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**Technical Requirements for Connecting Photovoltaic Power
System to Distribution Network**
光伏发电系统接入配电网技术规定

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Technical Requirements for Connecting Photovoltaic Power System to Distribution Network

1 Scope

This document specifies the active power, reactive voltage, fault ride-through, operational adaptability, power quality, start-stop, relay protection, power prediction, electricity metering, communication and information, simulation model and parameter technical requirements for photovoltaic power generation system connected to the distribution network, as well as grid connection detection and evaluation content.

This document is applicable to the access, commissioning and operation of new or modified (expanded) photovoltaic power generation systems with voltage levels of 10 kV and below and three-phase grid connection. Photovoltaic power generation systems equipped with energy storage may take this as a reference.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 12325 Power Quality - Deviation of Supply Voltage

GB/T 12326 Power Quality - Voltage Fluctuation and Flicker

GB/T 13955 Installation and Operation of Residual Current Operated Protective Devices

GB/T 14285 Technical Code for Relaying Protection and Security Automatic Equipment

GB/T 14549 Quality of Electric Energy Supply - Harmonics in Public Supply Network

GB/T 15543 Power Quality - Three-phase Voltage Unbalance

GB/T 15945 Power Quality - Frequency Deviation for Power System

GB/T 17215.321 Electricity Metering Equipment (AC) - Particular Requirements - Part 21: Static Meters for Active Energy (classes A, B, C, D and E)

GB/T 19862 General Requirements for Monitoring Equipment of Power Quality

GB/T 24337 Power Quality - Interharmonics in Public Supply Network

GB/T 32826 Guide for Modeling Photovoltaic Power System

GB/T 32892 Model and Parameter Test Regulation for Photovoltaic Power System

GB/T 33982 Technical Specification for Grid Connection Protection of Distributed Resources

GB/T 40595 Guide for Technology and Test on Primary Frequency Control of Grid-connected Power Resources

DL/T 448 Technical Administrative Code of Electric Energy Metering

DL/T 614 Multifunction Electricity Metering Equipment (A.C.)

DL/T 634.5101 Telecontrol Equipment and Systems - Part 5: Transmission Protocols - Section 101: Companion Standard for Basic Telecontrol Tasks

DL/T 634.5104 Telecontrol Equipment and Systems - Part 5-104: Transmission Protocols - Network Access for IEC 60870-5-101 Using Standard Transport Profiles

DL/T 645 Multi-function Watt-hour Meter Communication Protocol

DL/T 698.45 Data Acquisition and Management System for Electrical Energy - Part 4-5: Communication Protocol - Object Oriented Data Exchange Protocol

3 Terms and Definitions

The terms and definitions defined in GB/T 12325 and GB/T 40595 and the following are applicable to this document.

3.1 photovoltaic (PV) power generation system

A power generation system that utilizes the photovoltaic effect of solar cells to convert solar radiation energy into electrical energy.

3.2 point of common coupling

The point where the photovoltaic power generation system is connected to the public power grid.

3.3 point of connection

For a photovoltaic power generation system with a booster station, it is the bus or node on the high-voltage side of the booster station; for a photovoltaic power generation system without a booster station, it is the output aggregation point of the photovoltaic power generation system.

NOTE: see Appendix A for an illustration of the point of connection and point of common coupling.

3.4 response time

During the control process, the time required from receiving a control command or detecting a change in the state quantity triggering the control operation, until the actual output change of the observed variable reaches 90% of the difference between the control target value and the initial value for the first time.

[source: GB/T 40289-2021, 3.13]

4 Active Power

4.1 Active Power Control

4.1.1 The photovoltaic power generation system connected to the grid through the 10(6) kV voltage level shall be able to receive and automatically execute active power control command. The absolute value of the control error shall not exceed 1% of the rated active power, and the response time shall not exceed 5 s.

