TECHNICAL SPECIFICATION

ISO/TS 7637-4

First edition
2020-05

Road Vehicles — Electrical disturbance by conduction and coupling —

Part 4: Electrical transient conduction along shielded high voltage supply lines only

Vehicules routiers — Perturbations electriques par conduction et par couplage —

Partie 4: Conduction transitoire electrique seulement le long des lignes à haute tension blindées

Reference number
ISO/TS 7637-4:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **iv**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Test methods **1**
- 4.1 General 1
- 4.2 Standard test conditions 2
- 4.3 Ground plane 2
- 4.4 General test setup conditions 2
- 4.5 Voltage transient emissions test along high voltage supply lines 3
  - 4.5.1 General - Test methodology 3
  - 4.5.2 Test set-up for emission test 3
  - 4.5.3 Test procedure for emission test 4
- 4.6 Transient immunity test along high voltage supply lines 5
  - 4.6.1 General - Test methodology 5
  - 4.6.2 Immunity test for pulsed sinusoidal disturbances (pulse A) 5
  - 4.6.3 Immunity test for pulsed sinusoidal disturbances (pulse B) 9

5 Test instrument description and specifications **12**
- 5.1 High voltage artificial network (HV-AN) 12
- 5.2 HV power supply 15
- 5.3 Measurement instrumentation 15
- 5.4 Load for high voltage battery or power supply 16

Annex A (normative) **Example of test severity levels associated with functional performance status classification** **17**

Annex B (normative) **Transient voltage waveform evaluation** **19**

Annex C (informative) **Test pulse generators and verification** **22**

Bibliography **24**

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

A list of all parts in the ISO 7637 series can be found on the ISO website.

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 — Electrical disturbance by conduction and coupling —

Part 4: Electrical transient conduction along shielded high voltage supply lines only

1 Scope

This document specifies test methods and procedures to ensure the compatibility to conducted electrical transients along shielded high voltage supply lines of equipment installed on passenger cars and commercial vehicles fitted with electrical systems with voltages higher than 60 V d.c. and lower than 1 500 V d.c. and a power supply isolated from the vehicle body. It describes bench tests for both, injection and measurement of transients. It is applicable to all types of electrical independent driven, road vehicles (e.g. battery electrical vehicle (BEV) or hybrid electrical vehicle (HEV), plugin hybrid electric vehicle (PHEV)).

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 7637-1, *Road vehicles — Electrical disturbances from conduction and coupling — Part 1: Definitions and general considerations*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7637-1 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/

4 Test methods

4.1 General

Various types of transients appear on the high voltage supply lines generated by the switching of various devices. Pulse A represents ringing caused by switching operations of high voltage semiconductors. Pulse B represents sinusoidal waves generated by harmonics from the grid and revolutions from, for example, electric propulsion motors.

Methods for measuring the transient emission on shielded high-voltage supply lines and test methods for the immunity of devices against transients are given in this document. These tests, called "bench tests", are performed in a laboratory.

The bench-test methods provide comparable and reproducible results between laboratories. They also give a test basis for the development of devices and systems and may be used during the production phase.

A bench-test method for the evaluation of the immunity of a device against supply-line transients may be performed by a test pulse generator. This might not cover all types of transients which can occur in a vehicle. Therefore, all described test pulses are typical pulses.

In special cases, it may be necessary to apply additional test pulses. However, some test pulses may be omitted, if a device, depending on its function or its connection, is not influenced by comparable transients in the vehicle. It is part of the vehicle manufacturer's responsibility to define the test pulses required for a specific device.

There are two types of disturbances:

— Pulsed sinusoidal disturbances (Waveform A);

— Low frequency sinusoidal disturbances (Waveform B).

Pulsed sinusoidal disturbances on high voltage supply lines are caused by overshoots on square wave signals, e.g. produced by interaction of switching IGBTs in high voltage systems with parasitic capacities and inductivities of electrical engine systems, DC-DC-converters and any other kind of high voltage switching/commutation system. Pulsed sinusoidal disturbances on high voltage supply lines can be both common mode [line-to-ground (HV+ or/and HV- to ground)] and differential mode [line-to-line (HV+ to HV-)].

Test pulse A is used for testing high frequency oscillations, e.g. fast switching.

Test pulse B is used to test equipment against transient voltages.

The device under test (DUT) shall be operated under typical conditions which cause the maximum disturbance and sensitivity during the measurement. This is the worst-case mode for every test and frequency step. Conditions shall be agreed between the vehicle manufacturer and the supplier and shall be documented in the test plan.

