RESEARCH ARTICLE

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Placement of DG in Distribution System using TLBO Algorithm

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ABSTRACT

Theaim of this proposed work is to minimize the real power loss and improve the voltage profile of a radial distribution network using distributed generation (DG). The site and size of DG have been determined with the help of teaching learning based optimization (TLBO) algorithm. Here, three different cases have been examined the first case is without DG consideration, the second case is with one DG and the third case is with two DG placement under different power factor. The presented approach has been validated on a 33-bus network.

Keywords: Distributed generation; power loss; TLBO; voltage profile.

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INTRODUCTION

Loss minimization in the distribution system has been playing an important role in recent years. Different approaches have been implemented by researches to minimize the losses. However, from the literature, it has been found that optimal placement of DG at a suitable place with best size improves the voltage profile and minimizes the system power losses. The distribution system has both real power losses and reactive power losses.

$$Realpower_{loss} = \sum_{i=1}^{nr} I_i^2 r_i \tag{1}$$

Equation (1) represent the real power loss, where I_i is the current flowing between the two nodes, and r_i the resistance of the segment respectively and *i* represent the segment number.

Several researchers [1-6] have done a penalty of work regarding the optimal location and sizing of DG using various optimization techniques such as particle swarm optimization, genetic algorithm etc.

The contribution of this paper is to determine the optimal location and size of DG using the TLBO algorithm. Distributed generation has been sited at varioussites with different power factors.

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PROBLEM FORMULATION

The goal is to minimize the total real power loss and enhancement of voltage behavior by integrating DG in the system. Subject to the system operating constraints and assumptions made. The two main constraints are (i) the total power penetrated by DG must be less than the total load demand and (ii) the voltage balance at the node.

The objective function is defined by equation (2).

$$\text{Minimize} = Realpower_{loss} \tag{2}$$

TEACHING-LEARNING BASED OPTIMIZATION (TLBO) ALGORITHM

Based on the outcome and learning process of learners in a class, the TLBO has been developed by the authors [4]. The algorithm has two methods of learning first through the teacher (known as teacher phase) and second through communication with the other learners (known as learner phase).

Teacher Phase

In this stage, a teacher attempts to escalate the mean result of the class in the subject taught by him or her depending on his or her capability. Learners learn through the teacher.

Learner Phase

In the second part, learners improve their knowledge by interacting with each other's. This process is done randomly.

RESULTS AND DISCUSSION

The goal of this paper is to minimize the total active power loss of the 33-bus system by integrating DG at the optimal sites with optimal sizes. The TLBO algorithm has been implemented to achieve the aim.

The following scenarios have considered for the test system.

Case 1: Without DG integration

Case 2: Single DG operating at u.p.f (unity power factor) has placed at the optimal location.

Case 3: Two DG operating at u.p.f.

Case 4: Single DG operating at 0.90 p.f.

Case 5: Two DG operating at 0.90 p.f.

Case 6: Single DG operating at 0.85p.f.

Case 7: Two DG operating at 0.85 p.f.

The whole work has been carried in the MATLAB environment. The outcomes of the proposed approach are presented in the next section.

TEST SYSTEM

Standard 33-node radial distribution network system has been considered here for the proposed analysis and it is shown in Figure 1. The system data have been taken from [7]. It has an active load and the reactive load of 3715 kW and 2300 kVAr. The overall results comparison for all the cases are displayed in Table I. The penetration level of DG is 50% of the total active loading.

Three different studies have been carried and the results obtained are examined.

Case-1: In this case, the system has been simulated without penetration of DG. The active power loss and reactive power loss obtained is 210.97 kW and 143.11 kVAr. The bottom and pinnacle voltages of the system are 0.816 p.u and 0.994 p.u.

Case-2: In this case, the system has been simulated with one DG having power factor unity. The optimal location found by the algorithm is at bus 11 with 1000 kVA capacity. The active power loss and reactive power loss obtained is 129.96 kW and 87.00 kVAr. The bottom and pinnacle voltages of the system are 0.932 p.u and 0.998 p.u. It is noted from Table I that, the active power has been reduced by 38.57 %.

Case-3: In this case, the system has been simulated with two DG having power factor unity. The optimal locations found by the algorithm are 845 kVA at bus 12 and 1000 kVA at bus 29 respectively. The active power loss and reactive power loss obtained is 88.02 kW and 60 kVAr. The bottom and pinnacle voltages of the system are 0.963 p.u and 0.998 p.u. It is noted from Table I that, the active power has been reduced by 58.29%.

Table-1: Overall Results of 33-Bus System

Parameters	**Without DG**	**With unity pf**		**With 0.90 pf**		**With 0.85 pf**	
	Study-1 (Base case)	**Study-2**	**Study-3**	**Study-4**	**Study-5**	**Study-6**	**Study-7**
		with one DG	**with two DG**	**with one DG**	**with two DG**	**with one DG**	**with two DG**
Total P_{loss} (kW)	210.97	129.96	88.02	100.45	**39.77**	93.91	88.89
% P_{loss} Reduction	-	38.57	58.29	52.39	**81.15**	55.48	57.86
Total Q_{loss} (kVAr)	143.11	87.00	60.00	70.80	**27.25**	66.48	60.40
% Q_{loss} reduction	-	64.50	58.00	50.52	**80.96**	53.54	57.80
Size and Site of DG	-	1000 kVA at bus 11	845 kVA at bus 12 and 1000 kVA at bus 29	1111.12 kVA at bus 29	**1111.12 kVA at bus 29 and 945.56 kVA at bus 12**	1176.47 kVA at bus 29	1002.56 kVA at bus 29 and 1096.35 kVA at bus 11
Vmin. (p.u)	0.816	0.932	0.963	0.924	**0.978**	0.926	0.961
Vmax. (p.u)	0.994	0.998	0.998	0.997	**0.998**	0.998	0.998

Case-4: The results otained with 0.90 pf are active power loss = 100.45 kW and reactive power loss = 70.80 kVAr. The optimal location found is bus number 29 with capacit of 1111.12 kVA. The active power has been reduced by 52.39 %. The bottom and pinnaclevoltages of the system are 0.924 p.u and 0.997 p.u.

