Research on Active Management Strategy of Distributed Power Supply Access to Distribution Network

Jianhua Zhang, Xichao Zhou, Jingjing Zheng, Fan Luo, Caiqin Liu, Guojian Jiao and Wei Wang

ABSTRACT

With the wide access of distributed power supply, the planning and operation mode of distribution network becomes more and more complex, and the economy and the mode of supervision of distribution network have also been greatly affected. Based on the active management of distribution network fault management level, voltage control and power flow management (Active Management AM) technology, from the current, voltage and power loss are analyzed in terms of DG electrical characteristics, proposed to cut active, reactive power control and active management strategy of load transformer regulation. It has positive significance for model analysis and Strategy Research of distributed power supply access to distribution network, and has certain reference and application value.

KEYWORDS

Distributed power supply; Distribution network; Active management technology; Line loss

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INTRODUCTION

The application of distributed power supply in power system has been paid more and more attention, especially the emergence of distributed power generation to the distribution network from the traditional passive power grid into active power grid. In the passive power grid is the trend of one-way, from the higher voltage transmission network to the lower load side of the voltage; and in the active power grid is likely to reverse the trend. In this chapter, the active management technology of distribution network is briefly described. The influence of distributed power supply distribution network and distribution network on the distribution network is analyzed, as well as the relationship between active management technology and distributed power generation is quantitatively analysis.

ACTIVE MANAGEMENT TECHNOLOGY OF DISTRIBUTION NETWORK

With the extensive use of distributed power supply, the permeability of distributed energy is increasing at all levels of the power system. The planning and operation of the power system, especially the distribution network, are also complicated, and the economy of the distribution network sexual and regulatory methods have also had a greater impact. Active network management (Active Management, AM) technology, is in the distribution network secondary system parameters (voltage and current) on the basis of real-time measurement of distributed generation and distribution network equipment for real-time monitoring. Roughly divided into three categories: active fault level management, active voltage control and active power flow management. Complex measurement, control and communication facilities are the hardware base for implementing the distribution network AM. Figure 1 shows the schematic diagram of AM. The active process is to send control instructions to the transformer, generator, circuit breaker, and reactive power compensation equipment to complete the control.

When the distributed power generation capacity in the distribution network is too large, the node voltage of the distribution network will rise and is likely to be limited, which becomes the main obstacle to limit the distributed power generation capacity. In view of this, AM's main goal is to increase the load capacity of distributed generation without violating the voltage constraints. The three methods are as follows.

1) cut the generator output: by limiting the distributed power generation output power to control the voltage;
2) on-load transformer tap adjustment: by adjusting the transformer side of the variable tap to make the distribution network voltage within the specified range;
3) reactive power compensation: in the distributed power generation access point
side to increase the reactive power compensation equipment to reduce the voltage increase.

**ANALYSIS OF ELECTRICAL CHARACTERISTICS OF DISTRIBUTION POWER DISTRIBUTION NETWORK**

Trend Analysis of Distributed Power Generation Access

Distributed power generation connected to the distribution network can be simplified as a PV node or a PQ node. During analysis, distributed generation can be treated as a PQ node with a constant power factor.

![Figure 1. Simple radiation type with distributed power generation.](image1)

![Figure 2. Distributed single - radiation radiation for power generation.](image2)

As shown in Figure 1, when the distributed power generation access to the end of the line load node, through the line of active power and reactive power are reduced. The maximum load capacity allowed by the line is Plmax, Qlmax, then the distributed power generation access, so that the line load capacity increased PDG and QDG, that is, after adding the distributed power generation, the line The load value exceeds the maximum load value that the line can allow without a distributed power access, thus changing the load capacity of the line. For a radial line with multiple load nodes, the active flow in the distribution network is divided into three cases when the distributed power generation is connected to the i-th load node:

When PDG>PLi, the load node becomes a power supply node that supplies the Pd-PLi active power to the distribution network;

When PDG=PLi, there is no active flow between the distribution network and the load node;

When PDG<PLi, the distribution network to the node to provide PLi-P distributed power generation active;
At that time, the line will appear reverse trend.

