



BSI Standards Publication

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

National foreword

This British Standard is the UK implementation of EN IEC 55025:2022. It is identical to CISPR 25:2021. It supersedes BS EN 55025:2017, which will be withdrawn on 20 January 2025.

The UK participation in its preparation was entrusted to Technical Committee GEL/210, EMC - Policy committee.

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Published by BSI Standards Limited 2022

ISBN 978 0 539 03979 5

ICS 33.100.10; 33.100.20

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2022.

Amendments/corrigenda issued since publication

Date	Text affected
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English Version

Vehicles, boats and internal combustion engines - Radio
disturbance characteristics - Limits and methods of
measurement for the protection of on-board receivers
(CISPR 25:2021)

Véhicules, bateaux et moteurs à combustion interne -
Caractéristiques des perturbations radioélectriques - Limites
et méthodes de mesure pour la protection des récepteurs
embarqués
(CISPR 25:2021)

Fahrzeuge, Boote und von Verbrennungsmotoren
angetriebene Geräte - Funkstöreigenschaften - Grenzwerte
und Messverfahren für den Schutz von an Bord befindlichen
Empfängern
(CISPR 25:2021)

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document CIS/D/477/FDIS, future edition 5 of CISPR 25, prepared by CISPR SC D “Electromagnetic disturbances related to electric/electronic equipment on vehicles and internal combustion engine powered devices” of CISPR “International special committee on radio interference” was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 55025:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2022–10–20 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2025–01–20 document have to be withdrawn

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Endorsement notice

The text of the International Standard CISPR 25:2021 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

CISPR 12:2007 NOTE Harmonized as EN 55012:2007 (not modified)

CISPR 16-2-3:2016 NOTE Harmonized as EN 55016-2-3:2017 (not modified)

IEC 62196-1:2014 NOTE Harmonized as EN 62196-1:2014 (modified)

CISPR 16-2-1:2014 NOTE Harmonized as EN 55016-2-1:2014 (not modified)

CISPR 32:2015 NOTE Harmonized as EN 55032:2015 (not modified) +A11:2020

CISPR 16-4-2:2011 NOTE Harmonized as EN 55016-4-2:2011 (not modified)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61851-1	2017	Electric vehicle conductive charging system - Part 1: General requirements	EN IEC 61851-1	2019
CISPR 16-1-1	2019	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus	EN IEC 55016-1-1	2019
CISPR 16-1-2	2014	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-2: Radio disturbance and immunity measuring apparatus - Coupling devices for conducted disturbance measurements	EN 55016-1-2	2014
AMD1	2017		A1	2018
CISPR 16-1-6	2014	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-6: Radio disturbance and immunity measuring apparatus - EMC antenna calibration	EN 55016-1-6	2015
AMD1	2017		A1	2017
ISO 7637-3	2016	Road vehicles - Electrical disturbances from conduction and coupling - Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines	-	-
ISO 11452-4	2020	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 4: Harness excitation methods	-	-
SAE ARP 958.1 Rev D	2003-02	Electromagnetic Interference Measurement Antennas; Standard Calibration Method	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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

FOREWORD

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

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) inclusion of new frequency bands,
- b) deletion of the annex on TEM cells,
- c) inclusion of annexes on measurement uncertainty,
- d) overall improvement.

The text of this International Standard is based on the following documents:

Draft	Report on voting
CIS/D/477/FDIS	CIS/D/480/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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

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INTRODUCTION

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

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

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

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

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

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

Radio technology developed for use by government agencies, emergency services (police forces, fire departments, ambulance/health services, etc) are not detailed and the protection limits provided are not necessarily applicable. For these technologies, limits and/or measurement parameters are generally agreed upon by the manufacturer and the service providers.

Mobile services up to 4G technologies have been considered in this edition. 5G technology and/or all mobile services under development have not been considered due to lack of established information in regards to frequency bands and limits.

To accomplish this end, this document:

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

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

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

1 Scope

This document contains limits and procedures for the measurement of radio disturbances in the frequency range of 150 kHz to 5 925 MHz. This document applies to vehicles, boats, internal combustion engines, trailers, devices and any electronic/electrical component intended for use in vehicles, boats, trailers and devices. Refer to International Telecommunications Union (ITU) publications for details of frequency allocations. The limits are intended to provide protection for on-board receivers installed (per the manufacturer's guidelines) in a vehicle from disturbances produced by components/modules in the same vehicle.

The receiver types to be protected are, for example, broadcast receivers (sound and television), land mobile radio, radio telephone, amateur, citizens' radio, Satellite Navigation (GPS etc.), Wi-Fi, V2X, and Bluetooth.

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

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

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

The emission requirements in this document are not intended to be applicable to the intentional transmissions from a radio transmitter as defined by the ITU including their spurious emissions.

NOTE 1 This exclusion is limited to those intended transmitter emissions, which leave the EUT as radiated emissions and are coupled onto the wire line in the measurement setup. For conducted transmissions on frequencies intentionally produced by the radio part of an EUT, this exclusion does not apply.

NOTE 2 It is usual for customers and suppliers to use radio regulation standards to manage the effect of spurious emissions from a radio transmitter unless limits of spurious emission are agreed in the test plan.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 61851-1:2017, *Electric vehicle conductive charging system – Part 1: General requirements*

CISPR 16-1-1:2019, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*
CISPR 16-1-2:2014/AMD1:2017

CISPR 16-1-6:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-6: Radio disturbance and immunity measuring apparatus – EMC antenna calibration*
CISPR 16-1-6:2014/AMD1:2017

ISO 7637-3:2016, *Road vehicles – Electrical disturbances from conduction and coupling – Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines*

ISO 11452-4:2020, *Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Harness excitation methods*

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

absorber lined shielded enclosure

ALSE

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

3.2

antenna factor

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

3.3

antenna matching unit

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

3.4

artificial mains network

AMN

network that 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

Note 1 to entry: 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 interchangeably.

Note 2 to entry: Network inserted in the power mains of the vehicle in charging mode or of a component (e.g. charger) which provides, in a given frequency range, a specified load impedance and which isolates the vehicle / component from the power mains in that frequency range.

3.5 **artificial network** **AN**

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 can isolate the apparatus from the supply or signal sources/loads in that frequency range

Note 1 to entry: Network inserted in the DC 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 DC power supply in that frequency range.

3.6 **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 1 to entry: This network is inserted in the communication/signal lines of the vehicle in charging mode or of a component (e.g. charger) to provide a specific load impedance and/or a decoupling (e.g. between communication/signal lines and power mains). The AAN is also used in this document for symmetric lines.

3.7 **bandwidth**

3.7.1 **bandwidth**

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

Note 1 to entry: The given characteristic may be, for example, the amplitude/frequency characteristic, the phase/frequency characteristic or the delay/frequency characteristic.

[SOURCE: IEC 60050-161:2018, 161-06-09, modified – Addition of "an equipment or" in the definition.] [5]

3.7.2 **bandwidth**

<emission or signal> the width of the frequency band outside which the level of any spectral component does not exceed a specified percentage of a reference level

[SOURCE: IEC 60050-161:2018, 161-06-10] [5]

3.8 **boat**

vessel intended to be used on the surface of water, its length being no greater than 15 m intended to carry persons or goods and equipped with either an inboard or outboard engine

3.9 **bonded**

<ground connection and DC resistance> grounding connection with a DC resistance not exceeding 2,5 mΩ and that provides the lowest possible impedance (resistance and inductance) connection between two metallic parts (see 5.3 of CISPR 16-2-1:2014/AMD1:2017)

Note 1 to entry: A low current (≤100 mA) 4-wire milliohm meter is recommended for this measurement.

3.10**broadband emission**

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

Note 1 to entry: An emission which has a pulse repetition rate (in Hz) less than the bandwidth of a particular measuring instrument can also be considered as a broadband emission.

3.11**charging mode**

mode that is intended to charge the traction battery with one of the following four categories described from 3.11.1 to 3.11.4

3.11.1**charging mode 1**

charging mode as defined in IEC 61851-1:2017, 6.2.1

Note 1 to entry: In some countries, mode 1 charging is prohibited or requires special precautions.

3.11.2**charging mode 2**

charging mode as defined in IEC 61851-1:2017, 6.2.2 where the vehicle is connected to AC mains using a charging cable including an Electric Vehicle Supply Equipment (EVSE) box providing control pilot signalling between the vehicle and the EVSE box and personal protection against electric shock

Note 1 to entry: In some countries, special restrictions are applied for mode 2 charging.

Note 2 to entry: There is no communication between the vehicle and the AC supply network (mains).

3.11.3**charging mode 3**

charging mode as defined in IEC 61851-1:2017, 6.2.3 where the vehicle is connected to an EVSE (e.g charging station, wall box) providing AC power to the vehicle with communication between the vehicle and the charging station (through signal/control lines and/or through wired network lines)

3.11.4**charging mode 4**

charging mode as defined in IEC 61851-1:2017, 6.2.4 where the vehicle is connected to an EVSE providing DC power to the vehicle (with an off-board charger) with communication between the vehicle and the charging station (through signal/control lines and/or through wired network lines)

3.12**class**

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

3.13**compression point**

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

3.14**controller area network****CAN**

network documented in ISO 11898-1 that connects devices, sensors and actuators in systems

3.15

device

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

Note 1 to entry: Devices include, but are not limited to, chainsaws, irrigation pumps, snow blowers, air compressors, and landscaping equipment.

3.16

disturbance voltage

interference voltage (deprecated in this sense)
voltage produced between two points on two separate conductors by an electromagnetic disturbance, measured under specified conditions

[SOURCE: IEC 60050-161:1990, 161-04-01][5]

3.17

electric vehicle

vehicle propelled exclusively by electric motor(s) powered by on-board traction battery or batteries

Note 1 to entry: Vehicles equipped with an additional power source (e.g. auxiliary combustion engine, fuel cell) used to provide electric power to the electric motor/traction battery only, without contributing to the mechanical propulsion of the vehicle, are considered as an electric vehicle.

