Research on Statcom Current Detection Method and Control Technology Based on Instantaneous Reactive Power Theory

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Abstract: The increase and decrease of non-linear load and impact load of power grid lead to lower and lower power quality, which has become a hot issue in reactive power compensation and harmonic suppression technology research. As one of the AC output equipments, the static synchronous compensator has strong compensation performance and can provide technical support for no power compensation. Therefore, based on the theory of instantaneous reactive power, the current detection method and related control technology of the static synchronous compensator are proposed, and finally the experimental simulation is carried out. The simulation results show that the improved detection algorithm can detect the reactive current of the system efficiently and accurately. Using STATCOM current detection method and control technology, it can adjust reactive power in time, compensate for actual power demand, further suppress system voltage fluctuations and improve system performance.

1. RESEARCH BACKGROUND

1.1 Literature review
To build a smart grid to meet the power needs of different users, it is necessary to reduce the negative impact of power quality disturbances on users. At present, with the continuous development of power technology, the influx of a large number of non-linear electrical equipment brings voltage drop and under voltage to the grid\cite{1}. At the same time, the digitization of electrical equipment is more sensitive to power quality requirements. In order to better apply the power active filter technology to power, some scholars have established an optimal mathematical model. From the moment of no power, instantaneous active current, the instantaneous total energy of the three phases is guaranteed to be constant, and the minimum current of the three-phase transmission is reduced. The voltage and current transients change from a, b, c three-phase to αβ0 three-phase orthogonal transformation\cite{2}. This shows that the harmonic detection and reactive power compensation strategy should not be used when the voltage of the three-phase three-wire system is distorted. Some scholars believe that with the continuous development of power technology, the application of various nonlinear devices in the fields of industry, transportation, and home is gradually expanding, and various hazards caused by harmonics are gradually expanding\cite{3}. At this time, the use of power electronic devices to suppress the hazards of harmonics has become a new trend of development. Wherein, the active power filter detects the harmonic current from the compensation object. Although there are many current detection methods for active power filters, these methods have yet to be upgraded\cite{4}. Some scholars believe that the increase in the life cycle of power electronic equipment has led to an increase in harmonic hazards in power systems. Optimization by active power filters is considered an effective method to improve power quality\cite{5}. Others believe that the voltage fluctuation acts as a power frequency voltage carrier, and its peak value is modulated by the
voltage fluctuation component amplitude modulation wave. Based on the instantaneous power of three-phase circuits, the author deduces the process of obtaining amplitude-modulated waves from voltage fluctuation signals. The instantaneous and non-power detection method is used to simulate and calculate the voltage fluctuation detection. The results show that the instantaneous reactive power voltage fluctuation detection method is close to the true value [6].

In summary, the current hazards and solutions for power fluctuations are more realistic, but lack specific current detection methods and control techniques. This paper will establish the STATCOM current detection method and control technology from the theory of instantaneous reactive power, in order to obtain a better solution.

1.2 Purposes of research

In the process of building a smart grid, suppressing harmonics and reactive power compensation is a key issue, and it is also the focus of this paper. In the case of no harmonic guidance, reactive power is set and applied using conventional power. However, in the case of harmonics, the definition of reactive power is closely related to harmonics, which affects the power factor and power of the grid. In general, various power electronic devices have low power factor and will consume a large amount of reactive power, which is not conducive to the efficient use of electrical energy. In view of this, this paper will use the instantaneous reactive power theory, using STATCOM current detection method and control technology to solve the above problems.

2. THEORETICAL ANALYSIS OF INSTANTANEOUS REACTIVE POWER

With the increasing speed of industrial power development, multi-resistance load and power electronic devices have been widely used. A large amount of high power is continuously generated in the power grid, which reduces the power factor and imposes a heavy burden. Among them, the static var compensator (STATCOM) can continuously adjust the reactive power to meet the actual needs of the power distribution system, which is of great significance for effectively improving power quality and saving energy [7]. At present, STATCOM has a good application effect in high pressure and large capacity. The reactive power and active power in the traditional theory are defined in the mean value. These variables are only applicable when U and I are both sinusoidal. Instantaneous active power or instantaneous reactive power is defined on an instantaneous basis and can be applied not only to non-sinusoidal or transient processes, but also to sinusoidal waves [8]. Therefore, the application of instantaneous reactive power is wider.

Generally, in residential electricity and industrial electricity, the proportion of resistive load is large. For example, transformers, fluorescent lamps, electric motors, etc. are all resistive loads, and the reactive power required for induction motors and transformers accounts for the majority of the ratio provided by the power system. In particular, some electronic devices, such as phase-controlled AC power adjustment circuits and cycle converters, consume a large amount of reactive power. In industrial electric arc furnaces, reactive power consumption is large. In addition, transformers and other electrical components can generate a lot of harmonic pollution, which has certain adverse effects.

3. DESIGN OF STATCOM CURRENT CONTROL SYSTEM

It can be seen from the detection method of reactive harmonic current that after the current component detected in the load current, the tracking control of compensation current needs to be realized, that is to say, the output current of STATCOM can supplement the current change well. By properly adjusting the AC phase of bridge circuit, the reactive power absorbed by STATCOM can be changed and the reactive power can be tracked and compensated. At this time, it can be discussed whether to directly control the output current of STATCOM.