4.1.2 The photovoltaic power generation system connected to the grid through the 380 V voltage level shall be able to receive and automatically execute active power control command.

4.2 Primary Frequency Modulation

4.2.1 The photovoltaic power generation system connected to the grid through the 10(6) kV voltage level shall have the capability of primary frequency modulation.

4.2.2 When the frequency deviation of the power system exceeds the dead zone range of the primary frequency modulation, the active power change of the photovoltaic power generation system shall be calculated in accordance with Formula (1):

$$\Delta P_t = -k_f \times \frac{f_t - f_N}{f_N} \times P_N \quad \dots\dots\dots (1)$$

Where,

ΔP_t ---the variation of active power of the photovoltaic power generation system, expressed in (MW);

k_f ---the active frequency modulation coefficient;

f_t ---the power system frequency, expressed in (Hz);

f_N ---the rated frequency of the power system, expressed in (Hz);

P_N ---the rated active power of the photovoltaic power generation system, expressed in (MW).

4.2.3 The active frequency modulation coefficient and dead zone range of primary frequency modulation shall be determined by the power system dispatching institution in accordance with the frequency modulation characteristics of the connected power system. The value range of

the active frequency modulation coefficient should be 10 ~ 50, and the dead zone range should be $\pm(0.02 \text{ Hz} \sim 0.06 \text{ Hz})$.

4.2.4 When the power system frequency is greater than 50 Hz, the limit of active power reduction of the photovoltaic power generation system should be not less than 10% of the rated active power.

4.2.5 When the power system frequency is less than 50 Hz, the photovoltaic power generation system equipped with energy storage shall increase the active power, and the limit of the increase in active power should be not less than 6% of the rated active power.

4.2.6 The response lag time of the primary frequency modulation shall be not greater than 1 s, the response time shall be not greater than 5 s, the modulation time shall be not greater than 15 s, and the active power regulation deviation when the primary frequency modulation reaches stability shall not exceed $\pm 1\%$ of the rated active power.

5 Reactive Voltage

5.1 The reactive output range of the photovoltaic inverter shall be dynamically adjustable within the rectangular frame shown in Figure 1.

5.2 The photovoltaic power generation system shall have multiple reactive power control modes, including reactive voltage control, constant power factor control and constant reactive power

control, etc.

5.3 The photovoltaic power generation system shall have the capability of participating in voltage regulation of the point of connection, and it is advisable to participate in voltage regulation by adjusting its own reactive power and active power.

5.4 The power factor of the point of connection of the photovoltaic power generation system shall be continuously adjustable within the range of 0.95 (leading) ~ 0.95 (lagging).

6 Fault Ride-through

6.1 Low Voltage Ride-through

6.1.1 When a fault occurs in the power system and causes the voltage at the point of connection of the photovoltaic power generation system to drop, the photovoltaic power generation system shall have the low voltage ride-through capability specified in Figure 2. The specific requirements are as follows:

- a) When the voltage at the point of connection of the photovoltaic power generation system drops to 0, the photovoltaic power generation system shall be able to continuously operate for 150 ms without being disconnected from the grid;
- b) When the voltage at the point of connection of the photovoltaic power generation system drops to 20% of the nominal voltage, the photovoltaic power generation system shall be able to continuously operate for 625 ms without being disconnected from the grid;
- c) When the voltage at the point of connection of the photovoltaic power generation system drops to more than 20% to 85% of the nominal voltage, the photovoltaic power generation system shall be able to continuously operate without being disconnected from the grid in the shaded area shown in Figure 2.

7 Operational Adaptability

7.1 Voltage Adaptability

7.1.1 When the voltage at the point of connection is between 85% ~ 110% of the nominal voltage, the photovoltaic power generation system shall be able to normally and continuously operate.

7.1.2 When the voltage at the point of connection is lower than 85% of the nominal voltage or exceeds 110% of the nominal voltage, the photovoltaic power generation system shall meet the requirements of 6.1 and 6.2.

