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Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



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TITLE:

Photovoltaic power generating systems connection with grid - Conformity assessment for power conversion equipment - Part 6: Power control functions and grid support

NOTE FROM TC/SC OFFICERS:

This project was discussed and supported by WG6 during their meeting in 2024-10.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PHOTOVOLTAIC POWER GENERATING SYSTEMS
CONNECTION WITH THE GRID – TESTING OF
POWER CONVERSION EQUIPMENT****Part 6: Power control functions and grid support****FOREWORD**

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The text of this International standard is based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

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

168 The language used for the development of this International Standard is English.

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

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

- 176 • reconfirmed,
- 177 • withdrawn,
- 178 • replaced by a revised edition, or
- 179 • amended.

180

INTRODUCTION

Background

TC82 has been making efforts to contribute the standardization of DER connection with the grid. In 2016, It joined TC8/JWG10 to harmonize with utility power system operation requirements. In parallel with such a liaison work, TC82 has also been preparing the standardization of testing of grid connection requirements for power conversion equipment (PCE) for use in PV systems since 2016.

Purpose

This document proposes the Part 6 of this series which gives test procedures for confirming power control functions and grid support of PCE.

Figure 1 shows the relationships of the seven parts in IEC 63409.

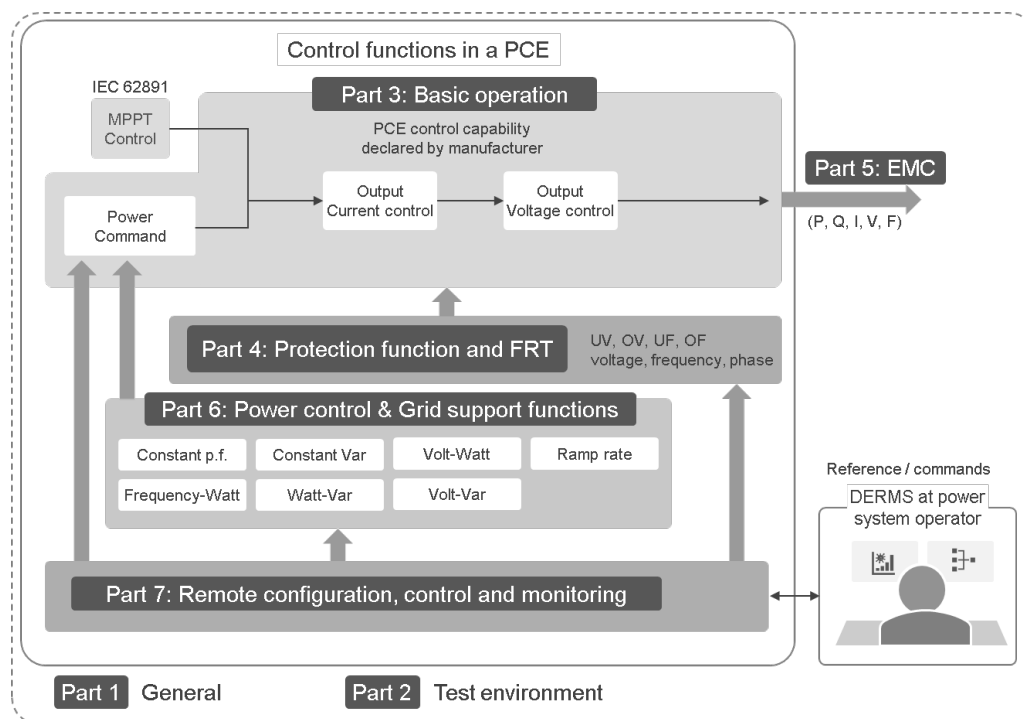


Figure 1 – Scope of IEC 63409

PHOTOVOLTAIC POWER GENERATING SYSTEMS CONNECTION WITH THE GRID – TESTING OF POWER CONVERSION EQUIPMENT

PART 6: POWER CONTROL FUNCTIONS AND GRID SUPPORT

1 Scope

This part of IEC 63409 specifies test procedures for the evaluation of performance of power control functions of power conversion equipment (PCE) for use in photovoltaic (PV) power systems with or without energy storage. This document covers testing requirements of the following functions equipped with the PCE:

- Autonomous connection and disconnection
- Constant power control
 - Active power control
 - Change of maximum active power configuration
 - Reactive power control (constant reactive power control, constant power factor control)
- Response control
 - Active power response to frequency variations (frequency - watt control)
 - Active power response to voltage variations (voltage - watt control)
 - Reactive power response to voltage variations (voltage - var control)
 - Power - reactive power / power factor control

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 61850-7-4:2010/AMD1:2020, *Amendment 1 - Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes*

IEC 61850-7-420:2021, *Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources and distribution automation logical nodes*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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**battery energy storage system****BESS**

electrical energy storage system with an accumulation subsystem based on batteries with secondary cells

Note 1 to entry: Battery energy storage systems include flow battery energy systems.

