Self-adaptive Protection Strategies for Distribution System with DGs and FCLs Based on Data Mining and Neural Network

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***Abstract*—Owing to development of renewable energy and environmental protection issues, distributed generations (DGs) have become a trend. In addition, fault current limiters (FCLs) may be installed to prevent the short circuit current from exceeding the capacity of the power apparatus. Nevertheless, some issues appear, simultaneously, the most important among which is the mis-coordination of the protection system. This paper proposes overcurrent protection strategies for distribution systems with DGs and FCLs. Via the proposed approach, the relays with communication ability can determine their own operating states from the operation setting decision tree and topology-adaptive Neural Network model based on the data processed by Fast Fourier Transformer (FFT). The performance and effectiveness of the proposed protection strategies are verified via the simulation results obtained from different system topologies with/without DGs, FCLs, and load variation.**

***Key Words*—Adaptive protection strategy, protection coordination, distributed generations, fault current limiter**

I. INTRODUCTION

Owing to development of renewable energy and environmental protection issues, distributed generations (DGs) have been introduced to many distribution systems around the world. The penetration of DGs, such as cogeneration, photovoltaic, gas turbines, wind power, and fuel cells, is fast increasing. The fact changes the traditional power system from radial to meshed topology. Moreover, high DG penetration may lead to great contribution of short-circuit current, when a fault occurs. Meanwhile, due to this, in some areas the fault current surpasses the interruption capacity of circuit breaker (CB), a fact which results in its failure to isolate the fault or even cascading blackouts [1]-[3].

In such a situation, fault current limiters (FCLs) attract lots of attention from utility for its advantages of causing nearly zero power loss as in normal operation and restrains fault current once a fault occurs [4][5]. Combinational applications of DGs and FCLs do increase the reliability and security of power system. Nevertheless, some issues appear, simultaneously, the most important among which is the mis-coordination of the protection system due to the addition of DG and FCL in the system[6]-[8].

To solve the issues, some methods employs the techniques of nonlinear programming [9], mixed integer nonlinear programming, or some kinds of artificial intelligent algorithms [10][11] to optimize the setting parameters of different relays. The optimization ensure the protection coordination among the system with DGs and/or FCLs. However, as the relay setting is still a fixed value, it is hard to adapt to the system with distributed power sources.

Therefore, a few kinds of adaptive approaches are proposed to solve the mis-coordination problem. Some employ digital devices, such as Intelligent Electrical Device (IED), installed in substation to employ the information all through the lines downstream to determine the parameters of over-current relay (OCR) based on traditional principles [12][13]. Most adaptive protection models build the relay settings off-line firstly, and the fault is detected on-line by IEDs installed on one-end or both ends of the line. The real-time data are collected for tuning the protection model to obtain the function of adaptive optimal relay setting [14][15]. Although these studies are proved to well prevent the mis-coordination issues, this kind of scheme is not flexible enough, when topology changes or new distributed power resources are added in the system. The relay settings often need to be updated by data re-collection and offline training again. Recently, the topology-adaptive schemes are considered to make the optimization settings fit for different structures of power system [16][17]. However the structures should be pre-determined before the model settled and the number of conditions considered is fixed.

Based on Ethernet-based communication network technology, a pier-to-pier (P2P) structure has been proposed and employed by using IED in the literature [12]. Compared with the central communication system, P2P architecture is scalable, identical, and efficient. The IEDs employed exchange the measured data, calculate results, and determine its operation status independently. Moreover, IEC 61850 standard-based environment ensures the devices available in a position and devoted to multi-type protection functions

II. PROPOSED PROTECTIVE STRATEGIES

To solve the problems mentioned above, Fig.1 is the general flowchart of the proposed method, including the software tools used for each step. Event Generator is used to generate different kinds of faults, covering single-phase-ground, two-phase-ground, three phase-ground, and so on, occurring at

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