



SURFACE VEHICLE STANDARD

J1113™-12

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Superseding J1113-12 NOV2017

Electrical Interference by Conduction and Coupling -
Capacitive and Inductive Coupling via Lines Other than Supply Lines

RATIONALE

The technical committee determines that the using community is moving towards newer technology and would like to alert users that this newer technology exists which may want to be considered for new design. However, because the technical committee has no complete visibility of where and how a technical report is being used, and because a technical report may be necessary to support legacy platforms or design reuse, the technical report should not be cancelled but rather stabilized with a rationale statement that alerts users to new technology.

The EMC standards committee have determined that this standard contains similar documentation as ISO 7637-3 and also has the section 5.4 Transient Pulse Generator (the capacitive/inductive coupling (CIC) method).

Because of the inclusion of 5.4, it is realized that the LD vehicle as a whole is moving away from mechanical switching devices and towards a newer technology of solid state switching devices.

However, because the EMC standards committee sees it necessary to support legacy platforms or design reuse, SAE J1113-12 should not be cancelled but stabilized at this time.

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Documents

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1. SCOPE

This SAE Standard establishes test methods for the evaluation of devices and equipment in vehicles against transient transmission by coupling via lines other than the power supply lines. The test methods demonstrates the immunity of the instrument, device, or equipment to coupled fast transient disturbances, such as those caused by switching of inductive loads, relay contact bouncing, etc. Four test methods are presented in SAE J1113-12:

- the capacitive coupling clamp (CCC) method
- the direct capacitive coupling (DCC) method
- the inductive coupling clamp (ICC) method
- the capacitive/inductive coupling (CIC) method

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 ISO Publication

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 7637-1	Road vehicles — Electrical disturbances from conduction and coupling — Part 1: Definitions and general considerations
ISO 7637-2	Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only
ISO 7637-3	Road vehicles — Electrical disturbances from conduction and coupling — Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines
ISO 11452-4	Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Harness excitation methods.

3. TERMS AND DEFINITIONS

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

4. TEST METHODS

4.1 General

This clause describes bench test methods for testing the immunity of electrical system components or devices under test (DUTs) against coupled transient pulses. These tests shall be performed in the laboratory.

The defined transient pulses represent the characteristics of most of the known transient pulses which may occur in the vehicle.

Some transient pulses tests may be omitted if a device, depending on its function or its configuration, is not subjected to comparable transient pulses in the vehicle. It is part of the vehicle manufacturer's responsibility to define the transient pulses tests needed for specific components.

A test plan shall be written to define:

- the test methods to be used;
- the transient pulses tests to be applied;
- the transient pulses levels;
- the number of transient pulses to be applied;
- the DUT operating modes;

- the wiring harness (test versus production);
- the wires to be included in the capacitive coupling clamp, if used;
- the wires to be tested using the direct coupling capacitor method, if used;
- the capacitance values to be used, if the direct coupling capacitor method is used for specific communication lines;
- the wires to be included in the inductive coupling clamp, if used; and
- the type of inductive coupling clamp, if the inductive coupling method is used.

For CCC, DCC and ICC methods, suggested values for the evaluation of immunity of DUTs can be chosen from Tables E1, E2. The transient pulses test severity levels should be mutually agreed upon between the vehicle manufacturer and the supplier prior to the test.

The applicability of the four different test methods is indicated in Table 1. When considering use of CCC, DCC or ICC methods, it is sufficient to select one test method for slow transient pulses and one test method for fast transient pulses. When considering use of the CIC method, test pulses A and B should both be selected

Table 1 - Test method applicability

Transient Type	Test Method			
	CCC	DCC	ICC	CIC
Slow transient pulses 2a of 5.3.2		✓	✓	
Fast transient pulses 3a and 3b of 5.3.3	✓	✓		
Pulses A and B of 5.4.3				✓

4.2 Standard Test Conditions

Standard test conditions shall be according to ISO 7637-1 for the following:

- test temperature;
- supply voltage.

