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Reconfiguration of Distribution System by Optimal Placement of Distributed Generator

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Abstract— Due to increase in the population and change in the lifestyle there is huge increase in the electricity demand and shortage in the generation, making new platform for the growth of distributed generator integration with power grids. The main reason for selecting the distributed generator is to reduce the power loss and improve the voltage profile of the network. This report deals with the total power loss reduction and improvement in the voltage profile of power system network by optimal location of distributed generator. The fuzzy logic method is used to find the candidate node for placement of DG. Results are validated. The fuzzy logic tool box gives faster results when compared with conventional method. The results obtained are satisfactory.

Index Terms— Distribution system, Fuzzy logic, Distributed generation, Power World Simulator.

1 Introduction

The distribution system is a largest portion of network in electrical power system. Distributed generations (DG) which are also called as decentralized generation or dispersed generation, is a small scale power generation source. It is an approach that employs small-scale technologies to generate electricity near the end users of power. DG includes both conventional and non-conventional types of energy resource to generate power. The development of new technologies allows the DG leading to various benefits like low transmission loss, improvement in the voltage profile etc.

The main aim of the DG is to generate 20% of existing power generation when it is interconnected with system to reduce the burden on the existing network. The concept of DG is not new in distribution system; there is a growing tendency towards DG application in power systems. Environmental advantages, economical benefits, new technology and power system deregulation are major accelerating factors for DG application. While improving voltage profile and reducing power loss in the network, application of DG requires enhanced and conclusive protection scheme. Normally, impact on distribution system due to DG depends on several factors such as DG location, technology and capacity as well as the mode of DG operation with network. Application of DG in distribution networks can lead to improvement in voltage profile, loss reduction and reduce the green house gases [8]. The Fuzzy logic method is applied for determining the optimal location of DG. The fuzzy method is validated with the conventional method for 14 bus system.

Several methods of loss reduction by placing DG in distribution systems have been reported over the years. The early approaches to this problem includes those using analytical methods, artificial intelligence methods and those using dynamic programming technique to include the discrete nature of DG. The analytical network is based on the mixed programming to find the optimal size of DG to reduce the losses in the distribution system. Another proposed method of minimizing the loss associated with reactive component of branch currents by placing DG at proper location. The first method finds the optimal location of the Dg in a sequential manner.

Once the DG locations are determined the optimal DG size at each selected node is determined by optimizing the loss. More recently, the various non-deterministic methods like tabu search, genetic algorithm and simulated annealing to determine the location and size of DG to improve the voltge profile of the system.

In this project the Fuzzy Expert System (FES) is used to determine the optimal location of DG placements and the sizing of the DG is based on analytical approach. The FES uses Power Loss Index and Bus Voltages (in p.u) as the input and a set of rules are developed on qualitative description. The output obtained from Fuzzy Expert System is Distributed Generator Suitability Index (DGSI) and depending on DGSI values the DG is placed on the bus with high sensitivity index. Hence optimal location of the DG is determined.

When the DG are placed Power Loss is minimized and Voltage Profile is enhanced. Both these factors contribute in increasing in the profit and efficiency of the network.

2 Objective

1. To enhance the Voltage at each bus.
2. To reduce the losses at each bus.
3. This is done by optimal placement of Distributed Generator.

2.1 Power Flow Analysis Method

The methods proposed for solving distribution power flow analysis in this paper is Newton-Raphson (NR) method. Here the Single line diagram of the entire network is carried out using Power World Simulator (PWS) and using the same platform the power loss at each bus and voltage profile at each bus is obtained.

