

INTERNATIONAL STANDARD

NORME INTERNATIONALE

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers

Véhicules, bateaux et moteurs à combustion interne – Caractéristiques des perturbations radioélectriques – Limites et méthodes de mesure pour la protection des récepteurs embarqués



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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**VEHICLES, BOATS AND INTERNAL COMBUSTION ENGINES –
RADIO DISTURBANCE CHARACTERISTICS –
LIMITS AND METHODS OF MEASUREMENT FOR
THE PROTECTION OF ON-BOARD RECEIVERS**

FOREWORD

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International Standard CISPR 25 has been prepared by CISPR subcommittee D: Electromagnetic disturbances related to electric/electronic equipment on vehicles and internal combustion engine powered devices.

This third edition cancels and replaces the second edition published in 2002. This edition constitutes a technical revision.

The following significant changes were made with respect to the previous edition:

- addition of required measurements with both an average detector and a peak or quasi-peak detector;
- addition of methods and limits for the protection of new analogue and digital radio services, which cover the frequency range up to 2 500 MHz;
- addition of a new measurement method for components (stripline) as an informative Annex G;

- addition of the contents of CISPR 21 as Annex H; CISPR 21 in its entirety now becomes obsolete.
- deletion of narrowband / broadband determination;
- deletion of the Annex on rod antenna characterisation (this is now covered by CISPR 16-1-4);
- deletion of the Annex on characterisation of shielded enclosure (CISPR 25 will be amended when the CISPR/D / CISPR/A Joint Task Force on chamber validation finishes its work).

The text of this standard is based on the following documents:

Enquiry draft	Report on voting
CISPR/D/344/CDV	CISPR/D/352/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above Table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of January 2009 have been included in this copy.

WITHDRAWN

INTRODUCTION

This International Standard is designed to protect on-board receivers from disturbances produced by conducted and radiated emissions arising in a vehicle.

Test procedures and limits given are intended to provide provisional control of vehicle radiated emissions, as well as component/module conducted/radiated emissions of long and short duration.

To accomplish this end, this standard:

- establishes a test method for measuring the electromagnetic emissions from the electrical system of a vehicle;
- sets limits for the electromagnetic emissions from the electrical system of a vehicle;
- establishes test methods for testing on-board components and modules independent from the vehicle;
- sets limits for electromagnetic emissions from components to prevent objectionable disturbance to on-board receivers;
- classifies automotive components by disturbance duration to establish a range of limits.

NOTE Component tests are not intended to replace vehicle tests. Exact correlation between component and vehicle test performance is dependent on component mounting location, harness length, routing and grounding, as well as antenna location. Component testing, however, permits components to be evaluated prior to actual vehicle availability.

Withhold

VEHICLES, BOATS AND INTERNAL COMBUSTION ENGINES – RADIO DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT FOR THE PROTECTION OF ON-BOARD RECEIVERS

1 Scope

This International Standard contains limits and procedures for the measurement of radio disturbances in the frequency range of 150 kHz to 2 500 MHz. The standard applies to any electronic/electrical component intended for use in vehicles, trailers and devices. Refer to International Telecommunications Union (ITU) publications for details of frequency allocations. The limits are intended to provide protection for receivers installed in a vehicle from disturbances produced by components/modules in the same vehicle. The method and limits for a complete vehicle are in Clause 5 and the methods and limits for components/modules are in Clause 6. Only a complete vehicle test can be used to determine the component compatibility with respect to a vehicle's limit.

The receiver types to be protected are, for example, broadcast receivers (sound and television), land mobile radio, radio telephone, amateur, citizens' radio, Satellite Navigation (GPS, etc.) and Bluetooth. For the purpose of this standard, a vehicle is a machine, which is self-propelled. Vehicles include (but are not limited to) passenger cars, trucks, agricultural tractors and snowmobiles. Annex A provides guidance in determining whether this standard is applicable to particular equipment.

The limits in this standard are recommended and subject to modification as agreed between the vehicle manufacturer and the component supplier. This standard is also intended to be applied by manufacturers and suppliers of components and equipment which are to be added and connected to the vehicle harness or to an on-board power connector after delivery of the vehicle.

This International Standard does not include protection of electronic control systems from radio frequency (RF) emissions, or from transient or pulse-type voltage fluctuations. These subjects are included in ISO publications.

Since the mounting location, vehicle body construction and harness design can affect the coupling of radio disturbances to the on-board radio, Clause 6 of this standard defines multiple limit levels. The level class to be used (as a function of frequency band) is agreed upon between the vehicle manufacturer and the component supplier.

CISPR 25 defines test methods for use by vehicle manufacturers and suppliers, to assist in the design of vehicles and components and ensure controlled levels of on-board radio frequency emissions.

Vehicle test limits are provided for guidance and are based on a typical radio receiver using the antenna provided as part of the vehicle, or a test antenna if a unique antenna is not specified. The frequency bands that are defined are not applicable to all regions or countries of the world. For economic reasons, the vehicle manufacturer must be free to identify what frequency bands are applicable in the countries in which a vehicle will be marketed and which radio services are likely to be used in that vehicle.

As an example, many vehicle models will probably not have a television receiver installed; yet the television bands occupy a significant portion of the radio spectrum. Testing and mitigating noise sources in such vehicles is not economically justified.

The vehicle manufacturer should define the countries in which the vehicle is to be marketed, then choose the applicable frequency bands and limits. Component test parameters can then be selected from CISPR 25 to support the chosen marketing plan.

The World Administrative Radio communications Conference (WARC) lower frequency limit in region 1 was reduced to 148,5 kHz in 1979. For vehicular purposes, tests at 150 kHz are considered adequate. For the purposes of this standard, test frequency ranges have been generalized to cover radio services in various parts of the world. Protection of radio reception at adjacent frequencies can be expected in most cases.

Annex H defines a qualitative method of judging the degradation of radio communication in the presence of impulsive noise.

Annex I lists work being considered for future revisions.

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.

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*
Amendment 1:1997
Amendment 2:1998

CISPR 12:2007, *Vehicles, motorboats, and internal combustion engine-driven devices – Radio disturbance characteristics – Limits and methods of measurement for the protection of receivers except those installed in the vehicle/boat/device itself or in adjacent vehicles/boats/devices.*

CISPR 16-1-1:2006, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*
Amendment 1:2006
Amendment 2:2007

CISPR 16-1-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*
Amendment 1:2004
Amendment 2:2006

CISPR 16-1-4:2007, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances*
Amendment 1:2007

CISPR 16-2-3:2006, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

ISO 11452-4:2005 - *Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)*

SAE ARP 958.1 Rev D:2003-02 – Electromagnetic Interference Measurement Antennas; Standard Calibration Method

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

absorber lined shielded enclosure (ALSE)

shielded enclosure/screened room with radio frequency-absorbing material on its internal ceiling and walls

3.2

antenna factor

the factor which is applied to the voltage measured at the input connector of the measuring instrument to give the field strength at the antenna

3.3

antenna matching unit

a unit for matching the impedance of an antenna to that of the 50 Ω measuring instrument over the antenna measuring frequency range

3.4

class

a performance level agreed upon by the purchaser and the supplier and documented in the test plan

3.5

component continuous conducted emissions

the noise voltages/currents of a steady-state nature existing on the supply or other leads of a component/module which may cause disturbance to reception in an on-board receiver.

3.6

compression point

the input signal level at which the gain of the measuring system becomes non-linear such that the indicated output deviates from an ideal linear receiving system's output by the specified increment in dB

3.7

device

a machine driven by an internal combustion engine which is not primarily intended to carry persons or goods.

NOTE Devices include, but are not limited to, chainsaws, irrigation pumps, snow blowers, air compressors, and landscaping equipment.

3.8

receiver terminal voltage (antenna voltage)

the voltage generated by a source of radio disturbance and measured in dB (μ V) by a radio disturbance measuring instrument conforming to the requirements of CISPR 16

3.9

RF boundary

an element of an EMC test set-up that determines what part of the harness and/or peripherals are included in the RF environment and what is excluded. It may consist of, for example, ANs, filter feed-through pins, RF absorber coated wire, and/or RF shielding

3.10

artificial network (AN) ; line impedance stabilization network (LISN)¹

a network inserted in the supply lead or signal/load lead of apparatus to be tested which provides, in a given frequency range, a specified load impedance for the measurement of *disturbance voltages* and which may isolate the apparatus from the supply or signal sources/loads in that frequency range

[IEV 161-04-05, modified]

3.11

average detector

a detector, the output voltage of which is the average value of the envelope of an applied signal

NOTE The average value must be taken over a specified time interval.

[IEV 161-04-26]

3.12

bandwidth

3.12.1

bandwidth (of an equipment)

the width of a frequency band over which a given characteristic of an equipment or transmission channel does not differ from its reference value by more than a specified amount or ratio

NOTE The given characteristic may be, for example, the amplitude/frequency characteristic, the phase/frequency characteristic or the delay/frequency characteristic.

[IEV 161-06-09, modified]

3.12.2

bandwidth (of an emission or signal)

the width of the frequency band outside which the level of any spectral component does not exceed a specified percentage of a reference level

[IEV 161-06-10]

3.13

broadband emission

an *emission* which has a *bandwidth* greater than that of a particular measuring apparatus or receiver

[IEV 161-06-11, modified]

NOTE An emission which has a pulse repetition rate (in Hz) less than the bandwidth of a particular measuring instrument can also be considered as a broadband emission.

3.14

disturbance suppression

action which reduces or eliminates *electromagnetic disturbance*

[IEV 161-03-22]

¹ USA

3.15

disturbance voltage; interference voltage (deprecated in this sense)

voltage produced between two points on two separate conductors by an *electromagnetic disturbance*, measured under specified conditions

[IEV 161-04-01]

3.16

electromagnetic environment

the totality of electromagnetic phenomena existing at a given location

[IEV 161-01-01]

3.17

ground (reference) plane

a flat conductive surface whose potential is used as a common reference.

[IEV 161-04-36]

3.18

narrowband emission

an *emission* which has a *bandwidth* less than that of a particular measuring apparatus or receiver

[IEV 161-06-13]

NOTE An emission which has a pulse repetition rate (in Hz) greater than the bandwidth of a particular measuring instrument can also be considered as a narrowband emission.

3.19

peak detector

a detector, the output voltage of which is the peak value of an applied signal

[IEV 161-04-24]

3.20

quasi-peak detector

a detector having specified *electrical time constants* which, when regularly repeated identical *pulses* are applied to it, delivers an output voltage which is a fraction of the peak value of the pulses, the fraction increasing towards unity as the pulse repetition rate is increased

[IEV 161-04-21]

3.21

shielded enclosure; screened room

a mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and the external environment

[IEV 161-04-37]

4 Requirements common to vehicle and component/module emissions measurement

4.1 General test requirements and test plan

4.1.1 Categories of disturbance sources (as applied in the test plan)

Electromagnetic disturbance sources can be divided into two main types:

- Narrowband sources (examples of narrowband disturbance sources are vehicle electronic components which include clocks, oscillators, digital logic from microprocessors and displays).
- Broadband sources (examples of broadband disturbance sources are electrical motors and ignition system).

NOTE 1 While most vehicle or electrical/electronic components are a source of both narrowband and broadband disturbances, some may be a source of only one type of disturbance.

NOTE 2 Broadband sources can be classified in short-duration broadband (examples are washer pump, door mirror, electrical windows) and long-duration broadband (examples are front wiper motor, heater blower, engine cooling).

For the purposes of this standard, categorization of the disturbance type is used only in simplifying the testing demands by potentially reducing the number of detectors that shall be used (i.e. eliminating the average detector if the device is known to be broadband-type of source, such as a d.c. brush commutated motor). Otherwise, this standard requires that sources comply with limits based upon both types of measurement detectors and not the type of disturbance.

4.1.2 Test plan

A test plan shall be established for each item to be tested. The test plan shall specify the

- frequency range to be tested,
- the emissions limits,
- antenna types and locations,
- test report requirements,
- supply voltage and other relevant parameters.

The test plan shall define for each frequency band whether the conformance can be obtained with average and peak limits or with average and quasi-peak limits.

