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Particle Swarm Optimization Technique Used for Optimal Network Reconfiguration with Dispersed Generation

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***Abstract* - Dispersed Generation and Network Reconfiguration have been generally engaged to maintain voltage level with permissible limit and decrease the energy losses in the Distribution Systems. In this article, a Particle Swarm Optimization (PSO) technique is developed and it is used to reduce the energy losses in Network Reconfiguration and Dispersed Generation placement. Different scenarios are used to analyze the performance of developed method. The proposed and designed technique is efficiently tested on IEEE 33-bus RDS (Radial Distribution System) with three various load models. The voltage summary in IEEE 33-buses is better when compared to other basic voltage profile.**
***Keywords:* Network Reconfiguration, Distributed Generation, PSO, Radial Distribution System**

I. INTRODUCTION

Power generated at power distribution stations are utilized in great and composite networks like power transformers, underground cables, overhead power lines, and attain at end consumer. It's a verity that unit of electric power generated by control station does now not equal with the units disbursed to the customers. Some percent of the element is misplaced in distribution network. Radial and network are the two types of Distribution networks. A radial structure is designed a tree everyplace each consumer has one supply. Network structures have multiple sources operating at parallel supply. In distribution scheme preparation reduced the energy loss is major issues in distribution developers. To ignore this concern, reconfiguring the switching network in the feeders is done [2].

To solve the reconfiguration problem several methods are presented: some limitation and objectives are the characterize utilizing continuous variables except the switches composes to split set, it is difficult from a statistical viewpoint in the direction of radial constriction and in multi-objective, also, little modify in network topology can source large variations into the value. In [3], a general approach to resolve the reconfiguration difficulties is to utilize gradually heuristics, in which most excellent choice is for eternity made recognized as greedy technique. Merlin *et al.,* [4] has developed the pioneers techniques with meshed network attain concluding all switches. The switches are release successively to return radial configuration by the slightest current as criterion-sequential opportunity. Cinvanlaret *et al.,* [5] has developed and proposed a switch exchanging technique that commence with radial pattern instead of network. The methods guarantee that opportunity of some switch is pursue through closure of another switch, make sure that the correlation and radiality constriction would be conserved. On the falling distribution losses during reconfiguration on instantaneous operation allows load changeability [6].

However, suitable to dynamic character of loads, whole classification load is further generation ability that creates reduce of load scheduled the feeders doest achievable and thus voltage summary of the scheme will not be present better toward the required point. In organize to required stage of load requirement, Distributed Generation are incorporated into distribution network toward recover voltage summary. Because there are a lot of applicant configurations of distribution network with appropriate to the separate character of every switching status.

A heuristic technique [7] has developed, resolve to change in energy loss during the branch replacing time. The difficulty of this technique is single pair of operating switches is measured at an instance and network depended on early switching status and instantaneous switching. The feeder reconfiguration was not considered in this paper. An explanation with [3], several met heuristics based techniques has been developed into the DNR field, like: GS, Simulated Annealing, PSO, and PGS.

ABC (Artificial Bee Colony) technique [8] has developed to resolve a 33-bus RF reconfiguration with distributed generation to decrease system failure in the network and reduce the total losses not including contravene process constraints and continue the radial arrangement. Olamaei J *et al.,* [9] has been designed and presented a customized HBM optimization technique for DFR for loss reduction in distributed generations. The optimization processes combine equally distributed generation assignment and reconfiguration be newly introduced. The ACO technique has developed for the optimization. The collective procedure of deterministic technique and heuristic algorithm is used for network system reconfiguration and distributed generation placement for energy loss drop and voltage summary development at distribution networks [10, 11].

From the above discussion, the optimal restructured radial distribution developed scheme utilized to changing power flow through lines towards important way. This distorted flow modification the real energy losses, reactive energy losses and voltage summary. To reduce the difficulty of energy losses in proposed network, distributed generation and reconfiguration units of RDS is presented in this article. Different methods are tried to resolve this difficulty. The PSO technique is used to analysis the performance and optimization difficulty of the system. The designed work is experienced with IEEE-33 bus RD scheme.

II. DISTRIBUTED GENERATION USING PSO

The purpose of this function is to reduce the Energy losses in Distribution Networks through NR and DG using PSO technique, as given in (1), subject to the constraints (2)-(4).

$$F = \min\left(\sum_{l=1}^{L}\left(\sum_{i=1}^{n_b} k_i \times R_i \times \frac{P_{i_l}^2 + Q_{i_l}^2}{V_{i_l}^2}\right) \times \tau_l\right) \quad (1)$$

Subject to,

$$|V_i^{\min}| \leq |V_{i_l}| \leq |V_i^{\max}| \quad (2)$$

$$|I_{i_l}| \leq |I_i^{\max}| \quad (3)$$

$$P_{DG}^l \leq DG_{penetration} \times P_{total}^l \quad (4)$$

A. PSO Algorithm

In this section, the approach of implementing the PSO algorithm for minimizing the Energy Loss is described. The process of PSO algorithm can be summarized as follows.

