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Multi objective Network Reconfiguration of Distribution systems with Distributed Generators

G. Balakrishna[1], Ch. Sai Babu[2]

Associate Professor, Dept. of EEE, Intell Engineering College, Anantapur, A.P, India

Professor, Dept. of EEE, JNTUK, Kakinada, A.P, India

ABSTRACT*:* In this paper an algorithm based on modified discrete particle swarm algorithm (MDPSO) and modified particle swarm optimization (MPSO) is proposed to find the optimal network reconfiguration and optimal size of the DG units. The loss sensitive factors are used to identify the sensitive nodes to fix the optimal locations of DG units and its size is obtained by the modified particle swarm optimization algorithm. The problem has been solved by considering the multiple objective functions of minimization of power loss, minimization of cost function and minimization of deviation of bus voltage subjected to a set of practical constraints. The proposed algorithm is tested on IEEE-33 and IEEE-69 radial distribution system and results are presented and analyzed.

KEYWORDS*:* Network reconfiguration, Loss sensitive factors, optimal DG sitting and sizing, multi objective function, modified particle swarm optimization, modified discrete particle swarm optimization.

I. INTRODUCTION

Electrical Power system utilities continuously and constantly expecting new and latest technologies that will cause to improve the performance of power delivery. Electrical power generators that generate electrical power at small ratings are treated as Distributed Generators (DGs). These DG units are going to be installed in the distribution systems itself will relieve the conventional generating stations and existing transmission and distribution lines from being excessive power transfer burden and hence reduces the losses and improves the voltage profile. Network reconfiguration of distribution system is the process of changing the on/off patterns of sectionalizing switches and tie switches that alters the topological structure of the network and hence reduces the current through the various branches of the system and causes to lower the power loss.

Under normal operating conditions, achieving the objectives eliminates the excessive transformer load, over heating of conductor, minimizes the abnormal voltages and reduces the real power loss. One of the early papers on the topic of network reconfiguration was presented by Merlin and Back [1]. Civanlar et al [2] reported a paper on reconfiguration problem with the aim of reducing the power loss. Baran and Wu [3] reported the problem of loss reduction and load balancing as an integer programming. Prasad and Nara et al. [4-5] proposed a genetic algorithm to obtain the minimum loss configuration. Shirmohammadi and Hong [6,7] reported a power flow method based heuristic algorithm to obtain the minimum loss configuration for radial distribution networks. It is assumed that the penetration of the distributed generation will surpass more than 25% of the total generation, in the foreseeable future [8]. V. Gomes and S. Carneiro [9] suggested a heuristic algorithm to determine the optimal configuration of the network and for minimization of loss. V. Parada, J.A. Ferland [10] have proposed a solution procedure, employing simulated annealing (SA), to search an acceptable non-inferior solution. In [11,12], the authors have presented artificial intelligence-based applications. In [13], the authors have discussed time-varying load analysis to reduce losses. In [14,15], the authors have combined the optimization techniques with

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heuristic rules and fuzzy logic for higher efficiency and robust performance. Recently, genetic algorithm (GA) and evolutionary programming have been used [16].

II. MPSO AND MDPSO

In basic PSO, the velocity of any element of any particle is updated by using equation

$$V_{id}^{k+1} = \omega.V_{id}^{k} + c1.rand*(Pbest_{id} - S_{id}^{k}) + c2.rand*(Gbest_{id} - S_{id}^{k}) \quad \ldots(1)$$

This velocity update equation given above has three components:

i) The first term - "Momentum" or "Inertia".

ii) The second term -"Self knowledge" or "Memory".

iii) The third term -"cooperation", "group knowledge" or "shared information".