4.1.3 Determination of conformance of EUT with limits

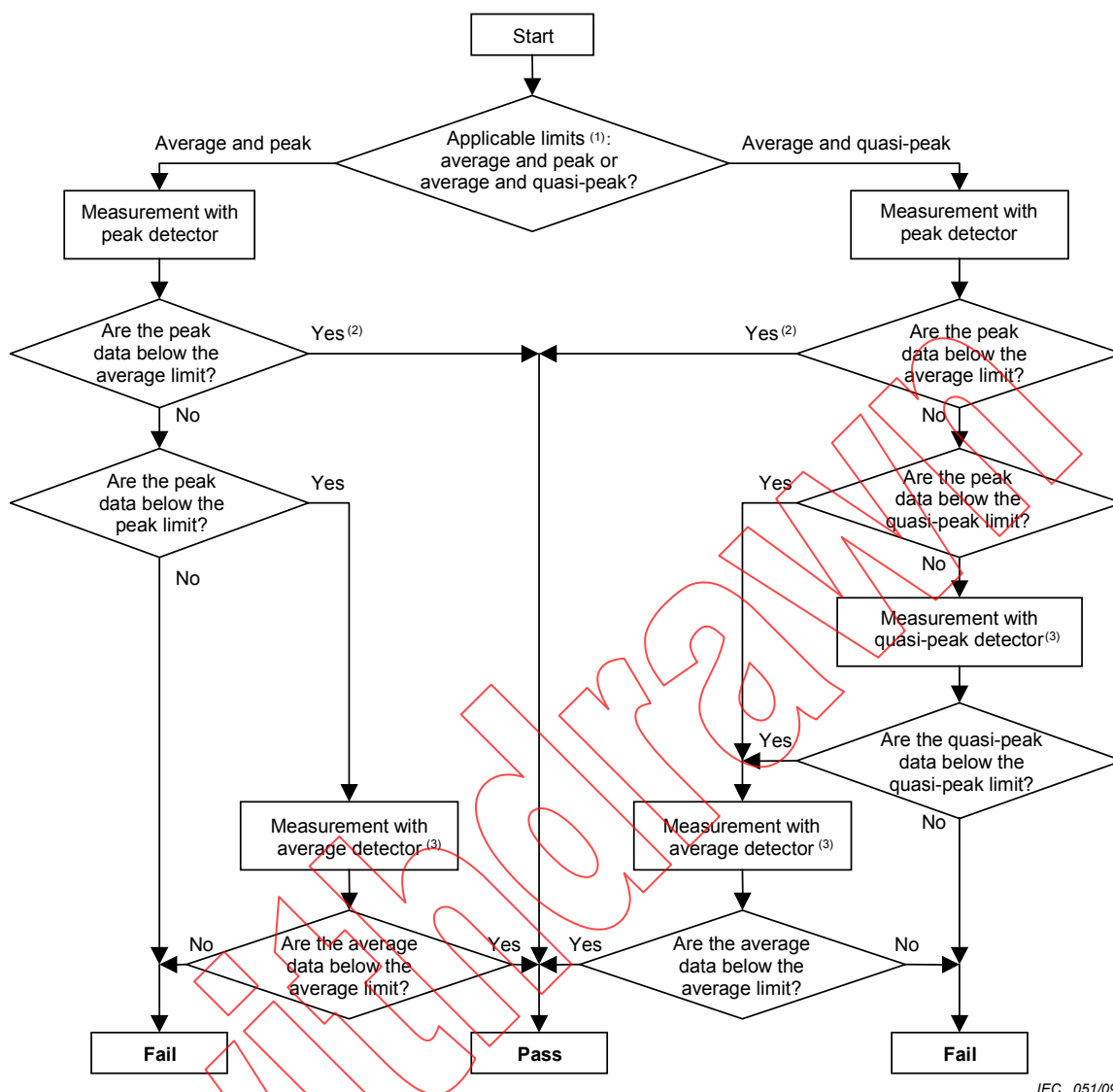
In all cases the EUT shall conform with the average limit.

The EUT shall also conform with either peak or quasi-peaks limits as follows.

- For frequencies where both peak and quasi-peak limits are defined, the EUT shall conform with either the peak or the quasi-peak limits (as defined in the test plan).
- For frequencies where only peak limits are defined, the EUT shall conform with the peak limit.

The general procedure applicable for all frequency bands is described in Figure 1.

The limits given in this standard take into account uncertainties.



IEC 051/09

NOTE 1 The conformance should normally be obtained by compliance to both average and peak limits or both average and quasi-peak limits unless the test plan defines that conformance can be obtained by compliance to the single appropriate limit (depending on the case, peak, or average, or quasi-peak).

NOTE 2 Because measurement with peak detector is always higher or equal to measurement with average detector and applicable peak limit is always higher or equal to applicable average limit, this single detector measurement can lead to a simplified and quicker conformance process.

NOTE 3 This flow-chart is applicable for each individual frequency, e.g. only frequencies that are above the applicable limit need be remeasured with average or quasi-peak detector.

Figure 1 – Method of determination of conformance for all frequency bands

4.1.4 Operating conditions

Different operating conditions of the EUT can influence emission measurement results. When performing component/module tests, the EUT shall be made to operate under typical loading and other conditions as in the vehicle such that the maximum emission state occurs. The operating conditions shall be specified in the test plan.

To ensure correct operation of components/modules during test, a peripheral interface unit shall be used which simulates the vehicle installation. Depending on the intended operating modes, all significant sensor and actuator leads of the EUT shall be connected to a peripheral interface unit. The peripheral interface unit shall be capable of controlling the EUT in accordance with the test plan.

The peripheral interface unit may be located internal or external to the shielded enclosure. If located in the shielded enclosure, the disturbance levels generated by the peripheral interface unit shall be at least 6 dB below the test limits specified in the test plan.

4.1.5 Test report

The report shall contain the information agreed upon by the customer and the supplier, e.g.

- sample identification,
- date and time of test,
- bandwidth,
- step size,
- required test limit,
- ambient data
- test data.

4.2 Shielded enclosure

The ambient electromagnetic noise levels shall be at least 6 dB below the limits specified in the test plan for each test to be performed. The shielding effectiveness of the shielded enclosure shall be sufficient to ensure that the required ambient electromagnetic noise level requirement is met.

NOTE Although there will be reflected energy from the interior surfaces of the shielded enclosure, this is of minimal concern for the measurement of conducted disturbances because of the direct coupling of the measuring instrument to the leads of the EUT. The shielded enclosure may be as simple as a suitably grounded bench-top screened cage.

4.3 Absorber-lined shielded enclosure (ALSE)

For radiated emission measurements, however, the reflected energy can cause errors of as much as 20 dB. Therefore, it is necessary to apply RF absorber material to the walls and ceiling of a shielded enclosure that is to be used for radiated emissions measurements. No absorber material shall be placed on the floor for vehicle or component level tests. The following ALSE requirements shall also be met for performing radiated RF emissions measurements.

4.3.1 Reflection characteristics

Performance of the absorption material shall be greater than or equal to 6 dB in the 70 MHz to 2 500 MHz frequency range.

NOTE A test method is described in IEEE STD 1128-1998: *IEEE recommended practice for radio frequency (RF) absorber – Evaluation in the range of 30 MHz to 5 GHz*.

4.3.2 Size

For radiated emissions tests, the shielded enclosure shall be of sufficient size to ensure that neither the vehicle/EUT nor the test antenna shall be closer than 1 m from the walls or ceiling, or to the nearest surface of the absorber material used thereon.

4.3.3 Objects in ALSE

For radiated emissions measurements in particular, the ALSE shall be cleared of all items not pertinent to the tests. This is required in order to reduce any effect they may have on the measurement. Included are unnecessary equipment, cable racks, storage cabinets, desks, chairs, etc. Personnel not actively involved in the test shall be excluded from the ALSE.

4.4 Measuring instrument

The measuring instrument shall comply with the requirements of CISPR 16-1-1. Either manual or automatic frequency scanning may be used. However Annex D of CISPR 16-2-3 explains the differences between the CISPR AV detector and an AV detector (complying with CISPR 16-1:1999). For the purpose of this standard either detector may be used, since the pulse repetition rate for internal combustion engines is above 10 Hz.

NOTE 1 Spectrum analysers and scanning receivers are particularly useful for disturbance measurements. The peak detection mode of spectrum analysers and scanning receivers provides a display indication which is never less than the quasi-peak indication for the same bandwidth. It may be convenient to measure emissions using peak detection because of the faster scan possible than with quasi-peak detection.

NOTE 2 A preamplifier may be used between the antenna and measuring instrument in order to achieve the 6 dB noise floor requirements. If a preamplifier is used to achieve the 6 dB noise floor requirement, the laboratory should establish a procedure to avoid overload of the preamplifier, such as using a step attenuator.

NOTE 3 In particular cases, because of very low average detector limits and/or instrumentation limitations, the 6 dB noise floor requirements may not be fulfilled. In this case and if an appropriate preamplifier has been used, alternatives such as RBW/BW reduction with appropriate step size changes may be used. These measures should be documented in the test report.

4.4.1 Spectrum analyser parameters

The scan rate of the spectrum analyser shall be adjusted for the CISPR frequency band and detection mode used.

Spectrum analysers may be used for performing compliance measurements to this standard providing the precautions cited in CISPR 16-1-1 on the use of spectrum analysers are adhered to and that the broadband emissions from the product being tested have a repetition frequency greater than 20 Hz.

The minimum scan time and recommended bandwidth are listed in Table 1.

The bandwidth of the spectrum analyser shall be chosen such that the noise floor is at least 6 dB lower than the applicable limits.

NOTE See 4.4, Notes 2 and 3.

Table 1 – Spectrum analyser parameters

Service / Frequency range MHz		Peak detection		Quasi-peak detection		Average detection	
		RBW at -3 dB	Scan time	RBW at -6 dB	Scan time	RBW at -3 dB	Scan time
AM broadcast and mobile services	0,15 - 30	9/10 kHz	10 s / MHz	9 kHz	200 s / MHz	9/10 kHz	10 s / MHz
FM broadcast	76 - 108	100/120 kHz	100 ms / MHz	120 kHz	20 s / MHz	100/120 kHz	100 ms / MHz
Mobile services	30 - 1 000						
TV Band I	41- 88						
TV Band III	174 - 230						
TV Band IV/V	470- 890						
DAB	171- 245						
DTTV	470 - 770	100/120 kHz	100 ms / MHz	Does not apply	Does not apply	100/120 kHz	100 ms / MHz
Mobile service	1 000 - 2 500	100/120 kHz	100 ms / MHz	Does not apply	Does not apply	100/120 kHz	100 ms / MHz
GPS L1 civil	1 567 – 1 583	Does not apply	Does not apply	Does not apply	Does not apply	9/10 kHz	1 s / MHz

When a spectrum analyser is used for measurements, the video bandwidth shall be at least three times the resolution bandwidth (RBW).

4.4.2 Scanning receiver parameters

The dwell time of the scanning receiver shall be adjusted for the CISPR frequency band and detection mode used. The minimum dwell time, maximum step size and recommended bandwidth (BW) are listed in Table 2.

The bandwidth of the scanning receiver shall be chosen such that the noise floor is at least 6 dB lower than the applicable limits.

NOTE See 4.4, Notes 2 and 3.

Table 2 – Scanning receiver parameters

Service / Frequency range MHz	Peak detection			Quasi-peak detection			Average detection		
	BW at -6 dB	Step size	Dwell time	BW at -6 dB	Step size	Dwell time	BW at -6 dB	Step size	Dwell time
AM broadcast and mobile services 0,15 - 30	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1 s	9 kHz	5 kHz	50 ms
FM broadcast 76 - 108	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms
Mobile services 30 to 1 000									
TV Band I 41 – 88									
TV Band III 174 – 230									
TV Band IV/V 470 – 890									
DAB 171 - 245									
DTTV 470 - 770	120 kHz	50 kHz	5 ms	Does not apply	Does not apply	Does not apply	120 kHz	50 kHz	5 ms
Mobile service 1 000 - 2 500	120 kHz	50 kHz	5 ms	Does not apply	Does not apply	Does not apply	120 kHz	50 kHz	5 ms
GPS L1 civil 1 567 – 1 583	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	9 kHz	5 kHz	5 ms

NOTE For emissions generated by brush commutator motors without an electronic control unit, the maximum step size may be increased up to 5 times the bandwidth.

4.5 Power supply

The power supply shall have adequate regulation to maintain the supply voltage U_s within the ranges specified:

Vehicle tests: Ignition on, engine off

$$U_s = \begin{pmatrix} 12 \\ -1 \end{pmatrix}^{+2} \text{ V for systems with 12 V nominal supply voltage}$$

$$U_s = \begin{pmatrix} 24 \\ -2 \end{pmatrix}^{+4} \text{ V for systems with 24 V nominal supply voltage}$$

Vehicle tests: Engine running

$$U_s = \begin{pmatrix} 13 \\ -0 \end{pmatrix}^{+3} \text{ V for systems with 12 V nominal supply voltage}$$

$$U_s = \begin{pmatrix} 26 \\ -0 \end{pmatrix}^{+6} \text{ V for systems with 24 V nominal supply voltage}$$

NOTE Most of the vehicle tests will be performed without the engine running, but with the ignition switched on, therefore care must be taken to ensure that the battery is sufficiently well charged.

Component/module tests:

Unless otherwise stated in the test plan the values below shall be used.

$$U_s = \begin{pmatrix} 13 & +1 \\ & -1 \end{pmatrix} \text{ V for systems with 12 V nominal supply voltage}$$

$$U_s = \begin{pmatrix} 26 & +2 \\ & -2 \end{pmatrix} \text{ V for systems with 24 V nominal supply voltage}$$

The power supply shall also be adequately filtered such that the RF noise produced by the power supply is at least 6 dB lower than the limits specified in the test plan.

When specified in the test plan, a vehicle battery shall be connected in parallel with the power supply.

5 Measurement of emissions received by an antenna on the same vehicle

5.1 Antenna measuring system

5.1.1 Type of antenna

An antenna of the type to be supplied with the vehicle shall be used as the measurement antenna for the bands for which it is designed to be used for radio reception.

If no antenna is to be furnished with the vehicle (as is often the case with a mobile radio system), the antenna types in Table 3 shall be used for the test. The antenna type and location shall be included in the test plan.

If an active antenna is used, the noise floor of the measured signal at the radio antenna connector may increase (see also the note in 5.3).

Table 3 – Antenna types

Frequency MHz	Antenna type
0,15 to 6,2	1 m monopole
26 to 54	Loaded quarter-wave monopole
68 to 1 000	Quarter-wave monopole
1 000 to 2 500	As recommended by the vehicle manufacturer

5.1.2 Measuring system requirements

5.1.2.1 Broadcast bands

For each band, the measurement shall be made with instrumentation which has the following specified characteristics.

