BS ISO 11452-8:2015

BSI Standards Publication

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

## Part 8: Immunity to magnetic fields

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## National foreword

This British Standard is the UK implementation of ISO 11452-8:2015. It supersedes BS ISO 11452-8:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AUE/16, Data Communication (Road Vehicles).

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.



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**Compliance with a British Standard cannot confer immunity from legal obligations.**

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INTERNATIONAL STANDARD

**ISO 11452-8**

Second edition
2015-06-01

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

## Part 8: **Immunity to magnetic fields**

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

*Partie 8: Méthodes d'immunité aux champs magnétiques*

Reference number
ISO 11452-8:2015(E)

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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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

This second edition cancels and replaces the first edition (ISO 11452-8:2007), of which it constitutes a minor revision.

ISO 11452 consists of the following parts, under the general title *Road vehicles — Component test methods for electrical disturbances for 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: Harness excitation methods*

— *Part 5: Stripline*

— *Part 7: Direct radio frequency (RF) power injection*

— *Part 8: Immunity to magnetic fields*

— *Part 9: Portable transmitter*

— *Part 10: Immunity to conducted disturbances in the extended audio frequency range*

— *Part 11: Reverberation chamber*

Annex A of this part of ISO 11452 is for information only.

# Introduction

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

ISO 11452-1 specifies general test conditions, definitions, practical use, and basic principles of the test procedure.

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

# Part 8:
# Immunity to magnetic fields

## 1 Scope

This part of ISO 11452 specifies tests for electromagnetic immunity of electronic components for passenger cars and commercial vehicles, regardless of the propulsion system (e.g. spark-ignition engine, diesel engine, electric motor), to magnetic fields. These sources are classified into “internal magnetic field” (sources internal to the vehicle, e.g. vehicle electro-mechanical motors, actuators,...) and “external magnetic field” (sources external to the vehicle e.g. power transmission lines, generating stations,…). To perform this test, the device under test (DUT) is exposed to a magnetic disturbance field.

The radiating loop method can be applied to small DUTs or to larger DUTs by positioning the coil in multiple locations.

The Helmholtz coil is sometimes used as an alternative method. This technique is limited by the relationship between the size of the DUT and the size of the coils. The electromagnetic disturbances considered in this part of ISO 11452 are limited to continuous narrowband electromagnetic fields.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

VG 95377-13:1993, *Electromagnetic compatibility — Measuring devices and measuring equipment — measuring antennas, measuring coils and field probes*

## 3 Terms and definitions

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

## 4 Test conditions

### 4.1 General

The applicable frequency range of this test method is d.c. and 15 Hz to 150 kHz.

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

Standard test conditions are given in ISO 11452-1 for the following:

— test temperature;

— supply voltage;

— dwell time;

— definition of test severity levels.

### 4.2 Frequency step sizes

The tests shall be conducted at d.c. and at frequencies of 16,67 Hz, 50 Hz, 60 Hz, 150 Hz, and 180 Hz and with frequency step sizes (logarithmic or linear) not greater than those specified in Table 1. The step sizes agreed upon by the users of this part of ISO 11452 shall be documented in the test report.

**Table 1 — Maximum frequency steps sizes**

| **Frequency band**<br>kHz | **Linear steps**<br>kHz | **Logarithmic steps**<br>% |
|---|---|---|
| 0 (d.c.) | - | - |
| 0,015 to 0,1 | 0,01 | 10 |
| 0,1 to 1 | 0,1 | 10 |
| 1 to 10 | 1 | 10 |
| 10 to 150 | 10 | 10 |

NOTE The 5th harmonic of 16,67 Hz, 50 Hz and 60 Hz can also be tested.

If it appears that the susceptibility thresholds of the DUT are very near to the chosen test level, these frequency step sizes should be reduced in the frequency range concerned in order to find the minimum susceptibility thresholds.

## 5 Test location

A shielded room is not required.

**IMPORTANT — The appropriate guidelines (national regulation, ICNIRP,[2][3] etc.) shall be followed for the protection of the test personnel.**

## 6 Test apparatus description and specification

### 6.1 General

The test apparatus shall consist of the following:

— field-generating device(s): radiating loop or Helmholtz coil;

— magnetic field strength monitor;

— low-frequency (LF) generator;

— low-frequency (LF) amplifier (capable of driving inductive load);

— voltmeter;

— current monitor;

— artificial network(s) (AN) (optional, see ISO 11452-1 for characteristics).

