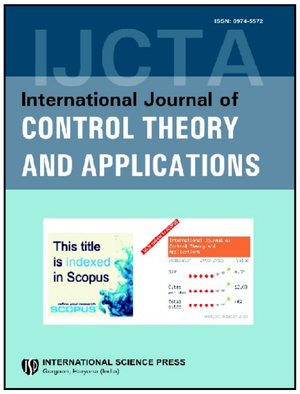

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Analysis of IA and PSO Algorithms for Siting and sizing of DG in Primary Distribution Networks

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Abstract: In Power Systems, Distributed Generation (DG) has been developing quickly because of their prospective solutions for power quality issues, similar to the deregulation in power system, to take care of the shortage of transmission capabilities and power demand. Inappropriate placement of DG sources in power system would not just prompt to increase power or energy losses but it also collapses voltage profile of the system. The ideal location of DG is needed for improving reliability and stability of a power system. This paper investigates the difficulty of distributed generator location to obtain an unnecessary loss reduction and enhancement of voltage profile in distribution networks. A stepped Improved Analytical (IA) technique and Particle Swarm Optimization (PSO) strategies proposed in this paper. Improved analytical (IA) method [1] is based on IA expressions to calculate the highest capacity of DG unit and a technique to perceive the pleasant place for DG allocation. The other task on this work a multi objective formula is proposed for premiere location and sizing of the DG is optimized the use of Particle Swarm Optimization (PSO). The proposed concepts validated the usage of an IEEE 33 bus network and the consequences display the suitability of the proposed strategies in decreasing the losses and enhancing the voltage profile of the network. A few thrilling outcomes are also mentioned on this paper.

Keywords: Analytical expression, loss reduction, improved analytical (IA), Distributed Generation (DG), optimal location and size and IEEE 33 Bus system

I. INTRODUCTION

Global temperature gradually increases with the continuous exhaustion of fossil energy, and the restriction of existing transmission network capability causes rapid development of Distributed Generators (DGs) [2]. Distributed generation (DG) is associated with the use of small generating unit mounted at planned point of electrical power device or places of load centre's [3]. Distributed generation is an electric powered power source linked immediately to the distribution system or on the purchaser location of the meter [4]. DG technology consists of diesel engines, wind generators, solar cells and fuel cells. Despite their small length, DG technologies are having a more potent effect in energy markets. In some markets, DGs are certainly changing the greater highly-priced grid electricity. DG can meet all or part of a patron's energy wishes. The principle motives for the increasingly full-size use of DG are it may be more economic than running a transmission lines to remote locations [5], it gives require power, with the effectiveness giving back up and supplemental power, it can give support control amid effectiveness system blackouts. DG units must be located in suitable areas with proper capacities to realize system advantage. It is observable that any loss reduction is important to distribution utilities, those are for the maximum part the substance successful to maintain losses at minimum. Losses diminishment is, in this manner, the most significant calculate to be regarded because the locating and function of DG [6], [7]. As an instance, multi target index for execution algorithm of distribution network for single DG size and location has been planned [6] in an radial feeder, contingent upon the innovation, DG units can deliver a section of the total active and moreover reactive power to loads in order that the feeder current diminishes from the supply to the place of DG systems. Be that as it is able to, thinks about [8]–[10] have proven that if DG systems are disgracefully scattered and expected, the reverse power flows from the capacity DG can stimulate to better active and reactive power loss. A technique for DG placement utilizing "2/3 rule" that's typically related to capacitor description in distribution system with consistently distributed loads has been supplied [9]. A systematic approach has been obtainable in [11], to recognize the place to preferably placement of single DG with unity power factor in radial and additionally meshed systems to decrease losses. A scientific technique has been proposed in [8], in view of a specific loss formulation to calculate the ideal size and location of DG.

