Study on the Control Method of ac Side Voltage Balance in New Energy Distribution Network

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Abstract: Because of the unstable balancing control of the ac side voltage by traditional methods, the power supply effect of the new energy distribution network is not ideal. Therefore, a new energy distribution network ac side voltage balance control method is proposed. The distributed data is used to mark the balance control target of the voltage on the ac side, and the range of control target is defined. With the help of the balance control algorithm, the ac side voltage in the new energy distribution network is balanced and controlled to realize the balance control of ac side voltage. The simulation results show that the distributed balance control method can enhance the stability of ac side voltage, guarantee the quality of power supply and be effective. The simulation results show that the distributed balance control method can enhance the stability of ac side voltage, guarantee the quality of power supply and be effective.

Keywords: New energy; Distribution network; Acside voltage; Balancing control

1. Introduction

As an important material basis for people's production and life, new energy can improve the level of national economic development. At the present stage, due to the excessive energy consumption of China's new energy distribution network, effective measures must be taken to balance the voltage of the distribution network. Although the traditional control method can effectively control the ac side voltage of the distribution network, the control process is unstable and expensive, which seriously limits the further development of China's new energy distribution network. Therefore, a new energy distribution network ac side voltage balance control method is proposed. In this paper, firstly the energy of the energy storage system of distribution network is exchanged through three-phase three-wire system. And then the ac side voltage in the distribution network is mined by using distributed data, and the target side voltage is marked and demarcated. Finally, balance control algorithm is adopted to achieve distributed balance control of ac side voltage of distribution network. To verify the effectiveness of the distributed ac side voltage balance control method designed in this paper, a simulation experiment was designed. The experimental results show that the distributed balance control method can effectively control the ac side voltage of the distribution network, and improve the stability of ac side voltage of the distribution network, which ensure the power supply quality of the distribution network is effectively improved.

2. Design of Distributed ac Side Voltage Balance Control Method

The distributed new energy distribution network ac side voltage balance control method realizes the balance control of ac side voltage through energy exchange of energy storage system. The whole process is completed by three-phase three-wire system, which mainly consists of alternating side voltage conversion unit, inverter unit, filter network and controller [2]. Adopting the conversion unit can improve the balancing control efficiency of the side voltage, further determine the target range of the balancing control of the distributed ac side voltage, execute distributed control algorithm on the target side voltage, and realize effective balancing and control of the ac side voltage of the new energy distribution network. The distributed ac side voltage balance control structure is shown in Figure 1.

2.1. Determine the distributed ac side voltage balance control target

The control target and range of the voltage loop of different ac sides will be different. Therefore, the ac side voltage in the new energy distribution network should be classified by the use of ac power network. According to the principle of polar electric transmission, the ac side

voltage is supercharged by the module [3], and the voltage level changes during the conversion are recorded by changing the voltage enhancement range of the two circuits. The ac side voltage in the new energy distribution network is calculated as 380V, and the voltage change of the ac side of the circuit in the conversion process is $0.38 \times 2n \approx 0.38$kV, 0.75kV, 1.5 kV, 3kV, 6kV, 12kV, 24kV, 48 kV $\cdots$ (n=1,2,3$\cdots$).

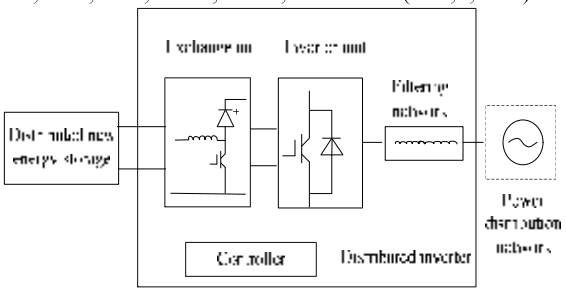

Figure 1. The distributed ac side voltage balance control structure

Considering the insulation performance of ac power distribution cables in the new energy distribution network at the present stage, the resistance value of rated voltage is limited to 8.7/10 kV and 18/20 kV. From the perspective of matching between ac distribution system and distribution network, the ac side voltage output value in ac distribution system is determined as:

$$U = \frac{1}{\sqrt{2}} M \frac{U_{a-b}}{2} \tag{1}$$

Here M represents the mixing ratio between ac distribution system and distribution network; U_{a-b} represents the voltage difference between two adjacent circuits is also the embodiment of the utilization rate of the ac side voltage.

When the output value of ac side voltage is determined, adjust the mixture ratio to the maximum. According to the calculation of equation (1), with considering the harmonic performance of ac side voltage [4], the ac side voltage grade of the new energy distribution network is: ±12~±14kV and ±24~±28kV. Since the three-phase three-wire system of energy storage system has high power consumption in the process of voltage exchange, it is necessary to remove the voltage consumption of three-phase three-wire system when using distributed data to control ac side voltage. In order to make the measurement of control target more flexible, the loop voltage of +/-7.5~+/15 kV was used as the measurement object. Combined with the compatibility of the conversion unit, inverter unit, filter network and controller, The voltage bus of the ac side of the loop is set at 7.5kv and the voltage of the lowest ac bus side is set at 400V. The total voltage consumption of the three-phase three-wire system is obtained. Considering the total voltage consumption of the energy storage system within the control target range, the acquisition and division of the ac side voltage of the new energy distribution network by distributed data can be better realized, providing the basis for the control level of ac side voltage and the determination of the target range. Based on the above analysis, the method for determining the voltage level of the ac side of the distribution network is determined [5]. The voltage control module in the distribution network is pressurized through the energy exchange process of the energy storage system. At the same time, considering the insulation phenomenon of ac cable, the power load of the distribution network is matched and the average grade of ac voltage is obtained.

