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Proposed horizontal standard

☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the TC/SC secretary

Functions concerned:

☐ Safety ☒ EMC ☐ Environment ☐ Quality assurance

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Title:
CISPR 12: Vehicles, boats and internal combustion engines - Radio disturbanc characteristics - Limits and methods of measurent for the protection of off-board receivers

(Titre) :

Introductory note

This draft is the result of the maintenance work on CISPR 12.

Besides an improvement of the wording the following changes were applied:

- New test setups for emission tests on electric and plug-in hybrid electric vehicles in charging mode
- Statements dealing with type approval, product surveillance are moved to an informative annex (Annex F)
- Definition of networks for impedance stabilization needed for the test setups for the charging mode (Annex G)
- New annexes covering measurement instrumentation uncertainties (Annex H and I)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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

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International Standard CISPR 12 has been prepared by CISPR subcommittee D: Electromagnetic disturbances related to electric/electronic equipment on vehicles, boats and internal combustion powered devices.

This seventh edition cancels and replaces the sixth edition published in 2007 and its Amendment 1 (2009). This edition constitutes a technical revision.

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

– test setups for electric vehicles and plug-in hybrid vehicles in charging mode were added
– some statements dealing with series surveillance and type approval were moved into an informative annex
– annexes for measurement instrumentation uncertainties were added
– an annex describing networks to be used for the charging mode was added
– general improvements

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

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

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 stability 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.

INTRODUCTION

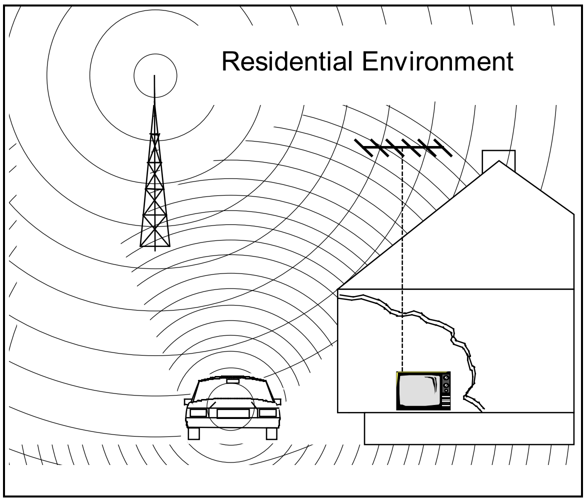
There is a specific need for standards to define acceptable radio frequency performance of all electrical/electronic products. CISPR 12 has been developed to serve the Road Vehicle, boats, internal combustion engines and related industries with test methods and limits that provide satisfactory protection for radio reception.

CISPR 12 has been used for many years as a regulatory requirement in numerous countries, to provide protection for radio receivers in the residential environment. It has been extremely effective in protecting the radio environment outside the vehicle.

All items that concern specific use of this standard (as a regulatory requirement, surveillance of series production, quick prototype check) are defined in Annex F.

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

1 Scope



The limits in this International Standard are designed to provide protection for broadcast receivers in the frequency range of 30 MHz to 1 000 MHz when used in the residential environment. Compliance with this standard may not provide adequate protection for new types of radio transmissions or receivers used in the residential environment nearer than 10 m to the vehicle, boat or device.

NOTE 1 Experience has shown that compliance with this standard may provide satisfactory protection for receivers of other types of transmissions when used in the residential environment, including radio transmissions in frequency ranges other than that specified.

This standard applies to the emission of electromagnetic energy which may cause interference to radio reception and which is emitted from

a) vehicles propelled by an internal combustion engine, electrical means or both (see 3.1);

b) boats propelled by an internal combustion engine, electrical means or both (see 3.2). Boats are to be tested in the same manner as vehicles except where they have unique characteristics as explicitly stated in this standard;

c) devices equipped with internal combustion engines or traction batteries (see 3.3).

See Annex E for a flow chart to help determine the applicability of CISPR 12.

This standard does not apply to aircraft, household appliances, traction systems (railway, tramway and electric trolley bus), vehicle / boat / device off-board chargers or to incomplete vehicles. In the case of a dual-mode trolley bus (e.g. propelled by power from either a.c./d.c. mains or an internal combustion engine), the internal combustion propulsion system shall be included, but the a.c./d.c. mains portion of the vehicle propulsion system shall be excluded from this standard.

NOTE 2 Protection of receivers used on board the same vehicle as the disturbance source(s) are covered by CISPR 25

The measurement of conducted electromagnetic disturbances while the vehicle is connected to power mains for charging is not covered in this standard. The user is referred to appropriate IEC and CISPR standards which define measurement techniques and limits for this condition.

NOTE 3 see IEC 61851-21-1

Annex J 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): *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

CISPR 16-1-1:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*
Amendment 1 (2010)

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

CISPR 16-1-3:2004, Specification for radio disturbance and immunity measuring apparatus *and methods – Part 1-3 Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*

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*

CISPR 16-2-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*
Amendment 1 (2010)

CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and networks – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty*

CISPR 16-4-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*
Amendment 1 (2006)

CISPR 25: *Radio disturbance characteristics for the protection of receivers used on board vehicles, boats, and on devices – Limits and methods of measurement*

3 Terms and definitions

For the purpose of this document, the terms and definitions contained in IEC 60050-161 as well as the following apply.

3.1
vehicle
machine operating on land which is intended to carry persons or goods

NOTE Vehicles include, but are not limited to, cars, trucks, buses, mopeds, agricultural machinery, earth-moving machinery, material-handling equipment, mining equipment, floor treatment machines and snowmobiles

3.2
boat
vessel intended to be used on the surface of water, its length being no greater than 15 m

3.3
device
machine driven by an internal combustion engine or traction batteries 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, walk-behind floor treatment machines and landscaping equipment

3.4
impulsive ignition noise
unwanted emission of electromagnetic energy, predominantly impulsive in content, arising from the ignition system within a vehicle, boat or device

3.5
ignition noise suppressor
that portion of a high-voltage ignition circuit intended to limit the emission of impulsive ignition noise

3.6
Outdoor test site (OTS)
measurement site similar to an open area test site as specified in CISPR 16, however a ground plane is not required and there are dimensional changes

NOTE Specific requirements are defined in this document.

3.7
resistive distributor brush
resistive pick-up brush in an ignition distributor cap

3.8
frequency sub-band
segment of the frequency spectrum (30 MHz to 1 000 MHz) defined to enable statistical evaluation of the test data acquired by swept frequency testing

3.9
representative frequency
assigned frequency of a frequency sub-band to be used for comparison of the data to the limit

3.10
characteristic level
controlling (or dominant) emission level experienced in each frequency sub-band. The characteristic level is the maximum field-strength level obtained for both antenna polarizations and for all the specified measurement positions of the vehicle, boat or device. Known ambient signals shall not be considered part of the characteristic level.

3.11
tracking generator
test signal oscillator (continuous wave, cw) that is frequency locked to the receive frequency of a measuring receiver

3.12
RF disturbance power
RF power measured with a current transformer of an absorbing clamp and an RF measuring receiver. It may be measured – as the RF disturbance voltage – in a peak or quasi-peak mode

3.13
spark discharge
in this document, the discharge of energy stored in the ignition coil, in an arc across the electrodes of a measuring spark-plug

3.14
resistive high-voltage (HV) ignition cable
ignition cable whose conductor has a high resistance (attenuation)

3.15
residential environment
environment having a 10 m protection distance between the source and the point of radio reception and where the source uses the public low voltage power system or battery power

NOTE Examples of a residential environment include rooming houses, private dwellings, entertainment halls, theatres, schools, public streets, etc.

3.16
traction batteries
high power batteries used for electric vehicle applications or devices

3.17
unladen
not carrying any additional weight in the vehicle (passengers or cargo)

3.18
asymmetric artificial network (AAN)
network used to measure (or inject) asymmetric (common mode) voltages on unshielded symmetric signal (e.g. telecommunication) lines while rejecting the symmetric (differential mode) signal

Note: This network is inserted in the communication/signal lines of the vehicle in charging mode to provide a specific load impedance and/or a decoupling (e.g. between communication/signal lines and power mains)

3.19
artificial network (AN)
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

Note : network inserted in the d,c power lines of the vehicle in charging mode which provides, in a given frequency range, a specified load impedance and which isolates the vehicle from the d.c power supply in that frequency range

3.20
artificial mains network (AMN)
provides a defined impedance to the EUT at radio frequencies, couples the disturbance voltage to the measuring receiver and decouples the test circuit from the supply mains. There are two basic types of AMN, the V-network (V-AMN) which couples the unsymmetrical voltages, and the delta-network which couples the symmetric and the asymmetric voltages separately. The terms line impedance stabilization network (LISN) and V-AMN are used

Note : network inserted in the power mains of the vehicle in charging mode which provides, in a given frequency range, a specified load impedance and which isolates the vehicle from the power mains in that frequency range”

3.21
controller area network (CAN)
a network documented in ISO 11898 that connects devices, sensors and actuators in systems

3.22
powerline communications (PLC)
a communication technique based on error tolerant modulation schemes which transmits information superimposed to electrical power over lines or cables

3.23
absorber lined shielded enclosure (ALSE)
shielded enclosure/screened room with radio frequency-absorbing material on its internal ceiling and walls

3.24
wireless power transfer (WPT)
the transfer of electrical energy from a power source to an electrical load via electric and/or magnetic fields or waves between a primary and a secondary device

3.25
bonded (ground connection and d.c. resistance)
when the term “bonded” is used to describe a grounding connection within this standard, the purpose of the bonding is to provide the lowest possible impedance (resistance and inductance) connection between two metallic parts (see 5.3 of CISPR 16-2-1). The d.c. resistance of this connection shall not exceed 2,5 mΩ.

NOTE A low current (≤100 mA) 4-wire milliohm meter is recommended for this measurements

4 Limits of disturbance

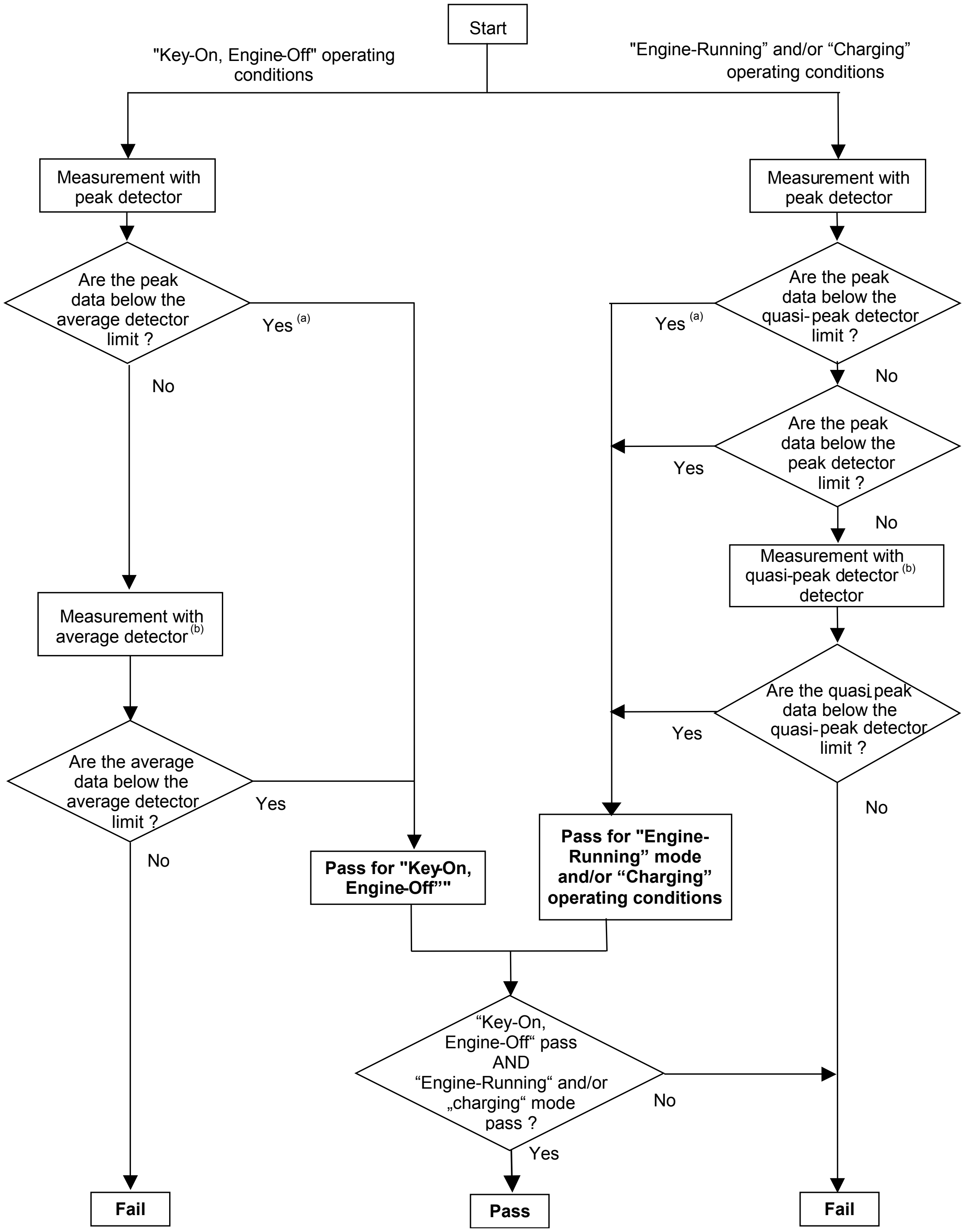
4.1 Determination of conformance of vehicle/boat/device with limits

In the 30 MHz – 1 GHz frequency range, the vehicle/boat/device shall comply with both:

- average detector limits when the vehicle/boat/device is in “Key-On, Engine-Off” mode (see 5.5.2.1 and 5.5.3), and
- peak or quasi-peak detector limits when the vehicle/boat/device is in “Engine-Running” mode (see 5.5.2.2 and 5.5.3) and
- if applicable peak or quasi-peak detector limits when the vehicle/boat/device is in “Charging mode connected to the power grid” (see 5.5.2.3 and 5.5.3)

The limits given in this standard take into account uncertainties.

Figure 1 defines the method for determination of conformance.



a Because measurement with peak detector is always higher than or equal to measurement with quasi-peak detector (and average detector respectively) and applicable peak detector limit is always higher than or equal to applicable quasi-peak detector limit (and average detector limit respectively), this single detector measurement can lead to a simplified and quicker conformance process.

b This flow-chart is applicable for each individual frequency, e.g only frequencies that are above the applicable limit need to be remeasured with quasi-peak detector (and average detector respectively).

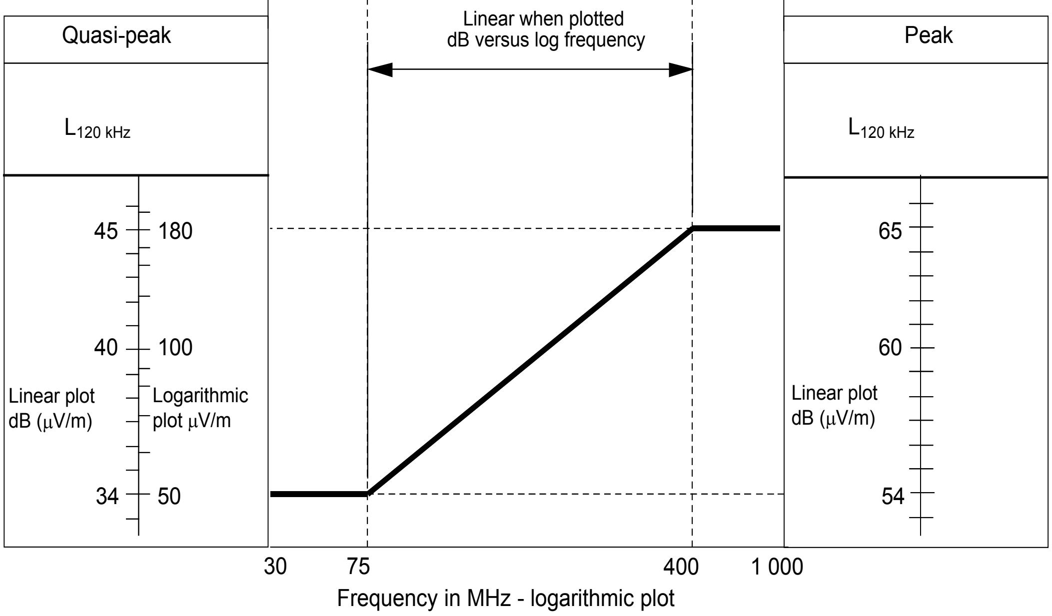
Figure 1 – Method of determination of conformance

4.2 Peak and quasi-peak detector limits

The limit for emissions measured with peak or quasi-peak detector at 10 m antenna distance is given in the table of Figure 2 and is shown graphically in Figure 2. For more accurate determination, the equations given in Figure 2 shall be used. For measurements at 3 m antenna distance, 10 dB shall be added to the limit.

Limit L_{bw} in dB (µV/m) as a function of detector and frequency *f* in MHz

L_{bw}	30-75 MHz	75-400 MHz	400-1000 MHz	Measurement type
$L_{120\ kHz}$	34	34 + 15,13 lg (f/75)	45	Quasi-peak
$L_{120\ kHz}$	54	54 + 15,13 lg (f/75)	65	Peak



NOTE 1 For vehicles equipped with electric propulsion motors, see 5.4.2.

NOTE 2 For peak measurements, see 5.5.

Figure 2 – Limit of disturbance (peak and quasi-peak detector) at 10 m antenna distance

4.3 Average detector limit

The limit for emissions measured with the average detector at 10 m antenna distance is shown in Figure 3. Vehicles/boats/devices not including electronic oscillators with an operating frequency greater than 9 kHz shall be deemed to be in compliance with the requirements of this clause without performing tests for emissions with average detector. Vehicles/boats/devices which meet the average emissions requirements of CISPR 25, Clause 5 shall also be deemed to be in compliance with the average requirements of this subclause and no further testing is necessary.

For measurements at 3 m antenna distance, 10 dB shall be added to the limit.

The average detector is defined in CISPR 16-1-1.

Note: The definition of the AV detector was changed in CISPR 16-1 in 2002. The difference between the old definition and the new definition is described in Annex D of CISPR 16-2-3.

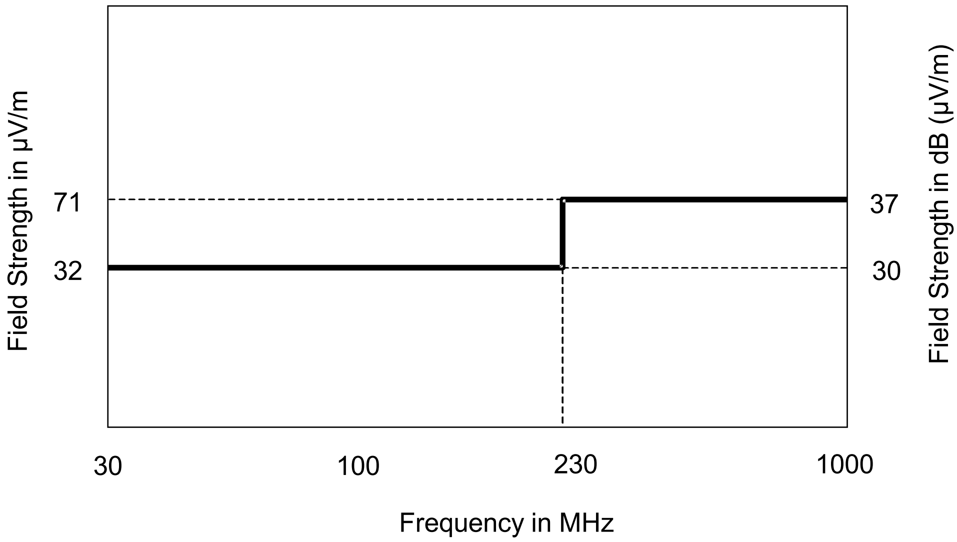


Figure 3 – Limits of disturbance (average detector) at 10 m antenna distance

5 Methods of measurement

5.1 Measuring instruments

5.1.1 Measuring receiver

5.1.1.1 General

The measuring receiver shall comply with the requirements of CISPR 16-1-1. Either manual or automatic frequency scanning may be used.

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 receiver 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.

When quasi-peak limits are being used, and a peak detector is used for time efficiency, any peak field-strength levels at or above the test limit shall be re-measured using the quasi-peak detector.

5.1.1.2 Spectrum analyser parameters

The scan rate of the spectrum analyser shall be adjusted for the CISPR frequency band and detection mode used. The maximum scan rate shall comply with the requirements of CISPR 16-2-3.

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 recommended scan time and resolution bandwidth (RBW) are listed in Table 1

Table 1 – Spectrum analyser parameters

Frequency range MHz	**Peak detector**		**Quasi-peak detector**		**Average detector**	
	RBW at -3 dB	**Scan time**	**RBW at -6 dB**	**Scan time**	**RBW at -3 dB**	**Scan time**
30 to 1 000	100 or 120 kHz	100 ms / MHz	120 kHz	20 s / MHz	100 or 120 kHz	100 ms /MHz

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

5.1.1.3 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 bandwidth (BW) are listed in Table 2.

Table 2 – Scanning receiver parameters

Frequency range MHz	**Peak detector**			**Quasi-peak detector**			**Average detector**		
	BW at -6 dB	**Step size**	**Dwell time**	**BW at -6 dB**	**Step size**	**Dwell time**	**BW at -6 dB**	**Step size**	**Dwell time**
30 to 1 000	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms

5.1.2 Antenna types

5.1.2.1 Preferred Antenna

The antenna shall be a balanced dipole (see CISPR 16-1-4). Free-space antenna factors are to be used. For frequencies of 80 MHz or above, the antenna shall be resonant in length, and for frequencies below 80 MHz it shall be the length equal to the 80 MHz resonant length. It shall be matched to the transmission line by a suitable symmetric-asymmetric transformer device.

5.1.2.2 Alternative Antennas

Any linearly polarized broadband antenna may be used when making measurements with an automated receiving system using a scanning measuring receiver. Such a broadband antenna is usable for measuring emission levels (over the frequency spectrum covered by this standard), provided that its output can be normalized to the output of the reference antenna and its antenna factor is determined with one of the following methods:

- Alternate Antenna Characterization (See annex B)
- ANSI C63.5 method

When broadband antennas are used, they shall meet the requirements for complex antennas given in CISPR 16-1-4.

