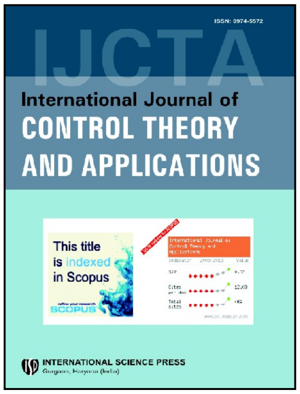

International Journal of Control Theory and Applications

ISSN : 0974-5572

© International Science Press

Volume 10 • Number 10 • 2017

Crow Search Algorithm for Optimal PV and Capacitor Placement for Loss Reduction in the Distribution Systems

M Padma Lalitha*, P. Suresh Babu†, K. Sai Krishna Teja

**Professor, Department of EEE, AITS Rajampet, Kadapa, A.P. India*
†Assistant Professor, AITS Rajampet, Kadapa, A.P. India
P.G Scholar, Department of EEE, AITS Rajampet, A.P. India-516126
E-mail: Padmalalitha_mareddy@yahoo.co.in sureshram48@gmail.com saikrish125@gmail.com

Abstract: Distributed generation (DG) is one of the increasing technologies for power systems, with the help of which issues of power systems can be solved. Present day distribution systems are facing the problem of increasing load demand which results in increasing power losses and reduced voltage profiles which are the major issues for the power system engineers. Distributed generation finds a good solution for resolving these issues. Distributed generation represents the small scale power generators which are generally embedded in the distribution systems. With optimal placement and sizing of distributed generators, power loss reduction and voltage profile improvement in the distribution systems can be obtained. This paper presents the recently developed meta-heuristic algorithm called Crow Search algorithm based on intelligent behavior of crows for finding optimal locations and sizes of PV and capacitor simultaneously. Test system considered for the validation of results is IEEE 33 bus system.

Keywords: Distributed generation (DG), Crow Search algorithm (CSA), real power loss, voltage profile, optimal locations and sizes, Photo voltaic (PV)

1. INTRODUCTION

The interest of distributed generation (DG) for power systems is increasing rapidly. This is explained by the factors like environmental concerns, restructuring of electricity market, and the development of technologies for small-scale power generation. DG's are alternative to the residential, industrial and commercial application. Many definitions are defined for DG across the world, based upon plant rating, generated voltage levels, point of connection, etc. The Electric Power Research Institute (EPRI) defined distributed generation as the generation from "a few kilo-watts to 50 MW". Distributed generation generally consists of different types of renewable energy sources. Some technologies like photovoltaic, wind turbines, fuel cells, micro-turbines, gas turbines, reciprocating engines etc are used as DG technologies. Also depending upon the type of power they deliver, Conclusion is made that the DG is an electrical power generation within distribution system [1]. DG's are classified into following types

Type 1: DG's that produce only active power (e.g. PV, micro turbines, fuel cells)

Type 2: DG's that produce only reactive power (e.g. capacitors, synchronous compensators)

Type 3: DG's that produce both active and reactive power (e.g. synchronous generators)

Type 4: DG's that produce active power by consuming reactive power (e.g. induction generators)

Studies had shown that 70% of that total power losses will occur in distribution systems [2]. Increased active power losses leads to loss in savings to the utility and reduction of feeder utilization.

Placing DG alters the power flow and the bus voltages of the system. Non-optimal DG placement may increase the system losses and affects the voltage profiles of the system. It should also be of optimal size so that it can give the positive impacts like improved voltage profile, reduce the losses, and increase the distribution capacity and improvement in the reliability of utility system [3, 4].

Previously, different methodologies are applied for determining the optimum size and location of DG. Analytical approach was proposed [5] for optimal DG allocation. Dynamic based programming [6] was utilized for finding optimal location for DG. A novel optimization approach [7] that used an Artificial Bee Colony (ABC) algorithm for finding the optimum DG size, power factor, and location for minimizing the total system real power loss. In [8], PSO and GA are combined for optimal location of DG.

