INTERNATIONAL STANDARD

**ISO 16750-2**

Fourth edition
2012-11-01

# Road vehicles — Environmental conditions and testing for electrical and electronic equipment —

## Part 2: Electrical loads

*Véhicules routiers — Spécifications d'environnement et essais de l'équipement électrique et électronique —*

*Partie 2: Contraintes électriques*

Reference number
ISO 16750-2:2012(E)

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16750-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electric and electronic equipment*.

This fourth edition cancels and replaces the third edition (ISO 16750-2:2010), which has been technically revised.

ISO 16750 consists of the following parts, under the general title *Road vehicles — Environmental conditions and testing for electrical and electronic equipment*:

— *Part 1: General*

— *Part 2: Electrical loads*

— *Part 3: Mechanical loads*

— *Part 4: Climatic loads*

— *Part 5: Chemical loads*


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# Road vehicles — Environmental conditions and testing for electrical and electronic equipment —

# Part 2: Electrical loads

## 1 Scope

This part of ISO 16750 applies to electric and electronic systems/components for road vehicles. This part of ISO 16750 describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the road vehicle.

This part of ISO 16750 describes the electrical loads. Electromagnetic compatibility (EMC) is not covered by this part of ISO 16750. Electrical loads are independent from the mounting location, but can vary due to the electrical resistance in the vehicle wiring harness and connection system.

## 2 Normative references

The following referenced documents are indispensable for the application 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 8820 (all parts), *Road vehicles — Fuse-links*

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

ISO 16750-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16750-1 apply.

## 4 Test and requirements

### 4.1 General

If not otherwise specified, the following tolerances shall apply:

— frequency and time: ±5 %;

— voltages: ±0,2 V;

— resistance: ±10 %;

All voltage curves are shown without load.

If not otherwise specified, measure all voltages at the relevant terminals of the device under test (DUT).

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## 4.2 Direct current supply voltage

### 4.2.1 Purpose

The purpose of this test is to verify equipment functionality at minimum and maximum supply voltage.

### 4.2.2 Test method

Set the supply voltage as specified in Table 1 or Table 2 to all relevant inputs of the DUT. Operating modes are specified in ISO 16750-1.

The voltages listed in Table 1 or Table 2 are relevant within the operating temperature range as specified in ISO 16750-4, without time limits.

**Table 1 — Supply voltage for system devices with 12 V nominal voltage**

| **Code** | **Minimum supply voltage**, $U_{Smin}$ V | **Maximum supply voltage**, $U_{Smax}$ V |
|---|---|---|
| A | 6 | 16 |
| B | 8 | 16 |
| C | 9 | 16 |
| D | 10,5 | 16 |

**Table 2 — Supply voltage for system devices with 24 V nominal voltage**

| **Code** | **Minimum supply voltage**, $U_{Smin}$ V | **Maximum supply voltage**, $U_{Smax}$ V |
|---|---|---|
| E | 10 | 32 |
| F | 16 | 32 |
| G | 22 | 32 |
| H | 18 | 32 |

### 4.2.3 Requirements

All DUT functions shall remain class A as defined in ISO 16750-1 when tested in the supply voltage ranges given in Table 1 or Table 2, respectively.

## 4.3 Overvoltage

### 4.3.1 Systems with 12 V nominal voltage

#### 4.3.1.1 Test at a temperature of $T_{max}$ − 20 °C

##### 4.3.1.1.1 Purpose

This test simulates the condition where the generator regulator fails, so that the output voltage of the generator rises above normal values.

##### 4.3.1.1.2 Test method

Heat the DUT in a hot air oven to a temperature that is 20 °C below the maximum operating temperature, $T_{max}$. Apply a voltage of 18 V for 60 min to all relevant inputs of the DUT.

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#### 4.3.1.1.3 Requirement

The functional status for the DUT shall be minimum class C as defined in ISO 16750-1. Functional status shall be class A where more stringent requirements are necessary.

### 4.3.1.2 Test at room temperature

#### 4.3.1.2.1 Purpose

This test simulates a jump start.

