BS ISO 21498-2:2021

BSI Standards Publication

Electrically propelled road vehicles — Electrical specifications and tests for voltage class B systems and components

Part 2: Electrical tests for components

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/69, Electric vehicles.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Electrically propelled road vehicles — Electrical specifications and tests for voltage class B systems and components —

Part 2: Electrical tests for components

Véhicules à propulsion electrique — Spécifications et essais electriques pour les systèmes et composants de classe B —

Partie 2: Composants et essais electriques

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 37, *Electrically propelled vehicles*.

A list of all parts in the ISO 21498 series can be found on the ISO website.

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Introduction

The requirements for voltage class B electric circuits that are used for electric power transfer for the propulsion of electric road vehicles and their characteristics are significantly different to those of voltage class A electric circuits. Moreover, the range of voltage class B is too wide to be used for a component design regarding to voltage.

The ISO 21498 series divides voltage class B in a set of voltage sub-classes to enable a component design for each voltage sub-class regarding to voltage. It provides appropriate descriptions and definitions for requirements and characteristics of voltage class B systems for electrically propelled vehicles.

The voltage sub-class itself and the component characteristics have a large cost impact on the component design and on the overall design of the electric system. Additionally, a high variety of different voltage sub-classes and operating conditions impedes the use of an existing component in different vehicle models. The standardisation of voltage sub-classes and characteristics and the reduction of varieties will enable the reduction of component and system costs. This allows the decoupling of the system or component designs of a voltage class B electric circuit from the design of the electric energy source. Finally, the exchange of components from different suppliers for different customers is facilitated.

ISO 21498-1 provides definitions of and for voltage sub-classes and characteristics for rechargeable energy storage systems (RESS) and electric propulsion systems. It defines specific values for these sub-classes based on maximum working voltage. Voltage sub-classes listed in ISO 21498-1 are used for voltage class B systems of all kinds of current or future electrically propelled road vehicles.

This document provides electrical tests for electric and electronic components at voltage class B used for electrically propelled road vehicles. All relevant characteristics are covered considering usual driving scenarios as well as deviations from normal operation. The descriptions are generalized and include purpose, setup, procedure and requirements for the tests.

The specifications in this document are not intended to restrict the development of component performance or technology. The given definition of sub-classes does not exclude the use of other maximum operating voltages for an individual system design.

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Electrically propelled road vehicles — Electrical specifications and tests for voltage class B systems and components —

Part 2: Electrical tests for components

1 Scope

This document applies to voltage class B electric propulsion systems and connected auxiliary electric systems of electrically propelled road vehicles. It applies to electric circuits and components in these systems.

This document focuses on the characteristics at the DC voltage class B terminals of these components as specified in ISO 21498-1. It describes testing methods, test conditions and test requirements for components exposed to electrical behaviour caused by operation of electric loads and power sources.

This document does not cover electrical safety (see ISO 6469, ISO 17409).

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 cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TR 8713, *Electrically propelled road vehicles — Vocabulary*

ISO 21498-1, *Electrically propelled road vehicles – Electrical specifications and tests for voltage class B systems and components – Part 1: Voltage sub-classes and characteristics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and the following apply.

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

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

— IEC Electropedia: available at http://www.electropedia.org/

3.1
component operating status
general functional behaviour of components which depend directly on the voltage in *voltage class B* (3.13) *electric circuits* (3.3)

[SOURCE: ISO 21498-1:2021, 3.1]

3.2
customer
party that is interested in using *voltage class B* (3.13) components or systems

[SOURCE: ISO 21498-1:2021, 3.2]

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3.3
electric circuit
entire set of interconnected electric/electronic parts through which electrical current is designed to flow under normal operating conditions

[SOURCE: ISO 21498-1:2021, 3.3]

3.4
lower voltage limit
minimum voltage of a *voltage class B* (3.13) sub-class

3.5
maximum working voltage
highest value of AC voltage (rms) or of DC voltage that can occur under any normal operating conditions according to the *customer's* (3.2) specifications, disregarding *transients* (3.10) and *ripple* (3.8)

[SOURCE: ISO 21498-1:2021, 3.5]

3.6
power network
all components within *voltage class B* (3.13) DC network including their connections

[SOURCE: ISO 21498-1:2021, 3.6]

3.7
rechargeable energy storage system
RESS
rechargeable system that stores energy for delivery of electric energy for the electric drive

EXAMPLE Batteries, capacitors, flywheel.

