ISSN 2348 – 7968

Optimal Location of Distributed Generators in Non-Autonomous Microgrid

Sooraj T.V[1], Jaikrishna V[2] ,Linss T Alex[3] and Abhijith Augustine[4]

Department of EEE, Met's School of Engineering, Mala,Kerala

Abstract

Energy market has become highly competitive and concerns more about quality, reliability and cost of electric power. In recent times Distributed Generation (DG) has become a regular practice. This project aim to locate the optimal position for Distributed Generators in a Non-Autonomous Distribution system in order to obtain maximum benefits. ETAP software is used to perform the load flow and transient analysis in order to obtain the optimal location. Distributed Generators have to be placed in proper location in order to utilize the maximum benefits from those. The losses should be minimum and the bus voltages should not go beyond the permissible limits. If the DGs are not fixed at the optimal location the losses will be more leading to the lesser benefits from the distributed generation.

Keywords: *Distributed Generation, Photovoltaic cell, Micro turbine*

1. Introduction

Today's power sector and energy market has become highly competitive and concerns more about quality, reliability and cost of electric power. Round the globe, meeting energy needs with decentralized or Distributed Generation (DG) has become a regular practice. Distributed generation means the generation of power by the customers itself rather than buying from the grid. Distributed generation is growing rapidly due to five major factors viz., technological advancement in DG technologies, difficulties in construction of new transmission lines in remote areas of occupancy in particular, increased customer demand for highly reliable electric power, electricity market liberalization and concerns about environmental pollution.

Most DG technologies are more efficient, reliable, and easy to own and operate. Main DG technologies include gas turbines, micro-turbines, wind turbines generator, fuel cells, photovoltaic cell (PV cell), etc. Literature shows that DGs have positive impact on the operation of power system to which they are connected. Accurate modeling can reduce the risk associated with real time application of the DGs.

Appropriate modeling of these DGs is needed in order to study their operation and impact on power system. DGs come in different forms such as on-site gas or diesel fired turbines, reciprocating engines, micro-turbines, small hydro induction generators, wind turbines and fuel cells. The micro-turbine (MT) generation system is a new developed thermal generation technique. It is because the characteristics of MT system are lower cost, higher efficiency, more reliability and convenience; it is regarded as one of the best promising ways of distributed generation.

Application of individual distributed generators can cause as many problems as it may solve. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a "microgrid". The sources can operate in parallel to the grid or can operate in island. The system will disconnect from the utility during large events (i.e. faults, voltage collapses), but may also intentionally disconnect when the quality of power from the grid falls below certain standards. Utilization of waste heat from the sources will increase total efficiency, making the project more attractive.

In order to obtain DGs' maximum potential benefits, proper location and optimal penetration level need to be calculated .Among the many benefits of distributed generation, there are many directions to solve problem of DG but all also want to accomplish to achieve the optimality of the power system. The main purpose is to optimize location and sizing of DG on distributed systems for solving the problem of line loss reduction. The optimal calculation realizes the highest voltage eligible ratio and minimum power loss by adjusting the reactive output of DG in precondition of system security.
Indiscriminant application of individual distributed generators can cause as many problems as it may solve. A

better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a "microgrid". This approach allows for local control of distributed generation thereby reducing or eliminating the need for central dispatch. During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the micro grid's load from the disturbance (and thereby maintaining high level of service) without harming the transmission grid's integrity. Intentional islanding of generation and loads have the potential to provide a higher local reliability than that provided by the power system as a whole. The smaller size of emerging generation technologies permits generators to be placed optimally in relation to heat loads allowing for use of waste heat.

The main issue thrown light upon in this project is to optimize the location and sizing of DG on distributed systems for solving the problem of increasing line losses that occur in any transmission system. The optimal calculation realizes the best location for a combination of the DG units in the system without violation of the voltage limits and also achieving minimum power loss by adjusting the reactive output of DG in precondition of system security. Simulation has been done on a IEEE standard distribution system using ETAP software to validate the results.