5.2 Measurement instrumentation uncertainty

The measurment instrumentation uncertainty shall be calculated as described in Annex H. Measurment instrumentation uncertainty shall not be taken into account in the determination of compliance.

Examples of uncertainty budgets are given in Annex I. If the calculated expanded measurement instrumentation uncertainty exceeds those of the example in Annex I, the value of the expanded uncertainty shall be documented in the test report.

NOTE to National Committees: The provisions on measurment instrumentation uncertainty (MIU) do not follow the agreed CISPR policy for considering MIU. The deviation from policy is justified due to the missing site validation method which will be covered in a future project for CISPR 12. Without site validation criterion an estimation of the uncertainty contribution caused by site imperfections cannot be made and which leaves MIU incomplete.

5.3 Measuring location requirements

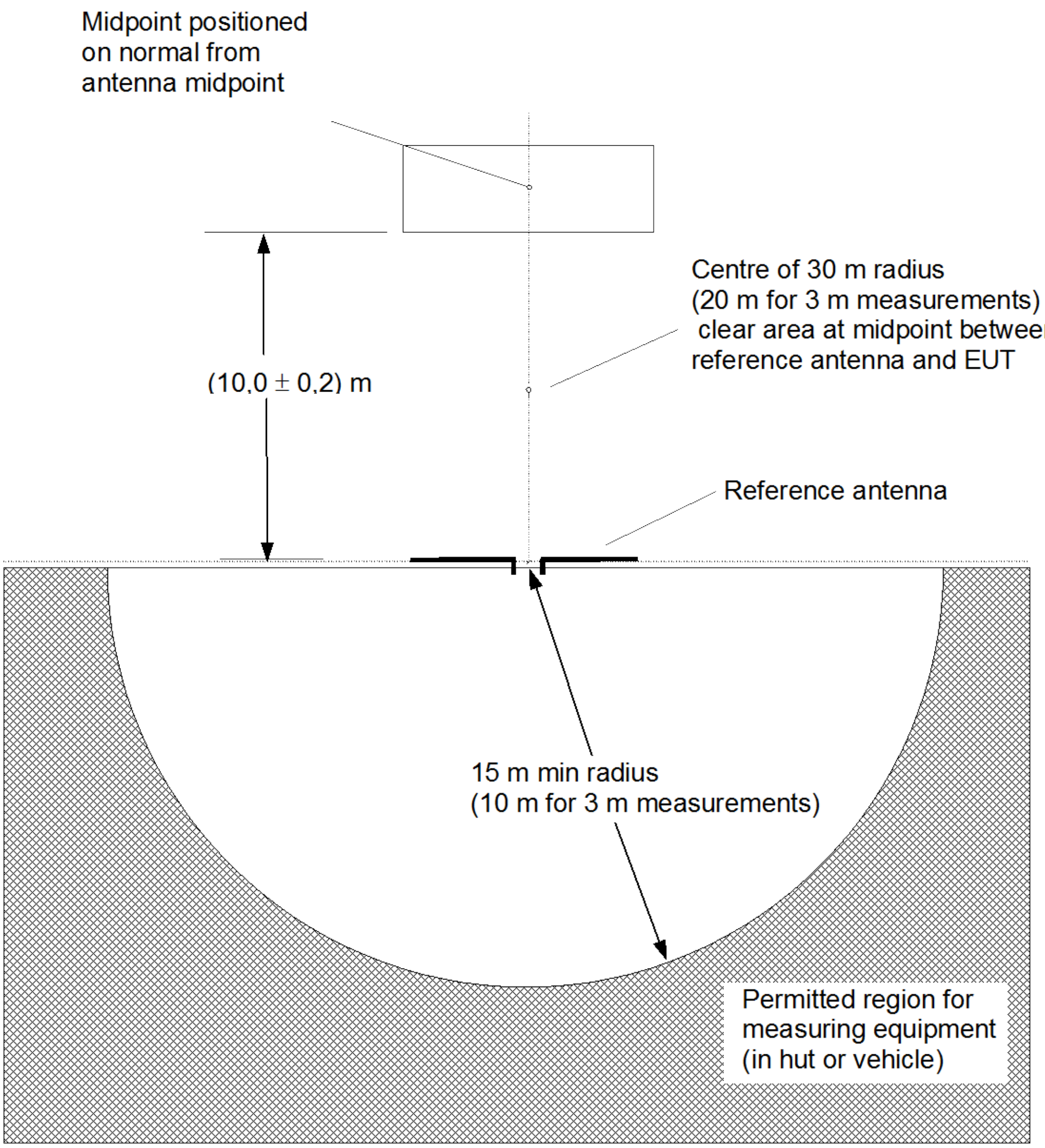
5.3.1 Outdoor Test Site (OTS) requirements

5.3.1.1 OTS for vehicles and devices

The test site shall be a clear area, free from electromagnetic reflecting surfaces within a circle of minimum radius 30 m (20 m radius for 3 m measurements) measured from a point midway between the vehicle or device and the antenna. As an exception, the measuring equipment, and test hut or vehicle in which the measuring equipment is located (when used) may be within the test site, but only in the permitted region indicated by the crosshatched area of Figure 4.

NOTE The site requirements defined in 5.3.1.1 and Figure 4 are the application of CISPR 16-1-4 to large automotive objects.

Vehicles and devices smaller than 2 m in length and width may be tested on an OTS with dimensions corresponding to CISPR 16-1-4, Figures 2 or 3.



NOTE The 10,0 m ± 0,2 m dimension may be changed to 3,00 m ± 0,05 m in accordance with 5.4.1.2.3.

Figure 4 – Measuring site (OTS) for vehicles and devices

5.3.1.2 OTS for boats

The test site shall be a clear area free from electromagnetic reflecting surfaces within a circle of minimum radius 30 m (20 m radius for 3 m measurements) measured from a point midway between the engine under test and the antenna. Exceptions for the measuring equipment are specified in 5.3.1.2.1 and also in 5.3.1.2.2. As an exception, the measuring equipment may be within the test site, but only in the permitted region indicated by the crosshatched area of Figure 5. The test hut or vehicle or non-metallic boat of test fixture in/on which the measuring equipment is located may be within the test site.

Boats or engines/motors for boats tested separately shall be tested in salt or fresh water at a measuring site as shown in Figure 5.

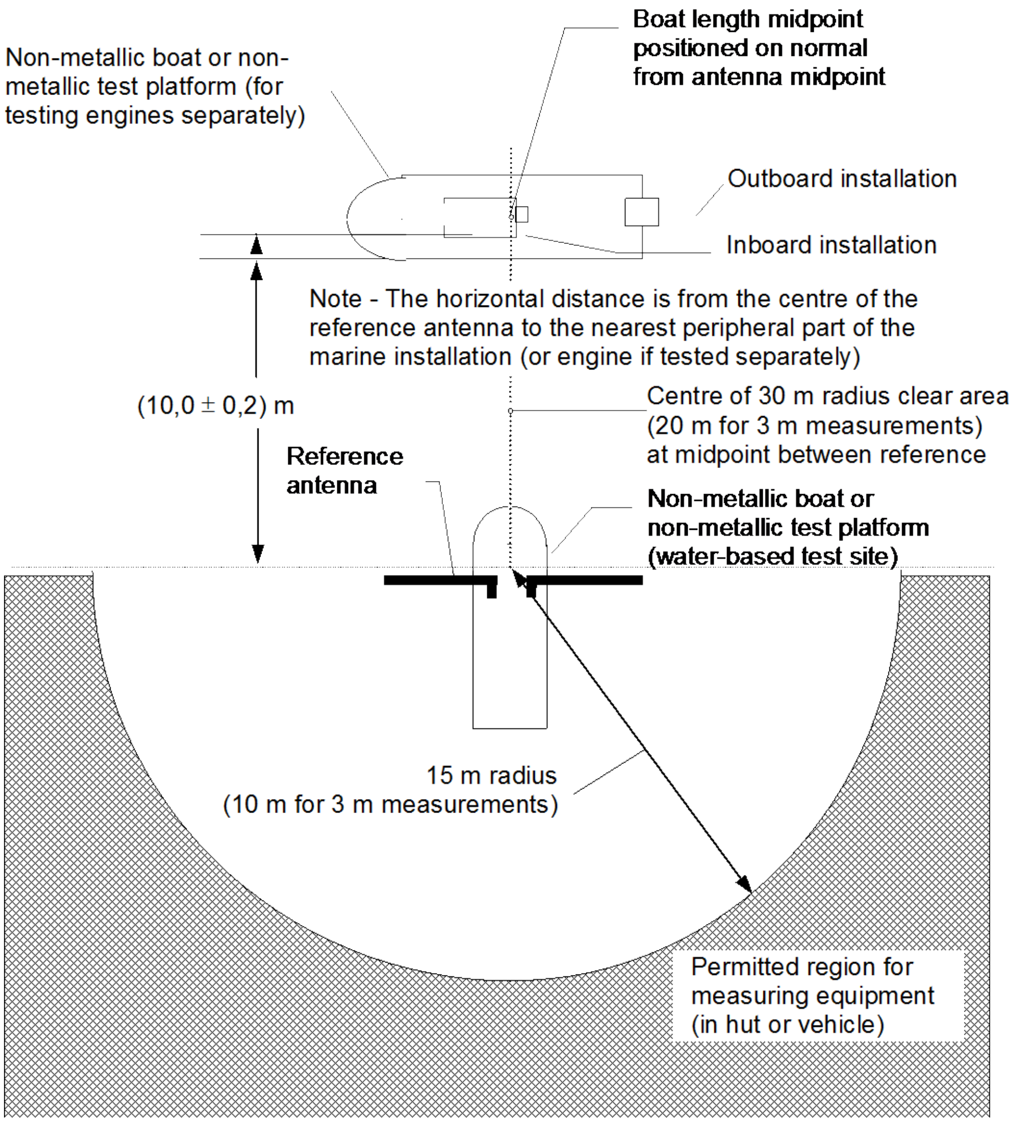


Figure 5 – Measuring site (OTS) for boats

5.3.1.2.1 Land-based measuring equipment

When the measuring equipment is on land, the test hut or vehicle in which the measuring equipment is located may be within the test site, but only in the permitted region indicated by the cross-hatched area of Figure 5.

5.3.1.2.2 Water-based measuring equipment

The measuring equipment shall be installed in a non-metallic boat or non-metallic test fixture which may be within the test site, but only within the permitted region indicated by the cross-hatched area of Figure 5.

5.3.1.3 Ambient requirements

To ensure that there is no extraneous noise or signals of sufficient magnitude or density to affect materially the vehicle measurement, ambient measurements shall be taken before and after the main test, but without the vehicle/boat/device under test running. In both of these measurements, the ambient noise shall be at least 6 dB below the limits of disturbance given in Clause 4, excluding intentional radiators. When assessing compliance in accordance with Clause 6 any emission exceeding the limits shall require investigation to ensure that they are not attributable to the vehicle/boat/device in order to be excluded.

NOTE For further guidance, see 5.4 of CISPR 16-1-4.

5.3.2 Absorber lined shielded enclosure (ALSE) requirements

5.3.2.1 Correlation

Absorber lined shielded enclosures may be used provided that the results obtained can be correlated with those obtained using the OTS described in 5.3.1.

NOTE Such chambers have the advantages of all weather testing, controlled environment and improved repeatability because of stable chamber electrical characteristics.

5.3.2.2 Ambient requirements

The ambient noise level shall be at least 6 dB below the limits of disturbance given in Clause 4. The ambient level shall be verified periodically or when test results indicate the possibility of non-compliance.

5.4 Test setup for measurement

5.4.1 General test setup for vehicle, boat and device

5.4.1.1 General

The test setup characteristics described in tis clause concern all operating conditions for vehicle/boat/devices.

5.4.1.2 Antenna requirements

5.4.1.2.1 General

At each measurement frequency (including the end frequencies), measurements shall be taken for horizontal and vertical polarization.

Electrical interaction between the antenna elements and the antenna support/guy system shall be avoided.

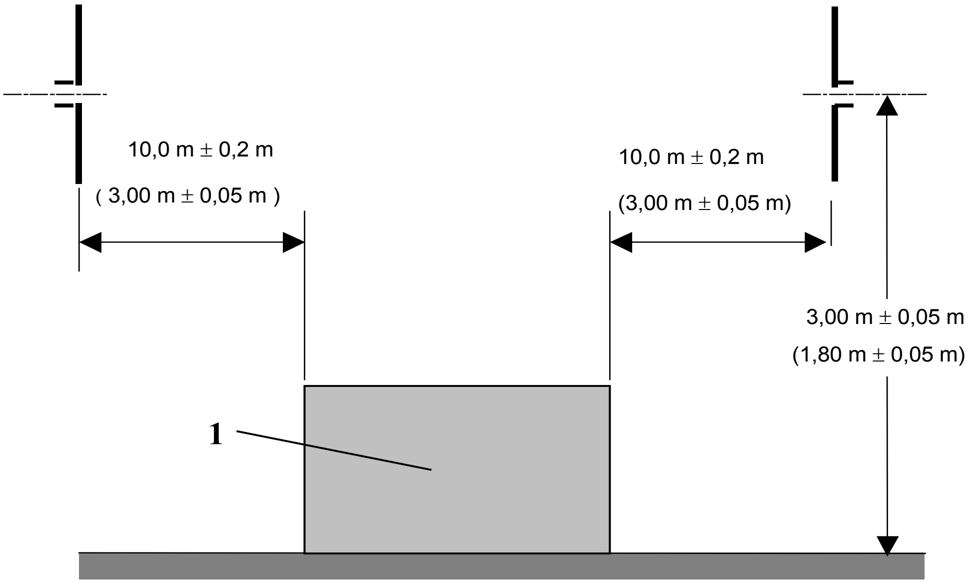
Theoretical considerations of antenna and transmission line geometry demand that the transmission line does not interact electrically with the antenna elements.

NOTE One acceptable transmission line geometry for a dipole antenna routes the transmission line horizontally rearward for a distance of 6 m at a height of 3 m (or 1,8 m for the 3 m antenna distance) before descending to ground level or below. Other geometries are acceptable if they can be shown not to affect the measurements, or if the effects can be included in equipment calibration.

5.4.1.2.2 Height

For an antenna distance of 10 m, the centre of the antenna shall be 3,00 m ± 0,05 m above the ground/floor or water surface. For an antenna distance of 3 m, the height shall be 1,80 m ± 0,05 m.

Antenna height conditions are represented in Figure 6.



(Dimensions in brackets for 3 m antenna distance testing) Drawing not to scale

Key

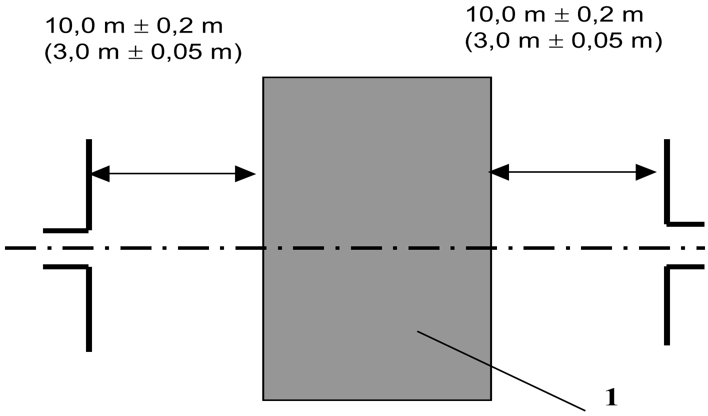
1 Equipment under test

Figure 6 – Antenna height to measure emissions – Elevation view (Vertical polarization shown)

5.4.1.2.3 Distance

The preferred horizontal distance between the reference point of the antenna and the nearest metal part of the vehicle/boat/device shall be 10,0 m ± 0,2 m; as an alternative measurements may be made at a distance of 3,00 m ± 0,05 m.

Antenna distance conditions are represented in Figure 7.



(Dimensions in brackets for 3 m antenna distance testing) Drawing not to scale

Key

1 Equipment under test

Figure 7 – Antenna distance to measure emissions – Plan view (Horizontal polarization shown)

5.4.1.2.4 Position

For vehicle/boat, measurements shall be made on the left and right sides of the vehicle/boat (see Figures 6 and 7)

For devices, measurements shall be made in the direction of the maximum disturbance emission. Where practical, the device under test shall be measured in three orthogonal planes.

Multiple antenna positions are required (both for 10 m and 3 m antenna distance) depending on the vehicle/boat/device length. The same positions shall be used for both horizontal and vertical polarization measurements.

- if the length of the vehicle/boat/device is smaller than the 3 dB beamwidth of the antenna, only one antenna position is necessary. The antenna shall be aligned with the middle of the total vehicle/boat/device length (see Figure 8)

- if the length of the vehicle/boat/device is greater than the 3 dB beamwidth of the antenna, multiple antenna positions are necessary in order to cover the total length of the vehicle/boat/device (see Figure 9). The number of antenna positions shall allow to meet the following condition :

$$N \cdot 2 \cdot D \cdot \tan(\beta) \geq L \quad (1)$$

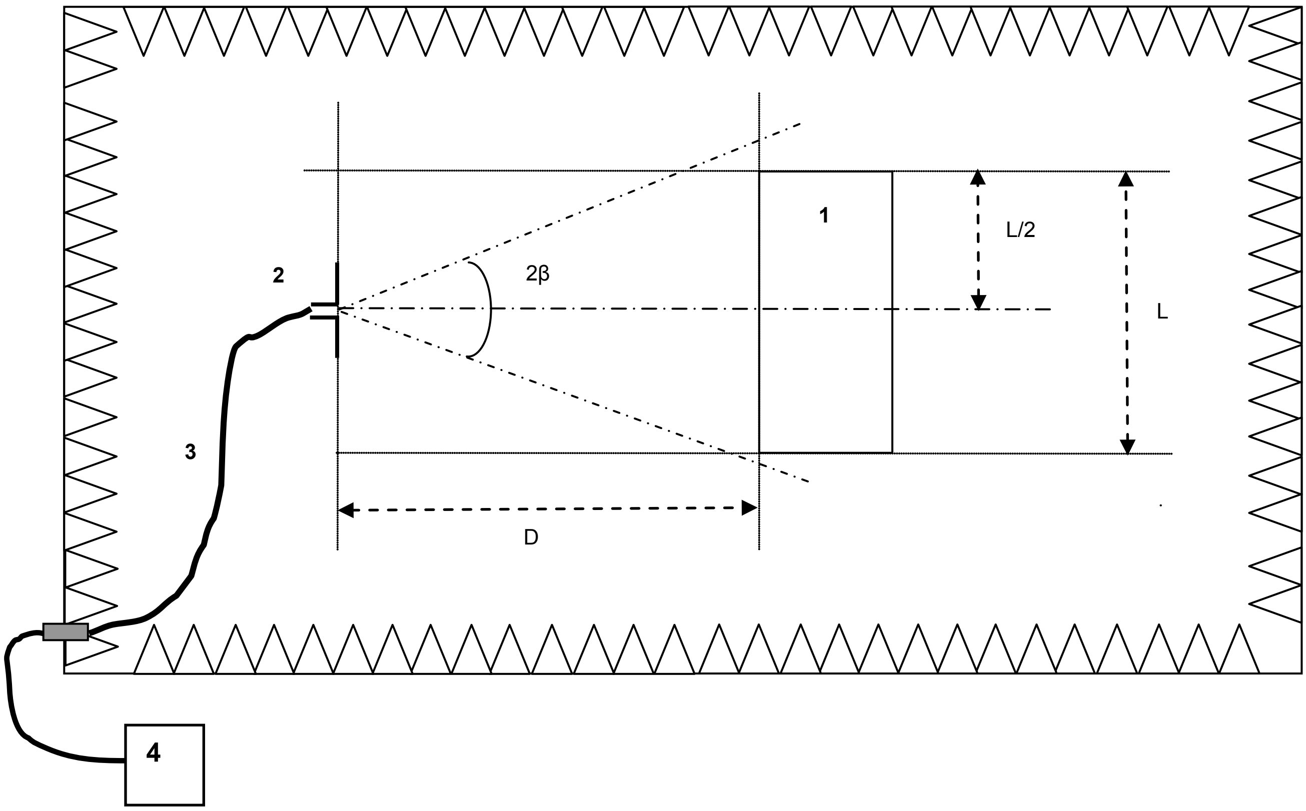
with

N : number of antenna positions

D : measurement distance (3 m or 10 m)

$2 \cdot \beta$: 3 dB antenna beamwidth angle

L : total vehicle/boat/device length



Key

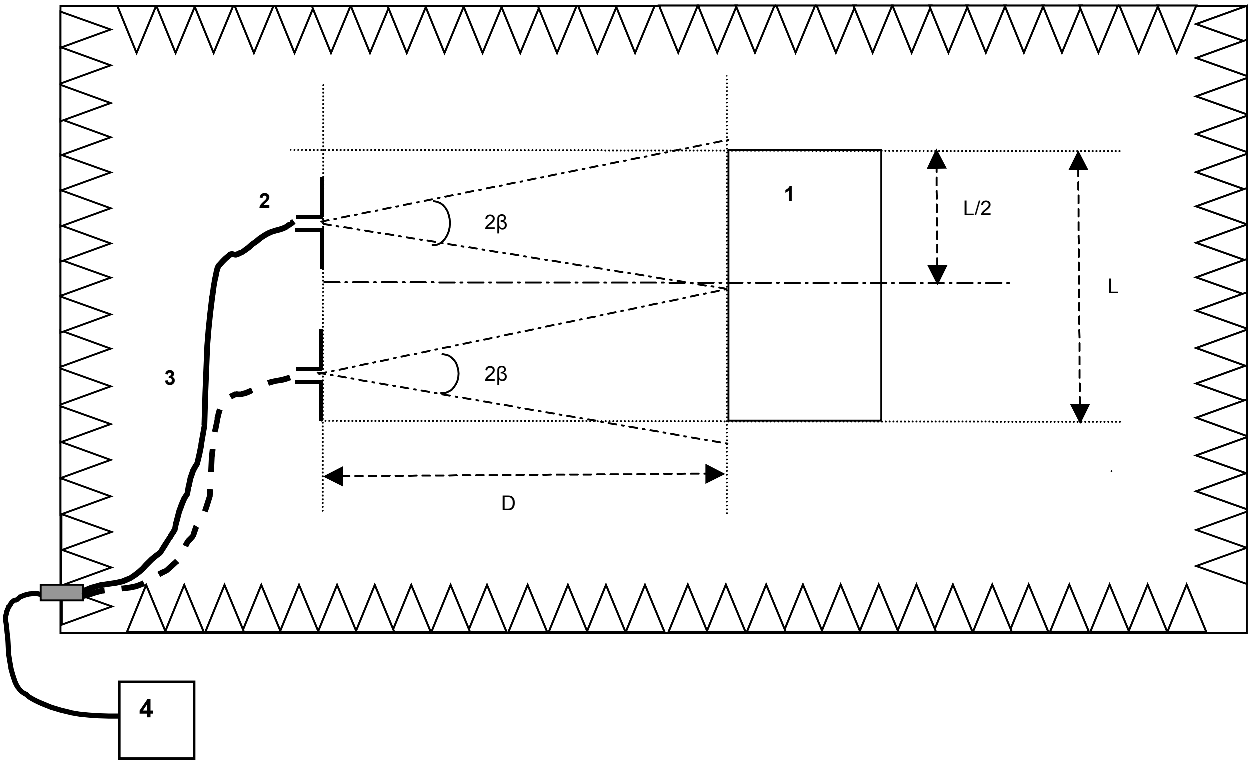
1 Vehicle/boat/device under test

2 Antenna

3 Cable

4 Measuring equipment

Figure 8 – Antenna position when length of the vehicle/boat/device is smaller than the 3 dB beamwidth of the antenna – Horizontal polarisation shown



Key

1 Vehicle/boat/device under test

2 Antenna (two or more positions)

3 Cable

4 Measuring equipment

Figure 9 – Multiple Antenna positions when length of the vehicle/boat/device is greater than the 3 dB beamwidth of the antenna - Horizontal polarisation shown

5.4.1.2.5 Auxiliary (multiple) antennas

Auxiliary antennas are permitted, but if two antennas are facing each other, one shall be vertically polarized while the other is horizontally polarized.