The meta heuristic algorithms are self sustaining of primary solution and can keep away from local optima [12]. These techniques are robust and can provide near optimal solution for large and complex systems. The principle disadvantage is the high computational endeavors required for best solution. Then again, meta heuristic strategies have their own drawbacks, as an instance, use of trial and error procedure throughout parameter tuning and lack of certification of global achievement a times. That is one reason that made researchers to coordinate a super deal of exertion toward doling out with such troubles by merging more than one algorithm to frame a hybrid algorithm. Particle swarm optimization(PSO) is one of the most met heuristic algorithm proposed by Dr. Eberhart and Dr. Kennedy in 1995, and it is a populace primarily based stochastic optimization [13, 14], inspired by social behavior of bird gathering and fish schooling. It is utilized for optimization of continuous nonlinear functions [15,16]. Authors in [17] introduced a strategy for perfect siting and estimating of various distributed generators (DGs) utilizing PSO based technique. Similar various DGs arrangement was proposed for variable load with lagging or leading power factors in [18] with PSO as an optimization algorithm. In an additional progress an improved PSO technique was also planned for optimal placement with an in built mechanism for better investigate that is able of escaping local optima in [19]. The model of hybridized PSO was initiated by authors in [20] as part of upgrading on initial PSO technique, in which Genetic Algorithm (GA) was combined with PSO. In kind of the difficulties and to strengthen the advantages of DG variety of studies papers on siting and sizing of the DG units are exists in literature.

The ideal placement for locating the distributed generators based on loss sensitivity factor determined by the authors of [21] and also discussed a successive sizing based algorithm for calculating their ideal capacities of DG. The research can be gathered [22] in seven groups: i) The maximum size of the DG which can be introduced to the distributed network [23]. ii) Optimizing the ideal capacity of the DG [24-26]. iii) Determination of ideal location of the DG unit. iv) Estimating the ideal size and placement of the DG [27-35]. v) Obtaining a solution for differing load condition [36]. vi) best arranging of multiple DG units [37-39]. vii) Ideal arranging of various DG units with lagging and leading power factors [40]

II. PROPOSED ALGORITHM

2.1. IA method

In a power system the total active power loss is formulated by using an accurate loss formula [42]

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

In the above expression

$$\alpha_{ij} = \frac{r_{ij}}{v_i v_j}\cos(\delta_i - \delta_j) \; And \; \beta_{ij} = \frac{r_{ij}}{v_i v_j}\sin(\delta_i - \delta_j)$$

$V_i \angle \delta i$: i^{th} bus complex voltage
$r_{ij}+jx_{ij}=Z_{ij}$: Impedance Matrix of ij^{th} element
P_i and P_j : insertion of active power at the i^{th} and j^{th} buses correspondingly
Q_i and Q_j : injection of reactive power at the i^{th} and j^{th} buses correspondingly
n : Total number of buses

A brief explanation about IA terms and ideal power factors for single DG allotment is explained as follows [26]:

2.1.1. IA Expressions

Case 1 DG (i.e., 0 < PFDG < 1) is able to injecting together active and reactive power. The ideal size of DG at every bus i for lessening losses [1] can be given through (2) and (3)

$$P_{DGi} = \frac{\alpha_{ii}(P_{Di} + aQ_{Di}) - X_I - aY_i}{a^2\,\alpha_{ii} + \alpha_{ii}} \tag{2}$$

$$Q_{DGi} = \alpha P_{DGi} \tag{3}$$

Here
a = (sign) tan ($\cos^{-1}(PF_{DG})$)
sign = +1 Injecting reactive power by DG

$$X_i = \Sigma_{\substack{j=1 \\ j\neq i}}^{n}(\alpha_{ij}P_j - \beta_{ij}Q_j) \quad and \quad Y_i = \Sigma_{\substack{j=1 \\ j\neq i}}^{n}(\alpha_{ij}Q_j + \beta_{ij}P)$$

the ideal size of DG for every bus i, can be given by formerly mentioned conditions , for the loss to be least. Any size of DG apart from P_{DGi} positioned at bus i can activate to a higher loss.

Case 2 DG (i.e., 0 < PFDG < 1) is able up for infusing active power however eating reactive power (sign = –1). Like kinds 1 DG, the appropriate size of sort 2 DG at every bus i for the bottom loss is given by means of (2) and (3). Simple Distribution system with single DG [1] is shown in Figure 1.

