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Research paper

Distribution Generation Optimal Placement with Various Power Factors and Loading Margins

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Abstract

In the new era of power system world depleting conventional resources and increasing rapid power demand leads to focus more on distribution power generation or distribution generation (DG). DG contributes to solve numerous issues like to meet out the peak load demand in distribution system, diminishing power system losses and enhance voltage levels. And one of the major issues of distribution generation is to allocate optimally to hold the most benefits. The work in this paper focuses on the optimal placement of DG by considering pre assumed various power factors along with different loading conditions and the study has been carried out by the technique colliding body optimization. This paper also presents a comparison and influence of variations in DG optimal location with pre assumed load power factors 0.85, 0.87, and 0.89 corresponding to the various loading margins of 0.7, 1.0 and 1.25 of total real power load. The above analysis effectively implemented and tabulated for standard 38 bus system in radial distribution network.

***Keywords**: Colliding bodies' optimization; distributed generation; load margins, radial distribution system.*

1. Introduction

The primary eminence of power system is to supply unceasing and assurance electricity. This requires continuous power generation from different sources, huge power can be generating through traditional power plants are located hundreds of kilometers distance from load centers. In the present scenario due to rapid growth in electrical utilities the power from traditional generation in not adequate and moreover huge amount of power losses being happening while transmits power for long distances [1]. The other alternative to minimize the burden on traditional power plants, transmission power losses and to maintain voltage in limits a new era was raised called distribution generation (DG). Furthermore many types of DG sources were available for power generation due to their major technical benefits [2] [3] [4] and setting up of alternate energy for electricity has developed at a yearly rate of 25% [5]. Several papers are concentrated on the subject of optimal location and sizing of distributed generators to enhance voltage levels and to reduce power losses [6][7]. This work contributes best possible location of distributed generation for the given bus system by considering the variation in loading margins and pre assumed load power factors in radial distribution networks.

2. Mathematical Approach

The major intention is to recognize the best possible position of distributed generation and tumbling the impact of power system losses and voltage profile indices. Now, the main concern is given to renewable DGs outstanding of the low maintenance and cost..

$$Objective function = \left(ILP + ILQ = IVD \right) \quad (1)$$

$$ILQ = \left[\frac{total\ reactive\ power\ loss\ with\ DG}{total\ reactive\ power\ loss\ without\ DG} \right] \quad (3)$$

$$IVD = \underset{i=2}{\overset{n}{Max}} \left[\frac{|V_s| - |V_i|}{|V_s|} \right] \quad (4)$$

With Equality constraints,

$$P_{gs} + \sum_{DG=1}^{m} P_{DG} = P_{demand} + P_{loss} \quad (5)$$

Equality constraints,

$$V_{i\min} \le V_i \le V_{i\max} \quad (6)$$

3. Colliding Bodies Optimization

The projected method enlarged by kaveh and mahdavi impelled by the normal occurrence of collision involving two objective bodies [8]

3.1. Physical Laws of Collision

Law of collision between two objective bodies is supervised by converse law of momentum and energy. Assume two masses of bodies m_1 & m_2 travelling in one dimensional space, the momentum of m_1 & m_2 collision before & after represents in the below figure 1.

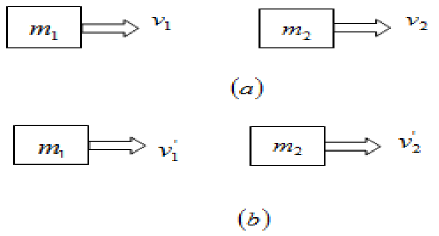

Fig.1: (a) and (b) collision before and after among two bodies.

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

$$m_1 v_1 + m_2 v_2 = m_1 v_1^{'} + m_2 v_2^{'} \tag{7}$$

Besides, the constancy of entire kinetic energy is directed by:

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_1 v_1^{'2} + \frac{1}{2} m_2 v_2^{'2} + Q \tag{8}$$

v_1, v_2 stand for early velocity 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 of objects, and the Q represents loss of kinetic energy owed in contact [9].