The test site clear area requirement of 5.3.1.1 and 5.3.1.2 shall be applied also to the point midway between the vehicle/boat/device and the auxiliary antenna(s).

5.4.1.2.6 Multiple antenna positions

Multiple antenna positions can be avoided in the case where the measured emissions are lower than the original limit values minus a gain reduction calculated from the geometric dimensions of the test set-up and the antenna gain data (see Annex A).

NOTE A typical log periodic antenna has a 3 dB beamwidth of approximately 60°. This results in about 3,5 m of illumination at 3 m antenna distance, e.g. 1,75 m either side of the antenna centreline. Thus, a vehicle 8 m long requires three antenna positions on each side to quantify the radiation signature of that vehicle.

5.4.2 Test setup for vehicle in charging mode

5.4.2.1 General

The test setup characteristics described in this clause are specific for charging mode operating conditions.

Examples of test set-ups are shown in Figures 10 and 11.

5.4.2.2 AC power charging without communication

This configuration concerns only charging mode without communication lines.

5.4.2.2.1 Power mains

The power mains socket can be placed anywhere in the test location with the following conditions:

- It shall be placed on the ground plane.
- The length of the harness between the power mains socket and the AMN(s) shall be kept as short as possible.
- The harness shall be placed as close as possible to the ground plane.

5.4.2.2.2 Artificial network

Power mains shall be applied to the vehicle through 50 µH/50 Ω artificial networks (AMN(s)) (see Annex G).

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

The measuring port of each AMN shall be terminated with a 50 Ω load.

The power charging cable shall be placed in a straight line between the AMN(s) and the vehicle charging plug and shall be routed perpendicularly to the vehicle longitudinal axis (see Figures 10 and 11).

5.4.2.2.3 Power charging cable

The power charging cable shall be placed in a straight line between the AMN(s) and the vehicle charging plug. The projected cable length shall be 0,8 (+0,2 / -0) m as shown in Figure 10.

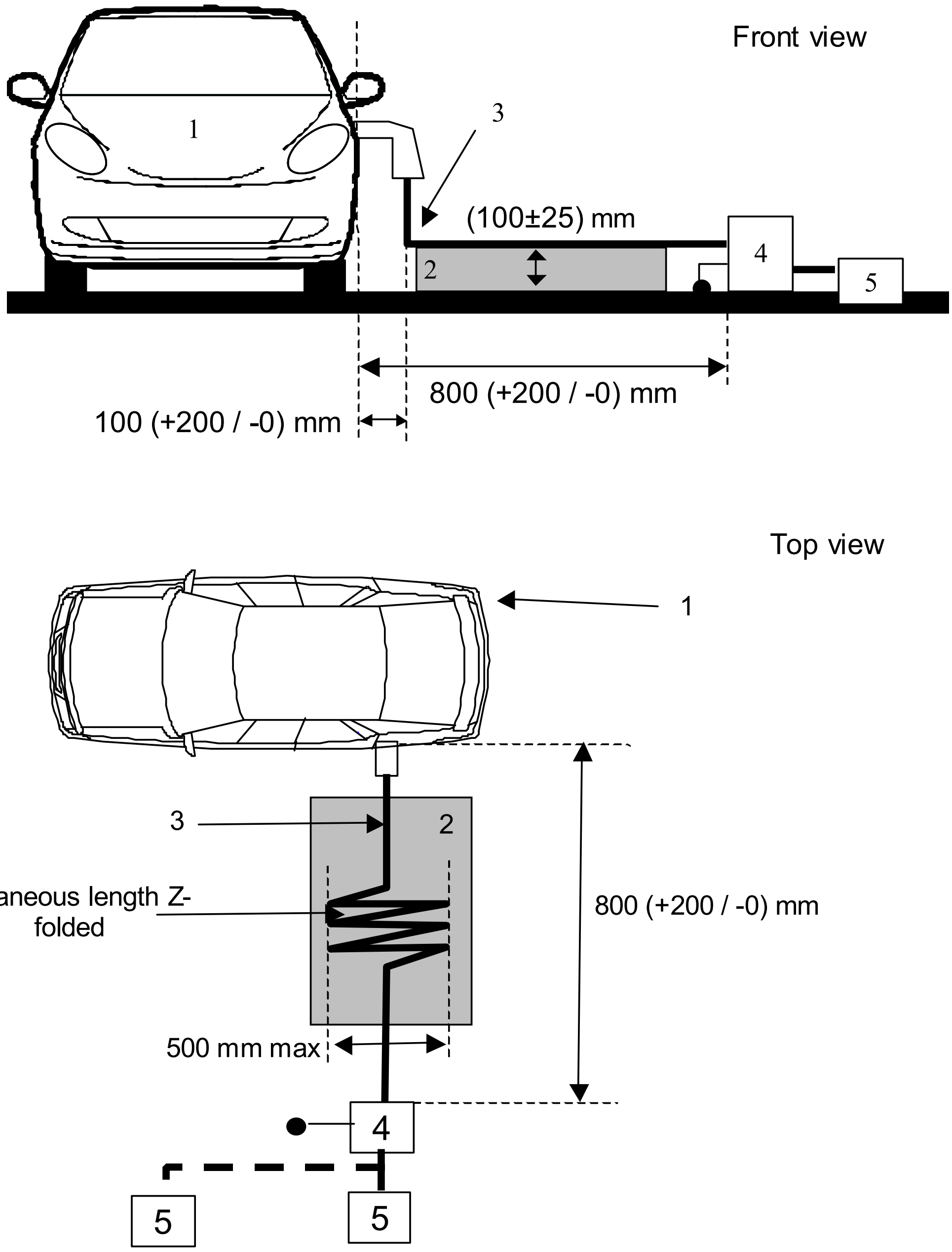
If the length of the cable is longer than 1 m, the extraneous length shall be “Z-folded” in less than 0,5 m width. If it is impractical to do so because of cable bulk or stiffness, or because the testing is being done at a user installation, the disposition of the excess cable shall be precisely noted in the test report.

The charging cable at the vehicle side shall hang vertically at a distance of 100 (+200 / -0) mm from the vehicle body.

The whole cable shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\varepsilon_r \leq 1,4$), at (100 ± 25) mm above the ground plane.

5.4.2.2.4 Antenna position

The measuring antenna shall be placed as defined in clause 5.4.1.2.4. The position of the charging cable between the vehicle and the AMN shall be kept identical for the left and right side measurements.



Key

1 Vehicle/boat under test

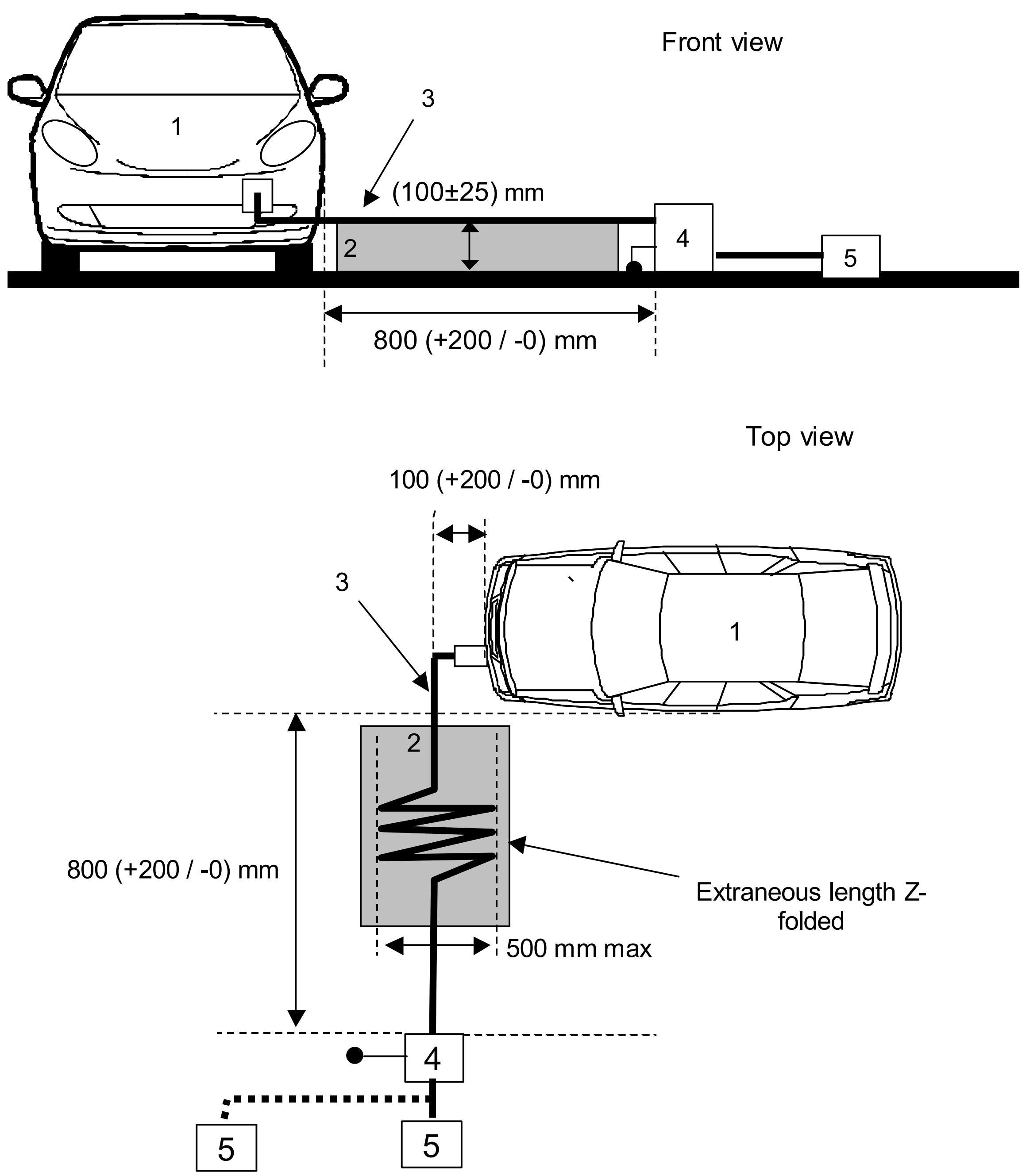
2 Insulating support

3 Charging cable

4 Artificial Mains Network(s) grounded

5 Power mains socket (see 5.4.2.2.1)

Figure 10 – Example of test setup for vehicle with plug located on vehicle side (AC powered without communication)



Key

1 Vehicle/boat under test

2 Insulating support

3 Charging cable

4 Artificial Mains Network(s) grounded

5 Power mains socket (see 5.4.2.2.1)

Figure 11 – Example of test setup for vehicle with plug located front / rear of vehicle (AC powered without communication)

5.4.2.3 AC or DC power charging with communication line(s) or with signal line(s)

5.4.2.3.1 General

This configuration concerns charging mode for AC power and for DC power using communication lines. Wired network ports (as defined in CISPR 32) shall be terminated by an AAN as defined in Annex G.

Note: Lines used for communication and signalling between vehicle and charging station cannot be considered as “wired network ports” if limited to private/local communication (short range point to point communication), e.g. control pilot line, CAN lines.

Examples of test set-ups are shown in Figures 12 and 13.

5.4.2.3.2 Charging station / Power mains

The charging station may be placed either in the test location or outside the test location.

NOTE 1 If the communication between the vehicle and the charging station can be simulated, the charging station may be replaced by the supply from power mains

In both cases duplicated power mains and communication or signal lines socket(s) shall be placed in the test location with the following conditions:

- It shall be placed on the ground plane.
- The length of the harness between the power mains / communication or signal lines socket and the AMN(s) / HV-AN(s) / AAN(s) shall be kept as short as possible.
- The harness between the power mains / communication or signal lines socket and the AMN(s) / HV-AN(s) / AAN(s) shall be placed as close as possible of the ground plane.

NOTE 2 The power mains and communication/signal lines or communication/signal lines socket(s) should be filtered.

If the charging station is placed inside the test location then the harness between charging station and the power mains / communication or signal lines socket shall be placed with the following conditions :

- The harness at charging station side shall hang vertically down to the ground plane.
- The extraneous length shall be placed as close as possible of the ground plane and “Z-folded” if necessary.

NOTE 3 The charging station should be placed outside the beamwidth of the receiving antenna

5.4.2.3.3 Artificial networks

AC Power mains shall be applied to the vehicle through 50 µH/50 Ω AMN(s) (see Annex G).

DC Power mains shall be applied to the vehicle through 5 µH/50 Ω High Voltage Artificial Networks (HV-AN(s)) (see Annex G for the schematic).

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

The measuring port of each AMN / HV-AN shall be terminated with a 50 Ω load.

The power charging cable shall be placed in a straight line between the AMN(s), HV-AN(s) and the vehicle charging plug and shall be routet perpendicularly to the vehicle longitudinal axis (see Figures 12 and 13).

5.4.2.3.4 Asymmetric Artificial Network

Communication lines connected to wired network ports–shall be applied to the vehicle through AAN(s) (see Annex G).

Note: Signal lines may be applied to the vehicle through AAN(s) (see Annex G).

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

The measuring port of each AAN shall be terminated with a 50 Ω load.

The power charging cable shall be placed in a straigth line between the AAN(s) and the vehicle charging plug and shall be routed perpendicularly to the vehicle longitudinal axis (see Figures 12 and 13).

The private/local communication lines between the vehicle and the charging station shall be terminated with the associated equipment on the charging station side to work as designed. The AAN is not connected to these lines.

5.4.2.3.5 Power charging / communication cable

The power charging cable with communication/signal wires shall be placed in a straight line between the AMN(s) / HV-AN(s) / AAN(s) and the vehicle charging plug. The projected cable length shall be 0,8 (+0,2 / -0) m.

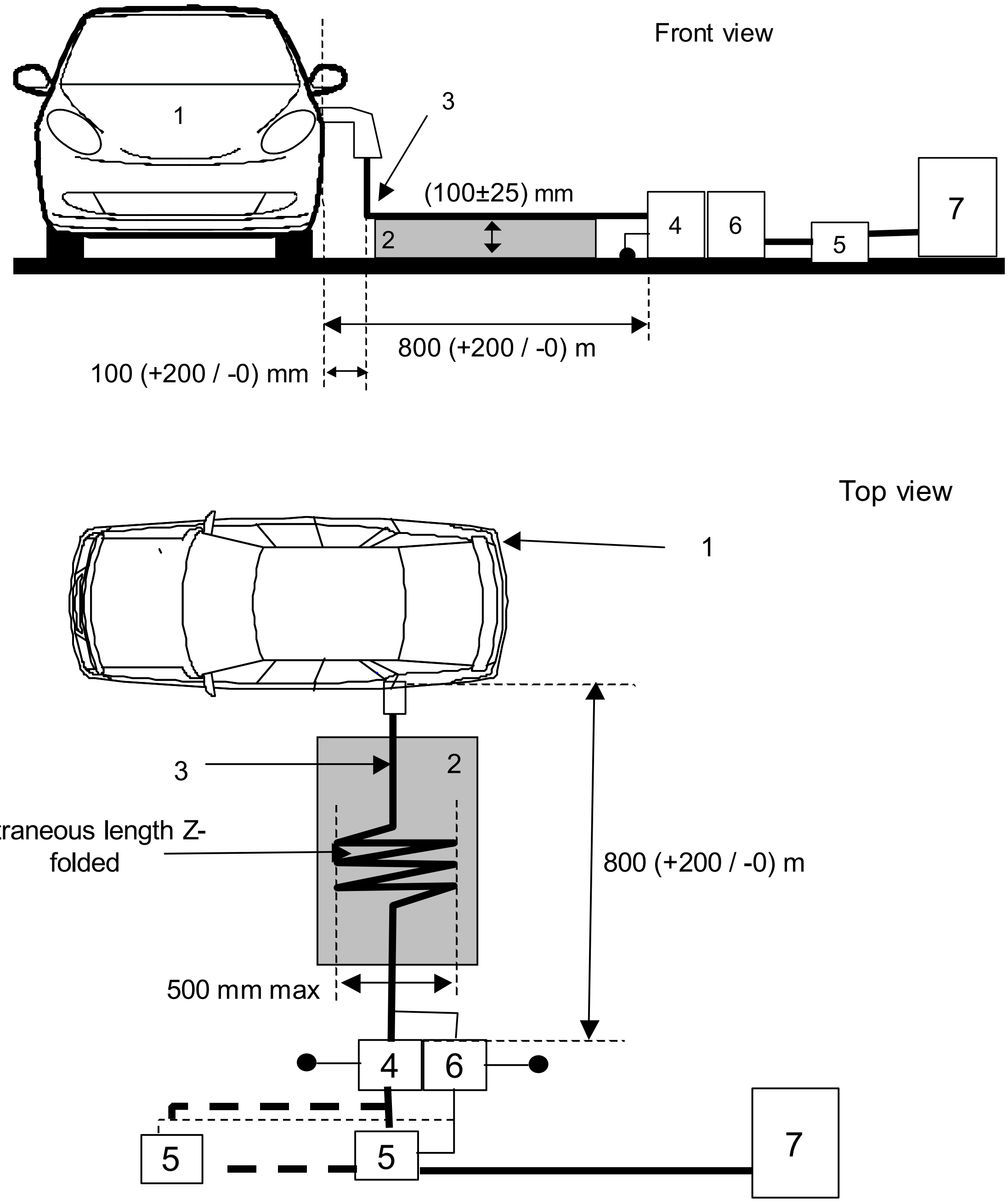
If the length of the cable is longer than 1 m, the extraneous length shall be “Z-folded” in less than 0,5 m width. If it is impractical to do so because of cable bulk or stiffness, or because the testing is being done at a user installation, the disposition of the excess cable shall be precisely noted in the test report.

The charging cable with communication/signal wires at vehicle side shall hang vertically at a distance of 100 (+200 / -0) mm from the vehicle body.

The whole cable shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\varepsilon_r \leq 1,4$), at (100 $\pm$ 25) mm above the ground plane.

5.4.2.3.6 Antenna position

The measuring antenna shall be placed as defined in clause 5.4.1.2.4. The position of the charging cable between the vehicle and the AMN(s) / HV-AN(s) / AAN(s) shall be kept identical for the left and right side measurements



Key

1 Vehicle/boat under test

2 Insulating support

3 Charging cable with communication/signal wires

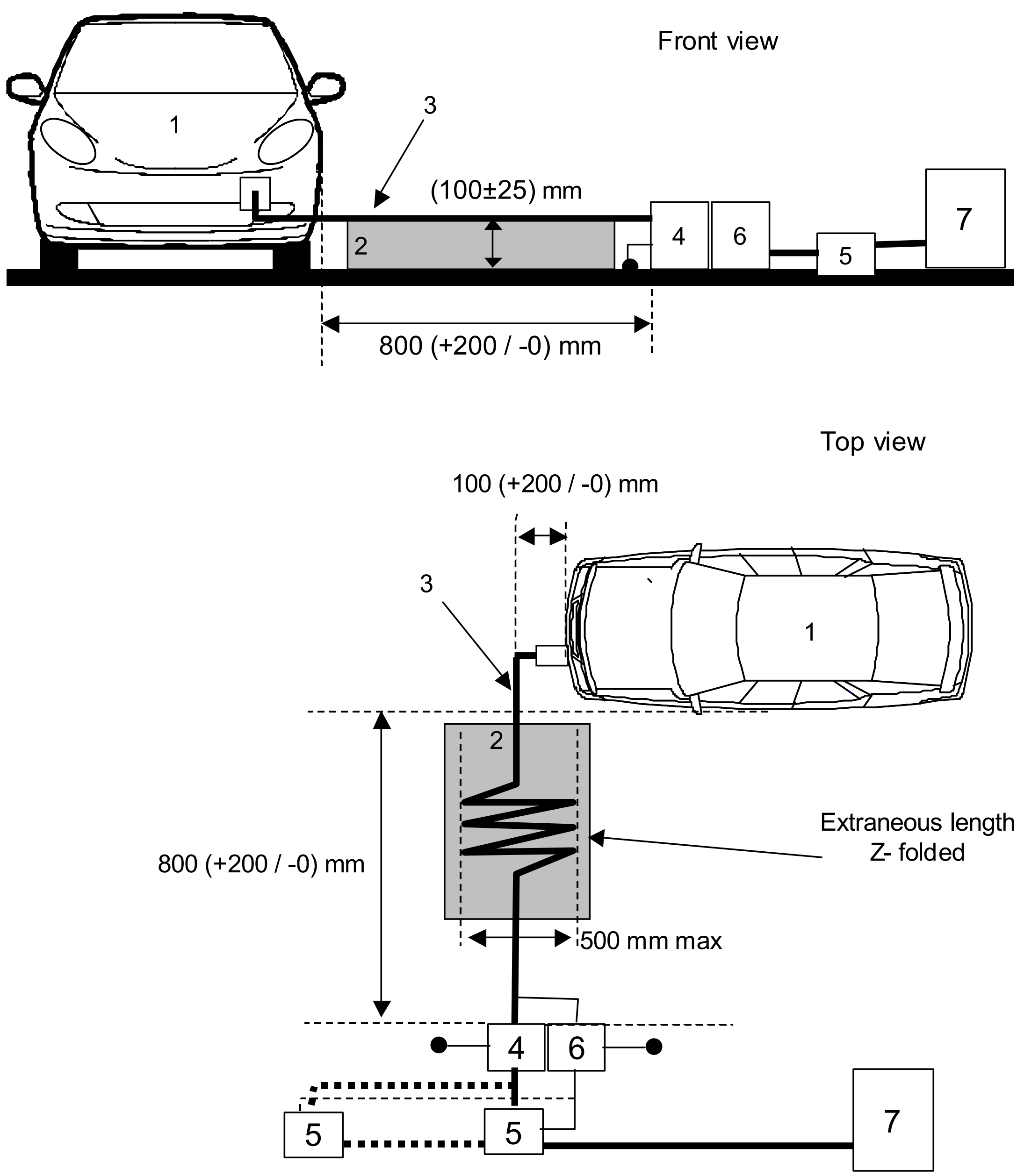
4 AC or DC Artificial Network(s) grounded

5 Power mains socket

6 Asymmetric artificial network(s) grounded

7 Charging Station

Figure 12 – Example of test setup for vehicle with plug located on vehicle side (AC or DC powered with communication)



Key

1 Vehicle/boat under test

2 Insulating support

3 Charging cable with communication/signal wires

4 AC or DC Artificial Network(s) grounded

5 Power mains socket

6 Asymmetric artificial network(s) grounded

7 Charging Station

Figure 13 – Example of test setup for vehicle with plug located front / rear of vehicle (AC or DC powered with communication)

5.4.2.4 Wireless charging

5.4.2.4.1 General

The various configurations are considered in this clause for a wireless power transfer system.

