Research and Simulation of grid connected strategy for microgrid

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Abstract. With the growing demand for electricity, fossil energy gradually dried up, energy crisis and environmental pollution problems become increasingly serious, the global power industry is facing great challenges, so the micro grid from distributed generation arises at the historic moment. Flexible operation mode and high quality power supply service are the advantages of microgrid, but it needs perfect control system support. Therefore, the research of microgrid control strategy is of great significance. In view of this, a brief analysis of several important factors need to be considered when the micro grid connected to the grid, and then combined with the topological structure of a power academy microgrid experimental platform of control, research on micro grid control strategy, and through the MATLAB simulation with actual data.

1. Introduction

Distributed generation is an important way to use clean energy, and it is also a more effective form of utilization. The micro grid can more efficiently integrate distributed generation equipment, energy storage equipment and load, flexible and efficient use of distributed generation or new energy power generation to contribute to the development of China's electric power industry.

The traditional power grid to unidirectional flow power supply load for power supply, micro grid access can change the operation characteristics, [1]and the access point voltage, power flow, line current will affect the degree of influence, and the micro grid location and capacity, the load characteristics are closely related. This paper analyzes several important factors need to be considered when the micro grid access network, such as the basic conditions, the micro grid access system of micro grid's basic requirements, and then combined with the topological structure of a power academy microgrid experimental platform of control, research on micro grid control strategy, and combined with the actual data by Matlab simulation.

2. Important factors of microgrid integration

2.1. Prerequisite for grid connection of microgrid

The voltage on both sides of the grid connected PCC switch is zero. [2-3] at the same time, the current direction must be ensured from the large power grid to the micro grid. When the voltage difference, frequency difference and phase angle difference are zero in grid connected, when the large power grid with high frequency is ahead of the low frequency microgrid, [4] and the voltage amplitude of the large grid is lower than the micro grid, [5] it is most conducive to the smooth transition of the microgrid.

2.2. Basic requirements of microgrid integration

Microgrid needs to provide the power grid management department with the micro power components, overall performance and load characteristics in microgrid. [6] The basic structure of grid connected microgrid is shown in figure 1.

In general, the total capacity of the microgrid does not exceed the maximum load capacity of 1/4 in the upper power supply area or 1/3 of the minimum load capacity. Through technical and economic comparison, low voltage level access can be adopted when microgrid uses low voltage level access better than high voltage level access.

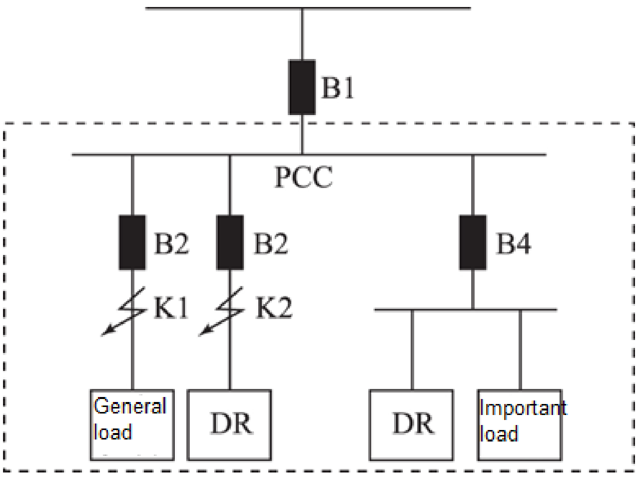

Figure 1. Basic structure diagram of microgrid integration

3. Simulation of grid connected control strategy for microgrid based on droop control

3.1. Droop control principle

When the distributed power supply adopts droop control strategy in microgrid, its output can be automatically adjusted according to the given P-f and Q-U characteristics. The following is mainly about the principle of droop control.

Droop control is a control method to describe the frequency static characteristics of analog generator sets. In micro grid system, the output power is P_0, the reactive power is Q_0, the system frequency is F_0, and the system voltage is U_0. When the system active load suddenly increases, the active power is insufficient, leading to the decline of frequency; the system reactive power load increases suddenly, and the reactive power is insufficient, which will lead to voltage amplitude drop. And vice versa, eventually a new balance is reached between the droop control system and the regulation effect of the load itself, that is, (1) the new equilibrium point is reached. The droop relation of P-f and Q-U is as follows (2):

$$f = f_0 + (P_0\text{-}P)K_{\mathrm{p}} \tag{1}$$

$$U = U_0 + (Q_0\text{-Q})K_Q \tag{2}$$

3.2. Microgrid Structure Model and Parameter Setting

On the platform of Matlab/Simulink micro grid structure model as shown in Figure 2, the micro power three-phase voltage type inverter for three-phase alternating current, and then by the filter, finally through the line and load, the switch is connected to the power grid, micro power in islanded and grid connected mode using droop control.

