

VSC-HVDC Application to Improve the Long-Term Voltage Stability

SWAPNIL SOLANKI¹, MR. PRAVIN KUMAR², DR. DEEPIKA CHOUHAN³, MD. ASIF IQABAL⁴

^{1,2,3,4} Department of electrical engineering, Poornima College of engineering, Jaipur, India

Abstract -- This paper proposes the VSC-HVDC application to enhance and increase long-term voltage stability. A suitable controlling technique for VSC-HVDC is proposed in the paper. The goal is to reach the best possibilities from long-term voltage stability perspective with respect to system configuration and also the VSC-HVDC capability curve. To show the capability of the proposed control methodology, two long-term voltage instability scenarios are considered. For the first scenario, VSC-HVDC can lead to a stable condition with its initial active-reactive power set points. In the second voltage instability scenario which is more severe, the proper power flow change in the system using VSC-HVDC is needed to avoid the voltage collapse. VSC-HVDC is ever to effectively compete with classical HVDC, protective devices must be implemented in the system. Presently classic protection devices are widely in use for protection in HVDC Systems.

Index Terms- HVDC, VSC, Protection, Fault Analysis, STATCOM

I. INTRODUCTION

A high-voltage, direct current (HVDC) electric power transmission utilizes DC for the mass transmission of electrical power then the more typical classic AC networks. HVDC is otherwise called the electric superhighway or power superhighway as a result of its ability to exchange a lot of energy.

These days voltage source converter based high voltage direct current (VSC-HVDC) system are ending up increasingly an adversary of established thyristor-based HVDC system. As the converter's power rating increases, it may be able to one day replace the thyristor-based HVDC. VSC-HVDC is very impressive because, unlike classical-HVDC, no reactive power support is needed to operate the system. In fact, VSC's can generate reactive power, and control both active and reactive power independently. Due to economic reasons, power systems today work closer to

their operating limits and it makes the blackouts more likely to happen. Many of the recent large blackouts were the consequence of voltage collapses. As we move towards the modern day VSC converter which uses the IGBT (insulated gate bipolar transistor) instead of classic thyristors. Our degree of control will improve because we will be able to control both on and off cycle of the device

II. HVDC TECHNOLOGY

2.1 Common System Topologies

- A. Symmetric Monopole: In symmetric monopole course of action a solitary converter with mid-point ground amongst positive and negative voltage polarities.
- B. Asymmetric Monopole: In Asymmetric Monopole course of action a solitary converter with grounded unbiased. This could be with either ground or metallic return.
- C. Bipole: In Bipole course of action a converter is made of two Monopoles. This could be with either ground or metallic neutral.
- D. Series Bridge Scheme: In Series bridge scheme a converter is made of monopoles in series. This could be with either ground or metallic return.
- E. Multi-Terminal: In this type of course of action Multiple converters (more than two) are connected to a DC-Link

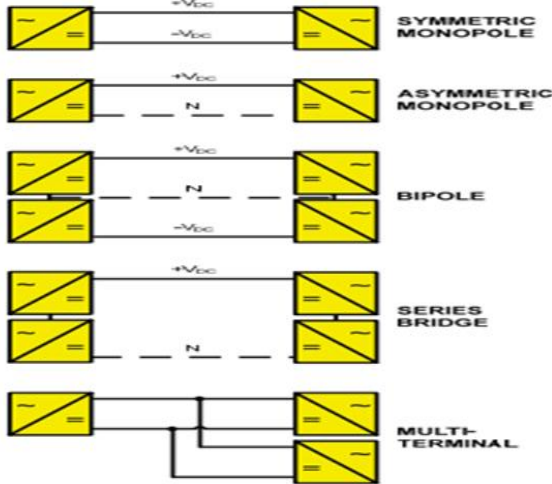


Fig1. Common System Topologies

2.2 Difference between Vsc-Hvdc & Llc-Hvdc

There are some brief difference between classic LLC (Line load commutated) HVDC and VSC (Voltage source converter) HVDC given below-

Technology	HVDC Classic (LCC)	HVDC Light® (VSC)
Semiconductor (control)	Thyristor (turn on only)	IGBT (turn on / off)
Power Control	Active only	Active / reactive
AC Filters	Yes	No
Minimum Short Circuit Ratio	Grater than 2	Zero
Black Start Capability	No	Yes