3.18

equipment under test

EUT

vehicle, boat, device, component, module or internal combustion engine within this document

3.19

hybrid electric vehicle

vehicle propelled by electric motor(s) and internal combustion engine

Note 1 to entry: The two propulsion systems can operate individually or in a combined mode depending on the hybrid system.

Note 2 to entry: Vehicle where the electric motor is used to start the internal combustion engine are not considered as a hybrid vehicle.

3.20

high voltage

HV

operating DC voltage between 60 V to 1 000 V

Note 1 to entry: The term high voltage can be defined with a different voltage range in other standards.

3.21

high voltage artificial network

HV-AN

network inserted in the high voltage DC 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 can isolate the apparatus from the supply in that frequency range

3.22

direct current charging artificial network

DC-charging-AN

network inserted in the high voltage DC lead of vehicle in charging mode which provides, in a given frequency range, a specified load impedance and which can isolate the vehicle from the HV DC charging station in that frequency range

3.23**low voltage****LV**

operating DC voltage below 60 V, e.g. nominal voltages of 12 V, 24 V or 48 V

Note 1 to entry: The term low voltage can be defined with a different voltage range in other standards.

3.24**measurement time**

effective, coherent time for a measurement result at a single frequency

- for the peak detector, the effective time to detect the maximum of the signal envelope,
- for the quasi-peak detector, the effective time to measure the maximum of the weighted envelope,
- for the average detector, the effective time to average the signal envelope

3.25**narrowband emission**

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

Note 1 to entry: An emission which has a pulse repetition rate (in Hz) greater than the bandwidth of a particular measuring instrument can also be considered as a narrowband emission.

3.26**open area test site****OATS**

facility used for measurements of electromagnetic fields the intention for which is to simulate a semi-free-space environment over a specified frequency range that is used for radiated emission testing of products

Note 1 to entry: An OATS typically is located outdoors in an open area and has an electrically-conducting ground plane. This is defined in CISPR 16-2-3.

3.27**powerline communications****PLC**

communication technique based on error tolerant modulation schemes which transmits information superimposed to electrical power over lines or cables

3.28**reference ground plane**

flat conductive surface whose potential is used as a common reference

Note 1 to entry: For the purpose of this document, the reference ground plane is defined as the top metallic surface of the test bench/table.

3.29**RF boundary**

element of an EMC test setup that determines what part of the harness and/or peripherals are included in the RF environment and what is excluded

Note 1 to entry: A RF boundary can consist of, for example, ANs, filter feed-through pins, RF absorber coated wire, and/or RF shielding.

3.30**shielded enclosure**

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

[SOURCE: IEC 60050-161:1990, 161-04-37, modified – The second preferred term “screened room” has been omitted.][5]

3.31

signal/control port

port intended for the interconnection of components of an EUT, or between an EUT and local auxiliary equipment (AE) and used in accordance with relevant functional specifications (for example for the maximum length of cable connected to it)

Note 1 to entry: Examples include RS-232, Universal Serial Bus (USB), High-Definition Multimedia Interface (HDMI), IEEE Std 1394 ("FireWire").

Note 2 to entry: For vehicles in charging mode, this includes Control Pilot signal, PLC technology used on Control Pilot signal line and CAN.

3.32

traction battery

high voltage (HV) battery used for the propulsion of electric or hybrid electric vehicle

3.33

validation reference ground plane

elevated reference ground plane with the dimensions of 2,5 m × 1 m which is used as the standard for modelling in Annex I

Note 1 to entry: The validation reference ground plane size and grounding used during the modelling can be different from what a laboratory would use during EUT measurements.

3.34

wired network port

port for the connection of voice, data and signalling transfers intended to interconnect widely dispersed systems by direct connection to a single-user or multi-user communication network

Note 1 to entry: Examples of these include CATV, PSTN, ISDN, xDSL, LAN and similar networks.

Note 2 to entry: Wired network ports can support screened or unscreened cables and can also carry AC or DC power where this is an integral part of the telecommunication specification.

3.35

vehicle

machine operating on land which is intended to carry persons or goods or that is operated by a person

Note 1 to entry: Vehicles include, but are not limited to cars, trucks, buses, mopeds, agricultural machinery, earth-moving machinery, trailers, material-handling equipment, mining equipment, floor treatment machines, walk-behind floor treatment machines and snowmobiles.

3.36

vehicle inlet

electric vehicle inlet

part of a vehicle coupler incorporated in, or fixed to, the electric vehicle or hybrid vehicle (if equipped)

[SOURCE: IEC 62196-1:2014, 3.3.2, modified – Addition of "or hybrid vehicle (if equipped)".]

4 Requirements common to vehicle and component/module emissions measurement

4.1 General test requirements

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

Electromagnetic disturbance sources can be divided into two main types:

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

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

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

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

4.1.2 Test plan

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

- frequency range to be tested,
- the emissions limits,
- antenna types and locations,
- test report requirements,
- supply voltage and other relevant parameters, including EUT operating conditions as described in 4.1.4.

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

4.1.3 Determination of conformance of equipment under test (EUT) with limits

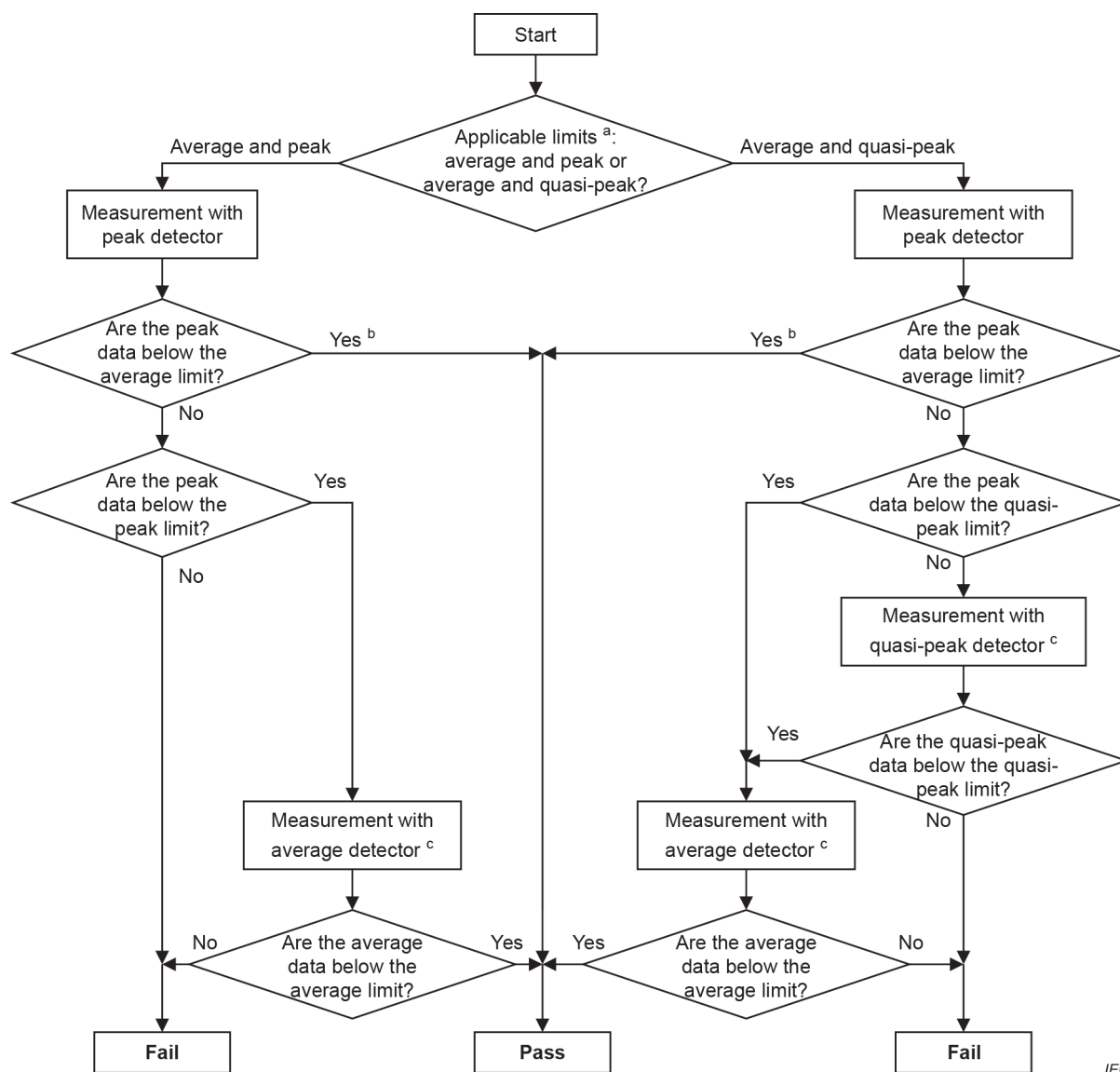
In all cases the EUT shall conform to the average limit.

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

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

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

The limits given in this document take uncertainties into account.



IEC

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

^b Because measurements with a peak detector are always higher than or equal to measurements with an average detector and the applicable peak limit is always higher than or equal to the applicable average limit, this single detector measurement can lead to a simplified and quicker conformance process.

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

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

4.1.4 Operating conditions

Different operating conditions of the EUT can influence emission measurement results.

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

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

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

4.1.5 Test report

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

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

4.2 Shielded enclosure

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

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

4.3 Absorber-lined shielded enclosure (ALSE)

4.3.1 General

For radiated emission measurements the reflected energy can cause errors of as much as 20 dB. Therefore, it is necessary to apply RF absorber material to the walls and ceiling of a shielded enclosure that is to be used for radiated emission measurements.

The following ALSE requirements shall also be made when performing radiated RF emissions measurements.

4.3.2 Size

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

4.3.3 Objects in ALSE

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

4.3.4 ALSE performance validation

4.3.4.1 Vehicle ALSE

The performance of the absorption material shall be greater than or equal to 6 dB in the 70 MHz to 5 925 MHz frequency range.

