biased. Without a firing pulse, the valve will ideally keep non semiconducting or blocked, even though it experiences a forward bias.

All d.c. valves require removal of the internal keep charges created throughout the forward conducting amount before the valve will with success establish its ability to dam a forward bias. The d.c. inverter there for needs a minimum amount of negative bias or minimum extinction angle γ for forward block to achieve success. If forward blocking fails and conductivity is initiated while not a firing pulse, commutation failure occurs. This also results in a right away failure to take care of current within the succeeding convertor arm because the d.c. line current returns to the valve that was antecedently conducting and which has unsuccessful to sustain forward block.

Commutation failure at a converter bridge in operation as AN electrical converter is caused by any of the following reasons:

1. When the d.c. current entering the electrical converter experiences AN increase in magnitude that causes the overlap angle μ to extend, the extinction angle γ is reduced and will reach the purpose where the valve is unable to take care of forward block. Increasing the inductance of the d.c. current path through the converter by means that of the d.c. smoothing reactor and commutating reactance reduces the rate of amendment of d.c. current. This has the greatest effect on commutation failure onset.

2. When the magnitude of the a.c. side voltage on one or a lot of phases reduces or is distorted inflicting the extinction angle to be inadequate as commutation is tried.

3. A phase angle shift within the a.c. commutating voltage can cause commutation failure. However, the a.c. voltage magnitude reduction and not the corresponding part shift is the most dominant issue determinant the onset of commutation failures for single phase faults.

4. The value of the pre-disturbance steady state angle γ conjointly affects the sensitivity of the electrical converter to commutation failure. A value of γ = 18O is common for many inverters. Increasing γ to values of 25O, 30O or higher will scale back the chance of commutation failure (at the expense of accelerating the reactive power demand of the inverter).

5. The value of valve current before the commutation failure conjointly affects the conditions at that a commutation failure might occur. A commutation failure may a lot of without delay happen if the pre-disturbance current is at full load compared to lightweight load current operation. In general, the more rigid the a.c. voltage to which the electrical converter feeds into ANd with an absence of a.c. system disturbances, the less likelihood there can be commutation failures.

3. PROPOSED SYSTEM

The block diagram of the proposed system is illustrated in fig 2. Traditional Line-Commutated convertor (LCC) based mostly High Voltage Direct Current (HVDC) technology has compete a vital role in long distance bulk power transmission round the world since its initial application sixty years past.

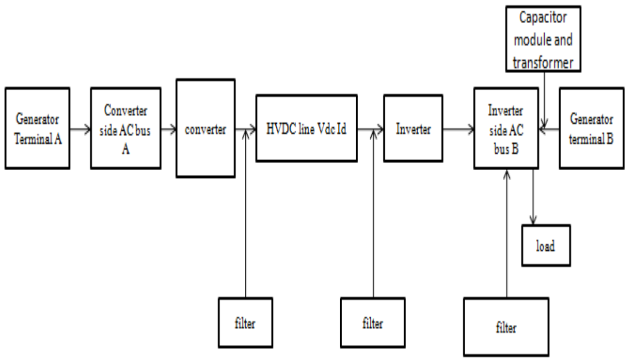

Figure 2. Block diagram of proposed system

However some well-known limitations associated with it still exist nowadays that to an explicit extent limit any applications of such a technology. One of the restrictions is critical reactive power requirement at either side of the HVDC system.

The reactive power requirement originates from the firing of thyristors once commutation voltage becomes positive, which in result delayed the current waveforms with relevance the voltage waveforms. In this case since the 2

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converter stations area unit placed on an equivalent website, the problems of communication delay and therefore the risk of loss of communications between rectifier and electrical converter management systems area unit decreased. Also the measurements from each terminals area unit pronto obtainable for each management systems. Hence it is attainable for the electrical converter to regulate its reactive power consumption by variable its angle of extinction whereas the danger of losing commutation margin may be alleviated by the rectifier controller modifying its operational conditions. This type of management helps improve the AC voltage stability at the electrical converter bus by dominant reactive power consumption, but extended steady state reactive power consumption still remains. In addition this sort of control strategy is restricted to consecutive HVDC schemes. For purpose to point HVDC schemes, unlike consecutive schemes, the communication delay and/or the requirements for the system to work while not communications for the most part limit the chance of reactive. Most power control of the literatures area unit then targeted on reactive power compensation rather than reducing reactive consumption level of convertor.

