

ISO/TC 22/SC 32

Secretariat: JISC

Voting begins on:
2020-05-04

Voting terminates on:
2020-06-29

Road vehicles — Supply voltage of 48 V — Electrical requirements and tests

Véhicules routiers — Tension d'alimentation de 48 V — Exigences électriques et essais

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Reference number
ISO/FDIS 21780:2020(E)

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Published in Switzerland

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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 32, *Electrical and electronic equipment and general system aspects*.

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Road vehicles — Supply voltage of 48 V — Electrical requirements and tests

1 Scope

This document covers requirements and tests for the electric and electronic components in road vehicles equipped with an electrical system operating at a nominal voltage of 48 V DC.

This includes the following:

- general requirements on 48 V DC electrical systems;
- voltage ranges;
- slow voltage transients and fluctuations (not including EMC).

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.

ISO 16750-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 16750-2, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

EN 13018, *Non-destructive testing — Visual testing — General principles*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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

a part that is directly installed in a vehicle and is the Device Under Test (DUT)

3.2 fire

self-supporting combustion which spreads, uncontrolled, with time and in space and may result in bright light, heat, smoke, burning or a combination of all the above

3.3 ground for 12 V/24 V electrical system

$GND_{12/24}$
ground pin on the 12 V/24 V electrical system

**3.4
ground for 48 V electrical system**

GND_{48}
ground pin on the 48 V electrical system

**3.5
12 V/24 V positive voltage connection pin**

$U_{12/24}$
positive voltage connection pin on the 12 V/24 V electrical system

**3.6
48 V positive voltage connection pin**

U_{48}
positive voltage connection pin on the 48 V electrical system

**3.7
nominal 12 V/24 V supply voltage**

U_N
voltage of the 12 V/24 V external supply distribution system

**3.8
nominal 48 V supply voltage**

U_{48N}
voltage of the 48 V external supply distribution system

**3.9
maximum operating temperature**

T_{max}
highest temperature of operation of the DUT

**3.10
minimum operating temperature**

T_{min}
lowest temperature of operation of the DUT

**3.11
room temperature**

T_{RT}
ambient temperature at which the test is performed

**3.12
test temperature**

T_{test}
temperature of the DUT at which the test is performed

4 Functional status

4.1 General

A component may include several functions which might have different functional statuses for the same value of the influencing parameter. For the purpose of this document the influencing parameter is the supply voltage.

The functional status is a minimum requirement.

The component functional behaviour, (including derating), relating to each chosen functional status level and the customer perception (e.g. visual, acoustic, tactile and thermal), shall be defined and agreed between the customer and supplier and described in the required component documentation. See [Annex A](#) for application examples.

4.2 Functional status 1 (FS1)

The function shall meet a specified performance without deviation. Derating or switch-off is not allowed.

4.3 Functional status 2 (FS2)

The function shall meet a specified performance with a specified variation below or above the specified performance of FS1. Derating is allowed, switch-off is not allowed.

4.4 Functional status 3 (FS3)

The function may not provide the specified performance. Derating or switch-off is allowed. The function shall automatically recover and return to the specified performance level if the necessary operating conditions are met.

4.5 Functional status 4 (FS4)

The function may not provide the specified performance. Derating or switch-off is allowed. The function shall recover and return to specified performance only after a change in vehicle operational status (e.g. change of ignition status, vehicle restart) has occurred and if the necessary operating conditions are met.

4.6 Functional status 5 (FS5)

The DUT fails to perform one or more functions whilst the test parameters are applied, the DUT does not set itself on fire as defined in [3.2](#). After application is terminated, the DUT can no longer be used unless it is repaired or replaced

5 Supply voltage range

The supply voltage ranges are described in [Figure 1](#).

Upper overvoltage range	60 V Upper overvoltage limit
Overvoltage range	58 V Overvoltage limit
Upper transitory voltage range	54 V Upper transitory voltage limit
Nominal voltage range	52 V Upper nominal voltage limit
Lower transitory voltage range	36 V Lower nominal voltage limit
Undervoltage range	31 V Lower transitory voltage limit
Lower undervoltage range	24 V Undervoltage limit
	0 V Lower undervoltage limit

Figure 1 — Supply voltage ranges

Upper overvoltage range (58 V – 60 V):

Reason for being in this voltage range could be a control error.