Unless otherwise defined in this part of ISO 7637, the tolerance on test severity levels is (-0 / +10) %

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 1000 mm, or underneath the entire set-up 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 2000 mm, or underneath the entire set-up length (excluding power supply and transient pulse generator) plus 200 mm, whichever is larger.

4.4 General Test Set-Up Conditions

The DUT is arranged and connected according to its requirements. The DUT should be connected to the original operating devices (loads, sensors, etc.) using the test setup described in 4.5.4, 4.6.4, 4.7.4 and 4.8.4. Test items agreed between the vehicle manufacturer and the supplier.

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

The DUT shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\epsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane, unless the DUT case is connected to the chassis and has its own ground connection.

Grounding of the DUT case to the ground plane shall reflect the vehicle installation and shall be defined in the test plan.

Unless otherwise stated for a specific test method, all harnesses shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\epsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane.

Unless otherwise specified in the test plan, all loads, sensors, etc. are connected to the ground plane using the shortest possible length.

NOTE: 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 set-up), should be more than 0,5 m.

4.5 CCC Method

4.5.1 General

The CCC method is suitable for coupling the fast transient pulses, particularly for DUTs with a moderate or large number of leads to be tested. It will not couple the slow transient pulses.

4.5.2 Generator Verification

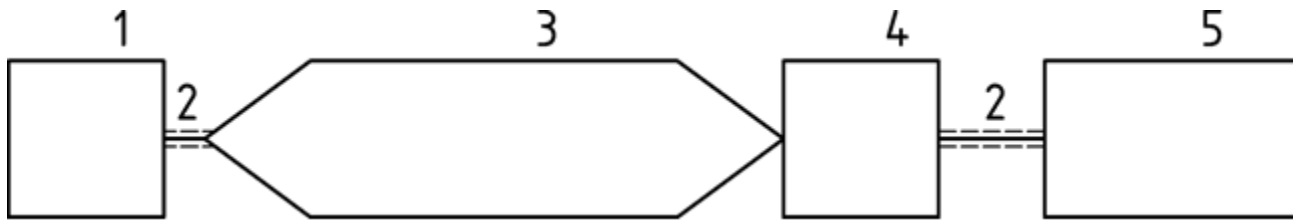
The transient pulse parameters (of Figures 11 and 12) shall be verified prior to the test according to ISO 7637-2. Verification shall be performed with the 50 Ω load condition only.

4.5.3 Transient Pulses Level Adjustment

The transient pulse generator shall be connected as shown in Figure 1.

The transient pulse level is adjusted with a 50 Ω input oscilloscope connected through a 50 Ω coaxial cable to a 50 Ω attenuator which is mounted to the coupling clamp as shown in Figure 1. There shall be no lines routed through the coupling clamp during adjustment. Examples of test severity levels are listed in Appendix E.

NOTE: The open circuit voltage of the transient pulses generator is approximately twice the value of the specific test voltage, due to 50 Ω loading of the attenuator and the oscilloscope.

**Key**

- 1 transient pulses generator
- 2 50 Ω coaxial cable (≤ 1 m)
- 3 CCC
- 4 50 Ω attenuator
- 5 oscilloscope (50 Ω input)

Figure 1 - Set-up for transient pulses level adjustment - CCC method

4.5.4 DUT Test

The test method using the CCC is shown in Figure 2. The coupling circuit consists of a CCC through which lines of the DUT are installed as agreed between the vehicle manufacturer and the supplier and documented in the test plan. The coupling length is 1 m.

The DUT 12 / 24 V supply lines (ground and supply) should not be included in the CCC. Any other ground or supply line delivered by the DUT to an auxiliary equipment (sensors, actuators) shall be included in the CCC. If the auxiliary equipment is locally grounded, this local ground connection shall be excluded from the CCC. Any exception about ground or supply lines included in the CCC shall be stated in the test plan.

The lines which are included in the CCC shall be limited to the maximum number of lines which can be placed flat in a single layer in the CCC (typically 10 to 20 lines); this may require multiple tests to be performed in order to test all the DUT lines.

