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Fault localization in electrical power systems: A pattern recognition approach

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ABSTRACT

Electrical power system is one of the most complex artificial systems in this world, which safe, steady, economical and reliable operation plays a very important part in social economic development, even in social stability. The fault in power system cannot be completely avoided. In this paper, we developed a method to resolve fault localization problems in power system. In our researches, based on real-time measurement of phasor measurement units, we used mainly pattern classification technology and linear discrimination principle of pattern recognition theory to search for laws of electrical quantity marked changes. The simulation results indicate that respectively study on the phase voltage, positive sequence voltage, negative sequence voltage, phase current, positive sequence current, negative sequence current of single-phase grounding faults and the positive sequence voltage, positive sequence current of three-phase short circuit faults, the pattern classification technology and linear discrimination principle are able to quickly and accurately identify the fault components and fault sections, and eventually accomplish fault isolation. In the study of electrical power systems, pattern recognition theory must have a good prospect of application.

1. Introduction

A fault is defined as a departure from an acceptable range of an observed variable or calculated parameter associated with systems. It may arise in the basic technological components or in its measurement and control instruments, and may represent performance deterioration, partial malfunctions or total breakdowns. Fault analysis implies the capability of determining, either actively or passively, whether a system is functioning as intended or as modeled. The goal of fault analysis is to ensure the success of the planned operations by recognizing anomalies of system behavior. A system with faults does not necessarily imply that the system is not functioning. Detecting a fault involves identifying a characteristic of the system, which when a fault occurs, can be distinguished from other characteristics of the system [1–4].

It is relay protection that plays the role to isolate the various random faults, which is also the first guarantee line for security operation of power system. Inevitably, if the primary protection fails to operate or to be in service temporarily, the backup protections should have the task to operate and clear the fault. However, many power system cascading events in recent years have underlined the limitation of traditional backup protections, which only utilize the local data without considering the impact on the whole system. The installation of the wide area measurement system (WAMS) [5–8] has opened a new route for the design of relay protection, especially for the backup protections. Accordingly, a novel wide area backup protection, which is based on identification of fault component, has become one of focuses in relaying field with the application of wide area information. The traditional fault diagnosis methods are usually based on the data provided by the Supervisory Control and Data Acquisition/Energy Management System (SCADA/EMS), which mainly contains the operation information of Circuit Breakers (CB) and protection devices and the recorded sampling data in fault recorder during the process of fault clearance [9–12]. Then, the fault section will be estimated by the playback of the development and clearance of fault. On the contrary, the fault component identification used in novel backup protection principle needs to be carried in an on-line way before the expire of time delay setting. During this time range, the data source utilized in the new fault location algorithm is the nodal voltage and branch current synchro-phasors from WAMS. In addition, enough time should be saved for the adaptive adjusting of the corresponding backup protections. In this way, the corresponding Circuit Breakers will be inspired to isolate the fault, so that the security and stability of the rest of power system will be guaranteed. In a summary, the novel fault location algorithm needed in wide area backup protection is different from the traditional fault diagnosis method in main target and data source.

Pattern recognition (PR) is one of the most vigorous science and engineering research areas nowadays. It is concerned with the finding and identifying structures which may be hidden amid a great deal of confusing and irrelevant data [13–16]. The process of PR consists of extracting information from an object and

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