No absorber shall be placed on the floor for vehicle tests.

NOTE A test method is described in IEEE STD 1128-1998 [4].¹

4.3.4.2 Component ALSE

The performance of the absorption material shall be greater than or equal to 6 dB in the 70 MHz to 5 925 MHz frequency range.

For component testing, no absorber shall be placed on the floor, however, flat ferrite tiles with a maximum thickness of 25 mm can be utilised on the floor for component level testing if the chamber performance in this configuration meets the requirements of Annex I.

NOTE A test method is described in IEEE STD 1128-1998 [4].

The ALSE performance validation procedure described in Annex I shall be used to evaluate the performance of the ALSE as configured for 6.5 component radiated emissions testing. This performance verification procedure will evaluate the influences of the chamber, absorber, reference ground plane, reference ground plane grounding, and any other possible cause for measurement variation

4.4 Measuring instrument

4.4.1 General

The measuring instrument (including FFT-based instruments) shall comply with the requirements of CISPR 16-1-1. Either manual or automatic frequency scanning can be used. For the limits given in this document, the appropriate average detector is the linear detector with meter time constants defined in CISPR 16-1-1.

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 can be convenient to measure emissions using peak detection because of the faster scan possible than with quasi-peak detection.

NOTE 2 A preamplifier can be used between the antenna and measuring instrument in order to achieve the 6 dB ambient noise requirements (see 4.2). If a preamplifier is used to achieve the 6 dB ambient noise requirement, the laboratory establishes a procedure to avoid overload of the preamplifier, such as using a step attenuator.

4.4.2 Spectrum analyser parameters

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

Spectrum analysers can be used for performing compliance measurements to this document 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.

¹ Numbers in square brackets refer to the Bibliography.

The minimum scan time in Table 1 is applicable only for the measurement of emissions where the pulse repetition interval of the signal is shorter than the minimum observation time at each frequency based on a step size equal to half of the resolution bandwidth B_{res} . For the measurement of signals with a pulse repetition interval longer than the minimum observation time and for the measurement of intermittent signals the minimum scan time shall be increased.

If the pulse repetition interval of the signal is known the scan shall be performed with a scan time that allows an observation time at each frequency that is longer than the reciprocal of the pulse repetition frequency of the signal.

As alternative multiple faster scans with the use of a maximum hold function can be used if the total scanning time is equal to or greater than the time that would have been spent using the minimum scan time defined in Table 1. The following equation can be used to calculate the minimum scan time for multiple scans.

$$T_{\text{s,min}} = 2 \times \frac{\Delta f}{B_{\text{res}}} \quad (1)$$

where

$T_{\text{s,min}}$ is the minimum scan time for multiple scans,

Δf is the frequency span,

B_{res} is the resolution bandwidth (RBW).

For further guidance on the measurement of the duration of disturbance and the determination of the minimum scan time, see CISPR 16-2-1 and CISPR 16-2-3 [7].

Table 1 – Spectrum analyser parameters

Service / Band	Frequency range MHz	Peak detection		Quasi-peak detection		Average detection	
		RBW at –3 dB	Minimum scan time	RBW at –6 dB	Minimum scan time	RBW at –3 dB	Minimum scan time
Analogue broadcast services							
LW	0,15 to 0,30	9/10 kHz	10 s / MHz	9/10 kHz	200 s / MHz	9/10 kHz	10 s / MHz
MW	0,53 to 1,8						
SW	5,9 to 6,2						
FM	76 to 108	100/120 kHz	100 ms / MHz	100/120 kHz	20 s / MHz	100 / 120 kHz	100 ms / MHz
TV Band I	41 to 88						
TV Band III	174 to 230						
TV Band IV	470 to 944						
Digital broadcast services							
DAB III	167 to 245	1 MHz	100 ms / MHz	Does not apply		1 MHz	100 ms / MHz
TV Band III	174 to 230						
DTTV	470 to 770						
DAB L Band	1 447 to 1 494						
SDARS	2 320 to 2 345						
Mobile services							
CB	26 to 28	9/10 kHz	10 s/MHz	9/10 kHz	200 s/MHz	9/10 kHz	10 s/MHz
VHF	30 to 54	100 / 120 kHz	100 ms / MHz	100 / 120 kHz	20 s / MHz	100 / 120 kHz	100 ms / MHz
VHF	68 to 87						
VHF	142 to 175						
Analogue UHF	380 to 512			Does not apply			
RKE & TPMS 1	300 to 330						
RKE & TPMS 2	420 to 450						
Analogue UHF	820 to 960			100 / 120 kHz	20 s / MHz		
GPS L5	1 156,45 to 1 196,45	Does not apply				9/10 kHz	1 s / MHz
BDS, B1I	1 553,098 to 1 569,089						
GPS L1	1 567,42 to 1 583,42						
GLONASS L1	1 590,781 to 1 616,594						
Wi-Fi / Bluetooth	2 402 to 2 494	1 MHz	100 ms/ MHz	Does not apply		1 MHz	100 ms / MHz
Wi-Fi	5 150 to 5 350						
Wi-Fi	5 470 to 5 725						
V2X (Wi-Fi)	5 850 to 5 925						

Service / Band	Frequency range MHz	Peak detection		Quasi-peak detection		Average detection	
		RBW at -3 dB	Minimum scan time	RBW at -6 dB	Minimum scan time	RBW at -3 dB	Minimum scan time
Digital mobile phone services							
2G	a)	100/120 kHz	100 ms / MHz	Does not apply		100 / 120 kHz	100 ms / MHz
3G		1 MHz	100 ms / MHz	Does not apply		1 MHz	100 ms / MHz
4G							
5G							
a) Frequency bands associated with these technologies are detailed in limits tables.							

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

4.4.3 Scanning receiver parameters

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

The minimum measurement time in Table 2 is applicable only for the measurement of emissions where the pulse repetition interval of the signal is shorter than the minimum measurement time in Table 2. For the measurement of signals with a pulse repetition interval longer than the minimum measurement time in Table 2 and for the measurement of intermittent signals the minimum measurement time shall be increased.

If the pulse repetition interval of the signal is known the scan shall be performed with a measurement time that is longer than the reciprocal of the pulse repetition frequency of the signal.

If using FFT-based instruments, the minimum measurement time should be 1 s.

For further guidance on the measurement of the duration of disturbance and the determination of the minimum measurement time see CISPR 16-2-1 and CISPR 16-2-3 [7].

Table 2 – Scanning receiver parameters

Service / Band	Frequency range MHz	Peak detection			Quasi-peak detection			Average detection		
		RBW at -6 dB	Max step size	Min mea- sure- ment time	RBW at -6 dB	Max step size	Min mea- sure- ment time	RBW at -6 dB	Max step size	Min mea- sure- ment time
Analogue broadcast services										
LW	0,15 to 0,30	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1 s	9 kHz	5 kHz	50 ms
MW	0,53 to 1,8									
SW	5,9 to 6,2									
FM	76 to 108	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms
TV Band I	41 to 88									
TV Band III	174 to 230									
TV Band IV	470 to 944									
Digital broadcast services										
DAB III	167 to 245	1 MHz	500 kHz	50 ms	Does not apply			1 MHz	500 kHz	50 ms
TV Band III	174 to 230									
DTTV	470 to 770									
DAB L Band	1 447 to 1 494									
SDARS	2 320 to 2 345									
Mobile services										
CB	26 to 28	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1 s	9 kHz	5 kHz	50 ms
VHF	30 to 54	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms
VHF	68 to 87									
VHF	142 to 175									
Analogue UHF	380 to 512				Does not apply					
RKE & TPMS 1	300 to 330									
RKE & TPMS 2	420 to 450									
Analogue UHF	820 to 960				120 kHz	50 kHz	1 s			
GPS L5	1 156,45 to 1 196,45	Does not apply						9 kHz	5 kHz	5 ms
BDS, B1I	1 553,098 to 1 569,089									
GPS L1	1 567,42 to 1 583,42									
GLONASS L1	1 590,781 to 1 616,594									
Wi-Fi / Bluetooth	2 402 to 2 494	1 MHz	500 kHz	50 ms	Does not apply			1 MHz	500 kHz	50 ms
Wi-Fi	5 150 to 5 350									
Wi-Fi	5 470 to 5 725									
V2X (Wi-Fi)	5 850 to 5 925									

Service / Band	Frequency range MHz	Peak detection			Quasi-peak detection			Average detection		
		RBW at −6 dB	Max step size	Min mea- sure- ment time	RBW at −6 dB	Max step size	Min mea- sure- ment time	RBW at −6 dB	Max step size	Min mea- sure- ment time
Digital mobile phone services										
2G	a)	120 kHz	50 kHz	5 ms	Does not apply			120 kHz	50 kHz	5 ms
3G		1 MHz	500 kHz	50 ms	Does not apply			1 MHz	500 kHz	50 ms
4G										
5G										
a) Frequency bands associated with these technologies are detailed in limits tables.										

4.5 Power supply

4.5.1 General

The power supply shall have adequate regulation to maintain the supply voltage U_s within the ranges specified in 4.5.2, 4.5.3, 4.5.4, 4.5.5 and 4.5.6.

4.5.2 Internal combustion engine vehicle – ignition on, engine off

The vehicle battery voltage shall be recorded before and after the measurement with ignition off and battery disconnected from the vehicle electrical network. The values shall be within the following values:

$$U_s = \left(12^{+2}_{-1} \right) \text{ V for systems with 12 V nominal supply voltage}$$

$$U_s = \left(24^{+4}_{-2} \right) \text{ V for systems with 24 V nominal supply voltage}$$

$$U_s = \left(48^{+8}_{-4} \right) \text{ V for systems with 48 V nominal supply voltage}$$

4.5.3 Internal combustion engine vehicle – engine running

The vehicle battery voltage shall be recorded before and after the measurement with engine running in idle mode and battery connected to the vehicle electrical network. The values shall be within the following values:

$$U_s = \left(13^{+3}_{-0} \right) \text{ V for systems with 12 V nominal supply voltage}$$

$$U_s = \left(26^{+6}_{-0} \right) \text{ V for systems with 24 V nominal supply voltage}$$

$$U_s = \left(48^{+8}_{-0} \right) \text{ V for systems with 48 V nominal supply voltage}$$

NOTE Most of the vehicle tests will be performed without the engine running, but with the ignition switched on, therefore ensure that the battery is sufficiently well charged. A permanent recording of the battery voltage can be installed during the measurements as a complementary information.