The wireless power transfer (WPT) system mainly consists of a primary device (ground side), a secondary device (vehicle side) and an off-board power unit.

NOTE Wireless power transfer (WPT) refers to the transfer of electrical energy from a power source to an electrical load via electric and or magnetic fields or waves between a primary and a secondary device.

5.4.2.4.2 Off-board power unit

The off-board power unit can be placed outside of the ALSE or anywhere on the ground plane of the ALSE. Care shall be taken to avoid disturbances from the off-board power unit and the primary device.

The harness between the off-board power unit and the primary device shall be placed as close as possible of the ALSE ground plane with a length greater than or equal to 2 m.

If the off-board power unit is placed inside the test location then the harness between the off-board power unit and the primary device shall be placed with the following conditions:

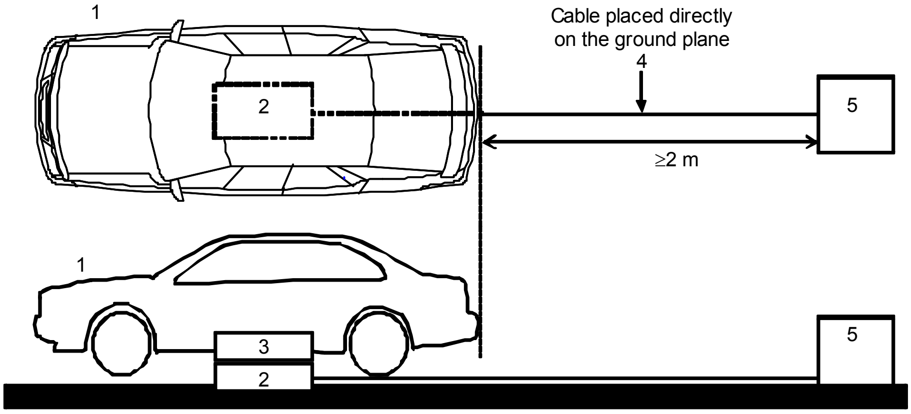
- The harness on the off-board power unit side shall hang vertically down to the ground plane.
- The extraneous length shall be placed as close as possible to the ground plane and “Z-folded” if necessary.

NOTE The off-board power unit should be placed outside the beamwidth of the receiving antenna

5.4.2.4.3 Primary device

The primary device shall be aligned with the vehicle secondary device. The distance between the primary coil and the secondary coil shall be defined in the test plan. If the air gap between the primary and secondary devices should be adjusted, then the transferred power and air gap should be set to the values defined in the test plan.

Example of test set-up is shown in Figure 14.



Key

1 Vehicle under test

2 Primary device (supply device)

3 Secondary device (vehicle)

4 Cable (between primary device and off-board power unit)

5 Off-board power unit

Figure 14 - Example of test setup for vehicle in charging mode through wireless power transmission

5.5 Test object conditions

5.5.1 General

Measurements made while the vehicle/boat/device is dry or made more than 10 min after precipitation has stopped falling are preferred. For outboard engines or propulsion motors and devices, all surfaces normally in contact with water while in use shall be exempt from the dryness criteria.

NOTE Dew or light moisture may seriously affect readings obtained on test objects having plastic enclosures.

For methods of evaluating compliance based on test object dryness see Clause 6.

5.5.2 Vehicles and boats

All equipment which is automatically switched on together with the propulsion system shall be measured while operating in a manner which is as representative of normal operation as possible. The engine shall be at normal operating temperature.

For vehicles or boats with independent electric and internal combustion propulsion systems in the same vehicle or boat, the propulsion systems shall be tested separately.

Auxiliary engines shall be operated in their normal intended manner and tested separately from the main engine, if possible.

When tested separately, inboard, stern drive, and outboard engines or propulsion motors for boats shall be attached to a non-metallic board or non-metallic test fixture and tested in a way similar to that specified for boats with inboard engines/motors.

Measurements shall be made for each of the following operating conditions of vehicles and boats.

- "Key-On, Engine-Off" mode, and
- "Engine-Running" mode
- "Charging mode connected to the power grid" (applicable only for electric or hybrid plug-in with on board charger)

These operating conditions are applicable for vehicles/boats with an internal combustion engine and/or equipped with an electric propulsion motor (including hybrid propulsion systems)

5.5.2.1 "Key-On, Engine-Off" mode operating conditions

The "Key-On, Engine-Off" mode operating conditions are

- The ignition switch shall be switched on.
- The engine shall not be operating.
- The vehicle's electronic systems shall all be in their normal operating mode.

All equipment with internal oscillators >9 kHz or repetitive signals, which can be operated continuously, should be in normal operation.

5.5.2.2 "Engine-Running" mode operating conditions

5.5.2.2.1 Vehicle/boat with internal combustion engine

Vehicles/boats with an internal combustion engine, shall be tested with the engine operated as shown in Table 3. The specified engine speed is the same for quasi-peak or peak measurements.

Table 3 – Internal combustion engine operating speeds

Number of cylinders	**Engine speed** rpm
1	2 500 ± 10%
>1	1 500 ± 10%

5.5.2.2.2 Vehicle/boat with an electric propulsion motor

Vehicles/boats equipped with an electric propulsion motor shall be tested with the vehicle driven on a dynamometer without a load, or on non-conductive axle stands, with a constant speed of 40 km/h ± 20%, or the maximum speed, if this is less than 40 km/h

5.5.2.2.3 Vehicle with hybrid propulsion system

The vehicle shall be tested:

- either in a single mode:

  Vehicles driven on a dynamometer without a load, or on non-conductive axle stands, with both the electrical and the internal combustion propulsion systems functioning to operate the vehicle at 40 km/h ± 20%.

The value of the engine speed shall be recorded in the test report.

Note when possible the engine speed should be at (1 500 ± 150) rpm

- or in two modes

Internal combustion engine operating alone: operating conditions defined in 5.5.2.2.1.

Electric propulsion system operating alone: operating conditions defined in 5.5.2.2.2.

5.5.2.3 "Charging mode" operating conditions

The vehicle/boat "Charging mode" operating conditions are:

- In an unladen condition except for the necessary test equipment.
- Immobilized, engine off and in charging mode:

  The state of charge (SOC) of the traction battery shall be kept between 20 % and 80 % of the maximum SOC during the whole frequency range measurement (this may lead to split the measurement in different sub-bands with the need to discharge the vehicle's traction battery before starting the next sub-bands). If the current consumption can be adjusted in case of conductive charging, then the current shall be set to at least 80% of its nominal value. For WPT the transferred power shall be kept between 20% and 80% of the nominal value unless otherwise specified in the test plan. The air gap should be set to the value defined in the test plan, if it is adjustable.
- All the other equipment which can be switched on permanently by the driver or passenger shall be off.

5.5.3 Devices

The operating conditions for devices ("Key-On, Engine-Off" mode, "Engine-Running" mode and "charging mode"), operation position(s), height(s) and load condition(s) shall be defined in the test plan and documented in the test report.

Depending on the situation, the following conditions shall also be taken into account:

- if the operating position and height are variable, the device to be tested shall be so positioned that the spark-plug is 1,0 m ± 0,2 m above the ground;
- no operator shall be present, but, if necessary, a mechanical arrangement shall be made, using non-metallic material as far as possible, to keep the device in normal position(s) and at the specified engine speed.

5.6 Data collection

The entire required frequency range shall be measured.

The results of average, quasi-peak and peak measurements shall be expressed in terms of dB (μV/m) for statistical evaluation.

The results of peak measurements shall be expressed in accordance with the bandwidth shown in Figure 2.

6 Methods of checking for compliance with CISPR requirements

6.1 General

Some differences in the construction of vehicles/boats/devices are unlikely to have a significant effect on ignition noise emissions.

6.2 Application of limit curves

6.2.1 Measurements under dry conditions

Certification measurements made while the vehicle/boat/device is dry (see 5.5.1), or made more than 10 min after the precipitation has stopped falling shall use the limit curves shown in Figures 2 and 3.

6.2.2 Measurements under wet conditions

If circumstances dictate that type approval measurements be made while precipitation is falling, or within 10 min after it has stopped, the vehicle/boat/device shall be deemed to comply with the requirements of this standard if the measured levels do not exceed a level of 10 dB below that shown in Figures 2 and 3.

6.3 Evaluation (General)

For evaluation of a vehicle/boat/device the data from a complete scan shall be used.

For statistical analysis of multiple vehicles/boats/devices, the characteristic levels and calculation process of CISPR 16-4-3 shall be used. The levels shall be compared to the limit at the representative frequency for the appropriate sub-band.

Annex A
(normative)

Procedure to determine an alternative emission limit for measurements

Calculate the maximum antenna angle α_{max} from the vehicle dimensions, the antenna distance (vehicle surface – antenna reference point), and the antenna position (see Figure A.1).

Example: d = 3 m, vehicle length = 5 m → α_{max} . = 40°.

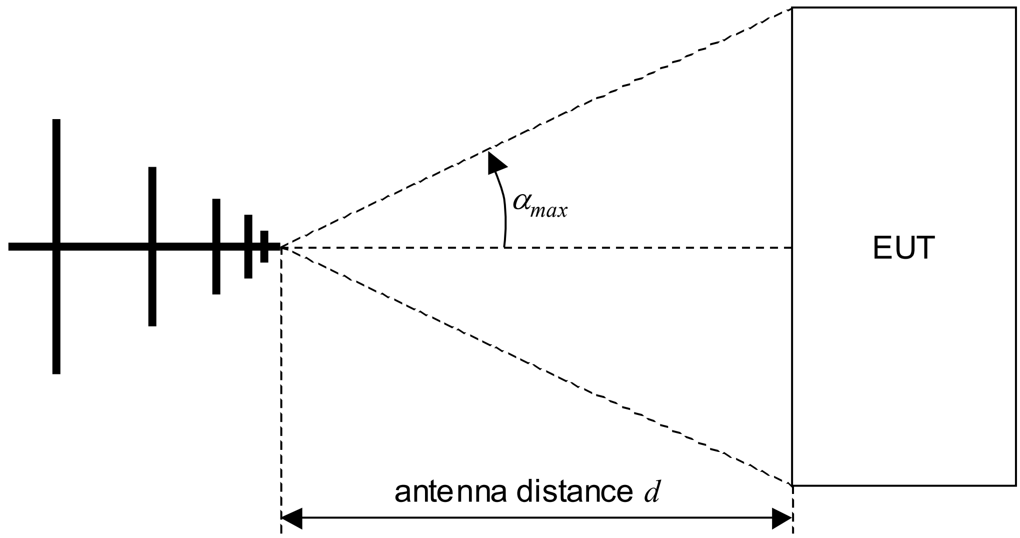


Figure A.1 – Determination of the maximum antenna angle

Read from the antenna directional pattern the gain reduction a_{max} at the maximum antenna angle α_{max} (see Figure A.2).

Because antennas have a frequency dependent gain, either the maximum gain reduction over the whole frequency range (typically at the highest frequency) has to be used or the gain attenuation shall be determined for a number of frequency steps. In each of those frequency sub-bands the local maximum gain reduction shall be used.

Example: for a log-periodic antenna (80 MHz to 1 000 MHz) and α_{max} = 40° this leads to a_{max} = 6 dB (VULB 9160 200 MHz E-plane).

NOTE 1 Reference for the gain is the reference antenna (see 5.1.2.1)

NOTE 2 The radiation pattern provided from the manufacturer can be used unless visible damage of the antenna can be observed.

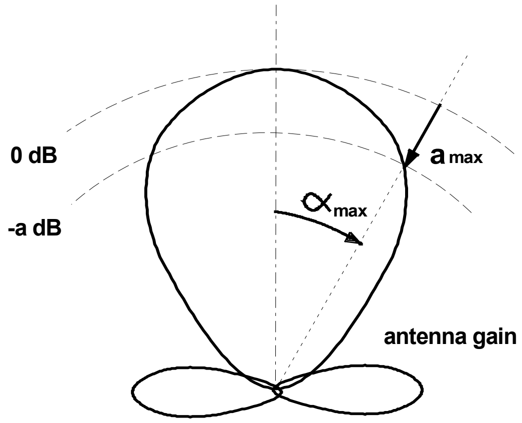


Figure A.2 – Calculation of the resulting gain reduction *a*

Calculate the alternative emission limit by subtracting from the original limit line the absolute value of the maximum gain reduction a_{max}.

Annex B
(informative)

Antenna and coaxial cable maintenance and characterization

B.1 Introduction

This annex contains, for guidance, an example of an antenna and coaxial cable characterization procedure that complies with the intent of 5.1.3. Proper antenna and coaxial cable characterization is essential to account for cable loss and mismatch errors, and to define the antenna factor for a broadband antenna, if used. Because coaxial cables used for transmission lines are subject to much wear and possible abuse, a suggested procedure is included to be used when cables require replacement.

This report is intended to be tutorial in nature, as an aid for those who may not be familiar with antenna and transmission line characterization. Other methods, such as those using tracking generators, network analysers, or narrowband signal sources may be equally satisfactory and nothing in this annex should be interpreted as precluding their use.

B.2 Maintenance

Characterization of antennas and cables as a combination or individually is at the option of the user. It is highly recommended, however, that they be characterized separately because:

- frequently, antennas are supplied without cables;
- any cable may be used with any antenna without need for characterization of the combination;
- cables are easier to characterize than antennas and almost any test facility can characterize them. Some laboratories may not be able to characterize complex antennas with their associated coaxial cables easily;
- either the antenna or cable can be modified or replaced without need to characterize the other.

B.2.1 Periodic checks required

B.2.1.1 Cables

Checks should be made monthly, contingent upon whether the cables are handled or flexed frequently, or if they are exposed to sun and weather for long periods.

NOTE Even cables in conduits can develop problems, if temperature and humidity are uncontrolled.

B.2.1.2 Antennas

Because they are subject to less wear than cables, antennas may be checked less frequently, possibly only once or twice per year.

B.2.1.3 Physical examination

B.2.1.3.1 Cables

Serious kinks (very sharp bends), flat spots, abrasions, stretched spots, damaged connectors/braid, contamination of the inner insulation, or ageing of the cable shall require replacement and characterization.

B.2.1.3.2 Antennas

Broken elements or other obvious mechanical problems shall be corrected or parts replaced. Characterization is required.

B.2.1.4 Electrical examination

Antennas and cables shall be checked for higher loss and other problems periodically. If a characteristic such as loss has changed, the antenna, the cable, or the combination shall be characterized. Severe changes in characteristics may require replacement and characterization.

B.2.2 Cable and antenna characterization

The following requirements apply when the transmission line cable or antenna is replaced:

B.2.2.1 If the antenna factor data contains the loss and other characteristics of a specific cable in combination with the antenna, they shall be considered a matched pair. If either is replaced, the combination shall be characterized.

B.2.2.2 If the antenna and cable have been characterized separately with separate losses, etc. replacement of either shall require characterization only of that portion replaced.

B.3 Antenna characterization

Electric field strength shall be expressed in units of dB (μV/m). The relationship expressing electric field strength to the measurement system is:

$$E = V + F_a + a_c \qquad \text{(B.1)}$$

where

E is the electric field strength in dB (μV/m)

V is the instrument reading in dB (μV)

F_a is the antenna factor in dB (1/m), defined in Clauses B.5 or B.6.

a_c is the cable loss in dB, defined in Clause B.7.

For broadband measurements, *E* and *V* are a function of the measuring receiver bandwidth.

B.4 Preferred antenna

See 5.1.2.1.

B.5 Antenna factor

The factor relating the field strength at the reference point of the antenna to the loaded antenna terminal voltage (see Note 1) is called the antenna factor, designated F_a, expressed in dB (1/m). The antenna factor shall include the effects of baluns, impedance matching devices, any mismatch losses, and operation outside the resonant frequency of the antenna.

NOTE 1 As this is a voltage ratio, the calculations to convert to decibels should be made using the factor of 20 lg of the ratio of the parameters.

NOTE 2 This factor is a function of frequency and is usually provided by manufacturers of resonant dipoles. Knowledge of the antenna factor for free space operation for resonant dipoles is sufficiently accurate for purposes of this international standard. Greater accuracy can be obtained by knowing the antenna factor for the particular resonant dipole being used in the test environment. A method for determining antenna factor is described in ANSI C63.5 (see Clause B.14).

B.6 Alternate antennas

The antenna factor for the alternate antenna is the antenna factor for the reference antenna (resonant dipole) minus the gain (dB) of the alternate antenna relative to the reference antenna.

B.7 Coaxial cable

The cable loss shall be measured over the test frequency range. The factor is designated *T* and is:

$$a_c = 20 \cdot \lg\left(\frac{\text{input voltage}}{\text{output voltage}}\right) \text{ dB} \qquad \text{(B.2)}$$

NOTE It is recommended that the coaxial cable be double braided or solid shielded to achieve proper shielding. It is permissible that cable loss and mismatch errors be accounted for by including the cable in the measuring receiver calibration. When this is done, a_C is dropped from equation (B.1) for *E*.

B.8 Alternate antenna characterization instrumentation

The prime function of the characterization instrumentation is to provide a repeatable RF field for the comparison of an alternate antenna to the reference dipole antenna.

B.8.1 Characterization signal generator

A measuring receiver with a built-in tracking generator or a network analyser or a signal generator together with a measuring receiver shall be used for alternate antenna characterization.

The output of the characterization signal generator shall be known to within ±1,0 dB. The characterization signal generator shall be capable of creating an electric field at least 6 dB above the least measurable field strength of the measuring receiver. A value of at least 10 dB is preferred.

A less accurate characterization signal generator is the impulse generator.

NOTE 1 If a broadband impulse generator is used, it should be capable of producing an uniform spectrum to within ±3,0 dB in the frequency range 30 MHz to 1 000 MHz.

NOTE 2 Experience indicates that an impulse generator that has a nominal 100 dB (µV/kHz) level can produce a field of approximately 10 dB (µV/m/kHz) at the receiving antenna when a 10 dB impedance matching attenuator is used at the output of the generator. This field strength varies depending on transmitting antenna losses and radiation characteristics and on propagation anomalies. This approximate value is provided so that the antenna factor determination can be performed. It is then possible to estimate the required sensitivities and the tolerable losses in the measuring system.

B.8.2 Transmitting antenna

For ease in measurement and to assure freedom from variation caused by antenna adjustment, it is recommended that broadband antennas be used. Typical antennas are the biconical for 30 MHz to 200 MHz, and the log periodic for 200 MHz to 1 000 MHz.

B.9 Alternate antenna factor determination

If an alternate antenna (see Clause B.6) is used, the antenna factor shall be determined by a substitution technique in the intended test environment. The reference shall be the dipole (see Clause B.4). The radiated field to be measured for the substitution technique is generated by the transmitting antenna and the characterization signal generator as specified in Clause B.8.

NOTE Error factors associated with this procedure include non-linearity of the measuring receiver, influence of the surroundings on the reference antenna and possible change in location of the alternate antenna phase centre relative to that of the reference antenna.

B.10 Test geometry

The alternate antenna shall be located at its intended test position. When substitution occurs, the dipole shall be placed so that its reference point is placed at the precise place that the reference point for the alternate antenna normally occupies. The reference point of the antenna is defined as:

– the phase centre (mid-point) for a dipole antenna,

– the phase centre (mid-point) for a biconical antenna,

– the tip or any specific point along the longitudinal axis for an antenna with log-periodic elements (including biconilog antennas).

The transmitting antenna shall be 10 m in horizontal distance from the alternate antenna reference point in Figure B.1 (taking the place of the nearest vehicle periphery) and shall be 1 m high.

For the 3 m antenna distance, the transmitting antenna shall be 3 m in horizontal distance from the alternate antenna, as in Figure B.1.

B.11 Test procedure

The procedure to be used is to measure the reference field with the reference antenna positioned as in Clause B.10 to obtain a meter reading (usually voltage). Then the alternate antenna is substituted and a second reading is taken.

The antenna factor for the alternate antenna is calculated as discussed in Clause B.6. This procedure should be conducted for both horizontal and vertical polarizations to determine whether different antenna factors are required for each of the two cases.