4.2 Standard test conditions

Standard test conditions according to ISO 7637-1 shall be used for test temperature and supply voltage (low voltage).

The high supply voltage U_N can vary in a range from 60 V d.c. up to 1 500 V d.c. The used high voltage and its allowed tolerances of battery/generator in operation shall be agreed between vehicle manufacturer and supplier and shall be documented in the test plan.

4.3 Ground plane

The ground plane shall be made of 0,5 mm thick (minimum) copper, brass or galvanized steel.

Unless otherwise specified in the test plan, the minimum width of the ground plane shall be 1 000 mm, or underneath the entire setup width (excluding power supply and transient pulse generator) plus 200 mm, whichever is larger.

Unless otherwise specified in the test plan, the minimum length of the ground plane shall be 2 000 mm, or underneath the entire setup length (excluding power supply and transient pulse generator) plus 200 mm, whichever is larger.

4.4 General test setup conditions

The DUT is arranged and connected according to its requirements. The DUT should be connected to the original operating devices (loads, sensors, etc.) and the test setup described in 4.5.2, 4.6.2.1 and 4.6.3.1 shall be used, unless otherwise agreed between the vehicle manufacturer and the supplier.

If the actual DUT operating signal sources are not available, they may be simulated.

Unless otherwise specified in the test plan, all loads, sensors, grounds (lines, metallic cases) are connected to the ground plane.

To minimize extraneous capacitive coupling to the DUT, it is advisable that the minimum distance between the DUT and all other conductive structures, such as walls of a shielded enclosure (with the exception of the ground plane underneath the test setup), should be more than 0,5 m.

4.5 Voltage transient emissions test along high voltage supply lines

4.5.1 General - Test methodology

A DUT which is considered as a potential source of conducted disturbances shall be tested according to the procedure described in this clause.

Transients shall be measured between HV+ and HV- (line-to-line) and between HV+ respectively HV- and ground (line-to-ground).

Care shall be taken to ensure that the surrounding electromagnetic environment does not interfere with the measurement set-up.

4.5.2 Test set-up for emission test

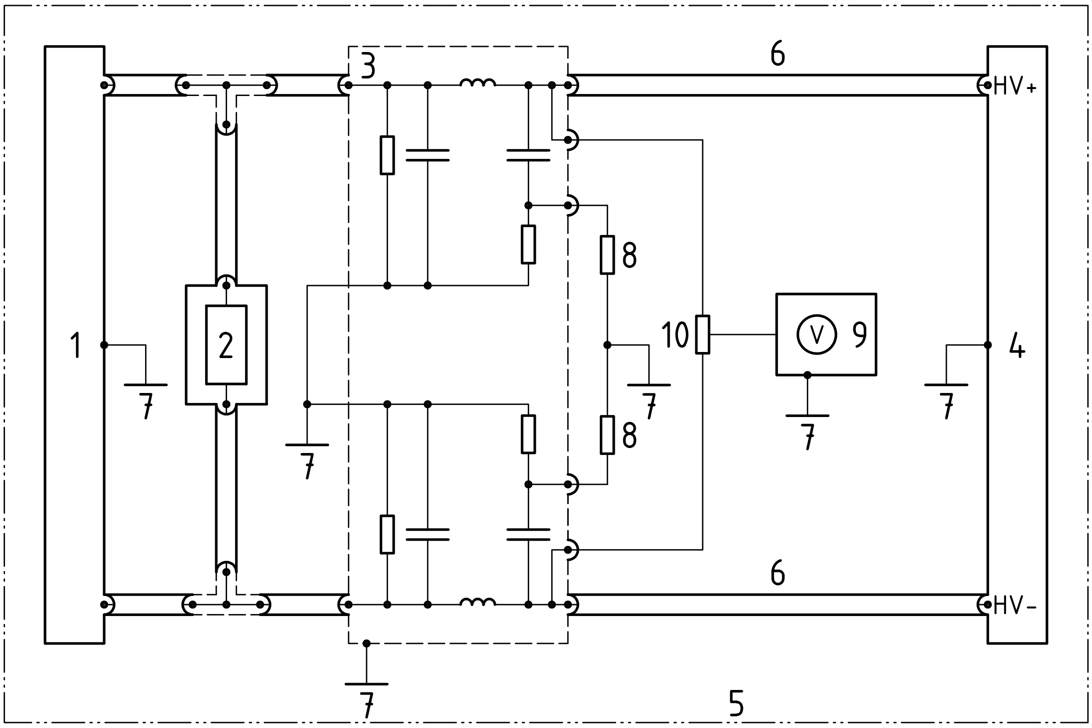
Voltage transients from the DUT, are measured using a high voltage artificial network (HV-AN) (see 5.1) to standardize the impedance loading on the DUT. The DUT is connected via the artificial network to the high voltage power supply (see 5.2) as given in Figure 1.

