Primary Frequency Response in PV Power Plant

(SA-B-20220308-001)

With the gradual establishment of a new power system which renewable energy as the main source, profound changes have taken place in the power system in terms of power supply structure. Thermal power stations are still the main frequency regulation resources of the power system and undertake the most important frequency regulation work. With the rapid increase in installed capacity of renewable energy such as photovoltaic and wind power, the proportion of renewable energy is 36.6% by the year of 2020('Renewable Capacity Statistics 2021' from IRENA), but due to the volatility, intermittency and randomness of new energy, the power system is facing an urgent demand for frequency response. The normal frequency power systems is either 50Hz or 60Hz, in general, the allowance of the frequency range is ±0.2~0.5Hz. The transboundary frequency limit will have a great impact on the safe operation of the power system, and even cause the collapse of the power system.

The Technical Provisions of The Primary Frequency Regulation

Primary frequency response is mainly for the first-class load short-term rapid fluctuations, the differential control, when the grid frequency over the limit, the value exceeds the dead zone value set by the primary frequency response, automatically provide active support to ensure the frequency stability of the power system.

Primary frequency control is the fastest deployed type of frequency control. It is generally deployed within a few seconds for a duration of up to several minutes.

1. Primary frequency regulation response control parameters and strategies

(1) Fast frequency regulation response dead zone: the primary frequency response dead zone of PV power plant should be set within the range of 0.02Hz~0.06Hz, according to the needs of the local power grid to determine the specific value. This value is 0.015Hz in Great Britain.

(2) Primary frequency regulation response amplitude limit: PV power plant in accordance with not less than 10% of the rated load limit (the value can be determined according to the actual situation of each regional power grid), and shall not cause the inverter off-grid or shutdown due to the primary regulation frequency response.

(3) Regulation difference rate: 3% (the value can be determined according to the actual situation of each regional power grid). The speed droop which is the ratio of the relative change in frequency to the relative change in power output of Britain in most cases is set to 4%.

(4) High-frequency disturbance of the grid, the active power of the new energy station down to 10% of the rated load can no longer be adjusted downward.

(5) Low-frequency disturbance of the power grid, new energy power station should according to real-time operating conditions respond quickly to the frequency of the power grid, without reserving active in advance.

(6) The primary frequency response function of new energy power station is coordinated with PPC control, and the control target of the active power of a new energy power station is the algebraic sum of PPC command value and primary frequency response regulation, in which, when the new energy station is under non-load limiting condition, PPC command is calculated according to the real power generated at the moment when the frequency exceeds the dead zone. When the grid frequency exceeds 50±0.1HZ, the priority of new energy primary frequency regulation is higher than that of PPC.

(7) When there are new parameter requirements from the relevant national power management departments and local power management institution, the new parameter requirements will be implemented and the test report will be finally obtained through acceptance.

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2. A frequency regulation response performance requirements(Base on the Grid Code of the Great Britain)

As shown in Figure 1, primary frequency response is the fastest type of frequency response provided after a loss of generation. It must be released and ramped up to the required level within 10 s and then sustained for at least an additional 20 s. Once primary frequency control has stabilized the frequency, secondary frequency is implemented to start bringing the frequency back to its target value.