Procedure I: Initialize

Start the population items; calculate no of variables and no of iteration, lower limits and upper limits.

Procedure II: Production

The V_{id} and X_{id} are produce randomly depends on population width and variable ranges. Open and closed status of tie switches.

Procedure III: Calculation of Fitness Function

PSO reflect on all variables because constant variables. When additional DG is established, after producing the early population, it is confirmed that single device is located. The bus and line data's are simplified for the DG place.

Procedure IV: V_{id} and X_{id} Updation

The inactivity weight is modernized (5).

$$W = W_{\max} - W_{\min} i_{\max} * i \quad (5)$$

New V_{id} are considered utilizing (6) and (7).

$$V_{i_d(t+1)} = wxV_{id} + c_1 xr_1 x(P_{id} - X_{id}) + c_2 xr_2 xP_{gd} - X_{id}) \quad (6)$$

$$X_{i_d(t+1)} = X_{id} + V_{id} \quad (7)$$

Procedure V: Stop

Repeat the procedure III and IV.

B. Load Model

Fig. 1 shows the typical load curves for different load profiles. The proposed method employs the different Daily Load Curves (DLCs) of different customers like commercial, residential and industrial customers, to estimate the power losses of distribution DN. The everyday weight summary for various types of loads is selected [16]. The exponential values for equation (8) and (9) are listed in Table I.

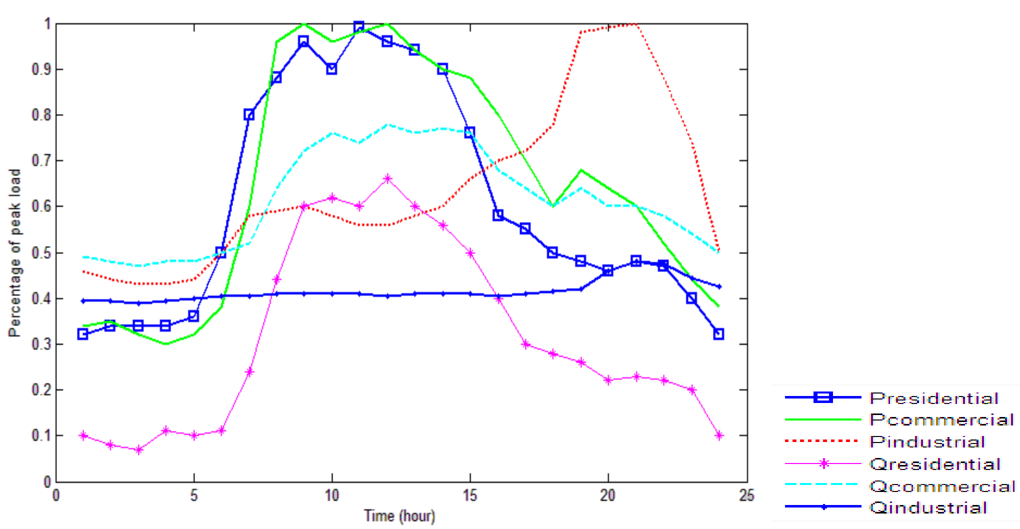

Fig. 1 Typical Daily Load Curves

TABLE I EXPONENTIAL PARAMETERS VALUES FOR DIFFERENT LOAD TYPES [15]

Parameter	Industrial (α)	Commercial (β)	Residential (γ)
P	0.09	0.589	1.96
Q	0.62	2.86	2.925

$$P = P_o(A_P(\frac{V}{V_o})^{\alpha P} + B_P(\frac{V}{V_o})^{\beta P} + C_P(\frac{V}{V_o})^{\gamma P}) \quad (8)$$

$$Q = Q_o(A_Q(\frac{V}{V_o})^{\alpha Q} + B_Q(\frac{V}{V_o})^{\beta Q} + C_Q(\frac{V}{V_o})^{\gamma Q}) \quad (9)$$

DLC can be separated into various intervals to moderate the load, because of several apparent load levels during a day. Using this objective function (10), minimum fitness value is calculated by PSO algorithm subjected to (11). The number of load intervals to be selected depends upon the number of loads used in the proposed method.

$$F = \min(\sum_{l=1}^{L}\sum_{t=1}^{\tau_l}((P_{avg_l} - P_{t_l})^2 + (Q_{avg_l} - Q_{t_l})^2)) \quad (10)$$

$$\sum_{l=1}^{L}\tau_l = 24 \quad (11)$$

Distributed Generation should be properly allocated in the distribution networks to alleviate the energy losses inside the networks. In arrange to decrease the maximum no of iterations of optimization process, location of Distributed Generation units preserve be calculated by compassion examination. Utilizing equ. (12), LSF preserve be designed.

