The Journal of CPRI,
Vol. 8, No. 3, September 2012 pp. 123–134

DG Placement in Radial Distribution Network with Reconfiguration

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This paper presents a simple method for finding the optimal DG size and optimal DG location in distribution network. By using this method, optimal DG capacity and location are determined considering without network reconfiguration and with network reconfiguration. The method is tested with three test cases: 33-node, 69-node and 117-node IEEE standard network. Result shows that the proposed method is very efficient and competitive with the existing methods available in the literature.

Keywords: *Optimal istributed generator (DG), Distribution network reconfiguration, Loss minimization by reconfiguration, Reconfiguration algorithm, 117-bus network.*

1.0 INTRODUCTION

Loss minimization in distribution power system is one of the biggest challenges before power engineers. It has been estimated that distribution systems cause a loss of about 5 %–13 % of the total power generated in developing countries. Therefore, the challenges are more pronounced in distribution systems. Basic reason behind these huge power losses is resistive loss, as distribution systems are operated at much lower voltages as compared to transmission systems. The operating current in distribution system is much more than that in transmission systems and hence, larger power loss (active) in distribution systems as compared to transmission systems.

In recent years, the penetration of distributed generator (DG) into distribution systems has also been increasing rapidly in many parts of the world. The main reasons for the increase in penetration are the liberalization of electricity markets, constraints on building new transmission and distribution lines, and environmental concerns. Technological advances in small generators, power electronics, and energy storage devices for transient backup have also accelerated the penetration of DG into electric power generation plants.

Network reconfiguration is an important optimization tool in distribution network automation systems .With loads prediction system and remote monitoring system, network structure can be reconfigured in real time. By changing open/closed states of some tie and sectionalizing switches, active power losses can be reduced. The other advantages are balancing of overloads, improvement in power supply reliability, etc.

Sivanagaraju *et al.* [1] presented an application of Genetic Algorithm for radial distribution systems using a chromosome coding method and gene operation strategy. Crossover operations are defined as to exchange between templates while mutation operations are restricted in template. The above strategy greatly reduces infeasible solutions, which are produced during gene operations. Further, a vector-based load flow method for a distribution system is also proposed and the reciprocal value of the active power losses is taken as fitness function. The above measures improve the performance of GA for distribution reconfiguration. Several tests are conducted and

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the results have shown that proposed algorithm has more advantages over previously developed algorithms. Prasad *et al.* [2] presented genetic algorithm-based network reconfiguration which is proposed for load balancing. Using the proposed technique, the optimal network reconfiguration by load balancing can be obtained with reduced computational effort. The proposed method is applicable in systems with the possibility for on line changing of the topological network structure. Ching-Tzong *et al.* [3] introduces a hybrid differential evolution (HDE) method for dealing with optimal network reconfiguration aiming power loss reduction. The proposed method determines the proper system topology that reduces the power loss according to a load pattern. This article presents a new approach that employs the HDE algorithm with integer variables to solve the problem. Two other methods, namely the genetic algorithm and the simulated annealing, are also employed to solve the problem. Das [4] presented an algorithm for network reconfiguration based on fuzzy multiobjective approach. Multiple objectives are considered for load balancing among the feeders, i.e. minimum deviation of the nodes voltage, minimize the power loss and branch current constraint violation, while subject to a radial network structure in which all loads must be energized. These objectives are modeled with fuzzy sets to evaluate their imprecise nature and one can provide his or her anticipated value of each objective. These four objectives are first fuzzified and then a fuzzy satisfaction objective function is formed and maximized for each tie-switch operation. Heuristic rules are also incorporated in the algorithm for minimizing the number of tie-switch operation. Subrahmanyam *et al.* [5] presents a simple reconfiguration algorithm that is specially suited for balanced and unbalanced radial distribution systems. The proposed algorithm involves less complex mathematical expressions, and a more efficient network configuration can be obtained with reduced power losses. The choice of the switches to be closed is based on the calculation of bus voltages and the minimum total system losses using a power flow program. Lin *et al*. [6] have applied refined genetic algorithm to network reconfiguration problem for reduction of resistive line losses. In this method, the authors have refined the conventional crossover and mutation scheme by a competition mechanism to avoid premature convergence. Mendoza *et al.* [7] have proposed and evaluated a method that improves the adaptability and efficiency of genetic algorithms (GAs) when applied to the minimal loss reconfiguration problem. This research reduces the searching space (population) when a new codification strategy and novel genetic operators, called accentuated crossover and directed mutation, are used. This allows a drastic reduction of the computational time and minimizes the memory requirements, ensuring a efficiency search when compared to current GA reconfiguration techniques. Kumar Injeti *et al.* [8] had presented planning and operation of active distribution networks, with respect to placement and sizing of Distributed Generators with the help of a new methodology. DG unit placement and sizing were calculated using fuzzy logic and new analytical method, respectively. Vinoth Kumar *et al.* [9] had investigated the problem of multiple distributed generators (DG units) placement to achieve a high loss reduction in large-scale primary distribution networks. An improved analytical (IA) method is proposed in that work. This method is based on improved analytical expressions to calculate the optimal size of four different DG types, and methodology is proposed to identify the best location for DG allocation. Naresh *et al.* [10] had presented and analytical method for DG placement in radial distribution network. Analytical expressions have presented to calculate the optimal size and an effective methodology to identify the corresponding optimum location for DG placement for minimizing the total power losses in primary distribution systems. The analytical expression and the methodology are based on the exact loss formula. The effect of size and location of DG with respect to loss in the network is also examined in detail. Khorshidi *et al.* [11] has presented an approach for distribution reconfiguration considering Distributed Generators (DGs). The objective function is summation of electrical power losses of the whole system. A Tabu search optimization is used to solve the optimal operation problem. Rugthaicharoencheep *et al*. [12] had presented a feeder reconfiguration problem to the distribution system with dispatchable distributed generators. A Tabu search algorithm is applied to search for the on-off patterns of the sectionalizing switches and tie switches to obtain the minimum total power loss, whereas the dispatch schedule of the distributed generators which gives the minimum total cost of generation is solved by optimal power flow.

