International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 11, November-2018

Optimal Network Reconfiguration using BPSO in Distribution Systems

P.Haritha[1], Dr. V. Usha Reddy[2], P.Dinakara Prasad Reddy[3]

[1]*Department of EEE, Student & Sri Venkateswara University College of Engineering,Tirupati,INDIA,*
[2]*Department of EEE, Assistant Professor& Sri Venkateswara University College of Engineering,Tirupati,INDIA,*
[3]*Department of EEE, Research Scholar & Sri Venkateswara University College of Engineering,Tirupati,INDIA,*

Abstract— ***Network reconfiguration in distribution systems can be done by changing the status of sectionalizing switches, and is usually done for minimizing losses, voltage improvement, or for load balancing in the system. This paper deals with the reduction of real power loss in the distribution system by reconfiguration of the distribution network. The optimal configuration with minimum real power loss is to be found by applying different optimization techniques. In this paper Binary Particle Swarm Optimization algorithm (BPSO) optimization technique is used to find the optimal configuration. This method is tested on IEEE 33-bus distribution system. The results show that the reconfiguration is very useful in reducing active power loss and improving the voltage profile of the network.***

Keywords— ***Network reconfiguration, Power loss reduction, Load flow, BPSO***

I. INTRODUCTION

Distribution system is a very important part of the power system because it connects the transmission system to the consumers. The distribution system is designed as an interconnected network, but it must be operated in radial structure. One of the major problems in the distribution system is active power loss.So to reduce the active power losses of the distribution system, one of the methods is the reconfiguration of the network. The main advantages of network reconfiguration are reduction in power loss, improved voltage profile, balanced system load and increased reliability. Here, it is taken that the network is made up of sectionalizing (normally closed) and tie (normally open) switches. The configuration of the network is varied by changing the status of these switches so that all the loads are supplied and the real power loss of the system is reduced. While maintaining the radiality of distribution system the status of these switches is changed for optimal configuration.

The first method for Distribution system reconfiguration to reduce loss was proposed by Merlin and Back[1],this paper discussed about optimization and heuristics to find the less loss operating reconfiguration in the distribution network. Civanlar[2] was suggested a branch and bound type heuristic algorithm, in this paper a formula was introduced for finding change in power loss due to exchange of branch. Optimal power flow analysis for network reconfiguration to reduce losses was proposed by Shirmohammdi and Hong [3]. Heuristic approach to reduce the search for switching Baran and Wu [4] was proposed an algorithm. Goswami and Basu [5] discussed a heuristic algorithm based on the optimum flow pattern. Different optimization algorithms for loss reduction are employed in [6-11,15,17-19]. In recent years,the fast development of distributed generations led to compensation of both active and reactive power. By employing different optimization techniques in [12-14], the optimal locations and sizes have been employed.

In this paper, a Binary particle swarm optimization[21] technique is used for determining the minimum loss configuration of a radial distribution system. The proposed method starts with initial configuration with all tie switches in open position. As the power loss due to other sectionalizing switches is more than the current losses, it is not necessary to open the sectionalizing switches further in the loop. The proposed algorithm is tested on IEEE 33-bus system and results are compared with the Heuristic Approach. The remaining part of the paper is organized as follows: Section II gives the problem formulation, Section III discusses the proposed algorithm, Section IV develops the reconfiguration results and discussions and Section V discusses the conclusions.

II. PROBLEM FORMULATION

The network reconfiguration problem in a distribution system is to obtain the configuration with minimum loss while satisfying the operating constraints. The operating constraints are voltage drop, current capacity and radial operating structure of the system. The mathematical formulation for the minimization of power loss in reconfiguration problems is formulated as,

A. Objective Function and Constraints

For obtaining the objectives of this network reconfiguration technique, the problem is defined mathematically as an objective function (OF) for optimization [17],

$$\text{Minimize f} = \min(P_{T,Loss}) \tag{1}$$

Subject to:

a) Node voltage constraint:

Voltage magnitude at each node must lie within their permissible ranges to maintain power quality

$$0.95 \le V_i \le 1.05 \tag{2}$$

c) Generator operation constraints:

All DG units are only allowed to operate within the acceptable limit where $P_i^{\min}$ and $P_i^{\max}$ are the lower and upper bound of DG output.

$$P_i^{\min} \le P_g \le P_i^{\max} \tag{3}$$

d) Feeder capability limits:

$$\left|I_k\right| \le I_k^{\max} \quad k \in \{1,2,3,......l\} \tag{4}$$

Where, $I_k^{\max}$ = maximum current capability of branch k.