In this paper, the Crow Search Algorithm (CSA) is utilized for determining the optimal locations and sizes for placing single and then multi-DGs for minimizing the real power losses to the maximum extent and improving the voltage profile. IEEE 33-bus system is examined as test case.

2. CROW SEARCH ALGORITHM (CSA)

This is a latest Meta heuristic algorithm and was proposed by Alireza Askarzadeh [9] in the year 2016. The algorithm works on the basis of intelligent behaviour of crows. Based on this behaviour, the crows store their excess food in the hiding places and retrieve when needed. Crows are treated as the most intelligent birds and have largest brain with relative to their body size. They can remember the faces of other crows and warns the others when an unknown crow approaches it. They watch the food locations of other birds and steal when there are no birds at that place. Based on this idea, the Crow Search Algorithm proceeds.

Let us assume that there are N crows present in the environment and the position of the crow '*i*' at an iteration is given by $X^{i.iter}$ and $iter_{max}$ is the maximum number of iterations. Each crow will have a memory of their food hiding position and for the i^{th} crow it is given as $m^{i,iter}$. Crows searches for the best food sources (locations) in the environment.Assume that, at an iteration crow *j* wants to go to its food hiding location, $m^{j,iter}$. At this iteration crow *i* decide to follow the crow *j* to approach the j^{th} crow food hiding place. In this situation, two cases may happen:

Case 1: j^{th} crow is unaware that crow *i* is following it. As a result crow *i* will goes to the food hiding place of crow *j*. The position (location) of the crow *i* is modified and is given as

$$x^{i,iter+1} = x^{i,iter} + r_i \times fl^{i,iter} \times (m^{j,iter} - x^{i,iter}) \tag{1}$$

where r_i is the random number between 0 and 1 and $fl^{i,iter}$ is the flight length of crow *i* at iteration iter. Small values of flight length lead to problem of local optima, as a result larger values which gives global optima are used.

Case 2: j^{th} crow is aware that crow *i* is following it, and tries to protect its food location by fooling the crow *i* by going to another place in the search space. The new location is a random location in the search space.

Totally two cases may happen in the algorithm.

$$x^{i,iter+1} = x^{i,iter} + r_i \times fl^{i,iter} \times (m^{j,iter} - x^{i,iter})$$
$$if\ r_j \geq AP^{j,iter} \tag{2}$$

Or

$$x^{i,iter+1} = a\ random\ position \tag{3}$$

Where, AP^{iter} is the awareness probability of the crow j at iteration iter. Two main characteristics of meta-heuristics i.e., intensification and diversification are controlled by the awareness probability (*AP*) in the proposed algorithm. Small values of AP increase the intensification, whereas larger values increase the diversification.

2.1. Pseudo code of the CSA Algorithm

Initialize the random positions of N crows in the search space

Evaluate the crow's positions

Memory of the each crow is initialized

While $iter < iter_{max}$

For i=1:N

Randomly choose one of the crows to follow

Define awareness probability

If $r_j \geq iter_{\max}$

$$x^{i,iter+1} = x^{i,iter} + r_i \times fl^{i,iter} \times (m^{j,iter} - x^{i,iter})$$

else

$$x^{i,iter+1} = a\ random\ position\ of\ searchspace$$

end if

end for

Check the new solutions feasibility

Evaluate the new positions for the crows

Update the crow's memory

End while

3. PROBLEM FORMULATION

The main objective for proposing this work is for minimizing the real power losses and improving the voltage profiles of the system by placing and sizing the distributed generation optimally. The DG considered is the photo voltaic with unity power factor inverters assumed i.e. active power generation. The assumption made is that the load is constant and balanced.

The objective function can be mathematically formulated as

$$objective\,function = minimize\left(\sum_{i=1}^{n}\left|I_i^2\,R_i\right|\right) \tag{4}$$

Where 'n' is the total number of branches, I_i and R_i are the current and resistance of the i[th] branch. The current I_i will comprises of two components, active (I_a) and reactive (I_r) components of the branch current.