In this paper, a new method for feeder reconfiguration has been used. This paper presents a minimal tree search to find the possible switching options for loss reduction. A simple loss change formula is developed to determine the switching option that gives a maximum reduction in losses. The proposed method is found to be efficient and obtains the optimal or near optimal configuration for loss minimization. In this paper, a simple algorithm to calculate optimum size and location for DG placement is proposed. The DG is considered to be located in the primary distribution system and the objective of DG placement is to reduce the losses. The cost of DG and the other associated benefits have not been considered while solving the location and sizing problem. The sizing and placement of DG are based on single instantaneous demand at peak, when the losses are maximum. The proposed methodology is suitable for allocation of single DG in a given distribution network.

2.0 DISTRIBUTION NETWORK RECONFIGURATION

Feeder reconfiguration for loss minimization in distribution systems is realized by changing the status of sectionalizing and tie switches. Most electric distribution networks are operated radially. Configuration alterations are performed by changing the state of network switches in such a way that radiality is always preserved. The optimal operating condition of distribution networks is obtained when line losses are minimized without any violations of branch-loading and voltage limits. Therefore, feeder reconfiguration is implemented to minimize real power losses and at the same time alleviate transformer overload, feeder thermal overload and abnormal voltages of the system. There are two types of switches in the system:

1. normally closed switches connecting the line sections called sectionalizing switches
2. normally open switches on the tie-lines connecting either two primary feeders or two substations, or loop-type laterals called tie-switches. The change in network configuration is achieved by opening or closing of these two types of switches in such a way that the ‘radiality’ of the network is maintained.

2.1 Formulation of Loss Reduction Problem

Feeder reconfiguration is performed by changing the open/closed status of the sectionalizing and ties switches. The system is reconfigured for many purposes. In system reconfiguration, a whole feeder or part of a feeder is transferred to another feeder by closing a tie switch connecting the two, while an appropriate sectionalizing switch must be opened to preserve the radial structure. The loss minimization problem to be addressed in this work is to determine the open/closed states of the tie and sectionalizing switches in order to achieve a maximum reduction in power losses. The change in losses can be easily estimated from the two power flow solutions, which are obtained before and after feeder reconfiguration. However, the number of switching options even for a moderate size distribution system is so large and therefore a large number of load flow solutions have to be executed for all the possible options. It becomes not only inefficient from a computational point of view, but also unrealistic as a feeder reconfiguration strategy. Therefore, it is desirable to propose a method that can provide a criterion that may be used to eliminate the undesirable switching options.

2.2 Objective Function for Loss Minimization by Reconfiguration

To solve the loss reduction problem, it is necessary to calculate the change of losses by various switching options and to select the switching candidates which give the maximum loss reduction. Active and reactive power losses in the network can be calculated using the following equations.

$$LP_{jj} = \frac{R_{jj}[P_{jj}^{2} + Q_{jj}^{2}]}{|V_{jj}^{2}|} \tag{1}$$

$$LQ_{jj} = \frac{X_{jj}[P_{jj}^{2} + Q_{jj}^{2}]}{|V_{jj}^{2}|} \tag{2}$$

where LP_{jj} and LQ_{jj} are active and reactive power losses in the branch jj. R_{jj} and X_{jj} are resistance and reactance of branch jj. V_{jj} is the voltage of sending node. It is clear from (1) that the power loss in the system is inversely proportional to the voltage square of sending node. Sending node voltage can be calculated using following equation:

$$V_{m2} = V_{m1} - I_{(jj)} \times Z_{(jj)} \tag{3}$$

where V_{m2} is the voltage of load side node of branch jj, V_{m1} is source side node voltage of branch jj. By selecting proper combination of switches, source side voltage can be improved which in turn automatically improves voltage of receiving node, as well as the voltage profile of follower branches.