B. Optimal Load Flow Calculation

As the distribution systems have low line X/R ratios, distribution networks will be ill-conditioned for the calculation of voltage and currents at each bus and branch using conventional load flow methods. Other than that, the load flow method of distribution system should have efficient time and robust characteristics. Therefore, backward-forward sweep method is employed as distribution load flow technique to calculate currents of each branch (Ibr) [20].

1. Backward Propagation: The backward sweep starts at the extreme end node and proceeds towards source node. The voltage (V_b) values obtained in the forward path are held constant during the backward propagation and power flows (S_b) at each branch updated are transmitted backward using backward path along the feeder. The current at each bus is computed as,

$$i_b^k(b) = \frac{S_b^k(b)}{V_b^k(b)} \tag{5}$$

The current of each branch is then calculated as the current difference between last branch and last bus from the end node i.e.

$$i_{br}^k(br) = i_{br}^k(br-1) - i_b^k(b) \tag{6}$$

2. Forward propagation: The voltage at each node starting from the source node of feeder is calculated in the forward sweep. Here, the effective power in each branch is held constant to the obtained value in the backward sweep. Voltage at each bus is calculated as voltage difference between last bus and last branch from the starting node to the last one.

$$V_b^k(b+1) = V_b^k(b) - Z_{br}(br) i_{br}^k(br) \tag{7}$$

Zbr(br) represents the impedance of each branch. The voltages calculated in the previous and present iterations are compared for the convergence criteria. 'k' here in all equations is the iteration count. The procedure is repeated until the voltage of each bus is converged i.e., $\Delta V_b^k(b) \le \varepsilon(tolerance)$ is satisfied in

$$\Delta V_b^k(b) = V_b^k(b) - V_b^{k-1}(b) \tag{8}$$

III. PROPOSED METHOD

The BPSO algorithm was introduced by Kennedy and Eberhart to allow the PSO algorithm operation in binary problem spaces [22]. It uses the concept of velocity as a probability that a bit (position) takes on one or zero.The BPSO algorithm is initialized with the population of individuals being randomly placed in the search space and search for an optimal solution by updating individual generations. At each iteration, the velocity and the position of each particle are updated according to its previous best position and the best position found by informants. In the original continuous version [23], each particle's velocity and position are adjusted by the following formula:

$$v_{i,j}(t+1) = wv_{i,j}(t) + c_1 R_1 (p_{best,i,j} - x_{i,j}(t)) + c_2 R_2 (g_{best,i,j} - x_{i,j}(t)) \tag{9}$$

$$x_{i,j}(t+1) = x_{i,j}(t) + v_{i,j}(t+1)$$

Where, C1 , C2 are the acceleration coefficients,

w is the inertia parameter,

R1 , R2 are random variables ,

g_{best} is the global best and

p_{best} is the best position of the particles.

The acceleration coefficients, c1 and c2 finds the influence of the personal best and the neighborhood best solutions on the particle's current velocity vector The inertia parameter, w controls the influence of the previous velocity on the current velocity [24]. In [25], it was shown that a good convergence can be obtained by making these two constants (acceleration and inertia) dependent. The relation between acceleration parameters and inertia parameter is shown in equation(12) with an intermediate parameter. In this paper C1 and C2 values are taken as 2.

$$w = \frac{1}{\varphi - 1 + \sqrt{\varphi^2 - 2\varphi}} \tag{10}$$

$$c_1 = c_2 = \varphi w$$

Where, φ is an intermediate parameter.