#### 4.3.1.2.2 Test method

Ensure that the DUT has stabilized at room temperature. Apply a voltage of 24 V for (60 ± 6) s to all relevant inputs of the DUT.

#### 4.3.1.2.3 Requirement

The functional status shall be minimum class D as defined in ISO 16750-1. Functional status shall be class B where more stringent requirements are necessary.

### 4.3.2 Systems with 24 V nominal voltage

#### 4.3.2.1 Purpose

This test simulates the condition where the generator regulator fails, so that the output voltage of the generator rises above normal values.

### 4.3.2.2 Test at a temperature of $T_{max}$ − 20 °C

Heat the DUT in a hot air oven to a temperature that is 20 °C below the maximum operating temperature, $T_{max}$. Apply a voltage of 36 V for 60 min to all relevant inputs of the DUT.

#### 4.3.2.3 Requirement

The functional status shall be minimum class C as defined in ISO 16750-1. Functional status shall be class A where more stringent requirements are necessary.

## 4.4 Superimposed alternating voltage

### 4.4.1 Purpose

This test simulates a residual alternating current on the direct current supply.

### 4.4.2 Test method

Connect the DUT as shown in Figure 1. Apply the following test simultaneously to all applicable inputs (connections) of the DUT; the severity level (1, 2, 3 or 4) shall be chosen in accordance with the application:

— maximum supply voltage, $U_{Smax}$ (see Figure 2):

  — 16 V for systems with nominal voltage, $U_N$, of 12 V;

  — 32 V for systems with nominal voltage, $U_N$, of 24 V;

— a.c. voltage (sinusoidal):

  — severity 1: peak to peak voltage, $U_{PP}$, of 1 V, for $U_N$ = 12 V and $U_N$ = 24 V;

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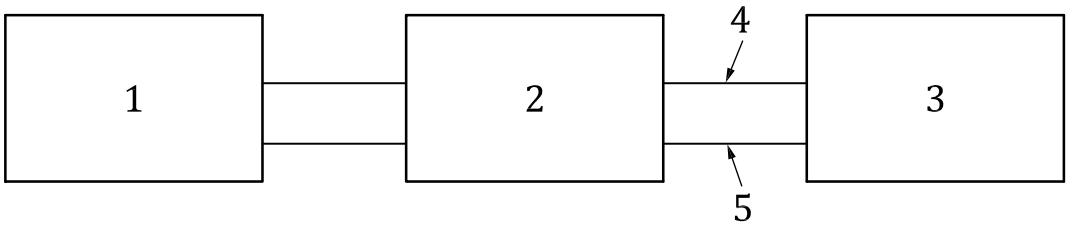
  - severity 2: peak to peak voltage, $U_{PP}$, of 4 V, for $U_N$ = 12 V and $U_N$ = 24 V;
  - severity 3: peak to peak voltage, $U_{PP}$, of 10 V, for $U_N$ = 24 V only;
  - severity 4: peak to peak voltage, $U_{PP}$, of 2 V, for $U_N$ = 12 V only;
- internal resistance of the power supply: 50 mΩ to 100 mΩ;
- frequency range (see Figure 3): 50 Hz to 25 kHz;
- type of frequency sweep (see Figure 3): triangular, logarithmic;
- sweep duration (see Figure 3): 120 s;
- number of sweeps: 5 (continuously).




**Key**

1 sweep generator
2 power supply unit capable of being modulated
3 DUT
4 positive
5 ground or return