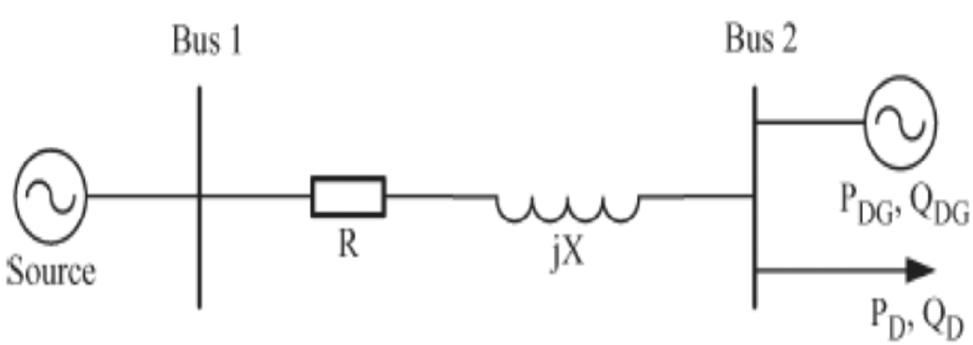

Figure 1: Simple distribution system with single DG

Case 3 DG (i.e., PFDG = 1, a = 0) is in a position of infusing actual electricity best. The proper size of DG at every bus i for the least amount loss [1] am given by decreased (4)

$$P_{DGi} = P_{Di} - \frac{1}{\alpha_{ii}} \Sigma_{\substack{j=1 \\ j \neq i}}^{n} (\alpha_{ij} P_j - \beta_{ij} Q_j) \tag{4}$$

Case 4 DG (i.e., PFDG = 0, a = ∞) is in a position of sending reactive electricity handiest. The best length of DG at every bus i for the least quantity loss [1] am given through reduced (5)

$$Q_{DGi} = Q_{Di} - \frac{1}{\alpha_{ii}} \Sigma_{\substack{j=1 \\ j \neq i}}^{n} (\alpha_{ij} Q_j - \beta_{ij} P_j) \tag{5}$$

2.2. Particle Swarm Optimization

The major intention of this formulation is to make sure ideal placement and estimation of capacity of DG units while allowing for multiple intention of decrease in active power loss, reactive power loss and improving the voltage profile. These multiple intentions are collective through weights to generate a liner equation which is representative of all the intentions.

In this proposal the primary limits considered as

1) Power loss when DG introduced in network ≤ Power loss before DG introduced in network
2) Voltage limits are $V_{BUS\,MIN} \leq V_{BUS} \leq V_{BUS\,MAX}$

The multi objective function is given as

$$Max\ (F) = W1\{\max[0, \frac{1}{n} \Sigma_{i=1}^{n} (Voltage\%_{\ i\ with\ DG} - Voltage\%\ i\ without\ DG)]\}$$

$$+W2\{\max[0, \frac{1}{n} \Sigma_{i=1}^{n} (P_{j\ with\ DG} - P_{j\ without\ DG})]\} + W3\{\max[0, \frac{1}{n} \Sigma_{i=1}^{n} (Q_{j\ with\ DG} - Q_{j\ without\ DG})]\} \tag{6}$$

In the above expression,

Voltage % $_{i\ with\ DG}$: *voltage percentage in* i_{th} *bus with DG unit*
Voltage % $_{i\ without\ DG}$: *voltage percentage in* i_{th} *bus without DG unit*
$P_{j\ with\ DG}$: *Active Power Losses in* j_{th} *branch with DG unit*
$P_{j\ without\ DG}$: *Active Power Losses in* j_{th} *branch without DG unit*
$Q_{j\ with\ DG}$: *Reactive Power Losses in* j_{th} *branch with DG unit*
$Q_{j\ without\ DG}$: *Reactive Power Losses in* j_{th} *branch without DG unit*
n : Number of Buses for given network
m: Number of Branches for given network
w_1, w_2 *and* w_3 *are weights in this suggestion they are theoretical to be equal. Right here* $w_1 + w_2 + w_3 = 1$

