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ADAPTIVE PSO BASED MULTIPLE DG PLACEMENTS IN DISTRIBUTION SYSTEM FOR POWER LOSS REDUCTION

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ABSTRACT

Proper placement of Distributed Generation(DG) in the distribution network is a veryvital and challenging task. If the DGs are not properly placed inthe distribution network, it may lead to increase of electric powerlosses instead of reducing the same. So, the placement of DG atproper strategic location is a very important task. At the sametime, optimum sizing of DG plays anessential role to reduce the network losses. For that reason, finding the optimum location and obtaining the appropriate size of DG have become an important topic of research. The proposed Adaptive Particle Swarm Optimization (APSO) technique gives better results for all the test systems. Proposed APSO for voltage stability index will provide better locations for distributed generation sources and better management of real and reactive power deployment. Experimental results have been carried out for IEEE 33 radial bus systems in which three different locations are selected from 37 lines in 33 bus system. When the locations are optimized; new configuration gives 70.36 % less power loss than the older configuration.

Keywords: Distributed generation, Optimal size, Optimal location, Particle swarm optimization, Power factor, Newton-Raphson etc.

I. INTRODUCTION

Distributed generation (DG) is a little scale age generally called as embedded generation, decentralized or scattered generation, which produces control in the scope of 3– 10,000 kW from wind, sunlight based, bio-mass, power devices, miniaturized scale turbines and so forth. DG units are associated nearer to the clients and are utilized for modern, business and household applications. The primary points of interest of utilizing DG units are enhancing voltage solidness, genuine power misfortune decrease, dependability, lattice fortifying and diminishment of SO2, CO2 gas outflows. In spite of the fact that DG has loads of points of interest, the key issue in DG situation is the choice of ideal area and size of DG units. On the off chance that DG units are despicably allotted and measured, the switch control spill out of bigger DG units can prompt higher framework misfortunes, voltage changes and increment in cost. Consequently, to limit misfortunes, it is essential to locate the best area and size of DG units [1]. As of late numerous scientists have proposed new logical methodologies in view of Power Stability Index (PSI) and Power Loss Sensitivity (PLS) record to locate the ideal area and measuring of DGs for getting an ideal arrangement of the power misfortune minimization issue in the spiral circulation framework [2].

The basic transport can be discovered from PSI and the DG ought to be set toward the finish of the line which is having most astounding PSI. The measure of DG is resolved in view of genuine power misfortune minimization. Voltage profile, the genuine and responsive power allow by the network, genuine and receptive power stream designs, cost of vitality misfortunes, reserve funds in the cost of vitality misfortune and cost of influence acquired from DGs have likewise been considered while taking care of the DG issue. Close ideal outcomes are the fundamental downsides in all the above strategies. The strategy portrayed in [3], however the union is accomplished at few emphasis, yet the technique isn't relevant for unequal and fit dispersion framework. A few man-made reasoning based procedures have been proposed for tackling the DG enhancement issue. In [4], the creators utilized firefly calculation for settling DG arrangement and estimating keeping in mind the end goal to get least misfortune, voltage profile change and least age cost. In any case, the fundamental inconvenience is moderate joining. Bacterial scrounging advancement calculation (BFOA) and changed BFOA are utilized as a part of [5] and [6] individually to solve the ideal DG position issue. The principle disadvantage is many-sided quality of the calculation and subsequently the less meeting speed.