5.1.2.1.1 AM broadcast:

Long wave (0,15 MHz to 0,3 MHz)

Medium wave (0,53 MHz to 1,8 MHz)

Short wave (5,9 MHz to 6,2 MHz)

The measuring system shall have the following characteristics:

- output impedance of impedance matching equipment: 50 Ω resistive;
- gain: The gain (or attenuation) of the measurement antenna system shall be known with an accuracy of $\pm 0,5$ dB. The gain of the equipment shall remain within a 6 dB envelope for each frequency band as shown in Figure 2. Verification shall be performed in accordance with Annex B;

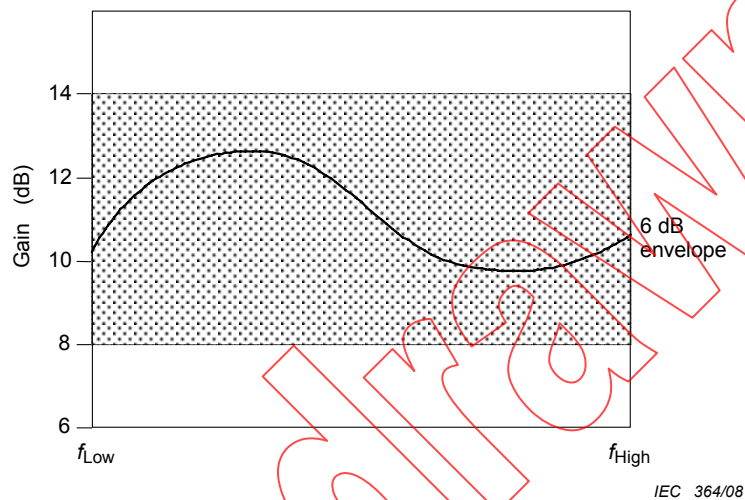


Figure 2 – Example of gain curve

- **compression point:** The 1 dB **compression point** shall occur at a sine wave voltage level greater than 60 dB(μ V);
- **measurement system noise floor:** The noise floor of the combined equipment including measuring instrument, impedance matching equipment, and preamplifier (if used) shall be at least 6 dB lower than the applicable limits;
- **dynamic range:** from the noise floor to the 1 dB **compression point**;
- **input impedance:** the impedance at the input of the matching network shall have a resistance of at least 100 k Ω in parallel with a maximum capacitance of 10 pF.

5.1.2.1.2 FM broadcast (76 MHz to 108 MHz) and TV broadcast

Measurements shall be taken with a measuring instrument which has an input impedance of 50 Ω . If the standing wave ratio (SWR) is greater than 2:1 an input matching network shall be used. Appropriate correction shall be made for any attenuation/gain of the matching unit.

5.1.2.2 Mobile services (26 MHz to 2 500 MHz)

The test procedure assumes a 50 Ω measuring instrument and a 50 Ω antenna in the frequency range 26 MHz to 2 500 MHz. If a measuring instrument and an antenna with differing impedances are used, an appropriate network and correction factor shall be used.

5.2 Method of measurement

The disturbance voltage shall be measured at the receiver end of the antenna coaxial cable using the ground contact of the connector as reference. The antenna connector shall be grounded to the housing of the on-board radio. The radio housing shall be grounded to the

vehicle body using the production harness. A coaxial bulkhead connector shall be used for connection to the measuring instrument outside the shielded room. See Figure 3. In the case of an active vehicle antenna, which is fed by the radio via the antenna cable (phantom network), a decoupling network similar to that used in the radio shall be installed at the antenna connector to feed the active antenna from the vehicle supply voltage.

When making measurements in the AM broadcast bands (LW, MW, SW), the vehicle/matching unit ground and ground of the ALSE shall be electrically isolated from each other by means such as an isolation transformer, sheath-current suppressor, battery-powered measurement instrumentation, fiber optics, etc. Appropriate correction shall be made for the insertion loss of any isolation network. (See Annex C for an example of a sheath-current suppressor.)

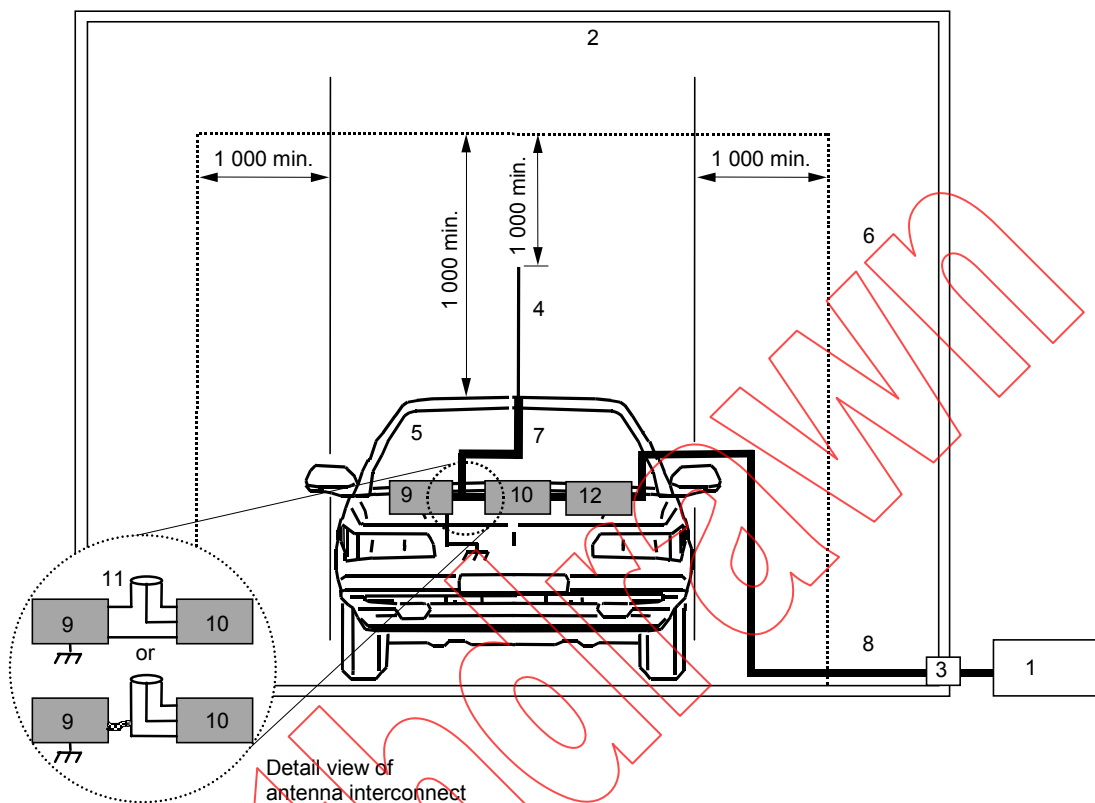
NOTE The use of a high-quality coaxial cable e.g. double-shielded cable for connection to the measuring instrument is recommended as well as the use of ferrite rings on the cable for suppression of surface currents.

Some vehicles may allow a receiver to be mounted in several locations (e.g. under the instrument panel, under the seat, etc.). In these cases a test shall be carried out as specified in the test plan for each receiver location.

When vehicle measurements are made without the engine running, the power supply of 4.5 shall be used, when needed, to maintain the system voltage within its required range.

Withdrawn

Dimensions in millimetres



IEC 365/08

Key

- 1 Measuring instrument
- 2 ALSE
- 3 Bulkhead connector
- 4 Antenna (see 5.1)
- 5 Vehicle
- 6 Typical absorber material
- 7 Antenna coaxial cable
- 8 High-quality coaxial cable e.g. double-shielded (50 Ω)
- 9 Housing of on-board radio
- 10 Impedance matching unit (when required)
- 11 Modified coaxial "T" connector
- 12 AM broadcast band ground isolation network (when required)

Figure 3 – Vehicle-radiated emissions – Example for test layout (end view with monopole antenna)

5.3 Examples of limits for vehicle radiated disturbances

It is recommended for acceptable radio reception in a vehicle using typical radio receivers, that the disturbance voltage at the end of the antenna cable should not exceed the values shown in Table 4. Where different receivers are used or different coupling models for the propagation of disturbances are valid, the limits may be changed and detailed in the vehicle manufacturer's own specification.

Table 4 – Example for limits of disturbance – Complete vehicle

Service / Band ^a	Frequency MHz	Terminal disturbance voltage at receiver antenna terminal in dB (μV)		
		Peak	Quasi-peak	Average
BROADCAST				
LW ^b	0,15 - 0,30	26	13	6
MW ^b	0,53 - 1,8	20	7	0
SW ^b	5,9 - 6,2	20	7	0
FM ^b	76 - 108	26	13	6
TV Band I ^c	41 - 88	16	-	6
TV Band III ^c	174 - 230	16	-	6
DAB III	171 - 245	10	-	0
TV Band IV/V ^c	468 - 944	16	-	6
DTTV	470 - 770	20 ^d	-	10 ^d
DAB L band	1 447 - 1 494	10	-	0
SDARS	2 320 - 2 345	16	-	6
MOBILE SERVICES				
CB ^b	26 - 28	20	7	0
VHF ^b	30 - 54	20	7	0
VHF ^b	68 - 87	20	7	0
VHF ^b	142 - 175	20	7	0
Analogue UHF ^b	380 - 512	20	7	0
RKE ^f	300 - 330	20	-	6
RKE ^f	420 - 450	20	-	6
Analogue UHF ^b	820 - 960	20	7	0
GSM 800	880 - 895	26	-	6
EGSM/GSM 900	925 - 960	26	-	6
GPS L1 civil ^e	1 567 - 1 583	-	-	0
GSM 1800 (PCN)	1 803 - 1 882	26	-	6
GSM 1900	1 850 - 1 990	26	-	6
3G / IMT 2000	1 900 - 1 992	26	-	6
3G / IMT 2000	2 010 - 2 025	26	-	6
3G / IMT 2000	2 108 - 2 172	26	-	6
Bluetooth/802.11	2 400 - 2 500	26	-	6

a	LW: Long wave, MW: Medium wave, SW: Short wave (amplitude modulation, AM) VHF: Very high frequency, UHF: Ultra high frequency (frequency modulation, FM) DAB: Digital audio broadcasting, TV: Television, DTTV: Digital Terrestrial Television RKE: Remote keyless entry, GPS: Global positioning system, GSM: Global system mobile 3G: Third generation
b	In this analogue service the peak and quasi-peak limits can be relaxed by 6 dB for short duration disturbances (e.g. short duration PK (or QPK) limit = PK (or QPK) limit + 6 dB).
c	Analogue TV only.
d	This limit is less stringent than the analogue limit and should only be applied where analogue TV is no longer in use.
e	The bandwidth and frequency steps to be used for the GPS L1 civil band are respectively 9 kHz and 5 kHz rather than the bandwidth and frequency steps defined in Table 1 and Table 2 for services above 30 MHz.
f	RKE limits are defined over a large frequency band. Any modification of the average limit around the operating frequency due to sensitivity of RKE systems should be defined in the test plan.

NOTE 1 Stereo signals may be more susceptible to disturbance than monaural signals in the FM broadcast band. This phenomenon has been factored into the FM (76 MHz to 108 MHz) limits.

NOTE 2 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.

Level dB(μV)

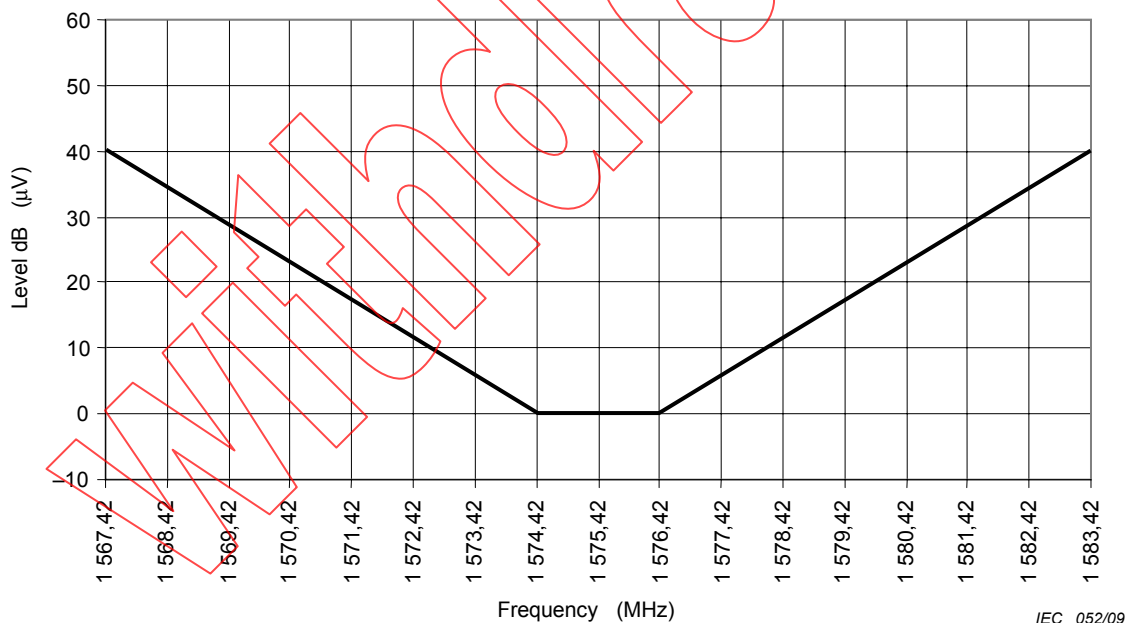


**Figure 4 – Average limit for radiated disturbances from vehicles GPS band
1 567,42 to 1 583,42 MHz**

NOTE If an active antenna is used, the noise floor may increase. The additional noise floor depends on the type of antenna and must be subtracted from the measured value to determine the real value of the disturbance using the following formula (all terms in μV):

$$U_{\text{real Disturbance}} = \sqrt{U_{\text{Measured}}^2 - U_{\text{Antenna noise}}^2} \quad (1)$$

A relaxation of the limit because of the active antenna noise floor does not guarantee compliance. Subsequent changes to the active antenna design may result in non-compliance. This topic remains under study. Annex D describes a method to determine the noise floor of an active antenna.

6 Measurement of components and modules

6.1 Test equipment

6.1.1 Ground plane

The ground plane shall be defined as the top metallic surface of the test bench/table.

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

The minimum size of the ground plane for conducted emissions shall be 1 000 mm × 400 mm.