The length of the high voltage supply line shall be $(500\ ^{+200}_{0})$ mm, if not otherwise specified in the test plan. The used cable length shall be documented in the test report.

Ground connection of DUT shall be connected to ground plane. The default length is (200 ±50) mm, if not otherwise specified in the test plan. If the DUT has a metallic case, this case shall be bonded to the ground plane. The DC resistance of the ground connection shall not exceed 2,5 mΩ.

The DUT shall be placed on the ground plane as in the vehicle application. If no other requirements are specified the DUT and all wiring connections between artificial network and DUT shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\varepsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane.

Supply voltage U_N and the disturbance voltage shall be measured close to the DUT terminals using a voltage probe and oscilloscope or waveform acquisition equipment at the power supply terminals (see Figure 1).



Key

1 high voltage power supply (optional: shielded and / or filtered)

2 load for high voltage battery (if necessary, see 5.4)

3 high voltage artificial network (HV-AN)

4 DUT

5 ground plane

6 high voltage supply line

7 ground connection

8 50 Ω termination

9 oscilloscope or waveform acquisition equipment

10 high voltage differential probe

Figure 1 — Transient emission test set-up to measure voltage ripple along high voltage supply lines

Figure 1 shows the test setup for the measurement between HV+ and HV-. For measurement between HV+ and ground or HV- and ground the other terminal of the voltage probe shall be connected to ground.

4.5.3 Test procedure for emission test

The various operating modes and the conditions of the DUT shall be considered for the measurements and specified in the test plan.

The measured transients shall be evaluated according to Annex B. The results shall be documented in the test report.

The voltage amplitude and transient parameters (rise time, fall time, transient duration) shall be recorded and documented in the test report.

4.6 Transient immunity test along high voltage supply lines

4.6.1 General - Test methodology

4.6 provides the test setup and procedure for testing transient immunity.

If not otherwise specified, all transient tests shall be performed between HV+ and HV- (line-to-line) and between HV+ respectively HV- and ground (line-to-ground).

4.6.2 Immunity test for pulsed sinusoidal disturbances (pulse A)

4.6.2.1 Test set-up for immunity test for pulsed sinusoidal disturbances (pulse A)

Figure 2 shows the test setup for coupling between HV+ and HV-.

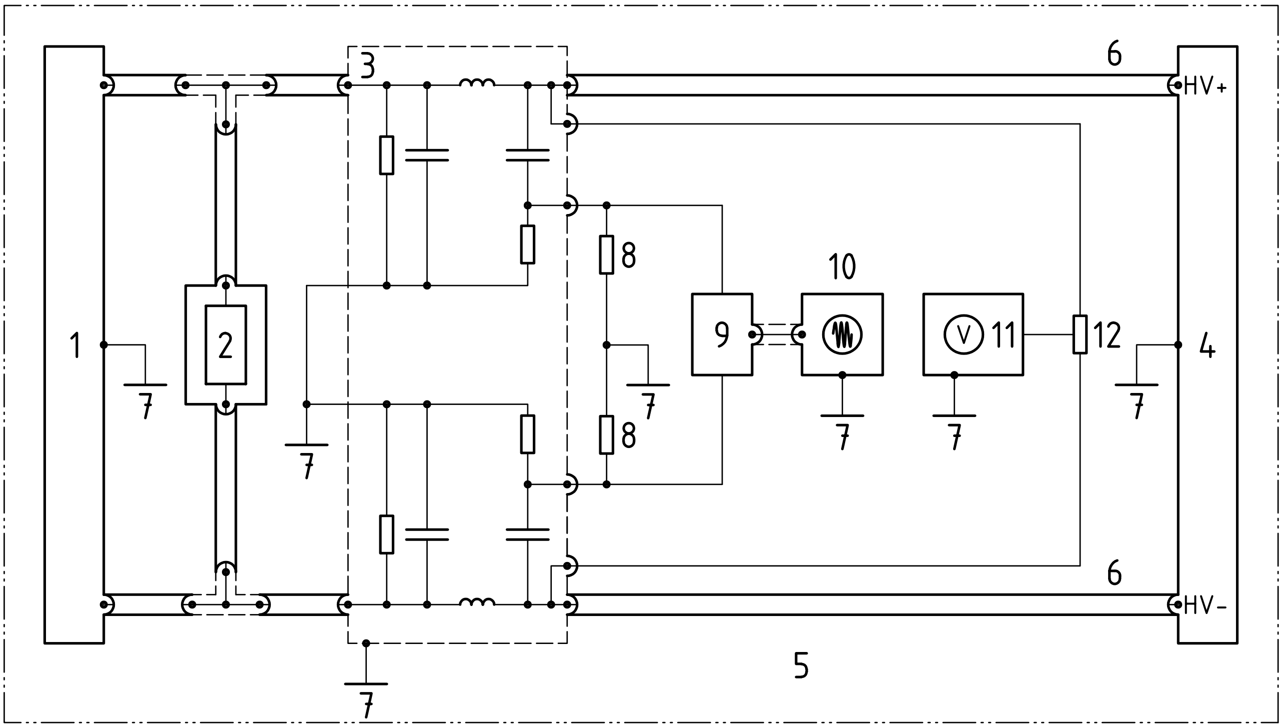
Figure 3 shows an example of test set-up for coupling between HV+ and ground. The lower terminal of generator shall be connected to ground. The upper terminal shall be connected to HV+ via the HV-AN (as shown in Figure 3) or respectively to HV-. The corresponding voltage probe terminal shall be connected to HV+ respectively to HV-; the other voltage probe terminal shall be connected to ground.

