CISPR 11

Edition 7.0 2024-02
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

PRODUCT FAMILY EMC STANDARD

Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement

CISPR 11:2024-02 CMV(en)

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC®

CISPR 11

Edition 7.0 2024-02
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

PRODUCT FAMILY EMC STANDARD

Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10

ISBN 978-2-8322-8316-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

____

INDUSTRIAL, SCIENTIFIC AND MEDICAL EQUIPMENT – RADIO-FREQUENCY DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

This commented version (CMV) of the official standard CISPR 11:2024 edition 7.0 allows the user to identify the changes made to the previous CISPR 11:2015+AMD1:2016+AMD2:2019 CSV edition 6.2. Furthermore, comments from CISPR Subcommittee B experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

International Standard CISPR 11 has been prepared by CISPR Subcommittee B: Interference relating to industrial, scientific and medical radio-frequency apparatus, to other (heavy) industrial equipment, to overhead power lines, to high voltage equipment and to electric traction.

This seventh edition cancels and replaces the sixth edition published in 2015, Amendment 1:2016 and Amendment 2:2019. This edition constitutes a technical revision.

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

a) introduction of limits for radiated disturbances in the frequency range above 1 GHz for group 1 equipment in line with the requirements given in the generic emission standards;
b) introduction of limits for conducted disturbances on the wired network port in line with the requirements given in the generic emission standards;
c) introduction of requirements for equipment which incorporates radio transmit/receive functions;
d) introduction of definitions for various types of robots;
e) consideration of some particular conditions when measuring robots, such as measurement setups and operating modes of robots.

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

Draft	Report on voting
CIS/B/831/FDIS	CIS/B/837/RVD

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

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

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

This document has the status of a Product Family EMC standard in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications (2014)*.

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

The main content of this document is based on CISPR Recommendation No. 39/2 given below:

RECOMMENDATION No. 39/2

Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

The CISPR

CONSIDERING

a) that ISM RF equipment is an important source of disturbance;

b) that methods of measuring such disturbances have been prescribed by the CISPR;

c) that certain frequencies are designated by the International Telecommunication Union (ITU) for unrestricted radiation from ISM equipment,

RECOMMENDS

that the latest edition of CISPR 11 be used for the application of limits and methods of measurement of ISM equipment.

INTRODUCTION

This CISPR publication contains, amongst common requirements for the control of RF disturbances from equipment intended for use in industrial, scientific, and medical electrical applications, specific requirements for the control of RF disturbances caused by ISM RF applications in the meaning of the definition of the International Telecommunication Union (ITU), see also Definition 3.1.18 in this document. CISPR and ITU share their responsibilities for the protection of radio services in respect of the use of ISM RF applications.

The CISPR is concerned with the control of RF disturbances from ISM RF applications by means of an assessment of these disturbances either at a standardised test site or, for an individual ISM RF application which cannot be tested at such a site, at its place of operation. Consequently, this CISPR Publication covers requirements for ~~conformity assessment of~~ both, equipment assessed by means of ~~type~~ tests at standardised test sites or of individual equipment under *in situ* conditions.

The ITU is concerned with the control of RF disturbances from ISM RF applications during normal operation and use of the respective equipment at its place of operation (see Definition 1.15 in the ITU Radio Regulations (2020)). There, use of radio-frequency energy decoupled from the ISM RF application by radiation, induction or capacitive coupling is restricted to the location of that individual application.

This CISPR publication contains, in 6.3, the essential emission requirements for an assessment of RF disturbances from ISM RF applications at standardised test sites. These requirements allow for ~~type~~ testing of ISM RF applications operated at frequencies up to 18 GHz. It further contains, in 6.4, the essential emission requirements for an *in situ* assessment of RF disturbances from individual ISM RF applications in the frequency range up to 1 GHz. All requirements were established in close collaboration with the ITU and enjoy approval of the ITU.

However, for operation and use of several types of ISM RF applications the manufacturer, installer and/or customer should be aware of additional national provisions regarding possible licensing and particular protection needs of local radio services and applications. Depending on the country concerned, such additional provisions ~~may~~ can apply to individual ISM RF applications operated at frequencies outside designated ISM bands (see Table 1). They also ~~may~~ can apply to ISM RF applications operated at frequencies above 18 GHz. ~~For the latter type of applications, local protection of radio services and appliances requires an accomplishment of the conformity assessment by application of the relevant national provisions in the frequency range above 18 GHz in accordance with vested interests of the ITU and national administrations. These additional national provisions may apply to spurious emissions, emissions appearing at harmonics of the operation frequency, and to wanted emissions at the operation frequency allocated outside a designated ISM band in the frequency range above 18 GHz.~~

Recommendations of CISPR for the protection of radio services in particular areas are found in Annex C of this document.

~~Definition 1.15 of the ITU Radio Regulations reads as follows:~~

~~**1.15** *industrial, scientific and medical (ISM) applications (of radio frequency energy)*: Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications.~~

~~[ITU Radio Regulations Volume 1: 2012 – Chapter I, Definition 1.15]~~

Introduction to Amendment 1

This Amendment introduces the fully-anechoic room (FAR) for measurements of the disturbance field strength in the range 30 MHz to 1 GHz on equipment in the scope of CISPR 11.

It contains the complete set of requirements for measurement of radiated disturbances from equipment fitting into the validated test volume of a given FAR. It specifies a separation distance of 3 m and restricts use of the FAR to measurements on table-top equipment.

At the moment the FAR can be used:

- for measurements on table-top equipment fitting into the validated test volume of the given FAR,
- for a separation distance of 3 m only, and
- if the FAR was validated according to CISPR 16-1-4.

The limits for class A and class B group 1 equipment in this CDV base on the limits in the generic emission standards IEC 61000-6-3:2006/AMD 1 (2010) and IEC 61000-6-4:2006/AMD 1 (2010). The limits for class A and class B group 2 equipment were derived using the same approximation formula as used when deriving the limits for the generic emission standards in mid of the years 2000 to 2010. CISPR/H/104/INF, published in 2005, gives detailed explanations how these limits for the FAR were derived.

More detailed background information is still found in CISPR/B/627/CDV.

CISPR/B WG1 in October 2015

Introduction to the Amendment 2

This AMD 2 combines the contents of two fragments which have been circulated as CIS/B/688/CDV (f2) and CIS/B/697/CDV (f3).

Fragment 2: Requirements for semiconductor power converters (SPC)

CISPR 11 Ed. 6.1 needs to be supplemented with further information for full inclusion of type test requirements for SPCs specified hereafter. These requirements apply only to the following types of equipment:

a) power conversion equipment intended for assembly into photovoltaic power generating systems, such as grid connected power converters (GCPCs) and d.c. to d.c. converters,

b) GCPCs intended for assembly into energy storage systems.

Fragment 3: Improvement of repeatability for measurements in the frequency range 1-18 GHz

Based on the comments from the National Committees on CIS/B/662/DC, CIS/B/WG1 decided on its meeting in Hangzhou 2016 to amend the test procedure for group 2 equipment in the frequency range 1 to 18 GHz for the following reasons:

a) CISPR 11 allows final measurements on group 2 equipment operating at frequencies above 400 MHz with two different weighting functions, the traditional “LogAV detector” with a video bandwidth of 10 Hz and the new APD method, where the Amplitude Probability Distribution is evaluated.

With the alignment of emission requirements for sources of fluctuating emissions with those generating CW-type emissions (Fraction 4 of the last general maintenance of CISPR 11) for most of the frequency range 1 to 18 GHz the peak detector is used mostly for preliminary measurements, while the number of final measurements with the LogAV detector has been increased from 2 frequencies to max. 7 frequencies.

In parallel, with fraction 3, the APD detector has been introduced, but only with the traditional 2 final frequencies (one in the range 1 GHz to 2.4 GHz and one in the range 2,5 GHz to 18 GHz).

The number of final frequencies to be measured should be aligned for both weighting functions.

b) During practical measurements cases have been observed, where the critical frequency changed between preliminary and final measurement by more than 5 MHz. The range of 10 MHz for weighted measurements (±5 MHz from highest peak emission) seems therefore not always to be sufficient.

An extension of this frequency range seems advisable and could increase the repeatability.

In the range 11,7 to 12,7 GHz, an EUT fails immediately if one peak exceeds the limit of 73 dB[µV/m]. Observations on a big number of different microwave ovens have shown that during the final measurement (at least 2 min) such peaks may occur very seldom, and with a very short duration, and an estimated overall duration of less than 1 % of the measuring time.

A state-of-the-art digital communication service should be able to tolerate such peaks. Meanwhile, in countries where broadcasting systems, which are already standardized and widely spread and is difficult to avoid disturbance by such peaks, are under operation, additional limits could be separately introduced as necessary.

c) The repeatability of the peak measurement on microwave ovens is poor. Moreover, the sheer height of the highest peak emission, without information on its duration and repetition rate, provides very limited information on the real disturbance potential.