In MPSO in addition to the particles with best solution, particles having worst solution are also considered and the velocity update equation is modified as

$$V_{id}^{k+1} = \begin{bmatrix} \omega.V_{id}^{k} + c1\times r1\times k1\times(Pbest_{id} - S_{id}^{k}) + c2\times r2\times k2\times(Gbest_{id} - S_{id}^{k}) + \\ c3\times r3\times k3\times(Pworst_{id} - S_{id}^{k}) + c4\times r4\times k4\times(Gworst_{id} - S_{id}^{k}) \end{bmatrix} \quad \ldots(2)$$

Where,

Gbest	is the global best of the entire swarm
Gworst	is the global worst of the entire swarm
C1 and C3	are the cognitive acceleration coefficients
C2 and C4	are the social acceleration coefficients
K=[k1,k2,k3,k4]	is switch matrix and its value is [1,1,0,0] for best particles and[0,0,1,1] for worst particles
P_{best}	is the particle's best
P_{worst}	is the particle's worst
r1,r2,r3 and r4	are the random numbers between 0 to 1
K	is the previous iteration number
K+1	is the current iteration number
S_{id}^{k}	is the position of i^{th} particle
V_{id}^{k}	is the velocity of i^{th} particle

The individual element's position in $(k+1)^{th}$ iteration can be modified according to

$$S_{id}^{k+1} = S_{id}^{k} + V_{id}^{k+1} \quad \ldots(3)$$

i = 1,2,……,n. d = 1,2,…..,m.

This modified particle swarm optimization technique is used to find the optimal sizes of DG units whose locations are fixed by the sensitivity analysis.

Modified Discrete Particle swarm optimization: In equation (2), the values of parameters $P_{best,id}$, $Gbest,id$ and S_{id}^{k} may have real values during the process of optimization, but in reconfiguration problem the particle consists of status of tie switches and sectionalizing switches that may be either 0 or 1 ('0' represents open and '1' represent the close). Therefore it is required to consider these values of $P_{best,id}$, $Gbest,id$, S_{id}^{k} and V_{id}^{k} either 0 or 1. The values of updated values of $(P_{best,id} - S_{id}^{k})$ and $(G_{best,id} - S_{id}^{k})$ will takes a values of [-1, 0 or 1]. In order to achieve this, a logical transformation $S(V_{id}^{k})$ is used. Therefore the resulting change in position is then defined by the rule:

$$X_{id}^{k} = \begin{cases} 1\cdots\cdots rand(.) \le S\left(V_{id}^{k}\right) \\ 0\cdots\cdots otherwise \end{cases} \quad \ldots(4)$$

$$\left(V_{id}^{k}\right) = \frac{1}{1+\exp(-V_{id}^{k})} \quad \ldots(5)$$

Each particle of a swarm is randomly initiated in values 0 or 1 and then objective function is determined according to this initial guess. Next, for each iteration, $P_{best,id}$ is calculated according to the results obtained for each particle, and $G_{best,id}$ is found based on all the previous iterations. Then in the next iteration, two partial probability values $(P_{best,id} - S_{id}^{k})$ are added to or subtracted from the previous state of each element.

III. PROBLEM FORMULATION

The main goal of the proposed method is to determine the optimal locations and their optimal sizes of the DGs and reconfiguration of the distribution system by MPSO and MDPSO respectively. Three objective functions of minimization of power loss, cost function and deviation of bus voltage are considered to solve the problem.

Sensitivity analysis is used to identify the sensitive nodes to install DG units. 3.1 Objective Functions:

3.1.1 Minimization of active power loss:

Minimization of power loss is considered as first objective function for the placement of DG.

$$f_1(x) = Minimizing \sum_{l=1}^{N_l} \left[\left|I_l\right|^2 \times R_l \right] \quad \ldots(6)$$

Where I_i is the current through branch 'i' and R_i is the resistance of branch 'i'.

3.1.2 Minimization of cost function

Cost function minimization is considered as second objective function. Cost function consists of cost of DG units, cost of substation, cost of capacitor units and cost of energy loss. This cost function is considered for 15 years.

$$f_2(x) = Minimizing \sum_{i=1}^{N_{DG}} C(DG_i) + P_{sub} \times T \times price_{sub} + C(E_L) + \sum_{i=1}^{cn} C(CB_i) \quad \ldots(7)$$

Where N_{DG} is the number of dg units used, $C(DG_i)$ is cost of energy generated by the i^{th} DG units (\$), $C(E_L)$ is the cost of energy loss, P_{sub} is the real power supplied by the substation bus (kWh), $Price_{sub}$ is the price of energy at substation in (\$/kWh). In this work three DGs (Fuel cell, photo voltaic and wind turbines) are used and their cost functions has taken from [17].