The tie switch or sectionalizing switch can be sorted in descending order as per the voltage difference. The switch with the highest voltage difference should be operated first. To reduce total power loss, lower voltage side branch has to be opened first. This will continue till the voltage difference between open switches is less than 0.001 pu. The steps used to determine the branch to be exchanged give the maximum loss reduction, which is described in next section.

2.3 Reconfiguration Algorithm

1. Run the load flow program to find out total power loss and voltage across open switches.
2. Check weather voltage difference across open switch is less than 0.001 or not if yes then select these switchs and save its value in array variable nmb.
3. Short array nmb in descending order to find switch with maximum voltage difference.
4. Start with the first switch of nmb relay. Close that switch and open branch at lower voltage side.
5. Run load flow and calculate power loss.
6. Continue step no 4 until power loss of new switch combination is greater than previous combination. With the constraint that source node should not be opened, network should be radial and all load must be served.
7. Again repeat steps no 5 and 6 for other variables of nmb array.
8. After changing combination of all open switches (one cycle of reconfiguration) ,compare power loss of new network with previous network power loss if it is less then again start from step 1.
9. If after reconfiguration loss of network is same as previous network, then stop repeating reconfiguration and print results.

Flow chart for the same is shown in Figure 1.

2.4 Results for Reconfiguration

Results for power loss after reconfiguration for 32, 68 and 117 bus have shown in Table 1.

TABLE 1

RESULTS FOR RECONFIGURATION

Radial network	**Power loss actual (kW)**	**Loss (kW) after rec existing method [1]**	**Loss (kW) after rec proposed method**
32 Bus	211	139.5	139.5
68 Bus	224	98	98
117 Bus	1250	859	859

3.0 DISTRIBUTED GENERATOR PLACEMENT

Distributed generation is an electric power source connected directly to the distribution