**Figure 1 — Test set-up to superimpose a.c. voltage on component power supply lines**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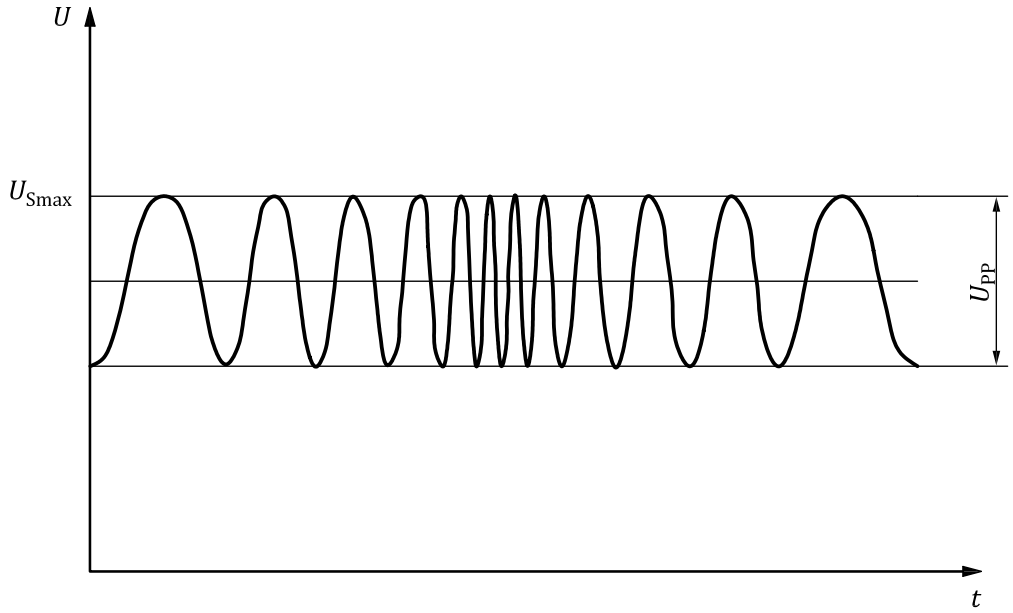
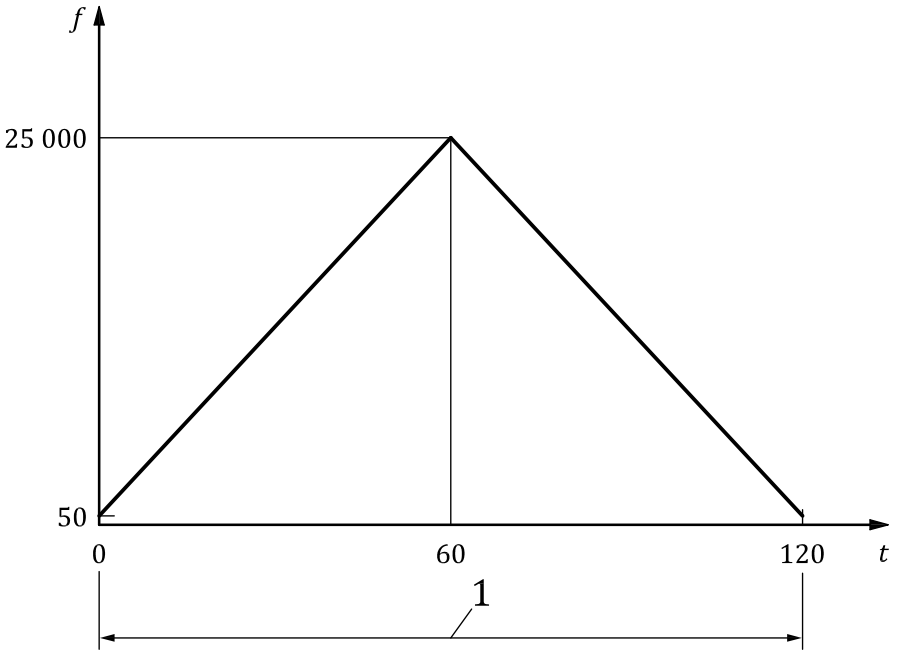



**Key**

| | |
|---|---|
| $t$ | time |
| $U$ | test voltage |
| $U_{PP}$ | peak to peak voltage |
| $U_{Smax}$ | maximum supply voltage |

**Figure 2 — Test voltage with superimposed sinusoidal a.c. voltage**




**Key**

| | |
|---|---|
| $t$ | time, in seconds |
| $f$ | frequency, logarithmic scale, in hertz |
| 1 | one cycle |

**Figure 3 — Frequency sweep**

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#### 4.4.3 Requirement

The functional status shall be class A as defined in ISO 16750-1.

### 4.5 Slow decrease and increase of supply voltage

#### 4.5.1 Purpose

This test simulates a gradual discharge and recharge of the battery.