Subjected to the constraints as follows

- Voltage constraint

$$V_{\min} \le V_i \le V_{\max} \tag{5}$$

Where V_i is the voltage magnitude at i[th] bus, V_{min} and V_{max} are the minimum and maximum voltages.

- Distributed generation capacity limits

$$P_{DG}^{\min} \le P_{DG} \le P_{Dg}^{\max} \tag{6}$$

4. RESULTS AND DISCUSSIONS

To validate the proposed CSA algorithm, the IEEE 33-Bus (Figure 1) radial distribution feeder system is considered. This network has 32 lines and 33 buses, base voltage of 12.66kV, load size of 3.715MW and 2.300 MVar [10] .

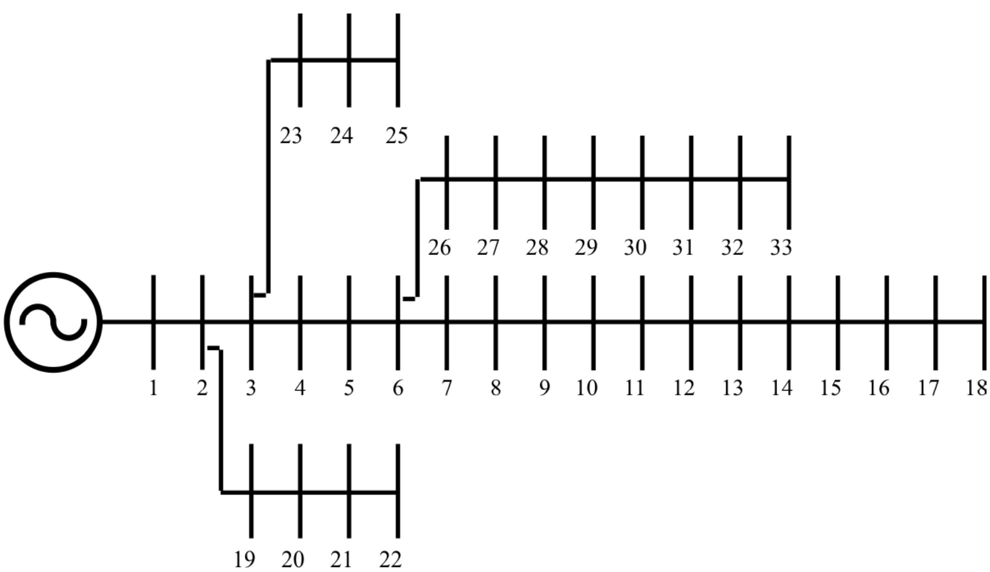

Figure 1: Single line diagram of IEEE 33 bus system

Initially load flows are carried out to obtain the power losses and voltage profiles of the system. Conventional N-R and G-S method do not converge for the radial distribution network. In this paper distribution power flow method [11], which uses Bus injection to branch current matrix (BIBC) and Branch currents to bus voltages (BCBV) matrix is used for power flows to get the losses. The load flow results obtained are shown in Table 1.

Table 1
Load flow results of 33 bus system

Active current component loss P_{La} (KW)	*Reactive current componentloss P_{Lr} (KW)*	*Total real power loss P_{Lt} (KW)*
135.942	66.724	202.666

The parameters considered for the simulation in this paper are

DG sizes: DG_{min}= 50 KW and DG_{max}=5000 KW

Population size (N) = 30

Flight length (fl) = 2

Awareness probability (AP) = 0.5

4.1. Results of optimal PV and capacitor placement in IEEE 33 bus system

By placing Type 1DG the active currents flowing in the lines are compensated and by placing Type 2 DG the reactive currents flowing in the lines are compensated. The local active and reactive loads connected at the buses can be compensated. As a result, the real power loss associated with active and reactive components of the branch currents can be reduced. Here by the proposed algorithm both optimal locations and sizes of DG are obtained simultaneously rather than a two stage methodology. Here one DG placed represents the simultaneous placement of one DG of Type 1 and Type 2 (capacitor).

