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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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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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.

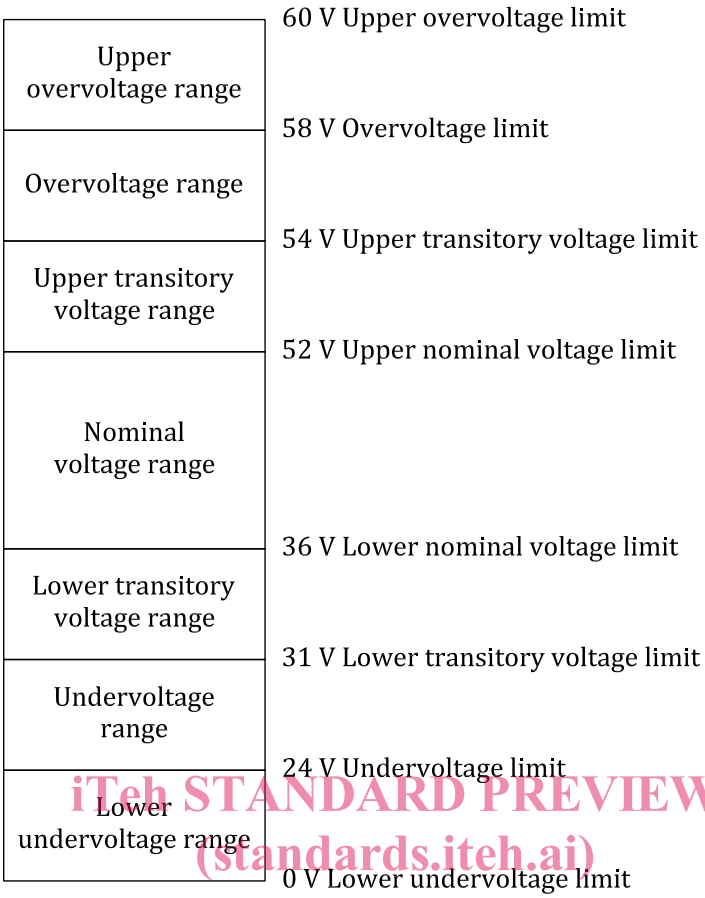

Figure 1 — Supply voltage ranges

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 V < U_{48} ≤ 70 V	Test-03 Short term overvoltage	FS1	FS2	FS2	FS3	As agreed
58 V < U_{48} ≤ 60 V	Test-06 Long term overvoltage	FS3	FS3	FS3	FS3	As agreed
54 V < U_{48} ≤ 58 V	Test-07 Overvoltage with consumer components which may supply electrical energy	FS1	FS2	FS3	FS3	As agreed
52 V < U_{48} ≤ 54 V	Test-02 Lower and upper transitory voltage ranges	FS1	FS2	FS3	FS2	As agreed
52 V < U_{48} ≤ 54 V	Test-09 Voltage ripples	FS1	FS2	FS3	FS2	As agreed
36 V ≤ U_{48} ≤ 52 V	Test-01 Nominal voltage range	FS1	FS1	FS1	FS1	As agreed
31 V ≤ U_{48} < 36 V	Test-02 Lower and upper transitory voltage ranges	FS1	FS2	FS2	FS3	As agreed
31 V ≤ U_{48} < 36 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 V ≤ U_{48} < 36 V	Test-09 Voltage ripples	FS1	FS2	FS2	FS3	As agreed
31 V ≤ U_{48} < 36 V	Test-10 Reinitialization	FS1	FS2	FS2	FS3	As agreed
24 V ≤ U_{48} < 31 V	Test-05 Starting profile	FS1	FS2	FS2	FS3	As agreed
24 V ≤ U_{48} < 31 V	Test-08 Decrease and increase of supply voltage	FS1	FS3	FS3	FS3	As agreed
24 V ≤ U_{48} < 31 V	Test-10 Reinitialization	FS1	FS2	FS2	FS3	As agreed
0 V ≤ U_{48} < 24 V	Test-08 Decrease and increase of supply voltage	FS3	FS3	FS3	FS3	As agreed
0 V ≤ U_{48} < 24 V	Test-10 Reinitialization	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 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	±1 %
T	Temperature	±2 °C
RH	Relative humidity	±5 %
t	Time	+5 % to 0 %
U	Voltage	±0,5 %
I	Current	±2 %
R	Resistor	±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 °C ±5 °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.

All 48 V components that are equipped with an interface for 12 V/24 V supply, or communication interfaces, shall also satisfy the corresponding requirements for the 12 V/24 V supply:

— during the 12 V/24 V supply system tests, the voltage in the 48 V supply system is U_{48N}, unless required otherwise in the individual tests;

— during the 48 V supply system tests, the voltage in the 12 V/24 V supply system is U_N, unless indicated otherwise in the individual tests.

