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A selective single-phase-to-ground fault protection for neutral un-effectively grounded systems ☆

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ABSTRACT

Single-phase-to-ground faults are the most frequent faults likely to occur in power distribution networks. As for a neutral un-effectively grounded system (NUGS), the low fault current is very common in the case of occurrence of a single-phase earth fault, leading to hard identification of the faulty feeder. In conventional way, this target can be possibly achieved by the comparison of the polarities, magnitudes, or the phase angles of the zero-sequence currents of all feeders connected to the same busbar. However, it becomes a difficult task to implement this functionality into the protection of feeder. In this paper, a novel single-phase-to-ground fault protection for NUGS is put forward. Different from conventional centralized-comparison protection, this protection can detect single-phase-to-ground fault on the feeder individually, and can be realized on FTU (Feeder Terminal Unit). It is based on the measurement of the zero-sequence voltage and zero-sequence current. The tripping strategy follows the characteristic of the modified inverse-time delay curve. By means of analyzing the characteristics of the zero-sequence transient currents, it is disclosed that the magnitude of the zero-sequence current of the faulty feeder should be greater than that of any sound feeder. Then a composite compensated voltage is formed based on the zero-sequence voltage and zero-sequence current to evaluate a revising factor for every feeder respectively. Using this revising factor to modify the identical standard inverse-time delay curve adopted by all the feeder zero-sequence overvoltage protections, the tripping time of the zero-sequence overvoltage protections of all feeders will differ from each other. In this case, the selectivity of the protection can be guaranteed. This proposed algorithm is validated with the EMTP simulation tests.

1. Introduction

Among all the faults likely to occur in a power grid, single-phase-to-ground faults are the most frequent ones. The magnitudes of the earth fault currents depend on the neutral grounding method [1,2]. In North America, the neutral points of most distribution systems adopt the mode of grounded via a small resistance [3]. In this case, the fault current is great enough to allow the protection tripping selectively when a single-phase-to-ground fault occurs. Therefore, there is no faulty feeder-selecting problem. However, in China and some European countries, most medium voltage distribution networks employ an un-effectively grounded (i.e. isolated or a Peterson-coil-grounded) neutral to reduce outages caused by single-phase-to-ground faults [4]. As a result, the very low fault current and unstable fault arc make the detection of single-phase-to-ground fault very difficult. Some countermeasures are put forward to detect the faulted feeder in NUGS, and most of them utilize the steady state zero-sequence currents. In [1], the feeder of which the current phase differs from others is regarded as the faulty one. In [4], the faulty feeder is selected according to the highest magnitude of the currents. In [5], the method based on the phase comparison is combined with the one based on magnitude-comparison to enhance the correctness of detection. In Peterson-coil-grounded systems, above-mentioned schemes will be invalid. In this case, the 5th harmonic current is used as the basic measurement quantity. However, the existing methods and equipment seldom meet the on-site demand since the structure of distribution network is complex and the zero-sequence current is very low [6]. Besides, the zero-sequence currents of all feeders need to be collected together and compare with each other to implement the above methods. It will increase the complicacy of the device. It is necessary to design a novel scheme detect faulty

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