Case-5: The results otained with 0.90 pf are active power loss = 39.77 kW and reactive power loss = 27.25 kVAr. The optimal locations found are 1111.12 kVA at bus 29 and 945.56 kVA at bus 12. The active power has been reduced by 81.15 %. The bottom and pinnaclevoltages of the system are 0.978 p.u and 0.998 p.u.

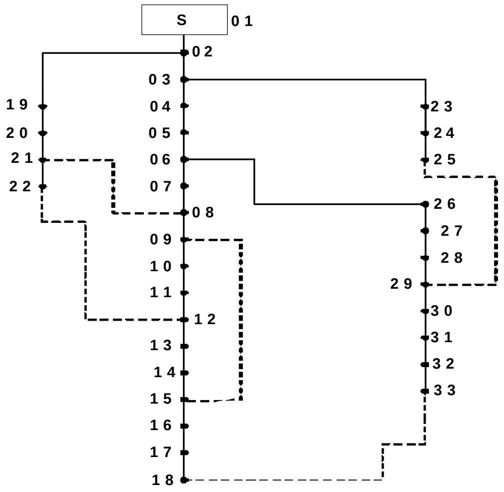

Figure 1 : 33-bus radial distribution network system

Case-6: The results otained with 0.85 pf are active power loss = 93.91 kW and reactive power loss = 66.48 kVAr. The optimal location found is 1176.47 kVA at bus 29. The active power has been reduced by 55.48 %. The bottom and pinnaclevoltages of the system are 0.926 p.u and 0.998 p.u.

Case-7: The results otained with 0.85 pf are active power loss = 88.89 kW and reactive power loss = 60.40 kVAr. The optimal locations found are 1002.56 kVA at bus 29 and 1096.35 kVA at bus 11. The active power has been reduced by 57.86 %. The bottom and pinnaclevoltages of the system are 0.961 p.u and 0.998 p.u.

It is observed from Table I that, the optimal results found by the TLBO algorithm are with two DG placement having 0.90 pf. The active power loss reduction, improvement in voltage curve, and reactive power loss minimization yield by an optimization algorithm for case-5 are superior to all the other cases. Figure 2 shows the comparison between the behavior of the voltages obtained from all the cases studied. And it is noted that the voltage profile obtained in case-5 is better than all the other cases.

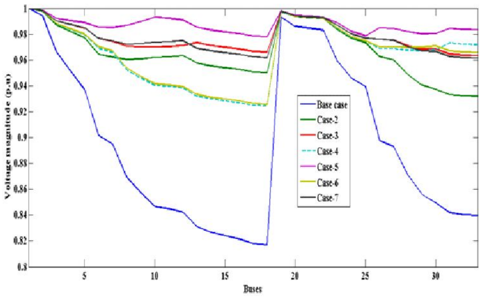

Figure 2: Voltage summary comparison of 33-bus RDN for all thestudies

The active power loss minimization curve for the system of case-5 is shown in Figure 3.

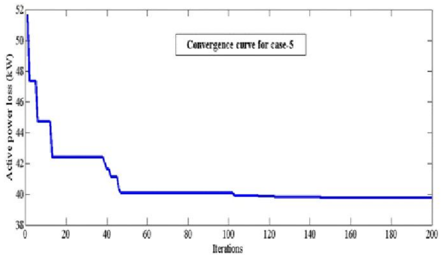

Figure 3: Convergence characteristic graph of case-5

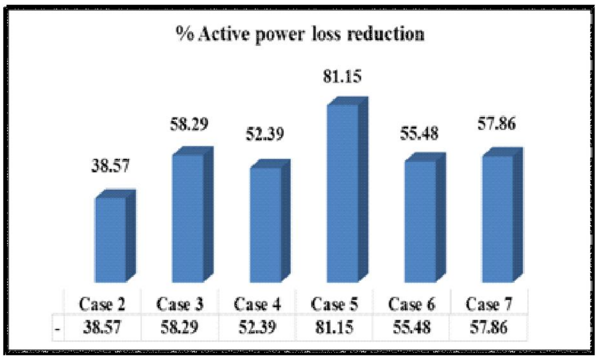

Figure 4: Active power loss reduction of the system

The percentage active power loss reduction for all the cases of the system is displayed in Figure 4. It is observed that case-5 gives better results than other cases.

CONCLUSION

The proposed study has been carried out with and with DG placement considering different power factors. The results obtained are analyzed. The following points are drawn from all the cases studied.

- It is noted that, as the power factor is close to unity it is giving good results compared with unity pf and 0.85 pf respectively.
- The active power loss reduction increases with an increase in the number of DG penetration.
- The locations and sizes of the DG vary as the power factor varies.
- Case-5 provides better results than other cases.

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