Measurements with both of the weighting methods have a significantly better repeatability and should, by their physical nature, give a better judgement for the disturbing potential of the EUT on digital radio services.

d) The conditions for preliminary and final measurements became ambiguous in Edition 6.0 (CISPR 11:2015), particularly regarding the required test time. Furthermore, it has been found that, in some cases, a duration of 20 s for the preliminary peak measurement may not be enough. To further increase the repeatability, WG1 decided not to divide the peak measurements anymore into preliminary and final measurements, but to require a 2-minute max hold peak measurement at every azimuth.

CISPR SC/B WG1 agreed to present the following proposals to the National Committees:

1) Define the same 7 final frequency ranges for the APD method as already defined for the LogAV method (detector).
2) Extend the frequency range for the final weighted measurement to 20 MHz.

For the APD method this would mean to measure on 5 final frequencies, the critical frequency itself, +/− 5 MHz and +/− 10 MHz.

For the LogAV detector, the requirement remains to perform for the final measurements at least 5 consecutive sweeps in max hold mode. The test time increases accordingly, and coverage of the fluctuations is the same as before.

3) Change the peak limit in Table 13 to a constant value of 70 dB[µV/m] throughout the frequency range and replace the requirement of a final peak measurement in the range 11,7 GHz to 12,7 GHz by a requirement of an additional weighted measurement at the frequency of the highest peak emission in this range. This may lead to a maximum of 8 final weighted measurements.
4) Discard the distinction between preliminary and final peak measurements and make instead the peak measurements on all azimuths for 2 minutes.

INDUSTRIAL, SCIENTIFIC AND MEDICAL EQUIPMENT – RADIO-FREQUENCY DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

1 Scope

This document applies to industrial, scientific and medical electrical equipment operating in the frequency range 0 Hz to 400 GHz and to domestic and similar appliances designed to generate and/or use locally radio-frequency energy.

This document covers emission requirements related to radio-frequency (RF) disturbances in the frequency range of 9 kHz to 400 GHz. ~~Measurements need only be performed in frequency ranges where limits are specified in Clause 6.~~

For ISM RF applications in the meaning of the definition found in the ITU Radio Regulations (2020) (see Definition 3.1.18), this document covers emission requirements related to radio-frequency disturbances in the frequency range of 9 kHz to 18 GHz.

ISM equipment which incorporates radio transmit/receive functions (host equipment with radio functionality) is included in the scope of this document, see Annex F. However, the emission requirements in this document are not intended to be applicable to the intentional transmissions from a radio transmitter as defined by the ITU including their spurious emissions. **1**

NOTE 1 This exclusion only applies to emissions from the intentional radio transmitter. However, combination emissions, for example emissions resulting from intermodulation between the radio and the non-radio subassemblies of the ISM equipment, are not subject to this exclusion.

NOTE 2 Emission requirements for induction cooking appliances are specified in CISPR 14-1 [1][1].

Requirements for ISM RF lighting equipment and UV irradiators operating at frequencies within the ISM frequency bands defined by the ITU Radio Regulations are contained in this document.

Robots used for industrial, scientific and medical applications are in the scope of this document. **2**

EXAMPLE Welding robots, spraying robots, handling robots, processing robots, assembly robots, medical robots, education and experimental robots. A comprehensive list of robots in the scope of this document is given on the IEC EMC zone.

NOTE 3 Flying robots, domestic helper robots, toy robots and entertainment robots are examples of robots in the scope of other CISPR standards.

Equipment covered by other CISPR product and product family emission standards are excluded from the scope of 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.

CISPR 16-1-1:~~2010~~2019, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus –*

1 Figures in square brackets refer to the Bibliography.

Measuring apparatus
~~CISPR 16-1-1:2010/AMD 1:2010~~
~~CISPR 16-1-1:2010/AMD 2:2014~~

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

CISPR 16-1-4:~~2010~~2019, *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~~2019/AMD1:2020
CISPR 16-1-4:2019/AMD2:2023

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:~~2010~~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 16-2-3:~~2010/AMD1:2010~~2016/AMD1:2019
CISPR 16-2-3:~~2010/AMD2:2014~~2016/AMD2:2023

CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measuring instrumentation uncertainty*
CISPR 16-4-2:2011/AMD1:2014
CISPR 16-4-2:2011/AMD2:2018

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission requirements*
CISPR 32:2015/AMD1:2019

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility*

~~IEC 60601-1-2:2014, *Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral standard: Electromagnetic disturbances – Requirements and tests*~~

IEC 60601-2-2:~~2009~~2017, *Medical electrical equipment – Part 2-2: Particular requirements for the basic safety and essential performance of high frequency surgical equipment and high frequency surgical accessories*

~~IEC 60974-10:2014, *Arc welding equipment – Part 10: Electromagnetic compatibility (EMC) requirements*~~

IEC 61000-4-6:2023, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61307:2011 [2], *Industrial microwave heating installations – Test methods for the determination of power output*

~~IEC 62135-2:2007, *Resistance welding equipment – Part 2: Electromagnetic compatibility (EMC) requirements*~~

ITU Radio Regulations (~~2012~~2020), *Radio regulations* (available at http://www.itu.int/en/myitu/Publications/2020/09/02/14/23/Radio-Regulations-2020)

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 terminology databases for use in standardization at the following addresses:

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

3.1.1
AC mains power port
port used to connect to a public low voltage AC mains power distribution network or other low voltage AC mains installation

3.1.2
associated equipment
AE
apparatus that is not part of the system under test, but needed to help exercise the EUT

[SOURCE: CISPR 16-2-3:2016, 3.1.5]

3.1.3
arc welding equipment
equipment for applying current and voltage and having the required characteristics suitable for arc welding and allied processes

3.1.4
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 this network, the V-network (V-AMN) which couples the unsymmetrical voltages, and the Delta-network, which couples the symmetric (DM) and the asymmetric (CM) voltages separately.

Note 2 to entry: The terms line impedance stabilization network (LISN) and V-AMN are used interchangeably.

[SOURCE: CISPR 16-1-2:2014/AMD1:2017, 3.1.6, modified – added Note 2]

[2] This publication was withdrawn.

3.1.5
boundary of the equipment under test
imaginary straight line periphery describing a simple geometric configuration encompassing the equipment under test

Note 1 to entry: All interconnecting cables are included within this boundary.

3.1.6
component
product which serves a specific function or functions and which is intended for use in a higher order assembled equipment or system

3.1.7
DC artificial network
artificial DC network
DC-AN
artificial network that provides defined termination to the EUT's DC power port under test while also providing the necessary decoupling from conducted disturbances originating from the laboratory DC power source or from the load

3.1.8
DC power port
port used to connect to a low voltage DC power generating system or energy storage, or to another source/load

Note 1 to entry: Such a system ~~may~~ can be for example a photovoltaic or a fuel cell power generating system, or also a battery.

3.1.9
electro-discharge machining ~~(EDM)~~ equipment
EDM equipment
all the necessary units for the spark erosion process including the machine tool, the generator, control circuits, the working fluid container and integral devices

3.1.10
electromagnetic radiation
~~1)~~ phenomenon by which energy in the form of electromagnetic waves emanates from a source into space

~~2) energy transferred through space in the form of electromagnetic waves~~

Note 1 to entry: By extension, the term "electromagnetic radiation" sometimes also covers induction phenomena.

[SOURCE: IEC 60050-161:1990, 161-01-10]

3.1.11
equipment for resistance welding and allied processes
all equipment associated with carrying out the processes of resistance welding or allied processes

Note 1 to entry: Such equipment consists of e.g. power source, electrodes, tooling and associated control equipment, which ~~may~~ can be a separate unit or part of a complex machine.

3.1.12
equipment with radio functionality 3
non-radio equipment (host equipment) including one or more radio devices or radio modules that can use host control function(s) and/or power supply

Note 1 to entry: The use of the included radio equipment can be for remote control (of the host equipment by an external equipment or vice versa) or for data exchange with external equipment.

Note 2 to entry: A radio device or radio module can be plugged-in, built-in or external.

3.1.13
fully-anechoic room
FAR
shielded enclosure, the internal surfaces of which are lined with radio-frequency-energy absorbing material (i.e. RF absorber) that absorbs electromagnetic energy in the frequency range of interest

3.1.14
fundamental frequency
fundamental ISM frequency
frequency on which the ISM equipment operates

Note 1 to entry: Electromagnetic RF energy at the fundamental frequency (of an ISM equipment) can be used in, or transmitted by, or received by the equipment. This energy can be generated in the equipment but used outside the equipment (e.g. X-ray diagnostic equipment), or generated outside and used in the equipment or generated and used in the equipment (e.g. switching mode power supply, RF sterilizer, microwave oven).