[SOURCE: ISO 21498-1:2021, 3.7]

3.8
ripple
set of unwanted periodic deviations with respect to the average value of the measured or supplied quantity, occurring at frequencies which can be related to that of components within a system

[SOURCE: ISO 21498-1:2021, 3.8]

3.9
supplier
party that provides *voltage class B* (3.13) components or systems

[SOURCE: ISO 21498-1:2021, 3.9]

3.10
transient
phenomenon or quantity which varies between two consecutive steady states during a short time interval compared to the time-scale of interest

[SOURCE: ISO 21498-1:2021, 3.10]

3.11
upper voltage limit
maximum voltage of a *voltage class B* (3.13) sub-class

Note 1 to entry: *Maximum working voltages* (3.5) within a *voltage sub-class* (3.15) are less than or equal to the upper voltage limit.

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3.12
voltage class A
classification of an electric component or circuit with a *maximum working voltage* (3.5) of ≤30 V AC (rms) or ≤60 V DC respectively

[SOURCE: ISO 21498-1:2021, 3.12]

3.13
voltage class B
classification of an electric component or circuit with a *maximum working voltage* (3.5) of (> 30 and ≤ 1 000) V AC (rms) or (> 60 and ≤ 1 500) V DC respectively

[SOURCE: ISO 21498-1:2021, 3.13]

3.14
voltage range
general term covering *voltage sub-class* (3.15), *working voltages* (3.16) and deviations from working voltages

[SOURCE: ISO 21498-1:2021, 3.14]

3.15
voltage sub-class
classification of an electric component or circuit with a DC voltage within the *voltage class B* (3.13)

3.16
working voltage
AC voltage (rms) or DC voltage that can occur in an electric system under normal operating conditions according to the *customer's* (3.2) specifications, disregarding *transients* (3.10) and *ripple* (3.8)

4 Abbreviated terms

DUT device under test

EV electrically propelled road vehicle

HV high voltage

OS operating status

LV low voltage

5 General assumptions for voltage class B components

General assumptions and definitions for voltage class B systems shall be as in ISO 21498-1.

Figure 1 shows a generalized view on a voltage class B component. Some of the connections shown may not be available for all voltage class B components. All voltage profiles or voltage values in this document refer to the voltage between the "HV+" and "HV-" terminals of a voltage class B component, if not otherwise stated.

Due to the differences between different voltage class B components, Table A.1 gives an overview on how the different tests, which are described in this document, are applicable. Not all tests are reasonable for all voltage class B components.

A voltage class B component may have multiple interfaces for each type of voltage (voltage class B DC, voltage class B AC, voltage class A, according to Figure 1). For example, a DC/DC converter may interface to two voltage class B electric circuits.

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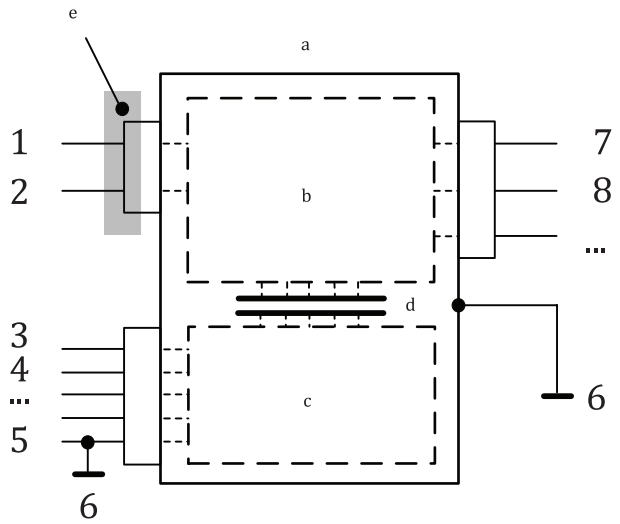
A voltage class B component may have multiple voltage class B DC terminals, which can be galvanically separated. The tests described in this document shall be fulfilled for each of these terminals.



