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OPTIMAL DG PLACEMENT USING FUZZY AND ANT LION ALGORITHM

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Abstract: This article proposes a novel methodology for placing DG units in electrical distribution systems that incorporates Fuzzy and Ant Lion Algorithms (ALA) in order to minimize power losses and improve the voltage profile. Electrical energy is critical to daily existence. A keen interest in all available sources of energy has resulted in the promotion of generating electrical power using renewable energy sources such as solar, tidal waves, and wind. Due to the growing interest in renewable energy sources in recent years, research on distributed generating integration into the power grid has accelerated. Distributed generation (DG) sources are added to the network primarily to mitigate power losses by supplying a net quantity of energy. To minimize power system line losses, it is critical to establish the amount and placement of local generating. Numerous studies have been conducted to determine the optimal site for dispersed generating. The research employs a fuzzy technique to determine the ideal positions of DG units and a ant lion algorithm based on the intelligent behavior of ant lions to determine the optimal locations and sizes to reduce the losses and to improve the voltage. The proposed approach is written in MATLAB, and the results are provided for 15-bus and 33-bus test systems.

1.Introduction:

The term "distributed generation" refers to small-scale generation placed near or at load centers. Additionally, it has been referred to as decentralized generation, scattered generation, embedded generation, decentralized energy, or distributed energy. Distributed generation is accomplished by utilizing a variety of small-scale energy generation systems. The term "distributed energy resources" refers to a range of small, modular power generation technologies that can be combined with energy management and storage systems to improve the operation of the electricity distribution system, regardless of whether those technologies are connected to the grid. Distributed generation is a method that lowers the amount of energy wasted during electrical transmission by generating power close to the load centre, sometimes even in the same building. Additionally, this minimizes the size and quantity of power lines that must be built. Numerous analyses have been conducted on the placement of DG units. The DG placement problem's purpose is to establish the positions and sizes of the DGs in order to minimize power loss. Even though much research has been conducted on optimal DG placement, there is still a need to develop more appropriate and effective strategies for optimal DG placement. Certain ways for solving the optimal DG placement problem are quite efficient. Their effectiveness is completely dependent on the quality of the data used. The fuzzy technique compensates for the absence of uncertainty in the data. The advantage of the fuzzy approach is that it incorporates heuristics and engineering judgments into the optimal DG placement problem. The answers provided using a fuzzy technique can readily be examined to determine the ideal position of DGs. Global optimization is more effective in determining the ideal DG sizes. Ant Lion algorithm (ALA) is a novel meta-heuristic method that is being used in all sectors of engineering. The ideal DG positions are determined in the first step using the fuzzy approach proposed. The second stage employs the Ant Lion algorithm (ALA) to determine the ideal location and sizes. The proposed method is validated using test systems with 33-bus, 34-bus, and 69-bus configurations, and the results are provided.

2.Definition of the Issue:

The total real power loss (PL) in a distribution system with n branches is calculated as follows:

$$P_L = \sum_{i=1}^{n} I_i^2 \, Ri \qquad (2.1)$$

Ii denotes the magnitude of the branch current, while Ri denotes the resistance of the ith branch. The branch current can be determined by solving for the load flow. There are two components to the branch current: the active component (Ia) and the reactive component (Ir) (Ir). The loss associated with branch currents' active and reactive components can be expressed as the loss PLa associated with the active component of branch currents cannot be minimized in a single-source radial network because all active power must be supplied by the source at the root bus. Providing a portion of the reactive power demand locally, on the other hand, can help reduce the loss PLr associated with the reactive component of branch currents. This article describes a method for minimizing the loss caused by the reactive component of branch current by efficient capacitor placement, hence lowering the total loss in the distribution system.

3.Optimal dg placement using fuzzy approach

3.1 Introduction:

Distribution systems are typically spread over large areas and are responsible for a significant portion of total power losses. Reduction of total power loss in distribution system is very essential to improve the overall efficiency of power delivery. can be achieved by placing the optimal value of units at proper locations in radial distribution systems. units are installed at strategic locations to reduce the losses and to maintain the voltages within the acceptable limits.

The advantages anticipated include boosting the load level of the feeder so that additional loads can be carried by the feeder for the same maximum voltage drop, releasing a certain KVA at the substation that can be used to feed additional loads along other feeders and reducing power and energy losses in the feeder.

The objective of the placement problem is to determine the locations and sizes of the DGs so that the power loss is minimized and annual savings are maximized.

3.2 Placement:

work presents a fuzzy approach to determine suitable locations for placement. Two objectives are considered while designing a fuzzy logic for identifying the optimal locations. The two objectives are: (i) to minimize the real power loss and (ii) to maintain the voltage within the permissible limits. Voltages and Power loss indices of distribution system nodes are modeled by fuzzy membership functions. A fuzzy inference system (FIS) containing a set of rules is then used to determine the placement suitability of each node in the distribution system. Distributed generation units can be placed on the nodes with the highest suitability. In a distribution system with high losses and low voltage is highly ideal for placement of units. Whereas a low loss section with good voltage is not ideal for placement. A set of fuzzy rules has been used to determine suitable locations in a distribution system.

