REACTIVE POWER AND AC VOLTAGE CONTROL OF LCC HVDC WITH SFCL SYSTEM WITH CONTROLLABLE CAPACITORS

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ABSTRACT

This paper implements the AC voltage control of HVDC using superconducting fault current limiter (SFCL) in AC voltage control of LCC HVDC using controllable capacitors. Also to analyze the behavior of a Voltage Source Converter Based HVDC system under DC pole to ground fault & AC fault. HVDC (HVDC) systems involving overhead transmission lines are prone to severe over-currents and over-voltages during dc line faults. The development of VSC-based dc networks is constrained by the lack of operational experience, the immaturity of appropriate protective devices and the lack of appropriate fault analysis techniques. VSCs are vulnerable to dc cable short-circuits and ground faults due to the high discharge current from the dc link capacitance. The SFCL utilizes both superconducting coils (SCs) and resistance to limit the rapidly growing current. Firstly, the working principle and operating characteristics of the SFCL are studied. Secondly, the rules of parameters coordination are analyzed in order to obtain the best current limiting effect of the SFCL. Thirdly, the electromagnetic design of SCs is done to prove the feasibility of the scheme.

Keywords: High voltage direct current(HVDC), Line commutated converter(LCC), Super conducting fault current limiter(SFCL), Integrated gate commutated thyristors(IGCTs), MOS-Controlled thyristors(MCTs), Insulated gate bipolar transistors(IGBT), Voltage source converter(VSC), Alternating current(AC).

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1. INTRODUCTION

A high-voltage, direct current (HVDC) electric power transmission system (also called a power superhighway or an electrical superhighway) uses direct current for the bulk transmission of electrical power, in contrast with the more common alternating current (AC)

systems. For long-distance transmission, HVDC systems may be less expensive and suffer lower electrical losses. For underwater power cables, HVDC avoids the heavy currents required to charge and discharge the cable capacitance each cycle. For shorter distances, the higher cost of DC conversion equipment compared to an AC system may still be justified, due to other benefits of direct current links. HVDC uses voltages between 100 kV and 1,500 kV.

HVDC allows power transmission between unsynchronized AC transmission systems. Since the power flow through an HVDC link can be controlled independently of the phase angle between source and load, it can stabilize a network against disturbances due to rapid changes in power. HVDC also allows transfer of power between grid systems running at different frequencies, such as 50 Hz and 60 Hz. This improves the stability and economy of each grid, by allowing exchange of power between incompatible networks.

2. HIGH VOLTAGE TRANSMISSION

High voltage is used for electric power transmission to reduce the energy lost in the resistance of the wires. For a given quantity of power transmitted, doubling the voltage will deliver the same power at only half the current. Since the power lost as heat in the wires is directly proportional to the square of the current, doubling the voltage reduces the line losses by a factor of 4. While power lost in transmission can also be reduced by increasing the conductor size, larger conductors are heavier and more expensive.

High voltage cannot readily be used for lighting or motors, so transmission-level voltages must be reduced for end-use equipment. Transformers are used to change the voltage levels in alternating current (AC) transmission circuits. Because transformers made voltage changes practical, and AC generators were more efficient than those using DC, AC became dominant after the introduction of practical systems of distribution in Europe in 1891 and the conclusion in 1892 of the War of Currents, a competition being fought on many fronts in the US between the DC system of Thomas Edison and the AC system of George Westinghouse.

Practical conversion of power between AC and DC became possible with the development of power electronics devices such as mercury-arc valves and, starting in the 1970s, semiconductor devices as thyristors, integrated gate-commutated thyristors (IGCTs), MOS-controlled thyristors (MCTs) and insulated-gate bipolar transistors (IGBT).

3. METHODOLOGY

In this paper, the methodology used SFCL is studied and applied to mitigate the influence of DC short circuit on a VSC-HVDC transmission system. This limiter utilizes the superconducting coils (SCs) and resistance to limit the rapidly growing current. Due to the abandon of quench during current-limiting process, the SFCL can achieve instantaneous reaction and return back to normal operation immediately after isolating the DC fault.

4. BLOCK DIAGRAM

5. SUPERCONDUCTING FAULT CURRENT LIMITER

Growing electricity demand, the expansion of renewable power and progressive power grid meshing face operators of electric grids with a new challenge: Higher loads, more distributed generation, and changing load flows in the networks lead to increasing fault currents in the event of short circuits. This trend will require substantial spending for replacements of transformers and switchgear in stretched sections of the power distribution infrastructure where fault current levels threaten to exceed the rating of operating equipment in place. The Superconducting Fault Current Limiter (SFCL) launched by Nexans is a fundamentally new self-acting system that protects grid operating equipment from damaging current peaks during faults events and circuit feedbacks. The SFCL can be deployed to facilitate grid expansion and avert ahead-of-schedule upgrading. It also enables cost-efficient grid stabilization and optimization.

A superconducting fault current limiter (SFCL) is potentially an attractive candidate for this application and satisfies most of the requirements. SFCLs can operate naturally and quickly to prevent the increase in the fault current, limiting the DC fault current to more acceptable levels. Superconducting materials are ideal for DC networks since there are no losses for pure DC current making them virtually invisible to the system when operating normally. The application of SFCLs for HVDC systems has received very limited attention though.

6. SUPER CONDUCTING TECHNOLOGIES

The concept of using the superconductors to carry electric power and to limit peak currents has been around since the discovery of superconductors and the realization that they possess highly non-linear properties. More specifically, the current limiting behavior depends on their nonlinear response to temperature, current and magnetic field variations. Increasing any of these three parameters can cause a transition between the superconducting and the normal conducting region. The curve in the lower half is a normalized plot showing the non-linear relation between current flow in a superconductor and its resistance. The data for the curve was measured while the superconductor was in a constant magnetic field and a constant temperature. Similar curves can be produced for changes in temperature and magnetic field. The current increase can cause a section of superconductor to become so resistive that the heat generated cannot be removed locally. This excess heat is transferred along the conductor, causing the temperature of adjacent sections to increase. The combined current and temperature can cause these regions to become normal and also generate heat. The term

“quench” is commonly used to describe the propagation of the normal zone through a superconductor. Once initiated, the quench process is often rapid and uncontrolled.

7. SIMULATION RESULT

Figure 1 fault at first system

Figure 2 Fault at second system

Figure 3 DC Link voltage

Figure 4 DC Line voltage

8. CONCLUSION

This project proposes a novel SFCL topology based on the current-limiting features of both inductance and resistance. By the operation of the fast DC breaker, the SCs are prevented from quench. Theoretical analysis, electromagnetic design and modeling simulation are carried out. The influence of design parameters on the current-limiting effect is also presented in formulas and simulations. The results demonstrate that the maximum current and the drop velocity of DC-line voltage are deduced by installing the proposed SFCL. Moreover, through electromagnetic design of SCs, the feasibility of the SFCL is proved.

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