Key

1 voltage class B connection: HV+

2 voltage class B connection: HV-

3 voltage class A power

4 I/O and bus signals

5 terminal with direct connection to voltage class A ground reference

6 ground reference

7 connection to further voltage class B component (e.g. electric motor)

8 connection to further voltage class B component (e.g. AC or DC power network)

a DUT.

b Voltage class B circuit.

c Voltage class A circuit.

d Galvanic separation between voltage class A and voltage class B.

e Voltage class B terminals under test.

Figure 1 — Generalized voltage class B component diagram

For the purpose of testing, Figure 2 summarizes the voltage operating ranges and OS of a voltage class B component at its voltage class B DC voltage terminals. The overvoltage limit, the upper voltage limit and the lower voltage limit are properties of the component.

Each voltage class B component shall have a voltage range in which it can be operated with its specified performance (unlimited operating capability). All designated functions, including short-time overload operations, shall be available. Within this voltage range, the component operates in OS1.

Above a maximum voltage, a component may reduce its performance as specified. This specified voltage is called the maximum unlimited operating voltage ($U_{max_unlimited_op}$). The component shall provide its upper limited operating capability until the upper voltage limit (U_{upper_limit}) is reached. In this case, the component operates in OS2.

Above the upper voltage limit (U_{upper_limit}) the component may derate or cut-off its performance for self-protection. The component shall withstand this overvoltage until the overvoltage limit (U_{over_limit}) is reached. In this case, the component operates in OS3 or OS4.

A component shall perform in OS1 until the supply voltage drops to the minimum unlimited operating voltage ($U_{min_unlimited_op}$). Between the minimum unlimited operating voltage ($U_{min_unlimited_op}$) and the lower voltage limit (U_{lower_limit}), the component may reduce its performance as specified. In this case, the component operates in OS2.

If the supply voltage is below the U_{lower_limit}, the component may derate or cut-off its performance. In this case, the component operates in OS3 or OS4.

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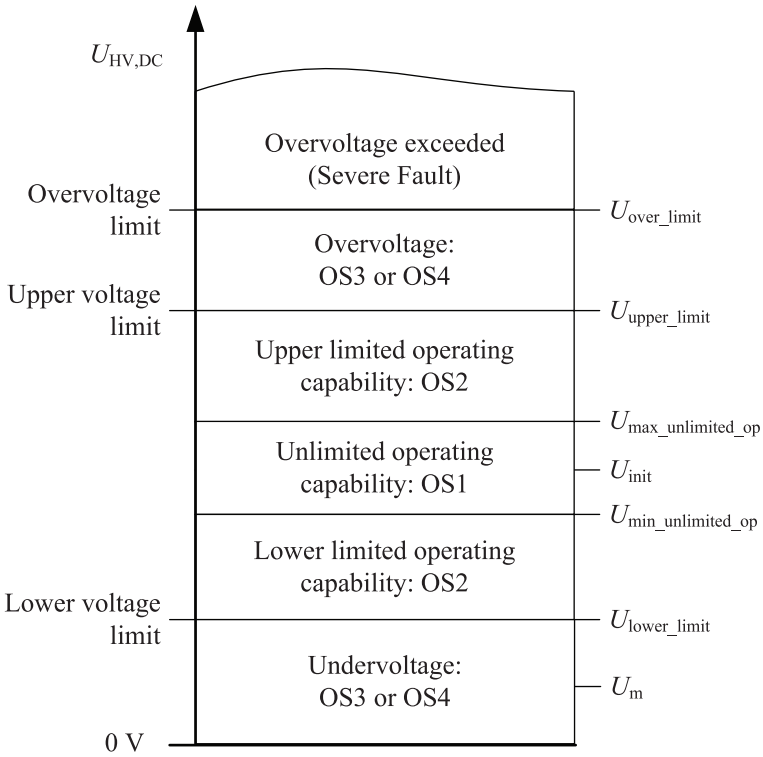