In the first step, load flow solution for the original system is required to obtain the real and reactive power losses. Again, load flow solutions are required to obtain the power loss reduction by compensating the total reactive load at every node of the distribution system. The loss reductions are then linearly normalized into a [0, 1] range with the largest loss reduction having a value of 1 and the smallest one having a value of 0. Power Loss Index value for nth node can be obtained using equation (4.1).

$$\mathrm{PLI}_{(n)} = \frac{(Lossreduction\ (n) - Lossreduction\ (\min))}{(Lossreduction\ (\max) - Lossreduction\ (\min))} \quad (3.1)$$

These power loss reduction indices along with the p.u. nodal voltages are the inputs to the Fuzzy Inference System (FIS), which determines the node more suitable for installation. In work, two input and one output variables are selected. Input variable-1 is power loss index (PLI) and Input variable-2 is the per unit nodal voltage (V). Output variable is suitability index (SI). Power Loss Index range varies from 0 to 1, P.U. nodal voltage range varies from 0.9 to 1.1 and suitability index range varies from 0 to 1. Five membership functions are selected for PLI. They are L, LM, M, HM and H. All the five membership functions are triangular as shown in Figure 4.1. Five membership functions are selected for Voltage. They are L, LN, N, HN and H. membership functions are trapezoidal and triangular as shown in Figure 4.2. Five membership functions are selected for SI. They are L, LM, M, HM and H. These five membership functions are also triangular as shown in Figure 4.3.

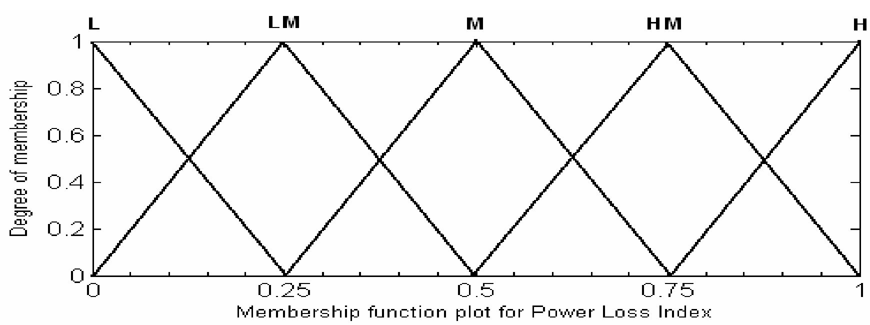


Fig.3.1: Membership Function Plot for P.L.I.

