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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

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

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



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CONTENTS

FOREWORD.....	8
INTRODUCTION.....	10
1 Scope.....	11
2 Normative references	12
3 Terms and definitions	13
4 Requirements common to vehicle and component/module emissions measurements.....	17
4.1 General test requirements.....	17
4.1.1 Categories of disturbance sources (as applied in the test plan).....	17
4.1.2 Test plan	17
4.1.3 Determination of conformance of equipment under test (EUT) with limits	17
4.1.4 Operating conditions.....	18
4.1.5 Test report.....	19
4.2 Shielded enclosure	19
4.3 Absorber-lined shielded enclosure (ALSE)	19
4.3.1 General	19
4.3.2 Size	19
4.3.3 Objects in ALSE	19
4.3.4 ALSE performance validation.....	20
4.4 Measuring instrument.....	20
4.4.1 General	20
4.4.2 Spectrum analyser parameters	20
4.4.3 Scanning receiver parameters	23
4.5 Power supply	25
5 Measurement of emissions received by an antenna on the same vehicle	26
5.1 Antenna measuring system	26
5.1.1 Type of antenna.....	26
5.1.2 Measuring system requirements	26
5.2 Method of measurement	28
5.3 Test setup for vehicle in charging mode	30
5.3.1 General	30
5.3.2 AC power charging without communication	30
5.3.3 AC or DC power charging with communication line(s) or with signal line(s)	33
5.4 Examples of limits for vehicle radiated disturbances	37
6 Measurement of components and modules	39
6.1 General.....	39
6.2 Test equipment	39
6.2.1 Reference ground plane	39
6.2.2 Power supply and AN	40
6.2.3 Load simulator.....	40
6.3 Conducted emissions from components/modules – Voltage method	41
6.3.1 General	41
6.3.2 Test setup	41
6.3.3 Test procedure	42

6.3.4	Limits for conducted disturbances from components/modules – Voltage method	46
6.4	Conducted emissions from components/modules – Current probe method	49
6.4.1	Test setup	49
6.4.2	Test procedure	49
6.4.3	Limits for conducted disturbances from components/modules – Current probe method	52
6.5	Radiated emissions from components/modules – ALSE method	54
6.5.1	General	54
6.5.2	Test setup	54
6.5.3	Test procedure	57
6.5.4	Limits for radiated disturbances from components/modules – ALSE method	62
6.6	Radiated emissions from components/modules – TEM cell method	65
6.7	Radiated emissions from components/modules – Stripline method	65
Annex A (informative)	Flow chart for checking the applicability of CISPR 25	66
Annex B (normative)	Antenna matching unit – Vehicle test	67
B.1	Antenna matching unit parameters (150 kHz to 6,2 MHz)	67
B.2	Antenna matching unit – Verification	67
B.2.1	General	67
B.2.2	Gain measurement	67
B.2.3	Test procedure	67
B.3	Impedance measurement	67
Annex C (informative)	Sheath-current suppressor	69
C.1	General information	69
C.2	Suppressor construction	69
Annex D (informative)	Guidance for the determination of the noise floor of active vehicle antennas in the AM and FM range	70
Annex E (normative)	Artificial networks (AN), artificial mains networks (AMN) and asymmetric artificial networks (AAN)	73
E.1	General	73
E.2	Artificial networks (AN)	73
E.2.1	Component powered by LV	73
E.2.2	Component powered by HV	75
E.2.3	Component involved in charging mode connected to DC power mains	77
E.2.4	Vehicle in charging mode connected to DC power mains	77
E.3	Artificial mains networks (AMN)	77
E.3.1	Component AMN	77
E.3.2	Vehicle in charging mode connected to AC power mains	77
E.4	Asymmetric artificial network (AAN)	78
E.4.1	General	78
E.4.2	Symmetric communication lines	78
E.4.3	PLC on power lines	79
E.4.4	PLC (technology) on control pilot	80
Annex F (informative)	Radiated emissions from components/modules – TEM cell method	82
F.1	General	82
F.2	Test setup	83
F.2.1	Setup with major field emission from the wiring harness	83

F.2.2	Setup with major field emissions from the EUT	84
F.2.3	Power supply and AN	84
F.2.4	Signal/control line filters	85
F.3	Test procedure.....	86
F.4	Limits for radiated disturbances from components/modules – TEM cell method	87
F.5	TEM cell design	89
Annex G (informative) Radiated emissions from components/modules – Stripline method		91
G.1	General.....	91
G.2	Test setup.....	91
G.2.1	General	91
G.2.2	Stripline impedance matching	91
G.2.3	Location of the EUT	92
G.2.4	Location and length of the test harness	92
G.2.5	Location of the load simulator	92
G.3	Test procedure.....	92
G.4	Limits for radiated emissions from components/modules – Stripline method.....	93
G.5	Stripline design	96
Annex H (informative) Interference to mobile radio communication in the presence of impulsive noise – Methods of judging degradation		99
H.1	General.....	99
H.2	Survey of methods of judging degradation to radio channel.....	99
H.2.1	General	99
H.2.2	Subjective tests	99
H.2.3	Objective tests.....	100
H.2.4	Conclusions relating to judgement of degradation	101
Annex I (normative) Test methods for shielded power supply systems for high voltages in electric and hybrid vehicles		102
I.1	General.....	102
I.2	Conducted emission from components/modules on HV power lines – Voltage method	102
I.2.1	Ground plane arrangement	102
I.2.2	Test set-up	103
I.2.3	Limits for conducted emission – Voltage method.....	108
I.3	Conducted emission from components/modules on HV power lines – current probe method.....	110
I.3.1	Reference ground plane arrangement.....	110
I.3.2	Test setup	110
I.3.3	Limits for conducted emission – current probe method.....	115
I.4	Radiated emissions from components/modules – ALSE method.....	115
I.4.1	Reference ground plane arrangement.....	115
I.4.2	Test setup	115
I.4.3	Limits for radiated emissions – ALSE method	120
I.5	Coupling between HV and LV systems	120
I.5.1	General	120
I.5.2	Measurement based on test setups defined in Clause 6.....	120
I.5.3	Measurement of the HV-LV coupling attenuation	126
Annex J (informative) ALSE performance validation 150 kHz to 1 GHz		129
J.1	General.....	129

J.2	Reference measurement method	131
J.2.1	Overview	131
J.2.2	Equipment	131
J.2.3	Procedure.....	133
J.2.4	Requirements	137
J.3	Modelled long wire antenna method	137
J.3.1	Overview	137
J.3.2	Equipment	138
J.3.3	Procedure.....	140
J.3.4	Requirements	149
Annex K (informative)	Items under consideration	151
K.1	General.....	151
K.2	Measurement techniques and limits	151
K.3	Measurement uncertainty	151
K.4	Reconsideration of the Scope of the standard	151
K.5	Digital Service bands	151
K.6	Reorganizing the document into separate parts similar to CISPR-16 document series	151
Bibliography.....		152
Figure 1	– Method of determination of conformance for all frequency bands	18
Figure 2	– Example of gain curve.....	27
Figure 3	– Vehicle-radiated emissions – Example for test layout (end view with monopole antenna)	29
Figure 4	– Example of test setup for vehicle with plug located on vehicle side (AC powered without communication)	31
Figure 5	– Example of test setup for vehicle with plug located front / rear of vehicle (AC powered without communication)	32
Figure 6	– Example of test setup for vehicle with plug located on vehicle side (AC or DC powered with communication)	35
Figure 7	– Example of test setup for vehicle with plug located front /rear of vehicle (AC or DC powered with communication)	36
Figure 8	– Average limit for radiated disturbance from vehicles.....	39
Figure 9	– Conducted emissions – Example of test setup for EUT with power return line remotely grounded	43
Figure 10	– Conducted emissions – Example of test setup for EUT with power return line locally grounded	44
Figure 11	– Conducted emissions – Example of test setup for alternators and generators	45
Figure 12	– Conducted emissions – Example of test setup for ignition system components	46
Figure 13	– Conducted emissions – Example of test setup for current probe measurements	51
Figure 14	– Test harness bending requirements.....	56
Figure 15	– Example of test setup – Rod antenna	58
Figure 16	– Example of test setup – Biconical antenna	59
Figure 17	– Example of test setup – Log-periodic antenna	60
Figure 18	– Example of test setup – Above 1 GHz	61
Figure 19	– Example of average limit for radiated disturbances from components.....	64

Figure A.1 – Flow chart for checking the applicability of this standard	66
Figure B.1 – Verification setup	68
Figure C.1 – Characteristic S_{21} of the ferrite core	69
Figure D.1 – Vehicle test setup for equipment noise measurement in the AM/FM range	71
Figure D.2 – Vehicle test setup for antenna noise measurement in the AM/FM range	72
Figure E.1 – Example of 5 μ H AN schematic	74
Figure E.2 – Characteristics of the AN impedance Z_{PB}	74
Figure E.3 – Example of 5 μ H HV AN schematic	76
Figure E.4 – Example of 5 μ H HV AN combination in a single shielded box	76
Figure E.5 – Impedance matching network attached between HV ANs and EUT	77
Figure E.6 – Example of an AAN for symmetric communication lines	79
Figure E.7 – Example of AAN circuit of PLC on AC or DC powerlines	80
Figure E.8 – Example of an AAN circuit for PLC on pilot line	81
Figure F.1 – TEM cell (example)	82
Figure F.2 – Example of arrangement of leads in the TEM cell and to the connector panel	83
Figure F.3 – Example of the arrangement of the connectors, the lead frame and the dielectric support	84
Figure F.4 – Example for the required minimum attenuation of the signal / control line filters	85
Figure F.5 – Setup for measurement of the filter attenuation	85
Figure F.6 – Example of the TEM cell method test setup	86
Figure F.7 – TEM cell	89
Figure G.1 – Example of a basic stripline test setup in a shielded enclosure	93
Figure G.2 – Example for a 50 Ω stripline	97
Figure G.3 – Example for a 90 Ω stripline	98
Figure I.1 – Conducted emission – Example of test setup for EUTs with shielded power supply systems	105
Figure I.2 – Conducted emission – Example of test setup for EUTs with shielded power supply systems with electric motor attached to the bench	106
Figure I.3 – Conducted emission – Example of test setup for EUTs with shielded power supply systems and inverter/charger device	107
Figure I.4 – Conducted emission – Example of test setup current probe measurement on HV lines for EUTs with shielded power supply systems	112
Figure I.5 – Conducted emission – Example of test setup current probe measurement on HV lines for EUTs with shielded power supply systems with electric motor attached to the bench	113
Figure I.6 – Conducted emission – Example of test setup current probe measurement on HV lines for EUTs with shielded power supply systems and inverter/charger device	114
Figure I.7 – Radiated emission – Example of test setup measurement with biconical antenna for EUTs with shielded power supply systems	117
Figure I.8 – Radiated emission – Example of test setup measurement with biconical antenna for EUTs with shielded power supply systems with electric motor attached to the bench	118
Figure I.9 – Radiated emission – Example of test setup measurement with biconical antenna for EUTs with shielded power supply systems and inverter/charger device	119
Figure I.10 – Test setup for calibration of the test signal	124

