International Journal of Engineering & Technology, 7 (3.3) (2018) 168-173

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Optimal placement of distributed generation using colliding bodies optimization

Gera Kalidas Babu [1] *, P. V. Ramana rao [2]

[1] *Research scholar, Department of EEE, Acharya Nagarjuna University*
[2] *Professor & HOD, Department of EEE , Acharya Nagarjuna University*
**Corresponding author E-mail: kalidas.gera@gmail.com*

Abstract

The present paper foremost objective is to resolve best practicable location of solar photovoltaic distribution generation (DG) of several cases using different distribution load power factors and to analyze power loss reduction. This objective achieved by a recent developed method, the so called colliding bodies' optimization algorithm, to perceive optimum location. Performances of colliding bodies' optimization algorithm have been evaluated and compared with other search algorithms. The execution to test viability and efficiency, the proposed collid-ing bodies' optimization is simulated on standard IEEE 38 bus radial distribution networks. The acquired outcome from colliding bodies Optimization algorithm exhibits the possible location of distributed generation through different pre assumed load power factors compared to the other stochastic search bat and genetic algorithm.

Keywords: *Colliding Bodies Optimization (CBO); Distribution Generation; Power Factor; Radial Distribution Network.*

1. Introduction

Distribution generations being given more importance in the recent years since it has improved a lot over years of research and development with solemn benefits over the conventional method of generation and transmission of electrical energy. In any type of distribution system due to more resistance to reactance ratio there exist significant power losses and voltage drop than transmission system which leads to disturbing the quality and consistency of power in distribution system. In worldwide power generating by conventional large power stations by fossil fuel resources like (coal, natural gas and oil) is not sufficient to encounter the growing energy demand, in addition to the emission of harmful gasses like carbon dioxide, methane, etc., by fossil fuel [1] leads to embarrassing the atmosphere. Alternate power resources given elevated priority in recent years around the globe owing to its imposing benefits [2]. The basic definition of distribution generation (DG) is generating power (few MW to large MW) at load centers. There are different forms of DG systems like solar, wind, bio mass tidal and many other used based on the topological location, where the DG is to be installed. From the accessible DG systems solar DG system is being used expansively because of the natural fuel that is sunlight available in abundance for free of cost. To determine complex problems in entire power system there being many meta-heuristics optimization techniques based on natural phenomena [3], [4].The main objective of all proposed techniques in distribution systems is to position best distribution generation for improving the system performance. One of the recent optimization technique based on colliding bodies is proposed in this paper.

2. Mathematical approach

The main objective is to perceive the optimal locality of the DG and minimizing the impact indices by objective function (OF). Here, the first priority is given to renewable DGs owing of the low maintenance and cost. After including one or more DGs the aspiration is to minimize OF by selecting properly the location and size with equality and in equality constraints.

$$OF = \left(ILP + ILQ = IVD \right) \tag{1}$$

$$ILP = \left[\frac{TPlossDG}{TPlossWODG} \right] \tag{2}$$

$$ILQ = \left[\frac{TQlossDG}{TQlossWODG} \right] \tag{3}$$

$$IVD = \underset{i=2}{\overset{n}{Max}} \left[\frac{|V_1 - |V_i||}{|V_1|} \right] \tag{4}$$

With Equality constraints,

$$P_{gs} + \sum_{DG=1}^{m} P_{DG} = P_{load} + P_{loss} \tag{5}$$

Equality constraints,

$$V_{i\min} \le V_i \le V_{i\max} \tag{6}$$

3. Colliding body optimization

The proposed technique amplified by kaveh and madhavi, it is impelled from the natural phenomenon of collision between two objective bodies [5], in which every object is model as colliding body of enumerate velocity and mass. By collision laws, a collision of any two pair objects results colliding bodies move to other place of new velocity and mass outcome to move best position. Key characteristic of proposed technique not encloses any tuning variables and is also simple in structure.

3.1. Physical laws of collision

The collision among bodies is supervised by converse law of momentum and energy. Think m_1 and m_2 are two masses of bodies moving in one dimensional space. The colliding representation with each other is shown in figure1, the momentum of objects before and after collision is alike.