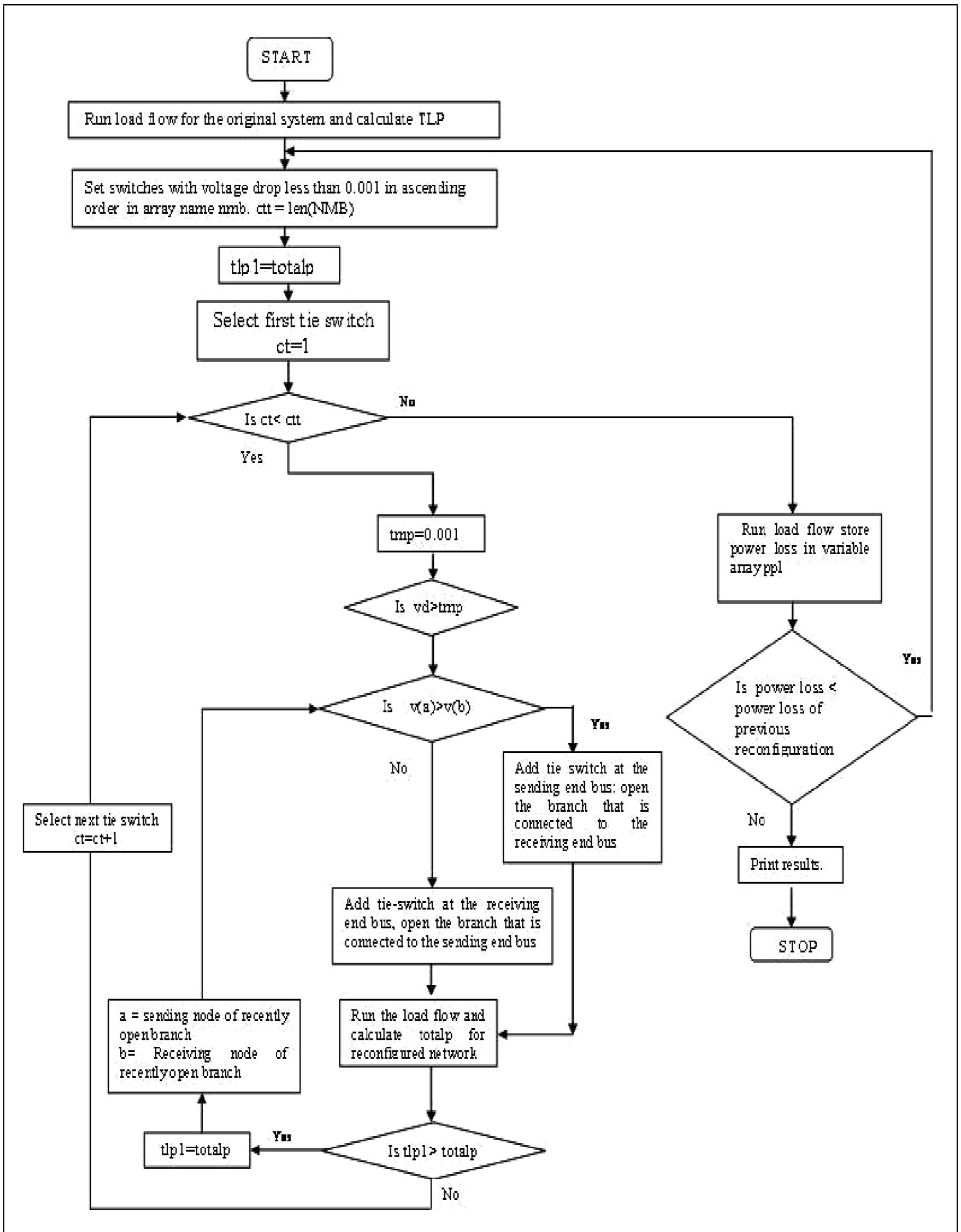

FIG. 1 FLOW CHART FOR RECONFIGURATION

network or customer side of the meter [10]. It may be understood in simple term as small-scale electricity generation. The definition of distributed generation takes different forms in different markets and countries, and is defined differently by different agencies. International Energy Agency (IEA) defines Distributed generation as generating plant serving a customer on-site or providing support to a distribution network, connected to the grid at distribution-level voltages. CIGRE defines DG as the generation, which has the following characteristics: it is not centrally planned; it is not centrally dispatched at present; it is usually connected to the distribution network; it is smaller than 50–100 MW. Other organization like Electric Power Research Institute defines distributed generation as generation from a few kilowatts up to 50 MW [10]. In general, DG means small-scale generation.

There are a number of DG technologies available in the market today and few are still in research and development stage. Some currently available technologies are reciprocating engines, micro turbines, combustion gas turbines, fuel cells, photovoltaic, and wind turbines. Each one of these technologies has its own benefits and characteristics. Among all the DG, diesel or gas reciprocating engines and gas turbines make up most of the capacity installed so far. Simultaneously, new DG technology like micro turbine is introduced and an older technology like reciprocating engine is improved [10]. Fuel cells are technology for the future. However, there are some prototype demonstration projects. The costs of photovoltaic systems are expected to fall continuously over the next decade.

DG also has several benefits like reducing energy costs through combined heat and power generation, avoiding electricity transmission costs and less exposure to price volatility. Although the DG is considered as a viable solution, it creates auxiliary problems towards the utility. Moreover, there are many problems, e.g. DG integration into grid, pricing, change in protection scheme, nuisance tripping, etc. that needs to be addressed. Furthermore, the type of DG technology adopted will have a significant impact on the solution approach. In this study, it is assumed that DGs are capable of supplying real power only.

3.1 Objective Function for Loss Minimization by DG

To find out the optimum loss reduction, it is necessary to calculate the changes of losses after inserting DG into the system. By comparing losses of different capacity of DG at different locations, the optimum capacity of DG can be found out which can reduce the losses to minimum. If DGs of capacity P_{DG} are installed at branch i, then total power of that branch will be given as:

$$P_i = P_i^{Act} - P_{DG} \tag{2}$$

Value of P_i will start increasing in negative direction when value of P_{DG} will become more than actual value of connected load P_i^{Act}. By replacing the actual load of branch with this new load P_i, new load data can be obtained. From new load data power loss of network can be found out by forward backward swap method. This process will be repeated for different capacity of load varying from 10 kW to maximum or until minimum loss condition occurs on that node. This will give the optimum DG capacity for that node.

The above-mentioned processes for all nodes have to be repeated one by one to find out optimum DG capacity and minimum loss for each node. By comparing these values minimum loss condition for network can be found out and optimum DG capacity for that minimum loss can be obtained.

3.2 The Algorithm for DG Placement

1. Run the load flow program to find out total power loss and voltage across open switches.
2. Start connecting DG from the first receiving node 2 and is continued till the last receiving node.
3. Consider loss before DG placement as minimum loss (loss min) for that node.
4. Install DG of starting capacity (variable DGC) from 10 kW. Loop variable kkk=1.
5. Subtract installed DG value (DGC) from the connected load.
6. Run load flow and calculate power loss.
7. If power loss is less than minimum loss, then consider power loss with this DG as minimum loss. Store capacity of DG in variable sub.
8. If kkk (DG capacity loop count) >2 and loss of (kkk) > loss of (kkk-1) and loss of (kkk-1) > loss of (kkk-2) then stop increasing DG capacity for that node and go to step 10.
9. If max DG capacity not reached, then increase DGC by 10 and kkk by 1go to step no. 5.
10. Print Loss and DG capacity.
11. If final node is not reached, then increase nmin by 1 and go to step no. 3.

Flow chart for the same is presented in Figure 2. Results after one DG placement is shown in Table 2.