Figure I.11 – Example of test setup for conducted emissions – Voltage method – Measurement on LV ports with injection on HV supply ports	122
Figure I.12 – Example of test setup for conducted emissions – Current probe method – Measurement on LV ports with injection on HV supply ports	123
Figure I.13 – Example of test setup for radiated emissions – ALSE method – Measurement with biconical antenna with injection on HV supply ports	125
Figure I.14 – Test setup for EUT S_{21} measurements	127
Figure I.15 – Examples of requirements for coupling attenuation, a_c	128
Figure J.1 – Examples of typical ALSE influence parameters over the 10 MHz to 100 MHz frequency range	130
Figure J.2 – Visual representation of ALSE performance validation process	131
Figure J.3 – Example of construction of a transmitting monopole	132
Figure J.4 – Side view of the antenna configuration for reference measurement below 30 MHz	134
Figure J.5 – Top view of antenna configuration for reference measurement 30 MHz and above (with the biconical antenna shown as example)	135
Figure J.6 – Side view of antenna configuration for reference measurement 30 MHz and above (with the biconical antenna shown as example)	135
Figure J.7 – Top view of antenna configuration for the ALSE measurement below 30 MHz	136
Figure J.8 – Metallic sheet angles used as support for the rod	139
Figure J.9 – Radiator side view 50 Ω terminations	139
Figure J.10 – Photo of the radiator mounted on the ground reference plane	139
Figure J.11 – Example VSWR measured from four radiation sources (without 10 dB attenuator)	140
Figure J.12 – Example setup for ALSE equivalent field strength measurement (rod antenna shown for the frequency range below 30 MHz)	142
Figure J.13 – MoM-modell for the frequency range 30 MHz to 200 MHz	144
Table 1 – Spectrum analyser parameters	22
Table 2 – Scanning receiver parameters	24
Table 3 – Antenna types	26
Table 4 – Example for limits of disturbance – Complete vehicle	37
Table 5 – Examples of limits for conducted disturbances – Voltage method	48
Table 6 – Examples of limits for conducted disturbances – Current probe method	53
Table 7 – Examples of limits for radiated disturbances – ALSE method	63
Table E.1 – Magnitude of the AN impedance Z_{PB}	75
Table F.1 – Examples of limits for radiated disturbances – TEM cell method	88
Table F.2 – Dimensions for TEM cells	90
Table G.1 – Examples of limits for radiated disturbances – Stripline method	95
Table I.1 – Example for HV limits for conducted voltage measurements at shielded power supply devices (HV-LV decoupling class A5)	109
Table I.2 – Example of configurations for equipment without negative LV line	127
Table I.3 – Example of configurations for equipment with negative LV line	127
Table I.4 – Examples of requirements for minimum coupling attenuation, a_c	128
Table J.1 – Reference data to be used for chamber validation	145

INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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

FOREWORD

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

This fourth edition cancels and replaces the third edition published in 2008. This edition constitutes a technical revision.

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

- a) inclusion of charging mode for electric vehicles (EV) and plug-in electric vehicles (PHEV),
- b) the methods for chamber validation have been included,

- c) test methods for shielded power supply systems for high voltages for electric and hybrid electric vehicles have been included,
- d) overall improvement.

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

FDIS	Report on voting
CISPR/D/432/FDIS	CISPR/D/435/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.

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The contents of the corrigendum of October 2017 have been included in this copy.

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INTRODUCTION

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

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

To accomplish this end, this standard:

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

NOTE Component tests are not intended to replace vehicle tests. Exact correlation between component and vehicle test performance is dependent on component mounting location, harness length, routing and grounding, as well as antenna location. 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 International Standard contains limits and procedures for the measurement of radio disturbances in the frequency range of 150 kHz to 2 500 MHz. The standard applies to any electronic/electrical component intended for use in vehicles, trailers and devices. Refer to International Telecommunications Union (ITU) publications for details of frequency allocations. The limits are intended to provide protection for receivers installed in a vehicle from disturbances produced by components/modules in the same vehicle. The method and limits for a complete vehicle (whether connected to the power mains for charging purposes or not) are in Clause 5 and the methods and limits for components/modules are in Clause 6. Only a complete vehicle test can be used to determine the component compatibility with respect to a vehicle's limit.

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

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

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

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

This standard defines test methods for use by Vehicle Manufacturers and Suppliers, to assist in the design of vehicles and components and ensure controlled levels of on-board radio frequency emissions.

Vehicle test limits are provided for guidance and are based on a typical radio receiver using the antenna provided as part of the vehicle, or a test antenna if a unique antenna is not specified. The frequency bands that are defined are not applicable to all regions or countries of the world. For economic reasons, the vehicle manufacturer 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 standard to support the chosen marketing plan.

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

Annex E defines artificial networks used for the measurement of conducted disturbances and for tests on vehicles in charging mode.

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

Annex I defines test methods for shielded power supply systems for high voltage networks in electric and hybrid vehicles.

Annex J defines methods for the validation of the ALSE and the reference ground plane used for component testing.

Annex K lists work being considered for future revisions.

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.

CISPR 16-1-1:2015, *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 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus –Antennas and test sites for radiated disturbances measurements*
CISPR 16-1-4:2010/AMD1:2012

CISPR 16-2-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

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 11452-4:2011, *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 with radio frequency-absorbing material on its internal ceiling and walls

Note 1 to entry: This note applies to the French language only.

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.

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.

Note 3 to entry: This note applies to the French language only.

3.5

artificial network

AN

network inserted in the supply lead or signal/load lead of an 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 1 to entry: 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.

Note 2 to entry: This note applies to the French language only.

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 telecommunication signal and power mains).

Note 2 to entry: This note applies to the French language only.

3.7

average detector

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

Note 1 to entry: The average value shall be taken over a specified time interval.

[SOURCE: IEC 60050-161:1990, 161-04-26] [5]¹

3.8

3.8.1

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 60050-161:1990, 161-06-09] [5]

3.8.2

bandwidth

<emission or signal> 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 60050-161:1990, 161-06-10] [5]

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)

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

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.

¹ Numbers in square brackets refer to the Bibliography.

3.11**class**

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

3.12**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 a specified increment in dB

3.13**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.

3.14**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]

3.15**high voltage****HV**

operating voltage between 60 V to 1 000 V

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

3.16**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 may isolate the apparatus from the supply in that frequency range

Note 1 to entry: This note applies to the French language only.

3.17**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 may be defined with a different voltage range in other standards.

3.18**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

3.19

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.

3.20

peak detector

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

[SOURCE: IEC 60050-161:1990, 161-04-24] [5]

3.21

quasi-peak detector

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

[SOURCE: IEC 60050-161:1990, 161-04-21][5]

3.22

reference ground plane

flat conductive surface whose potential is used as a common reference

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

[SOURCE: IEC 60050-161:1990, 161-04-36, modified – Modification of the definition.] [5]

3.23

RF boundary

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

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

Note 2 to entry: This note applies to the French language only.

3.24

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]

3.25

validation reference ground plane

elevated reference ground plane with the dimensions of 2,5 m × 1 m which is used as the standard for the reference measurements/modelling per Annex J

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

4 Requirements common to vehicle and component/module emissions measurements

4.1 General test requirements

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

Electromagnetic disturbance sources can be divided into two main types:

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

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

4.1.2 Test plan

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

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

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

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

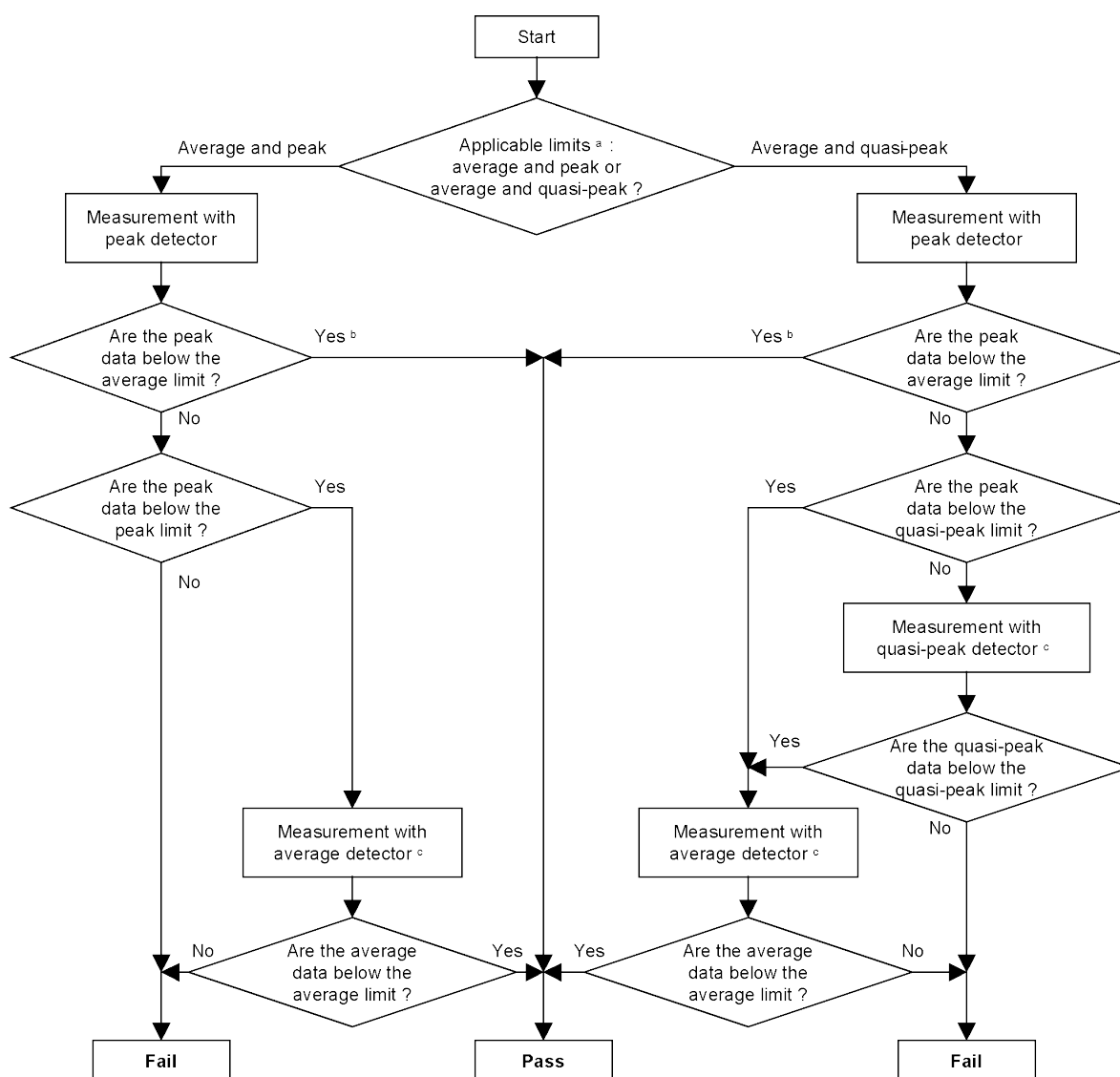
In all cases the EUT shall conform to the average limit.