Figure 2 — Component voltage range and limits of corresponding OS

6 Tests and requirements

6.1 Test parameters and general test requirements

6.1.1 Purpose

6.1 describes the specification of test parameters including tolerances and general test requirements. Frequency, time and voltage levels used for the tests are introduced.

6.1.2 Test setup

The test setup shall provide appropriate interfaces, connections and loads to achieve representative DUT operation and characteristics. Measurement of voltages shall be performed at the voltage class B terminals of the DUT.

6.1.3 Voltages

Table 1 contains voltage definitions and their abbreviations.

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Table 1 — Voltage definitions and abbreviations

Test parameter	Meaning
U_{over_limit}	Overvoltage limit[a]
U_{upper_limit}	Upper voltage limit[a]
U_{lower_limit}	Lower voltage limit[a]
$U_{max_unlimited_op}$	Maximum voltage for unlimited operating capability[b]
$U_{min_unlimited_op}$	Minimum voltage for unlimited operating capability[b]
U_{init}	Initial voltage for all tests
U_{HV}	Voltage at the terminals of the DUT
$U_{HV,DC}$	DC part of the voltage at the terminals of the DUT
$U_{HV,AC}$	AC part of the voltage at the terminals of the DUT (peak value)
U_{PP}	Peak-to-peak value of AC voltage
$U_{HV,idle}$	HV DC voltage at no load operation
$U_{HV,Ppeak}$	HV DC voltage at peak power operation
U_m	Voltage in the undervoltage range

[a] Voltage defined in ISO 21498-1.

[b] See Figure 2 for illustration. The unlimited operating capability is defined in ISO 21498-1.

6.1.4 Powers

Table 2 contains power definitions and their abbreviations.

Table 2 — Power definitions and abbreviations

Test parameter	Meaning
P_{cont}	Continuous power of the DUT
P_{max_gen}	Generated HV DC maximum power by the DUT
P_{peak}	Maximum short-term power of the DUT
P_{idle}	Power of the DUT during no load operation
$P_{request}$	Power request to the DUT[a]

[a] This value is related to the desired output power of the DUT, the actual set value may have another physical quantity (e.g. current, speed, torque) depending on the DUT.

6.1.5 Temperatures

The focus of all tests in this document is on the electrical behaviour of the component at the voltage class B terminals. Thermal derating is not considered. Therefore, all tests shall be performed at ambient temperature.

If a component needs additional liquid cooling, the cooling system shall be chosen as such that the DUT's performance is not affected by thermal derating. Flow rate and coolant temperature shall be documented.

If the electric tests have to be performed at different temperature levels, Annex B gives guidance on how to perform these tests.

6.1.6 Times and durations

Table 3 contains definitions of times and durations and their abbreviations.

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Table 3 — Times/duration definitions and abbreviations

Test parameter	Meaning
t_d	Duration time (e.g. of a voltage profile or a transient event)
t_f	Fall time (e.g. of a voltage profile or a transient event)
t_h	Hold time (e.g. of a voltage profile)
t_{idle}	Duration of the idle power request
t_{Peak}	Duration of the peak power request
t_r	Rise time (e.g. of a voltage profile or a transient event)
t_{test}	Test duration

6.1.7 Standard tolerances

Unless otherwise specified, the tolerances in accordance with Table 4 apply with accuracy as shown in Table 5.

Tolerances refer to the required setting value. Tolerances of the component measurement shall not lead to an OS change.

Tolerances shall only be applied in a way that requirements are not weakened.