PSO is a populace of particles is in the beginning randomly produced. In PSO, answer for each optimization problem is measured as a bird in the identifying space and it is called "particle". Each particle having its own fitness value which is determined by multi objective functions (6) and it has also a velocity which verifies its objective and distance. All particles investigate in the solution space for their ideal positions and the positions of the ideal particles in the swarm. Initially PSO configures a set of arbitrary particles and then through repeated investigating finds the ideal solution. In each iteration the ideal position recognized with a particle is called p_{best} ; correspondingly the ideal position recognized with the entire swarm is called g_{best}. For each particle, the velocity and its position are restructured. every particle renews its position based upon its own ideal position, global ideal position along with particles and its earlier velocity vector according to the subsequent equations:

$$v_i^{k+1} = w \times v_i^k + c_1 \times r_1 \left(p_{best_i} - x_i^k \right) + c_2 \times r_2 \times (g_{best_i} - x_i^k) \quad (7)$$

$$x_i^{k+1} = x_i^k + \chi \times v_i^{k+1} \quad (8)$$

Where,

v_i^{k+1} : i^{th} *Particle Velocity at* $(k+1)^{th}$ *iteration*

w : Inertia weight of a Particle

v_i^k : i^{th} Particle Velocity at k^{th} iteration

c_1, c_2 : Positive constants having values between [0, 2.5]

r_1, r_2 : Randomly generated numbers between [0, 1]

p_{best_i} : The best position of the i^{th} particle obtained based upon its own knowledge

g_{best}: Global best position of the particle in the population

x_i^{k+1} : Particle position at iteration

x_i^k : Particle position at iteration

χ : Constriction factor. It may assist insure convergence.

III. TEST SYSTEM DEPICTION, RE-ENACTMENT RESULTS AND EXAMINATION

The test system design of the network is having a solitary supply point with 33-buses, 3 laterals, 37 branches, 5 loops or tie switches which are saved frequently open and is shut just amid problem situation to keep up congruity of deliver or may be close to change circuit imperviousness to lower losses. The overall active and reactive power for test system is 3715 kW, 2300 kvar with a total real power loss of 202.6 kW. The upper voltage limit is 1.05 p.u and lower voltage limit is 0.9 p.u. The single line diagram of test system is shown in Figure 2. Newtons-Raphson algorithm is used for power flow calculations. For simulation load model designed with a uniform power and primary bus voltage at 1.0 p.u.

Based totally at the proposed technique, an analytical software device has been developed in Matlab surroundings to run the power flow, calculate electricity losses, and become aware of the superior size and area of DG unit. The iteration settings for PSO contain 50 maximum numbers of iterations, with acceleration constant of 2 and 2.5 and highest and lowest inertia weights at 1 and 0.2 respectively. The highest and lowest velocity of particles is preset at 0.003 and -0.003 correspondingly. The simulations are carried out in a computer system having i5 processor cloaking a speed of 2.5 GHz with a RAM of 4GB.

The results of measuring capacity and location are illustrated in the TABLE I. It may be observed from the IA method identifies suitable area for placing DG of length 2560.23kw at bus number 6 and there is greater decrement in losses. It is able to be discovered from TABLE I, at the same time as placement of DG of capacity 2560.23kw reduces the actual energy loss of 110.1537 kW. The time require to complete this approach is an round 10.29 sec. From TABLE I it can be located from PSO method identifies appropriate region for placing DG

