Research on Method of Improving Voltage Stability of Distribution Network with Distributed Generation

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Abstract. With the increase of distributed generation capacity, grid-connected distributed generation (DG) has an impact on the stability of distribution network. This paper studies the influence of the access of DG on the stability of distribution network. In view of the impact of the access of DG on the distribution network, a method is proposed to improve the voltage stability of the distribution network through the configuration of energy storage equipment in the distribution network. The effectiveness of adding energy storage equipment to improve the voltage stability of distribution network is verified by the simulation results through the MATLAB / Simulink simulation model of DG.

1. Introduction

With the development of micro grid technology, the proportion of distributed generation (DG) is becoming larger and larger. Distributed generation has the characteristics of clean energy, small investment, large benefit, flexible generation mode, etc. it can effectively improve and coordinate the traditional large grid, and it is a beneficial supplement to centralized power supply [1]. However, the output of DG is greatly affected by the environmental conditions, and the output is random and fluctuant. The grid connection of DGs has a certain impact on the stability of the distribution network [2]. At the same time, the original distribution network structure will change into a multi-source network structure when DG is connected to the distribution network, which will affect the power flow distribution of the system, and then cause the node voltage fluctuation of the distribution network, and even cause some nodes on the feeder to exceed the voltage limit [3]. Therefore, it is of great significance to study the influence of grid connected DG on the stability of distribution network for large-scale development of DGs [4]. At the same time, the location, capacity and control mode of DG have different influences on distribution network [5-7]. This paper studies the influence of the access of DG on the stability of distribution network, improves the voltage stability of the distribution network through the configuration of energy storage equipment in the distribution network. Verify the effectiveness of adding energy storage equipment to improve the voltage stability of distribution network through the MATLAB / Simulink simulation model of DG. It provides a reference for the application of DG in distribution network in practical engineering.

2. Structure of grid-connected DG model

In order to analyse the influence of DG access on the voltage stability of distribution network, a typical 8-node distribution network simulation model is built based on MATLAB / Simulink, as shown in Figure 1.
Figure 1. 8-node distribution network structure with DG.

The power supply of distribution network is replaced by three-phase programmable voltage source, and the voltage of three-phase power line is 380V, the active power and reactive power of three-phase power supply are 3715kw and 2300kvar respectively, the impedance of each branch is 0.092+j0.047Ω, and the load of each node is 100+j60kVA. Photovoltaic power generation model is used for distributed power supply, and the lighting condition of photovoltaic power s = 1000W / m², and the temperature T=25℃. The photovoltaic power is connected to distribution network in each node for analysing the influence of DG access on the voltage stability of distribution network.

3. Analysis the influence of grid connected DG on distribution network voltage

Analyse the change of distribution network voltage in different access positions of distributed generation through accessing the DG in different node of 8-node distribution network in Figure 1. The simulation results of various working conditions are as follows.

The voltage distribution of each node in the distribution network without DG is shown in Figure 2. The voltage of each node is stable, and the voltage distribution of each node conforms to the power flow distribution of the system. The voltage value of the node N0 near the power supply side is the maximum, and the voltage value of the node N4 far away from the power supply side is the minimum. The system is stable.

Figure 2. Voltage of each node without DG.

Figure 3. Voltage of each node when DG is connected at node N1

It can be seen from Figure 3 that the voltage of each node is about 310V and keeps its value unchanged before t = 0.5s and the three-phase circuit breaker is closed and DG is connected to the distribution network at t = 0.5s. The voltage curves of nodes N1, N2, N3, N4, N5, N6 and N7 coincide and the voltage of node N4 is the highest when DG is connected at N1 node.

It can be seen from Figure 4 that the voltage curves of nodes N1, N2, N3, N5, N6 and N7 coincide and the voltage of node N4 is the highest when DG is connected at N4 node. It is proved that DG can support the feeder voltage.
It can be seen from Figure 5 that the voltage curves of nodes N2 and N7, N1, N5 and N6 coincide respectively and the voltage of node N4 is the highest when DG is connected at N4 node. It is proved that DG can support the feeder voltage.

From the above analysis, the closer the access position of DG is to the end of feeder, the greater the rise of voltage value of each node.

The voltage of each node when DG is connected at node N4 is shown in Figure 6 and the voltage distribution curve when connecting DG at different positions at t = 0.7s is shown in Figure 7. From Figure 6 and Figure 7, it can be seen that DG access will increase the voltage value of the distribution network and the voltage of N4 node is the highest in all cases when DG is connected at node N4. In the same feeder, the closer the access position of DG is to the end of the feeder, the greater the voltage rise of each node, and the maximum voltage rise of the end node.

4. Analysis of energy storage device improving voltage stability of distribution network with DG

4.1. Energy storage equipment modeling

The common control strategies of energy storage device (ESD) include constant power (PQ) control strategy, constant voltage and constant frequency (VF) control strategy and droop control strategy. PQ control is applicable to the grid connected state of ESD, VF control is applicable to the off-grid state, and droop control is applicable to the situation where multiple inverters work in parallel. In this paper, the ESD is connected to the distribution network to optimize the voltage, and PQ control is adopted in this paper.
The grid connected operation control of ESD is shown in Figure 8, and the simulation model of ESD base on Figure 8 is shown in Figure 9. The ESD consists of the control circuit and the main circuit. The control part of the ESD includes the phase-locked loop, the current inner loop and the SVPWM module. By setting the charging and discharging time of the ESD to control the active power and reactive power of the ESD, the voltage of the distribution network can be reduced and the voltage stability of the photovoltaic grid connected system can be improved.

4.2. Simulation and analysis of distribution network voltage after adding ESD

Photovoltaic power is assessed at node N4 of distribution network. The capacity of photovoltaic power is 200kW. The ESD is connected to the node N3. The DG and ESD are connected to the grid at t = 0.5s.

The voltage of each node is shown in Figure10 when the DG is connected to the grid at t = 0.5s without ESD. The voltage of each node is shown in Figure11 when the DG is connected to the grid at t = 0.5s with ESD.

It can be seen from Figure10 and Figure11 that after the ESD is connected to node N3, not only the voltage of the node N3 is decreased, but also the voltage of other nodes is reduced. The voltage of each node in the distribution network drops instantly when the ESD is connected at t = 0.5s, and the voltage gradually stabilizes after about 0.1s. After the adjustment of energy storage device, the voltage values of each node are close to each other.

The comparison of voltage distribution curves of each node with or without energy storage system is shown in Figure 12. It can be seen from Figure 12 that the overall voltage of the system has decreased significantly, the voltage of node N0 has a small change, the voltage of node N3 and N4 have a large change, among which the voltage of node N4 has decreased from 345V to 340V after the regulation of energy storage system, which shows that after the optimization of energy storage system, the voltage stability of the distribution network has indeed been improved to a certain extent.
Figure 1. Comparison of voltage distribution curves of each node with or without energy storage system.

5. Conclusion
In this paper, the simulation model is built in Matlab / Simulink to study the influence of the access location of DG on the voltage stability of distribution network. At the same time, the stability of distribution network with DG is improved by adding ESD. Through the analysis of simulation waveform, adding ESD can effectively improve the system voltage stability.

6. References
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