Table 4 — Standard tolerances for test equipment

Test parameter	Value	Remark
Amplitude of AC voltage	0 % to +5 % relating to the specified value [b]	Tolerance of AC voltage
Capacitance	± 10 % of specified component value [a]	Tolerance of capacitance
DC voltage	± 0,2 % of U_{upper_limit}	Tolerance of DC voltage
Frequency of AC voltage	± 1 % relating to the specified value [a]	Tolerance of AC voltage frequency
Inductance	± 10 % of specified component value [a]	Tolerance of inductance
Resistance	± 10 % of specified component value [a]	Tolerance of resistance
Time/duration	0 % to +5 % relating to the specified value [b]	Tolerance of time/duration

[a] The specified value is given in the test description or in Annex C.

[b] The specified value is given in the test description. The value may not be below the given value.

Table 5 — Accuracy of measurement

Test parameter	Value
Voltage measurement	± 0,5 % of U_{upper_limit}
Current measurement	± 1 % of measured current or 100 mA, whichever is greater

6.1.8 Ambient conditions

Unless otherwise specified, the parameter values of ambient conditions in accordance with Table 6 shall be used.

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Table 6 — Test conditions

Test parameter	Value	Remark
RT	(23 ± 5) °C	Room temperature
RH	25 % to 75 %	Relative humidity
T_{amb}	RT[a]	Ambient temperature
T_{cool}	According to specification or as agreed between customer and supplier	Coolant temperature
[a] RT shall be used if temperature has no impact.		

6.1.9 Wiring harness

The DUT shall be connected to the test setup using the following conditions. If there is an attached cable tail at the DUT or a designated wiring harness, the test setup shall be connected at the end of the existing cable. If not, a cable with a length of maximum 2 m shall be used to connect the DUT to the test setup.

6.1.10 Load conditions

The DUT shall be connected to an appropriate load or source. For all tests the DUT shall be operated at continuous power, if not otherwise stated. If this condition can be reached at several operating points (e.g. speed, torque), an appropriate operating point shall be agreed between customer and supplier.

If a component is able to consume and to deliver electrical energy (e.g. motor/generator), the component shall be tested in both energy flow directions.

6.1.11 Sampling rates and measured value resolutions

Sampling rate, bandwidth and resolution of the measuring system shall be adapted for the respective test. This document contains tests concerning DC operation only and tests concerning AC characteristics within a frequency range from 10 Hz to 150 kHz.

6.1.12 Parameter monitoring

All additional parameters to be monitored shall be defined for the relevant tests with their value ranges. During the complete test, the parameters to be monitored shall be recorded. The data resulting from the continuous parameter monitoring shall be examined for trends and drifting to detect abnormalities or malfunctions of the component. For components with fault memory, the customer and the supplier shall prior to the testing agree upon which component behaviour that is to be stored during the test. The fault memory shall be monitored and all entries shall be documented.

6.1.13 Interface description

A detailed description of the states and electrical properties of all interfaces (measuring setup and component) shall be provided.

6.1.14 Documentation

For documentation, see individual requirements as given during the test description.

