Original Article

Review And Analysis On Hybrid Control Of Fault Ride Through And Transient Stability Of Vsc-Hvdc

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Abstract

A steady DC-Link Voltage, a CV voltage control and a reactive power control on the basis of the previous reviewers' analysis are the goals of the VSC-HVDC connecting controller. In order to achieve these objectives, the appropriate controller is required at both VSC-HVDC terminals. This paper presents a non-linear control approach to improve the VSC-HVDC relationship's control robustness. A sliding mode control (SMC) and an integrated proportional control (PI) were used for the configuration of a hybrid controller. The hybrid controller will provide mathematical simulation. This hybrid driver provides malfunction driving and the transient reliability of the VSC-HVDC link. This paper presents a non-linear approach to control to improve the robustness of the VSC-HVDC controller. The hybrid controller configuration is a control of the sliding mode (SMC) and an integrated proportional control (PI) for a hybrid controller design. Fault ride the stability of this hybrid control unit is provided through and transient VSC-HVDC links. MATLAB and Simulink simulate the hybrid controller and increases the performance of the controller. The simulation induces a symmetrical grid-side malfunction to maintain transient stability.

Keywords: AC voltage control, DC voltage control, high voltage direct-current, AC voltage control, DC voltage control, Power system simulation, real-time systems, hybrid simulation technology, VSC HVDC.

1. INTRODUCTION

HVDC technologies and FACTS devices have today grown increasingly complex and advanced in electric power electronics, playing an increasingly important role in the production of EPS [1]. Electronics systems are also increasingly used as an alternative and scalable current transmission system. These technologies enhance the robustness, reliability and controllability of the often-passive EPS into an active and adaptive network [2-8].

Two HVDC technologies are available on the market. First is the HVDC based on line switching (LCC) which uses a thyristor [9]. The second is the HVDC-based voltage converters (VSC) with a bipolar transistor (IGBT) insulation gate [10-13]. Due to the advantage of fail-storm blocking power, poor CA device activity and constant maintenance of DC voltage in changeable current directions, VSC dependent HVDC takes more care of [14-17]. Two separate end-to-end configurations would make the multi-terminal network more desirable as it needs fewer terminals and supports a failing power flow in the DC line [18-20].

The construction of a secure scheme of the transmission line of HVDC is more complex than an AC line because its impedance requirement is low, no normal zero-circulation, no semiconductor overload capacity, low risk duration, and highly stable state failure streams. The traditional protection systems are not appropriate for protection against DC grids. Moreover, DC Grid system security still presents challenges, and in multi-terminal networks, detecting a defective line is very difficult.

For the DC delivery system multi-terminal VSC, the device and current protection are given. However, it can lead to communication delays and selectiveness problems VSC-HVDC system multi-terminal. In multi-terminal DC systems a handshaking technique is proposed for identifying and separating DC defects. The operation, however, is incredibly slow and destroys electronic equipment causing major failure streams. With multi-terminal networks, the power flux can also be disrupted on the healthy line. The authors have also proposed wavelet transformation and transient protection schemes to work well on a high-speed HVDC line for failure detection. In a wavelet analysis on multi-terminal VSC-HVDC systems based on DC voltage and current signals, dc defects are recommended for observation. The coefficient of error detection is therefore set. The efficiency of the co-efficient protective is influenced by the fault angle and fault resistance. Accurate detection of faults could not be achieved only with fault-induced transient signals due to transient switching in real-time.

Compared with the CSC-based HVDC, the VSC HVDC has different advantages. (d) it can be easily installed on the shore due to its flexibility and compact dimensions, (e) contact between the two side VSCs is not required, and (f) lower AC Harmonic filters (b) are (a) VSC provides free over-reactive, active power control; (b) it is linked to poor and isolated areas; (c) it begins black;

The traditional methods of control are restricted to modifying non-linear system parameters and reducing system efficiency. Driven architecture points for controllers are parametric undefined, nonlinear and bandwidth constraints sliding mode power (SMC). Since OWSFs are extremely non-linear, the controller architecture is stable, non-linear and adaptable to improve the reliability of the transient power system. For example, For OSWF grid integration, advanced control-based controllers produce better performance. Authors in literature focused on advanced control technologies have been working on Many problems of the VSC-HVDC system control system. For VSC/HVDC correction and inverter controllers, the author applied adaptive sliding mode control. For the design of the VSC-HVDC control system, a robust non-linear SMC-based control system is used to boost the system efficiency and stability. For the design of VSC hybrid systems on both sides of VSC-HVDC connection, the generic SMC-based inertia emulation and the perturbation observatory-based SMCs are proposed.

