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Research on Two-shot Reclosing Technology of UHV AC/DC Interconnected Power Grid Based on Off Line Simulation

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***Abstract*—In AC/DC interconnected power system, when the important AC transmission lines have faults and power supply is broken, the safe and stable operation of power grid will be seriously threatened. At present, one-shot auto-reclose is widely used in high voltage transmission lines. In order to enhance the reliability of power supply, this paper presents a design idea of the two-shot auto-reclose for AC/DC hybrid power grid, and introduces a specific implementation method of adding the secondary reclose logic to circuit breaker relay. The PSCAD program is used to simulate and analyze a practical power grid. The results show that AC system had faults lead to multiple trip and reclose, and system disturbances produce multiple shocks. When the time interval of tripping and closing is set reasonably, although DC voltage drops twice or more continuously, it will not lead to DC pole blockade. Therefore, the reliability of power supply can be improved by adding the secondary reclose logic, and it will not do great harm to the DC power system of AC/DC interconnected power grid.**

Keywords—the two-shot reclosing; extra-high voltage; AC/DC interconnected power grid; DC system blocked; off line simulation

I. INTRODUCTION

At present, the main reclose mode of relay for UHV transmission line is one-shot auto-reclose. Its basic operation flow is: single-phase grounding short-circuit fault of transmission line -- relay action trip ault phase -- auto-reclosing startup -- single-phase reclosing. If the fault is instantaneous, the auto-reclose will be successful. If the fault is permanent, the relay will operate again, trip the three-phase, and not reclose it any more. The success rate of one shot auto-reclose depends on many factors, such as line structure, meteorological conditions, voltage level and main fault types, which can generally reach 60%-90%. The probability of permanent faults in power system is less than 10%. Most of the faults are transient faults caused by flashover of insulator surface caused by lightning overvoltage, short-term collision of wires by strong wind, falling of branches or kites on wires, etc. When the relay device operates, the arc at the fault point will automatically extinguish. If the insulation of the line is not restored at this time after starting reclose, the wrong trip caused by the wrong action of the fault-free relay after reclose may cause reclose failure. At this time, the line needs manual intervention to reclose, and the time is much longer than that of automatic reclose, which not only reduces the time of reclose. The security and reliability of power supply increase the loss of power outage, reduce the transient stability level of power system and reduce the capacitance of high voltage lines.

Based on the above situation, in recent years, the attempt to adding the secondary reclose logic in the power system to improve the power supply capability and stability of the system is also increasing slowly. By adding the secondary reclose for the reliable operation of system, it has a good effect on the reliability of the power supply and the quick recovery of power supply capability after the fault to a certain extent.

For this reason, the secondary auto-reclose technology has been applied in 500 kV TaiShan Line II and TangAn Line II of North China Power Grid, and the reliability and correctness of the secondary auto-reclose technology have been successfully verified in actual power grid faults. The operation results show that it can significantly improve the power supply capacity of 500 kV lines after fault removal. Relevant articles and applications are also many, here we do not elaborate its advantages and disadvantages too much, but from another aspect to study the impact of the secondary reclose on power grid operation.

With the rapid construction of Ultra High Voltage Direct Current (UHVDC) transmission project, China has formed a number of AC/DC interconnected power grids with UHVDC. UHVDC feeding not only enriches the system operation mode and improves the transmission capacity, but also produces the problem of fault interaction between systems, which affects the reliability of transmission line protection in AC/DC interconnected system. In particular, AC system faults easily lead to commutation failure of DC inverters. Continuous commutation failure is likely to lead to bipolar blockade of DC system, leading to major accidents such as DC system collapse. This hidden danger must be paid enough attention to by us, and it is also the focus of our research on secondary reclose.

II. THE DESIGN IDEA OF THE SECONDARY RECLOSE

Secondary reclose can greatly improve the existing comprehensive reclose function, improve the probability of line reclose success rate, and enhance the level of rapid restoration of power transmission, so that the comprehensive secondary

reclose function can meet the requirements of dispatching production operation, more adapt to the development requirements of future power grid operation, and significantly improve the stability of the system.