Velocities subsequent to one-dimensional collision,

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

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

ε represent restitution multiplication between the collision of two bodies, defined as ratio of variation in velocity separation to velocity access.

$$\varepsilon = \frac{|v_2^{'} - v_1^{'}|}{|v_2 - v_1|} = \frac{v^{'}}{v} \tag{11}$$

3.2. Structure of algorithm

In the colliding bodies optimization, each resolution aspirant X_i comprise several variables $\left(i.e\ X_i = \{x_{i,j}\}\right)$ marked as colliding bodies [10]. The colliding bodies optimization algorithm [11] has been taken and implemented.

4. Results

The test data of 38 bus proposed radial distribution network [12] is appearance in figure 2.

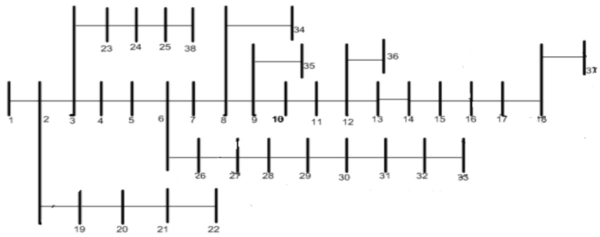

Fig. 2: 38 bus radial distribution network

12.66 kV is the substation voltage and the total power load is 2.0MW real power and 0.970MVAR with total losses 20.2KW and 13.4847KVAR. The proposed technique for optimal location of DG having size of 1338.55 KVA is carried and implemented on 38 bus radial distribution network.

Table 1: voltage profiles on different loading factors without DG

Load margins	0.75 (P +j Q)	1.0 (P +j Q)	1.25 (P +j Q)
V1	1	1	1
V2	0.9978	0.997	0.9962
V3	0.9874	0.9829	0.9783
V4	0.9819	0.9755	0.9688
V5	0.9765	0.9681	0.9593
V6	0.963	0.9497	0.9358
V7	0.9604	0.9462	0.9314
V8	0.9569	0.9414	0.9252
V9	0.9523	0.9351	0.9172
V10	0.948	0.9293	0.9098
V11	0.9474	0.9285	0.9087
V12	0.9463	0.927	0.9068
V13	0.9448	0.9249	0.9041
V14	0.9431	0.9227	0.9012
V15	0.9421	0.9213	0.8994
V16	0.9411	0.9199	0.8977
V17	0.9396	0.9179	0.8951
V18	0.9392	0.9173	0.8943
V19	0.9974	0.9965	0.9956
V20	0.9963	0.995	0.9936
V21	0.9957	0.9943	0.9928
V22	0.9953	0.9936	0.992
V23	0.9847	0.9794	0.9738
V24	0.9798	0.9727	0.9654
V25	0.9773	0.9694	0.9612
V26	0.9616	0.9478	0.9334
V27	0.9597	0.9452	0.9301
V28	0.9513	0.9338	0.9154
V29	0.9453	0.9256	0.9049
V30	0.9427	0.922	0.9004
V31	0.9396	0.9178	0.895
V32	0.939	0.9169	0.8939
V33	0.9388	0.9166	0.8935
V34	0.9569	0.9414	0.9252
V35	0.9523	0.9351	0.9172
V36	0.9463	0.927	0.9068
V37	0.9392	0.9173	0.8943
V38	0.9773	0.9694	0.9612

Table 2: Losses and voltage sensitivity index on different loading factors without DG

Load margins	0.75(P +j Q)	1.0(P +j Q)	1.25 (P +j Q)
P loss in KW	107.8694	199.1061	323.8657
Q loss in KW	73.2587	135.2761	220.1387
V index	0.0436	0.0593	0.0757

Table 3: Voltage profiles on factors 0.75 & 1.0 loading of various power factors with DG