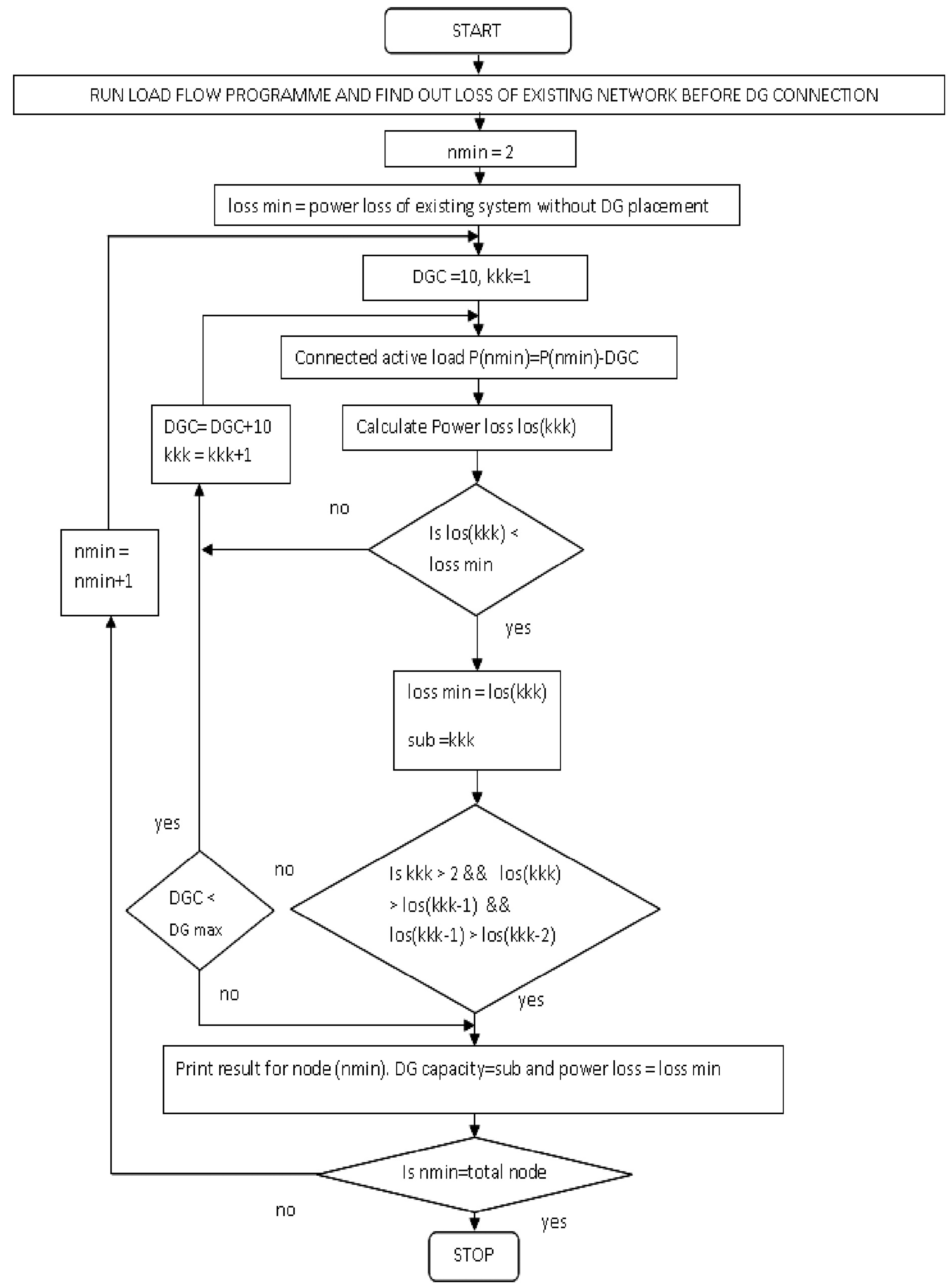

FIG. 2 FLOW CHART FOR DG PLACEMENT

TABLE 2				
RESULTS FOR DG PLACEMENT				
	Without DG	**Only one DG**		
System	**Total loss**	**Node**	**DG capacity**	**Total loss**
		Proposed Method		
32 Bus	211	6	2590	110.99
68 Bus	224	61	1870	83.312
117 Bus	1250	74	2980	996.81
		Other Method [8]		
32 Bus	211	6	2590	110.99
68 Bus	224	61	1870	83.312
117 Bus	1250	74	2980	996.81

4.0 DISTRIBUTED GENERATOR PLACEMENT AFTER RECONFIGURATION

After reconfiguration, algorithm and flow chart for DG placement will remain same. Then repeat the step described in Section 2. Afterwards, the data of the reconfigured system will become the base data for the DG placement calculations. By following above-mention steps, optimum capacity of DG and its location can be obtained.

