An Enhanced Swarm Optimization Algorithm for Network Reconfiguration

Suman Rani[1] Dr. Silki[2]
[1]Research Scholar [2]Associate Professor
[1,2]Department of Electronics and Communication Engineering
[1,2]JCDM College of Engineering, Sirsa, Haryana, India

Abstract— Power distribution networks are mostly operated in a radial configuration. The dynamics of distribution system operation often requires reconfiguration of the network. Distribution network reconfiguration is achieved by using sectionalizing switches that remain normally closed and tie switches that remain normally open. The main purpose of reconfiguration is to minimize active power losses in order to improve distribution system performance. Particle Swarm optimization to find the best switching pattern which leads to minimum load confined to all equality and inequality constrains allied to distribution system. The objective of the optimization is minimizing active power loss and to improve voltage profile while the distribution network is maintained in the radial structure. In this paper, reconfiguration of IEEE-33 Bus distribution system is done using PSO and results obtained are compared with existing algorithms. The outcome attained illustrates the improvement in voltage profile of each bus and reduction in loss profile as compared with existing algorithms.

Keywords: DG, Network Reconfiguration, PSO, IEEE-33

I. INTRODUCTION

This paper presents a successful strategy to ideally reconfigure a power distribution system. It represent a best method to interpret the network reconfiguration problem with an objective of minimizing real power loss and simultaneously, improving the voltage profile in radial distribution system (RDS).Particle swarm optimization (PSO) is employed to reconfigure and recognize the optimal tie switches for reduction of real power loss during a radial distribution system. Different scenarios of reconfiguration of distributed network are precise to review the performance of the proposed technique. The constraints of voltage and branch current carrying capacity are incorporated within the assessment of the target function. The proposed method has been tested on IEEE 33-bus systems at different load patterns to demonstrate the performance and effectiveness of the predictable method. The outcomes attained, illustrates that improvement in voltages and a discount within the real power loss. [1] Mirna Fouad Abu Haggar et al. described two meta-heuristic based algorithms, Grey Wolf Optimizer (GWO) and Particle Swarm Optimizer (PSO), to solve network reconfiguration problem in the presence of installing multiple renewable Distributed Generators (DGs)**.[2]** A.K.Saonerkar and at el. Described about optimized distribution loss evaluation in ring main distribution system with Distributed Generation (DG) placement, reconfiguration and capacitor placement using Genetic Algorithm (GA) [3] Hoyong described as reconfiguration of the feeder by using artificial neural network and it determines the topology that reduces the power loss according to the variation of load requirements. [4]M. Damodar Reddy described a fuzzy multi objective algorithm that was used for the network reconfiguration to loss reduction, whilst reconfiguration also improves auxiliary operational parameters are nodal voltage digressions and branch current constraint violation. [5] WuChang Wu described an effective approach based on the particle swarm optimization to determine the switching operation schemes for feeder reconfiguration. [6] R. Srinivsa Rao described a meta heuristic harmony search algorithm (HSA) was used to simultaneously reconfigure and identify the optimal locations for installation of DG units in a distribution network.[7]S. Naveen described the modified bacterial foraging algorithm is described and then applied exclusively to the network reconfiguration problem. It is observed that the results can be more powerful with particle swarm optimization techniques. The Swarm Optimization technique has been used widely for optimizing the Network Power Loss based on the input values. PSO (Particle Swarm Optimization) consists of mainly mutation and selection. There is no crossover in PSO, which means that PSO can have a high mobility in particles with a high degree of exploration. In this work PSO has been used to reduce network power loss. In this work, network configuration of IEEE-33 bus system is proposed using PSO Particle swarm optimization. The objective function of this work is to maximize the power loss reduction in distributed system

II. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) method is a population based evolutionary computation technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by a social behavior of bird flocking or fish schooling. The Particle swarm concept originated as a simulation of a simplified social organization, and has been found to be robust in solving linear and nonlinear problems. PSO technique can generate top quality solutions within less calculation time and have more stable convergence characteristic than other stochastic methods. The PSO based approach is taken into account together of the foremost powerful methods for resolving the non-smooth global optimization problems. PSO shares many similarities with evolutionary computation techniques like Genetic Algorithms. Both algorithms start with a group of a randomly generated population and both have fitness values to evaluate the population. Both update the population with random techniques. However, PSO doesn't have genetic operators like crossover and mutation. Particles update themselves with the internal velocity. The mechanism of data sharing is significantly different compared to genetic algorithms. In genetic

algorithms, chromosomes share the knowledge with one another. In PSO, only, gbest gives out the information to others. The evolution only looks for the best solution.