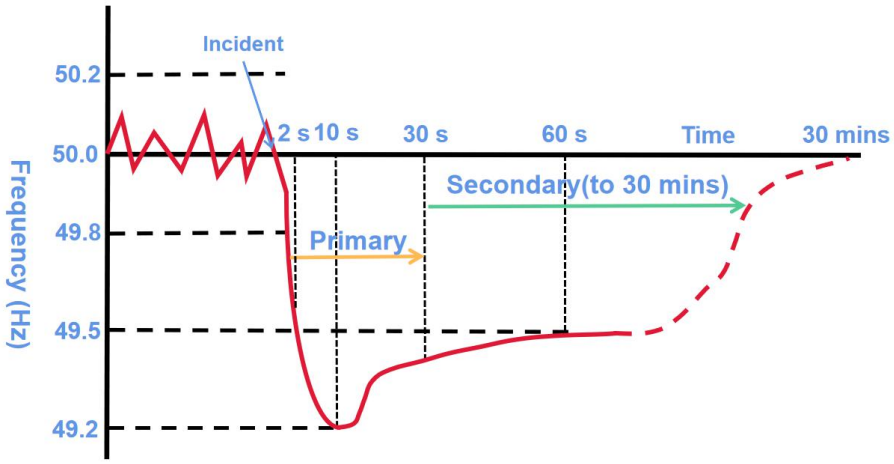

Figure 1 Primary and Secondary frequency control in Great-Britain.

Primary frequency response is the automatic response to a decrease in system frequency. PV power plants, on the other side, increase in active power output. From the grid code of National Grid(Great Britain), as shown in figure 2. Response in this category should provide their generation capability within 10 seconds of the frequency deviation. The device is required to maintain the frequency above a 0.8 Hz drop until secondary response becomes available. also, it should be sustainable for 20 seconds following initiation. Devices may supply some or all of the primary response requirement.

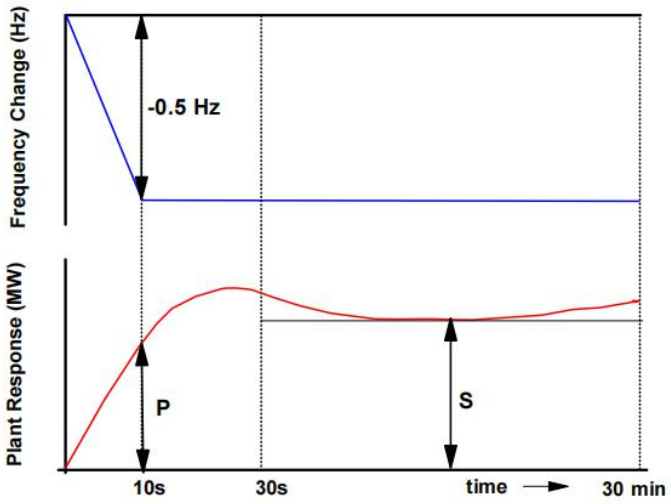

Figure 2 Interpretation of Primary and Secondary Response Values

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Different countries have different rules for frequency regulation, and even in the same country, there are differences in the rule of frequency regulation for different power grids. And the definition of primary frequency regulation varies from region to region. GoodWe inverters can meet the requirements of grid frequency regulation in China, UK, India, Europe and other countries and regions.

The Process of Primary Frequency Regulation System:

At present, the primary frequency regulation system is based on the PPC to join the fast frequency monitoring device to realize the frequency measurement and regulation function of primary frequency regulation, and its network structure is shown as follows.

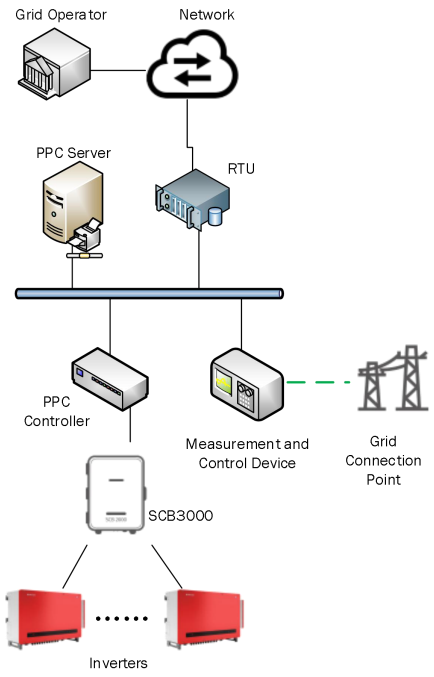

Figure 3 Network structure of primary frequency regulation

Fast frequency measurement device always measures the frequency variation and power variation value of the grid-connected point in real-time.