## 6.2 Field-generating device

### 6.2.1 Radiating loop

The radiating loop of MIL STD 461 F is recommended (not suitable for high level d.c. fields), but any similar coil may be used. The MIL STD 461 F coil has the following characteristics:

— diameter: 120 mm;

— number of turns: 20;

— wire: approximate diameter 2,0 mm (AWG12).

For d.c. fields up to 3 000 A/m, a specialized coil is required in accordance with VG 95377-13.

The magnetic flux density $B_{50\text{mm}}$ of this radiating loop of MIL STD 461 F with a current $I$ at a distance of 50 mm from the plane of the loop is given by Formula (1):

$$B_{50\text{mm}} = \mu_0 H = 95I \quad (1)$$

where

- $B$ is the magnetic flux density, in microtesla;
- $H$ is the magnetic field, in amperes per metre;
- 95 is a constant, in volt. second per ampere per square meter;
- $I$ is the coil current, in amperes.

The magnetic field strength $H_{50\text{mm}}$ of this radiating loop of MIL STD 461 F with a current $I$ at a distance of 50 mm from the plane of the loop is given by Formula (2):

$$H_{50\text{mm}} = 75{,}6I \quad (2)$$

where

- $H$ is the magnetic field, in amperes per metre;
- 75,6 is a constant, per metre;
- $I$ is the coil current, in amperes.

The radiating loop should be characterized over the frequency range. Linearity characteristics shall be considered in determining the calculated current value for the DUT test.

### 6.2.2 Helmholtz coil

Ideally, Helmholtz coils set up a region of uniform magnetic fields. The primary usage of the coils is to expose the DUT to a uniform magnetic field.

The radius of the coils is determined by the size of the DUT. In order to obtain a uniform magnetic field (±10 %), the relationship between the coils and the DUT should be met, as shown in Figure 3. The uniform field region shown in Figure 3 should be a minimum of 300 mm × 300 mm × 300 mm.

For Helmholtz coils spaced one radius apart, the magnetic flux density at the centre of the system is given by Formula (3):

$$B = \mu_0 H = \frac{0{,}899 \times N \times I}{R} \tag{3}$$

where

| | |
|---|---|
| $B$ | is the magnetic flux density, in microtesla; |
| $N$ | is the number of wire turns on the coil; |
| $R$ | is the coil radius, in metres; |
| $I$ | is the coil current, in amperes; |
| $H$ | is the magnetic field, in amperes per metre; |
| $\mu_0$ | is the magnetic constant, permeability of the vacuum, in henry per metre; |
| 0,899 | is a constant, in henry per metre. |

The magnetic field, $H$, at the centre of the system is given by Formula (4):

$$H = \frac{0{,}7155NI}{R} \tag{4}$$

where

| | |
|---|---|
| $H$ | is the magnetic field, in amperes per metre; |
| $N$ | is the number of wire turns on the coil; |
| $R$ | is the coil radius, in metres; |
| $I$ | is the coil current, in amperes. |

The current-carrying capability and number of turns of the coils should be selected such that the test specification can be met.

The coils shall not have a self-resonant frequency at or lower than the upper frequency of 150 kHz.

The Helmholtz coil should be characterized over the frequency range. Linearity characteristics shall be considered in determining the calculated current value for the DUT test.

## 6.3 Current monitor

The current monitor shall ensure that true RMS current measurement is made within the frequency range d.c. and 15 Hz to 150 kHz, either by using a clamp-on probe or by measuring voltage across a shunt resistor.

An oscilloscope, a true RMS a.c. voltmeter, or a true RMS a.c. current meter may be used.

## 6.4 Magnetic field strength monitor

For the radiating loop method, the magnetic field strength monitor to be used is as follows:

— For d.c., the magnetic field strength monitor shall be a Hall-sensor-based measuring instrument.

  A typical magnetic field strength monitor should be capable of measuring a magnetic field strength of at least 3 000 A/m at d.c..

— If $f \geq 15$ Hz, the recommended magnetic field strength monitor is a loop sensor having the following specifications:

  — diameter: 40 mm;

  — number of turns: 51;

  — wire: approx. 0,071 mm (7 strand 41 AWG);

  — shielding: electrostatic;

  — correction factor: see manufacturer's data for factor to convert sensor coil voltage to magnetic intensity.

