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**Road vehicles — Component test  
methods for electrical disturbances from  
narrowband radiated electromagnetic  
energy —**

**Part 2:  
Absorber-lined shielded enclosure**

*Véhicules routiers — Méthodes d'essai d'un équipement soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite —*

*Partie 2: Chambre anéchoïque*



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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 11452-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This second edition cancels and replaces the first edition (ISO 11452-2:1995), which has been technically revised.

ISO 11452 consists of the following parts, under the general title *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy*:

- *Part 1: General principles and terminology*
- *Part 2: Absorber-lined shielded enclosure*
- *Part 3: Transverse electromagnetic mode (TEM) cell*
- *Part 4: Bulk current injection (BCI)*
- *Part 5: Stripline*
- *Part 7: Direct radio frequency (RF) power injection*

The radiating loop method is to form the subject of a future part 8.

## Introduction

Immunity measurements of complete vehicles are generally able to be carried out only by the vehicle manufacturer, owing to, for example, high costs of an absorber-lined shielded enclosures, the desire to preserve the secrecy of prototypes or a large number of different vehicles models.

For research, development and quality control, a laboratory measuring method can be used by both vehicle manufacturers and equipment suppliers to test electronic components.



# Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy —

## Part 2: Absorber-lined shielded enclosure

### 1 Scope

This part of ISO 11452 specifies an absorber-lined shielded enclosure method for testing the immunity (off-vehicle radiation source) of electronic components for passenger cars and commercial vehicles regardless of the propulsion system (e.g spark-ignition engine, diesel engine, electric motor). The device under test (DUT), together with the wiring harness (prototype or standard test harness), is subjected to an electromagnetic disturbance generated inside an absorber-lined shielded enclosure, with peripheral devices either inside or outside the enclosure. It is applicable only to disturbances from continuous narrowband electromagnetic fields. See ISO 11452-1 for general test conditions.

### 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 11452-1, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*<sup>1)</sup>

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11452-1 apply.

### 4 Test conditions

The applicable frequency range of the absorber-lined shielded enclosure test method is 80 MHz to 18 GHz.

The user shall specify the test severity level(s) over the frequency range. Suggested test levels are included in Annex C.

Standard test conditions shall be according to ISO 11452-1 for the following:

— test temperature;

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1) To be published. (Revision of ISO 11452-1:2001)

- supply voltage;
- modulation;
- dwell time;
- frequency step sizes;
- definition of test severity levels;
- test signal quality.

## 5 Test location

The tests shall be performed in an absorber-lined shielded enclosure.

The purpose of such an enclosure is to create an isolated electromagnetic compatibility test facility which simulates open field testing. Basically, an absorber-lined shielded enclosure consists of a shielded room with absorbing material on its internal reflective surfaces, optionally excluding the floor. The design objective is to attenuate the reflected energy in the test area by at least 10 dB compared to the direct energy.

## 6 Test apparatus and instrumentation

### 6.1 General

Radiated electromagnetic fields are generated using antenna with a radio frequency (RF) energy source capable of producing the desired field strengths. A set of antennae and multiple RF amplifiers could be required to cover the range of test frequencies. The field is monitored electrically with small probes to ensure proper test levels. To reduce test error, the operation of the DUT is usually monitored by fibre-optic couplers.

### 6.2 Measuring equipment

**6.2.1 Field-generating device:** any available antenna (including high-power baluns, if appropriate) capable of radiating the specified field strength at the DUT with the available power may be used. The construction and orientation of any field-generating device shall be such that the generated field can be polarized in the mode specified in the test plan.

**6.2.2 Field probes,** which should be electrically small and isotropic. The transmission lines from the probes should be either fibre-optic links or very high resistance.

**6.2.3 Artificial network(s) (AN):** see 7.2 and Annex A.

**6.2.4 HF generator,** with internal (or external) modulation capabilities

**6.2.5 High-power amplifier**

**6.2.6 Powermeter** (or equivalent measuring instrument), for measuring forward power and reflected power.

### 6.3 Stimulation and monitoring of DUT

The device under test (DUT) shall be operated as required in the test plan by actuators that have a minimum effect on the electromagnetic characteristics, e.g. plastic blocks on the push-buttons, pneumatic actuators with plastic tubes.



Connections to equipment monitoring electromagnetic interference reactions of the DUT may be accomplished by using fibre-optics, or high-resistance leads. Other types of lead may be used but require extreme care to minimize interactions. The orientation, length and location of such leads shall be carefully documented to ensure repeatability of test results.

Any electrical connection of monitoring equipment to the DUT may cause malfunctions of the DUT. Extreme care shall be taken to avoid such an effect.

