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BASIC EMC PUBLICATION

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Electromagnetic compatibility (EMC) –
Part 6-4: Generic standards – Emission standard for industrial environments

Compatibilité électromagnétique (CEM) –
Partie 6-4: Normes génériques – Norme sur l'émission pour les environnements industriels

INTERNATIONAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 6-4: Generic standards – Emission standard for industrial environments

FOREWORD

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International Standard IEC 61000-6-4 has been prepared by CISPR subcommittee H: Limits for the protection of radio services.

This third edition cancels and replaces the second edition published in 2006 and Amendment 1:2010 This edition constitutes a technical revision.

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

a) possible future requirements on DC ports;
b) possible future radiated polarity specific emission limits within a FAR;
c) the definition of which average detector is used for emission measurements at frequencies above 1GHz and that results using a peak detector are acceptable for all measurements;
d) the definition of different EUT test arrangements.

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

FDIS	Report on voting
CIS/H/339A/FDIS	CIS/H/350/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

It forms Part 6-4 of the IEC 61000 series of standards. It has the status of a basic EMC publication in accordance with IEC Guide 107.

A list of all parts in the CISPR 61000 series, published under the general title *Electromagnetic compatibility*, can be found on the IEC website.

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- withdrawn,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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 61000 is published in separate parts according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (insofar as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into several parts published either as International Standards or technical reports/specifications, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 6-4: Generic standards – Emission standard for industrial environments

1 Scope

This part of IEC 61000 for emission requirements applies to electrical and electronic equipment intended for use within the environment existing at industrial (see 3.1.12) locations.

This document does not apply to equipment that fall within the scope of IEC 61000-6-3.

The environments encompassed by this document cover both indoor and outdoor locations.

Emission requirements in the frequency range 9 kHz to 400 GHz are covered in this document and have been selected to provide an adequate level of protection of radio reception in the defined electromagnetic environment. No measurement needs to be performed at frequencies where no requirement is specified. These requirements are considered essential to provide an adequate level of protection to radio services.

Not all disturbance phenomena have been included for testing purposes but only those considered relevant for the equipment intended to operate within the environments included within this document.

Requirements are specified for each port considered.

This generic EMC emission standard is to be used where no applicable product or product-family EMC emission standard is available.

NOTE 1 Safety considerations are not covered by this document.

NOTE 2 In special cases, situations will arise where the levels specified in this document will not offer adequate protection; for example where a sensitive receiver is used in close proximity to an equipment. In these instances, special mitigation measures may have to be employed.

NOTE 3 Disturbances generated in fault conditions of equipment are not covered by this document.

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 60050-161, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

IEC 61000-4-20:2010, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguide*

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
CISPR 11:2015/AMD1:2016

CISPR 14-1:2016, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

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 disturbance measurements*
CISPR 16-1-4:2010/AMD1:2012
CISPR 16-1-4:2010/AMD2:2017

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

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*
CISPR 16-2-1:2014/AMD1:2017

CISPR 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty*
CISPR 16-4-2:2011/AMD1:2014

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161 and the following 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

3.1.1
port
physical interface of the specified equipment with the external electromagnetic environment

Note 1 to entry: See Figure 1.

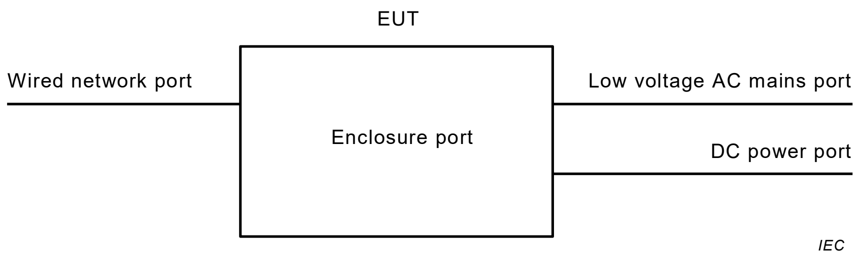


Figure 1 – Example of ports

3.1.2
enclosure port
physical boundary of the equipment which electromagnetic fields may radiate through or impinge on

3.1.3
cable port
port at which a conductor or a cable is connected to the equipment

Note 1 to entry: Examples are signal, wired network, control and power ports.

3.1.4
wired network port
point of connection for 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: These ports may support screened or unscreened cables and may also carry AC or DC power where this is an integral part of the telecommunication specification.

Note 3 to entry: A port generally intended for interconnection of components of a system under test (e.g. RS-232, RS-485, field buses in the scope of IEC 61158, IEEE Standard 1284 (parallel printer), Universal Serial Bus (USB), IEEE Standard 1394 (“Fire Wire”), etc.) and used in accordance with its functional specifications (e.g. for the maximum length of cable connected to it), is not considered to be a wired network port.

Note 4 to entry: In previous editions of this document and many product standards, this port was defined as a telecommunications or network port.

3.1.5
power port
port for the connection of the equipment to the primary electrical power supply

3.1.6
public mains network
electricity lines to which all categories of consumers have access and which are operated by a supply or distribution undertaking for the purpose of supplying electrical energy

3.1.7
low voltage
LV
a set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V AC or 1 500 V DC

[SOURCE: IEC 60050-601:1985, 601-01-26, modified – addition of the words "or 1 500 V DC"]

3.1.8
DC distribution network
local supply network in the infrastructure of a site or building intended for use by one or more different types of equipment and providing power independent of the public mains network

Note 1 to entry: Connection to a remote local battery is not regarded as a DC distribution network, if such a link comprises only power supply for a single piece of equipment.