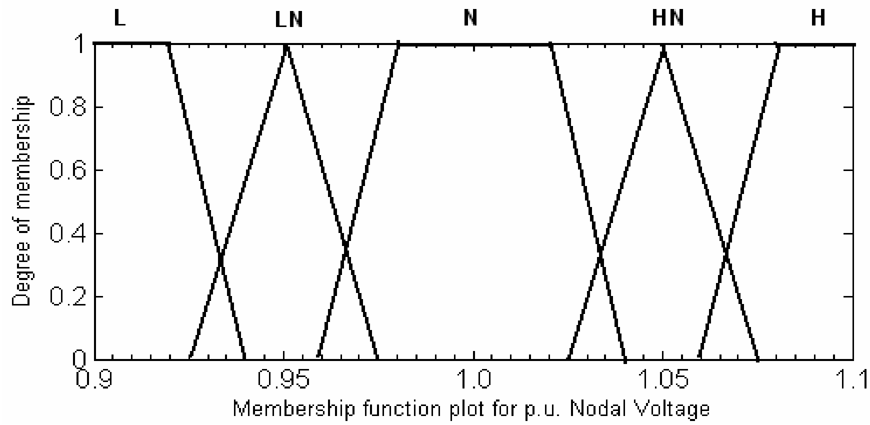


Fig.3.2: Membership Function Plot for p.u. Nodal Voltage

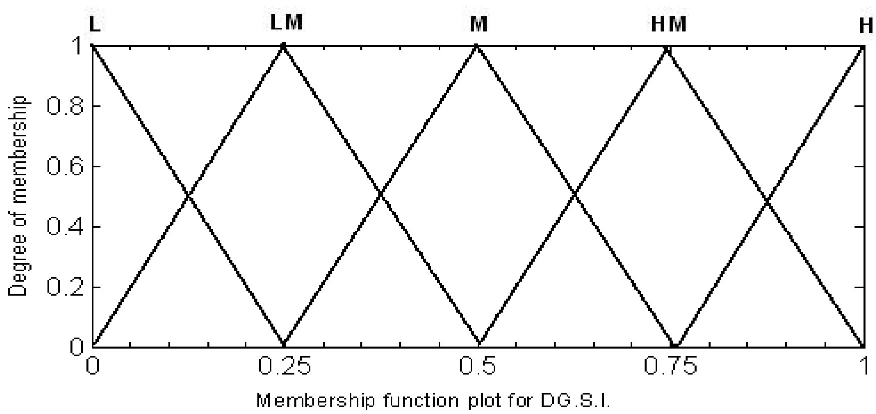


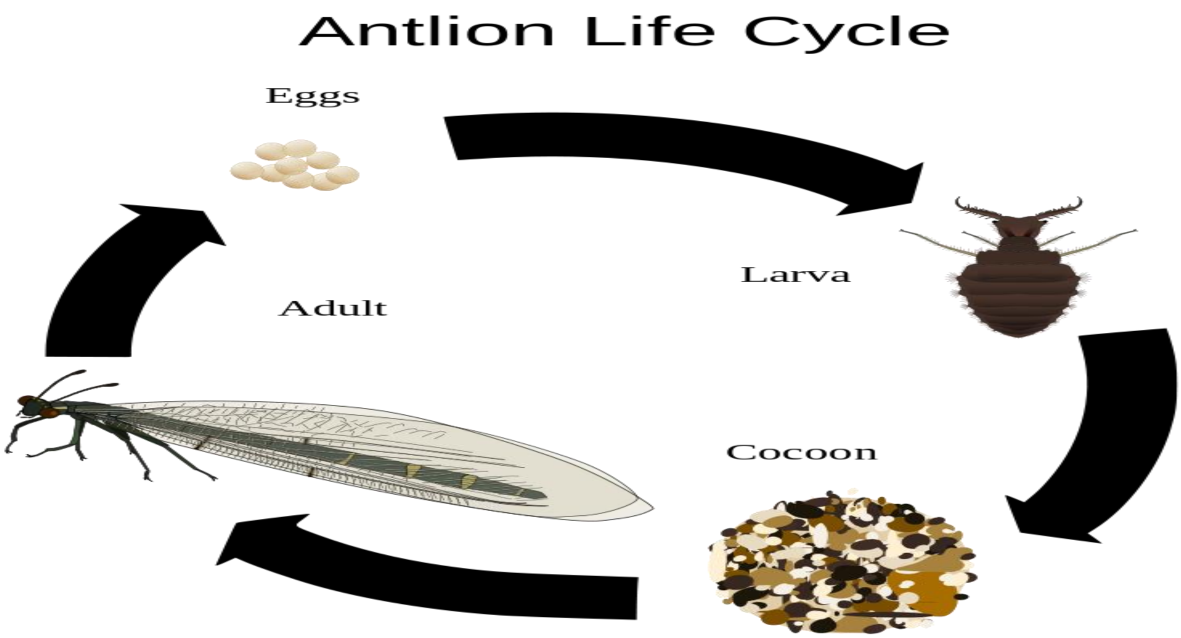
Fig.3.3: Membership Function Plot for S.I.

Table – 1: Decision matrix for determining the DG location

AND		Voltage				
		L	LN	N	HN	H
	L	LM	LM	L	L	L
	LM	M	LM	LM	L	L
	M	HM	M	LM	L	L
	HM	HM	HM	M	LM	L
	H	H	HM	M	LM	LM

4.Optimal dg sizing using ant lion algorithm

Ant Lion Optimizer (ALO) is a recent novel algorithm developed in the literature that simulates the foraging behavior of a Ant lions. Recently, it has been applied to a huge number of optimization problems. It has many advantages: easy, scalable, flexible, and have a great balance between exploration and exploitation. In this comprehensive study, many publications using ALO have been collected and summarized. Firstly, we introduce an introduction about ALO. Secondly, we categorized the recent versions of ALO into 3 Categories mainly Modified, Hybrid and Multi-Objective. we also introduce the applications in which ALO has been applied such as power, Machine Learning, Image processing problems, Civil Engineering, Medical, etc. The review paper is ended by giving a conclusion of the main ALO foundations and providing some suggestions & possible future directions that can be investigated.



5. Outcomes of the 15 & 33-bus system

The suggested algorithm is tested on 15-bus and 33-bus [17] test systems, with the results shown in Tables 2 and 3.

Table 2: DG Unit sizes at the preferred bus locations for 15-bus system

Bus No.	DG Unit size in kVA
6	546

3	769
11	364
Minimum bus voltage in p.u.(before)	0.9451
Minimum bus voltage in p.u. (after)	0.9923
Total power loss in kW (before)	61.7339
Total power loss in kW (after)	4.6685
Reduction in power loss (%)	92.44 %

Table-3: DG Unit sizes at the preferred locations for 33-bus system

Bus No.	DG Unit size in kVA
6	1843
28	92
Minimum bus voltage in p.u. (before)	0.8793
Minimum bus voltage in p.u (after)	0.9664
Total power loss in kW (before)	368.9625
Total power loss in kW(after)	35.4085
Reduction in power loss (%)	90.40%

6.CONCLUSION:

A new two-stage methodology of finding the optimal locations and sizes for reactive power compensation of distribution systems is presented. Fuzzy approach is proposed to find the optimal locations and ALA method is proposed to find the optimal sizes. Based on the simulation results, the following conclusions are drawn-By installing distributed generation units at all the potential locations, the total real power loss of the system has been reduced significantly and bus voltages are improved substantially. The proposed fuzzy approach is capable of determining the optimal distributed generation locations based on the S.I values. The proposed ALA method iteratively searches the optimal unit sizes effectively for the maximum power loss reduction.