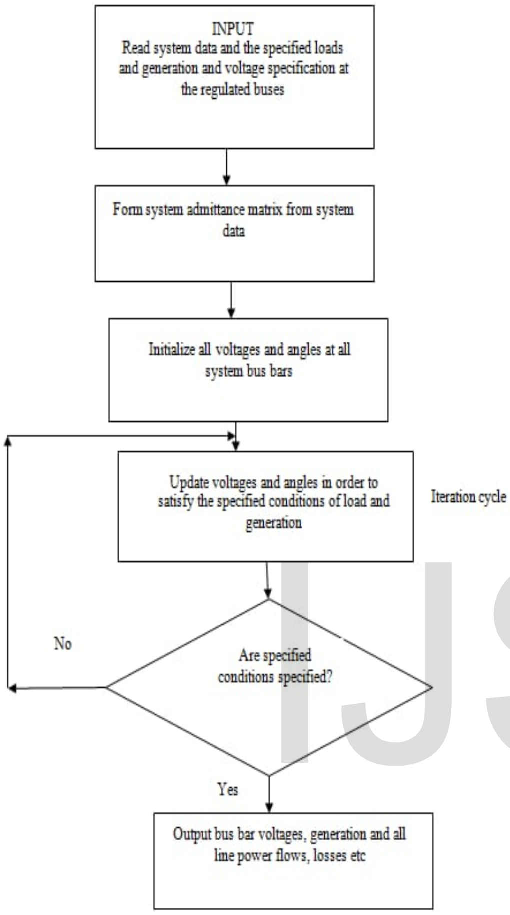

Fig 1: Flow chart for NR Load flow method

2.2. Methodology

The main aim of this research is to reconfigure the network by placing the distributed generator at appropriate locations (candidate node). Which can be found by incorporating Fuzzy Expert System (FES)?

[1] Read the data for the load flow analysis.
[2] Run the load flow (NR-Load flow) data for base case.
[3] Compute the total power loss, power loss at each node and voltage profile at each node.
[4] Using voltage profile and loss index as an input to the FES in order to find candidate node.
[5] Place the DG at the candidate node and again run the load flow.
[6] Check whether the results are violated or not.
[7] Compute the new power loss and voltages at each bus.
[8] After adding the DG observe the voltages and power.

3. FUZZY LOGIC

Fuzzy logic starts with and builds on a set of user-supplied human language rules. Fuzzy logic idea is similar to the human being's feeling and inference process. Unlike classical control strategy, which is a point–to-point control, fuzzy logic control is a range-to-point or range-to-range control. Fuzzy logic is a form of many valued logic in which the truth values of variables may be any real number between 0 and 1, considered to be "Fuzzy". By contrast, in Boolean logic the truth values of variables may only be 0 or 1, often called "Crisp" values. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. A set of fuzzy rules are developed from quantitative description by the user further, the

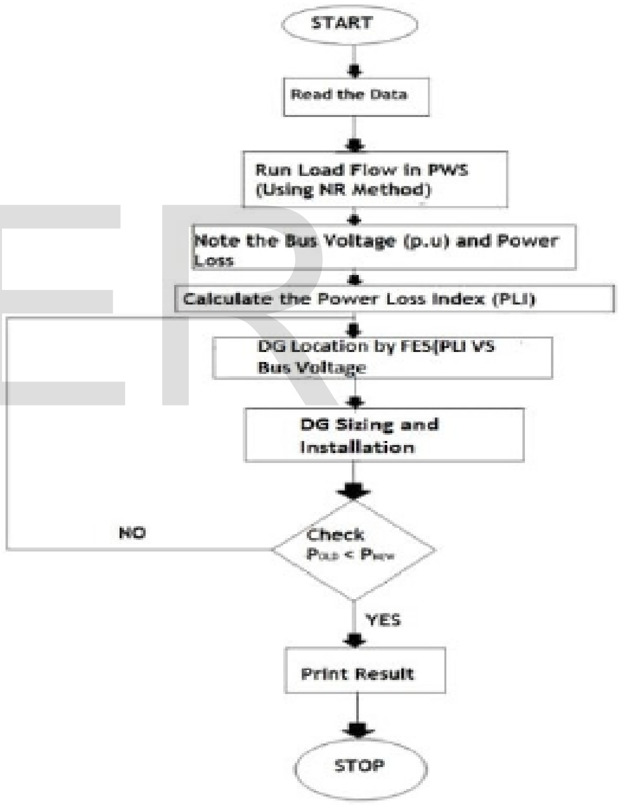

Fig2: Flow chart for Methodology

Fuzzy systems convert these rules to their mathematical equivalents. This simplifies the job of the system designer and the computer, and results in much more accurate representations of the way systems behave in the real world.