[SOURCE: IEC 60050-631:2024]

3.2**power conversion equipment****PCE**

electrical device converting one kind of electrical power from a voltage or current source into another kind of electrical power with respect to voltage, current and frequency

[SOURCE: IEC 62109-1:2010, 3.66]

3.3**step response time**

for a step response the duration of the time interval between the instant of the step change of an input variable and the instant when the output variable reaches for the first time a specified percentage of the difference between the final and the initial steady-state value

Note: See Figure 2

[SOURCE: IEC 60050-351:2013, 351-45-36]

3.4**settling time**

for a step response the duration of the time interval between the instant of the step change of an input variable and the instant, when the difference between the step response and their steady-state value remains smaller than the transient value tolerance

Note: See Figure 2

[SOURCE: IEC 60050-351:2013, 351-45-37]

3.5**overshoot**

for a step response of a transfer element the maximum transient deviation from the final steady-state value of the output variable, usually expressed in percent of the difference between the final and the initial steady-state values and for reference-variable step response or disturbance-variable step response of a control system the maximum transient deviation from the desired value

Note: See Figure 2

[SOURCE: IEC 60050-351:2013, 351-45-37]

3.6**dead time**

in a dead-time element the duration of the time interval by which the output variable is shifted relative to the input variable

Note: See Figure 2

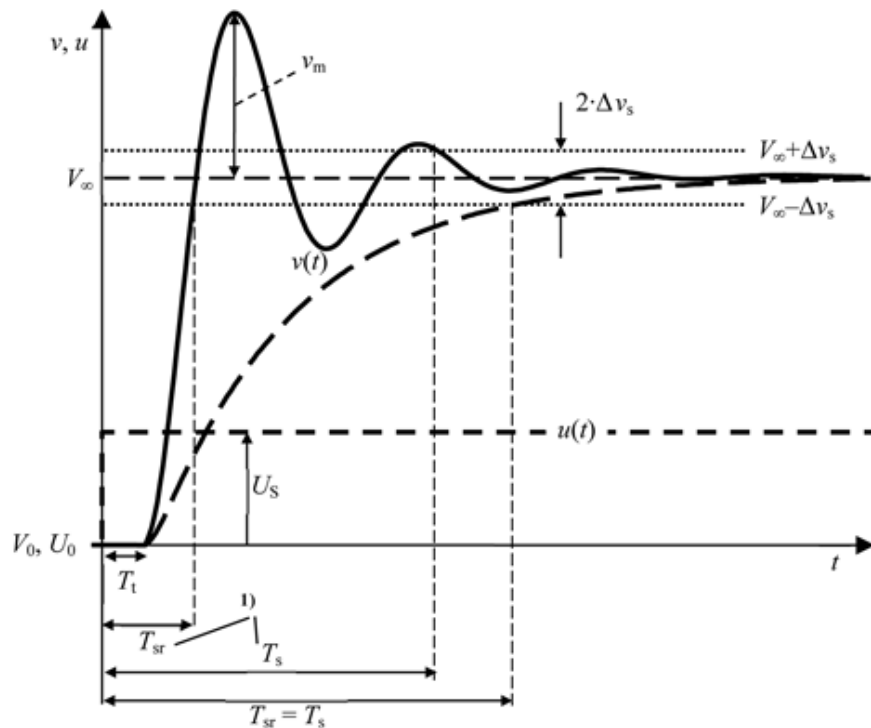
[SOURCE: IEC 60050-351:2013, 351-50-30]

3.7 tolerance band tolerance limit

with stabilized power supplies the range of steady-state values of a stabilized output quantity lying between specified limits of deviation from a preset value, e.g. a nominal value

Note: See Figure 2

[SOURCE: IEC 60050-551:1998, 551-19-07]



Key

- 1) For periodic behaviour
- 2) For aperiodic behaviour

u	Input variable
U_0	Initial value of the input variable
U_s	Step height of the input variable
v	Output variable
V_0, V_∞	Steady-state values before and after application of the step
v_m	Overshoot (maximum transient deviation from the final steady-state value)
$2 \cdot \Delta v_s$	Tolerance band
T_{sr}	Step response time
T_s	Settling time
T_t	Dead time

[SOURCE: IEC 60050-351: 2013, 351-45-36]

Figure 2 – Example of step response

4 General requirements

4.1 General conditions for testing

4.1.1 Sequence of tests

The test may be performed in any order unless otherwise specified in this document. It is not necessary to use the same sample for all tests unless otherwise specified in this document.