#### 4.5.2 Test method

Apply the following test simultaneously to all applicable inputs (connections) of the DUT.

Decrease the supply voltage from the minimum supply voltage, $U_{Smin}$, to 0 V, then increase it from 0 V to $U_{Smin}$, applying a change rate of (0,5 ± 0,1) V/min linear, or in equal steps of not more than 25 mV.

#### 4.5.3 Requirement

The functional status inside the supply voltage range (see Table 1 or Table 2) shall be as specified in 4.2.3. Outside that range, it shall be minimum class D as defined in ISO 16750-1. The functional status of class C may be specified where more stringent requirements are necessary.

### 4.6 Discontinuities in supply voltage

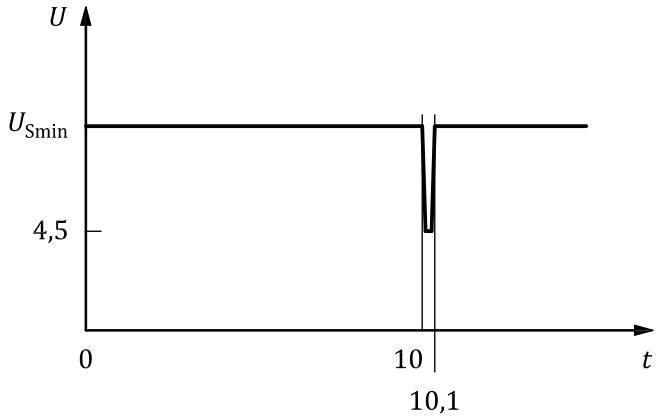
#### 4.6.1 Momentary drop in supply voltage

#### 4.6.1.1 Purpose

This test simulates the effect when a conventional fuse element melts in another circuit.

#### 4.6.1.2 Test method

Apply the test pulse (see Figures 4 and 5) simultaneously to all relevant inputs (connections) of the DUT. The rise time and fall time shall be not more than 10 ms.




**Key**

| | |
|---|---|
| $t$ | time, in seconds |
| $U$ | test voltage, in volts |
| $U_{Smin}$ | minimum supply voltage |

**Figure 4 — Short voltage drop for systems with 12 V nominal voltage**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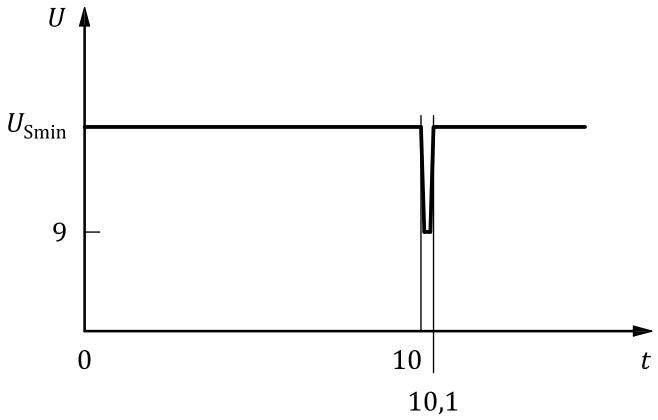


**Key**

| | |
|---|---|
| $t$ | time, in seconds |
| $U$ | test voltage, in volts |
| $U_{Smin}$ | minimum supply voltage |

**Figure 5 — Short voltage drop for systems with 24 V nominal voltage**

#### 4.6.1.3 Requirement

The functional status shall be minimum class B as defined in ISO 16750-1. Reset is permitted upon agreement.

### 4.6.2 Reset behaviour at voltage drop

#### 4.6.2.1 Purpose

This test verifies the reset behaviour of the DUT at different voltage drops. This test is applicable to equipment with reset function, e.g. equipment containing microcontroller(s).

#### 4.6.2.2 Test

Apply the test pulse simultaneously in Figure 6 to all relevant inputs (connections) and check the reset behaviour of the DUT.