Disadvantages: Significant reactive power demand at each sides of the HVDC system. Due to no voltage control the massive AC disturbances within the system. The LCC HVDC system with controllable capacitors and the connected AC system at the electrical converter facet. In the figure, TY1-TY6 and TD1-TD6 are thyristor valves, CapYa, CapYb, CapYc and CapDa, CapDb, CapDc are capacitance modules, S1Ya-S4Ya are four Insulated Gate Bipolar semiconductor device (IGBT) switches for capacitance module CapYa. An induction machine is adscititious to the electrical converter AC bus to check the AC voltage controller performance. Capacitor modules area unit connected in series between the secondary facet of convertor transformers and thyristor valves. Each capacitance module will be complete by one module or by variety of series connected sub-modules to attain higher insertion voltage. Each module consists of four IGBT switches with anti-parallel diode across every one of them.

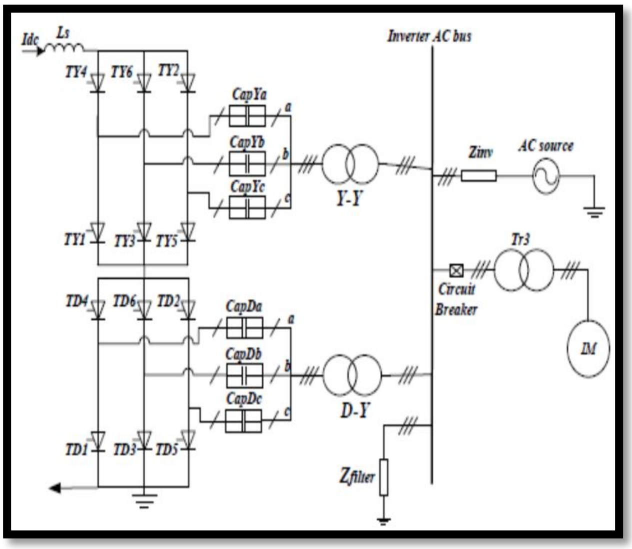

Figure 3 Line-Commutated convertor (LCC) based mostly High Voltage Direct Current (HVDC) system

The reference polarity of the capacitor is shown in Figure 3. Each capacitance module can be inserted as a positive voltage once S1 and S4 area unit switched on and S2 and S3 area unit converted, and will be inserted as a negative voltage once S2 and S3 area unit switched on and S1 and S4 area unit converted. Bypass is achieved by switching S1 and S3 on or S2 and S4 on at the same time. Advantages: An induction machine is adscititious to the electrical converter AC bus to check the AC voltage controller performance. Commutation voltage from the inserted capacitors guarantees the successful commutations once electrical converter is exportation reactive power. Fig 5 shows the simulation result of the proposed method.

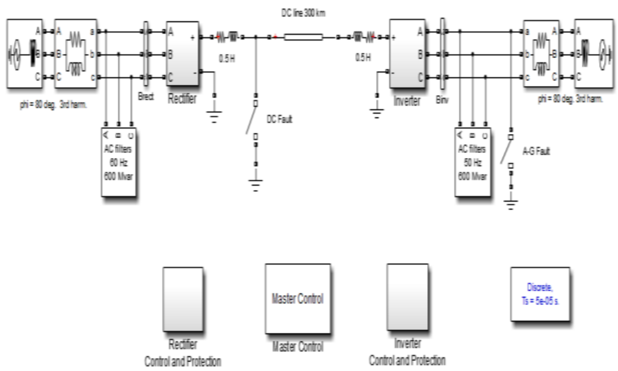

Figure 4 Circuit diagram

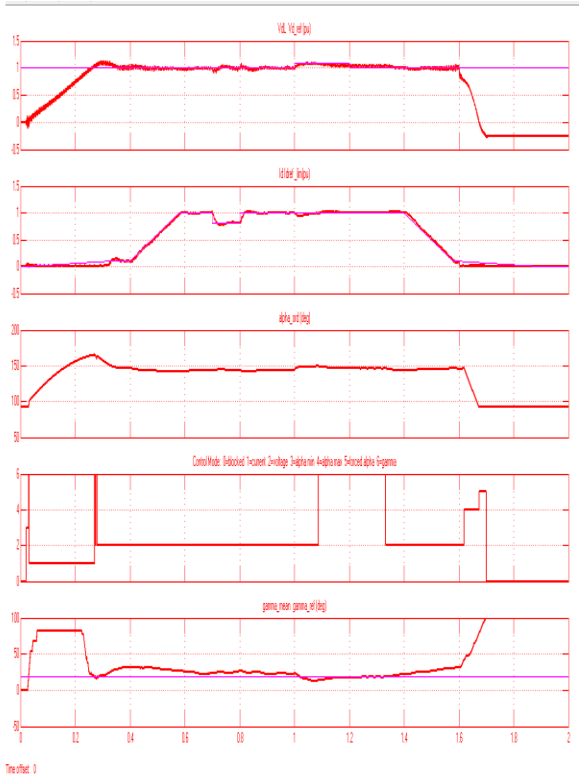

Figure 5. Simulation result

4. CONCLUSION AND FUTURE WORK

This paper presents a new dynamic modeling approach for HVDC converters supported turn-on devices, i. e. the line commutated convertor and also the condenser commutated converter. The standard models for these converters area unit supported quasi-static approximations and assume a relentless ripple-free electrical energy. In contrast to this, the dynamic approach takes into account the dynamics of a (slowly) varying electrical energy. Slow in this context implies that the present may be approximated by a linear function throughout commutation. The new approach was first applied to the line commutated convertor. The resulting model is a natural dynamic extension of the quality model and each models area unit identical for steady-state conditions. The dynamic model also agrees with the notion of a mean commutation inductance as seen from the dc aspect.

