Analysis of SVG Function with PV Inverter

(SA-A-20210903-001)

As the main clean energy, solar energy is widely used in photovoltaic power stations. However, because the output power of PV systems will be affected by factors such as weather and temperature, resulting in changes in the active power output to the grid connection point, the reactive power adjustment of the system is required to stabilize the voltage of the grid-connected point. During the operation of the power grid, the output power that changes over time will not only affect the stability of the power grid, but also affect the quality of electrical energy. With the increase in the application of renewable energy power generation, its impact on electric energy and the grid will become greater and greater. Therefore, it is necessary to rationally deploy reactive power compensation devices based on the actual conditions of the power station to provide reliable guarantees for the safe and stable operation of the power station and power support for the grid.

1. Reactive power trend direction of photovoltaic power station

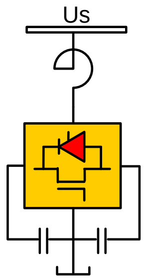
The main equipment that affects the reactive power of the ground power station is the step-up transformer, the step-up line and the line of the collection station in the power station. In the daytime, the main factors affecting the reactive power of utility power station are the reactive power loss caused by the step-up transformer and lines in the station. At this time, the photovoltaic power station absorbs reactive power from the grid. At night, the main reactive power influencing factors are the excitation reactive power of the step-up transformer in no-load operation and the capacitive reactive power on the line. At this time, the reactive power is returned to the grid in the capacitive state.

2. Introduction to existing SVG compensation schemes

At present, most photovoltaic power plants adopt the scheme of installing SVG reactive power compensation devices. Because the reactive power compensation adjustment device of SVG has smooth voltage control ability and short response time. Even in the case of undervoltage, the compensation capability is very strong, which can improve the performance of photovoltaic power plants, guarantee the quality of electric energy, and effectively improve the stability of the power grid.

2.1 SVG principle

SVG type reactive power compensation device is an active reactive power generator using IGBT. Compared with the SVC that uses large-capacity capacitors and reactors, SVG realizes the conversion of reactive energy through the switch function of power electronic devices, and can dynamically emit and absorb reactive power. The SVG power module is a bridge circuit composed of multiple IGBT components and capacitors in series and parallel connected to the grid in parallel through a reactor. The reactor can effectively suppress the harmonics generated by the SVG switching circuit, make the non-step fluctuation of the reactive power output by the SVG smoother, and prevent the current impact from malfunctioning. The schematic diagram of SVG principle is as follows:



2.2. SVG equipment composition and advantages

（1） Main equipment composition

SVG equipment is mainly composed of the linking groups of reactors (the linking groups of transformers), starting device, IGBT valve set and control system.

·Linking groups of reactors: to achieve electrical isolation, increase system reliability, and inhibit current mutations.

·Starting device: buffer the starting circuit to reduce the impact of grid connection.

·IGBT valve set: core component, for real-time power conversion.

·Control system: real-time acquisition of current and voltage signals, calculating and analyzing the reactive power and power quality.

（2） SVG advantages

SVG has been widely used in all aspects of power generation, transmission and distribution, such as new energy power generation, power systems, electrified railways, urban rail transit, airports, ports, metallurgy, chemical industries and other industries. Compared with the traditional compensation device, it has the following advantages:

·Fast response speed: SVG can effectively suppress voltage fluctuation and flicker.

·Good low-voltage characteristics: the output current is not affected by the bus voltage, and it can effectively support the bus voltage.

·Good compensation performance: two-way adjustable reactive power, can quickly adjust reactive power output, and ensure that the power factor of the assessment point meets the standard.
·The operating loss is small: Compared with the traditional compensation device, the power electronic device has high operating efficiency and low loss.
·Good harmonic characteristics: low output voltage and current harmonic distortion rate.