In the BPSO, Eq. (9) for updating the velocity remains unchanged, but Eq. (10) for updating the position is redefined by the rule [24].

$$x_{i,j}(t+1) = \begin{cases} 0 & if \quad rand() \geq S(v_{i,j}(t+1)) \\ 1 & if \quad rand() < S(v_{i,j}(t+1)) \end{cases} \tag{11}$$

Where, $S(.)$ is the sigmoid function for transforming the velocity to the probability as the following expression:

$$S(v_{i,j}(t+1)) = \frac{1}{1 + e^{-v_{i,j}(t+1)}} \tag{12}$$

rand() is the pseudo-random number selected from a uniform distribution over [0, 1]. For a velocity of 0, the sigmoid function returns a probability of 0.5, resulting that there is a 50% chance for the bit to flip.

IV. RESULTS AND DISCUSSIONS

The proposed algorithm is implemented on IEEE 33-bus radial distribution system. The distribution network given in [4] is used to explain the importance and effectiveness of the proposed method. The proposed method is implimented in MATLAB on a PC Pentium IV, 3-GHz computer with 0.99 GB RAM. The distribution system for reconfiguration contains 33- buses and 5 tie lines. The normally open tie switches are 33, 34, 35, 36, and 37 indicated by the dotted lines and normally closed switches 1 to 32 are indicated by the solid lines as shown in figure 1.

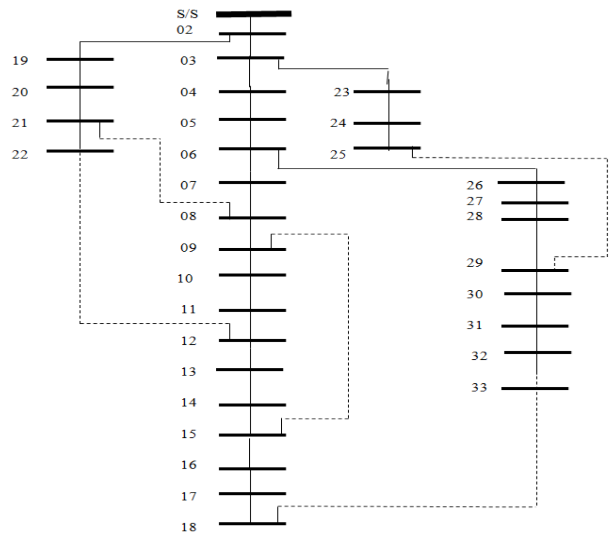

Fig. 1 IEEE 33–Bus Initial configuration of the radial distribution system

For this base case, the initial losses are 208.4592 kW. The network data of 33-bus system are given in Table I.

TABLE I
NETWORK DATA FOR 33 – BUS SYSTEM

Line No:	From Bus:	To Bus:	R (Ω)	X (Ω)	Real power Load (KW)	Reactive Power Load (KVAr)
1	1	2	0.0922	0.0477	100.0	60.0
2	2	3	0.4930	0.251	90.0	40.0
3	3	4	0.3660	0.1840	120.0	80.0
4	4	5	0.3811	0.1941	60.0	30.0
5	5	6	0.8190	0.0700	60.0	20.0
6	6	7	0.1872	0.6188	200.0	100.0
7	7	8	1.7114	1.2351	200.0	100.0
8	8	9	1.0300	0.7400	60.0	20.0
9	9	10	1.0400	0.7400	60.0	20.0
10	10	11	0.1966	0.0650	45.0	30.0
11	11	12	0.3744	0.1238	60.0	35.0
12	12	13	1.4680	1.1550	60.0	35.0
13	13	14	0.5416	0.7129	120.0	80.0
14	14	15	0.5910	0.5260	60.0	10.0
15	15	16	0.7463	0.5450	60.0	20.0
16	16	17	0.2890	1.7210	60.0	20.0
17	17	18	0.7320	0.5740	90.0	40.0
18	2	19	0.1640	0.1565	90.0	40.0
19	19	20	1.5042	1.3554	90.0	40.0
20	20	21	0.4095	0.4784	90.0	40.0
21	21	22	0.7089	0.9373	90.0	40.0
22	3	23	0.4512	0.3083	90.0	50.0
23	23	24	0.8980	0.7091	420.0	200.0
24	24	25	0.8960	0.7011	420.0	200.0
25	6	26	0.2030	0.1034	60.0	25.0
26	26	27	0.2842	0.1447	60.0	25.0
27	27	28	1.0590	0.9337	60.0	20.0
28	28	29	0.8042	0.7006	20.0	70.0
29	2	30	0.5075	0.2585	200.0	600.0
30	30	31	0.9744	0.9630	150.0	70.0
31	31	32	0.3105	0.3619	210.0	100.0
32	32	33	0.3410	0.5302	60.0	40.0
33	21	8	2.0000	2.0000		
34	9	15	2.0000	2.0000		
35	12	22	2.0000	2.0000		
36	18	33	0.5000	0.5000		
37	25	29	0.5000	0.5000		