3.1.3. Minimization of deviation of bus voltage (D.V.B)

Minimization of deviation of bus voltages is considered as third objective, mathematically it is given as

$$f_2(x) = Minimizing \sum_{i=1}^{N_b} \left|V_r - V_i\right| \quad \ldots(8)$$

Where Nb is the number of buses or nodes, Vi is the voltage magnitude at i^{th} bus

Vr is the rated voltage magnitude at i^{th} bus (1 p.u.)

3.2 Constraints:

The above objective function is solved by considering a set of practical constraints.

(i) Voltage magnitude constraint - $V_{\min} \le V_j \le V_{\max}$

(ii) Feeder capability constraint - $I_k \le I_k^{\max}, k \in \{1,2,3......l\}$

(iii) Distributed generator constraint

$$W_i.P_{G,i}^{\min} \le P_{G,i} \le W_i.P_{G,i}^{\max} \qquad i \in N \text{ and } i \ne Sub \quad \ldots(9)$$

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$$W_i.Q_{G,i}^{\min} \le Q_{G,i} \le W_i.Q_{G,i}^{\max} \qquad i \in N \text{ and } i \ne Sub$$

(iv) Radial nature of the network constraint

Det[A] =1 or -1 for radial system …(10)

Det[A] = 0 not a radial system …(11)

Multi-objective network reconfiguration problem can be formulated mathematically as a constrained optimization problem with an objective function of the form

$$f(X) = Minimizing\left[\begin{array}{l} W_1 \times \sum_{l=1}^{N_l}\left[\left|I_l\right|^2 \times R_l\right] + W_2 \times \left(\sum_{i=1}^{N_{DG}} C(DG_i) + P_{sub} \times T \times price_{sub} + C(P_L)\right) \\ + W_3 \times \sum_{i=1}^{N_b}\left|V_r - V_i\right| \end{array}\right] \quad ….(12)$$

Where

For case-1

X=(TS_1, TS_2,……..TSn,SS_1, SS_2,……..SSn)

For case-2

X=(TS_1, TS_2,……..TSn,SS_1, SS_2,……..SSn, Pdg_1, Pdg_2…..Pdgn, Qdg_1, Qdg_2,….Q_{dgNdg})

Where

TS_i is the first tie switch, SS_i is the sectionalizing switch of any randomly selected line from the group of lines that forms the loop by closing TS_i, P_{dgi} and Q_{dgi} are the real and reactive power output of i^{th} DG unit, W_1, W_2 and W_3 are the weighing factors and W_1+W_2+W_3=1.0.

IV. RESULTS AND ANALYSIS

The effectiveness of the proposed algorithm has tested on IEEE-33 and IEEE-69 radial distribution systems for two cases

Case 1: Optimal network reconfiguration without DG units
Case 2: Network reconfiguration with optimal DG sizing

The objective function values are calculated by considering a single objective values, three combinations of two objective functions and three objective functions for different weight factors. Weight factors are obtained based on non-dominated solutions that are obtained from Pareto set dominance criterion.

Based on sensitivity analysis three DG units are installed at buses 17, 18 and 33 for IEEE-33 and at busses 65, 64 and 63 for IEEE-69 bus radial distribution system.

The simulation results IEEE-33 bus system for single objective of minimization of loss, minimization of cost function and minimization of deviation of bus voltage are given in table 1. From these results it is observed that the objective function values have been reduced, when reconfiguration of the system is carried along with the DG units when compared to the objective functions obtained for reconfiguration only. It is also identified from this multi objective MDPSO results that, giving priority (allocating higher weight factor) for one objective function does not show much improvement in the other two objective function values.

The multi objective results of IEEE-33 bus system for two objective functions in three combinations and three objective functions for different weight factors are given table 2 and 3. Convergence characteristics of the MDPSO for IEEE-33 bus system for single objective function is shown in fig.1.