Load margins	0.75 (P +j Q) with different power factors			1.0 (P +j Q) with different power factors		
PF	0.85	0.87	0.89	0.85	0.87	0.89
V1	1	1	1	1	1	1
V2	0.9987	0.9987	0.9987	0.998	0.998	0.998
V3	0.9932	0.9932	0.9932	0.989	0.989	0.989
V4	0.9914	0.9914	0.9914	0.9853	0.9853	0.9853
V5	0.9897	0.9897	0.9897	0.9818	0.9819	0.9819
V6	0.9856	0.9856	0.9855	0.9733	0.9733	0.9732
V7	0.9831	0.9831	0.983	0.9699	0.9699	0.9698
V8	0.9797	0.9796	0.9795	0.9652	0.9652	0.9651
V9	0.9752	0.9752	0.9751	0.9591	0.9591	0.959
V10	0.971	0.971	0.9709	0.9535	0.9534	0.9533
V11	0.9704	0.9704	0.9703	0.9526	0.9526	0.9525
V12	0.9694	0.9693	0.9692	0.9512	0.9511	0.951
V13	0.9679	0.9678	0.9678	0.9492	0.9491	0.949
V14	0.9663	0.9662	0.9661	0.947	0.9469	0.9468
V15	0.9653	0.9652	0.9651	0.9456	0.9455	0.9454
V16	0.9643	0.9643	0.9642	0.9443	0.9442	0.9441
V17	0.9629	0.9628	0.9627	0.9423	0.9423	0.9422
V18	0.9624	0.9624	0.9623	0.9417	0.9417	0.9416
V19	0.9983	0.9983	0.9983	0.9975	0.9975	0.9975
V20	0.9972	0.9972	0.9972	0.9959	0.9959	0.9959
V21	0.9967	0.9967	0.9967	0.9952	0.9952	0.9952
V22	0.9962	0.9962	0.9962	0.9946	0.9946	0.9946
V23	0.9906	0.9906	0.9906	0.9854	0.9855	0.9855
V24	0.9856	0.9856	0.9857	0.9788	0.9788	0.9788
V25	0.9832	0.9832	0.9832	0.9755	0.9755	0.9755
V26	0.9862	0.9862	0.9861	0.9734	0.9734	0.9733
V27	0.9871	0.987	0.987	0.9737	0.9737	0.9736
V28	0.9908	0.9907	0.9905	0.9748	0.9746	0.9744
V29	0.9939	0.9937	0.9934	0.976	0.9758	0.9755
V30	0.9962	0.996	0.9957	0.9775	0.9773	0.977
V31	0.9933	0.9931	0.9929	0.9736	0.9734	0.9731
V32	0.9927	0.9925	0.9922	0.9727	0.9725	0.9722
V33	0.9925	0.9923	0.992	0.9725	0.9723	0.972
V34	0.9797	0.9796	0.9795	0.9652	0.9652	0.9651
V35	0.9752	0.9752	0.9751	0.9591	0.9591	0.959
V36	0.9694	0.9693	0.9692	0.9512	0.9511	0.951
V37	0.9624	0.9624	0.9623	0.9417	0.9417	0.9416
V38	0.9832	0.9832	0.9832	0.9755	0.9755	0.9755

Table 4: Voltage profiles on factor 1.25 loading of various power factors with DG

