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Optimal Placement of Distribution Generations for Reconfiguration of Distributed Networks using PQV Bus

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Abstract: This paper presents the reconfiguration of the distribution network in the presence of distributed generations (DGs) by considering two bus types i.e., P bus and PQV bus (remotely voltage controlled bus). The 'P' bus is spoken to by active power specification just though the PQV bus is one whose voltage is remotely controlled by the P bus. A methodology is proposed to choose the P bus for controlling the voltage magnitude of remotely found PQV bus. A Sensitivity analysis approach is utilized for choosing the buses for the arrangement of DGs working at unity power factor. The arrangement of DGs is done in two ways i.e., non-sequential and sequential placement of DG in a distribution system. Genetic Algorithm (GA) procedure is utilized for the optimization of DGs took after by network reconfiguration. The objective work for network reconfiguration in this paper is thought to be real power loss reduction. Effectiveness of the proposed technique is exhibited through cases of 33 bus and 69 bus distribution systems.
Keywords: Network reconfiguration; Distributed generators; P and PQV bus; Distribution system; Genetic algorithm.

I. INTRODUCTION

The configuration of a distribution network can be changed by opening closing the tie switches of the network. In order to reduce the line losses in the network the tie-switches are all initially closed to form a meshed network. The network reconfiguration is carried out for loss reduction as well as for load balancing of distribution system. The network reconfiguration considering P and PQV buses in the presence of distributed generations. Multi objective optimization problem with an effective solution search space using a modified Genetic Algorithm (GA) and a Fuzzy Mutation Control. Optimal placement of Distributed Generation (DG's) can be achieved by Particle Swarm Optimization.

The effectiveness of the proposed objective has been demonstrated using 33 and 69 node distribution networks. This paper proposes the placement and sizing of DGs in two ways (non-sequential & sequential approach) along with reconfiguration of the network. This combinatorial approach is adopted to reduce the real and reactive power losses, improve the voltage profile, enhance the system reliability and security, and improve the overall technical benefits. A simple methodology is adopted based on loss reduction for selecting P type bus and reactive power injection at P type bus is computed after the load flow study. The appropriate size of the shunt capacitor to be connected at P type bus to control the voltage magnitude of PQV bus is also computed.

The main contributions of this paper are:

1) Incorporation of P and PQV buses into the distribution network and to suggest a methodology for selecting P bus to control the voltage magnitude of a remotely located PQV bus.
2) Reconfiguration of the distribution network for power loss minimization (based on voltage difference heuristics using modified circular mechanism) with and without considering DGs operating at unity power factor in the presence of P and PQV buses.
3) Sensitivity analysis approach for DG placement is based on a sensitivity index involving apparent power, voltage profile and real power loss.
4) Non-sequential and sequential approach of DG placement on 33 and 69 node distribution networks with DG sizes optimized using genetic algorithm (GA).

All these conditions are met subject to the voltage and the branch current capacity constraints within limits.

II. INCORPORATION OF P AND PQV BUSES IN THE LOAD FLOW ALGORITHM

With the introduction of P and PQV buses, the Jacobian matrix gets modified. A P bus is basically a generation bus with no reactive power specified. Hence, the reactive power Q associated with the P bus becomes a state variable. On the other hand, a PQV bus is a remotely voltage controlled bus whose real power; reactive power and the voltage magnitude are specified. The voltage magnitude of the PQV bus is controlled by the P bus.

In Fig. 1, suppose bus 2 is a P bus, bus 3 is assumed to be PQ bus and bus 4 is treated as a PQV bus. Bus 1 is treated as the slack bus. For this system having a 'P' bus (bus 2) controlling the voltage at a PQV bus (bus 4), the augmented set of equations takes the form given by Eq. (1) and Eq. (2).

$$\Delta V = \begin{bmatrix} \Delta V_2 \\ \Delta V_3 \end{bmatrix} \quad (1) \qquad \Delta Q = \begin{bmatrix} \Delta Q_3 \\ \Delta Q_4 \end{bmatrix} \quad (2)$$

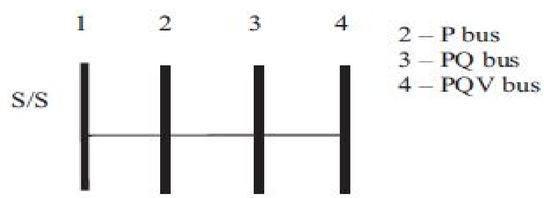

Fig. 1. Distribution network with P and PQV bus.

Then the equation relating the changes in power to the changes in the voltage magnitudes and phase angles for the Newton-Raphson
method is given as,

$$\begin{bmatrix} \Delta P_2 \\ \Delta P_3 \\ \Delta P_4 \\ \Delta Q_3 \\ \Delta Q_4 \end{bmatrix} = \begin{bmatrix} \partial P_2/\partial\delta_2 & \partial P_2/\partial\delta_3 & \partial P_2/\partial\delta_4 & \partial P_2/\partial V_2 & \partial P_2/\partial V_3 \\ \partial P_3/\partial\delta_2 & \partial P_3/\partial\delta_3 & \partial P_3/\partial\delta_4 & \partial P_3/\partial V_2 & \partial P_3/\partial V_3 \\ \partial P_4/\partial\delta_2 & \partial P_4/\partial\delta_3 & \partial P_4/\partial\delta_4 & \partial P_4/\partial V_2 & \partial P_4/\partial V_3 \\ \partial Q_3/\partial\delta_2 & \partial Q_3/\partial\delta_3 & \partial Q_3/\partial\delta_4 & \partial Q_3/\partial V_2 & \partial Q_3/\partial V_3 \\ \partial Q_4/\partial\delta_2 & \partial Q_4/\partial\delta_3 & \partial Q_4/\partial\delta_4 & \partial Q_4/\partial V_2 & \partial Q_4/\partial V_3 \end{bmatrix} . \begin{bmatrix} \Delta\delta_2 \\ \Delta\delta_3 \\ \Delta\delta_4 \\ \Delta V_2 \\ \Delta V_3 \end{bmatrix} \quad (3)$$

After this, the Newton Raphson load flow method is used to solve the network. 'Q2' at bus 2 (i.e., at P bus) is then obtained. Voltage at PQV bus may be controlled by using shunt capacitor [58]. In this work, shunt capacitor is used to control the voltage of a PQV bus.

