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Mesh distribution system analysis in presence of distributed generation with time varying load model

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ABSTRACT

With the implementation of competitive electricity supply system all over the world, there is the need of optimal utilization of the existing generation sources at the same time to curtail the generation from the conventional power plants and add the renewable sources generation looking into the environmental concern and limitation of the fossil fuels. This has lead to the motivation for the studies on the integration of distributed resources to the grid. In this paper optimal locations and sizes for DG is determined for weakly meshed distribution networks based on the sensitivity method. Novel method based on loss sensitivity is used in this paper to determine optimal size and location of DGs. The modified Novel method is proposed for DG allocation. The main contribution of the paper is: (i) distributed generation allocation for mesh network using sensitivity approach, (ii) modified Novel method for DG allocation and sizes calculation for meshed distribution system with load variations, (iii) comparison of the results obtained with single and two DG placement with load variations, (iv) the loss savings and overall cost savings per annum with single and two DGs placement with load variations. In this paper we considered the impact of time varying load flow with realistic load model. The realistic ZIP load model has been considered for study. The results have been obtained for a distribution network of UK Distribution Corporation consisting of 38 buses. The results have also been obtained for radial distribution system for comparison.

Introduction

With technological improvements micro-turbines, fuel cells, mini-hydro, battery storage etc., this has provided an opportunity for large-scale integration of these generation sources called as distributed energy sources (DERs) into distribution systems. These distributed generation sources are modular in design and can be deployed near load sites to address increasing power demand of the current electric utilities [1–6]. The integration of the DGs may provide technical as well as economical benefits by supplying loads during peak load periods, when the cost of electricity is higher. DG can best serve as a price hedging mechanism in real time pricing mechanism in the new competitive electricity market regime. However, penetration and viability of DG at a particular location is influenced by technical as well as economic factors. The technical merits of DG integration include voltage support, energy-loss reduction, release of system capacity, and improve utility system reliability [1,4–6]. Economical merit, on the other hand, encompasses hedge against high electricity price. The distributed generation renewable resources such as; small hydro, wind, solar energy can be integrated into distribution systems with the several issues related to technical barriers that are challenging. Distributed Generation is electricity production that is on-site or close to the load center to avoid the need of the network expansions in order to cover new load centers and to support the increased energy transfer which would be necessary for satisfying consumers increased demand. DG can be an alternative for residential, commercial, and industrial applications. However, distributed generation can be defined in a variety of ways as reported in the literature [1–4]. The impact of DG on radial distribution network is explained i.e., voltage support, loss reduction, and distribution capacity release and power quality issues in [5]. There are many reasons behind the increasingly widespread use of DG deferring the Transmission and Distribution (T&D) costs, good efficiencies especially in cogeneration and in combined cycles, are reduced, creating opportunities for new utilities in the power generation sector, provides a flexible way to choose a wide range of combinations of cost and reliability [6]. DG impacts different parameters of a power system, comprising voltage profile, line losses, and short circuit current, amount of injected harmonic, and system reliability and stability and the installation of DG units should be allocated in an optimal way to maximize the system