3.1.9
low voltage AC mains port
port used to connect to the low voltage AC mains supply network to power the equipment

Note 1 to entry: Equipment with a DC power port is considered low voltage AC mains powered if it is powered from an AC/DC power converter.

Note 2 to entry: The low voltage AC mains supply could be public or non-public.

3.1.10
highest internal frequency F_x
highest fundamental frequency generated or used within the EUT, or the highest frequency at which it operates

3.1.11
small equipment
equipment, either positioned on a table top or standing on the floor which, including its cables fits in a cylindrical test volume of 1,2 m in diameter and 1,5 m above the ground plane

Note 1 to entry: These dimensions are currently under discussion in CISPR.

3.1.12
industrial location
location characterized by a separate power network, supplied from a high- or medium-voltage transformer, dedicated for the supply of the installation

Note 1 to entry: Industrial locations can generally be described by the existence of an installation with one or more of the following characteristics:

- items of equipment installed and connected together and working simultaneously;
- significant amount of electrical power generated, transmitted and/or consumed;
- frequent switching of heavy inductive or capacitive loads;
- high currents and associated magnetic fields;
- presence of industrial, high power scientific and medical (ISM) equipment (for example, welding machines).

The electromagnetic environment at an industrial location is predominantly produced by the equipment and installation present at the location. There are types of industrial locations where some of the electromagnetic phenomena appear in a more severe degree than in other installations.

Example locations include metalworking, pulp and paper, chemical plants, car production, farm building, high-voltage areas of airports

Note 2 to entry: The connection between location and electromagnetic environment is given in 3.1.13.

3.1.13
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

Note 1 to entry: In general, the electromagnetic environment is time-dependent and its description may need a statistical approach.

Note 2 to entry: It is very important not to confuse the electromagnetic environment and the location itself.

[SOURCE IEC 60050-161:1990, 161-01-01, modified – Note 2 to entry has been added.]

3.2 Abbreviated terms

AAN Asymmetric Artificial Network

AC Alternating Current

AMN Artificial Mains Network

CATV	Cable TV network
DC	Direct Current
DSL	Digital Subscriber Line
EUT	Equipment Under Test
FAR	Fully Anechoic Room
FSOATS	Free Space Open Area Test Site
ISDN	Integrated Services Digital Network
ITE	Information Technology Equipment
LAN	Local Area Network
MME	Multi Media Equipment
OATS	Open Area Test Site
PSTN	Public Switched Telephone Network
SAC	Semi Anechoic Chamber
TEM	Transverse Electromagnetic Mode
USB	Universal Serial Bus
xDSL	Generic term for all types of DSL technology

4 Conditions during testing

The EUT shall be tested in the operating mode producing the largest emission in the frequency band being measured, consistent with normal applications. The configuration of the test sample shall be varied to achieve maximum emission consistent with typical applications and installation practice. Pre-testing may be used to reduce test time.

If the EUT is part of a system, or can be connected to associated equipment, the EUT shall be tested while connected to the minimum representative configuration of associated equipment necessary to exercise the ports in a similar manner to that described in CISPR 11 or CISPR 32.

The EUT shall be arranged in accordance with the requirements of Table 1.

Table 1 – Test arrangements of EUT

Intended operational arrangement(s) of EUT	Test arrangement	Remarks
Table-top only	Table-top	
Floor-standing only	Floor-standing	
Can be floor-standing or table-top	Table-top	
Rack mounted	In a rack or table-top	
Other, for example wall mounted, ceiling mounted, handheld, body worn	Table-top	With normal orientation If the equipment is designed to be mounted on a ceiling, the downward-facing portion of the EUT may be oriented facing upward.
If a physical hazard would be caused by testing the device on a table-top, then it can be tested as floor standing and the test report shall document the decision and justification.		

In cases where a manufacturer's specification requires external filtering and/or shielding devices or measures that are clearly specified in the user's manual, the test requirements of this document shall be applied with the specified devices or measures in place.

The configuration and mode of operation during the measurements shall be precisely noted in the test report. If the EUT has a large number of similar ports or ports with many similar connections, a sufficient number shall be selected to simulate actual operating conditions and to ensure that all the different types of termination are covered.

The measurements shall be carried out at one single set of parameters within the operating ranges of temperature, humidity and atmospheric pressure specified for the product and at the rated supply voltage, unless otherwise indicated in the basic standard. The relevant conditions shall be recorded in the test report.

Where applicable, additional information on EUT configuration can be found in CISPR 16-2-1, CISPR 16-2-3, CISPR 11 or CISPR 32 as referenced in Table 3 to Table 5.

5 Product documentation

The purchaser/user/installer shall be informed within the product documentation if special measures have to be taken to achieve compliance. One example, would be the need to use shielded or special cables.

6 Applicability

The application of measurements for emission(s) depends on the particular equipment, its configuration, its ports, its technology and its operating conditions.

Measurements shall be applied to the relevant ports of the equipment according to the requirements defined in Table 3 to Table 5. Measurements shall only be carried out where the relevant ports exist.

It may be determined from consideration of the electrical characteristics and usage of particular equipment that some of the measurements are inappropriate and therefore unnecessary. In such a case it is required that the decision and justification not to measure shall be recorded in the test report.

7 Measurement uncertainty

Where guidance for the calculation of the instrumentation uncertainty of a measurement is specified in CISPR 16-4-2 this shall be followed, and for these measurements the determination of compliance with the limits in this document shall take into consideration the measurement instrumentation uncertainty in accordance with CISPR 16-4-2. Calculations to determine the measurement result and any adjustment of the test result required when the test laboratory uncertainty is larger than the value for U_{cispr} given in CISPR 16-4-2 shall be included in the test report.

