Electrical Distribution Network Performance Enhancement using DG

Shivanand Hirekodi,Vijayalakshmi Walikar, Renuka Ganager, Sangeeta M.Huchhannavar, Gajanand Koli
Dept. of Electrical and Electronics Engg.
Hirasugar Institute of Technology,
Nidasoshi, India

Abstract- **Quality of power is important issue for utility companies and end users of low and medium voltage. So to minimize the dependency on generation of electric energy from conventional fuel, distributed renewable energy technologies are gaining importance in the energy supply systems. Hence to focus on solution towards environment and economical related challenges, Distributed Generations (DGs) systems are being widely installed to overcome challenges caused by conventional plants. Because of rise in the demands for electrical energy, now a day's Distributed generation (DG) has become more attractive. To reduce real power losses, running cost and improve the voltage stability, DG plays a prime role. This paper deals with power loss minimization as prime objective function. To realize this, placing and sizing of DG has to be done optimally. Hence the technique for most favorable location and sizing of several units for distribution set-up with different load model for standard IEEE Bus system is analyzed.**

Keywords—Power loss, Distribution Network, Voltage profile, Stability,Power quality

I.INTRODUCTION

As a solution to environment and cost effective challenges posed by normal power plants, DGs are gaining huge interest in electrical power systems [1]. For building new infrastructure of power plants and transmission networks, needs lot of investment compared with errection of DGs. Hence such arrangement makes installation of DGs a better alternative solution to usual power plants in delivering growing load demands of electrical energy [2]. Energy distributions Systems are finding enormous augmentation in the field of DG for the reason that of financial benefits, ecological concerns, reliability requisite etc.[3] At present there is rapid development for utilization of DG at power supply level in modernized power system. This is owing to the apparent gains like boost in reliability of supply, enhanced voltage profile and decline in transmission loss [4]. For keeping less pollution problems related to environment, utilization of renewable sources of energy has more importance, as it provides sustainable living [5]. For load centers which are away from big size generation plants, renewable sources can be used for small-scale purpose. In recent years, researchers and professionals are focusing more to resolve power quality issues. Owing to use of critical electrical devices, adverse effects of present equipment's, rising demand to better quality electricity, energy suppliers inclination to consumers satisfactions and easy accessibility to quality power etc.[6] The choice of best possible site and rating of DG units in the power supply network is optimization issue [7]. Here an analytical and simulation approach is used for deciding the most favorable rating and place of DG to decrease power loss [8]-[10].

II.METHODOLOGY

The methodology of the proposed work deals with the main objective function for optimization of power losses i.e. to reduce the losses. Fig.1. shows flow chart of optimal placement and sizing of DG. Initially 1st step will start and then power losses of the existing system without DG are verified at various buses in power distribution system. Then those losses are assigned as objective function to determine suitable sizing of DG connected at any selected node 'i' buses except slack bus. Further power losses with DG will be verified. Then comparison of power loss with and without DG is performed. If losses with DG are less than losses without DG, then results

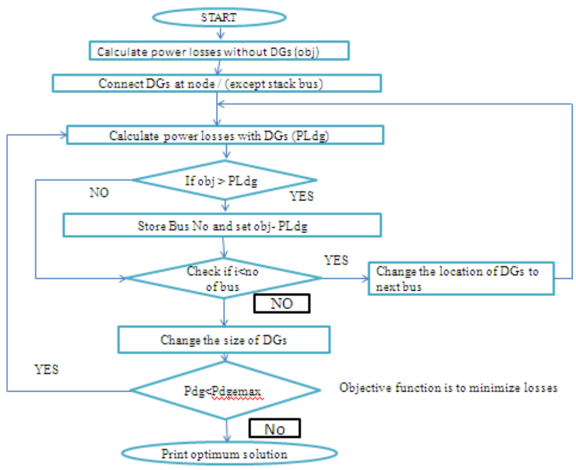

Fig.1. Flow chart of optimal placement and sizing of DG

like bus number are stored and those minimum losses will assigned as objective function. If power losses are greater, then verify power loss of another bus to optimally locate the DG till desired output is obtained. If above condition is satisfied, next step is to decide optimal sizing of DG as per objective function

Equations of bus voltage and power

$$V_i = \frac{1}{Y_{ii}}[P_i - jQ_i]\ [V_i * - \sum_{k=1, k\neq i}^{n} Y_{ik}V_k]; \qquad (1)$$

$$[P_i - jQ_i] = [V_i * - \sum_{k=1, k\neq i}^{n} Y_{ik}V_k] \qquad (2)$$

Where V_i is Voltage of i^{th} bus
P_i is real power of i^{th} bus
Q_i is reactive power of i^{th} bus
Y_i is admittance of i^{th} row and column

