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Fault diagnosis system for tapped power transmission lines

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ABSTRACT

This paper presents a design for a fault diagnosis system (FDS) for tapped HV/EHV power transmission lines. These lines have two different protection zones. The proposed approach reduces the cost and the complexity of the FDS for these types of lines. The FDS consists basically of fifteen artificial neural networks (ANNs). The FDS basic objectives are mainly: (1) the detection of the system fault; (2) the localization of the faulted zone; (3) the classification of the fault type; and finally (4) the identification of the faulted phase. This FDS is structured in a three hierarchical levels. In the first level, a preprocessing unit to the input data is performed. An ANN, in the second level, is designed in order to detect and zone localize the line faults. In the third level, two zone diagnosis systems (ZDS) are designed. Each ZDS is dedicated to one zone and consists of seven parallel-cascaded ANN's. Four-parallel ANN's are designed in order to achieve the fault type classification. While, the other three cascaded ANN's are designed mainly for the selection of the faulted phase. A smoothing unit is also configured to smooth out the output response of the proposed FDS.

The proposed FDS is designed and evaluated using the local measurements of the three-phase voltage and current samples acquired at only one side. The sampling rate was taken 16 samples per cycle of the power frequency. Data window of 4 samples was utilized. These samples were generated using the EMTP simulation program, applied to the High-Dam/Cairo 500 kV tapped transmission line. All possible shunt fault types were considered. The effect of fault location and fault incipience time were also included. Moreover, the effect of load and capacitor switchings on the FDS performance was investigated. Testing results have proved the capability as well as the effectiveness of the proposed FDS.

1. Introduction

Protective relaying is one of the basic and necessary elements of an electric power system. The protective relaying role is to cause the prompt removal from service of any element, when it suffers a short circuit or when it starts to operate in an abnormal manner that may cause damage to the power system. In fact, in power systems, most of the faults occur on the transmission lines. Faults MVA levels are usually high, and if they are not cleared rapidly they may cause system instability as well as damage and hazards to equipment and persons. Hence, the proper diagnosis or classification of line faults is essential to the appropriate operation of power systems. Therefore, the fault type classification is a crucial protective relaying feature due to its significant effect on the operation enhancement of relaying scheme. The correct operation of major protective relays depends mainly on the fault classification feature [1,2].

On the other hand, the faulted phase selection is as important as the fault detection. It would lead to an increase in the system stability and availability by allowing the healthy phases to operate using the single pole (or phase) tripping [3]. Single pole tripping has many benefits such as improving the transient stability and reliability of the power system, reducing the switching over-voltages and mitigating of the shaft torsional oscillations of large thermal units [3]. Fig. 1 shows the essential structural modules of a modern protective relay, where the fault diagnosis modules are considered very important ones.

Tapped transmission lines are those lines that are tapped usually through transformer bank primarily to supply loads. They are usually economical in their breakers requirements, but they need a complex relaying scheme for adequate protection and operation. These lines have two different protection zones, and faults must be detected and isolated in each zone individually. Simply, two different FDS's can be designed in order to achieve the standard requirements. There are few research studies that have been carried out on these types of lines, due to the need of a very difficult

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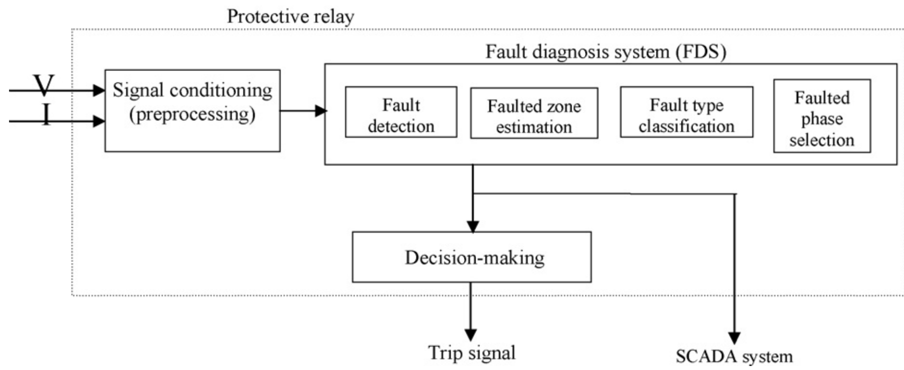

Fig. 1. Essential modules of a protective relay.

protection scheme [1]. This study is trying to explore the design details of a proposed fault diagnosis module [4], based on the application of ANN technology, as a part of the protection scheme required for these types of lines.