8 Compliance with this document

Where this document gives options for testing particular requirements with a choice of test methods, compliance can be shown against any of the relevant test methods, using the specific limits with the restrictions provided in the relevant tables clauses. For example, floor standing shall be assessed against table clause 3.1, considering table clause 3.2 is limited to small equipment and table clause 3.3 is limited to table top equipment.

In any situation where it is necessary to retest the equipment the test method originally chosen shall be used in order to ensure consistency of the results.

Equipment which fulfils the requirements across the frequency ranges specified in Table 3 to Table 5 in this document is deemed to fulfil the requirements in the entire frequency range from 9 kHz to 400 GHz.

Measurements do not need to be performed at frequencies where no limits are specified.

NOTE CISPR TR 16-4-3 provides guidance on the applicability of limits to series produced equipment.

9 Emission requirements

The emission requirements for equipment covered by this document are given on a port by port basis and defined in Table 3 to Table 5. Annex A is provided for information purposes only and lists proposed limits for DC power ports.

The measurements shall be conducted in a well-defined and reproducible manner and performed in any order.

The description of the measurement, the measurement instrumentation, the measurement methods, and the measurement set-up to be used are given in the standards, which are referred to in Table 3 to Table 5. These standards are not repeated here, however modifications or additional information needed for the practical application of the measurements are given in this document.

The following shall be taken into account during the application of the measurements defined in Table 3 to Table 5.

- At transitional frequencies, the lower limit applies.
- Where the limit value varies over a given frequency range, it changes linearly with respect to the logarithm of the frequency.
- The test site shall be validated for the measurement distance chosen.
- Where the table clause defines more than one detector, then the measurements shall be performed using both types of detector. Results obtained using a peak detector may be used instead of the other defined detectors.
- Where a different measurement distance is chosen, other than the reference distance defined in the limit column of Table 3, the limits shall be offset based upon the following formula:

  new limit = defined limit – 20 log (measurement distance/reference distance)

  The unit of metres shall be used for distance and dB(μV/m) for the limits.

  With regard to each table clause, the measurements shall be performed at only one distance.
- For radiated emission measurements, Table 2 shows the highest frequency up to which radiated emission measurements shall be performed based up the value of F_x.

Table 2 – Required highest frequency for radiated measurement

Highest internal frequency (F_x)	Highest measured frequency
$F_x \leq 108$ MHz	1 GHz
108 MHz $< F_x \leq 500$ MHz	2 GHz
500 MHz $< F_x \leq 1$ GHz	5 GHz
$F_x > 1$ GHz	$5 \times F_x$ up to a maximum of 6 GHz
NOTE 1 Where the highest internal frequency is not known, tests are performed up to 6 GHz.	
NOTE 2 F_x is defined in 3.1.10.	

- For emission measurements above 1 GHz, the peak detector limits shall not be applied to disturbances produced by arcs or sparks that are high voltage breakdown events. Such disturbances arise when devices contain or control mechanical switches that control current in inductors, or when devices contain or control subsystems that create static electricity (such as paper handling devices). The average limits apply to disturbances from arcs or sparks, and both peak and average limits will apply to other disturbances from such devices.
- For radiated emission measurements using a FSOATS, FAR or SAC, the measurement distance is the horizontal distance between the vertical projections of the calibration point of the receiving antenna and the boundary of the EUT. The boundary of the EUT is the smallest imaginary circular periphery around the most compact arrangement of the EUT, using typical spacing.
- Where this document specifies the use of an average detector, the linear average detector defined in Clause 6 of CISPR 16-1-1:2015 shall be used.

NOTE In the measurement specifics columns of Table 3 to Table 5, where relevant, the format is as follows: characteristic, basic standard, clause. For example, from table clause 3.1, Instrumentation, CISPR 16-1-1:2015, Clause 4.

Table 3 – Requirements for radiated emissions – enclosure port

Table clause	Test facility	Frequency range MHz	Limits dB(μV/m) Detector / measurement distance	Measurement specifics [a]	Limitations and restrictions [a]
3.1	OATS or SAC	30 to 230	40 Quasi-peak / 10 m	Instrumentation, CISPR 16-1-1, Clause 4 Antennas, CISPR 16-1-4, 4.5 Test site, CISPR 16-1-4, Clause 5 Method, CISPR 16-2-3, 7.3	Allowed measurement distances: 3 m, 5 m, 10 m or 30 m For equipment meeting the size criterion defined in 3.1.11, the measurements may be performed at the 3 m distance. Note this size criterion is currently under discussion. For measurement distances less than 30 m, the receiving antenna height shall be varied between 1 m to 4 m, else 1 m to 6 m shall be used. Additional guidance on the test method can be found in CISPR 16-2-3, 7.3 and Clause 8.
		230 to 1 000	47 Quasi-peak / 10 m		
3.2	TEM	30 to 230	40 Quasi-peak / n/a	IEC 61000-4-20	Only applicable to battery powered equipment not intended to have external cables attached. Restricted to equipment complying with the definition of small equipment within 6.2 in IEC 61000-4-20.
		230 to 1 000	47 Quasi-peak / n/a		
3.3	FAR	30 to 230	52 to 45 Quasi-peak / 3 m	Instrumentation, CISPR 16-1-1, Clause 4 Antennas, CISPR 16-1-4, 4.5 Test site, CISPR 16-1-4, 5.4.7 Method, CISPR 16-2-3, 7.4.	Restricted to table top equipment, and floor-standing equipment which can be placed on table during the test. Allowed measurement distances: 3 m, 5 m or 10 m The limitations on EUT size in CISPR 16-2-3 apply.
		230 to 1 000	52 Quasi-peak / 3 m		
3.4	FSOATS OATS FAR SAC (see limitations)	1 000 to 3 000	76 Peak / 3 m	Instrumentation, CISPR 16-1-1, Clauses 5 and 6 Antennas, CISPR 16-1-4, Clause 4.5 Test site, CISPR 16-1-4, Clause 8 Method, CISPR 16-2-3, Clause 7.6.	Allowed measurement distances: 3 m, 5 m or 10 m. Other facilities, such as FAR, SAC or OATS may be used provided they satisfy the free space conditions as defined in CISPR 16-1-4. For SAC and OATS, additional absorber may be required.
			56 Average / 3 m		
		3 000 to 6 000	80 Peak / 3 m		
			60 Average / 3 m		