Line current and line losses

$$I_{12}=Y_{12}\,[V_1 - V_2] \quad (3)$$

Where 'I' is bus current

Line flows: $\delta_{12}=V_1 I_{12}^*$ (4)

Where δ is bus angle

Line losses $\delta_{L12}= [\delta 12 + \delta 21]$ (5)

III.LOAD FLOW ANALYSIS

The IEEE 5 bus system with generator at buses 1, 2 & 3 are considered. Bus 1 with its voltage set at 1.06∠0° P.U is taken as the slack bus. Voltage magnitude & real power generation at buses 2 &3 are 1.045 P.U 40MW and 1.030 P.U, 30MW respectively. Line impedance is marked as run unit on a 100MVA bus 10KV is the Base voltage & the lines charging are neglected. Computation of Y-bus matrix and determination of phasor values of the voltages at the load buses 4 & 5 (P-Q buses) is performed.

Table 1. shows the transmission line impedances in PU

TABLE.1. TRANSMISSION LINE IMPEDANCES

Bus No.	PU line impedance values
2-3	0.06+j0.18
4-5	0.08+j0.24
2-5	0.04+j0.12
2-4	0.06+j0.18
1-2	0.02+j0.06
3-4	0.01+j0.03
1-3	0.08+j0.24

Table 2. shows bus voltages in PU values , generation and the load data

TABLE 2. GENERATION AND LOAD DATA

Bus no	Bus voltage in PU	Generation in MW	Generation in MVAR	Load in MW	Load in MVAR
1	1.06	-	-	-	-
2	1.045	40	-	20	10
3	1.03	30	-	20	15
4	-	-	-	50	30
5	-	-	-	60	40

Table 3. shows calculated values of admittance

TABLE 3. ADMITTANCE OF 5 BUS SYSTEM

Y13 =1.24-3.75j	Y32=-1.666-5j	Y11=6.24-18.75j
Y34=10-30j	Y24=-1.666-5j	Y33=12.906-38.75j
Y12=5-15j	Y25=-2.5-7.5j	Y44=12.916-38.75j
Y25=2.5-7.5j	Y54=-1.25-3.75j	Y22=10.83-32.5j
Y45=1.25-3.75j	Y21=-5-15j	Y55=3.75-11.25j
Y23=1.666-5j	Y52=-2.5-7.5j	Y31=-1.24-3.75j
Y42=1.666-5j	-	-
Y43= -10-30j	-	-

Voltage of Each Bus is

$V_1=1.06\angle 0°$
$V_2=1.05\ \angle 0°$
$V_3=1.03\ \angle 0°$
$V_4=V5=1\angle 0°$

$$V_i = \frac{1}{Y_{ii}}\,[P_i - jQ_i]\ [\mathrm{Vi} * - \sum_{\substack{k=1\\k\neq i}}^{n} \mathrm{YikVk}\,]; \quad (6)$$

Voltage at 4^{th} Bus in first titration.

$$V_{4\wedge 1}=\frac{1}{12.916-38.75j}\left[\frac{0.5-0.3j}{V4* -0-1.25-375j*1.05\angle 0°}\right]$$

$V_{4\wedge 1}$=1.0195-0.0348i, $V_{4\wedge 1}$=1.0195 ∠-1.96°

Voltage at 5^{th} Bus in first titration.

$$V_i = \frac{1}{Y_{ii}}\,[P_i - jQ_i]\ [\mathrm{Vi} * - \sum_{\substack{k=1\\k\neq i}}^{n} \mathrm{YikVk}\,];$$

$$V_{5\wedge 1}=\frac{1}{3.75-11.25j}\left[\frac{0.6-j0.4}{V5*(-0-1.25-3.75j)*1\angle 0°}\right]$$

$V_{5\wedge 1}$=-1.0101-0.044i
$V_{5\wedge 1}$=1.0112∠-2.55°

Table 4. shows simulated results of bus voltages and power without DGs for IEEE – 5 Bus system.

NODE NO	FROM NAME	V-MAG P.U	ANGLE DEGREE	MW GEN	MVAR GEN	MW LOAD	MVAR LOAD
1	Bus 1	1.0600	0.00	55.992	21.606	0.000	0.000
2	Bus 2	1.0450	-1.17	40.000	55.988	20.000	10.000
3	Bus 3	1.0300	-1.38	30.000	20.194	20.000	15.000
4	Bus 4	1.0195	-1.96	0.000	0.000	50.000	30.000
5	Bus 5	1.0112	-2.55	0.000	0.000	60.000	40.000

TABLE 4.BUS VOLTAGES AND POWER WITHOUT DGS

Table 5. shows simulated results of bus voltages and power with DGs for IEEE – 5 Bus system.