## 7 Test set-up

### 7.1 Ground plane

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

The minimum width of the ground plane shall be 1 000 mm. The minimum length of the ground plane shall be 2 000 mm, or the length of the entire underneath of the equipment plus 200 mm, whichever is the larger.

The height of the ground plane (test bench) shall be  $(900 \pm 100)$  mm above the floor.

The ground plane shall be bonded to the shielded enclosure such that the d.c. resistance shall not exceed 2,5 m $\Omega$ . In addition, the bond straps shall be placed at a distance no greater than 0,3 m apart edge to edge.

### 7.2 Power supply and AN

Each DUT power supply lead shall be connected to the power supply through an AN.

Power supply is assumed to be negative ground. If the DUT utilizes a positive ground, then the test set-ups shown in the figures need to be adapted accordingly. Power shall be applied to the DUT via a 5  $\mu$ H/50  $\Omega$  AN (see Annex A for the schematic). The number of ANs required depends on the intended DUT installation in the vehicle.

- For a remotely grounded DUT (vehicle power return line longer than 200 mm), two ANs are required: one for the positive supply line and another for the power return line (see Annex B).
- For a locally grounded DUT (vehicle power return line 200 mm or shorter), only one AN is required, for the positive supply (see Annex B).

The AN(s) shall be mounted directly on the ground plane. The case or cases of the AN(s) shall be bonded to the ground plane.

The power supply return shall be connected to the ground plane — between the power supply and the AN(s).

The measuring port of each AN shall be terminated with a 50  $\Omega$  load.

### 7.3 Location of DUT

The DUT shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ( $\epsilon_r \leq 1,4$ ), at  $(50 \pm 5)$  mm above the ground plane.

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

The face of the DUT shall be located at a distance of  $(200 \pm 10)$  mm from the edge of the ground plane.

#### 7.4 Location of test harness

The part of the test harness parallel to the front edge of the ground plane shall be  $(1500 \pm 75)$  mm.

The total length of the test harness between the DUT and the load simulator (or the RF boundary) shall not exceed 2 000 mm. The wiring type is defined by the actual system application and requirement.

The test harness shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ( $\epsilon_r \leq 1,4$ ), at  $(50 \pm 5)$  mm above the ground plane.

That part of the test harness parallel to the front edge of the ground plane shall be at a distance of  $(100 \pm 10)$  mm from the edge of the ground plane.

#### 7.5 Location of load simulator

Preferably, the load simulator shall be placed directly on the ground plane. If the load simulator has a metallic case, this case shall be bonded to the ground plane.

Alternatively, the load simulator may be located adjacent to the ground plane (with the case of the load simulator bonded to the ground plane) or outside of the test chamber, provided the test harness from the DUT passes through an RF boundary bonded to the ground plane.

When the load simulator is located on the ground plane, the d.c. power supply lines of the load simulator shall be connected through the AN(s).

#### 7.6 Location of field generating device (antenna)

The height of the phase centre of the antenna shall be  $(100 \pm 10)$  mm above the ground plane.

No part of any antenna radiating element shall be closer than 250 mm to the floor. The radiating elements of the antenna shall not be closer than 500 mm to any absorber material, and shall not be closer than 1 500 mm to the walls or ceiling of the shielded enclosure.

The distance between the wiring harness and the antenna shall be  $(1\ 000 \pm 10)$  mm. This distance is measured from