Note 2 to entry: Some ISM equipment categories do not have a fundamental ISM frequency. Examples: spectrum analyser, frequency counter.

3.1.15
grid connected power converter
GCPC
power converter connected to an AC mains power distribution network or other AC mains installation and used in a power generating system

3.1.16
high power electronic systems and equipment
one or more semiconductor power converters with a combined rated power greater than 75 kVA, or an equipment containing such converters

Note 1 to entry: Examples of such high power electronic equipment are semiconductor power converters for application in UPS (Uninterruptible Power Systems) and PDS (Power Drive Systems).

3.1.17
highest internal frequency
F_x
highest fundamental frequency generated or used within the EUT or highest frequency at which it operates

Note 1 to entry: This includes frequencies which are solely used within an integrated circuit.

3.1.18
industrial, scientific and medical applications
ISM applications
<of radio frequency energy> operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications

Note 1 to entry: Typical applications are the production of physical, biological, or chemical effects such as heating, ionisation of gases, mechanical vibrations, hair removal, acceleration of charged particles. A non-exhaustive list of examples is given in Annex A.

[SOURCE: ITU Radio Regulations Volume 1:~~2012~~2020 – Chapter I, Definition 1.15, modified – added Note 1.]

3.1.19
ISM RF equipment and appliances
equipment or appliances designed to generate and/or use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field

of telecommunications and information technology and other applications covered by other CISPR publications

Note 1 to entry: The abbreviation “ISM RF” is used throughout this document for such equipment or appliances only.

3.1.20
industrial robot 4
automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or fixed to a mobile platform for use in automation applications in an industrial environment

Note 1 to entry: The industrial robot includes:

- the manipulator, including robot actuators controlled by the robot controller;
- the robot controller;
- the means by which to teach and/or program the robot, including any communications interface (hardware and software).

Note 2 to entry: Industrial robots include any auxiliary axes that are integrated into the kinematic solution.

Note 3 to entry: Industrial robots include the manipulating portion(s) of mobile robots, where a mobile robot consists of a mobile platform with an integrated manipulator or robot.

[SOURCE:ISO 8373:2021[2], 3.6]

3.1.21
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".]

3.1.22
medical robot
robot intended to be used as medical electrical equipment or medical electrical system

[SOURCE: IEC TR 60601-4-1:2017[3], 3.20]

3.1.23
open-area test site
OATS
facility used for measurements of electromagnetic fields the intention for which is to simulate a semi-free-space environment over a specified frequency range that is used for radiated emission testing of products

Note 1 to entry: An OATS typically is located outdoors in an open area and has an electrically-conducting ground plane.

3.1.24
photovoltaic power generating system
electric power generating system which uses the photovoltaic effect to convert solar power into electricity

3.1.25
power conversion equipment
electrical device converting one form of electrical power to another form of electrical power with respect to voltage, current, frequency, phase and the number of phases

[SOURCE: IEC 62920:2017/AMD1:2021[4], 3.2]

3.1.26
radio device
assembly consisting of one or more radio transmitters and/or receivers, capable to function on a stand-alone basis with or without additional accessories

Note 1 to entry: These accessories can be incorporated in the assembly or connected to it from outside. Examples of accessories are: external antenna, remote control, headsets, power supply, display, etc.

3.1.27
radio module
assembly consisting of one or more radio transmitters and/or receivers, intended to be incorporated in a host equipment

Note 1 to entry: A radio module can incorporate a power supply or any other accessories.

Note 2 to entry: A radio module can be plugged-in, built-in or external.

3.1.28
radio transmitter
device producing radio-frequency energy intended to be radiated by an antenna for the purpose of radiocommunication or radiodetermination

[SOURCE: IEC 60050-713:1998[5], 713-08-01 – modified – “apparatus” replaced with “device”, deletion of “normally”, addition of “or radiodetermination”.]

3.1.29
rated load
<for robots> maximum load that can be applied to the mechanical interface or mobile platform in normal operating conditions without degradation of any performance specification

Note 1 to entry: The rated load includes the inertial effects of the end effector, accessories and workpiece, where applicable.

[SOURCE: ISO 8373:2021[2], 7.2.1]

3.1.30
robot
programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation or positioning

Note 1 to entry: A robot includes the control system.

Note 2 to entry: Examples of mechanical structure of robots are manipulator, mobile platform and wearable robots.

[SOURCE: ISO 8373:2021[2], 3.1]

3.1.31
semi-anechoic chamber
SAC
shielded enclosure, in which five of the six internal surfaces are lined with radio-frequency energy absorbing material (i.e. RF absorber) that absorbs electromagnetic energy in the frequency range of interest, and the bottom horizontal surface is a conducting ground plane for use with OATS test set-ups

3.1.32
~~**small size equipment**~~
small equipment under test
small EUT
equipment under test, either positioned on a table top or standing on the floor, which, including its cables, fit~~s~~ in a~~n imaginary~~ cylindrical~~ test~~ volume of~~ 1,2~~ 1,5 m~~ in~~ diameter and 1,5 m height (~~to ground plane~~ as measured from the floor)

Note 1 to entry: At an OATS or in a SAC, the radiated emission measurement distance of 3 m is applicable only to small EUTs

[SOURCE: CISPR 16-2-3:2016 and CISPR 16-2-3:2016/AMD1:2019, 3.1.35, modified – The definition was reworded and a Note to entry was added]

3.1.33
spark erosion
removal of material in a dielectric working fluid by electro-discharges, which are separated in time and randomly distributed in space, between two electrically conductive electrodes (the tool electrode and the work piece electrode), and where the energy in the discharge is controlled

~~**3.19**~~
~~**type test**~~
~~test of one or more devices made to a certain design to show that the design meets certain specifications~~

~~Note 1 to entry: Recognition of a type test as type approval may depend on national or regional regulation, see H.2 in Annex H.~~

3.1.34
wired network port 5
port for the connection of a communication device/system intended to be interconnected to widely dispersed systems by direct connection to a single-user or multi-user network

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

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

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 1284.1 [6] (parallel printer), Universal Serial Bus (USB), IEEE Standard 1394[7] (“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 many product standards, this port was defined as a telecommunications or network port.

[SOURCE: IEC 61000-6-3:2020[8], 3.1.3, modified — In the definition, addition of “device/system”. Deletion of Note 1 to entry. Addition of Notes 2, 3 and 4 to entry.]

3.2 Abbreviated terms

AGV	Automated guided vehicle
AMN	Artificial mains network
AN	Artificial network
APD	Amplitude probability distribution
CATV	Cable television
CDN	Coupling-decoupling network
CM	Common mode
CMAD	Common mode absorption device
CVCF	Constant voltage constant frequency
DM	Differential mode
EDM	Electro-discharge machining
EMC	Electromagnetic compatibility
EUT	Equipment under test
FAR	Fully anechoic room
FSOATS	Free space open area test site
GCPC	Grid connected power converter

ISDN Integrated services digital network
LAN Local area network
LV Low voltage
OATS Open area test site
PDS Power drive system
PSTN Public switched telephone network
RF Radio frequency
SAC Semi-anechoic chamber
UM Unsymmetrical mode
UPS Uninterruptible power supply
USB Universal serial bus
VCP Vertical coupling plane
xDSL All digital subscriber line technologies (e.g., ADSL, SDSL, etc.)

4 Frequencies designated for ISM use

Certain frequencies are designated by the International Telecommunication Union (ITU) for use as fundamental frequencies for ISM RF applications (see also Definition 3.1.18). These frequencies are listed in Table 1.

NOTE In individual countries different or additional frequencies can be designated for use by ISM RF applications.

Table 1 – Frequencies in the radio-frequency (RF) range designated by ITU for use as fundamental ISM frequencies

Centre frequency MHz	**Frequency range** MHz	**Maximum radiation limit** [a]	**Number of appropriate footnote to the table of frequency allocation of the ITU Radio Regulations** [b]
6,780	6,765 to 6,795	Under consideration	5.138
13,560	13,553 to 13,567	Unrestricted	5.150
27,120	26,957 to 27,283	Unrestricted	5.150
40,680	40,66 to 40,70	Unrestricted	5.150
433,920	433,05 to 434,79	Under consideration	5.138 in Region 1, except countries mentioned in 5.280
915,000	902 to 928	Unrestricted	5.150 in Region 2 only
2 450	2 400 to 2 500	Unrestricted	5.150
5 800	5 725 to 5 875	Unrestricted	5.150
24 125	24 000 to 24 250	Unrestricted	5.150
61 250	61 000 to 61 500	Under consideration	5.138
122 500	122 000 to 123 000	Under consideration	5.138
245 000	244 000 to 246 000	Under consideration	5.138

[a] The term “unrestricted” applies to the fundamental and all other frequency components falling within the designated band. Outside of ITU designated ISM bands the limits for the disturbance voltage and radiation disturbance in this document apply.

