Distribution Network Voltage Profile Improvement Using Renewable Energy Sources

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Abstract

Improving the voltage profile of a distribution network under peak load condition in this paper an IEEE 9 distribution network is modeled in Digsilent Power factory Software. To improve voltage profile at load centers considering renewable energy sources such as Photovoltaic (PV) systems are installing. Load flow analysis gives the best location of placing of PV system. Results shows that the improving the voltage profiles and also power profiles with PV system.

Introduction

The RES participation in the DG has made the DN more active and complex. Integration of DG according to the availability of natural resources, load center location has been a challenging task for the researchers. Further the smart grid and RES provide energy efficient and less cost system. The optimal location and integration of various RES will make the system more stable. New study tools were introduced to investigate the impact of PV integration in the grid. A new smart grid lab was introduced which enabled the researchers design the smart grid and develop protocols for improvement [1].

Due to the nonlinearity of the AC load-flow equations, the existence and uniqueness of the solution to the load-flow problem is not guaranteed globally. In fact, it is well known that the load-flow problem might have multiple solutions [2].

Increasing the use of solar photovoltaic (PV) generation in order to decarbonizes the electric energy system results in many challenges. Overvoltage is one of the most common problems in distribution systems with high penetration of solar PV [3].

The organization of this paper is structured as follows: the section II and section III of the paper discuss the study of load flow analysis and IEEE9 node test distribution network. In section IV explains the results and analysis before and after installation of PV system.

Methodology

In distribution network the loads connected are of continuously varying and remains unbalanced. The series admittance and simple distribution network is shown in Figure 1 and load flow equations are (1) - (2) [4].

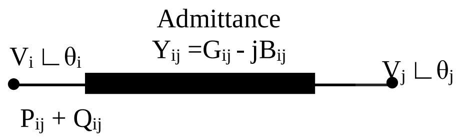

Figure 1: Distribution network model

$$P_{xy} = G_{xy}V_x^2 - G_{xy}V_xV_y\cos\theta_{xy} + B_{xy}V_xV_y\sin\theta_{xy} \quad 1$$

$$Q_{xy} = B_{xy}V_x^2 - B_{xy}V_xV_y\cos\theta_{xy} - G_{xy}V_xV_y\sin\theta_{xy} \quad 2$$

First to solve the load flow for a Distribution Network need to do load flow analysis. A simple and most efficient method quasi-dynamic load flow analysis to solve the load flow analysis. To analyze the real time performance of a three phase practical distribution network an extension of compensation based power flow method was introduced [5-7].

In IEEE 9 node distribution network in this work and placing of different loads across the distribution network. Loads such as residential, commercial and service loads are taking consideration.

IEEE 9 node test Distribution network

To analyze the seasonal impact of solar PV integration in the distribution network the standard IEEE9 node test distribution network is modified. Fig. 2 shows the modified IEEE 9 Node Test distribution network taken for integration of PV system. The IEEE 9 test distribution network is a practical test system with a source voltage of 440/230 KV. This distribution network is a lengthy feeder with heavily loaded condition. The entire network consists of over head and underground line system. It is a highly-unbalanced system with three phase and single phase laterals. It has only spot loads and no distributed loads. The system has an inline distribution transformer with a nominal voltage of 11 KV for a small span of the network. It has 6 spot loads out of which 2 loads are constant impedance loads, 2 loads are constant current loads and 2 loads are PQ loads.

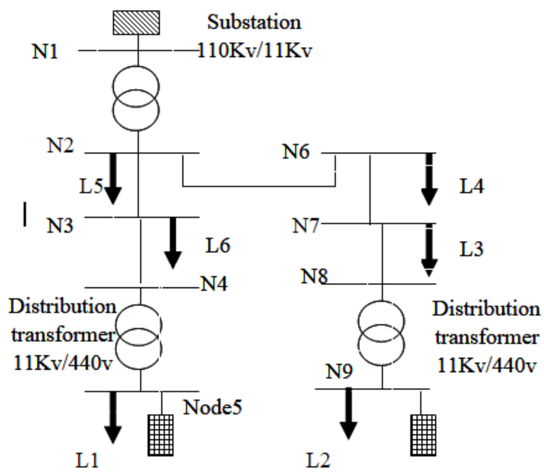

Figure 2: block diagram of IEEE 9 node test distribution network.

Results and analysis

The load flow analysis (LFA) simulations have been performed on the IEEE 9 node distribution network. The distribution network is modified to include a solar PV system at nodes 5 and node9. This system is supplied by a 3-phase overhead line 110kV/11Kv substation.

