

Investigating the Electric Power Distribution System (EPDS) Bus Voltage in the Presence of Distributed Generation (DG)

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Abstract: - This paper investigates the Electric Power Distribution System (EPDS) bus voltage in the presence of Distributed Generation (DG). Distribution Company's (Discos) planner endeavor to develop new planning strategies for their network in order to serve the load growth and provide their customers with a reliable electric supply. In this research work, five different cases including preplanned islanding and grid-connected mode has been discussed. The studies are performed based on well known software package PSCAD/EMTDC. The work shows that presence of DG provides a significant support to EPDS in term of power quality and voltage stability of bus voltage.

Key-Words: - Electric Power Distribution System, power quality, islanding, distributed generation, PSCAD, voltage stability

1 Introduction

The Distributed Generation (DG) technologies have an important role in the electric power distribution system (EPDS) structure, design, up gradation issues and power quality problems. In the era of deregulation, the competitive market forces drive the Discos planner to investigate the economical, flexible and technically feasible alternative for new capacity. Utilities have recognized the DG as an imperative tool that can partially replace the need to erect new generating stations in order to meet the increasing load demand. The Distributed Generation option is enjoying a global popularity to offset the future load growth [1]. The Discos / end-users can install DG units within their service area. Due to the availability of such a flexible option at the distribution voltage level, the distribution network is now being transformed from passive network to an active one.

A recent study by the electric power research Institute (EPRI) indicates that by the year 2010, 25% of the new generation will be that of distributed generation type. Another study in the

national Gas Foundation concludes that the figure may be as high as 30% [2].

2 Why DG?

The main reasons behind the expected wide spreads of DG are:

- Deregulation in power market, which encourages public investment to sustain the development in power demand.
- Emergence of new generation techniques with small ratings, ecological benefits, increased profitability and which can be combined with heat generation.
- Saturation of existing networks and continuous growth demands.

As DG system is of limited capacity and small in size, it can be installed easily near the load [3]. In this way it avoids the transmission and distribution line requirements. The other technical merits associated with the implementation of distributed generation are voltage support, energy loss reduction, release of system capacity, and improve utility system reliability [4].

3 Islanding Phenomena

An islanding is the scenario where dispersed generators could be served off from the utility networks, but continue to operate after the utility supply is disconnected. The phenomena of islanding complicate the orderly reconnection of the utility circuit and pose a hazard to utility personnel [5]. The protective system should operate within a minimum time [half a second] following the occurrence of islanding.

4 Test System

Figure 1 shows a single line diagram of the test system [6]. The test system is composed of 1000MVA, 69 KV main utility source with three 13.8KV feeders. Combinations of linear and non-linear loads (L1 to L5) are supplied through three radial feeders of sub system. The system includes two DG units that are DG1 of 5MVA and DG2 of 2.5MVA on feeder F1 and F3 respectively. Loads L1 and L2 of feeder F1 are supplied by DG1, L3 of feeder F2 is non-critical load and is supplied by utility source. Loads L4, L5 of feeder F3 comprises of critical load and are energized by DG2.

5 Simulation and Modeling of Test System

In the context of steady system of figure 1, when switching event or fault occur on utility main source, 13.8 KV system including DG1, DG2 and load constitute a micro-grid. The islanding phenomena that result in the formation of micro grid can be due to either preplanned or unplanned switching incidents. Preplanned islanding of 13.8

KV systems can be happen by schedule opening of circuit breaker at both ends of 69 KV line.

The unplanned islanding operation is due to either a fault or it subsequent switching incident or some other unplanned switching process.

Figure 2 shows test system diagram developed using PSCAD [7]. In order to study the Point of Common Coupling (PCC) voltage (V_{pcc}), the circuit has been run in PSCAD for various cases and their results are analyzed.

In case 1, the system is simulated when normal conditions prevails over there. Seeing the results of figure 3, it is clear that there is no prominent change in the PCC voltage. The system operates smoothly and is capable of providing power to the load connected (L1 to L5).

