Voltage Profile Improvement of Distribution System by Optimal Placement of Distributed Generator

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Abstract: This paper explains the importance of Distributed generator (DG). DGs are used in power system to minimize total active power loss and voltage profile improvement. In order improve the power quality the issue is to find the optimal capacity and optimal place. To achieve this objective, meta-heuristic algorithm is proposed. Total real power loss in the network can be reduced without affecting the voltage stability of the buses. Initially by load flow analysis the real power loss and voltages at all the busses will be estimated later these parameters will be validated with the results obtained using meta-heuristic algorithms. In this paper a Photo Voltaic (PV) renewable energy source is considered as DG. For validation of real power and improve voltage, IEEE 69 bus has been considered. All the methods in this paper were computed using MATLAB software. All the results obtained using different methods shows a considerable minimization of total active power loss in the network, improved voltage profiles of all the buses.

Keywords: Forward/Backward (FW/BW) sweep analysis, Gravitational Search Algorithms (GSA), Voltage Profile.

I. INTRODUCTION

The Power Quality (PQ) issues in the Distribution Systems (DSs) are majorly because of penetration of various types of nonlinear loads, expansions of unplanned distribution network, etc. [1]. This kind of issues in the network will leads to active and reactive power losses in the system. These losses are also responsible for voltage waveform deviation. But the end consumer always expects a quality and reliable power from the source. This situation leads to install various types of renewable sources to get a quality and reliability of power end. This kind of installation of renewable sources at consumer end is considered as DG installation to improve power quality by reducing losses and improving voltage profile waveform. DG penetration is the most effective technology.

Radial Distribution System Power Flow Analysis:

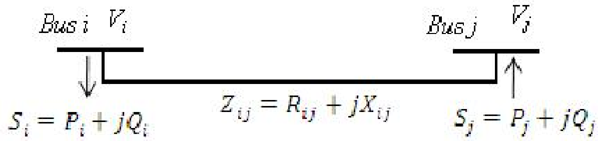

Figure.1: Single line diagram of two bus system

This paper majorly focused on improvement of voltage profile waveform at all the system buses by penetrating DGs into system for optimal capacity and optimal location in the given system. This objective function shows mathematically as follows:

Voltage Constraint:

The voltage tolerance range of all buses is as follows:

$$V_{min} \leq V_{ni} \leq V_{max}$$

DG Constraint:

$$S^{dg}_{min} \leq S^{dg}_{ni} \leq S^{dg}_{max}$$

Where, Sdgmin = minimum apparent power at bus ni, Sdgmax = maximum apparent power at bus ni, Sdgni = apparent power at bus ni.

Backward/Forward sweep algorithm:

Step 1: Read Bus data and line resistance and reactance data
Step 2: Read base MVA and base KV
Step 3: Calculate per unit value of load and impedance
Step 4: Backward sweep from end node to source node to find all bus voltage , real & reactive power
Step 5: Forward Sweep to find all voltage, real and reactive Loss
Step 6: Perform backward sweep from end node to source node to find source voltage and check for convergence criterion.
Vcalculated - Vspecified < ε, where: ε is tolerance value
Step 7: If the load flow not converged then repeat step 5 and step 6 otherwise go to step 8
Step 8: Print the result of all bus voltage and Total loss in the system
Step 9: Stop

By this forward/backward sweep load flow analysis the power loss before placing the DG is found out. Then the optimal placement of distributed generations in IEEE 69 bus radial distribution system is found.

MODEL OF PV ARRAY :

Solar energy can be made more economical by reducing investment and operating costs and by increasing solar plant performance. The solar field represents the largest share of the cost of any CSP plant. Depending on the technology, this cost could vary from about 43% for tower and Fresnel technology to almost 60% for parabolic trough and dish Stirling CSP plants. The most significant cost reductions are likely to come from innovations in solar field design, which could bring down the levelized cost of energy (LCOE) by 15% to 28%, depending on the technology.