Decrease the supply voltage by 5 % from the minimum supply voltage, $U_{Smin}$, to $0{,}95U_{Smin}$. Hold this voltage for 5 s. Raise the voltage to $U_{Smin}$. Hold $U_{Smin}$ for at least 10 s and perform a functional test. Then decrease the voltage to $0{,}9U_{Smin}$. Continue with steps of 5 % of $U_{Smin}$

**Table 6 — Pulse for test B in systems with 12 V and 24 V nominal voltage**

| Parameter | Type of system | | Minimum test requirements |
|---|---|---|---|
| | $U_N$ = 12 V | $U_N$ = 24 V | |
| $U_S$[a] (V) | $79 \le U_S \le 101$ | $151 \le U_S \le 202$ | 5 pulses at 1 min intervals |
| $U_S$* (V) | 35 | As specified by customer (typical value 58) | |
| $R_i$[a] (Ω) | $0{,}5 \le R_i \le 4$ | $1 \le R_i \le 8$ | |
| $t_d$ (ms) | $40 \le t_d \le 400$ | $100 \le t_d \le 350$ | |
| $T_3$ (ms) | $10^{\ 0}_{-5}$ | $10^{\ 0}_{-5}$ | |

[a] If not otherwise agreed, use the upper voltage level with the upper value for internal resistance or use the lower voltage level with the lower value for internal resistance.

#### 4.6.4.3 Requirement

The functional status shall be minimum class C as defined in ISO 16750-1.

## 4.7 Reversed voltage

### 4.7.1 Purpose

This test checks the ability of a DUT to withstand against the connection of a reversed battery in case of using an auxiliary starting device.

This test is not applicable to:

— generators, and

— terminals with clamping diodes without external reverse polarity protection device.

### 4.7.2 Test method

#### 4.7.2.1 General

Connect and fuse the DUT as in the real vehicle, but without generator and battery. Choose the applicable voltages from the following cases and apply them simultaneously to all relevant power terminals with reversed polarity.

#### 4.7.2.2 Case 1

If the DUT is used in a vehicle in which the alternator circuit is not fused and the rectifier diodes withstand a reversed voltage for 60 s, for systems with 12 V nominal voltage with reversed polarity, apply a test voltage of 4 V simultaneously to all relevant inputs (terminals) of the DUT for a duration of (60 ± 6) s.

This test is not applicable for systems with 24 V nominal voltage.

#### 4.7.2.3 Case 2

In all other cases, apply the test voltage, $U_A$ (see ISO 16750-1 and Table 7), with reversed polarity simultaneously to all relevant inputs (terminals) of the DUT for a duration of (60 ± 6) s.

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**Table 7 — Test voltage**

| **Nominal voltage**, $U_N$ V | **Test voltage**, $U_A$ V |
|---|---|
| 12 | 14 |
| 24 | 28 |

#### 4.7.3 Requirement

After replacing all blown fuse-links, the functional status shall be class A as defined in ISO 16750-1.

### 4.8 Ground reference and supply offset

#### 4.8.1 Purpose

This test shall be agreed between customer and supplier.

This test serves to verify reliable operation of a component if two or more power supply paths exist. For instance, a component may have a power ground and a signal ground that are outputs on different circuits.

#### 4.8.2 Test method

All inputs and outputs shall be connected to representative loads or networks to simulate the in-vehicle configuration. Apply $U_A$ to the DUT and confirm normal operation.

The ground/supply offset test applies to ground/supply lines. The offset shall be applied to each ground/supply line and between each ground/supply line separately in sequence.

For all DUTs, the offset voltage shall be (1,0 ± 0,1) V.

a) Apply $U_A$ to the DUT.

b) Subject ground/supply line to the offset voltage relative to the DUT ground/supply line.

c) Perform a functional test under this condition.

d) Repeat step c) for each next ground/supply line combination.

Repeat the test with reverse offset voltage.

#### 4.8.3 Requirement

With regard to the functional performance status class A for all functional groups, there shall be no malfunction or latch up of the DUT.

### 4.9 Open circuit tests

#### 4.9.1 Single line interruption

##### 4.9.1.1 Purpose

This test simulates an open contact condition.

NOTE This is not a test for connectors.