The length of the high voltage supply line shall be $(500\ ^{+200}_{\ \ 0})$ mm, if not otherwise specified in the test plan. The used cable length shall be documented in the test report.

Ground connection of DUT shall be connected to ground plane. The default length is (200 ±50) mm, if not otherwise specified in the test plan. If the DUT has a metallic case, this case shall be bonded to the ground plane. The DC resistance of the ground connection shall not exceed 2,5 mΩ.

The DUT shall be placed on the ground plane as in the vehicle application. If no other requirements are specified the DUT and all wiring connections between artificial network and DUT shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\varepsilon_r \leq 1{,}4$), at (50 ± 5) mm above the ground plane.

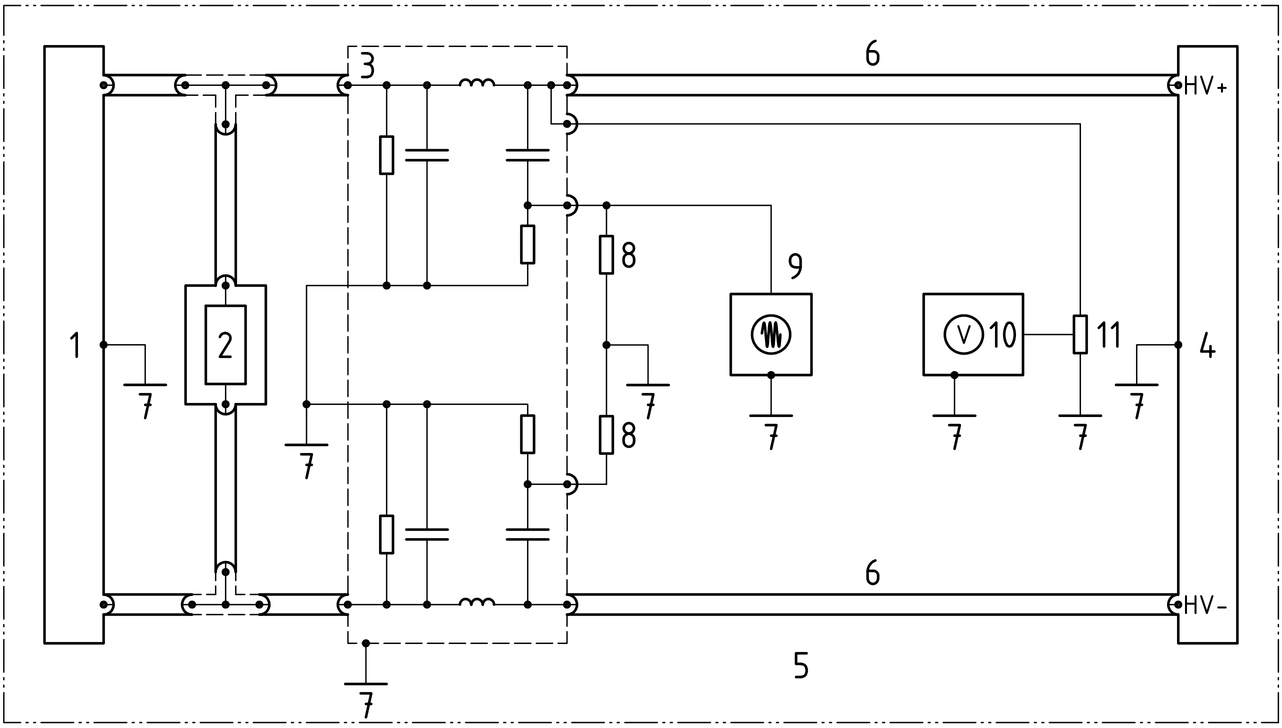
For sine wave generator description/characteristics see C.2.