4.5.4 Plug-in hybrid electric or electric vehicle in charging mode

In case of AC charging the AC power supply voltage during the test shall be nominal –15 % / +10 %. The rated value of the frequency shall be nominal ±1 %.

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 can lead to splitting 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 the case of conductive charging, then the current shall be set to at least 80 % of its maximum rated value for AC charging.

If the current consumption can be adjusted in the case of conductive charging, then the current shall be set to at least 80 % of its maximum rated value for DC charging unless another value is agreed in the test plan.

In case of multiple batteries, the average of SOC should be considered.

The vehicle battery voltage shall be recorded before and after the measurement in charging mode and battery connected to the vehicle electrical network. The values shall be within the following values:

$$U_s = \begin{pmatrix} 14 \\ +1 \\ -1 \end{pmatrix} \text{ V for systems with 12 V nominal supply voltage}$$

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

4.5.5 Hybrid electric or electric vehicle in running mode

The vehicle battery voltage shall be recorded before and after the measurement in running mode and battery connected to the vehicle electrical network. The values shall be within the following values:

$$U_s = \begin{pmatrix} 14 \\ +1 \\ -1 \end{pmatrix} \text{ V for systems with 12 V nominal supply voltage}$$

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

4.5.6 Component/module tests

The DC power supply voltage during the test shall be nominal ±10 %.

The AC power supply voltage during the test shall be nominal –15 % / +10 %. The rated value of the frequency shall be nominal ±1 %.

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

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

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

$$U_s = \begin{pmatrix} 48^{+4} \\ -4 \end{pmatrix} \text{ V for systems with 48 V nominal supply voltage}$$

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

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

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

5.1 General

The test shall be performed in an ALSE.

5.2 Antenna measuring system

5.2.1 Type of antenna

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

If no antenna is to be furnished with the vehicle the antenna types in Table 3 shall be used for the test. The antenna type and location shall be included in the test plan.

If an active antenna is used, the noise floor of the measured signal at the radio antenna connector can increase (see also the note in 5.5).

Table 3 – Antenna types

Frequency MHz	Antenna type
0,15 to 6,2	1 m monopole
26 to 54	Loaded quarter-wave monopole
68 to 1 000	Quarter-wave monopole
1 000 to 5 925	As recommended by the vehicle manufacturer

5.2.2 Measuring system requirements

5.2.2.1 Broadcast bands

5.2.2.1.1 General

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

5.2.2.1.2 AM analog broadcast

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

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

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

The measuring system consisting of antenna element, antenna matching unit, coaxial cable(s) and preamplifier, if used, shall have the following characteristics:

- noise floor of the measurement system shall be at least 6 dB lower than the applicable limits.

Antenna matching unit

- The input impedance shall have a resistance of at least 100 k Ω in parallel with a maximum capacitance of 10 pF;
- Output impedance: 50 Ω resistive;
- Gain: The gain (or attenuation) shall be known with an accuracy of $\pm 0,5$ dB. The gain shall remain within a 6 dB envelope for each frequency band as shown in Figure 2. Verification shall be performed in accordance with Annex B;

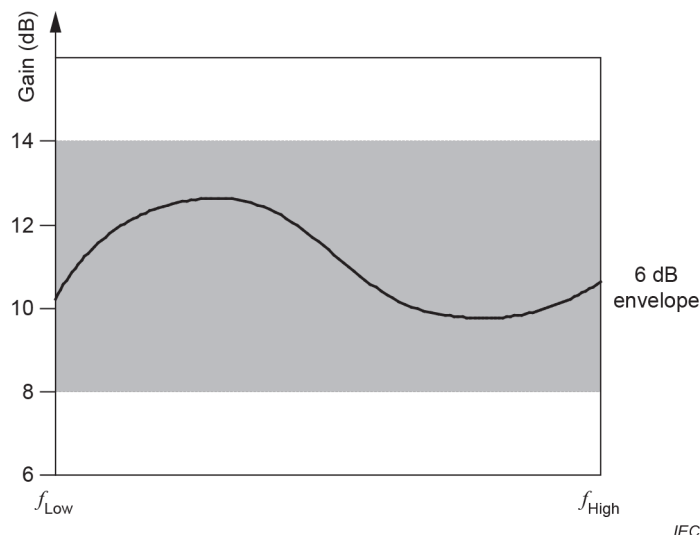


Figure 2 – Example of gain curve

- Compression point: The 1 dB compression point shall occur at a sine wave voltage level (generator output level) greater than 60 dB(μ V). Verification shall be performed in accordance with Annex B.

5.2.2.1.3 FM and TV analog broadcast and DAB digital broadcast

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

5.2.2.2 Mobile services (26 MHz to 5 925 MHz) and digital mobile phone services (2G, 3G, 4G, 5G)

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

5.3 Method of measurement

The disturbance voltage shall be measured at the receiver end of the antenna coaxial cable using the ground contact of the antenna coaxial cable connector as a reference. The antenna coaxial cable connector shall be grounded to the housing of the on-board radio. The radio housing shall be grounded to the vehicle body using the production harness. A coaxial bulkhead connector shall be used for connection to the measuring instrument outside the shielded room. In the case of an active vehicle antenna, which is fed by the radio via the antenna cable (phantom network), a decoupling network similar to that used in the radio shall be installed at the antenna connector to feed the active antenna from the vehicle supply voltage.

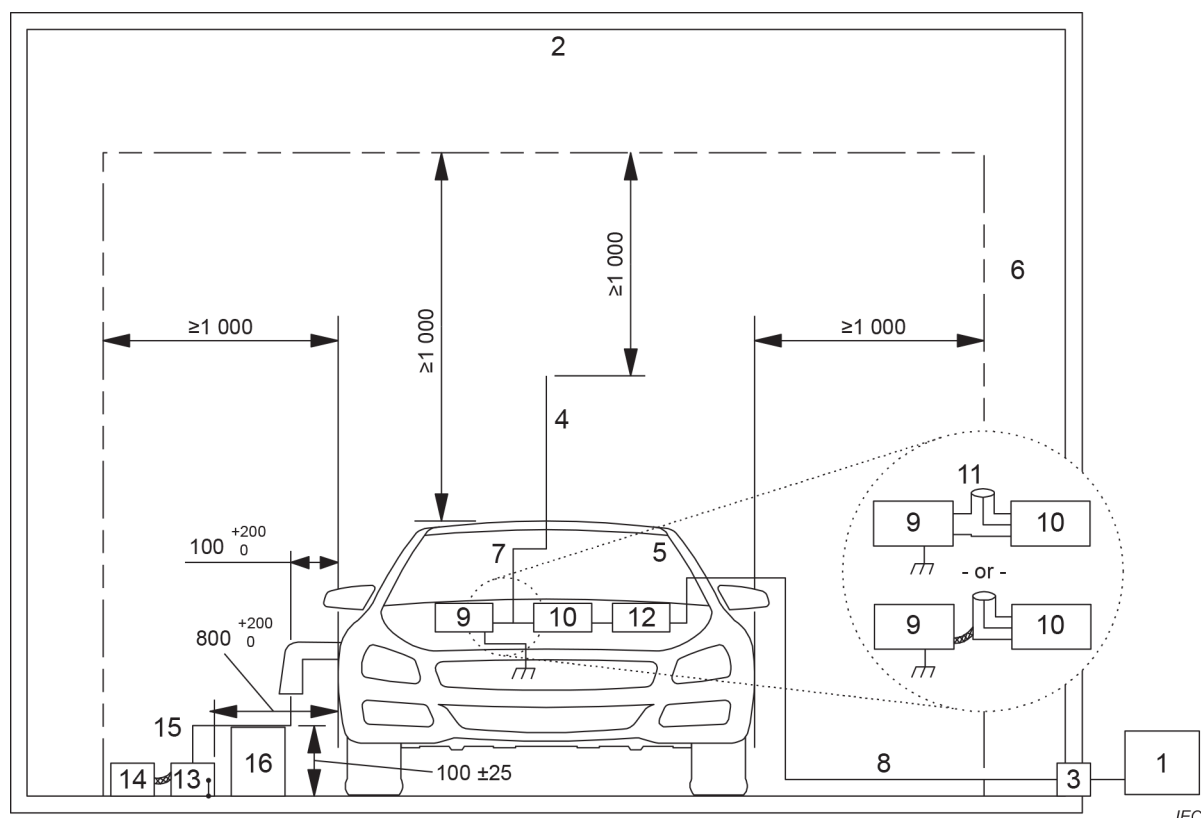
When making measurements in the AM broadcast bands (LW, MW, SW), the vehicle/matching unit ground and ground of the ALSE shall be electrically isolated from each other by means such as an isolation transformer, sheath-current suppressor, battery-powered measurement instrumentation, fibre optics, etc.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

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

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

The test setup is described in Figure 3.

Dimensions in millimetres



Key

- 1 Measuring instrument
- 2 ALSE
- 3 Bulkhead connector
- 4 Antenna (see 5.2)
- 5 Vehicle
- 6 Typical absorber material
- 7 Antenna coaxial cable
- 8 High-quality coaxial cable e.g. double-shielded (50 Ω)
- 9 Housing of on-board radio
- 10 Impedance matching unit (when required)
- 11 Modified coaxial "T" connector
- 12 AM broadcast band ground isolation network (when required)
- 13 Artificial Mains Network (only for charging mode configuration)
- 14 Power mains (only for charging mode configuration)
- 15 Charging harness (only for charging mode configuration)
- 16 Insulating support (only for charging mode configuration)

**Figure 3 – Example of test setup – Vehicle-radiated emissions
(front view with monopole antenna)**

5.4 Test setup for vehicle in charging mode

5.4.1 General

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

5.4.2 Vehicle in charging mode 1 or mode 2 (AC power charging without communication)

5.4.2.1 General

This configuration concerns only charging mode 1 and mode 2.