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

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

The ground plane shall be bonded to the walls or the floor of the shielded enclosure such that the d.c. resistance shall not exceed 2,5 mΩ. The distance from the edge of the ground strap to the edge of the next strap shall not be greater than 300 mm. The maximum length to width ratio for the ground straps shall be 7:1.

NOTE Because of resonances of the ground plane the location, width and length of the bond straps may influence the measurement results. A sufficient number of low inductive bond straps are necessary to ensure a low impedance connection to the shielded room.

6.1.2 Power supply and AN

For the tests defined in 6.2, 6.3, 6.4, 6.5 and 6.6, each EUT power supply lead shall be connected to the power supply through an artificial network. For the TEM cell emissions tests of 6.5, an AN with a coaxial connector will facilitate connection to the TEM cell EUT power connector. The AN shall have a nominal 5 μH inductance. The impedance characteristics and a suggested schematic are shown in Annex E.

Power supply is assumed to be negative ground. If the EUT utilizes a positive ground then the test set-ups shown in the Figures need to be adapted accordingly. Depending on the intended EUT installation in the vehicle:

- EUT remotely grounded (vehicle power return line longer than 200 mm): two artificial networks are required, one for the positive supply line and one for the power return line.
- EUT locally grounded (vehicle power return line 200 mm or shorter): one artificial network is required, for the positive supply.

The AN(s) shall be mounted directly on the ground plane. The case(s) 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 the AN not connected to the measuring instrument shall be terminated with a 50 Ω load.

6.1.3 Load simulator

The load simulator includes sensors and actuators, and terminates the test harness connected to the EUT.

To ensure sufficient reproducibility the same termination must be used for each measurement either by using special termination equipment (e.g. artificial networks, filters) – located at the RF boundary – or by using the same load simulator.

6.1.4 Signal/control line filters

In the TEM cell test method using the coaxial connectors for EUT leads each lead shall pass through a filter which has impedance characteristics similar to that of the AN defined above.

The attenuation of the filters shall be specified for the whole frequency range of the intended component/module test (see 6.2 to 6.6) according to the requirements shown in Figure 5. The minimum attenuation shall be more than 40 dB from 30 MHz up to the upper cut-off frequency (f_c), which depends on the intended test method. Figure 5 shows e.g. an upper cut-off frequency (f_c) of the chosen test method of 400 MHz.

NOTE Other low pass RF filter configurations may be used if the filter characteristics are not applicable to special wanted signals of the EUT's inputs or outputs (e.g. high speed network data interfaces). The filters shall be specified in the test plan.

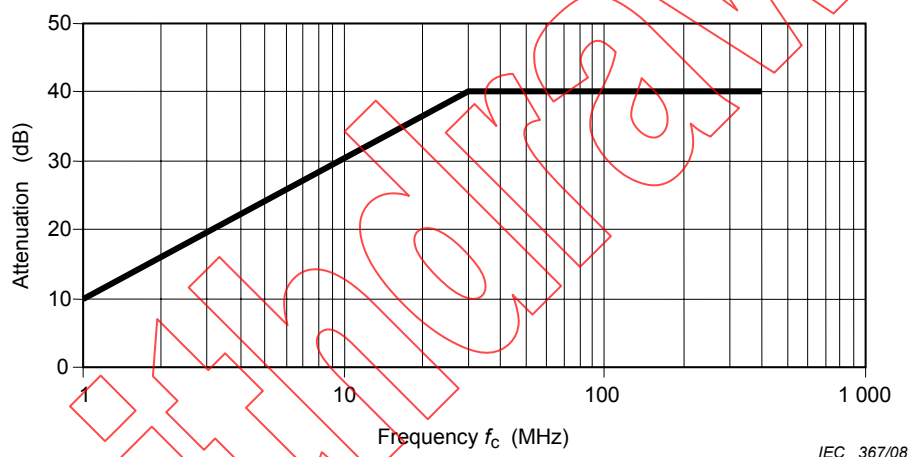


Figure 5 – Example for the required minimum attenuation of the signal / control line filters

6.2 Conducted emissions from components/modules – Voltage method

6.2.1 General

Voltage measurements are able to characterize the emissions on single leads only. The test method is not usable to characterize the radiated emission transmitted e.g. by different antenna structures on the printed board of electronic components or to characterize the efficiency of shielding. Therefore, voltage measurements are not able to characterize the complete EUT emission. At lower frequencies (e.g. in the AM-bands) voltage measurements usually ensure more dynamic range than radiated measurements.

6.2.2 Ground plane arrangement

6.2.2.1 Test set-up

6.2.2.1.1 Location of the EUT

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

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

All sides of the EUT shall be at least 100 mm from the edge of the ground plane. In the case of a grounded EUT, the ground connection point shall also have a minimum distance of 100 mm from the edge of the ground plane.

6.2.2.1.2 Location of the test harness

The power supply line(s) between the connector of the AN(s) and the connector(s) of the EUT (l_p) shall have a standard length of $(200 + {}^{200}_0)$ mm.

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

If, for particular EUTs (multi-connectors, special connectors, etc.), this standard length for the power supply line(s) cannot be met, the minimum necessary length to be used shall be defined in the test plan. This minimum length shall satisfy the requirement of $f_c \geq 108$ MHz, or the measurements shall be limited to f_c .

The following equation defines f_c :

$$f_c \approx 30 / l_p \quad (2)$$

where

f_c is the frequency in MHz

l_p is the length in m

(This equation is based on $l_p \leq \lambda_{\min} / 10$).

To minimize the coupling between power and input/output leads, the space between those lead types shall be maximized (≥ 200 mm from or perpendicular to the power supply lines connecting the AN(s) and the EUT).

The total length of the test harness (excluding power lines) shall not exceed 2 m. The wiring type is defined by the actual system application and requirement.

All leads and cables shall be located at a minimum distance of 100 mm from the edge of the ground plane.

6.2.2.1.3 Location of the 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.

NOTE 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 EUT 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 directly to the power supply and not through the AN(s).

6.2.2.2 Test procedure

The general arrangement of the disturbance source (EUT), connecting harnesses, etc. represents a standardised 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 EUT shall be made to operate under typical loading and other conditions as in the vehicle such that the maximum emission state occurs. These operating conditions must be clearly defined in the test plan to ensure supplier and customer perform identical tests.

- For EUT remotely grounded (vehicle power return line longer than 200 mm), the voltage measurements shall be made on each lead (supply and return) relative to the ground plane.
- For EUT locally grounded (vehicle power return line 200 mm or shorter), voltage measurements on power supply leads shall be made relative to the ground plane.
- Generators/alternators shall be loaded with a battery and parallel resistor combination, and connected to the artificial network in the manner shown in Figure 8. The load current, operating speed, harness length and other conditions shall be defined in the test plan.

The conducted emissions on power lines are measured successively on positive power supply and power return by connecting the measuring instrument on the measuring port of the related AN, the measuring port of the AN in the other supply lines being terminated with a 50 Ω load.

NOTE For EUT's with multiple positive power supply connections and/or multiple power return connections, the measurements (on power supply and on power return) may be performed with all power supply connections tied together at the AN and all power return connections tied together at the other AN.

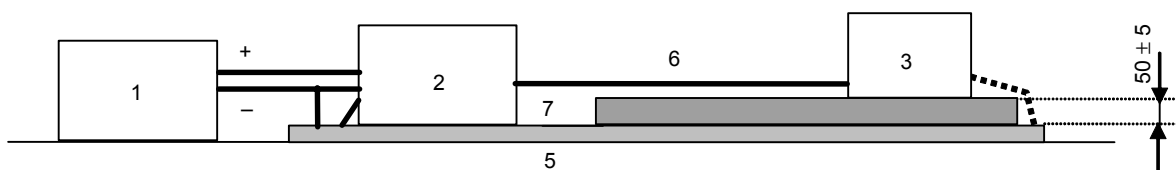
The configuration shall be defined in the test plan.

For voltage measurements, the arrangement of the EUT and measuring equipment shall be as shown in Figures , 6, 7 8 and 9 depending on the intended EUT installation in the vehicle.

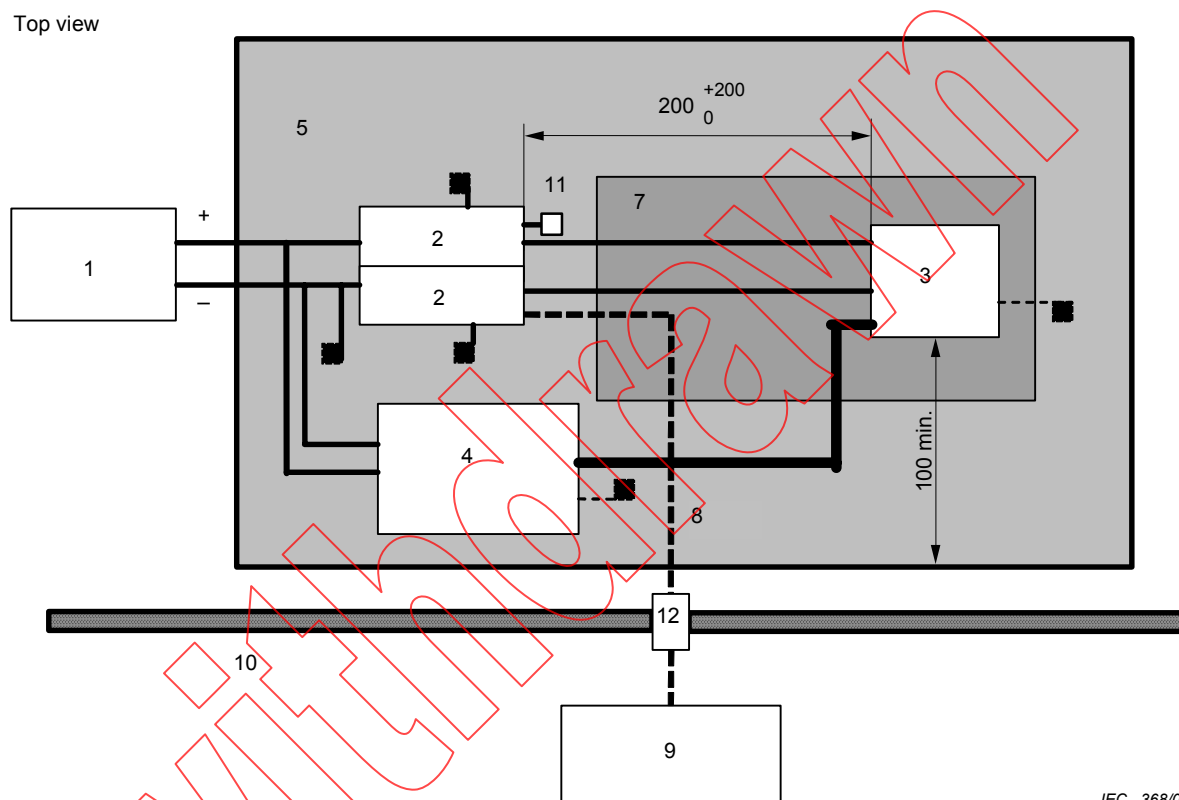
Withhold

Dimensions in millimetres – not to scale

Side view



Top view



IEC 368/08

Key

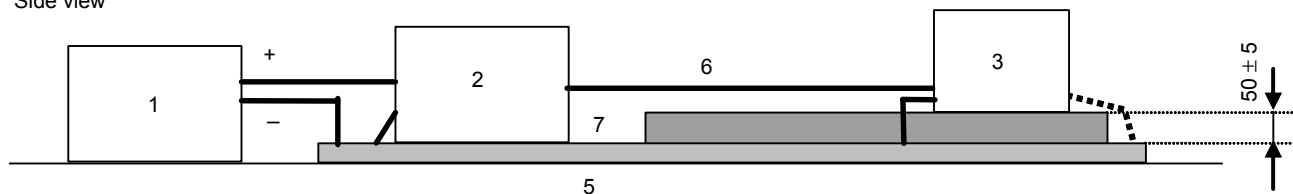
- | | |
|--|--|
| 1 Power supply (may be placed on the ground plane) | 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) |
| 2 Artificial network | 8 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 3 EUT (housing grounded if required in test plan) | 9 Measuring instrument |
| 4 Load simulator (metallic casing grounded if required in test plan) | 10 Shielded enclosure |
| 5 Ground plane | 11 50 Ω load |
| 6 Power supply lines | 12 Bulkhead connector |

NOTE The EUT housing ground lead, when required in the test plan, should not be longer than 150 mm.