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 standard 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 need to be remeasured with average or quasi-peak detector.

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

4.1.4 Operating conditions

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

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

interface unit. The peripheral interface unit shall be capable of controlling the EUT in accordance with the test plan.

The peripheral interface unit may be located internally or externally 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, however, the reflected energy can cause errors of as much as 20 dB. Therefore, it is necessary to apply RF absorber material to the walls and ceiling of a shielded enclosure that is to be used for radiated emission measurements. No absorber shall be placed on the floor for vehicle tests. For component testing, no absorber shall be placed on the floor, however, flat ferrite tiles with a maximum thickness of 25 mm may be utilised on the floor for component level testing if the chamber performance in this configuration meets the requirements of Annex J.

The following ALSE requirements shall also be met for 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 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

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

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

4.3.4.2 Component ALSE

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

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

NOTE 2 Additionally, the ALSE performance validation procedure described in Annex J may be used to evaluate the performance of the shielded enclosure as configured for 6.5 component radiated emissions testing. This performance verification procedure will evaluate the influences of the chamber, absorber, ground plane, ground plane grounding, and any other possible cause for measurement variation.

4.4 Measuring instrument

4.4.1 General

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

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

The minimum scan time 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 has to 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 may be used if the total scanning time is equal to, or greater than, the time that would have been spent in

the minimum scan time defined in Table 1. The following equation can be used to calculate the minimum scan time for multiple scans.

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

where

$T_{s,\min}$ 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 MHz	Peak detection		Quasi-peak detection		Average detection	
		RBW at –3 dB	Min. scan time	RBW at –6 dB	Min. scan time	RBW at –3 dB	Min. scan time
BROADCAST							
LW	0,15 to 0,30						
MW	0,53 to 1,8	9 kHz or 10 kHz	10 s / MHz	9 kHz	200 s / MHz	9 kHz or 10 kHz	10 s / MHz
SW	5,9 to 6,2						
FM	76 to 108						
TV Band I	41 to 88						
TV Band III	174 to 230	100 kHz or 120 kHz	100 ms / MHz	120 kHz	20 s / MHz	100 kHz or 120 kHz	100 ms / MHz
DAB III	171 to 245						
TV Band IV/V	468 to 944						
DTTV	470 to 770						
DAB L band	1 447 to 1 494	100 kHz or 120 kHz	100 ms / MHz	Does not apply	Does not apply	100 kHz or 120 kHz	100 ms / MHz
SDARS	2 320 to 2 345						
MOBILE SERVICES							
CB	26 to 28	9 kHz or 10 kHz	10 s / MHz	9 kHz	200 s / MHz	9 kHz or 10 kHz	10 s / MHz
VHF	30 to 54						
VHF	68 to 87						
VHF	142 to 175						
Analogue UHF	380 to 512						
RKE	300 to 330	100 kHz or 120 kHz	100 ms / MHz	120 kHz	20 s / MHz	100 kHz or 120 kHz	100 ms / MHz
RKE	420 to 450						
Analogue UHF	820 to 960						
GSM 800	860 to 895						
EGSM/GSM 900	925 to 960						
GPS L1 civil	1 567 to 1 583	Does not apply	Does not apply	Does not apply	Does not apply	9 kHz or 10 kHz	1 s / MHz
GLONASS L1	1 591 to 1 613						
GSM 1800 (PCN)	1 803 to 1 882						
GSM 1900	1 850 to 1 990						
3G / IMT 2000	1 900 to 1 992	100 kHz or 120 kHz	100 ms / MHz	Does not apply	Does not apply	100 kHz or 120 kHz	100 ms / MHz
3G / IMT 2000	2 010 to 2 025						
3G / IMT 2000	2 108 to 2 172						
Bluetooth/ 802.11	2 400 to 2 500						

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 dwell 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 has to 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.

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 MHz	Peak detection			Quasi-peak detection			Average detection		
		BW at –6 dB	Max. step size	Min. measure- ment time	BW at –6 dB	Max. step size	Min. measure- ment time	BW at –6 dB	Max. Step size	Min. mea- sure- ment time
BROADCAST										
LW	0,15 to 0,30									
MW	0,53 to 1,8	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1 s	9 kHz	5 kHz	50 ms
SW	5,9 to 6,2									
FM	76 to 108									
TV Band I	41 to 88									
TV Band III	174 to 230	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms
DAB III	171 to 245									
TV Band IV/V	468 to 944									
DTT	470 to 770									
DAB L band	1 447 to 1 494	120 kHz	50 kHz	5 ms	Does not apply	Does not apply	Does not apply	120 kHz	50 kHz	5 ms
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									
VHF	68 to 87									
VHF	142 to 175									
Analogue UHF	380 to 512									
RKE	300 to 330	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms
RKE	420 to 450									
Analogue UHF	820 to 960									
GSM 800	860 to 895									
EGSM/GSM 900	925 to 960									
GPS L1 civil	1 567 to 1 583	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	9 kHz	5 kHz	5 ms
GLONASS L1	1 591 to 1 613									
GSM 1800 (PCN)	1 803 to 1 882									
GSM 1900	1 850 to 1 990									
3G / IMT 2000	1 900 to 1 992	120 kHz	50 kHz	5 ms	Does not apply	Does not apply	Does not apply	120 kHz	50 kHz	5 ms
3G / IMT 2000	2 010 to 2 025									
3G / IMT 2000	2 108 to 2 172									
Bluetooth/ 802.11	2 400 to 2 500									
NOTE For emissions generated by brush commutator motors without an electronic control unit, the maximum step size can be increased up to 5 times the bandwidth.										

4.5 Power supply

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

Vehicle tests: ignition on, engine off

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:

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

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

Vehicle tests: 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:

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

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

NOTE Most of the vehicle tests will be performed without the engine running, but with the ignition switched on, therefore care is taken to 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.

Vehicle tests: charging mode

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 %.

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

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

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 Antenna measuring system

5.1.1 Type of antenna

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

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

If an active antenna is used, the noise floor of the measured signal at the radio antenna connector may increase (see also the note in 5.4).

Table 3 – Antenna types

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

5.1.2 Measuring system requirements

5.1.2.1 Broadcast bands

5.1.2.1.1 General

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

5.1.2.1.2 AM broadcast

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

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

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

The measuring system consisting of an 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.

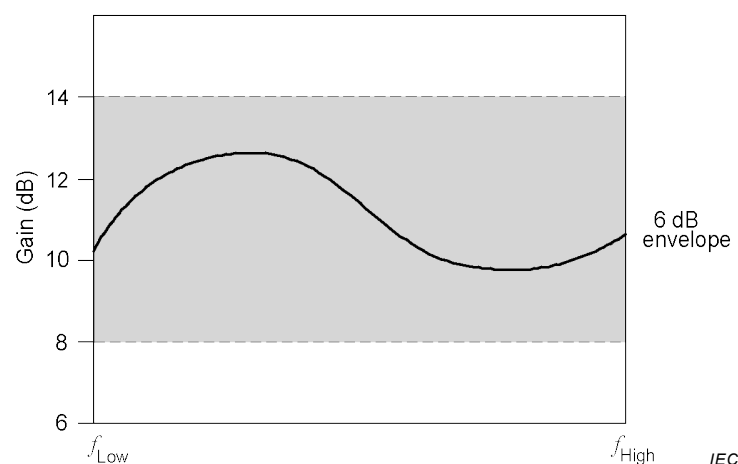


Figure 2 – Example of gain curve

- 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.

5.1.2.1.3 FM broadcast (76 MHz to 108 MHz) and Digital audio and TV 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.

5.1.2.2 Mobile services (26 MHz to 2 500 MHz)

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 Method of measurement

The disturbance voltage shall be measured at the receiver end of the antenna coaxial cable using the ground contact of the connector as reference. The antenna connector shall be grounded to the housing of the on-board radio. The radio housing shall be grounded to the vehicle body using the production harness. A coaxial bulkhead connector shall be used for connection to the measuring instrument outside the shielded room. 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.

