Allocation Control of Multi-functional Grid Connected Inverter and the Power Quality between of Grid Connected Microgrid Based on PSCAD Simulation Platform

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Abstract. On the one hand, the application of microgrid can effectively cut down the effect of distributed generation on distribution network, on the other hand, it helps to improve the power quality of distribution network. However, for the distribution network, a single multi-functional inverter has limited effect on the improvement of its power quality. Therefore, the allocation control of power quality by decentralized multi-functional inverters can further improve the utilization of inverters. This paper proposes to calculate the output current of multiple multi-functional inverters according to the harmonic and reactive current of the parallel node and the residual capacity of the multi-functional inverter. The simulation results show that the allocation control strategy proposed in this paper can effectively control the compensation capacity of the multi-functional inverter, so as to control the harmonic at the grid connection in place.

Keywords: Multifunctional Grid Connected Inverter, Microgrid, Grid Connection, Power Quality, Control Strategy

1. Introduction

The rapid economic development not only promotes social progress and the improvement of scientific and technological level, but also aggravates the shortage of resources and environmental pollution. Therefore, the coordinated development of renewable resources, environmental protection and economic development has become the common pursuit of all countries in the world. For distributed generation, wind energy, solar energy and biomass energy are of great significance as clean energy. Environmental factors lead to the randomness of the output power of distributed generation, which affects the stability and power quality of power system after grid connection [1]. Therefore, the concept of microgrid came into being. Microgrid is a small power generation and distribution system including distributed generation, energy storage equipment, converter, load and protection device. Microgrid is a controllable small power supply system, which helps to reduce the influence of distributed generation grid connection on distribution network [2-3]. However, microgrid contains a great quantity of nonlinear load, unbalanced load, reactive load and power electronic devices. The harmonic current, reactive current and negative sequence current will increase line loss and affect the
power quality of distribution network. In order to solve the impact of microgrid grid connection on power quality of distribution network, multi-functional grid connected inverter has been widely concerned and studied [4]. At present, multi-functional grid connected inverter is more used to improve the power quality of distribution network. Due to the limited compensation capacity of a single multi-functional inverter, if the grid connected microgrid can realize the sharing control of multiple multi-functional inverters and improve the power quality problems such as reactive power compensation, harmonic current treatment, power factor correction and three-phase imbalance in the distribution network, the utilization rate of multi-functional inverter can be further improved, At the same time, the impact of microgrid access to the system on the power quality of distribution network is reduced [5-6].

Firstly, this paper analyzes the composition of the grid connected microgrid system, and then proposes to coordinate and control the output current of multiple multi-functional inverters according to the harmonic and reactive current of the parallel network and the residual capacity of the multi-functional inverter. Finally, the grid connected microgrid system is built on the PSCAD simulation platform to change the switching state of the distributed power supply and the working state of the multi-functional inverter, Calculate the total current harmonic distortion rate at the grid connection [7].

2. Composition of grid connected microgrid and allocation control strategy of multifunctional inverter

Grid connected microgrid is generally composed of converter, load and protection device, energy storage equipment and distributed power supply. Its topology is shown in Figure 1.

![Figure 1. Topology of grid connected microgrid](image)

The isolation transformer can control the grid connection and off grid status of the microgrid. Distributed power supply is composed of photovoltaic power supply, energy storage equipment, power conversion equipment and multi-functional grid connected inverter. On the one hand, the multi-functional grid connected inverter can realize grid connected power tracking, on the other hand, it can compensate the harmonics, reactive power and unbalanced current of microgrid. Microgrid contains multiple decentralized multi-functional inverters, which can control harmonic and reactive current locally [8].

The allocation control strategy of decentralized multi-function inverter in grid connected microgrid is shown in Figure 2. Each multi-functional inverter automatically completes the improvement of power quality at the parallel node according to the harmonic and reactive current of the parallel node and the compensation capacity it can input [9].
According to the above allocation control strategy, a grid connected microgrid system is built on the PSACD simulation platform. The simulation system built in this paper includes two distributed generators with rated capacity of 20kVA. The grid connection parameter settings of the two distributed generators are shown in Table 1.