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Table 1: Results of IEEE-33 bus system for different single objective functions

S.No.	Control Parameter	Original System	Minimization of power loss		Minimization of Cost function		Minimization of Deviation of bus voltage	
			With Reconfigu-ration only	Simultaneous Reconfiguration with DG units	With Reconfigu-ration only	Simultaneous Reconfiguration with DG units	With Reconfigu-ration only	Simultaneous Reconfiguration with DG units
1	Switches to be opened	-	6	7	3	19	33	6
2		-	14	13	34	14	10	34
3		-	10	10	9	9	13	9
4		-	17	16	15	36	30	17
5		-	37	29	29	24	24	29
6	P_{DG1}	-	-	178.32	-	144.27	-	169.98
7	P_{DG2}	-	-	77.36	-	54.32	-	74.12
8	P_{DG3}	-	-	748.19	-	641.49	-	749.22
9	Q_{DG3}	-	-	647.48	-	412.87	-	717.46
10	Power Loss (kW)	211.48	136.47	81.24	137.11	86.19	142.47	82.37
11	Cost function *(Million $)*	31.4111	29.4255	26.6172	29.4266	26.5439	29.5043	26.8124
12	D.V.B	1.806	0.911	0.816	0.938	0.828	0.901	0.818

Table 2: Results of IEEE-33 bus system for two objective functions for different weight factors

Set No.	Weighing Factors		Combination-1				Combination-2				Combination-3			
			Case-1 (Reconfiguration only)		Case-2 (Reconfiguration with DG units)		Case-1 (Reconfiguration only)		Case-2 (Reconfiguration with DG units)		Case-1 (Reconfiguration only)		Case-2 (Reconfiguration with DG units)	
	W1	W2	T.P.L (kW)	Cost function (Million *$)*	T.P.L (kW)	Cost function (Million *$)*	Cost function (Million *$)*	D.B.V	Cost function (Million *$)*	D.B.V	T.P.L (kW)	*D.B.V*	T.P.L (kW)	D.B.V
1	0.1	0.9	144.88	29.4172	89.34	26.5108	29.5122	0.902	24.5982	0.719	145.65	0.903	89.56	0.718
2	0.2	0.8	141.18	29.4356	86.71	26.5186	29.5122	0.902	26.5982	0.719	145.65	0.903	89.56	0.718
3	0.3	0.7	141.18	29.4356	86.71	26.4186	29.4687	0.915	26.5687	0.789	138.71	0.918	84.48	0.804
4	0.4	0.6	139.49	29.4652	83.67	26.5598	29.4687	0.915	26.5687	0.789	141.22	0.918	88.21	0.791
5	0.5	0.5	139.49	29.4652	83.67	26.5598	29.4687	0.915	26.5687	0.801	141.22	0.918	88.21	0.791
6	0.6	0.4	139.49	29.4652	83.67	26.6598	29.4346	0.929	26.6324	0.801	138.71	0.930	84.48	0.804
7	0.7	0.3	137.24	29.4874	81.16	26.6647	29.4346	0.929	26.6324	0.801	138.71	0.930	84.48	0.804
8	0.8	0.2	137.24	29.4874	81.16	26.6647	29.4026	0.941	26.6111	0.832	136.47	0.942	81.31	0.833
9	0.9	0.1	135.84	29.5360	80.85	26.6916	29.4026	0.941	26.6111	0.832	136.47	0.942	81.31	0.833

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Table 3: Results of IEEE-33 bus system for three objectives for different weight factors

S. No.	Weighing Factors			Case-1 (Reconfiguration only)			Case-2 (Reconfiguration with DGs)		
	W1	W2	W3	T.P.L (kW)	Cost function (Million *$)*	D.B.V	T.P.L (kW)	Cost function (Million *$)*	D.B.V
1	0.1	0.1	0.8	152.78	29.6398	0.9018	95.33	26.5781	0.7188
2	0.1	0.8	0.1	152.78	29.4612	0.9389	95.33	26.5246	0.8291
3	0.8	0.1	0.1	139.19	29.6398	0.9389	83.44	26.5781	0.8291
4	0.5	0.3	0.2	142.87	29.5521	0.9311	86.91	26.5517	0.8137
5	0.5	0.2	0.3	142.87	29.5937	0.9247	86.91	26.6579	0.8129
6	0.3	0.5	0.2	146.11	29.5096	0.9311	89.34	26.5345	0.8137
7	0.3	0.2	0.5	146.11	29.5937	0.9124	89.34	26.6579	0.7956
8	0.2	0.5	0.3	149.27	29.5096	0.9247	92.75	26.6351	0.8129
9	0.2	0.3	0.5	149.27	29.5521	0.9124	92.75	26.6517	0.7956

