Grid Connected Control Strategy of Microgrid

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Abstract. The Combination of large power grid and distributed power supply is recognized by electric power experts as the development direction of power industry, which can save energy consumption, improve the reliability and flexibility of power system. Therefore, it is of great value to study distributed power supply. According to the shortcomings of PI control gain at the fundamental frequency of small, poor control effect, introducing the band-pass quasi PR controller, and improve the algorithm in order to improve the control effect, and finally through the MATLAB simulation software to test the improved algorithm, verify the feasibility of the algorithm and accuracy.

1. Introduction

Analysis of. Grid control grid control purpose and methods usually seen in micro grid process, as to improve the quality of grid connected inverter output current, need to be changed into high quality sine wave, and let the wave with the frequency and phase of the wave pressure line network. According to the relevant standards, requirements of grid current generated by the total harmonic distortion rate cannot exceed the standard 5%. [1] Therefore, the grid current harmonic control is a very complex problem. To solve this problem, people put on the grid connected inverter by harmonic current or voltage adjustment and control. At present, the mainstream of the inverter can be divided into two kinds of voltage and current. The results are shown in Figure 1.

2. Grid control objectives of the grid connected distributed power control is concerned, its goal is to make the inverter

The output of the same frequency and voltage control circuit of sine wave. The control process can be equivalent to the circuit diagram shown in Figure 2.

In Figure 2, U₀ represents the output voltage of the inverter; I₀ represents the inductor current; Unet represents the grid voltage; L plays a major role in filtering. [2] For inverter output control, it is to make the output current and the network voltage same frequency and phase. In order to achieve the same goal, it is necessary to ensure that the AC side of the inverter output the lead grid voltage 90 degrees, which can ensure the same frequency and phase of IL and Unet.

Grid connected inverter is the core of grid connected microgrid. The topology structure of inverter is more, and the network topology structure is selected reasonably, which can improve the performance of grid connected system reasonably. [3] At present, the common inverter structure includes half bridge, full bridge and 3 kinds of transformer with center tap. Among them, the whole bridge is a widely used
one. In order to simplify the research, this paper selects single-phase full bridge inverter, military voltage source input, current source output control mode, the specific circuit topology as shown in figure 3.

In the figure, T1-T4 anti parallel diode switch, through the PWM control mode, the T1, T4 and T2, T3 of the circuit are alternately turned on, then the output sine wave current grid, Udc voltage DC output, RL series circuit and inductance L and resistance.

According to KVL’s law, it can be obtained (1):

\[
L \frac{dI_{grid}}{dt} = U_{ab} - I_{grid} R_L - U_{grid}
\]

The transfer function of the filter part is:

\[
\frac{U_{grid}}{I_{grid}} = \frac{1}{sL}
\]

**Figure 1.** Schematic diagram of inverter

**Figure 2.** Equivalent circuit diagram of grid connected inverter

**Figure 3.** Full bridge inverter circuit
Thus, the output open-loop transfer function of the system power can be obtained (3):

\[
G_z(s) = \frac{1}{R_L + Ls}
\]

Thus, the output open-loop transfer function of the system power can be obtained (3):

\[
G(s) = G_1(s)G_z(s) = \frac{K_{pwm}}{R_L + Ls}
\]

3. Design of grid connected control strategy

3.1. Integrated grid control strategy design

For the power generation system, the energy level mainly depends on the quality of the grid connected inverter technology. In the process of inverter control, it mainly includes voltage and current double closed loop control, hysteresis current control, repetitive control, deadbeat control, repetitive +PI control and fuzzy control strategy. [4] Combined with the above research, the control strategy of voltage outer loop PI control and current loop quasi PR control is adopted to control the output current with the side current as the control output target. Thus, the grid connected control strategy as shown in Figure 4 is obtained.