Table -1. Difference between LLC-HVDC & VSC-HVDC

III. TEST SYSTEM

The test system is used to conduct dynamic simulations. This test system is shown in Fig It includes three voltage levels; 400, 220 and 130 kV and is divided into four main areas:

- a. North: mostly hydro generation and some load
- b. Central: with many loads and large thermal power-Plants
- c. Southwest: few thermal units and some load
- d. External: connected to the north. It has a mixture of generation and load units

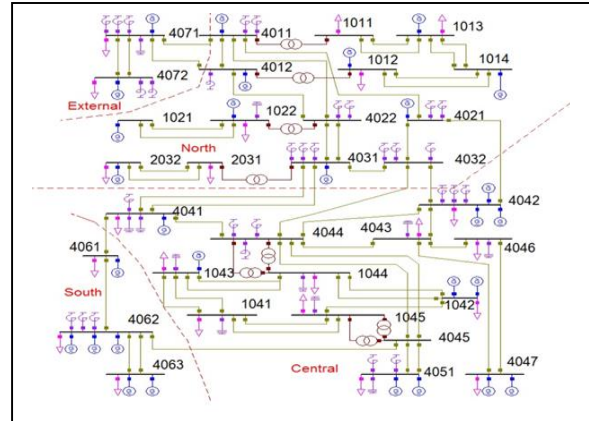


Fig2. Test System

3.1 Simulation

A. Scenario I

- The first disturbance applied to the test system is the tripping of one generator at bus 4047 which is indicated by the last circle in Fig at 150 s. When the generator is tripped at the central area, then lack of the reactive power is one important problem that shows up in the central and south areas.
- To improve the long-term voltage stability, the south-west link is placed between buses 4032,4045 in the test system

B. Scenario II

- To push further stress on the system, the second long-term voltage instability scenario is considered at this point. This scenario is the combination of the transmission line and generator outages.
- In fact in this scenario, the transmission line placed between buses 4032-4042 which is indicated by the red color in Fig.2 is out of

service from the beginning of the simulation, then the generator at bus 4047 is tripped at 150 s during the simulation.

IV. RESULT

To evaluate the capability of the VSC-HVDC link to improve the long-term voltage stability, the simulation results for two long-term voltage instability scenarios are presented and discussed.

Fig. 3 shows the voltages at different buses of the south part of the system. As it can be seen in this figure, the VSC-HVDC link could compensate the lack of the reactive power and the voltages are stable in the south area.

Fig. 4 shows the voltages in the southern part of the system for the second scenario. As it can be seen, even the VSC-HVDC link is in place, but still, the long-term voltage collapse happens. The collapse also happens for the central area but in the paper, the voltages at south part are presented as representative of the system behavior. After the short-term transients following the disturbances, the system is stable. Then long-term dynamics like tap changer actions, OXL actions also load dynamics take over the system. At this time, some of the generators in the central area reach their over excitation limits and their OXL act to return the field currents to the rated values. Lack of reactive power in the central and south areas is the consequence of OXL action. Meanwhile, to counteract the disturbances effect and compensate the lack of the reactive power, there are some connections and disconnections of the shunt elements in the system but the voltage collapse cannot be avoided as it is shown in Fig. 4. So it could be said that the evolution of the long-term variables leads to voltage collapse in the south and central parts of the test system.

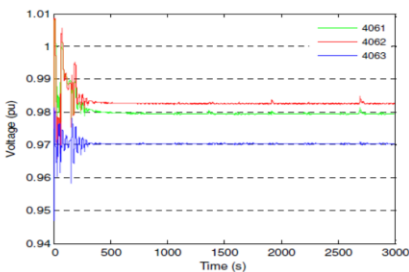


Fig3.The Voltage at the southern bus in I Scenario

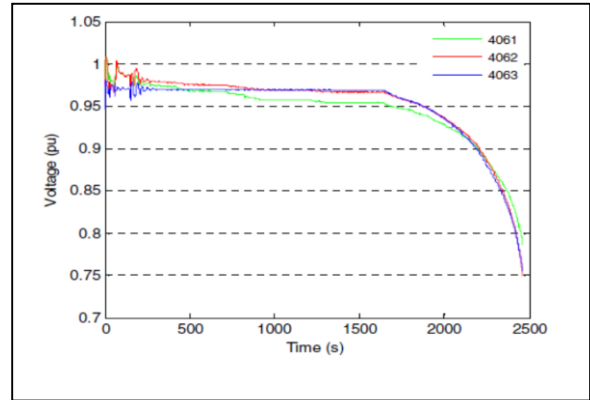


Fig4.The Voltage at the southern bus in II Scenario

V. ADVANTAGE OF HVDC

There are so many advantages of using HVDC instead of classic AC transmission system some of them are listed below-

- A long distance point to point HVDC transmission scheme generally has lower overall investment cost and lower losses than an equivalent AC transmission scheme.
- HVDC transformation hardware at the terminal stations is exorbitant; however the aggregate DC transmission line costs over long separations are lower.
- Endpoint-to-endpoint long-haul bulk power transmission without intermediate 'taps', usually to connect a remote generating plant to the main grid.
- Integration of renewable resources such as wind into the main transmission grid.

