Research on Harmonic Suppression and Reactive Power Compensation of APF and SVG Based on Computer Support

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Abstract. With the application of intelligent electronic components in power grid, the problem of harmonic pollution is further aggravated. The power supply level of power grid is affected, and it will bring extra burden to the whole power grid system. APF and SVG have outstanding performance advantages in the aspects of timely response and continuous adjustment, which make them become the research value in the process of power grid compensation and harmonic suppression. Based on this, this paper first analyzes the concept and definition of harmonic and reactive power, and then studies the harmonic suppression and reactive power compensation of APF and SVG.

Keywords: APF, SVG, Reactive Power Compensation (RPC), Harmonic Suppression

1. Introduction

With the iterative development of computer tech, it has made a more in-depth application and development in all walks of life, especially in the power industry, which greatly optimizes the stable operation of the power grid system [1]. On the other hand, the progress of science and tech makes the process of power production and transportation constantly optimized and adjusted. For example, the application of distributed generation tech in distribution network system further ensures the stable operation of power grid system. However, there are still many deficiencies in distributed generation system, which is manifested in the limitation of its auxiliary role, which leads to its advantages of high energy saving and low pollution.

At the same time, power semiconductor as the representative of the continuous progress of component tech, greatly enhance the upgrading of power conversion tech. The application and operation of more intelligent electronic tech in the power grid system makes the process of electric energy in several aspects as shown in Figure 1 to be further optimized. This not only further improves the security and constancy of the power grid system, but also promotes the transmission and use efficiency of the power grid greatly, and improves the level of power.
However, the application of more and more electronic components in the power grid system, in addition to bringing the above significant advantages, also makes the problem of harmonic pollution in the power grid further intensified [2]. Electronic components also have lower power factor, which will affect the power supply level of the power grid, and will cause extra burden on the whole power grid system. In this context, it is necessary to eliminate harmonic pollution of power grid system and realize dynamic tracking compensation to improve power factor. APF and SVG have outstanding performance advantages in the aspects of timely response and continuous adjustment, which make them play an increasingly important role in the process of power grid compensation and harmonic suppression.

In addition, the working principle of APF and SVG is similar, which can enhance the nonlinear function of power grid operation control. Among them, APF has gradually become the main means of harmonic control because of its dynamic accurate compensation for harmonic combination. SVG can realize fast dynamic regulation, quickly and accurately absorb or send out the required reactive power. Therefore, it plays an important role in maintaining grid voltage, reducing power system loss, improving power system constancy and power level. But the control process of them is more complex, and it is divided into signal detection, constancy control and bottom drive control. Therefore, it is of great practical value to study harmonic suppression and Reactive Power Compensation (RPC) based on APF and SVG supported by computer.

2. Concept and definition of harmonic and reactive power in power grid

2.1. Definition and classification of reactive power
There is a reversible energy exchange between the power supply energy and the magnetic field energy in the inductive load coil or the electric field energy in the capacitive load capacitor, and the power grid capacity occupied is called reactive power [3]. In a sinusoidal circuit, the power factor is determined by the phase angle difference between voltage and current. The classification of reactive power includes inductive reactive power, capacitive reactive power, fundamental reactive power and harmonic reactive power. Reactive power will increase the capacity of equipment, resulting in the increase of current and apparent power, which will increase the capacity of electrical equipment, conductor and line loss. In addition, it will increase the line voltage drop, make the voltage fluctuate violently, and reduce the level of power supply seriously.

2.2. Concept and harm of harmonic
A component whose frequency is an integral multiple of fundamental frequency is called harmonic, and its order is the integral ratio of harmonic frequency and fundamental frequency. Harmonic will lead to additional harmonic loss of components in the power grid, thus reducing the efficiency of power generation, transmission and electrical equipment [4]. When a large number of third harmonic current flows through the neutral line, the line will overheat and affect the normal operation of all
kinds of electrical equipment. In addition, the harmonic will cause local parallel resonance and series resonance in the public power grid, which will amplify the harmonic, cause the relay protection and automatic device misoperation, and make the electrical measuring instrument inaccurate, and interfere with the communication line.

2.3. Function and method of RPC
RPC improves the power factor of power supply system and load, reduces equipment capacity and power loss. It can stabilize the voltage of receiving end and power grid and improve the level of power supply. Through appropriate RPC, the synchronous generator can operate under the leading power factor, and output active power and reactive power at the same time [5]. Static var compensation device has the function of condenser. In addition, according to the dynamic reactive power in the power grid, the fast dynamic compensation of reactive power in power system can realize the power factor correction of dynamic reactive load, improve the voltage regulation rate, and improve the static and dynamic constancy of power system. It can also reduce overvoltage, voltage flicker, damp subsynchronous oscillation and less unbalance of voltage and current. Several main forms of RPC are shown in Table 1.

