
**Povezava fotonapetostnih sistemov za proizvodnjo električne energije z omrežjem
- Preskušanje opreme za pretvorbo električne energije - 6. del: Funkcije za nadzor
moči in podpora omrežju**

Photovoltaic power generating systems connection with the grid - Testing of power
conversion equipment - Part 6: Power control functions and grid support

Photovoltaische Stromerzeugungssysteme mit Netzanschluss - Konformitätsbewertung
für Leistungswandler - Teil 6: Leistungsregelungsfunktionen und Netzunterstützung

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

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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.

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- 177 • withdrawn,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

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INTRODUCTION

Background

TC82 has been making efforts to contribute to the standardization of DER connection with the grid. In 2016, TC82 joined TC8/JWG10 to standardize utility power system operation requirements. In parallel with this 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 Part 6 of this series which gives test procedures for confirming power control functions and grid support of PCE.

Figure 1 gives an overview of the structure of the whole IEC 63409 series.

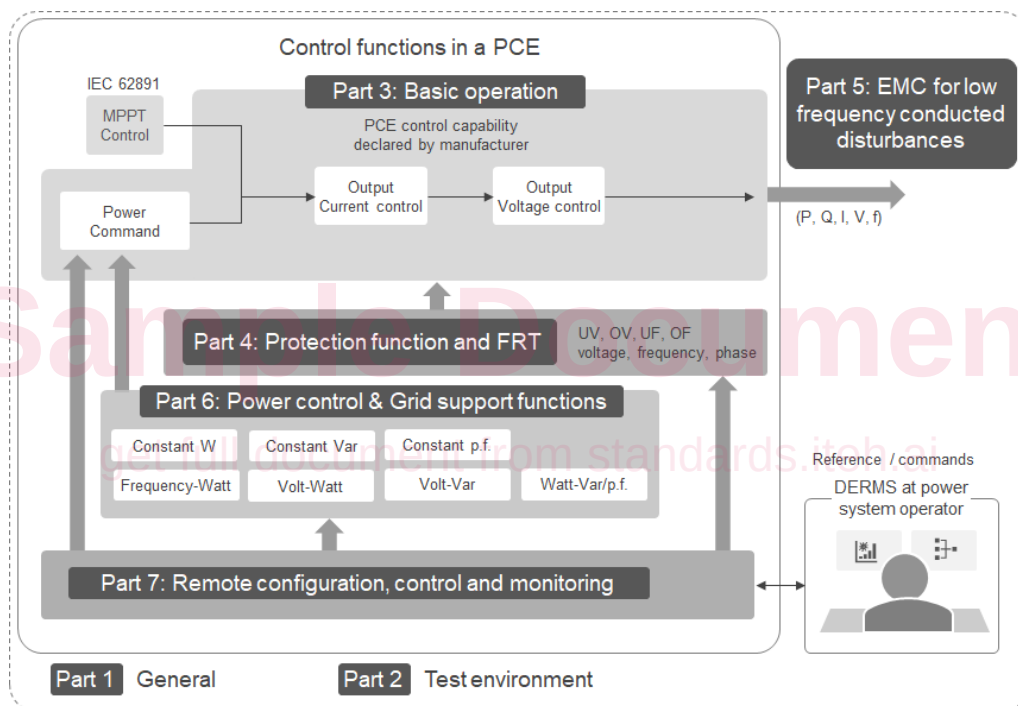


Figure 1 – Overview of IEC 63409 series

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:

- 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 60050-351:2013, *International Electrotechnical Vocabulary (IEV) - Part 901: Control technology*

IEC TS 62786-1:2023, *Distributed energy resources connection with the grid – Part 1: General requirements*

IEC TS 61836, *Solar photovoltaic energy systems - Terms, definitions and symbols*

IEC 62934:2021, *Grid integration of renewable energy generation - Terms and definitions*

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 terms and definitions given in IEC TS 61836, IEC 62934, IEC TS 62786 series, 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