In case 2, the system is run by disconnecting DG1 and DG2 from PCC bus. Examining the results as illustrated in figure 4, the PCC voltage decreases from 13.8 to 10.8 KV. For smooth running of the system it must be 13.8KV. System overloading is one of the major reasons which causes to decrease the PCC voltage. To overcome such sort of problems, DGs are likely to connect with utility source such that the system voltage could be stabilized for sensitive load and power quality problems could be eliminated.

In case 3, the pre-planned switching is exerted on the utility main by operating the protective device of 13.8KV bus. During the subsequent process, the phenomena of islanding and micro grid formation occur. The results are shown in figure 5. It is concluded that the DGs are capable of supplying sensitive load during micro grid operation. The micro grid can feed the sensitive load without any interruption.

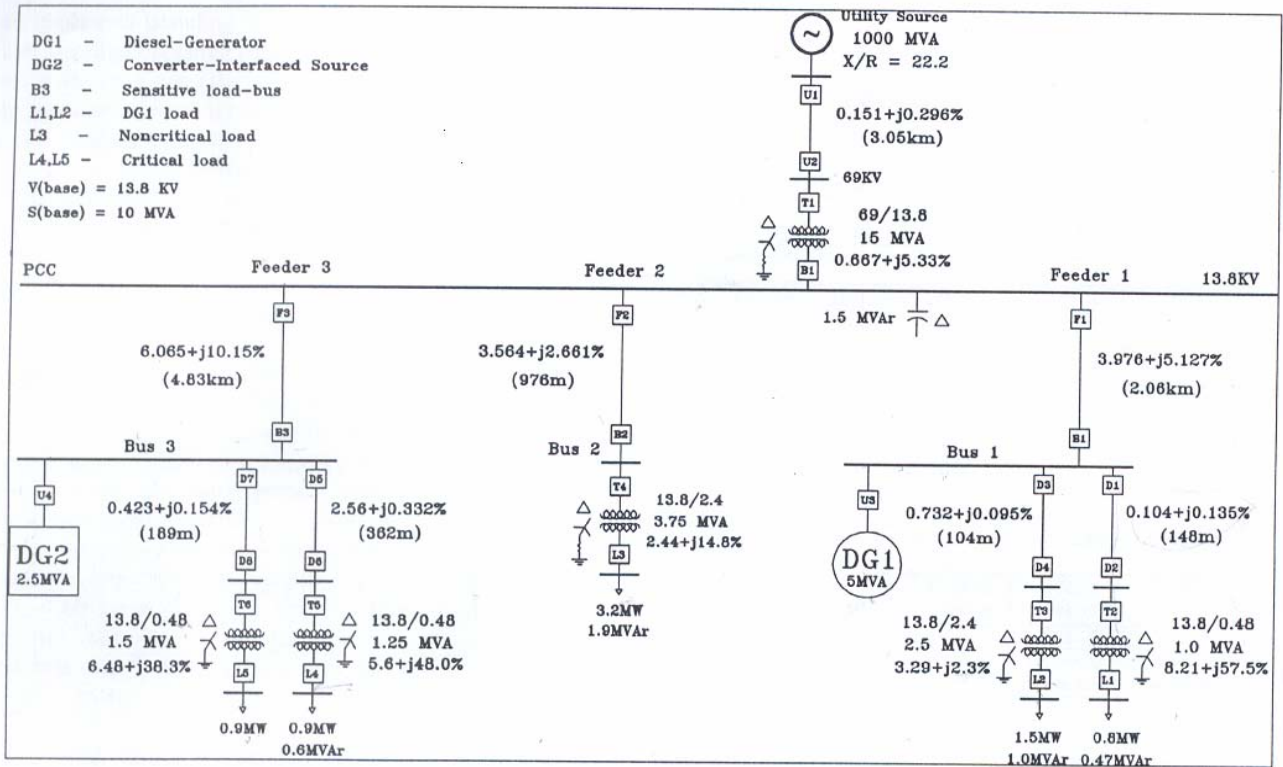


Fig.1. Single line diagram of the Test System

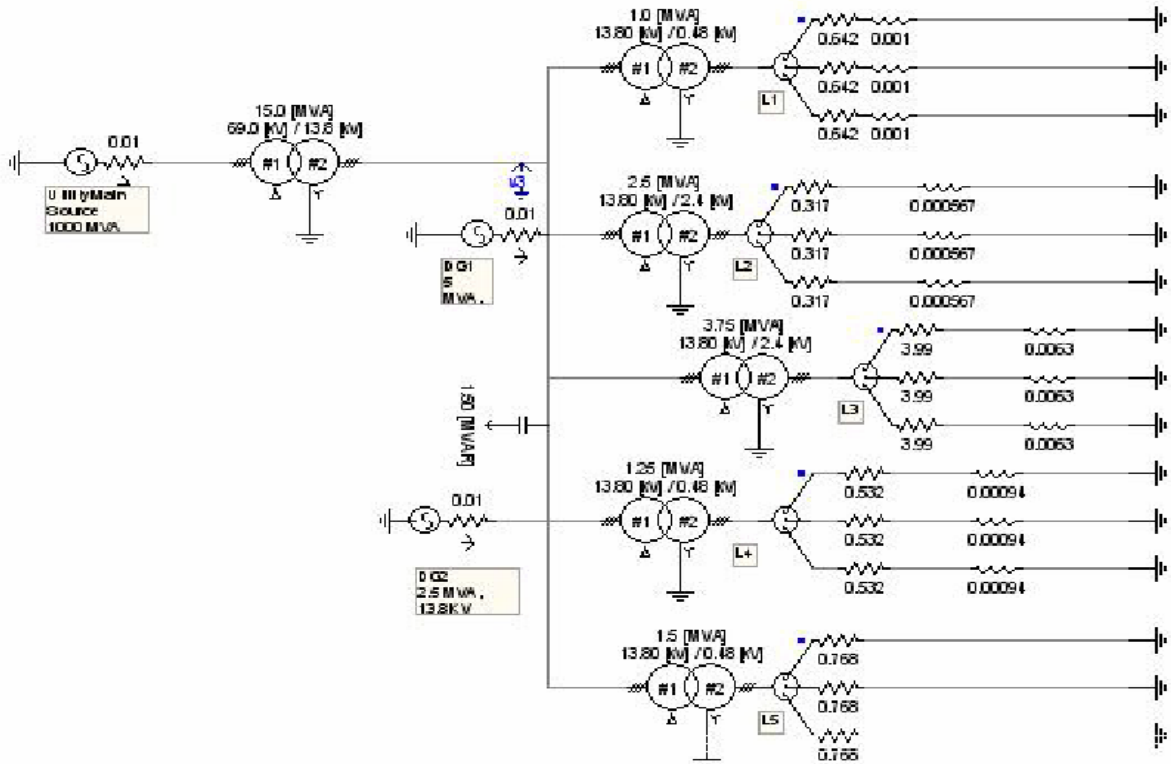