4.1.2 Test equipment conditions

Examples of the test equipment such as external power supplies and test instruments are described in Annex A.

4.1.3 Manufacturer's stated tolerance

The tolerance bands for ac voltage, frequency, active power, reactive power and the time measurements can be subject to local regulations. If not, the manufacturer of the PCE under evaluation shall state the tolerance.

4.1.4 Required setting for EUT (equipment under test)

All the grid support functions, except being tested function, should be disabled throughout the test. If any one of the grid support functions is essential to perform the test, it is permissible to enable it. In that case, it shall be written in the test report as remark that the specific function was enabled during the test because it was essential to complete the test.

Maximum power point tracking (MPPT) and DC power supply shall be configured as written in 4.2.

4.1.5 PCE firmware used during the test

The versions of the PCE firmware used during the test shall be recorded in the test report.

4.2 Test setup

During testing, the EUT's DC and AC ports shall be connected to external DC and AC power supplies according to EUT manufacturer's instructions. The test circuit diagram with positions of measurement sensors shall be recorded in the test report. Figure 3 shows the typical test setup required for test items described in this document.

Apparent power, active power and reactive power shall be measured at AC ports of EUT. The current measuring instruments at AC port of the EUT shall be installed so that the current flowing from EUT to AC power supply is measured as positive. See Annex B or more detailed definitions of sign conventions for measurements of voltage, current and power in this document.

The testing of the EUT shall not be influenced by the performance of DC power supply used for the test. Therefore, where the EUT has the capability to disable MPPT control, it is allowed to do so and a DC power supply that is able to provide constant voltage at any required power levels shall be used. A PV simulator may be used provided that the test results are not influenced by any DC instability by the PV simulator. In each case, remarks shall be written in the test report to note the type of the DC power supply or PV simulator used in the test. See Annex C for supplemental information regarding the influences from the PV simulator.

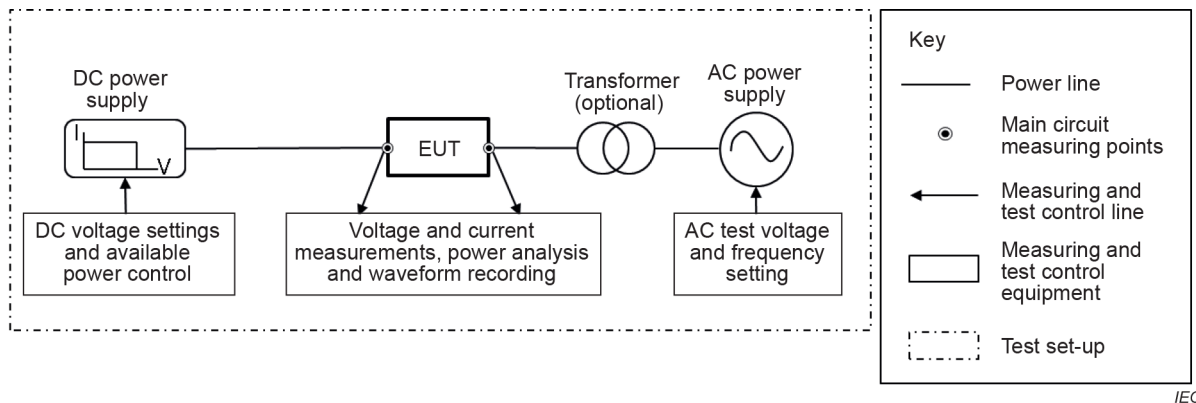


Figure 3 – Example of a test setup

4.3 Parameters used in the tests

This document describes the parameter setting procedure using the Logical node (LN) and Data object (message parameter) written in IEC 61850-7-4, and IEC 61850-7-420.

The tests described in this document require parameter setting changes and status monitoring, but it is not matter whether using communications to change or monitor the parameters. It does not mean that information exchange or remote monitoring with logical nodes specified in IEC 61850 shall be applied to evaluate the performance of functions. Data objects, or parameters, are used to describe test procedures.

The monitoring parameters for status of PCE are shown in Table 1, and measured value of PCE are shown in Table 2. Manufacturer shall declare the parameters before starting the tests.