  The open-circuit voltage, $U$, measured in volts by means of a high-impedance voltmeter, is induced in the loop sensor and is calculated as shown in Formula (5):

$$U = 2\pi f NAB \tag{5}$$

where

| | |
|---|---|
| $f$ | is the frequency, in Hertz; |
| $N$ | is the number of wire turns in the coil; |
| $A$ | is the cross-sectional area of the coil, in square metres, calculated with the average diameter of the coil; |
| $B$ | is the magnetic flux density, in tesla. |

A typical magnetic field strength monitor should be capable of measuring a magnetic field strength of at least 1 000 A/m across the frequency range 15 Hz to 150 kHz.

### 6.5 Stimulation and monitoring of the DUT

If required in the test plan, the DUT shall be operated by actuators which have minimum effect on the electromagnetic characteristics, e.g. plastic blocks on the push buttons or pneumatic actuators with plastic tubes.

Connections to equipment monitoring electromagnetic interference reactions of the DUT can be accomplished by using fibre optics or high-resistance leads. Other types of leads 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 might cause malfunction of the device. Extreme care shall be taken to avoid such effects.

## 7 Test set-up

### 7.1 General

The test area should be of a suitable size to house all of the required test equipment and shall be free from disturbances that might affect the test results. The magnetic field generator (radiating loop or Helmholtz coil) should be at least 2 m away from the DUT monitoring equipment. The magnetic field generator shall be maintained at a minimum of 1 m from metal surfaces parallel to the plane of the coil(s).

**IMPORTANT — The appropriate guidelines (national regulation, ICNIRP,[2][3] etc.) shall be followed for the protection of the test personnel.**

### 7.2 Power supply

The power supply as described in ISO 11452-1 shall be used.

### 7.3 Location of the test harness and DUT

The test harness shall be designed in order to minimize different coupling effects inside the harness (e.g. twisted pairs) and to minimize interference to the load box and power supply. The test harness and the DUT shall be placed on a non-conductive, non-ferro-magnetic low-permeability support (e.g. wooden table).

### 7.4 Radiating loop method

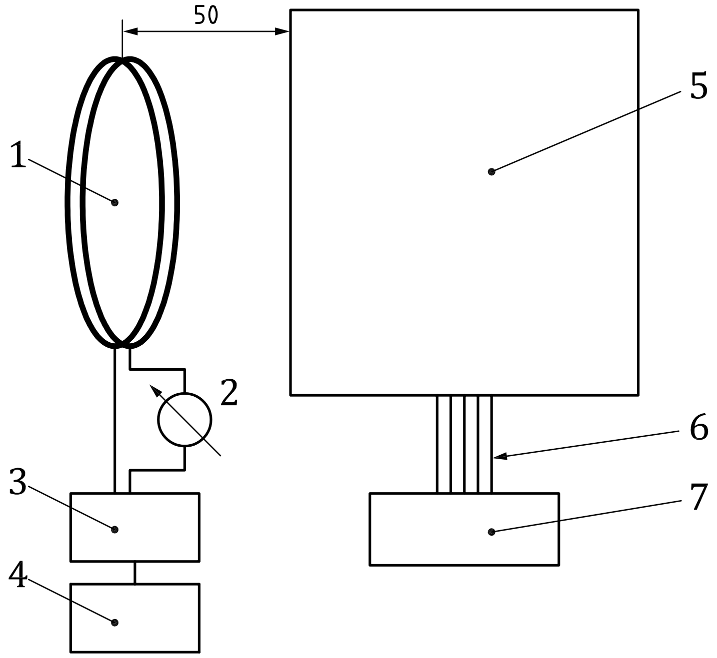
The test configuration should be as shown in Figure 1.

Each face of the DUT shall be partitioned into equal areas of 100 mm × 100 mm or less. The radiating loop shall be positioned 50 mm from the centre of each of these areas and parallel to the face of the DUT.

In addition, the radiating loop shall be placed at each electrical interface connector and at any attached magnetic sensor(s). The radiating loop shall be placed so that maximum coupling occurs between it and any attached magnetic sensor(s).

All wires in the harness shall be terminated or opened according to the vehicle application. If possible, the actual loads and actuators shall be used.