2. Micro Grid structure

The micro grid is the small scale complex energy network system. By gathering many small scale generations of electricity equipment and demand equipment, power supply controlling limited area is realized with dispersed power system. Micro grid approach is that one which views generation and associated loads as a subsystem. This approach allows for local control of distributed generation thereby reducing or eliminating the need for central dispatch. During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the micro grid's load from the disturbance (and thereby maintaining high level of service) without harming the transmission grid's integrity.

The smaller size of emerging generation technologies permits generators to be placed optimally in relation to heat loads allowing for use of waste heat. Such applications can more than double the overall efficiencies of the systems. A basic architecture of a microgrid is shown in fig 1.

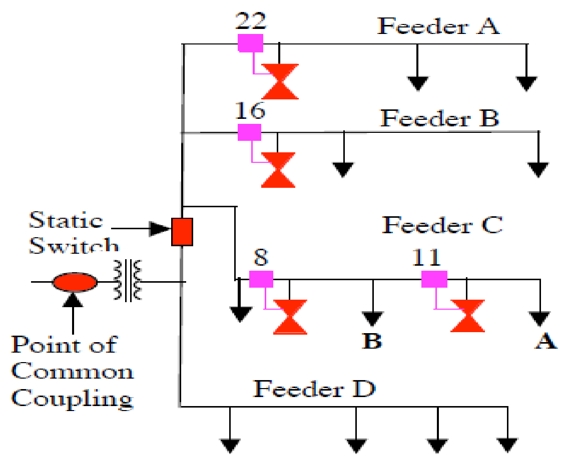

Fig 1. Basic architecture of a microgrid

3. Micro grid Protection

Any protection scheme used in the microgrid based distribution systems must respond to both system and microgrid faults. If the fault is on the utility grid, the desired response may be to isolate the microgrid from the main utility as rapidly as necessary to protect the microgrid loads. The speed of isolation is dependent on the specific customer's loads on the microgrid. If the fault is within the microgrid, the protection coordinator isolates the smallest possible section of the radial feeder to eliminate the fault. Most conventional distribution protection is based on short circuit current sensing**.** Power electronic based micro-sources cannot normally provide the levels of short circuit required.

The unique nature of the microgrid design and operation requires a fresh look into the fundamentals of relaying. Low cost approach such as CT based zero sequence detection, and differential current and/or voltage methods show promise. These are not in common use on distribution systems but can provide the required functions.

4. Autonomous and Non-Autonomous Microgrid

The microgrid can operate in either an autonomous or non-autonomous mode. In the autonomous mode, the microgrid serves the electrical load without power from the utility; basically the microgrid supplies power while interconnected to the utility system. The potential disadvantage of microgrid operation is that it has to supply reliable power to all required demand without the benefits of load diversity.

ISSN 2348 – 7968

Non-autonomous type of microgrid, are those distribution systems which draw power from the utility grid and they are incapable of feeding the loads in absence of the mains. When the distributed generator units connected to the system fail the additional power is also drawn from the utility grid. A key concept of this system is the possibility of creating an electrical micro-system that is dependent on the grid-tie to provide the high level of service quality which is often delivered by a traditional mains supply. Conversely if the mains supply of the region is unreliable, the local generation system can be used to power important equipment but for a short while and this is only restricted to few loads.

There are many variables that affect the technical and economical feasibility of establishing a microgrid. The types and number of customers the microgrid is to serve is a major concern. Due to the diversity problem, the microgrid will have to support a higher demand on a comparative basis to the utility grid.

An autonomous microgrid is that serves a group of customers without an external grid connection. The autonomous microgrid will have to have several sources and most likely several different types of DG to provide necessary reliability and cost for the establishment of the microgrid. There are many problems with successful operation of an autonomous microgrid. As exists in a utility, distribution facilities are needed to transmit the power from the DG resources to the connected customers. Thus an outside source will most likely need to step into help the customers in this process.

The problem with separate microgrid relies with the issues of supply and demand to main frequency and voltage, the system must provide the power that is required by the customer load. Communications will need to be setup between the DG resources to allow feedback control to regulate voltage and frequency.

In the case of non-autonomous microgrid, many of the problems of the autonomous microgrid either reduce or disappear. When interconnecting the microgrid to the utility system several technical issues change. The utility grid can provide base levels for both frequency and voltage. Thus, the DG resources connecting technologies can synchronize with the utility grid before switching into parallel operation.