$$LSF = \frac{1}{24}\sum_{l=1}^{L}\frac{2 \times P_L \times R_b \times \tau_l}{V_n^{l^2}} \quad (12)$$

III. RESULTS AND DISCUSSION

The developed system is tested on IEEE 33 bus RDS with three Distributed Generation units and four tie switches additionally. Fig. 2 shows the distribution network. In this paper, the Distributed Generation units are located at the buses 6, 3 and 8 based on loss sensitivity index.

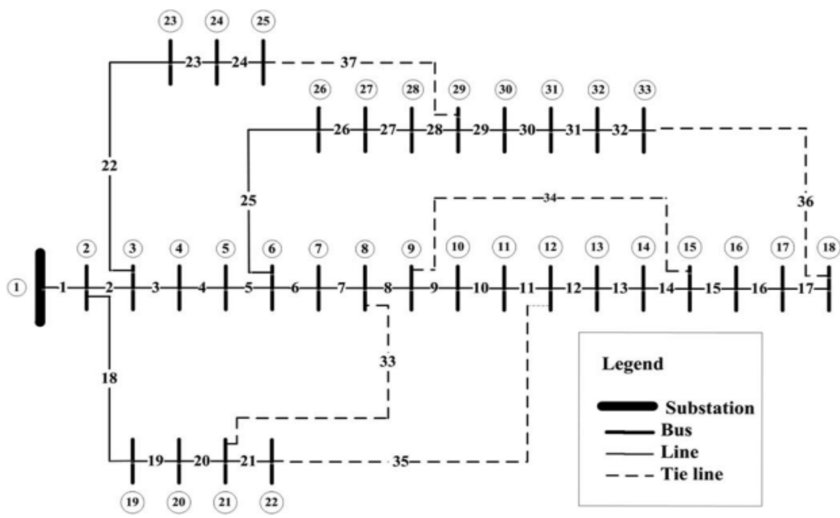

Fig. 2 IEEE standard- 33 Bus RDS [15]

The proposed system is demonstrated with PSO technique and it is tested with 33 buses. The developed system is utilized to reduce losses of network with the various loads. The demonstrated system contains with 32 sectionalizing and 5 tie switches. The sectionalizing switches are Closed and marked with 1 to 32.

TABLE II PSO PARAMETERS

PSO Parameters	Value
c_1, c_2	1,3
w_{min}, w_{max}	0.8, 0.9
Population size	30
Maximum iteration	100

The tie switches are Opened and marked as 33 to 37. The 210 kW and 142 kVAr are the real power and reactive power losses. Table II presented the parameters used in the proposed system.

A. Base Case Study

The base case results for IEEE 33 bus test system are listed on table III. At each load point, the portion of residential, commercial and industrial loads are set to 25 percentages, 35 percentages and 40 percentages. DLCs indicated in fig. 1 are used to simulate, and three load intervals are assumed. Table IV shows the Energy losses at each load intervals (1, 2, 3) for corresponding loads. The 3 step for calculations of loss are

1. Step I: DG alone
2. Step II: Network Reconfiguration
3. Step III: Network Reconfiguration and DG

TABLE III BASE CASE RESULTS

S. No.	Interval	Time Duration (hours)	Energy loss (KWh)
1	1	1 – 9	377.03
2	2	10 – 16	622.95
3	3	17 – 24	458.07

B. Case Study I

The optimal location of Distributed Generation item for the experiment scheme is selected based on the LSF. In IEEE standard 33 bus experiment scheme, the LSF value is calculated for each bus and the values are plotted in the graph Fig. 3. From the graph, it is known that buses 6, 3, and 8 having the LSF value of 0.0213, 0.0184, and 0.0155, respectively. Hence, the buses 6, 3, 8 are selected as optimal DG location for the test system.