A. *Mathematical Algorithm:*

In PSO, after finding the two best values, the particle updates its velocity and positions with following equation (1) and (2**)**

v[] = v[] + c1 * rand() * (pbest[] - present[]) + c2 * rand() * (gbest[] - present[])……..(1)

present[] = persent[] + v[]……(2)

where v[] is the particle velocity, persent[] is the current particle (solution). pbest [] and gbest[] are defined as personal best and Global best. rand () is a random number between (0,1). c1, c2 are learning factors. usually c1 = c2 = 2.

The pseudo code of the procedure is as follows:
For each particle
Initialize particle
END
Do
For each particle
Calculate fitness value
If the fitness value is better than the best fitness value (pBest) in history set current value as the new pBest
End
Choose the particle with the best fitness value of all the particles as the gBest
For each particle
Calculate particle velocity according to equation (a)
Update particle position according to equation (b)
End
While maximum iterations or minimum error criteria is not attained

B. *PSO Process*

Algorithm is used for solving the problem step by step which can be implemented with help of programming in any language. In the network reconfiguration, Particle Swarm Optimization method has been proposed to manage the network power loss on multiple networks based on the request on server. The algorithm below explains the flow of Network Reconfiguration concept to manage the workload and reduce the power loss. The algorithm has been implemented for resolving the power loss in network reconfiguration scenario and manage the switched automatically based on the working.

1) Start
2) Create Swarm
3) Set Initial Velocity
4) Initialize Personal Best Velocity
5) Initialize Global Best Position
6) Calculate Fitness Function
7) Move Step7 to 9 Until Optimal Results
8) Update Velocity
9) Update Particles Co-Ordinate
10) Re-Calculate Fitness Function
11) Generate the Results
12) End

III. Simulation Setup for Network Reconfiguration

Table 1 and 2 provides the simulation set up used in this work to evaluate the performance of proposed Particle swarm optimization (PSO) algorithm. The Initial configuration used for IEEE 33 Bus standard distribution network for number of tie switches in a network reconfiguration process is given in Table 1.

S_0	33	34	35	36	37

Table 1: Number of tie switches

Tie Switches are used for the optimal switching corresponding to minimum loss in each loop while maintaining the radial structure in the distribution systems [13]. This switching persists up to reaching minimum loss by scrutiny all possible combinations by closing or opening status of sectional and tie switches. Switch choices to be opened for network reconfiguration are given below:

TAP NO	Switch No								
	8	9	10	11	21	33	35	0	0
	2	3	4	5	6	7	18	19	20
	12	13	14	34	0	0	0	0	0
	15	16	17	29	30	31	32	0	0
	22	23	24	25	26	27	28	0	0

Table 2: Switching Combinations for Reconfiguration

IV. Results and Discussion

The Particle swarm optimization technique has been followed/carried out for generate the efficient results for maintain the network state and based on the results of algorithm, the switches operations performed such as the tie switches working with increase of power supply with less time consumption. Different experiments have been carried to get the effectiveness of the proposed work. The performance of proposed algorithm has been evaluated with variation in load levels of the network from low to high and results are compiled in Table 3.