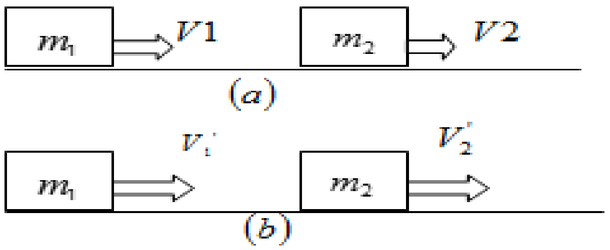

Fig. 1: (a) Before and (b) After Collision between Two Bodies.

Perpetuation of entire force before collision is alike after collision directed by subsequent equation

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2' \quad (7)$$

Besides, the perpetuation of entire kinetic energy is directed by

$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_1v_1'^2 + \frac{1}{2}m_2v_2'^2 + Q \quad (8)$$

v_1 , v_2 represent starting velocities of first and second object before contact. v_1', v_2' represent end velocities of first and second object after contact. m_1, m_2 reflects mass first and second object, and Q represents waste of kinetic energy owed in contact [6].
Velocities subsequent to one-dimensional collision,

$$V_1' = \frac{(m_1 - \varepsilon m_2)v_1 + (m_2 + \varepsilon m_2)v_2}{m_1 + m_2} \quad (9)$$

$$V_2' = \frac{(m_2 - \varepsilon m_1)v_2 + (m_1 + \varepsilon m_1)v_1}{m_1 + m_2} \quad (10)$$

ε is restitution multiplication among collision of two bodies, explained as the ratio of difference in velocity of separation to difference in velocity of access.

$$\varepsilon = \frac{|v_2' - v_1'|}{|v_2 - v_1|} = \frac{v'}{v} \quad (11)$$

When $Q = 0 \; and \; \varepsilon = 1$,restitution multiplication is great elastic collision with no waste of kinetic energy, high velocity of separation occurs after collision and in the collision kinetic energy changes to other forms of energy. When $Q \neq 0 \; and \; \varepsilon \leq 1$, coefficient of restitution is not perfect elastic collision and low velocity of separation occurs. Most real objects ε lie in $0 \; and 1$.

3.2. Construction of algorithm

In CBO, every resolution aspirant X_i contains numerous variables $(i.e \; X_i = \{x_{i,j}\})$ marked as colliding bodies [7]. The colliding bodies are placid stationary and moving objects, whereas the moving objects propel to ensure stationary objects and a collision occurs among pairs of objects. Colliding bodies is made to modify the locality of objects in motion and to thrust unalterable new objects tending to enhanced locality. Behind, the collision localities of colliding bodies are improved and up to date found on fresh velocities using collision laws. This process is able to outline as follow:

1) The starting positions of CBs are resolute by means of arbitrary to set a population of individuals

$$x_i^0 = x_{min} + rand(x_{max} - x_{min}), \; i = 1, 2, ..., 2n \quad (12)$$

Here, x_i^0 determines starting value vector of i^{th} colliding bodies, x_{min} and x_{max} be the least and highest acceptable value vector for variables, rand is random number in the interval [0, 1] and $2n$ is the number of colliding bodies.

2) Body mass magnitude indication for each colliding bodies is

$$m_k = \frac{\frac{1}{fit(k)}}{\sum_{i=1}^{n}\frac{1}{fit(i)}}, \qquad i = 1, 2, ..., 2n \quad (13)$$

Objective function value of i^{th} cause symbolize by $fit(i)$, $2n$ is the number of population size. To maximize the objective function, the term $\frac{1}{fit(i)}$ is rearranged by $fit(i)$.

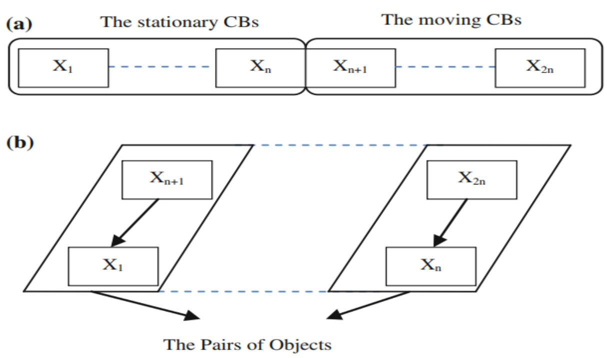

Fig. 2: (A) Colliding Bodies Sort in Rising Order, (B) Colliding Bodies Object Pairs.