TABLE 5.BUS VOLTAGES AND POWER WITH DGs

						Forward		Loss	
SL NO.	CS	FROM Node	From Bus.	TO Node	TO Bus	In MW	In MVAR	In MW	In MVAR
1	1	1	BUS1	2	BUS2	42.109	12.851	0.34	1.035
2	1	1	BUS1	3	BUS3	13.883	8.754	0.19	0.575
3	1	2	BUS2	3	BUS3	4.559	7.192	0.03	0.119
4	1	2	BUS2	4	BUS4	11.758	10.958	0.14	0.425
5	1	2	BUS2	5	BUS5	55.946	40.684	0.87	2.629
6	1	3	BUS3	4	BUS4	42.649	22.115	0.21	0.652
7	1	4	BUS4	5	BUS5	5.068	1.836	0.02	0.067

Fig.2. shows simulated results of bus voltages and power with DGs

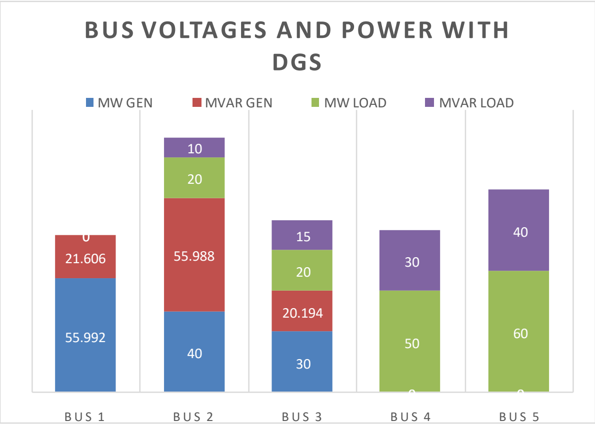

Fig. 2. Bus voltages and power with DGs

Fig.3. shows simulated results of line flows and line losses with DGs.

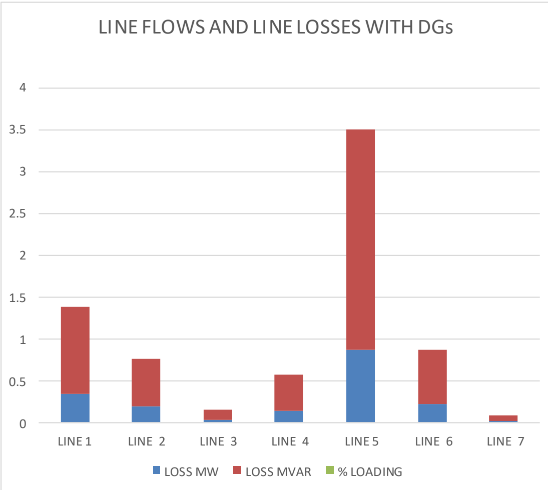

Fig.3. Line flows and line losses with second DG

Table 5. shows summary of simulated results with DGs

TABLE 5. SUMMARY OF RESULTS WITH DGS

Real power generation in MW	159.436
Total react. Power generation in MVAR	124.521
Generation P.F.	0.788
Total real power in MW	150.000
Total reactive power load in MVAR	95.000
Load P.F.	0.845
Total real power loss in MW	10.0603
Percentage real power loss	6.310
Total reactive power loss in MVAR	30.181032

Table 6. shows simulated results of bus voltages and power for slack bus

TABLE 6.BUS VOLTAGES AND POWER FOR SLACK BUS

NODE NO	FROM BUS	V-MAG P.U	ANGLE DGE	MW GEN	MVAR GEN	MW LOAD	MVAR LOAD	MVAR COMP
1	BUS1	1.060	0.00	159.09	120.28	0.000	0.000	0.000
2	BUS2	0.989	-2.87	0.000	0.000	20.00	10.00	0.000
3	BUS3	0.957	-4.25	0.000	0.000	20.00	15.00	0.000
4	BUS4	0.9468	-4.82	0.000	0.000	50.00	30.00	0.000
5	BUS5	0.9219	-5.86	0.000	0.000	60.00	40.00	0.000

Fig.4. shows bus Voltages and Power with slack bus

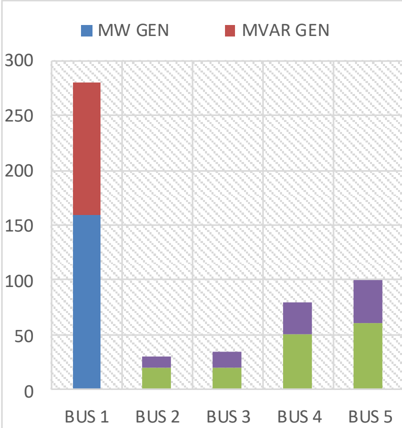

Fig.4. Bus Voltages and Power with slack bus

Table 7. shows simulated results with second generator placed in fifth bus.