REFERENCE

[1] C. V. Thio, J. B. Davies, and K. L. Kent, “Commutation failures in HVDC transmission systems,” IEEE Trans. Power Del., vol. 11, pp. 946–957, 1996.

[2] X. Zhou, “Simultaneous commutation failures and forced blocking of multi-in-feed HVDC in east china power grid,” in Proc. CIGRE Large Disturbances Workshop, Paris, France, 2014.

[3] Z. Lidong and L. Dofnas, “A novel method to mitigate commutation failures in HVDC systems,” in Proc. Int. Conf. Power System Technology, 2002, vol. 1, pp. 51–56.

[4] W. Zhinong, Y. Yang, L. Xiao, W. Huawei, S. Guoqiang, and S. Yonghui, “Direct-current predictive control strategy for inhibiting commutation failure in HVDC converter,” IEEE Trans. Power Syst., vol. 29, pp. 2409–2417, 2014.

[5] Y. Z. Sun, P. Ling, M. Feng, G. J. Li, and P. F. Lv, “Design a fuzzy controller to minimize the effect of HVDC commutation failure on power system,” IEEE Trans. Power Syst., vol. 23, pp. 100–107, 2008.

[6] J. Bauman and M. Kazerani, “Commutation failure reduction in HVDC systems using adaptive fuzzy logic controller,” IEEE Trans. Power Syst., vol. 22, pp. 1995–2002, 2007.

[7] S. Tamai, H. Naitoh, F. Ishiguro, M. Sato, K. Yamaji, and N. Honjo, “Fast and predictive HVDC extinction angle control,” IEEE Trans. Power Syst., vol. 12, pp. 1268–1275, 1997.

[8] D. Jovcic, “Thyristor-based HVDC with forced commutation,” IEEE Trans. Power Del., vol. 22, pp. 557–564, 2007.

[9] J. Reeve, J. A. Baron, and G. A. Hanley, “A technical assessment of artificial commutation of HVDC converters with series capacitors,” IEEE Trans. Power App. Syst., vol. PAS-87, pp. 1830–1840, 1968.

[10] G. M. Kristmundsson and D. P. Carroll, “The effect of AC system frequency spectrum on commutation failure in HVDC inverters,” IEEE Trans. Power Del., vol. 5, pp. 1121–1128, 1990.

[11] T. Tanaka, M. Nakazato, and S. Funabiki, “A new approach to the capacitor-commutated converter for HVDC-a combined commutationcapacitor of active and passive capacitors,” in Proc. IEEE Power Eng. Soc. Winter Meeting, 2001, vol. 2, pp. 968–973.

[12] K. Sadek, M. Pereira, D. P. Brandt, A. M. Gole, and A. Daneshpooy, “Capacitor commutated converter circuit configurations for DC transmission,” IEEE Trans. Power Del., vol. 13, pp. 1257–1264, 1998.

P-ISSN: 2347-4408
E-ISSN: 2347-4734

[13] I. Matsumoto and S. Nomura, "Power factor correction of large current line commutated converters using variable series capacitors," in Proc. 15th Eur. Conf. Power Electronics and Applications (EPE), 2013, pp. 1–9. [14] H. H. Zeineldin, E. F. El-Saadany, and M. Kazerani, "Capacitor commutated converter using an adaptive active capacitor for HVDC system," in Proc. IEEE Can. Conf. Electrical and Computer Engineering (CCECE), 2003, vol. 1, pp. 529–534.

[15] G. Chunyi, L. Yuchao, Z. Chengyong, W. Xiaoguang, and X. Weihua, "Power component fault detection method and improved current order limiter control for commutation failure mitigation in HVDC," IEEE Trans. Power Del., vol. 30, pp. 1585–1593, 2015.

[16] M. Meisingset and A. M. Gole, "A comparison of conventional and capacitor commutated converters based on steady-state and dynamic considerations," in Proc. 7th Int. Conf. AC-DC Power Transmission, Conf. Publ. No. 485, 2001, pp. 49–54.

[17] M. Szechtman, T. Wess, and C. V. Thio, "A benchmark model for HVDC system studies," in Proc. Int. Conf. AC and DC Power Transmission, 1991, pp. 374–378.