Islanding is possible in non-autonomous microgrid. Islanding occurs when a fault occurs on the utility system disconnecting the DG resources from the utility grid. When this occurs depending on the location and type of fault, the DG resources may be able to continue to feed the amount of load that is connected. Of the two options, the non-autonomous microgrid is the most beneficial mode of operation for both utility and the customer.

5. Algorithm to find out the optimal location for distributed generators

Step1. Standard IEEE 33 bus distribution system was formed in ETAP software workspace.
Step2. Load flow analysis has been performed on the system for the base case of operation.
Step3. Position of one DG unit is fixed randomly at bus no. 1 and the other DG is placed in turn at every other bus.
Step 4. For each of the above mentioned combination load flow was run and the losses were recorded.
Step5. The position of the DG1 is now shifted to 2nd bus and again the position of DG2 is varied at all other possible locations.
Step6. Load flow analysis was performed for all combinations with DG2 at all positions from 3rd to 33rd bus
Step7. The above process is repeated with DG1 at all the positions up to 32nd bus and each time position of DG2 starts from next bus to DG1 and shifted up to 33rd bus.
Step8. The line losses with all the combinations of Distributed generators at different positions are recorded.
Step9. The combination for minimum line losses are obtained is selected as optimal location provided if no bus suffers from violation of limits for voltage magnitudes.
Step10. If any combination leads to voltage limit violations then such combination cannot be chosen as optimal.
Step11. The combinations are ranked and tabulated to choose for any pre determined number of distributed generator units.

5.1 Load flow analysis

The standard 33 bus distribution system has been constructed in ETAP workspace. The utility grid remains to be connected to the distribution system and the load flow analysis is being made.

ISSN 2348 – 7968

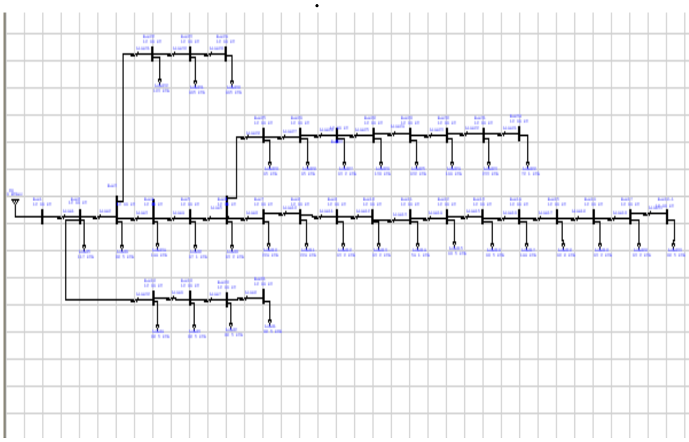

Fig 2. Load flow analysis

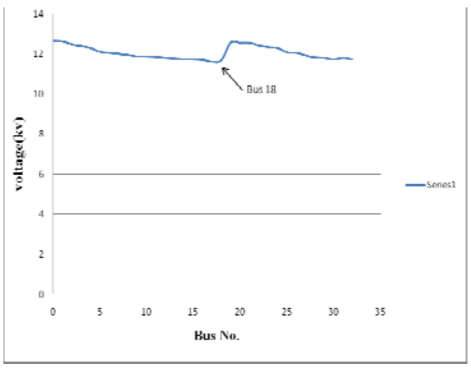

Fig. 3 Voltage profile of 33 kV standard IEEE 33 bus distribution system

Distributed generators (DG_1 &DG_2) are introduced to the system. DG_1 is fixed at bus1 and DG_2 at bus 2. Load flow analysis is performed and the results are noted. Again DG_2 is shifted to third bus and again load flow analysis is performed. The DG1 is always fixed at bus 1 and the dg2 is shifted from bus 2 to 33rd bus. Each time load flow analysis is performed. After completing the combination at 2nd and 33rd bus DG1 is moved to second bus. Now DG2 is again shifted, starting from bus3 to 33rd .This procedure is continued up to DG1 at 32nd bus.