3.1 STATCOM current detection based on instantaneous reactive power theory

Generally speaking, reactive current detection and DC side voltage control are important factors that have compensatory effects on STATCOM, especially the reactive current detection method used in
STATCOM, which will directly affect the compensation effect of the compensator. When the DC side voltage of STATCOM is controlled to an appropriate value, good supplementary performance can be guaranteed. If the DC side voltage fluctuates too much, compensation or undervoltage will directly affect the safe operation of the system. At present, most of the industrial, commercial and household use harmonic current detection method, which is based on the theoretical detection method of instantaneous reactive power. When this method is applied to three-phase circuits, a unit cosine wave with a phase difference of 90 ° is needed. Although the three-phase four wire system is adopted in this experiment, each phase is independent of each other, which is regarded as single-phase structure control. Therefore, reactive current separation method can be used for design.

Suppose the power supply voltage is pure sine wave, its formula is expressed as $u_s(t) = U_{sm} \sin \omega t = U_{sm} \sin 2\pi ft$. Among them, $U_{sm}$ is the amplitude of the grid voltage, $f$ is the voltage frequency, 50Hz is used here.

Further assuming that the load current with non sinusoidal distortion is transformed by means of Fourier series theory, it can be expressed as follows,

$$i(t) = I_{pm} \sin \omega t + I_{qam} \cos \omega t + \sum_{n=2}^{\infty} I_{nvm} \sin(n\omega t + \phi_n)$$

In the formula, $i_p(t)$, $i_q(t)$, $i_n(t)$ are the fundamental active / reactive components and all the higher harmonic components. Upper middle, $I_{qam}$ multiplied by $I_{pm}$, the reactive current component needed by the compensator can be obtained.

3.2 Control strategy

According to the analysis of STATCOM theory, the control strategy is usually divided into traditional PID control, internal structure control and intelligent control. Among them, the intelligent control includes nonlinear robust control, space vector control and so on. But in engineering, life, industry and so on, PID control is mainly used. Generally, PWM converter and DPC structure are used to effectively control STATCOM mode, as shown in Figure 1. As can be seen from the figure, the control system is divided into three parts: the external voltage module, the instantaneous power solving module and the internal power ring module. In these blocks, the instantaneous power solution module mainly studies the calculation method of instantaneous power; in the process of voltage outer ring plate research, its content mainly focuses on the design of outer ring controller, in addition to the traditional PID controller, there are also fuzzy controllers, etc.; in the power inner ring module block, DPC control is modified according to the control needs, or the DPC vector selection table is improved, at the same time According to the fact that the switching frequency of DPC is not fixed, some scholars put forward various DPC control schemes to stabilize the switching frequency.
4. RESEARCH ON STATCOM SIMULATION BASED ON INSTANTANEOUS REACTIVE POWER THEORY

In order to analyze the effect of system modeling and dynamic simulation, we need to use Simulink software and MATLAB software. Simulink software supports linear and nonlinear systems and can model in discrete, continuous or mixed time periods. In order to verify the accuracy of the current detection algorithm and the authenticity of the corresponding control strategy, the simulation model of the synchronous compensation device is designed by using MATLAB and its supporting software kit. Among them, the current detection algorithm of STATCOM based on instantaneous reactive power theory is that the current control strategy is based on direct current control. Before that, some Butler parameters of reactive power compensation are determined to provide ideas for simulation experiments.

4.1 Preparation in advance

In the whole simulation system, STATCOM involves reactive power detection, power supply and load, PWM signal generation and other circuit parts. The power module adopts Simpower Systems three-phase AC power supply to simulate the operation grid environment, with parameters of 380V and 50Hz. In the aspect of reactive power detection module, traditional \( i_p - i_q \) detection method is used to detect harmonic and reactive current. During the simulation, the PWM signal module generates the pulse signal of STATCOM system, which is controlled by hysteresis and triangle wave. When designing the main circuit of STATCOM, the inverter uses the universal bridge module and sets the parameters as PWM inverter.

4.2 Simulation operation and result analysis

In order to verify the correctness of the above detection algorithm and control strategy, the harmonic and reactive power compensation ability is simulated. The simulation mode can be in the form of linear and non-linear load, or in case of sudden change. The simulation results of linear load are analyzed and the following results are obtained. The voltage parameter is 220V, 50Hz. The current side voltage setting is 1000V. DC side capacitance \( C \) is 5 μF. The connection reactor \( L \) is 2KHz. When \( t = 0.08 \)s, the simulation experiment of STATCOM is needed.

In conclusion, the improved detection algorithm can effectively and accurately detect the reactive current of the system, and provide accurate command current for STATCOM. With the above current detection method and control technology, STATCOM can adjust the reactive power in time, compensate the actual power demand, further restrain the system voltage fluctuation and improve the system.
performance.

5. CONCLUSION
In summary, in the process of using electric energy, the key real-time technology of effective reactive power compensation is harmonic and reactive current detection and its control technology. Whether the reactive component of the current applied compensation can be accurately measured and whether the dynamic tracking belief is perfect has a great influence on the reactive power compensation device. Focusing on the research of STATCOM system detection and control methods, the effective improvement of reactive current and compensation current control technology is the focus of current research. By analyzing the advantages and disadvantages of current harmonic and reactive current detection, an improved detection algorithm with low homology filtering is proposed. In this paper, MATLAB is used to simulate the voltage, and the conclusion that this detection method has good real-time performance has good development prospects.

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