The DG placement results are shown in Table 2

Table 2
Results of 33 bus system with DG's of Type 1 and Type 2 (capacitor)

Number of DG's placed	*optimal Type 1 location*	*optimal Size (MW)*	*optimal Type 2 (capacitor) location*	*optimal Size (MVAr)*	*Loss with DG's (KW)* Active PLa	*Loss with DG's (KW)* Reactive PLr	*Loss with DG's (KW)* Total PLt	*Loss without DG (P_{Lt}) (KW)*	*% reduction in loss P_{Lt}*
1	6	2.5180	30	1.2487	40.079	11.715	51.795		74.443
	13	0.8399	12	0.4524					
2	30	1.1402	30	1.0411	23.164	5.701	28.865		85.557
	6	1.1736	3	0.8079					
3	14	0.6033	14	0.3351	15.223	3.429	18.652	202.666	90.796
	31	0.6798	30	0.9923					
	3	1.2687	7	0.3776					
	7	0.8005	14	0.2720					
4	14	0.5859	24	0.4715	10.989	1.256	12.245		93.958
	31	0.6944	30	0.8947					

In the above table, PLa is the active component loss of real power loss and PLr is the reactive component loss of real power loss. PLt is the total real power loss. From the results, it is observed that, the active component current loss of real power loss is getting reduced from 135.942 KW to nearly 10 KW , and the reactive current loss of real power loss getting reduced from 66.724 KW to nearly 1 KW by placing DG's and capacitors simultaneously. The total real power loss reduction of above 90 % can be obtained by this placement. The voltage profile of this 33 bus system without placing and after placing of DG's of Type 1 and Type 2 (capacitor) is shown in figure 2.