3.1 Fuzzy logic technique to a real application requires the following three steps:

1. Fuzzification-Convert classical data into fuzzy data or membership Function (MFs) system. A degree of zero means that the value is not in the set and a degree of one means that the value is completely representative of the set.
2. Fuzzy Inference Process-Combine membership functions with the control rules to device the fuzzy output.
3. Defuzzification-Use different methods to calculate each associated output and put them into a output based on the current input during an application.

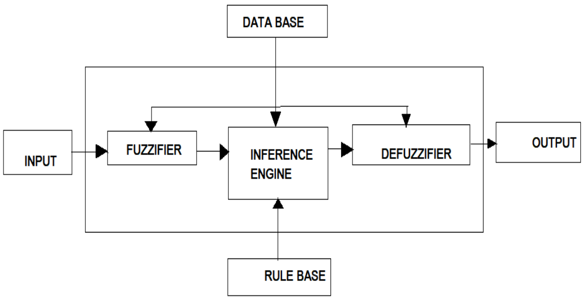

Fig 3: Elements of Fuzzy Rule Base System

3.2 Implementation of fuzzy expert system for distribution generator placement

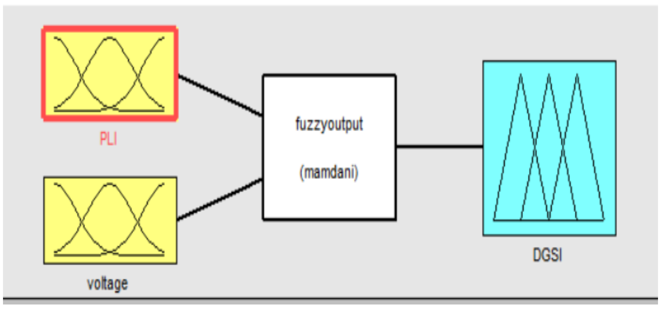

Fig 4: Fuzzy Expert System

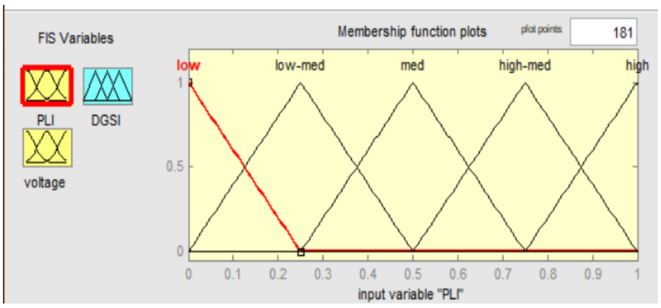

Fig 5: Power Loss Index Membership Function

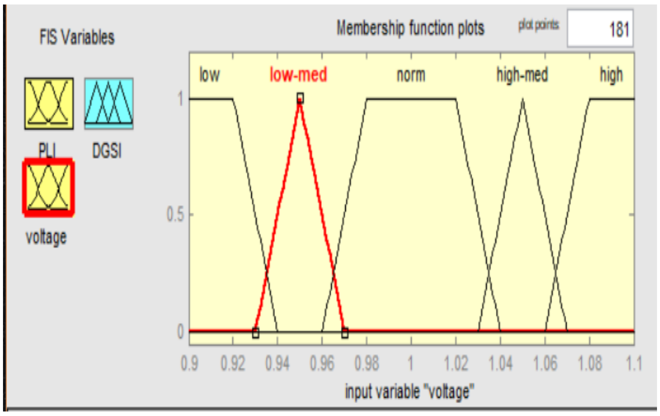

Fig 6: Voltage Membership Function

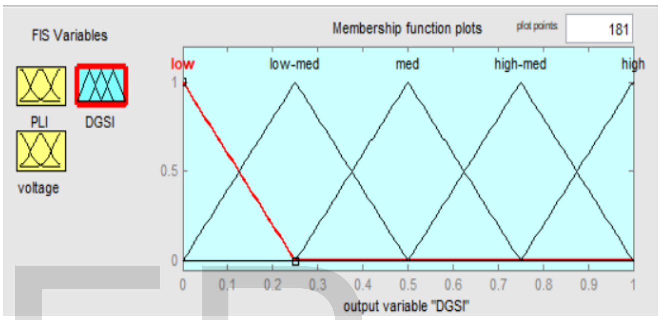

Fig 7: DGSI Membership Function

The power loss indices and bus voltages are used as the inputs to the fuzzy expert system, which determines the buses which are more suitable for distributed generator installation. The power loss indices range varies from 0 to 1, the voltage range varies from 0.9 to 1.1 and the output [distribution generator suitability index (DGSI)] range varies from 0 to 1.

These variables are described by five membership functions of high, high-medium/normal, medium, normal, low-medium/normal and low. The membership functions of power loss indices and DGSI are triangular in shape, the voltages combination of triangular and trapezoidal Membership functions. These are graphically shown above in fig 4,5,6,7.

