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Application of Power Electronics in Power System

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Abstract. As the society develops, automation and intelligence is becoming the inevitable tendency of power system, and power electronics is an essential technology for modern science. Advanced power electronics can strengthen and optimize power system to ensure the stability and safety of operation and improve the power quality better. Accelerating power electronics is an important path to constructing the strong smart grid and accelerating the development of power system.

Introduction

With the science stepping forward, electric engineering is developing with an amazing speed, which has a great change to our industry status and a lot of influences on people's life style and social production, plays an important role in modernization. Power electronics which is applied in power system widely provides solid support for its development, is fountainhead and significant foundation of national economy. Power electronics is everywhere, in power system, traffic transportation, electric vehicle, led lighting etc, providing people with extreme convenience and necessary support. The paper mostly points out the application of power electronics in power system.

Development of Power Electronics

The evaluation and revolution of power electronic devices are the fundamental driving force behind the development of power electronics. In 1947, the transistor was invented by Bell laboratories in America sparked off the first revolution of PE. The thyristor was applied to many occasions rapidly, such as electrochemistry, power industry, steel and so on, out of its great electrical and control performance, and the technique was improved though the practice time after time. In the late of 1970s, fully controlled devices developed swiftly [2] which were represented by GTO (Gate-Turn-Off Thyristor) [1], BJT (Bipolar Junction Transistor), Power-MOSFET, etc. These power electronic devices were applied to high frequency circuit, and its control mode changed from phase-controlled to chop-controlled (Pulse Width Modulation), which made power electronics take on a new look. In the late of 1980s, composite devices represented by IGBT (Insulated-Gate Bipolar Transistor) thrived, improving the characteristics of former power electronics circuit. Composite devices had advantage of both Power MOSFET and BJT: smaller state voltage drop, stronger current carrying capability, higher voltage endurance, etc. Those all made a hit and were applied to our life widely. Afterwards, PIC (Power electronic integrated circuit) was born at the proper time in order to reduce the volume o f power electronic devices, which became an important direction of power electronics.

Application of Power Electronics

Power electronics is widely applied in power system, and promotes development of power system towards a more intelligent and sustainable direction. 60% of the final electric energy used in developed country is processed by power electronic converter at least one time according to the data. That is to say, power electronics contributes to the power generation, power transmission, power system harmonics control, power supply stability, etc.

Power Generation. The hydroelectric and wind power is operating dynamically due to the natural condition. Power generated by water is related to the pressure and current velocity, and power generated by wind is related to the third power of the wind velocity. We can achieve variable-speed constant-frequency excitation through the power electronic devices, that is to say, we can adjust the speed of rotor excitation current, so that when the rotor excitation current speed added with its own speed is consistent with the stator frequency, it can operate with the maximum effective power, through which improve power generation quality and power generation efficiency.

Power Transmission. Power electronics applied to High Voltage DC Transmission originally [3], as the power system develops, the demand of transmission distance and capacity was becoming tremendous, the power structure was also more complex. There would be a large cost of transmission line and facility if we still continue the usage of AC transmission. Demand makes productivity. HVDC appeared. Power energy generated by alternating-current generator is transferred to thyristor rectifier which makes current change to direct current from alternating current after stepped up by boost transform. Finally, power energy will be allocated to users after inversion and stepped down by step-down transformer. Compared to AC transmission, HVDC is more propitious to far-distance and large-capacity power energy transmission or submarine or underground cable transmission, power grid connection and system control.

Power Quality. With the constant development of technology and society, power quality leads more and more people to pay attention to. Large-scale wind power station, photovoltaic, micro grid, electric vehicle, etc, these facility's parallel operation would have some influence on power quality. The application of SVC (Static Var Compensator) in power system could improve power supply stability and power quality, control voltage flicker and compensate var according to load variation to achieve the high-quality operation. FACTS(Flexible AC Transmission System) [4] is based on power electronic devices, combined with modern control theory to control former power system key parameter and grid topology, which changes the status that relying on inaccurate facility fundamentally and improves strong control and transmission ability of system. Typical FACTS devices are SVC (Static Var Compensator), STATCOM (Static Compensator), TCPST (Thyristor Control Phase Shifter), etc [5].

It is very vital for power system to control var, through which we can stabilize grid voltage, improve power factor and power quality. Capacitor compensator is a kind of traditional var compensator, however, it can not meet the compensation need aiming at variable load, so it was replaced by superior SVC, including TCR (Thyristor Controlled Reactor), TSC (Thyristor Switched Capacitor), and a mixing device, TCR & TSC [6].

TCR is a typical application of thyristor AC voltage controller with inductive load. Single-phase basic structure is two reverse thyristor in series and then a reactor in series. Then we can adjust the current through the reactor continuously through controlling the triggering angle α, to control the var absorbed from power grid. Usually using branch control delta connection, then there is no access for third harmonics and no third harmonics.

The basic unit of TSC is the two reverse parallel thyristors to control the connection into grid or disconnection from grid of capacitor C, and a small series inductance can restrain the impulse current all the time. Effectively, the capacitors are always divided into several groups, which can make required capacitors connect into the grid aiming to different occasions. After compensation it will be disconnected from the grid. TSC switch principle is that the AC power supply voltage and the capacitor pre-charge voltage is equal at the exact moment, when the power supply voltage's change rate is zero, so the impulse current this moment is zero, which can benefit the facility in return.

Active Power Filter. There are two main methods to suppressing the power system harmonics caused by power electronic devices and other harmonic sources. One is to improve the device itself, eliminating harmonics fundamentally. The other is to detect harmonics, then install compensation devices to compensate [7]. Compared to LC passive filter, AFC (Active Power Filter) has more superior performance, it can be used to compensate for the dynamic harmonics, and the

compensation performance will not be affected by the frequency and impedance of the power grid, so it is widely used [8].

Power electronic devices can adjust the distribution of power load of power grid, enhance the grid structure and the self-healing ability of power grid in a variety of circumstances as the main control method of the system, to ensure the security, stability, reliability, economy of the operation of power system. To a certain extent, power electronics guarantee the significant role that power grid plays in the national economy. There are plenty of power electronic devices in power generation, power transmission, energy storage and other aspects [9]. Power electronics which has become a inseparable part of power system helps to improve power quality, power system performance, and promote the gradual transformation of intelligent power system [10]. The most important thing is that advanced power electronics lays substantial foundation for the long-term development of power systems in the future.

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