Key

1 high voltage power supply (optional: shielded and / or filtered)
2 load for high voltage battery (if necessary, see 5.4)
3 shielded high voltage artificial network
4 DUT
5 ground plane
6 high voltage supply line
7 ground connection
8 50 Ω termination
9 balun transformer (see Figure C.2)
10 sine wave generator
11 oscilloscope or waveform acquisition equipment
12 high voltage differential probe

Figure 2 — Transient immunity test set-up for pulsed sinusoidal disturbances pulse A (e.g. "line-to-line")



Key

1 high voltage power supply (optional: shielded and / or filtered)
2 load for high voltage battery (if necessary, see 5.4)
3 shielded high voltage artificial network
4 DUT
5 ground plane
6 high voltage supply line
7 ground connection
8 50 Ω termination
9 sine wave generator
10 oscilloscope or waveform acquisition equipment
11 high voltage differential probe

Figure 3 — Transient immunity test set-up for pulsed sinusoidal disturbances pulse A (e.g. "HV+ line-to-ground")

4.6.2.2 Test procedure for immunity test for pulsed sinusoidal disturbances (pulse A)

Test voltage and waveform of pulse A shall be set prior to the test as described in 4.6.2.3 and 4.6.2.4. Test levels are described in Table A.1.

The test shall be performed for both configurations shown in Figure 2:

— with generator (key 10) connected to HV+ and HV- via balun (key 9) and HV-AN (key 3), oscilloscope (key 11) and HV probe (key 12) connected to HV+ and HV-,

and Figure 3:

— with generator (key 9) connected to HV+ and respectively HV- via HV-AN (key 3), oscilloscope (key 10) and HV probe (key 11) connected to HV+ and respectively to HV-.

Attach the generator to the test setup.

4.6.2.3 Level setting procedure (line to ground)

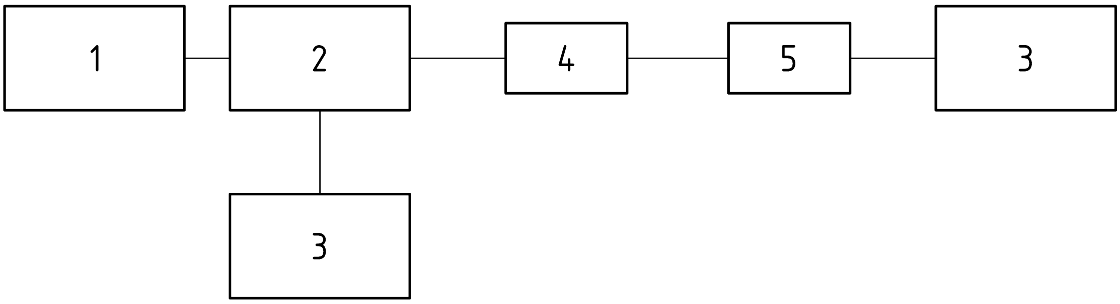
1. Set pulse frequency.

2. Connect a power meter to measure the output of the test generator (see Figure 4).

   NOTE An attenuator can be needed to protect the power meter input.

3. Record the forward power to obtain the desired test level (follow Table A.2) (without modulation) measured at the output of the test generator.

4. Repeat steps 1 to 2 for all pulse frequencies.



Key

1 generator
2 directional coupler
3 power meter
4 50 Ω load (not needed if used measurement devices have a 50 Ω impedance)
5 attenuator (optional)

Figure 4 — Test setup for level setting line to ground

4.6.2.4 Level setting procedure (line to line)

1. Set pulse frequency.

2. Connect a power meter to measure the output of the test generator. The balun shall be terminated with a 50 Ω load (see Figure 5).

   NOTE An attenuator can be needed to protect the power meter input.

3. Record the forward power to obtain the desired test level (see Table A.1) (without modulation) measured at the output of the test generator.

4. Correct the forward power by adding the correction factor of the balun transformer at the respective pulse frequencies.

5. Repeat steps 1 to 4 for all pulse frequencies.