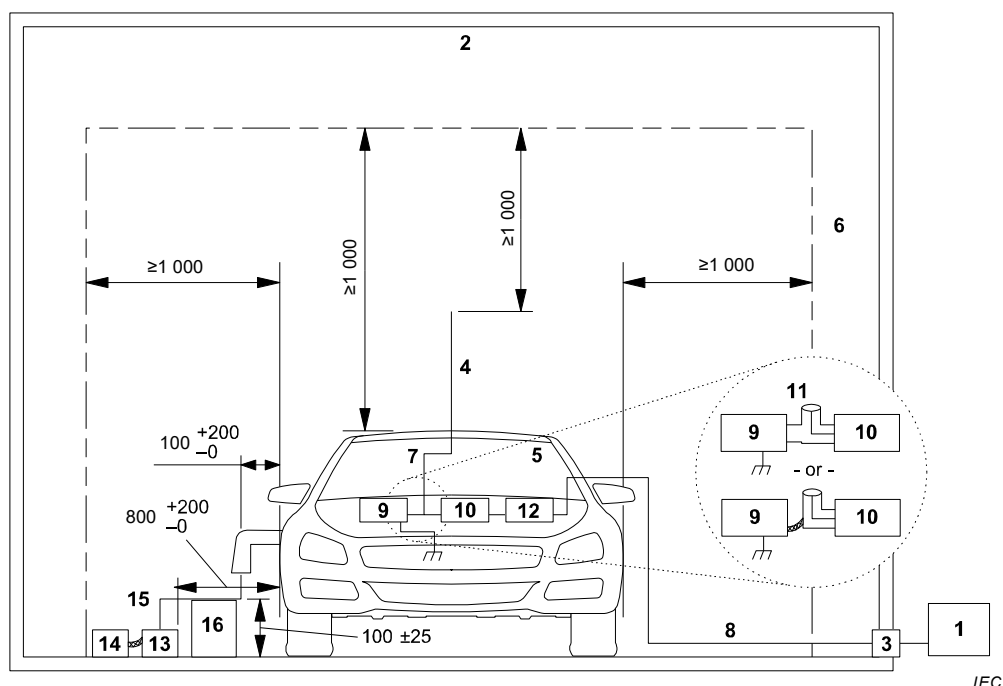
When making measurements in the AM broadcast bands (LW, MW, SW), the vehicle/matching unit ground and ground of the ALSE shall be electrically isolated from each other by means such as an isolation transformer, sheath-current suppressor, battery-powered measurement instrumentation, fibre optics, etc. 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 may allow a receiver to be mounted in several locations (e.g. under the instrument panel, under the seat, etc.). In these cases a test shall be carried out as specified in the test plan for each receiver location.

The test setup is described in Figure 3.

Dimensions in millimetres – not to scale

**Key**

- 1 Measuring instrument
- 2 ALSE
- 3 Bulkhead connector
- 4 Antenna (see 5.1)
- 5 Vehicle
- 6 Typical absorber material
- 7 Antenna coaxial cable
- 8 High-quality coaxial cable e.g. double-shielded ($50\ \Omega$)
- 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 cable (only for charging mode configuration)
- 16 Insulating support (only for charging mode configuration)

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

5.3 Test setup for vehicle in charging mode

5.3.1 General

The various configurations (AC or DC, with or without communication) are considered in this clause.

5.3.2 AC power charging without communication

5.3.2.1 Power mains

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

- It shall be placed on the reference 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 on the reference ground plane.

5.3.2.2 Artificial mains network

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

The AMN(s) shall be mounted directly on the reference ground plane. The case of the AMN(s) shall be bonded to the reference 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 plug located front/rear of the vehicle, the AMN shall be placed on one side of the vehicle and perpendicularly to the vehicle power charging plug and shall be aligned with the vehicle charging cable. For vehicles with plug located on vehicle side, the AMN shall be placed on one side of the vehicle and aligned with the vehicle power charging plug and shall be aligned with the vehicle charging cable.

5.3.2.3 Power charging cable

The power charging cable shall be placed in a straight line between the AMN(s) and the vehicle charging plug and shall be routed perpendicularly to the vehicle longitudinal axis as shown in Figure 4 and Figure 5. The projected cable length shall be 800 $^{+200}_0$ mm.

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

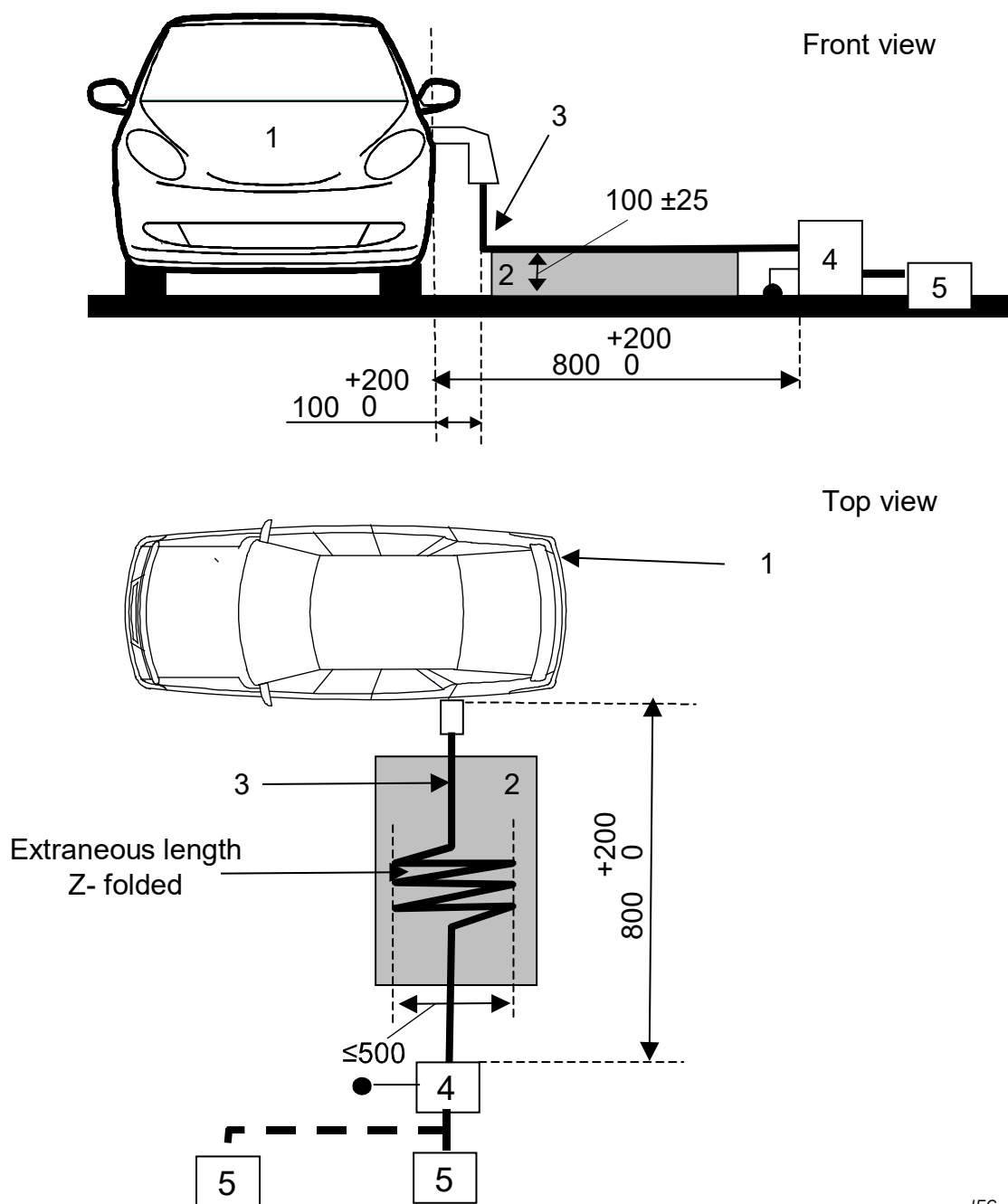
The whole cable shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\epsilon_r \leq 1,4$), at (100 $\pm$ 25) mm above the reference ground plane.

5.3.2.4 Measuring system

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

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

Dimensions in millimetres



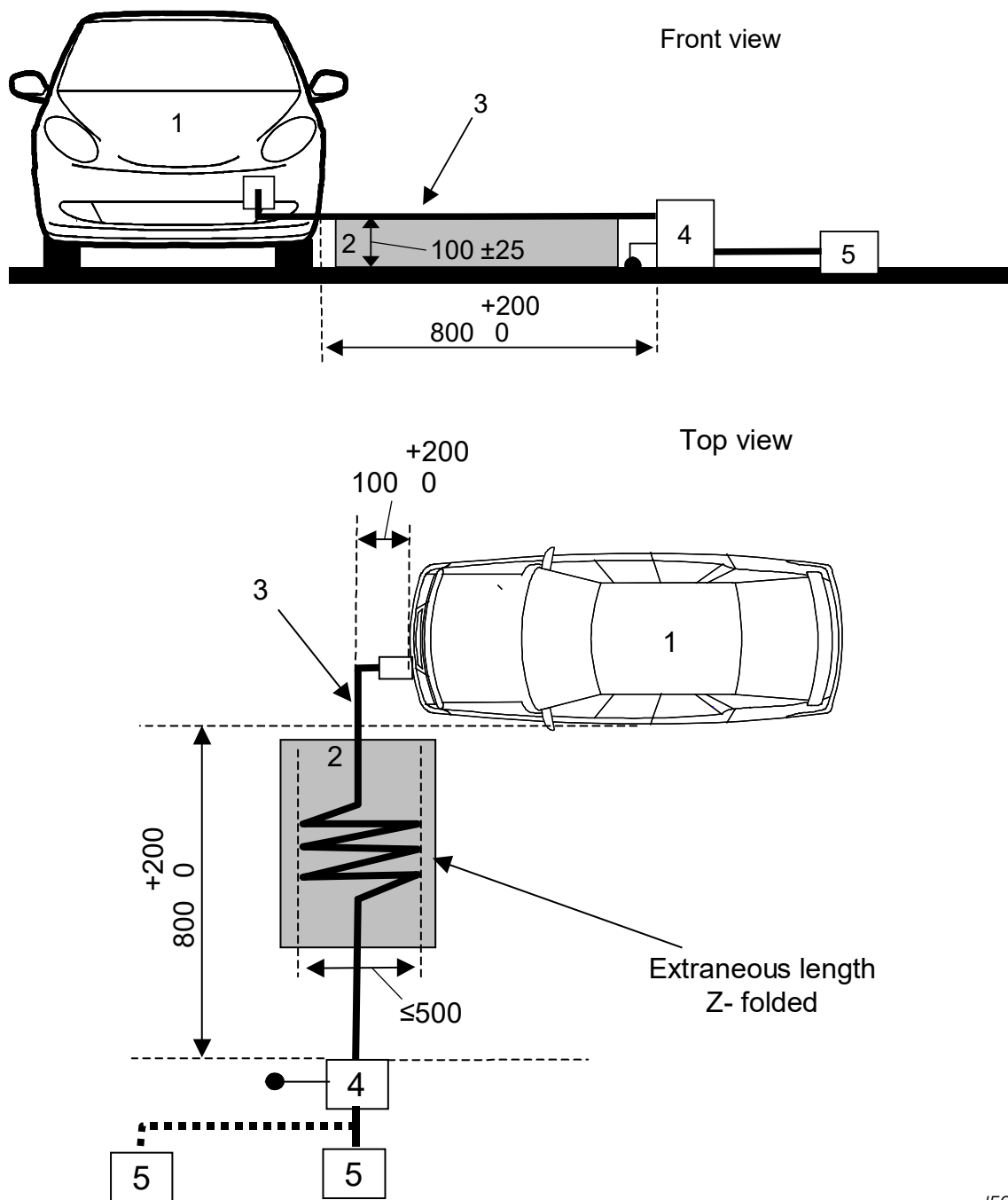
IEC

Key

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging cable
- 4 Artificial mains network(s) grounded
- 5 Power mains socket (see 5.3.2.1, alternative positions shown in the figure.)