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#### 4.9.1.2 Test method

Connect and operate the DUT as intended. Open one circuit of the DUT/system interface, then restore the connection. Observe the device behaviour during and after the interruption.

Repeat for each circuit of the DUT/system interface.

— Interruption time: (10 ± 1) s.

— Open circuit resistance: ≥ 10 MΩ.

#### 4.9.1.3 Requirement

The functional status shall be minimum class C as defined in ISO 16750-1.

### 4.9.2 Multiple line interruption

#### 4.9.2.1 Purpose

The purpose of this test to ensure functional status as defined in the specification of the DUT when the DUT is subjected to a rapid multiple line interruption.

NOTE This is not a test for connectors.

#### 4.9.2.2 Test method

Disconnect the DUT, then restore the connection. Observe the device behaviour during and after the interruption.

— Interruption time: (10 ± 1) s.

— Open circuit resistance: ≥ 10 MΩ.

For multi-connector devices, each possible connection shall be tested.

#### 4.9.2.3 Requirement

The functional status shall be minimum class C as defined in ISO 16750-1.

## 4.10 Short circuit protection

### 4.10.1 Purpose

These tests simulate short circuits to the inputs and outputs of a device.

### 4.10.2 Signal circuits

#### 4.10.2.1 Test method

Connect all relevant inputs and outputs of the DUT in sequence for duration of 60 s ±10 % to $U_{Smax}$ (see Table 1 and 2) and to ground. All other inputs and outputs remain open or as agreed upon.

Perform this test with:

— connected supply voltage and ground terminals:

  — outputs active,

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— outputs inactive;

— disconnected supply voltage terminals.

All unused inputs remain open unless otherwise agreed between customer and supplier.

#### 4.10.2.2 Requirement

The functional status shall be minimum class C as defined in ISO 16750-1.

### 4.10.3 Load circuits

#### 4.10.3.1 Test method

Connect the DUT to the power supply. The load circuits shall be in operation. For test duration, the specifications of the appropriate part of ISO 8820 (operating time rating) shall be used, considering the upper tolerance plus 10 %. If protection other than fuses is used (e.g. electronic protection), the test duration shall be agreed between manufacturer and user. This test is applicable only for systems/components with load circuits.

#### 4.10.3.2 Requirements

All electronically protected outputs shall withstand the currents as ensured by the corresponding protection and shall return to normal operation upon removal of the short circuit current (the functional status shall be minimum class C as defined in ISO 16750-1.

All conventional fuse protected outputs shall withstand the currents as ensured by the corresponding protection and shall return to normal operation upon replacement of the conventional fuse (the functional status shall be minimum class D as defined in ISO 16750-1.

All unprotected outputs may be damaged by the test current (the functional status shall be class E as defined in ISO 16750-1 provided that the materials in the DUT are compliant with the flammability requirements of UL94-V0 [7].

## 4.11 Withstand voltage

### 4.11.1 Purpose

This test ensures the dielectric withstand voltage capability of circuits with galvanic isolation. This test is required only for systems/components which contain inductive elements (e.g. relays, motors, coils) or are connected to circuits with inductive load.

The deliberate overvoltage between the galvanically isolated current carrying parts of the DUT could have a negative effect on insulation performance caused by the electrical field. This test stresses the insulation system and checks the ability of the dielectric material to withstand a higher voltage caused by switching off inductive loads.

### 4.11.2 Test method

Perform a damp heat cyclic test in accordance with ISO 16750-4.

The system/components shall remain at room temperature for 0,5 h after the damp heat cyclic test.

Apply a sinusoidal test voltage of 500 V rms (50 Hz to 60 Hz) to devices in systems with 12 V and 24 V nominal voltage for a duration of 60 s, as follows, between:

— terminals with galvanic isolation;

— terminals and housing with electrically conductive surface with galvanic isolation;


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— terminals and an electrode wrapped around the housing (e.g. metal foil, sphere bath) in the case of plastic housing.

#### 4.11.3 Requirement

The functional status shall be minimum class C as defined in ISO 16750-1. Neither dielectric breakdown nor flash-over shall occur during the test.