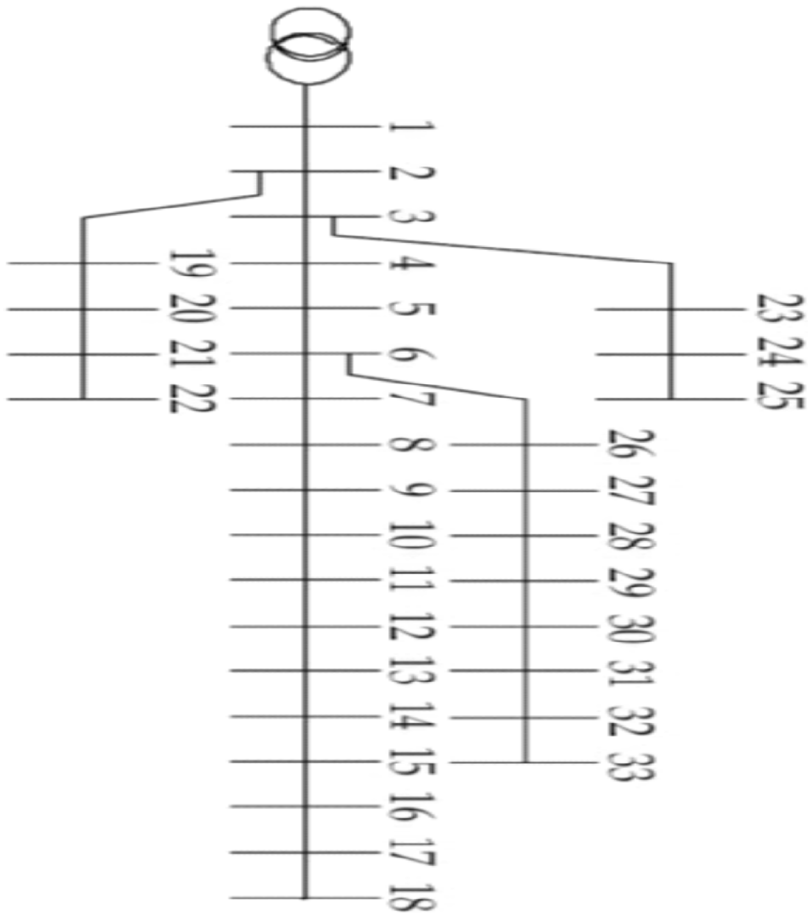

Figure 2: Line diagram of IEEE 33 Bus distribution system

Table I
DG Placement by Various Techniques For 33-Bus System

Case	*Technique*	*installed DG Size*	*Location*	P_{loss}	*Loss Reduction*	*Time (s)*
No DG		——	——-	202.677 kW	0.00	0.02
with DG	IA Method	2560.2300kW	6	110.1537 kW	47.9548	10.29
	PSO	1857.5kw	7	92.4365 kW	45.60913	6.75

of capacity 1857.5kw at bus number 7 and there is more reduction in losses. It could be discovered from the above table whilst placement of DG of capacity 1857.5kw reduces the real electricity loss of 92.4365 kW. The time to complete this method is an around 6.75 sec.

The position of DG additionally brings approximately development in voltage profile of the device. The bus voltage magnitudes of 33-bus device after placement of DG are illustrated in the TABLE II.

The plot of voltage profiles for various buses after the position of DG the usage of IA technique is printed within the Figure 3. The plot of voltage profiles for various buses after the placement of DG using PSO approach is outlined within the Figure 4.

Table II
Bus voltage magnitudes of 33-Bus system

BUS Number	*Voltage (PU)*	
	IA Method	*PSO Method*
1	1	1
2	0.999018	0.99814
3	0.995566	0.989975
4	0.995977	0.986885
5	0.996818	0.984066
6	0.99618	0.975559
7	0.992466	0.972171
8	0.987695	0.967462
9	0.981243	0.96137
10	0.975222	0.95572
11	0.97436	0.954884
12	0.97285	0.953427
13	0.966276	0.947488
14	0.963653	0.945286
15	0.961964	0.943914
16	0.960377	0.942585
17	0.957995	0.940616
18	0.957416	0.940027
19	0.998491	0.997612
20	0.99492	0.994038
21	0.994217	0.993335
22	0.993581	0.992698
23	0.992027	0.986415
24	0.985442	0.979792
25	0.982161	0.976492
26	0.995356	0.976033
27	0.994334	0.976834
28	0.98877	0.978
29	0.985011	0.97944
30	0.984178	0.981961
31	0.985087	0.989294
32	0.985761	0.99203
33	0.987175	0.995719