After the FES receives input from the load flow program, several rules may fire with some degree of membership. The fuzzy inference methods such as mamdani max-min implication methods are used to determine the aggregated output from a set of triggered rules. A final aggregated membership functions is achieved by taking the union of all the truncated consequent membership functions of the fired rules.

TABLE 1 FUZZY RULES

BUS No	DG at 13rd Bus					
	20MW	40MW	60MW	80MW	100MW	120MW
1	1	1	1.00053	1.00744	1.01387	1.01983
2	1	1	1	1.00404	1.00892	1.01347
3	0.98627	0.99712	1	1	1	1
4	0.97811	0.99047	1	1	1	1
5	0.97398	0.99044	0.99882	1	1	1
6	0.97231	0.98258	0.98561	0.98788	0.98981	0.9914
7	0.96949	0.97406	0.97585	0.97636	0.97644	0.97611
8	0.96435	0.97256	0.97424	0.97336	0.97221	0.97194
9	0.95357	0.95882	0.96245	0.96619	0.96934	0.9708
10	0.95096	0.95724	0.96019	0.96184	0.96342	0.96584
11	0.94898	0.95704	0.95975	0.96046	0.96274	0.96292
12	0.94502	0.95577	0.95808	0.95875	0.95722	0.95516
13	0.94418	0.95199	0.95693	0.95698	0.95539	0.9536
14	0.93597	0.94236	0.94642	0.94932	0.9517	0.95335
Active Power Loss	6.59	5.62	4.82	4.11	3.5	3.75
Reactive Power Loss	18.21	15.81	13.11	10.74	8.66	7.51

TABLE.2. SET OF MULTIPLE ANTECEDENTS FUZZY RULES

AND		VOLTAGE				
		LOW	LOW-MEDIUM	MEDIUM	HIGH-MEDIUM	HIGH
POWER LOSS INDEX (PLI)	LOW	LOW-MED	LOW-MED	LOW	LOW	LOW
	LOW-MED	MED	LOW-MED	LOW-MED	LOW	LOW
	MEDIUM	HIGH-MED	MED	LOW-MED	LOW	LOW
	HIGH-MED	HIGH-MED	HIGH-MED	MED	LOW-MED	LOW
	HIGH	HIGH	HIGH-MED	MED	LOW-MED	LOW-MED

The above table.1 explains about the fuzzy rules which are used in order to find the DGSI for the given problem.