Load margins	1.25 (P +j Q) with different power factors		
Power Factor	0.85	0.87	0.89
V1	1	1	1
V2	0.9972	0.9972	0.9972
V3	0.9847	0.9847	0.9847
V4	0.9791	0.9791	0.9791
V5	0.9737	0.9737	0.9737
V6	0.9605	0.9605	0.9604
V7	0.9562	0.9561	0.956
V8	0.9502	0.9501	0.95
V9	0.9424	0.9424	0.9422
V10	0.9352	0.9351	0.935
V11	0.9341	0.9341	0.934
V12	0.9323	0.9322	0.9321
V13	0.9297	0.9296	0.9295
V14	0.9269	0.9268	0.9267
V15	0.9251	0.9251	0.925
V16	0.9234	0.9234	0.9233
V17	0.9209	0.9209	0.9208
V18	0.9202	0.9201	0.92
V19	0.9966	0.9966	0.9966
V20	0.9946	0.9946	0.9946
V21	0.9938	0.9938	0.9938
V22	0.993	0.993	0.993
V23	0.9802	0.9802	0.9802
V24	0.9718	0.9718	0.9718
V25	0.9677	0.9677	0.9677
V26	0.9602	0.9601	0.96
V27	0.9598	0.9598	0.9597
V28	0.9582	0.958	0.9578
V29	0.9575	0.9572	0.9569
V30	0.9581	0.9579	0.9576
V31	0.9531	0.9529	0.9526
V32	0.952	0.9518	0.9515
V33	0.9517	0.9515	0.9511
V34	0.9502	0.9501	0.95
V35	0.9424	0.9424	0.9422
V36	0.9323	0.9322	0.9321
V37	0.9202	0.9201	0.92
V38	0.9677	0.9677	0.9677

Table 5: Losses and voltage sensitivity index on .075 load factor with DG

Load margins	0.75 (P +j Q) with different power factors		
Power factor	0.85	0.87	0.89
P_{LOSS}	35.5452	36.313	37.355
Q_{LOSS}	27.0416	27.5956	28.3356
V_{INDEX}	0.021	0.021	0.0211
ILP	0.1785	0.1824	0.1876
ILQ	0.1999	0.204	0.2095
Location of DG	30	30	30

Table 6: Losses and voltage sensitivity index on 1.0 load factor with DG

Load margins	1.0 (P + j Q) with different power factors		
Power factor	0.85	0.87	0.89
P_{LOSS}	75.6364	76.7209	78.1886
Q_{LOSS}	54.8898	55.6703	56.7105
V_{INDEX}	0.0348	0.0349	0.035
ILP	0.3799	0.3853	0.3927
ILQ	0.4058	0.4115	0.4192
Location of DG	30	30	30

Table 7: Losses and voltage sensitivity index on1.25 load factor with DG

Load margins	1.25 (P + j Q) with different power factors		
Power factor	0.85	0.87	0.89
P_{LOSS}	142.3226	143.7682	145.7198
Q_{LOSS}	100.8835	101.9209	103.3012
V_{INDEX}	0.0496	0.0497	0.0498
ILP	0.7148	0.7221	0.7319
ILQ	0.7458	0.7534	0.7636
Location of DG	30	30	30

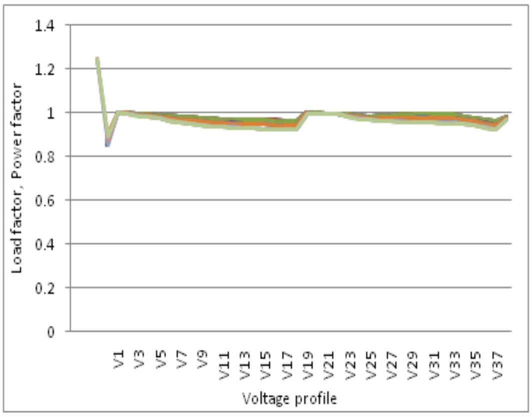

Fig. 4: voltage profiles with DG

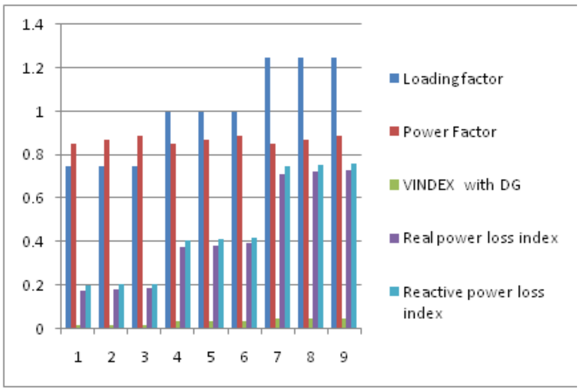

Fig. 5: power factor & load factor verses voltage, loss power index (PU)