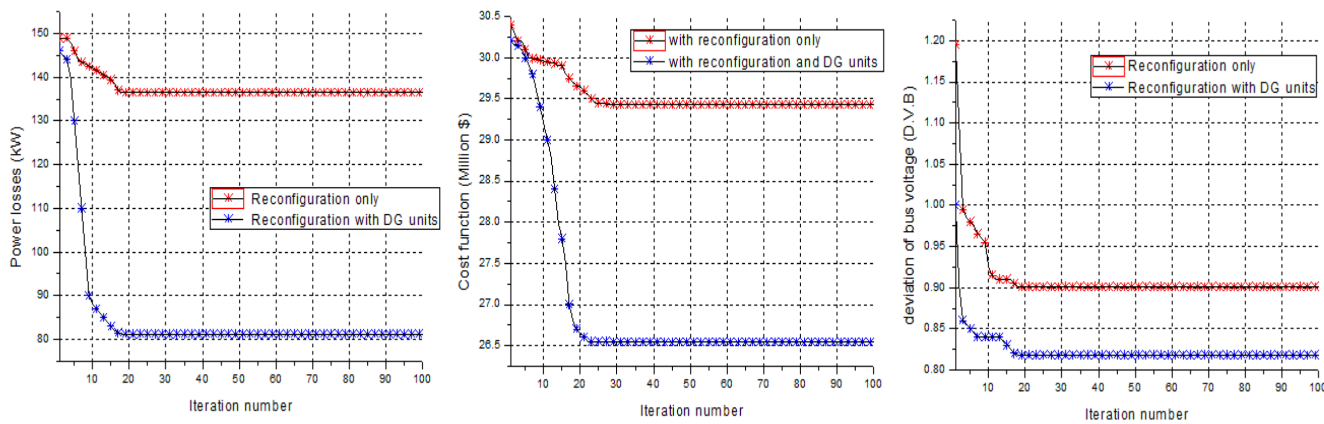

Fig.1. Convergence characteristics of MDPSO for single objective functions of minimization of power loss, cost function and deviation of bus voltage for IEEE-33 bus system

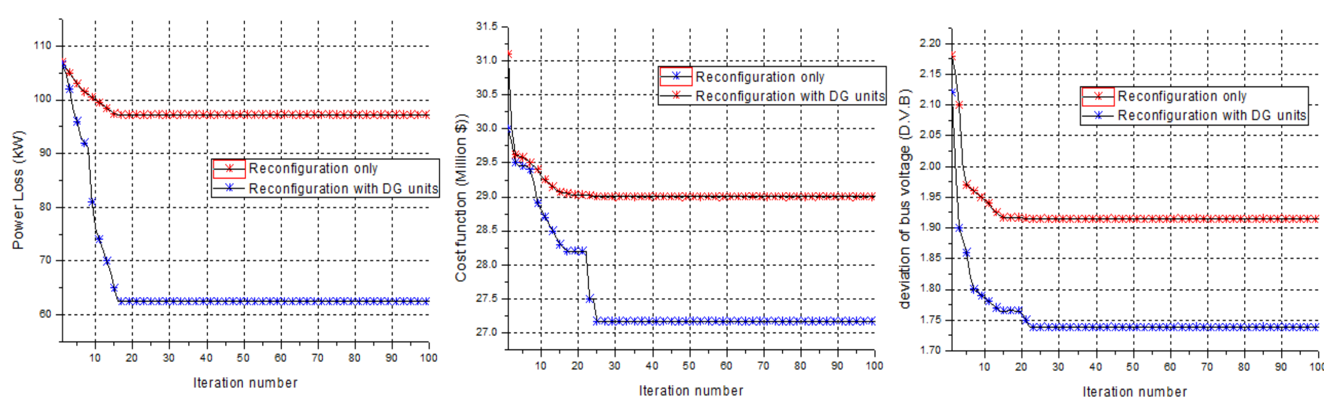

Fig.2. Convergence characteristics of MDPSO for single objective functions of minimization of power loss, cost function and deviation of bus voltage for IEEE-69 bus system

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Similarly the results for IEEE-69 bus system for single objectives are given in table 4 and for two and three objectives are given in table 5 and 6. Convergence characteristics of the MDPSO for IEEE-69 bus system for single objective function is shown in fig.2.