Overvoltage range (54 V – 58 V):

This voltage range may occur due to (short term) return of electrical energy or maybe a control error.

The system may operate only temporarily in this range.

Upper transitory voltage range (52 V – 54 V):

This range is intended for calibrating the storage media and for uptake of recovered energy.

The system may operate only temporarily in this range.

Nominal voltage range (36 V – 52 V):

The system is expected to operate in this range most of the time.

Lower transitory voltage range (31 V – 36 V):

The voltage may for example be in this range during boost or during cold crank.

The system may operate only temporarily in this range.

Undervoltage range (24 V – 31 V):

The voltage may for example be in this range during cold crank.

The system may operate only temporarily in this range.

Lower undervoltage range (0 V – 24 V):

Storage protection.

The voltage is not expected to be in this range except for short term discontinuities in the supply voltage or due to long term parking.

6 Functional categories

The required performance, (e.g. torque of an electrical motor or flow rate of a water pump), shall be specified for each relevant function of the DUT. The performance specified is then used as a reference to enable the selection of a functional status level for each relevant function. The functional categories which specify the changes in functional status of the DUT as a function of the 48 V supply voltage are described in [Table 2](#). Use [Table 2](#) to select the required category for each function of the DUT. Examples for the different functional categories are given in [Table 1](#).

Table 1 — Functional categories

Functional category	Example of functions or components
FC I	Communication, diagnostic
FC II	Voltage conversion from 48 V to 12 V Functions relevant to vehicle safety Functions relevant to propulsion Components which act as 48 V sources.
FC III	Components/functions relevant to starting. Components/functions that need to operate during starting (cranking).
FC IV	Comfort functions
FC Z	To be used if the above definitions of functional categories are judged to be unsuitable for the DUT. In this case, functional status is to be agreed between supplier and customer for each test.

Table 2 — Functional status

Voltage range	Test	Functional category				
		I	II	III	IV	Z
$60\text{ V} < U_{48} \leq 70\text{ V}$	Test-03 Short term overvoltage	FS1	FS2	FS2	FS3	As agreed
$58\text{ V} < U_{48} \leq 60\text{ V}$	Test-06 Long term overvoltage	FS3	FS3	FS3	FS3	As agreed
$54\text{ V} < U_{48} \leq 58\text{ V}$	Test-07 Overvoltage with consumer components which may supply electrical energy	FS1	FS2	FS3	FS3	As agreed
$52\text{ V} < U_{48} \leq 54\text{ V}$	Test-02 Lower and upper transitory voltage ranges	FS1	FS2	FS3	FS2	As agreed
$52\text{ V} < U_{48} \leq 54\text{ V}$	Test-09 Voltage ripples	FS1	FS2	FS3	FS2	As agreed
$36\text{ V} \leq U_{48} \leq 52\text{ V}$	Test-01 Nominal voltage range	FS1	FS1	FS1	FS1	As agreed
$31\text{ V} \leq U_{48} < 36\text{ V}$	Test-02 Lower and upper transitory voltage ranges	FS1	FS2	FS2	FS3	As agreed
$31\text{ V} \leq U_{48} < 36\text{ V}$	Test-08 Decrease and increase of supply voltage	FS1	FS2	FS2	FS3	As agreed

Table 2 (continued)