In Fig. 2, suppose QC2 is the reactive power injected by shunt capacitor at bus 2 to maintain the voltage magnitude of bus 4 (PQV
bus). For this system, the amount of reactive power required at bus 2 (P bus) to control the voltage at bus 4 (PQV bus) is given by QC2 which can be computed using the expression that follows in Eq. (4),

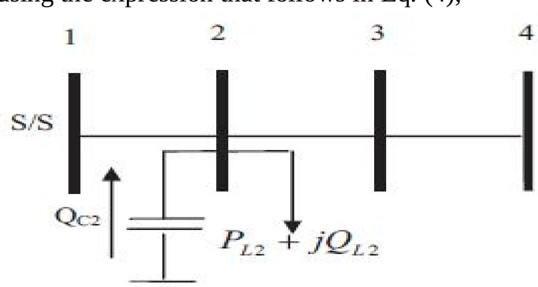

Fig. 2. Reactive power injected by the shunt capacitor at P bus (Bus 2).

$$Q_2 = Q_{C2} - Q_{L2} \qquad (4)$$

Where Q_2 = net reactive power injected at bus 2.
Q_{C2} = reactive power injected by shunt capacitor.
Q_{L2} = reactive power load at bus 2.

$$Q_{C2} = Q_2 + Q_{L2} \quad (5)$$

It is to be noted that Q_{C2} is the amount of reactive power to be injected by the shunt capacitor at bus 2 to maintain bus 2 as P bus and bus 4 as PQV bus.

III. SELECTION OF P AND PQV BUSES

The effectiveness of the proposed method is illustrated with the help of 33 bus and 69 bus distribution networks and data for these

Systems are available in [3, 4]. Firstly, a 12.66 kV, 33 bus distribution network as shown in Fig. 3 is considered. Secondly, a 12.66 kV, 69 bus distribution network as shown in Fig. 4 is considered for study. As the basic objective in this work is to reduce the real power loss, the selection of P bus is to be done judiciously.

A. *Selection Criteria*

1) *PQV bus:* The bus selected for PQV bus is unique as it is the one having the minimum voltage in the distribution network. The

Voltage of the PQV bus can be maintained at a desired level for it is to be controlled by the P bus. So, the voltage of the PQV bus can be set within desired level.

2) *P bus:* This bus will control the voltage of the PQV bus by maintaining the 'Q' injected at the P bus. At the same time, it is to

Be seen that the real power loss of the network is reduced. Hence, the P bus is to be chosen judiciously.

Below are the results for selecting P and PQV buses for 33 and 69 bus distribution networks.

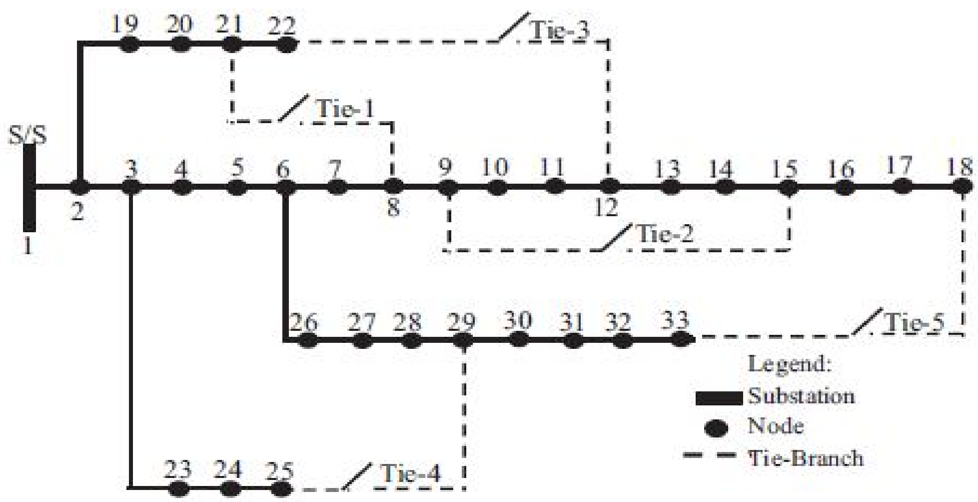

Fig. 3. 33 bus distribution network.

B. *33 bus and 69 bus distribution networks*

For the 33 bus system, the minimum voltage of the network is 0.9131 p.u. (which occurs at bus 18). Hence, bus 18 is chosen as the PQV bus. It is desired that the voltage to be maintained at PQV bus =0.93 p.u. For selecting P-type bus, the lateral branch is identified on which bus −18 (minimum voltage bus) is present. Then all the buses on this lateral are tested for P-type buses based on real power loss reduction.

Similarly, the minimum voltage of 69 bus system is 0.9091 p.u. (which occurs at bus 65). Hence, bus 65 is chosen as the PQV bus. It is desired that the voltage to be maintained at the PQV bus is 0.93p.u. (bus 65). For selecting P-type bus, the lateral branch is identified on which bus −65 (minimum voltage bus) is present. Then all the buses on this lateral are tested for P-type buses based on real power loss

Reduction.

Table 1 and Table 2 present the results for the 33 bus and the 69 bus test systems respectively. For the 33 bus system, from Table 1 it is seen that if Bus 6 is chosen as the P bus then the real power loss is minimum. Similarly for the 69 bus system, from Table 2 it is seen that if Bus 61 is chosen as the P bus then real power loss is minimum. Hence, Bus 6 and Bus 61 are chosen as P bus for the 33 bus and the 69 bus networks respectively. The amount of reactive power injection by shunt capacitor at P bus to maintain the voltage magnitude of PQV bus is computed using Eq. (5) for both the systems and presented in Table 3.

IV. SENSITIVITY INDEX FOR BUS SELECTION OF DG PLACEMENT

For placement of unity power factor DGs, a sensitivity analysis approach is considered for finding the optimal buses in the existing

Distribution network. The objectives for placing a unity power factor DG at a particular bus are

1) Buses with higher load values should have higher voltages.
2) Reduction in real power losses of the network.

Based on these objectives, a sensitivity index is defined and is formulated as given in Eq. (6),

$$S_k = \sum_{i=2}^{NB} KVA_i \cdot V_i^k + \frac{P_{loss} - P_{loss}^k}{P_{loss}} \qquad (6)$$

Where, KVA_i= apparent load power at the i-th bus.

V_k^i= voltage at the ith bus with upf DG at bus k.

P_{loss}= real power loss of the network without DGs.

P_{loss}^k = real power loss of the network after placement of unity power factor DG at the k-th bus.

Once the sensitivity index S_k is computed for all the buses, the values of S_k are arranged in descending order.