The hinged lid of the CCC shall be placed as flat as possible to ensure contact with the test harness which should be positioned as flat as possible.

Twisted and shielded wire configurations shall be maintained inside the CCC.

The test conditions for a DUT with multiple connectors (single test on all the branches or test on individual branch) or for a harness with more than 10 to 20 lines shall be specified in the test plan.

NOTE: For special applications a flat harness with maximum 10-20 lines inside the CCC may be agreed upon in the test plan.

The distance between the DUT and the CCC, and between peripheral devices and the CCC, shall be greater or equal than 300 mm. The portions of the lines being tested which are outside the CCC shall be placed at a distance of (50 ± 5) mm above the ground plane and oriented $90^\circ \pm 15^\circ$ to the longitudinal CCC axis.

The DUT shall be placed on a (50 ± 5) mm height insulating support.

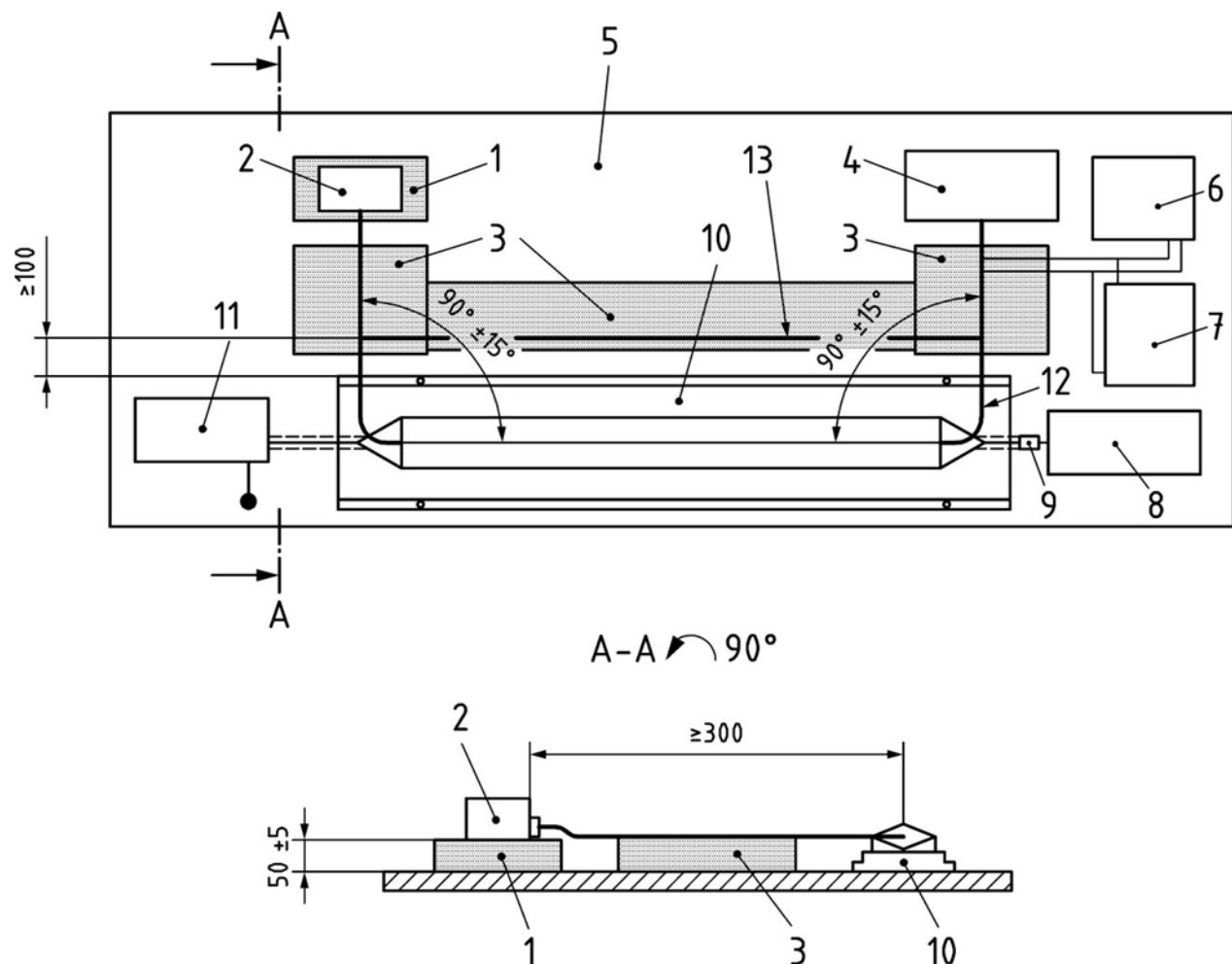
The case of the DUT shall not be grounded to the ground plane unless it is intended to simulate the actual vehicle configuration.

