Assessment of Distribution System with Integration of Distributed Generation sources

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Abstract

In past distribution system is passive network. But, after deregulation it is active network. Further, losses in DS is quite high as compared to transmission. So, in order to reduce these losses and fulfil the load requirement of society it is significant to utilize distributed generators in a suitable way. In this article assessment of DS with integration of DGs in an optimal way. First locations of these are found using voltage stability index (VSI). Next, ratings of DGs are determined using firefly algorithm. Also, the main aim of this paper us reduce loss, improve VSI and voltage profile. Further, it is tested on 85 bus Indian DS. Important results are finding out and those are tabulated. Finally, it is assessed that better locations of DGs with proper sizes reduces the losses of DS.

Keywords: Distribution System, Voltage profile, Voltage stability, Power loss, Firefly Algorithm

1.Introduction

In recent years, demand of the electricity is increases abruptly. Further, generation from conventional sources such as coal and gas are declined in a fast manner. So, in order to fulfil the gap of generation and demand it is imperative to use nonconventional based sources. After, deregulation DS are active and DGs are connected nearly to the consumer. But, allocation of DGs in a proper way is significant in order to maximum possible benefits such as improvement in voltage profile, VSI and power loss reduction of DS. In the literature authors solved above problem using capacitors [1-14]. Further, various optimization techniques such as tabu search, genetic algorithm, fuzzy logic, ESGA, differential evolution, PSO, heuristic constructive algorithm, TLBO, gravitational search algorithm, ant colony optimization and crow search algorithm are used. But, placement of capacitors not fulfil the load requirement. So, it necessary to use DGs in place of capacitors. In [15-23] authors solved this problem using PSO, simulated annealing, BSOA, shuffled bat algorithm, Imperialistic Competitive Algorithm, TLBO, IGSA and ALO. In this paper a combined approach based on VSI and firefly algorithm is presented to solve DG allocation problem. Further, the main aim is to minimize DS power loss. Different cases are taken for the analysis and it is implemented on Indian 85 bus system.

2. Problem Formulation

The power loss of DS is minimized by placing DGs optimally. The objective function is represented as follows.

$$objfun = Min(P_{loss}) \tag{1}$$

Also, the OF satisfies the following constraints.

2.1 Constraints

2.1.1 Power balance constraint

$$\sum_{l=2}^{m} P_{DG,l} \le \sum_{l=2}^{m} P_l + \sum_{l=1}^{b} P_D \tag{2}$$

2.1.2 Voltage Magnitude Constraint

$$V_{\min} \le V \le V_{\max} \tag{3}$$

2.1.3 DG Constraint

$$P_{DG}^{\min} \le P_{DG} \le P_{DG}^{\max} \tag{4}$$

2.1.4 Thermal Constraint

$$|J| \le |J_{max}| \quad (5)$$

3. VSI for DG placement

VSI method is used for identifying suitable buses such as weak buses for placement of DGs [24]. Also, the formulae for VSI is given in Eqn. (6). Buses with least value of VSI are considered and the same is represented in fig.1.

$$VSI_q = |V_p|^4 - 4[P_q r_{qp} + Q_q x_{qp}]|V_p|^2 - 4[P_q x_{qp} - Q_q r_{qp}]^2 \quad (6)$$