As Fig. 1, the bus mode for 3/2 in 500kV substation is shown. Six circuit breakers are installed with CSC-121 circuit breaker relay devices of Beijing Sifang Company. For CB1, CB2, CB3 and CB4, one of them is voltage-free mode, and the other three are voltage-free mode. First close the side without voltage, and then close the side at the same time. In case of reclose failure caused by malfunction of fault-free relay protection after protection re-tripping or closing, the secondary reclose can be carried out quickly without human intervention.

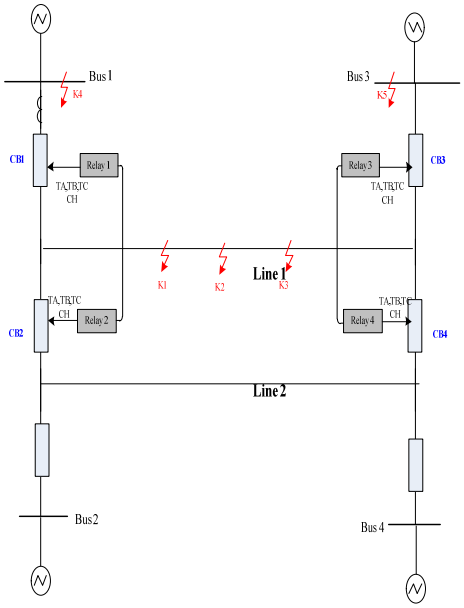

FIGURE I. 3/2 BUS MODE FOR SUBSTATION

III. SIMULATION OFF LINE

The two-shot auto-reclose function has been proved in actual operation to improve the reliability of power supply and restore the power supply capacity quickly. However, the 500 kV North China Power Grid has AC/DC interconnection situation. Whether the operation of secondary reclose function will have a greater impact on the stability of the existing AC/DC interconnected power grid, we need to use PSCAD to model building. The simulation results show that the system parameters used in the simulation refer to the actual parameters of an AC/DC interconnected power grid in North China Power Grid. The simulation data can provide a clearer understanding of the impact of the secondary reclose on AC/DC interconnected power system. As Figure 2 shown, the cross-region power grid is connected through the HVDC transmission system.

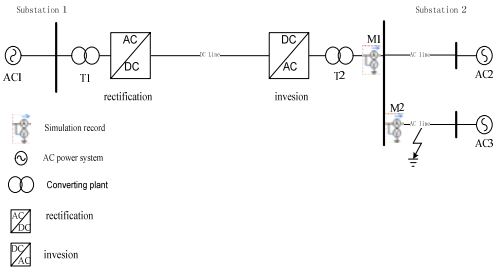

FIGURE II. AC/DC POWER SYSTEM MODEL FOR SIMULATION

Due to the large number of operation of DC system, there are many studies on the operation of DC system at present. However, due to the relatively small operation experience of DC system and the relatively large correlation between the stability of DC system and the control and protection system and strategy, there is no authoritative confirmation on the impact of faults on DC system side in AC/DC interconnected power grid, but there is no authoritative confirmation on the impact of faults on DC system side. Generally speaking, in extreme cases, the DC system should not have two or more commutation failures in a short period of time, which is generally believed to be no less than 200 ms. Therefore, our simulation test will make different settings for the secondary reclose setting value T2 time in Figure 8, and see how long the voltage sag and commutation failure will occur in the two tripping time interval under the different setting conditions of the secondary reclose time, which will play a reference role for us to set T2, that is, the secondary reclose time.