VI. CHALLENGES IN USE OF HVD

- The challenges of HVDC are in conversion, switching, control, availability, and maintenance.
- HVDC is less dependable and has brought down accessibility than classic (AC) networks, primarily because of the additional change hardware.

- Single-pole system has accessibility of around 98.5%, with about 33% of the downtime unscheduled because of deficiencies.
- Fault-tolerant bipole frameworks give high accessibility for 50% of the link capacity, but the availability of the full capacity is about 97% to 98%
- HVDC scheme requires many spare parts to be kept, often exclusively for one system, as HVDC systems are less standardized than AC systems and technology changes faster.

VII. CONCLUSION

The VSC-HVDC application to improve the long-term voltage stability is investigated in this paper. An appropriate control strategy is proposed to control the power flow of the VSC-HVDC link to improve the AC system stability as much as possible. The test system is utilized to investigate the performance of VSC-HVDC link. Two long-term voltage instability scenarios are considered to show the capability of the VSC-HVDC link to enhance the AC power system performance and improve the long-term voltage stability. Simulation results show that the optimal control of VSC-HVDC link leads to voltage collapse avoidance in the system. Many other voltage instability scenarios have been conducted to verify the proposed control method but are not shown in the paper due to space limitations. In all other cases having VSC-HVDC with optimal control leads to long-term voltage stability improvement.

REFERENCES

- [1] "VSC-HVDC Application to Improve the Long-Term Voltage Stability", M. Reza Safari Tirtashi, Jörgen Svensson, Olof Samuelsson, 2010.
- [2] "VSC-HVDC System Protection: A Review of Current Methods", Jared Candelaria, 2014.
- [3] "Enhanced Fault Ride-Through Method for Wind Farms Connected to the Grid Through VSC-Based HVDC Transmission", Christian Feltes, Holger Wrede, 2014.
- [4] "Analysis of Active Power Control for VSC-HVDC", Wenyan Wan, 2009.

- [5] "Comparison of HVDC Light (VSC) and HVDC Classic (LCC) Site Aspects, for a 500MW 400kV HVDC Transmission Scheme", Dr. RL Sellick, M Åkerberg, 2013.
- [6] "DC Fault Ride-Through Capability And STATCOM Operation Of A Hybrid Voltage Source", R. Feldman, A.J. Watson, J.C. Clare, 2010.
- [7] "Enhanced Voltage Control of VSC-HVDC Connected Offshore Wind Farms Based on Model Predictive Control", Yifei Guo, Houlei Gao, 2009.
- [8] "Fast Frequency Response From Offshore Multi-terminal VSC-HVDC Schemes", Oluwole Daniel Adeuy, 2013.
- [9] "Frequency Control of Island VSC-HVDC Links Operating in Parallel with AC Interconnectors and Onsite Generation", Sotirios I. Nano, 2011.
- [10] "Multi-Terminal VSC-HVDC System for Integration of Offshore Wind Farms and Green Electrification of Platforms in the North Sea", Temesgen M. Haileselassie, Marta Molina, 2010.
- [11] "New Breed of Network Fault-Tolerant Voltage-Source-Converter HVDC Transmission System", Grain Philip Adam, 2014.
- [12] "New Technologies of Voltage Source Converter (VSC) for HVDC Transmission System Based on VSC", GuanJun Ding, Guangfu Tang, Zhiyuan He, and Ming Ding, 2015.
- [13] "Offshore Wind Integration to a Weak Grid by VSC-HVDC Links Using Power-Synchronization Control", Pinaki Mitra, 2013.
- [14] "Small-Signal Dynamics Of Hybrid LCC-VSC HVDC Systems", Chunyi Gu, 2008.
- [15] "Fault Analysis of VSC HVDC Systems Using Fuzzy Logic", Benish Penny, 2013.