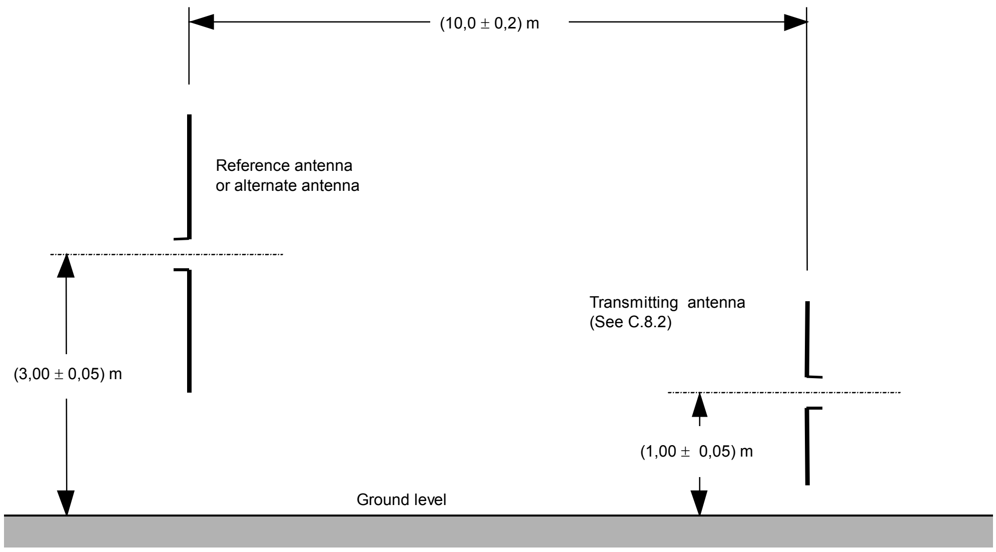
NOTE The antenna factor of the reference antenna may be assumed to be the same for both polarizations.

B.12 Frequencies

The number of frequencies at which antenna factor values are required depends on the alternate antenna being evaluated. A sufficiently large number of frequencies shall be considered to describe the function adequately.

B.13 Complete system verification

The complete measurement system comprised of antenna, coaxial cable, measuring receiver and readout devices shall be verified by measuring an electric field established with the characterization signal generator and antenna(s) described in B.8. This verification shall be made on a periodic basis so that any change in system performance can be detected (see Figure B.1).



Drawing not to scale

NOTE For 3 m antenna distance the 10,0 m ± 0,2 m horizontal dimension changes to 3,00 m ± 0,05 m; the 3,00 ± 0,05 m vertical dimension changes to 1,80 m ± 0,05 m.

Figure B.1 – Alternate antenna factor determination (10 m antenna distance)

B.14 Reference document

ANSI C63.5, *American National Standard for Calibration of Antennas used for Radiated Emission Measurement in Electromagnetic Interference (EMI) Control – Calibration of Antennas (9 kHz to 40 GHz). American National Standards Institute, 11 West 42nd Street, New York, NY 10036, USA.*

Annex C
(informative)

Measurement of the insertion loss of ignition noise suppressors

C.1 Introduction

Two methods of measurement of the insertion loss of ignition noise suppressors are used.

C.1.1 CISPR box method (50/75 Ω laboratory method)

This method is described in Clause C.3.

C.1.2 Field comparison method

In this method, the insertion loss of the suppressor (or set of suppressors) is determined from the measurement of interference field strength caused by the vehicle/boat/device on the open test site. It is evaluated according to the formula:

$$A = E_1 - E_2 \qquad \text{(C.1)}$$

where:

E_1 is the field strength caused by the ignition system without suppressors, expressed in dB (μV/m);

E_2 is the field strength caused by the same ignition system but with suppressors (or set of suppressors) expressed in dB (μV/m).

NOTE Field strength is to be measured in accordance with Clause 5.

C.2 Comparison of test methods

C.2.1.1 CISPR box method

With the help of the CISPR box method, it is possible to compare only the characteristics of single suppressors of the same kind under standard laboratory conditions. At present, this method is used in the frequency range from 30 MHz to 300 MHz. Results obtained have no significant correlation with the efficiency of suppressors observed in practice. This method does not allow measurement of a set of suppressors consisting, for example, of four resistors and five cables with distributed attenuation. Nevertheless, it provides a means of quick control, for instance of suppressors during manufacture after previous verification of their effectiveness in actual conditions.

C.2.2 Field comparison method

The field comparison method may be considered the reference method since the results obtained give the insertion loss of suppressors observed in practice. It automatically takes into account all the factors influencing the insertion loss and it has no limitations in frequency range. Its main disadvantage is the need to perform measurements on an open test-site (or in an absorber lined shielded enclosure as specified in 5.2.2) and the need to test the complete vehicle/boat/device.

C.3 CISPR box method (50/75 Ω laboratory method of measurement of insertion loss of ignition noise suppressors)

C.3.1 General conditions and limitations of measurement

The insertion loss of an ignition noise suppressor is measured with the test circuit shown in Figure C.1. This method is intended to be used only as a comparative method for suppression devices of the same type and is not intended to give direct correlation with emission measurements.

C.3.2 Test procedure

In Figure C.1, the coaxial switches (2) are adjusted so that the signal from the signal generator (1) is passed through the test box (4) and the specimen under test (5) giving an indication on the output indicator of the measuring receiver (7). Fixed "T" attenuators (3) have a loss of 10 dB.

The coaxial switches (2) are then turned so that the signal passes through the calibrated variable attenuator (6), which is adjusted to give the same indication on the output indicator of the measuring receiver (7). The insertion loss of the ignition noise suppressor is then given by the attenuation read on the calibrated variable attenuator (6) minus the attenuation of the fixed attenuators (3).

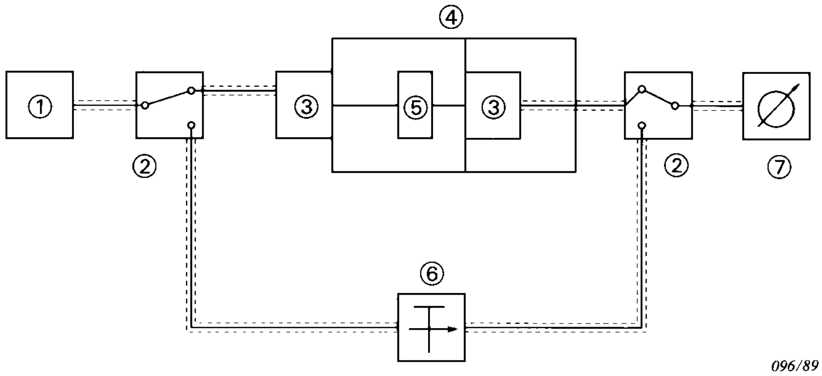
C.3.3 Test box construction

Details of the usual test box are shown in Figures C.2 to C.4. For the majority of applications, this box is applicable: however, hole positions and box size may require modification for some applications. The arrangement of the suppressors in the test box is shown in Figures C.5 to C.11. All non-coaxial connecting leads within the CISPR box to the suppressors under measurement shall be kept as short as possible, or of specified length where shown. In all arrangements the spark-plug is modified to accept a coaxial input and is constructed from a standard spark-plug assembly having a direct connection between the spark-plug terminal and the central electrode.

C.3.4 Results

For ignition noise suppressors having a high impedance, the insertion loss a_1 in a circuit having a characteristic impedance z_1 can be converted to the insertion loss a_2 in a circuit having a characteristic impedance z_2; the following formula applies:

$$a_2 = a_1 + 20 \cdot \lg\left(\frac{z_1}{z_2}\right) \qquad \text{(C.2)}$$



1097

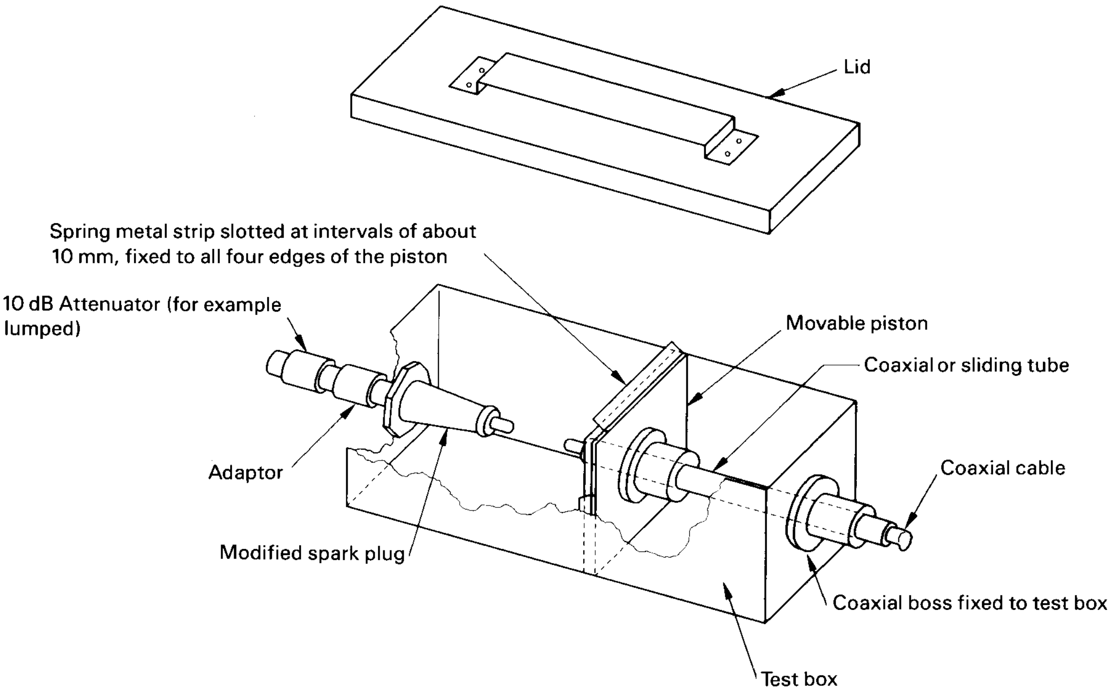
Key

①	Signal generator	⑤	Specimen under test
②	Coaxial switch	⑥	Calibrated variable attenuator
③	Fixed ”T” attenuator (10 dB)	⑦	Measuring receiver
④	Test box		

1098 Items ①, ②, ③, ⑥ and ⑦ shall have the same characteristic impedance.

1099 **Figure C.1 – Test Circuit**

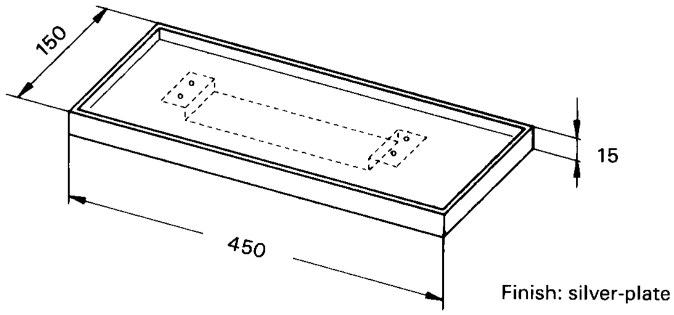
1100



1101

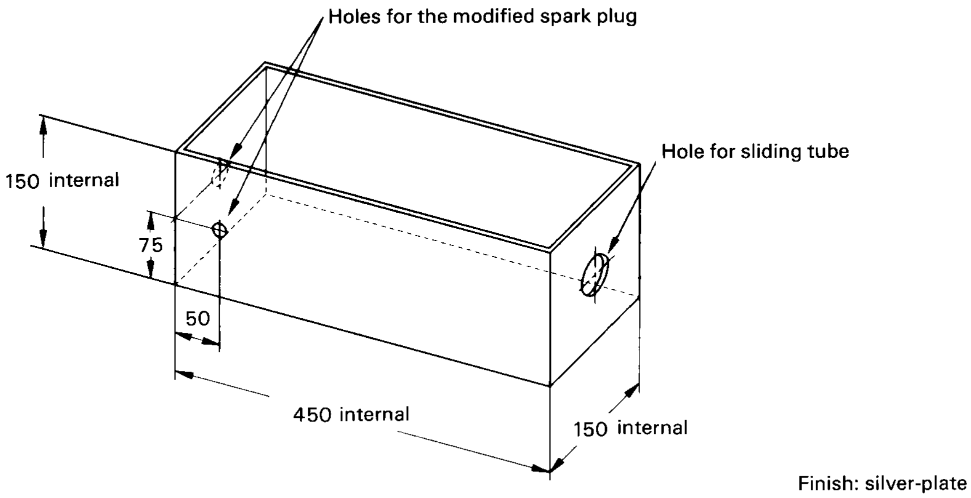
1102 **Figure C.2 – General arrangement of the test box**

1103



NOTE Lid made to give U-shaped overlapping push fit on to upper face of the test box.

Figure C.3 – Details of the test box lid



Dimensions in millimetres

Figure C.4 – Details of the test box

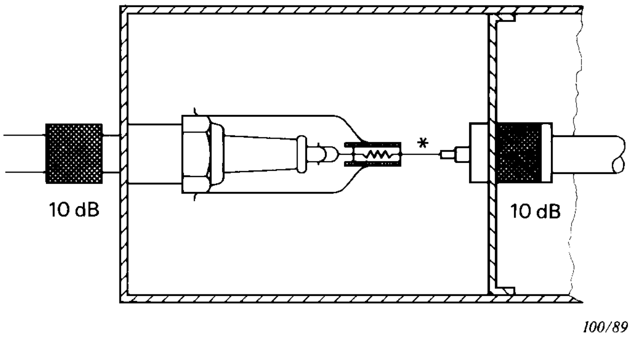


Figure C.5 – Straight spark-plug ignition noise suppressor (screened or unscreened)

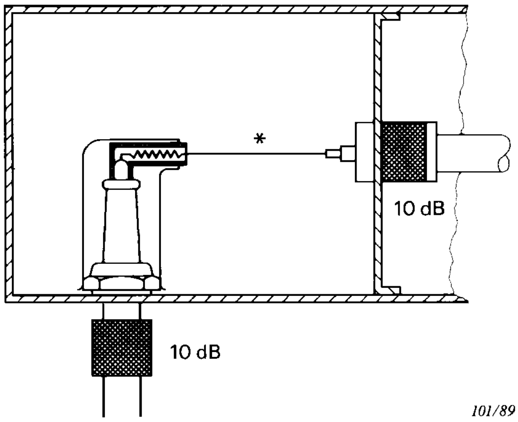


Figure C.6 – Right-angle spark-plug ignition noise suppressor (screened or unscreened)

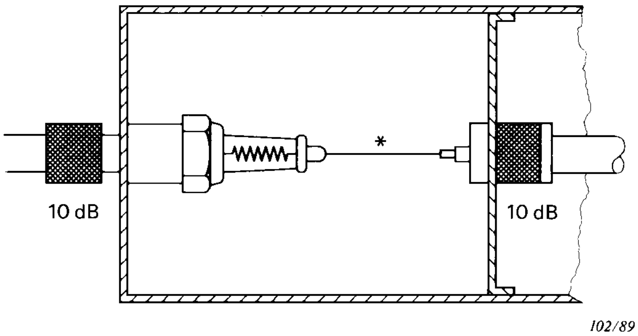


Figure C.7 – Noise suppression spark-plug

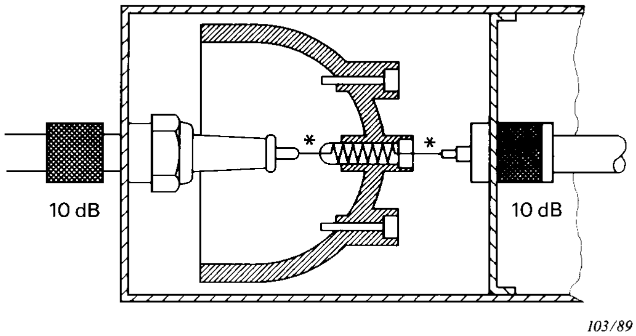


Figure C.8 – Resistive distributor brush

* All connecting leads to noise suppressors under measurement to be kept as short as possible or of specified length where shown.

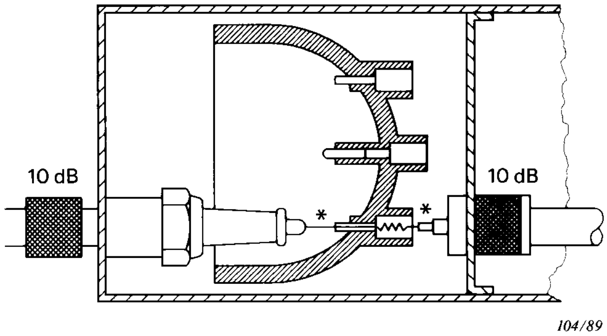


Figure C.9 – Noise suppressor in distributor cap

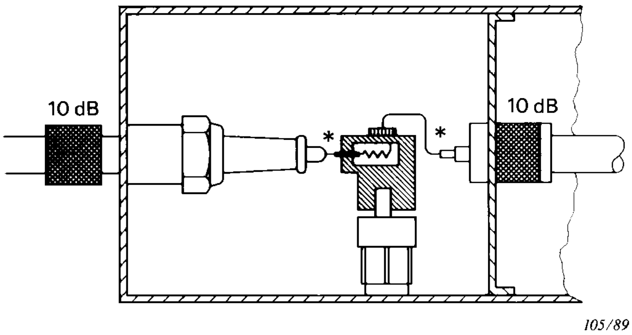


Figure C.10 – Noise suppression distributor rotor

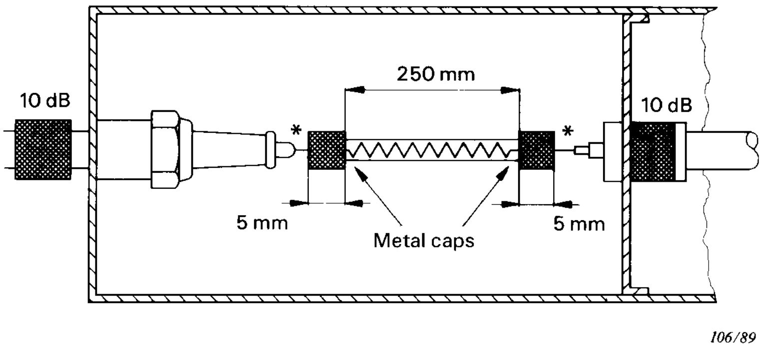


Figure C.11 – Noise suppression ignition cable (resistive or reactive)

* All connecting leads to suppressors under measurement to be kept as short as possible or of specified length where shown.

Annex D
(informative)

Methods of measurement to determine the attenuation characteristics of ignition noise suppressors for high voltage ignition systems

D.1 Introduction

This annex specifies test methods for the evaluation of the efficiency of ignition noise suppressors used in the high-voltage part of ignition systems of internal combustion engines, such as suppressive HV connectors, resistive spark-plugs.

The frequency range is 30 MHz to 1 000 MHz.

D.2 Recommended requirements for ignition noise suppressors

The required limit class(es) for noise suppressors shall be defined by the users of this standard based on the values in Table D.1.

NOTE At the transition frequencies the higher attenuation should be considered as a limit.

Table D.1 – Limits

Class	**Range I 30–70 MHz**	**Range II 70–200 MHz**	**Range III 200-500 MHz**	**Range IV 500-1 000 MHz**
	Attenuation in dB			
1	6	14	8	6
2	12	20	14	12
3	18	26	20	18
4	24	32	26	24
5	30	38	32	30
6	36	44	38	36

D.3 Test set-up

The test set-up is shown in Figures D.1 and D.2.

The measurement is performed with a measuring receiver and an absorbing clamp according to CISPR 16-1-3.

The RF measuring receiver is set to quasi-peak measurement.

NOTE 1 Since the ignition disturbance is of a broadband nature and the system resonances have been minimized by use of the absorbing clamp, the frequency range need not be scanned continuously – it may be stepped (e.g. logarithmically) instead.

The peak voltage, measured at the ignition coil output, shall be set to 10 kV by adjusting the inert gas pressure in the pressure chamber. The amplitude for the pulses shall be as constant as possible. The pulse frequency shall be 50 Hz. The measuring distance *a* shall be 150 mm if no other values are specified in the examples of Clause D.5.

NOTE 2 Protection against high voltages – The energy of modern transistorized ignition systems is so high that touching the low-voltage side may create dangerous currents in a human body. Protection against high-voltage hazards is necessary.

NOTE 3 Protection of the absorbing clamp – The insulation of the ignition cable through the absorbing clamp may not be sufficient for this application. The ignition cable must therefore be housed within the absorbing clamp in insulating pipes.

In order to stabilize the spark discharge and thus the RF spectrum it is recommended to ventilate the pressure chamber (refer to Figure D.3).

A lateral minimum distance to metallic parts (e.g. walls) of 400 mm shall be maintained.

If the set-up is constructed using different parts of sheet metal, good electrical connection between the different parts shall be ensured.

The ground strap shall have a minimum cross-sectional area of 5 mm^2, a minimum width of 8 mm and a maximum length of 1 200 mm.

The connections of the EUT to the measuring equipment shall be as close to reality as possible.

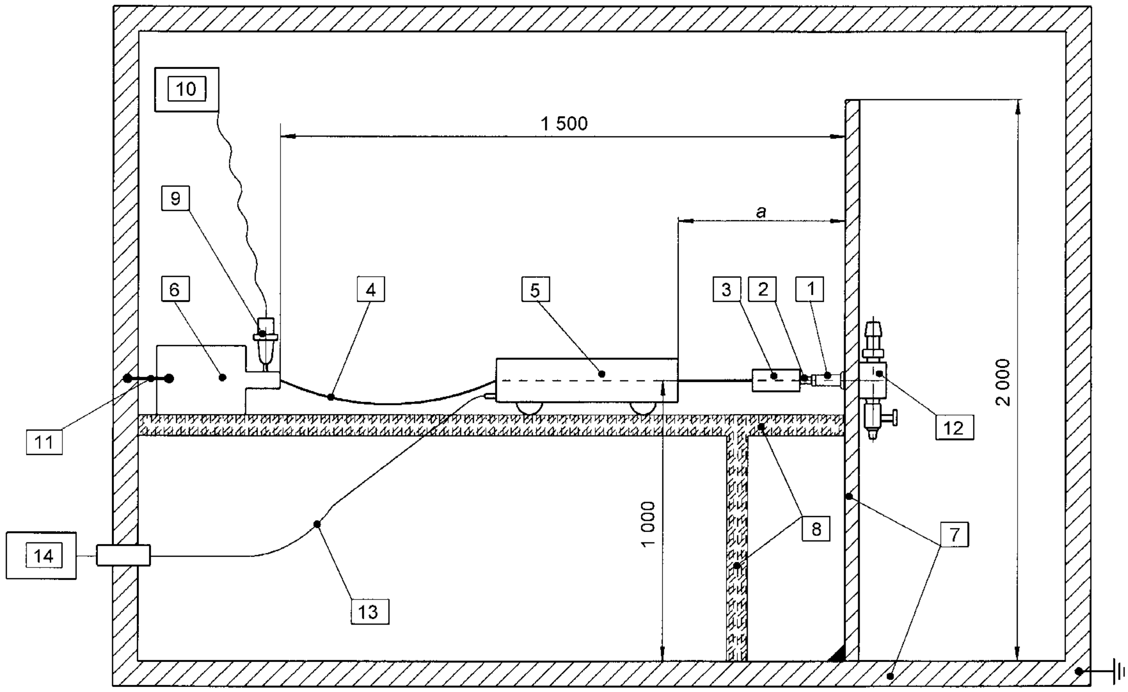
D.4 Test procedure

Install a measuring spark-plug as defined in Clause D.5.