This enhances the dynamic stability of the system and regulates energy oscillations. The fuzzy, for power transmission in VSC-HVDC connections the VSC-neutral dot-clamped logic controller is used at three speeds. The OSWF is integrated into the grid by the adaptive back steeping method and it aims at stabilizing the DC voltage. To enhance the HVDC control unit and to control the DC relation tension, a sensor less control technique based on the extended Kalman filter is suggested. The purpose of this article is to provide the link between a VSC-HVDC connecting to the Onshore AC grid by means of the permanent magnet synchronous generator (PMSG) on the basis of the OSWF. A suitable controller for both VSC-HVDC terminals is needed to fulfill these objectives. To build the controller and provide internal and external controllers, It uses the technique of hybrid regulation. The internal and external controllers are designed with the robust PI-control and non-linear control method.

1.1 System modeling

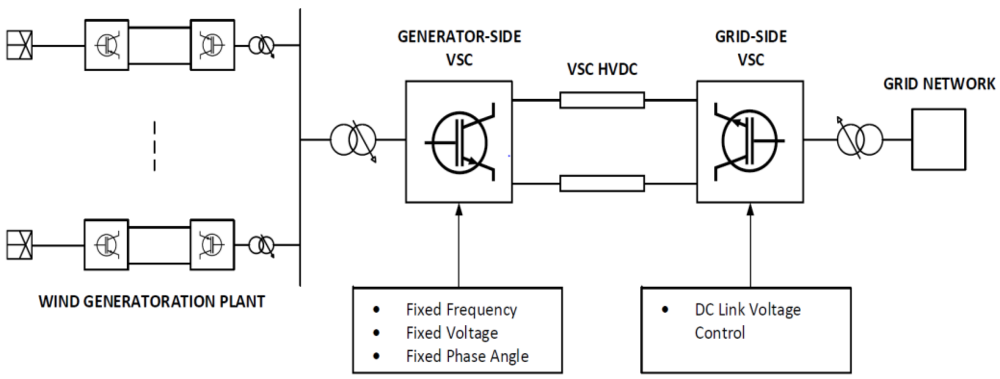

Fig. 1: The single line diagram of PMSG based OSWF with VSC-HVDC transmission link

The PMSG-based OSWF single line diagram and VSC-HVDC connection are presented in fig.1. The OSWF has an output of 400 MW and is radially connected to the PMSG wind turbines. The single-line scheme includes OSWF, HVDC and grid-based VSC. The side of the wind farm VSC (WSVSC) is connected with the side grid by a DC cable (GSVSC).

1.1.1 Description of the hybrid model of VSC HVDC

The VSC HVDC Hybrid Development Model and hybrid simulation concept are key principles.

- An ongoing, implicit integration process (to avoid a differential equations resolution methodologic error, EPS simplification) will overcome and eliminate all models of mathematical control devices;
- The digital level offers simulation visualization and multiple, Control accurate model parameters (coefficients of various equations of the respective models of power mathematical devices);

The physical level permits the interaction in models of the power system by translating mathematical Physical model voltages values (via appropriate voltage-current converters).

1.2 VSC-HVDC Fault Analysis

DC defects happen on a VSC-HVDC line frequently [56]. They are defects between the poles and the poles. It is very important to assess the characteristics of DC defects before designing a safety system for the VSC-HVDC multi-terminal transmission line.

1.2.1 DC Pole-to-Pole Faults

The VSC is most seriously affected by the DC pole-to-pole faults. IGBT for self-protection may be blocked after the loss. Fault current flows across the VSC anti-parallel diode direction. Figure 2 illustrates pole-to-pole VSC-fed faults in three phases such as a condenser release, free-wheel diode and grid-feeding phases.