3) Order of colliding bodies values are carrying out in rising order $(figure\,2.2(a))$.Sort of colliding bodies are equally alienated into lower and upper half groups. First in lower, half-colliding bodies are at a standstill and zero velocity before collision shows equation (14). Next in upper half, colliding bodies travel in the direction of lower half. Subsequently $(figure\,2.2(b))$ shows the improved and poorer colliding bodies, i.e. agent with higher fitness value, of each group will collide together. The change of the bodies' position represents the velocity of these bodies before collisions by equation [15].

$$v_i = 0, \qquad i = 1, ..., n \quad (14)$$

$$v_i = (x_i - x_{i-n}), \; i = n+1, ..., 2n \quad (15)$$

v_i, x_i represents the velocities and location vector of i^{th} colliding bodies in present group, x_{i-n} is the i^{th} colliding bodies pair location of i^{th} in the earlier group.

4) Velocities of colliding bodies after the collision within every group are estimated by equations [9] and [10]. The velocity of each moving colliding bodies behind the collision is determined by:

$$v_i' = \frac{(m_i - \varepsilon m_{i-n})v_i}{(m_i + m_{i+n})}, \quad i = n+1,....,2n \tag{16}$$

v_i , v_i' represents the velocities of i^{th} moving colliding bodies before and after the collision correspondingly, mass of the i^{th} colliding bodies is m_i and mass of the i^{th} colliding bodies pair is m_{i-n} .Velocity of each stationary colliding bodies after the collisions:

$$v_i' = \frac{(m_{i+n} + \varepsilon m_{i+n})v_{i+n}}{(m_i + m_{i+n})}, \quad i = 1,....,n \tag{17}$$

Here, v_{i+n} and v_i' are the velocities of the i^{th} moving and stationary colliding bodies pair before and after the collision correspondingly, m_i is mass of the i^{th} colliding bodies m_{i+n} is mass of the i^{th} moving colliding bodies pair, $\boldsymbol{\varepsilon}$ is restitution multiplication parameter. Fresh position of colliding bodies is evaluated by way of the generate velocities after the collision in position of stationary colliding bodies. The fresh positions of each moving colliding bodies determined by means of

$$x_i^{new} = (x_{i-n} + rand o v_i'), \; i = n+1,...,2n \tag{18}$$

Here, x_i^{new} and v_i' are the fresh position and velocities after the collision of i^{th} moving colliding bodies correspondingly, x_{i-n} be the previous position of i^{th} stationary colliding bodies' pair. The fresh positions of stationary colliding bodies are determined by means of

$$x_i^{new} = (x_i + rand o v_i'), \quad i = 1,,...,n \tag{19}$$

Here x_i^{new} , x_i and v_i' are the new position, old position and velocities after the collision of i^{th} stationary colliding bodies correspondingly, $rand$ is a random vector evenly disseminated in the range $[-1,1]$ and the mark "o" denote as element-by-element multiplication.

5) The optimization progression is repeated from step 2 in anticipation of an extinction condition, such while greatest iteration number be remunerated. Alter stationary or moving bodies and its numbering in two succeeding iterations.

4. Distributed generation modeling

Distributed generations like photovoltaic systems, micro turbines and wind turbine units are inject into the power lines by means of control electronic interfaces. During such gear, the representations of distributed generation entity in power flow relying on the control method used in the converter control circuit [8]. Distributed generations comprise in command of above the voltage through adaptable excitation voltage like synchronous generator or the control circuit of the converter used to control real power (P) and voltage (V) autonomously, in that case the distributed generation entity be representation as PV mode. Other distributed generations resembling induction generator or converters based units used to control real power (P) and reactive power (Q) independently, and in that case the distributed generation is model as PQ mode. With these models for distributed generation, current insertion base power flow process is applied for distribution structure study. In this paper, photo voltaic systems distributed generation is implementing as constant power factor model of PQ mode

5. Constant power factor distributed generation

Constant power factor model have been implementing regularly in distributed generations. Controllable distributed generation like synchronous generator base model and power electronic base model unit are choosing as constant power factor model. Intended for instance, the output power is able to be attuned by regulating the exciting current and trigger angles for synchronous generator base distributed generation and power electronic base distributed generation respectively. In this pattern, distributed generation real power and power factor values are mention. Distributed generation reactive power resolute by [20] and corresponding current injection acquired by [21].

$$Q_{iDG} = P_{iDG}\tan\left(\cos^{-1}\left(PF_{iDG}\right)\right) \tag{20}$$

$$I_{iDG} = I_{iDG}^{i}(V_{iDG}) + jI_{iDG}^{i}(V_{iDG}) = \left[\frac{P_{iDG} + jQ_{iDG}}{V_{iDG}}\right] \tag{21}$$

In this work, the photovoltaic distributed generation with constant power factor model through different values and its parameters are tabulated in table 1.