[b] Resolution No. 63 of the ITU Radio Regulations applies (see Radio Regulations (2020), Volume 3).

5 Classification of equipment

5.1 Separation into groups

In order to simplify identification of the relevant limits, the equipment in the scope of this document is categorized into two groups, i.e. into group 1 and group 2.

Group 1 equipment: group 1 contains all equipment in the scope of this document which is not classified as group 2 equipment.

Group 2 equipment: group 2 contains all ISM RF equipment in which radio-frequency energy in the frequency range 9 kHz to 400 GHz is intentionally generated and used or only used locally, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material, for inspection/analysis purposes, or for transfer of electromagnetic energy.

NOTE See Annex A for examples of the separation of equipment into group 1 or 2.

5.2 Division into classes

In accordance with the intended use of equipment in the electromagnetic environment, this document defines two classes of equipment, namely class A and class B.

Class A equipment is the equipment suitable for use in all locations other than those allocated in residential environments and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class A equipment shall meet class A limits.

An arc welding equipment which contains arc striking or stabilizing devices and stand-alone arc striking or stabilizing devices for arc welding shall be classified as class A equipment.

Class B equipment is the equipment suitable for use in locations in residential environments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class B equipment shall meet class B limits.

5.3 Documentation for the user

The manufacturer and/or supplier of equipment shall ensure that the user is informed about the class and group of the equipment, either by labelling or by the accompanying documentation. In both cases the manufacturer/supplier shall explain the meaning of both the class and the group in the documentation accompanying the equipment.

The documentation accompanying the equipment shall contain details of any precautions to be observed by the purchaser or user to ensure that regular operation and use of the equipment in the field does not cause harmful radio frequency interference (RFI). In the framework of this document, these details concern information about:

- the possibility of radio frequency interference originating from operation of class A equipment in certain environments,
- special precautions to be observed when connecting class A equipment to a low voltage power supply network, see Footnotes to table b and c in Table 2, Footnote to table b in Table 3 and Footnote to table c in Table 8, respectively,
- measures which can be taken at installation level to reduce emissions from installed class A equipment, see Footnote to table c in Table 2 and Footnote to table a in Table 12.

For class A equipment, the instructions for use accompanying the product shall contain the following text:

Caution: This equipment is not intended for use in residential environments and ~~may~~ might not provide adequate protection to radio reception in such environments.

6 Limits of electromagnetic disturbances

6.1 General

For measurements at standardized test sites, the requirements specified hereafter constitute the requirements for ~~type~~ tests.

Class A equipment may be measured either on a test site or *in situ* as preferred by the manufacturer.

NOTE 1 Due to size, complexity or operating conditions some equipment ~~may have to~~ can be measured in situ in order to show compliance with the radiation disturbance limits specified herein.

Class B equipment shall be measured on a test site.

NOTE 2 The limits have been determined on a probabilistic basis taking into account the likelihood of interference. In cases of interference, additional provisions ~~may have to be applied~~ can apply.

The lower limit shall apply at all transition frequencies.

Measuring apparatus and methods of measurement are specified in Clause 7, Clause 8 and Clause 9.

Where this document gives options for testing particular requirements with a choice of test methods, compliance ~~can~~ may be shown against any of the test methods, using the specified limits with the restrictions provided in the relevant tables. In any situation where it is necessary to retest the equipment, the test method originally chosen should be used in order to ensure consistency of the results.

For equipment with radio functionality, the additional requirements of Annex F shall apply. 6

6.2 Group 1 equipment measured on a test site

6.2.1 Limits for conducted disturbances

6.2.1.1 General

The equipment under test shall meet either:

a) both the average limit specified for measurements with an average detector and the quasi-peak limit specified for measurements with a quasi-peak detector (see 7.3); or

b) the average limit when using a quasi-peak detector (see 7.3).

The limits for the LV DC power ports specified hereafter apply only to the following types of equipment:

1) power conversion equipment intended for assembly into photovoltaic power generating systems;
2) grid connected power convertors (GCPCs) intended for assembly into energy storage systems.

6.2.1.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz limits are not specified.

6.2.1.3 Frequency range 150 kHz to 30 MHz

Limits for the disturbance voltage at low voltage AC mains power ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site using the 50 Ω/50 μH CISPR artificial mains network (V-AMN) or the CISPR voltage probe (see 7.3.3 and Figure 1) are given in Table 2 and Table 4.

Limits for conducted disturbances at low voltage DC power ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site using the 150 Ω CISPR network (DC-AN) (see 7.3.2.3) and ~~Annex I)~~ /or the current probe (see CISPR 16-1-2) are given in Table 3 and Table 5.

Limits for conducted disturbances at wired network ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site are given in Table 7. 7

For measurements at LV DC power ports, the applicability criteria in accordance with Table 6 apply.

Table 2 – Disturbance voltage limits for class A group 1 equipment measured on a test site (AC mains power port)

Frequency range MHz	Rated power of ≤ 20 kVA [a]		Rated power of > 20 kVA and ≤ 75 kVA [b, a]		High power electronic systems and equipment, Rated power of > 75 kVA [c, a]	
	Quasi-peak dB(μV)	Average dB(μV)	Quasi-peak dB(μV)	Average dB(μV)	Quasi-peak dB(μV)	Average dB(μV)
0,15 to 0,50	79	66	100	90	130	120
0,50 to 5	73	60	86	76	125	115
5 to 30	73	60	90 decreasing linearly with logarithm of frequency to 73	80 decreasing linearly with logarithm of frequency to 60	115	105

At the transition frequency, the more stringent limit shall apply.

For class A equipment intended to be connected solely to isolated neutral or high impedance earthed (IT) industrial power distribution networks (see IEC 60364-1[9]) the limits for equipment with a rated power > 75 kVA ~~may~~ can be applied, regardless of its actual rated power.

NOTE A rated input or output power of 20 kVA corresponds for example to a current of approximately 29 A per phase in case of 400 V three-phase power supply networks and to a current of approximately 58 A per phase in case of 200 V three phase power supply networks.

[a] The selection of the appropriate set of limits shall be based on the rated AC power stated by the product documentation.

[b] These limits apply to equipment with a rated power > 20 kVA and intended to be connected to a dedicated power transformer or generator and which is not connected to low voltage (LV) overhead power lines. For equipment not intended to be connected to a user specific power transformer the limits for ≤ 20 kVA apply. ~~The manufacturer, and/or supplier shall provide information~~ Information shall be provided on installation measures that can be used to reduce emissions from the installed equipment. In particular, it shall be indicated that this equipment is intended to be connected to a dedicated power transformer or generator and not to LV overhead power lines.

[c] These limits apply only to high power electronic systems and equipment with a rated power greater than 75 kVA when intended to be installed as follows:

– installation is supplied from a dedicated power transformer or generator, which is not connected to Low Voltage (LV) overhead power lines,

– installation is physically separated from residential environments by distance greater than 30 m or by a structure which acts as a barrier to radiated phenomena,

– the ~~manufacturer and/or supplier~~ product documentation shall indicate that this equipment meets the disturbance voltage limits for high power electronic systems and equipment of rated input power >75 kVA and provide information on installation measures to be applied by the installer. In particular, it shall be indicated that this equipment is intended to be used in an installation which is powered by a dedicated power transformer or generator and not by LV overhead power lines.

Table 3 – Limits for conducted disturbances of class A group 1 equipment measured on a test site (DC power port)

Frequency range MHz	Rated power of ≤ 20 kVA [a]		Rated power of > 20 kVA to ≤ 75 kVA [a, b, c]				Rated power of > 75 kVA [a, b, c]			
	Voltage limits		Voltage limits		Current limits		Voltage limits		Current limits	
	QP dB(μV)	AV dB(μV)	QP dB(μV)	AV dB(μV)	QP dB(μA)	AV dB(μA)	QP dB(μV)	AV dB(μV)	QP dB(μA)	AV dB(μA)
0,15 to 5	97 to 89	84 to 76	116 to 106	106 to 96	72 to 62	62 to 52	132 to 122	122 to 112	88 to 78	78 to 68
5 to 30	89	76	106 to 89	96 to 76	62 to 45	52 to 32	122 to 105	112 to 92	78 to 61	68 to 48

In certain frequency ranges, the limits in this table decrease linearly with logarithm of frequency.

[a] The selection of the appropriate set of limits shall be based on the rated AC power stated by the ~~manufacturer~~ product documentation.