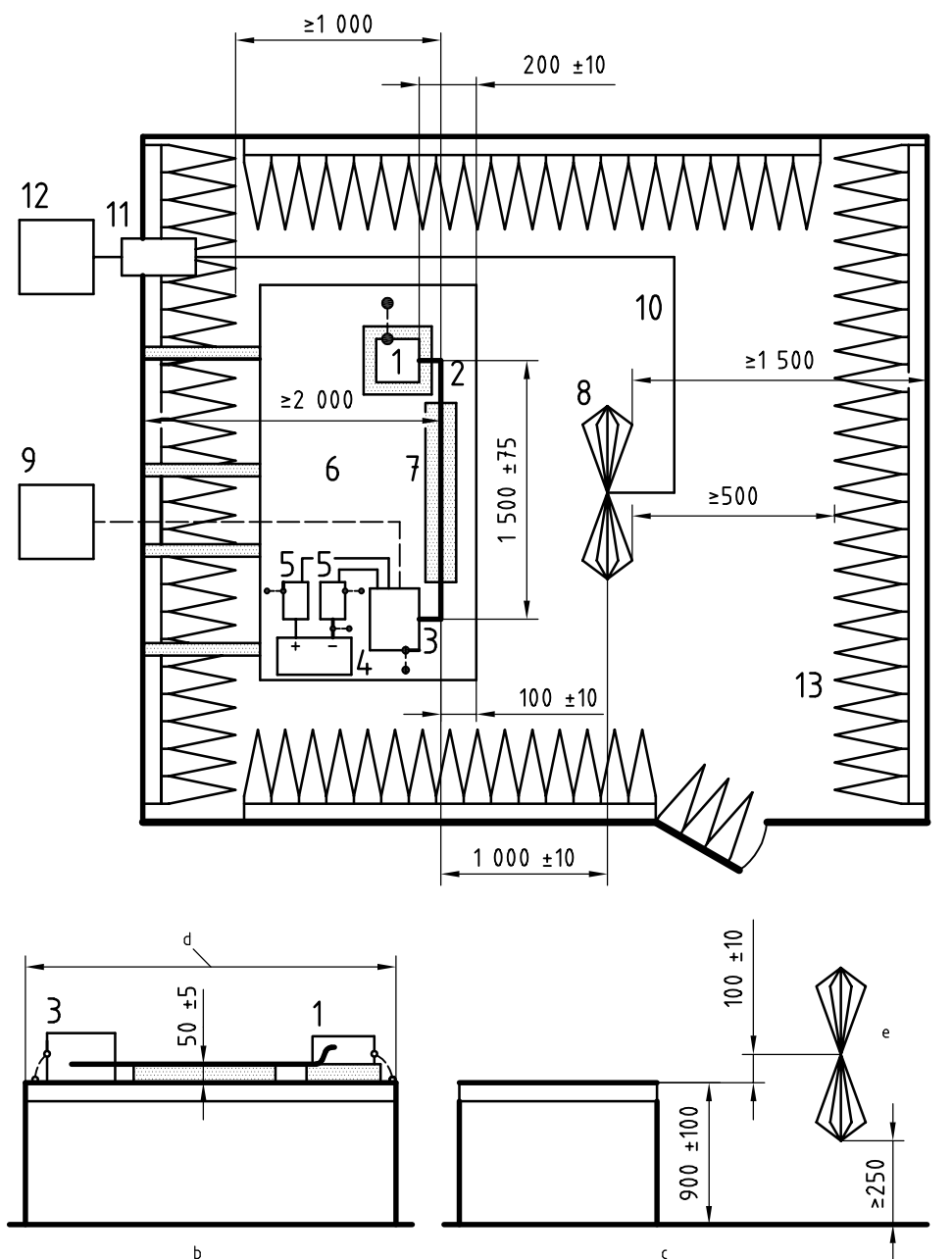
- the phase centre (mid-point) of the biconical antenna, or
- the nearest part of the log-periodic antenna, or
- the nearest part of the horn antenna.

The phase centre of the antenna for frequencies from 80 MHz to 1 000 MHz shall be in line with the centre of the longitudinal part (1 500 mm length) of the wiring harness.

The phase centre of the antenna for frequencies above 1 000 MHz shall be in line with the DUT.

Examples of test set-ups are shown in Figures 1 to 3.