Similarly, for other single or several nodes access to distributed power generation, the line and other branches of the direction of the trend can be similar to the analysis.

**Distributed Power Generation Access to Voltage Analysis**

In the actual system, the impedance of the feeder can not be ignored, so also have to consider the feeder on the voltage of a certain impact. It can be seen that before the distributed power generation access, the voltage on the line along the direction away from the distribution of continuous decline. In order to ensure the voltage level of the end user, in the actual operation of the general use of voltage regulator to adjust the tap to enhance the voltage curve. When the distributed power generation access line, the line on the trend changes, the voltage curve changes. When the load is very small, the distributed power output power may flow back to the system side, in this case, the line voltage from the distribution to the distributed power generation access point rising.

When the distributed power generation is connected to the medium voltage feeder, the voltage of the load node is increased, which reduces the power transmitted in the feeder line, and also supports the reactive power output of the distributed power generation, which is beneficial to the voltage support of the load node. As the X/R value of the distribution line is small, the active and reactive power of the distributed power generation have an influence on the feeder voltage, and the reactive power has a greater effect on the voltage. In the distributed power generation support, the line voltage regulator often have to adjust the tap, to meet the distributed generation of some nodes voltage elevation. If distributed power generation suddenly exits, those nodes that are sensitive to voltage changes suffer from low voltage problems due to lack of voltage support. Because the voltage regulator action takes some time, waiting for the regulator to make adjustments, the user is unacceptable.

To avoid this phenomenon, nodes that are particularly sensitive to voltage changes should also consider installing a voltage support device that can act quickly. From another point of view also shows that the distributed power generation operation should be maintained as much as possible in the high power factor, to minimize reactive power, the system to maintain the voltage of the lack of reactive power provided by the capacitor. In this way, even if the distributed power generation to run out, the corresponding node voltage will not fluctuate greatly.
<table>
<thead>
<tr>
<th>Access location</th>
<th>Allows access to distributed maximum power generation capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>400V Line</td>
<td>50kVA</td>
</tr>
<tr>
<td>400V Bus</td>
<td>200–250kVA</td>
</tr>
<tr>
<td>11kV Line</td>
<td>2–3MVA</td>
</tr>
<tr>
<td>11kV Bus</td>
<td>8MVA</td>
</tr>
<tr>
<td>15–20kV Line and bus</td>
<td>1.5–10MVA</td>
</tr>
<tr>
<td>63–90kV Line and bus</td>
<td>10–40MVA</td>
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</tbody>
</table>

In order to limit the potential for distributed overriding of distributed power distribution networks, many countries and organizations have limited the capacity of distributed power distribution networks, and according to different voltage levels and access methods, detailed technical requirements have been set for the maximum stand-alone capacity for distributed generation that allows access to the distribution network. At the same time require large-scale distributed power generation, such as large wind farms, solar power plants and regional fuel cell power stations and other access points should be selected in the distribution of low-voltage bus or direct access to the high-voltage lines; and small distributed power generation, such as small household wind power and solar power, can be directly connected to the feeder. Countries have similar requirements for distributed power generation capacity, Table 1 lists the EU’s distributed power generation capacity standards.

ACTIVE POWER MANAGEMENT TECHNOLOGY AND STRATEGY FOR POWER DISTRIBUTION

The active management technology of distribution network is to monitor the distributed power generation and distribution network equipment in real time on the basis of real-time measurement of the secondary system parameters (voltage and current) of the distribution network, which is helpful to realize the relationship between power generation and load and auxiliary service.

Active Management Techniques and Strategies to Reduce the Active Output of Distributed Generation

The reduction of the active output control voltage limits the voltage rise by limiting the active output of the distributed power generation. Since the probability of simultaneous occurrence of maximum output power and minimum load is low, the constraint time for power output is generally short. If the system is equipped with a larger capacity of the power plant, the use of cutting distributed power output method is more economical, in the restraint time outside the time, the higher output power can compensate for the temporary reduction of power generation influence,
the constraints of the time generally corresponds to the low load situation, the price will be relatively low.