Table 1: DG Size in 38 Bus System through Different Power Factors

Size of DG (KVA)	Power Factor	P (KW)	Q (KVAR)
1338.55	0.89	1191.31	610.326
1338.55	0.87	1164.539	659.9744
1338.55	0.85	1137.768	705.125

6. CBO implementation flow chart

Flow chart of colliding bodies optimization intended for optimal position of Distributed generation.

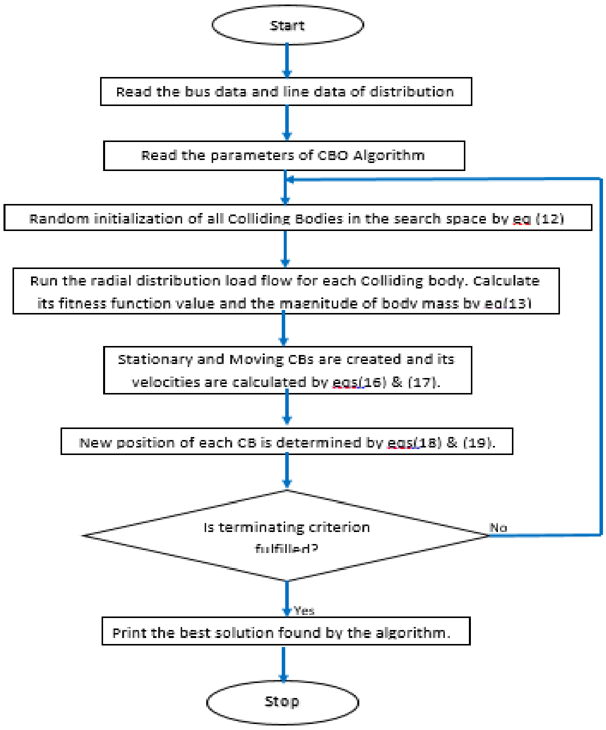

Fig. 3: The Flow Chart of Proposed Technique.

7. Results

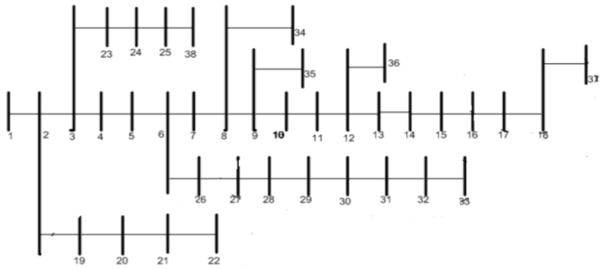

Fig. 4: 38 Bus Radial Distribution System.

38 bus radial distribution system test data [9] is intended for proposed study as shown here figure 4.Substation voltage has been taken as 12.66 kV. The overall crest load of 38 bus radial distribution system is 2.0 MW 0.970 MVAR, the corresponding real and reactive power losses are 20.2 KW and 13.4847 KVAR. The projected algorithm is tested on 38 bus radial distribution structure to trace out optimal placement of distributed generation. Outcome of optimal placement consequences of colliding bodies optimization (CBO) through different load power factors (PF) are compared with the bat algorithm (BA) and genetic algorithm (GA) techniques results as shown in table 2(I), 2(II) and 2(III).

Table 2: (I): Optimal Position of the Distributed Generation through Different Load Power Factors in 38 Bus System Using CBO, BA and GA

