

Lsf Based Voltage Profile Improvement In Radial Distribution System

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Abstract—This paper proposes the application of clustering analysis technique to find the optimal size and optimum location for the placement of DG in the radial distribution networks for enhancement in voltage profile. The analytical expression is based on exact loss formula. The optimal size of DG is calculated at each group using the exact loss formula and the optimal location of DG is found by using the loss sensitivity factor (LSF). The proposed technique is tested on standard 33-bus test system.

Keywords— lsf; vsi; ct; dg

I. INTRODUCTION

The objective of power system operation is to meet the demand at all the locations within power network as economically and reliably as possible. The traditional electric power generation systems utilize the conventional energy resources, such as fossil fuels, hydro, nuclear etc. for electricity generation. The operation of such traditional generation systems is based on centralized control utility generators, delivering power through an extensive transmission and distribution system, to meet the given demands of widely dispersed users. Nowadays, the justification for the large central-station plants is weakening due to depleting conventional resources, increased transmission and distribution costs, deregulation trends, heightened environmental concerns, and technological advancements. Distributed Generations (DGs), a term commonly used for small-scale generations, offer solution to many of these new challenges. CIGRE define DG as the generation, which has the characteristics (CIGRE, 1999): it is not centrally planned; it is not centrally dispatched at present; it is usually connected to the distribution networks; it is smaller than 50-100MW. Other organization like,

Electric Power Research Institute define distributed generation as generation from few kilowatts up to 50MW. Ackermann *et al.* have given the most recent definition of DG as: “DG is an electric power generation source connected directly to the distribution network or on the customer side of the meter.” Using DG can enhance the performance of a power system in many aspects. Employing DG in a distribution network has several advantages as (Khoa et al, 2006), reduction in line losses, emission pollutants, overall costs due to improved efficiency & peak saving. Improvement of voltage profile, power quality, system reliability and security and the disadvantages are (Illerhsus et al, 2000), reverse power flow, injected harmonics, Increased fault currents depending on the location of DG units. DG also has several benefits like energy costs through combined heat and power generation, avoiding electricity transmission costs and less exposure to price volatility (Ghosh et al, 2010).

II. MATHEMATICAL FORMULATION

The load flow of a single source network can be solved iteratively from two sets of recursive equations. The first set of equations for calculation of the power flow through the branches starting from the last branch and proceeding in the backward direction towards the root node. The other set of equations are for calculating the voltage magnitude and angle of each node starting from the root node and proceeding in the forward direction towards the last node. These recursive equations are derived as follows.

The fig. 1 shows the representation of 2 nodes in a distribution line. Consider a

branch 'j' is connected between the nodes 'i' and 'i+1'.

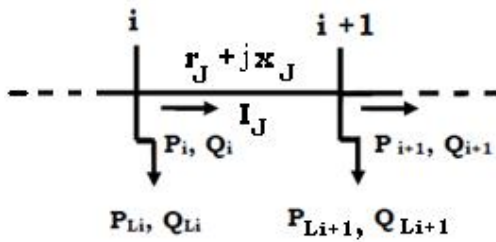


Fig.1. Representation of two nodes in a distribution line

The effective active (P_i) and reactive (Q_i) powers that of flowing through branch 'j' from node 'i' to node 'i+1' can be calculated backwards from the last node and is given as,

$$P_i = P_{i+1}^1 + r_j \frac{(P_{i+1}^1)^2 + (Q_{i+1}^1)^2}{V_{i+1}^2}$$

$$Q_i = Q_{i+1}^1 + x_j \frac{(P_{i+1}^1)^2 + (Q_{i+1}^1)^2}{V_{i+1}^2}$$

Where $P_{i+1}^1 = P_{i+1} + P_{Li+1}$ & $Q_{i+1}^1 = Q_{i+1} + Q_{Li+1}$

P_{Li+1} & Q_{Li+1} Are the loads that are connected at node 'i+1'

P_{i+1} & Q_{i+1} Are the effective real and reactive power flows from node 'i+1'

The voltage magnitude and angle at each node are calculated in forward direction. Consider a voltage $V_i \angle \delta_i$ at node i and $V_{i+1} \angle \delta_{i+1}$ at node i+1, then

$$V_{i+1} = [V_i^2 - 2[P_i r_j + Q_i x_j] + [r_j^2 + x_j^2] \frac{[P_i^2 + Q_i^2]}{V_i^2}]^{\frac{1}{2}}$$