Hence,

$$S_{opt} = max(S_k), \quad for\ k = 2,3, ------NB \qquad (7)$$

The bus with the highest sensitivity index value has the maximum potential in achieving the aforesaid objectives after the placement of unity power factor DGs. For this study, thirty percent of the total real power load of the network is injected at each bus considering one bus at a time. Then the value of S_k as given in Eq. (6) is computed and arranged in descending order. In this study, top three buses are selected for the placement of DGs while optimizing the DG size using GA. As the concept of P and PQV buses is considered in this work, the amount of 'Qc' to be supplied by the shunt capacitor at 'P' bus to control the voltage at PQV bus remains intact throughout. The amount of 'Qc' doesn't change at all while computing the sensitivity index 'S_k' at any particular bus.

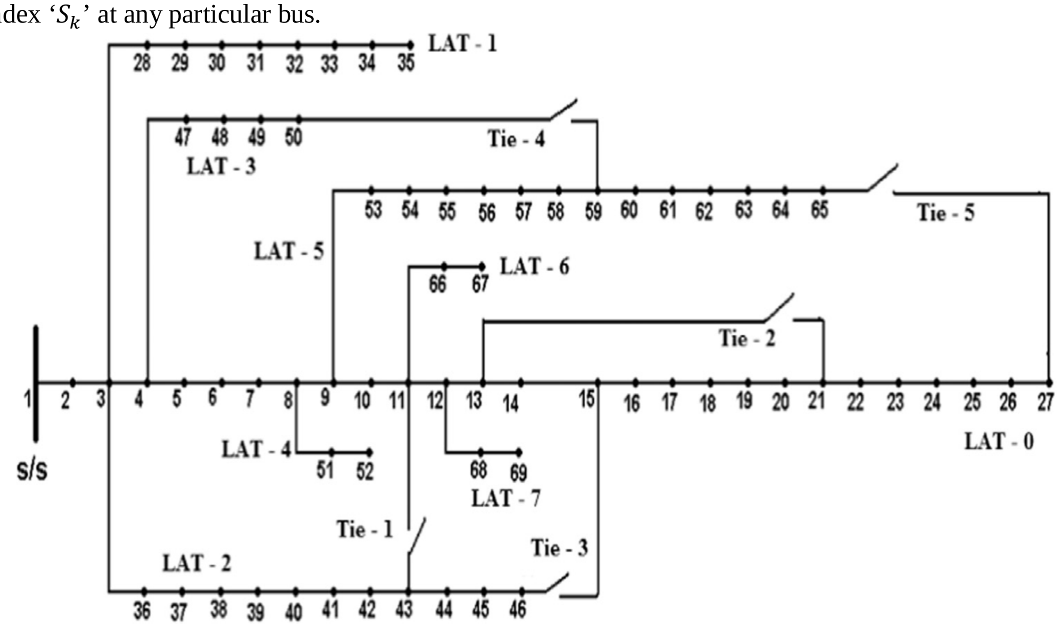

Fig. 4. 69 bus distribution network.

Table 1
Selection of P bus For 33 bus distribution network

Suggested P bus	Qc (kVAr) injected at P bus to maintain a specified voltage at PQV bus	Ploss (kW)
2	54719.86	1727.1
3	8487.39	322.0614
4	5181.78	233.6219
5	3668.45	194.3646
6	1753.53	154.44
7	1215.36	159.3741
8	1090.45	162.9015
9	822.19	168.8629

Table 2
Selection of P bus For 69 bus distribution network

Suggested P bus	Qc (kVAr) injected at P bus to maintain a specified voltage at PQV bus	Ploss (kW)
58	1669.28	166.34
59	1568.80	161.87
60	1465.04	157.41
61	1280.96	152.09
62	1255.28	153.42
63	1219.06	154.42

Table 3
Selection of P and PQV bus

Network	P bus	PQV bus	V (p.u.)	Q_c (kVAr)
33 bus	6	18	0.93(18)	1754(6)
69 bus	61	65	0.93(65)	1281(61)

A. Non-sequential Approach

In this form of approach, the top three nodes obtained using Eq. (7) is together considered at a time for DG placement. The nodes obtained using this approach for 33 bus and 69 bus networks are presented in Table 4.

Table 4
Selection of Buses (Non-Sequential Approach)

33 bus Network	69 bus Network
29, 30, 11	62, 63, 61

B. Sequential Approach

For sequential approach, the top node is selected as obtained using Eq. (7) for DG placement (i.e. node 29 for 33 bus and node 62 for 69 bus network). Once the DG is placed, the process of sensitivity index for bus selection is again carried out to find out another optimal location of DG to be placed. This process is explained in detail in Section-8. The number of DGs placed using sequential approach method is limited to three buses.

V. DG OPTIMIZATION USING GENETIC ALGORITHM

Once the buses are selected, the sizes of the DGs are optimized using Genetic Algorithm (GA). GA is an optimization method based on the mechanics of natural selection and natural genetics. During the last two decades, GA has become quite popular for solving a variety of optimization and machine learning problems. In GA, 'fitness' is associated with the objective function to be maximized.

The main objective for optimization in this problem is to reduce the real power losses of the distribution networks after installation of the DGs subject to satisfying the voltage constraint and without violating the branch current carrying capacity (ICi), i.e., Vmin ≤ Vi ≤ Vmax and Ii ≤ICi.

In this work, Vmin =0.93 p.u. and Vmax =1.05 p.u. are considered. The optimization is carried out for two examples i.e., 33 bus and 69 bus distribution networks. Maximum value of DG size at any bus for both the examples is taken as 2000 kW.

The problem is formulated as follows:

In GA, the fitness is defined as,

$$\text{Fitness J} = \max\left(\frac{m}{P_{loss}}\right) i \qquad (8)$$

$$\text{for i} = 1, 2, \ldots, N_{pop}$$

where, 'm' is a small positive integer and

'P_{loss}' is the total real power loss of the network with DGs.

Candidate locations for placement of unity power factor DGs are buses 29, 30, 11 for the 33 bus network and for the 69 bus network; they are 62, 63 and 61. The steps for optimization are explained with the help of a flowchart as given in Fig. 5.

VI. RECONFIGURATION WITH MODIFIED CIRCULAR MECHANISM

Reconfiguration is a process of changing the existing structure of the network into another one for achieving desired objectives.