In [7], Particle Swarm Optimization (PSO) is proposed for multi DG position for control misfortune diminishment and voltage profile change. Symbiotic Organism Search (SOS) calculation has been utilized for DG arrangement issue [8]. SOS calculation is a nature motivated heuristic procedure, in light of the cooperative connection between various organic individual species. In [9], the creators proposed Gray Wolf Optimizer (GWO) to comprehend the multi target work as far as minimization of responsive power misfortunes and voltage profile change. A cross breed approach proposed with a scientific strategy used to locate the measure of DGs and PSO based system is connected to decide the area [10]. Diverse kinds of DGs have been considered for investigation. Multi-objective Shuffled Bat calculation is utilized to decide the DG position and measuring, so as to limit the multi target work thinking about the power misfortunes, cost and voltage deviation [11]. The technique depends on the Shuffled frog jumping calculation and Bat calculation. In [12], altered Firefly Algorithm is connected to decide the ideal size and area of DGs in uneven circulation framework. The DG in this calculation is encircled with an adaptability to change the PV hub to PQ hub, when the receptive power constrain is disregarded. In [13], bloom fertilization calculation (FPA) is proposed to discover the DG size and list vector strategy to decide the DG area. File vector is surrounded with responsive segment of current in the branches and receptive power stack fixation at every hub acquired from the base case stack stream comes about. In [14], backtracking seek calculation is displayed to locate the ideal area and size of DG. The underlying area of DGs is discovered by encircling fluffy master rules utilizing misfortune affectability factor and transport voltages. The creators surrounded multi target work which involves minimization of intensity misfortune and amplification of voltage soundness file. Stud Krill crowd Algorithm [15] is utilized to locate the ideal area and limits of DGs for control misfortune minimization in outspread dissemination framework. DG sources delegated four categories.

i. Type-I: DG capable of injecting real power only
ii. Type-II: DG capable of injecting reactive power only
iii. Type-III: DG capable of injecting both real and reactive power
iv. Type-IV: DG capable of injecting real but consuming reactive power

II. PRESENT WORK

In present work, adaptive weight based PSO is actualized, which alters the weight parameter at each emphasis. Power stream examination is done utilizing Newton Raphson strategy. The brief of PSO calculation and power stream issue is given in this area.

A. Newton Raphson method for power flow

The ideal size and area of DG result in least misfortune in the appropriation framework. PSO has been utilized to limit the framework genuine power misfortune considering the correct misfortune recipe as target work. Considering N bus distribution system, the loss minimization issue might be defined as given underneath:
Minimize

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N}[\alpha_{ij}(P_iP_j + Q_iQ_j) + \beta_{ij}(Q_iP_j + P_iQ_j)] \quad (1)$$

Where $\alpha_{ij} = \frac{r_{ij}}{V_iV_i}\cos(\delta_i - \delta_j)$ (2)

$$\beta_{ij} = \frac{r_{ij}}{V_iV_i}\sin(\delta_i - \delta_j) \quad (3)$$

And $Z_{ij} = r_{ij} + jx_{ij}$ (4)

where Z_{ij} is the impendence of the line between bus $i^{th}$and bus j^{th}; r_{ij} the resistance of the line between bus i^{th} and bus j^{th}; x_{ij} the reactance of the line between bus i^{th} and bus j^{th}; V_i the voltage magnitude at bus i^{th}; V_j the voltage magnitude at bus j^{th}; δ_i the voltage angle at bus i^{th}; $\delta_j$the voltage angle at bus j^{th}; P_i and Q_i the active and reactive power injections at bus i^{th} and P_j and Q_j is the active and reactive power injections at bus j^{th}.
Subjected to

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(i) System power flow equations must be satisfied.

$$P_{Gi} - P_{Di} = \sum_{j=1}^{N} V_i V_j [G_{ij} \cos(\delta_i - \delta_j) + B_{ij} \sin(\delta_i - \delta_j)]$$
$$\forall \, i = 1, 2, 3, ... N \qquad (5)$$

$$Q_{Gi} - Q_{Di} = \sum_{j=1}^{N} V_i V_j [G_{ij} \sin(\delta_i - \delta_j) - B_{ij} \cos(\delta_i - \delta_j)]$$
$$\forall \, i = 1, 2, 3, ... N \qquad (6)$$

WhereG_{ij} is the conductance of the line between bus ith and bus jthand B_{ij} is the susceptance of the line between bus ith and bus jth.

$$P_i = P_{Gi} - P_{Di} \text{ and } Q_i = Q_{Gi} - Q_{Di} \qquad (7)$$

P_{Gi} and Q_{Gi} are power generations of generators at bus ith. P_{Di} and Q_{Di} are the loads at bus ith.