Highly developed control can assist minimize running costs and increase solar plant performance. The major control challenges are:

- ❖ Most favorable healthy control methods capable to sustain the working temperature as close to optimum as possible despite disturbances such as changes in solar irradiance level (caused by clouds), mirror reflectivity, and other working conditions.
- ❖ Optimal and hybrid control algorithms that determine optimal operating points and modes and take into account the production commitments, expected solar radiation, state of energy storage, and electricity tariffs.
- ❖ Modes and methods for forecasting solar radiation using heterogeneous information (cameras, satellites, weather forecasts).
- ❖ Algorithms to estimate main process variables and parameters from heterogeneous and distributed measurements (oil temperature and solar radiation at different parts of the field, mirror reflectivity, thermal losses).
- ❖ Automatic mirror cleaning devices. The main factor degrading the optical performance of concentrating mirrors is accumulation of dirt on the mirror surface. Cleaning mirrors represents a considerable expense in manpower and water, usually a scarce resource where solar plants are located. Automatic devices need to be developed that minimize the use of water and degradation of the reflective surface.
- ❖ Heliostat self-calibration mechanisms. Heliostats need to be retuned periodically because of errors in the sun model, latitude and longitude of the site, heliostat position in the field, mechanical errors, optical errors, and the like. Heliostat recalibration may represent an important cost in manpower and time when done manually. Methods are needed for fast, automatic, online recalibration of heliostats.
- ❖ Fault recognition and separation in solar power stations. Algorithms are required to sense and separate faults and malfunctions in electrical power stations, such as recognition of hot spots.

Gravitational Search Algorithm (GSA):

GSA is proposed by Esmat Rashedi et al in 2009, which is based on law of gravity and mass interactions. In this algorithm, the masses are interacted with each other in a population based on the Newtonian gravity and the laws of motion for achieving best position in a search space. The position of each mass has a solution, wherein the position of heaviest mass has optimum solution which attracts other masses by proper acceleration of their gravitational and inertia masses. At the end of iteration count the heaviest mass will present an optimum solution in the search space.

Algorithm For DG Sizing Using GSA

• Initially [nom x n] number of masses are generated randomly within the limits, where ‘nom’ is the population size and ‘n’ is the number of DG units. Each row represents one possible solution to the optimal DG-sizing problem.

• Similarly [nom x n] number of initial velocities is generated randomly between the limits. Iteration count (T) is set to one.

• Calculate the force on the ith mass by the remaining other masses using

$$F_{ij} = G \times \frac{M_a * M_P}{R_{ij} + \varepsilon} \times (X_j^d - X_i^d) \qquad (7)$$

Where, Ma = Active gravitational mass related to agent j, Mp = Passive gravitational mass related to agent i, G = Gravitational constant, ε = Small constant,

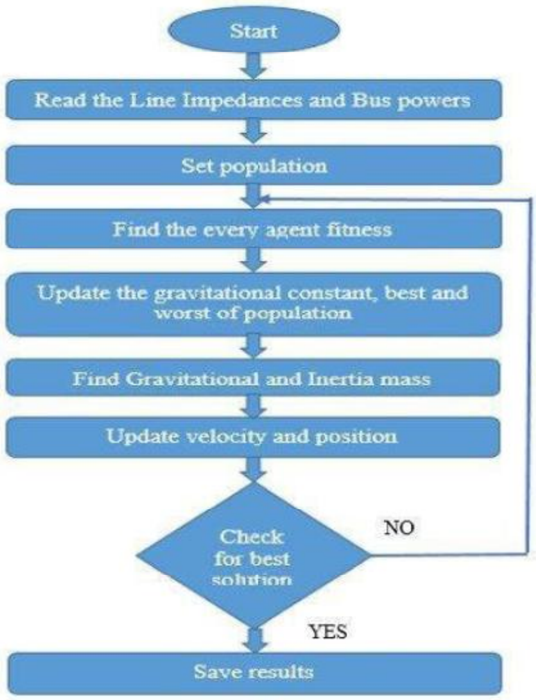

Figure: 2. GSA Algorithm Analysis Flowchart

IEEE-69 Radial Distribution System:

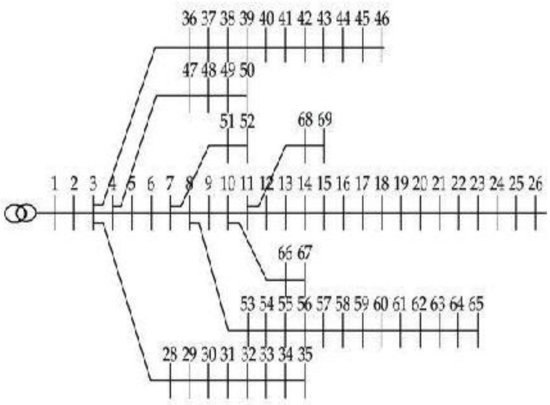

Figure:3. IEEE-69 Radial Distribution System

The IEEE 69 Radial distribution system has the total real and reactive power loads of 3.8MW and 2.69 MVAR respectively.

Here the power factors are considered to be 0.85[21] with base MVA as100MVA and base kV as 12.6kV.

