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Research Papers

LOSS REDUCTION IN PRIMARY DISTRIBUTION NETWORKUSING OPTIMAL PLACEMENT OF TYPE -1 DG

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Abstract

In this paper, the optimal locations of particular sizes of Type -1 Distributed Generators (DGs) is determined by Direct Search Algorithm to obtain the maximum possible reduction in power loss. Type-1 DG injects both active and reactive powers. The algorithm searches for all possible locations in the system for a particular size of DG and places it at the bus which gives maximum reduction in Total power loss. The optimal sizes of DGs are chosen to be standard sizes i.e., discrete sizes of DGs are considered. The algorithm is tested on 33 bus and 69 Bus Radial Distribution Systems. The loss reduction obtained in this paper for the 33 bus and 69 Bus Test Systemsare highest compared to the other techniques as reported in the literature. Power factor of the DG is considered in this study is 0.85.

On 33 bus system, without placement of DGs the loss is 211 kW whereas after placement it is 13.55 kW. There is a reduction of 93.57% in the losses. Before placement of DGs, the power loss is 5.37% of the total power supplied by the slack bus. After optimal placement by the DSA algorithm, the totalpower loss is 0.36% of the total power supplied by the system.On 69 bus system, without placement of DGs the loss is 225 kW whereas after placement it is 5.75 kW. There is a reduction of 97.44% in the losses. Before placement of DGs, the power loss is 5.36% of the total power supplied by the slack bus. After optimal placement by the DSA algorithm, the Total power loss is 0.15% of the total power supplied by the system It is implemented using MATLAB/Simulink.

KEYWORDS:
Direct Search Algorithm, Optimal DG placement, Distribution Systems.

INTRODUCTION

Optimal capacitor placement is implemented for improving the voltage profile and reducing the power loss.Optimal DG placement is implemented for reduction of active power loss and to improve the reliability of the system.Very few papers have addressed the concept of minimizing the active loss by placing both DGsand Capacitors [1-3]at their optimal locations. This concept works well for the developing countries like India, where the 11KV rural distribution feeders are too long. The voltages at the far end of many such feeders are very low with very poor voltage regulation.

The computational methods used in the analysis and design of distribution systems are not as robust as they are in transmission systems. In particular, the design of compensation systems for radial distribution system has become very complex because, the system does not fit into the usual optimization methods used in transmission system. Mamta Karayat et. al [1] have used Modified KVS-Direct Search algorithm for optimal placement of Type -2 DG. T. S. Sirish et. al[2] have used KVS- Direct Search Algorithm for placing Type-3 DG. They demonstrated the results on 69 Bus Distribution System. In this paper, only one phase of KVS- Direct Search Algorithm [3] is used according to the requirement of

Type-1 DG. Capacitive compensation is not required in this case as reactive power is injected by DG itself. In the case of Type-2 and Type-3 DG, capacitive compensation is separately required. This algorithm is an extension of Direct Search Algorithm for Capacitive compensation proposed by M.Ramalinga Raju et. al.[4].

The technical merits of DG implementationinclude voltage support, energy-loss reduction, release of system capacity, and improve utility system reliability [5]. By supplying power during peak load periods DG can best serve as a price hedging mechanism. Numerous techniques are proposed so far to address the viability of DGs in power system. Besides, several optimization tools, including artificial intelligence techniques, such as genetic algorithm (GA), Tabu search, etc., are also proposed for achieving the optimal placement of DG. An optimization approach using GA for minimizing the cost of network investment and losses for a defined planning horizon is presented in [6]. The method for optimal placement of DG for minimizing real power losses in power distribution system using GA is proposed in [7].

The gradient and second order methods to determine the optimal location for the minimization of losses is employed in [8]. An iterative method that provides an approximation for the optimal placement of DG for loss minimization is demonstrated in [9]. Analytical methods for determining optimal location of DG with the aim of minimizing power loss are proposed in [10]. Optimal placement of DG with Langrangian based approach using traditional pool based Optimal Power Flow and voltage stability constrained Optimal Power Flow formulations is proposed in [11].