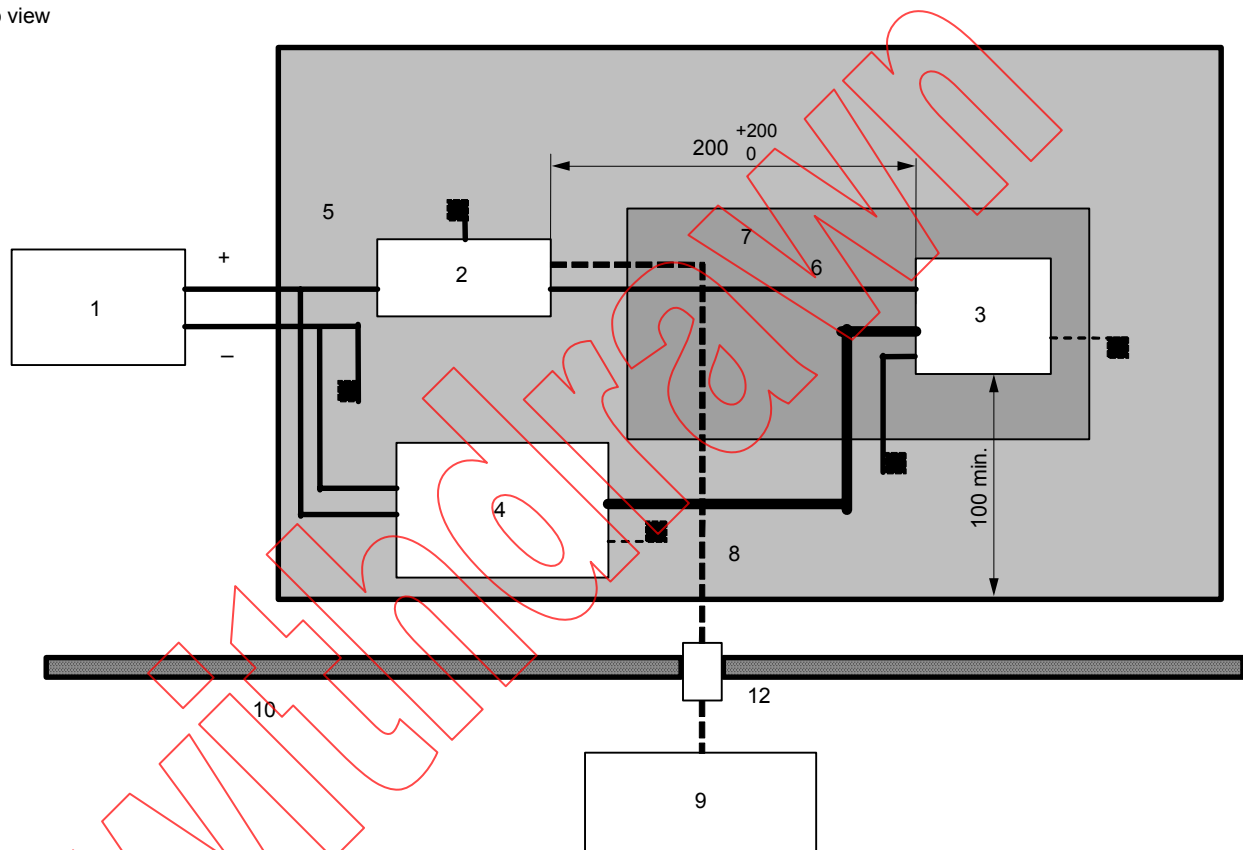
Figure 6 – Conducted emissions – EUT with power return line remotely grounded.

Dimensions in millimetres – not to scale

Side view



Top view



IEC 369/08

Key

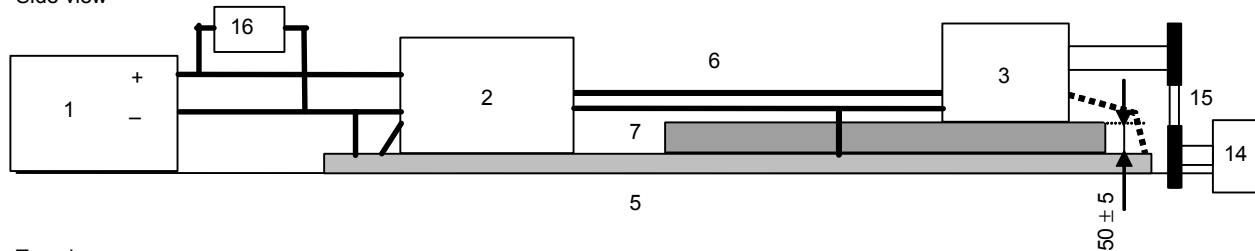
- | | |
|--|--|
| 1 Power supply (may be placed on the ground plane) | 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) |
| 2 Artificial network | 8 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 3 EUT (housing grounded if required in test plan) | 9 Measuring instrument |
| 4 Load simulator (metallic casing grounded if required in test plan) | 10 Shielded enclosure |
| 5 Ground plane | 12 Bulkhead connector |
| 6 Power supply line | |

NOTE The EUT housing ground lead, when required in the test plan, should not be longer than 150 mm.

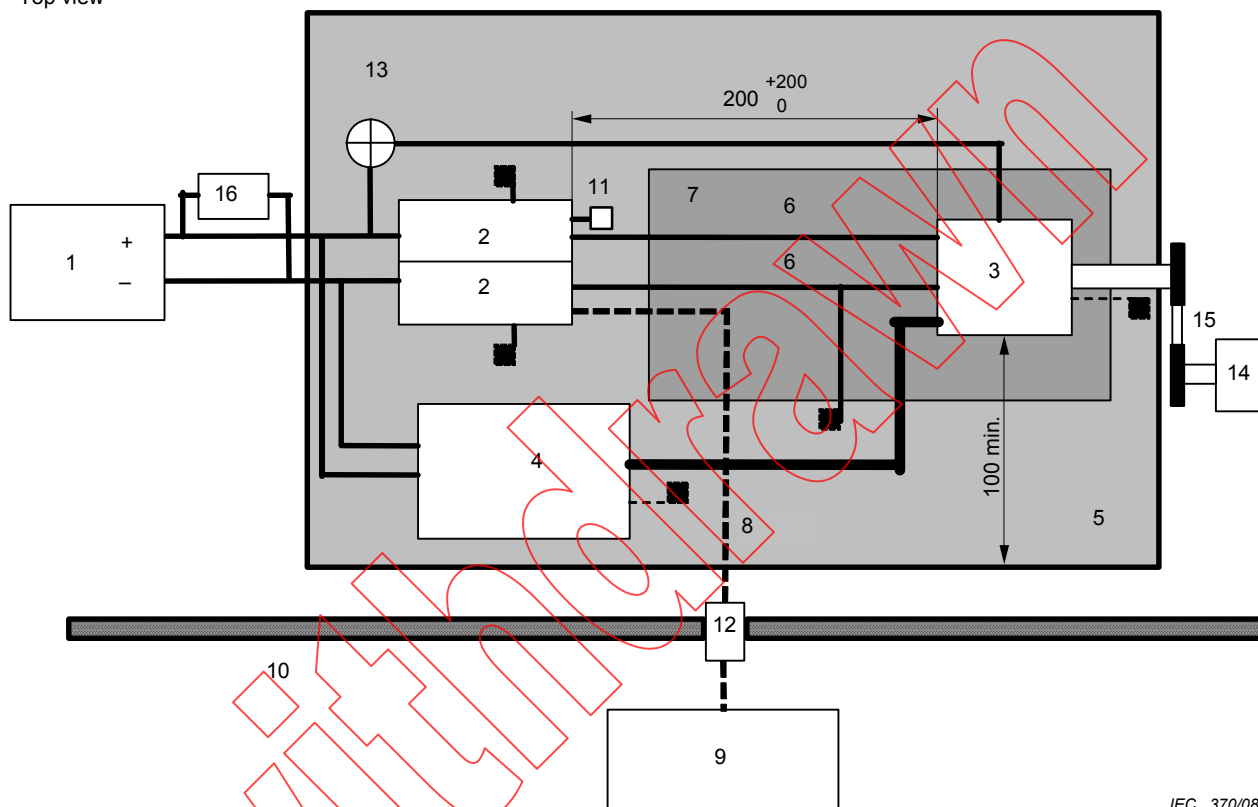
Figure 7 – Conducted emissions – EUT with power return line locally grounded

Dimensions in millimetres – not to scale

Side view



Top view



IEC 370/08

Key

- | | |
|---|--|
| 1 Battery (may be placed on the ground plane) | 8 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 2 Artificial network | 9 Measuring instrument |
| 3 EUT | 10 Shielded enclosure |
| 4 Load simulator (metallic casing grounded if required in test plan) | 11 50 Ω load |
| 5 Ground plane | 12 Bulkhead connector |
| 6 Power supply lines | 13 Indicator lamp/control resistor (if applicable) |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) – typically not installed | 14 Motor (Air/Low Emissions) |
| | 15 Non-conductive belt/coupler |
| | 16 Load resistor |

NOTE The EUT housing ground lead, when required in the test plan, should not be longer than 150 mm.

Figure 8 – Conducted emissions – Test layout for alternators and generators

The diagram illustrates a test setup for a power MOSFET. The MOSFET (15) is mounted on a PCB (5). Its gate is connected to a gate driver (1) and its drain is connected to a load (17) and a sense resistor (7). The gate driver (1) is connected to a gate supply (4) and a gate resistor (12). The drain is connected to a drain supply (18) and a drain resistor (11). The sense resistor (7) is connected to the drain and a sense amplifier (3). The sense amplifier (3) is connected to a sense supply (12) and a sense resistor (10). The MOSFET (15) is connected to a drain supply (18) and a drain resistor (11). The MOSFET (15) is connected to a drain supply (18) and a drain resistor (11). The MOSFET (15) is connected to a drain supply (18) and a drain resistor (11). Dimensions: 200 ± 10 mm for the MOSFET, 100 min. for the sense resistor.

Key

- | | | | |
|----|---|----|-------------------------------|
| 1 | Power supply (may be placed on the ground plane) | 11 | 50 Ω load |
| 2 | Artificial network | 12 | Bulkhead connector |
| 3 | Pencil coil | 15 | Optical fibre converter |
| 4 | ECU simulator (metallic casing grounded if required in test plan) | 16 | 1 000 μF capacitor |
| 5 | Ground plane | 17 | Engine simulator |
| 7 | Low relative permittivity support ($\epsilon_r \leq 1,4$) | 18 | Battery |
| 8 | High-quality coaxial cable e.g. double-shielded (50 Ω) | 19 | Signal line |
| 9 | Measuring instrument | | |
| 10 | Shielded enclosure | | |

Figure 9 – Conducted emissions – Test layout for ignition system components

6.2.3 Limits for conducted disturbances from components/modules – Voltage method

The level class to be used (as a function of the frequency band) shall be agreed upon between the vehicle manufacturer and the component supplier. When using the provided limits, no correction factors for the AN shall be used.

NOTE It is recommended for acceptable radio reception in a vehicle that the conducted noise should not exceed the values shown in Tables 5 and 6, peak and average or quasi-peak and average, respectively. Since the mounting location, vehicle body construction and harness design can affect the coupling of radio disturbances to the on-board radio, multiple limit levels are defined.

Table 5 – Examples of quasi-peak or peak limits for conducted disturbances – Voltage method

Service / Band	Frequency MHz	Levels in dB(μV)									
		Class 1		Class 2		Class 3		Class 4		Class 5	
		Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak
BROADCAST											
LW	0,15 - 0,30	110	97	100	87	90	77	80	67	70	57
MW	0,53 - 1,8	86	73	78	65	70	57	62	49	54	41
SW	5,9 - 6,2	77	64	71	58	65	52	59	46	53	40
FM	76 - 108	62	49	56	43	50	37	44	31	38	25
TV Band I	41 - 88	58	-	52	-	46	-	40	-	34	-
TV Band III	174 - 230	Conducted emission – Voltage method Not applicable									
DAB III	171 - 245										
TV Band IV/V	468 - 944										
DTTV	470 - 770										
DAB L band	1447 - 1494										
SDARS	2320 - 2345										
MOBILE SERVICES											
CB	26 - 28	68	55	62	49	56	43	50	37	44	31
VHF	30 - 54	68	55	62	49	56	43	50	37	44	31
VHF	68 - 87	62	49	56	43	50	37	44	31	38	25
VHF	142 - 175	Conducted emission – Voltage method Not applicable									
Analogue UHF	380 - 512										
RKE	300 - 330										
RKE	420 - 450										
Analogue UHF	820 - 960										
GSM 800	860 - 895										
EGSM/GSM 900	925 - 960										
GPS L1 civil	1567 - 1583										
GSM 1800 (PCN)	1803 - 1882										
GSM 1900	1850 - 1990										
3G / IMT 2000	1900 - 1992										
3G / IMT 2000	2010 - 2025										
3G / IMT 2000	2108 - 2172										
Bluetooth/802.11	2400 - 2500										

NOTE 1 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.

NOTE 2 Where multiple bands use the same limits the user shall select the appropriate bands over which to test. When the test plan includes bands that overlap the test plan shall define the applicable limit.

Table 6 – Examples of average limits for conducted disturbances – Voltage method

Service / Band	Frequency MHz	Levels in dB(μV)									
		Class 1	Class 2	Class 3	Class 4	Class 5					
		AVG	AVG	AVG	AVG	AVG					
BROADCAST											
LW	0,15 - 0,30	90	80	70	60	50					
MW	0,53 - 1,8	66	58	50	42	34					
SW	5,9 - 6,2	57	51	45	39	33					
FM	76 - 108	42	36	30	24	18					
TV Band I	41 - 88	48	42	36	30	24					
TV Band III	174 - 230	Conducted emission – Voltage method Not applicable									
DAB III	171 - 245										
TV Band IV/V	468 - 944										
DTTV	470 - 770										
DAB L band	1447 - 1494										
SDARS	2320 - 2345										
MOBILE SERVICES											
CB	26 - 28	48	42	36	30	24					
VHF	30 - 54	48	42	36	30	24					
VHF	68 - 87	42	36	30	24	18					
VHF	142 - 175	Conducted emission – Voltage method Not applicable									
Analogue UHF	380 - 512										
RKE	300 - 330										
RKE	420 - 450										
Analogue UHF	820 - 960										
GSM 800	860 - 895										
EGSM/GSM 900	925 - 960										
GPS L1 civil	1567 - 1583										
GSM 1800 (PCN)	1803 - 1882										
GSM 1900	1850 - 1990										
3G / IMT 2000	1900 - 1992										
3G / IMT 2000	2010 - 2025										
3G / IMT 2000	2108 - 2172										
Bluetooth/802.11	2400 - 2500										
NOTE 1 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.											
NOTE 2 Where multiple bands use the same limits the user shall select the appropriate bands over which to test. When the test plan includes bands that overlap the test plan shall define the applicable limit.											

6.3 Conducted emissions from components/modules – current probe method

6.3.1 Test set-up

6.3.1.1 Location of the EUT

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

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

The EUT shall be at least 100 mm from the edge of the ground plane. The test plan shall simulate the actual vehicle configuration and shall specify: remote versus local grounding, the use of an insulating spacer, and the electrical connection of the EUT case to the ground plane.

