International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Analyze power stability in Distributed Generation in electrical grid with different load using IEEE-14 Bus

Mohammed Abdulhadi Almahdi Alsaddeeq*

Om-Alaranb College of Science & Technology, Libya

Received 10 Nov 2022, Accepted 01 Dec 2022, Available online 03 Dec 2022, **Vol.12, No.6 (Nov/Dec 2022)**

Abstract

Power requirement is the most necessary requirement of the modern high power advanced technology. To fulfil this increased demand of power requirement, a new technology has been developed which is known as the Distributed Generation (DG). It uses renewable energy sources for the generation of electric power with little impact on the environment of the surrounding area at its site of construction, economical production, less exclusion of toxic sea wastes etc. however it also has some disadvantages. The inclusion of distributed energy resources (DER) in Micro grids (MGs) comes at the expense of increased changes in current direction and magnitude. In the autonomous mode of MG operation, the penetration of synchronous distributed generators (DGs) induces lower short circuit current than when the MG operates in the grid-connected mode. Such behavior impacts the overcurrent relays and makes the protection coordination difficult. In this paper we are going to observing the effect of power stability during load in DG using IEEE 14 Bus.

Keywords: *IEEE-14 Bus, DG, MG, DER*

1. Introduction

Distributed generate electricity at or near where it will be used, such as solar panels and combined heat and power. Distributed generation may serve a single structure, such as a home or business, or it may be part of a micro grid (a smaller grid that is also tied into the larger electricity delivery system), such as at a major industrial facility, a military base, or a large college campus. When connected to the electric utility's lower voltage distribution lines, distributed generation can help support delivery of clean, reliable power to additional customers and reduce electricity losses along transmission and distribution lines.

In the residential sector, common distributed generation systems include:

- Solar photovoltaic panels
- Small wind turbines
- Natural-gas-fired fuel cells
- Emergency backup generators, usually fueled by gasoline or diesel fuel

In the commercial and industrial sectors, distributed generation can include resources such as:

- Combined heat and power systems
- Solar photovoltaic panels
- Wind
- Hydropower
- Biomass combustion or cofiring
- Municipal solid waste incineration
- Fuel cells fired by natural gas or biomass
- Reciprocating combustion engines, including backup generators, which are may be fueled by oil

way to think about the benefits of distributed energy is to visualize your cell phone's network. Imagine for a moment that your carrier had only a few towers in just a few spots around the country. The towers would be massive and powerful, but you wouldn't have the same reliability and coverage that you have now. The reasons should be obvious. With a network of smaller, more evenly placed towers, cell-phone carriers are able to provide the best service possible to their customers.

Distributed generation is no different. When centralized power plants transmit energy over long distances, some of that energy is lost. With distributed generation, the generators are closer to those who use the energy. Thus, there's less waste. Increased efficiency. In the old model, a loss in service at any point of the grid means everyone suffers. In the new model, that's less likely to happen.

DG can also serve as a backup to the grid, acting as an emergency source for public services in the case of a

*Corresponding author's ORCID ID: 0000-0000-0000-0000
DOI: https://doi.org/10.14741/ijcet/v.12.6.2

natural disaster. Here in North Alabama, that kind of service could be invaluable after a tornado. And by producing energy locally, DG systems can reduce demand at peak times in specific areas and alleviate congestion on the main grid.

Finally, because distributed energy tends to come from renewable sources, it's good for the environment. Using more renewables means lowering emissions. And lowering emissions makes the world a more enjoyable place for all of us. In this context, several technical indexes for the localization and optimization of DG capacity with regard to energy loss, voltage quality and stability were considered. Authors have proposed a decision making algorithm for the optimal sizing and placement of DG units. A survey on various optimal DG allocation techniques and their classification was presented.

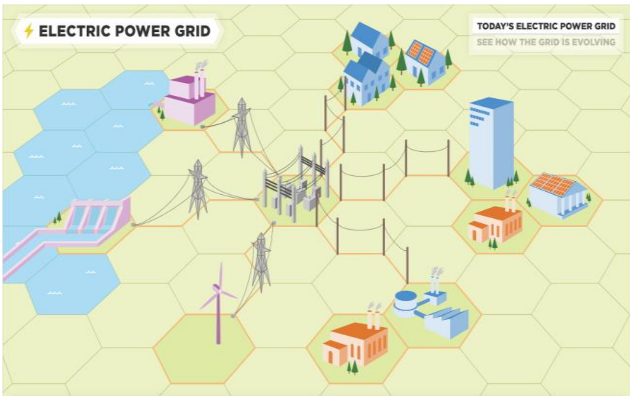

Fig 1.: The proposed methodology was implemented using PSAT 2.1.7 simulation software. An IEEE-14 bus network with and without DG connection