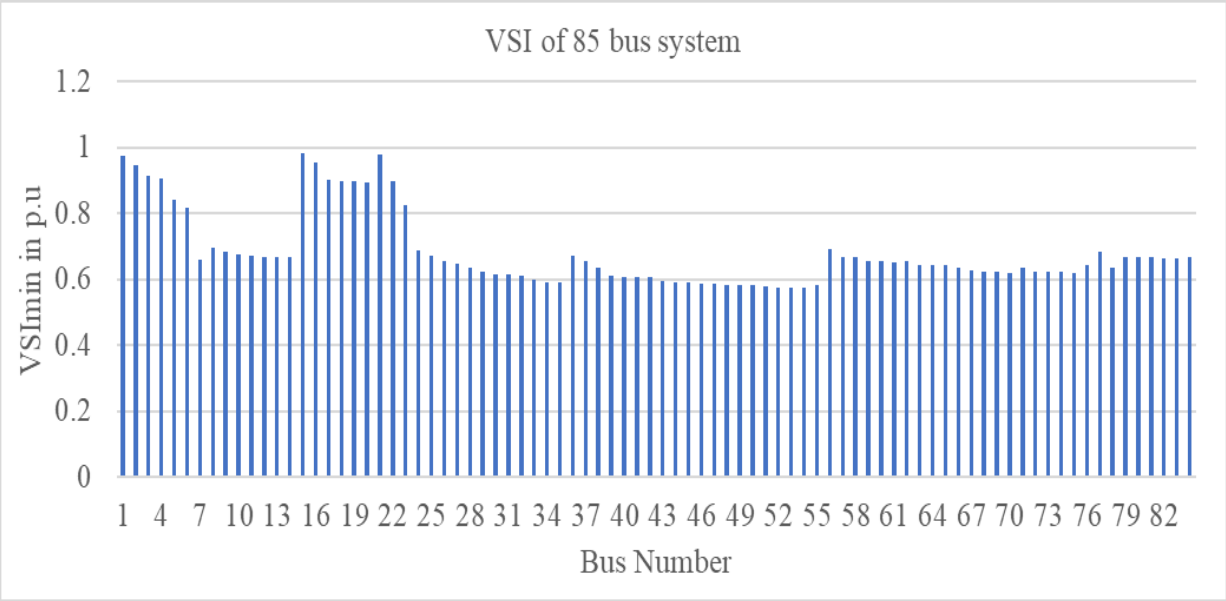

Fig.1 VSI of 85 bus system

4. Firefly Algorithm

Firefly algorithm is a metaheuristic technique developed by Xin-She Yang based on flashing behavior of fireflies [25].

4.1 Steps to solve DG allocation problem

1. Read the data of 85 bus.

2.Intialize the parameters of FA [25].

3. Locations are found using VSI.

4. These locations as given as input to FA.

5. The best sizes of DGs are given by attractiveness that is given by Eq. (7).

$$\beta = \beta_0 e^{-\gamma r^2} \quad (7)$$

6. For updated light intensity calculate updated DG sizes.

7. Repeat steps 4-6 until best solution reached.

8. Repeat the same process up to maximum iterations.

5. Results and Discussions

The integrated approach such as VSI and FA is implemented in MATLAB. First, distribution load flow is used for calculate VSI and identified best buses. The buses are 54,53, 52,51,50,56,49,48,47,46,45 and 36. Out of 85 buses 10% of buses are chosen for placement. Further, sizes are calculated using FA. Different cases are taken

and study the performance of DS. Further, 85 bus Indian system considered for the analysis and results are tabulated in Table 1. The data of the system is considered from [26].

Base case
Case1: 1 DG
Case 2: 2 DGs
Case 3: 3 DGs

Table 1 Simulation results of 85 bus DS

Particulars	Location of DG	Size of DGs (kW)	P_{loss} (kW)	$\%P_{loss}$ Red	V_{min} (p.u)	VSI_{min} (p.u)
Base Case	…..	…..	313.75	NA	0.8710	0.5756
Case 1	54	909.11	225.37	28.16	0.9095	0.6843
Case 2	54 49	179.43 936.41	208.15	33.65	0.9144	0.6991
Case 3	54 49 36	129.49 285.46 775.57	202.88	35.33	0.9161	0.7044

Before allocation of DGs, the power loss is 313.75 kW, minimum voltage profile, VSI in p.u are 0.8710 and 0.5756. After placement of DG at 54 bus the loss is reduced to 225.37 kW. Also, the voltage profile and VSI is enhanced to 0.9095 p.u and 0.6843 p.u. In case 2, two DGs are considered and placed at buses 54 and 49. After allocation of 2 DGs the power loss is minimized to 208.15 kW. Also, minimum voltage profile and VSI is improved to 0.9144 p.u and 0.6991 p.u. Finally, 3 DGs are considered and placed at buses 54,49 and 36. After placing DGs at these locations the power loss is reduced to 202.88 kW, voltage profile and VSI is enhanced to 0.9161 p.u and 0.7044 p.u. From, overall comparison analysis the maximum percentage loss reduction is obtained in case 3 that is 35.33. Finally, voltage profile and VSI of all buses are improved to maximum extent and it is shown in Fig.2 and Fig.3. From, the overall discussion, the power loss of DS is minimized with optimal allocation of DGs. Further, it is also depending on the active power injected into the system.