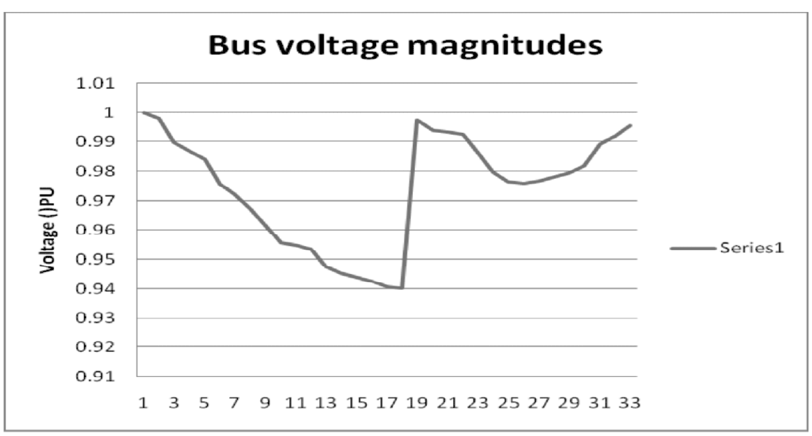

Figure 3: Vltage Profile of 33 Bus System After Placement of DG uising IA Method

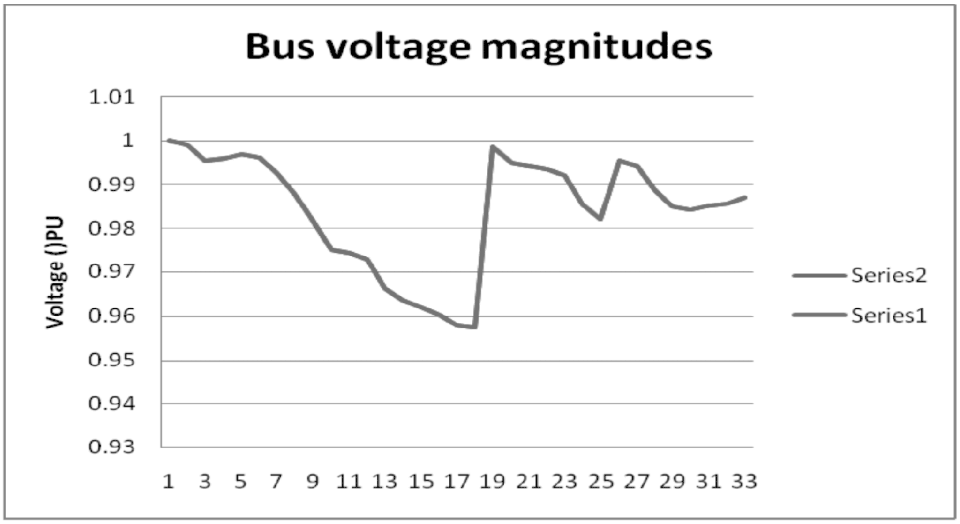

Figure 4: Vltage Profile of 33 Bus System After Placement of DG uising PSO Method

Table III
Location and Minimum Voltage Magnitude for the System

CASE	*Bus at which Minimum Voltage Occurs*	*Voltage (PU)*
Base Case (without DG)	18	0.9052
with DG-IA Method	18	0.957416
with DG - PSO Method	18	0.940027

It can be seen from the TABLE-III there is colossal change in voltage profile after the ideal position of right DG capacity.

IV. CONCLUSION

This paper has provided IA and PSO methods for DG allocation for minimizing power loss and enhancement of voltage profile in distribution systems while enjoyable the principle objective of power injection. In IA method it is observed, it is that a approach to acquire an foremost or close to highest quality power aspect has been also provided for placing DG unit able to delivering active and reactive power. For DG capable of delivering in real and reactive energy, power factors to play a critical role in loss reduction. Another technique also proposed in this paper for ideal placement and capacity for generators was identified using PSO technique and the best of 50 trails runs have been presented. The importance of ideal placement was also suitably explained in this work. It was noted that incorrect location of DG will not bring in essential progress in the losses. It can also be noted from the conversation that the ideal placement of DG also improves the voltage profile of the network as a whole. It can be concluded that the proposed approaches, PSO is best optimization technique compared to the IA method because with small size of DG enhancement of voltage profile is more and reduction of loss percentage also more. Particle swarm optimization is projected for figuring out the final ability of DG and the vicinity is decided wherein loss is minimized and capability and area of DG anticipated for loss minimization.

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