Bus Voltage	Without DG	CBO With DG		
		0.85 PF	0.87 PF	0.89 PF
V_1 (p.u.)	1.0000	1.0000	1.0000	1.0000
V2 (p.u.)	0.9970	0.9980	0.9980	0.9980
V3 (p.u.)	0.9829	0.9890	0.9890	0.9890
V4 (p.u.)	0.9755	0.9853	0.9853	0.9853
V5 (p.u.)	0.9681	0.9818	0.9819	0.9819
V6 (p.u.)	0.9497	0.9733	0.9733	0.9732
V7 (p.u.)	0.9462	0.9699	0.9699	0.9698
V8 (p.u.)	0.9414	0.9652	0.9652	0.9651
V9 (p.u.)	0.9351	0.9591	0.9591	0.9590
V10 (p.u.)	0.9293	0.9535	0.9534	0.9533
V11 (p.u.)	0.9285	0.9526	0.9526	0.9525
V12 (p.u.)	0.9270	0.9512	0.9511	0.9510
V13 (p.u.)	0.9249	0.9492	0.9491	0.9490
V14 (p.u.)	0.9227	0.9470	0.9469	0.9468
V15 (p.u.)	0.9213	0.9456	0.9455	0.9454
V16 (p.u.)	0.9199	0.9443	0.9442	0.9441
V17 (p.u.)	0.9179	0.9423	0.9423	0.9421
V18 (p.u.)	0.9173	0.9417	0.9417	0.9416
V19 (p.u.)	0.9965	0.9975	0.9975	0.9975
V20 (p.u.)	0.9950	0.9959	0.9959	0.9959
V21 (p.u.)	0.9943	0.9952	0.9952	0.9952
V22 (p.u.)	0.9936	0.9946	0.9946	0.9946
V23 (p.u.)	0.9794	0.9854	0.9855	0.9855
V24 (p.u.)	0.9727	0.9788	0.9788	0.9788
V25 (p.u.)	0.9694	0.9755	0.9755	0.9755
V26 (p.u.)	0.9478	0.9734	0.9734	0.9733
V27 (p.u.)	0.9452	0.9737	0.9737	0.9736
V28 (p.u.)	0.9338	0.9748	0.9746	0.9744
V29 (p.u.)	0.9256	0.9760	0.9758	0.9755
V30 (p.u.)	0.9220	0.9775	0.9773	0.9770
V31 (p.u.)	0.9178	0.9736	0.9734	0.9731
V32 (p.u.)	0.9169	0.9727	0.9725	0.9722
V33 (p.u.)	0.9166	0.9725	0.9723	0.9720
V34 (p.u.)	0.9414	0.9652	0.9652	0.9651
V35 (p.u.)	0.9351	0.9591	0.9591	0.9590
V36 (p.u.)	0.9270	0.9512	0.9511	0.9510
V37 (p.u.)	0.9173	0.9417	0.9417	0.9416
V38 (p.u.)	0.9694	0.9755	0.9755	0.9755

Bus Voltage	Without DG	BA With DG		
		0.85 PF	0.87 PF	0.89 PF
V_1 (p.u.)	1.0000	1.0000	1.0000	1.0000
V2 (p.u.)	0.9970	0.998	0.998	0.998
V3 (p.u.)	0.9829	0.989	0.989	0.989
V4 (p.u.)	0.9755	0.9853	0.9853	0.9853
V5 (p.u.)	0.9681	0.9818	0.9819	0.9818
V6 (p.u.)	0.9497	0.9733	0.9733	0.9733
V7 (p.u.)	0.9462	0.9699	0.9699	0.9699
V8 (p.u.)	0.9414	0.9652	0.9652	0.9652
V9 (p.u.)	0.9351	0.9591	0.9591	0.9591
V10 (p.u.)	0.9293	0.9534	0.9534	0.9534
V11 (p.u.)	0.9285	0.9526	0.9526	0.9526
V12 (p.u.)	0.9270	0.9511	0.9511	0.9511
V13 (p.u.)	0.9249	0.9491	0.9491	0.9491
V14 (p.u.)	0.9227	0.9469	0.9469	0.9469
V15 (p.u.)	0.9213	0.9455	0.9455	0.9455
V16 (p.u.)	0.9199	0.9442	0.9442	0.9442
V17 (p.u.)	0.9179	0.9423	0.9423	0.9423
V18 (p.u.)	0.9173	0.9417	0.9417	0.9417
V19 (p.u.)	0.9965	0.9975	0.9975	0.9975

V20 (p.u.)	0.9950	0.9959	0.9959	0.9959
V21 (p.u.)	0.9943	0.9952	0.9952	0.9952
V22 (p.u.)	0.9936	0.9946	0.9946	0.9946
V23 (p.u.)	0.9794	0.9854	0.9855	0.9855
V24 (p.u.)	0.9727	0.9788	0.9788	0.9788
V25 (p.u.)	0.9694	0.9755	0.9755	0.9755
V26 (p.u.)	0.9478	0.9734	0.9734	0.9733
V27 (p.u.)	0.9452	0.9736	0.9737	0.9736
V28 (p.u.)	0.9338	0.9747	0.9746	0.9744
V29 (p.u.)	0.9256	0.9759	0.9758	0.9755
V30 (p.u.)	0.9220	0.9725	0.9773	0.977
V31 (p.u.)	0.9178	0.9686	0.9734	0.9731
V32 (p.u.)	0.9169	0.9677	0.9725	0.9722
V33 (p.u.)	0.9166	0.9675	0.9723	0.972
V34 (p.u.)	0.9414	0.9652	0.9652	0.9651
V35 (p.u.)	0.9351	0.9591	0.9591	0.959
V36 (p.u.)	0.9270	0.9511	0.9511	0.951
V37 (p.u.)	0.9173	0.9417	0.9417	0.9416
V38 (p.u.)	0.9694	0.9755	0.9755	0.9755

