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TECHNICAL SPECIFICATION

colour inside

Grid code compliance assessment methods for grid connection of wind and PV power plants

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GRID CODE COMPLIANCE ASSESSMENT METHODS FOR GRID CONNECTION OF WIND AND PV POWER PLANTS

FOREWORD

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IEC TS 63102 has been prepared by subcommittee SC 8A: Grid integration of renewable energy generation, of IEC technical committee TC 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/80/DTS	8A/86/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/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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GRID CODE COMPLIANCE ASSESSMENT METHODS FOR GRID CONNECTION OF WIND AND PV POWER PLANTS

1 Scope

This technical specification highlights recommended technical methods of grid code compliance assessment for grid connection of wind and PV power plants as the basic components of grid connection evaluation. The electrical behaviour of wind and PV power plants in this technical specification includes frequency and voltage range, reactive power capability, control performance including active power based control and reactive power based control, fault ride through capability and power quality.

Compliance assessment is the process of determining whether the electrical behaviour of wind and PV power plants meets specific technical requirements in grid codes or technical regulations. The assessment methods include compliance testing, compliance simulation and compliance monitoring. The input for compliance assessment includes relevant supporting documents, testing results and validated simulation models, and continuous monitoring data. The scope of this technical specification only covers assessment methods from a technical aspect; processes related to certification are not included.

This technical specification is applicable to wind and PV power plants connected to the electrical power grid.

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 60050-415:1999, *International Electrotechnical Vocabulary – Part 415: Wind turbine generator systems*

IEC 61400-21-1, *Wind energy generation systems – Part 21-1: Measurement and assessment of electrical characteristics – Wind turbines*

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

3 Terms, definitions, abbreviations and subscripts

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61400-21-1, IEC 60050-415, IEC 62934 and the following apply.

ISO and IEC also maintain terminological database for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
compliance monitoring
monitoring activity with the purpose of demonstrating the continuous compliance with the required specifications throughout the lifetime of the power plant

3.1.2
compliance simulation
simulation activity with the purpose of demonstrating the compliance with the required specifications, especially where testing is not applicable or risk of damaging the facility exists

3.1.3
controller hardware in the loop testing
CHIL testing
testing method for the subject controller based on physical and digital real-time simulation

Note 1 to entry: A simulation model is used to build the external real-time testing environment. Then a closed loop test system is composed of the simulation model and embedded physical controller under test.

3.1.4
grid code
document that recommends practices or procedures for the activities of connection, management, planning, development and maintenance of the electrical transmission and distribution grid, as well as dispatching and metering, etc.

3.1.5
grid code compliance
demonstration that the electrical behaviours of power plants satisfy specific technical requirements in grid codes or technical regulations

3.2 Abbreviations and subscripts

3.2.1 Abbreviations

The following abbreviations are used in this document:

CHIL	controller hardware in the loop
CIGRE	International Council on Large Electric Systems
CT	Current Transformer
DB	Dead Band
FACTS	Flexible Alternating Current Transmission Systems
HVDC	High Voltage Direct Current
OF	Over Frequency
OVRT	over-voltage ride-through
PCS	power conditioning system
PV	photovoltaic
POC	point of connection
PQ	active power and reactive power
SCR	short circuit ratio
STATCOM	static synchronous compensator
TS	technical specification
UF	Under Frequency
UVRT	under-voltage ride-through
VT	Voltage Transformer

3.2.2 Subscripts

F	fault
meas	measured value
max	maximum
min	minimum
n	nominal
Omax	maximum value of over voltage fault
poc-s	produced by the grid
poc-c	produced by the power plant
ref	reference value
s	variable of grid
sa	phase A of grid
sb	phase B of grid
sc	phase C of grid
Umin	minimum value of under voltage fault

4 Symbols and units

In this document, the following symbols and units are used.

I_{poc}	tested results of the current at POC (A)
$I_{\text{poc-s}}$	harmonic currents produced by the grid (A)
$I_{\text{poc-c}}$	harmonic currents produced by the power plant (A)
I_{s}	equivalent current of the grid
I_{c}	equivalent current of the plant
P	active power of the power plant (W)
P_{n}	active power rated value (W)
P_{meas}	active power measured value (pu)
P_{lt}	maximum long-term flicker
P_{lt0}	maximum background long-term flicker
P_{ltRE}	maximum long-term flicker caused by power plant
Q	reactive power of the power plant (Var)
Q_{ref}	reactive power reference value (pu)
Q_{meas}	reactive power measured value (pu)
Q_{max}	maximum reactive power at POC (Var)
Q_{min}	minimum reactive power at POC (Var)
S_{k}	short circuit power (VA)
U_{n}	rated value of voltage at POC (V)
U_{s}	voltage of the grid (V)
U_{sa}	phase A voltage of the grid (V)
U_{sb}	phase B voltage of the grid (V)
U_{sc}	phase C voltage of the grid (V)
U_{max}	maximum voltage under normal operation at POC (V)
U_{min}	minimum voltage under normal operation at POC (V)