The equipment is deemed to comply with the enclosure port requirement below 1 GHz if it meets the requirements defined in one or more of the table clauses 3.1, 3.2 or 3.3.

Antenna calibration shall be in accordance with CISPR 16-1-6:2014/AMD1:2017.

[a] Within this table, the version of the references are as follows:

CISPR 16-1-1 is CISPR 16-1-1:2015, CISPR 16-1-4 is CISPR 16-1-4:2010, CISPR 16-1-4:2010/AMD1:2012 and CISPR 16-1-4:2010/AMD1:2012/AMD2:2017, CISPR 16-2-3 is CISPR 16-2-3:2016 and IEC 61000-4-20 is IEC 61000-4-20:2010.

Table 4 – Requirements for conducted emissions – low voltage AC mains port

Table clause	**Measurement network**	**Frequency range** MHz	**Limits** dB(μV) / **Detector**	**Measurement specifics** [a]	**Limitations and restrictions** [a]
4.1	AMN	0,15 to 0,5	79 Quasi-peak	Instrumentation, CISPR 16-1-1, Clauses 4 and 6 Networks, CISPR 16-1-2, 4.4 Method, CISPR 16-2-1, Clause 7 Set-up, CISPR 16-2-1, Clause 7	For clicks appearing between 5 and 30 times per minute, a relaxation of the limits is allowed of 20 log 30/N dB (where N is the number of clicks per minute). Criteria for separated clicks shall be found in CISPR 14-1.
			66 Average		
		0,5 to 30	73 Quasi-peak		
			60 Average		

The AMN characteristics shall be 50 Ω / 50 μH as defined in CISPR 16-1-2, 4.4, unless this network interferes with the operation of the EUT. In these cases, the AMN characteristics and the justification shall be recorded in the test report.

[a] Within this table, the version of the references are as follows:

CISPR 14-1 is CISPR 14-1:2016, CISPR 16-1-1 is CISPR 16-1-1:2015, CISPR 16-1-2 is CISPR 16-1-2:2014, CISPR 16-2-1 is CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017.

Table 5 – Requirements for conducted emissions – wired network port

Table clause	**Measurement network**	**Frequency range** MHz	**Limits** dB(μV) / **Detector**	**Limits** dB(μA) / **Detector**	**Measurement specifics** [a]	**Limitations and restrictions** [a]
5.1	As defined in CISPR 32	0,15 to 0,5	97 to 87 Quasi-peak	53 to 43 Quasi-peak	As defined in CISPR 32	The current and voltage disturbance limits are derived for use with an Asymmetric Artificial Network (AAN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the wired network port under test (conversion factor is 20 log10 150 / I = 44 dB). When performing measurements using an AAN, only the voltage limits apply. All elements within CISPR 32 shall be followed, including but not limited to selection of test method, test configuration, cable characteristics.
			84 to 74 Average	40 to 30 Average		
		0,5 to 30	87 Quasi-peak	43 Quasi-peak		
			74 Average	30 Average		

[a] Within this table, the version of the reference CISPR 32 is CISPR 32:2015.

Annex A
(informative)

Testing of DC powered systems

This annex is informative containing proposed requirements for conducted emissions on DC power ports, defined in Table A.1, with further specifics for which ports need to be measured given in Table A.2.

Table A.1 – Proposed requirements for conducted emissions – DC power port

Table Clause	**Measurement network**	**Frequency range** MHz	**Limits** dB(μV) **Detector**	**Measurement specifics** [a]	**Limitations and restrictions** [a]
A.1.1	AMN	0,15 to 0,5	89 Quasi-peak	Instrumentation, CISPR 16-1-1, Clauses 4 and 6	See Table A.2, for DC power ports that require testing.
			76 Average	Networks, CISPR 16-1-2, Clause 4	
		0,5 to 30	83 Quasi-peak	Method, CISPR 16-2-1, Clause 7	
			70 Average	Set-up, CISPR 16-2-1, Clause 7	

These informative limits have been considered by CISPR H (in conjunction with Table A.2) and are provided as a possible basis for new requirements.

[a] Within this table, the version of the references are as follows:

CISPR 16-1-1 is CISPR 16-1-1:2015, CISPR 16-1-2 is CISPR 16-1-2:2014, CISPR 16-2-1 is CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017.

Table A.2 – Conducted testing of DC powered equipment

Table clause	Description of DC power source connection [e]	Testing to be required on DC power port	Proposed Intended cable connection [d, e]	Specifics and additional recommendations
A.2.1	Internal batteries, with no external DC input	No DC input port	None	No tests are required.
A.2.2	Distribution network [a]	Yes	All types	
A.2.3	Wired network port	No	As defined in CISPR 32	Port should be treated as a wired network port and tested against the requirements of Table 5.
A.2.4	Remote battery	Yes	Is longer than 3 m	
A.2.5	External AC/DC converter or battery charger	Yes	Is longer than 3 m [b]	The AC input port of the charger/converter[c] should also be tested against the requirements of Table 4.
A.2.6	External DC/DC converter or battery charger	Yes	Is longer than 3 m [b]	The DC input port of the charger/converter[c] should also be tested against the requirements of table clause A.2.7.
A.2.7	All other systems not defined above	Yes	Is longer than 3 m	Should be tested against the requirements of Table A.1.