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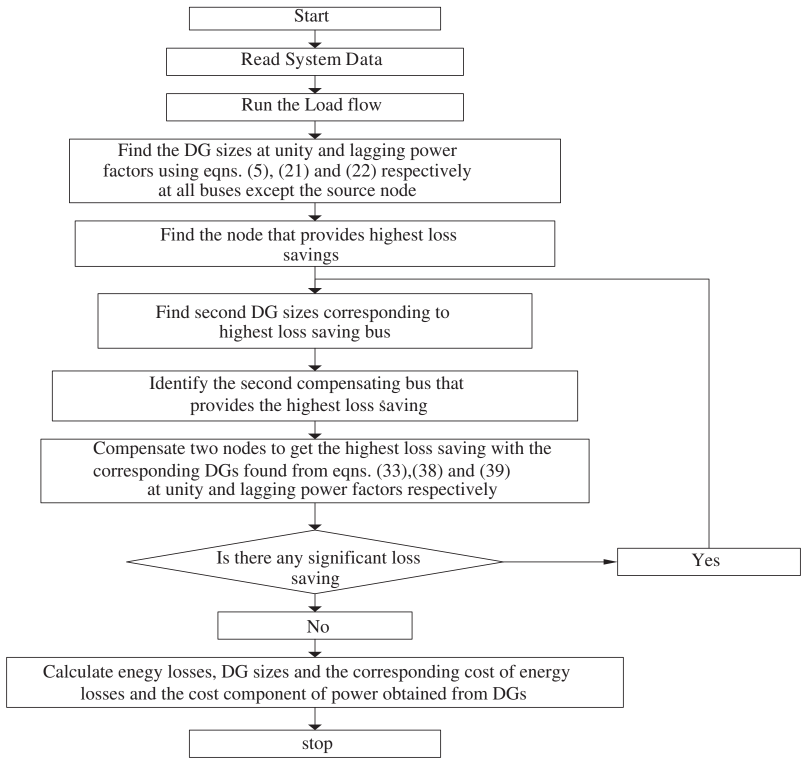

Fig. 1. Flow chart for DG allocation.

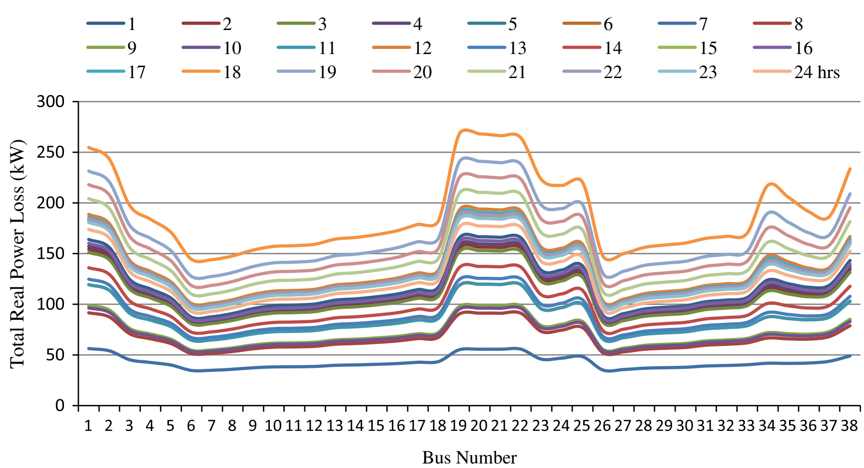

Fig. 2. Total real power loss variation with single.

efficiency. To analyze the distributed energy resources (DER) impacts, different types of 'generator groups' can be considered [6].

In [7] a new method has been suggested based on nodal pricing for optimally allocating DG in radial distribution system. Authors in [8] presented a method for optimal sitting and sizing of multiple distributed generators (DGs) using particle swarm optimization (PSO) based approach. A simple and effective cumulative performance index, utilizing voltage profile improvement, loss reduction, and voltage stability index improvement is considered. Loss sensitivity factor, based on equivalent current injection method for sizing and sitting of DG in radial distribution system is given in [9]. Calculation of cost of DG is given in [10] based on conventional, triangular, and complex power limit. Authors in [11] described a technique for selection of buses in a sub transmission system for location of distributed generation (DG) and determination of their optimum capacities by minimizing transmission losses. The buses have been selected based on incremental voltage (dV/dP) sensitivities. Ref. [12] presented two new methodologies for optimal placement of distributed generation sources using an optimal power flow (OPF) based model in real time wholesale electricity market. The problem of optimal placement, including size, is formulated for two different objectives, namely, social welfare maximization and profit maximization. The candidate locations for DG placement are identified on the basis of locational marginal price (LMP). Optimal sizing and sitting decisions for DG capacity planning using heuristic approach was proposed in [13]. A multi-objective optimization approach using evolutionary algorithm with an objective of minimizing cost of energy losses, network upgrading and service interruptions for sizing and sitting of DG in distribution systems has been presented in