[b] These limits apply to equipment with a rated power > 20 kVA and intended to be installed in a large photovoltaic power generating system by a professional. In the manual accompanying the product, ~~the manufacturer, and/or supplier shall provide~~ information shall be provided on mitigation measures that can be used to reduce emissions from the installed equipment, with the goal of preventing harmful interference to radio reception in a distance of 30 m from the installation. In particular it shall be indicated that this equipment can be equipped with additional filtering and that installation is physically separated from residential environments by distance greater than 30 m. The installer is invited to check the mitigated installation against CISPR 11 *in situ* measurements as indicated in 6.4.

[c] Either the voltage limits or the current limits apply.

Table 4 – Disturbance voltage limits for class B group 1 equipment measured on a test site (AC mains power port)

Frequency range MHz	Quasi-peak dB(μV)	Average dB(μV)
0,15 to 0,50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0,50 to 5	56	46
5 to 30	60	50

At the transition frequency, the more stringent limit shall apply.

For diagnostic X-ray generators operating in intermittent mode the quasi-peak limits of Table 2 or Table 4 can be relaxed by 20 dB.

Table 5 – Disturbance voltage limits for class B group 1 equipment measured on a test site (DC power port)

Frequency range MHz	Quasi-peak dB(μV)	Average dB(μV)
0,15 to 0,50	84 Decreasing linearly with logarithm of frequency to 74	74 Decreasing linearly with logarithm of frequency to 64
0,50 to 30	74	64

~~For measurements at LV d.c. power ports, the applicability criteria in accordance with Table 19 apply.~~

Table 6 – Applicability of measurements at DC power ports

Cable length L	Class B group 1 equipment	Class A group 1 equipment
L < 3 m	No measurements are required	No measurement are required
3 m ≤ L < 30 m	For measurements, the limits in Table 5 apply The frequency range for measurement starts at a frequency equal to: f(MHz) = 60/L	For measurements, the limits in Table 3 apply [a] The frequency range for measurement starts at a frequency equal to: f(MHz) = 60/L
L ≥ 30 m	For measurements, the limits in Table 5 apply	For measurements, the limits in Table 3 apply [a]

L: maximum length of a cable (in metres) connected to an LV DC power port, and provided with the product or as specified ~~by manufacturer~~ in the product documentation. Where no maximum cable length is specified, L shall be considered as longer than 30 m.

This table applies unless specific conditions are given in the applicable product standard leading at least to the same level of protection of radio reception. Product standards ~~may~~ can define specific conditions according to their particular application with the purpose of avoiding radiation.

[a] No limits apply if the equipment is installed using good engineering practice regarding EMC.

Examples of good engineering practice are:

– symmetrical DC port line configuration,
– installation internal to the building,
– grounded metallic cable trays,
– use of shielded cables,
– manage a separation distance that acts as a barrier from residential environment (e.g. greater than 30 m).

If exception [a] is used, the installer ~~may~~ can refer to CISPR 11 for *in situ* measurement.

Table 7 – Limits for conducted disturbances measured on a test site (wired network port)

Frequency range MHz	Class A				Class B			
	Voltage		Current		Voltage		Current	
	QP	AV	QP	AV	QP	AV	QP	AV
	dB(µV)	dB(µV)	dB(µA)	dB(µA)	dB(µV)	dB(µV)	dB(µA)	dB(µA)
0,15 to 0,5	97 to 87	84 to 74	53 to 43	40 to 30	84 to 74	74 to 64	40 to 30	30 to 20
0,5 to 30	87	74	43	30	74	64	30	20

In the frequency range from 0,15 MHz to 0,5 MHz, the limits in this table decrease linearly with the logarithm of frequency.

Excluding measurement uncertainty, all other elements within CISPR 32 shall be applied, including but not limited to the selection of measurement procedures, test configuration, cable characteristics and ancillary equipment (current probe, capacitive voltage probe and/or artificial network).

NOTE 1 The voltage and current disturbance limits are based on a common mode impedance of 150 Ω for the wired network port under test.

NOTE 2 The application of the voltage and/or current disturbance limits is dependent on the port type and on the measurement procedure used; see Table C.1 of CISPR 32:2015/AMD1:2019.

6.2.2 Limits of electromagnetic radiation disturbance

6.2.2.1 General

The equipment under test shall meet the quasi-peak limits when using a quasi-peak detector.

6.2.2.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz, limits are not specified.

6.2.2.3 Frequency range 150 kHz to 1 GHz

In the frequency range 150 kHz to 30 MHz, limits are not specified.

In the frequency range above 30 MHz, the limits refer to the electric field strength component of the electromagnetic radiation disturbance.

The electromagnetic radiation disturbance limits for the frequency range 30 MHz to 1 GHz for group 1, classes A and B equipment are specified in Table 8 and Table 9, respectively. Recommendations for the protection of specific safety-related radio services are given in Annex C and Table C.1.

On an open-area test site (OATS) or in a semi-anechoic chamber (SAC), class A equipment can be measured at a nominal distance of 3 m, 10 m or 30 m (see information in Table 8), and class B equipment at a nominal distance of 3 m or 10 m (see information in Table 9). A measuring distance less than 10 m is allowed only for equipment that complies with the definition for ~~*small size equipment* given in 3.17~~ *small EUT* (see 3.1.32).

In a fully-anechoic room (FAR) class A or class B equipment can be measured at a nominal distance of 3 m (see information in Table 8 and Table 9), provided that the EUT fits into the validated test volume of the given FAR. In conjunction with measurements according to this document, the use of the FAR is restricted to table-top equipment.

Table 8 – Electromagnetic radiation disturbance limits for class A group 1 equipment measured on a test site

Frequency range MHz	OATS or SAC				FAR	
	10 m measuring distance rated power of		3 m measuring distance [a] rated power of		3 m measuring distance [a, b] rated power of	
	≤ 20 kVA [c]	> 20 kVA ~~[a]~~ [c, d]	≤ 20 kVA [c]	> 20 kVA ~~[a]~~ [c, d]	≤ 20 kVA [c]	> 20 kVA ~~[a]~~ [c, d]
	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)
30 to 230	40	50	50	60	52 decreasing linearly with logarithm of frequency to 45	62 decreasing linearly with logarithm of frequency to 55
230 to 1 000	47	50	57	60	52	55

On an OATS or in a SAC, class A equipment can be measured at a nominal distance of 3 m, 10 m or 30 m. In case of measurements at a separation distance of 30 m, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance.

At the transition frequency, the more stringent limit shall apply.

In the frequency range 30 MHz to 230 MHz, the limit for measurements in the FAR decreases linearly with the logarithm of frequency.

[a] The 3 m separation distance applies only to ~~small size equipment meeting the size criterion defined in 3.17~~ *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR.

[c] The selection of the appropriate set of limits shall be based on the rated AC power stated ~~by the manufacturer~~ in the product documentation.

[d] These limits apply to equipment with a rated power of > 20 kVA and intended to be used at locations where there is a distance greater than 30 m between the equipment and third party sensitive radio communications. ~~The manufacturer shall indicate~~ It shall be indicated in the technical documentation that this equipment is intended to be used at locations where the separation distance to third party sensitive radio services is > 30 m. If these conditions are not met, then the limits for ≤ 20 kVA apply.

Table 9 – Electromagnetic radiation disturbance limits for class B group 1 equipment measured on a test site

Frequency range MHz	OATS or SAC		FAR
	10 m measuring distance	3 m measuring distance [a]	3 m measuring distance [a, b]
	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)
30 to 230	30	40	42 Decreasing linearly with logarithm of frequency to 35
230 to 1 000	37	47	42

On an OATS or in a SAC, class B equipment ~~can~~ may be measured at a nominal distance of 3 m or 10 m.

At the transition frequency, the more stringent limit shall apply.

a	The 3 m separation distance applies only to ~~*small size equipment* meeting the size criterion defined in 3.17~~ *small EUT* (see 3.1.32).
b	The table-top equipment shall fit into the validated test volume of the FAR.

For medical electrical equipment intended to be permanently installed in shielded locations, further provisions with regard to the measurement arrangement and load conditions are found in IEC 60601-1-2 [10].

6.2.2.4 Frequency range 1 GHz to 18 GHz

The equipment shall meet the electromagnetic radiation disturbance limits specified in Table 11 up to the maximum measurement frequency determined in accordance with Table 10. If the highest internal frequency F_x is not known, measurements shall be performed up to 6 GHz. The equipment shall meet both the peak and the average limits. If the measurements using peak detector pass the average limit, there is no need to apply the average detector. 8

In the frequency range ~~1~~ 6 GHz to 18 GHz limits are not specified.

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. Only the average limits shall apply to disturbances from arcs and sparks, while both the peak and average limits shall apply to all other disturbances from such devices.

Measurements may be performed at distances of 3 m or 10 m taking into account the EUT size criterion as specified in 3.1.32. When using the 10 m distance, the limits of Table 11 shall be modified as follows:

$$Limit\ (10\ m) = Limit\ (3\ m) - 20\ \log\ (10/3)$$

where both limits are expressed in dB(μV/m).