Dimensions in millimetres




**Key**

1 radiating loop

2 current monitor

3 LF amplifier (if required)

4 LF generator / d.c. power supply

5 DUT

6 wiring harness

7 peripheral

**Figure 1 — Radiating loop configuration**

## 7.5 Helmholtz coil method

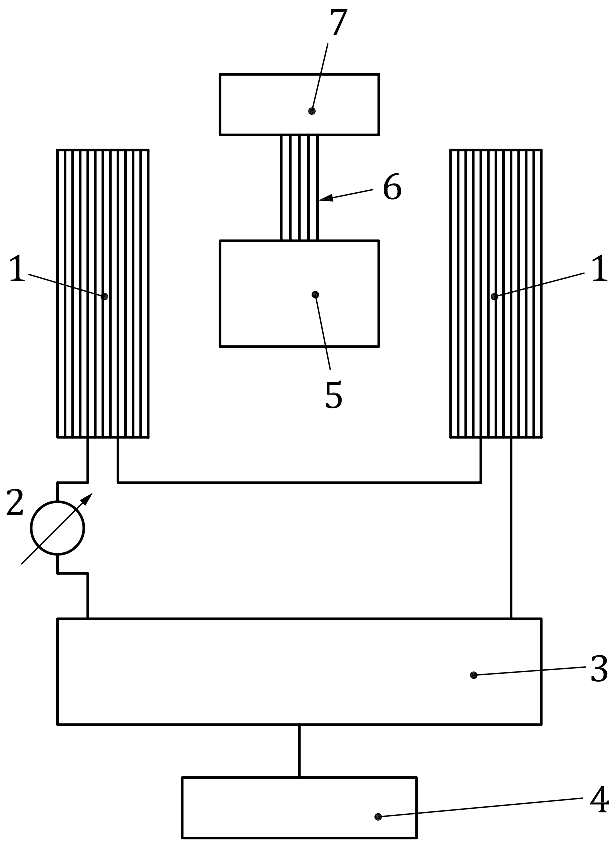
The test configuration should be as shown in Figure 2 and Figure 3.

The DUT shall be positioned in one of its three principal axes (X, Y, and Z) on a non-conducting, low-permeability ($\mu_r$ approximately 1) material into the uniform field region of the Helmholtz coil.

The wiring harness of the DUT shall be routed vertically down and then away from the coils to the support/monitoring equipment.

All wires in the harness shall be terminated or opened according to the vehicle application. If possible, the actual loads and actuators shall be used.

Power may be applied to the DUT via a 5 µH/50 Ω artificial network.




**Key**

1 coil

2 current monitor

3 LF amplifier (if required)

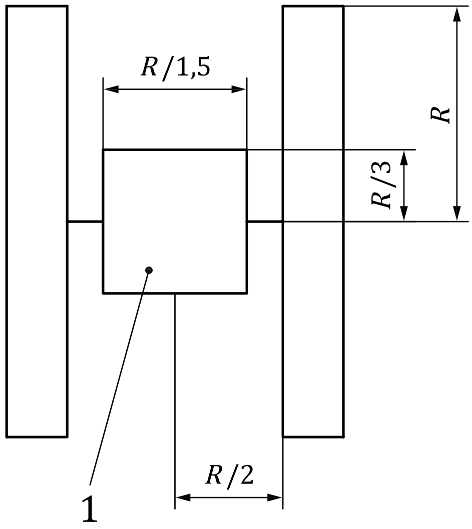
4 LF generator / d.c. power supply

5 DUT or magnetic field meter (for characterization or verification)

6 wiring harness

7 peripheral

**Figure 2 — Test set-up**




**Key**

1 uniform field region

*R* coil radius

**Figure 3 — Helmholtz coil configuration**

## 8 Test procedure

### 8.1 General

The general arrangement of the disturbance source, connecting harnesses, etc. represents a standardized test condition. Any deviations from the standard test set-up 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 that the test is repeatable.

For the radiating loop method, the DUT test points shall be defined in the test plan.

For the Helmholtz coil method, the orientations (X, Y, and Z axes) of the DUT for the test shall be defined in the test plan.

### 8.2 Test plan

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

— test method;

— test set-up;

— test points for the radiating loop method;

— DUT axes for the Helmholtz coil method;

— specific test frequencies and frequency range;

— DUT mode of operation;

— DUT acceptance criteria;

— DUT monitoring conditions;

— definition of test severity levels;

— test report content;

— any special instructions and changes from this part of ISO 11452.

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

## 8.3 Test method

**CAUTION — Caution shall be exercised when operating high-power amplifiers to avoid hazards to the apparatus. Apparatus in the near vicinity of the coils shall be shielded to prevent interference from magnetic fields.**

NOTE Most apparatus shielding is not effective for magnetic fields.

### 8.3.1 Radiating loop method

#### 8.3.1.1 General

The test shall be performed with verification at d.c. and at one additional frequency and based upon the use of coil current as the reference parameter used for field verification and test.

