Voltage control strategy of microgrid for multi inverters

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Abstract. Microgrid technology can solve the large-scale access problem of distributed energy, the key problem to be solved is how to realize multiple distributed electricity. In the work, the integrated control method for droop control and droop control is adopted to realize the microgrid without communication lines. The seamless switching of two modes of grid connection and isolated operation improves the stability and reliability of the system and realizes the control of distributed power supply.

Keywords: Multi inverter, microgrid, voltage control

1. Overview of Voltage control strategy

Microgrid is a single controllable unit composed of distributed generation unit load from the perspective of system. Distributed generation unit is usually composed of micro power (photovoltaic power, wind turbine and battery) and power electronic inverter. Compared with the simple distributed generation, microgrid can give full play to the advantages of micro power, realize the large-scale grid connection of micro power, and provide users with services such as USPS. Therefore, microgrid has become a research highlights [1].

Generally, the infrastructure of microgrid is presented in Figure 1. Its operation includes two states of grid connection and isolated operation, and the switching between the two states. When linked to the large power system, the microgrid is similar to a controllable load or power supply. In this state, the main function of microgrid is to make the grid obtain the maximum output power according to the situation of micro source (MS). When the main grid has abnormal conditions (such as voltage drop, island operation, etc.), the micro grid can actively cut from the power system and enter the isolated operation state. At this time, there should be one or more distributed generation units to determine microgrid’s voltage and frequency. After the main grid returns to normal, the micro grid should complete the synchronization with the power system and stably enter the main grid to realize grid connected operation [2]. At this time, DG in microgrid does not play a control role and does not participate in regulating the frequency and voltage of the common point. The frequency and voltage of the power system are determined by the main grid.

The problem to be solved in microgrid control is the large number of DG, it is difficult to adopt a central control point to make a rapid response to the whole system through the communication line
and carry out the corresponding comprehensive control, especially how to realize the stable and reliable transition between the two states of grid connected and isolated operation is the key to microgrid control.

This paper introduces several basic operation control strategies of microgrid, then analyzes the advantages and disadvantages of several control strategies in the conversion process, and proposes a comprehensive control strategy combining droop control and droop control in microgrid, which can not only make microgrid can be integrated into microgrid on a large scale, but also make microgrid realize seamless state switching.

2. Basic control strategy of inverter in microgrid

For the sake of completing the basic operating of microgrid, the controller of inverter should be able to control the output power of energy storing system and micro power supply only by measuring local information [3]. The inverter of energy storage system or micro power supply (integrated energy storage device at DC side) should automatically respond to variations in load or network structure according to predetermined characteristics. Droop control, inverted droop control and PQ control are available control strategies [4].

2.1. PQ control
In PQ control mode, the reactive and active power output of DG is the given value of the controller [5]. The power output of the inverter is set as a constant, and the controller will keep the power output of the inverter at a given value no matter how the frequency and voltage change. In this case, DG is similar to a voltage controlled current source.

2.2. Droop control
The droop control simulates the operation characteristics of generators in traditional power grid, controls the output frequency and voltage of voltage source inverter (VSI) according to the change of output power, so that it can automatically track the predetermined droop characteristics as shown in Figure 2. This control method is called droop control, and the control principle is presented in Figure 3. The droop controller includes a frequency droop controller and a voltage droop controller, in which DG is approximately a voltage source.
3. Comparison and selection of integrated control strategies for microgrid

The operation of microgrid includes two kinds of steady-state: grid connection mode and isolation mode, and two kinds of transient: off grid and grid connected operation [6]. The stability of transient process has a great influence on the reliable switching of system state, so it is a crucial problem to choose which control strategy to realize the off grid and re grid operation.

3.1. Scheme 1
For the state of grid connection, PQ control strategy is adopted for all VSIs. Each DG injects certain reactive and active power into the system to satisfy the MS or other needs. The voltage and frequency of the system can be determined by the system. When microgrid starts the isolated operation mode, switch the VSI of the energy storage system or micro power supply (DC integrated energy storage device) to the droop control mode, generate certain power in accordance with the predefined droop characteristics, compensate the power from the power system when the micro grid is linked to the system, support the frequency and voltage of the microgrid, and control the voltage quality within the allowable range. The plan can satisfy the requirements of microgrid well in grid connected operation and isolated operation. However, during the process of transition from grid connected operation to isolated operation, islanding detection is necessary to determine when to switch the control method, which requires high real-time and accuracy of islanding detection. When the system is linked to the power system again, because the frequency synchronization needs to be adjusted, when the DG is integrated in large scale, the droop control strategy will produce the oscillating process. This is harmful for stabilizing the system transition process, and it is hard to realize the seamless switching of the system.

3.2. Scheme 2
The VSI with droop control has almost no reactive power oscillation when it cuts into the microgrid, but it needs external reference voltage when it operates in isolation.

3.3. Option 3
The droop control method is polished up, i.e., the setting values of active and reactive power are increased in droop control. For grid connected operation, the droop controlled VSI can also output the given active and reactive power. At this way, the switching from grid connection to isolated operation. Therefore, there is no need for islanding detection and seamless switching in the process of off grid. However, the strategy also has reactive power oscillation process when reconnecting, which can be harmful to the stability. Because VSI which is based on the droop control method can be realized. The VSI which is based on the improved droop control method can give voltage and frequency supporting, and the VSI based on the improved droop control strategy can be used as the main power supply to provide reference voltage for the microgrid, so the seamless switching can be realized when the microgrid is disconnected, and there is no VSI based on the improved droop control strategy. The power oscillation is also weakened by the large reduction of the droop control inverter, thus achieving the approximate seamless switching.

To improve the reliability, the operation mode of multi main energy can also be used. The advantage of VSI which is based on droop control method and VSI which is based on droop control method is that droop control may solve the control stability problem of large-scale integrated MS in microgrid. Generally, the time constant of the droop control is relatively large, Because of the sudden change of load or network structure, the power output of the energy storage system can be greatly changed, and the service life of the energy storage system can be reduced.

4. Low voltage system droop controller
It can be seen from the above analysis that the droop characteristics of VSI controller in low-voltage power grid are different from that of high-voltage system. According to the above formula, the droop
controller can be designed as follows. In order to reduce the delay caused by the power calculation, the differential term is introduced into the control equation, which is as follows:

\[
E = V^{\circ} - K_r( P - P^3 ) - K_r dP \\
\omega = \omega^{\circ} + K_q( Q - Q^3 ) + q dQ dt 
\]  \[1\]

Compared with the conventional droop control method, the power setting \( p \) and \( Q \) are added to ensure that the power can be controlled even in the grid connected state. Output the set active and reactive power to the grid as required. To realize the decoupling control of active and reactive power better, the droop control is introduced into the device. Low voltage system droop controller is given in Figure 4.

![Figure 4. Droop control block diagram](image)

5. Conclusions
In this paper, several common control strategies of microgrid are summarized. According to the dynamic switching process of microgrid, a droop control strategy is proposed to effectively compensate the system’s voltage and frequency. The droop control DG simulates the synchronous generator of high voltage power system to provide reference voltage and frequency for the system. The combination of the two control strategies can not only play the role of energy storage system and micro power supply more effectively, and realize the similar seamless switching of micro grid mode, but also the system can operate safely and reliably automatically even when the communication line fails or there is no communication line.

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