Table 10 – Required highest frequency for radiated measurements

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 × F_x up to a maximum of 6 GHz
NOTE F_x is defined in 3.1.17.	

Table 11 – Electromagnetic radiation disturbance limits for group 1 equipment measured on a test site

Frequency range GHz	Limits for a measurement distance of 3 m dB(µV/m)			
	Class A		Class B	
	Peak	Average	Peak	Average
1 to 3	76	56	70	50
3 to 6	80	60	74	54
At the transitional frequency, the more stringent limit shall apply.				

6.2.2.5 Frequency range 18 GHz to 400 GHz

In the frequency range 18 GHz to 400 GHz, limits are not specified.

6.3 Group 2 equipment measured on a test site

6.3.1 Limits for conducted disturbances

6.3.1.1 General

The equipment under test shall meet either:

a) both the average limit specified for measurements with an average detector and the quasi-peak limit specified for measurements with a quasi-peak detector (see 7.3); or

b) the average limit when using a quasi-peak detector (see 7.3).

6.3.1.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz, limits are not specified.

6.3.1.3 Frequency range 150 kHz to 30 MHz

Limits for the disturbance voltage at low voltage AC mains power ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site using the 50 Ω/50 µH CISPR artificial mains network (V-AMN) or the CISPR voltage probe (see 7.3.3 and Figure 1) are given in Table 12 and Table 13, except for the ITU designated frequency bands listed in Table 1 where no limits apply.

For electric welding equipment the limits of Table 12 or Table 13 apply in active mode of operation. In stand-by (or idle) mode, the limits of Table 2 or Table 4 apply.

For ISM RF lighting devices operating in dedicated ISM frequency bands (defined by the ITU in Table 1) the limits of Table 13 apply.

Limits for conducted disturbances at wired network ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site are given in Table 7.

Table 12 – Disturbance voltage limits for class A group 2 equipment measured on a test site (AC mains power port)

Frequency range MHz	Rated power of ≤ 75 kVA [a, b]		Rated power of > 75 kVA [a, ~~b~~c]	
	Quasi-peak dB(µV)	**Average** dB(µV)	**Quasi-peak** dB(µV)	**Average** dB(µV)
0,15 to 0,50	100	90	130	120
0,50 to 5	86	76	125	115
5 to 30	90 decreasing linearly with logarithm of frequency to 73	80 decreasing linearly with logarithm of frequency to 60	115	105
At the transition frequency, the more stringent limit shall apply.				

[a] Selection of the appropriate set of limits shall be based on the rated AC power stated in the product documentation.

[b] For class A equipment with a rated power ≤ 75 kVA intended to be connected solely to isolated neutral or high impedance earthed (IT) industrial power distribution networks (see IEC 60364-1[9]) the limits defined for group 2 equipment with a rated power > 75 kVA may be applied.

[c] ~~The manufacturer and/or supplier shall provide information~~ Information shall be provided on installation measures that can be used to reduce emissions from the installed equipment.

NOTE A rated input or output power of 75 kVA corresponds for example to a current of approximately 108 A per phase in case of 400 V three phase power supply networks and to a current of approximately 216 A per phase in case of 200 V three phase power supply networks.

High-frequency (HF) surgical equipment shall meet the limits of Table 2 or Table 4 specified for group 1 equipment in stand-by mode of operation. For high-frequency (HF) surgical equipment operating at frequencies outside designated ISM bands (see Table 1), these limits also apply at the operating frequency and inside the designated frequency bands. The related measurements shall be performed in a test arrangement in accordance with IEC 60601-2-2.

Table 13 – Disturbance voltage limits for class B group 2 equipment measured on a test site (AC mains power port)

Frequency range MHz	**Quasi-peak** dB(µV)	**Average** dB(µV)
0,15 to 0,50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0,50 to 5	56	46
5 to 30	60	50
At the transition frequency, the more stringent limit shall apply.		

6.3.2 Limits of electromagnetic radiation disturbance

6.3.2.1 General

The equipment under test shall meet the limits when using a measuring instrument with a peak, quasi-peak or average detector as indicated in the appropriate table.

Up to 30 MHz the limits refer to the magnetic component of the electromagnetic radiation disturbance. Above 30 MHz, the limits refer to the electric field strength component of the electromagnetic radiation disturbance.

6.3.2.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz, limits are not specified.

6.3.2.3 Frequency range 150 kHz to 1 GHz

Except for the designated frequency range listed in Table 1, the electromagnetic radiation disturbance limits for the frequency range 150 kHz to 1 GHz for group 2 class A equipment are specified in Table 14 and for group 2 class B equipment in Table 16.

The limits in Table 14 and Table 16 apply to all electromagnetic disturbances at all frequencies not exempted according to Table 1 footnote a.

For class A equipment for resistance welding, the limits of Table 14 apply in the frequency range 30 MHz to 1 GHz in active mode of operation. In stand-by (or idle) mode, the limits of Table 8 apply. For class B equipment for resistance welding, the limits of Table 16 apply in active mode of operation. In stand-by (or idle) mode, the limits of Table 9 apply.

For class A arc welding equipment, the limits of Table 15 apply in active mode of operation. In stand-by (or idle) mode, the limits of Table 8 apply. For class B arc welding equipment, the limits of Table 9 apply in active mode of operation and in stand-by (or idle) mode.

For class A EDM equipment the limits of Table 15 apply.

For ISM RF lighting devices operating in dedicated ISM frequency bands (in Table 1 as defined by the ITU) the limits of Table 16 apply.

For high-frequency (HF) surgical equipment, the limits of Table 8 or Table 9 apply. High-frequency (HF) surgical equipment shall meet the respective limits when tested in stand-by mode of operation.

Recommendations for the protection of specific safety services are given in Annex C and Table C.1.

On an open-area test site (OATS) or in a semi-anechoic chamber (SAC), class A equipment ~~can~~ may be measured at a nominal distance of 3 m, 10 m or 30 m, and class B equipment at a nominal distance of 3 m or 10 m (see Table 14 and Table 16).

In the frequency range 30 MHz to 1 GHz, a measuring distance of 3 m is allowed only for equipment which complies with the definition given in 3.1.32.

In a fully-anechoic room (FAR) class A or class B equipment ~~can~~ may be measured at a nominal distance of 3 m, provided that the EUT fits into the validated test volume of the given FAR. In conjunction with measurements according to this document, use of the FAR is restricted to table-top equipment.

For group 2 class A or class B equipment other than EDM or arc welding, measurements in the FAR in the range 30 MHz to 1 GHz shall be supplemented by measurement of the magnetic component of the disturbance field strength in the range 150 kHz to 30 MHz, at an OATS or in a SAC; see also footnote b in Table 14 and footnote c in Table 16.

Table 14 – Electromagnetic radiation disturbance limits for class A group 2 equipment measured on a test site

Frequency range MHz	OATS or SAC						FAR
	Limits for a measuring distance *D* in m						
	D = 30 m		*D* = 10 m		*D* = 3 m [a]		*D* = 3 m [a, b]
	Electric field **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** dB(µA/m)	**Electric field** **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** dB(µA/m)	**Electric field** **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** dB(µA/m)	**Electric field** **Quasi-peak** dB(µV/m)
0,15 to 0,49	–	33,5	–	57,5	–	82	–
0,49 to 1,705	–	23,5	–	47,5	–	72	–
1,705 to 2,194	–	28,5	–	52,5	–	77	–
2,194 to 3,95	–	23,5	–	43,5	–	68	–
3,95 to 11	–	8,5	–	18,5	–	68 ~~decreasing linearly with logarithm of frequency~~ to 28,5	–
11 to 20	–	8,5	–	18,5	–	28,5	–
20 to 30	–	–1,5	–	8,5	–	18,5	–
30 to 47	58	–	68	–	78	–	80 to 78
~~47 – 53,91~~	~~40~~	~~–~~	~~50~~	~~–~~	~~60~~	~~–~~	~~60~~
~~53,91 – 54,56~~	~~40~~	~~–~~	~~50~~	~~–~~	~~60~~	~~–~~	~~60~~
47 to 54,56	40	–	50	–	60	–	60
54,56 to 68	40	–	50	–	60	–	60 to 59
68 to 80,872	53	–	63	–	73	–	72
80,872 to 81,848	68	–	78	–	88	–	87
81,848 to 87	53	–	63	–	73	–	72 to 71
87 to 134,786	50	–	60	–	70	–	68 to 67
134,786 to 136,414	60	–	70	–	80	–	77
136,414 to 156	50	–	60	–	70	–	67 to 66
156 to 174	64	–	74	–	84	–	80
174 to 188,7	40	–	50	–	60	–	56
188,7 to 190,979	50	–	60	–	70	–	66
190,979 to 230	40	–	50	–	60	–	56 to 55
230 to 400	50	–	60	–	70	–	65
400 to 470	53	–	63	–	73	–	68
470 to 1 000	50	–	60	–	70	–	65

On an OATS or in a SAC, class A equipment ~~can~~ may be measured at a nominal distance of 3 m, 10 m or 30 m. A measuring distance less than 10 m is allowed only for equipment which complies with the definition given in 3.1.32.