This method is carried out in the following two phases:

a) field verification at d.c. and at one additional frequency (without the DUT, wiring harness, and peripheral devices present);

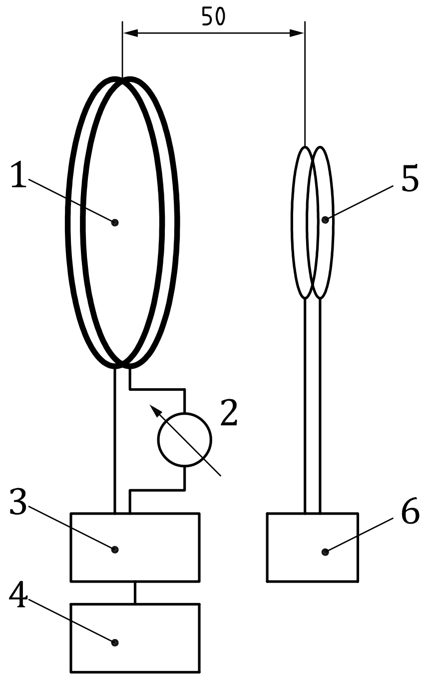
b) test of the DUT with wiring harness and peripheral devices connected.

#### 8.3.1.2 Verification

The specific test level (field) shall be verified periodically at one frequency (e.g. 1 kHz) and d.c. by recording the coil current required to produce a specific field strength, measured with a field probe. This verification shall be performed with an unmodulated sinusoidal wave.

Connect the set-up according to Figure 4.

