Research on Application of Energy Storage Technology in Microgrid

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Abstract. With the introduction and development of modern working process control technology theories, people are more convenient and flexible in controlling the working process of energy storage power generation equipment, and thus their application scope and space have also been greatly expanded and expanded. In this paper, the main technical approaches, functions and feasibility of the application of energy storage power generation equipment in the load system microgrid are extensively studied.

1. Introduction

As a perfect combination of superconducting magnetic energy storage technology and other power electronic technologies, SMES has the superior performance of low loss, fast response and high energy density that other power electronic energy storage devices cannot match. It is a superconducting magnetic energy storage device, the most outstanding and typical representative of the family. The superconducting magnetic energy storage device is one of many power electronic energy storage devices. Its energy storage system structure, model, control design method, etc. are highly representative of the world. The typical representative of magnetic energy storage devices, specifically study the practical application of superconducting magnetic energy storage technology in power electronic microgrid energy storage system.

2. Modeling of energy storage system

In the structure of superconducting magnetic principle system, the four main energy storage technologies, flywheel electronic microgrid energy storage technology, superconducting magnetic transformer energy storage technology, battery energy storage technology and super capacitor energy storage technology have the following similarities.

(a). From the perspective of principle and structure, they are all composed of four main energy storage components (whether chemical energy, magnetic energy, mechanical energy), variable flow part, control design part, etc.

(b). From the perspective of actual functions and applications, according to different uses, the microgrid can be regarded as a voltage source that can provide any voltage and any frequency, a current source of any current and frequency, and any reactive power and Active power source.
(c). In the microgrid, they are mainly used for two purposes: as a micro-power supply for sensitive loads and as an energy storage device to balance system power. Improving power quality is manifested by stabilizing voltage and adjusting frequency.

3. Application of energy storage device as micro power supply
As a micro power source, the energy storage device can be used as a controllable current source or a controllable voltage source. Regardless of the type of energy storage technology, we can use the simplified model of the energy storage power supply system for system calculation and analysis, and we can use it as a controllable AC current source or a controllable voltage source in the microgrid. Such a model fully meets the structure and technical performance requirements of the controllable micro-power source used in the micro-grid. It can be clearly seen that the balance and control of the output voltage and current of the energy storage power supply system is actually the balance and control of the output power of the energy storage power supply system. If you want to effectively output stable AC energy for a long time, the energy storage power supply system must store enough AC energy. However, the cost of energy storage power supply systems used to build large AC capacity is too high. In addition, it is not ideal to use energy storage power supply systems as a power source for AC power supply systems suitable for microgrids for a long time. This article simply demonstrates its technical advantages and feasibility. In practice, the energy storage power supply system is only used as a short-term AC power supply to maintain the AC power supply that is suitable for sensitive loads when conventional AC power systems fail.

4. Application of energy storage device as energy storage equipment
The energy storage device is a device of the microgrid energy storage system. The technical role of the energy storage power supply device is mainly to balance the power of the energy storage system and simultaneously improve the quality of AC power supply at the load end. This paper mainly studies the technical role and ways of balancing the energy storage power supply system and improving the quality of AC power supply at the sensitive load end. This is also the most important technical application and way of energy storage devices in the microgrid. Regardless of whether the converter used is a voltage-type or current-type energy storage device system, it can be completely decoupled and controlled, so that its energy storage system has independent four-quadrant active power and reactive power analysis and Adjust the control ability. In this way, the energy storage device system can completely request the micro grid power system to adjust any four-quadrant active output power and reactive power with the permission of the output load capacity. In various microgrid power systems, the energy storage device is the system that controls the power and voltage of the output load at the receiving end of the system according to the unquadrant active output frequency corresponding to the output voltage required by the system. The output uses the corresponding four-quadrant active The output power is used to control the system to change the voltage and frequency of the load on the end of the microgrid, and to improve the stability of the entire microgrid by balancing the power of the entire microgrid.

5. Research on Control Mode of Energy Storage Device
At present, there are three basic working control modes in the main control mode of the device of the energy storage system: power supply for the system load oscillator alone, and power supply for the system load oscillator in conjunction with other power generation control modes, to suppress the shock of changing the load power of the system.

(a). Separate power supply for system load oscillator
The energy storage device system supplies power to the load oscillator alone, which requires the stability of the output voltage of the system and the load frequency of the receiving end to fully meet the stability requirements of the load of the microgrid power system. Therefore, in the system power analysis, it is better to use other parallel load voltage regulation system models, as shown in Figure 1.
Due to the limited energy storage of its own power generation system, the energy storage system cannot supply power to each input load independently and continuously for a certain period of time. The task of power supply, so the way to connect with other parallel power generation systems is mainly to cooperate with the power supply for each input load, and the energy storage parallel system cooperates as a power and electrical energy regulation system to improve its power and energy system quality is its best Technology applications and methods, as shown in picture 2.