The RF disturbance power is first measured without ignition noise suppressors, then the measurement is repeated with the ignition noise suppressors inserted.

NOTE Overload protection of the measuring receiver input – During recording the situation without ignition noise suppression, pulses of about 1 kV reach the measuring receiver input. This may destroy the measuring receiver. The use of a 20 dB attenuator with sufficient voltage/pulse resistance avoids this problem.

The difference between both measurements is the insertion loss of the ignition noise suppression device.



Dimensions in millimetres

Key

1 Spark-gap provided by a measuring spark-plug according to D.5

2 Connection to the spark-plug

3 EUT

4 HV ignition cable, not shielded and without suppressive elements

5 Absorbing clamp

6 Transistorized ignition coil system with power supply and pulse frequency generator (negative terminal connected to ground)

7 Wall and floor sheet metal

8 Table and supports, non-metallic

9 HV probe

10 Peak-voltage measuring instrument (e.g. oscilloscope)

11 Ground strap

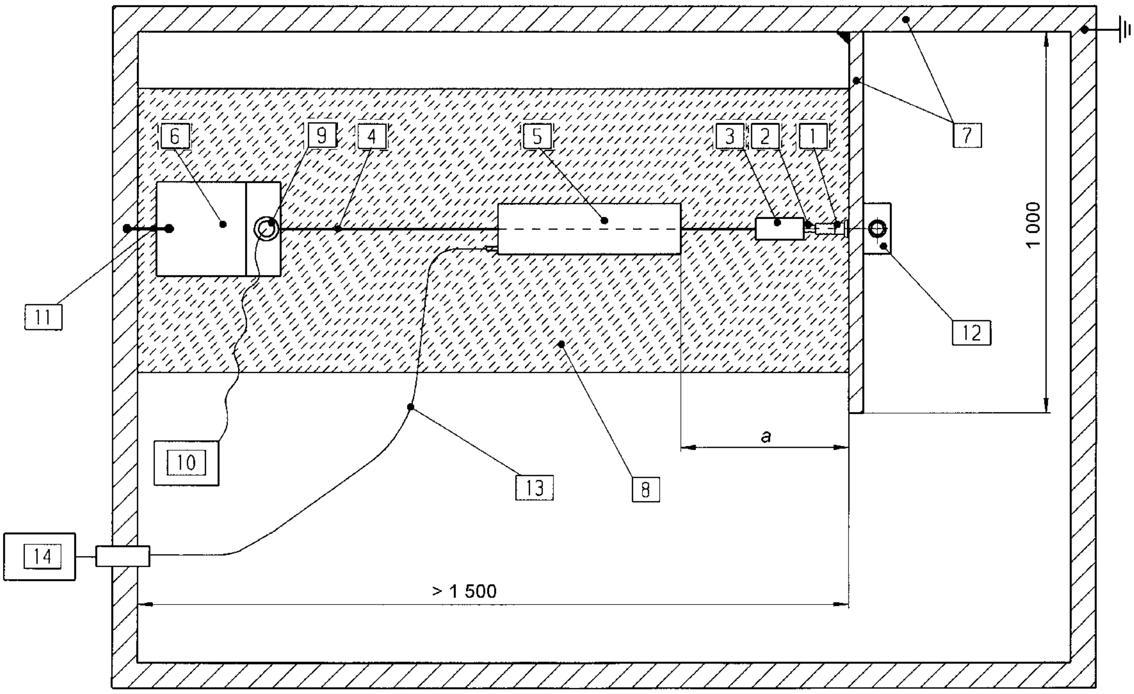
12 Pressure chamber with ventilation according to D.3

13 Measuring cable

14 RF disturbance measuring instrument

a is the measuring distance (see D.3).

Figure D.1 – Test set-up, side view



Dimensions in millimetres

Key

1 Spark-gap provided by a measuring spark-plug according to D.5

2 Connection to the spark-plug

3 EUT

4 HV ignition cable, not shielded and without suppressive elements

5 Absorbing clamp

6 Transistorized ignition coil system with power supply and pulse frequency generator (negative terminal connected to ground)

7 Wall and floor sheet metal

8 Table and supports, non-metallic

9 HV probe

10 Peak-voltage measuring instrument (e.g. oscilloscope)

11 Ground strap

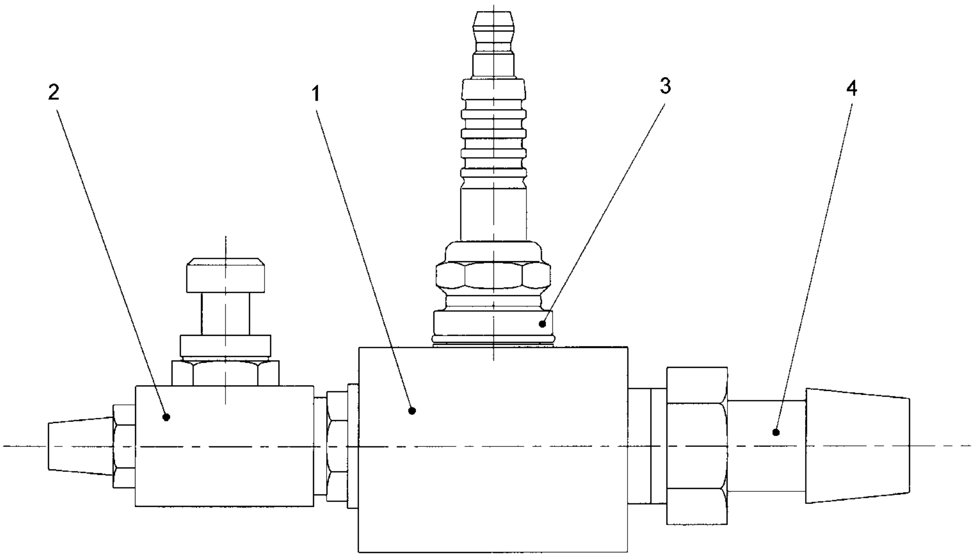
12 Pressure chamber with ventilation according to D.3

13 Measuring cable

14 RF disturbance measuring instrument

a is the measuring distance (see D.3).

Figure D.2 – Test set-up, top view



Key

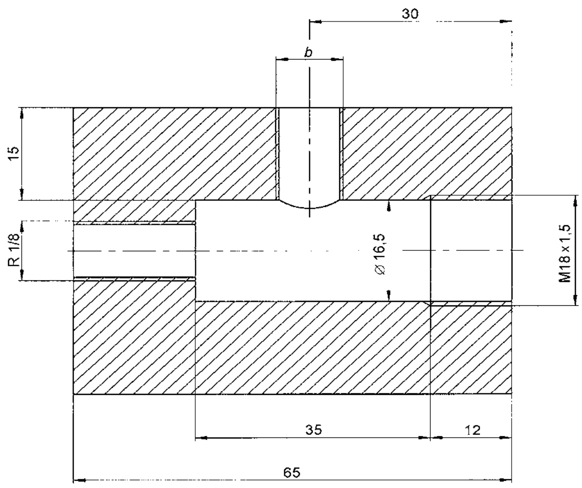
1 Pressure chamber

2 Throttle valve with attenuator (ventilation requirements to be evaluated empirically)

3 Measuring spark-plug

4 Connection for oil- and waterfree pressurized inert gas

Figure D.3a – General view



Dimensions in millimetres

b = M10 x 1, M12 x 1,25, or M14 x 1,25

Values not specified may be selected by the manufacturer

Material: metal

Figure D.3b – Cross-sectional view

Figure D.3 – Pressure chamber with ventilation

D.5 Measuring spark-plugs without suppression elements

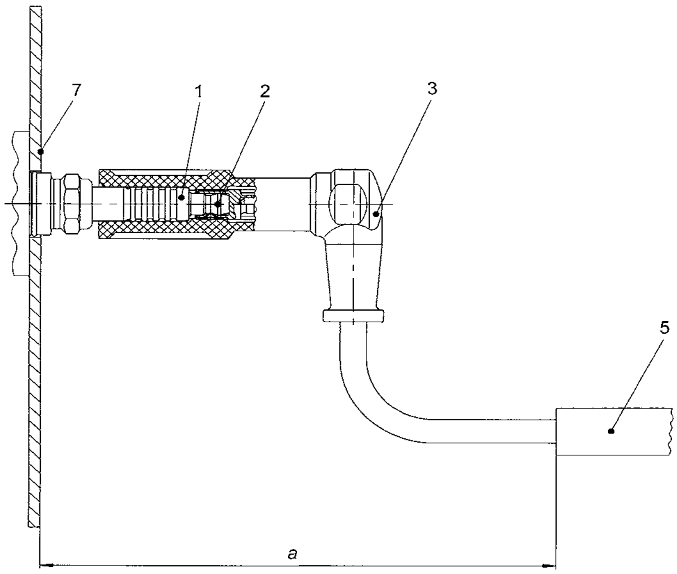
A measuring spark-plug shall be used to evaluate ignition noise suppressors, designed as part of the spark-plug assembly or by some other technique (for example, resistive ignition cables).

All spark-plugs without ignition noise suppression according to the relevant standards ISO 1919, ISO 2344, ISO 2704 and ISO 2705 may be used. The electrode gap shall be adjusted to 0,7 mm ± 0,1 mm.

D.6 Test set-up examples

Because of the high variety of different geometrical dimensions of suppression elements, the connection (see item 2 in Figure D.4, for example) shall be agreed between manufacturer and user.

D.6.1 Connection of a right-angle spark-plug ignition noise suppressor



Dimensions in millimetres

Key

1 Spark-gap provided by a measuring spark-plug according to D.5

2 Connection

3 EUT

5 Absorbing clamp

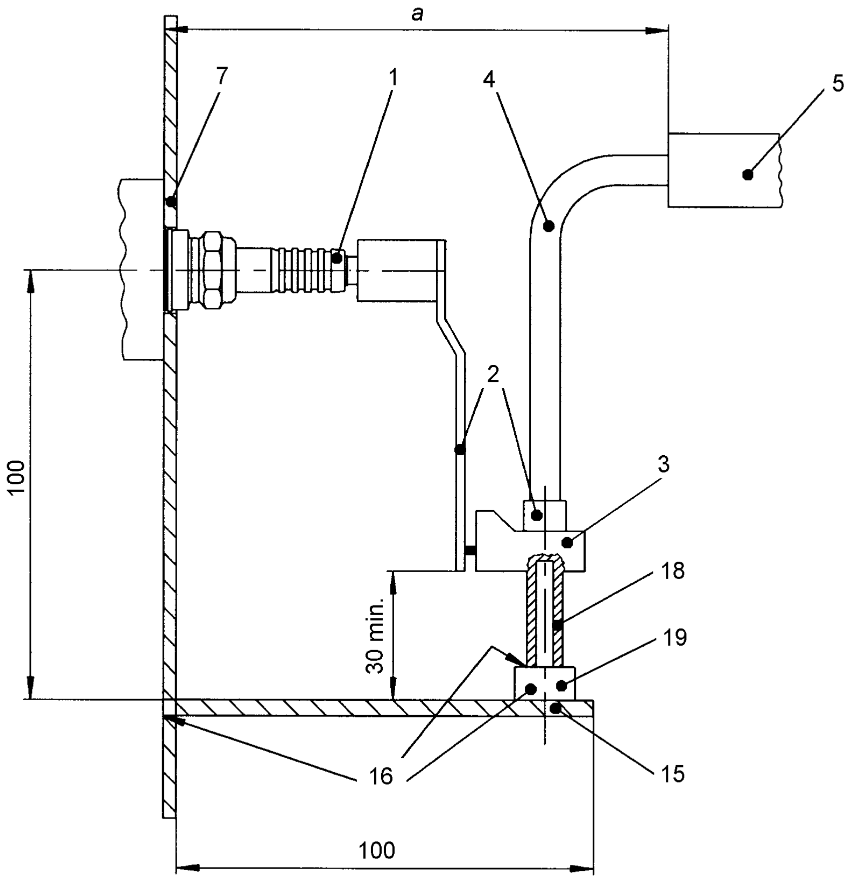
7 Wall sheet metal

a is the measuring distance (see D.3)

NOTE The HV ignition cable to the absorbing clamp must be as short as possible.

Figure D.4 – Top view of the set-up of a right-angle ignition noise suppressor for distributors

D.6.2 Connection of a distributor rotor



Dimensions in millimetres

Key

1 Spark-gap provided by a measuring spark-plug according to D.5

2 Connection

3 EUT

4 HV ignition cable, not shielded and without suppressive elements

5 Absorbing clamp

7 Wall sheet metal

15 Metallic ground plane

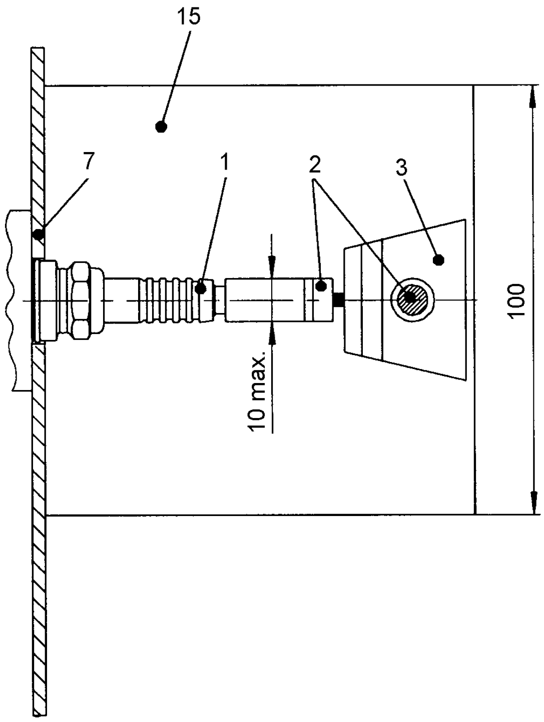
16 Wall sheet metal (7), ground plane sheet metal (15), adaptor part (19) and original shaft end (18) well connected electrically and in terms of RF

18 Original shaft end

19 Adaptor part

a is the measuring distance (see D.3)

Figure D.5 – Location of high voltage ignition components



Dimensions in millimetres

Key

1 Spark-gap provided by a measuring spark-plug according to D.5

2 Connection

3 EUT

7 Wall sheet metal

15 Metallic ground plane

Figure D.6 – Top view of the test set-up for distributor rotors

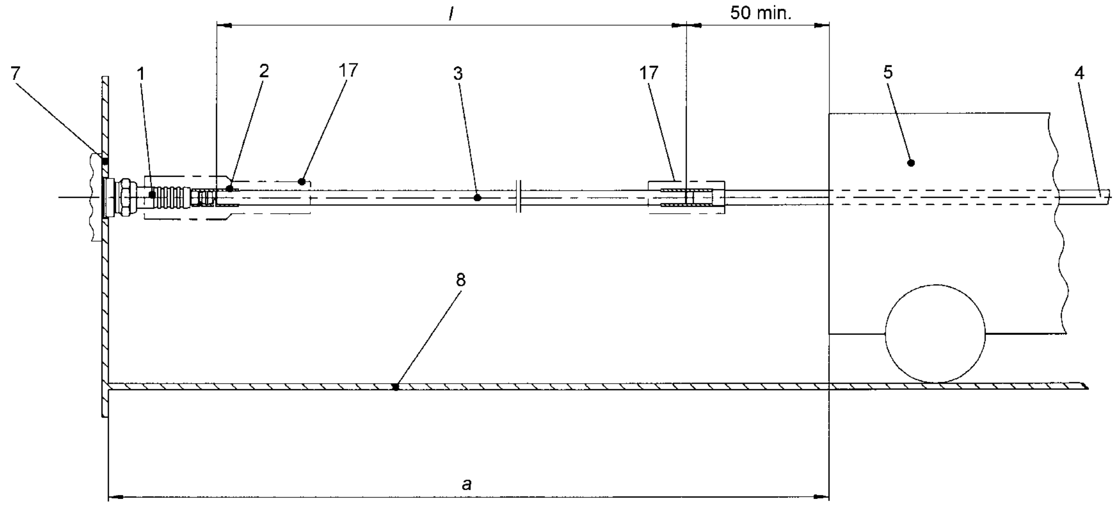
D.6.3 Connection of distributor caps with integrated ignition noise suppressors

Because of the high variety of different geometrical dimensions of distributor caps, the complete test set-up shall be agreed upon between manufacturer and user.

D.6.4 Connection of resistive ignition cables

D.6.4.1 Ready-to-use resistive ignition cables

Ready-to-use ignition cables shall be measured with their original length l; the measuring distance shall be chosen as $a = l + 120$ mm. The connection between the EUT and the non-suppressive HV ignition cable shall be protected by insulating material against touching. Its minimum distance to the absorbing clamp shall be 50 mm.



Dimensions in millimetres

Key

1 Spark-gap provided by a measuring spark-plug according to D.5

2 Connection

3 EUT

4 HV ignition cable, not shielded and without suppressive elements

5 Absorbing clamp

7 Wall sheet metal

8 Table and supports, non-metallic

17 Protective insulation and ready-to-use protective cap

a is the measuring distance (see D.6.4.1)

l is the length of the ready-to-use resistive ignition cable

Figure D.7 – Side view of the test set-up for ready-to-use resistive ignition cables

D.6.4.2 Resistive ignition cables not ready-to-use

These cables shall be measured preferably with a measuring distance of *a* = 0,5 m.

The length of the EUT is measured from the connection (item 2 in Figure D.1) to the ignition system (item 6 in Figure D.1).

D.7 Reference documents

ISO 1919:1998, *Road vehicles – M14 × 1,25 spark-plugs with flat seating and their cylinder head housings*

ISO 2344:1998, *Road vehicles – M14 × 1,25 spark-plugs with conical seating and their cylinder head housings*

ISO 2704:1998, *Road vehicles – M10 × 1 spark-plugs with flat seating and their cylinder head housings*

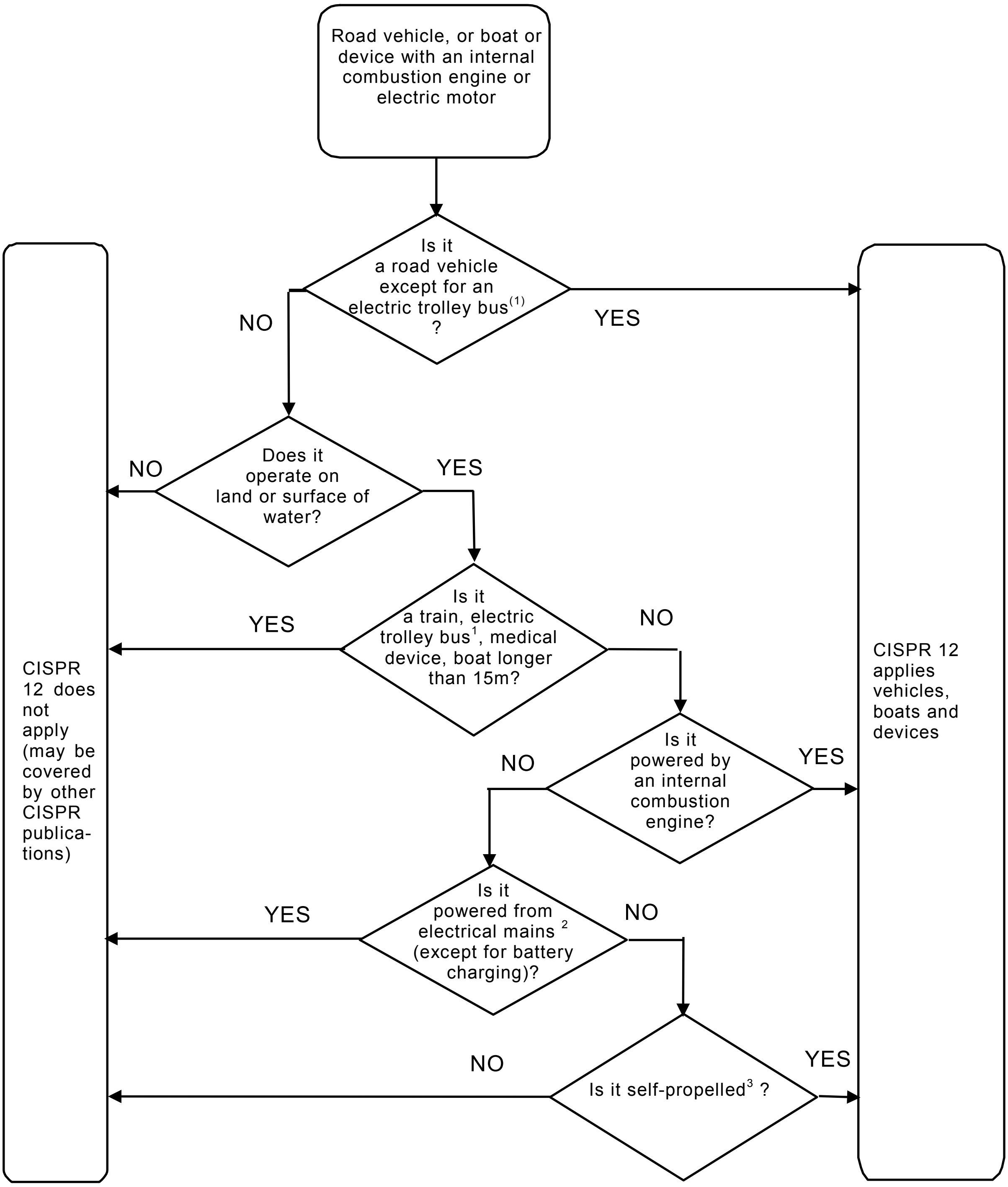
ISO 2705:1999, *Road vehicles – M12 × 1,25 spark-plugs with flat seating and their cylinder head housings*

Annex E
(informative)

Flow chart for checking the applicability of CISPR 12

E.1 Introduction

This chart is intended to assist with determining whether a particular product is covered by this international standard. In case of conflict between this chart and Clause 1, Clause 1 shall take precedence.



1 In the case of a dual-mode trolley bus (e.g. propelled by power from either a.c./d.c. mains or an internal combustion engine), the a.c./d.c. mains portion of the vehicle propulsion system shall be excluded from this standard.