For all combination of the DGs connected, load flow analysis is performed and the losses and voltage violations are noted. With these results made a table which holds the data about losses and voltage violating buses if any.

5.2 Transient Analysis

For the best combination as per the table 4.2, the transient analysis has been performed. Three phase short circuit has been simulated and the behavior of the generators has been observed. The short circuit fault has been simulated at each and every bus and the response of the rotor angle deviations of the generators has been monitored for all possibilities. The response has been monitored without any additional control unit as well as with the presence of power system stabilizer at each generator. The settling time of the rotor angle oscillations seems to be improved when power system stabilizer is added. The settling time and the rotor angle deviations have been shown in the figures below.

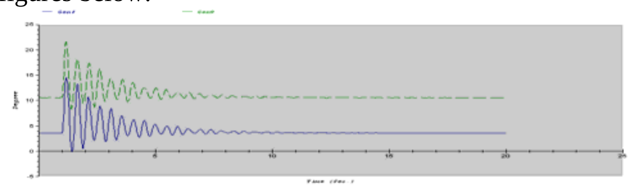

Fig 4. Rotor angle oscillations of DGs for fault at bus number 27 without PSS

DG combinations	Voltage violation	Rank	Losses	
			MW	Mvar
10 & 30	NIL	1	.033	.023
8 & 30	NIL	2	.033	.024
8 & 29	NIL	3	.034	.024
7 & 30	NIL	4	.035	.025
11 & 29,7 & 30	NIL	5	.036	.025
7 & 29	NIL	6	.037	.025
6 & 30	NIL	7	.037	.026
10 & 29	NIL	8	.038	.026
6 & 29	NIL	9	.039	.030
8&28,10&31,11 &31	NIL	10	.040	.030

Table 1. Data about losses and voltage violating buses

6. Conclusion and Future Scope

Distributed Generation (DG) technologies are expected to play an important role in future power systems. So the proper allocation of these Distributed Generators in maximum potential benefits out of those. In this work, an algorithm has been illustrated for identifying the optimal location for placing the distributed generators in the distribution system to achieve the minimum losses in the system. Load flow studies and transient analysis have done using the software ETAP.

The optimal location for the DGs has been found out from the data obtained from these analyses. Also ranking of the combinations has been made to get the optimal placement location of the generators in the distribution system in a non-autonomous mode of operation.

The stability of the generators at the optimal location has been studied with and without power system stabilizers located each at each generator.

.

The work can be extended with programming technique and also application of governor control for the generators. Moreover any optimization techniques can be used for optimizing the gains and time constants of the power system stabilizers to further improve the settling time of the rotor angle oscillations of the generators used in the distribution system.

REFERENCES

[1] Robert H. Lasseter, Paolo Piagi," Microgrid: A Conceptual Solution**",** PESC'04 Aachen, Germany 20-25 June 2004.

[2] Colleen Williams, "*CHP Systems,"* Distributed Energy, pp.57-59, March/April 2004,

[3] Lasseter, R.," *MicroGrids,"* IEEE PES Winter Meeting, January 2002.

[4] Chris Marnay and Giri Venkataramanan," Micro grids in the Evolving Electricity Generation and Delivery Infrastructure" . Power Engineering Society General Meeting, pp.761-766, 2005

[5] Yue Yuan, Kejun Qian and Chengke Zhou,"The Optimal Location and Penetration Level of Distributed Generation", UPEC 2007

[6] G.P. Peponis, M.P. Papadopoulous, and N.D. Hatziargyriou, "Distribution networks reconfiguration to minimize resistive line losses," *IEEE Trans. on Power Delivery* vol. 10(3), pp. 1338–42, July 1995

[7] A. Pregelj, M. Begovic, A. Rohatgi, and D. Novosel, "On optimization of reliability of Distributed Generation-Enhanced Feeders", in *Proc. 2002 IEEE* 36th *Hawaii International Conf. on System Sciences*, pp. 6, Jan 2003.

[8] M. Pipattanasomporn, M. Willingham, S. Rahman, Implications of onsite distributed generation for commercial/industrial facilities, IEEE Trans. Poerw Syst. 20 (February (1)) (2005) 206–212.