5.0 CASE STUDIES

To demonstrate the effectiveness of the proposed method, three test cases have been selected. The first test case is a 32-bus distribution feeder. The second and third test cases are for 68 and 117 bus distribution system, respectively. Tables 3, 4 and 5 gives results for 32 bus, 68 bus and 117 bus cases, respectively. In all these cases value of DG before and after reconfiguration has been compared. It has been observed that on any node after reaching to optimum capacity of DG if the value of injected DG power is increased, further loss of network starts increasing. Same results have shown for 32 bus system in Figure 3. Comparison between DG capacity for system without reconfiguration and system with reconfiguration is shown in Table 6.

TABLE 3				
RESULTS FOR 32-BUS NETWORK				
	Before reconfiguration DG capacity		**After reconfiguration DG capacity**	
Node No.	**DG capacity (kW)**	**Loss (kW)**	**DG capacity (kW)**	**Loss (kW)**
2	4100	200.991	3980	130.336
3	3650	160.489	2690	112.386
4	3180	147.857	2190	110.187
5	2910	135.804	1910	107.752
6	2590	110.992	1620	101.99
7	2460	111.968	1500	104.396
8	1790	118.093	960	112.787
9	1560	121.357	860	113.544
10	1400	123.678	730	120.38
11	1370	124.148	750	119.801
12	1330	125.203	800	118.749
13	1170	129.401	660	121.255
14	1110	130.996	610	122.156
15	1060	133.465	710	114.708
16	1000	136.723	670	115.206
17	900	142.534	600	116.39
18	850	145.682	570	117.207
19	1720	206.148	2310	130.92
20	480	208.345	1390	117.257
21	420	208.452	1340	113.918
22	340	208.792	1120	115.814
23	2470	169.786	1930	114.733
24	1710	173.767	1420	114.161
25	1300	179.324	1100	117.048
26	2450	112.898	1560	101.51
27	2280	115.313	1480	101.03
28	1850	120.96	1260	99.291
29	1640	123.227	1150	98.076
30	1540	125.115	**1090**	**98.04**
31	1350	131.175	970	100.166
32	1300	133.543	930	101.27
33	1230	137.281	550	118.027

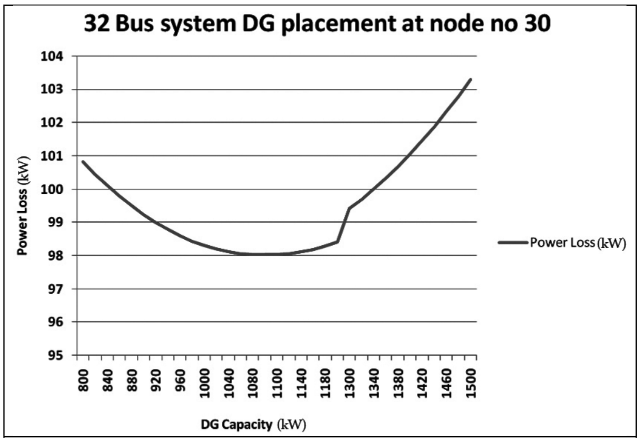

FIG. 3 GRAPH POWER LOSS VS DG CAPACITY

TABLE 4

RESULTS FOR 68-BUS NETWORK

	Before reconfiguration DG capacity		**After reconfiguration DG capacity**	
Node No.	**DG capacity (kW)**	**Loss (kW)**	**DG capacity (kW)**	**Loss (kW)**
2	4100	225.023	4080	98.638
3	4100	224.904	4080	98.534
4	4100	224.703	3550	98.426
5	3300	223.167	1080	98.53
6	3110	200.816	710	97.489
7	3040	178.454	690	96.395
8	3020	173.321	680	96.164
9	3000	170.828	560	96.091
10	1960	181.197	540	95.312
11	1850	182.102	540	95.152
12	1500	186.037	450	95.286
13	1180	191.301	330	96.183
14	1000	194.05	260	96.72
15	880	195.631	740	90.305
16	860	195.83	730	89.738
17	830	196.344	720	88.821
18	830	196.355	720	88.812
19	800	197.143	690	88.36
20	780	197.604	680	88.063
21	750	198.293	660	87.578
22	750	198.337	660	87.571
23	730	198.804	650	87.5
24	700	199.773	630	87.33
25	640	201.779	590	87.055
26	620	202.511	570	86.919
27	610	202.921	570	86.855
28	1520	225.055	1420	98.666
29	190	225.126	180	98.727
30	60	225.131	60	98.731
31	60	225.131	60	98.73
32	50	225.128	50	98.727
33	50	225.125	50	98.72
34	40	225.127	40	98.715
35	30	225.136	30	98.72
36	1630	225.042	2000	98.592
37	290	225.106	960	98.358
38	200	225.101	880	97.906
39	190	225.098	880	97.776
40	190	225.098	870	97.768
41	110	225.077	800	94.986
42	100	225.064	790	93.81
43	100	225.062	790	93.655
44	100	225.062	790	93.621
45	100	225.059	780	93.216
46	100	225.059	780	93.212
47	2760	224.809	3030	98.339
48	80	224.569	80	93.512
49	820	223.506	2260	86.154
50	750	223.512	2180	84.432
51	2740	178.066	620	96.38
52	2050	189.857	470	96.977
53	2830	167.33	580	96.443
54	2690	163.039	500	96.738
55	2540	157.059	410	97.062
56	2420	151.232	350	97.315
57	2090	118.721	190	97.971
58	2000	103.444	150	98.114
59	1960	97.667	1520	59.993
60	1920	91.464	1480	56.096
61	**1870**	**83.312**	**1440**	**50.989**