The measuring equipment shall be as shown in Figure 10.

6.3.1.2 Location of the test harness

The test harness shall be $(1\,700^{+300}_0)$ mm long (or as agreed upon in the test plan), and shall be placed on a non-conductive, low relative permittivity material ($\epsilon_r \leq 1.4$), positioned (50 ± 5) mm above the ground plane. The test harness wires shall be nominally parallel and adjacent unless otherwise defined in the test plan.

6.3.2 Test procedure

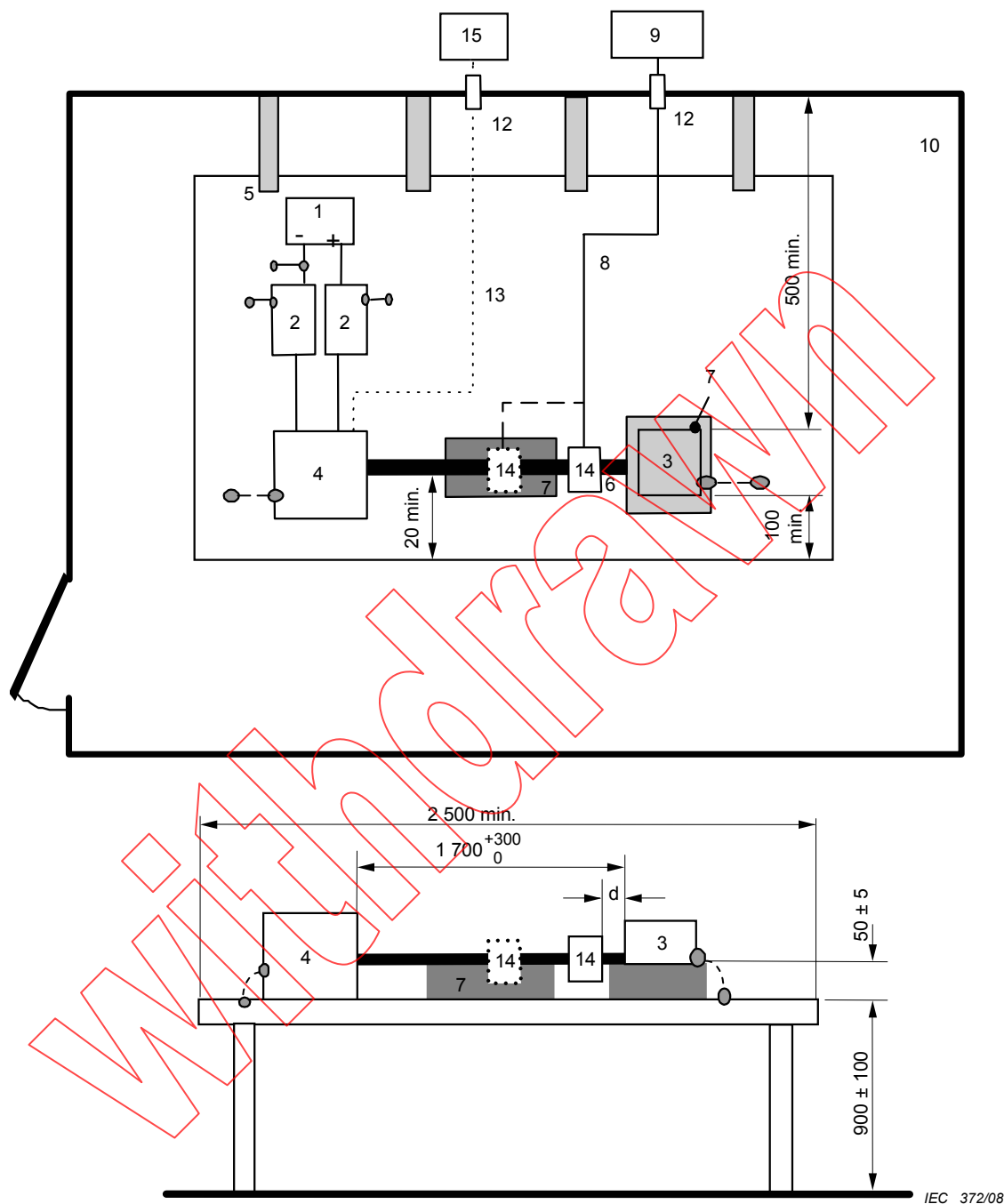
The probe (see CISPR 16-1-2) shall be mounted around the complete harness (including all wires).

Measure the emissions with the probe positioned 50 mm and 750 mm from the EUT.

In most cases, the position of maximum emission will be as close to the EUT connector as possible. Where the EUT is equipped with a metal shell connector, the probe shall be clamped to the cable immediately adjacent to the connector shell, but not around the connector shell itself. The EUT and all parts of the test set-up shall be a minimum of 100 mm from the edge of the ground plane.

NOTE Some additional measurements may be defined in the test plan with only the positive supply wire in the probe and/or only the negative supply wire in the probe. For these test configurations limits should be defined in the test plan.

Dimensions in millimetres – not to scale



IEC 372/08

Key

- | | |
|---|---|
| 1 Power supply | 9 Measuring instrument |
| 2 Artificial network | 10 Shielded enclosure |
| 3 EUT (connected to ground if specified in the test plan) | 12 Bulkhead connector |
| 4 Load simulator (placement and ground connection according to ISO 11452-4) | 13 Optical fibers |
| 5 Ground plane | 14 Current probe (represented at 2 positions) |
| 6 Wiring harness | 15 Stimulation and monitoring system |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | d The distance from the EUT to the closest probe position |
| 8 High-quality coaxial cable e.g. double-shielded (50 Ω) | |

Figure 10 – Conducted emissions – Example of test layout for current probe measurements

6.3.3 Limits for conducted disturbances from components/modules – Current probe method

The level class to be used (as a function of the frequency band) shall be agreed upon between the vehicle manufacturer and the component supplier.

NOTE It is recommended for acceptable radio reception in a vehicle that the conducted noise should not exceed the values shown in Tables 7 and 8, peak and average or quasi-peak and average limits, respectively. Since the mounting location, vehicle body construction and harness design can affect the coupling of radio disturbances to the on-board radio, multiple limit levels are defined.

Table 7 – Examples of quasi-peak and peak limits for conducted disturbances – Control/signal lines – Current probe method

Service / Band	Frequency MHz	Levels in dB(μA)									
		Class 1		Class 2		Class 3		Class 4		Class 5	
		Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak
BROADCAST											
LW	0,15 - 0,30	90	77	80	67	70	57	60	47	50	37
MW	0,53 - 1,8	58	45	50	37	42	29	34	21	26	13
SW	5,9 - 6,2	43	30	37	24	31	18	25	12	19	6
FM	76 - 108	28	15	22	9	16	3	10	-3	4	-9
TV Band I	41 - 88	24	-	18	-	12	-	6	-	0	-
TV Band III	174 - 230	Conducted emission – control/signal lines Not applicable									
DAB III	171 - 245										
TV Band IV/V	468 - 944										
DTTV	470 - 770										
DAB L band	1447 - 1494										
SDARS	2320 - 2345										
MOBILE SERVICES											
CB	26 - 28	34	21	28	15	22	9	16	3	10	-3
VHF	30 - 54	34	21	28	15	22	9	16	3	10	-3
VHF	68 - 87	28	15	22	9	16	3	10	-3	4	-9
VHF	142 -175	Conducted emission – control/signal lines Not applicable									
Analogue UHF	380 - 512										
RKE	300 - 330										
RKE	420 - 450										
Analogue UHF	820 - 960										
GSM 800	860 - 895										
EGSM/GSM 900	925 - 960										
GPS L1 civil	1567 - 1583										
GSM 1800 (PCN)	1803 - 1882										
GSM 1900	1850 - 1990										
3G / IMT 2000	1900 - 1992										
3G / IMT 2000	2010 - 2025										
3G / IMT 2000	2108 - 2172										
Bluetooth/802.11	2400 - 2500										

NOTE 1 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.

NOTE 2 Where multiple bands use the same limits the user shall select the appropriate bands over which to test. When the test plan includes bands that overlap the test plan shall define the applicable limit.

**Table 8 – Examples of average limits for conducted disturbances –
Control/signal lines – Current probe method**

Service / Band	Frequency MHz	Levels in dB(μA)				
		Class 1	Class 2	Class 3	Class 4	Class 5
		AVG	AVG	AVG	AVG	AVG
BROADCAST						
LW	0,15 - 0,30	70	60	50	40	30
MW	0,53 - 1,8	38	30	22	14	6
SW	5,9 - 6,2	23	17	11	5	-1
FM	76 - 108	8	2	-4	-10	-16
TV Band I	41 - 88	14	8	2	-4	-10
TV Band III	174 - 230	Conducted emission – control/signal lines Not applicable				
DAB III	171 - 245					
TV Band IV/V	468 - 944					
DTTV	470 - 770					
DAB L band	1447 - 1494					
SDARS	2320 - 2345					
MOBILE SERVICES						
CB	26 - 28	14	8	2	-4	-10
VHF	30 - 54	14	8	2	-4	-10
VHF	68 - 87	8	2	-4	-10	-16
VHF	142 - 175	Conducted emission – control/signal lines Not applicable				
Analogue UHF	380 - 512					
RKE	300 - 330					
RKE	420 - 450					
Analogue UHF	820 - 960					
GSM 800	860 - 895					
EGSM/GSM 900	925 - 960					
GPS L1 civil	1567 – 1583					
GSM 1800 (PCN)	1803 - 1882					
GSM 1900	1850 - 1990					
3G	1900 - 1992					
3G	2010 - 2025					
3G	2108 - 2172					
Bluetooth/802.11	2400 - 2500					
NOTE 1 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.						
NOTE 2 Where multiple bands use the same limits the user shall select the appropriate bands over which to test. When the test plan includes bands that overlap the test plan shall define the applicable limit.						

6.4 Radiated emissions from components/modules - ALSE method

6.4.1 General

Measurements of radiated field strength shall be made in an ALSE to eliminate the high levels of extraneous disturbance from electrical equipment and broadcasting stations.

NOTE 1 Conducted emissions will contribute to the radiated emissions measurements because of radiation from the wiring in the test set-up. Therefore, it is advisable to establish conformance with the conducted emissions requirements before performing the radiated emissions test.

NOTE 2 Disturbance to the vehicle on-board receiver can be caused by direct radiation from one or more leads in the vehicle wiring harness. This coupling mode to the vehicle receiver affects both the type of testing and the means of reducing the disturbance at the source.

NOTE 3 Vehicle components which are not effectively grounded to the vehicle by short ground leads, or which have several harness leads carrying the disturbance voltage, will have radiated emissions that do not correlate well with its conducted emissions. This has been shown to give better correlation with the complete vehicle test for components installed in this way.

Examples of component installations for which this test is applicable include, but are not limited to:

- electronic control systems containing microprocessors;
- two speed wiper motors with negative supply switching;
- suspension control systems with strut-mounted actuator motors;
- engine cooling and heater blower motors mounted in plastic or other insulated housings.

6.4.2 Test set-up

For radiated emissions measurements, the arrangement of the EUT, test harness, load simulator and measuring equipment shall be equivalent to the examples shown in Figures 12 to 15.

6.4.2.1 Antenna systems

Measurements shall be made using linearly polarised electric field antennas that have a nominal 50 Ω output impedance.

NOTE 1 To improve consistency of results between laboratories, the following antennas are recommended:

- | | | |
|----|------------------------|---|
| a) | 0,15 MHz to 30 MHz | 1 m vertical monopole (where this is not 50 Ω , a suitable antenna matching unit must be used); |
| b) | 30 MHz to 300 MHz | a biconical antenna; |
| c) | 200 MHz to 1 000 MHz | a log-periodic antenna; |
| d) | 1 000 MHz to 2 500 MHz | a horn or log-periodic antenna. |

The method to be used for characterization of the vertical monopole (rod) antenna is given in CISPR 16-1-4.

NOTE 2 Use the 1 m method in SAE ARP 958.1 Rev D February 2003 for determining biconical, log-periodic and horn antenna factors.

NOTE 3 Biconical antennas usually have a SWR of up to 10:1 in the frequency range of 30 MHz to 80 MHz. Therefore an additional measurement error may occur when the receiver input impedance differs from 50 Ω . The use of an attenuator (3 dB minimum) at the receiver's input or the input of an additional preamplifier (if possible) will keep this additional error low.

6.4.2.2 Antenna matching unit for monopole antenna

Correct impedance matching between the antenna and the measuring instrument of 50 Ω shall be maintained in the frequency ranges selected for the test. There shall be a maximum SWR of 2:1 at the output port of the matching unit. Appropriate correction shall be made for any attenuation/gain of the antenna system from the antenna to the receiver.

NOTE Care should be taken to ensure that input voltages do not exceed the pulse input rating of the unit or overloading may occur. This is particularly important when active matching units are used.

6.4.2.3 Location of the EUT

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

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

The side of the EUT, which is nearest to the front edge of the ground plane, shall be located at a distance of (200 ± 10) mm from the front edge of the ground plane.

6.4.2.4 Test harness and location

The total length of the test harness between the EUT and the load simulator (or the **RF boundary**) shall not exceed 2 000 mm (or as defined in the test plan). 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 material ($\epsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane.

The length of test harness parallel to the front of the ground plane shall be $(1\,500 \pm 75)$ mm.

The long segment of test harness shall be located parallel to the edge of the ground plane facing the antenna at a distance of (100 ± 10) mm from the edge. Location of the EUT and load simulator requires that the harness bend angle shall be (90^{+45}_0) degrees as shown in Figure 11.