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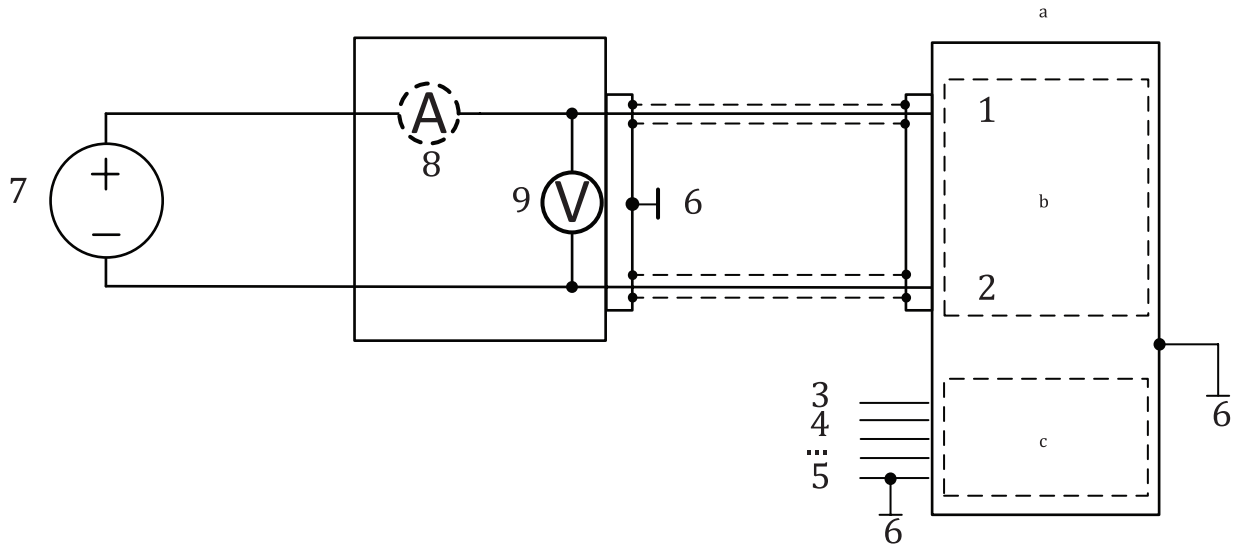
6.2 DC supply voltage variation within operational range

6.2.1 Purpose

This test verifies that the DUT is able to perform as specified when the DC voltage varies in the range between the lower voltage limit and the upper voltage limit. The purpose is to emulate real battery operation.

6.2.2 Test setup

The test setup according to Figure 3 shall be used. It consists of a variable HV DC power supply and the DUT. A profile for the voltage U_{HV} at the connection to the DUT is given in Figure 4.



Key

1	voltage class B connection: HV+	7	HV DC power supply
2	voltage class B connection: HV-	8	current sensor (optional)
3	voltage class A power	9	voltage sensor (reference for U_{HV})
4	I/O and bus signals	a	DUT.
5	terminal with direct connection to voltage class A ground reference	b	Voltage class B circuit.
6	ground reference	c	Voltage class A circuit.

Figure 3 — Test setup for DC supply voltage variation within operational range

6.2.3 Test procedure

Install the DUT in a test setup according to Figure 3 and verify that all functions operate according to OS1 at a voltage within the specification for unlimited operation (e.g. at U_{init}).

Change the level of the HV DC power supply so that the measured voltage at the DUT (U_{HV}) becomes according to the voltage profile in Figure 4 and Table 7.

If a component has no OS2 ($U_{max_unlimited_op}$ has the same value as U_{upper_limit} and/or $U_{min_unlimited_op}$ has the same value as U_{lower_limit}) the respective test procedures and test profiles shall be adapted accordingly. The adaptation shall be agreed between customer and supplier.

The voltage at the voltage class B terminals of the DUT (U_{HV}) and relevant parameters to evaluate the OS shall be recorded during the test.