Table 1. Grid connection parameters of distributed generation

| Number | Sn/kVA | P/kW | Q/var | k   | Iomax/Io0 |
|--------|--------|------|-------|-----|-----------|
| DG1    | 20     | 14   | 0     | 0.5 | 3         |
| DG2    | 20     | 16   | 0     | 0.4 | 3         |

Where, k refers to the proportion of the remaining capacity of the multi-functional inverter that can be used to improve the power quality of the microgrid. According to grid connection parameters in Table 1, calculate icmax:

\[
I_{c_{\text{max}1}} = \frac{0.5 \times \sqrt{S_n^2 - P_n^2 - Q_n^2}}{U_q} = \frac{0.5 \times 14.28 \times 10^3}{190} \approx 37.58 \text{A}
\]

\[
I_{c_{\text{max}2}} = \frac{0.4 \times \sqrt{S_n^2 - P_n^2 - Q_n^2}}{U_q} = \frac{0.4 \times 12 \times 10^3}{190} \approx 25.26 \text{A}
\]
The simulation parameter settings of grid connected microgrid are shown in Table 2.

**Table 2.** Parameters value in PSCAD simulation

| Parameter type                   | Parameter value                                                                 |
|----------------------------------|---------------------------------------------------------------------------------|
| Distribution network             | U_l=190V, f=50Hz, L_d=3mH                                                        |
| Reactive load                    | R_a=R_b=R_c=10 Ω, C_a=C_b=C_c=1000 μ F                                          |
| Nonlinear load                   | R_L=20 Ω                                                                         |
| Multifunctional inverter         | U_DC=350V, CDC=4000 μ F                                                          |

During the simulation, the switching state of the distributed power supply and the compensation state of the multi-functional inverter are changed. The results of current total harmonic distortion rate and power factor at the grid connection are shown in Table 3.

**Table 3.** Results of total harmonic distortion rate and power factor of current at grid connection under different operating conditions

| Running state                                         | THD     | cos φ   |
|-------------------------------------------------------|---------|---------|
| DG1 and DG2 are off grid                              | 14.01%  | 0.9723  |
| Both DG1 and DG2 are connected to the grid, and DG1 is put into compensation capacity | 6.13%   | 0.9695  |
| Both DG1 and DG2 are put into compensation capacity   | 5.87%   | 0.9927  |
| DG1 input compensation capacity, and DG2 off grid     | 8.67%   | 0.9703  |

It can be found from Table 3 that:

1. When both DG1 and DG2 are off grid, the THD of current at grid connection is 14.01%, and cos φ is 0.9723;
2. When both DG1 and DG2 are connected to the grid and DG1 is put into compensation capacity, the THD of current at the grid connection is reduced from 14.01% to 6.13%, cos φ from 0.9723 to 0.9695, it shows that the output compensation capacity of the multi-functional inverter in DG1 can improve the current harmonics at the grid connection;
3. When both DG1 and DG2 are put into compensation capacity, the at grid connection is reduced from 6.13% to 5.87%, cos φ from 0.9695 to 0.9927, the harmonic current at the grid connection is obviously improved;
4. When DG1 is put into compensation capacity and DG2 is off grid, compared with DG1 and DG2 are off grid, the total harmonic distortion rate at grid connection is reduced.

4. Conclusion

In order to verify the effectiveness of the control strategy of multi-functional inverter on the power quality of grid connected microgrid proposed in this paper, build the microgrid simulation system PSCAD platform and change the switching state of distributed generation and whether the multi-functional inverter outputs compensation capacity. The simulation results show that when DG1 and DG2 are off grid, the THD of current at the grid connection is 14.01%, and cos φ is 0.9723; When both DG1 and DG2 are connected to the grid and DG1 is put into compensation capacity, the THD of current at the grid connection is reduced from 14.01% to 6.13%, cos φ is from 0.9723 to 0.9695; When both DG1 and DG2 are put into compensation capacity, the at grid connection is reduced from 6.13% to 5.87%, cos φ is from 0.9695 to 0.9927. According to harmonic and reactive current of the parallel node, this paper researches the new allocation control strategy, which can effectively control whether the multi-functional inverter outputs compensation capacity and effectively improve the harmonics at the grid connection.

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