The Suppression and Influence of Photovoltaic Power Grid on Power Grid Harmonics

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Abstract: In recent years, China's demand for electrical energy has been increasing, and power grid construction is increasing.Based on the principle of photovoltaic power generation and its mathematical model, this paper analyzes and studies the circuit model of photovoltaic inverter with LCLfilter, and sets reasonable parameters according to the derivation formula of filter parameters.Aiming at the resonance problem of LCLtype photovoltaic grid-connected inverter, the damping control strategy of capacitor branch series resistor is selected.Finally, simulations were carried out with MATLAB/simulink, and they were verified to have good resonance suppression effects from the grid-connected current and voltage waveform quality.

1. Introduction

Grid-connected PV inverters enable energy interaction between solar panels and the grid, but their output currents often contain large amounts of harmonics.Therefore, how to optimize the grid-connected current of photovoltaic inverters becomes a key issue in photovoltaic power generation systems.The low-voltage distribution network at the interface of the distributed photovoltaic power generation system often contains low-order harmonics. These background harmonics of the power grid will introduce harmonics of the same frequency to the output current of the grid-connected inverter, Seriously affected the power quality of the grid-connected inverter output.

Distributed photovoltaic power generationThe impact of grid connection on the power quality of the public grid is mainly reflected in the following points:

(1) It has an impact on the system voltage of the public power grid.Output PowerChanges with natural factors such as sunshine, weather, season, temperature, etc.Output PowerUnstable, especiallyOutput PowerLarge changes can cause system access pointsVoltage fluctuations and flicker.

(2) Generate harmonics. The photovoltaic power generation system passesPhotovoltaic moduleConverting solar energy into DC power and then converting it to AC power through an inverter will generate a large number of harmonics during the conversion process. Therefore, real-time monitoring of harmonics is required during grid connection. Install filter and other corresponding measures.

(3) Reactive powerThe power factor of photovoltaic power generation is relatively high, generally around 0.98, which is basically active output, in order to meet the principles of hierarchical partitioning and balancing of reactive power compensation,Photovoltaic power stationShould be configured accordinglyReactive power compensation deviceTo meet the grid's demand for reactive power.

(4) Photovoltaic power generation passedPower ElectronicsThe inverter is connected to the grid, which easily causes three-phase current imbalance.

(5) When a fault occurs on the photovoltaic power generation system line, it is easy to affect the power gridRelay protectionAnd reclosing action.

Since the grid connection of photovoltaic power generation has an important impact on the power quality of public grids, national regulationsPhotovoltaic power stationOn-line power quality monitoring devices must be used at grid-connected sites for long-term monitoring of power quality. As photovoltaic power quality has certain national standards, online power quality monitoring devices that comply with photovoltaic standards are only a few manufacturers, Zhiyuan Electronics e8000 online power quality Monitoring devices are used more in the industry and their recognition is relatively high.

2. Harmonics Generated by Power Electronic Systems and Power Sources Themselves

(1) The three-phase winding of the generator is difficult to achieve complete symmetry in the winding process.(2) The core should be completely uniform in size, and it is also a very difficult structural and manufacturing factor.The above two factors make the fundamental wave u and harmonic e of the power electronic system appear at the same time, but the value is very small, which is often neglected when studying the harmonic problem of the power electronic system.The harmonics generated by the transformer are the main factors in the transmission and distribution system. Because the iron core is a nonlinear device when it is saturated, it is a nonlinear magnetization curve, and the saturation degree and the waveform distortion become proportional. The economic design is generally considered economically. In the near-saturated region, the magnetization line is in the working area, and thus there is a harmonic i.Even if harmonics are generated in the transmission and distribution equipment and power supply, the harmonics appearing in these two aspects are often a small proportion.

Harmonics are sine wave components whose frequency is an integer multiple of the fundamental frequency, but harmonics also have hazards, which are easy to cause harm to generators, motors, power grids, etc. Let us introduce the dangers of harmonics.