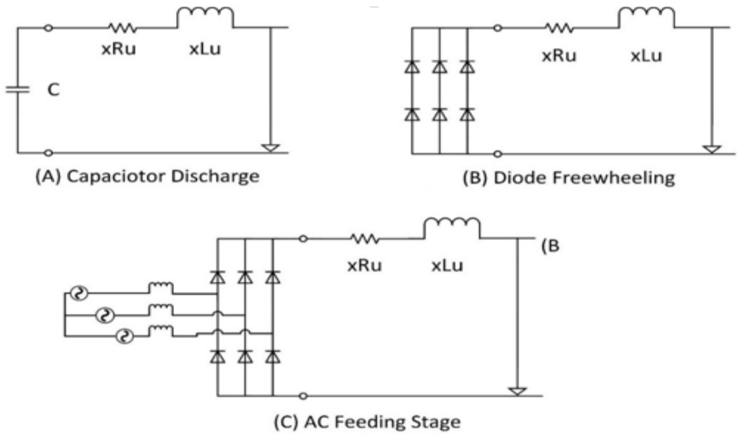

Fig. 2: VSC-HVDC pole-to-pole fault. A. Capacitor discharging phase, B. diode freewheeling phase, C. grid current fed phase.

The DC connection condenser is discharged and the DC voltage collapses after the error occurs. The second phase is the DC connection voltage zero, i.e., diode freewheeling. At this point the inductance pushes the current into the freewheel direction of the diode, and the diode is incredibly high and will destroy electronics. The most harmful phases are therefore the discharge of the capacitor and the diode freewheeling events. IGBTs are blocked and the converter is unregulated in the third stage of grid power feeding. A non-controlled rectifier moves grid current (iGrid) to the fault. The Different Faults to be considered for the system study shown in TABLE.I.

TABLE 1: The Main Faults to be considered

SERIAL NO	TYPES
1	AC Grid Fault at rectifier
2	DC bus Fault at rectifier
3	Fault at terminal of rectifier
4	Fault at middle of transmission line
5	Fault at terminal of inverter
6	DC bus Fault near inverter
7	AC Grid Fault at inverter

2. LITERATURE REVIEW

2.1 Introduction

At the turn of the 1990s, the development of power-electronics semiconductors (IPGBTs) And GTOs like IGBTs (Gate Turn-Off Thyristor) (Insulated Gate Bipolar transistor) had reached the point where their ratings enabling the use of VSCs. On the island of Gotland the first commercial VSC-based HVDC transmission with an underground cable, for example, 50MW was initially commissioned in 1999. The VSC-HVDC or HVDC-PLUS are the HVDC-Light (ABB) (Siemens) is often referred to as an HVDC device. DC-based POWER transmission isn't a novel concept. Thomas Alva Edison's first industrial power was the low voltage DC in the 1880s. DC was also the first transmission electrical system, but electricity must be generated near to its customers because of the low voltage levels so that too large losses were avoided. The Nikola Tesla AC system has enabled the transformation of the voltage into high voltage levels, which is suited for long-distance transmissions of electric power. Power generation should not be near its consumers anymore, but should instead be situated where the energy source is. Therefore, in the 'battle of patterns' at the end of the 1880s, AC technology was the winner and the primary power transfer technology since then. If, like the AC transformer, there were innovations that could elevate the DC voltage to a higher degree, history would have been different.

2.2 Overview

In transmission systems, HVDC technology is used for transmitting massive Electrical power via cable or overhead lines over long distances. It is often used for connecting the same frequency or different frequencies to asynchronous AC systems. The basic idea is that electricity would be transmitted from the AC or node in all directions. The simplistic schematic picture of an HVDC is shown in Figure 1. There are three components in the system: Two DC line and two transformer stations. Many components are involved in CA transformation into DC in each station block and vice versa.

- Conversion stations and transmission lines or cables are used in the HVDC system.
- AC switchyard, converter, and supporting subsystems are included at the HVDC converter facility.

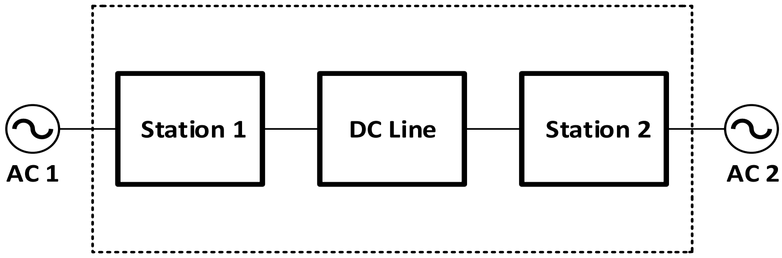

Fig.3: A diagram of the overall system perspective of a general HVDC system, moving electricity in any direction from one AC system or node to another.