TABLE II
SIMULATION RESULTS OF 33 BUS DISTRIBUTION NETWORK

	BEFORE RECONFIGURATION	AFTER RECONFIGURATION
Tie switches:	33 34 35 36 37	7 9 14 32 37
Power loss:	208.4592 kW	101.9275 kW
Power loss reduction:	------	51.1043%
Minimum voltage:	0.91075 pu	0.94234 pu

The optimal radial configuration of the network after all the switching operations is shown in figure 2. Table II shows the simulation results of the base configuration and the optimal configuration. The minimum and the maximum voltages of the two configurations are shown in fig. 3. The power loss before reconfiguration is 208.4592 kW and after reconfiguration is 101.9275 kW. From the results it is observed that reduction in power loss is 106.5317 kW which is approximately 51.1043%.

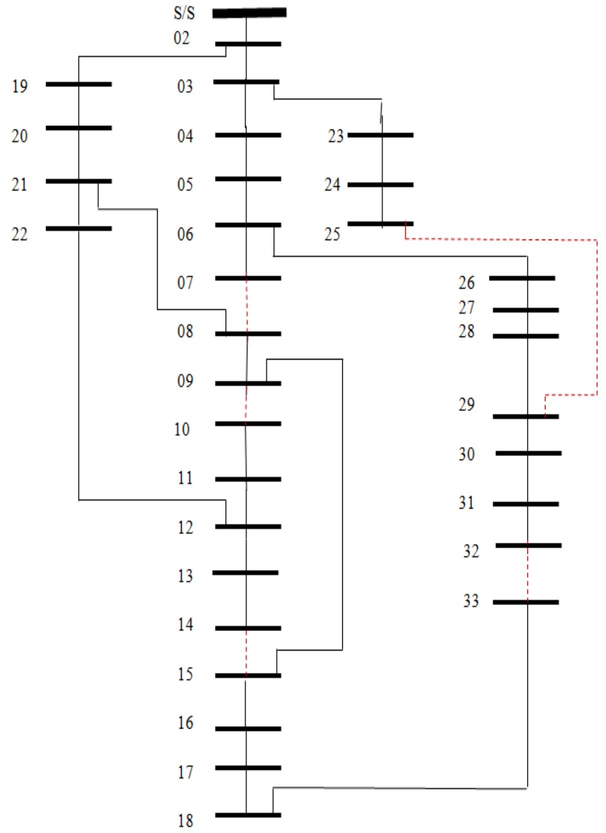

Fig. 2 IEEE 33–Bus Final configuration of the radial distribution system

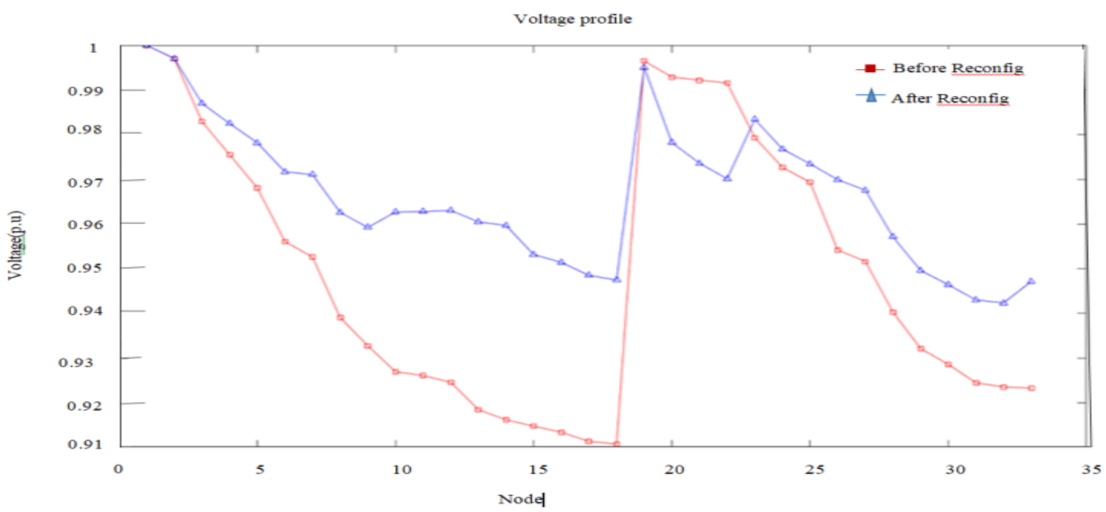

Fig. 3 IEEE 33–Bus System Voltage Profile.

COMPARISION OF RESULTS:

The proposed method is compared with Heuristic Approach [15] for the same 33-bus test system. For effective comparison, the results of the proposed method along with other method are shown in Table III.

TABLE III

COMPARISION OF RESULTS OF 33 BUS DISTRIBUTION NETWORK

Method	Final open switches	Total loss (KW)	Total loss savings (%)
Before Reconfiguration	33 34 35 36 37	208.45	-----
Heuristic Approach[15]	34 37 11 31 28	111.12	46.7
BPSO	7 9 14 32 37	101.9	51.1043

The comparative 33-bus test results for the reconfigured network are presented in Table III. The savings in total loss by the proposed method is higher than Heuristic Approach.

V. CONCLUSIONS