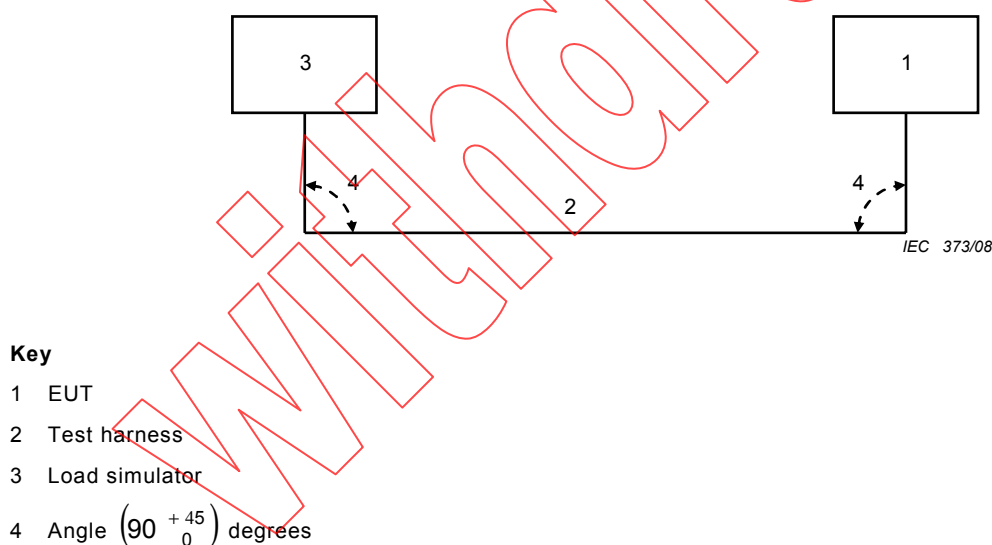


Figure 11 – Test harness bending requirements

6.4.2.5 Location of the 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 EUT 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).

6.4.2.6 Location of the measuring antenna

The phase centre of the measuring antenna shall be (100 ± 10) mm above the ground plane for the biconical, log-periodic and horn antennas.

The height of the counterpoise of the rod antenna shall be $(+10 / -20)$ mm relative to the ground plane and shall be bonded to the ground plane.

For radiated emissions tests, the shielded enclosure shall be of sufficient size to ensure that neither the EUT nor the test antenna shall be closer than 1 m from the walls or ceiling, or to the nearest surface of the absorber material used thereon. No part of any antenna radiating element shall be closer than 250 mm to the floor.

The distance between the longitudinal part (1 500 mm length) of the wiring harness and the reference point of the antenna shall be $(1\,000 \pm 10)$ mm.

The reference point of the antenna is defined as:

- the vertical monopole element for rod antennas,
- the phase centre (mid-point) for biconical antennas,
- the tip for antennas with log-periodic elements (including biconilog antennas),
- the front aperture for horn antennas.

Each antenna (excluding the rod antenna) shall be calibrated for this reference point for a 1 000 mm measuring distance.

NOTE 1 The rod antenna is excluded because calibration is achieved by using the method defined in CISPR 16-1-4.

The phase centre of the antenna shall be in line with the centre of the longitudinal part of the wiring harness for frequencies up to 1 000 MHz.

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

NOTE 2 The users of this standard should be aware that antenna manufacturers may give:

- Independent antenna factors for horizontal and vertical polarisations: in this case the appropriate antenna factor should be used for measurement in each polarisation.
- A single antenna factor: in this case this antenna factor should be used for measurements in both polarisations.

6.4.3 Test procedure

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

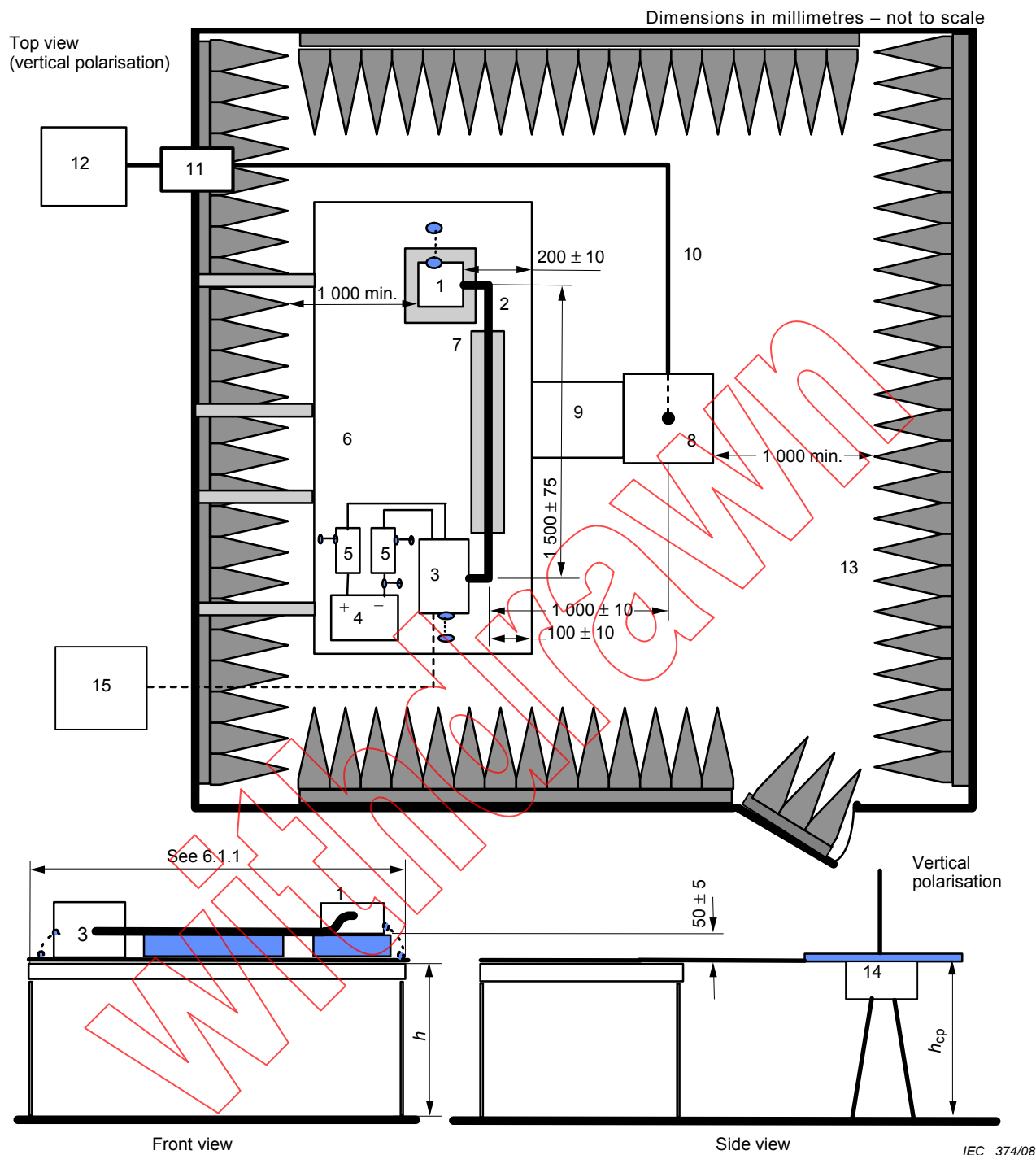
The EUT shall be made to operate under typical loading and other conditions as in the vehicle such that the maximum emission state occurs. These operating conditions shall be clearly defined in the test plan to ensure supplier and customer can perform identical tests. The orientation(s) of the EUT for radiated emission measurements shall be defined in the test plan.

From 150 kHz to 30 MHz measurements shall be performed in vertical polarisation only.

From 30 MHz to 2 500 MHz measurements shall be performed in vertical and horizontal polarisations.

For radiated emission measurements, the arrangement of the EUT and measuring equipment shall be functionally equivalent to the examples shown in Figures 12 to 15.

Withdrawn

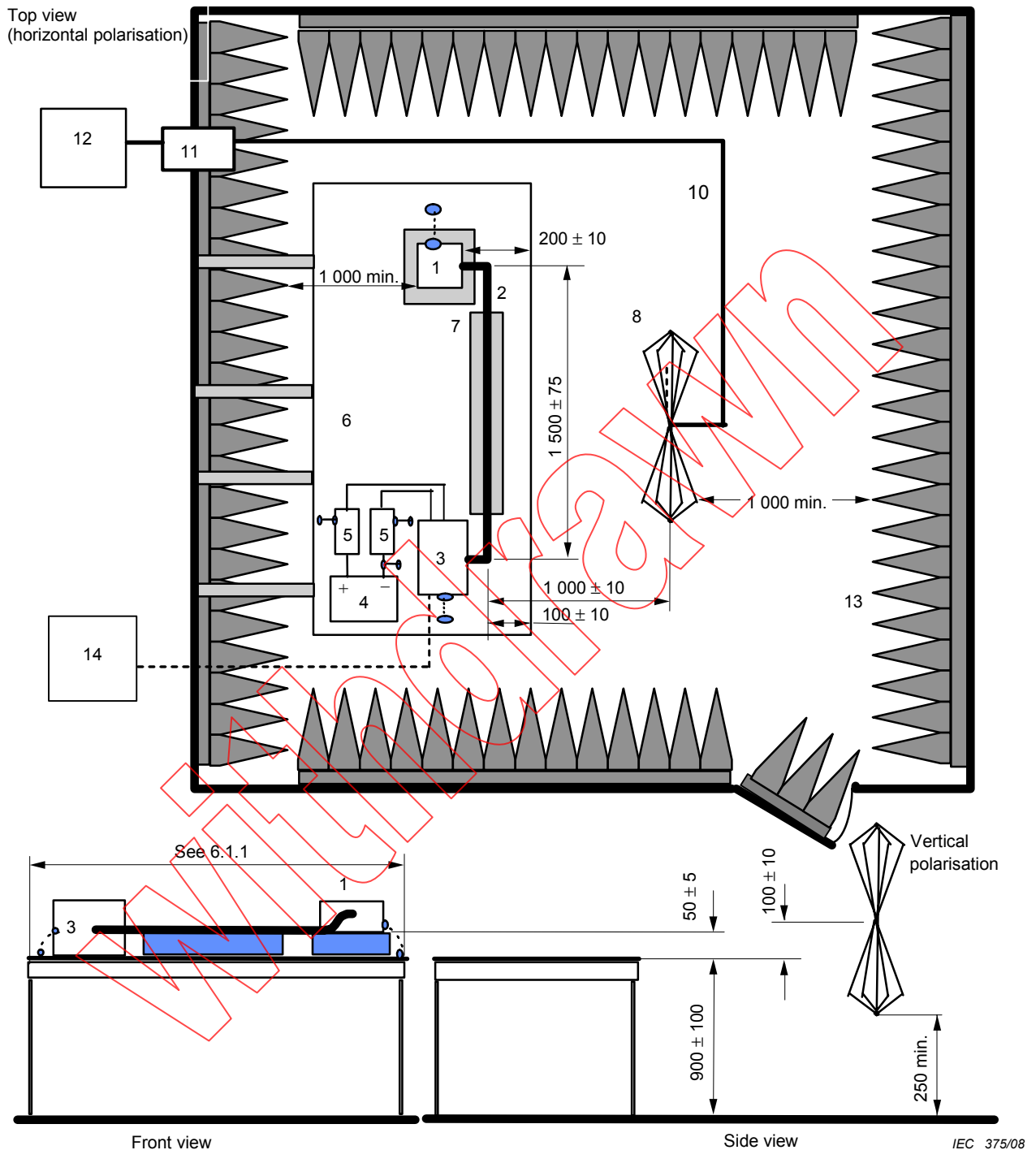


Key

- | | |
|---|--|
| 1 EUT (grounded locally if required in test plan) | 9 Grounding connection (full width bond between counterpoise and ground plane) |
| 2 Test harness | 10 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 3 Load simulator (placement and ground connection according to 6.4.2.5) | 11 Bulkhead connector |
| 4 Power supply (location optional) | 12 Measuring instrument |
| 5 Artificial network (AN) | 13 RF absorber material |
| 6 Ground plane (bonded to shielded enclosure) | 14 Antenna matching unit (the preferred location is below the counterpoise; if above the counterpoise then the base of the antenna rod shall be at the height of the ground plane) |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | 15 Stimulation and monitoring system |
| 8 Rod antenna with counterpoise (dimensions: 600 mm by 600 mm typical) | |
| $h = (900 \pm 100) \text{ mm}$ | |
| $h_{cp} = h + (+10 / -20) \text{ mm}$ | |