### 4.12 Insulation resistance

#### 4.12.1 Purpose

This test ensures a minimum value of ohmic resistance required to avoid current between galvanically isolated circuits and conductive parts of the DUT.

The test gives an indication of the relative quality of the insulation system and material.

#### 4.12.2 Test method

Perform a damp heat cyclic test in accordance with ISO 16750-4.

The system/components shall remain at room temperature for 0,5 h after the damp heat cyclic test.

Apply a test voltage of 500 V d.c. to the DUT for 60 s, as follows, between:

— terminals with galvanic isolation;

— terminals and housing with electrically conductive surface with galvanic isolation;

— terminals and an electrode wrapped around the housing (e.g. metal foil) in the case of plastic material housing.

For particular applications, the test voltage can be reduced to 100 V d.c. if agreed between customer and supplier.

#### 4.12.3 Requirement

The insulation resistance shall be greater than 10 MΩ.

### 4.13 Electromagnetic compatibility

EMC specifications are given in Bibliography References [1], [4], [5], [6], [8] and [9] for information only. Performance measurements based on these specifications are not included in the scope of ISO 16750.

## 5 Documentation

For documentation, the designations according to ISO 16750-1 shall be used.

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# Annex A
(normative)

# Test load dump pulse generator verification procedure

## A.1 Scope

The purpose of this annex is to provide a method for the verification of the output characteristics of the test pulse generator.

## A.2 General

The verification measurements given in A.3 shall be performed under two different loading conditions to determine the behaviour of the test pulse generator:

a) under no load condition;

b) under matched load conditions.

## A.3 Load dump pulse verification

The generator shall be verified to ensure conformance with the parameters given below for both open circuit and loaded conditions. The $U_A$ for this verification procedure shall be 0 V. The selected resistors shall have sufficient power dissipation for both pulses. The tolerance of the matching resistor shall be ± 1 %.The source impedance shall be selected such that it is equal to the load resistance defined for the test pulse.

### A.3.1 Test pulse

See Table A.1.

**Table A.1 — Load dump pulse - in systems with 12 V and 24 V nominal voltage**

| Parameter | Type of system | | | |
|---|---|---|---|---|
| | $U_N$ = 12 V | | $U_N$ = 24 V | |
| | **No load** | **2 Ω load** | **No load** | **2 Ω load** |
| $U_S$ | + 100 V ± 10 V | + 50 V ± 10 V | + 200 V ± 20 V | + 100 V ± 20 V |
| $t_r$ | $(10^{\ 0}_{-5})$ ms | — | $(10^{\ 0}_{-5})$ ms | — |
| $t_d$ | 400 ms ± 80 ms | 200 ms ± 40 ms | 350 ms ± 70 ms | 175 ms ± 35 ms |


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# Annex B
(informative)

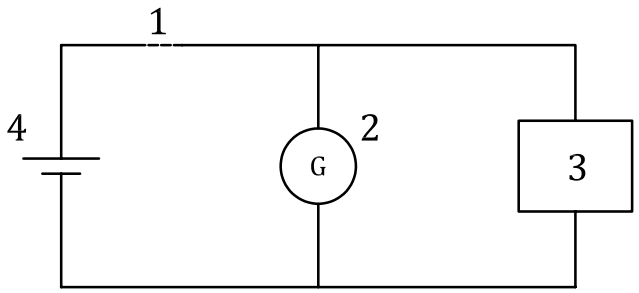
# Origin of load dump pulse in road vehicles electrical systems

## B.1 General

The load dump pulse used in this part of ISO 16750 based on load dump pulses measured in vehicle electric systems under certain conditions and created by basic configurations in the electric circuits. In this annex, a schematic diagram is presented which show the origin of the load dump pulse.

## B.2 Pulse

See Figure B.1. The load dump pulse occurs in the event of a discharged battery disconnect while the alternator is generating charging current with other loads remaining on the alternator circuit at the moment of battery disconnect. The load dump pulse shapes are represented in Figures 8 and 9.




**Key**
1 defective connection
2 alternator
3 DUT
4 battery

**Figure B.1 — Circuit diagram for load dump suppression**

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# Bibliography

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[9] CISPR 25, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of on-board receivers*


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