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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.

Table of Contents

Table of Contents	I
List of Tables	IV
List of Figures.....	VI
Chapter (1).....	1
Introduction	1
1.1 General	1
1.2 Thesis Objectives and Thesis Contribution	2
<i>1.2.1 Thesis Objectives</i>	2
<i>1.2.2 Thesis Contribution</i>	2
1.3 Problem Statement	4
1.4 Thesis outlines	7
Chapter (2).....	10
Background.....	10
2.1 Introduction to Protection Schemes in Radial Systems 10	
<i>2.1.1 General</i>	10
<i>2.1.2 Protection devices and characteristics</i>	10
<i>2.1.3 Protection coordination philosophy in radial systems</i> 12	
2.2 Introduction to Distributed Generation (DG)	12
<i>2.2.1 Definition</i>	12
<i>2.2.2 DG Technologies and Types</i>	13
<i>2.2.3 DG Benefits</i>	15
<i>2.2.4 Impacts of DG penetration on Protection Systems</i>	16
Chapter (3).....	19
Literature Review	19
3.1 Available solutions for coordination problems	19
3.2 Methods for load flow analysis	25
3.3 Methods for Fault Analysis	29
Chapter (4).....	32
Distribution Systems Components Models	32
4.1 General	32
4.2 Distribution Lines Model	32
4.3 Load Model	34
4.4 Capacitor Model	35

4.5 Transformer Model	36
4.6 Switch Model	37
4.7 Distributed Generator (DG) Model	37
4.7.1 DG modeled as PV node in Load Flow analysis	38
4.7.2 DG modeled as PV node in Short Circuit analysis....	41
4.8 Protection Devices Model	43
4.8.1 Fuses	44
4.8.2 Reclosers	44
4.8.3 Circuit breakers	45
Chapter (5).....	46
Load Flow Analysis.....	46
5.1 General	46
5.2 Load flow equations	46
5.2.1 Power summation principle	46
5.2.2 Current summation principle	50
5.3 Load flow algorithms	52
5.3.1 Single phase load flow algorithm	52
5.3.2 Three phase load flow algorithm	55
5.4 Simulation results	57
5.4.1 28-bus system	57
5.4.2 IEEE 37 node test feeder.....	62
Chapter (6).....	65
Fault Analysis.....	65
6.1 General	65
6.2 Fault analysis algorithm	65
6.3 Simulation results	72
Chapter (7).....	77
<i>Proposed Adaptive Protection Strategy</i>	77
7.1 General	77
7.2 Assumptions	77
7.3 Outlines of the proposed strategy	78
7.3.1 Protection Coordination Setting	78
7.3.2 Protection Coordination Assessment.....	80
7.3.3 Protection Coordination Improvement.....	81

7.4 Implementation of the proposed strategy on the IEEE	
37 node test feeder	84
7.4.1 IEEE 37node test feeder with an over-current	
protection scheme	84
7.4.2 Protection coordination setting results.....	85
7.4.3 Protection coordination assessment results	87
7.4.4 Protection coordination improvement results	89
7.5 Implementation of the proposed strategy on the IEEE	
34 node test feeder	100
7.5.1 IEEE 34node test feeder with an over-current	
protection scheme	100
7.5.2 Protection coordination setting results.....	101
7.5.3 Protection coordination assessment results	103
7.5.4 Protection coordination improvement results	104
Chapter (8).....	114
Conclusions and Future Work.....	114
8.1 Conclusions	114
8.2 Future work	115
List of Publications.....	116
REFERENCES	117

List of Tables

Table	Page
Table (2-1) Fault injection capabilities of different types of DG	15
Table (4-1) Load Models.....	35
Table (4-2) Constants for standard inverse relays characteristics	45
Table (5-1) Line data of 28 bus system.....	58
Table (5-2) Load data of 28 bus system.....	58
Table (5-3) Arrangement of Busses for the 28 Bus-Distribution System	59
Table (5-4) Load flow results for 28-bus system with DG connected at different locations.....	60
Table (5-5) Branch Currents of the IEEE 37-node feeder without DG.	64
Table (6-1) Branch fault Currents for phase (A) of the IEEE 37-node feeder without the presence of DG	73
Table (7-1) Fuse constant ' <i>b</i> '	86
Table (7-2) Number of cases (as a percentage) where coordination holds while changing fault location and DG penetration level.....	90
Table (7-3) Number of cases (%) where coordination holds while changing DG location and penetration level	93
Table (7-4) Number of cases (as a percentage) where coordination holds for each location of the second DG while the first DG is at node 15.....	96
Table (7-5) The appropriate DG to be disconnected to re-attain coordination.....	98
Table (7-6) Number of cases where coordination holds for the two DG scenario after disconnecting the appropriate DG.	99

List of Tables

Table (7-7) Branch fault Currents for phase (A) of the IEEE 34-node feeder without the presence of DG	102
Table (7-8) Fuse constant 'b' for the IEEE 34-node test feeder	103
Table (7-9) Number of cases (as a percentage) where coordination holds while changing fault location and DG penetration level.....	105
Table (7-10) Number of cases (%) where coordination holds for each DG location with different values of the TD parameter.....	108
Table (7-11) Number of cases (as a percentage) where coordination holds for each location of the second DG while the first DG is at node 6.....	110
Table (7-12) The appropriate DG to be disconnected to re-attain coordination.....	112
Table (7-13) Number of cases where coordination holds for the two DG scenario after disconnecting the appropriate DG.	113