(1) For rotating generators and motors, due to harmonic currents or harmonic voltages, additional losses are generated in the stator windings, rotor circuits and cores, thereby reducing the efficiency of power generation, transmission and power equipment. More serious is Harmonic oscillations can easily cause oscillating torque of the turbine generator, which may cause mechanical resonance, cause distortion of the turbine blades and cause fatigue damage.

(2) Harmonic voltage can make the sine wave sharper in many cases, which not only leads to increased hysteresis and eddy current loss of electrical equipment such as motors, transformers, capacitors, etc., but also increases the electrical stress experienced by insulating materials. It can increase the copper loss of the transformer, so motors and transformers will generate local overheating, increased vibration and noise, and increased temperature rise under severe harmonic loads, thereby accelerating insulation aging, shortening the life of electrical equipment such as transformers, and increasing waste Precious energy and reduced power supply reliability.

(3) due to motor, transformer,electric powerLoads such as capacitors and cables are subject to frequent changes.It is very easy to form series or parallel resonance conditions with a large number

of harmonic sources contained in the power grid, forming harmonic oscillations, generating overvoltages or overcurrents, and endangering loads such as motors and transformers. The safe operation of the power system has caused transmission and distribution accidents.

(4) Grid harmonics will cause errors in measuring instruments and metering devices, failing to reach the correct indication and metering. When the circuit breaker opens a current with a high harmonic content, the circuit breaker's breaking capacity will be greatly reduced, causing an arc to reignite, A short circuit occurs, and even the circuit breaker explodes.

(5) In addition, due to the existence of harmonics, it is easy to cause various types of protection and automatic devices of the power grid to malfunction or refuse to move and generate audio interference in the communication system.In serious cases, it will threaten communication equipment and personal safety.

3. Modeling of Grid-Connected Photovoltaic Power Plants

In the environment of the power system integrated analysis software ETAP, the simulation model is built.The literature outlines the features and features of the advanced power system simulation software ETAP.The literature proposes two equivalent methods in ETAP. The models built are different due to the different data measurement points.As shown in Figure 1, two equivalent models of solar photovoltaic cells are integrated into the grid after passing through inverters and transformers.If the data is measured before the transformer, it is necessary to add a step-up transformer between the equivalent grid of the photovoltaic power plant and the busbar that is integrated into the grid when the model is built.However, at this time, it is necessary to consider the transformer loss and the harmonics generated by it; if the entire power generation, inverter, and boost, that is, the entire photovoltaic power plant as a whole, only need to measure the data measured by the access bus bus, without considering the transformer loss. Other data errors can be reduced in the simulation, which is more accurate for the entire substation.The data parameters required for the equivalent grid model of the PV power plant are ratedkV, mode, SCRating, harmonic.

4. Harmonic Influence and Suppression

Photovoltaic power generation and grid connection will generate harmonic interference.Therefore, starting from the needs of the photovoltaic grid-connected system, a filter is set therein, which can make the incoming current meet the actual needs, and also effectively control the thd in the output voltage of the inverter. Figure 1 shows the topology of the LCL type photovoltaic grid-connected system.