All 48 V components that are equipped with an interface to any other supply voltage level shall also satisfy the corresponding standards.

8.8 Test procedure

The test procedure shall be defined in conjunction with the customer and documented within a test plan. For each test, as applicable, the permitted error memory entries and the functional statuses for each function of the component shall be agreed with the customer and documented within the test plan.

Details of the test setup, operating loads (e.g. triggering, original sensors, original actuators and replacement circuitry) and the required boundary conditions shall be agreed between the customer and the supplier and documented in a test plan and in the resultant test report. Components that are electrically both a source and a sink shall be tested in both modes of operation.

The test equipment shall ensure that all interfaces which are required to meet the specified performance of the DUT are populated and functional to the required level. Signals or messages which shall be received from or transmitted to the vehicle controller in order to ensure the DUT functions as expected may be simulated if a full vehicle or HIL simulation is not used.

In all cases, program and data storage devices shall remain in FS1 until the component is deactivated. If the device has non-volatile memory, the integrity (not the current status) of the non-volatile memory shall be ensured at all times.

Damage to the DUT is not permitted in FS1 to FS4. The permissible limit values specified in the data sheets (e.g. electrical, thermal or mechanical) of the electric/electronic components in the DUT shall not be exceeded. Evidence of this is provided at least by the parameter check as described in 8.9.

An electrical test begins when the DUT has started up completely and is in FS1.

Before and after every test, the DUTs shall be subjected to a parameter check as described in 8.9 in accordance with specifications. The DUT shall be in a steady state of temperature at the beginning of each test.

During each test, the key parameters to be monitored shall be recorded as described in 8.10. Component resets shall be monitored and documented in an appropriate form to be included in the test report.

Damaged DUTs (FS5) shall be removed from the test cycle, analysed regarding the root cause for the failure and documented. In such cases, the test shall be repeated with a new DUT, or the following test in the test plan shall be performed with a new DUT. The procedure shall be agreed with the customer.

The physical analysis as described in 8.11 shall be carried out on at least one DUT following completion of all the electrical tests. All component parts including hardware, software or calibrations of the DUT undergoing final validation stage, shall be recorded. Any change in these parts shall require revalidation or justification of no impact.

8.9 Parameter check

A set of sensitive parameters called key parameters shall be defined both in the component specifications and in consultation with the customer, e.g. quiescent current consumption, operating currents, output voltages, contact resistances, input impedances, signal rates (rise and fall times) and bus specifications. These parameters shall be checked before the start and after the completion of each test to verify that they match the specification.

The key parameters shall be measured and the functional behaviour of the components at T_{RT} and U_{48N} shall be checked. For components with error memory, the error memory shall be read out and documented and then deleted before the start of the test. After the test, the error memory shall again be read out and documented.

The results and data from the before/after tests may differ only within the specified permissible tolerances. Any changes in the measured values exceeding the measurement accuracies shall be indicated as such. The results shall be examined for trends and drifts so that any abnormalities, ageing or malfunctions of the component can be identified.

The components shall be inspected visually in accordance with EN 13018 for external damage/changes, for example cracks, chipping/peeling, discolouration, distortion, etc., without opening the DUT.

All the results shall be documented in the test report.

8.10 Continuous parameter monitoring with drift analysis

A list of key parameters shall be defined within the specification of the component.

These parameters shall be those which are necessary for the end user to understand, in order to achieve both full functional performance and reliable operation, when integrated within a vehicle.

The parameters shall also include those which are necessary to be understood to ensure compatibility with the vehicle systems to which the component is interfaced.

Such specifications may include, but not be limited to, written documents, drawings and/or schematic diagrams.

Examples of parameters which are recommended to be considered are: quiescent current consumption, peak and rated operating currents and voltages, contact resistances, input impedances, signal rates (rise and fall times) and bus specifications.

The key parameters to be monitored shall be recorded throughout the test.

In the case of components with error memory, the error memory shall be monitored at the beginning and at the end of each test and the entries shall be documented in the test report.

The data collected from the continuous parameter monitoring shall be examined for trends and drifts in order to identify abnormalities, ageing or malfunctions of the component.

8.11 Physical analysis

DUT (ECU or system) shall be opened and a visual inspection shall be performed in accordance with EN 13018. Component level physical analysis is optional.

Additional analyses (e.g. x-ray, Scanning Electron Microscope (SEM) analysis, cross section investigation and metallographic examination of the hardware design and connecting technology) shall be agreed between the customer and the supplier.

Any changes in the component beyond defined tolerances shall be documented and approved by the customer.

The results shall be documented and evaluated in the test report.