Dimensions in millimetres




**Key**

1 radiating loop

2 current monitor

3 LF amplifier (if required)

4 LF generator/d.c. power supply

5 sensor coil/Hall effect sensor

6 high-impedance voltmeter

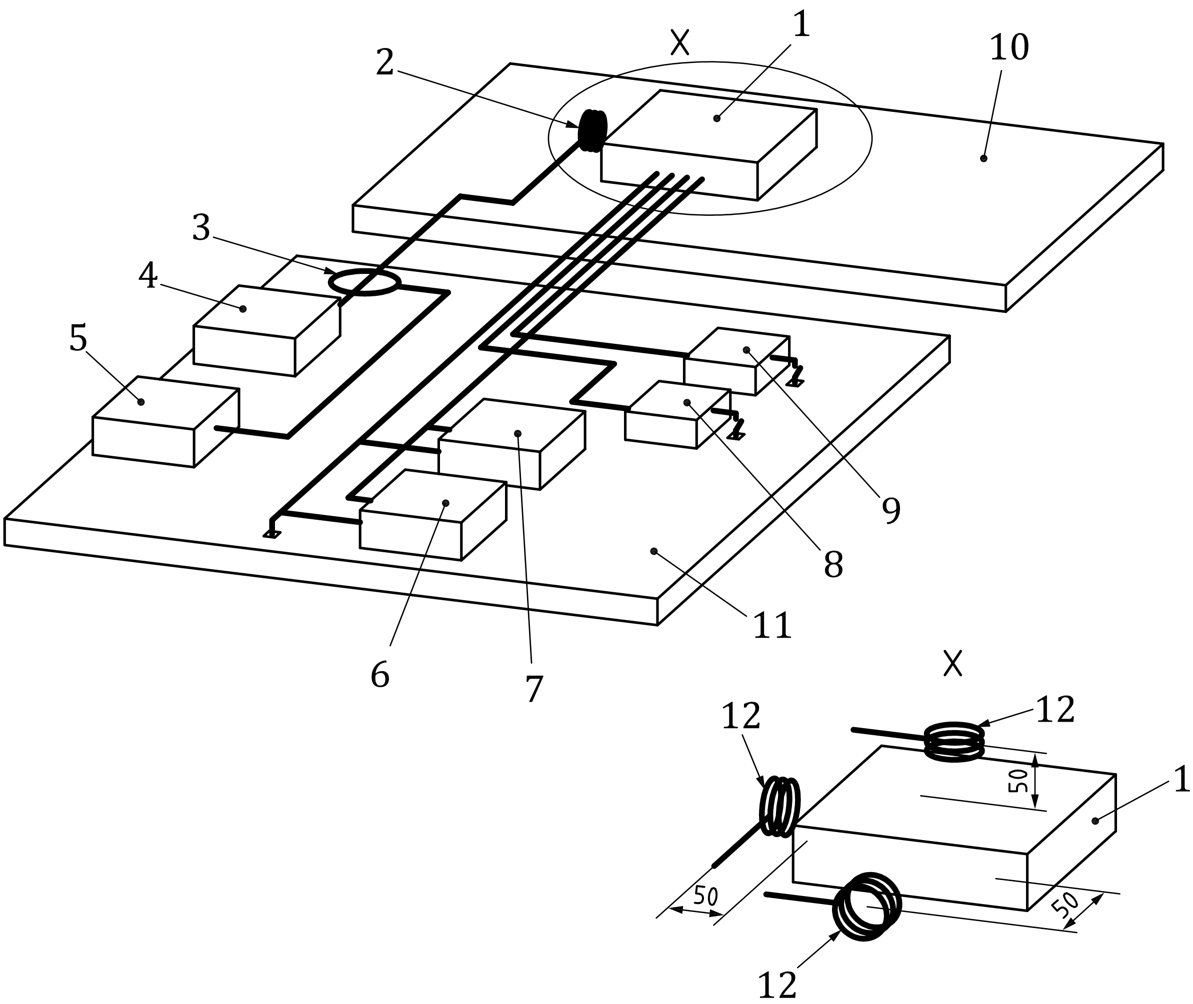
**Figure 4 — Verification**

### 8.3.1.3 DUT test

The test is conducted by subjecting the DUT to the test signal based on the calculated value as defined in the test plan. The test shall be performed with the three axial polarization.

The test set-up should be as shown in Figure 5.

Dimensions in millimetres




**Key**

| | | | |
|---|---|---|---|
| 1 | DUT | 7 | battery |
| 2 | radiating loop | 8 | sensors |
| 3 | current probe | 9 | actuators |
| 4 | generator and amplifier/d.c. power supply | 10 | insulating support |
| 5 | oscilloscope | 11 | ground plane (if required in the test plan) |
| 6 | power supply | 12 | three orthogonal positions (see 8.3.1.3) |

**Figure 5 — Radiating loop test set-up**

### 8.3.1.4 Procedure

Place the radiating coil 50 mm from a test point on the operating DUT (see Figure 5).

Generate the defined magnetic field levels from the calculated values (see 6.2.1).

At each frequency, expose the DUT for a minimum of 1 s.

Monitor any malfunction of the DUT and record the respective field intensity.

Repeat the above steps for the other test points of the DUT.

### 8.3.2 Helmholtz coil method

#### 8.3.2.1 General

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

This method is carried out in the following two phases:

— field verification (without the DUT, wiring harness, and peripheral devices present);

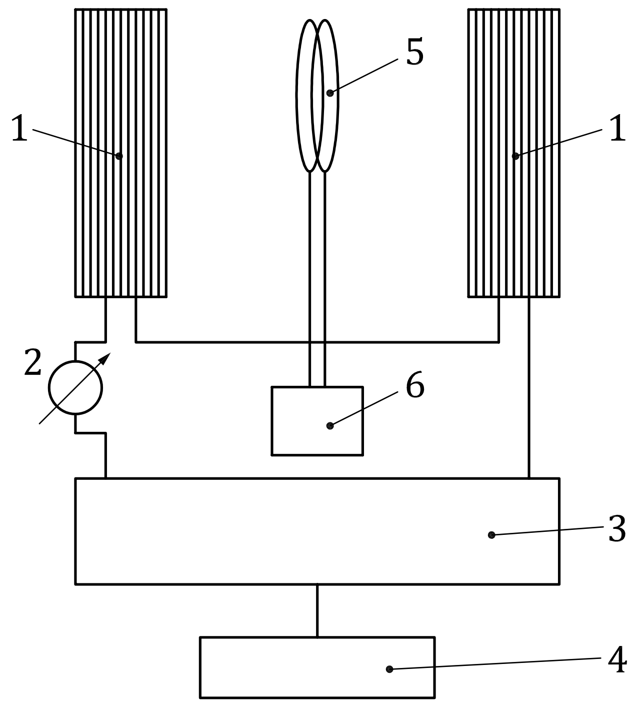
— test of the DUT with wiring harness and peripheral devices connected.

The coil current required to achieve the required field strength is determined during the field verification phase.

#### 8.3.2.2 Verification

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

Connect the set-up according to Figure 6.




**Key**

1 coil(s)
2 current monitor
3 LF amplifier (if required)
4 LF generator / d.c. power supply
5 sensor coil / Hall effect sensor
6 high-impedance voltmetre

**Figure 6 — Helmholtz coil verification**

#### 8.3.2.3 DUT test

The test is conducted by subjecting the DUT and the associated harness to the test signal based on the calibrated value as predetermined in the test plan.

Place the operating DUT in the uniform field region of the Helmholtz coil (see Figure 3).

At each frequency, expose the DUT and the associated harness for a minimum of 1 s.