[a] DC distribution networks include:

- those with an overall length greater than 3 m.

[b] The length of the cable between the DC port on the EUT and the convertor or charger.

[c] Where possible, use a device specified by the manufacturer, else use a typical device capable of developing the necessary DC voltage/current.

[d] Where the limitation is satisfied then the test is applicable, for example, for table clause A.2.4, where the cable attached to a DC power port is 10 m long (longer than the 3 m requirement), then testing would be required against the requirements of Table A.1.

[e] Based upon the intended use of the equipment as defined by the manufacturer and documented in the user documentation.

Annex B
(informative)

Further information on measurements using a FAR

B.1 General

During the development of the limits for table top equipment using a FAR measurement facility, as defined in Table 3, the committee analysed various options, including polarity specific limits. During the original discussions, these were considered far too radical and hence dismissed.

During the following years, there have been repeated requests by various national committees to improve the limits defined in Table 3 by the adaption of polarity specific types. Hence, this informative annex is intended to communicate how the originals limits were derived and the possible improvements if these alternative limits were adopted.

There is a significant amount of additional data and information presented in CISPR 16-4-5, CENELEC R210-010 and in SMT4-CT96-2133.

B.2 Analysis

B.2.1 Theoretical analysis of simple radiators

A difference of 6 dB is expected for measured field strengths above a ground plane (for example, using an OATS) compared with free space (for example using a FAR). A simple OATS geometrical optic model is shown in Figure B.1, two rays impinge on the receive antenna above a ground plane; namely the one transmitted directly between the transmit and receive antenna and the one reflected by the ground plane.

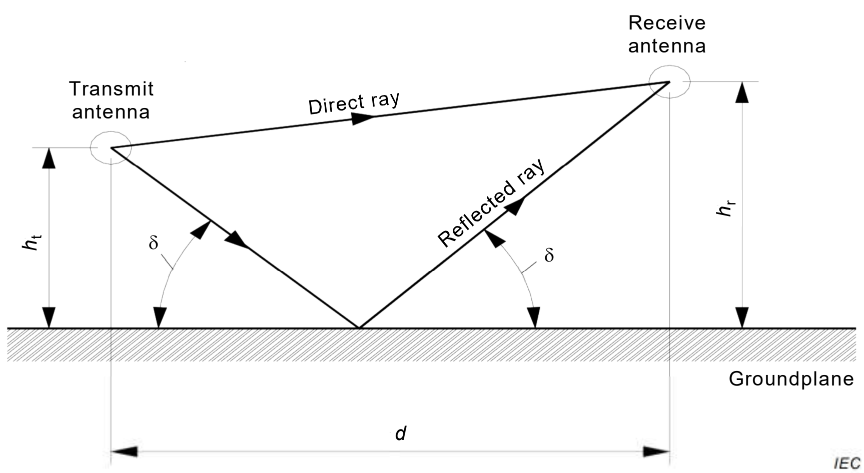


Figure B.1 – Geometrical optics model for OATS measurements

The difference in phase relation of these two rays results in an interference pattern which corresponds to the function of the height of the receive antenna above the ground. The resulting effect ranges from cancellation to doubling of the direct ray. As such, during OATS measurements h_r is varied until constructive interference (or doubling) is obtained.

Therefore, based upon this model, the limits when using a FAR should be 6 dB lower, in comparison with those of an OATS because within a FAR, there is no reflected ray, hence no doubling of emission levels will occur.

B.2.2 Limitations with the basic model

B.2.2.1 Theoretical analysis of simple radiators

Figure B.2 illustrates typical interference patterns via the height of the receive antenna above a ground plane. The interference pattern depends on the distance between transmit and receive antenna, height of the transmit antenna above the ground plane, polarisation, frequency and type of antennas. As there is no reflected ray in free space, it is assumed that no interference patterns exist in a FAR. This begins to question the basic model, because the two facilities are in reality different.

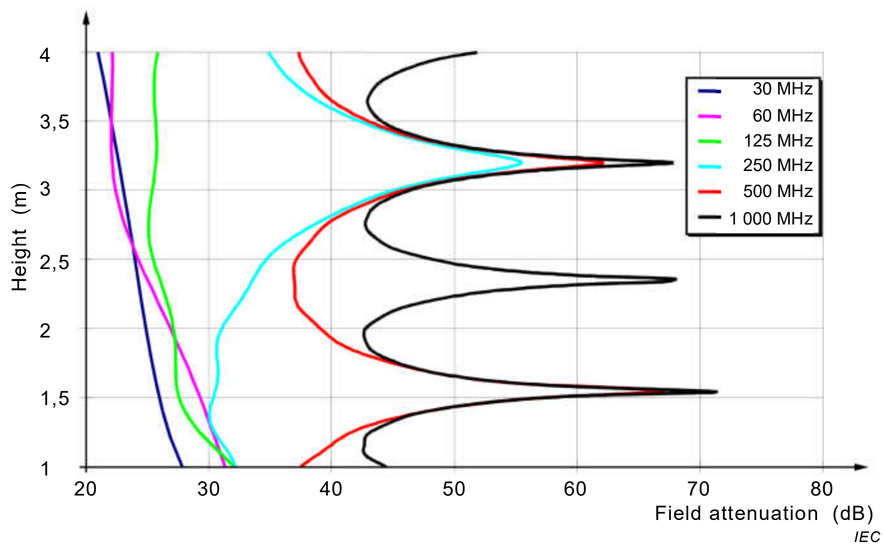


Figure B.2 – Field attenuation between two half-wave dipoles above ground plane with fixed transmit antenna height and variable receive antenna height

B.2.2.2 Analysis of an EUT

A real EUT can be represented by a number of RF sources driving different types of transmitting antennas with associated currents. Four possible sources are shown in Figure B.3, illustrating the different position, type of antenna, associated source and possible currents flowing. Within a typical EUT, the actual position of these sources, are generally unknown.