Dimensions in millimetres

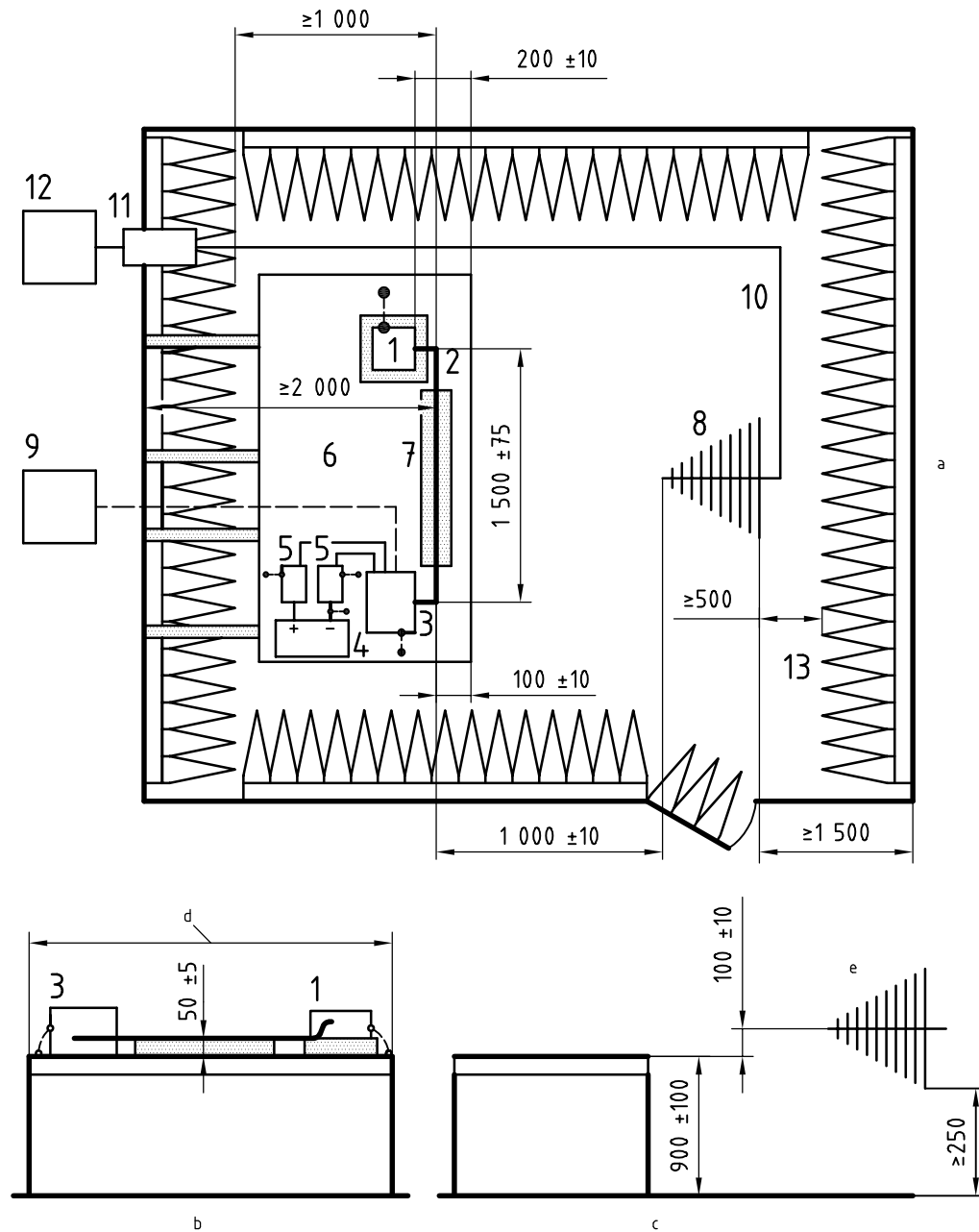


**Key**

- |                                                                      |                                                               |                                                      |
|----------------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------|
| 1 DUT (grounded locally if required in test plan)                    | 5 artificial network (AN)                                     | 10 high quality double-shielded coaxial cable (50 Ω) |
| 2 test harness                                                       | 6 ground plane (bonded to shielded enclosure)                 | 11 bulkhead connector                                |
| 3 load simulator (placement and ground: connection according to 7.5) | 7 low relative permittivity support ( $\epsilon_r \leq 1,4$ ) | 12 RF signal generator and amplifier                 |
| 4 power supply (location optional)                                   | 8 biconical antenna                                           | 13 RF absorber material                              |
| 9 stimulation and monitoring system                                  |                                                               |                                                      |

- a Upper view (horizontal polarisation).  
 b Front view.  
 c Side view.  
 d See 7.1.  
 e Vertical polarization.