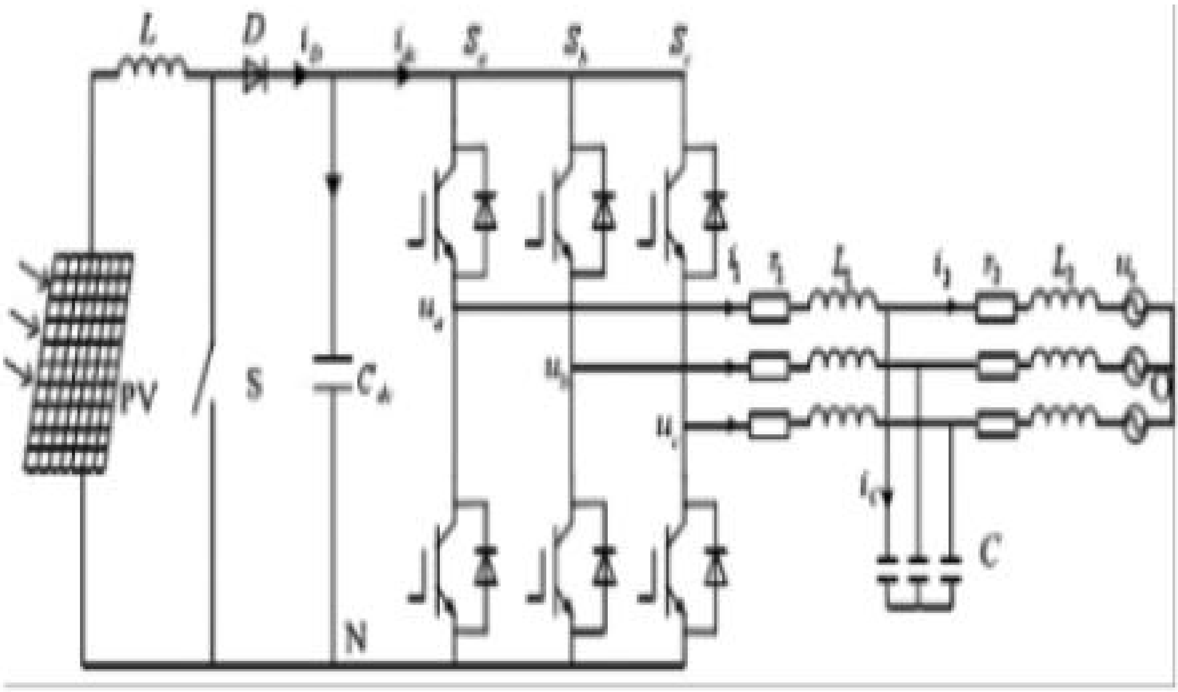

Figure 1: The topology of the LCL type photovoltaic grid-connected system.

5. Electrical Structure of Photovoltaic System

The main components of photovoltaic power station system: solar cell module, DC combiner box, inverter, step-up transformer.A solar photovoltaic cell is a power generation device that converts solar energy that is irradiated onto a semiconductor material into electrical energy.The principle is that the inverter converts the direct current output from the square array into alternating current with the same voltage and frequency as the grid power, and also plays the role of regulating the power.Depending on the number of phases of the inverter bridge, the number of stages of inverter power conversion, and the input and output modes, they can be divided into different types.In the photovoltaic power generation grid-connected system, the solar radiation energy received by the solar cell module is output to the grid through the DC combiner box, the inverter, and the step-up transformer, and the sinusoidal alternating current of the same frequency and the same phase of the grid voltage is directly or Connect to the grid through a transformer.A photovoltaic inverter composed of a large number of power electronic components, the harmonic generated during the inverter, is the main harmonic source of the photovoltaic power plant.