The lines which are not under CCC test are routed outside the coupling clamp. They shall be placed on a (50 ± 5) mm height insulating support and shall be placed at a minimum distance of 100 mm to the coupling clamp.

NOTE: It is not necessary for lines which are not under the CCC, to be placed in a straight line as illustrated in Figure 2. Arrangement due to additional length should be defined in test plan.

The DUT shall be placed on the same end of the CCC as the transient pulses generator. The test shall be performed with a total harness length of 1700 mm (+300 mm / 0 mm).

Dimensions in millimeters



Key

- 1 insulation support
- 2 DUT (grounding as specified in test plan)
- 3 insulating supports for test harness
- 4 load simulator
- 5 ground plane
- 6 power supply
- 7 battery
- 8 oscilloscope (50 Ω input)
- 9 50 Ω attenuator
- 10 CCC
- 11 transient pulses generator
- 12 lines to be tested
- 13 lines not to be tested

Figure 2 - Test set-up for CCC method – DUT test

4.6 DCC Method

4.6.1 General

The DCC method uses capacitors for transient coupling. The values of capacitors are defined in Table 2 except for coupling to communication lines (e.g., CAN BUS) for which specific values shall be defined in the test plan.

Table 2 - Capacitor values for DCC test method

Test pulse	Capacitor value
Slow transient pulses	0,1 μ F
Fast transient pulses	100 pF
The characteristics of the non-polarized capacitors are defined as follows: tolerance of $\pm 10\%$, rating of at least twice the maximum applied voltage, and dissipation factor less or equal than 1%.	

4.6.2 Generator Verification

The transient pulse parameters (of Figures 9, 10, 11 and 12) shall be verified (per ISO 7637-2) prior to performing the test. Verification shall include measurement of open circuit and loaded conditions.

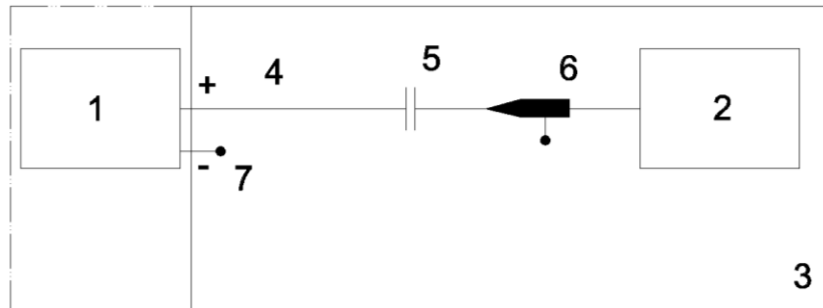
NOTE: When verifying fast transient pulse characteristics under open circuit conditions, it is recommended to use a 1 k Ω to 50 Ω adapter, with an oscilloscope configured for 50 Ω input. This minimizes the oscillations that may result when measuring a transient pulse with significantly short transient pulse rise time and duration into an open-circuit condition.