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

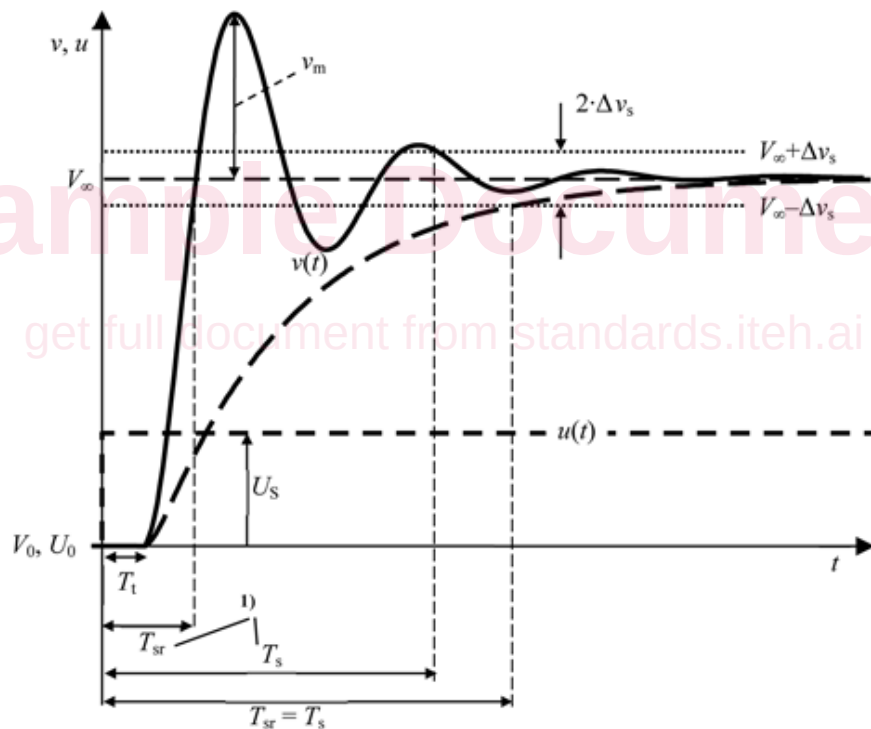
[SOURCE: IEC 60050-351:2013, 351-50-30]

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.

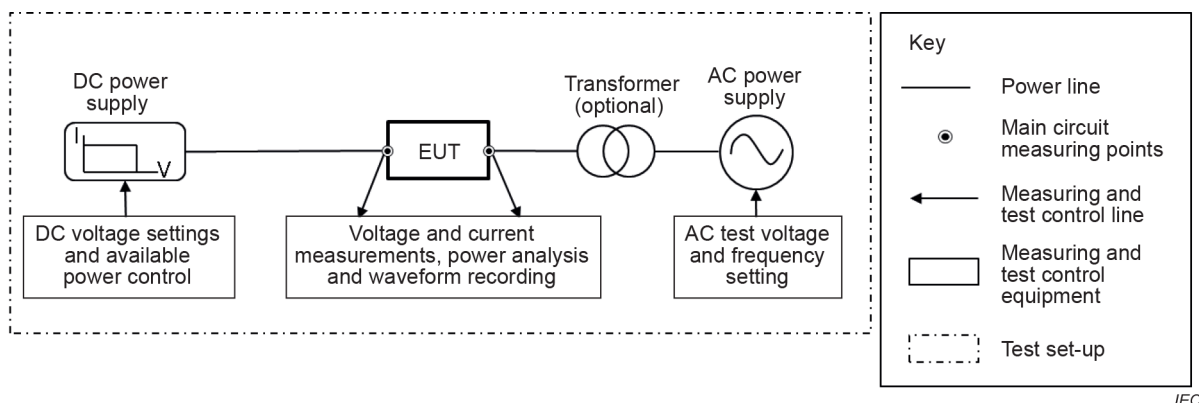


Figure 3 – Example of a test setup

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 does not matter whether remote communications are used 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"

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			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].
			VA.phsA		Phase A apparent power
			VA.phsB		Phase B apparent power
			VA.phsC		Phase C apparent power
Active power			TotW		The total Active power in a three-phase circuit [W].
			W.phsA		Phase A active power
			W.phsB		Phase B active power
			W.phsC		Phase C active power
Reactive power			TotVAr		The total Reactive power in a three-phase circuit [VAr].
			VAr.phsA		Phase A reactive power
			VAr.phsB		Phase B reactive power
			VAr.phsC		Phase C reactive power
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.