2 Connection to the electrical mains is the work of another CISPR subcommittee

3 Automatic battery powered cleaners are the work of another CISPR subcommittee

Annex F
(informative)

Specific application of CISPR 12

F.1 Introduction

This annex describes specific consideration when using CISPR 12 for :

- Regulation purpose (type approval test)
- Surveillance (quality audit) of series production
- Quick prototype check for development testing

F.2 Type approval test

Compliance with the requirements given in Clause 4 shall be checked as defined in F.2.1 and F.2.2.

NOTE For type-approval testing, use of an alternative test method based upon other regulatory standards is permitted as detailed herein. This alternate type-approval test applies to those vehicles/boats/devices for which on-board receivers can be installed. If, when measured in accordance with the vehicle test methodology of CISPR 25 for emissions using an average detector, the signal strength at the vehicle/boat/device broadcast radio antenna is less than 20 dB (μV) (10 μV) over the frequency range 76 MHz to 108 MHz, then the vehicle/boat/device can be deemed to comply with the limits for average emissions and no further testing must be required.

F.2.1 Single sample

Measurements may be made on a prototype vehicle/boat/device of a later production series. The results shall be at least 2 dB below the limits specified in Clause 4.

F.2.2 Multiple samples (optional)

If optional multiple samples are tested, five or more additional vehicles/boats/devices shall be tested and the results combined with the data from the first test in F.2.1. The result for each frequency sub-band shall be below the specified limits of Clause 4 at the representative frequency for that sub-band (see 6.3).

F.2.3 Data collection

Spot frequency testing is only acceptable as used in F.4, or for type approval purposes if the results of prior measurements covering the entire frequency range are available and prove compliance.

F.3 Surveillance (quality audit) of series production

F.3.1 Single sample

The results of the measurements on one vehicle/boat/device shall be a maximum of 2 dB above the specified limits of Clause 4.

F.3.2 Multiple samples (optional)

If optional multiple samples are tested, five or more additional vehicles/boats/devices shall be tested and the results combined with the data from the first test in F.3.1. The results for each frequency sub-band shall be evaluated statistically, as described in CISPR 16-4-3; the result for each frequency sub-band shall be a maximum of 2 dB above the specified limit of Clause 4 at the representative frequency for that sub-band (see 6.3).

F.4 Quick prototype check for development testing (optional, quasi-peak detector emissions only)

An optional test using spot frequencies may be made to evaluate the approximate levels of emission of the vehicle/boat/device to determine whether the levels are likely to meet the limit of Clause 4. The spot frequencies to be used for specific measurements are the representative frequencies given in Table F.1.

Table F.1 – Example of frequency sub-bands

Frequency sub-band MHz	**Representative frequency** MHz
30 to 34	32
34 to 45	40
45 to 60	55
60 to 80	70
80 to 100	90
100 to 130	115
130 to 170	150
170 to 225	200
225 to 300	270
300 to 400	350
400 to 525	460
525 to 700	600
700 to 850	750
850 to 1 000	900

F.5 Measurements under wet conditions

In the event of any dispute concerning compliance, it shall be resolved by carrying out measurements under dry conditions.

Compliance based on good-faith wet measurements (and with the performance penalty mentioned above) shall remain valid until such time as it may be contested and dry measurements prove non-compliance. In such cases retrofitting of vehicles/boats/devices sold during the period when there was deemed compliance shall not be required.

When compliance is deemed on the basis of wet measurements, particular attention shall be paid to the surveillance of series production.

Annex G
(normative)

High Voltage Artificial Networks (HV-AN), Artificial Mains Networks (AMN) and Asymmetric Artificial Networks (AAN)

G.1 General

Currently different types of power supplies and power supply cabling are used for a vehicle in charging mode connected to the power grid (AC power mains, DC power supply). Therefore, it is necessary to use networks which provide specific load impedance and isolate the vehicle from the power supply:

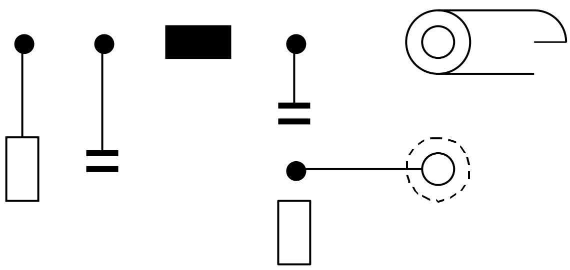
- High Voltage Artificial networks (HV-AN) : used for DC power supplies;
- Artificial Mains Networks (AMN) : used only for AC power mains;
- Asymmetric artificial network (AAN): used only for communication/signal lines.

G.2 High Voltage Artificial networks (HV-AN)

For a vehicle in charging mode connected to a DC power supply, a 5 µH / 50 Ω HV-AN as defined in Figure G.1 shall be used.

Measurement ports of HV-AN(s) shall be terminated with a 50 Ω load.

The HV-AN impedance Z_{PB} (tolerance ±20 %) in the measurement frequency range of 0,1 MHz to 100 MHz is shown in Figure G.2. It is measured between the terminals P and B (of Figure G.1) with a 50 Ω load on the measurement port with terminals A and B (of Figure G.1) short circuited.



L_1: 5 µH
C_1: 0,1 µF
C_2: 1 µF (default value, if another value is used, it has to be justified)
R_1: 1 kΩ
R_2: 1 MΩ (discharging C_2 to < 50 V_{dc} within 60 s)

Figure G.1 – Example of 5 µH HV-AN schematic

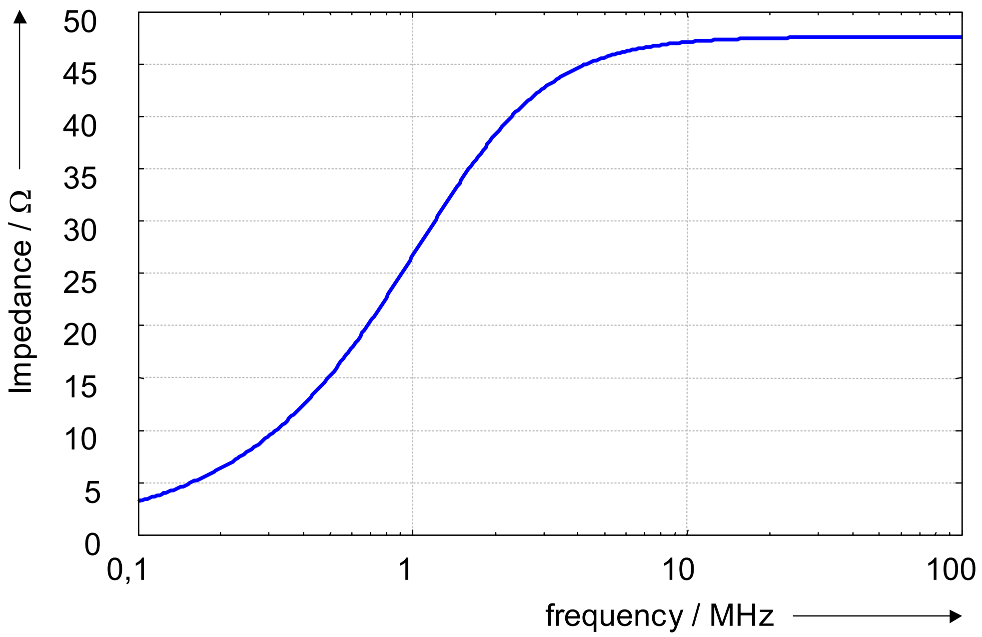


Figure G.2 – Characteristics of the HV AN impedance

G.3 Artificial Mains networks (AMN)

For a vehicle in charging mode connected to a AC power mains, a 50 µH / 50 Ω-AMN as defined in CISPR 16-1-2 clause 4.3 edition 1.2 shall be used.

Measurement ports of AMN(s) shall be terminated with a 50 Ω load.

G.4 Asymmetric artificial network (AAN):

Currently different types of communication system and communication cabling are used for the communication between charging station and vehicle. Therefore a distinction between some specific cabling/operation types is necessary.

Measurement ports of AAN(s) shall be terminated with a 50 Ω load.

G.4.1 Symmetric communication lines

An asymmetric artificial network (AAN) to be connected between vehicle and charging station or any associated equipment (AE) used to simulate communication is defined in CISPR 16-1-2 Annex E clause E.2 (T network circuit) (see example in Figure G.3).

The AAN has a common mode impedance of 150 Ω. The impedance Z_{cat} adjusts the symmetry of the cabling and attached periphery typically expressed as longitudinal conversion loss (LCL). The value of LCL should be predetermined by measurements or be defined by the manufacturer of the charging station/charging cable. The selected value for LCL and its origin shall be stated in the test report.

Note: For some communications networks (e.g. CAN) this AAN cannot be used on these lines.

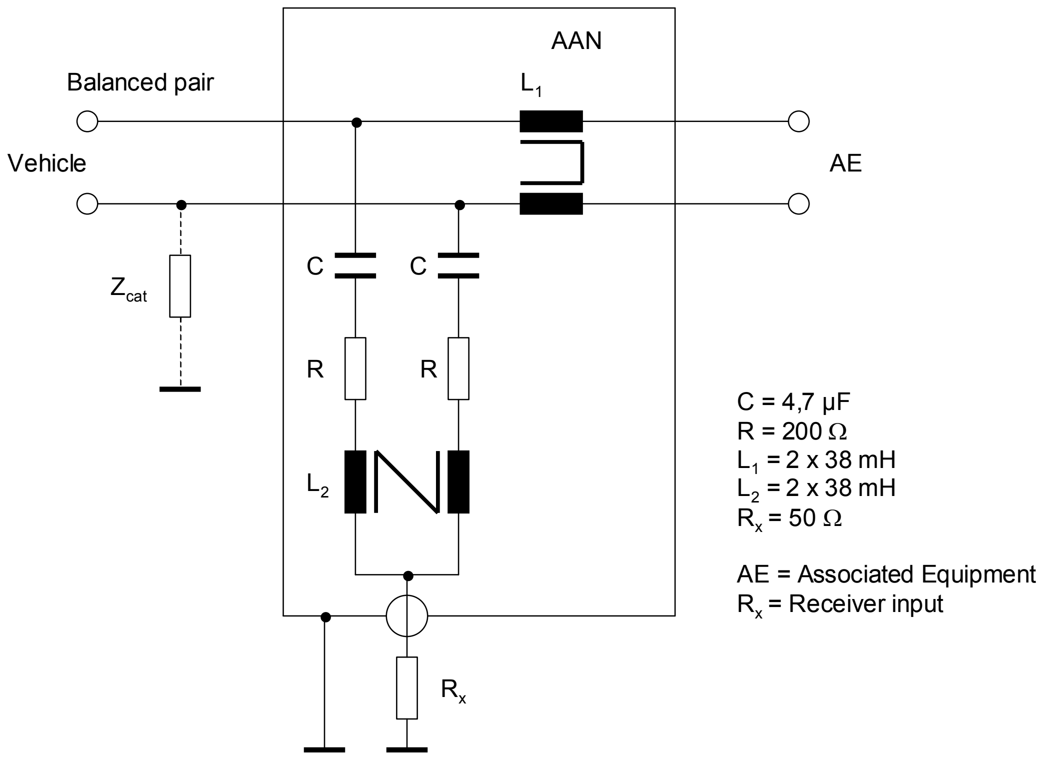


Figure G.3 Example of an AAN for symmetric communication lines

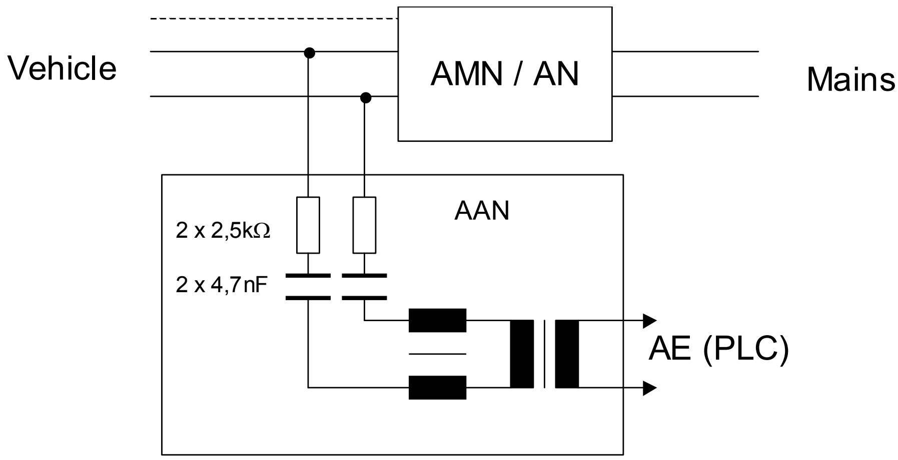
G.4.2 PLC on power lines

If an original charging station can be used for the test, it might be not necessary to add any AAN for PLC communication.

If PLC communication cannot be ensured with original charging station and AMN, or shall be simulated with use of an associated equipment (AE) (e. g. as a PLC modem) instead of an original charging station, it is necessary to add an AAN for PLC communication between PLC modem and the AMN (vehicle side) as defined in Figure G.4.

Note: This AAN is not intended for any conducted emission measurement, but only to ensure adequate decoupling between PLC modem and power mains.

The circuit in Figure G.4 provides a common mode termination by the AN/AMN. For emission testing only the emissions from the PLC modem of the vehicle should be measured. Therefore, an attenuator is located between powerline and the PLC modem at the AE side in the circuit for emission tests. This attenuator consists of two resistors in combination with the input/output impedance of the PLC modem. The value of the resistors depends on the design impedance of the PLC modems and the allowed attenuation for the PLC system.



The value of the resistors depends on the allowed attenuation and the design impedance of the PLC modem (here: 40dB attenuation, 100Ω PLC design impedance)

Figure G.4 Example of AAN circuit of PLC on AC or DC powerlines

G.4.3 PLC (technology) on control pilot

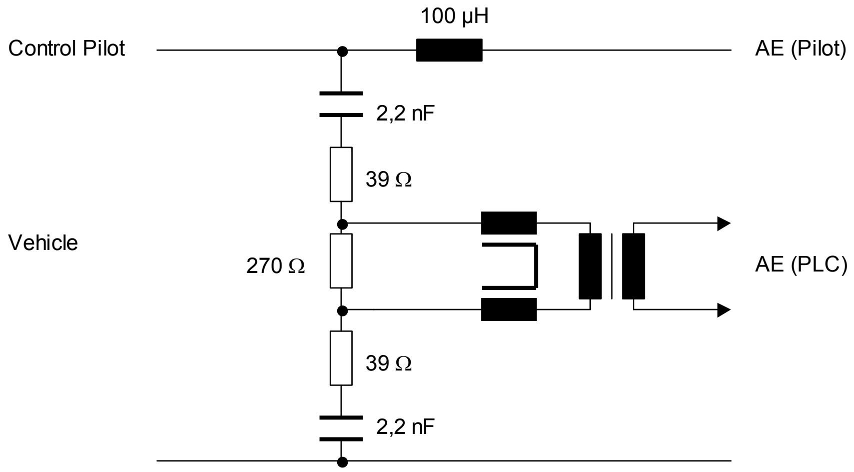
Some communication systems use the control pilot line (versus PE) with a superimposed (high frequency) communication. Typically the technology developed for powerline communication (PLC) is used for that purpose. On one hand the communication lines are operated unsymmetrically, on the other hand two different communication systems operate on the same line. Therefore a special AAN must be used as defined in Figure G.5.

It provides a common mode impedance of 150 Ω ± 20 Ω (150 kHz to 30 MHz) on the control pilot line (assuming a design impedance of the modem of 100 Ω). Both types of communications (control pilot, PLC) are separated by the network.

Therefore, typically a communication simulation is used in combination with this network. The attenuator built by the resistors and the design impedance of the PLC modem makes sure that the signal on the charging cable is dominated by the vehicle's communication signals rather than the AE PLC modem.

The values of inductance and capacitance in the networks added for PLC on control pilot shown in Figure G.5 shall not induce any malfunction of communication between vehicle and AE or charging station. It may therefore be necessary to adapt these values to ensure proper communication.

Note: This AAN is not intended for any conducted emission measurement, but only to ensure a controlled impedance of the pilot line (and PLC) seen from the component or vehicle side.



The values of the three resistors depend on the design impedance of the PLC modem connected at AE side. The values given in the schematic are valid for a design impedance of 100 Ω.

Figure G.5 Example of AAN circuit for PLC on pilot line

Annex H
(normative)

Measurement instrumentation uncertainty

H.1 Scope

The purpose of this annex is to provide guidance in the evaluation of the measurement instrumentation uncertainty for the measurement method described in this standard. The relevant input quantities are listed and estimations for the calculation of the uncertainty budget are made.

The estimation of the overall uncertainty for CISPR 12 measurements should consider input quantities due to measurement method, measurement instrumentation, operators, EUT and environment.

This annex only considers the measurement instrumentation for uncertainty evaluation. Some other input quantities are not taken into consideration such as:

- Site imperfection because site validation is under study.
- Vehicle to antenna distance because it is not considered in measurement instrumentation but rather in method

H.2 Radiated disturbance measurements at an OTS or in an ALSE in the frequency range 30 MHz to 1 000 MHz

The various uncertainty sources are presented in figure H.1 and are mainly based on CISPR 16-4-2.

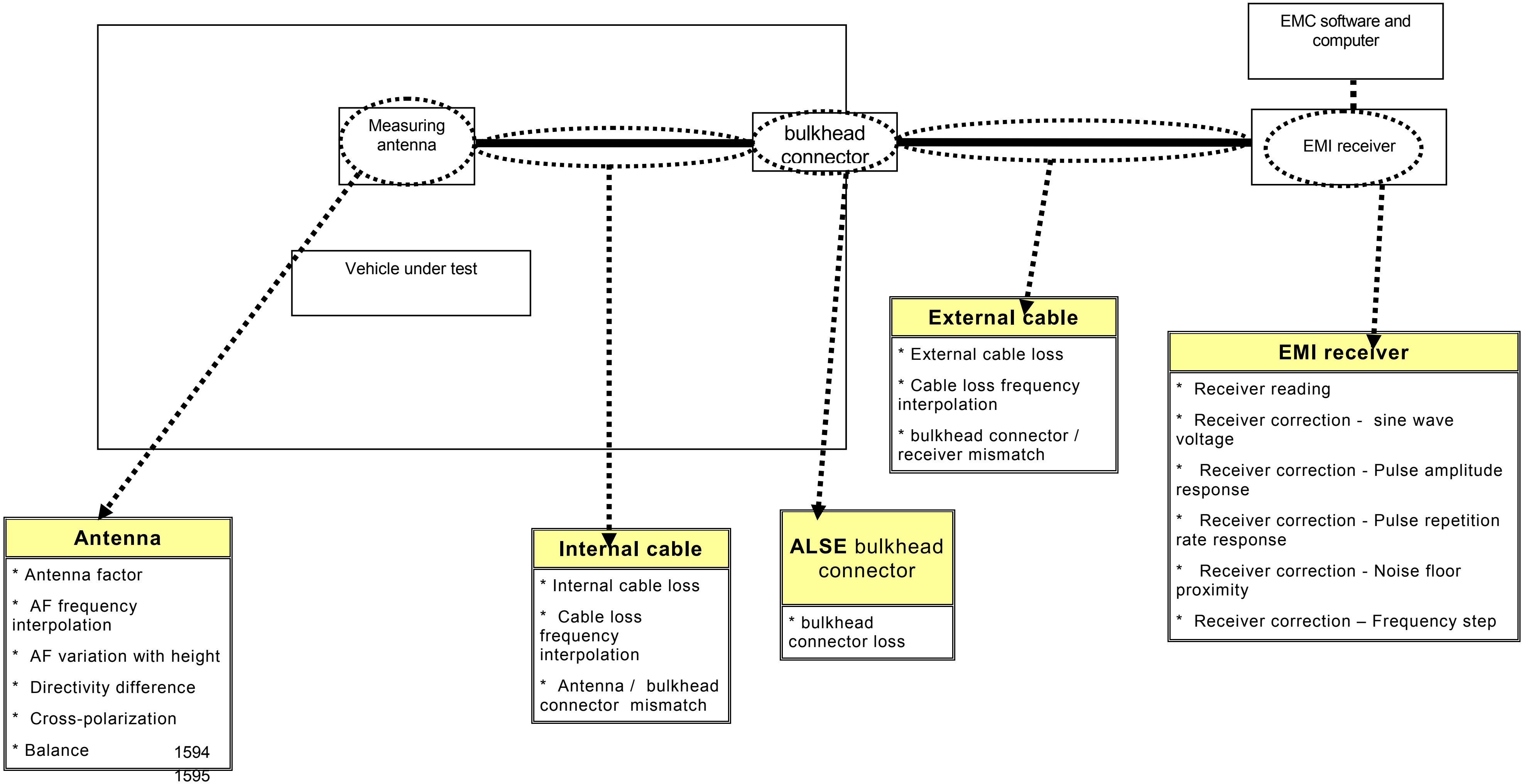


Figure H.1: Sources of measurement instrumentation uncertainty

H.2.1 Measurand

E Maximum electric field strength, in dB(μV/m), in horizontal and vertical polarizations measured at the specified horizontal distance from the EUT and the specified height above the ground/floor or the water surface.

The measurand E is calculated using:

$$E = V_R + L_{CAB} + M_{FR} + M_{AF} + F_a + \delta V_{CW} + \delta V_{PA} + \delta V_{PR} + \delta V_{NF} + \delta F_{STP} + \delta L_{FI} + \delta F_{FI} + \delta F_H + \delta F_{DIR} + \delta F_{CP} + \delta F_{BAL} \quad \text{(H.1)}$$

H.2.2 Input quantities to be considered for radiated disturbance measurements at an OTS or in an ALSE

The various quantities to be considered for radiated disturbance measurements at an OTS or in an ALSE are listed in Table H.1 with a description of:

- the used symbol,
- the probability distribution function,
- rational for the estimation of the input quantity.