(ii) Voltage constraint at each bus (±5% of rated voltage) must be satisfied [16].

$V_{min} \leq Vi \leq V_{max}$ where i = 1; 2; 3; . . .N (8)

Line current constraint must be satisfied.

$I_i \leq I_i^{Rated} \; \forall \in \{\text{branches of the network}\}$ (9)

where I_i^{Rated} is current permissible for branch i within safe limit of temperature

(iii) The right-of-way buses (The bus which is not appropriate for DG allocation due to some restricting considerations) are excluded.

(iv)

PSO calculation and explanatory approach have been utilized to decide the ideal size and area of various kinds of DGs. The retrogressive range and forward breadth technique for conveyance stack stream [17] has been utilized to satisfy the coveted goal. The concise depiction of PSO and expository approach are given in the accompanying areas:

B. Particle swarm optimization technique

Particle swarm optimization (PSO) is a populace based enhancement strategy which gives a populace based pursuit methodology. In PSO system people (called particles) change their position (state) with time. In PSO particles fly around in a n-dimensional pursuit space. Amid flight, every molecule modifies its situation as indicated by its own particular experience (this value is called pbest), and as indicated by the experience of a neighboring particles (this value is called gbest), making utilization of the best position experienced without anyone else's input and its neighbors [18].

Numerically, the situation of particle in an n-dimensional vector is represented as:

$$X_m = (x_{m,1}, x_{m,2}, x_{m,3}, ... x_{m,n}), (10)$$

The current position is modified according to the following equation:

$$S_{id}^{k+1} = S_{id}^{k} + v_{id}^{k+1}, i = 1, 2, ..., n,$$
$$d = 1, 2, ..., m, \qquad (11)$$

WhereS^k is the current position of particle and S^{k+1} the modified position of particle.

The velocity of each particle is also in an n-dimensional vector,

$$V_m = (v_{m,1}, v_{m,2}, v_{m,3}, ... v_{m,n}), (12)$$

Velocity of each particle can be modified according to the following equation:

$$v_{id}^{k+1} = \omega_i v_{id}^{k} + c_1 rand \times (\text{pbest}_{id} - S_{id}^{k}) +$$
$$c_2 rand \times (\text{gbest}_{id} - S_{id}^{k}) \qquad (13)$$

where v^k is the current velocity; v^{k+1} the modified velocity of particle i^{th};v_{pbest} the velocity based on pbest; V_{gbest} the velocity based on gbest; n the number of particles in a group; m the number of members in a particle; $pbest_i$ the pbest of particle i^{th}; $gbest_i$ the gbest of the group; ω_i the weight function for velocity of particle i and ci the weight coefficients for each particle.

The following weight function is used:

$$\omega_i = \omega_{\max} - \frac{\omega_{\max} - \omega_{\min}}{k_{\max}}.k \quad (14)$$

Where $\omega_{\min}$ and $\omega_{\max}$ are the minimum and maximum weights respectively. k and k_{max} are the current iteration and maximum number of iterations. Appropriate values for $c_1$and c_2 lies in the range 1–2.

For fast convergence of the PSO algorithm, values of $c_1$and c_2. $\omega_{\min}$ and $\omega_{\max}$ have been selected by hit and trial approach , and the final values are considered as: $c_1 = c_2 = 2$, $\omega_{\min} = 0.4$ and $\omega_{\max} = 0.9$.

The correct loss equation given in (1) has been taken as fitness function for PSO calculation. The best position identified with the most reduced esteem (for minimization objective) of the target work for every molecule is

$$Pbest_m = (\text{pbest}_{m,1}, \text{pbest}_{m,2}, \text{pbest}_{m,3}$$
$$,\ldots\ldots\ldots\ldots \text{pbest}_{m,\text{n}}),$$

and the global best position among all the particles or best pbest is denoted as:

$$Gbest_m = (\text{gbest}_{m,1}, \text{gbest}_{m,2}, \text{gbest}_{m,3},$$
$$\ldots\ldots\ldots\ldots \text{gbest}_{m,\text{n}}),$$