Table 1. The application performance advantages of this material.

| MSC / MSR | SVC | SVG |
|-----------|-----|-----|
| Mechanical switch | Thyristor valve | Control and protection |
| AC capacitor bank | Control and protection | GTO/IGBT/IGCT valve |
| AC reactor | AC reactor | DC capacitor |
| 52 ≤ kV ≤ 800 | 52 ≤ kV ≤ 800 | 52 ≤ kV ≤ 800 |
| 50 ≤ Mvar ≤ 500 | 50 ≤ Mvar ≤ 800 | 50 ≤ Mvar ≤ 500 |

3. Harmonic suppression and RPC of APF and SVG

3.1. SVG RPC device
SVG is composed of chain type static synchronous compensator and fixed capacitor, which can be combined into active dynamic reactive power and harmonic compensation device with various compensation ranges according to their respective capacities. The SVG is different from the traditional SVC, which relies on capacitors and reactors to generate and absorb reactive power. It is based on the voltage source converter. It is equivalent to the static synchronous condenser in principle, but its performance is far better than that of the condenser and SVC. The working principle formula of SVG is shown in the following formula 1:

\[ I_1 = (U_s - U_i) + jX_L \]  \hspace{1cm} (1)

The self-commutation bridge circuit is linked in parallel with the power grid through reactance. By properly adjusting the phase and amplitude of the AC output voltage of the bridge circuit, or controlling its AC side current, the circuit can absorb or emit reactive current and realize dynamic RPC [6]. When the grid voltage drops and the voltage current feature of the compensator is adjusted downward, SVG can adjust the amplitude and phase of the AC side voltage of the converter to keep the maximum reactive current constant, which is only limited by the current capacity of its power semiconductor devices. Its operation range is approximately rectangular area with equal width above and below, as shown in figure 2 below. When it is necessary to offset the harmonic current generated by the load, SVG detects the harmonic component of the load current of the offset object, and takes its reverse polarity as the instruction signal of the offset current. The offset current generated by the offset current generation circuit is equal to the harmonic component in the load current, and the direction is opposite. Therefore, the two offset each other, making the power supply current contain only fundamental wave and no harmonic.
3.2. Performance characteristics of SVG

SVG has the typical characteristics of small starting impact, continuous offset range, fast dynamic response and excellent harmonic output characteristics. Secondly, SVG has small footprint, high efficiency and super offset ability. The output current of SVG does not depend on the system voltage and has a wider operating range. Through the comprehensive control of the fixed capacitor bank, it can better meet the requirements of the system and load offset range. In addition, SVG has high reliability. Through a large number of capacitors and reactors, when the capacity of external system is comparable to that of offset device, SVC will produce inconstancy and oscillation.

SVG also has a modular circuit structure. When a power module fails, the controller will detect and send instructions to make the output of the faulty power module short circuit through the fast electronic bypass circuit, so that the device can continue to run at full load, greatly improving the reliability of the device. The fast instantaneous reactive current control strategy can realize the continuous and stable operation of the system in case of short circuit fault. The full digital controller micon has high integration and high reliability.

3.3. AFP active power filter

APF filter is to send the current with the same amplitude, same phase and opposite direction to the original harmonic current to the power grid, so that the total harmonic current flowing into the power supply is zero. The common APF can be divided into current type and voltage type. The structure in series with the line is shown in Figure 3 below. It combines the parallel passive filter and the relatively small capacity series APF. Among them, the passive filter absorbs the harmonic current generated by the nonlinear load, and APF improves the filtering performance of the passive filter. The system solves the problem of harmonic amplification caused by passive filter. In addition, compared with the traditional APF, the capacity is greatly reduced.

![Figure 3. AFP structure in series with lines.](image-url)
4. Conclusion

In summary, APF has gradually become the main means of harmonic control because of its dynamic and accurate offset of harmonic combination. SVG can realize fast dynamic regulation, quickly and accurately absorb or send out the required reactive power. Therefore, it plays an important role in maintaining grid voltage, reducing power system loss, improving power system constancy and power level. Based on the research of the concept and definition of harmonic and reactive power, this paper analyzes the definition and harm of reactive power and harmonic, the role and method of RPC. Through the analysis of harmonic suppression and RPC of APF and SVG, the characteristics, performance and application advantages of SVG RPC device are studied, as well as the principle and application advantages of APF.

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