In the present work, the network reconfiguration problem is solved optimally to achieve the lowest power loss in the distribution systems. The minimum power losses with improved voltage profile can be achieved by using optimal network reconfiguration while observing all possible combinations of switching automatically. The proposed BPSO algorithm has been tested on the IEEE 33-bus system. The results shows that the power loss is minimized compared to heuristic algorithm. Results also indicate that there is a significant improvement of voltage stability for most of the buses, but the time taken for obtaining optimal solution is more compared to Heuristic method.

REFERENCES

[1] A. Merlin, H. Back, Search for a minimal-loss operating spanning tree configuration in an urban power distribution system, in: Proceedings of 5th Power System Computation Conference (PSCC), Cambridge, UK, 1975, pp. 1–18.

[2] S. Civanlar, J.J. Grainger, H. Yin, S.S.H. Lee, Distribution feeder reconfiguration for loss reduction, IEEE Trans. Power Del. 3 (July (3)) (1988) 1217–1223.

[3] D. Shirmohammadi, H.W. Hong, Reconfiguration of electric distribution networks for resistive line loss reduction, IEEE Trans. Power Del. 4 (April (2)) (1989) 1492–1498.

[4] M.E. Baran, F.F. Wu, Network reconfiguration in distribution systems for loss reduction and load balancing, IEEE Trans. Power Del. 4 (April (2)) (1989) 1401–1407.

[5] S.K. Goswami, S.K. Basu, A new algorithm for the reconfiguration of distribution feeders for loss minimization, IEEE Trans. Power Del. 7 (July (3)) (1992) 1484–1491.

[6] T.P. Wagner, A.Y. Chikhani, R. Hackam, Feeder configuration for loss reduction: an application of distribution automation, IEEE Trans. Power Del. 6 (October (4)) (1991) 1922–1931.