In this case DGs number has taken as 1. The DGs size is restricted by the total real power demand of the system. The considered penetration of DG is 50% of MW load demand of the system.

Results

The performance results of the BW/FW sweep analysis before DG placement, GSA analysis on load condition on IEEE 69 bus are as shown in table.1.

S. No	Base Voltage	Load Voltage	GSA Voltage
1	1	1	1
2	0.999958	0.999958	0.99996
3	0.999917	0.999916	0.99992
4	0.999797	0.999795	0.999804
5	0.998813	0.998795	0.998893
6	0.988668	0.988413	0.989775
7	0.978249	0.977747	0.980431
8	0.9758	0.975237	0.978242
9	0.974497	0.973902	0.977078
10	0.970024	0.968913	0.974845
11	0.969242	0.968129	0.974414
12	0.967564	0.966449	0.974062
13	0.965198	0.964078	0.973616
14	0.962777	0.961653	0.971227
15	0.960214	0.959085	0.968696
16	0.959809	0.958679	0.968296
17	0.959228	0.958097	0.967723
18	0.959223	0.958092	0.967718
19	0.958844	0.957712	0.967344
20	0.95858	0.957448	0.967084
21	0.958524	0.957392	0.96703
22	0.958521	0.957389	0.967027
23	0.95847	0.957337	0.966976
24	0.958423	0.95729	0.96693
25	0.95823	0.957097	0.966741
26	0.958167	0.957034	0.966679
27	0.958138	0.957005	0.96665
28	0.999911	0.99991	0.999914
29	0.999862	0.999861	0.999865
30	0.999841	0.99984	0.999844
31	0.99983	0.999829	0.999833
32	0.999739	0.999738	0.999742
33	0.999554	0.999554	0.999557
34	0.999348	0.999347	0.999351
35	0.999107	0.999107	0.99911
36	0.999906	0.999905	0.999909
37	0.999782	0.999781	0.999785
38	0.999669	0.999668	0.999672
39	0.999644	0.999644	0.999647
40	0.999643	0.999643	0.999646
41	0.999182	0.999181	0.999185
42	0.998954	0.998953	0.998957
43	0.998923	0.998923	0.998926

44	0.998915	0.998914	0.998918
45	0.998872	0.998872	0.998875
46	0.998872	0.998872	0.998875
47	0.999729	0.999727	0.999736
48	0.998189	0.998187	0.998196
49	0.99545	0.995449	0.995458
50	0.995384	0.995382	0.995391
51	0.975811	0.975248	0.978253
52	0.97583	0.975268	0.978272
53	0.971026	0.970428	0.97362
54	0.967018	0.966416	0.969627
S. NO	BASE VOLTAGE	LOAD VOLTAGE	GSA VOLTAGE
55	0.961457	0.960851	0.964088
56	0.955925	0.955314	0.958576
57	0.927767	0.927128	0.930538
58	0.913852	0.913199	0.916682
59	0.908777	0.908119	0.911629
60	0.902416	0.901752	0.905296
61	0.900606	0.899941	0.903493
62	0.900286	0.89962	0.903175
63	0.899793	0.899126	0.902683
64	0.899284	0.898617	0.902176
65	0.899174	0.898507	0.902067
66	0.969189	0.968076	0.974362
67	0.969188	0.968075	0.974361
68	0.967505	0.966389	0.974004
69	0.967505	0.966389	0.974004
PV Bus Location			13
PV Capacity			100

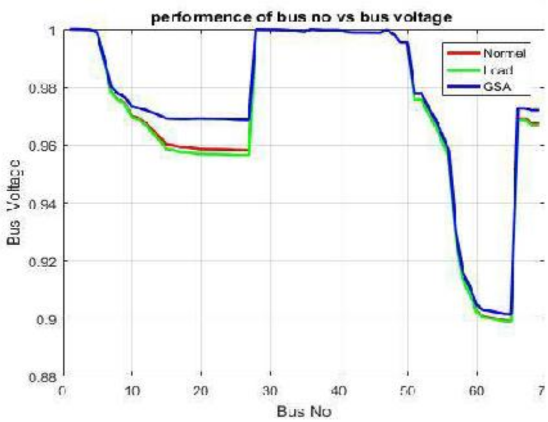

FIGURE:4

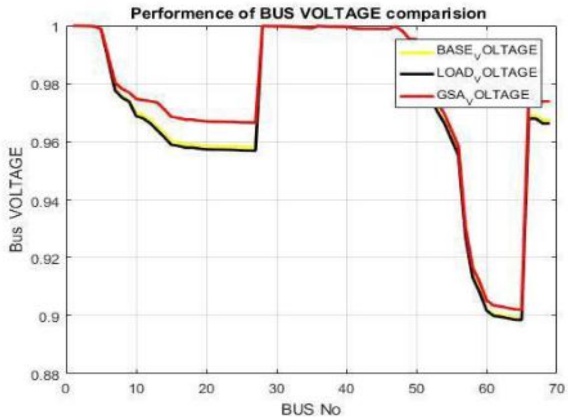

FIGURE:5

CONCLUSION:

