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Identifying Fault in a Transient Harmonic Current Protection Scheme for HVDC Transmission Line

Priyanka Giradkar[1], Ashwini Deshmukh[2]

[1, 2]Department of Electrical Engineering, G. H. Raisoni Institute of Engineering & Technology for Women, Nagpur, Maharashtra 440016, India

Abstract: ***In this project, Based on the boundary characteristic of a dc line, the response of transient harmonic current in the line-commutated converter HVDC transmission system is analyzed under various fault conditions. The discrete Fourier transform is used to extract transient harmonic currents at both terminals of the dc transmission line and the type of fault can be identified by the transient harmonic currents. Transient harmonic current protection scheme is developed based on the distributed parameter line model in which the transient energy distribution over the line can be obtained from the current measurement at both terminals and the fault can be recognized from the calculated value simply. The two main factors that affect performance of the protection, fault resistance, and fault location are also considered. The increments of transient energy in the dc line are utilized to identify internal fault and external fault. With MATLAB, the test system is modeled considering the distributed parameters. It can identify the external fault correctly and quickly and provide correct responses under various fault conditions including high ground resistance faults.***

Keywords: HVDC converter, test and result, transient harmonic current, transmission-line, HVDC transmission, voltage source converter.

1. Introduction

The number of high-voltage direct current (HVDC) systems is increasing rapidly throughout the world, due to their advantages in long distance and large capacity power transmission, asynchronous interconnections, and their ability to prevent inadvertent loop flows in an interconnected ac system [1]. These definite technical and environmental advantages make HVDC transmission systems more attractive than high-voltage alternating current (HVAC) systems in many power system projects.The traditional protection system for the HVDC transmission line often uses the voltage and its change rate to detect a ground fault in the dc line

In fact, owing to the boundary characteristic, the responses of typical transient characteristic harmonic currents at two terminals of the dc line are different under various fault conditions. So the transient characteristic harmonic currents can be employed to identify an internal fault from an external fault. A novel transient harmonic current protection scheme is proposed in this paper. Comprehensive test studies show that the proposed scheme is simple, reliable, and practical. It can provide correct responses under various fault conditions including high ground resistance faults. Finally, the two main factors that affect performance of the protection, fault resistance, and fault location are also discussed. The relationships between the two factors and the sensitivity of transient harmonic current protection are also presented.

Transient harmonic current protection scheme is developed based on the distributed parameter line model in which the transient energy distribution over the line can be obtained from the current measurement at both terminals and the fault can be recognized from the calculated value simply. The two main factors that affect performance of the protection, fault resistance, and fault location are also considered. The increments of transient energy in the dc line are utilized to identify internal fault and external fault. With MATLAB, the test system is modeled considering the distributed parameters. Comprehensive test studies show that the performance of the transient harmonic current protection scheme is simple, reliable, and practical. It can identify the external fault correctly and quickly and provide correct responses under various fault conditions including high ground resistance faults.

2. Transient Harmonic Current Protection Principle

When converters at both terminals of the HVDC transmission system operate, power conversion harmonics with integral multiple frequencies of the fundamental frequency are generated in the system . For example, the output voltage of a 12-pulse converter mainly has 12th, 24th, and 36th harmonics. Harmonic voltages are generated during the conversion process in HVDC transmission systems. Superimposed on the direct voltage, they produce harmonic currents of the same orders flowing in the HVDC transmission systems. The main problem associated with harmonic currents is that they will increase transmission loss, disturb control and monitoring equipment, and cause electromagnetic pollution. To overcome these problems, shunt-connected dc filters and smoothing reactors generally are installed in HVDC systems. Usually, they are installed at both terminals of the dc transmission line with the purpose of filtering the characteristic harmonics effectively [8].