Figure 12 – Example of test set-up – rod antenna

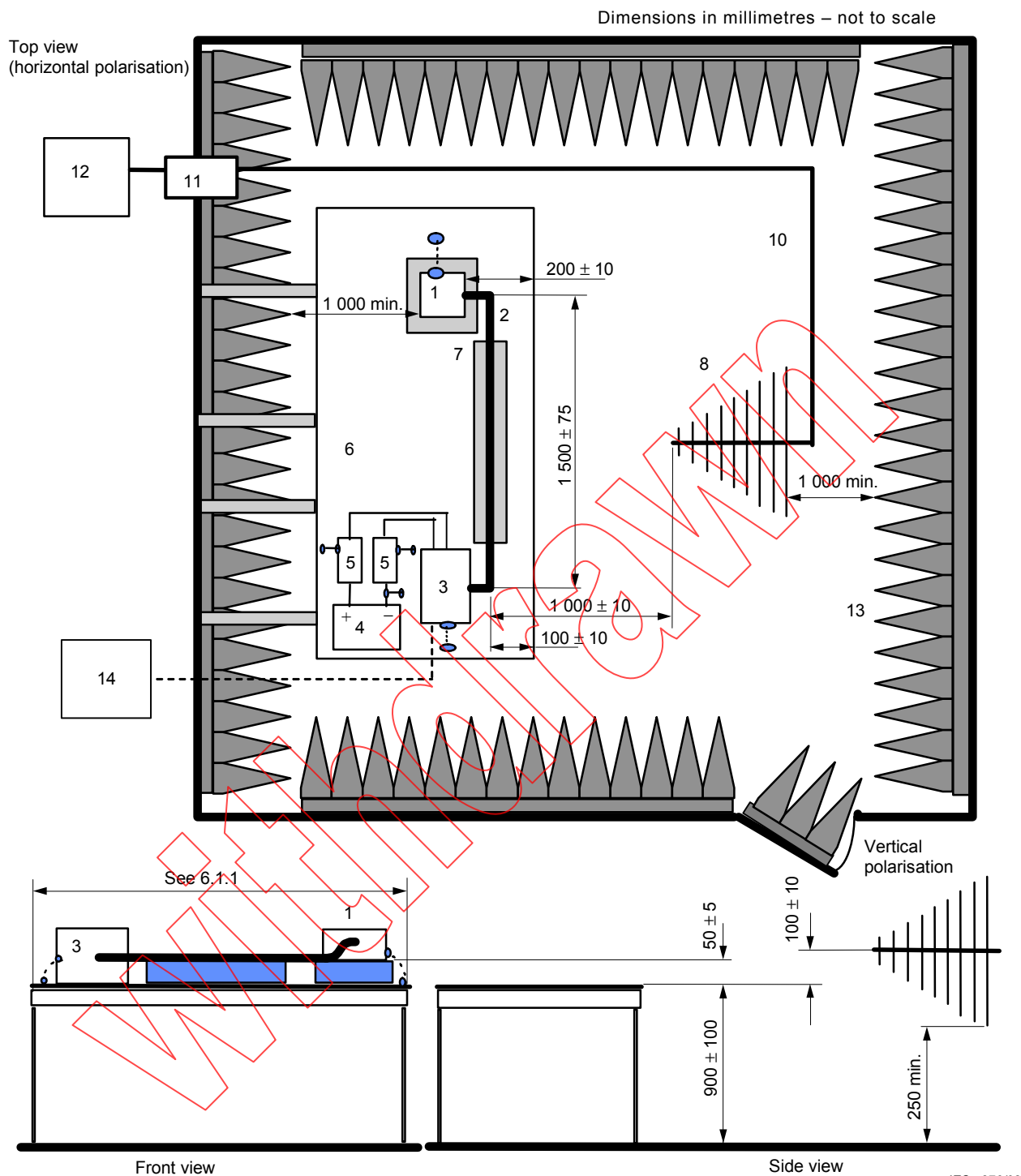
Dimensions in millimetres – not to scale



Key

- | | |
|---|---|
| 1 EUT (grounded locally if required in test plan) | 8 Biconical antenna |
| 2 Test harness | |
| 3 Load simulator (placement and ground connection according to 6.4.2.5) | 10 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 4 Power supply (location optional) | 11 Bulkhead connector |
| 5 Artificial network (AN) | 12 Measuring instrument |
| 6 Ground plane (bonded to shielded enclosure) | 13 RF absorber material |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | 14 Stimulation and monitoring system |

Figure 13 – Example of test set-up – biconical antenna



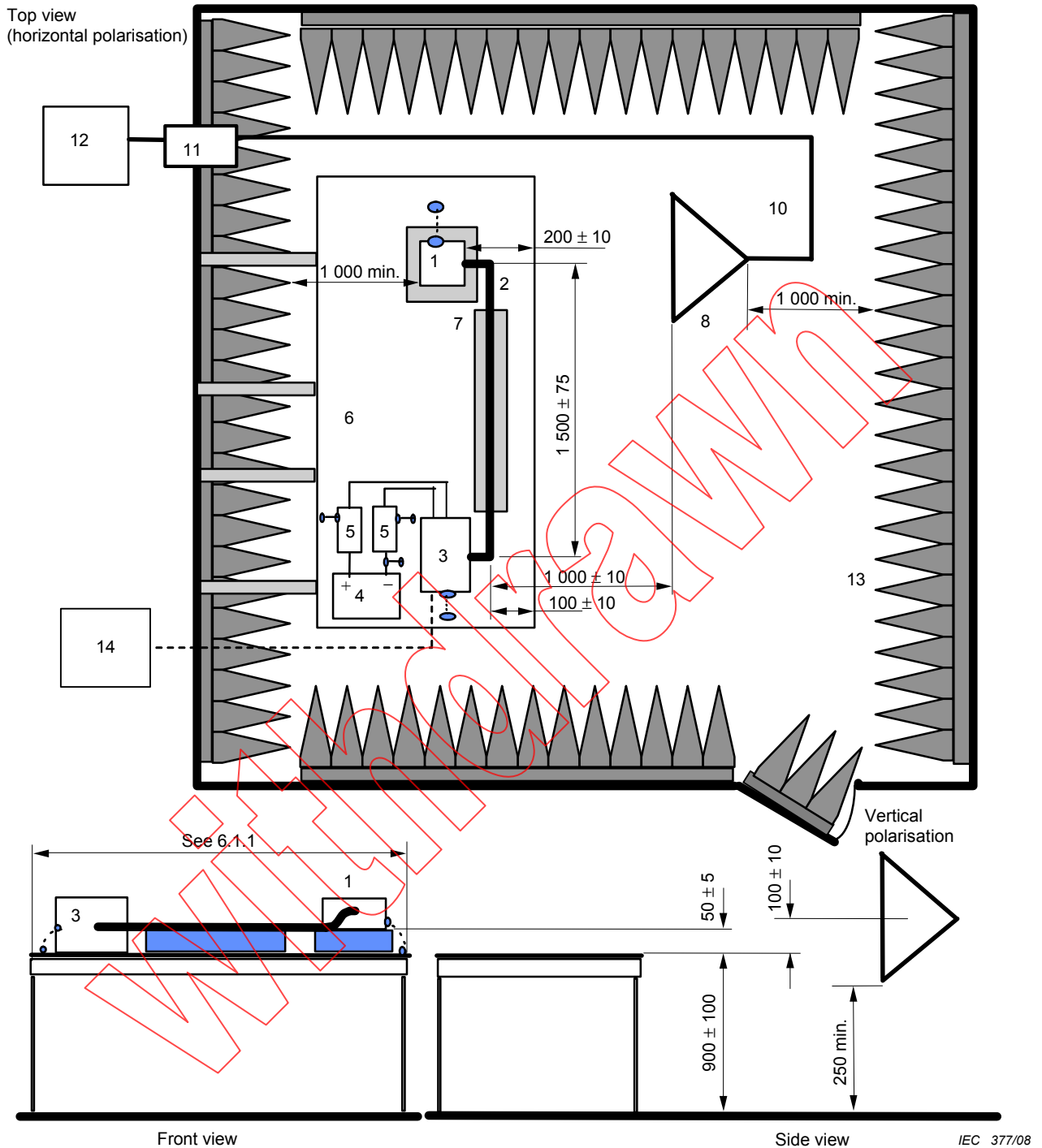
IEC 376/08

Key

- | | |
|---|---|
| 1 EUT (grounded locally if required in test plan) | 8 Log-periodic antenna |
| 2 Test harness | |
| 3 Load simulator (placement and ground connection according to 6.4.2.5) | 10 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 4 Power supply (location optional) | 11 Bulkhead connector |
| 5 Artificial network (AN) | 12 Measuring instrument |
| 6 Ground plane (bonded to shielded enclosure) | 13 RF absorber material |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | 14 Stimulation and monitoring system |

Figure 14 – Example of test set-up – log-periodic antenna

Dimensions in millimetres – not to scale



Key

- | | |
|---|---|
| 1 EUT (grounded locally if required in test plan) | 8 Horn antenna |
| 2 Test harness | |
| 3 Load simulator (placement and ground connection according to 6.4.2.5) | 10 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 4 Power supply (location optional) | 11 Bulkhead connector |
| 5 Artificial network (AN) | 12 Measuring instrument |
| 6 Ground plane (bonded to shielded enclosure) | 13 RF absorber material |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | 14 Stimulation and monitoring system |

Figure 15 – Example of test set-up – above 1 GHz

6.4.4 Limits for radiated disturbances from components/modules – ALSE method

The level class to be used (as a function of the frequency band) shall be agreed upon between the vehicle manufacturer and the component supplier.

NOTE It is recommended for acceptable radio reception in a vehicle that the radiated noise should not exceed the values shown in Tables 9 and 10, peak and average or quasi-peak and average limits, respectively. Since the mounting location, vehicle body construction and harness design can affect the coupling of radio disturbances to the on-board radio, multiple limit levels are defined. For the GPS band a specific limit characteristic is recommended. This is shown in Figure 16.

Table 9 – Examples of quasi-peak or peak limits for radiated disturbances – ALSE

Service / Band	Frequency MHz	Levels in dB(μV/m)									
		Class 1		Class 2		Class 3		Class 4		Class 5	
		Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak	Peak	Quasi-peak
BROADCAST											
LW	0,15 - 0,30	86	73	76	63	66	53	56	43	46	33
MW	0,53 - 1,8	72	59	64	51	56	43	48	35	40	27
SW	5,9 - 6,2	64	51	58	45	52	39	46	33	40	27
FM	76 - 108	62	49	56	43	50	37	44	31	38	25
TV Band I	41 - 88	52	-	46	-	40	-	34	-	28	-
TV Band III	174 - 230	56	-	50	-	44	-	38	-	32	-
DAB III	171 - 245	50	-	44	-	38	-	32	-	26	-
TV Band IV/	468 - 944	65	-	59	-	53	-	47	-	41	-
DTTV	470 - 770	69	-	63	-	57	-	51	-	45	-
DAB L band	1447 - 1494	52	-	46	-	40	-	34	-	28	-
SDARS	2320 - 2345	58	-	52	-	46	-	40	-	34	-
MOBILE SERVICES											
CB	26 - 28	64	51	58	45	52	39	46	33	40	27
VHF	30 - 54	64	51	58	45	52	39	46	33	40	27
VHF	68 - 87	59	46	53	40	47	34	41	28	35	22
VHF	142 - 175	59	46	53	40	47	34	41	28	35	22
Analogue UHF	380 - 512	62	49	56	43	50	37	44	31	38	25
RKE	300 - 330	56	-	50	-	44	-	38	-	32	-
RKE	420 - 450	56	-	50	-	44	-	38	-	32	-
Analogue UHF	820 - 960	68	55	62	49	56	43	50	37	44	31
GSM 800	860 - 895	68	-	62	-	56	-	50	-	44	-
EGSM/GSM 900	925 - 960	68	-	62	-	56	-	50	-	44	-
GPS L1 civil	1567 - 1583	-	-	-	-	-	-	-	-	-	-
GSM 1800 (PCN)	1803 - 1882	68	-	62	-	56	-	50	-	44	-
GSM 1900	1850 - 1990	68	-	62	-	56	-	50	-	44	-
3G / IMT 2000	1900 - 1992	68	-	62	-	56	-	50	-	44	-
3G / IMT 2000	2010 - 2025	68	-	62	-	56	-	50	-	44	-
3G / IMT 2000	2108 - 2172	68	-	62	-	56	-	50	-	44	-
Bluetooth/802.11	2400 - 2500	68	-	62	-	56	-	50	-	44	-

NOTE 1 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.

NOTE 2 Where multiple bands use the same limits the user shall select the appropriate bands over which to test. When the test plan includes bands that overlap the test plan shall define the applicable limit.

Table 10 – Examples of average limits for radiated disturbances – ALSE

Service / Band	Frequency MHz	Levels in dB(μV/m)				
		Class 1	Class 2	Class 3	Class 4	Class 5
		AVG	AVG	AVG	AVG	AVG
BROADCAST						
LW	0,15 - 0,30	66	56	46	36	26
MW	0,53 - 1,8	52	44	36	28	20
SW	5,9 - 6,2	44	38	32	26	20
FM	76 - 108	42	36	30	24	18
TV Band I	41 - 88	42	36	30	24	18
TV Band III	174 - 230	46	40	34	28	22
DAB III	171 - 245	40	34	28	22	16
TV Band IV/V	468 - 944	55	49	43	37	31
DTTV	470 - 770	59	53	47	41	35
DAB L band	1447 - 1494	42	36	30	24	18
SDARS	2320 - 2345	48	42	36	30	24
MOBILE SERVICES						
CB	26 - 28	44	38	32	26	20
VHF	30 - 54	44	38	32	26	20
VHF	68 - 87	39	33	27	21	15
VHF	142 - 175	39	33	27	21	15
Analogue UHF	380 - 512	42	36	30	24	18
RKE	300 - 330	42	36	30	24	18
RKE	420 - 450	42	36	30	24	18
Analogue UHF	820 - 960	48	42	36	30	24
GSM 800	860 - 895	48	42	36	30	24
EGSM/GSM 900	925 - 960	48	42	36	30	24
GPS L1 civil	1567 - 1583	34	28	22	16	10
GSM 1800 (PCN)	1803 - 1882	48	42	36	30	24
GSM 1900	1850 - 1990	48	42	36	30	24
3G / IMT 2000	1900 - 1992	48	42	36	30	24
3G / IMT 2000	2010 - 2025	48	42	36	30	24
3G / IMT 2000	2108 - 2172	48	42	36	30	24
Bluetooth/802.11	2400 - 2500	48	42	36	30	24
NOTE 1 All values listed in this table are valid for the bandwidths in Tables 1 and 2. If measurements have to be performed with different bandwidths than those specified in Tables 1 and 2 because of noise floor requirements, then applicable limits should be defined in the test plan.						
NOTE 2 Where multiple bands use the same limits the user shall select the appropriate bands over which to test. When the test plan includes bands that overlap the test plan shall define the applicable limit.						