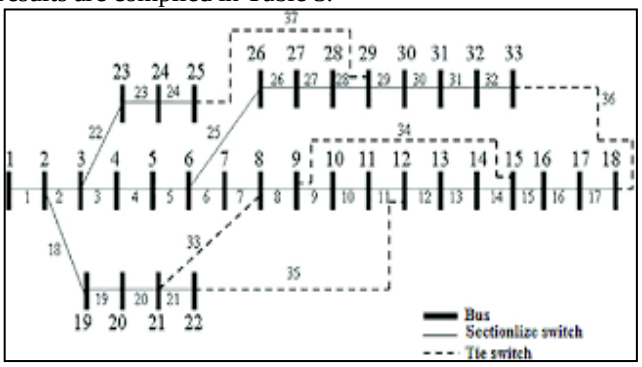

Fig. 1: IEEE 33-bus single line Diagram

Scenario	Item	Load Level			
		Light (0.4)	Light (0.5)	Nominal (1.0)	Heavy (1.8)
Base Case	Switches Opened	33-34-35-36-37	33-34-35-36-37	33-34-35-36-37	33-34-35-36-37
	Power Loss (Kw)	23.81	48.53	159.5	576.6
	Minimum voltage p.u)	0.9664	0.9571	0.9124	0.8308

	V (worst in p.u) (Bus No)	0.9583 (18)	0.9482 (18)	0.9131 (18)	0.8529 (18)
After Reconfiguration	Switches Opened	7-9-14-28-31	7-9-14-27-32	7-9-14-28-31	4-10-12-24-30
	Power Loss (Kw)	21.71	34.53	139.9	310.8
	Minimum Voltage (p.u)	0.97083	0.97071	0.9412	0.8622
	V (worst in p.u) (Bus No)	0.971 (32,33)	0.971 (31,32)	0.941 (32)	0.782 (33)
	Net Power loss Reduction	8%	29	12%	46%
	Elapsed Time (Second)	13	15	14	12

Table 3: Performance Analysis of Proposed Method on 33-Bus System at Different Load Levels

This system consists of five tie lines and 32 sectionalize switches. The normally closed sectionalize switches are 1 to 32 and the open tie switches are 33 to 37. The single line diagram of 33-bus system with the loops (LP1 to LP5) formed corresponding to each tie switch is shown in Fig.1. After simulation, it was observed that the total real and reactive power loads of the system are 3.72 MW and 2.3 MVAr, respectively. The total real and reactive power losses for the base case calculated from power flows are 202.67kW and 135.14 KVAr at nominal load respectively. The minimum voltage magnitude of the system is 0.9111 occurs at bus no 17 and 18. In the basic configuration, power loss was 159.5 KW and after optimal reconfiguration by using the projected PSO method, power loss is reduced to 139.9 KW at normal load conditions. Similarly, at light load level, initially the power loss was observed as 48.53KW and after optimal reconfiguration by using the projected PSO method, power loss gets reduced to 34.53KW. At Heavy load level, power loss of 576.6KW was observed and after optimal reconfiguration by using the projected PSO method, power loss reduced to 370.8KW. The minimum voltage magnitude of the system is 0.957p.u occurs at bus no 18. The total power loss and minimum voltage magnitude of the system for the optimum case is 139.9 KW and 0.94127 p.u. It is observed that nearly 40% of total power loss has been reduced in the optimum case. Also the minimum voltage magnitude has been improved from 0.9283 to 0.9356 p.u after reconfiguration by PSO. Fig.2, 3 and 4 provides comparison of voltage profiles before and after reconfiguration at different load levels.

Item		PSO (proposed)	RGA[11]	HSA[6]	FWA[9]
Base Case (Tie Switches)		33,34,35,36, 7	33,34,35,36,37,	33,34,35,36,37	33,34,35,36,37
Optimum case(Tie switches)		6,11,32,34,37	7,14,09,32,37	07,14,10,36,37	07,14,09,32,28
P_{Tloss} (Kw)	Best	139.13	145.11	146.39	144.37
	Worst	201.6	198.3	195.10	155.75
	Average	157.89	164.5	152.33	145.63
Average % Loss Reduced		24.2	18.65	24.85	28.14
Best % Loss Reduced		31	31.14	27.77	30.93
V(p.u)		0.9356	0.9336	0.936	0.9413
Average Computation Time (sec)		18	13.8	19	24

Table 4: Performance Comparison at Nominal Load

In order to illustrate the performance of the proposed method, the performance of PSO is compared with the results of HSA [6], GA [9] and RGA [11] available in the literature and is presented in Table 4. From the table, it is perceived that at all scenarios, the performance of the PSO is better than HSA, GA and RGA in terms of power loss minimization and voltage stability enhancement.

