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Title of Thesis: Some Intelligent Algorithms for Power Quality Studies in Radial Distribution Systems

Abstract:

This thesis addressed the problem of load flow, voltage stability and power quality in radial distribution systems by developing a new voltage stability index and an appropriate strategy for capacitor allocation. It also includes descriptions of the voltage stability problem, voltage stability assessment and computation methods of voltage collapse point.The work presented in this thesis puts forward new ideas for load flow problem, problem of voltage instability and the capacitor allocation problem in radial distribution systems.

In this research work, efforts have been made to identify commonly encountered difficulties in radial distribution operation and control. Appropriate solutions have been arrived at by doing mathematical modelling and developing index and integrating methods.

An efficient method of minimizing the power loss is proposed. Two way approach is followed to find the solution. The method first determines the sequence of nodes to be compensated by calculating the highest loss savings by singly located capacitor. The candidate nodes are verified by two other methods-power loss index method and fuzzy-based method. A fuzzy capacitor placement suitability index uses power loss and bus voltage as inputs to determine the optimal capacitor placement. In the second step, the optimal size of capacitor is determined by optimizing the savings equation obtained from loss reduction, with respect to capacitor currents. Expert system will help the operator to apply heuristic rules to select the most relevant standard capacitor available.

A scheme for radial load flow is introduced with the ability to simultaneously solve the non-linear power flow equations with all constraints satisfied for any size of radial network. The mathematical modelling of radial distribution system is carried out as reported in [P1]. The load flow solution provides many important and significant features that could be of use during planning and operation stages and in contingency.

Receiving end voltage at each node of the network and bus voltage phase angles of each node are calculated. Poor voltage at nodes gives warning about the inadequate voltage levels. The feeder current through each branch as well as real and reactive power loss is computed. Line losses exhibit the status of power handling capacity of feeders. The developed program is insensitive to type of load model and network topology such as number of laterals and number of buses.

The main contribution of this thesis can be summarised as follows:

1. A load flow program based on concepts of basic circuit analysis has been developed which can provide fast solution to the power flow equations in any size radial distribution network. The algorithm is implemented considering constant complex power load, however can be applied to composite loads also, if composition of loads is known. A comparison of the method with six other existing methods in terms of speed of convergence is also done. Further, the solution obtained is utilised as a subroutine to the problem of voltage instability and capacitor allocation problem.
2. A new voltage stability index is proposed to compute the proximity of bus to the point of voltage collapse.
3. A comprehensive strategy for capacitor siting and sizing is proposed to improve the voltage profile and reduce power losses in radial distribution system. Three methods-power loss index, fuzzy capacitor suitability index and loss savings are proposed for optimal capacitor placement. The optimal size of capacitor is determined by optimizing the savings equation obtained from loss reduction.
4. An analysis of thee results obtained using the proposed methodologies on several test systems including IEEE 15-bus, IEEE 33-bus and IEEE 69-bus system is discussed.
5. As the proposed methodologies are based on relatively simple techniques, the operators in electric utility are more likely to accept it. The thesis has an industrial significance not only to power utility companies like Power Trading Corporation, but also of interest to Central Electricity Regulatory Commission, State Electricity Boards, and Water& Power Consultancy Services.