**Figure 4 – Example of test setup for vehicle with plug located on vehicle side
(AC powered without communication)**

Dimensions in millimetres



IEC

Key

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging cable
- 4 Artificial mains network(s) grounded
- 5 Power mains socket (see 5.3.2.1, alternative positions shown in the figure)

Figure 5 – Example of test setup for vehicle with plug located front / rear of vehicle (AC powered without communication)

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

5.3.3.1 General

This configuration concerns charging mode for AC power and for DC power using communications or signal lines.

NOTE In some cases the lines used for communication between vehicle and charging station cannot be considered as “communication line” (as defined in CISPR 22 [2]) but rather as signal lines.

5.3.3.2 Charging station / power mains

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

NOTE 1 If communications between the vehicle and the charging station can be simulated, the charging station can 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 reference ground plane.
- The length of the harness between the power mains / communication or signal lines socket and the AMN(s) / 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) / AN(s) / AAN(s) shall be placed on the reference ground plane.

NOTE 2 The power mains and communication or signal lines socket(s) are 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 reference ground plane.
- The extraneous length shall be placed as close as possible to the reference ground plane and “Z-folded” if necessary.

5.3.3.3 Artificial mains networks / artificial networks

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

The DC power mains shall be applied to the vehicle through 5 μ H/50 Ω High Voltage Artificial Networks (HV-AN(s)). (see Annex E).

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

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

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

5.3.3.4 Asymmetric artificial network

Communication lines shall be applied to the vehicle through AAN(s) (see Annex E).

NOTE Signal lines can be applied to the vehicle through AAN(s) (see Annex E).

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

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

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

5.3.3.5 Power charging / communication or signal cable

The power charging/communication or signal cable shall be placed in a straight line between the AMN(s) / HV-AN(s) / AAN(s) and the vehicle charging plug and shall be routed perpendicularly to the vehicle longitudinal axis as shown in Figure 6 and Figure 7. 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 / communication or signal cable at vehicle side shall hang vertically at a distance of 100 $^{+200}_0$ mm from the vehicle body.

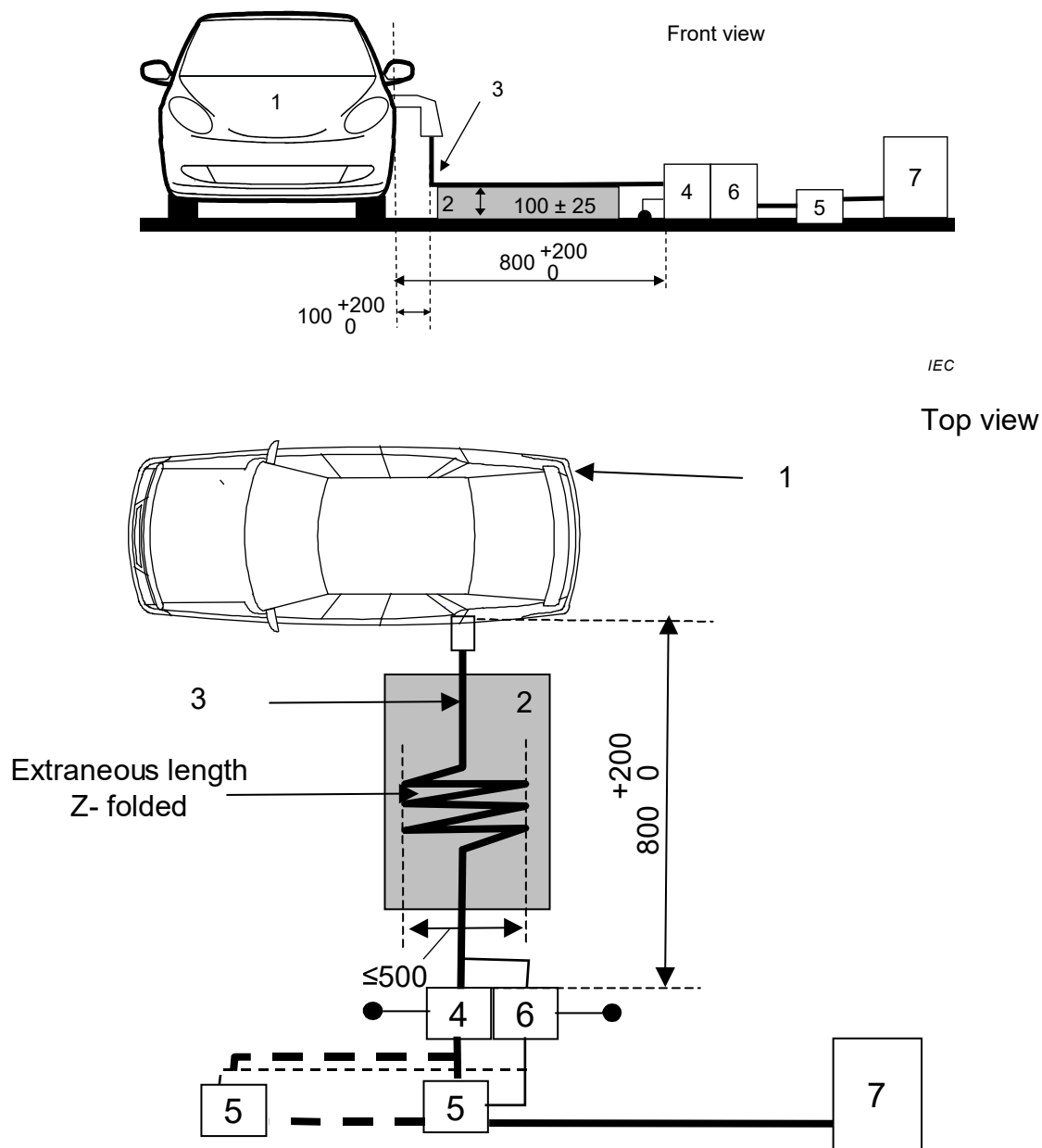
The whole cable shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\epsilon_r \leq 1,4$), at (100 ± 25) mm above the reference ground plane.

5.3.3.6 Measuring system

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

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

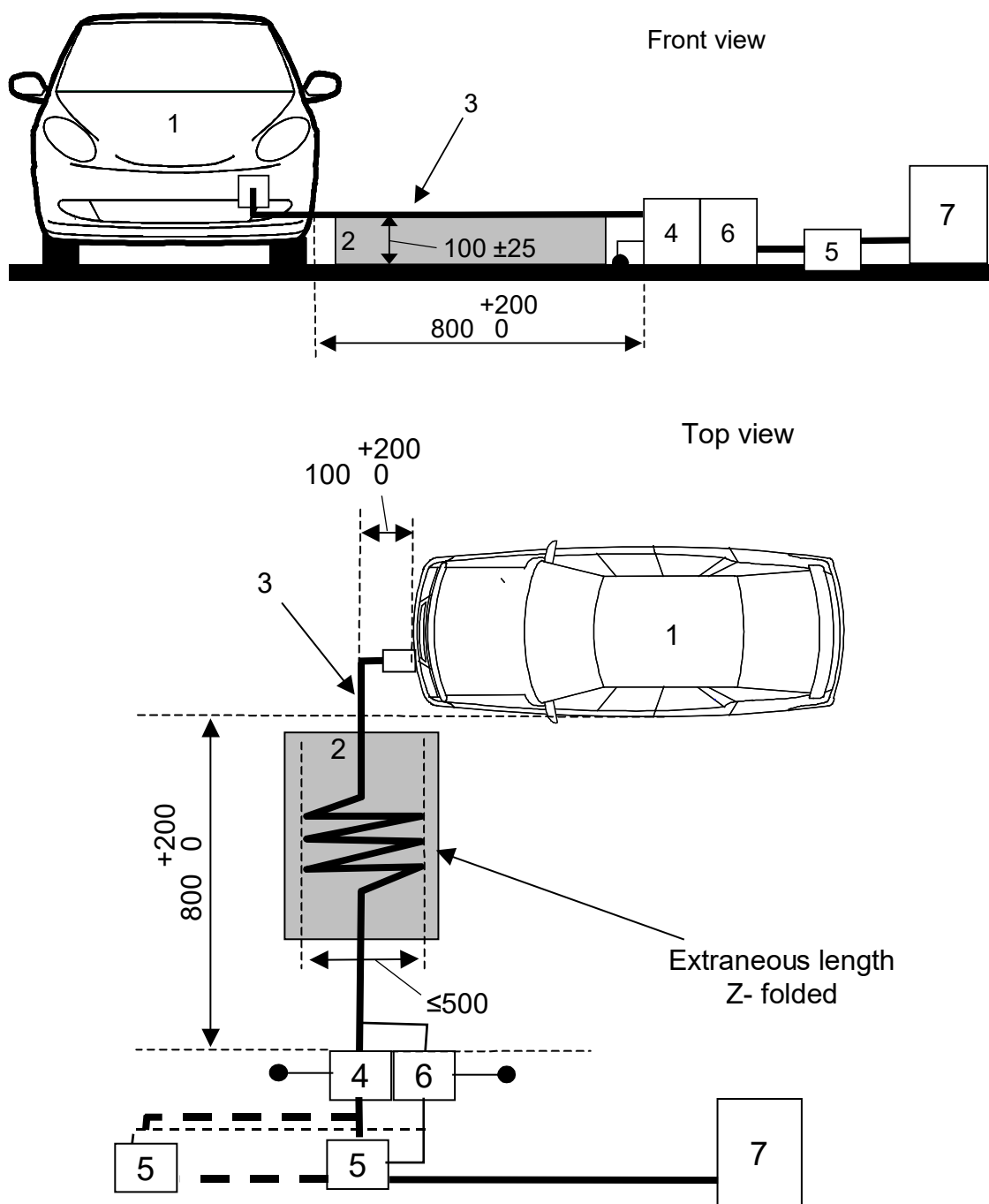
Dimensions in millimetres

**Key**

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging / communication or signal cable
- 4 AC-AMN(s) or DC HV-AN(s) grounded
- 5 Power mains socket (alternative positions shown in the figure)
- 6 Asymmetric artificial network(s) grounded
- 7 Charging station