3.4. IEEE-14 Bus Test System

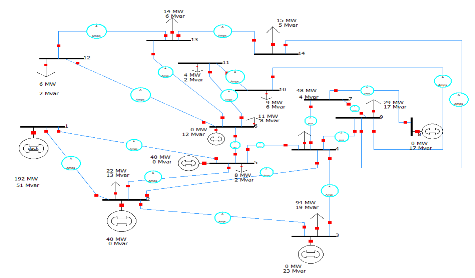

Fig 8: IEEE-14 Bus System in PWS

After running the load flow Power Loss Index is found by using below equation

PLI=(X(i)-Y) / (Z-Y)

Where i= 1,2,3,….n

X(i) = loss reduction at ith bus

Y = minimum loss reduction

Z = maximum loss reduction

POWER LOSS INDEX (PLI)	VOLTAGE SUITABILITY INDEX (VSI)	DGSI
0	1	0.08
0.625217	0.98567	0.375
1	0.97101	0.5
0.83913	0.96593	0.6
1.04	0.95457	0.75
0.7	0.94728	0.69
0.733043	0.94628	0.726
0.710435	0.94372	0.697
0.72	0.93826	0.694
0.709565	0.93549	0.66
0.717391	0.93481	0.67
0.717391	0.93067	0.733
0.712174	0.92509	0.75*
0.709565	0.92352	0.75

TABLE.2. DGSI FOR 14 BUS SYSTEM

RESULTS

The proposed method is applied to an IEEE-14 Bus Test System; optimal location is identified on DGSI value. For the case study one optimal location is identified and the suitable DG is placed at that location. Voltage profile improvement, active and reactive power loss reductions are illustrated in Table 2 and Table 3. Table.4. illustrates the voltage profile comparison with and without DG

TABLE.3 . VOLTAGE PROFILE WITH AND WITHOUT DG.

Bus No	WITHOUT DG	WITH DG
	Voltage (p. u)	Voltage (p .u)
1	1	1.01387
2	0.98567	1.00891
3	0.97101	1.00004
4	0.96593	1
5	0.95457	0.99999
6	0.94728	0.98981
7	0.94628	0.97646
8	0.94372	0.97222
9	0.93826	0.96934
10	0.93549	0.96343
11	0.93481	0.96277
12	0.93067	0.95724
13	0.92509	0.95542
14	0.92352	0.95171

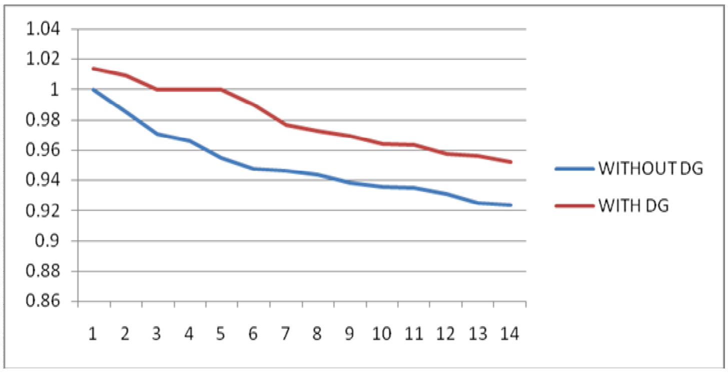

Fig 9: Voltage Profile comparision with and without DG

CONCLUSION

In this paper two stage methodologies is adopted. In the first stage the load flow analysis of the distribution system is carried out using Newton- Raphson method in power world simulator environment. On the basis of load flow solution, Power Loss Index (PLI) and per unit voltage for each bus is obtained. In the second stage Fuzzy Expert System is used to identify the Distributed Generator Suitability Index (DGSI). On the basis of DGSI values obtained the candidate node is determined for the optimal placement of DG.

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