In case of any malfunction of the DUT, the corresponding frequency and field intensity shall be recorded.

Repeat the above steps for the other two orientations (X, Y, or Z axes) of the DUT.

### 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, test levels, system interactions, and any other relevant information regarding the test.

# Annex A
(informative)

# Function performance status classification (FPSC) and test severity levels

## A.1 General

This Annex gives examples of test severity levels which should be used in line with the principle of functional performance status classification (FPSC) described in ISO 11452-1.

## A.2 Classification of test severity levels

### A.2.1 General

The suggested minimum and maximum severity levels are given in Tables A.1 and A.2 and in Figures A.1 and A.2.

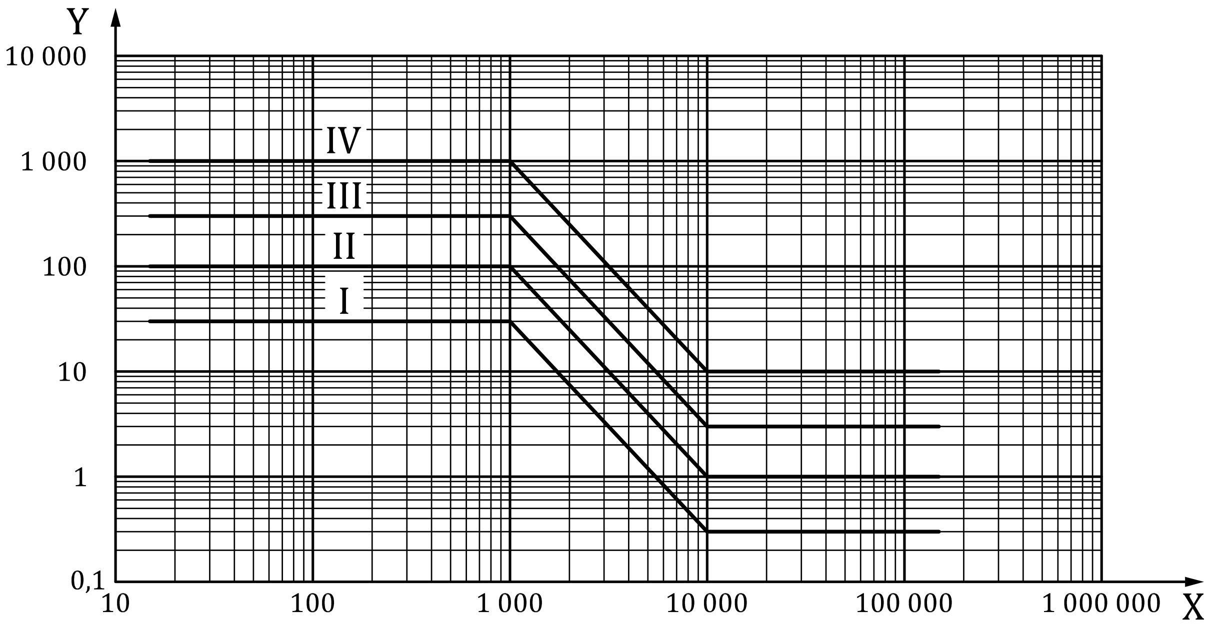
### A.2.2 Internal field

Examples of test severity levels are given in Table A.1 and Figure A.1.

**Table A.1 — Examples of test severity levels (internal field)**

| **Frequency band**<br>Hz | **Test level I**<br>A/m | **Test level II**<br>A/m | **Test level III**<br>A/m | **Test level IV**<br>A/m | **Test level V**<br>A/m |
|---|---|---|---|---|---|
| 0 (d.c.) | 90 | 300 | 900 | 3 000 | Specific value agreed between the users of this part of ISO 11452 |
| 15 to 1 000 | 30 | 100 | 300 | 1 000 | |
| 1 000 to 10 000 | $30/(f/1\,000)^2$ | $100/(f/1\,000)^2$ | $300/(f/1\,000)^2$ | $1\,000/(f/1\,000)^2$ | |
| 10 000 to 150 000 | 0,3 | 1 | 3 | 10 | |
| NOTE $f$ in Hz. | | | | | |




**Key**

X frequency (Hz)

Y magnetic field (A/m)

1,2,3,4 test severity levels (see Table A.1)

NOTE The d.c. point is not shown in the figure.

