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Guide for modelling photovoltaic power systems

光伏发电系统建模导则

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Table of Contents

5 Power Flow Calculation Model

5.1 The power flow calculation model should be built based on the topology of the photovoltaic power generation system, including photovoltaic generator units, unit step-up transformers, and collection... Equivalent models of power lines, substation step-up transformers, substation reactive power compensation equipment, and energy storage equipment, etc. A typical structure of the power flow calculation model is shown below. Appendix B.

5.2 Photovoltaic generator sets, reactive power compensation equipment, and energy storage equipment should be configured as generators in power flow calculations. The specific configuration should be determined based on the control method. The node type of the motor should be set as follows:

a) When using power control mode, it should be set to PQ node, and the active and reactive power of the generator should be given according to the set values.

b) When using voltage control mode, it should be set as a PV node, and the generator's active power and voltage amplitude should be given according to the set values; The reactive power of the machine should be set with upper and lower limits according to its actual capacity. When the reactive power reaches the limit, it should automatically switch to the PQ node.

6 Electromagnetic transient model structure of photovoltaic power generation unit

7.2.3 The electromagnetic transient model of the photovoltaic inverter should include a main circuit model and a control system model, wherein the main circuit model should adopt a structured model. For control systems, either a structured model or an encapsulated model can be used.

7.2.4 The photovoltaic power generation system should include a plant-level power control system model based on simulation requirements. The model structure is shown in Appendix F. Provide corresponding model interfaces.

7.3 Photovoltaic Array Model The photovoltaic array model should be able to reflect the photoelectric conversion characteristics of the photovoltaic array power in relation to irradiance, temperature, and DC voltage. The application model is shown in Appendix C.

6.1 Basic Requirements

6.1.1 The electromechanical transient model should be able to simulate power control, fault ride-through, and other electrical phenomena of the photovoltaic power generation system on a timescale of several cycles to tens of seconds. Control characteristics, and the ability to reflect the electrical characteristics of the photovoltaic power generation system's grid connection point (or point of common coupling) during environmental changes, power system faults, or disturbances. The results were validated through model verification and accuracy evaluation.

6.1.2 The electromechanical transient model should meet the electromechanical transient simulation requirements with a step size of 1ms to 10ms, and be able to perform initial simulations based on power flow calculation results. Initialization. Electrical quantities during the simulation process are represented by effective values.

6.1.3 The values of the electromechanical transient model parameters should be based on the rated capacity and rated voltage of the photovoltaic inverter or photovoltaic power generation system. The rated capacity of the power generation system should be the sum of the rated capacities of all photovoltaic inverters.

6.2 Overall Model Structure

6.2.1 The electromechanical transient model of the photovoltaic power generation system should consist of multiple photovoltaic power generation units, on-site step-up transformers, collection lines, and plant-level power control. The model consists of a control system, on-site reactive power compensation equipment, and energy storage equipment. The overall structure is shown in Figure 1. Figure

1.Structure of the electromechanical transient model of the photovoltaic power generation

system

6.2.2 The electromechanical transient model of the photovoltaic power generation unit should consist of models of the photovoltaic generator set and the unit step-up transformer. The electrical transient model should consist of models of the photovoltaic array and the photovoltaic inverter, and the overall structure is shown in Figure 2. Figure

2.Electromechanical transient model structure of photovoltaic power generation unit

6.3 Photovoltaic Array Model The photovoltaic array model should be able to reflect the photoelectric conversion characteristics of the photovoltaic array in relation to the maximum power point power, irradiance, and temperature. (Photovoltaic array operation...) The application model is shown in Appendix C.

6.4 Electromechanical Transient Model of Photovoltaic Inverter

6.4.1 The electromechanical transient model of a photovoltaic inverter should include the control and protection section and the grid connection interface section.

6.4.2 A photovoltaic inverter with fault ride-through capability should have a model that reflects active power control, reactive power control, fault ride-through, and protection. The protective and other characteristics are shown in Figure

3.The recommended model is shown in Appendix D.

6.4.3 For photovoltaic inverters lacking fault ride-through capability, their models should be able to reflect active power control, reactive power control, and overvoltage drop power. The model structure is shown in Figure 4, and the recommended model is shown in Appendix E. Figure

3.Electromechanical transient model structure of a photovoltaic inverter with fault ride-through capability. Figure

4.Electromechanical transient model structure of a photovoltaic inverter without fault ride-through capability.

6.5 Plant-level power control system model The power control system model at the plant level should include active/frequency control, reactive/voltage control, and other components. A recommended model is shown in Appendix F.

7.1 Basic Requirements

7.1.1 The electromagnetic transient model should be able to simulate the power control, fault ride-through, and other electrical control functions of a photovoltaic power generation system on a timescale of tens of microseconds to several seconds. It can reflect the control characteristics and the electrical characteristics of the photovoltaic power generation system's grid connection point (or point of common coupling) during power system faults or

disturbances, and through the model... Validation and accuracy evaluation.

7.1.2 The electromagnetic transient model should meet the electromagnetic transient simulation requirements with a step size of no more than 50 μs. The electrical quantities in the simulation process should be expressed as instantaneous values. express.

7.1.3 The values of the electromagnetic transient model parameters should be based on the rated capacity and rated voltage of the photovoltaic inverter or photovoltaic power generation system. The rated capacity of the power generation system should be the sum of the rated capacities of all photovoltaic inverters.

7.2 Overall Model Structure

7.2.1 The electromagnetic transient model of the photovoltaic power generation system should include the photovoltaic power generation unit, the collection line, the on-site step-up transformer, and the on-site reactive power compensation equipment. The model of the backup and energy storage equipment is shown in Figure 5. Figure

5.Electromagnetic transient model structure of photovoltaic power generation system

7.2.2 The electromagnetic transient model of the photovoltaic power generation unit should consist of models of the photovoltaic generator set and the unit's step-up transformer. The magnetic transient model should consist of models of the photovoltaic array and the photovoltaic inverter, and the overall structure is shown in Figure 6. Figure

7.4.1 Main Circuit Model

7.4.1.1 The main circuit model of the photovoltaic inverter should include DC capacitors, filters, DC/AC converter bridges, and DC/DC converter bridges (if any). And other steps.

7.4.1.2 The topology and parameters of DC capacitors and filters should be consistent with the actual equipment.

7.4.1.3 The models for DC/AC converter bridges and DC/DC converter bridges should be selected according to simulation requirements. Average value models or switching models can be used. Model.

7.4.2 Structured Model of Control System

7.4.2.1 The structured model of the photovoltaic inverter should provide a control strategy block diagram and provide the value range and default value of all parameters.

7.4.2.2 The structured model of a single-stage photovoltaic inverter should include a power outer loop, a current inner loop, fault ride-through, a phase-locked loop, and positive and negative sequence decoupling. The protection circuit and voltage modulation module, and other control circuits, are shown in Figure