Firstly, the characteristics of AC faults are determined as follows:

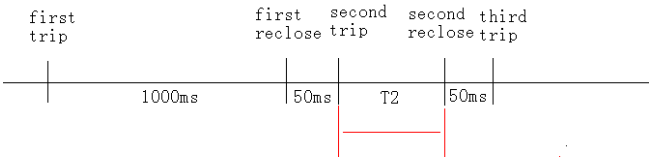

FIGURE III. TRIP AND RECLOSE INFORMATION FOR THE TWO RECLOSE

IV. SIMULATION RESULT

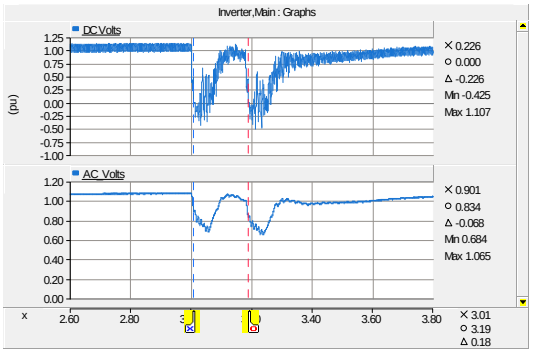

FIGURE IV. THE SECONDARY RECLOSE TIME SETTING AS 130MS

When T2 is set to 130ms, the simulation results of the above three fault combinations show that two faults on the AC side cause two voltage drops below the rated value of 0.25, which may lead to two commutation failures of the DC system. The simulation data of the time interval between two faults T = 180ms. (See the simulation data in the lower right corner above)

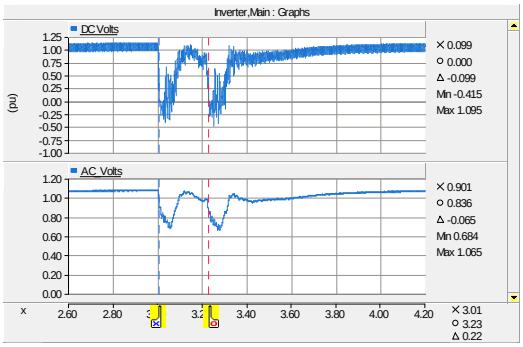

FIGURE V. THE SECONDARY RECLOSE TIME SETTING AS 170MS

When T2 is set to 170ms, the simulation results of the above three fault combinations show that two faults on the AC side cause two voltage drops below the rated value of 0.25, which may lead to two commutation failures of the DC system. The simulation data of the time interval between two faults (T = 220ms) are obtained. (See the simulation data in the lower right corner above)

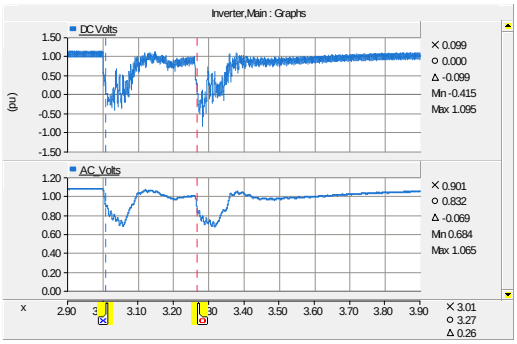

FIGURE VI. THE SECONDARY RECLOSE TIME SETTING AS 210MS

When T2 is set to 210ms, the simulation results of the above three fault combinations show that two faults on the AC side cause two voltage drops below the rated value of 0.25, which may lead to two commutation failures of the DC system. The simulation data of the time interval between the two drops T = 260ms. (See the simulation data in the lower right corner above)

According to the off line simulation results, we can see that when T2 is set to 150 ms, the voltage of DC system falls twice, which may cause the time interval of commutation failure to be 200 ms. It is generally believed that the time limit of bipolar blockade caused by two commutation failures. Therefore, through testing, we can conclude that the setting value of secondary reclose time should not be less than 170ms.

V. CONCLUSION

This paper presents a design idea of the two-shot auto-reclose, and verifies that as adding the secondary reclose is applied to UHV AC/DC interconnected power grid, AC system has fault to trip and then reclose many times, and power system has much impact and disturbances. Under the premise of reasonable time interval for tripping, although DC voltage continuously falls twice, it will not lead to DC system pole blockade. Therefore, by adding secondary reclose logic, the reliability of AC power supply can be improved without affecting the operation stability of DC system, which has important practical value.

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