Quantity	Symbol	Probability distribution function	Rational for the estimates
Receiver reading	V_R	k = 1	Receiver readings will vary for reasons that include measuring system instability and meter scale interpolation errors. The estimate is the mean of many readings (sample size larger than 10) of a stable signal, with a standard uncertainty given by the experimental standard deviation of the mean (k = 1).[1]
Receiver corrections - Sine wave voltage	δV_{CW}	k = 2	An estimate of the correction for receiver sine-wave voltage accuracy is assumed to be available from a calibration report, along with an expanded uncertainty and a coverage factor. [1]
Receiver correction - Pulse amplitude response	δV_{PA}	Rectangular	An estimate of the correction for receiver sine-wave voltage accuracy is assumed to be available from a calibration report, along with an expanded uncertainty and a coverage factor. [1]
Receiver correction - Pulse repetition rate response	δV_{PR}	Rectangular	An estimate of the correction for receiver sine-wave voltage accuracy is assumed to be available from a calibration report, along with an expanded uncertainty and a coverage factor. [1]

Quantity	Symbol	Probability distribution function	Rational for the estimates
Receiver correction - Noise floor proximity	δV_{NF}	Rectangular	For radiated disturbance measurement below 1 GHz, the deviation is estimated to be between zero and +1,1 dB. The correction is estimated to be zero as if the deviation would be symmetric around the value to be measured with a rectangular probability distribution having a half-width of 1,1 dB. Any correction for the effect of the noise floor would depend on the signal type (e.g. impulsive or unmodulated) and the signal to noise ratio and would change the noise level indication. (1)
Receiver correction – Frequency step	δF_{STP}	Rectangular	This correction concerns the error which depends of the frequency step size used with the measuring receiver in comparison of the used measurement bandwidth. This correction can be evaluated experimentally with a frequency generator and a receiver with adjustment of the frequency of the signal with a variation of + half and – half the step size and noting the amplitude change on the receiver (see annex I clause I.3)
Cable(s) loss(es) (2)	L_{CAB}	Normal (k=2)	The cable(s) loss(es) values with associated expanded uncertainty and coverage factor are normally available from calibration reports. Cable(s) loss(es) values are usually included in the measurement software to make the corrections in the measurement; therefore, only the uncertainty value should be kept for the measurement system uncertainty evaluation.
Cable(s) loss(es) frequency interpolation (3)	δL_{FI}	Rectangular	This parameter concerns the frequency interpolation used by the measurement software to evaluate cable(s) loss(es) between the frequencies for which cable(s) loss(es) values are available. If cable loss is measured for an important number of frequency points and if the data do not show any significant rough variation between two consecutive frequencies, the uncertainty can be considered to be equal to the maximum half amplitude variation between two consecutive cable loss measurement data.
bulkhead connector / receiver mismatch(4)	M_{FR}	U-shaped	This parameter concerns the impedance mismatch of the bulkhead connector / measuring receiver input connection Mismatch uncertainty can be evaluated through theoretical formula and measurements data (see CISPR 16-4-2 clause A.2 note A7).

Quantity	Symbol	Probability distribution function	Rational for the estimates
Antenna / bulkhead connector mismatch(4)	M_{AF}	U-shaped	This parameter concerns the impedance mismatch of the antenna / bulkhead connector liaison. Mismatch uncertainty can be evaluated through theoretical formula and measurements data (see CISPR 16-4-2 clause A.2 note A7).
Antenna factor	F_a	Normal (k=2)	The Antenna Factor values with associated expanded uncertainty and coverage factor is normally available from a calibration report. Antenna Factor values usually included in the measurement software to make the voltage to field corrections in the measurement; therefore, only the uncertainty value should be kept for the measurement system uncertainty evaluation.
AF frequency interpolation	δF_{FI}	Rectangular	This parameter concerns the frequency interpolation used by the measurement software to evaluate antenna factor between the frequencies for which antenna factor values are available. If antenna factor is measured for an important number of frequency points and if the data do not show any significant rough variation between two consecutive frequencies, the uncertainty can be considered to be equal to the maximum half amplitude variation between two consecutive antenna factor measurement data.
AF variation with height	δF_H	Rectangular	The antenna factor varies due to mutual coupling of the antenna with its image in a ground plane. This parameter concerns the antenna factor variation between the antenna height used for measurement and the antenna height used during antenna calibration (antenna factor evaluation). Typical uncertainty values can be obtained for principal antenna (biconical, log-periodic, ..) from theoretical data and practical experience (e.g CISPR 16-4-2).
Directivity difference	δF_{DIR}	Rectangular	This parameter concerns the impact of antenna pattern and antenna response for direct and ground reflected rays depending of antenna height and device under test position. Typical uncertainty values can be obtained for principal antenna (biconical, log-periodic, ..) from theoretical data and practical experience (e.g CISPR 16-4-2).
Cross-polarization	δF_{CP}	Rectangular	This parameter concerns possible imperfections specified by the cross-polarization response of the antenna (ratio of fields in horizontal and vertical polarizations) Typical uncertainty values can be obtained for principal antenna from theoretical data and practical experience (e.g CISPR 16-4-2) or from some calibration reports which include specific formula for this uncertainty item.

Quantity	**Symbol**	**Probability distribution function**	**Rational for the estimates**
Unbalance	δF_{BAL}	Rectangular	This parameter concerns the influence of antenna unbalance (dissymmetry) and can vary depending on cable positioning in regard to antenna geometry (coupling from antenna to cable)
(1): based on CISPR 16-4-2 ed 2.0 (2): single parameter for cable loss value (and bulkhead connector loss value) which includes all the different cables (and bulkhead connector) in the measuring system. If cable losses (and bulkhead connector) are measured separately for each cables (and bulkhead connector), the table should include one separate line for cable loss value per cable (and bulkhead connector) (3): single parameter for cable loss frequency interpolation which includes all the different cables in the measuring system. If cable losses frequency interpolation are considered separately for each cables, the table should include one separate line for cable loss frequency interpolation per cable (4): the worst configuration (in ALSE with one mismatch between receiver and chamber bulkhead connector and one mismatch between chamber bulkhead connector ant antenna) has been considered for mismatches. When the measurements are performed without feedtrough (e.g in OTS), only one mismatch (between receiver and antenna can be considered)			

Table H.1 : Input quantities to be considered for radiated disturbance measurements at an OTS or in an ALSE

Annex I
(Informative)

Uncertainty budgets for radiated disturbance measurements of electric field strength at an OTS or in an ALSE

I.1 General

This annex gives typical uncertainty budgets for the measurement instrumentation uncertainty for radiated disturbance measurements at an OTS.

I.2 Typical CISPR 12 uncertainty budgets

Uncertainty related to site imperfections (OTS or ALSE) are not considered in these budgets.

3m / 10 m distance measurement – Biconical antenna – Horizontal Polarization					
Quantity x_i	**Symbol**	**Uncertainty of x_i**		**C_iUx_i**	**Comment**
		dB	**Probability distribution function**		
Receiver reading	V_R	± 0,1 (1)	k = 1	0,1	
Receiver corrections - Sine wave voltage	δV_{CW}	± 1 (1)	k = 2	0,5	
Receiver correction - Pulse amplitude response	δV_{PA}	± 1,5 (1)	Rectangular	0,87	
Receiver correction - Pulse repetition rate response	δV_{PR}	± 1,5 (1)	Rectangular	0,87	
Receiver correction - Noise floor proximity	δV_{NF}	+0,5 / 0	Rectangular	0,14	See note (2)
Receiver correction – Frequency step	δF_{STP}	+0 / -1,3	Rectangular	0,38	
Cable(s) loss(es)	L_{CAB}	± 0,5	k=2	0,25	See note (3)
Cable(s) loss(es) frequency interpolation	δL_{FI}	± 0,25	Rectangular	0,14	See note (4)
Bulkhead connector / receiver mismatch	M_{FR}	+0,34 / - 0,36	U-shaped	0,25	See note (5)
Antenna / bulkhead connector mismatch	M_{AF}	+1,54 / - 1,87	U-shaped	1,21	See note (6)
Antenna factor	F_a	± 1,5	k=2	0,75	

3m / 10 m distance measurement – Biconical antenna – Horizontal Polarization					
AF frequency interpolation	δF_{FI}	± 1	Rectangular	0,58	
AF variation with height	δF_{H}	± 1	Rectangular	0,58	See note (7)
Directivity difference	δF_{DIR}	0	Rectangular	0	See note (7)
Cross-polarization	δF_{CP}	0	Rectangular	0	See note (7)
Balance	δF_{BAL}	± 0,3	Rectangular	0,17	See note (7)
Expanded uncertainty ($U(E)$ $2u_c(E)$) (in dB)				**4,37**	

(1): based on CISPR 16-4-2 ed 2.0

(2): based on CISPR 16-4-2 ed 2.0 (value for biconical antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

(3): The ± 0,5 dB value is valid if all measuring system cable(s) and bulkhead connector losses are measured simultaneously. If cable(s) and bulkhead connector losses are measured separately the ± 0,5 dB value shall be duplicated.

(4): The ± 0,25 dB value is valid if all measuring system cable(s) and bulkhead connector frequency interpolation are evaluated simultaneously. If cable(s) and bulkhead connector frequency interpolation are evaluated separately the ±0,25 dB value shall be duplicated.

(5): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- receiver input maximum reflexion coefficient of 0,2; cable maximum transmission parameter of 1

(6): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- antenna maximum reflexion coefficient of 0,97; cable maximum transmission parameter of 1

(7): based on CISPR 16-4-2 ed 2.0 (maximum value among biconical antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

Table I.1 : Typical uncertainty budget – 3 m / 10 m distance – Biconical antenna – Horizontal polarization

3m / 10 m distance measurement – Biconical antenna – Vertical Polarization					
Quantity x_i	**Symbol**	**Uncertainty of x_i**		**$C_i U x_i$**	**Comment**
		dB	**Probability distribution function**		
Receiver reading	V_R	± 0,1 [1]	k = 1	0,1	
Receiver corrections - Sine wave voltage	δV_{CW}	± 1 [1]	k = 2	0,5	
Receiver correction - Pulse amplitude response	δV_{PA}	± 1,5 [1]	Rectangular	0,87	
Receiver correction - Pulse repetition rate response	δV_{PR}	± 1,5 [1]	Rectangular	0,87	
Receiver correction - Noise floor proximity	δV_{NF}	+0,5 / 0	Rectangular	0,14	See note [2]
Receiver correction – Frequency step	δF_{STP}	+0 / -1,3	Rectangular	0,38	
Cable(s) loss(es)	L_{CAB}	± 0,5	k=2	0,25	See note [3]
Cable(s) loss(es) frequency interpolation	δL_{FI}	± 0,25	Rectangular	0,14	See note [4]
Bulkhead connector / receiver mismatch	M_{FR}	+0,34 / - 0,36	U-shaped	0,25	See note [5]
Antenna / bulkhead connector mismatch	M_{AF}	+1,54 / - 1,87	U-shaped	1,21	See note [6]
Antenna factor	AF	± 1,5	k=2	0,75	
AF frequency interpolation	δAF_{FI}	± 1	Rectangular	0,58	
AF variation with height	δAF_H	± 0,3	Rectangular	0,17	See note [7]
Directivity difference	δAF_{DIR}	± 1	Rectangular	0,58	See note [7]
Cross-polarization	δAF_{CP}	0	Rectangular	0	See note [7]

3m / 10 m distance measurement – Biconical antenna – Vertical Polarization					
Balance	δAF_{BAL}	± 0,9	Rectangular	0,52	See note (7)
Expanded uncertainty ($U(E)$ $2u_c(E)$) (in dB)				**4,50**	

(1): based on CISPR 16-4-2 ed 2.0

(2): based on CISPR 16-4-2 ed 2.0 (value for biconical antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

(3): The ±0,5 dB value is valid if all measuring system cable(s) and bulkhead connector losses are measured simultaneously. If cable(s) and bulkhead connector losses are measured separately the ±0,5 dB value shall be duplicated.

(4): The ±0,25 dB value is valid if all measuring system cable(s) and bulkhead connector frequency interpolation are evaluated simultaneously. If cable(s) and bulkhead connector frequency interpolation are evaluated separately the ±0,25 dB value shall be duplicated.

(5): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- receiver input maximum reflexion coefficient of 0,2; cable maximum transmission parameter of 1

(6): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- antenna maximum reflexion coefficient of 0,97; cable maximum transmission parameter of 1

(7): based on CISPR 16-4-2 ed 2.0 (maximum value among biconical antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

Table I.2 : Typical uncertainty budget – 3 m / 10 m distance – Biconical antenna – Vertical polarization

3m / 10 m distance measurement – Log-periodic antenna – Horizontal Polarization					
Quantity x_i	**Symbol**	**Uncertainty of x_i**		**C_iUx_i**	**Comment**
		dB	**Probability distribution function**		
Receiver reading	V_R	± 0,1 [1]	k = 1	0,1	
Receiver corrections - Sine wave voltage	δV_{CW}	± 1 [1]	k = 2	0,5	
Receiver correction - Pulse amplitude response	δV_{PA}	± 1,5 [1]	Rectangular	0,87	
Receiver correction - Pulse repetition rate response	δV_{PR}	± 1,5 [1]	Rectangular	0,87	
Receiver correction - Noise floor proximity	δV_{NF}	+1,1 / 0	Rectangular	0,32	See note [2]
Receiver correction – Frequency step	δF_{STP}	+0 / -1,3	Rectangular	0,38	
Cable(s) loss(es)	L_{CAB}	± 0,5	k=2	0,25	See note [3]
Cable(s) loss(es) frequency interpolation	δL_{FI}	± 0,25	Rectangular	0,14	See note [4]
Bulkhead connector / receiver mismatch	M_{FR}	+0,34 / - 0,36	U-shaped	0,25	See note [5]
Antenna / bulkhead connector mismatch	M_{AF}	+1,54 / - 1,87	U-shaped	1,21	See note [6]
Antenna factor	AF	± 1,5	k=2	0,75	
AF frequency interpolation	δAF_{FI}	± 1	Rectangular	0,58	
AF variation with height	δAF_H	± 0,3	Rectangular	0,17	See note [7]
Directivity difference	δAF_{DIR}	± 1	Rectangular	0,58	See note [7]
Cross-polarization	δAF_{CP}	± 0,9	Rectangular	0,52	See note [7]

3m / 10 m distance measurement – Log-periodic antenna – Horizontal Polarization					
Balance	δAF_{BAL}	0	Rectangular	0	See note (7)
Expanded uncertainty ($U(E)$ $2u_c(E)$) (in dB)				**4,53**	

(1): based on CISPR 16-4-2 ed 2.0

(2): based on CISPR 16-4-2 ed 2.0 (value for biconical antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

(3): The ±0,5 dB value is valid if all measuring system cable(s) and bulkhead connector losses are measured simultaneously. If cable(s) and bulkhead connector losses are measured separately the ±0,5 dB value shall be duplicated.

(4): The ±0,25 dB value is valid if all measuring system cable(s) and bulkhead connector frequency interpolation are evaluated simultaneously. If cable(s) and bulkhead connector frequency interpolation are evaluated separately the ±0,25 dB value shall be duplicated.

(5): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- receiver input maximum reflexion coefficient of 0,2; cable maximum transmission parameter of 1

(6): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- antenna maximum reflexion coefficient of 0,97; cable maximum transmission parameter of 1

(7): based on CISPR 16-4-2 ed 2.0 (maximum value among log-peridoc antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

Table I.3 : Typical uncertainty budget – 3 m / 10 m distance – Log-periodic antenna – Horizontal polarization

3m / 10 m distance measurement – Log-periodic antenna – Vertical Polarization					
Quantity x_i	**Symbol**	**Uncertainty of x_i**		**C_iUx_i**	**Comment**
		dB	**Probability distribution function**		
Receiver reading	V_R	± 0,1 (1)	k = 1	0,1	
Receiver corrections - Sine wave voltage	δV_{CW}	± 1 (1)	k = 2	0,5	
Receiver correction - Pulse amplitude response	δV_{PA}	± 1,5 (1)	Rectangular	0,87	
Receiver correction - Pulse repetition rate response	δV_{PR}	± 1,5 (1)	Rectangular	0,87	
Receiver correction - Noise floor proximity	δV_{NF}	+1,1 / 0	Rectangular	0,32	See note (2)
Receiver correction – Frequency step	δF_{STP}	+0 / -1,3	Rectangular	0,38	
Cable(s) loss(es)	L_{CAB}	± 0,5	k=2	0,25	See note (3)
Cable(s) loss(es) frequency interpolation	δL_{FI}	± 0,25	Rectangular	0,14	See note (4)
Bulkhead connector / receiver mismatch	M_{FR}	+0,34 / - 0,36	U-shaped	0,25	See note (5)
Antenna / bulkhead connector mismatch	M_{AF}	+1,54 / - 1,87	U-shaped	1,21	See note (6)
Antenna factor	AF	± 1,5	k=2	0,75	
AF frequency interpolation	δAF_{FI}	± 1	Rectangular	0,58	
AF variation with height	δAF_H	± 0,1	Rectangular	0,06	See note (7)
Directivity difference	δAF_{DIR}	± 3,2	Rectangular	1,85	See note (7)
Cross-polarization	δAF_{CP}	± 0,9	Rectangular	0,52	See note (7)

3m / 10 m distance measurement – Log-periodic antenna – Vertical Polarization					
Balance	δAF_{BAL}	0	Rectangular	0	See note (7)
Expanded uncertainty ($U(E)$ $2u_c(E)$) (in dB)				**5,72**	

(1): based on CISPR 16-4-2 ed 2.0

(2): based on CISPR 16-4-2 ed 2.0 (value for biconical antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

(3): The ±0,5 dB value is valid if all measuring system cable(s) and bulkhead connector losses are measured simultaneously. If cable(s) and bulkhead connector losses are measured separately the ±0,5 dB value shall be duplicated.

(4): The ±0,25 dB value is valid if all measuring system cable(s) and bulkhead connector frequency interpolation are evaluated simultaneously. If cable(s) and bulkhead connector frequency interpolation are evaluated separately the ±0,25 dB value shall be duplicated.

(5): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- receiver input maximum reflexion coefficient of 0,2; cable maximum transmission parameter of 1

(6): based on:
- bulkhead connector maximum reflexion coefficient of 0,2;
- antenna maximum reflexion coefficient of 0,97; cable maximum transmission parameter of 1

(7): based on CISPR 16-4-2 ed 2.0 (maximum value among log-periodic antenna not tilted used in OATS or ALSE and 3 m / 10 m distance)

Table I.4 : Typical uncertainty budget – 3 m / 10 m distance – log-periodic antenna – Vertical polarization

I.3 Receiver correction – frequency step

Example of frequency step correction evaluation for:

- Frequency generator at 100 MHz
- Measuring receiver with 120 kHz bandwidth and 5 kHz frequency step (lower than half-bandwidth to make a more precise evaluation of amplitude variation)

Example of measurement data shown in figure I.1 allows to have an uncertainty evaluation for frequency step parameter with a record of amplitude variation between the maximum peak level and the peak level for a frequency shift equal to one frequency step (half a frequency step on each side of center frequency):

- 1,3 dB for the given example

This uncertainty corresponds to a test level undervaluation ; therefore uncertainty value to be consider shall be 0 dB for positive value and -1,3 dB for negative value (unsymmetric uncertainty).

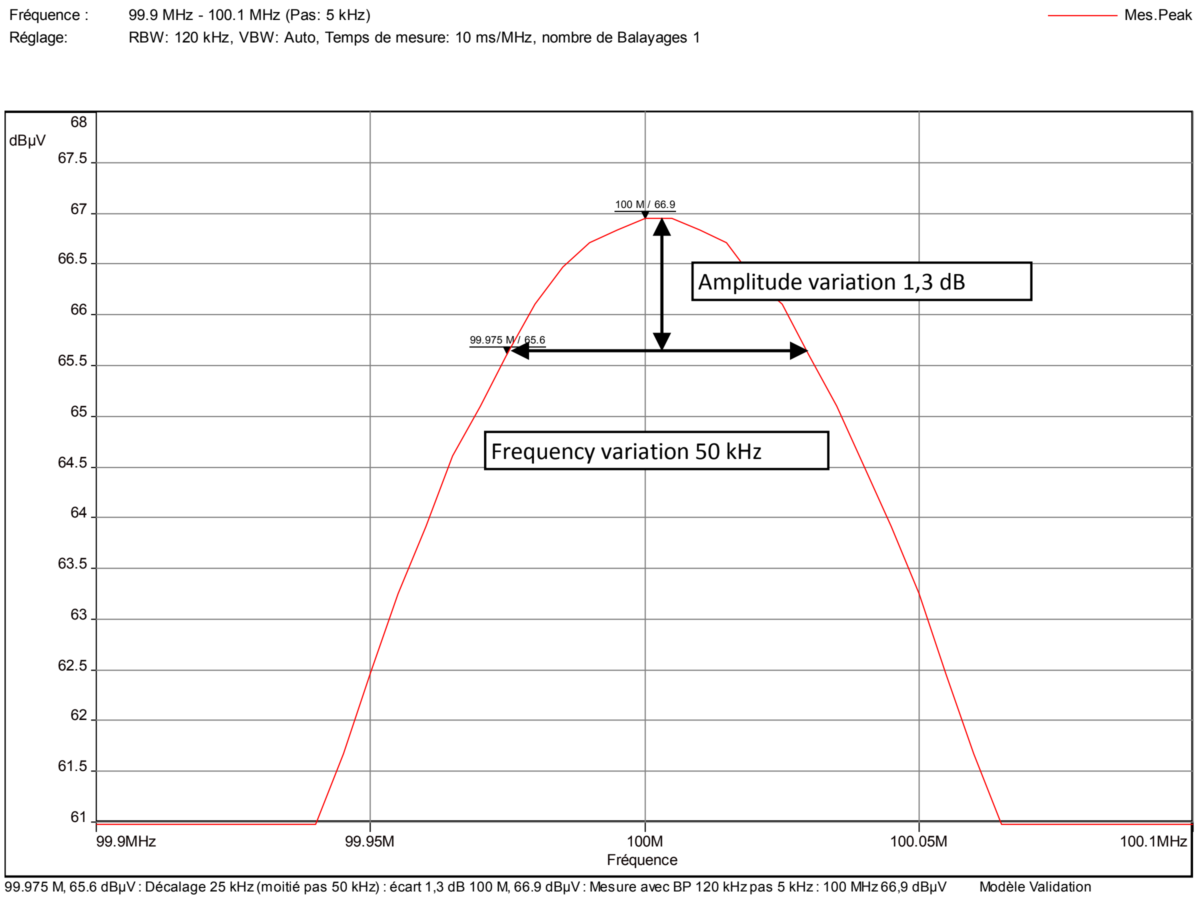


Figure I.1. : Example of measurement for frequency step uncertainty evaluation

Annex J
(informative)

Items Under Consideration

J.1 Introduction

This annex contains future work items that are under consideration.

J.2 Frequency range

As further work progresses in CISPR A and CISPR H this will be reviewed and CISPR 12 updated accordingly.

J.3 Operation conditions for electrically driven boats

As sufficient experience is available on this topic, it will be included in CISPR 12.

J.4 Correlation between OTS and ALSE Measurements

The work on this topic has been started in the CISPR/A – CISPR/D Joint Task Force.