TABLE 7.LINE FLOWS AND LINE LOSSES

						Forward		Loss		
SL NO.	CS	FROM NODE	FROM NAME	TO NODE	TO NAME	MW	MVAR	MW	MVAR	% LODING
1	1	1	BUS1	2	BUS2	61.135	13.050	0.6956	2.0867	59.0
2	1	3	BUS3	1	BUS1	20.131	-5.801	0.3310	0.9929	20.3
3	1	3	BUS3	2	BUS2	-6.88	-4.303	0.0373	0.1119	7.9
4	1	4	BUS4	2	BUS2	-13.1	-6.472	0.1218	0.3655	14.3
5	1	5	BUS5	2	BUS2	-20.05	9.969	0.1837	0.5512	21.4
6	1	4	BUS4	4	BUS3	-37.06	-13.58	0.1491	0.4473	38.6
7	1	5	BUS5	4	BUS4	0.015	9.872	0.0714	0.2142	9.4

Table 8. shows summary of simulated results with second generator placed in fifth bus.

TABLE 8SUMMARY OF RESULTS WITH SECOND GENERATOR PLACED IN FIFTH BUS

Total real power generation in MW	151.597
Total reactive power generation in MVAR	99.177
Total real power load in MW	150.00
Total reactive power load in MVAR	95.00
Total real power loss in MW	1.589893
Total reactive power loss in MVAR	4.769677

Table 9. shows simulated results of real power loss in percentage, with second generator placed in fifth bus. It can be observed that, line connected between bus 2 and 3 has minimum loss due to optimal placement of DG. The power generation and load demand is balanced with minimum real power loss to enhance performance of power distribution network.

TABLE 9 PERCENTAGE REAL POWER LOSS

Considering placement of Second generator in fifth bus to minimize power loss	Power Generation =Power Demand +Power load 151.97 MW = 150.0195 MW Loss = 1.589893
% real power loss	1.049

CONCLUSION

The proposed work deals with power loss minimization as prime objective function. Hence computation of particular bus voltage and angle is performed. The computed results are verified with simulation results using Mi power tool. The key conclusion is that, optimal placement of DG at fifth bus and sizing of second generator is recommended for power loss minimization.

REFERENCES

[1] K. Bhumkittipich W. “Minimizing Power Loss in Distribution System by Optimal Sizing and Sitting of Distributed Generators with Network Reconfiguration Using Grey Wolf and Particle Swarm Optimizers”, vol. 34 pp 307-317. 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe).

[2] R. B. Magadum and D. B. Kulkarni, “Energy Loss Minimization by Optimal Siting and Sizing of DG with Network Reconfiguration in Distribution Networks” International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-10, August 2019.

[3] R. B. Magadum and D. B. Kulkarni, “Power Loss Reduction by Optimal Location of DG using Fuzzy Logic” 2015 International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, T.N., India. 6 - 8 May 2015. pp.338-343.

[4] Rudresh B Magadum, D.B.Kulkarni, “Minimization of Power Loss with Enhancement of the Voltage Profile using Optimal Placement of Distribution Transformer and Distributed Generator” ,8th IEEE international conference on Communication and Signal Processing(ICCSP) Adhiparashakti College of Engineering, Melmavaruthur, T.N., India. April 4-6, 2019, pp-392-395.

[5] Rudresh B Magadum, D.B.Kulkarni “Performance Enrichment of Distribution Network with DG in Presence of STATCOM” 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS

[6] Rudresh B Magadum, D.B.Kulkarni, “Optimal Location and Sizing of Multiple DG for Efficient Operation of Power System”, 4th IEEE International Conference on Electrical Energy Systems (ICEES), SSN College of Engineering, Chennai, T.N., India. February 7-9, 2018, pp-696-699.

[7] Arjun Tyagi, Ashu Verma, Lokesh Kumar Panwar, “Optimal Placement and sizing of distributed generation in an unbalanced distribution system using grey wolf optimization method”, Inderscience publishers (IEL), Vol-10, No-2, 2019, pp, 208-224.

[8] D. Rama Prabha *, T. Jayabarathi “Optimal placement and sizing of multiple distributed generating units in distribution networks by invasive weed optimization algorithm Ain Shams Engineering Journal Volume 7, Issue 2, June 2016, Pages 683-694

[9] Fahad S. Abu-Mouti, Student Member, IEEE, and M. E. El-Hawary,Fellow,Optimal Distributed Generation Allocation and Sizing in Distribution Systems via Artificial Bee Colony Algorithm. IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 26, NO. 4, OCTOBER 2011.

[10] Masoud Esmaili a, Esmail Chaktan Firozjaee b Heidar Ali Shayanfar b “ Optimal placement of distributed generations considering voltage stability and power losses with observing voltage-related constraints” Applied Energy Volume 113, January 2014, Pages 1252-1260