At the transition frequency, the more stringent limit shall apply. In certain frequency ranges, the limit for magnetic field strength and for measurements in the FAR decreases linearly with the logarithm of frequency.

a	In the frequency range 30 MHz to 1 GHz, the 3 m ~~separation~~ measuring distance applies only to ~~*small size equipment* meeting the size criterion defined in 3.17~~ *small EUT* (see 3.1.32).
b	The table-top equipment shall fit into the validated test volume of the FAR. In the range below 30 MHz, such group 2 equipment shall be measured at an OATS or in a SAC (see limits in the respective magnetic field column in this table).

Table 15 – Electromagnetic radiation disturbance limits for class A EDM and arc welding equipment measured on a test site

Frequency range MHz	OATS or SAC		FAR
	10 m measuring distance	**3 m measuring distance [a]**	**3 m measuring distance [a, b]**
	Quasi-peak dB(µV/m)	**Quasi-peak** dB(µV/m)	**Quasi-peak** dB(µV/m)
30 to 230	80 Decreasing linearly with logarithm of frequency to 60	90 Decreasing linearly with logarithm of frequency to 70	102 Decreasing linearly with logarithm of frequency to 75
230 to 1 000	60	70	75

On an OATS or in a SAC, class A equipment ~~can~~ may be measured at a nominal distance of 3 m, 10 m or 30 m. In case of measurements at a separation distance of 30 m, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance.

[a] The 3 m separation distance applies only to ~~*small size equipment* meeting the size criterion defined in 3.17~~ *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR.

Table 16 – Electromagnetic radiation disturbance limits for class B group 2 equipment measured on a test site

Frequency range MHz	OATS or SAC					FAR	
	Limits for a measuring distance *D* in m						
	D = 10 m		*D* = 3 m [a]		*D* = 3 m	*D* = 3 m [b]	
	Electric field				Magnetic field	Electric field	
	Quasi-peak	Average [c]	Quasi-peak	Average [c]	Quasi-peak	Quasi-peak	Average [c]
	dB(μV/m)		dB(μV/m)		dB(μA/m)	dB(μV/m)	
0,15 to 30	–	–	–	–	39 ~~Decreasing linearly with the logarithm of frequency~~ to 3		
30 to 80,872	30	25	40	35	–	42 to 39	37 to 34
80,872 to 81,848	50	45	60	55	–	59	54
81,848 to 134,786	30	25	40	35	–	39 to 37	34 to 32
134,786 to 136,414	50	45	60	55	–	57	52
136,414 to 230	30	25	40	35	–	37 to 35	32 to 30
230 to 1 000	37	32	47	42	–	42	37

On an OATS or in a SAC, class B equipment ~~can~~ may be measured at a nominal distance of 3 m or 10 m.

At the transition frequency, the more stringent limit shall apply. In certain frequency ranges, the limit for magnetic field strength and for measurements in the FAR decrease linearly with the logarithm of frequency.

[a] In the frequency range 30 MHz to 1 GHz, the 3 m separation distance applies only to ~~*small size equipment* meeting the size criterion defined in 3.17~~ *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR. In the range below 30 MHz, such group 2 equipment shall be measured at an OATS or in a SAC (see limits in the respective magnetic field column in this table).

[c] The average limits apply to magnetron driven equipment and microwave ovens only. If magnetron driven equipment or microwave ovens exceed the quasi-peak limit at certain frequencies, then the measurement shall be repeated at these frequencies with the average detector and the average limits specified in this table apply.

6.3.2.4 Frequency range 1 GHz to 18 GHz

The limits in the frequency range 1 GHz to 18 GHz apply only to group 2 equipment operating at frequencies above 400 MHz. The limits specified in the Table 17 to Table 19 apply only to RF disturbances appearing outside designated ISM bands as listed in Table 1.

The electromagnetic radiation disturbance limits for the frequency range 1 GHz to 18 GHz are specified in Table 17 to Table 19. The equipment shall meet either the limits of Table 17, or at least the limits of Table 18 or Table 19 (see decision tree in 9.4.1, Figure 17).

ISM RF lighting devices operating in dedicated ISM frequency bands (in Table 1, as defined by the ITU) shall either meet the class B limits of Table 17 or at least the limits of Table 18.

For microwave-powered UV irradiators, the limits specified in Table 17 apply.

Recommendations for the protection of specific safety services are given in Annex C and Table C.1.

Table 17 – Electromagnetic radiation disturbance peak limits for group 2 equipment operating at frequencies above 400 MHz

Frequency range GHz	Limits for a measurement distance of 3 m Peak dB(μV/m)	
1 to 18	**Class A**	**Class B**
Within harmonic frequency bands	82 [a]	70
Outside harmonic frequency bands	70	70

Peak measurements with a resolution bandwidth of 1 MHz and a video signal bandwidth (VBW) higher than or equal to 1 MHz. The recommended VBW is 3 MHz.

NOTE In this table, "harmonic frequency bands" means the frequency bands which are multiples of the ISM bands allocated above 1 GHz.

[a] At the upper and lower edge frequencies of harmonic frequency bands, the more stringent limit of 70 dB(μV/m) applies.

Table 18 – Electromagnetic radiation disturbance weighted limits for group 2 equipment operating at frequencies above 400 MHz

Frequency range GHz	Limits for a measuring distance of 3 m weighted dB(μV/m)
1 to 2,4	60
2,5 to 5,725	60
5,875 to 18	60

Weighted measurements shall be performed with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz.

To check conformance with the limits of this table, weighted measurements shall be performed in all the following frequency ranges, in which the limit of Table 17 was exceeded during the peak measurement:

a) 1,0 GHz to 2,4 GHz [a];

b) 2,5 GHz to 6,125 GHz (outside the band 5,72 GHz to 5,88 GHz) [a];

c) 6,125 GHz to 8,575 GHz;

d) 8,575 GHz to 11,025 GHz;

e) 11,025 GHz to 13,475 GHz [b];

f) 13,475 GHz to 15,925 GHz;

g) 15,925 GHz to 18,0 GHz [a].

At subranges where the limit of Table 17 was exceeded, a weighted measurement shall be performed with a span of 20 MHz around the centre frequency adjusted to the frequency of the highest disturbance level in the respective subrange.

[a] In cases where the frequency of highest emission during peak measurement is found closer than 10 MHz from the frequency edges 1 GHz, 2,4 GHz, 2,5 GHz, 5,72 GHz, 5,88 GHz or 18 GHz, the span for weighted measurements shall remain 20 MHz, but in such a case, the centre frequency shall be adjusted so that the frequency edges are not exceeded.

[b] In any case, a final weighted measurement shall be performed at the frequency of the highest emission, which exceeds the limit of Table 17 in the frequency range 11,7 GHz to 12,7 GHz for satellite downlink. If the highest disturbance level in this subrange is outside of the range for satellite downlink, in this subrange two final measurements shall be performed.

~~NOTE See Annex B for further guidance on the use of the spectrum analyzer.~~

Table 19 – Electromagnetic radiation disturbance APD level corresponding to 10^{-1} limits for class B group 2 equipment operating at frequencies above 400 MHz

Frequency range GHz	**Limits for a measurement distance of 3 m** **APD level corresponding to 10^{-1}** dB(µV/m)
1 to 2,4	70
2,5 to 5,725	70
5,875 to 18	70

To check conformance with the limits of this table, APD measurements shall be performed in all the following frequency subranges, in which the limit of Table 17 was exceeded during the peak measurement:

a) 1,0 GHz to 2,4 GHz [a];

b) 2,5 GHz to 6,125 GHz (outside the band 5,72 GHz to 5,88 GHz) [a];

c) 6,125 GHz to 8,575 GHz;

d) 8,575 GHz to 11,025 GHz;

e) 11,025 GHz to 13,475 GHz [b];

f) 13,475 GHz to 15,925 GHz;

g) 15,925 GHz to 18,0 GHz [a].

Final APD measurements shall be performed at 5 frequencies as explained in 9.4.4.3.

[a] In cases where the frequency of highest emission during peak measurement is found closer than 10 MHz from the frequency edges 1 GHz, 2,4 GHz, 2,5 GHz, 5,72 GHz, 5,88 GHz or 18 GHz, final APD measurements shall be omitted at frequencies outside the corresponding bands~~, for which limits are defined~~ listed here.