The objective for reconfiguration in this paper is loss reduction and it is represented as given in Eq. (9),

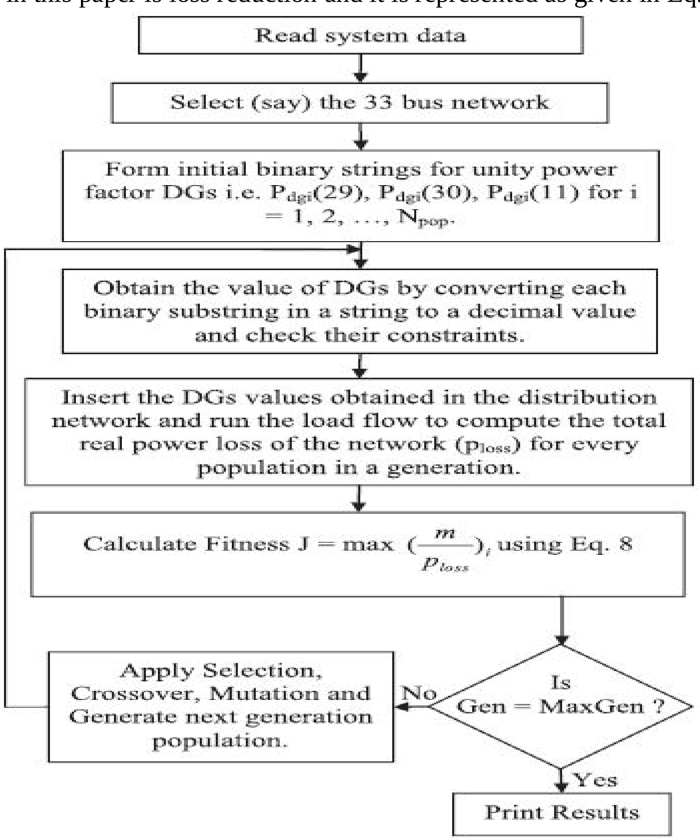

Fig. 5. Flowchart for DG optimization.

$$R = min(P_{loss})\text{ij} \qquad (9)$$

For i = 1, 2, -----------, NL; j = 1, 2, -------------, NT

Where, NL = number of branches in a loop and NT = number of tie – switches

The circular mechanism reconfiguration technique is adopted in this paper. In, the authors have used minimum branch current
method and the selection of tie-switch has been arbitrary. In this work, the tie-switch across which the voltage difference is maximum is considered first to form a loop. For minimum loss configuration, each branch in the loop is opened one at a time and the opening of that branch for which loss is minimum is considered as the 'minimum loss configuration' for this tie-switch operation. The same procedure is repeated for other tie-switches in the network.
The steps are explained with the help of a flowchart given in Fig. 6.

VII. RESULTS AND DISCUSSIONS

Two different networks are considered in this paper,
A 12.66 kV, 33 bus and a 12.66 kV, 69 bus distribution network with a total real and reactive power demand of 3715 kW, 2300 kVAr (Fig. 3) and 3791.89 kW, 2696.1 kVAr (Fig. 4) respectively are considered for analysis.

A. Non Sequential Approach (33 Node Distribution Network)

Table 5 shows the load flow result of 33 bus distribution network for base case. It can be seen that the real power loss in this network considering PQ buses only is 202.68 kW. The minimum voltage of the network is 0.9131 p.u. which occurs at Bus 18. With the incorporation of P bus at Bus 6 and PQV bus at Bus 18

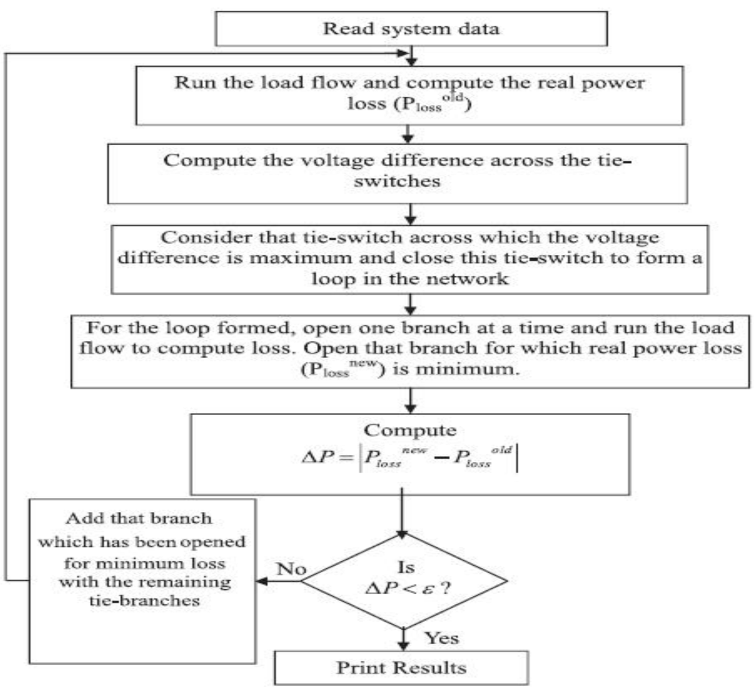

Fig. 6. Steps for reconfiguration with modified circular mechanism.

Table 5
Base case results of 33 bus network (Without DGs)

BASE CASE	Total real power load (kW)	3715
	Total reactive power load (kVAr)	2300
	Real power loss (kW)	202.68
	Reactive power loss (kVAr)	135.14
	Minimum Voltage (p.u.)	0.9131 (18)
	Maximum Voltage (p.u.)	1.0000 (1)
	Branches open	8-21, 9-15, 12-22, 18-33, 25-29
	Branches closed	Base case retained

Table 6
Base case analysis of 33 bus distribution network in presence of P and PQV bus (Without DGs)

P-PQV BUS	P bus	6
	PQV bus	18
	Reactive Power injected	1753.52
	Voltage to be maintained at PQV bus	0.93 p.u.
	Real power loss (kW)	154.44
	Reactive power loss (kVAr)	105.16
	Minimum voltage	0.93 (18)
	Maximum voltage	1.00 (1)

into the existing 33 bus distribution network as shown in Table 6, the real power loss drops down to 154.44 kW. In this scenario, the
minimum voltage of the network is maintained at a value of 0.93 p.u. at Bus 18. This could be achieved because of injection of 1753.52 kVAr at P bus (i.e. Bus 6) which in turn controls the voltage at Bus 18.

Table 7 presents the reconfiguration of the 33 bus distribution network with the incorporation of P and PQV bus (without installation of the DGs). It can be seen that for a 33 bus distribution network, the real power loss drops from 202.68 to 139.55 kW after reconfiguration under base case condition (This results in a 31.14% reduction). On the other hand, it can be seen that with the incorporation of P and PQV bus, the real power loss drops from 154.44 to 118.15 kW (This results in a 23.50% reduction). The minimum voltage of the network has improved to 0.9378 p.u. (at Bus 32) for base case and with P and PQV bus, the voltage has improved to 0.9477 p.u. (at Bus 33).