Voltage range	Test	Functional category				
		I	II	III	IV	Z
$31\text{ V} \leq U_{48} < 36\text{ V}$	Test-09 Voltage ripples	FS1	FS2	FS2	FS3	As agreed
$31\text{ V} \leq U_{48} < 36\text{ V}$	Test-10 Reinitialization	FS1	FS2	FS2	FS3	As agreed
$24\text{ V} \leq U_{48} < 31\text{ V}$	Test-05 Starting profile	FS1	FS2	FS2	FS3	As agreed
$24\text{ V} \leq U_{48} < 31\text{ V}$	Test-08 Decrease and increase of supply voltage	FS1	FS3	FS3	FS3	As agreed
$24\text{ V} \leq U_{48} < 31\text{ V}$	Test-10 Reinitialization	FS1	FS2	FS2	FS3	As agreed
$0\text{ V} \leq U_{48} < 24\text{ V}$	Test-08 Decrease and increase of supply voltage	FS3	FS3	FS3	FS3	As agreed
$0\text{ V} \leq U_{48} < 24\text{ V}$	Test-10 Re-initialization	FS3	FS3	FS3	FS3	As agreed

NOTE Not all of the tests in this document are listed in Table 2. Tests that are not listed in the table state their requirements in the individual test clauses.

7 Operating modes

The following operating modes apply.

The DUT is electrically operated with test voltage U_N and U_{48N} as defined in 3.7 and 3.8 (unless otherwise specified in the test procedure) with all electrical connections made.

If the component requires a cooling system, it shall be operated and adjusted if necessary, as described in the component specifications:

- operating mode 2.1: system/component functions are not activated (e.g. sleep mode);
- operating mode 2.2: electrical systems/components controlled to and operating at typical operating mode;
- operating mode 2.3: electrical systems/components controlled to and operating at minimum load. No activated loads (e.g. standby);
- operating mode 2.4: electrical systems/components controlled to and operating at maximum load.

Minimum, typical and maximum operating loads should be defined for each function by agreement between the supplier and customer.

NOTE 2 Since the application scope is different, these operating modes definitions are not strictly identical to the definitions of the ISO 16750-1. Operating modes 1, 3 are used in ISO 16750-1 but are not needed in this document.

8 General tests conditions

8.1 Standard tolerances

Unless otherwise stated, the tolerances specified in Table 3 apply for the measurement values in all the tests given in this standard.

Table 3 — Standard tolerances

Abbreviation	Meaning	Tolerance limits
f	Frequency	$\pm 1 \%$
T	Temperature	$\pm 2 \text{ }^\circ\text{C}$
RH	Relative humidity	$\pm 5 \%$
t	Time	+5 % to 0 %
U	Voltage	$\pm 0,5 \%$
I	Current	$\pm 2 \%$
R	Resistor	$\pm 10 \%$

8.2 General values

Unless otherwise specified, all tests shall be performed at:

- nominal 12 V/24 V voltage (U_N) as defined in ISO 16750-1;
- nominal 48 V voltage (U_{48N}): 48 V;
- room temperature (T_{RT}): $+23 \text{ }^\circ\text{C} \pm 5 \text{ }^\circ\text{C}$;
- relative humidity (RH_{test}): 25 % to 75 %;
- test temperature (T_{test}): room temperature.

8.3 Sampling rate and value resolution

Before each test, it shall be ensured that the sampling rate/bandwidth, the measurement range of the measuring system and the resolution of the measured values are set to values appropriate for the test to be performed and, where necessary, adjusted to suit. All measured values shall be recorded along with the maximum and minimum, or peak, values.

8.4 Description of interfaces

All interfaces to the DUT which enable functional performance of the DUT along with the specific test parameters to be met shall be defined. Examples of such are, electrical connectors and wiring, mechanical attachments, coolant mechanisms, etc.

8.5 Restrictions on performing the tests

The testing laboratory shall be organised and operated in accordance with ISO/IEC 17025. All the testing equipment used for making measurements shall be calibrated in accordance with ISO/IEC 17025 (or as determined or recommended by the manufacturer), and shall be traceable to a national metrology laboratory.

8.6 Number of tested samples

Final validation shall be performed with at least two DUTs, during initial design validation phases this requirement is waived.

8.7 Test voltages

Unless explicitly specified otherwise, voltage profiles indicated refer to the terminal voltages of the DUT and shall be measured and documented in the test report. The specified voltages shall be measured referenced to their respective grounds at connector or terminals of the DUT.