**Figure 1 — Example test set-up — Biconical antenna**

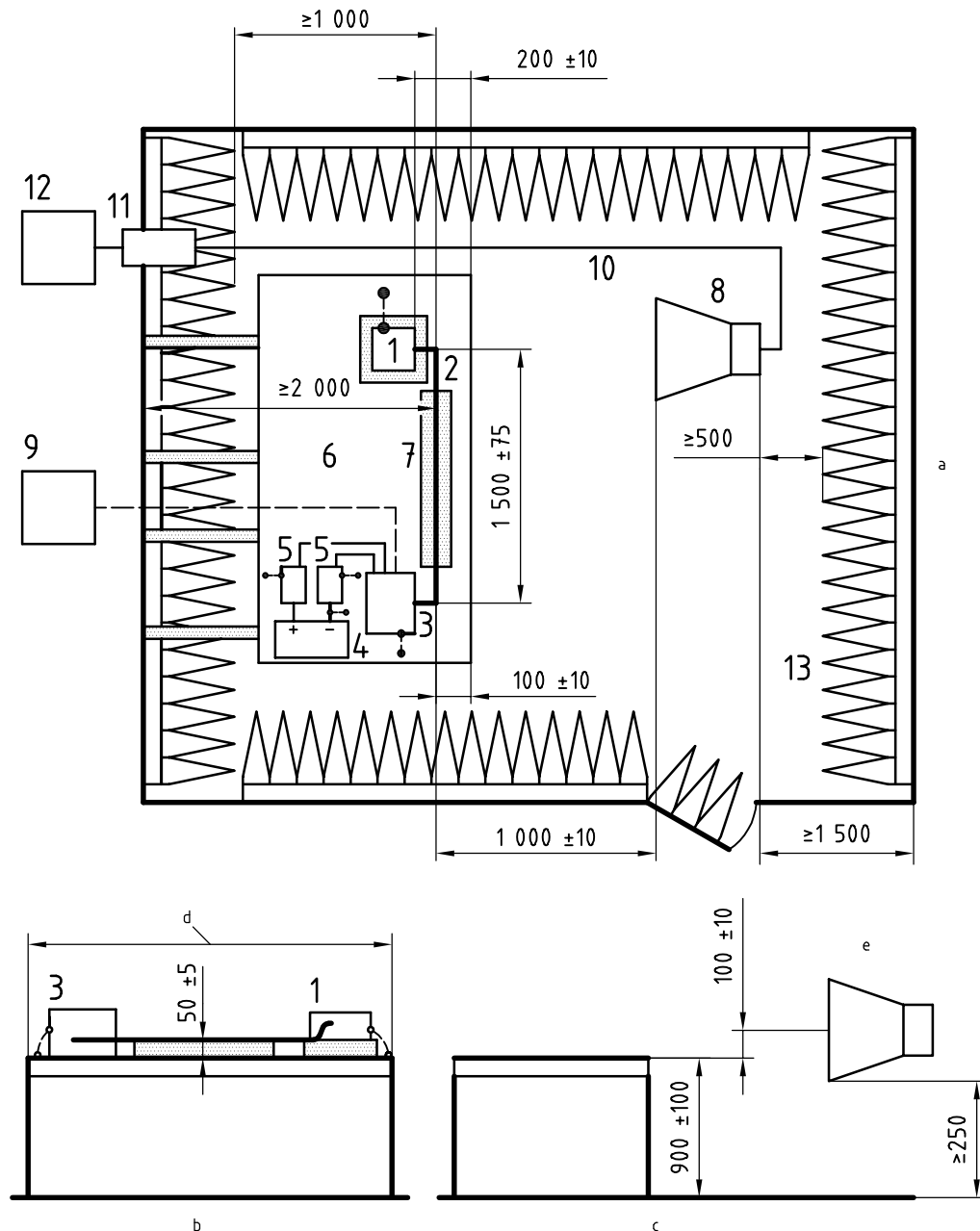


**Key**

- |                                                                      |                                                               |                                                      |
|----------------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------|
| 1 DUT (grounded locally if required in test plan)                    | 6 ground plane (bonded to shielded enclosure)                 | 10 high quality double-shielded coaxial cable (50 Ω) |
| 2 test harness                                                       | 7 low relative permittivity support ( $\epsilon_r \leq 1,4$ ) | 11 bulkhead connector                                |
| 3 load simulator (placement and ground: connection according to 7.5) | 8 log-periodic antenna                                        | 12 RF signal generator and amplifier                 |
| 4 power supply (location optional)                                   | 9 stimulation and monitoring system                           | 13 RF absorber material                              |
| 5 artificial network (AN)                                            |                                                               |                                                      |
- a Upper view (horizontal polarisation).  
 b Front view.  
 c Side view.  
 d See 7.1.  
 e Vertical polarization.

**Figure 2 — Example test set-up — Log-periodic-antenna**

Dimensions in millimetres



**Key**

- |   |                                                                    |    |                                                             |
|---|--------------------------------------------------------------------|----|-------------------------------------------------------------|
| 1 | DUT (grounded locally if required in test plan)                    | 7  | low relative permittivity support ( $\epsilon_r \leq 1,4$ ) |
| 2 | test harness                                                       | 8  | horn antenna                                                |
| 3 | load simulator (placement and ground: connection according to 7.5) | 9  | stimulation and monitoring system                           |
| 4 | power supply (location optional)                                   | 10 | high quality double-shielded coaxial cable (50 $\Omega$ )   |
| 5 | artificial network (AN)                                            | 11 | bulkhead connector                                          |
| 6 | ground plane (bonded to shielded enclosure)                        | 12 | RF signal generator and amplifier                           |
|   |                                                                    | 13 | RF absorber material                                        |
- a Upper view (horizontal polarisation).  
 b Front view.  
 c Side view.  
 d See 7.1.  
 e Vertical polarization.

**Figure 3 — Example test set-up for frequencies above 1 GHz — Horn antenna**

## 8 Test method

### 8.1 General

The general arrangement of the disturbance source and connecting harnesses etc. represents a standardized test condition. Any deviations from the standard test harness length etc. shall be agreed upon prior to testing and recorded in the test report.