4.6.3 Transient Pulses Level Adjustment

Prior to testing, the transient pulse level shall be adjusted at the output of the capacitor. Examples of test severity levels are listed in Appendix E.

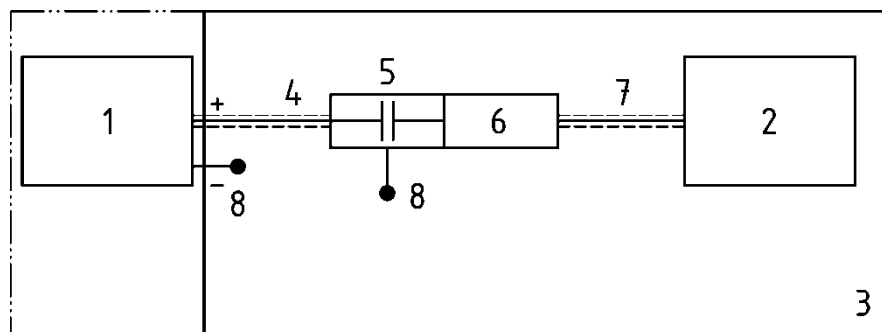
- For slow transient pulses use the setup shown in Figure 3a. The transient pulse level shall be measured using a high impedance passive probe.
- For fast transient pulses use the setup shown in Figure 3b. The output of the capacitor shall be connected to the 1 k Ω to 50 Ω adapter. The adaptor is connected to an oscilloscope configured for 50 Ω input. The measured peak pulse level is corrected for this adaptor. The capacitor shall be placed in a shielded box which shall be grounded. The 50 Ω coaxial cable shall be connected to this box.

The generator ground shall be bonded to the ground plane with a DC resistance $\leq 2,5$ m Ω and a bond length of less than 100 mm.

**Key**

- 1 transient pulses generator
- 2 high impedance input oscilloscope
- 3 ground plane
- 4 connecting wiring
- 5 coupling capacitor
- 6 high impedance passive voltage probe
- 7 ground connection (maximum length of 100 mm)

Figure 3A - Set-up for slow transient pulses level adjustment - DCC method

**Key**

- 1 transient pulses generator
- 2 50 Ω impedance oscilloscope
- 3 ground plane
- 4 50 Ω coaxial cable (maximum length of 500 mm)
- 5 coupling capacitor
- 6 1 kΩ to 50 Ω adapter
- 7 50 Ω coaxial cable
- 8 ground connection (maximum length of 100 mm)

Figure 3B - Set-up for fast transient pulses level adjustment - DCC method

Figure 3

4.6.4 DUT Test

The DCC method is shown schematically in Figure 4a (for slow transient) and Figure 4b (for fast transient). The length of the harness shall be 1700 mm (+300 mm/0 mm).

For fast transient test, the generator shall be connected to the capacitor using a 50 Ω coaxial cable with a length not greater than 500 mm.

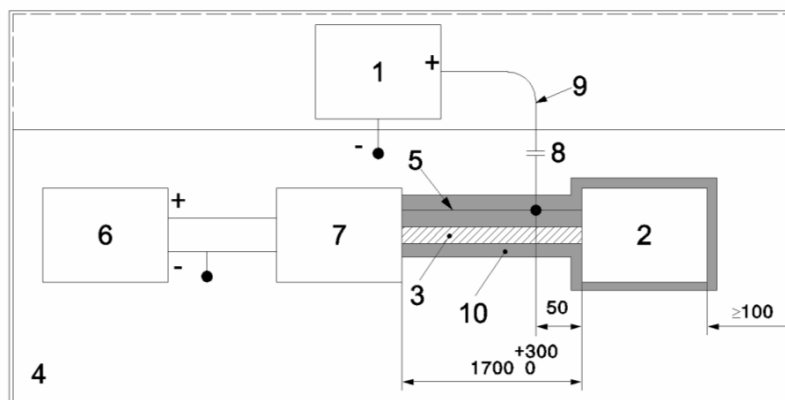
When using the DCC method, each DUT line is tested individually. However, when testing twisted and balanced symmetrical lines (e.g., bridge audio, CAN communications), the DCC method shall be modified to excite all lines identically at the same time (see Figure 5a for slow transient and Figure 5b for fast transient). Care shall be taken to ensure that intended DUT signals are not distorted by use of the DCC method.