6. Analysis Method of Harmonics in Power Grid

The analysis method and technical detection of harmonics in the power grid is an all-round analysis of the harmonic problems of electronic power systems in the power grid, such as the detection of harmonics of electronic power systems in electronic power grids, the analysis of harmonic sources of electronic power systems, and the harmonics of electronic power systems. Suppression, analysis of electronic power system distortion waveforms, etc., and the detection of harmonics in electronic power systems is an important aspect.However, random factors, non-stationarity, distribution and other factors may cause harmonics of the electronic power system. If accurate and immediate detection of harmonics in electronic power systems is not a very simple matter, so, with the world With the rapid progress of AC power systems, various harmonic detection methods have sprung up, such as frequency domain analysis based on Fourier transform, analog filter detection method, and detection method based on instantaneous reactive power theory.At present, the application analysis of wavelet analysis in harmonic detection mainly has the following advantages:(1) Multi-resolution analysis based on wavelet transform is to decompose electromagnetic signals into many low-frequency bands of f-blocks and then use them as fundamental components and different harmonics f high, using software to analyze harmonic changes.(2) Using the time-varying harmonic tracking method of wavelet transform and a=y-b×x fusion with Kalman filter, the time-varying amplitude of different kinds of harmonics is projected into the subspace of orthogonal wavelet base. Then a = y-b×x guess its wavelet coefficient, the time-varying harmonic amplitude guessing situation into a constant coefficient guess, and finally form the fastest speed tracking.(3) The wavelet packet of the wavelet transform allows him to divide the f space into finer parts, so that the higher harmonics in the electronic power system are projected to many places, which will produce the characteristics of f high and singular higher harmonic signals. Analyze the harmonics.(4) Using orthogonal wavelet decomposition, each of the original signals is observed to decompose different results, and the detected harmonic signals of different components are obtained, and the result is fast tracking.The theory and application analysis of wavelet transform is still not perfect, mainly because the harmonic measurement side needs to be continuously improved, and the practical application in the field needs to be further improved.Since the development of artificial neural network system technology, the most popular is the detection method based on neural network system, and with the development of electronic power neural network system, it is also widely used in electronic power system, like load. Predictive and harmonic detection as well as optimized scheduling and prediction, and achieved great results in the application of power electronic system engineering technology.Models, sample selection and algorithm determination are used in many cases. The neural network system is used to detect harmonics and iq. The periodic and non-periodic I have fast and stable detection. Tracking ability, there will be better ability to identify the random effects of f high.

7. Simulation Model

See Figure 2 and Figure 3 below.Under the control of the grid connection without damping control, the current and voltage glitch between the two phases a and b are more, and the distortion is obvious. After the passive damping adjustment, the waveform burr is reduced and smoother.Resonance can cause waveform distortion, and passive damping adjustment strategies can effectively reduce this phenomenon.

