Power Differential based Wide Area Protection

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Abstract: Current differential based wide area protection (WAP) has recently been proposed as a technique to increase the reliability of protection systems. It increases system stability and can prevent large contingencies such as cascading outages and blackouts. This paper describes how power differential protection (PDP) can be used within a WAP and shows that the algorithm operates correctly for all types of system faults whilst preventing unwanted tripping, even if the data has been distorted by CT saturation or by data mismatches caused by delays in the WAP data collection system.

The PDP algorithm has been simulated and tested on an Iranian 400kV transmission line during different fault and system operating conditions. The proposed operating logic and the PDP algorithm were also evaluated using simulation studies based on the Northern Ireland Electricity (NIE) 275 kV network. The results presented illustrate the validity of the proposed protection.

Keywords: Wide area protection, Power differential algorithm, Current differential relaying, Transmission networks.

1 Introduction

Busbars and transmission lines are of crucial importance in transferring electrical energy from bulk generating plants to distribution networks. This importance is recognized by the reliability of the protection systems and their ability to remain stable under all possible non-fault operating conditions, whilst operating correctly during a short-circuit fault [1-2].

One of the best methods to achieve the required balance between stability and dependability is wide area protection [3-12]. In a WAP the data collected from all the lines ends and busbars are transferred to a main control center and the performance of the overall system monitored. Under fault conditions, or when the power system is close to instability, the WAP will trip an appropriate selection of circuit breakers. The simplest WAP function is differential protection based on the comparison of the current signals at the line ends. If the input current to a circuit element differs significantly from the output current, a fault condition is detected and the element is isolated, by tripping its circuit breakers [9-11]. Adequate protection is more difficult when CT saturation and/or data mismatch, distorts some of the collected data and invalidates current comparison. WAP scheme must be adequately robust to cope with such problems. With bad data, fault conditions can be detected using differential algorithms based on mathematically complex techniques; such as symmetrical component vectors operating within a bias current differential protection (CDP) based WAP [12]. Power differential protection has been proposed as a technique that satisfies the need for immunity against bad data, whilst maintaining the advantages of operating simplicity [13]. A new type of WAP based on PDP is proposed in the paper. The wide area based logic is used in combination with conventional bias differential protection schemes. The logic will automatically widen its protection zones when data is distorted or communication delays cause a mismatch.

The proposed PDP based WAP was tested on a simulation model of the Northern Ireland Electricity (NIE) network and the results compared with more conventional CDP methods.

2 Differential Protection based Wide Area Protection

2.1 Wide Area Protection

As electrical networks become larger and the numbers of interconnections increase, conventional protection