[7] R.P. Broadwater, A.H. Khan, H.E. Shalan, R.E. Lee, Time varying load analysis to reduce distribution losses through reconfiguration, IEEE Trans. Power Del. 8 (January (1)) (1993) 294–300.

[8] G.J. Peponis, M.P. Papadopoulos, N.D. Hatziargyriou, Distribution network reconfiguration to minimize resistive line losses, IEEE Trans. Power Del. 10 (July (3)) (1995) 1338–1342.

[9] D. Mary, M. Ravichandra Babu, Network reconfiguration for loss minimization by optimal operations in distribution systems, Int. J. Recent Trends Eng. 2 (3) (2009) 129–131.

[10] E. Dolatdar, S. Soleymani, B. Mozafari, A New Distribution Network Reconfiguration Approach using a Tree Model, vol. 5, World Academy of Science, Engineering and Technology, 2009, pp. 1186–1193.

[11] J-.H. Teng, A direct approach for distribution system load flow solutions, IEEE Trans. Power Del. 18 (July (3)) (2000) 1085–1091.

[12] M.Padma Lalitha, V.C. Veera Reddy, V.Usha."Optimal Dg Placement For Minimum Real Power Loss In Radial Distribution Systems Using Pso." Journal of Theoretical and Applied Information Technology(2010).

[13] M.Padma Lalitha, V.C. Veera Reddy, V.Usha." Application of fuzzy and PSO for DG placement for minimum loss in radial distribution system." ARPN Journal of Engineering and Applied Sciences(2010).

[14] Reddy, P. Dinakara Prasad, VC Veera Reddy, and T. Gowri Manohar. "Application of flower pollination algorithm for optimal placement and sizing of distributed generation in distribution systems", Journal of Electrical Systems and Information Technology 3.1 (2016): 14-22.

[15] Ahmed R. Abul'Wafa, A new heuristic approach for optimal reconfiguration in distribution systems.

[16] R. Srinivasa Rao, S.V.L. Narasimham, A new heuristic approach for optimal network reconfiguration in distribution systems, Int. J. Appl. Sci. Eng. Technol. 5 (1) (2009) 15–21.

[17] Vanderson Gomes, et al., A new heuristic reconfiguration algorithm for large distribution systems, IEEE Trans. Power Syst. 20 (August (3)) (2005) 1373–1378.

[18] M. Kashem, V. Ganapathy, G.B. Jasmon, M.I. Buhari, A Novel model for loss minimization in distribution networks, in: IEEE International Power Technologies 2000 Conference on Electric Utility deregulation, restructuring at City University London, 4–7 April, 2000, pp. 251–256.

[19] X. Jin, J. Zhao, Y. Sun, K. Li, B. Zhang, "Distribution Network Reconfiguration for Load Balancing using Binary Particle Swarm Optimization", International Conference on Power System Technology, vol. 1, no. 1, Nov. 2004, pp. 507-510.

[20] E. Bompard, E. Carpaneto, G. Chicco, and R. Napoli, "Convergence of the backward/forward sweep method for the load-flow analysis of radial distribution systems," Int. J. Elect. Power Energy Syst., vol. 22,no. 7, pp. 521–530, 2000.

[21] Eberhart RC. A discrete binary version of the particle swarm algorithm. In: Proceedings of 1997 conference systems man cybernetics, NJ: Piscataway; 1997. p. 4104–8.

[22] Kennedy J, Eberhart RC. Particle swarm optimization. Proceedings of IEEE international conference on neural networks, vol. IV. NJ: Piscataway; 1995. p. 1942–8.

[23] Shi Y, Eberhart RC. A modified particle swarm optimizer. In: Proceedings of IEEE international conference on evolutionary computation, Alaska, USA: Anchorage; 1998. p. 69–72.

[24] Clerc M, Kenney J. The particle swarm-explosion, stability, and convergence in a multidimensional complex space. IEEE Trans Evol Comput 2002;6:58–73.

[25] Kennedy J, Mendes R. Population structure and particle swarm performance. In: Proc 2002 Congress Evol Comput 2002; 2: p. 1671–6.

.