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Adaptive Protection Strategies for Distribution Systems with Distributed Generation

Ph.D. thesis
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Abstract

In this thesis, a new strategy is developed to deal with the recloser-fuse coordination problem without doing major changes in the working protection scheme. This problem arises from the integration of distributed generation in distribution systems. The main core of this strategy is based initially on an assessment process using a developed classifier. This classifier will classify the recloser-fuse coordination status at fault conditions to either *coordination holds* or *coordination lost*. Accordingly, the distribution system operator can take the proper decision. Then different actions are recommended as a solution to decrease the cases where coordination is lost and to partially solve the coordination problem.

The classification process is based on checking the operating sequence of all protection devices in the path from the faulted node to the substation node with the presence of distributed generation. Then this sequence is compared with a pre-required sequence obtained from the protection coordination philosophy. If a close match between the obtained sequence and the required sequence occurs, then coordination holds and no further action is required. Otherwise coordination is lost and a solution is required to avoid the consequences of miscoordination between protection devices.

To decrease the cases where coordination is lost, two actions are proposed. The first one is based on searching for the best location at which DG can be connected from the coordination problem point of view. The best DG location considered is that one with the highest number of cases classified as coordination holds. The second one is based on changing the fast mode recloser characteristics by changing the time dial parameter in the equation describing the recloser

characteristics. In case of the presence of multiple DGs in the system, another solution is also proposed and integrated with the previous two actions to enhance the protection coordination behavior. This solution is based on an offline study to prepare information about which DG that when disconnected the protection coordination can be re-attained.

The proposed strategy implies the following main tasks; load flow analysis, fault analysis, protection coordination setting, protection coordination assessment and protection coordination enhancement by applying the proposed solutions.

The main advantages of the proposed strategy is that, applying the classification process will discriminate between the cases where an action is required against the distributed generation penetration at fault conditions, and the cases where no need for an action is required. By this way, disciplinary actions like disconnection of distributed generation each time a fault takes place can be avoided, and consequently, the system reliability will be improved. On the other hand, applying the proposed solutions leads to reduce significantly the number of cases where coordination is lost and avoids doing major changes in the working protection scheme.

The proposed strategy is evaluated by being implemented to the IEEE 37-node test feeder and the IEEE 34-node test feeder; the obtained results are presented and discussed. All the required software is developed using MATLAB m-files as a platform.

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Chapter (1)
Introduction

1.1 General

Distribution systems are usually designed using a radial structure where a single source of power, such as a substation transformer, is supplying a network of downstream feeders. The simplicity of operation and the cost effectiveness of the protection scheme for radial distribution systems are considered to be the main advantages for the radial structure. This is due to the fact that in radial systems, power flow is in one direction and hence the protection devices need only to sense current magnitude without the need to detect current direction [1].

According to the sharp and continuous increase for electrical energy demand, always electric power systems need to be upgraded by further adding new large central generation plants. However the decisions for installing such central plants are so complicated, due to the continuous rise in gas prices, the difficulty in finding suitable sites for new generation and transmission facilities and also due to environmental constrains.

As a solution to this situation, the interest is now directed to distributed generation (DG), where DG are small energy sources connected close to load centers in distribution systems. This solution provides many benefits to the customers, utilities and the environment, but on the other hand it has negative impacts especially on the distribution system's protection scheme, due to the fact that the integration of DG in distribution systems will deteriorate the radial nature of these systems.

Accordingly, the main target in this thesis is to propose an adaptive protection strategy that keeps in hand the benefits from integrating DG into distribution systems while reducing its negative impacts on the protection scheme as much as possible.

1.2 Thesis Objectives and Thesis Contribution

1.2.1 Thesis Objectives

The main concern in this thesis is directed to study the recloser-fuse miscoordination problem that arises due to the penetration of distributed generation in radial distribution systems. The following objectives will be in mind during the work in this research:

1. Introduce the problem and present a comprehensive literature survey about the available solutions.
2. Propose an adaptive protection strategy to minimize the impact of DG penetration on the recloser-fuse coordination problem.
3. Implement the proposed strategy on an actual distribution system then present and discuss the results obtained.
4. Develop all the required software using MATLAB m-files as a platform.
5. Summarize the obtained results and conclusions and then offer some ideas for a future work.

1.2.2 Thesis Contribution

The main contribution considered in this thesis is the development of a new adaptive protection strategy to deal with the recloser-fuse miscoordination problem that appear from the integration of distributed generation in distribution systems. This strategy is based mainly on two phases.