The discrete Fourier transform (DFT) is a good method to examine the signal and determine its harmonic content. It is employed to pick up the characteristic harmonics. The currents at two terminals of HVDC transmission line are monitored continuously. The transient characteristic harmonic currents will be calculated by the DFT module in the transient harmonic current protection unit. They reflect the operating information of the HVDC system including normal operation, and various kinds of internal and external faults.

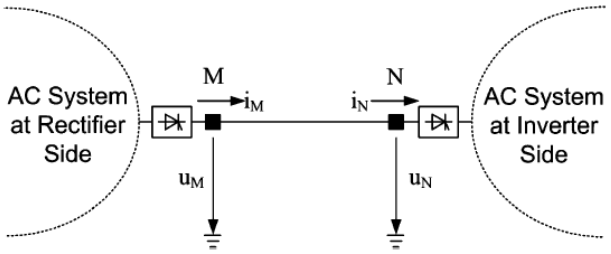

Fig. 1. Diagram of the HVDC transmission system.

Fig.1. shows HVDC bipolar transmission system .When converters at both terminals of the HVDC transmission system operate, power conversion harmonics with integral multiple frequencies of the fundamental frequency are generated in the system.

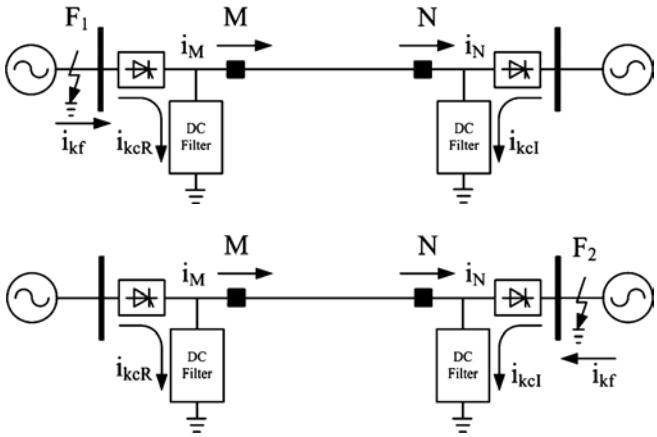

Figure 2: Transient harmonic currents analysis under an in external fault at the rectifier side & inverter side.

The transient harmonic current protection of the HVDC transmission line resides in the relays M and N in Fig. 1 and the two relays are taken as a protection unit. Under a rectifier side fault , the HVDC system generates harmonic currents which flow in the dc transmission line. The transient harmonic current is generated by the external fault at the rectifier side while and are generated by the converters at two terminals of the HVDC transmission line. However, those harmonics do not reach the transient harmonic protection unit because the dc filters essentially remove the harmonics from an external fault. Under an inverter side fault , a similar conclusion can be reached. As shown in Fig. 2, the transient harmonic current is generated by an external fault at the inverter side while and are generated by converters at the two terminals of the dc transmission line. Owing to the dc filters, those harmonics are not seen by the transient harmonic current protection unit. Therefore, the transient harmonic current protection cannot measure the characteristic harmonic currents in this case. In other words, the transient harmonic current protection unit at the two terminals of the HVDC transmission line cannot capture transient harmonic currents under external faults.

The transient harmonic current ikf is generated by the external fault at the rectifier side while ikcR and ikcI are generated by the converters at two terminals of the HVDC transmission line. However, those harmonics do not reach the transient harmonic protection unit because the dc filters essentially remove the harmonics from an external fault. Under an inverter side fault F2 , a similar conclusion can be reached. As shown in Fig. 2, the transient harmonic current ikf is generated by an external fault at the inverter side while ikcR and ikcI are generated by converters at the two terminals of the dc transmission line

3. Conclusion

A transient harmonic current protection method for the HVDC transmission line is proposed. The relation between the parameters of the dc transmission line and protection sensitivity deduced. Based on the test system, the different operation conditions and various faults are tested. Comprehensive test studies show that the performance of transient harmonic current protection is satisfied. It cannot only identify the external fault correctly, but can also respond to the high ground resistance fault.

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