List of Figures

Figure	Page
Figure (1-1) Part of an actual distribution system with DG penetration.....	5
Figure (1-2) Coordination is lost between recloser and fuses...	6
Figure (1-3) Coordination holds between recloser and fuses....	7
Figure (2-1) Typical Protection Devices Arrangement.....	11
Figure (2-2) Typical Coordination of Circuit Breaker, Recloser, and Fuse	13
Figure (2-3) Distributed Generation Types.....	14
Figure (2-4) False Tripping of Feeders.	17
Figure (3-1) Distribution system divided into separated zones	20
Figure (4-1) Three Phase Distribution Line π Model.....	33
Figure (5-1) Simple model of a distribution system line.	47
Figure (5-2) Distribution feeders without laterals.....	53
Figure (5-3) Single line diagram of a 30 bus DS with laterals	54
Figure (5-4) Flow chart for arranging the buses in distribution systems	54
Figure (5-5) Flow chart for load flow algorithm based on power summation principle.....	55
Figure (5-6) Flow chart for load flow algorithm based on current summation principle.	56
Figure (5-7) Single line diagram of a 28 bus distribution system with 5 laterals.	57
Figure (5-8) Voltage profile of the 28 bus distribution system when a DG is at bus 5 compared to the case without DG.....	61
Figure (5-9) Voltage profile of the 28 bus distribution system when a DG is at bus 11 compared to the case without DG.....	61

List of Figures

Figure (5-10) Voltage profile of the 28 bus distribution system when a DG is at bus 16 compared to the case without DG.....	61
Figure (5-11) Modified IEEE 37 Node Test Feeder	62
Figure (5-12) Line Voltage (V_{ab}) for different cases of the modified IEEE 37-node test feeder.....	63
Figure (6-1) Flow chart for fault analysis algorithm based on the hybrid compensation method	71
Figure (6-2) Voltage profile before fault inception.....	74
Figure (6-3) Voltage profile after a single line to ground fault at bus 26 on phase (A) has occurred	74
Figure (6-4) Voltage profile after a line to line fault at bus 26 on phases (A and B) has occurred	74
Figure (6-5) Voltage profile after a double line to ground fault at bus 26 on phases (A and B) has occurred	75
Figure (6-6) Voltage profile after a three line to ground fault at bus 26 has occurred.....	75
Figure (6-7) Voltage profile after a double line to ground fault at bus 13 phases (A and B) and a single line to ground fault at bus 26 has occurred	75
Figure (6-8) Magnitude of fault currents for phase A for different fault locations with and without the presence of DG at node 15.....	76
Figure (7-1) Flow chart for selecting the best DG location	82
Figure (7-2) Flow chart for protection coordination enhancement.....	83
Figure (7-3) Modified IEEE 37 Node Test Feeder with Implemented Protection Devices	84
Figure (7-4) Operating curves for the recloser and fuses F5, F4 and F1	86
Figure (7-5) Classification pattern for a fault at node 15 with TD equals 0.5 for recloser fast operation.....	88
Figure (7-6) Classification pattern for a fault at node 8 with TD equals 0.5 for recloser fast operation.	89

List of Figures

Figure (7-7) Number of cases (percentage %) where coordination holds for each DG location.....	91
Figure (7-8) Classification pattern for a fault at node 15 with TD equals 0.3 for recloser fast operation.....	92
Figure (7-9) Classification pattern for a fault at node 15 with TD equals 0.1 for recloser fast operation.....	92
Figure (7-10) number of cases (%) where coordination holds for each faulted node with different values of TD parameter.....	94
Figure (7-11) Classification pattern due to the presence of two DGs in the system.	96
Figure (7-12) Classification pattern after disconnecting one of the two DGs in the system according to fault location.....	97
Figure (7-13) The number of cases where coordination holds before and after disconnecting the appropriate DG.	99
Figure (7-14) Modified IEEE 34 Node Test Feeder with Implemented Protection Devices	100
Figure (7-15) Classification pattern for a DG at node 6 with TD equals 0.5 for recloser fast operation.	104
Figure (7-16) Classification pattern for a DG at node 28 with TD equals 0.5 for recloser fast operation.....	104
Figure (7-17) Number of cases (percentage %) where coordination holds for each DG location.....	106
Figure (7-18) Classification pattern for a DG at node 6 with TD equals 0.3 for recloser fast operation.	107
Figure (7-19) Classification pattern for a DG at node 6 with TD equals 0.1 for recloser fast operation.	107
Figure (7-20) number of cases (%) where coordination holds for each DG location with different values of TD parameter.....	109
Figure (7-21) Classification pattern due to the presence of two DGs in the system.	111

List of Figures

Figure (7-22) Classification pattern after disconnecting one of the two DGs in the system according to fault location.....	111
Figure (7-23) The number of cases where coordination holds before and after disconnecting the appropriate DG.....	113

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 constraints.

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.