The DUT shall be made to operate under typical loading and other conditions as in the vehicle. These operating conditions shall be clearly defined in the test plan to ensure supplier and customer are performing identical tests.

The orientation(s) of the DUT for radiated immunity tests shall be defined in the test plan.

From 400 MHz to 18 GHz, measurements shall be performed in horizontal polarization.

From 80 MHz to 18 GHz, measurements shall be performed in vertical polarization.

### 8.2 Test plan

Prior to performing the tests, a test plan shall be generated which shall include

- test set-up,
- frequency range,
- DUT mode of operation,
- DUT acceptance criteria,
- test severity levels,
- DUT monitoring conditions,
- antenna location, and
- test report content,

as well as any special instructions and changes from the standard test.

Every DUT shall be tested under the most significant conditions, i.e. at least in stand-by mode and in a mode where all the actuators can be excited

### 8.3 Test procedure

**CAUTION — Hazardous voltages and fields may exist within the test area. Care shall be taken to ensure that the requirements for limiting the exposure of humans to RF energy are met.**

#### 8.3.1 Substitution method

The test shall be performed with the substitution method, which is based upon the use of forward power as the reference parameter used for field calibration and test.

This method is carried out in two phases:

- a) field calibration (without the DUT, wiring harness and peripheral devices present, see 8.3.2);

b) test of the DUT with wiring harness and peripheral devices connected (see 8.3.3).

The RF power required to achieve the required field strength is determined during the field calibration phase.

### 8.3.2 Field calibration

The specific test level (field) shall be calibrated periodically by recording the forward power required to produce a specific field strength, measured with a field probe, for each test frequency. This calibration shall be performed with an unmodulated sinusoidal wave.

Place the electrical phase centre of the field probe ( $150 \pm 10$ ) mm above the ground plane and at a distance of ( $100 \pm 10$ ) mm from the front edge of the ground plane.

- For frequencies of from 80 MHz to 1 000 MHz, the phase centre of the field probe shall be in line with the centre of the longitudinal part (1 500 mm length) of the wiring harness position.
- For frequencies above 1 000 MHz, the phase centre of the field probe shall be in line with the DUT position.

Place the field-generating device (antenna) at a distance of ( $1\ 000 \pm 10$ ) mm from the electrical phase centre of the field probe.

Calibrate the field strength for vertical and horizontal polarisations.

When requested, the values of forward and reverse power recorded in the calibration file and a precise description of the associated position of the field probe shall be included in the test report.

### 8.3.3 DUT test

Install the DUT, harness and associated equipment on the test bench in accordance with Clause 7.

Subject the DUT to the test signal based on the calibrated value as predetermined in the test plan.

A field probe may be placed above the wiring harness during the test.

Perform the test for both horizontal and vertical polarisation in the appropriate frequency ranges.

## 8.4 Test report

As required in the test plan, a test report shall be submitted detailing information regarding the test equipment, test area, systems tested, frequencies, power levels, system interactions and any other relevant information regarding the test.

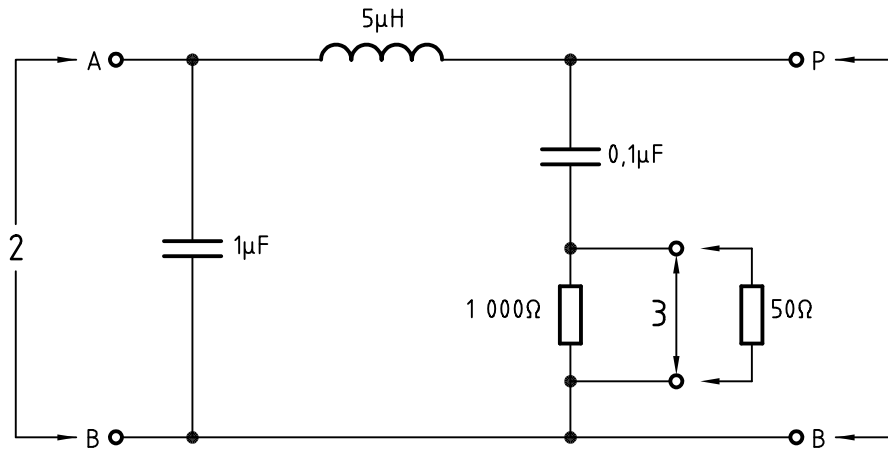
## Annex A (informative)

### Artificial network (AN)

#### A.1 General

The AN is used as a reference standard in the laboratory in place of the impedance of the vehicle wiring harness in order to determine the behaviour of equipment and electrical and electronic devices. It shall be able to withstand a continuous load corresponding to the requirements of the DUT.