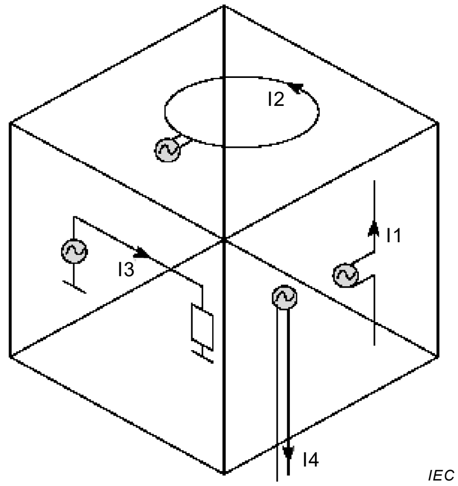
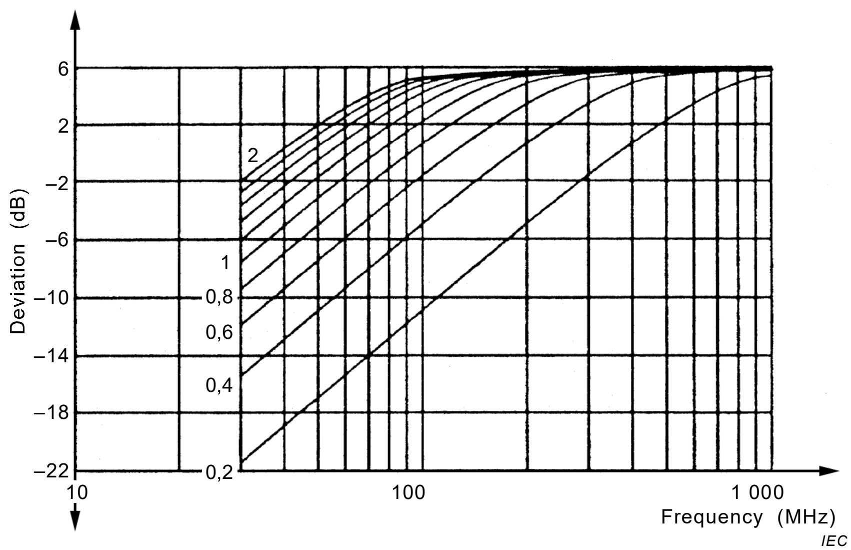


Figure B.3 – Equivalent circuit diagram of a typical EUT

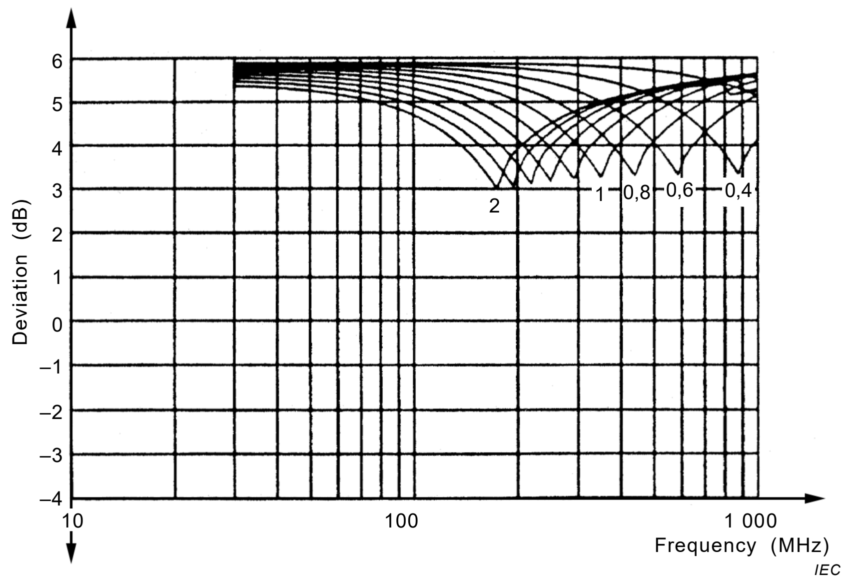
In order to establish a base line of the possible differences, a theoretical investigation[1] was performed and the results are shown in Figure B.4 and Figure B.8 for a 10 m distance and in Figure B.6 and Figure B.7 for a 3 m distance.



NOTE The numbers within the graph are the positions of the source above the ground plane on an OATS.