Table 4: Results of IEEE-69 bus system for single objective functions

S.No.	Control Parameter	Original system	Minimization of power loss		Minimization of Cost function		Minimization of Deviation of bus voltage	
			With Reconfiguration only	Simultaneous Reconfiguration with DG units	With Reconfiguration only	Simultaneous Reconfiguration with DG units	With Reconfiguration only	Simultaneous Reconfiguration with DG units
1	Switches to be opened	-	10	40	69	69	10	69
2		-	19	15	16	44	16	18
3		-	14	43	12	13	13	45
4		-	48	57	54	56	56	48
5		-	26	26	26	64	22	26
6	P_{DG1}	-	-	159.24	-	124.36	-	161.37
7	P_{DG2}	-	-	67.47	-	48.73	-	59.72
8	P_{DG3}	-	-	641.27	-	569.31	-	661.61
9	Q_{DG3}	-	-	548.26	-	479.27	-	557.49
10	Power Loss (kW)	224.68	97.24	62.47	98.37	68.74	98.44	63.77
11	Cost function *(Million $)*	30.7053	29.0307	27.4716	29.0011	27.1672	29.0465	27.5472
12	D.V.B	3.8377	1.9358	1.7348	1.9932	1.9146	1.9146	1.7382

Table 5: Results of IEEE-69 bus system for two objective functions for different weight factors

Set No.	Weighing Factors		Combination-1				Combination-2				Combination-3			
			Case-1		Case-2		Case-1		Case-2		Case-1		Case-2	
	W1	W2	T.P.L (kW)	Cost function (Million $)	T.P.L (kW)	Cost function (Million $)	Cost function (Million $)	D.B.V	Cost function (Million $)	D.B.V	T.P.L (kW)	*D.B.V*	T.P.L (kW)	D.B.V
1	0.1	0.9	106.71	29.0300	76.29	27.1689	29.5977	1.915	27.5652	1.735	1.998	96.44	1.760	61.42
2	0.2	0.8	106.71	29.0300	76.29	27.1689	29.5977	1.915	27.5652	1.735	1.998	96.44	1.760	61.42
3	0.3	0.7	103.27	29.3816	71.47	27.2295	29.4816	1.929	27.5248	1.742	1.954	98.18	1.751	64.79
4	0.4	0.6	103.27	29.3816	71.47	27.2295	29.4816	1.929	27.5248	1.742	1.954	98.18	1.751	64.79
5	0.5	0.5	101.11	29.4419	65.98	27.3477	29.4816	1.929	27.5248	1.753	1.931	102.43	1.743	68.11
6	0.6	0.4	101.11	29.4419	65.98	27.3477	29.2144	1.957	27.3812	1.753	1.931	102.43	1.743	68.11
7	0.7	0.3	97.18	29.6471	62.11	27.5642	29.2144	1.957	27.3812	1.753	1.931	102.43	1.743	68.11
8	0.8	0.2	97.18	29.6471	62.11	27.5642	29.0111	1.999	27.1678	1.761	1.914	106.79	1.734	74.86
9	0.9	0.1	97.18	29.6471	62.11	27.5642	29.0111	1.999	27.1678	1.761	1.914	106.79	1.734	74.86

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Table 6: Results of IEEE-69 bus system for three objective functions for different weight factors

S. No.	Weighing Factors			Case-1			Case-2		
	W1	W2	W3	T.P.L (kW)	Cost function (Million $)	D.B.V	T.P.L (kW)	Cost function (Million $)	D.B.V
1	0.1	0.1	0.8	110.76	29.2084	1.9151	77.81	27.5428	1.7384
2	0.1	0.8	0.1	110.76	29.0209	1.9946	77.81	27.1681	1.7599
3	0.8	0.1	0.1	96.49	29.2084	1.9946	61.78	27.5428	1.7599
4	0.5	0.3	0.2	99.21	29.1165	1.9728	64.16	27.3587	1.7511
5	0.5	0.2	0.3	99.21	29.1646	1.9544	64.16	27.4711	1.7497
6	0.3	0.5	0.2	103.77	29.0566	1.9728	68.61	27.2655	1.7511
7	0.3	0.2	0.5	103.77	29.1646	1.9367	68.61	27.4711	1.7455
8	0.2	0.5	0.3	107.43	29.0566	1.9544	72.47	27.2657	1.7497
9	0.2	0.3	0.5	107.43	29.1165	1.9367	72.47	27.3587	1.7456