As shown in Figure 2, the energy storage system is connected in parallel to the power generation system and installed at the output of other parallel power generation systems. The power of the power generation system through each input load in the parallel voltage regulation system and the reactive current are adjusted to other parallel types. The fluctuation of the power and electrical energy of each input load in the power generation system is adjusted. The main feature is to adjust the fluctuation of each input voltage. This is also the main voltage regulation function of the parallel energy storage system. Energy storage system voltage changes and fluctuations are the most harmful to each input load, and are also the most likely causes and consequences of energy storage system failures.

6. SMES block diagram
According to the topology and structure of the high-temperature converter used in the current source type, the high-temperature SMES converter can be divided into two types: high-temperature current source type (CSC) and voltage source type (VSC). The structure is shown in Figure 3 and Figure 4.
The invention and application of CSC was earlier than the current source type VSC, and when using the current source type CSC, the superconducting energy storage coil can be regarded as a high temperature current source. Therefore, early research on high temperature SMES used CSC. However, in recent years, the research on the topological structure of VSC high temperature conversion devices has become more mature, and its manufacturing cost is relatively low, and the application prospects are better.

With the in-depth understanding and research of high-temperature converters, the topology and structure of multi-level and multiple converters have emerged. The high-temperature converters independently developed by Huazhong University of Science and Technology using high-temperature current source SMES mainly adopt multiplexed topology structures. Effectively suppress current harmonics and thereby expand the capacity of the converter.

According to the basic structure of the system SMES, various comprehensive application performances of SMES are mainly related to various comprehensive application performances of superconducting driving coils, refrigeration driving devices, converters, quench automatic protection control systems and automatic measurement and control control systems. From the analysis of superconducting strips in Chapter 21, as an energy storage system in the microgrid, from the perspective of the importance of analyzing the effectiveness of SMES superconducting strips in the microgrid, we only need to care about superconductivity Strip SMES frequency and capacity and breaking response speed. The superconducting magnet is directly wound by superconducting tape, and the breaking response performance of the superconducting tape directly affects the on-off response capability of the superconducting magnet, which indirectly affects whether its function and stability are superior. The superconducting magnet usually needs to work in the case of a higher magnetic field, so the paper fully utilizes the laboratory's own magnetic field conditions, and conducts in-depth experimental research on the breaking response performance and function of the superconducting strip under the higher magnetic field. The control platform of the superconducting strip laboratory mainly includes a sample holder, Dewar, background sensor and other magnetic field signal generation control device, current and voltage sensor and other signal acquisition control device (as shown in Figure 5), the superconducting strip is made by a company Designed and provided by American superpower company, the parameters are shown in Figure 5 and Table 1.

**Table 1. Strip width parameter**

| Strip model | Short sample length | Short sample width | Short sample thickness | Stable layer thickness | Ic (77K field) |
|-------------|---------------------|--------------------|------------------------|-----------------------|---------------|
| SCS4050     | 195mm               | 4mm                | 0.09mm                 | 0.02mm (Surrounding copper) | 121A          |
7. SMES's breaking response speed

With the progress and development of modern power and electronic technology, the successful development of high-frequency power electronic switching devices has greatly improved the capacity and breaking response speed of power electronic switches in microgrids. Due to the development of chip technology, the calculation speed and precision of single chip microcomputer are greatly strengthened. Therefore, the response speed of SMES has also been significantly improved, which can better meet the needs of microgrid. The size of SMES capacity is related to two factors, one is the capacity of the converter used, and the other is the size of the energy storage of the superconducting magnet.

(a). Converter capacity

In recent years, the increasing capacity of the converter has benefited from the progress in two aspects. One is the withstand voltage value of the controllable switch such as IGBT, and the current withstand value is increased, which increases the capacity of a single controllable switch. Second, the converter's multi-level and multiple topological structures can easily expand the capacity of the converter.

(b). Energy storage of superconducting magnet

The magnitude of the magnetic energy stored in the superconducting magnet and the inductance of the superconducting coil are related to the flow capacity of the superconducting strip. The larger the two, the more energy the superconducting magnet can store.

The flow capacity of the superconducting tape can be improved by improving the performance of the superconducting tape. With the development of science and technology, the performance of superconducting strips is becoming more and more superior. The flow capacity of the second-generation superconducting strips in high fields is 3 to 4 times that of the first-generation superconducting strips, and other conditions remain unchanged. Next, an increase in the flow capacity alone can increase the capacity of SMES by 9 to 16 times.

8. Conclusion

The control function of the distributed energy storage system quickly and independently absorbs and adjusts the active and reactive power of the system in four quadrants, which suppresses the oscillation of the system power, improves the quality of the electric energy regulation system, balances the system load, and special It is important to be able to improve the static and transient stability of the distributed system and many other functions in the energy storage control system, especially its application can greatly improve the performance of the distributed power supply, and can independently absorb and control the micro The specific power output of the grid increases the stability of the microgrid and the controllability of the microgrid. It also has broad market applications and prospects in the microgrid.
Acknowledgements
Funded by the National Key R & D Program (2018YFE0208400), the State Grid Corporation Headquarters Science and Technology Project "Re-electrification Promotion Technology Route and Application Policy" (SGFJJY00GHJS1800087).

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