- Depending on HVDC technology, the valves in the conversion devices consist of several thyristors or transistors that are connected in series.
- The CTS is the system for converters connected to the valves. Transformers are the same as the CTS system.
- The technology used by CSC-HVDC is Converter of the current source (CSC). Trademarks of the business are either HVDC Classic (ABB) or HVDC.
- The VSC-HVDC transforms AC into DC using the VSC and vice versa. The marking shall be of HVDC PLUS (Siemens) or HVDC-HVDC.

2.3 Review of Literature:

Zhou Li, et.al, (2018), [1], Demand for massive integration of renewable energy and passive grid power is growing steadily. Moreover, global energy interconnection has become more and more common. A significant way of achieving this is to offer Favorable access to renewable and passive delivery of electricity network transmission systems with high voltage direct current (HVDC). Even asynchronous network interconnection may easily be accomplished. As a result, HVDC transmission systems requirements are rising, leading to the need for multi-terminal HVDC transmission systems, the key task being to formulate suitable power distribution control strategies according to each terminal.

Botong L, et.al, (2020), [2], VSC-HVDC technology, based on the electronic power equipment converter and fully controlled, has a range of technological advantages, including independent power control, AC grid supportless switching, low harmonic polarity and continuous stress when reverting. This paper provides for the permanent defect identification in the VSC-HVDC grid dependent on the overhead transmission line voltage ' single-pole grounding fault. The first thing to be studied is the operating theory of the DCCB hybrid disruptor and the mechanism of discharge of the DCCB hybrid's internal capacitor.

Premila Manohar, et.al, (2016), [3], Solid State technology advances recently led to increased ratings of the IGBTs and GTOs. The tum on or off characteristics of these devices have been regulated and new converters known as the Voltage Source Converter (VSC) have been developed. PWM technology manages the switching of these units. VSC-HVDC avoids the issue of switching failures and harmonics and allows reversal to weak AC systems. Conversion work is autonomous, ensuring the active and reactive force is independently regulated, decreasing the harmonic content of the lower order, making the conversion plant more compact and modular. In power transmission and industry, the traditional HVDC and VSC-HVDC systems show a higher advantage. Direct High Voltage Current (for modern power systems, HVDC transmission systems are still an excellent component.

D.M. Larruskain, et.al, (2015), [4], the majority of HVDC systems are point-to-point connections, where energy is exchanged. However, there are some HVDC multi-terminal (MT) systems that run for a wide interval. Italy – Corsica – transmission from Sardinia and Quebec – transmission from New England. There are three operational converters in both systems, Centered on the technology of Line Commutated Converters (LCC). Classical voltage converters (VSC) do not interrupt DC fault currents and HVDC power ratings do not yet have DC circuit breakers commercially available. Protection of VSC-HVDC systems therefore remains a major obstacle to growth. The characteristics of VSC-HVDC are optimized for HVDC grids.

Seetha Chaithanya, et.al, (2016), [5], the future of renewable energy is important for energy stability and CO2 reduction. New, In the energy systems, low carbon output requires significant quantities and the overseas wind plays a key role. In Europe and internationally, offshore wind is a strong competitor for fossil fuels. Wind turbines are pushed offshore by land challenges, progressively greater wind energy, and public resistance case of offshore wind turbines. This paper provides a detailed analysis of components of the LFAC transmission and their design considerations. Detailed consideration of offshore wind turbines, Collector networks and onshore frequency transformers of different forms.

Seyed Saed Heidary Yazdi, et.al, (2019), [6], Europe is rising in the commissioning of offshore wind farms over 60 km away from the ocean. The wind speed, the even wind profile and the reduced visual and acoustic disturbances are increasingly incentivized for the production of offshore farming. 84 offshore wind farms with a total capacity of 11 GW are to be built at the end of 2014 in 11 countries in Europe. Increased output of wind power penetrating factor (e.g., in Denmark and Spanish percentage 42 and 22). With Kondur's two areas power method, the findings show the four approaches to improve slow network oscillation with the same inertia as the primary frequency response (with negligible errors).

