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Design and testing methods for the AC side impedance of voltage source converter based HVDC transmission

高压直流输电用电压源换流器交流侧阻抗设计及测试方法

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Foreword

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Transmission Company, Xinjiang Uygur Autonomous Region Product Quality Supervision and Inspection Research Institute, Guangdong Electric Power Dongguan Power Supply Bureau of State Grid Co:, Ltd: and Electric Power Research Institute of State Grid Anhui Electric Power Co:, Ltd: The main drafters of this document: Xu Shukai, Zhou Huigao, Zou Changyue, Zhang Yining, Huang Chao, Feng Junjie, Gao Yang, Zhang Xiaoyu, Xu Fan, Weng Haiqing, Li Xinwei, Chen Yijing, Liu Jinsong, Yan Xilin, Ji Yiming, Xu Feng, Zhao Xiaobin, Fu Chuang, Xue Yinglin, Lu Jing, Yang Zhangbin, Zhao Yangyang, Liu Qijian, Wang Nannan, Ma Yanjun, Dai Shulong, Shi Jian, Wang Xiaoling, Ju Chenghao, Zhang Junyang, Fan Lijuan, Zhang Changhong, Yang Xiaohui, Xu Yang, Liu Jin, Wang Lei, Yang Yuanhang, Peng Junzhen, Xing Chao, Chen Ming, Tian Zhanling, Zhou Yuebin, Li Weiwei, Chen Wei, Hu Di: AC side impedance of voltage source converter for high voltage direct current transmission Design and test methods

1 Scope

China's national design and testing methods for the AC side impedance of VSC-HVDC transmission systems. The subject is one of the more consequential problems in modern power systems. A voltage source converter presents an impedance to the AC network that is determined by its control system rather than by physical components, and that impedance varies with frequency in ways a transformer's does not. When such a converter is connected to a weak grid, or near other converters and wind farms that are also control-defined, the combined system can become unstable and oscillate at frequencies between a few hertz and a few kilohertz - resonances that no component analysis would predict and that have caused real disturbances on real networks. Characterising the converter's impedance across frequency is how those interactions are assessed before commissioning rather than discovered afterwards.

This document specifies the design requirements for the AC side impedance of voltage source converters for high-voltage direct current transmission and describes the voltage sources for high-voltage direct current transmission: Factors affecting the AC side impedance of the converter, delay test conditions and test methods, and impedance test conditions and test methods: This document applies to high voltage direct current transmission systems using modular multi-level voltage source converters:

Note: This document mainly considers the impedance frequency range from hundreds of Hz to thousands of Hz, which is used for voltage source converters and AC systems that have electrical current within this frequency range: Gas oscillation analysis: Oscillation frequency range and analysis method of electrical oscillation of flexible DC transmission system, theoretical modeling of AC side impedance of voltage source converter, electrical Please see Appendix A for the precautions for AC side impedance testing of voltage source converters and oscillation suppression methods:

2 Normative reference documents

The contents of the following documents constitute essential provisions of this document through normative references in the text: Among them, the dated quotations For undated referenced documents, only the version corresponding to that date applies to this document; for undated referenced documents, the latest version (including all amendments) applies to this document:

GB/T 15289-2013 General specifications for digital storage oscilloscopes

GB/T 34118-2017 Terminology for voltage source converters for high voltage DC systems

GB/T 40601-2021 Technical requirements for real-time digital simulation of power systems

GB/T 40865-2021 Flexible DC transmission terminology

3 Terms and definitions

GB/T 15289-2013, GB/T 34118-2017, GB/T 40601-2021, GB/T 40865-2021 and the following The following terms and definitions apply to this document: 3:

1 An AC/DC converter provided by a centralized DC capacitor or multiple distributed DC capacitors within each leg of the converter Smooth DC voltage: [Source: GB/T 34118-2017, 5:3, with modifications] 3:2 converter unitconverterunit An integral operating unit consisting of all equipment between the common connection point on the AC side and the common connection point on the DC side:

Note: It mainly includes one or more voltage source converter units, one or more connecting transformers, converter control units, valve base control equipment, basic protection and Switchgear and auxiliary equipment for commutation (if any): [Source: GB/T 34118-2017, 7:5, with modifications] 3:3 convertercontrolconvertercontrol Control system for control, monitoring and protection of individual converter units: