Fault Characteristic Analysis of Pole-to-Ground Fault in DC Side of Energy Router in Interacted and Interconnected Micro Grid

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Abstract. This paper takes the AC / DC interconnected system based on DAB energy router as the research object, analyzes the fault characteristics of AC side and DC side in detail, compares and analyzes the influence of DAB energy router on fault characteristics in the system with different grounding methods of DC capacitor midpoint in converter station, and explores the mechanism of interaction between AC and DC sides. The effect of dab on the interaction of AC and DC side faults under different fault types and capacitor neutral grounding modes is analyzed. Finally, the method of post fault system partition and fault analysis is proposed, which lays a theoretical foundation for fault detection and rapid location of AC / DC hybrid distribution system, and provides theoretical support for system equipment selection.

1. Introduction

In recent years, relevant researches have been carried out on Fault Analysis of AC and DC distribution networks, selection of grounding mode, and interaction between AC and DC sides [1]. The DC fault characteristics of a single VSC converter station are divided into stages and analyzed in detail, which lays a foundation for fault characteristics analysis of multi-terminal AC / DC system. The influence of grounding mode on AC bus and DC bus fault characteristics of multi-terminal AC / DC system is studied, and puts forward the selection basis of system grounding mode. The contribution of DC capacitor and AC system to DC fault current of multi-terminal AC / DC system is studied in [2].

However, the above research mainly focuses on the fault characteristics of AC / DC system with single voltage level. At present, there are few researches on Fault Analysis of multi voltage level AC / DC hybrid distribution network based on DAB energy router and the interaction mechanism between AC and DC side faults. The DC fault current levels of 3+3 terminal AC / DC interconnected systems with different topologies is compared in [3], but did not provide the mechanism analysis of the influence of energy router on system fault characteristics. The qualitative analysis is made on DC fault characteristics of DC network with multi-port energy router, without considering AC side fault characteristics in [4]. The AC and DC fault characteristics of power electronic transformer with DAB is analyzed, and suggestions are given on the selection of its grounding mode [5], but does not involve the research on the interaction mechanism of AC and DC sides. The fault characteristics of cascaded
H-bridge power electronic transformer from the perspective of protection is summarized in [6], but lacked in-depth analysis of its fault mechanism. In [7], a topology of power electronic transformer based on DAB is proposed, but did not involve the study of system fault characteristics.

It can be seen that the fault characteristics analysis of DAB based AC / DC hybrid distribution network is not complete, and the research on the interaction mechanism of AC / DC side is not deep enough. The quantitative analysis of fault characteristics and interaction between AC and DC sides can provide theoretical basis for protection configuration and control strategy design of AC / DC hybrid distribution network.

2. A DAB based hybrid distribution network
The energy internet with energy router can be shown in Figure 1, and the topology of multi voltage level AC / DC hybrid distribution network based on DAB energy router is shown in Figure 2.

![Energy Internet](image)

Figure 1. The application of DAB based energy router.

The system consists of high voltage AC distribution network, medium voltage AC distribution network, medium voltage DC distribution network, low voltage AC distribution network and low voltage DC distribution network. Two medium voltage AC distribution networks are interconnected to form a medium voltage DC distribution network. The medium voltage AC distribution network and the low voltage AC distribution network form a low-voltage DC distribution network after unifying the voltage level through DAB.
3. Analysis of DC fault characteristics
Taking the high-voltage DC bus fault as an example, after the high-voltage DC bus single pole grounding fault occurs in the AC / DC hybrid distribution system, the fault stage can be divided into three stages: DC side capacitor discharge, grid side current feed in and steady-state [7]. The fault equivalent circuit of the high-voltage side VSC after the fault is shown in Figure 3.
between high-voltage DC bus poles, and the low-voltage system can work normally during the fault. The waveforms of phase voltage, high voltage DC bus voltage and low voltage DC bus voltage at VSC high voltage AC valve side after fault are shown in Figure 4.

Figure 4. Simulation results of the pole-to-ground fault

4. Conclusions
In this paper, various fault characteristics of AC / DC hybrid distribution network with DAB energy router are analyzed in detail. For the AC / DC system without DAB, AC fault will cause DC bus voltage fluctuation, and DC fault will quickly spread to the whole system, resulting in DC bus voltage drop, causing serious harm to the normal operation of the system. For the AC / DC system with DAB, DAB can isolate the fault system from the non fault system after the fault occurs, which greatly reduces the harm of the fault. On this basis, the influence of dab on the fault characteristics of VSC is studied when the neutral point of DC capacitor is grounded in different ways, and the interaction mechanism between AC and DC systems after various faults is summarized and compared.

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