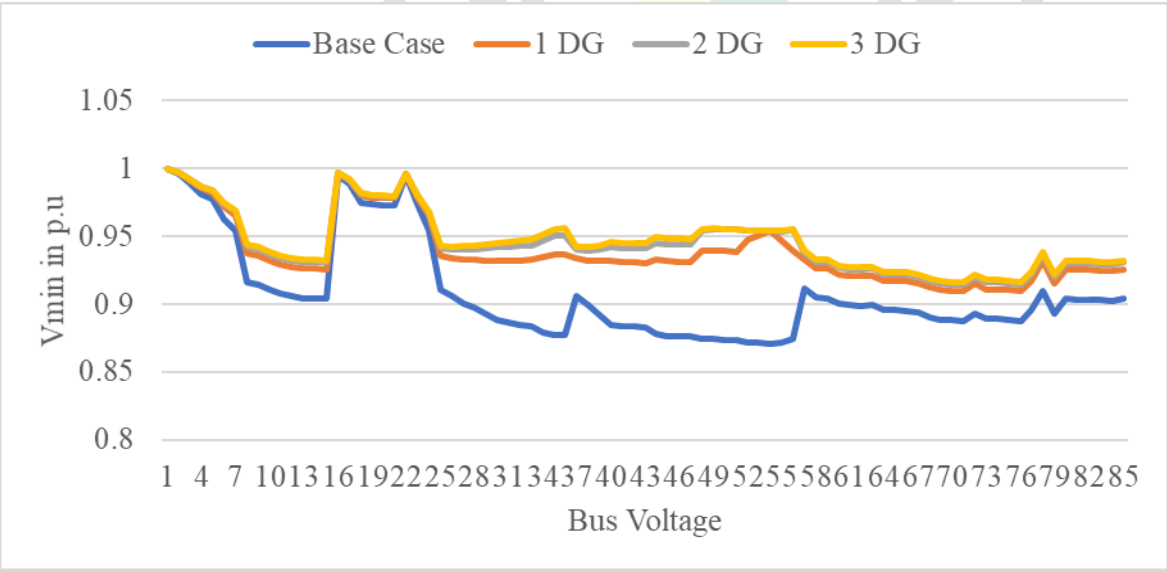

Fig.2. Vmin of 85 bus system (Different cases)

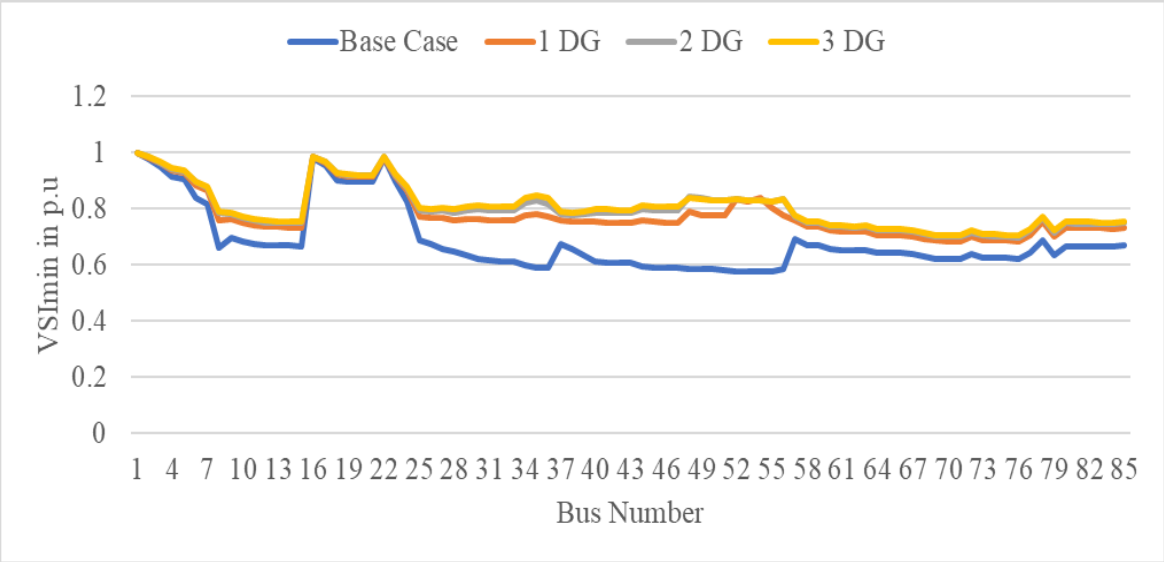

Fig.3. VSI_{min} of 85 bus system (Different cases)

6. Conclusion

In this article an effective method based on VSI and FA is presented to solve DG allocation problem. First, the effective locations are found using VSI and sizes corresponding to these locations are calculated using FA. The method is analysed on 85 bus system. Different cases are taken and asses the performance of DS in view of losses, voltage profile and VSI. Maximum loss reduction, good voltage profile and VSI are obtained by placing 3 DGs. Finally, the presented method minimizes the losses, improve voltage profile and VSI of DS to desired extent.

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