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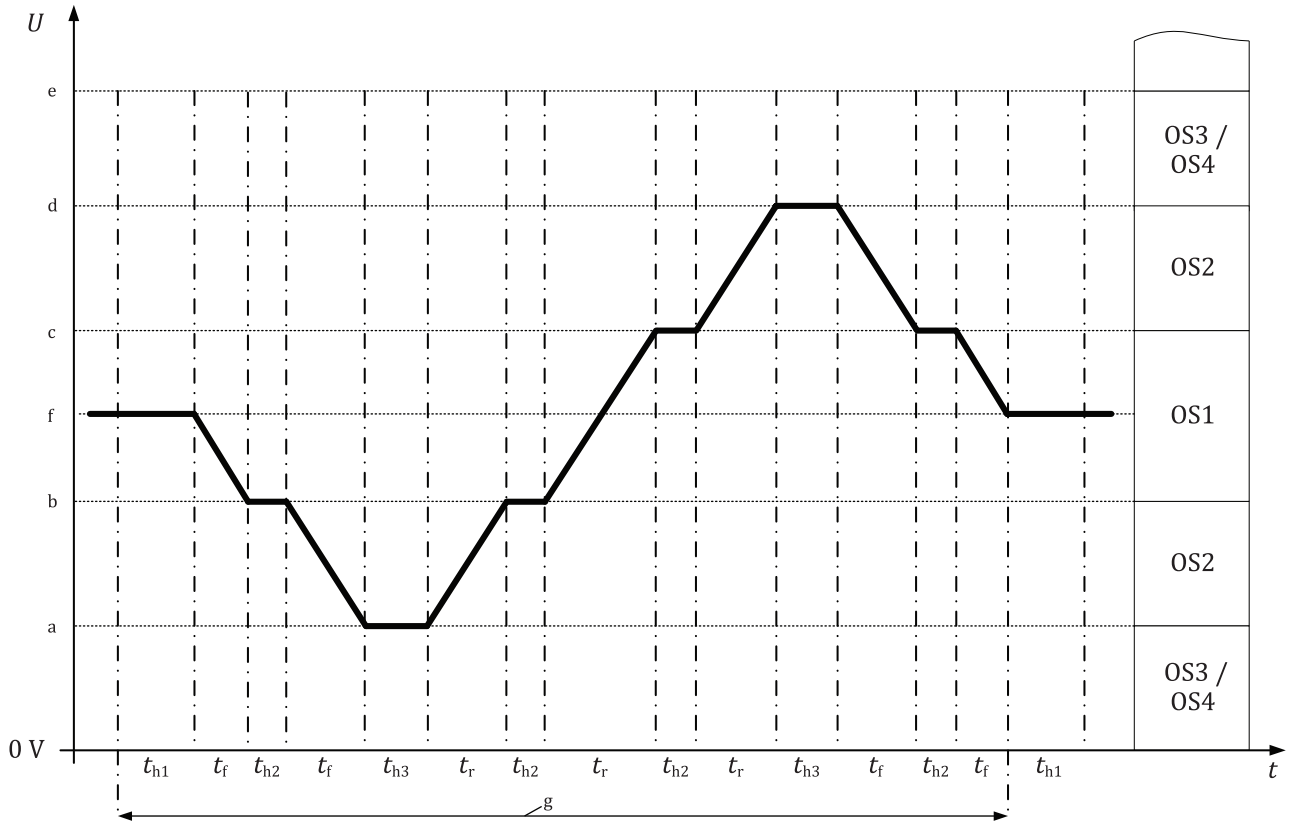

Key

U	voltage	b	$U_{min_unlimited_op.}$
t	time	c	$U_{max_unlimited_op.}$
t_f	fall time	d	$U_{upper_limit.}$
t_h	hold time	e	$U_{over_limit.}$
t_r	rise time	f	$U_{init.}$
a	$U_{lower_limit.}$	g	One cycle.

Figure 4 — Voltage profile for DC supply voltage variation within operational range

Table 7 — Test parameters for DC supply voltage variation within operational range

Test parameter	Value	Remark
U_{init}	$\left(U_{max_unlimited_op} + U_{min_unlimited_op}\right)/2$	Or as agreed between customer and supplier
t_{h1}	≥ 30 s	Hold time
t_f	$\lvert\Delta U/\Delta t\rvert \leq 2V/s$ [a]	Fall time, to be determined with $\lvert\Delta U/\Delta t\rvert$
t_{h2}	≥ 5 s	Hold time
t_r	$\Delta U/\Delta t \leq 2V/s$ [a]	Rise time, to be determined with $\Delta U/\Delta t$
t_{h3}	≥10 s	Hold time
ΔU	<1 V	HV voltage increment
n	10	Number of cycles
[a] Voltage change rate may be faster if the DUT stays in stable operation.		

6.2.4 Requirements

The DUT shall stay in OS1 for voltages between the minimum and maximum voltage for unlimited operating capability.

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