The DUT shall be placed on a non-conductive, low relative permittivity material ($\epsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane. If the DUT is locally grounded (maximum length of 200 mm), then the DUT's ground supply line shall be connected to the ground plane as defined in the test plan.

The case of the DUT shall not be grounded to the ground plane unless it is intended to simulate the actual vehicle configuration.

For slow and fast transient pulses test, the lines/harness shall be placed on a non-conductive, low relative permittivity material ($\epsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane.

Dimensions in millimeters



Key

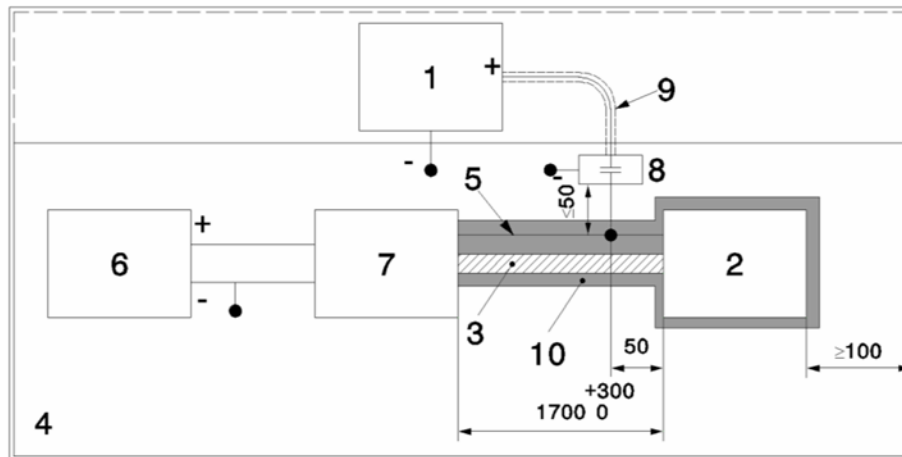
- 1 transient pulses generator
- 2 DUT
- 3 wiring harness
- 4 ground plane
- 5 I/O line under test
- 6 power supply
- 7 load simulator
- 8 high-voltage non polarized leaded capacitor (see 4.6.1)
- 9 injection line
- 10 Insulation support with low relative permittivity material ($\epsilon_r \leq 1,4$)

NOTE: For the value of the capacitor, see Table 2

Figure 4A - Test set-up for DCC method – Slow transients - DUT test



Dimensions in millimeters



Key

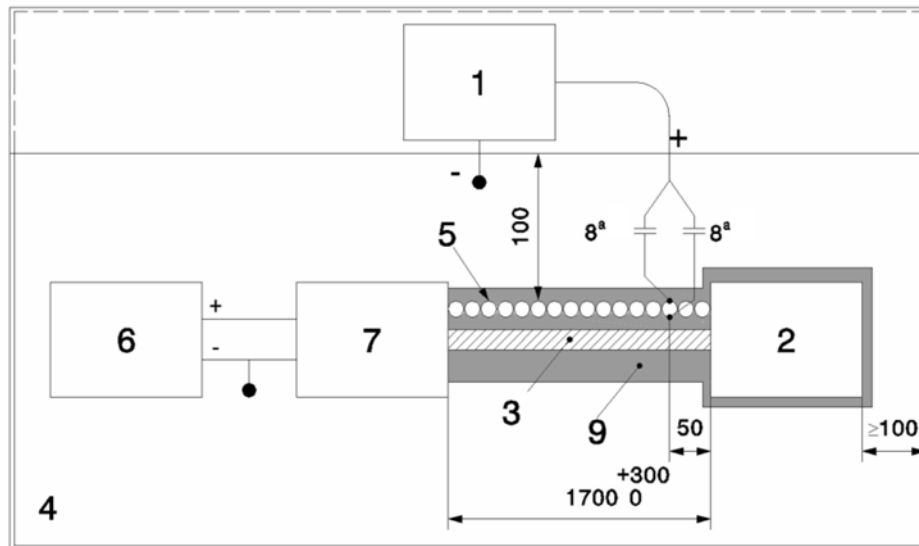
- 1 transient pulses generator
- 2 DUT
- 3 wiring harness
- 4 ground plane
- 5 I/O line under test
- 6 power supply
- 7 load simulator
- 8 high-voltage non polarized leaded capacitor (see 4.6.1)
- 9 50Ω coaxial cable (length not greater than 500 mm)
- 10 Insulation support with low relative permittivity mater
- 11 Insulation support with low relative permittivity material ($\epsilon_r \leq 1,4$)