According to the distributed data, the three-phase ac side voltage is redefined and the final balance control target range is determined, as shown in Table 1.

Table 1.

Distribution level	Voltage level /kV	Transmission distance /km	Transmission capacity /MW
High pressure I	180 above	150~800	800~1200
High pressure II	90~180	50~300	50~500
Middle pressure I	16~90	20~100	2~15
Middle pressure II	1.5~16	3~40	1~4
Low pressure	1.5 below	3.0 below	1.0 below

According to the analysis of the control target of ac side voltage shown in Table 1, the average voltage in the new energy distribution network is controlled at 10kV, which is not only conducive to the matching between the distribution network and the energy storage system, but also can reduce the cable resistance of ac side voltage, providing the foundation for the next step of the balance control algorithm.

2.2. Design of balancing control algorithm

According to the above distributed ac side voltage balance control target, the distributed balance control matrix is defined according to the control algorithm [6] in the reference.Assuming that the driving control signal is at high electrical time, the voltage electricity matrix of the ac side in the distribution network during this process is:

$$S_k = \begin{cases} 1 \text{ power on} \\ 2 \text{ Power off} \end{cases} \tag{2}$$

Here, k is a constant, represents the working frequency of the device, and does not make directional calculation. Ignoring the resistance in the process of power consumption based on kirchhoff's voltage law [7], the ac voltage of the dissipation circuit is obtained as follows:

$$V_{\min} = S_k \cdot U_a + R_t \tag{3}$$

Here, $V_{\min}$ represents the ac voltage in the power loop; U_a represents the ac voltage in switching time;

R_i represents the loop resistance value. When the conduction of the circuit V_1 ends, the setting loop V_2 is in the off state, then the voltage matrix V_1 and V_2 in the circuit is:

$$\begin{cases} V_1 = V_{\min} + L\dfrac{di}{dk} \\ V_2 = V_{\min} - L\dfrac{di}{dk} \end{cases} \tag{4}$$

Here, L represents the current flow in the loop; d represents the transformation frequency of the transformation unit; i represents the branch current in the transformation unit.Considering the symmetry of the converter of the three-phase three-wire energy storage system of the new energy distribution network, there are:

$$\begin{cases} U_a + U_b + U_c = 0 \\ i_a + i_b + i_c = 0 \end{cases} \tag{5}$$

By applying equation (5) to equation (3), the control function of distributed ac side voltage is obtained:

$$V_{\min} = S_k \cdot (-U_b - U_c) + R_{-(b-c)} \tag{6}$$

For the switching signal of the distribution network, its value change can be analyzed according to equation (3), so directional analysis is ignored. Now the distributed balance control algorithm for ac side voltage of new energy distribution network is designed.

3. The Experiment

In order to ensure the effectiveness of the distributed ac side voltage balance control method designed in this paper, experimental demonstration was carried out. Experimental demonstration was conducted to demonstrate the balance control of ac side voltage using the same new energy distribution network with the same structure of circuits. In order to ensure the rigor of the experiment, the traditional control method is used as the comparison of experimental demonstration, and the effect of ac side voltage control of the two methods is counted and recorded. The experimental results are shown in Figure 2.

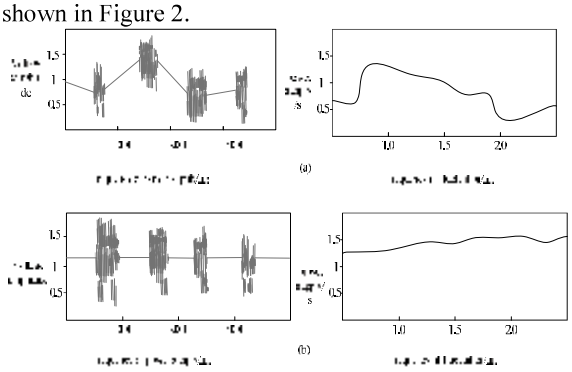

Figure 2. Comparison of experimental results

Figure (a) of Figure 1 represents the voltage amplitude and power supply change of ac side voltage control of distribution network using distributed balance control method. Figure (b) represents the voltage amplitude and power supply change of ac side voltage control of distribution network using traditional balance control method. Through the analysis of the experimental demonstration results shown in Figure 1, it can be seen that the control amplitude of the distributed balance control method on the ac side voltage fluctuates little and steadily. The control amplitude of traditional balance control method fluctuates greatly. After adopting the distributed balance control method to control the ac side voltage of the distribution network, the power supply of the distribution network is significantly higher than that of the traditional ac side voltage balance control method. Therefore, it can be concluded that the distributed balance control method designed in this paper is highly effective. When conducting the ac side voltage balance control of the new energy distribution network, the balance control process is simple, the voltage fluctuation is small, the balance control time is short and the quality of balance control is high. According to the weighted analysis, the distributed balance control method designed in this paper is 28.39% more efficient than the traditional balance control method in balancing the ac side voltage.

4. Conclusion

This paper analyzes and designs the control method of ac side voltage balance in new energy distribution network. Based on the distributed data, the ac side voltage of the distribution network is marked and demarcated, and the target ac side voltage is balanced to realize the design of the distributed ac side voltage balance control method. The experimental results show that the distributed balance control method designed in this paper can enhance the stability of ac side voltage of distribution network, which is effective. It is hoped that the study in this paper can provide theoretical basis and reference for balancing control method of ac side voltage in new energy distribution network.

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