John Fradley, et.al, (2015), [7] Major decarburization is required to reduce greenhouse gas emissions, in particular CO2, in power generation. Around 32 percent of Great Britain's CO2 emissions are due to the production of power. Renewable generating sources are replacing fossil-fuel energy plants to reduce the effect of CO2 pollution from electricity production. VSC-HVDC is a desirable interface to provide synthetic inertia in terms of energy levels and controllability. This paper reviews additional VSC-HVDC frequency control schemes and coordinated control strategies for connected HVDC systems.

Kai Liao, et.al, (2014), [8], Thanks to the advantages of the speed control and four quadrants of active and reactive capacity, large wind farms around the world are built on a twin induction generator (DFIG). A direct power converter with high voltage (VSC-HVDC) with the projected increase in the level of offshore wind energy penetration is important for the integration of wind power with in-shore ac networks. As a potential technology, VSC-HVDC transmission has emerged to solve the challenges of integrating future offshore wind energy into the market. Wide wind farms with high-voltage converters are connected to the onshore AC grid by means of an HVDC (VSC-HVDC) transmission system.

ALI RAZA, et.al, (2018), [9], The high voltage dc (HVDC) voltage source converters were increasingly interested (VSC). There are several advantages to VSC HVDC technology: Both active and reactive power controls are provided, and only when the current direction is reversed the power direction will change. The system can be implemented as a constant dc bus, in contrast to conventional Line Switching Converters (LCC), which is allowed to multi-terminal HVDC (MT-HVDC). To test the protective schemes, PSCAD / EMTDC is engineered and is prone to line faults at various places and times with A transmission four-terminal HVDC system. The findings demonstrate that a relay algorithm identifies the loss successfully and accelerates the primary security process. BP is accelerated by 0,2 ms on malfunctioning of PP. Moreover, the relayed algorithm provides faster security concerning literary techniques.

LeleNiu, et.al, (2018), [10], in recent years, VSC-HVDC technology, in particular on an offshore wind farm, has increasingly been used in the fields of power systems technology. In contrast to AC transmission, these features support strong networking and transmission efficiency, synchronous interconnection, division of wide-area power systems, and fast-acting electricity regulation. The conventional 2-terminal configuration of the VSC-HVDC did not meet the reliability, flexibility, and cost-effectiveness criteria for some application scenarios like the multiple-power supply and multiple drop-down points. The VSC-HVDC multi-terminal transmission system appears at this historic moment.

Dizhen Xu, et.al, (2018), [11], The high voltage direct current (HVDC) transmission started the invention during the 1920s. HVDC Transmission in 1954 from native Sweden to Gotland Island marked the foundation of HVDC-based transmission technologies of the first-generation, which were based on the switching of mercury-arc valves. Thyristor was applied on HVDC and the mercury-arc valve was removed soon, marking the birth of HVDC Technology-line (LCC) 2 generation. The thyristor was used until the 1970s. In the late 1990s, the HVDC transmission was used as the basis for a voltage-source converter (VSC), based on the switch off devices and pulse-width modulation technology. Hybrid transmission line switch converter-voltage source transmitter (LCC-VSC-HVDC) has unique technical benefits, but its overvoltage study is currently not adequate.

Ognjen Stanojev, et.al, (2019), [12], Most transmission networks today have attained capability limits through an increase in the transmission of electricity between systems, a combination of remote renewables and an overall increase in electricity. Transit flows increased since 2010 in Switzerland, resulting in increased line loading. Since 2010 the European market coupled. The steady congestion of the Swiss transmission system has led to increased energy traffic, especially in North and South corridors. The construction of new transmission facilities has been postponed due to environmental restrictions and public objections. This research explores the technical advantages for a possible hybrid AC/DC line of the Swiss transmission network.

REZA ROHANI, et.al, (2020), [13], Offshore wind farms can efficiently deliver huge energy through direct current transmission lines or HVDC systems. Their ability to transit long distances and high capacity is critical in modern power grids. This article therefore proposes a new Hilbert-Huang hybrid system (HH) with the optimum parameters for the failure position of the voltage converters given with HVDC (VSC-HVDC) Centered on the inference system of adaptive neuro-fuzzy. There are three major sections of the proposed defect position solution. In the first part, HH transform is used to derive new functionality from the current signal. The extracted features are used by ANFIS to determine the location of the defect in the second part of transmission lines.