**Figure 6 – Example of test setup for vehicle with plug located on vehicle side
(AC or DC powered with communication)**

Dimensions in millimetres



IEC

Key

- 1 Vehicle under test
- 2 Insulating support
- 3 Charging / communication or signal cable
- 4 AC AMN(s) or DC HV-AN(s) grounded
- 5 Power mains socket (alternative positions shown in the figure)
- 6 Asymmetric artificial network(s) grounded
- 7 Charging station

Figure 7 – Example of test setup for vehicle with plug located front /rear of vehicle (AC or DC powered with communication)

5.4 Examples of limits for vehicle radiated disturbances

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

Table 4 – Example for limits of disturbance – Complete vehicle

Service / Band ^a	Frequency MHz	Terminal disturbance voltage at receiver antenna terminal in dB (μV)		
		Peak	Quasi-peak	Average
BROADCAST				
LW ^b	0,15 to 0,30	26	13	6
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	6
TV Band I ^c	41 to 88	16	–	6
TV Band III ^c	174 to 230	16	–	6
DAB III	171 to 245	10	–	0
TV Band IV/V ^c	468 to 944	16	–	6
DTTV	470 to 770	20 ^d	–	10 ^d
DAB L band	1 447 to 1 494	10	–	0
SDARS	2 320 to 2 345	16	–	6
MOBILE SERVICES				
CB ^b	26 to 28	20	7	0
VHF ^b	30 to 54	20	7	0
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 ^f	300 to 330	20	–	6
RKE ^f	420 to 450	20	–	6
Analogue UHF ^b	820 to 960	20	7	0
GSM 800	860 to 895	26	–	6
EGSM/GSM 900	925 to 960	26	–	6
GPS L1 civil ^{e,g}	1 567 to 1 583	–	–	0
GLONASS L1 ^{e,h}	1 591 to 1 616	–	–	0
GSM 1800 (PCN)	1 803 to 1 882	26	–	6
GSM 1900	1 850 to 1 990	26	–	6
3G / IMT 2000	1 900 to 1 992	26	–	6
3G / IMT 2000	2 010 to 2 025	26	–	6
3G / IMT 2000	2 108 to 2 172	26	–	6
Bluetooth/802.11	2 400 to 2 500	26	–	6

a	LW: Long wave, MW: Medium wave, SW: Short wave (amplitude modulation, AM) VHF: Very high frequency, UHF: Ultra high frequency (frequency modulation, FM) DAB: Digital audio broadcasting, TV: Television, DTTV: Digital terrestrial television RKE: Remote keyless entry, GPS: Global positioning system, GSM: Global system mobile 3G: Third generation
b	In this analogue service the peak and quasi-peak limits can be relaxed by 6 dB for short duration disturbances (e.g. short duration PK (or QPK) limit = PK (or QPK) limit + 6 dB).
c	Analogue TV only.
d	This limit is less stringent than the analogue limit and should only be applied where analogue TV is no longer in use.
e	The bandwidth and frequency steps to be used for the GPS and GLONASS L1 civil band are respectively 9 kHz and 5 kHz rather than the bandwidth and frequency steps defined in Table 1 and Table 2 for services above 30 MHz.
f	RKE limits are defined over a large frequency band. Any modification of the average limit around the operating frequency due to sensitivity of RKE systems should be defined in the test plan.
g	The values given in the table apply to the 1 574,42 MHz to 1 576,42 MHz frequency range. The limits for the whole GPS L1 frequency range are given in Figure 8a.
h	The values given in the table apply to the 1 597,781 MHz to 1 609,594 MHz frequency range. The limits for the whole GLONASS L1 frequency range are given in Figure 8b.

a)	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.
b)	All values listed in this table are valid for the bandwidths in Table 1 and Table 2. If measurements have to be 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.

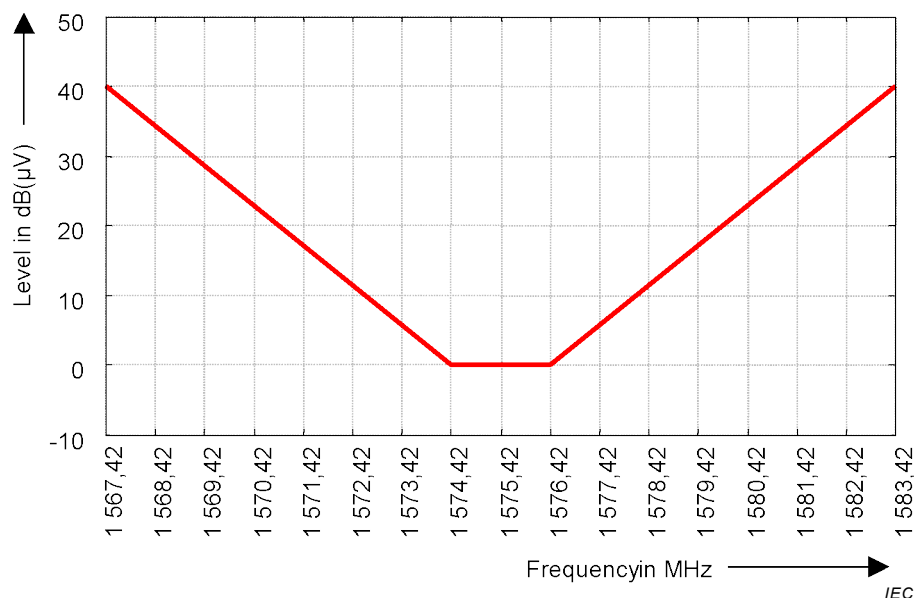


Figure 8a – GPS band 1 567,42 MHz to 1 583,42 MHz

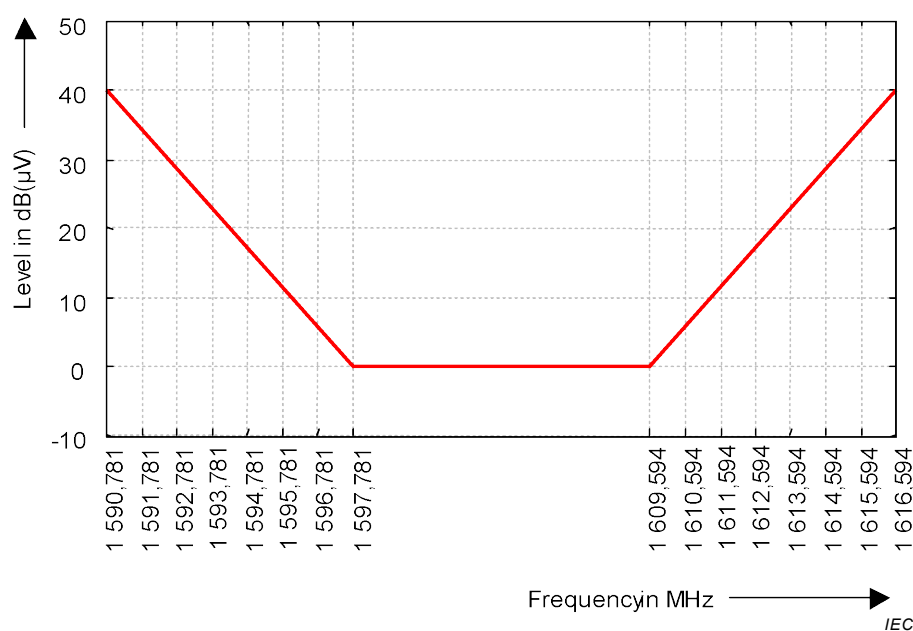


Figure 8b – GLONASS band 1 590,781 MHz to 1 616,594 MHz

Figure 8 – Average limit for radiated disturbance from vehicles

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

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 I.

For LV/HV components:

- Conducted emission (voltage method) on LV lines shall be performed according to setup defined in Clause I.2 and requirement in 6.3.4
- Conducted emission (voltage method) on HV lines shall be performed according to setup defined in Clause I.2 and requirement in I.2.3.
- Conducted emission (current method) on LV/HV lines shall be performed according to setup defined in Clause I.3 and requirement in 6.4.3.

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

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

The distance from the edge of the ground strap to the edge of the next strap shall not be greater than 300 mm. The maximum length to width ratio for the ground straps shall be 7:1.

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

6.2.2 Power supply and AN

For the tests defined in 6.3, 6.4, 6.5, 6.6 and 6.7, each positive EUT power supply lead shall be connected to the power supply through an artificial network. The AN shall have a nominal 5 μ H inductance. The impedance characteristics and a suggested schematic are shown in Annex E.

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

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

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

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

The measuring port of the AN not connected to the measuring instrument shall be terminated with a 50 Ω load.

6.2.3 Load simulator

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

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

6.3 Conducted emissions from components/modules – Voltage method

6.3.1 General

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

6.3.2 Test setup

6.3.2.1 Location of EUT

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

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

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

6.3.2.2 Location of the test harness

The power supply line(s) between the connector of the AN(s) and the connector(s) of the EUT shall have a standard length $l_p = \left(200 \begin{smallmatrix} +200 \\ 0 \end{smallmatrix}\right)$ mm.

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

To minimize the coupling between power supply lines and input/output leads (which includes any dedicated input/output signal return leads), the space between those lead types shall be maximized (≥ 200 mm from or perpendicular to the power supply lines connecting the AN(s) and the EUT). Unless otherwise specified in the test plan the test harness (excluding power lines) should be placed on a low relative permittivity material ($\epsilon_r \leq 1,4$), at (50 ± 5) mm above the reference ground plane.