3. Feasibility Analysis of Inverter Replacing SVG

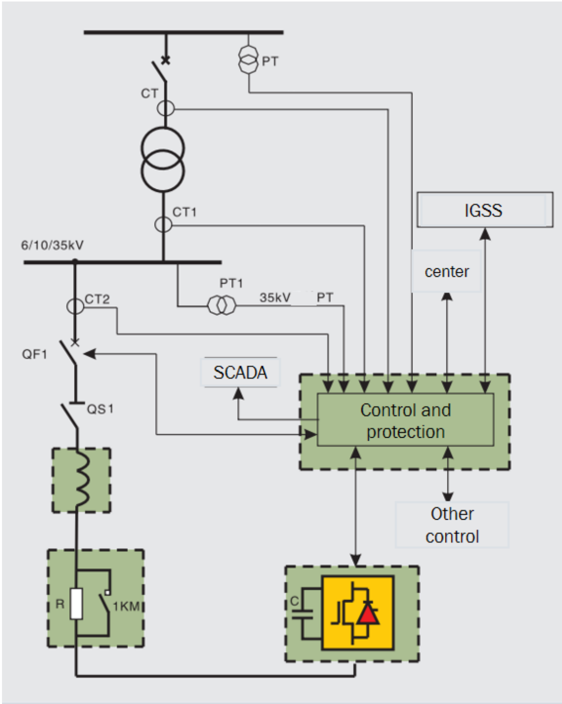
As a bridge between the photovoltaic power station and the grid, the inverter plays a key role in improving the grid-friendliness of photovoltaic power. The design of photovoltaic power station usually needs to be equipped with 20%-30% of the grid-connected capacity of the SVG dynamic reactive power compensation device for dynamic compensation adjustment of the power factor at the grid-connected point. At present, grid-connected photovoltaic inverters have a wide range of power factor adjustment and transient response capabilities. Therefore, the feasibility of replacing SVG compensation devices with inverters is analyzed as follows.

3.1 Compensation capacity comparison

According to the requirements of the reactive power compensation configuration of the PV plant design, the capacity of the reactive power compensation device is required to be 2Mvar--3Mvar. Taking a 10MW photovoltaic power station as an example, a 10MW photovoltaic power station needs to be equipped with about 45 photovoltaic inverters (HT225kW), the reactive power compensation amount of a single inverter is ±148.5kVar, and the total reactive power compensation amount of the inverter is 6682.5kVar . The inverter has a larger reactive power compensation amount and sufficient adjustment margin, which can replace SVG in terms of reactive power compensation capacity; the SVG function of the inverter also meets the requirements of the power grid for voltage dynamic response time.

3.2. Operational reliability analysis

The SVG currently used in photovoltaic power plants is a centralized adjustment and compensation device. Generally, SVG is connected at a voltage level of 10KV or 35KV, which requires a complete protection device and a reliable monitoring system. If the equipment fails or is overhauled, the SVG needs to exit operation, resulting in the photovoltaic power station being unable to adjust reactive power compensation. Compared with SVG dynamic reactive power compensation equipment, inverters are more reliable in operation. Even if a single or multiple equipment fails, it will not affect the compensation of other photovoltaic array inverters. For the power fluctuations of photovoltaic power plants affected by environmental factors, the decentralized compensation of inverters is more accurate.



3.3. Operation consumption analysis

The SVG of a large ground power station is connected to the grid by a reactor or a transformer. When the photovoltaic power is not available at night, the no-load loss of the SVG equipment itself and the reactive power loss of the photovoltaic system circuit, step-up transformer and other equipment can be regarded as a fixed value. The energy consumption of the SVG is greater than that of the inverter during standby at night. Secondly, because SVG is composed of multiple IGBT power modules in series, it generates a large amount of heat, and IGBT power modules have relatively high requirements on the surrounding environment humidity, temperature, dust, and corrosiveness. Therefore, it is necessary to configure corresponding high-power cooling and dehumidifying devices (industrial Air conditioning or water cooling), so the inverter has certain advantages in terms of energy consumption economy.

3.4. Equipment installation comparison

The installation area of SVG dynamic reactive power compensation equipment is large, and the switch outlet cabinet needs to be left in the switch station, which increases the corresponding construction investment cost and operation and maintenance cost. Compared with the SVG equipment, the inverter has the advantages of easy installation, small footprint, low failure rate and easy operation and maintenance.

3.5. Cost comparison

SVG reactive power compensation device is generally 1.1 times the overload capacity of long-term operation. The 1.1 times overload capacity has little advantage in cost savings on the DC side of the photovoltaic system, booster equipment, cables, etc. The inverter (HT225kW) has an over-matching capacity of more than 1.6 times, which has obvious advantages in saving the cost of inverter equipment procurement and AC and DC cable costs.

4. The conclusion

At present, utility PV plants and inverter manufacturers have carried out corresponding inverter tests to replace SVG, and the test results meet the assessment requirements of the grid for reactive power compensation. In the test, after the originally configured SVG device was disconnected from the grid, all the reactive power commands were executed by the photovoltaic inverter. The test results show that the inverter meets the requirements of national standards in terms of reactive power control capability, reactive power control accuracy, and grid voltage control accuracy.

Therefore, the reactive power compensation capability of the grid-connected inverter has certain advantages compared with the SVG centralized reactive power compensation device. By using grid-connected inverters to replace the SVG centralized reactive power compensation device, the investment expenditure for the procurement of SVG equipment can be reduced, while the equipment operation and maintenance costs can be saved, and the floor space in the photovoltaic booster station can be reduced. Therefore, the inverter has a very significant advantage to replace the SVG dynamic reactive power compensation device.