Fig.2. Test System diagram for PSCAD

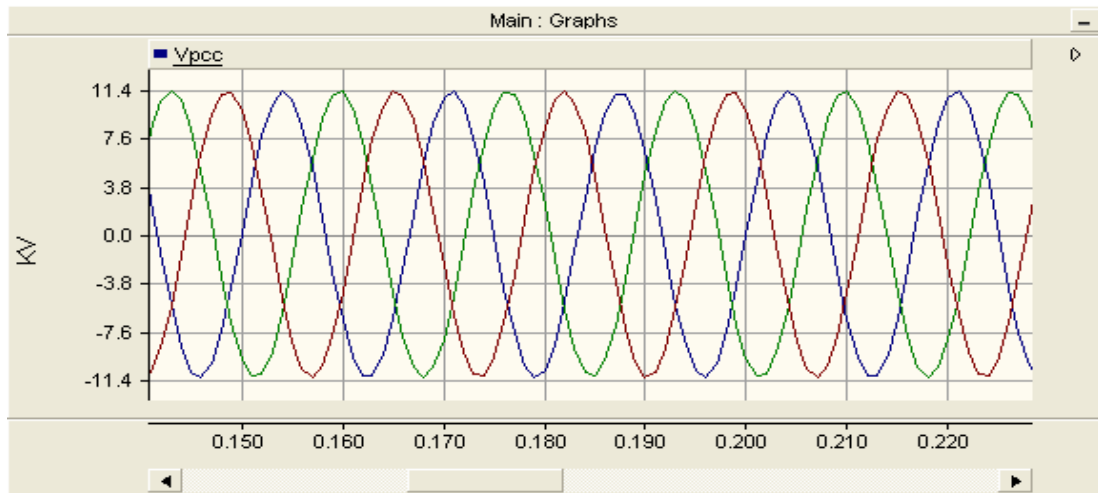


Fig.3. PCC voltage with main utility, DG1, DG2

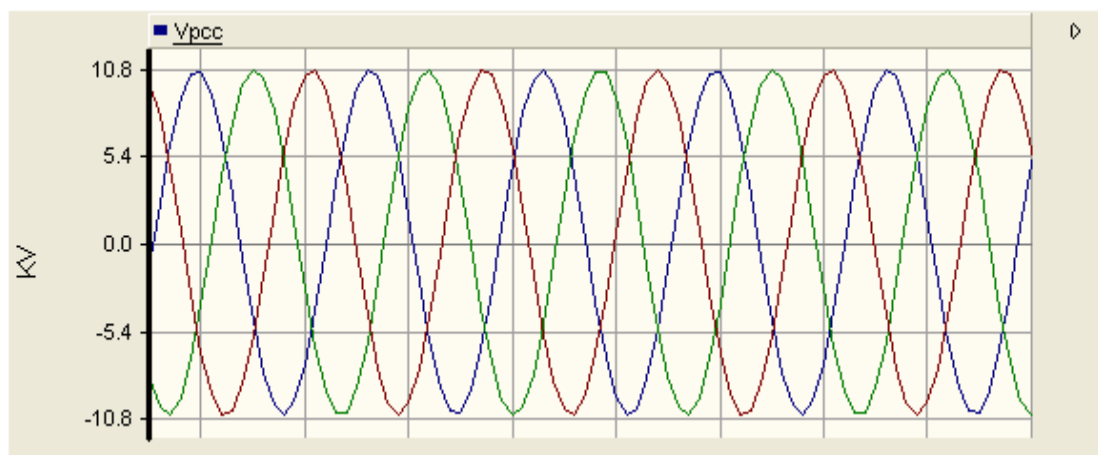


Fig.4. PCC voltage with main utility but without DG1, DG2

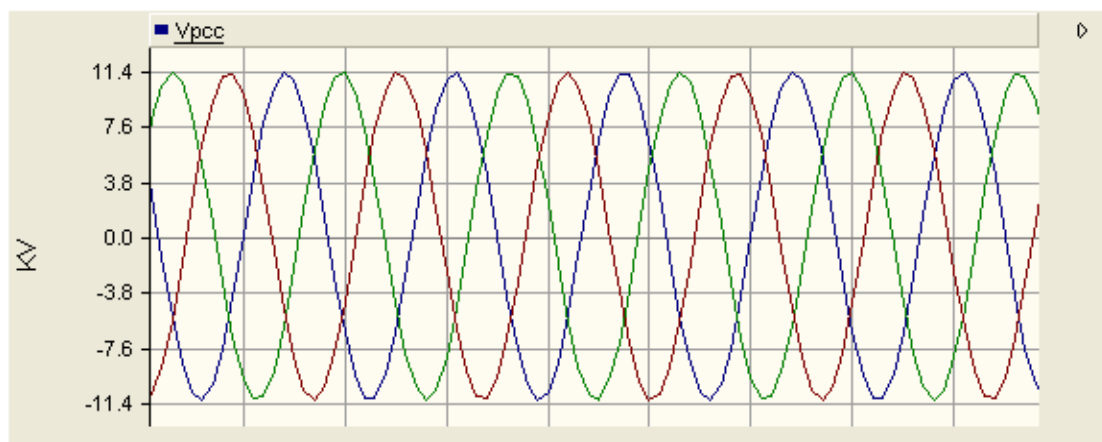


Fig.5. PCC voltage without utility main with DG1, DG2

The detailed analysis as presented in figure 6 indicates that DG1 is of sufficient capacity to supply load without DG2. However, if we run DG2 alone during micro grid, the PCC voltage waveform is badly distorted as shown in figure 7. It indicates that DG2 is not of sufficient capacity