**Figure A.1 — Test severity levels and frequency bands (internal field)**

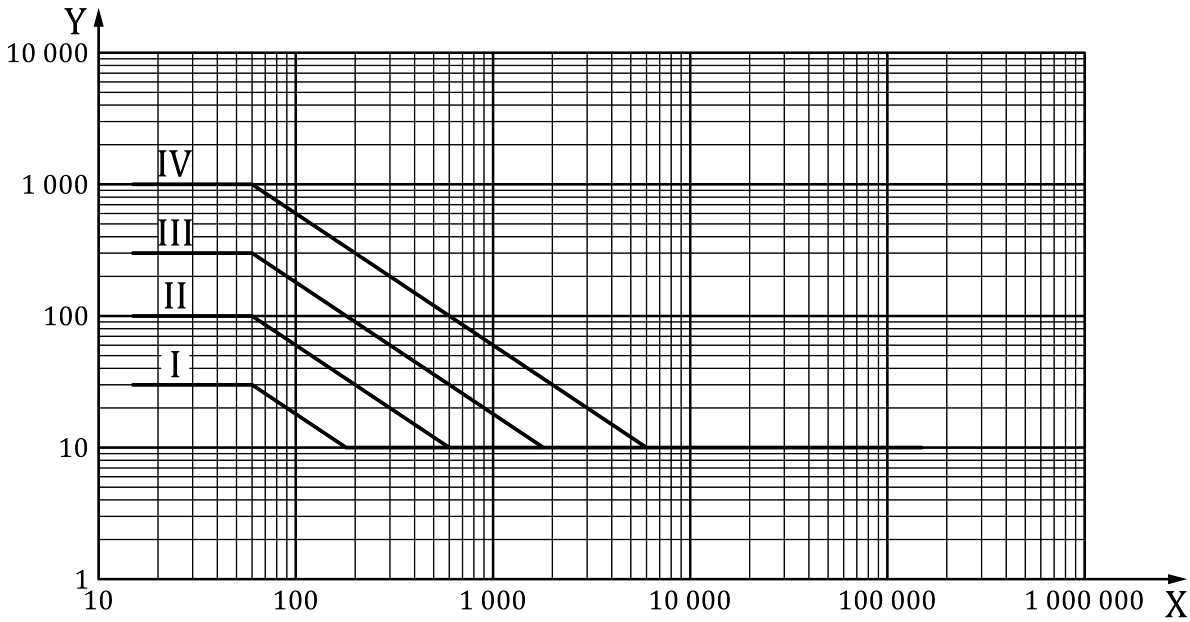
### A.2.3 External field

Examples of test severity levels are given in Table A.2 and Figure A.2.

**Table A.2 — Examples of test severity levels (external field)**

| **Frequency band**<br>Hz | **Test level I**<br>A/m | **Test level II**<br>A/m | **Test level III**<br>A/m | **Test level IV**<br>A/m | **Test level V**<br>A/m |
|---|---|---|---|---|---|
| 0 (d.c.) | 90 | 300 | 900 | 3 000 | Specific value agreed between the users of this part of ISO 11452 |
| 15 to 60 | 30 | 100 | 300 | 1 000 | |
| 60 to 180 | 30/(*f*/60) | 100/(*f*/60) | 300/(*f*/60) | 1 000/(*f*/60) | |
| 180 to 600 | 10 | | | | |
| 600 to 1 800 | | 10 | | | |
| 1 800 to 6 000 | | | 10 | | |
| 6 000 to 150 000 | | | | 10 | |
| NOTE *f* in Hz. | | | | | |




**Key**

X frequency (Hz)

Y magnetic field (A/m)

1,2,3,4 test severity levels (see Table A.2)

NOTE The d.c. point is not shown in the figure.

**Figure A.2 — Test severity levels and frequency bands (external field)**

## A.3 Example of FPSC application using test severity levels

Each DUT and its function(s) need to be evaluated prior to test. The category of the DUT function(s), test severity level(s), and response criteria should then be agreed upon between the supplier and vehicle manufacturer. This information should be documented in the test plan and used for determination of DUT acceptance upon completion of the testing and evaluation of the test results.

An example of severity levels is given in Table A.3. This table can be different for internal and external fields (levels from Tables A.1 and A.2).

**Table A.3 — Examples of test severity levels with FPSC application**

| Test severity level | DUT function Category 1 | DUT function Category 2 | DUT function Category 3 | DUT function Category 4 |
|---|---|---|---|---|
| $L_{4i}$ | Level IV | – | – | – |
| $L_{3i}$ | Level III | Level IV | – | – |
| $L_{2i}$ | Level II | Level III | Level IV | – |
| $L_{1i}$ | Level I | Level II | Level III | Level IV |

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