Table 7
Reconfiguration of 33 bus distribution network with and without the presence of P and PQV bus

RECONFIGURATION	Bus type	With PQ buses	With P-PQV bus
	Base real power loss (kW)	202.69	154.44
	Real power loss (kW)	139.55	118.15
	Reactive power loss (kVAr)	102.31	89.85
	% Real power loss reduction	31.14%	23.50%
	Minimum Voltage (p.u.)	0.9378 (32)	0.9477 (33)
	Maximum Voltage (p.u.)	1.0000 (1)	1.0000 (1)
	Branches open	7-8, 9-10, 14-15, 32-33	7-8, 9-10, 14-15, 32-33
	Branches closed	8-21, 9-15, 12-22, 18-33	8-21, 9-15, 12-22, 18-33

Table 8
DG installation in the presence of P and PQV bus (33 Node network)

DG INSTALLATION ONLY	Size of DGs (kW)	523.38 (29) 618.37 (30) 970.49 (11)
	Base real power loss (kW)	154.44
	Real power loss (kW)	43.78
	Reacive power loss (kVAr)	32.70
	% real power loss reduction	71.65%
	Minimum voltage (p.u.)	0.98 (18)
	Maximum voltage (p.u.)	1.0000 (1)
	Branches open	8-21, 9-15, 12-22, 18-33, 25-29
	Branches closed	Base case retained

Next, the DGs are installed on 33 bus distribution network along with the presence of P and PQV bus (no reconfiguration). It has been found that at three suitable locations (bus 29, 30, 11); the DGs were optimized to reduce the real power losses. It can be seen from Table 8 that the real power loss has reduced from 154.44 to 43.78 kW resulting in a 71.65% loss reduction. The minimum voltage of the network has improved to 0.9811 p.u. at Bus 18.

Table 9 presents the reconfiguration results of the 33 bus network in the presence of P and PQV bus after the installation of DGs at Bus 29, 30 and 11. It can be seen that the real power loss has dropped from 154.44 to 43.11 kW resulting in a total real power loss reduction of 72.09%. The minimum voltage of the network has improved to 0.9809 p.u. at Bus 25.

Table 9
Reconfiguration After DG installation (with P and PQV bus) (33 node Network)

RECONFIGURATION AFTER DG INSTALLATION	Base real power loss (kW)	154.44
	Real power loss (kW)	43.11
	Reactive power loss (kVAr)	31.93
	% real power loss reduction	72.09%
	Minimum voltage (p.u.)	0.9809 (25)
	Maximum voltage (p.u.)	1.0000 (1)
	Branches open	14-15, 21-22
	Branches closed	9-15, 12-22

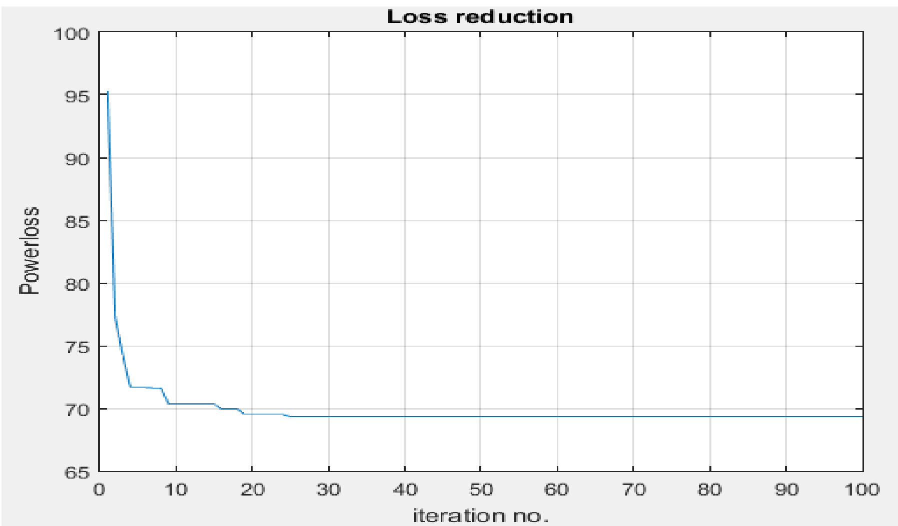

Fig. 7. Power loss Curve for 33 bus Distribution System

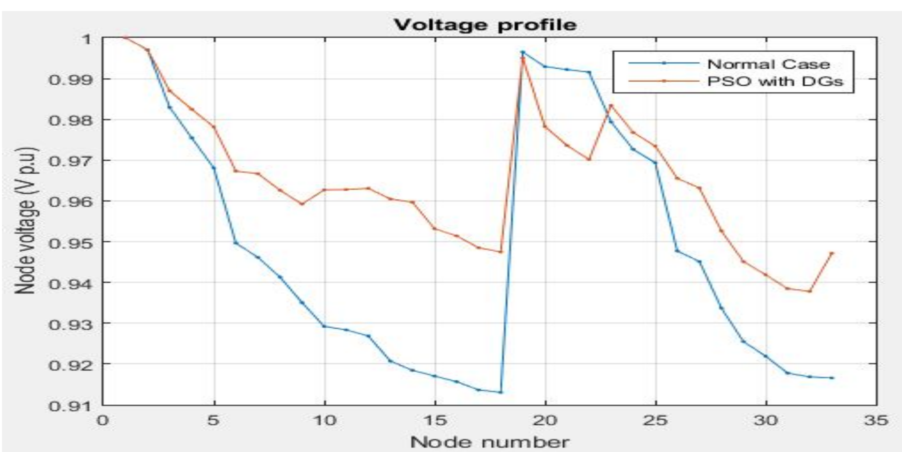

Fig. 8. Voltage Profile Curve For 33 Bus Distribution System

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B. Non-Sequential Approach (69 Node Distribution Network)

The proposed analysis is carried out for the 69 bus network. A 12.66 kV, 69 bus distribution network with a total real and reactive

power demand of 3791.89 kW and 2694.1 kVAr (Fig. 4) is considered for analysis. The base case load flow results of the 69 bus distribution network are presented in Table 10. It can be seen that the real power loss of the 69 bus network is 224.95 kW. The minimum voltage of the network is 0.9091 p.u. occurring at Bus 65. Table 11 presents the load flow results of the 69 bus distribution network in the presence of P and PQV bus (without installation of DGs). With the P bus at bus 61 and the PQV bus at bus 65, the voltage to be maintained at Bus 65 is 0.93 p.u. This voltage could be maintained at bus 65 because of the incorporation of 1280.96 kVAr injected by the shunt capacitor. The real power loss in the presence of P and PQV bus drops to 152.09 kW.