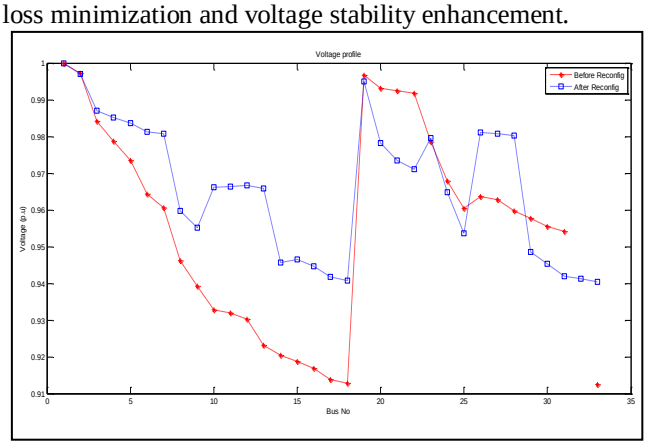

Fig. 2: Comparison of Voltage Profiles before and after reconfiguration for IEEE 33-bus System at Normal Load

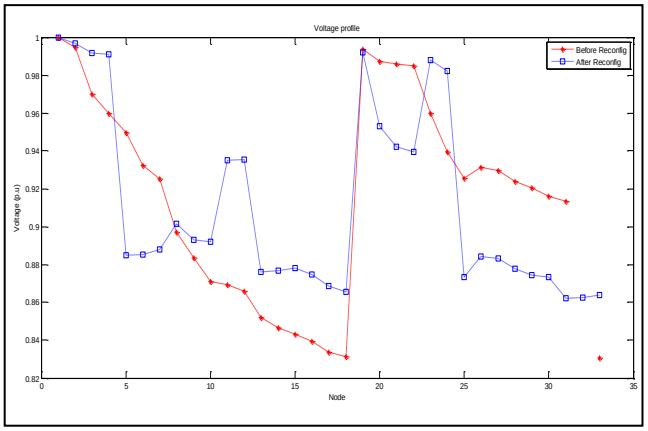

Fig. 3: Comparison of Voltage Profiles Before and After Reconfiguration for IEEE 33-bus System at High Load

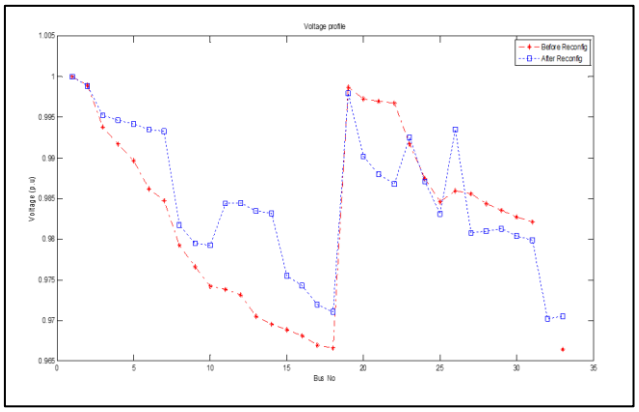

Fig. 4: Comparison of Voltage Profiles Before and After Reconfiguration for IEEE 33-bus System at Light Load

V. CONCLUSION

The research work has been carried out for network reconfiguration based on the particle swarm optimization. Particle swarm optimization (PSO) is an optimization method or algorithm that optimizes a problem by trying to improve a candidate solution upto a given measure of efficiency or quality. From the result it can be observed that PSO gives the best combination of tie switches for network reconfiguration resulting in minimum power loss and improved voltage profile. In Future, the PSO algorithm can be combined with Fuzzy Neuron or Genetic Algorithm to improve the results and accuracy. The Genetic algorithm resembles with the functions of the PSO and fuzzy works on neural network concepts so the results can be more powerful with these techniques.

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