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Unbalanced Distribution Network Planning by Sitting and Sizing of Distributed Generation and Harmonic Filter Due to Losses and THD Minimization

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Abstract – *The necessity for flexible electric systems, changing regulatory and economic scenarios, energy savings and environmental impact are providing impetus to the development of Distributed Generation (DG), which is predicted to play an increasing role in the electric power system of the future. The optimal placement and sizing of generation units on the distribution network has been continuously studied in order to achieve different aims. This paper describes planning of distribution systems in two scenarios. In the first scenario, optimal distributed generation allocation for voltage profile improvement, loss and Total harmonic Distortion (THD) reduction in distribution network has been implemented. Whereas, DG cannot reduce THD to the optimum range, in the second scenario an active filter and a capacitor is used to reduce THD as much as possible. Because of THD and Losses are based on different objective function, a "compromise programming" model that attains the "best compromise" among the conflicting objectives is introduced to overcome on this problem. Harmony Search Algorithm (HSA) was used as the solving tool, which referring two determined aim; the problem is defined and objective function is introduced according to losses, security and THD indices. The applied fast harmonic load flow method is based on the equivalent current injection that uses the bus-injection to branch-current (BIBC) and branch-current to bus-voltage (BCBV) matrices which were developed based on the topological structure of the distribution systems. This method is executed on 12 bus harmonic unbalanced distribution system and show robustness of this method in optimal and fast placement of DG, efficiency for improvement of voltage profile, reduction of power losses and THD.*

***Keywords**: Unbalanced Radial Distribution Network, Distributed Generation, Harmonic Filter, Harmonic Load Flow, Loss Minimization, Total Harmonic Distortion (THD), Harmony Search Algorithm (HSA), Optimum Location*

I. Introduction

In the near future, distributed generation systems, which have the advantages of high energy efficiency and low impact on the environment, will be interconnected to many unspecified points in the electric power distribution systems. Therefore, we must consider their influence on power quality and stability when the distributed generation systems are introduced to the electric power distribution systems, and must make the best use of the distributed generation systems. Before installing distributed generation, its effects on voltage profile, line losses, short circuit current, amounts of injected harmonic and reliability must be evaluated separately. The planning of the electric system with the presence of DG requires the definition of several factors, such as: the best technology to be used, the number and the capacity of the units, the best location, the type of network connection, etc. The impact of DG in system operating characteristics, such as electric losses, voltage profile, stability, total harmonic distortion and reliability needs to be appropriately evaluated.

The problem of DG allocation and sizing is of great importance. The installation of DG units at non-optimal places can result in an increase in system losses, implying in an increase in costs and, therefore, having an effect opposite to the desired. For that reason, the use of an optimization method capable of indicating the best solution for a given distribution network can be very useful for the system planning engineer. The selection of the best places for installation and the preferable size of the DG units in large distribution systems is a complex combinatorial optimization problem. DGs include technical, economical, regulatory, and possibly environmental challenges. As in the majority of planning process, a cost function is normally constructed to represent the overall operating and investment costs of a distribution planning area. Engineering parameters such as capacity, reliability, power losses, voltage regulation, power quality, load demand, are associated with the operation and investment. There can be several cost functions based on various planning scenarios. Objective functions and their constraints are solved using various

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