Discussion on Maximum Power Transmission Control Strategy of Photovoltaic Grid-connected Inverter

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Abstract: The inverter control strategy determines the PV grid-connected output power. To achieve maximum power transmission, it is necessary to improve the inverter performance. Firstly, the paper briefly introduces the photovoltaic grid-connected inverter control strategy and analyzes the inverter el power model. Based on this, a maximum power transmission control strategy is proposed and simulated to analyze the PV grid-connected operation. And adjustments provide a reference.

1. Introduction

In the process of photovoltaic grid connection, the power generated by the PV array needs to be transformed by the inverter and transmitted to the grid, and synchronized with the grid voltage to minimize the grid-connected harmonics. Therefore, the inverter is an important device in the photovoltaic grid connection, and its control strategy will also have an impact on the photovoltaic grid-connected output power. In the specific study of the inverter control strategy, it is necessary to find an effective maximum power control strategy to improve the efficiency of photovoltaic grid-connected power generation.

2. Photovoltaic Grid-Connected Inverter Control Strategy

At present, there are many researches on photovoltaic grid-connected inverter control strategies, including multi-loop control strategy based on pi controller, linear control strategy using transfer function, and small-signal linear model control structure. Different inverter control strategies can have different effects on photovoltaic grid-connected power transmission. For example, based on the multi-loop control strategy of the pi controller, current cross-decoupling and voltage disturbance feedforward compensation can be realized. According to the actual operation of photovoltaic grid connection, the grid voltage may be unbalanced or distorted. At present, there is also a grid-connected control structure realized by parallel passive damping, which mainly uses the complex filter positive sequence and negative sequence component algorithm to construct linear control. Strategy. However, due to the high requirements of PV grid-connected on the dynamic performance and stability of the inverter, the linear control strategy is difficult to meet the practical application requirements under the constraints of the inverter technology. At present, the research on nonlinear control strategy has attracted attention. For example, adaptive hysteresis control strategy, sliding mode variable structure control algorithm, and active reactive power unified control strategy. These linear or nonlinear control strategies are mainly for the control strategy of grid power factor and current harmonic design, and it is difficult to achieve maximum power transmission control. In this study, the expected output power of the inverter is calculated based on the maximum power of the photovoltaic array (mppt), and then the passive power control is implemented by the el power model to solve the maximum power transmission problem of the photovoltaic grid-connected inverter[1].

3. Photovoltaic Grid-Connected Inverter El Power Model

3.1. Inverter main circuit structure

Inverters in photovoltaic grid-connected are divided into two levels: multi-level and multi-level.

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In this study, a three-phase two-level voltage type PWM inverter is selected, and the research results can also be applied to other types of inverters. From the main circuit structure of the inverter, it is assumed that the output filter resistance and the internal resistance of the inverter are equivalent to R, excluding the internal resistance of the three-phase AC power grid. Let the bus voltage on the DC side be udc, the photovoltaic current is ipv, the input DC side capacitor current is ic, the input inverter current is idc, and the switch drive signal is Sa.), Sb and Sc, the unipolar binary logic switching function is Sj. Then, Sj=1 represents the upper arm conduction and the lower arm off state, and Sj=0 represents the upper arm off and the lower arm conduction state, j=a, b, c. In addition, the three-phase AC phase voltages on the inverter side are ua, ub and uc, respectively, and the three-phase line currents output by the inverter are ia, ib and i, respectively.c, the three-phase AC phase voltages on the grid side are uea, ueb and uec[2], respectively.

3.2. 1el power model

According to the above main circuit structure of the inverter, a mathematical model of the dq coordinate (two-phase synchronous rotation) of the inverter can be constructed, wherein Sd and Sq are the d-axis component and the q-axis component of the switching function, respectively. Among them, ud=Sdudx, uq=Squdc. In the dq coordinate system, udc of the three-phase balanced power grid is equal to the grid phase voltage amplitude Um. In the case of udc=0, the active power output by the photovoltaic grid-connected inverter is p= 3Umid/2, q=3Umiq/2.The power model with p, q, udc as variables can be derived from the dq coordinate model and the active reactive power model. Let x = (x1x2x3)t, where x1 is p, x2 is q, and x3 is udc, which can be based on the power model. The EL power model is derived, ie Mpx+Jpx+Rpx=up, where Mp is a positive definite diagonal matrix and Jp is an antisymmetric matrix. Rp is a symmetric positive definite matrix and up is a control input. The internal interconnect structure of the system can be reflected from Jp, and the system dissipative characteristics[3] are reflected from Rp.

4. Photovoltaic Grid-Connected Inverter Maximum Power Control Strategy

4.1. Determine the desired balance point

The realization of the maximum power transmission control strategy of the inverter must meet the requirements of the power factor of the grid and the harmonics of the power grid, so that the actual output power is as close as possible to the expected output power, ie p→Pm. In this case, the grid harmonics should be close to 0, and udc is the voltage Umax corresponding to the maximum power of the PV array. And the phase voltage peak and the maximum power corresponding voltage should satisfy the relationship of Umax>1.732Um.When determining the desired equilibrium point, x1 should be equal to Pm, x2 should be 0, and x3 should be equal to Umax. Pm is then determined using the steady state desired power balance equation, ie Pmax = 3(2Pm / 3Um)2 / 2+Pm.Among them, Pmax is the maximum power of the photovoltaic array.

