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Joint commissioning for grid-connection of offshore wind farms using VSC HVDC transmission

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Joint commissioning for grid-connection of offshore wind farms using VSC HVDC transmission

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IEC TS 63487 has been prepared by subcommittee 8A: Grid integration of renewable energy generation, of IEC technical committee 8: System aspects of electrical energy supply. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
8A/210/DTS	8A/223/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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– reconfirmed,
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– revised.

INTRODUCTION

This document addresses the joint commissioning of grid-connection of offshore wind farms (GCOWF) using the voltage source converter based high voltage direct current (VSC HVDC) transmission system. The test purpose, test preconditions, test procedures and methods, and test acceptance criteria for joint commissioning are introduced in this document. The scope of the document covers the commissioning of offshore wind farms, testing of the onshore DC energy dissipation device, special test items for transmission test, coordination function testing among the VSC HVDC system, DC energy dissipation device, offshore wind farm and automatic generation control (AGC). The conventional commissioning test items of the VSC HVDC system are out of scope.

Due to the advantages of abundant and highly qualified wind resources, offshore wind farms have become the development trend of wind power generation. Currently, the VSC HVDC power transmission technology provides a solution for grid connection of the large-scale and long-distance offshore wind power farms since it can achieve power supply for a passive system, long-distance power transmission, and flexible and independent control for active and reactive power. In this context, a number of large-scale and long-distance wind power farms, connected with power grid using VSC HVDC power transmission, have been put into commercial operation around the world, such as China, Germany, and the UK.

More and more offshore wind farms will be integrated into the onshore AC power grid using VSC HVDC power transmission. The commissioning is the final on-site test for grid-connection of offshore wind farms using VSC HVDC power transmission, to help ensure that the whole system can safely and reliably operate, and meet the grid connection requirements, as well as the relevant contracts and specifications.

Compared with the commissioning of conventional VSC HVDC projects, the joint commissioning procedures, methods, and grid-connection requirements of the VSC HVDC projects with integration of offshore wind farms are different, due to the special offshore operating conditions, as well as the existence of onshore DC energy dissipation device and the offshore wind farms. Therefore, it is important to draft a technical specification on joint commissioning for grid-connection of offshore wind farms using VSC HVDC power transmission.

The purpose of this document is to elaborate on the commissioning procedures, test items, conditions, methods, and special requirements of grid-connection of offshore wind farms to help ensure the integrity and correctness of the commissioning. It is possible that the document is not applicable to all projects but represents a range of possible system tests which should be considered. The commissioning requirements and procedures provided in this document are not for any specific project and these should be considered according to the agreement between the purchaser and supplier and as applicable.

1 Scope

This document serves as a specification for the joint commissioning of grid-connection of offshore wind farms (GCOWF) using the voltage source converter based high voltage direct current (VSC HVDC) transmission system.

This document provides the technical specification on the commissioning precondition, objectives, procedures, items, methods and requirements of grid-connection of offshore wind farms using the VSC HVDC power transmission, particularly focusing on the special test items of offshore wind farms.

This document covers the commissioning of offshore wind farms, testing of onshore DC energy dissipation device, special test items for transmission test, coordination function testing among VSC HVDC, DC energy dissipation device, offshore wind farm and automatic generation control (AGC). However, the conventional commissioning test items of the onshore VSC HVDC system are out of scope.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-811, *International Electrotechnical Vocabulary - Part 811: Electric traction, www.electropedia.org*

IEC 60270, *High-voltage test techniques - Charge-base measurement of partial discharges*

IEC 60633:2019, *High-voltage direct current (HVDC) transmission - Vocabulary*

IEC 61400-3-1, *Wind energy generation systems - Part 3-1: Design requirements for fixed offshore wind turbines*

IEC 61400-3-2, *Wind energy generation systems - Part 3-2: Design requirements for floating offshore wind turbines*

IEC 62747:2014, *Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems*
IEC 62747:2014/AMD1:2019

IEC 62934, *Grid integration of renewable energy generation - Terms and definitions*

IEC TS 63336:2024, *Commissioning of VSC HVDC systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-811, IEC 60270, IEC 60633, IEC 61400-3-1, IEC 61400-3-2, IEC 62747, IEC 62934, IEC TS 63336 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/

– ISO Online browsing platform: available at https://www.iso.org/obp

3.1
control mode
manner in which a converter unit, pole, or VSC HVDC converter station is controlled in order to maintain one or more electrical quantities at desired values

[SOURCE: IEC 60633:2019, 10.1, modified - Updated to VSC HVDC transmission.]