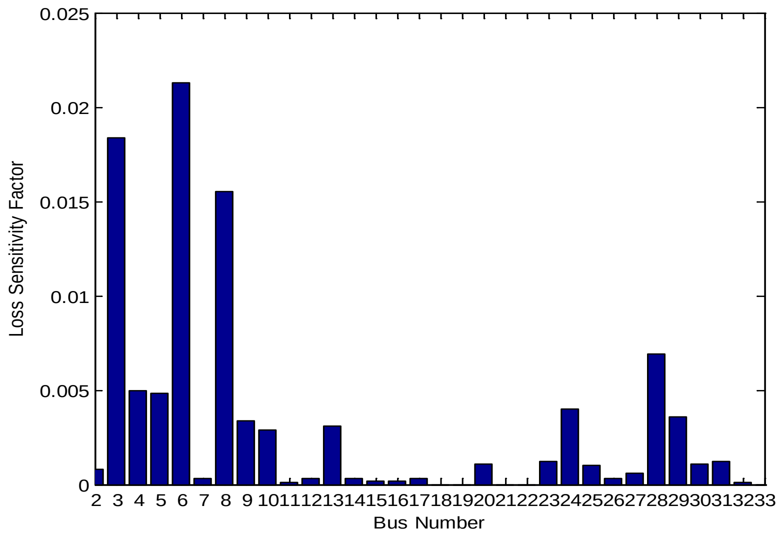

Fig. 3 Priority Order Based Load sensitivity Factor

Table IV shows the results for, DG size and loss minimization for with DG alone only. DG sizes are assumed as 50-250 MW. In each interval the power losses are calculated as 222.8, 412.9 and 286.8 kWh respectively.

Compare to base case results, after installation of DG units in DS, energy losses are minimized and it presented in Table IV.

TABLE IV CASE STUDY I

Interval and Duration (hours)	Size of DG (KW)			Energy Loss (KWh)
	Bus No. 6	Bus No. 3	Bus No. 8	
1(1-9)	249.6	235.5	243.4	222.8
2(10-16)	241.7	222.9	249.8	412.9
3(17-24)	249.5	133.5	234.9	286.8

C. Case Study II

In this case, energy losses in the test system are evaluated with network reconfiguration only. The tie switches are opened for corresponding load intervals and the Open position to the tie switches for load period are presented in table V.

The last column of the Table V gives the energy loss in the system after the network reconfiguration. For the three load intervals, the loss reduction is about 254.7 kWh, 424.16 kWh and 310.16 kWh from the corresponding base case results. From the results, it is clear that by implementing reconfiguration in the system, the energy loss for the corresponding load interval is greatly minimized.

TABLE V CASE STUDY II

Interval and Duration (hours)	Reconfiguration (Open Status)	Energy Loss (KWh)
1(1-9)	7, 12, 8, 15, 22	122.30
2(10-16)	7, 12, 8, 15, 22	198.79
3(17-24)	7, 12, 8, 15, 22	147.89

D. Case Study III

In Case Study III, energy losses in the test system are calculated with both the best DG and NR. The tie switches are released for corresponding load intervals and the release position of the tie switches for the load interval are presented in table VI. The voltage summaries of all buses with case studies are shown in fig 4. When evaluate to standard case, the voltage summary is better significantly in cases of DG Placement, Network Reconfiguration and both.

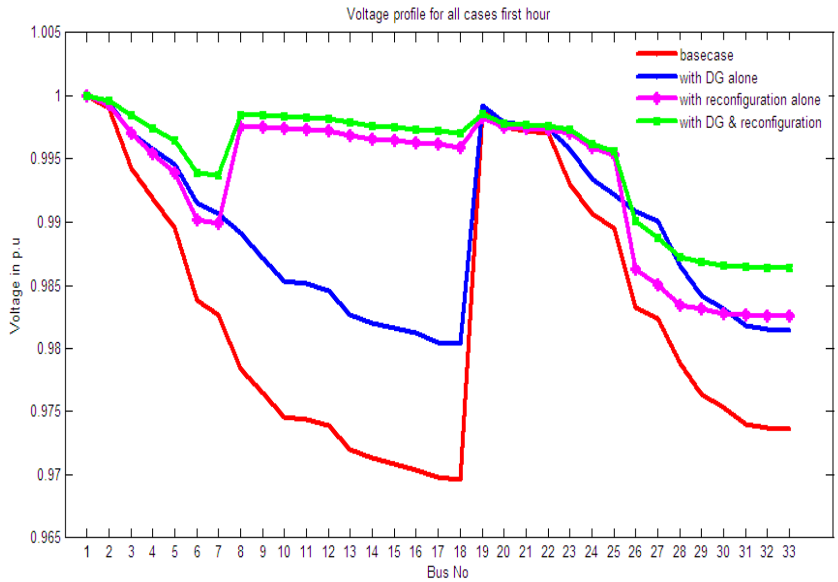

Fig. 4 Voltage Profile in all Case

IV. CONCLUSION

In this article, a developed and designed network reconfiguration with distribution system is presented. The different loss minimized methods are presented with simulated results of proposed technique. The developed PSO technique has been analyzed with optimization problem. The simulation results are compared with various case studies. The developed PSO technique has been analyzed on 33-bus RDS. The simulation results concluded that the effectiveness of the developed technique. The proposed method is minimized power loss, considered time-varying conditions of various load utilizing with a developed strategy.

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