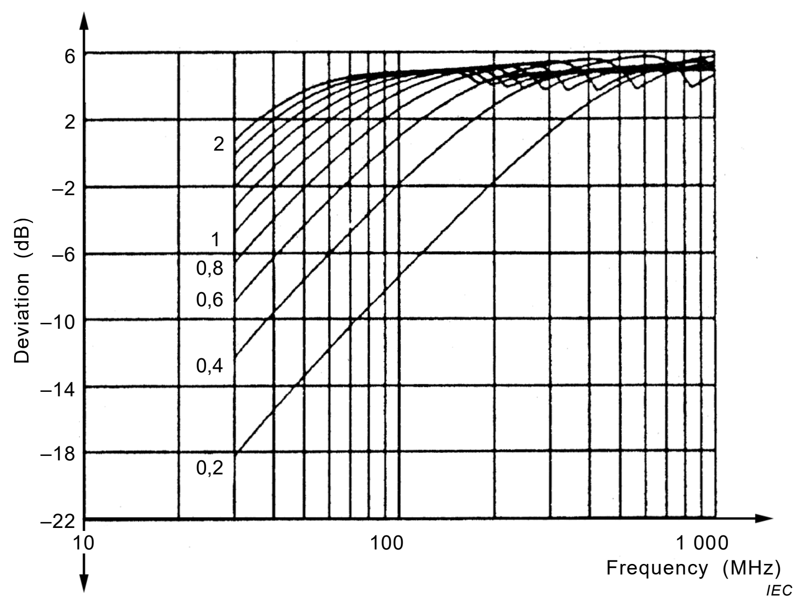
Figure B.4 – 10 m distance, horizontal polarization, calculated differences for an electrically short straight wire above the ground plane on an OATS compared with a FAR ($E_{OATS} - E_{FAR}$)

1 Dr. Garn, 'Proposal for a new radiated emission test method using a completely absorber lined Room without ground plane', 9th Zurich symposium on EMC.



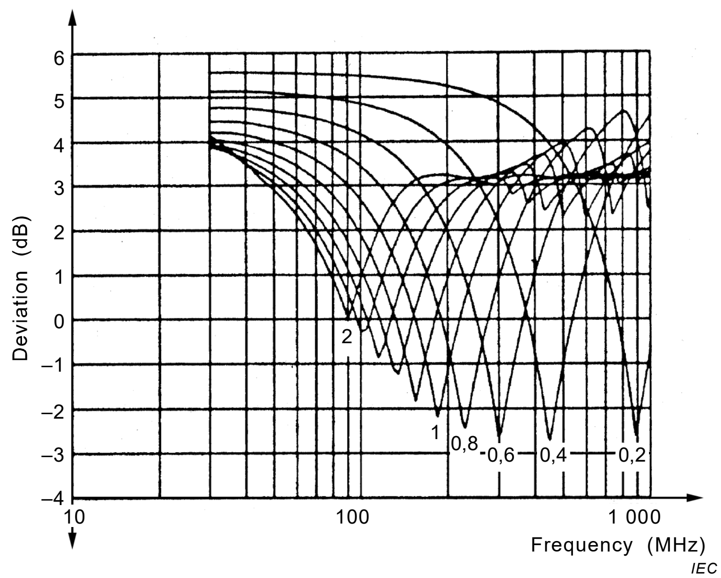
NOTE The numbers within the graph are the positions of the source above the ground plane on an OATS.

Figure B.5 – 10 m distance, vertical polarization, calculated differences for an electrically short straight wire above the ground plane on an OATS compared with a FAR (E_{OATS} – E_{FAR})



NOTE The numbers within the graph are the positions of the source above the ground plane on an OATS.

Figure B.6 – 3 m distance, horizontal polarization, calculated differences for an electrically short straight wire above the ground plane on an OATS compared with a FAR (E_{OATS} – E_{FAR})



NOTE The numbers within the graph are the positions of the source above the ground plane on an OATS.

Figure B.7 – 3 m distance, vertical polarization, calculated differences for an electrically short straight wire above the ground plane on an OATS compared with a FAR ($E_{OATS} - E_{FAR}$)

Figure B.4 to Figure B.7 shows the difference between the received field strength for different polarised electrically short straight wires placed above a ground plane and in free space. The receive antenna is moved between 1 m and 4 m above the ground plane and is fixed in the free space situation. The distance between the transmitting and the receiving antenna is the same for both sites.

For vertical polarized signals, the 2 models provide similar results, but for horizontal, the results are very different. As an example, Figure B.4 shows that the maximum difference in calculated field strengths above a ground plane and in free space is up to –22 dB for an EUT height of 0,2 m. The expected difference is +6 dB based on a simple model. That implies a difference of up to 28 dB in calculated field strength.

One of the reasons for this is the wave propagation on an OATS. In horizontal polarisation, below 100 MHz the constructive interference of direct and ground reflected signal cannot be found in the 1 m to 4 m height scan range. Therefore the same magnitude of radiated emission will give a different reading in the received field strength for horizontal and vertical polarisation on an OATS (13 dB at 10 m distance, 1 m source height).

B.2.2.3 OATS as a reference

For many years, measurements using an OATS facility have been used to assess products. This solution has been very successful at controlling interference; therefore, if we blindly accepted 5 dB as the good compromise we would be ignoring the data and in reality tightening the limits when there is no justification.

B.2.3 Measurements on an EUT

Many measurements have been performed to verify the limits, a very small sample is show in Figure B.8. This shows the differences of the horizontal polarised emissions of a small EUT with mains lead measured in 3 m FARs and on 10 m OATS. These measurements then contributed to the definition within CISPR 16-2-3 which effectively states that the maximum width and height of an EUT (including cables and associated equipment) shall be less than half of the measurement distance.

It is noticeable that the response is well above the 5 dB level at 30 MHz. This is caused by destructive interference on the OATS, as described in B.2.2.2. This phenomenon does not occur for vertical polarisation as the signal does not undergo a 180 phase change on reflection. That means the former proposed 5 dB difference in the limit values between 10 m OATS and 3 m FAR are not acceptable in the whole frequency range.