Examples of test setups are shown in Figure 4 and Figure 5.

5.4.2.2 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 but not necessarily aligned with the charging harness.
- The harness shall be placed as close as possible to the ground plane.

5.4.2.3 Artificial mains network

Power mains shall be applied to the vehicle through 50 μ H/50 Ω AMN(s) (see Clause E.3).

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 DC resistance between the ground of the AMN measurement port and the ground plane shall not exceed 2,5 m Ω .

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

For vehicles with the inlet located front/rear of the vehicle, the AMN should be placed on one side of the vehicle and perpendicularly to the vehicle power charging inlet and should be aligned with the vehicle charging harness. For vehicles with the inlet located side of the vehicle, the AMN should be placed on one side of the vehicle and aligned with the vehicle power charging inlet and should be aligned with the vehicle charging harness.

5.4.2.4 Power charging harness

The power charging harness shall be laid out in a straight line between the AMN(s) and the vehicle charging inlet and shall be routed perpendicularly to the vehicle's longitudinal axis as shown in Figure 4 and Figure 5. The projected harness length from the side of the AMN(s) to the side of the vehicle shall be 800^{+200}_0 mm.

For a longer harness, the extraneous length shall be "Z-folded" in a less than 0,5 m width approximately around the middle of the AMN to vehicle distance. If it is impractical to do so because of harness bulk or stiffness, or because the testing is being done at a user's installation, the disposition of the excess harness shall be precisely noted in the test report.

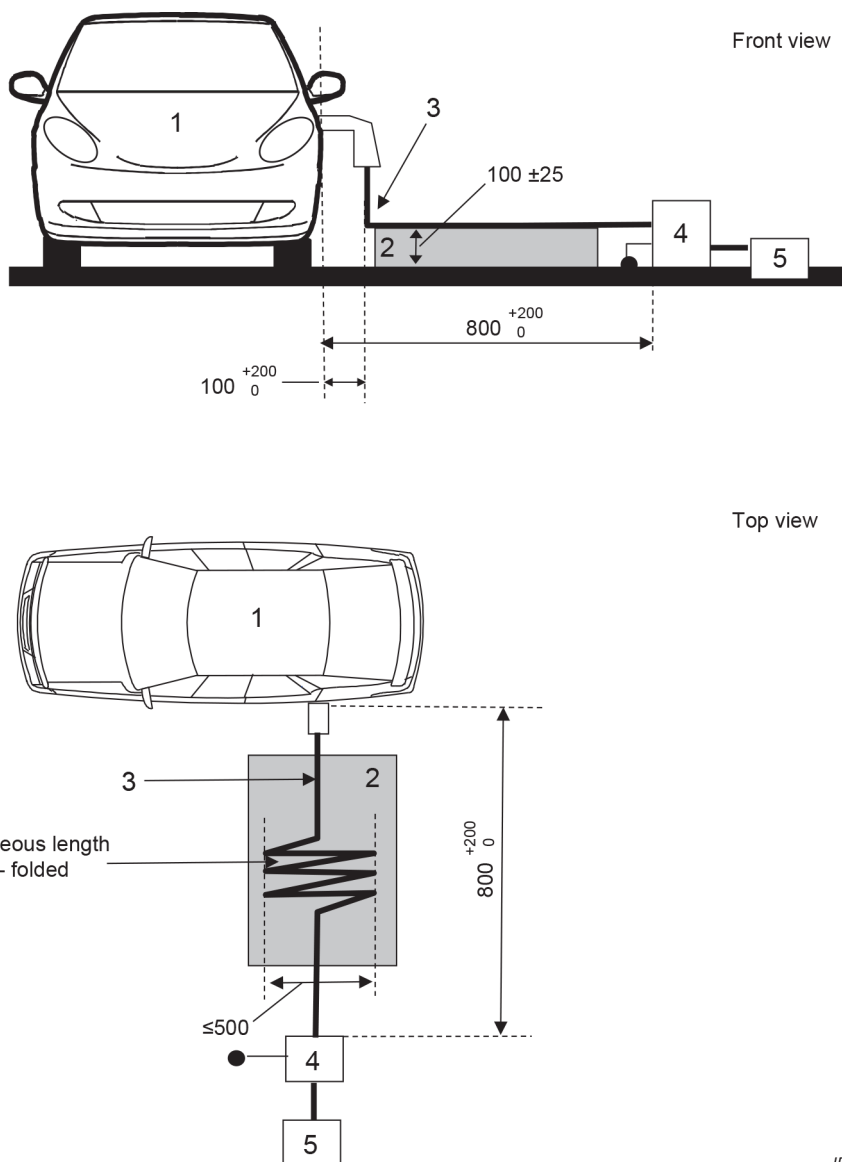
The charging harness at the vehicle side shall hang vertically at a distance of 100^{+200}_0 mm from the vehicle body.

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

5.4.2.5 Measuring system

The measuring system (receiver, impedance matching unit, cable...) shall be placed as defined in Figure 3.

Dimensions in millimetres

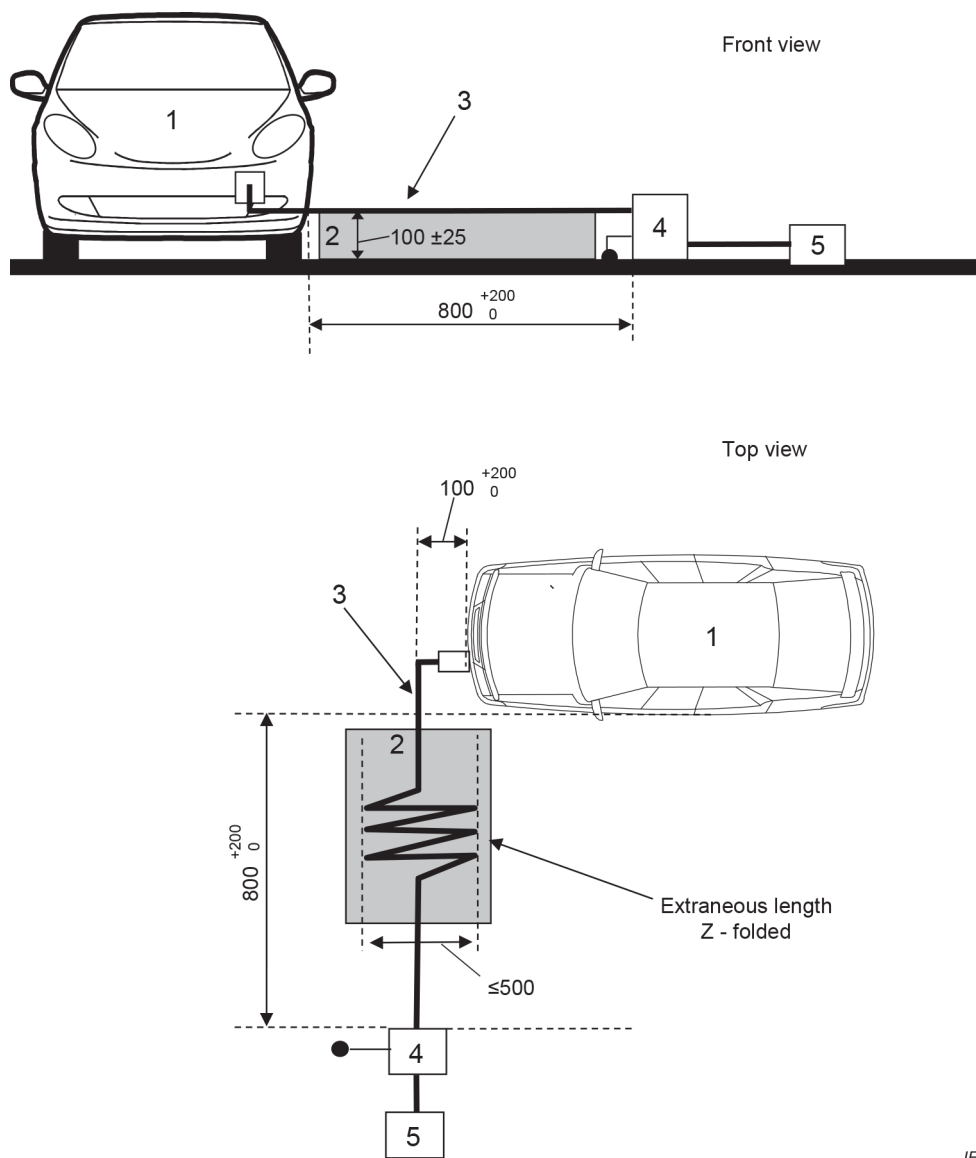


Key

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging harness
- 4 AMN(s) grounded
- 5 Power mains socket (see 5.4.2.2)

Figure 4 – Example of test setup for vehicle with the inlet located on vehicle side (charging mode 1 or 2, AC powered, without communication)

Dimensions in millimetres



IEC

Key

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging harness
- 4 AMN(s) grounded
- 5 Power mains socket (see 5.4.2.2)

Figure 5 – Example of test setup for vehicle with the inlet located front / rear of vehicle (charging mode 1 or 2, AC powered, without communication)

5.4.3 Vehicle in charging mode 3 (AC power charging with communication) or mode 4 (DC power charging with communication)

5.4.3.1 General

This configuration concerns charging mode 3 and mode 4.

Examples of test setups are shown in Figure 6 and Figure 7.

5.4.3.2 Charging station / power mains

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

If the local/private communication between the vehicle and the charging station can be simulated, the charging station can be replaced by a supply from the AC power mains network.