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

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

6.3.2.3 Location of the load simulator

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

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

When the load simulator is located on the reference ground plane, the DC power supply lines of the load simulator shall be connected directly to the power supply and not through the AN(s).

6.3.3 Test procedure

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

The EUT shall be made to operate under typical loading and other conditions as in the vehicle such that the maximum emission state occurs. These operating conditions shall be clearly defined in the test plan to ensure supplier and customer are performing identical tests.

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

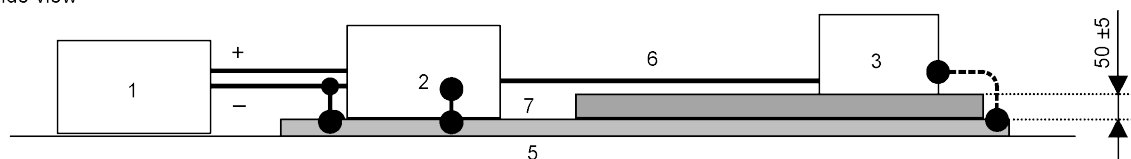
For voltage measurements the following applies.

- For EUT remotely grounded (vehicle power return line longer than 200 mm), the voltage measurements shall be made on each lead (supply and return) relative to the reference ground plane (see Figure 9).
- For EUT locally grounded (vehicle power return line 200 mm or shorter), voltage measurements on power supply leads shall be made relative to the reference ground plane (see Figure 10).
- Generators/alternators shall be loaded with a battery and parallel resistor combination, and connected to the artificial network in the manner shown in Figure 11. The load current, operating speed, harness length and other conditions shall be defined in the test plan.
- For the tests of ignition systems refer to Figure 12.

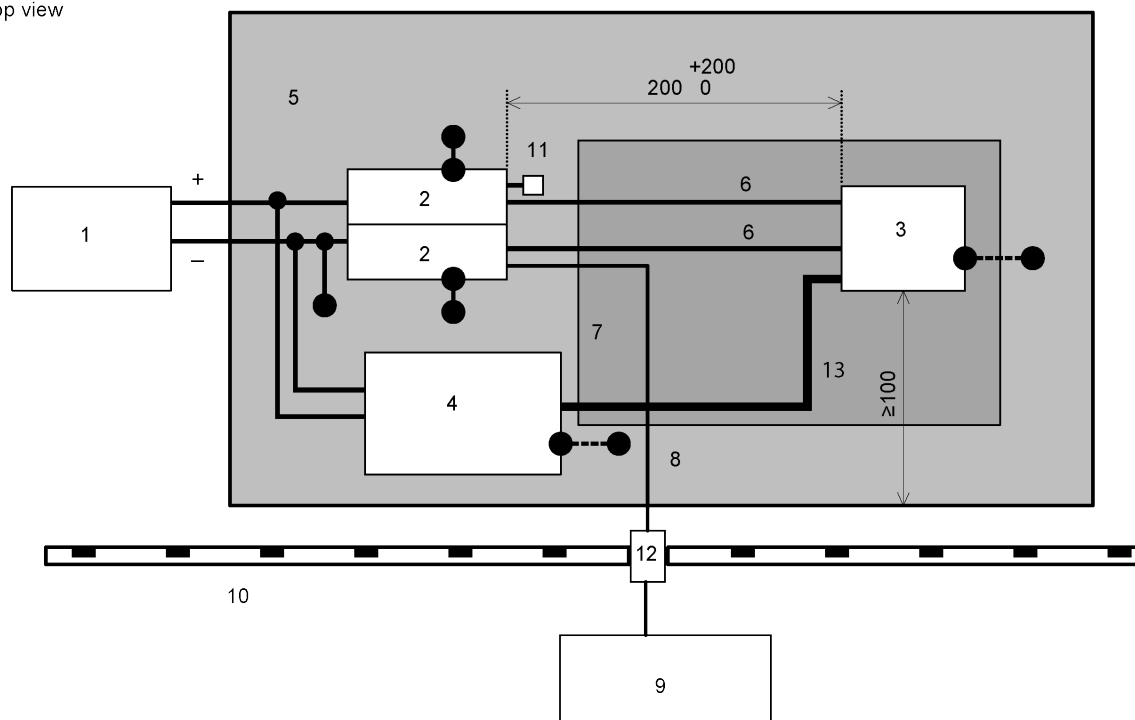
NOTE For EUTs with multiple positive power supply connections and/or multiple power return connections, the measurements (on power supply and on power return) can be performed with all power supply connections tied together at the AN and all power return connections tied together at the other AN. The details of the AN connection are defined in the test plan.

Dimensions in millimetres – not to scale

Side view



Top view



IEC

Key

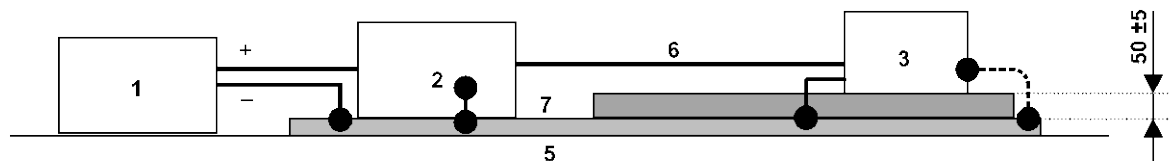
- | | |
|--|---|
| 1 Power supply (may be placed on the reference ground plane) | 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) |
| 2 Artificial network | 8 High-quality coaxial cable e.g. double-shielded (50Ω) |
| 3 EUT (housing grounded if required in test plan) | 9 Measuring instrument |
| 4 Load simulator (metallic casing grounded if required in test plan) | 10 Shielded enclosure |
| 5 Reference ground plane | 11 50Ω load |
| 6 Power supply lines | 12 Bulkhead connector |
| | 13 Test harness (excluding power lines) |

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

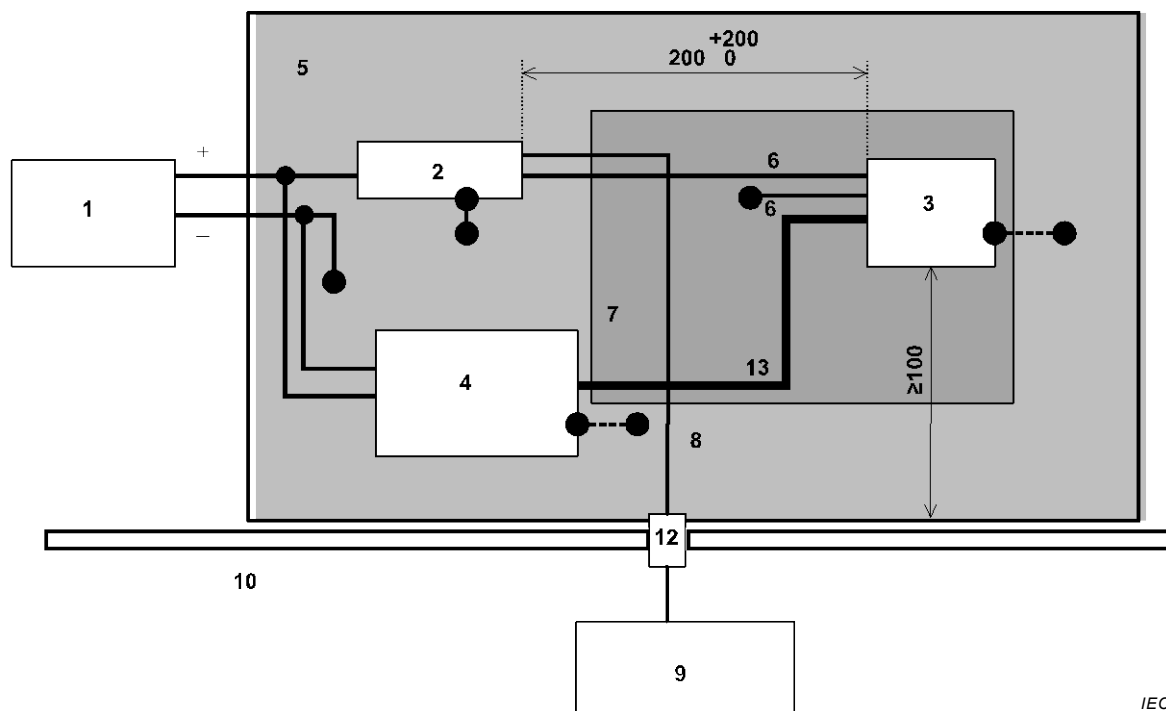
Figure 9 – Conducted emissions – Example of test setup for EUT with power return line remotely grounded