The reconfiguration results of the 69 bus distribution network in the presence of P and PQV bus are presented in Table 12. In case of PQ buses only, the real power loss has dropped from 224.95 to 99.59 kW resulting in a drop of 55.73%. On the other hand, the real power loss has dropped from 152.09 to 74.19 kW in the presence of P and PQV buses thereby showing a drop of 51.22%. The minimum voltage with PQ buses only has improved to 0.9427 p.u. at Bus 61 whereas it has improved to 0.9655 p.u. at Bus 64 in the presence of P and PQV buses.

Table 13 shows the results of DG values optimized using GA. The unity power factor DGs are optimized at buses 62, 63 and 61 to give a real power loss of 23.02 kW. It can be seen that there is a drop of 84.87% in real power loss. The minimum voltage after the installation of DGs has improved to 0.9747 p.u. at Bus 27. Once the DGs are installed on the 69 bus network in the presence of P and PQV bus, the network is reconfigured and the results are presented in Table 14. It can be seen that reconfiguring the network after the installation of DGs results in further reduction of real power loss to 11.69 kW. It can be seen that the real power loss has dropped from 152.09 to 11.69 kW resulting in a drop of 92.31%. The minimum voltage of the network has further improved to 0.9898 p.u. at Bus 21.

Table 10

Base case results of 69 bus network (Without DGs)

BASE CASE	Total real power load (kW)	3791.89
	Total reactive power load (kVAr)	2964.1
	Real power loss (kW)	224.95
	Reactive power loss (kVAr)	102.14
	Minimum Voltage (p.u.)	0.9091 (65)
	Maximum Voltage (p.u.)	1.0000 (1)
	Branches open	11-43,13-21, 15-46,50-59,27-65
	Branches closed	Base case retained

Table 11

Base case analysis of 69 bus distributed network in presence of P and PQV bus (Without DGs)

P-PQV BUS	P bus	61
	PQV bus	65
	VAR injected at P bus (kVAr)	1280.96
	Reactive Power injected	0.93 p.u.
	Real power loss (kW)	152.09
	Reactive power loss (kVAr)	70.57
	Minimum voltage	0.93 (65)
	Maximum voltage	1.00 (1)

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Table 12
Reconfiguration of 69 bus distribution network with and without the presence of P and PQV bus

RECONFIGURATION	Bus type	With PQ buses	With P-PQV bus
	Base real power loss (kW)	224.95	152.09
	Real power loss (kW)	99.59	74.19
	Reactive power loss (kVAr)	114.66	82.46
	% Real power loss reduction	55.73%	51.22%
	Minimum Voltage (p.u.)	0.9427 (61)	0.9655 (64)
	Maximum Voltage (p.u.)	1.0000 (1)	1.0000 (1)
	Branches open	14-15, 55-56, 61-62	14-15, 56-57, 63-64
	Branches closed	15-46, 50-59, 27-65	15-46, 50-59, 27-65

Table 13
DG installation using GA in the presence of P and PQV bus (69 Node Network)

DG INSTALLATION ONLY	Size of DGs (kW)	156.3 (62) 265.7 (63) 1401.5 (61)
	Base real power loss (kW)	152.09
	Real power loss (kW)	23.02
	Reacive power loss (kVAr)	14.33
	% real power loss reduction	84.87%
	Minimum voltage (p.u.)	0.9724 (27)
	Maximum voltage (p.u.)	1.0000 (1)
	Branches open	11-43, 13-21, 15-46, 50-59, 27-65
	Branches closed	Base case retained

Table 14
Reconfiguration after DG installation (with P and PQV bus) (69 Node Network)

RECONFIGURATION AFTER DG INSTALLATION	Base real power loss (kW)	152.09
	Real power loss (kW)	11.69
	Reactive power loss (kVAr)	11.81
	% real power loss reduction	92.31%
	Minimum voltage (p.u.)	0.9898 (21)
	Maximum voltage (p.u.)	1.0000 (1)
	Branches open	12-13, 20-21, 53-54
	Branches closed	13-21, 15-46, 27-65