to provide power to sensitive load. Anyhow, if DG2 is operated only for load L4 on LT side, it can provide power more effectively as illustrated in figure 8. Similarly DG2 can also be operated successfully for load L5 as shown in figure 9.

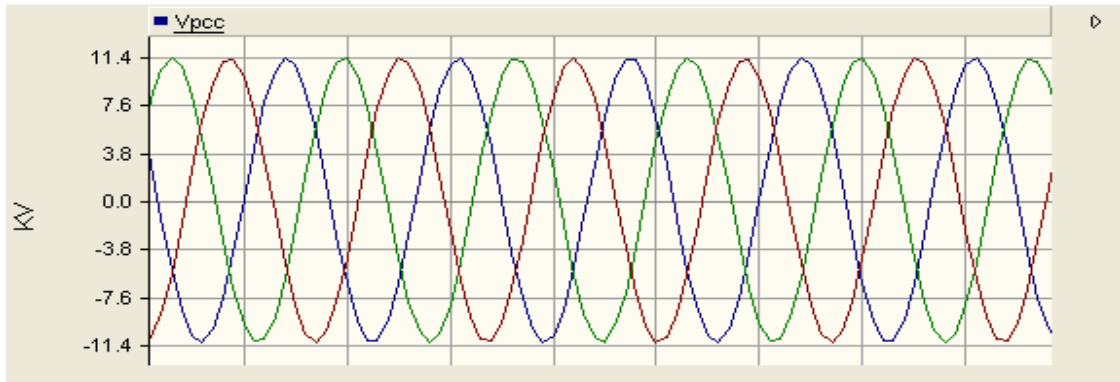


Fig.6. PCC voltage without utility main and DG2

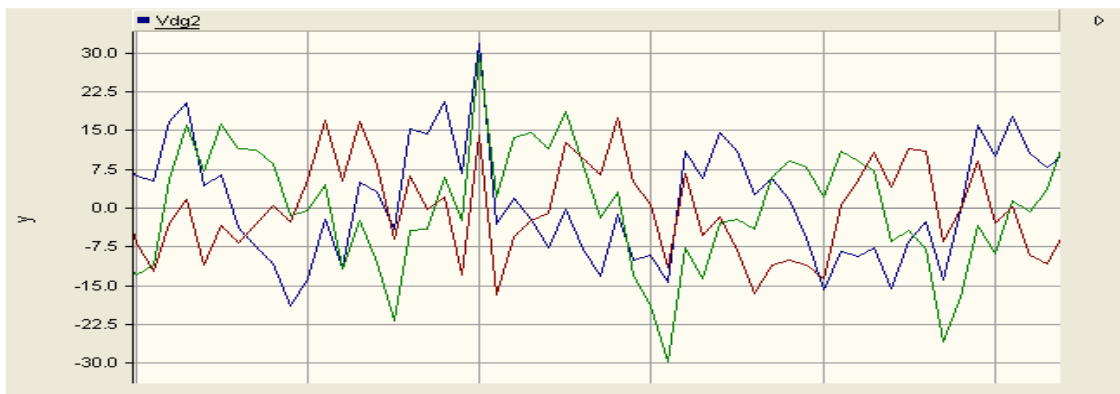


Fig.7. PCC voltage without utility main and DG1 for Critical load (L4, L5)