In both cases 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 / local/ private communication socket and the AMN(s) / DC-charging-AN(s) / AAN(s) shall be kept as short as possible but not necessarily aligned with the charging harness.
- The harness between the power mains / local/private communication socket and the AMN(s) / DC-charging-AN(s) / AAN(s) shall be placed on the ground plane.

If the charging station is placed inside the test location then the harness between the charging station and the power mains / local/private communication socket shall satisfy the following conditions:

- The harness on the charging station 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. If it is impractical to do so because of cable bulk or stiffness, or because the testing is being done at a user’s installation, the disposition of the excess cable shall be precisely noted in the test report.

5.4.3.3 Artificial mains networks / artificial networks

The AC mains shall be applied to the vehicle through 50 μ H/50 Ω AMN(s) (see Clause E.3).

The DC power mains shall be applied to the vehicle through 5 μ H/50 Ω DC-charging-AN(s) (see E.2.3).

The AMN(s) / DC-charging-AN(s) shall be mounted directly on the ground plane. The cases of the AMN(s) / DC-charging-AN(s) shall be bonded to the ground plane. The DC resistance between the ground of the AMN / DC-charging-AN measurement port and the ground plane shall not exceed 2,5 m Ω .

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

The AMN / HV-AN should be placed in front, aligned and on the same side of the vehicle power charging inlet. For vehicles with inlet located side of the vehicle, the AMN/AN should be placed on one side of the vehicle and aligned with the vehicle power charging inlet and should be aligned with the vehicle charging cable.

5.4.3.4 Asymmetric artificial network

Local/private communication lines connected to signal/control ports and lines connected to wired network ports shall be applied to the vehicle through AAN(s).

The various AAN(s) to be used are defined in Annex E:

- E.4.2 for signal/control port with symmetric lines,
- E.4.3 for wired network port with PLC on power lines,
- E.4.4 for signal/control port with PLC on control pilot line and
- E.4.5 for signal/control port with control pilot line.

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.

For vehicles with the inlet located front/rear of the vehicle, the AAN should be placed on one side of the vehicle and perpendicularly to the vehicle power charging inlet and should be aligned with the vehicle charging harness. For vehicles with the inlet located side of the vehicle, the AAN should be placed on one side of the vehicle and aligned with the vehicle power charging inlet and should be aligned with the vehicle charging harness.

If a charging station is used, AAN(s) are not required for the signal/control ports and/or for the wired network ports. The local/private communication lines between the vehicle and the charging station shall be connected to the associated equipment on the charging station side to work as designed.

5.4.3.5 Power charging with local/private communication harness

The power charging with local/private communication harness shall be laid out in a straight line between the AMN(s) / DC-charging-AN(s) / AAN(s) and the vehicle charging inlet and shall be routed perpendicularly to the vehicle's longitudinal axis as shown in Figure 6 and Figure 7. The projected harness length from the side of the AMN(s) to the side of the vehicle shall be 800^{+200}_0 mm.

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

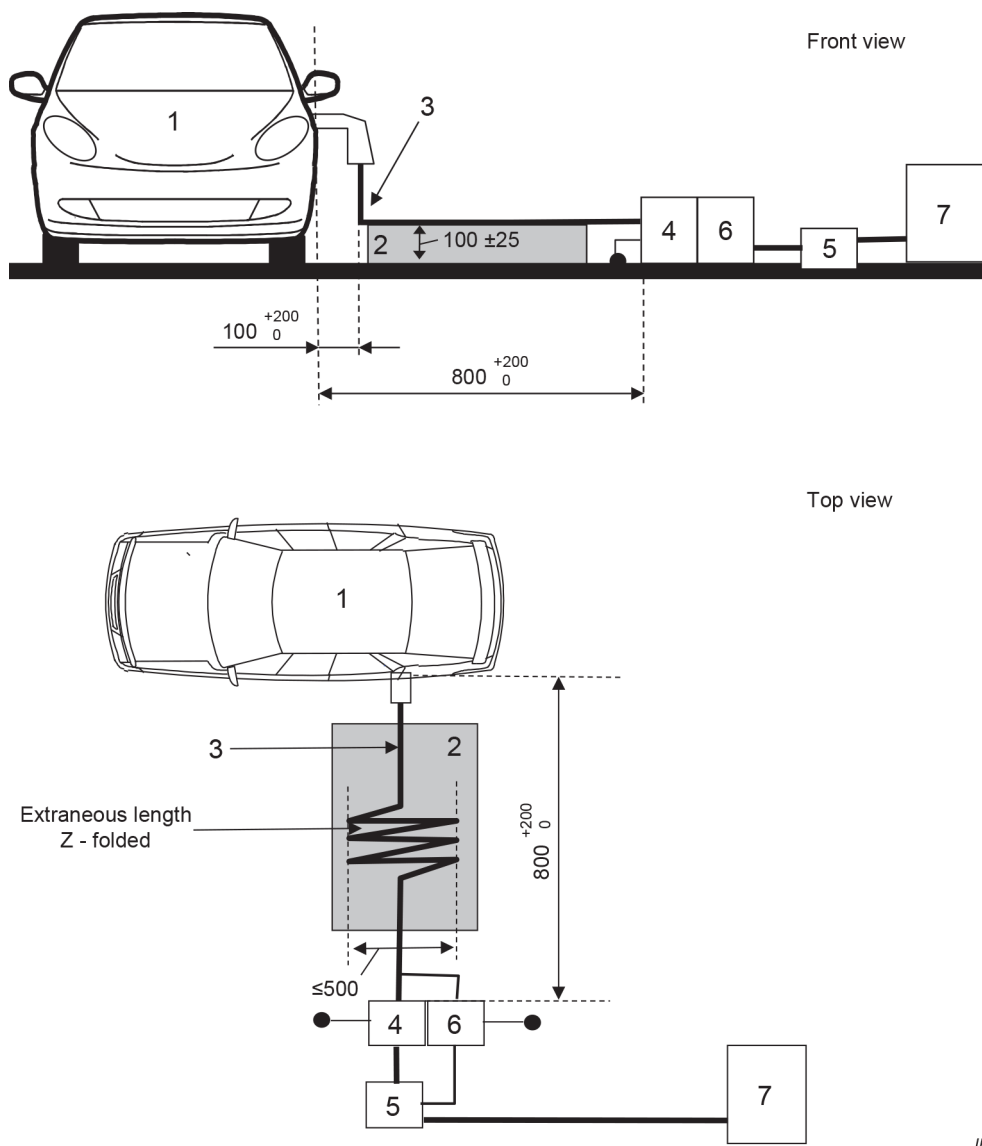
The power charging with local/private communication harness at the vehicle side shall hang vertically at a distance of 100^{+200}_0 mm from the vehicle body.

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

5.4.3.6 Measuring system

The measuring system (receiver, impedance matching unit, cable...) shall be placed as defined in Figure 3.

Dimensions in millimetres

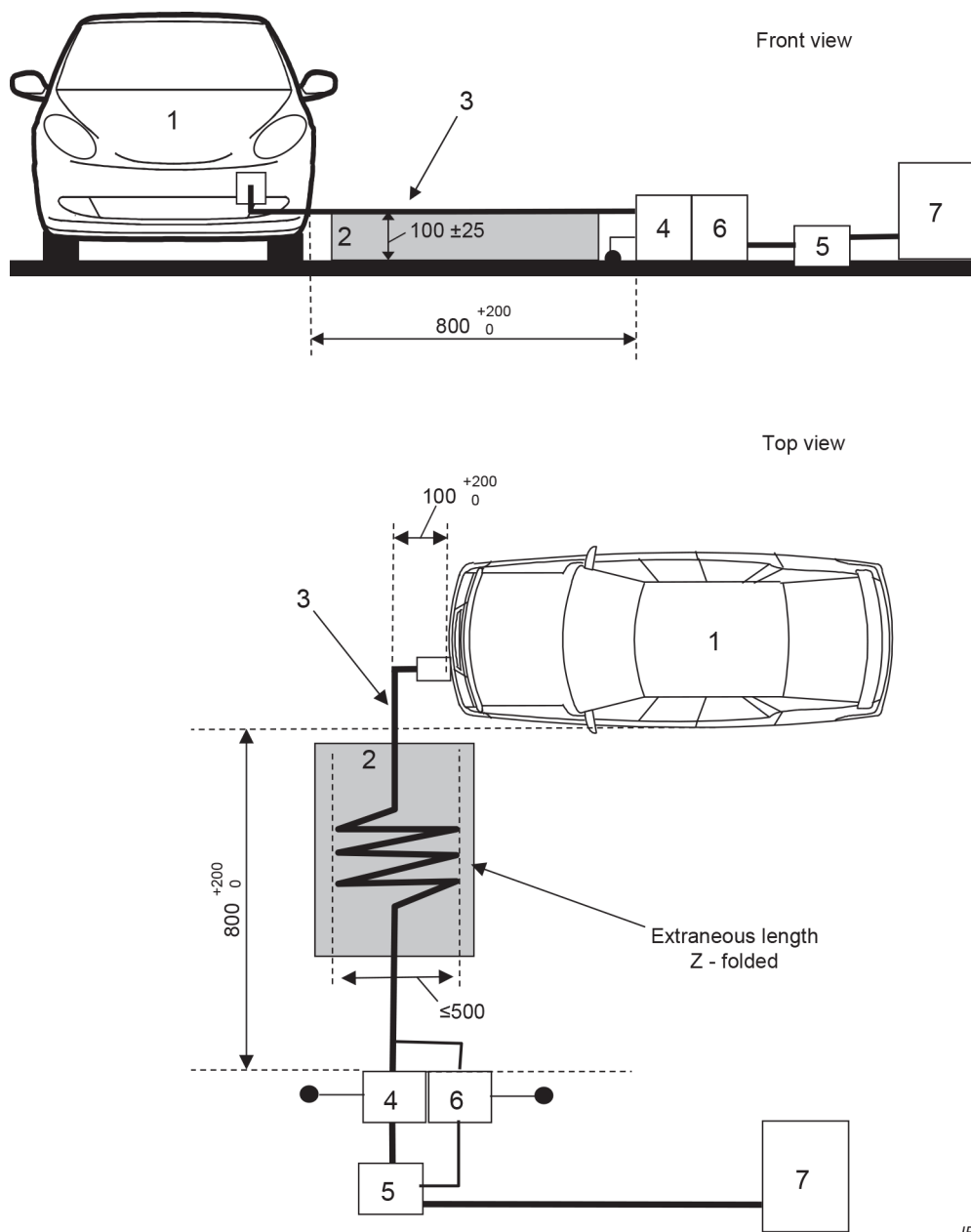


Key

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging harness with local/private communication lines
- 4 AMN(s) or DC-charging-AN(s) grounded
- 5 Power mains socket
- 6 AAN(s) grounded
- 7 Charging station