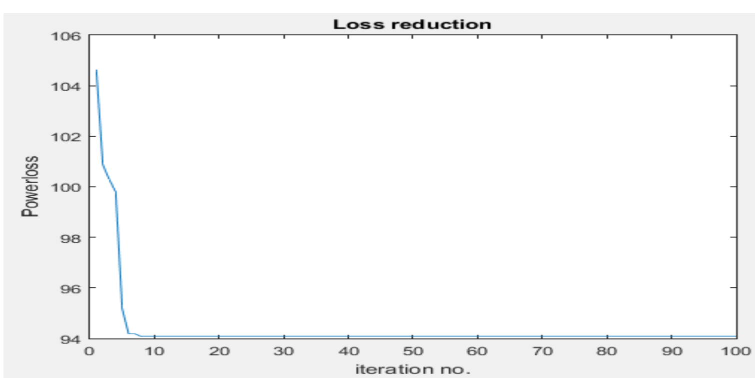

Fig. 9. Power Loss Curve For 69 Bus Distribution System

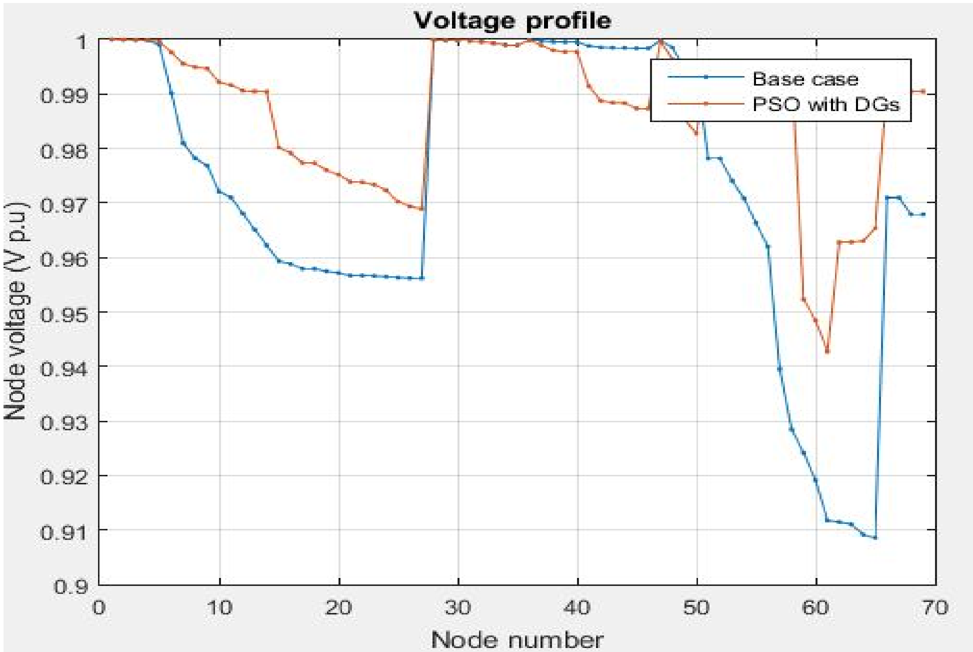

Fig. 10. Voltage Profile curve for 69 bus Distribution System

VIII. SEQUENTIAL APPROACH

The sequential approach of optimization of DGs is carried out in this section. In this case, the optimal location is first obtained using the sensitivity index mentioned in Eq. (6) and Eq. (7) [i.e. node 29 for 33 bus and node 62 for 69 bus network] and the DG value is optimized for that place using GA. Once the DG value is optimized and placed in that location, search for another optimal location is carried out using Eq. (6) and Eq. (7). This process is repeated up to the placement of three DGs. Table 15 and Table 16 present the results of the 33 bus and the 69 bus distribution networks in the presence of P and PQV buses using the sequential approach. It can be clearly seen that with the sequential placement of DGs, the real power loss keeps on decreasing. For the 33 bus system, the placement of first DG at Bus 29 gives a real power loss of 72.12 kW.

Placement of the second DG at Bus 15 gives a real power loss of 48.30 kW and the placement of third DG at Bus 25 gives a real power loss of 37.15 kW. The DG location and the size obtained in the proposed method gives satisfactory results in terms of loss reduction. For the 69 bus network, with the placement of DG at just one location i.e., Bus 62 gives significant reduction in loss. The placement of a second DG at Bus 16 gives further loss reduction and the placement of a third DG at Bus 50 gives a real power loss of 12.07 kW.

The relation between the DG size and the power loss obtained is quite satisfactory in the proposed method. Once the DGs are placed in the network, the reconfiguration is done in the presence of P and PQV buses. From Table 17, it can be seen that the reconfiguration of the network after placement of DGs at buses 29, 15, 25 gives a real power loss of 36.10 kW which shows a reduction of 69.44% for the 33 bus network. The reconfiguration of the 69 bus network in the presence of P and PQV buses after the placement of DGs at bus 62, 16 and 50 results in a real power loss drop to 9.30 kW. This shows 87.46% loss reduction in Table 18.

Table 19 presents the real power loss obtained using non-sequential and sequential approach for the 33 and the 69 bus networks. In case of the 33 bus network, the real power loss is 43.78 kW after DG installation which has slightly improved to 43.11 kW after reconfiguration using non-sequential approach. Whereas in case of the sequential approach method, the DG installation gives a loss of 37.15 kW which further drops to 36.10 kW after reconfiguration.

In case of the 69 bus network, a similar pattern can be seen. The DG installation using non-sequential approach gives a loss of 23.02 kW which further drops to 11.69 kW after reconfiguration. For the sequential approach method, the DG installation itself gives a loss of 12.07 kW which further reduces to 9.30 kW after reconfiguration. Hence, it could be seen that the non-sequential and the sequential approach of placement of DGs are capable of producing results of similar nature. However, the sequential approach of placement of DGs gives slightly better results in terms of loss reduction with network reconfiguration in the presence of P and PQV buses.

Table 15
33 Bus distribution network with P-PQV bus using sequential approach

No. of DG Units		Proposed Method	Analytical Method
-	Base case loss (KW)	154.44	163.75
1	Node location 1 Size (KW) Power loss (KW)	29 1618 72.12	6 2510 63.1
2	Node location 2 Size (KW) Power loss (KW)	15 652 48.30	25 730 53.17
3	Node location 3 Size (KW) Power loss (KW)	25 773 37.15	- - -

Table 16
69 Bus distribution network with P-PQV bus using sequential approach

No. of DG Units		Proposed Method	Analytical Method
-	Base case loss (KW)	152.0927	152.06
1	Node location 1 Size (KW) Power loss (KW)	62 1800 24.45	61 1860 23.18
2	Node location 2 Size (KW) Power loss (KW)	16 526 13.58	17 500 12.59
3	Node location 3 Size (KW) Power loss (KW)	50 718 12.07	- - -

Table 17
Reconfiguration after DG installation For 33 bus distribution network

	Real power loss (KW)	% Real power loss reduction
Without any DG installation	118.15	-
DG installed at bus 29, 15, 25	36.10	69.44%

Table 18
Reconfiguration after DG installation For 69 bus distribution network

	Real power loss (KW)	% Real power loss reduction
Without any DG installation	74.19	-
DG installed at bus 62, 16, 50	9.30	87.46%

Table 19
Real Power loss in kW for non-sequential and sequential approach (In the Presence of P and PQV bus)

Network	Non Sequential approach		Sequential approach	
	With DG installation only	Reconfiguration after DG installation	With DG installation only	Reconfiguration after DG installation
33 bus	43.78 (T-9)	43.11 (T-10)	37.15 (T-16)	36.10 (T-18)
69 bus	23.02 (T-14)	11.69 (T-15)	12.07 (T-17)	9.30 (T-19)