After every iteration, the speed and position of the particles are refreshed. The estimation of DG sizes fluctuates between 0 to entirety of the heaps (ceaseless) in the system. This is viewed as the situation of a molecule amid the enhancement procedure. In PSO calculation the populace size of swarms and the quantity of cycles are settled. The position and speed of the mth particle has been considered as Xm and Vm separately, these qualities are introduced by (11) and (13), i.e., arbitrarily creates an initial population (array) of particles with arbitrary positions and speeds on measurements in the arrangement space. For every molecule, scale the sizes of sort I and sort II DG as far as possible. PSO is a metaheuristic as it makes few or no presumptions about the issue being improved and can seek extensive spaces of applicant arrangements.

III. RESULTS AND DISCUSSIONS

The outcomes has been gone up against IEEE 33 Radial Bus System given in Figure 1. It is observed that the nonlinear and differential conditions can be understood just by the iterative techniques i.e. Newton-Raphson, Gauss-Seidal and so forth. The consequences of active power execution file and receptive power execution lists for the base case stacking condition is gotten by utilizing the newton-Raphson, and are given in Table 1 and Table 2. The DGs are first put at buses 4, 16 and 20.

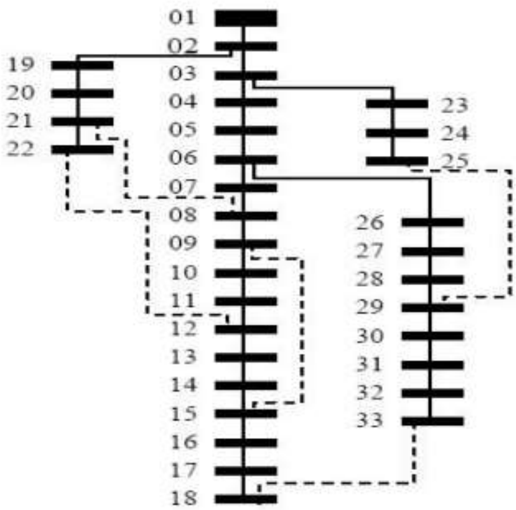

Figure 1: 33 radial bus system

Table 1: Change in active power loss and minimum voltage profile after new configuration given by traditional PSO and Adaptive PSO

Parameters	Initial configuration	Optimal DG using traditional PSO	Optimal DG using APSO
Loss in Overall Power(in kW)	420.508	130.443	124.633
Minimum Voltage Profile found	0.8343pu	0.9529pu	0.9508 pu

Table 2: Voltage profile after new configuration given by traditional PSO and Adaptive PSO

Bus number	Voltage Profile using traditional PSO	Voltage Profile using APSO
1	1	1
2	0.9970	0.9970
3	0.9871	0.9866
4	0.9839	0.9831
5	0.9811	0.9799
6	0.9764	0.9745
7	0.9586	0.9739
8	0.9616	0.9649
9	0.9602	0.9622
10	0.9592	0.9639
11	0.9592	0.9640
12	0.9601	0.9643
13	0.9554	0.9617
14	0.9536	0.9609
15	0.9527	0.9572
16	0.9520	0.9560
17	0.9508	0.9535
18	0.9508	0.9530
19	0.9949	0.9951

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20	0.9774	0.9792
21	0.9725	0.9748
22	0.9684	0.9713
23	0.9816	0.9812
24	0.9711	0.9708
25	0.9639	0.9636
26	0.9750	0.9733
27	0.9733	0.9717
28	0.9663	0.9655
29	0.9614	0.9612
30	0.9575	0.9577
31	0.9527	0.9538
32	0.9517	0.9530
33	0.9512	0.9529

The change in voltage profile before and after configuration using APSO is shown in Figure 2 and using PSO is shown in Figure 3.