The conventional analytical based classification approaches are expected to be affected by the system operating conditions. Also, a complete faulted phase selection cannot be achieved through these approaches. Moreover, these approaches are also time consuming [1–4]. On the other hand, artificial intelligence techniques (expert systems, pattern recognition, ANN, and fuzzy logic) in general and ANN in particular provides a very interesting and valuable alternative [4].

ANN [5–7] can efficiently deal with most situations, which are not defined sufficiently for deterministic algorithms to exe-

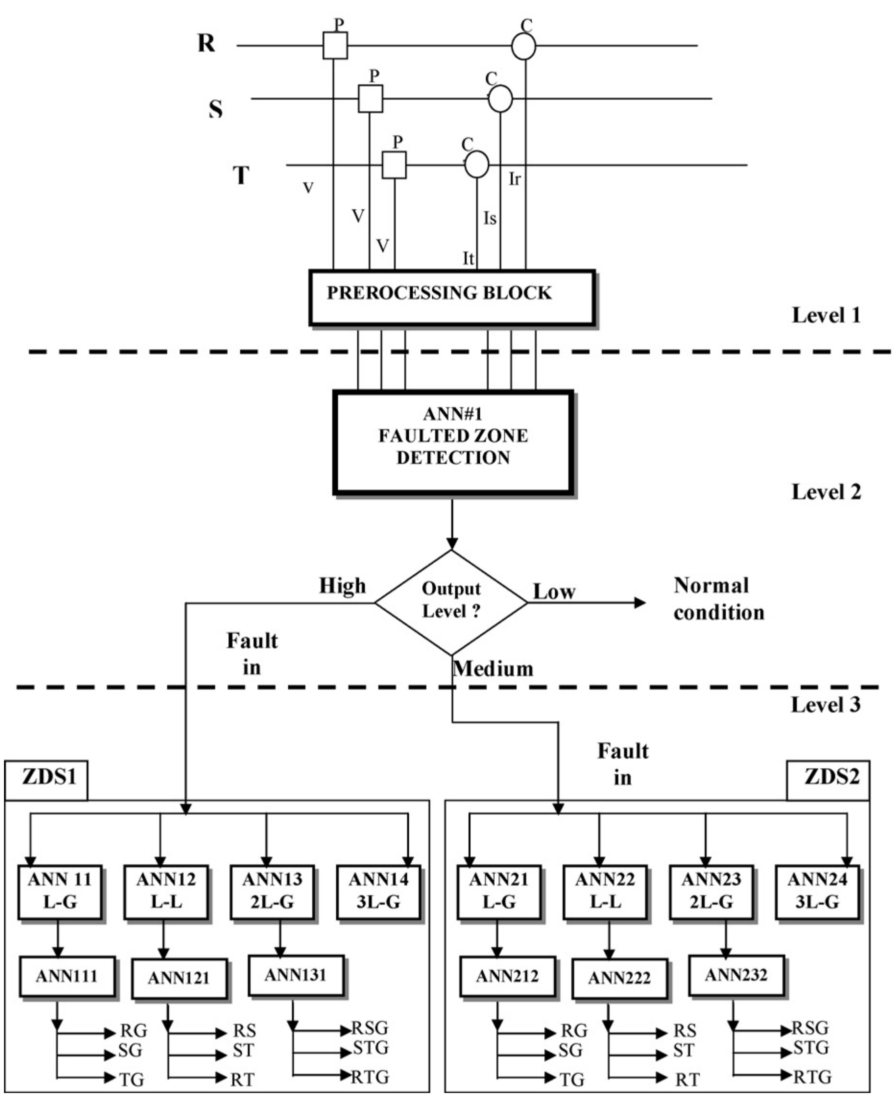

Fig. 2. Architecture of the suggested FDS.