A. Comparison

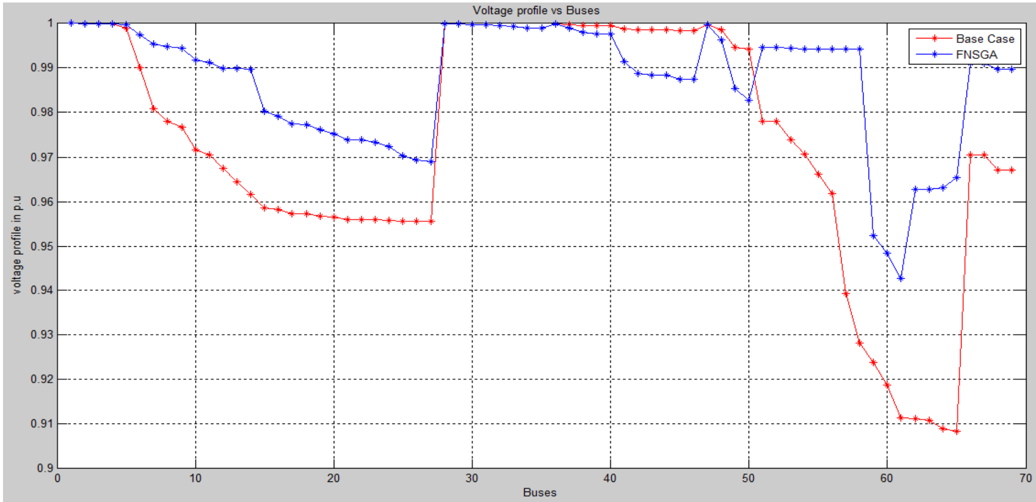

Fig. 11. Comparison of the Voltage profile in pu for base case & GA Optimization

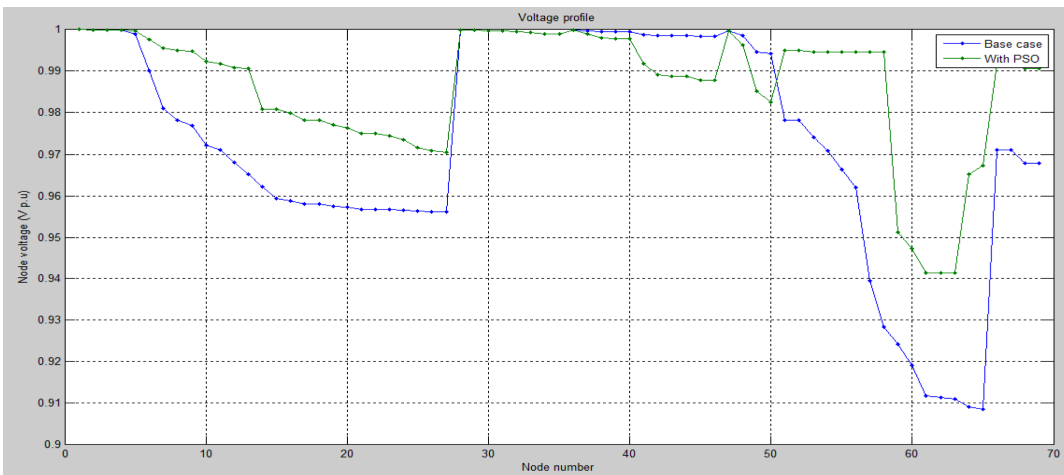

Fig. 12. Comparison of the Voltage profile in pu for base case & PSO Optimization

IX. CONCLUSION & FUTURE SCOPE

A. Conclusion

An improved version of the PSO and its application, for the first time, to the multi-objective DSR problem are described. The main characteristic of the PSO is that it deals with only the rand solution set and classifies it into only one rank, while other methods, such as the GA, search for all solutions and classify them into more than one rank, which is relatively time consuming. Power loss minimization is defined as the primary objective, while the other objectives are power quality improvement, defined by both the voltage profile and minimization of the number of switching operations. The set of non dominated solutions provides the operator with alternatives, depending on needs. If there is (are) no preferred objective(s), the optimum solution is defined as that with the smallest sum of normalized objectives.

Improvements to the PSO introduced here include a novel particles, which eliminates the need to choose or adapt mutation rates for each system; a novel approach to verifying system radiality, which eliminates the need to create in feasible solutions at each stage of the genetic evolution; and a novel approach to determining an optimum solution in the presence of equal importance objectives. Results of application of the revised PSO to two popular test systems and a real one are described and compared with results obtained with other algorithms.

The matlab results illustrate the ability of the algorithm to produce PSO solution sets in which all four objectives, rather than just one, are optimized simultaneously, and with relative smaller population sizes and/or numbers of generations, resulting in conveniently fast CPU times.

B. Future Scope

This work is being extended to the case of service restoration, characteristic of system operation in the presence of fault or maintenance conditions.

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 fifth power system Computation conference (PSCC), Cambridge, UK; 1975. pp. 1–8.

[2] Civanlar S, Grainger J, Yin H, Lee S. Distribution feeder reconfiguration for loss Reduction. IEEE Trans Power Deliv 1988; 3(3):1217–23.

[3] Shirmohammadi D, Hong HW. Reconfiguration of electric distribution networks for Resistive line losses reduction. IEEE Trans Power Deliv 1989; 4(2):1492–8.

[4] Baran ME, Wu FF. Network reconfiguration in distribution systems for load Reduction and load balancing. IEEE Trans Power Deliv 1989; 4(2):1401–7.

[5] Chiang HD, Jean-Jumeau R. Optimal network reconfigurations in distribution System: Part 2: solution algorithms and numerical results. IEEE Trans Power Deliv 1990; 5(3):1568.74.

[6] Nara K, Shiose A, Kitagawao M, Ishibara J. Implementation of genetic algorithm for Distribution systems loss minimum reconfiguration. IEEE Trans Power Syst 1992; 7(3):1044–51.

[7] Goswami SK, Basu SK. A new algorithm for the reconfiguration of distribution Feeder for loss minimization. IEEE Trans Power Deliv 1992; 7(3):1484–91.

[8] Peponis G, Papadopoulos M. Reconfiguration of radial distribution networks: Application of heuristic methods on large scale networks. IEEE Proc Gen Trans Distri 1995; 142(6):6318.

[9] Abur A. A modified linear programming method for distribution system reconfiguration. Electr Power Syst Res 1996; 18(7):469–74.

[10] Zhu JZ. Optimal reconfiguration of electrical distribution network using the Redefined genetic algorithm. Electr Power Syst Res 2002; 62(1):37–42.

[11] Prasad K, Ranjan R, Sahoo NC, Chaturvedi A. Optimal reconfiguration of radial Distribution systems using a fuzzy mutated genetic algorithm. IEEE Trans Power Deliv 2005; 20(2):1211–3.

[12] Su CT, Chang CF, Chion JP. Distribution network reconfiguration loss reduction ant colony search algorithm. Electr Power Syst Res 2005; 75:190–9.

[13] Schimdt PH, Ida N, Kagan N, Guaralds JC. Fast reconfiguration of Distribution Systems Considering Loss Minimization. IEEE Trans Power Syst 2005; 20(3):1311–9.

[14] Gomes FV, Carneiro S, Jr., Pereira JLR, Vinagre MP. A new distribution System Reconfiguration approach using optimum power flow and sensitivity analysis for loss reduction. IEEE Trans Power Syst 2006; 21(4):1616–23.