In Fig. 4, the grid connected control strategy, the main idea is to take the reference voltage of Udc and \( U_{\text{ref}} \) in PI and the actual controller, and then obtain the reference current signal \( i_{\text{ref}} \) then, the reference obtained via the \( i_{\text{ref}} \) digital PLL voltage unit detected by the network voltage current signal synchronization, thus you can practice with the overall phase voltage difference, which is also called the discrete sine table values; the discrete again will get the only product with reference to \( i_{\text{ref}} \), you can get in the next cycle when the current value, the value is a predictive value, usually denoted by \( I^* \); finally * and after A/D conversion of the IOUT input to the quasi PR controller, then you can get the PWM duty cycle, [5] and then through the drive circuit to switch from action. And realize the same frequency and phase sine wave current output.

3.2. Improvement of quasi PR algorithm

The principle of PI adjustment can be regarded as the pole in the left half plane of the coordinate axis, so as to improve the integral damping zero point and reduce the error, and then to improve the stability. Therefore, the gain of the base wave frequency can be defined as the gain of the base wave frequency:

\[
A(dB) = \sqrt{K_p^2 + \left(\frac{K_i}{\omega_0}\right)^2}
\]

In the formula (4), it can be seen that increasing the \( K_p \) can improve the precision of control and speed up the response of the system. However, if the \( K_p \) is not enlarged here, if it is too large, it may cause shock. At the same time, the \( K_i \) value can be reduced by integral adjustment, but the steady state error can be reduced, but the response speed of the system will be reduced.
Figure 4. Block diagram of grid connected control strategy

Figure 5. Quasi PR controller structure
Thus, according to the analysis above, there is a typical defect in the traditional PI controller. In order to solve the above problems, this paper introduces the principle of proportional resonant controller, controller is open loop transfer function in sin or cos form of the S domain of the sine signal is adjusted so as to obtain the transfer function (5):

\[
G_1(s) = \frac{s}{s^2 + \omega_0^2}, \quad G_2(s) = \frac{\omega_0}{s^2 + \omega_0^2}
\]  

(5)

However, there are some problems in the PR control mode itself. That is, although the frequency at the fundamental frequency is infinite, the control accuracy is limited. At the same time, the PR control mode cannot restrain the influence caused by the frequency change of the power grid efficiently, and resist the influence caused by the frequency mutation of the power grid. Therefore, a grid connected strategy of quasi PR controller is introduced to solve the problem.

The transfer function of the quasi PR controller is (6):

\[
G(s) = K_p + \frac{2K_p \omega_c s}{s^2 + 2\omega_c s + \omega_0^2}
\]  

(6)

\(\omega_c\) represents the cutoff frequency, \(\omega_0\) represents the resonant frequency.

In order to improve the control effect, the transfer function is decomposed into a combined form of integrator 1/s (7):
From this, the quasi PR controller structure can be obtained, as shown in figure 5.

4. Simulation Verification
In order to verify the correctness of the control strategy designed in this paper, the traditional MATLAB is used to simulate the inverter control system. In this study, set up the system frequency is 50Hz, the parameters of PI controller $KP=0.05$, $K1=0.2$; quasi PR controller parameters for $KP=0.05$, $KR=0.25$; and set related parameters of filter inductance is $L=5mH$, $R=0.3\Omega$ value of the whole power grid; voltage is 220V, the size of the frequency of the switch is set to 10kHz. By this simulation, the voltage and current waveforms can be obtained as shown in Fig. 6.

From Figure 6 can be seen, whether it is the current waveform, or voltage waveform, reflected wave is smooth and smooth, it can be indicated that the proposed quasi PR control strategy has great advantages, has anti voltage interference, and reduces the steady-state error, and makes the output current and voltage phase. Through this result, the efficiency of grid connection is improved to a certain extent.

5. Conclusion
The main purpose of the grid connected inverter is to make the inverter output current and the grid current in the same frequency and phase, so as to better achieve the effect of grid connection. In order to achieve this goal, this paper introduces a quasi-PR control method, and verifies the feasibility and accuracy of the above methods through simulation, which has certain reference and reference for the modern photovoltaic energy.

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