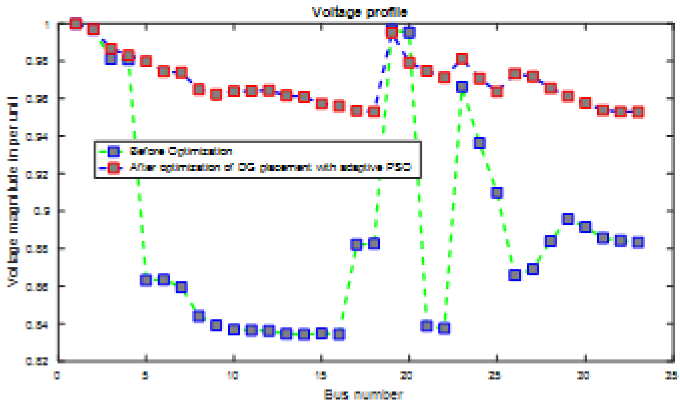

Figure 2: Change in voltage profile before optimization and after optimization using APSO

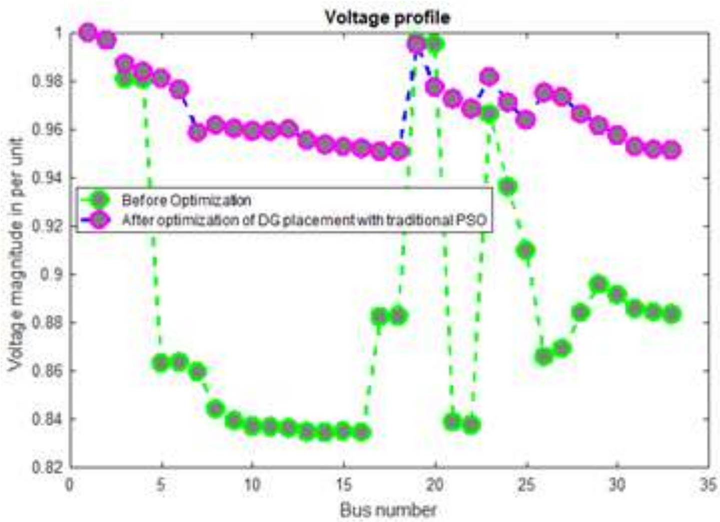

Figure 3: Change in voltage profile before optimization and after optimization using PSO

Considering the significance of the cost decrease in distribution system by applying DG units, the aggregate spared costs in the framework in enhancement process are gotten. The framework cost before improvement process (without DG units) is equivalent to 420.508 KW which is computed based on the information for 33 transport spiral transport framework, coming about because of framework misfortunes at various load levels.

Additionally, the estimations of the framework cost by applying the DG units are displayed in Table 1, it is comprehended that by playing out the advancement procedure in this framework, cost is spared equivalent to 295.875 KW not as much as the first framework which is around 70% decrease in control misfortunes. The saved cost is acquired from the distinction between framework cost before enhancement process and the aggregate yearly cost of the framework with gadgets which are ascertained by the use of Adaptive PSO calculation. Thusly, the proposed APSO strategy has achieved the most ideal arrangement keeping in mind the end goal to acquire minimal estimation of the cost of the framework. So the ideal DG is discovered utilizing conventional PSO. In which the enhanced DG areas has power loss 130.443 kw when contrasted with 124.633 kw given by APSO thus APSO delivered more improved areas then conventional PSO which gives 68% diminishment in power loss when kept running for comparable number of cycles.

IV. CONCLUSION

In this paper, a new voltage stability index (VSI) is developed for optimal DG placement in radial distribution systems. This paper presents comparison of proposed Adaptive PSO method with the losses obtained without optimization when DG is placed randomly by the user in which proposed method with APSO gives optimal placement of DG for reduction of power losses and improvement in voltage profile. The study is carried out on DG operating at unity power factor. The results have been obtained with and without consideration of load growth for real and reactive power losses, voltage profile, voltage stability margin profile, real and reactive power flow patterns, cost of energy loss, cost component for real power and reactive power obtained from DGs, and annual cost of energy loss savings. It can be concluded that there is much reduction in real, reactive power losses, and improvement in voltage profile. The proposed APSO method gives better results for the test system.

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