Carpinelli et al. implemented [12] non-linear programming technique for capacitor placement on three phase unbalanced system. Wang et al. implemented [13] integer programming technique, and Tabu search was used by Huang et al. [14] for optimal capacitor placement. Grainger implemented equal area criterion[15] and genetic algorithm applied to capacitor placement by Dlfanti [16] for determining optimal sizes of capacitors. Das applied Fuzzy- GA method for capacitor placement problem [17]. Sydulu and Reddy applied Index Vector to capacitor placement problem [18], Prakash and Sydulu applied particle swarm optimization for optimal capacitor placement problem [19]. Safigianni and Salis presented optimum VAr control of radial primary power distribution networks by shunt capacitor installation [20]. Das implemented genetic algorithm [21], Hsiao implemented Fuzzy-genetic algorithm for [22] for optimal capacitor placement problem. Huang applied immune multi objective algorithm for capacitor placement problem [23]. Kannana et al. applied Fuzzy-Differential Algorithm [24], Srinivasa Rao et al. applied plant growth algorithm for optimal capacitor placement problem [25].

DGs are considered as small power generators that complement central power stations by providing incremental capacity to power system. DGs may never replace the central power stations. However, penetration and viability of DG at a particular location is influenced by technical as well as economic factors.

The DSA algorithm implemented, with a possible expert interaction yields optimal locations with suitable sizes of DGs, results in minimum power loss. The algorithm is implemented on 33 Bus and 69 Bus Standard Test Systems. 69 Bus data is available in [26].Type -1 DG injects active power and reactive power into the system as mentioned in [27].

I.THE DSA ALGORITHM

The DSA algorithm is slightly modified for Type-1 DG placement in radial distribution system with source bus as slack bus and all other load buses as PQ buses. The algorithm implemented is described in following steps for deciding the optimal sizes of DGs and their locations (only load buses). The algorithm is presented in the following steps:

1. Calculate the total load in the system. To determine the optimal sizes of DGs, a number of options having group of various DG sizes are to be tried. A tolerance index is chosen. Losses under any option should be less than the tolerance index for convergence. All possible options may be enlisted.
2. Let m(k) be the number of DGs kth option, 'k' ranging from 1 to n where 'n' is the total number of options. m(1) , the first option is with single DG, the P (active power) of which is nearest to the total KW load, placed at all load buses, in turn, and load flow study is conducted. The line losses are determined. If the lowest loss satisfies the tolerance criterion, the process can be terminated. The size and location of DG are considered as the optimal solution.

3. In one set of DGs m(k), the first DG is kept at all load buses in turn, and the location for which losses are the lowest is considered as the optimal location for that DG. Placing this DG at that load bus, the procedure is repeated for placing the second DG at all load buses in turn and deciding the optimal location for the second DG. This procedure is repeated for all DGs.

4. The options m(2) to m(n) are sequenced taking more and more number of DGs of smaller size such that the total DG capacity is nearest to the total KW of the system. System losses are found out for each combination and checked for tolerance. If the tolerance is acceptable, process can be terminated.

III. RESULTS

The standard sizes of DGs, and their corresponding reactive power injections are presented in Table I at 0.85 power factor.

Table I : Different DGs considered for placement

S. No.	kW capacity	kVAr capacity
1	1000	619.74
2	500	309.87
3	300	185.92
4	200	123.94
5	100	61.97

The DSA Algorithm is implemented on 33 - Bus System. The total active and reactive power demand of the system is 3715 kW and 2300 kVAr respectively. Without compensation, the losses are 211kW. After placing Type-1 DGs the loss is 13.55 kW. Before placement of DGs, the loss is 5.37% of the total power supplied by Slack Bus. After placement, the loss is 0.36%of the total power supplied by the slack bus.

The DSA Algorithm is implemented on 69 - Bus System. The total active and reactive power demand of the system is 3802.19 kW and 2694.60 kVAr respectively. Without placement of DGs the loss is 225 kW. After placing Type-1 DGs the loss is 5.75 kW. There is a reduction of 97.44% in the losses. Before placement of DGs , the power loss is 5.58% of the total power supplied by the slack bus. After optimal placement by the KVS- DSA algorithm, the active power loss is 0.15% of the total power supplied by the system.