Dimensions in millimetres – not to scale

Side view



Top view



IEC

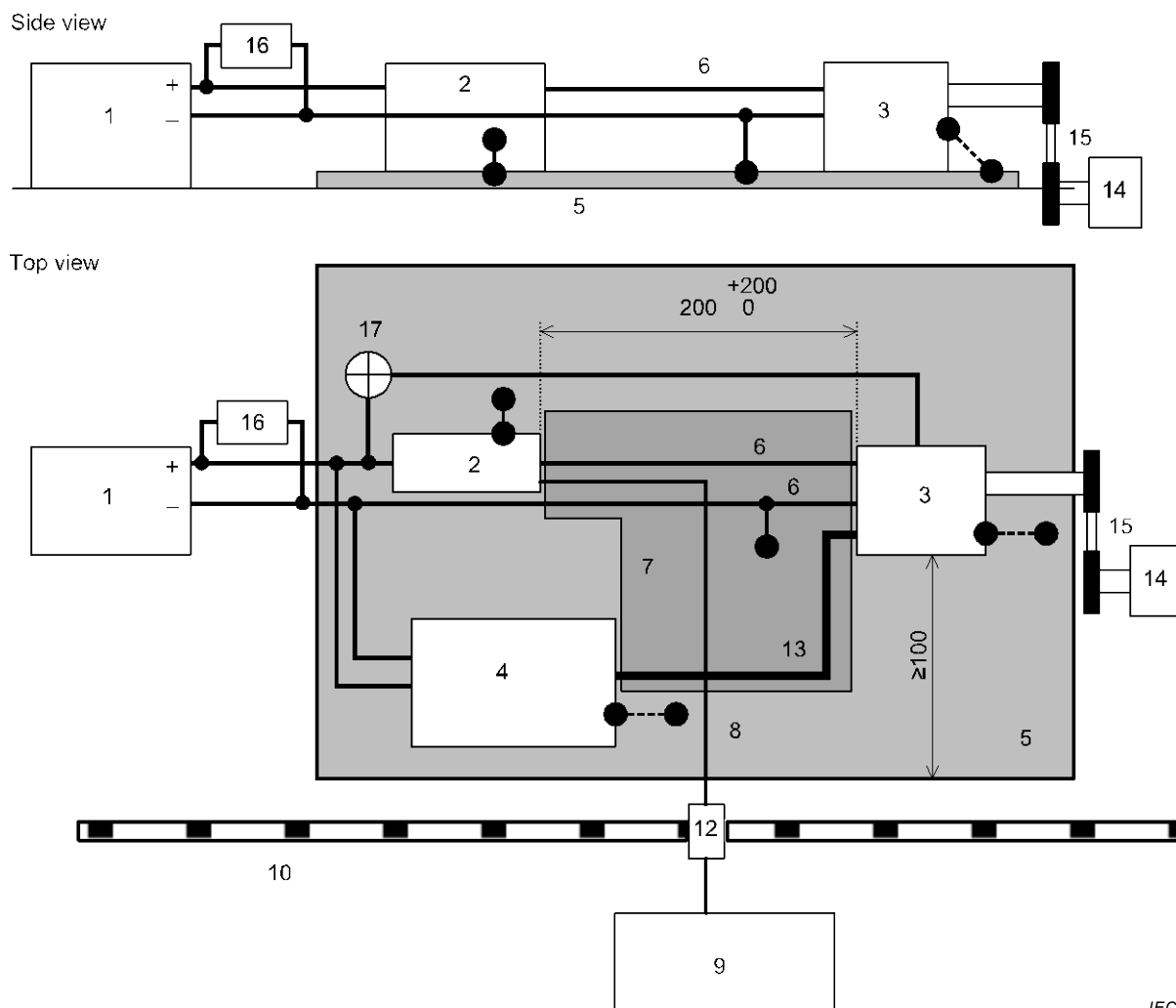
Key

- | | | | |
|---|--|----|--|
| 1 | Power supply (may be placed on the reference ground plane) | 7 | Low relative permittivity support ($\epsilon_r \leq 1,4$) |
| 2 | Artificial network | 8 | High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 3 | EUT (housing grounded if required in test plan) | 9 | Measuring instrument |
| 4 | Load simulator (metallic casing grounded if required in test plan) | 10 | Shielded enclosure |
| 5 | Reference ground plane | 12 | Bulkhead connector |
| 6 | Power supply line | 13 | Test harness (excluding power lines) |

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

Figure 10 – Conducted emissions – Example of test setup for EUT with power return line locally grounded

Dimensions in millimetres – not to scale



IEC

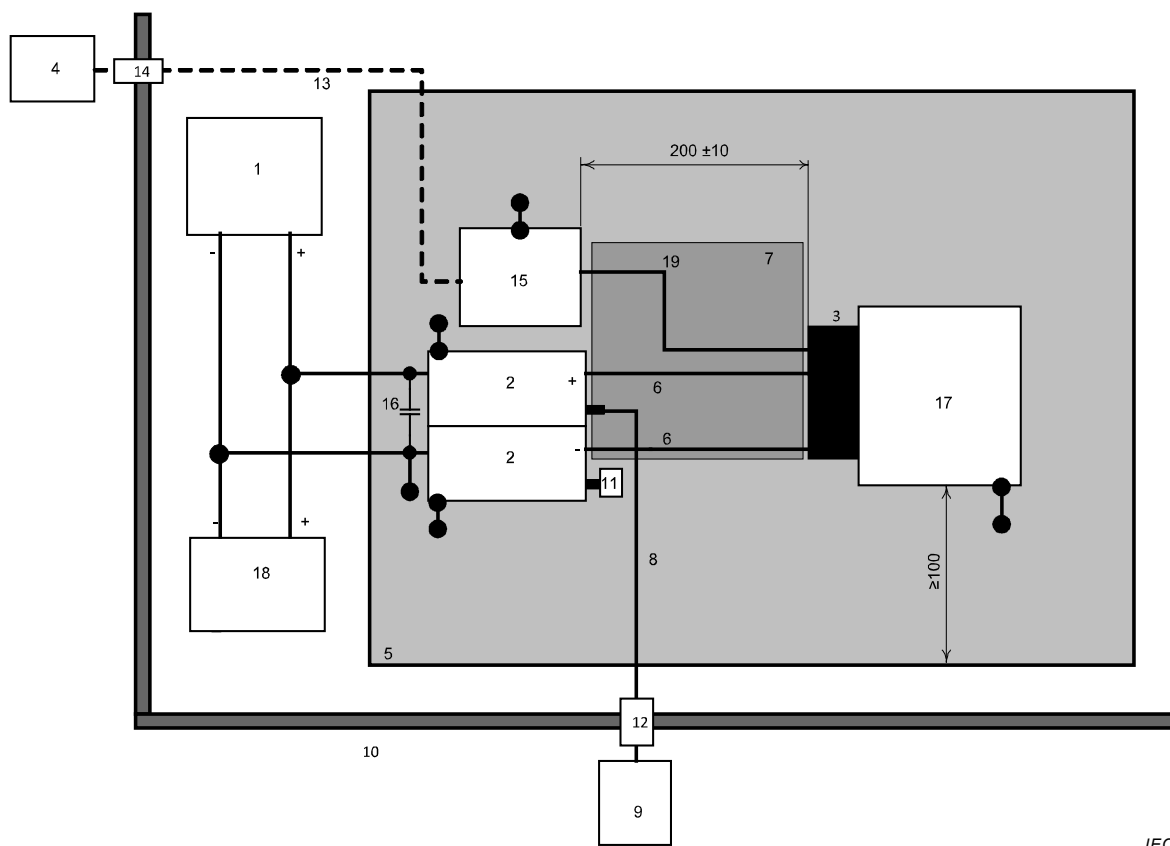
Key

- | | |
|--|--|
| 1 Battery (may be placed on the reference ground plane) | 8 High-quality coaxial cable e.g. double-shielded (50 Ω) |
| 2 Artificial network | 9 Measuring instrument |
| 3 EUT | 10 Shielded enclosure |
| 4 Load simulator (metallic casing grounded if required in test plan) | 12 Bulkhead connector |
| 5 Reference ground plane | 13 Test harness (excluding power lines) |
| 6 Power supply lines | 14 Motor (air/low emissions) |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | 15 Non-conductive belt/coupler |
| | 16 Load resistor |
| | 17 Indicator lamp/control resistor (if applicable) |

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

Figure 11 – Conducted emissions – Example of test setup for alternators and generators

Dimensions in millimetres – not to scale



IEC

Key

- | | |
|---|-----------------------------|
| 1 Power supply (may be placed on the reference ground plane) | 10 Shielded enclosure |
| 2 Artificial network | 11 50 Ω load |
| 3 Pencil coil | 12 Bulkhead connector |
| 4 ECU simulator (metallic casing grounded if required in test plan) | 13 Optical fibres |
| 5 Reference ground plane | 14 Fibre optic feed through |
| 6 Power supply lines | 15 Optical fibre converter |
| 7 Low relative permittivity support ($\epsilon_r \leq 1,4$) | 16 1 000 μ F capacitor |
| 8 High-quality coaxial cable e.g. double-shielded (50 Ω) | 17 Engine simulator |
| 9 Measuring instrument | 18 Battery |
| | 19 Signal line |

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

Figure 12 – Conducted emissions – Example of test setup for ignition system components

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

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

NOTE The method to be used for characterisation of the Voltage Division Factor of the AN, sometimes referred to as insertion loss, is given in Clause A.8 of CISPR 16-1-2:2014.

It is recommended for acceptable radio reception in a vehicle that the conducted noise should not exceed the values shown in Table 5, peak and average or quasi-peak and average.

respectively. Since the mounting location, vehicle body construction and harness design can affect the coupling of radio disturbances to the on-board radio, multiple limit levels are defined.

**Table 5 – Examples of limits for conducted disturbances –
Voltage method**

Service / Band	Frequency MHz	Levels in dB(μV)														
		Class 5			Class 4			Class 3			Class 2			Class 1		
		Peak	Quasipeak	Average	Peak	Quasipeak	Average	Peak	Quasipeak	Average	Peak	Quasipeak	Average	Peak	Quasipeak	Average
BROADCAST																
LW	0,15 to 0,30	70	57	50	80	67	60	90	77	70	100	87	80	110	97	90
MW	0,53 to 1,8	54	41	34	62	49	42	70	57	50	78	65	58	86	73	66
SW	5,9 to 6,2	53	40	33	59	46	39	65	52	45	71	58	51	77	64	57
FM	76 to 108	38	25	18	44	31	24	50	37	30	56	43	36	62	49	42
TV Band I	41 to 88	34	–	24	40	–	30	46	–	36	52	–	42	58	–	48
TV Band III	174 to 230	Conducted emission – Voltage method Not applicable														
DAB III	171 to 245															
TV Band IV	468 to 944															
DTTV	470 to 770															
DAB L Band	1 447 to 1 494															
SDARS	2 320 to 2 345															
MOBILE SERVICES																
CB	26 to 28	44	31	24	50	37	30	56	43	36	62	49	42	68	55	48
VHF	30 to 54	44	31	24	50	37	30	56	43	36	62	49	42	68	55	48
VHF	68 to 87	38	25	18	44	31	24	50	37	30	56	43	36	62	49	42
VHF	142 to 175	Conducted emission – Voltage method Not applicable														
Analogue UHF	380 to 512															
RKE	300 to 330															
RKE	420 to 450															
Analogue UHF	820 to 960															
GSM 800	860 to 895															
EGSM/GSM 900	925 to 960															
GPS L1 civil	1 567 to 1 583															
GLONASS L1	1 591 to 1 613															
GSM 1800 (PCN)	1 803 to 1 882															
GSM 1900	1 850 to 1 990															
3G / IMT 2000	1 900 to 1 992															
3G / IMT 2000	2 010 to 2 025															
3G / IMT 2000	2 108 to 2 172															
Bluetooth/802.11	2 400 to 2 500															