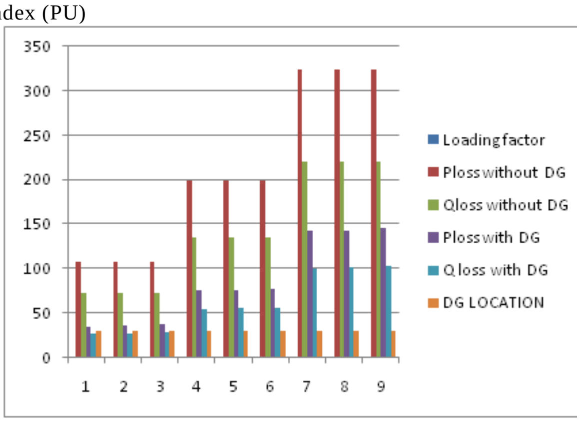

Fig. 6: Total power losses with and without DG for different load margins

Table 8: 38-bus system data

Bus		Line Impedances in p.u		Loads on to-bus (p.u)	
From	To	R (p.u)	X (p.u)	P	Q
1	2	0.000574	0.000293	0.1	0.06
2	3	0.00307	0.001564	0.09	0.04
3	4	0.002279	0.001161	0.12	0.08
4	5	0.002373	0.001209	0.06	0.03
5	6	0.0051	0.004402	0.06	0.06
6	7	0.001166	0.003853	0.2	0.1
7	8	0.00443	0.001464	0.2	0.1
8	9	0.006413	0.004608	0.06	0.06
9	10	0.006501	0.004608	0.06	0.06
10	11	0.001224	0.000405	0.45	0.03
11	12	0.002331	0.000771	0.06	0.035
12	13	0.009141	0.007192	0.06	0.035
13	14	0.003372	0.004439	0.12	0.08
14	15	0.00368	0.003275	0.6	0.01
15	16	0.004647	0.003394	0.06	0.02
16	17	0.008026	0.010716	0.06	0.02
17	18	0.004558	0.003574	0.09	0.04
2	19	0.001021	0.000974	0.09	0.04
19	20	0.009366	0.00844	0.09	0.04
20	21	0.00255	0.002979	0.09	0.04
21	22	0.004414	0.005836	0.09	0.04
3	23	0.002809	0.00192	0.09	0.05
23	24	0.005592	0.004415	0.42	0.2
24	25	0.005579	0.004366	0.42	0.2
6	26	0.001264	0.000644	0.06	0.025
26	27	0.00177	0.000901	0.06	0.25
27	28	0.006594	0.005814	0.06	0.02
28	29	0.005007	0.004362	0.12	0.07
29	30	0.00316	0.00161	0.2	0.6
30	31	0.006067	0.005996	0.15	0.07
31	32	0.001933	0.002253	0.21	0.1
32	33	0.002123	0.003301	0.06	0.04
8	34	0.012453	0.012453	0	0
9	35	0.012453	0.012453	0	0
12	36	0.012453	0.012453	0	0
18	37	0.003113	0.003113	0	0
25	38	0.003113	0.003113	0	0

5. Conclusion:

A new effort has been made to expansively examine and compare the performance of the DG at different loading factors corresponding to various load power factors has been done by the technique colliding body optimization. This paper elaborately shows comparison and influence of variations in voltage profile and total losses in the system with pre assumed load power factors 0.85, 0.87, and 0.89 corresponding to the various load factors of 0.75, 1 and 1.25 of total real power load. The best possible location of photovoltaic distribution generation is found at bus location at 30th bus for all the conditions, hence this method placement of the DG in radial distribution networks have the strong influence on the total power system loss and enhancing desirable voltage levels on the system. The consequences of projected approach have been carried out on standard 38 bus radial distribution network.

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