U_{Umin} minimum value under voltage according to gird codes (V)

U_{Omax} maximum value over voltage according to gird codes (V)

U_{poc} tested results of the voltage at POC (V)

Z_{c} equivalent impedance of the power plant (Ω)

Z_{F} equivalent fault impedance (Ω)

Z_{s} equivalent impedance of the grid (Ω)

Z_{sa} phase A equivalent impedance of the grid (Ω)

Z_{sb} phase B equivalent impedance of the grid (Ω)

Z_{sc} phase C equivalent impedance of the grid (Ω)

5 General specifications

5.1 General

Technical requirements of wind and PV power plants for connecting to the grid were given in the grid codes, such as operating area, active power control, reactive power control, fault ride through, etc. Some existing IEC standards like IEC 61400-21 (all parts) and IEC 61400-27 (all parts) specify the measurement procedures, modelling and validation methods of electrical characteristics for wind turbines and wind power plants. This technical specification will specify the compliance assessment methods of the electrical behaviours stipulated in the grid codes.

5.2 Type tested units – Wind turbines and PV inverters

Type tested units are a series of wind turbines or PV inverters that have a common design, materials and major components, subject to a common manufacturing process and uniquely described by specific values or ranges of values of machine parameters and design conditions. The definition of a type tested unit is dependent on the characteristics being assessed and should be agreed by all stakeholders. Type testing is usually performed only once per type in order to prove the general capability for all units of this type.

5.3 Projects – Wind and PV power plants

Wind or PV power plants are usually built clustering many units and jointly connecting them to the grid. For these, a project based assessment needs to be performed. This means using results from the type tested assessment, but taking the site-specific parameters into account.

5.4 Compliance assessment methods

In general, methods of project based compliance assessment can be classified into three general categories:

- testing, including field testing and controller hardware in the loop (CHIL) testing;
- simulation;
- monitoring.

NOTE Annex A includes detailed information and recommendations for monitoring.

Normally for each electrical behaviour there is more than one compliance assessment method. The selection of assessment methods should be carried out by system operators taking into consideration the following factors:

- the technology of the project, including whether the performance is likely to drift or degrade over a particular time-frame;
- experience with the particular generation technology, including manufacturer's advice;
- the connection point arrangement;

- an assessment of the risks and costs of different testing methods, including consideration of the relative size of the plant;
- the availability and location of testing equipment, monitoring/metering equipment and other necessary facilities.

Table 1 gives an overview of recommended assessment methods for different electrical behaviors.

Table 1 – Overview of assessment methods

		Field testing	CHIL	Simulation	Monitoring
Operating area	Frequency range				x
	Voltage range			x	x
	Reactive power capability			x	x
Control performance		x	x		x
Fault ride through				x	x
Power quality		x			
x: recommended assessment methods.					

6 Operating area

6.1 General

As the frequency and voltage of the power system are not constant, the wind and PV power plants need to be capable of being operated continuously or for certain durations within specified frequency and voltage ranges required by the grid codes. Reactive power capability is also required to help maintain the system voltage and fulfil reactive power demand of the grid. The operating area is generally focused on steady state conditions. For compliance assessment of transient behaviour during grid faults, see Clause 8.

Assessment of the operating area is the assessment of appropriate equipment rating. This rating assessment for power plants should be based on the units and the additional equipment installed in the plant. This assessment can be undertaken in the planning phase based on related documentation and load flow simulations. The continuous compliance should be monitored as well. Field testing at the wind or PV power plant level is not recommended for confirmation of the entire frequency and voltage area since this testing can endanger both grid and plant safety. However, field testing could be conducted to confirm reactive power capability and a limited range within the frequency or voltage area.

6.2 Frequency range

6.2.1 Documentation

Related documentation should be provided in the planning phase declaring the frequency range of units and additional equipment installed in the power plant. For the units and additional equipment, specification or manufacturer declarations should be submitted.

6.2.2 Method 1: Monitoring

The POC of the power plant and main equipment within the plant should be monitored and assessed continuously. For the evaluation of power plant operability with decreased or increased grid frequency, the protection settings at POC should be documented.