Consider the busbar 2 maximum allowable voltage $U_{2,\text{max}}$, then the maximum allowable capacity of distributed power generation:

$$P_{\text{DG, max}} = P_{\text{DG, curt}} + \frac{U_{2,\text{max}}^2 - U_1 U_{2,\text{max}} + \left(P_L R + Q_L X\right)}{R \lambda_y + (-1)^n \sqrt{1 - \lambda_y^2}} \lambda_y$$

It can be seen that in the non-extreme case, the maximum allowable grid-connected capacity of the distributed power generation is affected not only by the maximum withstand voltage $U_{2,\text{max}}$ on the bus 2 side but also by the reduced distributed power output and load.

It can be seen that the active and reactive power of distributed generators have a greater effect on the feeder voltage. Distributed power generation access will reduce the feeder voltage loss, is conducive to the load node voltage support. In operation, reducing the distributed output power will increase the feeder voltage loss. After reducing the distributed power generation active power, the feeder voltage loss can be expressed as:

$$\Delta U_i = \frac{(P_2 + P_{\text{DG, curt}}) R + Q_2 X}{U_2}$$

$$\delta U_i = \frac{(P_2 + P_{\text{DG, curt}}) R - Q_2 X}{U_2}$$

At the same time, if the distributed power generation power is too large to cut or even distributed power generation operation, it will cause the bus side 2 side voltage drop is too large, it will cause low voltage problem, so for some of the voltage quality requirements of the equipment, suddenly the large voltage drop will greatly affect its work.

**Active management technology and strategy of reactive power in distribution network**

Reactive power compensation can effectively control the voltage rise effect, increase the grid capacity, especially in the weak power grid. Reactive power compensation method is a better way to suppress the voltage rise, set the distributed power supply side of the reactive power compensation for the $Q_c$, after adding reactive power compensation, the bus side voltage $U_2$ can be expressed as follows:

$$U_2 = U_1 + \frac{R \left(P_{\text{DG}} - P_L\right) + \left(Q_{\text{DG}} - Q_L \pm Q_c\right) X}{U_2}$$

then

$$U_2 = U_1 + \frac{R \left[P_{\text{DG}} - P_L\right]}{U_2} + X \frac{\left(-1\right)^n P_{\text{DG}} \sqrt{1 - \lambda_y^2}}{U_2^2} - Q_L \pm Q_c$$

The maximum capacity of distributed power generation is:
The maximum allowable capacity for distributed power generation is related to reactive power compensation $Q_c$ and load.

**Active Management and Strategy of On-Load Transformer Regulation**

By adjusting the on-load tap-changer of the on-load tap-changer and keeping the voltage of the distribution network within a certain range, the distributed grid capacity can be increased.

The voltage $U_2$ on the bus 2 side can be expressed as:

$$U_2 \approx U_1 + \frac{R (P_{DG} - P_L) + (Q_{DG} - Q_L) X}{U_2}$$

Active adjustment of the on-load tap-changer tap changer can be adjusted $U_1$, where $U_1$ adjustment set the lower limit of $U_{1\text{min}}$.

The maximum capacity of distributed power generation is:

$$P_{DG,\text{max}} = \frac{U_{2,\text{max}}^2 - U_1 U_{2,\text{max}} + (P_L + Q_L X \pm Q_c X)}{R \lambda_g + (-1)^n \sqrt{1 - \lambda_g^2 X}} \lambda_g$$

**CONCLUSIONS**

In this paper, the distributed power generation access distribution network, the distribution network to bring the trend of the changes in the voltage changes and the impact of the impact of a more detailed analysis of the distribution of distributed power distribution network And the influence of distributed power generation is analyzed. Finally, three kinds of realization methods of active management technology of distribution network are analyzed: the relationship between distributed power generation output reduction, reactive power compensation and tap changer tap adjustment and distributed power generation is quantitatively analyzed.

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