The Table II shows the best combination of DGs with location for 33 bus system and fourth column shows Total power loss after placing DGs in turn. Fig. 1 shows the reduction in active power loss by optimal placement of DGs. X-axis shows the number of DGs mentioned in the order of Table II.

The Table III shows the best combination of DGs with location for 69 bus system and fourth column shows Total power loss after placing DGs in turn. Fig. 2 shows the reduction in total power loss by optimal placement of DGs. X-axis shows the number of DG mentioned in the order of Table III.

Table- II: Type -1 DG placement on 33- bus system using Direct Search Algorithm

S. No	Active Power supplied by the DG (kW)	Reactive Power supplied by DG (kVAr)	Min Loss Location	Total power loss after placing the DGs in turn (kW
1	1000	619.74	30	93.79
2	1000	619.74	11	33.72
3	500	309.87	25	19.84
4	500	309.87	24	15.96
5	100	61.97	32	15.06
6	100	61.97	22	14.22
7	100	61.97	21	13.83
8	100	61.97	5	13.55

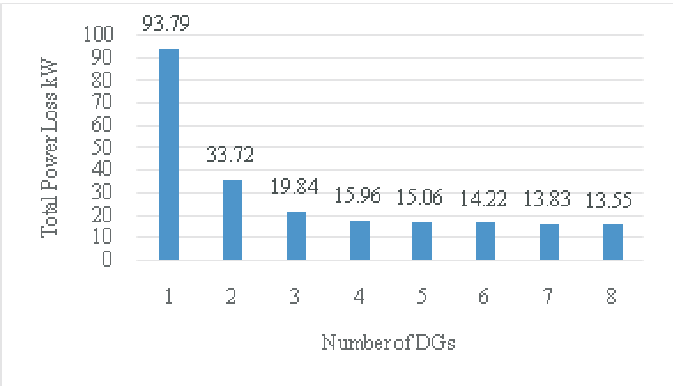

Fig. 1 Reduction in Total power loss by Type-1DG placement

Table- III: Type -1 DG placement on 69- bus system using Direct Search Algorithm

S. No	Active Power supplied by the DG (kW)	Reactive Power supplied by DG (kVAr)	Min Loss Location	Total power loss after placing the DGs in turn (kW
1	1000	619.74	61	64.80
2	1000	619.74	61	24.29
3	500	309.87	18	9.57
4	300	185.92	50	8.11
5	300	185.92	11	6.77
6	300	185.92	49	6.03
7	200	123.94	49	5.86
8	100	61.97	46	5.75

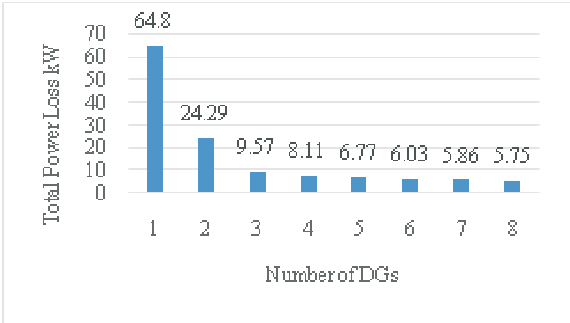

Fig. 2 Reduction in Total power loss by Type-1 DG placement

CONCLUSIONS

In this paper, Direct Search Algorithmis implemented to determine the optimal locations of particular sizes of Type -1 Distributed Generators (DGs) in 33 Bus and 69 Bus Radial Distribution System so that maximum possible reduction in Total power loss is obtained. The optimal sizes of Type - 1DGs are chosen to be standard sizes i.e., discrete sizes of DGs are considered.

On 33 bus system, without placement of DGs the loss is 211 kW whereas after placement it is 13.55 kW. There is a reduction of 93.57% in the losses. Before placement of DGs, the power loss is 5.37% of the total power supplied by the slack bus. After optimal placement by the DSA algorithm, the active power loss is 0.36% of the total power supplied by the system.

On 69 bus system, without placement of DGs the loss is 225 kW whereas after placement it is 5.75 kW. There is a reduction of 97.44% in the losses. Before placement of DGs, the power loss is 5.58% of the total power supplied by the slack bus. After optimal placement by the DSA algorithm, the power loss is 0.15% of the total power supplied by the system.

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