An example AN schematic is shown in Figure A.1 (see, also, A.2).



#### Key

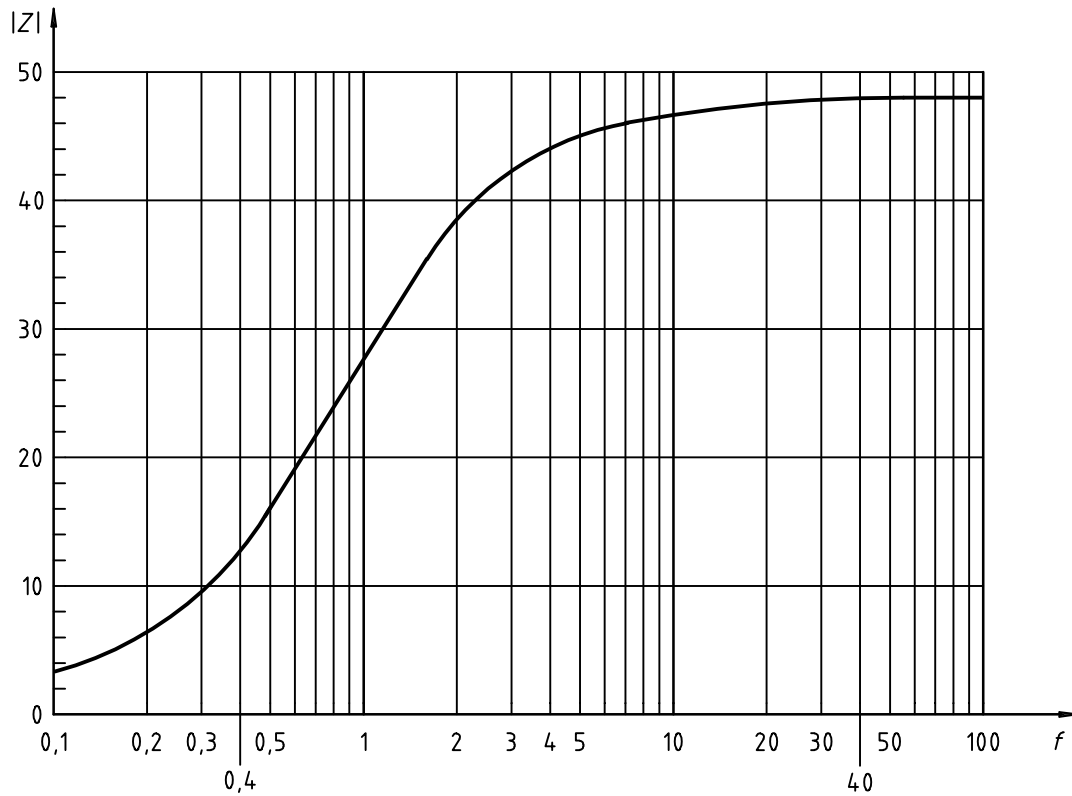
- 1 port for the DUT
- 2 power supply port
- 3 measurement port

**Figure A.1 — Example AN schematic**



## A.2 AN impedance

The AN impedance  $|Z_{PB}|$  in the measurement frequency range of 0,1 MHz to 100 MHz — assuming ideal electrical components — is shown in Figure A.2. In reality, a tolerance of  $\pm 20\%$  is permitted. The impedance is measured between the terminals P and B (Item 1 of Figure A.1) with a  $50\ \Omega$  load on the measurement port (Item 3 of Figure A.1) and with terminals A and B (Item 2 of Figure A.1) short-circuited.