(2) The primary frequency regulation server (which can also be served by the PPC server) calculates the theoretical power, real power, adjustable power, and other parameters of the whole PV area in real-time.

(3) When the frequency exceeds the limit or the dispatcher issued regulation command, the primary frequency regulation control server quickly calculates the capacity to be regulated and sends it to the frequency controller, which calculates the regulation margin of each PV array according to the number of inverters and the operation status and sends the command to the data acquisition device of each PV array, and finally the data acquisition device sends the execution command of the inverter.

(4) In the regulation process, the fast frequency measurement device uploads the regulated frequency and power values to the primary frequency regulation server and the dispatcher in real-time, forming a closed-loop regulation process.

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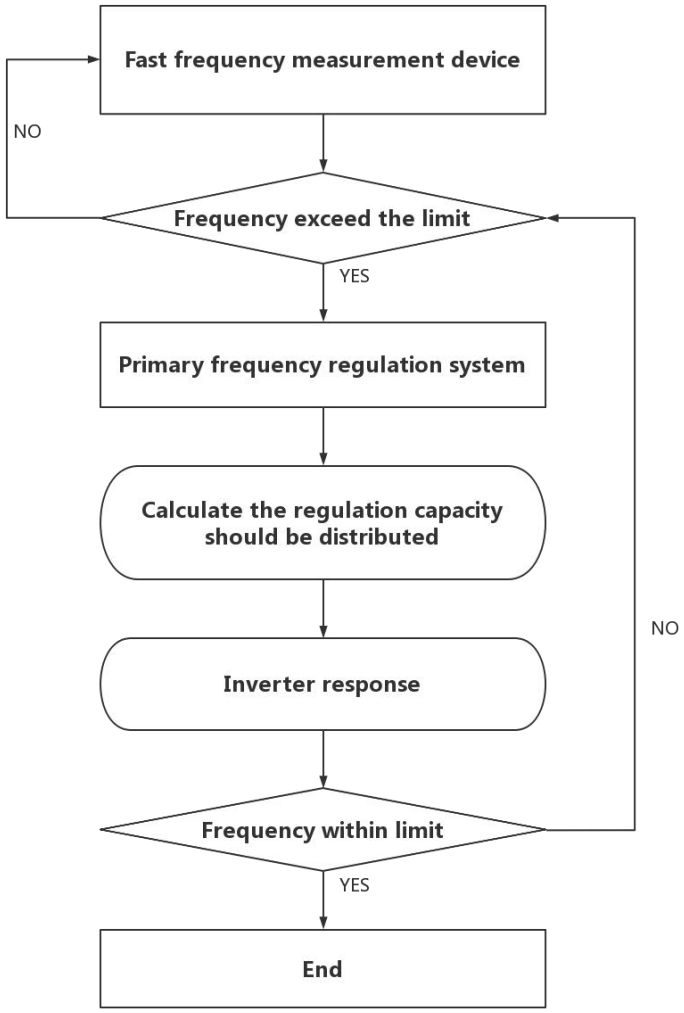

Figure 4 The process primary frequency regulation

Guarantee Measures for Primary Frequency Regulation:

Primary frequency regulation is a systematic control process, the whole process involves dispatching data network, primary frequency regulation server, power frequency controller, fast frequency measurement device, inverter, and the whole PV plant network. Any problem may lead to the failure of primary frequency regulation. Therefore, the following aspects should be focused on.

1、Networking method

The current networking method of utility scale PV power plant is normally PLC communication and fiber optic ring network communication. Such a networking method works well in operation, but the networking method in the PV array side mainly has 2 method.