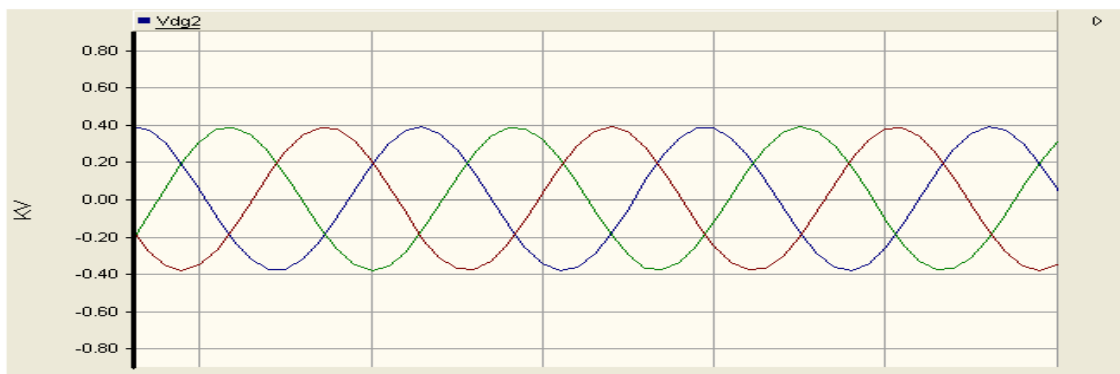


Fig.8. LT voltage without utility main and DG1 for Critical load L4

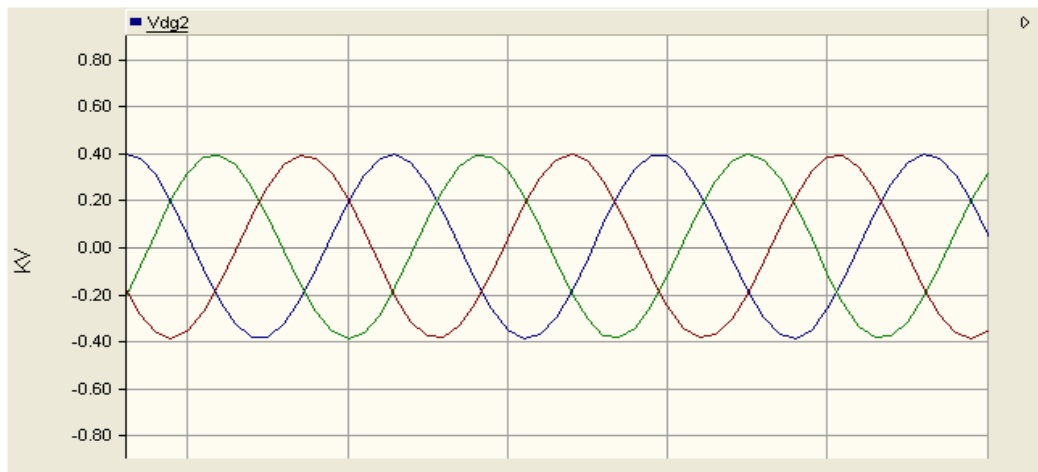


Fig.9. LT voltage without utility main and DG1 for Critical load L5

6 Conclusion

The technical merits associated with the implementation of distributed generation include voltage support, energy loss reduction, release of system capacity, and improve utility system reliability. In short, Dispersed Generation (DG) when operated as Micro-Grid can improve the

power quality by feeding the essential load. Also, with the parallel operation of DG and utility main source, the voltage distortion can also be controlled at load bus. The result of case studies shows that with the support of DG, significant improvement in EPDS bus-voltage can be made.

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