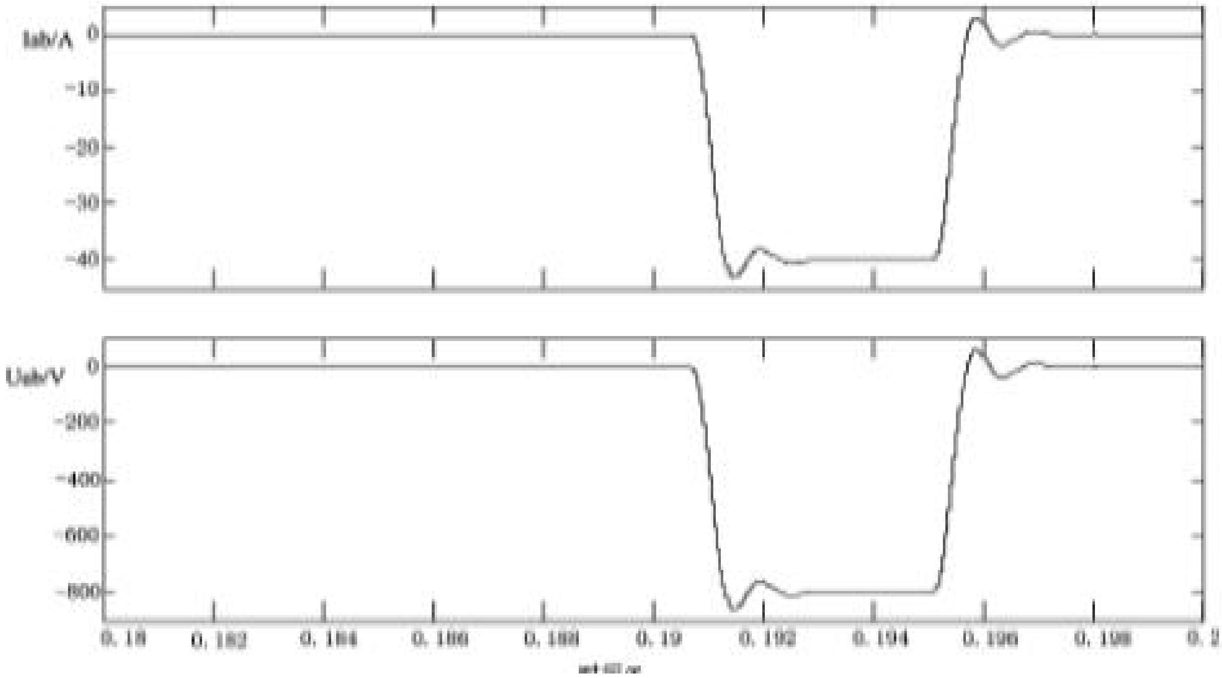

Figure 2: Under the control of the grid connection without damping control.

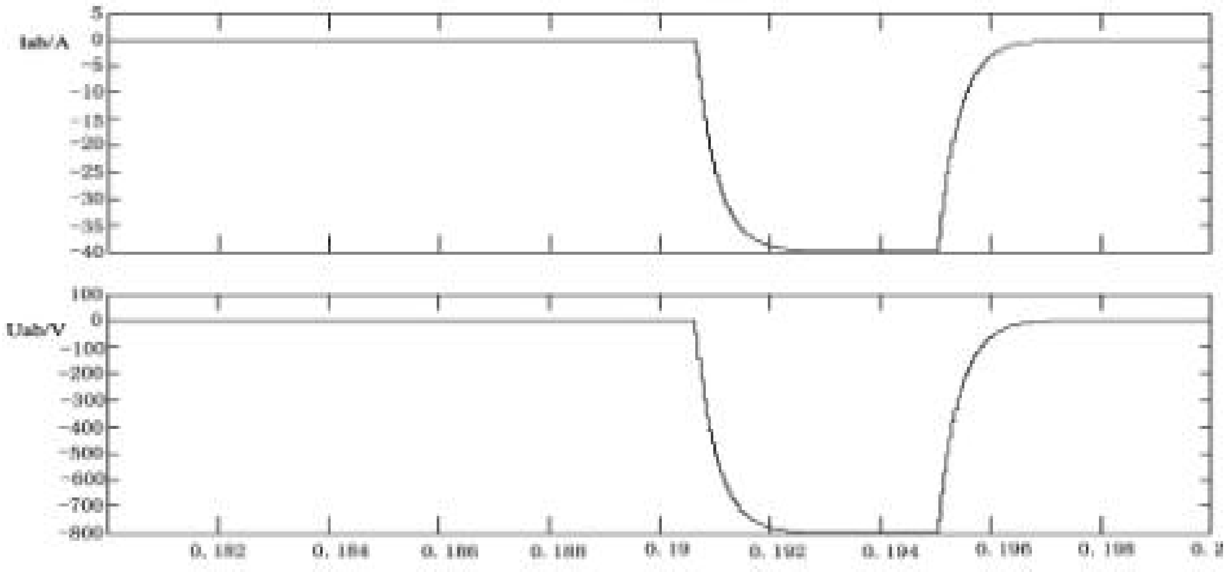

Figure 3: The waveform burr after the passive damping adjustment.

8. Conclusion

In summary, in a power grid with multiple photovoltaic power plants, in the face of such complex problems, it is recommended that in the initial stage of power system planning, the harmonic wave current should be affected by the equipment in the event of harmonic pollution. Calculations provide a theoretical basis for suppressing harmonic pollution.Using this idea, if a new power plant or substation is built in the system, you can use etap to perform harmonic evaluation, understand the harmonic status of the system, change the construction plan, and take effective measures to reduce the degree of harmonic distortion in the system and improve Power Quality.

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