7.2 Frequency Adaptability

7.2.1 The frequency adaptability of the photovoltaic power generation system shall meet the requirements of Table 2.

8 Power Quality

8.1 Voltage Deviation

After the photovoltaic power generation system is connected, the caused voltage deviation of the point of common coupling shall satisfy the requirements of GB/T 12325.

8.2 Voltage Fluctuation and Flicker

After the photovoltaic power generation system is connected, the caused voltage fluctuation and flicker of the point of common coupling shall satisfy the requirements of GB/T 12326.

8.3 Harmonics and Inter-harmonics

8.3.1 The harmonic injection current of the photovoltaic power generation system to the point of common coupling, to which, it is connected, shall satisfy the requirements of GB/T 14549, among which, the allowable value of the harmonic current injected by the point of connection of the photovoltaic power generation system into the power system shall be allocated in accordance with the ratio of the installed capacity of the photovoltaic power generation system to the total capacity of the power generation / supply equipment with harmonic sources at the point of common coupling.

8.3.2 After the photovoltaic power generation system is connected, the caused inter-harmonics of the point of common coupling shall meet the requirements of GB/T 24337.

8.4 Voltage Imbalance

After the photovoltaic power generation system is connected, the caused voltage imbalance of the point of common coupling shall meet the requirements of GB/T 15543.

8.5 DC Component

The DC current component injected by the photovoltaic power generation system to the point of common coupling shall not exceed 0.5% of its AC rated power.

8.6 Monitoring and Governance

8.6.1 The point of common coupling of the photovoltaic power generation system connected to the grid through the 10(6) kV voltage level shall be equipped with a Class A online power quality monitoring device that meets the requirements of GB/T 19862, and the power quality monitoring data shall be kept for at least one year.

8.6.2 The point of common coupling of the photovoltaic power generation system connected to the grid through the 380 V voltage level should be equipped with an online power quality monitoring device that meets the requirements of GB/T 19862 or an equipment with online power quality monitoring function, and the power quality monitoring data shall be kept for at least one year.

8.6.3 When the power quality indicators of the photovoltaic power generation system do not satisfy the requirements, power quality governance equipment shall be installed.

9 Start-stop

9.1 The power quality changes caused by the start-stop of the photovoltaic power generation system shall satisfy the requirements of Chapter 8.

9.2 When the photovoltaic power generation system is started, the voltage and frequency of the point of connection shall meet the requirements of GB/T 12325 and GB/T 15945, otherwise it shall not be started.

9.3 Photovoltaic power generation systems connected to the grid through the 10(6) kV voltage level shall resume grid connection after receiving a grid connection command from the power grid dispatching institution.

10 Relay Protection

10.1 General Requirements

10.1.1 The protection configuration of the photovoltaic power generation system shall meet the requirements of reliability, selectivity, sensitivity and speed, and meet the relevant requirements of GB/T 14285 and GB/T 33982.

10.1.2 For photovoltaic power generation systems connected to the grid through the 10(6) kV voltage level, disconnecting equipment that is easy to operate, can be locked, has a clear disconnection point, has a grounding function, and can disconnect fault currents shall be installed at the point of connection.

10.1.3 For photovoltaic power generation systems connected to the grid through the 380 V voltage level, a switch that is easy to operate, has a clear disconnection indication, and has the ability to disconnect fault currents shall be installed at the point of connection.

10.2 Line Protection

For photovoltaic power generation systems connected to the grid through the 10(6) kV voltage level, current protection can be adopted on both sides of the grid connection line, and when necessary, directional elements can be installed. When the action current setting value and time limit coordination cannot satisfy the requirements of reliability and selectivity, distance protection or longitudinal current differential protection should be adopted.

10.3 Low / high Voltage Protection

The low / high voltage protection of the photovoltaic power generation system shall meet the requirements of 6.1 and 6.2.

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