Table 1 – Status of PCE

Item	IEC 61850			
	Standard	LN	message parameter	Description
Switch controller	IEC 61850-7-4	CSWI	Pos.stVal	Circuit breaker / switch position

Table 2 – Measured values of PCE

Item	IEC 61850			
	Standard	LN	message parameter	Description
AC voltage	IEC 61850-7-4	MMXU	PPV.phsAB / PNV.phsA	"PPV: Phase to Phase Voltage PNV: Phase to Neutral Voltage"
			PPV.phsBC / PNV.phsB	"PPV: Phase to Phase Voltage PNV: Phase to Neutral Voltage"
			PPV.phsCA / PNV.phsC	"PPV: Phase to Phase Voltage PNV: Phase to Neutral Voltage"
AC current			A.phsA	phase current
			A.phsB	phase current
			A.phsC	phase current

Apparent power			TotVA	The total apparent power in a three-phase circuit [VA].
Active power			TotW	The total Active power in a three-phase circuit [W].
Reactive power			TotVAr	The total Reactive power in a three-phase circuit [VAr].
Power factor			TotPF	The total power factor in a three-phase circuit
Frequency			Hz	Frequency [Hz].
AC voltage		MMXN	Vol	Non-phase-related AC rms voltage.
AC current			Amp	Non-phase-related AC rms current.
Apparent power			VolAmp	Non-phase-related AC apparent power.
Active power			Watt	Non-phase-related AC real power.
Reactive power			VolAmpr	Non-phase-related AC reactive power.
Power factor			PwrFact	Average power factor in a three-phase circuit.
Frequency			Hz	Frequency [Hz].
DC voltage		MMDC	Vol	DC voltage.
DC current			Amp	DC current.
DC power			Watt	DC power.

5 Test procedures

5.1 Test items

Table 3 shows test items specified in this document. The test items are aligned with IEC TS 62786-1, which specifies technical requirements for distributed energy resources (DER) connected to an electric power network, and IEC 61850-7-420, which defines information models for DER.

Table 3 – Test items and relations to IEC TS 62786-1 and information models

IEC 63409-6	IEC TS62786-1	Information model
5.2.2 Active power control	4.11 Ceasing and reduction of active power on set point	DWGC
5.2.3 Change of maximum active power configuration	4.11 Ceasing and reduction of active power on set point	DWMX
5.2.4.1 Constant reactive power control	4.7.3 Reactive power control modes	DVAR
5.2.4.2 Constant power factor control	4.7.3 Reactive power control modes	DPPF
5.3 Response control against grid variation (Power - power factor control)	4.7.3 Reactive power control modes	DWPF
5.3 Response control against grid variation (Power – reactive power control)	4.7.3 Reactive power control modes	DWVR

5.3 Response control against grid variation (Frequency – watt control)	4.6 Active power response to frequency deviation	DHFW/DLFW
5.3 Response control against grid variation (Voltage – watt control)	4.7.4 Voltage related active power reduction	DVWC
5.3 Response control against grid variation (Voltage – var control)	4.7.2 Voltage support by reactive power 4.7.5 Voltage related reactive power response	DVVR

5.2 Constant power control

5.2.1 General

This subclause 5.2 describes following test items for constant power control.

- Active power control
- Change of maximum active power configuration
- Reactive power control
 - Constant reactive power control
 - Constant power factor control

5.2.2 Active power control

5.2.2.1 General

This subclause 5.2.2 describes how to verify whether active power tracks if the limit for the active power injection is changed.

5.2.2.2 Procedure

Minimum required parameters for active power control are shown in Table 4.

Table 4 – Minimum required parameters for active power control

Item	IEC 61850			
	Standard	LN	message parameter	Description
Switch controller	IEC 61850-7-4	CSWI	Pos.ctlVal	Circuit breaker / switch position
Enabling function	IEC 61850-7-420	DWGC	Mod.ctlVal	1 (on): The application represented by the LN works. 5 (off): The application represented by the LN does not work.
Active power setpoint			WSptPct	Active power setpoint setting as a percentage of Wmax.
Use ramp rates limit			RmpRteUse	Use ramp rates limit. True = limited to ramp rates ; False = Not limited to ramp rates
Value of ramp rate			RpuMax	Maximum ramp up rate during generating (discharging)/injecting. Ramp rate as percentage of WMax or VArMax or AMax per second.
			RpdMax	Maximum ramp down rate during generating (discharging)/injecting. Ramp rate as percentage of WMax or VArMax or AMax per second.

a) Set parameter of PCE “CSWI.Pos.ctlVal” with False.