For further examples, see CISPR 16-4-5, CENELEC R210-010, etc.

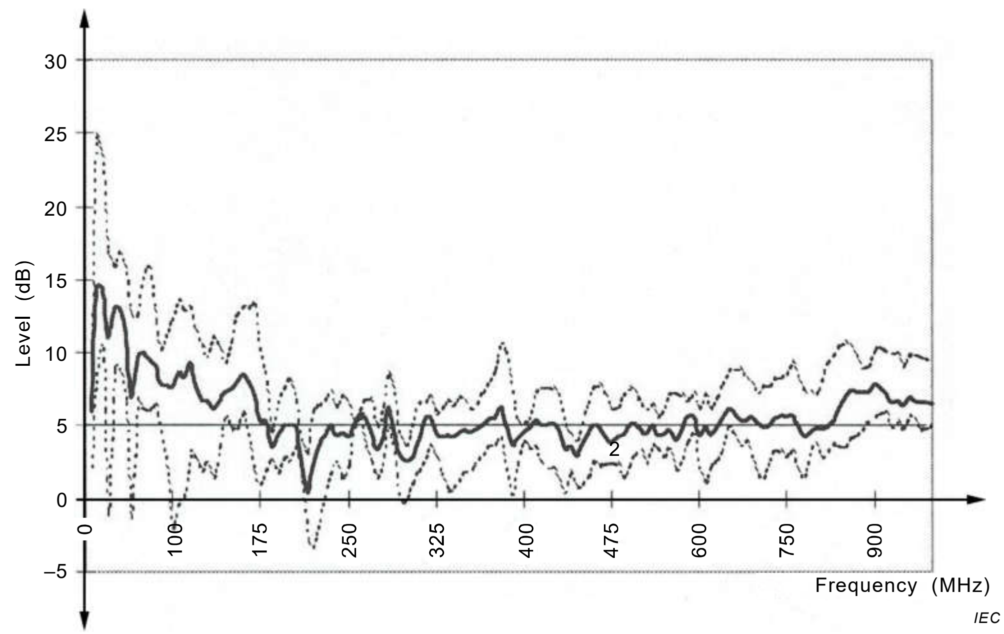


Figure B.8 – Differences of the horizontal polarised emission of the small EUT with mains lead in the 3 m FARs and on 10 m OATS

B.2.4 Derivation of limits

The limits were derived, based upon the details presented in B.2.1 to B.2.3 and summarized in the following:

- Polarity specific limits were considered too radical; hence any compromise would probably mean for vertical polarized signals, the FAR would be too strict and for horizontally polarized signals it would be a relaxation.
- Signals from horizontal polarized sources close to the ground plane give the biggest variants (see results at a height of 0,02 m in Figure B.4 and Figure B.6) hence only table top equipment should be assessed using a FAR. As the source of emissions is moved away from the ground plane, this variance decreases so this would be problematic for floor standing equipment.
- A compromise was finally adopted which would give a relaxation over those of an OATS, but only in the lower frequency range. The relaxation of 7 dB was based on approximately half of the difference between 5 dB and the -9 dB, where 5 dB is the idea response and -9 dB is the error associated emission from a 0,8 m high cable, derived from Figure B.4.

NOTE The half value would not be relevant if polarity specific limits were used, in the case the relaxation would then be 14 dB.

B.3 Requirements

The following limits and requirements, defined in Table B.1, are provided for information purposes only. They may provide equivalent protection to radio reception as those defined in

Table 3 and are included to give the user of these types of facilities an indication of the validity of the results.

Table B.1 – Proposed requirements for radiated emissions, FAR

Table clause	**Test facility**	**Frequency range** MHz	**Limits** dB(μV/m) **Detector / measurement distance**	**Measurement specifics** [a]	**Limitations and restrictions** [a]
B.1.1	FAR	30 to 230	**Horizontally polarized emissions** 59 to 45 Quasi-peak / 3 m	Instrumentation, CISPR 16-1-1, Clause 4 Antennas, CISPR 16-1-4, 4.5 Test site, CISPR 16-1-4, 5.4.7 Method, CISPR 16-2-3, 7.4	Allowed measurement distances: 3 m, 5 m or 10 m The limitations on EUT size in CISPR 16-2-3 apply. The measurement distance is from the receiving antenna to the boundary of the calibrated test volume. The horizontally exposed cabling shall be at a minimum, and not at 0,8 m as required by CISPR 16-2-3.
			Vertically polarized emissions 45 Quasi-peak / 3 m		
		230 to 1 000	52 Quasi-peak / 3 m		

[a] Within this table, the version of the references are as follows:

CISPR 16-1-1 is CISPR 16-1-1:2015, CISPR 16-1-4 is CISPR 16-1-4:2010,CISPR 16-1-4:2010/AMD1:2012 and CISPR 16-1-4:2010/AMD2:2017, CISPR 16-2-3 is CISPR 16-2-3:2016.

The following key points shall be noted.

1) Vertically polarized emission should correlate very well to those measured using an SAC/OATS.
2) The limits defined within Table B.1 would apply to both floor standing equipment and table top equipment.
3) Because of the correlation issues with FAR and SAC/OATS, the horizontally exposed cable shall be as short as possible. Not 0,8 m as required by CISPR 16-2-3. This will minimise these types of emissions.
4) The horizontal limit of 59 dB(μV/m) was developed to improve the correlation for cables close to the ground plane, see Figure B.6, this value may need to be different for table top equipment, for example 52 dB(μV/m).

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IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

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47 CFR 15, *TITLE 47 – Telecommunication Chapter I – Federal Communications Commission, Subchapter A Part 15 – Radio Frequency Devices*

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