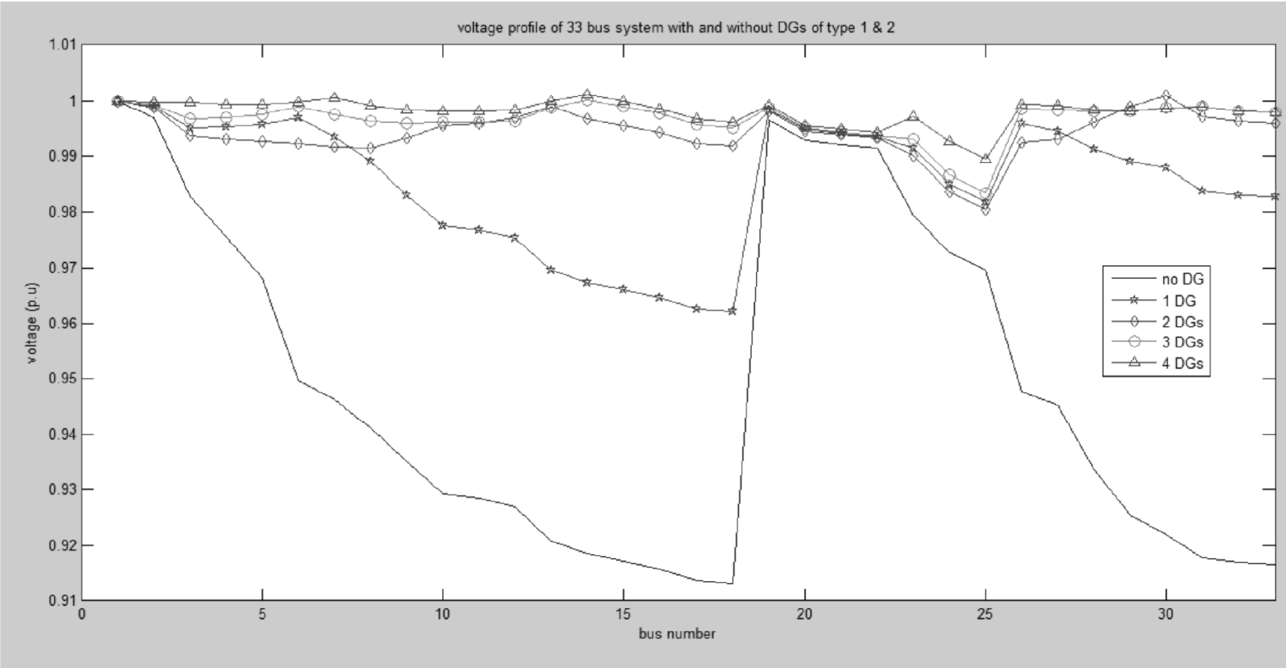

Figure 2: Voltage profile of 33 bus system with and without DG's of Type 1 and Type 2

The minimum voltages at the buses obtained by this placement are shown in Table3.

Table 3
Buses with minimum voltages after DG placement

Number of DG's placed	*Min voltage p.u*	*Bus number*
1	0.9622	18
2	0.9804	25
3	0.9834	25
4	0.9895	25

CONCLUSION

This paper presented a new meta-heuristic method called Crow Search Algorithm (CSA) for optimal placing and sizing of PV and capacitor simultaneously in the distribution systems. The objective considered is the power loss reduction. The simulation results obtained shows the effectiveness of the proposed algorithm. IEEE 33 bus system is considered as the test system. In this paper both optimal locations and sizes of PV and capacitor simultaneously are obtained by the algorithm.The methodology presented can be easily implemented in the practical distribution systems for planning and operational studies.

REFERENCES

[1] Al Abri R, El-Saadany EF, Atwa YM. Optimal placement and sizing method to improve the voltage stability margin in a distribution system using distributed generation. IEEE Trans Power Syst 2013;28:326–34.

[2] Jamian J, Aman M, Mustafa M, Jasmon G, Mokhlis H, Bakar A. et al. Optimum multi DG units placement and sizing based on voltage stability index and PSO. In: 47th International universities power engineering conference (UPEC); 2012. p. 1–6.

[3] Ameli SBA, Khazaeli F, Haghifam MR. A multiobjective particle swarm optimization for sizing and placement of DGs from DG owner's and distribution company's viewpoints. IEEE Trans Power Delivery 2014;29(4):1831–40.

[4] Rahim S, Musirin I, Sulaiman M, Hussain M, Azmi A. Assessing the performance of DG in distribution network. In: 2012 IEEE international power engineering and optimization conference (PEDCO). Melaka (Malaysia); 2012. p. 436–41.

[5] Gozel T, Hocaoglu MH. An analytical method for the sizing and siting of distributed generators in radial systems. Elect Power Syst Res 2009;79:912–8.

[6] Khalesi N, Rezaei N, Haghifam M-R. DG allocation with application of dynamic programming for loss reduction and reliability improvement. Int J Electr Power Energy Syst 2011;33:288–95.

[7] T. Niknam, S. I. Taheri, J. Aghaei, S. Tabatabaei, M. Nayeripour, "A modified honey bee mating optimization algorithm for multiobjective placement of renewable energy resources", Applied Energy, vol. 88, pp. 4817–4830, 2011.

[8] Safari, A., Jahani, R., Shayanfar, H.A., Olamaei, J.: "Optimal DG allocation in distribution network", Int. J. Electr. Electron. Eng., 2010, 4, (8), pp. 550–553.

[9] Alireza Askarzadeh " A novel metaheuristic method for solving constrained engineering problems: Crow search algorithm", Computers and Structures 169 (2016) 1–12

[10] KashemM,GanapathyV,JasmonG,BuhariM.Anovelmethod for loss minimization in distribution networks. In: Proceedings of the international conference on electric utility deregulation and restructuring and power technologies 2000, DRPT 2000; 2000. p. 251–6.

[11] Teng JH. A direct approach for distribution system load flow solutions. IEEE Trans Power Del 2003;18(3): 882–7.