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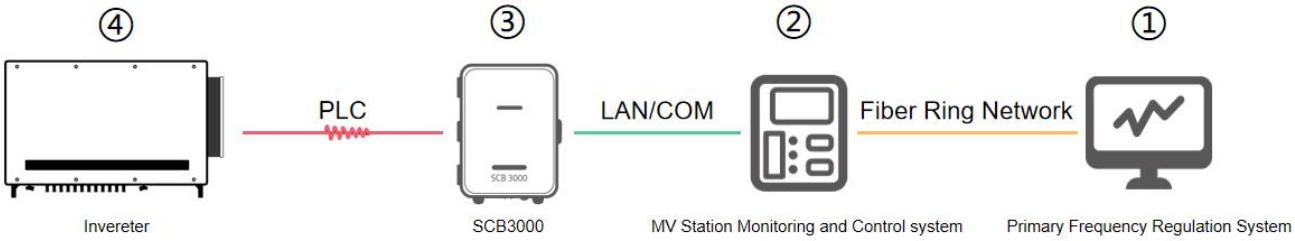
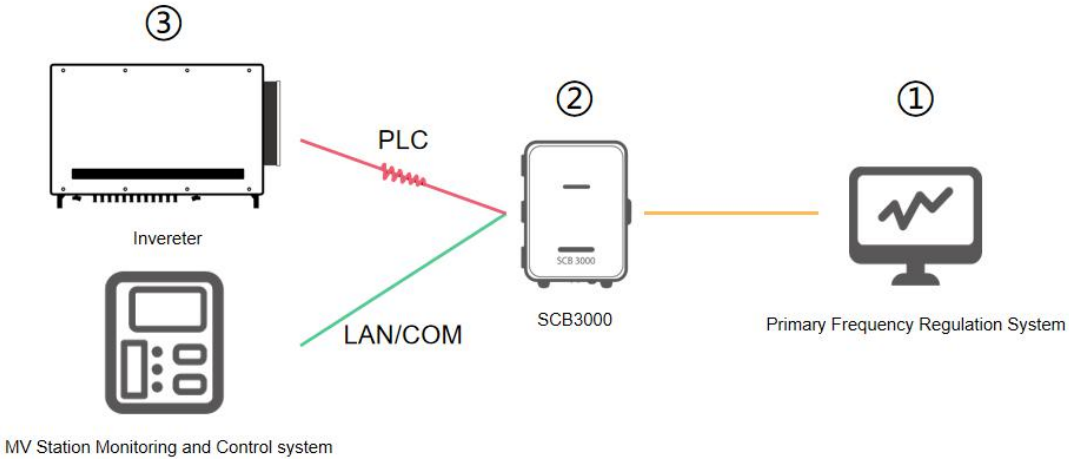
Method One



The first method is to communicate with the primary frequency regulation system through the "three-in-one" MV station monitoring box, with four communication nodes.

Method Two



The second method is to communicate with the primary frequency regulation system through SCB3000 that is provided by the same manufacturer of the inverter. There are 3 communication nodes.

From the comparison of the two methods above, method two has fewer communication nodes than method one, which is to reduce a communication failure point, not only saves communication time but also improves the reliability of communication. It is recommended to use the communication scheme of method two.

2、The requirement of inverter regulation ability

As the speed of primary frequency regulation is very fast, the response time of the inverter in the early stage is less than 1s, and the regulation time to 90% of the target value is less than 5s, in such a short time, it is a huge challenge to the performance of the inverter undoubtedly. First, the response time of the inverter's power components; second, the stability of the inverter. This all relates to the inverter algorithm and product process. Therefore, when choosing an inverter, priority should be given to the products of first-tier brands.

The response time of GoodWe's 250kW inverter applied to utility scale power plants is much lower than the specification requirement during the fast frequency regulation process, which can perfectly match the closed-loop task of primary frequency regulation.

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The Significance of Primary Frequency Regulation:

As the renewable energy continues to develop, the installed capacity continues to break new records, and the proportion of new energy in the whole power system is getting higher and higher. Although the stability of new energy generation is not as good as traditional thermal power plants, new energy is more rapid and stable than traditional thermal power plants in primary frequency regulation, and the way to achieve this is simpler. At the same time, the primary frequency regulation is one of the auxiliary services of the power system, which gives investors a new profit point to improve the operating income of the power station.

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