### Key

- $|Z|$  impedance,  $\Omega$
- $f$  frequency, MHz

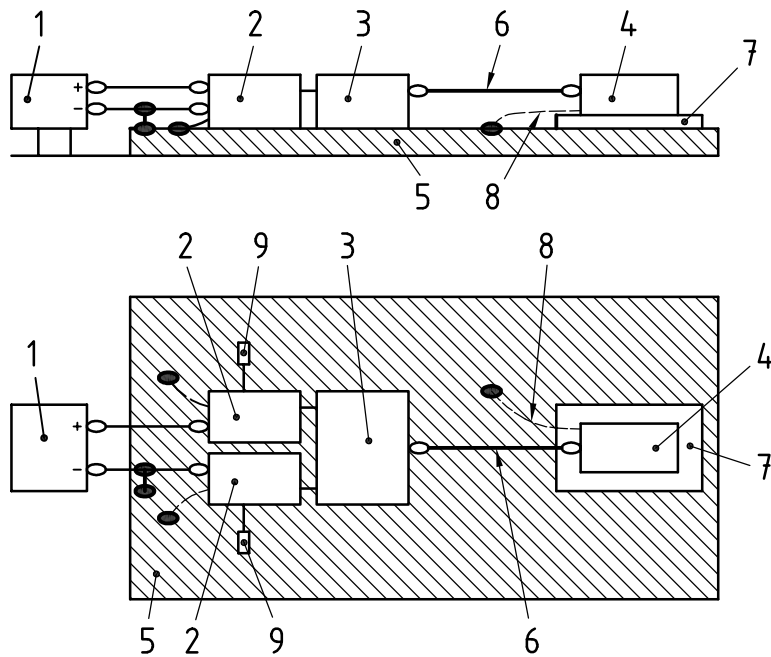
**Figure A.2 — Characteristics of AN impedance  $|Z_{PB}|$  as function of frequency,  $f$ , 0,1 MHz to 100 MHz**

## Annex B (informative)

### Remote/local grounding

#### B.1 DUT remotely grounded

The principle for connecting a remotely grounded DUT is shown in Figure B.1.



**Key**

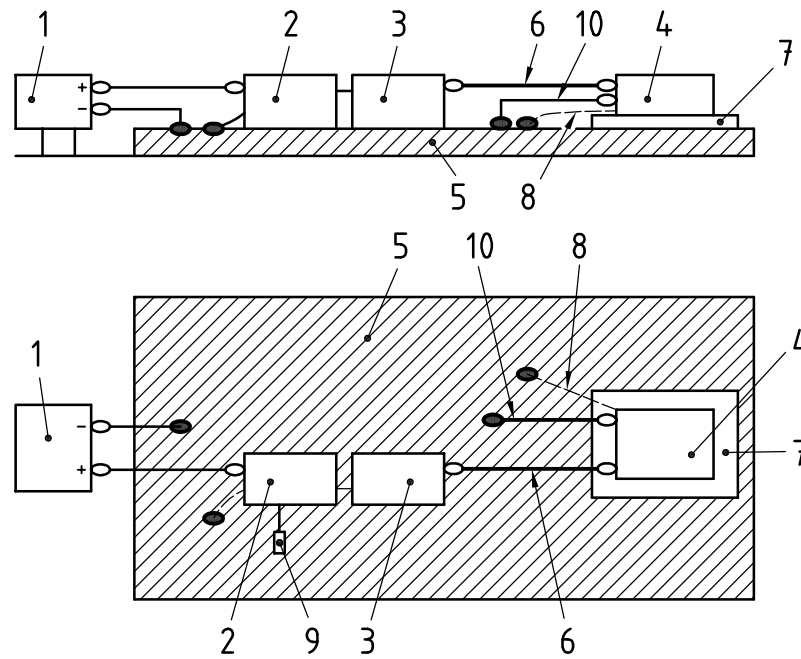
- 1 power supply
- 2 AN
- 3 simulator
- 4 DUT
- 5 ground plane
- 6 wiring harness (containing power supply and return line)
- 7 insulating support
- 8 housing of the DUT<sup>a</sup>
- 9 50 Ω load

<sup>a</sup> Not connected to the ground plane unless specified in the test plan (see 7.3).

**Figure B.1 — DUT remotely grounded**

## B.2 DUT locally grounded

The principle for connecting a locally grounded DUT is shown in Figure B.2.



### Key

- 1 power supply
- 2 AN
- 3 simulator
- 4 DUT
- 5 ground plane
- 6 wiring harness (not containing power return line)
- 7 insulating support
- 8 housing of the DUT<sup>a</sup>
- 9 50 Ω load.
- 10 power return line (maximum length: 200 mm)

<sup>a</sup> Not connected to the ground plane unless specified in the test plan (see 7.3).

Figure B.2 — DUT locally grounded

## Annex C (informative)

### Function performance status classification (FPSC)

Suggested test severity levels and the frequency bands are given in Table C.1 and Table C.2, respectively.

NOTE See ISO 11452-1 for a detailed explanation of FPSC.

**Table C.1 — Suggested test severity levels**

Test severity level	Value V/m
I	25
II	50
III	75
IV	100
V	Specific value agreed between the users of this part of ISO 11452, if necessary

**Table C.2 — Frequency bands**

Frequency band	Frequency range MHz
F1	$> 80$ to $\leq 400$
F2	$> 400$ to $\leq 1\ 000$
F3	$> 1\ 000$ to $\leq 10\ 000$
F4	$> 10\ 000$ to $\leq 18\ 000$

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