V. CONCLUSION

In this work an algorithm based on modified particle swarm optimization (MPSO) and modified discrete particle swarm optimization (MDPSO) has been successfully employed to solve the multi objective DG sitting and sizing and optimal network reconfiguration problem. Loss sensitive factors are used to identify the sensitive nodes to place the DG units and their size is obtained by modified particle swarm optimization (MPSO) by minimizing multiple objective functions subjected to a set of practical constraints. It is identified from results that the power loss, cost function and deviation of bus voltage are reduced by obtaining optimal configuration of the network with DG sitting and sizing simultaneously.

REFERENCES

[1] Merlin A, Back H. Search for a minimal-loss operating spanning tree configuration in an urban power distribution system. In: Proceedings of the 5th power system computation conference, Cambridge, UK; 1975. p. 1–18.
[2] Civanlar S, Grainger JJ, Yin H, Lee SSH. Distribution feeder reconfiguration for loss reduction. IEEE Trans Power Delivery 1988;3(3):1217–23.
[3] Baran ME, Wu FF. Network reconfiguration in distribution systems for loss reduction and load balancing. IEEE Trans Power Delivery 1989;4(2):1401–7.
[4] Nara K, Shiose A, Kitagawoa M, Ishihara T. Implementation of genetic algorithm for distribution systems loss minimum reconfiguration. IEEE Trans Power Syst 1992;7(3):1044–51.
[5] Shirmohammadi D, Hong HW. Reconfiguration of electric distribution networks for resistive line loss reduction. IEEE Trans Power Syst 1989;4(1):1492–8.
[6] Prasad K, Ranjan R. Optimal reconfiguration of radial distribution system using a fuzzy mutated genetic algorithm. IEEE Trans Power Delivery 2005;20(2):1211–3.
[7] Zhou Q, Shirmohammadi D, Liu WHE. Distribution feeder reconfiguration for service restoration and load balancing. IEEE Trans Power Syst 1997;12(2):724–9.
[8] T. Ackerman, G. Anderson, L. Soder, Distributed generation: a definition, Elsevier Sci. (2003) 195–204.
[9] V. Gomes, s. Carneiro, A new reconfiguration algorithm for large distribution systems, IEEE Trans. Power Del. Syst. 20 (3) (2005) 1373–1378.
[10] V. Parada, J.A. Ferland, Optimization of electrical distribution feeders using simulated annealing, IEEE Trans. Power Del. 19 (3) (2004) 1135–1141.
[11] A. Augugliaro, L. Dusonchet, M. Ippolito, E.R. Sanseverino, Minimum losses reconfiguration of MV distribution networks through local control of tie-switches, IEEE Trans. Power Del. 18 (3) (2003) 762–771.
[12] H. Kim, Y. Ko, Artificial neural network based feeder reconfiguration for loss reduction in distribution systems, IEEE Trans. Power Del. 8 (3) (1993) 1356–1367.
[13] R. Taleski, D. Rajicic, Distribution network reconfiguration for energy loss reduction, IEEE Trans. Power Syst. 12 (1) (1997) 398–406.
[14] Q. Zhou, D. Shirmohammadi, W.H.E. Liu, Distribution feeder reconfiguration for service restoration and load balancing, IEEE Trans. Power Syst. 12 (2) (1997) 724–729.
[15] Debaprya Das, A fuzzy multi-objective approach for network reconfiguration of distribution systems, IEEE Trans. Power Del. 21 (1) (2006) 202–209.
[16] I.Z. Zhu, Optimal reconfiguration of electrical distribution network using the refined genetic algorithm, Elect. Power Syst. Res. 62 (2002) 37–42.
[17] Teher Niknam, et al "A modified honey bee mating optimization algorithm for multiobjective placement of renewably energy sources", Journal of Applied Energy, july, 2011.