Bus Voltage	Without DG	GA With DG		
		0.85 PF	0.87 PF	0.89 PF
V_1 (p.u.)	1.0000	1.0000	1.0000	1.0000
V2 (p.u.)	0.9970	0.9980	0.9980	0.9980
V3 (p.u.)	0.9829	0.9890	0.9890	0.9890
V4 (p.u.)	0.9755	0.9853	0.9853	0.9853
V5 (p.u.)	0.9681	0.9818	0.9819	0.9819
V6 (p.u.)	0.9497	0.9733	0.9733	0.9732
V7 (p.u.)	0.9462	0.9699	0.9699	0.9698
V8 (p.u.)	0.9414	0.9652	0.9652	0.9651
V9 (p.u.)	0.9351	0.9591	0.9591	0.9590
V10 (p.u.)	0.9293	0.9535	0.9534	0.9533
V11 (p.u.)	0.9285	0.9526	0.9526	0.9525
V12 (p.u.)	0.9270	0.9512	0.9511	0.9510
V13 (p.u.)	0.9249	0.9492	0.9491	0.9490
V14 (p.u.)	0.9227	0.9470	0.9469	0.9468
V15 (p.u.)	0.9213	0.9456	0.9455	0.9454
V16 (p.u.)	0.9199	0.9443	0.9442	0.9441
V17 (p.u.)	0.9179	0.9423	0.9423	0.9422
V18 (p.u.)	0.9173	0.9417	0.9417	0.9416
V19 (p.u.)	0.9965	0.9975	0.9975	0.9975
V20 (p.u.)	0.9950	0.9959	0.9959	0.9959
V21 (p.u.)	0.9943	0.9952	0.9952	0.9952
V22 (p.u.)	0.9936	0.9946	0.9946	0.9946
V23 (p.u.)	0.9794	0.9854	0.9855	0.9855
V24 (p.u.)	0.9727	0.9788	0.9788	0.9788
V25 (p.u.)	0.9694	0.9755	0.9755	0.9755
V26 (p.u.)	0.9478	0.9734	0.9734	0.9733
V27 (p.u.)	0.9452	0.9737	0.9737	0.9736
V28 (p.u.)	0.9338	0.9748	0.9746	0.9744
V29 (p.u.)	0.9256	0.9760	0.9758	0.9755
V30 (p.u.)	0.9220	0.9775	0.9773	0.9770
V31 (p.u.)	0.9178	0.9736	0.9734	0.9731
V32 (p.u.)	0.9169	0.9727	0.9725	0.9722
V33 (p.u.)	0.9166	0.9725	0.9723	0.9720
V34 (p.u.)	0.9414	0.9652	0.9652	0.9651
V35 (p.u.)	0.9351	0.9591	0.9591	0.9590
V36 (p.u.)	0.9270	0.9512	0.9511	0.9510
V37 (p.u.)	0.9173	0.9417	0.9417	0.9416
V38 (p.u.)	0.9694	0.9755	0.9755	0.9755

Table 3: (III): Optimal Position of the Distributed Generation through Different Load Power Factors in 38 Bus System Using CBO, BA and GA.