This paper firstly shows that the voltage profile from power flow analysis using BW/FW sweep analysis on IEEE 69 bus radial system. After that GSA is used to find the optimal location and size of the DG in order to optimize the voltage. These methods implemented on MATLAB/Simulink software under normal and loaded conditions. By the comparison of different algorithms it is clearly shown that the GSA analysis is the efficient and effective power flow analysis for the radial power distribution networks.

REFERENCES:

[1]. Soma Biswas, Swapan Kumar Goswami and Amitava Chatterjee, "Optimum distributed generation placement with voltage sag effect minimization", An International Journal of Energy Conversion and Management, Vol. 53, pp. 163–174, 2012

[2]. M.H. Moradi, M. Abedini, "A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systems", An International Journal of Electrical Power and Energy Systems, Vol. 34, pp. 66–74, 2012

[3]. A.D. Rana, J. B. Darji, Mosam Pandya, "Backward / Forward Sweep Load Flow Algorithm for Radial Distribution System" IJSRD-International Journal for Scientific Research & Development| Vol. 2, Issue 01, 2014 | ISSN (online): 2321-0613.

[4]. P.V.V.Rama Rao, S.Sivanagaraju, P.V.Prasad "Forward Propagation Power Flow Method for Radial Distribution Systems", Vol.2 Iss.3, 2012 PP.20-23.

[5]. K Dharageshwari, C Nayanatara, "Multiobjective Optimal Placement of Multiple Distributed Generations in IEEE 33 Bus Radial System Using Simulated Annealing", International Conference on Circuit, Power and Computing Technologies [ICCPCT], 2015

[6]. R.Ranjan, B.Venkatesh and D.Das, "Voltage Stability Analysis of Radial Distribution Networks", Electric Power Components and Systems, Vol.31, No.5, pp.501-511, 2003

[7]. Banaja Mohanty and Sasmita Tripathy, "A teaching learning based optimization technique for optimal location and size of DG in distribution network", Journal of Electrical Systems and Information Technology, Vol. 3, pp. 33–44, 2016

[8]. Abd-Elazim SM, Ali ES, "Load frequency controller design via BAT algorithm for nonlinear interconnected power system", International Journal of Electrical Power & Energy Systems, Vol. 77, pp. 166-77, 2016.

[9]. Sudabattula SK, Kowsalya M, "Optimal allocation of solar based distributed generators in distribution system using Bat algorithm", Perspectives in Science, Vol 8, pp. 270-2, 2016.

[10]. Xin-She Yang, "Bat Algorithm: Literature Review and Applications", Int. J. Bio-Inspired Computation, Vol. 5, No. 3, pp. 141–149 (2013).

[11]. J. J. Jamian, M. W. Mustafa, H. Mokhlis, M. A. Baharudin, A. M. Abdilahi, "Gravitational Search Algorithm for Optimal Distributed Generation Operation in Autonomous Network", Arabian Journal for Science and Engineering October 2014, Volume 39, Issue 10, pp 7183–7188.

[12]. Rashedi E., Nezamabadi-pour H., Saryazdi S.: GSA: a gravitational search algorithm. Inf. Sci. 179, 2232–2248 (2009).

[13]. Majid Jamil and Ahmed Sharique Anees, "Optimal sizing and location of SPV (solar photovoltaic) based MLDG (multiple location distributed generator) in distribution system for loss reduction, voltage profile improvement with economical benefits", An International Journal of Energy, Vol.103, pp.231-239, 2016.

[14]. F.Rezaei and S.Esmaeili, "Decentralized reactive power control of distributed PV and wind power generation units using an optimized fuzzy-based method", An International Journal of Electrical Power and Energy Systems, Vol.87, pp.27–42, 2017.

[15]. Partha Kayal and C.K.Chanda, "Placement of wind and solar based DGs in distribution system for power loss minimization and voltage stability improvement", An International Journal of Electrical Power and Energy Systems, Vol.53, pp.795–809, 2013.

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