NOTE: For the value of the capacitor, see Table 2.

Figure 4B - Test set-up for DCC method – Fast transients - DUT test

Figure 4

Dimensions in millimeters

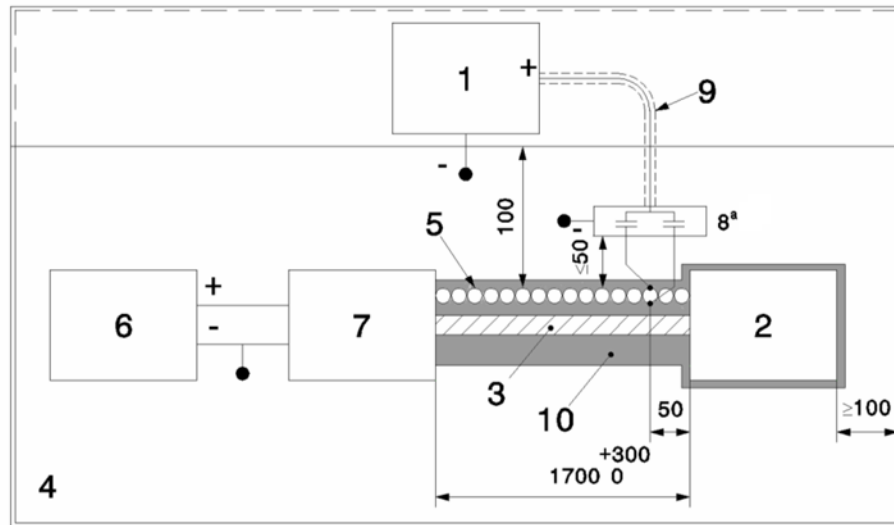


Key

- 1 transient pulses generator
- 2 DUT
- 3 wiring harness
- 4 ground plane
- 5 Balanced symmetrical lines
- 6 power supply
- 7 load simulator
- 8 high-voltage non polarized leaded capacitor
- 9 Insulation support with low relative permittivity material ($\epsilon_r \leq 1,4$)
- ^a The capacitor values are selected to ensure that the communication signals are not disturbed and that the transient pulses can still be coupled to these lines. For slow transient pulses test, the recommended capacitor value is 470 pF.

Figure 5A - Example of test setup for balanced symmetrical lines - Slow transients - DUT test

Dimensions in millimeters



Key

- 1 transient pulses generator
 - 2 DUT
 - 3 wiring harness
 - 4 ground plane
 - 5 Balanced symmetrical lines
 - 6 power supply
 - 7 load simulator
 - 8 high-voltage non polarized leaded capacitor
 - 9 50Ω coaxial cable (length not greater than 500 mm)
 - 10 Insulation support with low relative permittivity material ($\epsilon_r \leq 1,4$)
- ^a The capacitor values are selected to ensure that the communication signals are not disturbed and that the transient pulses can still be coupled to these lines. For fast transient pulses test, the recommended capacitor value is 100 pF.

Figure 5B - Example of test setup for balanced symmetrical lines - Fast transients – DUT test

Figure 5