62	1850	84.816	450	87.536
63	1810	87.07	450	87.374
64	1650	96.702	490	86.488
65	1440	112.234	**60**	**83.432**
66	1680	185.912	490	95.445
67	1680	186.002	490	95.451
68	1190	193.789	370	95.849
69	1190	193.834	370	95.853

TABLE 5

RESULTS FOR 117-BUS NETWORK

	Before reconfiguration DG capacity		**After reconfiguration DG capacity**	
Node No.	**DG capacity (kW)**	**Loss (kW)**	**DG capacity (kW)**	**Loss (kW)**
2	5100	1252.176	4100	837.662
3	5100	1259.279	4100	842.252
4	5100	1228.572	4100	817.685
5	5100	1231.381	4100	816.164
6	5100	1234.282	4100	814.721
7	5100	1237.284	4100	813.473
8	5100	1241.034	4100	812.113
9	5100	1245.459	4100	813.13
10	5100	1254.904	3570	837.475
11	3060	1253.395	2940	836.241
12	3060	1260.745	2050	841.302
13	3060	1263.493	1710	843.077
14	3060	1265.773	1440	844.503
15	3060	1267.416	1270	845.647
16	3060	1268.763	1140	846.571
17	3060	1269.833	1030	847.314
18	2390	1252.334	2170	837.723
19	2200	1251.07	1970	837.578
20	2010	1249.897	1750	837.683
21	2010	1250.927	1570	839.3
22	2010	1252.222	1420	841.023
23	2010	1258.258	660	850.012
24	2010	1258.864	2960	816.289
25	2010	1259.411	2670	815.66
26	2010	1260.385	740	849.819
27	2010	1261.296	810	848.955
29	5100	1221.215	4100	814.629
30	5100	1215.923	4100	812.68
31	5100	1191.997	4100	802.606
32	5100	1170.72	3530	811.735
33	4750	1164.331	2950	816.861
34	4190	1159.229	2320	824.56
35	3800	1154.001	1910	830.083
36	3550	1150.645	2100	811.986
37	3550	1216.327	3815	806.517
38	3550	1227.914	3190	810.219
40	3550	1231.111	2170	841.769
41	2710	1230.575	1290	848.572
42	2350	1227.484	2400	824.632
43	2350	1227.613	1960	826.772
44	2350	1231.238	1180	832.993
45	2350	1235.864	520	851.499
46	2350	1238.592	570	851.012
47	2350	1241.761	620	850.445
48	2350	1244.115	670	849.991
49	3270	1146.77	1960	810.608
50	3150	1144.607	1890	809.954
51	3010	1142.2	1810	809.377
52	2880	1140.42	1740	809.212
53	2880	1148.08	1320	828.171
54	2880	1152.342	1390	826.839
55	2880	1171.365	1160	832.099
56	2170	1165.032	1680	822.092
58	2170	1247.69	2420	834.372
59	2170	1252.137	1660	837.839
60	2170	1253.46	1340	838.909
61	2170	1254.143	1060	839.55
62	2170	1255.984	940	841.254
63	2170	1257.442	840	842.615
64	2170	1258.409	790	843.508
65	2170	1259.854	1980	820.367