Hong Rao, et.al, (2020), [14], The VSC- HVDC technology was developed in the last 20 years and is a new generation of HVDC technology. There are only about 30 projects worldwide using this technology and this technology continues to develop rapidly. This paper first describes the fundamental type of hybrid HVDC and explores the characteristics and challenges of various hybrid HVDC. The research will then investigate the matching properties of LCC and VSC in the HVDC station-hybrid, review key technologies such as VSC topologies and control strategies for overhead DC line error clearing and implement key technology to analyze and suppress high-frequency resonance between VSC and the grid. This paper analyses and tests the proposed main technologies using, for example, the Wudongde UHV multi-terminal HVDC.

FENG WANG, et.al, (2011), [15], The conventional electric power supply system, based on three-phase ac transmission, works well in general and has good availability and reliability. The growing share of renewable energy production, however, is likely to increase the degree of uncertainty and the unpredictability of electricity grid service, increase reserve power requirements for power balancing, and require more flexible power flow management. Consequently, much effort is made to expand its benefits further and remove its inconvenience, including high losses to HVDC and ac systems from the Existing Source Converter (CCS).

Omar Kotb,et.al, (2014), [16], In the modern power system it has been made increasingly popular with The development toward mature technology of HVDC transmission. There are a wide range of advantages to HVDC transmission systems, such as minimizing transmission losses and right of way, dropping voltage and avoiding enforced stability duration constraints. Their AC transmission systems offer several advantages. However, the use of HVDC is mainly cost-effective for the long-term, bulk transmission. In this article, a passive load-supplying hybrid HVDC transmission system is studied.

Raheel Muzzammel, et.al, (2019), [17], The grid protection MT – HVDC is configured for primary protection and backup. Protection equipment, relays and circuit breakers are located at the ends of the transmission lines. DC grid is used to transmit fault waves to VSC stations when a fault happens. Compared to HVDC-based Line Communicated Converters (LCCs), MT-HVdc is a practical/effective HVDC (m-HVDC) cross-terminal alternative, since VSC provides small filter dimensions, dark start capabilities, reactive capacity, and soft bidirectional dc power flow.

RIFAT ARA, et.al, (2020), [18], A defective portion of a transmission line is correctly discriminated against by several multipoint differential currents. When a defective line at a particular DC node is determined from each side to or from each line of each node to obtain the algebraic number, differential security is exactly discriminated against. Compared to the level of a preset threat, there is the current amount of local transient data in real-time and remote data delayed.

Yang, Q, et.al, (2017), [19],This paper proposes an extensive new HVDC multi-terminal system based on artificial neural network (ANN) and high-frequency components identified only by signaling faults. The method demonstrates that overhead line failures are correctly observed identified and located. In contrast to existing methods based on wave-driving capture and high sampling rates for the initial front, the new approach is more solid because it allows accurate detection of faults and a position of fault over a variety of post-fault window signals.

2.4 Review Summary:

This analysis aims to provide a general overview of key approaches to Assessment of total HVC transmission links availability and opinion on the basis of the technology of the Voltage Source Converter (VSC) HVDC transmission links. The authors have considered the involvement of HVDC-VSC conversion systems in the assessment of the available links to different converter technology and redundant strategies in this study.

CONCLUSION

The nature of the issue is provided by a brief overview from last few years of authors analysis, including the processes containing current HCDC systems with detailed and accurate details concerning the EPS. For solving this problem, the hybrid definition of simulation and the implementation of the VSC HVDC hybrid model are proposed. A simulation and comparison between them with the HVDC model built in MATLAB/Simulink based on the effects of the static and dynamic performance of the VSC HCD hybrid model of the simulation (step scenarios of controls references and extreme disorder in the AC network). AC voltage control and grid reactivation control and DC voltage control provide the better reactions with the proposed controller. The reactivity of the DC link voltage and grid is stabilized. However, the transfer of power between VSCs is stable. By checking the ability to ride fault, the robustness of the hybrid control unit is investigated by the LLLG fault.

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