- b) Set parameter of PCE “DWGC.Mod.ctlVal” with “1”, and “DWGC.RmpRteUse” with True.
- c) Set parameter of PCE “DWGC.RpuMax” and “DWGC.RpdMax” with the maximum value.
- d) Set parameter of PCE “DWGC.WSptPct” with 80 %.
- a) Set parameter of PCE “CSWI.Pos.ctlVal” with True.
- b) Measure active power at the AC power ports.
- c) Set parameter of PCE “DWGC.WSptPct” with 100 %.
- d) Measure active power at the AC power ports.
- e) Set parameter of PCE “DWGC.WSptPct” with 80 %.
- f) Measure active power at the AC power ports.
- g) Set parameter of PCE “CSWI.Pos.ctlVal” with False.
- h) Set parameter of PCE “DWGC.RpuMax” and “DWGC.RpdMax” with the minimum value, then repeat d) to g).

5.2.2.2.1 Criteria

The error between the parameter of PCE and the detected value of the measuring device (“MMXU.TotW” or “MMXN.Watt”) is within the allowable range declared by the manufacturer.

5.2.3 Change of maximum active power configuration

5.2.3.1 General

This subclause 5.2.3 describes how to verify whether active power tracks if the maximum active power configuration is changed.

5.2.3.2 Procedure

Minimum required parameters for active power control are shown in Table 5.

Table 5 – Minimum required parameters for Maximum active power control

Item	IEC 61850			
	Standard	LN	message parameter	Description
Switch controller	IEC 61850-7-4	CSWI	Pos.ctlVal	Circuit breaker / switch position
Enabling function	IEC 61850-7-420	DWMX	Mod.ctlVal	1 (on): The application represented by the LN works. 5 (off): The application represented by the LN does not work.
Maximum active power setting			WMaxSptPct	Maximum active power setting as percentage value

- a) Set parameter of PCE “CSWI.Pos.ctlVal” with False.
- b) Set parameter of PCE “DWMX.Mod.ctlVal” with “1”.
- c) Set parameter of PCE “DWMX.WMaxSptPct” with 80 %.
- d) Set parameter of PCE “CSWI.Pos.ctlVal” with True.
- e) Measure active power at the AC power ports.
- f) Set parameter of PCE “DWMX.WMaxSptPct” with 100 %.
- g) Measure active power at the AC power ports.
- h) Set parameter of PCE “CSWI.Pos.ctlVal” with False.

5.2.3.3 Criteria

The error between the parameter of PCE and the detected value of the measuring device (“MMXU.TotW” or “MMXN.Watt”) is within the allowable range declared by the manufacturer.

5.2.4 Reactive power control

5.2.4.1 Constant reactive power control

5.2.4.1.1 General

This subclause 5.2.4.1 describes how to verify whether reactive power tracks if the limit for the reactive power injection is changed.

5.2.4.1.2 Procedure

Minimum required parameters for reactive power control are shown in Table 6.

Table 6 – Minimum required parameters for Reactive power control

Item	IEC 61850			
	Standard	LN	message parameter	Description
Switch controller	IEC 61850-7-4	CSWI	Pos.ctlVal	Circuit breaker / switch position
Enabling function	IEC 61850-7-420	DVAR	Mod.ctlVal	1 (on): The application represented by the LN works. 5 (off): The application represented by the LN does not work.
Reactive power setpoint			VARtgtSptPct	Target reactive power setpoint expressed as percent as indicated by VARSetRef.
Use ramp rates limit			RmpRteUse	Use ramp rates limit. True = limited to ramp rates ; False = Not limited to ramp rates
Value of ramp rate			RpuMax	Maximum ramp up rate during generating (discharging)/injecting. Ramp rate as percentage of WMax or VARMax or AMax per second,
			RpdMax	Maximum ramp down rate during generating (discharging)/injecting . Ramp rate as percentage of WMax or VARMax or AMax per second,
Active power setpoint		DWGC	WSptPct	Active power setpoint setting as a percentage of Wmax.

- Set parameter of PCE “CSWI.Pos.ctlVal” with False.
- Set parameter of PCE “DVAR.Mod.ctlVal” with “1”, and “DVAR.RmpRteUse” with True.
- Set parameter of PCE “DVAR.RpuMax” and “DVAR.RpdMax” with the maximum value.
- Set parameter of PCE “DVAR.VARtgtSptPct” with 10 %.
- Set parameter of PCE “DWGC.WSptPct” with 80 %.
- Set parameter of PCE “CSWI.Pos.ctlVal” with True.
- Measure reactive power at the AC power ports.
- Set parameter of PCE “DVAR.VARtgtSptPct” with 0 %.
- Measure reactive power at the AC power ports.