Figure 6 – Example of test setup for vehicle with the inlet located on vehicle side (charging mode 3 or mode 4, with communication)

Dimensions in millimetres

**Key**

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging harness with local/private communication lines
- 4 AMN(s) or DC-charging-AN(s) grounded
- 5 Power mains socket
- 6 AAN grounded
- 7 Charging station

Figure 7 – Example of test setup for vehicle with the inlet located front /rear of vehicle (charging mode 3 or mode 4, with communication)

5.5 Examples of limits for vehicle radiated disturbances

It is recommended for acceptable radio reception in a vehicle using typical radio receivers, that the disturbance voltage at the end of the antenna cable should not exceed the values shown in Table 4 and Table 5. Where different receivers are used or different coupling models for the propagation of disturbances are valid, the limits can be changed and detailed in the vehicle manufacturer's own specification.

Table 4 – Example for limits of disturbance – Complete vehicle – General

Service / Band ^a	Frequency MHz	Limit of disturbance voltage at antenna terminal of receiver in dB (µV)			RBW
		Peak	Quasi-Peak	Average	
Analogue broadcast services					
LW ^b	0,15 to 0,3	26	13	6	9 kHz
MW ^b	0,53 to 1,8	20	7	0	
SW ^b	5,9 to 6,2	20	7	0	
FM ^b	76 to 108	26	13	0	120 kHz
TV Band I ^c	41 to 88	16	-	6	
TV Band III ^c	174 to 230	16	-	6	
TV Band IV ^c	470 to 944	16	-	6	
Digital broadcast services					
DAB III	171 to 245	26	-	16	1 MHz
TV Band III ^c	174 to 230	26	-	16	
DTTV	470 to 770	32 ^d	-	22 ^d	
DAB L Band	1 447 to 1 494	32	-	22	
SDARS	2 320 to 2 345	32	-	22	
Mobile services					
CB ^b	26 to 28	20	7	0	9 kHz
VHF ^b	30 to 54	20	7	0	120 kHz
VHF ^b	68 to 87	20	7	0	
VHF ^b	142 to 175	20	7	0	
Analogue UHF ^b	380 to 512	20	7	0	
RKE & TPMS 1 ^e	300 to 330	20	-	6	
RKE & TPMS 2 ^e	420 to 450	20	-	6	
Analogue UHF ^b	820 to 960	20	7	0	
GPS L5 ^f	1 156,45 to 1 196,45	-	-	10	9 kHz
BDS, B1I ^g	1 553,098 to 1 569,098	-	-	-4,5	
GPS L1 ^h	1 567,42 to 1 583,42	-	-	0	
GLONASS L1 ⁱ	1 590,781 to 1 616,594	-	-	0	
Wi-Fi / Bluetooth	2 402 to 2 494	26	-	6	1 MHz
Wi-Fi	5 150 to 5 350	26	-	6	
Wi-Fi	5 470 to 5 725	26	-	6	
V2X (Wi-Fi)	5 850 to 5 925	50	-	30	

- ^a LW: Long wave, MW: Medium wave, SW: Short wave (amplitude modulation, AM)
VHF: Very high frequency, UHF: Ultra high frequency (frequency modulation, FM)
DAB: Digital audio broadcasting, TV: Television, DTTV: Digital terrestrial television
RKE: Remote keyless entry, GPS: Global positioning system, GSM: Global system mobile,
BDS: BeiDou navigation System, GLONASS: Global navigation satellite system, V2X: Vehicle to X
- ^b In this analogue service the peak and quasi-peak limits can be relaxed by 6 dB for short duration disturbances (e.g. short duration PK (or QPK) limit = PK (or QPK) limit + 6 dB).
- ^c Analogue TV only.
- ^d This limit is less stringent than the analogue limit and should only be applied where analogue TV is no longer in use.
- ^e RKE limits are defined over a large frequency band. Any modification of the average limit around the operating frequency due to sensitivity of RKE systems should be defined in the test plan.
- ^f The values given in the table apply to the 1 156,45 MHz to 1 196,45 MHz frequency range. The limits for the whole GPS L5 frequency range are given in Figure 8a.
- ^g The values given in the table apply for the 1 553,098 MHz to 1 569,098 MHz frequency range. The limits for the whole BDS, B1I frequency range are given in Figure 8b.
- ^h The values given in the table apply to the 1 567,42 MHz to 1 616,42 MHz frequency range. The limits for the whole GPS L1 frequency range are given in Figure 8c.
- ⁱ The values given in the table apply to the 1 590,781 MHz to 1 616,594 MHz frequency range. The limits for the whole GLONASS L1 frequency range are given in Figure 8d.

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

NOTE 2 All values listed in this table are valid for the bandwidths in Table 1 and Table 2. If measurements are performed with different bandwidths than those specified in Table 1 and Table 2 because of ambient noise requirements, then applicable limits are defined in the test plan and the applied limits and bandwidths are documented in the test report.

Table 5 – Example for limits of disturbance – Complete vehicle – Digital mobile phone

Service / Band	Frequency MHz	Limit of disturbance voltage at antenna terminal of receiver in dB (µV)		RBW
		Peak	Average	
Digital mobile phone services ^{c d}				
4G	460 to 467,5	32	12	1 MHz
5G n71 (617 MHz to 652 MHz) 4G (617 MHz to 652 MHz)	617 to 652	32	12	
5G n12 (729 MHz to 746 MHz) 5G n14 (758 MHz to 768 MHz) 5G n28 (758 MHz to 803 MHz) 5G n29 (717 MHz to 728 MHz) 4G (703 MHz to 803 MHz)	703 to 803	32	12	
3G (729 MHz to 756 MHz) 3G (758 MHz to 768 MHz)		26 ^a	6 ^a	
5G n20 (791 MHz to 821 MHz)	791 to 821	32	12	1 MHz
3G (791 MHz to 821 MHz)		26	6	
5G n5 (869 MHz to 894 MHz) 5G n18 (860 MHz to 875 MHz) 5G n26 (859 MHz to 894 MHz) 4G (852 MHz to 894 MHz)	852 to 894	32	12	1 MHz
3G (859 MHz to 894 MHz)		26 ^a	6 ^a	
2G (869 MHz to 894 MHz)		26 ^b	6 ^b	120 kHz
5G n8 (925 MHz to 960 MHz) 4G (925 MHz to 960 MHz)	925 to 960	32	12	1 MHz
3G (925 MHz to 960 MHz)		26 ^a	6 ^a	
2G (925 MHz to 960 MHz)		26 ^b	6 ^b	120 kHz
5G n50 (1 432 MHz to 1 517 MHz) 5G n51 (1 427 MHz to 1 432 MHz) 5G n74 (1 475 MHz to 1 518 MHz) 5G n75 (1 432 MHz to 1 517 MHz) 5G n76 (1 427 MHz to 1 432 MHz) 5G n91 (1 427 MHz to 1 432 MHz) 5G n92 (1 432 MHz to 1 517 MHz) 5G n93 (1 427 MHz to 1 432 MHz) 5G n94 (1 432 MHz to 1 517 MHz) 4G (1 427 MHz to 1 518 MHz)	1 427 to 1 518	32	12	1 MHz
3G (1 452 MHz to 1 496 MHz)		26 ^a	6 ^a	
4G	1 525 to 1 559	32	12	1 MHz
5G n3 (1 805 MHz to 1 880 MHz) 4G (1 805 MHz to 1 880 MHz)	1 805 to 1 880	32	12	1 MHz
3G (1 805 MHz to 1 880 MHz)		26 ^a	6 ^a	
2G (1 805 MHz to 1 880 MHz)		26 ^b	6 ^b	120 kHz
5G n2 (1 930 MHz to 1 990 MHz) 5G n25 (1 930 MHz to 1 995 MHz) 5G n34 (2 010 MHz to 2 025 MHz) 5G n39 (1 880 MHz to 1 920 MHz) 5G n70 (1 995 MHz to 2 020 MHz) 4G (1 850 MHz to 2 025 MHz)	1 850 to 2 025	32	12	1 MHz
3G (1 850 MHz to 1 995 MHz) 3G (2 010 MHz to 2 025 MHz)		26 ^a	6 ^a	
2G (1 930 MHz to 1 990 MHz)		26 ^b	6 ^b	120 kHz