And angle at each bus is

$$\delta_{i+1} = \delta_i + \tan^{-1} \left(\frac{[Q_i r_j - P_i x_j]}{[V_i^2 - (P_i r_j + Q_i x_j)]} \right)$$

The real and reactive power losses at branch j can be calculated as

$$P_{loss}(j) = r_j \frac{[P_i^2 + Q_i^2]}{V_i^2}$$

$$Q_{loss}(j) = x_j \frac{[P_i^2 + Q_i^2]}{V_i^2}$$

2.1 Loss sensitivity factor:

The loss sensitivity factor is used for the placement of DG is explained as, the real power loss in the system is given by (1). This formula is popularly referred as "Exact Loss" formula (Elgerd, 1971; Kazemi et al, 2009).

$$P_L = \sum_{i=1}^N \sum_{j=1}^N [\alpha_{ij} [P_i P_j + Q_i Q_j] + \beta_{ij} [Q_i P_j + P_i Q_j]]$$

Where,

$$\alpha_{ij} = \frac{r_{ij}}{V_i V_j} \cos(\delta_i - \delta_j)$$

$$\beta_{ij} = \frac{r_{ij}}{V_i V_j} \sin(\delta_i - \delta_j)$$

And $Z_{ij} = r_{ij} + jx_{ij}$ is the ij th element of [Zbus] matrix.

$$P_i = P_{Gi} - P_{Di} \text{ And } Q_i = Q_{Gi} - Q_{Di}$$

P_{Gi} & Q_{Gi} Are powers injection of generator to the bus.

P_{Di} & Q_{Di} Are the loads.

P_i & Q_i Are active and reactive powers of the buses

The sensitivity factor of real power loss with respect to real power injection from the DG is given by

$$\alpha_i = \frac{\partial P_L}{\partial P_i} = 2\alpha_{ii} P_i + 2 \sum_{j=1}^N \sum_{j \neq i} [\alpha_{ij} P_j - \beta_{ij} Q_j]$$

Sensitivity factor are evaluated at each bus by using the values obtained from the base case load flow. The bus having highest loss sensitivity factor will be best location for the placement of DG (Acharya et al, 2006).

2.2 optimal sizing of DG

The total power loss against injected power is a parabolic function and at minimum losses, the

rate of change of losses with respect to injected power becomes zero [9].

$$\frac{\partial P_L}{\partial P_i} = 2\alpha_{ii}P_i + 2\sum_{j=1}^N \sum_{j \neq i} [\alpha_{ij}P_j - \beta_{ij}Q_j] = 0$$

It follows that

$$P_i = \frac{1}{\alpha_{ii}} \left[\sum_{j=1}^N \sum_{j \neq i} [\alpha_{ij}P_j - \beta_{ij}Q_j] \right]$$

Where P_i is the real power injection at node i , which is the difference between real power generation and the real power demand at that node i.e.,

$$P_i = [P_{DG_i} - P_{D_i}]$$

Where P_{DG_i} the real power injection from DG is placed at node i , and P_{D_i} is the load demand at node i . By combining

The above we get

$$P_{DG_i} = P_{D_i} - \frac{1}{\alpha_{ii}} \left[\sum_{j=1}^N \sum_{j \neq i} [\alpha_{ij}P_j - \beta_{ij}Q_j] \right]$$

The above equation gives the optimum size of DG at buses i for the loss to be minimum. Any size of DG other than P_{DG_i} placed at bus i , will lead to higher loss.

2.3 Test system

This methodology is tested on test system contains 33 buses and 32 branches as. It is a radial system with a total load of 3.72 MW and 2.3 MVAR (Kashem et al, 2000). A computer program is written in MATLAB 2010a.

III. RESULTS AND DISCUSSIONS

Here we considering vsi and lsf and cost function for optimal location. By using optimal location we go for hierarchal and k-means clustering and the results are

Description	Total Loss		Minimum Voltage and it's node number
	Real power (kW)	Reactive power (kVAR)	
With out DG	249.29	173.95	0.9038at 18
With DG	203.66	144.01	0.911 at 18

Table 1: Comparison Table

IV. Conclusion

The iterative techniques commonly used in transmission networks are not suitable for distribution power flow analysis because of poor convergence characteristics. In this work the distribution power flow is carried out by the backward and forward propagation iterative equations. The effective branch powers are calculated in backward propagation. In forward propagation voltage magnitudes at each node are calculated. By placing DGs at optimal three groups voltage profile is improved and losses are reduced.

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