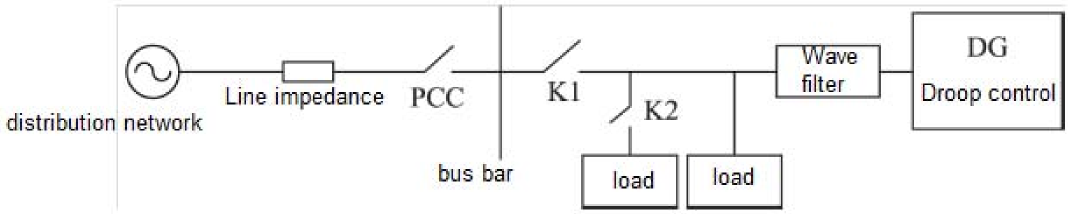

Figure 2. microgrid structure model

Set the simulation initial parameters as follows

(1) P_n=75 kW, Q_n=0 var, E_n=311 V, FN=50 Hz, V_{dc}=800 V.

(2) Filter parameters: R_F = 0.02 Ω, L_f=500 H, C_f=1 500 μF.

(3) Load parameters: P_l=75 kW, Q_l=0 var var. Among them, Pn is the output power of micro power supply operating at rated frequency; Q_n is the output power of micro power under rated voltage; E_n is rated voltage; F_N is rated frequency; V_{dc} is DC voltage. The simulation time is 1 s, and the microgrid is switched from island state to grid state at 0.5 s.

3.3. Simulation analysis

3.3.1. The influence of the Inverter control parameters. On the transient process of the grid connected is mainly simulated and analysed by the influence of the parameters of the micro power controller on the transient process of the grid connected.

M is the P-f droop coefficient, and the m=1e-5 can smoothly transition in the transient process of grid connected when other parameters remain unchanged. With the increase of M, the oscillation amplitude of F becomes larger at t=0.5 s (that is, the grid connected instant), and then tends to be stable after about 0.1 s.

In the case of microgrid off grid, microgrid is powered by wind power, photovoltaic and energy storage system. In this case, not only to ensure the quality of power supply, but also to achieve the balance of power supply and power consumption. In order to ensure the power balance of wind power, photovoltaic and load, the power supply of the energy storage system needs to change its output power, and at the same time, when the total power of the system is greater than the power consumed by the load, it will absorb power in time to ensure the power balance of the system. In order to eliminate the power impact on the power grid, the energy storage system also needs to adjust the power. Therefore, the energy storage system is the core of the stable operation of microgrid when the microgrid is running away from the network. Due to the structure of multi cluster battery used in energy storage, in order to improve the efficiency of the system, the optimal control strategy of battery cluster charging and discharging is also needed according to the power supply status.

In a large power grid, the regulation of the frequency of the system is done by the governor of the generator. For larger power shortage, the need to control the automatic generation, re power allocation between the generators. In microgrid, especially in off grid mode, the microgrid composed of wind and solar storage power supplies the power balance of the system by the energy storage system, which acts as the function of frequency modulation and voltage regulation. If there are multiple energy storage units in the system, if the main slave control mode is considered, an energy storage unit can realize the function of frequency modulation and voltage regulation, and other energy storage units adopt constant active and reactive power control mode. With the above control mode of microgrid, during the grid connected control period, the FM and voltage regulation signals are transmitted to the energy storage units of the frequency modulation and voltage regulation function in the microgrid by the synchronous control device of the microgrid, and the implementation control is detailed below of Fig.3.

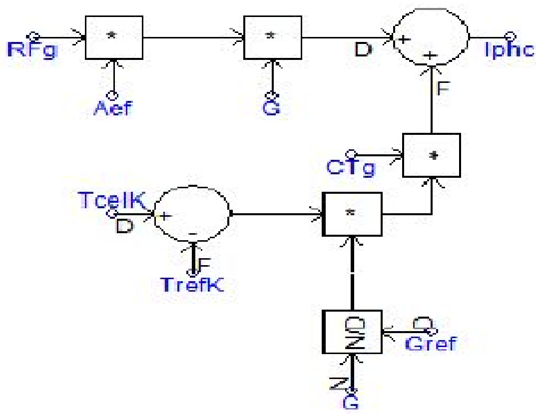

Figure 3. Sub module mode of I_{ph}

N Q-U droop coefficient, when the other parameters unchanged, with the increase of N in grid and grid frequency transient, slight fluctuations in the power quality requirements is not high relative to the case, can be allowed to occur, but in power when higher quality requirements are not allowed to happen.

K_{Vp} is the proportional factor of voltage inner loop control, in the case of other parameters unchanged, with the gradual increase of k_{Vp}, even in the absence of grid connected F, there is a slight concussion; after 0.5 s, as k_{Vp} gradually increases, the f oscillation becomes more and more intense, system instability.Fig.4 is Photovoltaic output current model