4.2. Passive power controller

Designing an inverter control strategy using the EL power model requires the use of a passive photovoltaic grid-connected inverter that can be designed in accordance with a passive power controller. Bring xe=xx* into the EL power model with the error energy function We(x)=xeTMpxe/2, then for passive power The controller is then represented by We(x)=-xeTRpxe<0.Among them, the convergence speed of We(x) depends only on Rp, and Rp is inherent, so We(x) converges slowly. In order to improve the convergence speed of We(x), the damping can be adjusted to adjust the damping to Rdxe=Rpxe+Raxe. .Among them, Ra is the damping of the injection. After Ra injection, the PV inverter error EL power model can be obtained. At this time, We=xeTMpxe=-xeTRdxe<0, from the formula, We(x) can be Convergence to 0. When ra is much larger than R, the convergence speed of We(x) is determined by ra, which is equivalent to improving the robustness of the inverter. a, let We(x) converge to 0 at a faster rate to ensure that the passive power controller can achieve the desired control target. In the EL power model, the switching function mainly controls the active power and the reactive power. In the case of reasonable selection of ra1 and ra2, the inverter can dynamically track the maximum power of the photovoltaic array, thereby completing Maximum power output control task. In this case, not only can the photovoltaic grid-connected output power be improved, but also the harmonic interference problem that may be caused by photovoltaic grid connection can be reduced to ensure the power quality of the grid. In order to ensure the feasibility of the maximum power control strategy based on the EL power model, it is also necessary to verify the above control strategy through simulation analysis.

5. Simulation Analysis

5.1. System Simulation

Assume that the external environmental parameters in the test conditions are light intensity (S) 1000 W/m2 and temperature (T) 25 °C. Among them, the light intensity produces a 400 W/m2 square wave jump every 0.1 s, and the temperature varies from 10 ° C to 40 ° C, and changes according to a sine wave. The maximum power point voltage (Umax) in the photovoltaic cell technical parameters is 352V, and the current (IPVmax) is 19.5A.The phase voltage peak value of the three-phase balanced power grid is 160V, the reactor inductance of the photovoltaic grid-connected inverter output is 15mH, the equivalent system internal resistance is 0.2 ohm, the bus capacitor capacitance is 2200μF, and the Ra is 20.In the Matlab environment, the simulation model is built according to the above parameters, and the maximum power output control strategy of the PV grid-connected inverter is simulated and verified. From the perspective of the output current, active power, reactive power, and grid AC voltage variation of the simulation structure, the inverter's maximum power control strategy can meet the requirements of grid power factor, output current sine, etc., and the active power is stable. Maintaining the maximum power output, the average value of the control reactive power is 0, indicating a better dynamic tracking effect on the maximum power of the photovoltaic array.

5.2. Physical test

In the process of constructing the physical test platform, PV arrays, inverters, isolation transformers and other devices are mainly used, wherein the PV arrays are simulated by a programmable controller, which can realize the function of the photovoltaic array, thereby replacing the photovoltaic array. The inverter used includes an IPM module, a DSP device, etc., and the hardware system is divided into a main circuit and a control circuit. Among them, the main circuit mainly includes voltage and current sensors, bus capacitors, IPM modules, filter circuits, and the like. The control circuit includes a DSP chip, a drive circuit, and a protection circuit. In the course of the test, in order to study the performance of the photovoltaic grid-connected inverter, it is necessary to carry out simulation tests at different maximum power points. The control light intensity varies from 100 to 1000 W/m2, and the control environment temperature varies from 5 °C to 60 °C. When the light intensity and ambient temperature change within this range, the maximum power point will also change, which will cause changes in the grid current and power. The performance of photovoltaic grid-connected inverters can be verified by observing the grid voltage, current and harmonic distribution at different maximum power points. From the simulation results, at different maximum power points, the inverter output power can achieve dynamic tracking of Pmax, ensuring maximum power transmission. In this case, the power factor of the grid is 1, which can meet the power quality requirements of the grid. Under the above control model, the inverter can ensure good performance, and it can be dynamically adjusted by using the method of injection damping, which has better practical use effect than the existing control strategy.

5.3. Discussion of results

From the above research situation, the maximum output power of the photovoltaic grid-connected inverter is determined according to the maximum power point of the photovoltaic array, and then the el power model and the passive control theory are adopted, and the maximum power of the photovoltaic array is realized by the method of injection damping. Dynamic tracking can effectively improve inverter performance and improve grid operation quality. Compared with the existing inverter control strategy, the main advantages of the maximum power output control strategy of the PV grid-connected inverter are strong dynamics, fast speed, and stable control results. This inverter control strategy is easy to implement and debug, and can be widely used in photovoltaic grid-connected. The linear and nonlinear inverter control strategies used in the past have certain harmonic suppression effects, but they do not fundamentally solve the inverter control problem. By adopting passive control theory, the shortcomings of the traditional control strategy can be compensated. Improve inverter dynamic and static performance and parameter robustness. Only the real maximum power transmission control can reduce the unnecessary energy waste and the negative impact on the grid operation during the photovoltaic grid connection process. In general, the maximum power output control strategy proposed in this study has been verified by simulation, and it has high feasibility and wide application range. It can be applied in photovoltaic grid-connected projects.

6. Conclusion

In summary, the maximum power control strategy of the inverter using the el power model can dynamically track the maximum power of the photovoltaic matrix to ensure that the power factor and harmonics of the grid meet the requirements. The advantage of this control strategy is that the inverter has high performance level and is easy to debug. It has strong applicability in photovoltaic grid-connected projects and is beneficial to improve the quality of photovoltaic grid-connected power supply.

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