66	2170	1263.939	4100	847.941
67	5100	1208.917	4100	804.842
68	5100	1146.097	4100	774.11
69	5100	1129.025	3870	779.251
70	4310	1108.861	2860	787.405
71	3750	1077.946	2300	788.415
72	3470	1054.179	2050	787.201
73	3050	1001.141	1700	782.508
74	2980	996.81	1640	783.665
75	2980	998.066	1660	794.672
76	2980	1000.398	1860	787.774
77	2980	1002.056	2240	762.334
78	2980	1012.812	2420	759.511
79	2980	1036.258	1890	779.122
80	2980	1041.562	1370	801.497
81	2980	1206.856	4000	758.194
82	3070	1203.287	3740	746.165
83	3070	1205.763	3260	754.965
84	3070	1212.328	2730	768.669
85	3070	1216.468	2470	776.272
86	3070	1222.986	1490	805.281
87	3070	1229.349	1380	809.295
88	3070	1233.172	1300	811.912
89	2670	1211.237	3400	748.174
90	2670	1221.348	3040	752.976
91	2670	1227.917	2800	755.885
93	3310	1173.508	3310	772.723
94	3310	1174.436	2750	768.524
95	2680	1173.84	2560	763.878
96	2680	1185.402	2240	774.28
97	2680	1195.222	1990	783.181
98	2680	1202.679	1800	789.974
99	2680	1214.913	1500	801.144
100	2510	1175.485	2400	764.383
101	2510	1180.751	2230	768.527
102	2510	1188.372	2050	775.122
103	2510	1209.613	1570	793.561
105	2510	1261.038	4100	843.256
106	5100	1228.64	4010	830.055
107	4890	1205.642	3540	821.869
108	4440	1176.7	3020	813.493
109	3900	1135.165	2490	803.51
110	3770	1121.881	2370	800.376
111	3550	1097.771	2180	794.957
112	3460	1087.484	2110	792.794
113	3210	1073.55	1890	793.425
114	3110	1069.51	1790	795.527
115	3110	1069.554	1790	773.885
116	3110	1075.235	1710	773.528
117	3110	1080.191	1690	777.154
118	3110	1093.456	1580	782.239
119	3110	1272.39	2520	822.427
120	3110	1272.839	2380	816.737
121	3110	1273.477	2200	806.279
122	3110	1274.352	2050	797.247
123	3110	1275.116	1920	787.125

TABLE 6

DG CAPACITY AFTER AND BEFORE RECONFIGURATION

	DG before reconf		DG after reconf	
System	**DG capacity**	**Total loss**	**DG capacity**	**Total loss**
32 Bus	2590	110.99	1090	98.037
68 Bus	1870	83.312	1440	50.989
117 Bus	2980	996.81	1640	783.67

6.0 CONCLUSIONS

In this paper, a novel algorithm is proposed to calculate the optimum size of DG at various nodes and methodology to identify the optimum location corresponding to the optimum size for reduction of total power losses in distribution system. The proposed methodology has been tested in 32 bus, 68 bus and 117 bus test systems and satisfactory results have been obtained. It identifies the best location for single DG placement in order to minimize the total power losses. The same methodology has been used to calculate optimum size and location of DG after reconfiguring system. From the results, it is clear that DG capacity after reconfiguration reduces drastically compared to the DG capacity before reconfiguration.

REFERENCES

[1] Sivanagaraju S, Srikanth Y, and Babu, Jagadish E. "An efficient genetic algorithm for loss minimum distribution system reconfiguration", Electric Power Components and Systems, Vol. 34, pp. 249–258, 2006.

[2] Zhang D, Fu Z, and Zhang L. "An improved TS algorithm for loss-minimum reconfiguration in large scale distribution systems", Electric Power Systems Research, Vol. 77, pp. 685–694, 2007.

[3] Ching-Tzong Su, Chung-Fu Chang and Chu-Sheng Lee. "Distribution network reconfiguration for loss reduction by hybrid differential evolution", Electric Power Components and Systems, Vol. 33, pp. 1297–1312, 2005.

[4] Das D. "Reconfiguration of distribution system using fuzzy multi-objective approach", Electrical Power and Energy Systems, Vol. 28, pp. 331–338, 2006.

[5] Subrahmanyam J.B.V, Radhakrishna C. "A simple method for feeder reconfiguration of balanced and unbalanced distribution systems for loss minimization", Electric Power Components and Systems, Vol. 38, pp. 72–84, 2010.

[6] Lin W M, Cheng F S, Tsay M T. "Distribution feeder reconfiguration with refined genetic algorithm", IEE Proc Generation Transmission Distribution, Vol. 147, pp. 349–54, 2000.

[7] Mandoza J, Lopez R, Mordles D, Lopez E. "Minimun loss reconfiguration using genetic algorithms with restricted population and addressed operators: Real application", *IEEE, Transactions on Power Systems*, Vol. 21, pp. 948–955, 2006.

[8] Kumar Injeti S, Dr. Navuri P Kumar, "Optimal planning of distributed generation for improved voltage stability and loss reduction", International Journal of Computer Applications, Vol. 15, pp. 8887–8975, 2011.

[9] Vinoth kumar K and Selvan M P. "Planning and operation of distributed generations in distribution systems for improved voltage profile", *IEEE, Transaction on power systems.* Vol. 09, pp. 3811–4244, 2009.

[10] Naresh Acharya, Pukar Mahat, Mithulananthan N. "An analytical approach for DG allocation in primary distribution network", Electrical power and energy systems, Vol. 28, pp. 669–678, 2006.

[11] Khorshidi R, Niknam T and Nayeripour M. "Distribution feeder reconfiguration considering distributed generators", World Academy of Science, Engineering and Technology, Vol. 46, 2008.

[12] Rugthaicharoencheep N and Sirisumrannukul S. "Feeder reconfiguration with dispatchable distributed generators in distribution system by tabu search", *IEEE, Transaction on power systems*. Vol. 44, pp. 947–978, 2009.