The placement of distributed generation in a distribution system improved the voltage profile with reduced losses. However, placing DG only at optimal location is not sufficient wherein the size of the DG should also be determined for its efficient working. Wind based distributed generation of 50MVA and 11kV had been connected under the study. Authors, suggested the method for finding the weakest node for the optimal location of DG in any grid connected network. The weakest node may be traced out by searching of the maximum voltage drop i.e. the bus with the smallest voltage magnitude is the weakest bus Distributed generation refers to a variety of technologies that generate electricity at or near where it will be used, such as solar panels and combined heat and power. Distributed generation may serve a single structure, such as a home or business, or it may be part of a microgrid (a smaller grid that is also tied into the larger electricity delivery system), such as at a major industrial facility, a military base, or a large college campus. When connected to the electric utility's lower voltage distribution lines, distributed generation can help support delivery of clean, reliable power to additional customers and reduce electricity losses along transmission and distribution lines.

2.Pros of Distributed Generation

1) There's more efficiency and less waste involved than centralized generation sources because the generators are closer to the consumers of the energy.
2) Distributed energy generation can be used to generate electricity at homes and businesses using renewable energy sources, such as solar and wind.
3) Distributed generation systems are far more reliable than centralized generation systems because multiple small microgrid units are less likely to fail simultaneously than a single large unit. Additionally, the consequences of failure are much less significant for a small unit than a large unit.

3. Cons of Distributed Generation

1) Distributed generation single units take up space and are located closer to the consumers, so they may cause land-use concerns and be displeasing to the eye.
2) Micro grids have many regulations that can be difficult to comply with. For example, cybersecurity is a major regulatory issue that a micro grid owner must be aware of when collecting personal information from individuals.
3) Distributed generation systems that involve burning fossil fuels can produce the same types of impacts as larger fossil-fuel-powered plants on a smaller scale, but closer to a populated area.

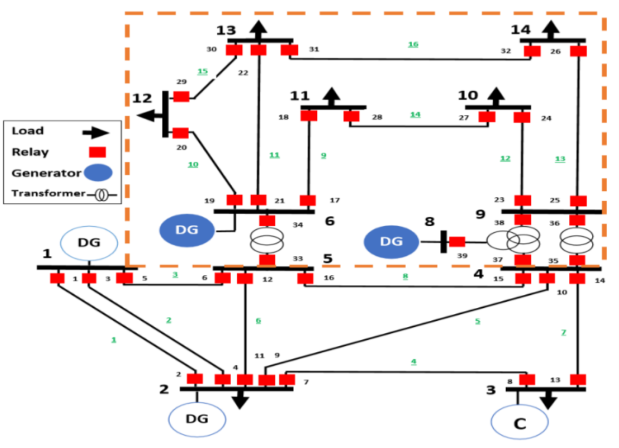

Fig.2.: A single-line diagram showing a sample MG that is a part of the IEEE 14 Bus system with distributed generators.

Power Source

During the islanded mode of operation, not all energy resources are capable of regulating the network voltage and frequency shedding. Generally, energy sources in a micro-grid are classified into two categories: dispatch able and non-dispatch able generators. In this paper we are considering only the dispatch able generators that have the ability to adjust its power supply by controlling the voltage and frequency. Dispatch able generators are associated with a power electronic converter, which act as a synchronous machine. The active power generation of this type of energy source is determined as:

$$P_{g,j} = \frac{P_{d-total}}{\delta_j \times \sum_j^{Cg} \frac{1}{\delta_j}}$$

Where Pd−total is the total active load power, δj is the droop coefficient for generator *j*, and *Cg* corresponds to the total power generation capacity.

Transmission Lines

The impedance parameters of transmission lines have great effect on grid operations, such as transient stability and state estimation, and are used as the basis for protective relay settings. We consider short transmission lines where the length is below 50 miles [28]. For such a category of lines, the parameters are lumped. Thus, the transmission line series impedance is a combination of the resistance and inductance together. Furthermore, the line capacitance is negligible and hence the admittance can be ignored. The short transmission line voltage and current equations are defined by:

Vs=Ir (ρ+jXL)+Vr
Is=Ir

Where ρ is the resistance, XL is the inductive reactance, Vs and Vr are the voltage at the sending and receiving ends of the transmission line. Similarly, Is and Ir reflect the current of sending and receiving ends of a transmission line.