Parameter	Without DG	CBO With DG		
		0.85 PF	0.87 PF	0.89 PF
PLoss (KW)	199.1061	75.6364	76.7209	78.2024
QLoss (KVAR)	135.2761	54.8898	55.6703	56.7186
IVD	0.059300	0.03480	0.03490	0.03500
ILP	1.000000	0.37990	0.38530	0.39280
ILQ	1.000000	0.40580	0.41150	0.41930
DG Location	-----	31	30	30

Parameter	Without DG	GA With DG		
		0.85 PF	0.87 PF	0.89 PF
PLoss (KW)	199.1061	75.6364	76.7209	78.1886
QLoss (KVAR)	135.2761	54.8898	55.6703	56.7105
IVD	0.059300	0.03480	0.03490	0.03500
ILP	1.000000	0.37990	0.38530	0.39270
ILQ	1.000000	0.40580	0.41150	0.41920
DG Location	-----	30	30	30

Parameter	Without DG	GA With DG		
		0.85 PF	0.87 PF	0.89 PF
PLoss (KW)	199.1061	75.6364	76.7209	78.1886
QLoss (KVAR)	135.2761	54.8898	55.6703	56.7105
IVD	0.059300	0.03480	0.03490	0.03500
ILP	1.000000	0.37990	0.38530	0.39270
ILQ	1.000000	0.40580	0.41150	0.41920
DG Location		30	30	30

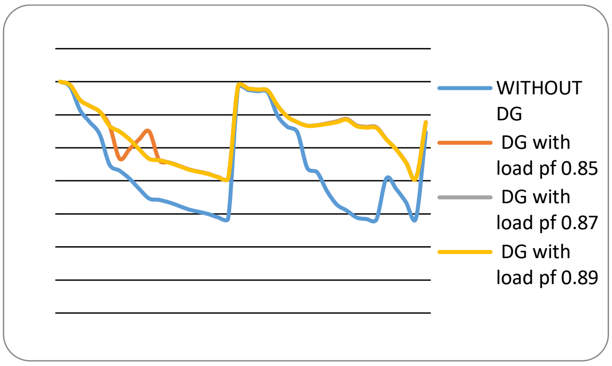

Fig. 5: Different Load Power Factors Voltage Profiles of 38 Bus Radial Distribution Structure.

8. Conclusion

The arrangement of photovoltaic distributed generation type with dissimilar power factors in standard radial distribution structure was analyze and computed with CBO, BA and GA optimization methods. From the above graph it is observed that the voltages are improved by means of optimal placement of distributed generation, identified location for different load power factors of various techniques. The power loss reduction index, power losses, voltage index at all busses are calculated at different load power factors of photovoltaic type distributed generation and observed the results are impressive at 0.85 power factor and located best possible at 31 bus for CBO and BA techniques, located at 30 bus for GA technique.

References

[1] Roberto Turconi, Alessio Boldrin, Thomas Astrup "Life cycle assessment of electricity generation technologies: Overview, comparitibility and limitations" Renewable and Sustainable energy reviews 28(2013) 555-565. https://doi.org/10.1016/j.rser.2013.08.013.

[2] Pathomthat Chiradeja, Member, IEEE, and R. RamaKumar, Life Fellow, IEEE "An Approach to Quantify the Technical Benefits of Distributed Generation" IEEE Transactions on Energy Conversion, Vol.19.No.4, December 2004. https://doi.org/10.1109/TEC.2004.827704.

[3] Ahmed R.Abul'Wafa "Novel Loss Voltage sensitivity factor for capacitor placement in Radial distribution system using approach", J Electron system 2017, 6:1.

[4] P. Vijay Babu & S.P.Singh " Optimal placement of DG in Distribution network for power loss minimization using NLP & PLS technique" 5th International Conference on Advances in Energy Research, ICAER 2015, 15-17 December 2015, Mumbai,India.

[5] A.Kaveh and V.R.Madhavi "Colliding bodies optimization: a novel meta heuristic method" Center for Excellence for Fundamental Studies in Structural Engineering, Revised for CAS, January 2014.

[6] kaveh A, Talatahari S "A novel heuristic optimization method: charged system search, Acta Mech 213:267-289. https://doi.org/10.1007/s00707-009-0270-4.

[7] A.Kaveh, and P.Asadi "Optimum design of grillage system using CBO and ECBO algorithms" International journal of optimization in civil engineering int.J.Optim.Civil eng.,2016;6(1):77-100.

[8] Sivakumar Mishra, member IEEE, Debapriya Das, member IEEE, Subrata Paul, " A simple algorithm for distribution system load flow with Distributed Generation. IEEE International Conference on Recent Advances and Innovations in engineering (ICRAIE-2014), May 09-11, 2014, Jaipur, India.

[9] Chandrasekar Yamini, Sydulu Maheswarapu, sailaja kumara Matam, "Enhancement of voltage profile and loss minimization in Distribution systems using optimal placement and sizing of power system modeled DGs", J.Electrical Systems 7-4(2011):448-457.