Service / Band	Frequency MHz	Limit of disturbance voltage at antenna terminal of receiver in dB (μ V)		RBW
		Peak	Average	
5G n1 (2 110 MHz to 2 170 MHz) 5G n65 (2 110 MHz to 2 200 MHz) 5G n66 (2 110 MHz to 2 200 MHz) 4G (2 110 MHz to 2 200 MHz)	2 110 to 2 200	32	12	1 MHz
3G (2 110 MHz to 2 170 MHz)		26 ^a	6 ^a	
5G n30 (2 350 MHz to 2 360 MHz) 5G n40 (2 300 MHz to 2 400 MHz) 4G (2 300 MHz to 2 400 MHz)	2 300 to 2 400	32	12	1 MHz
3G (2 300 MHz to 2 400 MHz)		26 ^a	6 ^a	
5G n53 (2 483,5 MHz to 2 495 MHz)	2 483,5 to 2 495	32	12	1 MHz
5G n7 (2 620 MHz to 2 690 MHz) 5G n38 (2 570 MHz to 2 620 MHz) V2X 5G n41 (2 496 MHz to 2 690 MHz) 5G n90 (2 496 MHz to 2 690 MHz) 4G (2 496 MHz to 2 690 MHz)	2 496 to 2 690	32	12	1 MHz
3G (2 570 MHz to 2 690 MHz)		26 ^a	6 ^a	
5G n48 (3 550 MHz to 3 700 MHz) 5G n77 (3 300 MHz to 4 200 MHz) 5G n78 (3 300 MHz to 3 800 MHz) 4G (3 300 MHz to 3 800 MHz)	3 300 to 4 200	32	12	1 MHz
3G (3 510 MHz to 3 590 MHz)		26 ^a	6 ^a	
5G n79 (4 400 MHz to 5 000 MHz)	4 400 to 5 000	32	12	1 MHz
4G	5 150 to 5 925	32	12	1 MHz
5G n47 (5 855 MHz to 5 925 MHz) V2X V2X (4G)	5 855 to 5 925	32	12	1 MHz
^a values if 3G protocol is implemented in the vehicle. ^b values if 2G protocol is implemented in the vehicle. ^c details on 2G, 3G and 4G frequency bands are available on ETSI TS 136 101 [14]. ^d details on 5G frequency bands are available on ETSI TS 138 101-1 V16.4 [20].				
NOTE 1 All values listed in this table are valid for the bandwidths in Table 1 and Table 2. If measurements are performed with different bandwidths than those specified in Table 1 and Table 2 because of ambient noise requirements, then applicable limits are defined in the test plan and the applied limits and bandwidths are documented in the test report.				
NOTE 2 The frequency bands specified in "Frequency" merge different mobile phone services frequency bands (e.g the frequency band 2 300 MHz to 2 400 MHz merges "Band 40 – TD 2300" and "Band 30- 2300 WCS", "5G n30" and "5G n40".				

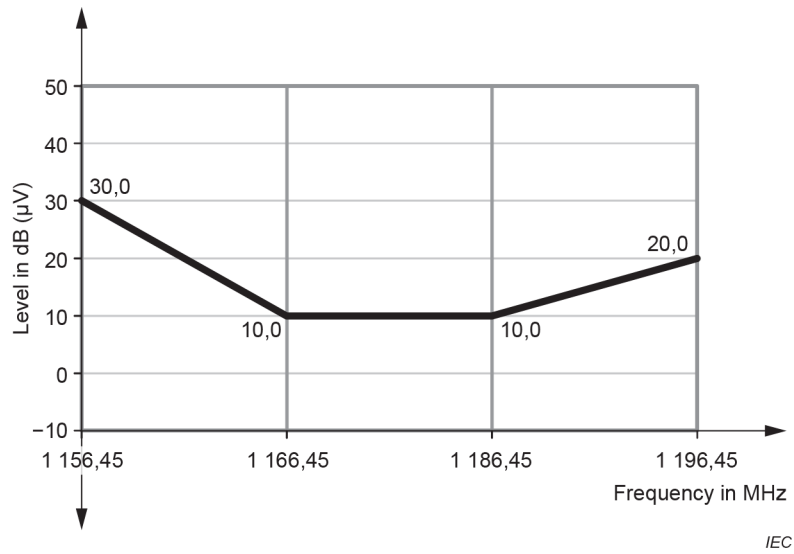


Figure 8a – GPS band L5 1 156,45 MHz to 1 196,45 MHz

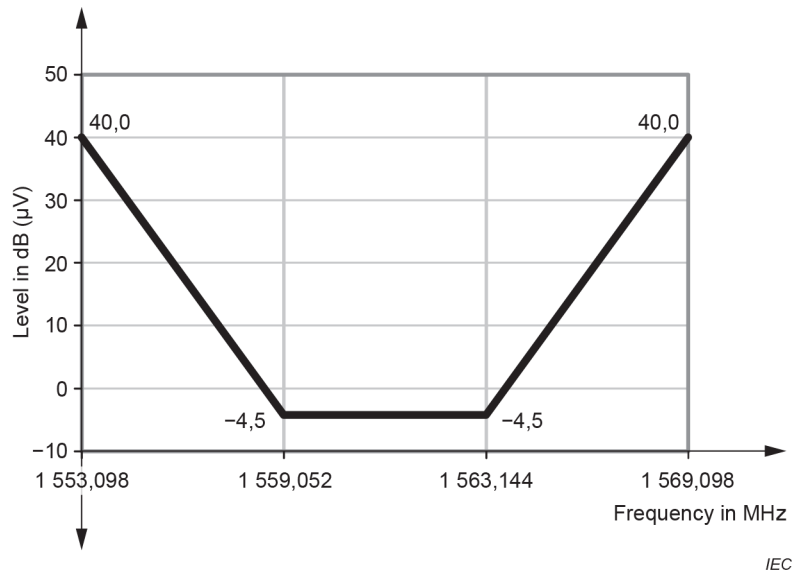


Figure 8b – BDS, B1I band 1 553,098 MHz to 1 569,098 MHz

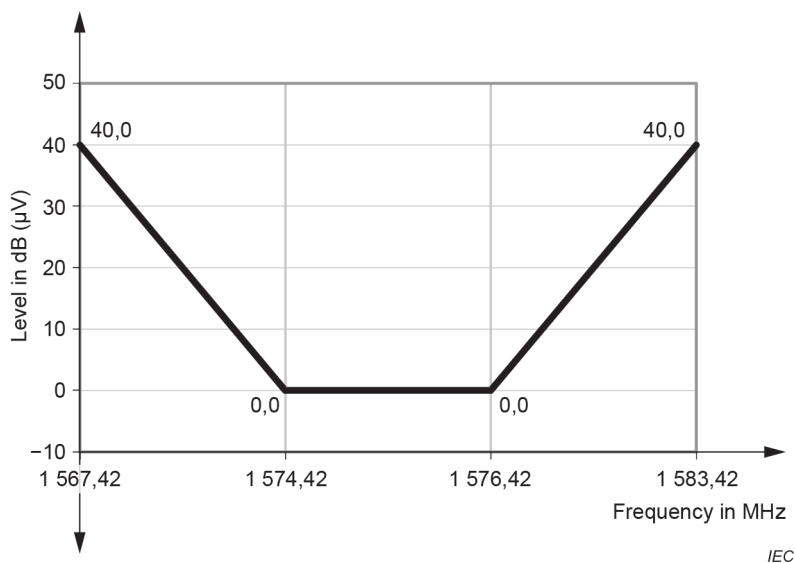


Figure 8c – GPS band 1 567,42 MHz to 1 583,42 MHz

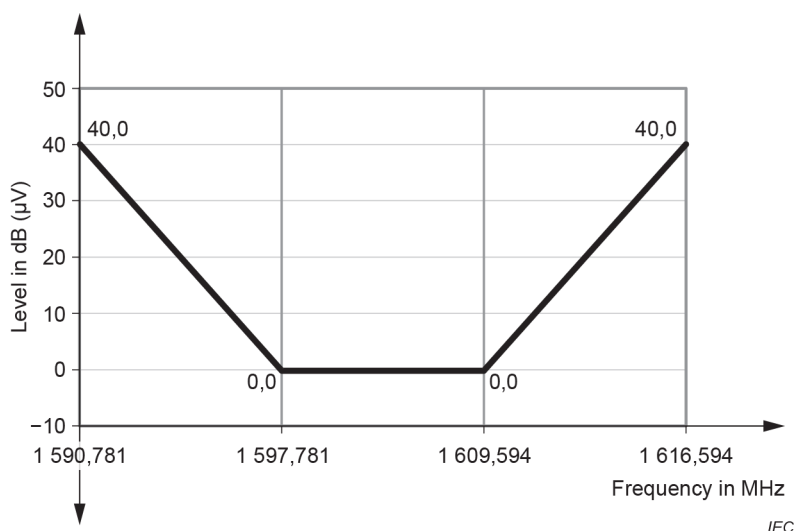


Figure 8d – GLONASS band 1 590,781 MHz to 1 616,594 MHz

Figure 8 – Details of average limits for GPS, BDS,B1I and GLONASS bands – Complete vehicle

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

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

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

6 Measurement of components and modules

6.1 General

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

For LV components test methods and requirements are defined in this clause.

For LV/HV components additional test methods and limits are defined in Annex H.

For LV/HV components:

- conducted emission (voltage method) on LV lines shall be performed according to setup defined in H.3.2 and requirement in 6.3.4;
- conducted emission (voltage method) on HV lines shall be performed according to setup defined in H.3.2 and requirement in H.3;
- conducted emission (current method) on LV/HV lines shall be performed according to setup defined in H.4.2 and requirement in 6.4.

6.2 Test equipment

6.2.1 Reference ground plane

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

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

The minimum size of the reference ground plane for conducted emissions (voltage method) shall be 1 000 mm × 400 mm.

The minimum size of the reference ground plane for conducted emissions (current probe method) shall be 2 500 mm × 400 mm.

The minimum dimensions of the reference ground plane for radiated emissions shall be 1 000 mm (width) × 2 000 mm (length), or the dimension of the entire underneath of the test setup (EUT and associated equipment (e.g. harness including supply lines, load simulator located on the test bench and AN(s)), excluding battery and/or power supply) plus 200 mm, whichever is the larger.

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

The reference ground plane shall be bonded to the shielded enclosure.

The distance from the edge of the ground strap to the edge of the next strap shall not be greater than 300 mm.

For radiated emission, to reduce resonances around 10 MHz to 30 MHz as detailed in Annex I, additional ground straps for both the front edge of reference ground plane and rear side of counterpoise can be installed if agreed upon between the customer and supplier.

The maximum length to width ratio for the ground straps for the rear side of reference ground plane shall be 7:1.