4.Result and Discussion

Comparison of the simulation results obtained with and without DG connection shows an improvement in the reactive power loss from 0.11621 p.u. to 0.10018 p.u. if the DG was connected at the optimal location (Table-1 and Table-2) respectively. The variation in the voltage profile of the network with and without DG connection was shown (Fig-) respectively. When loads suddenly exceed the output power of the generators, power instability takes place. To show the ability of our protection system (Phase 1) to handle such an issue, we performed IEEE 14 configurations. We considered dynamic loads, where the active and reactive power loads have increased by different amounts through each load bus simultaneously. It is observed that the voltage at each bus in the MG is impacted by load changes. The first phase of our protection system strives to enhance the stability by minimizing the active power losses. The generators seek to decrease their power losses in order to maximize their capability to feed the loads. Figure 3 depict the enhancement of voltage stability for both systems. In the IEEE 14 bus, the voltage stability has been enhanced where the voltage at the buses ranges between 0.11621 p.u and 0.10018p.u.

Table 1.: Electricity generation and load with DG connection.

Bus	Q. load (p.u)
Bus 1	0
Bus 2	0.25445
Bus 3	0.38268
Bus 4	0.07814
Bus 5	0.03206
Bus 6	0.15027
Bus 7	0
Bus 8	0
Bus 9	0.27176
Bus 10	0.11621
Bus 11	0.03606
Bus 12	0.03206
Bus 13	0.11621
Bus 14	0.10018

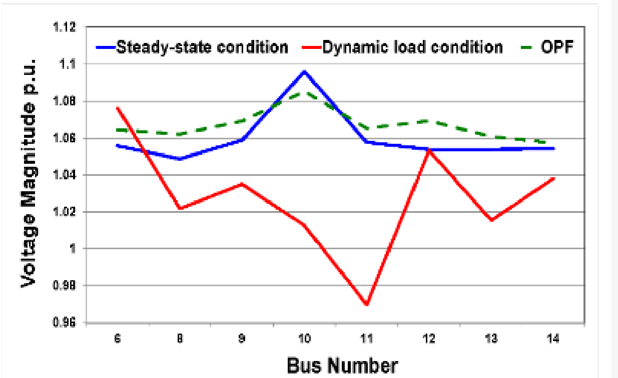

Fig.3: voltage stability in steady state and dynamic load conditions, and the results of applying optimal power flow when load varies for IEEE 14.

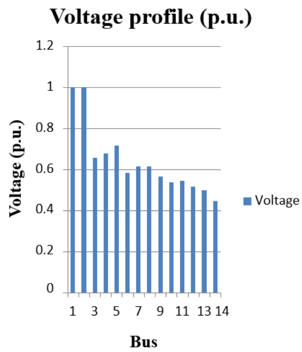

Fig.4: Voltage profile with DG connection

Conclusion

We have proposed protection and power stability system on 14-IEEE bus systems with load. We first have considered the effect of load variation. Then, we performed tests on the scenario of line failures under different conditions. We have also provided detailed examples to illustrate the implementation of our protection system for one and multiple independent faults. In addition, the proposed protection has been compared with a baseline competing approach that opts to solve the coordination problem. The results based on the IEEE 14 bus system have confirmed the superiority of the protection system to the baseline approach; the total operating time has reduced to greater than 60%. In the future, we plan to extend our work to handle inverter-based energy resources (IBRs), such as solar photovoltaic and wind farms. From the above study, it has been concluded that the distributed generation has several advantages like - it is eco-friendly, economical, uses renewable sources of energy, no toxic by-products etc. However, it also disturbs the voltage profile of the network if not connected at the optimal location. Under the study, the optimal location of the DG has been found by the study of the weakest bus and bus no. 14 was found to be the weakest. Integrating DG into the DN also decreases the stability of the connected grid network and thereby Increase the reactive losses.

References

[1] AcharyaNaresh, MahatPukar, and Mithulananthan N., "An analytical approach for DG allocation in primary distribution network", *ELSEVIER Electrical Power and Energy Syst., vol. 28, pp. 669-678, 2006.*

[2] Rajaram S. P., Rajasekaran V., and Sivakumar V., "Optimal Placement of Distributed Generation for Voltage Stability Improvement and Loss Reduction in Distribu-tion Network", *International Journal of Innovative Research in Science Engineering and Technology, vol. 3, no. 3, pp.529-543, 2014.*

[3] Pecas Lopes J. A., Hatziargyriou N., Mutale J., Djapic P., and Jenkins N., "Integrating Distributed Generation into electric power systems: A review of drivers, challenges and opportunities", *ELSEVIER Electric Power System Research, vol. 77, pp. 1189-1203, 2006.*

[4] Banerjee Rangan,"Comparision of options for distributed generation in India", *ELSEVIER Energy Policy, vol. 34, pp. 101-111, 2004.*

[5] El-KhattamWalid, Hegazy Y. G., and Salama M. M. A., "Investigating Distributed Generation Systems Performance Using Monte Carlo Simulation", *IEEE Transaction on Power System, vol. 21, no. 2, pp.524-532, 2006.*

[6] Ackermann Thomas, AnderssonGoran, and SoderLennart, "Distributed Generation: a definition", *ELSEVIER Electric Power Systems Research, vol. 57*