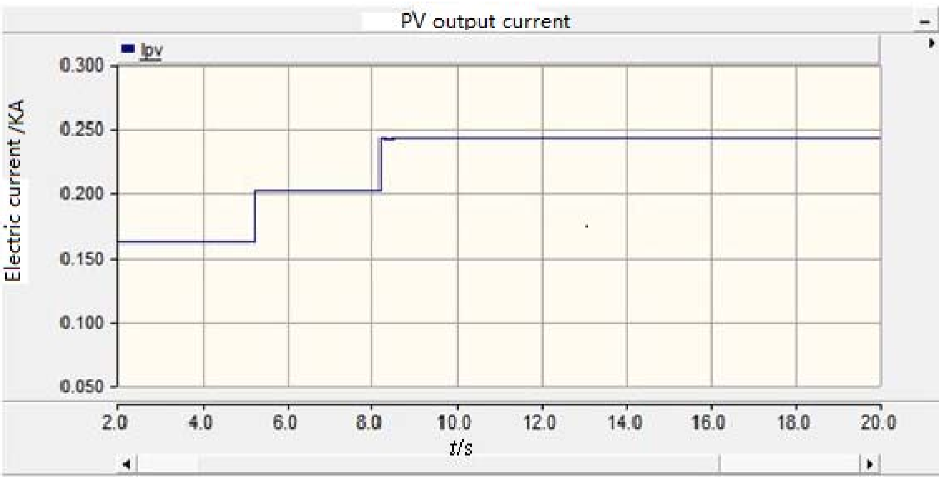

Figure 4. Photovoltaic output current model

From the simulation results, we can see that photovoltaic power generation is a relatively stable micro power supply, which can achieve stable output of voltage and current. Under the condition of illumination change, the control system can respond quickly, and make adjustment to restore the output of power smoothly.

3.3.2. Influence of load variation on grid connected transient process. Load using constant power load, the following will mainly discuss the impact of P and Q changes on grid connected transient process.

Keeping Q=0 VaR and changing P, the influence of simulation result P on the transient of grid connected process is obtained. It can be seen that when P=75 kW, the f before grid connection is 50 Hz, which has little influence on the transient process of grid connected, that is to say, a smooth transition is achieved in the process of grid connected.

The load power is equal to the rated output power of P micro power P_n, so P=75 kW "provisions of the load power load active power reference point; when the P increased gradually in 75 on the basis of kW, corresponding to the grid before the F is less than the rated frequency of 50 Hz, P increased, f decreased to 75 kW P the same number; as the benchmark decreases, the change of F also has a similar situation; in addition, the grid before the F and 50 Hz is bigger, the moment of shock f grid is fiercer, stable time is long.

P=50 kW, Q, can be seen from the simulation result, when Q=0 VaR, the grid before the F was 50 Hz, have little effect on the grid transient, in order to achieve a smooth integration, this time Q is exactly equal to the rated output power of the micro power Qn, called Q=0 VaR to load power load reactive power reference "; when Q at 0 VaR Based on the increase, f will also increase, when Q in 0 on the basis of VaR decreases, f will also decrease, the degree of shock and grid grid connection before f rated frequency, f deviates more intense shock.

In addition, the influence of P and Q on grid connected transient process is compared with P and Q which deviate from the same benchmark value. P makes f deviate from 50 Hz to a much greater extent than Q. According to a large number of simulation data can be obtained approximately 10 kW (relative to the reference point, increase or decrease) to decrease or increase the frequency of active Hz 0.1, due to the capacitive reactive power of 60 KVA (r relative to the reference point) to make the frequency decreases 0.1 Hz to 80 KVA (inductive reactive power R with respect to a reference point) to increase the frequency of 0.1 Hz. Therefore, the influence of reactive power on the load can be ignored when the load reactive power deviates little from the reference point.

4. Conclusion

The advantage of droop control strategy is that it is easy to implement plug and play of distributed generation; at the same time, the control strategy can be kept unchanged when the microgrid is running mode switching, thus avoiding the switching control strategy affecting the transient stability of microgrid. When the microgrid from grid connected mode switching for islanding mode, simply disconnect the micro grid switch, at this time to take the unbalanced distributed power droop control strategy can automatically share the micro grid system of active power and reactive power, realize the islanding mode and stable operation; when the microgrid from island mode switching the grid connected mode, at the same time can be directly closed power electronic switch, power supply will be distributed according to the voltage output power adjustment of the operating frequency and the access point system, to achieve stable operation.

References

[1] YU Xiaodan, XU Xuedong, CHEN Shuoyi, et al. A brief review to integrated energy system and energy internet [J]. Transactions of China Electro technical Society, 2016, 31 (1): 1 - 13.
[2] HUANG Yiping, MA Xiao Xuan. Research on microgrid technology [J]. Transactions of China Electrotechnical Society, 2015, 30 (S1): 320 -3 28.
[3] CHEN Na, WANG Jinsong. Development and application of microgrid’s connect & off-grid device [J]. Power System Protection and Control, 2015, 43 (11): 115 - 120.
[4] JING Long, HUANG Xing, WU Xuezhi. Research on improved microsource droop control method [J]. Transactions of China Electrotechnical Society, 2014, 29 (2): 145 - 152.

[5] XU Yuqin, MA Huanjun. Parallel operation technology of inverters based on improved droop control [J]. Power System Protection and Control, 2015, 43 (7): 103 - 107.
[6] CHEN Lijuan, WANG Zhijie. Research of operation control of micro-grid based on improved droop control [J]. Power System Protection and Control, 2016, 44 (4): 16 - 21.