3.2
converter station tests
tests verifying functions and performances of the converter unit disconnected from the VSC HVDC transmission line on-site

[SOURCE: IEC TS 63336:2024]

3.3
converter starting resistor
resistor temporarily connected in series with the converter to vary the voltage applied and limit the current during starting

[SOURCE: IEC 60050-811:2017, 811-27-01]

3.4
DC energy dissipation device
device used to achieve the conversion of electric energy into thermal energy non intended to be used

Note 1 to entry: This is also referred to as a DC braking chopper.

3.5
on-site equipment tests
electrical and mechanical tests which are performed on-site on a single equipment to verify that no equipment damage has occurred during transport and site assembly, and that installation has been correctly performed

[SOURCE: IEC TS 63336:2024]

3.6
high power transmission tests
tests verifying functions and performances of the whole system at a high power transmission level. The power value should be higher than 0.3 pu. Some test items can be carried out during the trial operation

[SOURCE: IEC TS 63336:2024]

3.7
interface transformer
transformer (if any) through which power is transmitted between the AC system connection point and one or more VSC units

[SOURCE: IEC 62747:2014]

3.8
joint commissioning
final test before putting into commercial operation, aimed at verifying that the functionality and performance of the system meet the design requirements

3.9
low power transmission tests
tests verifying functions and performances of the offshore wind farms and VSC HVDC system at a low power transmission level

Note 1 to entry: The power value depends on the grid connection and output conditions of offshore wind farms.

[SOURCE: IEC TS 63336:2024]

3.10
local workstation
LWS
local workstation near the control and protection devices of VSC HVDC, which can monitor, control, and manage the system

3.11
offshore wind farm
sea-based renewable energy facility using wind turbine generator systems to generate electricity for the grid

3.12
operator workstation
OWS
remote control centre where operators monitor, control, and manage the system

Note 1 to entry: The operator workstation provides a graphical interface for real-time data visualization and system operation.

3.13
point of common coupling
PCC
point of interconnection of the onshore converter station to the adjacent AC system, or point of interconnection of wind farms to the offshore converter station

3.14
reactive power control mode
control of the reactive power exchanged between a converter unit, or a HVDC substation, and the connected AC network

[SOURCE: IEC 60633:2019, 10.5]

3.15
submodule
part of the VSC valve comprising controllable switches and diodes connected to a half bridge or full bridge arrangement, together with their immediate auxiliaries, storage capacitors, if any, where each controllable switch consists of only one switched valve device connected in series

[SOURCE: IEC 62501:2024, 3.4.7]

3.16
STATCOM operation
static synchronous compensator operation
operation mode of the converter that can continuously generate or absorb reactive power for the power grid

3.17
subsystem test
test which is performed on-site to prove the correct interconnection and functioning of all individual items of equipment within a functional group (or subsystem) and that these items operate and interact correctly

[SOURCE: IEC TS 63336:2024, 3.1.3]

3.18
trial operation
<VSC HVDC systems> period following the completion of the commissioning

[SOURCE: IEC TS 63336:2024, 4.4]

3.19
end-to-end tests
tests verifying functions and performances of the VSC HVDC system when transmitting power between both converter stations on-site

[SOURCE: IEC TS 63336:2024, 3.1.6, modified - Term "transmission tests" removed, abbreviated term "VSC" added, and note to entry removed.]

3.20
islanded network operation mode
control mode in which the VSC HVDC substation controls the frequency and the voltage of the connected islanded AC network

[SOURCE: IEC 62747:2014, 11.6, modified - Abbreviated term "VSC" added.]

3.21
wind turbine generator system
WTGS
system which converts the kinetic wind energy into electric energy

[SOURCE: IEC 60050-415:1999, 415-01-02]

3.22
zero power transmission tests
tests verifying the functions and performance of the VSC HVDC system without transmitting power