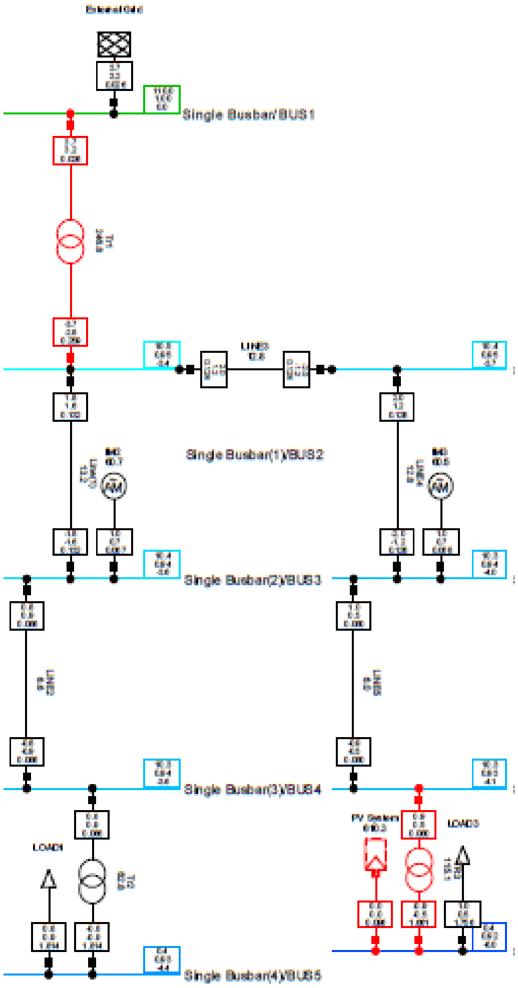

Figure 3: Simulink diagram IEEE 9 node distribution network DIgSILENT power factory circuit.

Case1. Without PV system in distribution network

Load flow analysis gives the minimum voltage loss nodes. To provide one day characteristics such as voltage profiles and power profiles have been calculated.

a) Voltage profiles

IEEE 9 node distribution network at node 5 the voltage profile shows that at peak hours drastic fall in voltage have been observed. In figure 4 shows the one day performance

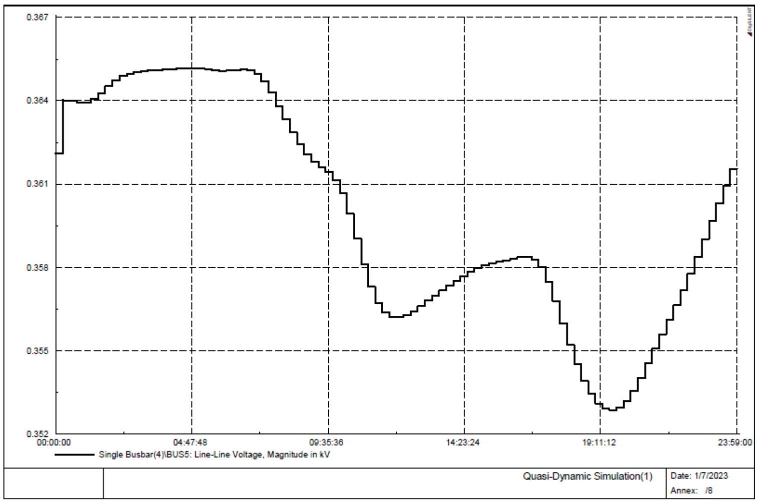

Figure 4: voltage profile in KV at node 5.

b) Power profiles

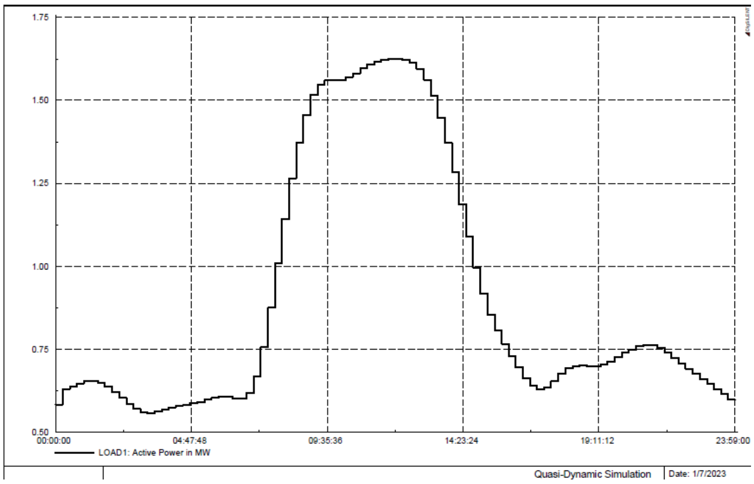

Figure 5: Active power at load 1

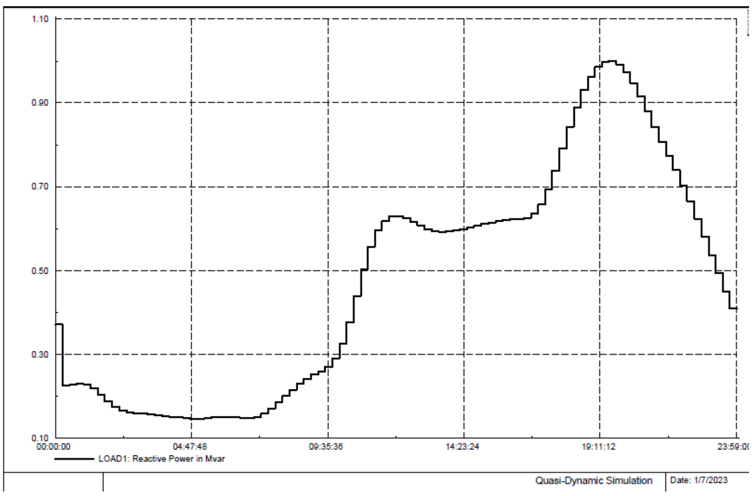

Figure 6: Reactive power at load 1

Case2: With PV system in distribution network

Placing and selection of PV system by using load flow analysis. In load flow analysis gives the best voltage profile and low power loss nodes. Rating of PV system connected in the IEEE 9 node distribution is 2MW, 1.6Mvar, 100KVA system is connected. The load flow analysis carried out in the feeder for with and without PV systems and the voltage profiles of load for 24 hour load cycle are shown in Figure. 7-Figure 9

a) Voltage profiles

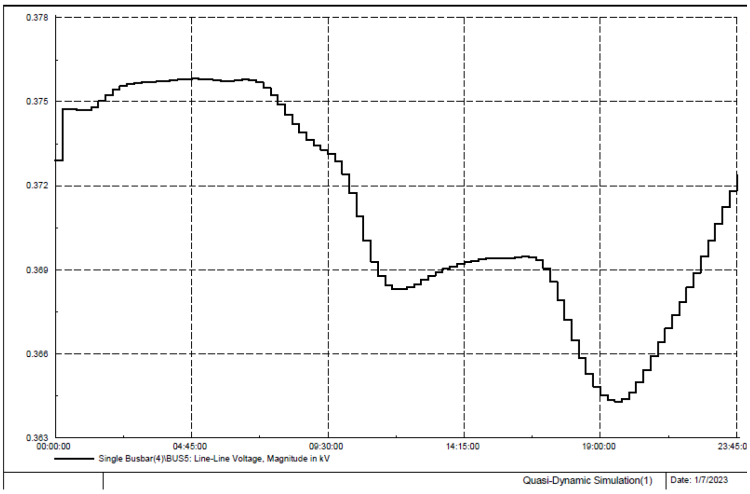

Figure 7: Voltage profile with PV system at Node5.

b) Power profiles

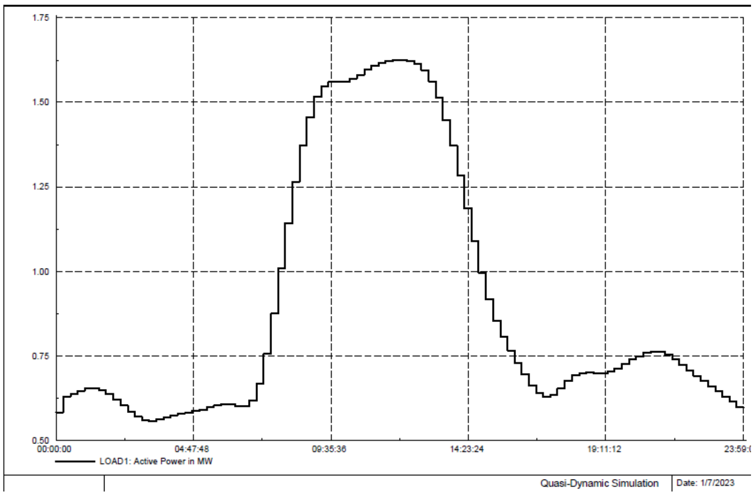

Figure 8: Active power profile with PV system at Load1.

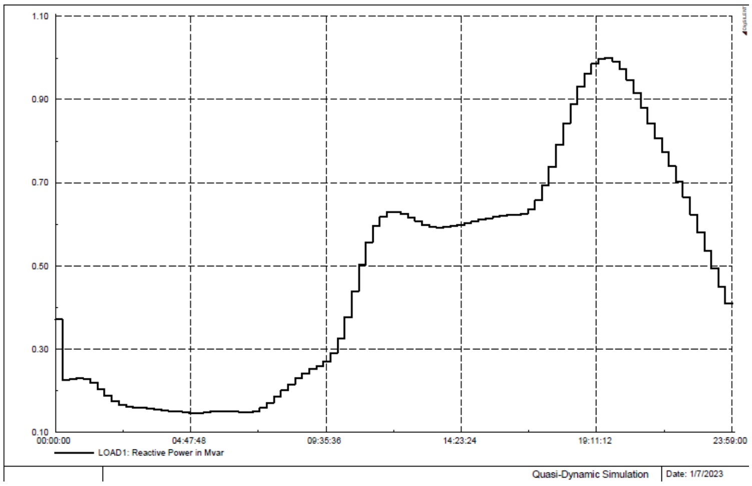

Figure 9: Reactive power profile with PV system at Load1.

Conclusion

In the results shows the one day characteristics of voltage profiles and power profiles with and without PV system are shown. Load flow analysis gives the location of renewable energy source such as PV system. Placing of PV system near the load centre gives an improvement voltage profile at peak load hours and also improved the power profiles across the loads.

In future work study of different IEEE test feeders need to analyse and installing and placing of PV systems to improve voltage profiles and decreasing the power loss across feeders. Study of day and monthly (seasonal) is required.

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