[b] In any case, final APD measurements shall be performed around the frequency of the highest emission, which exceeds the limit of Table 17 in the frequency range 11,7 GHz to 12,7 GHz for satellite downlink. If the highest disturbance level in this subrange is outside of the range for satellite downlink, in this subrange two final measurements shall be performed.

NOTE An APD level corresponding to 10^{-1} means that the amplitude of the disturbance exceeds the specified level during the observation time with a probability of 10 %.

6.4 Group 1 and group 2 class A equipment measured in situ

6.4.1 Limits for conducted disturbances

Under *in situ* conditions, an assessment of conducted disturbances is not required.

6.4.2 Limits of electromagnetic radiation disturbance

The limits given in Table 20 apply to class A group 1 equipment and the limits given in Table 21 apply to class A group 2 equipment.

Table 20 – Electromagnetic radiation disturbance limits for class A group 1 equipment measured *in situ*

Frequency range MHz	**Limits with measuring distance 30 m from the outer face of the exterior wall of the building in which the equipment is situated**	
	Electric field **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** [a] dB(µA/m)
0,15 to 0,49	–	13,5
0,49 to 3,95	–	3,5
3,95 to 20	–	–11,5
20 to 30	–	–21,5
30 to 230	30	–
230 to 1 000	37	–

At the transition frequency, the more stringent limit shall apply.

If local conditions do not allow for measurements at 30 m, then a larger distance ~~can~~ may be used. In this case, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance.

[a] These limits apply in addition to the limits in the frequency range 30 MHz to 1 GHz to radiated disturbances originating from the operation frequency and its harmonics appearing in the frequency range 150 kHz to 30 MHz, caused by the installed class A group 1 equipment with a rated power exceeding 20 kVA. In the event that the ambient noise level exceeds the above limits, the emissions of the EUT shall not increase this noise floor by more than 3 dB.

Table 21 – Electromagnetic radiation disturbance limits for class A group 2 equipment measured *in situ*

Frequency range MHz	Limits for a measuring distance of D in m from the exterior wall of the building	
	Electric field **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** dB(µA/m)
0,15 to 0,49	–	23,5
0,49 to 1,705	–	13,5
1,705 to 2,194	–	18,5
2,194 to 3,95	–	13,5
3,95 to 20	–	–1,5
20 to 30	–	–11,5
30 to 47	48	–
~~47 – 53,91~~	~~30~~	~~–~~
~~53,91 – 54,56~~	~~30~~	~~–~~
~~54,56 – 68~~	~~30~~	~~–~~
47 to 68	30	–
68 to 80,872	43	–
80,872 to 81,848	58	–
81,848 to 87	43	–
87 to 134,786	40	–
134,786 to 136,414	50	–
136,414 to 156	40	–
156 to 174	54	–
174 to 188,7	30	–
188,7 to 190,979	40	–
190,979 to 230	30	–
230 to 400	40	–
400 to 470	43	–
470 to 1 000	40	–
At the transition frequency, the more stringent limit shall apply.		

For group 2 equipment measured *in situ*, the measuring distance D from the exterior wall of the building in which the equipment is situated equals $(30 + x/a)$ m or 100 m whichever is smaller, provided that the measuring distance D is within the boundary of the premises. In the case where the calculated distance D is beyond the boundary of the premises, the measuring distance D equals x or 30 m, whichever is longer.

For the calculation of the above values:

x is the ~~nearest~~ distance in m between the exterior wall of the building in which the equipment is situated and the boundary of the user's premises in each measuring direction;

a = 2,5 for frequencies lower than 1 MHz;

a = 4,5 for frequencies equal to or higher than 1 MHz.

7 Measurement requirements

7.1 General

The requirements specified in Clause 7, together with the limits specified in Clause 6, constitute the essential EMC requirements of this document. ~~For measurements at test sites (see Clause 8), verification of compliance of a given type of equipment with these essential EMC requirements qualifies as *type test*.~~

~~Requirements which relate to measurements at such test sites are type test requirements. A type test may be recognized as type approval if the conditions for the statistical assessment of measurement results according to Annex H are observed.~~ 9

~~Class A equipment may be measured either on a test site or *in situ* as determined by the manufacturer. Class B equipment shall be measured on a test site.~~

Specific requirements for making measurements on a test site are given in Clause 8 and Clause 9, for making measurements *in situ* in Clause 10.

The requirements of the present clause are to be met for both test site and~~/or~~ *in situ* measurements.

Measurements ~~need~~ shall only be performed in frequency ranges where limits are specified in Clause 6.

For equipment with radio functionality, the additional requirements of Annex F shall apply.

Components or subassemblies for higher order equipment or systems which are intended to be only assembled at their respective place of operation can also be tested according to the requirements of this document. For testing purposes in the framework of this document, such components or subassemblies shall be regarded as stand-alone equipment. Components or subassemblies for which compliance with the relevant requirements cannot be shown when measured at a test site can also be assessed *in situ* when being installed into the higher order system, in which case the provisions of 6.4 shall apply.

NOTE 1 The environments encompassed in this document are residential, commercial ~~or~~ and industrial environments as described in IEC 61000-2-5 [11]. Adherence of equipment to the requirements of this document will allow for its operation and use in these environments without resulting in an increased risk of RFI. There ~~may~~ can also exist other IEC product standards which allow for compliance testing of components or subassemblies of higher order systems but which encompass other environments than those specified in IEC 61000-2-5 [11]. Choice of this document or the other appropriate IEC product standard for compliance testing of components or subassemblies is up to the manufacturer.

NOTE 2 Examples for such components include, but are not limited to: power converters used for distributed generation and supply of electric energy into LV AC mains networks or installations or, by means of their own dedicated transformer, into MV power distribution networks, but also power electric subassemblies intended for supply of higher order systems with power from LV AC mains networks.

7.2 Ambient noise

A test site ~~for type testing~~ shall allow emissions from the equipment under test to be distinguished from ambient noise. The suitability in this respect can be determined by measuring the ambient noise levels with the equipment under test inoperative and ensuring that the ambient noise levels are at least 6 dB below the limits specified in 6.2 or 6.3, as appropriate for the measurement being carried out. Further information on compliance testing in the presence of ambient noise is found in CISPR 16-2-1:2014, 6.2.2 and CISPR 16-2-3:~~2010~~2016/AMD1:2019, 6.2.2.

It is not necessary to reduce the ambient noise level to 6 dB below the specified limit where the combination of the ambient noise plus the emission from the equipment under test does not exceed the specified limit. Under these conditions the equipment under test is considered to satisfy the specified limit.

When carrying out measurements of conducted RF disturbances, local radio transmissions ~~may~~ can increase the ambient noise level at some frequencies. A suitable radio-frequency filter may be inserted between the artificial network (V-AMN and/or DC-AN) and the respective laboratory AC mains supply or DC power source, or measurements may be performed in a shielded enclosure. The components forming the radio-frequency filter should be enclosed in a metallic screen directly connected to the reference ground of the measuring system. The requirements for the impedance of the artificial network shall be satisfied at the frequency of measurement when the radio-frequency filter is connected.

If, when measuring radiated RF disturbances, the 6 dB ambient noise conditions cannot be met, then the antenna may be located at a distance closer to the equipment under test than specified in Clause 6 (see 8.3.4). Further advice on measurement conditions in presence of high level ambient noise is found in Annex B.

7.3 Measuring equipment

7.3.1 Measuring instruments

Receivers with quasi-peak detectors shall be in accordance with CISPR 16-1-1. Receivers with average detectors shall be in accordance with CISPR 16-1-1.

NOTE 1 Both detectors can be incorporated in a single receiver and measurements carried out by alternately using the quasi-peak detector and the average detector.

NOTE 2 The average detector in CISPR 16-1-1 is commonly referred to as "CISPR-Average". This is to emphasize that the average detector used in a CISPR receiver obtains a measurement result that is equivalent to the peak reading of a meter with a time constant as defined in CISPR 16-1-1.

The measuring receiver used shall be operated in such a way that a variation in frequency of the disturbance being measured does not affect the results.

NOTE 3 Measuring instruments having other detector characteristics can be used provided the measurement of the disturbance values can be proved to be the same. Attention is drawn to the convenience of using a panoramic receiver or a spectrum analyzer, particularly if the working frequency of the equipment under test changes appreciably during the work cycle.

To avoid the possibility of the measuring instrument incorrectly indicating non-compliance with the limits, the measuring receiver shall not be tuned closer to the edge of one of the bands designated for ISM use than the frequency at which its 6 dB bandwidth point aligns with the edge of the designated band.

When making measurements on high power equipment, care should be taken to ensure that screening and the spurious response rejection characteristics of the measuring receiver are adequate.

For measurements at frequencies above 1 GHz, a spectrum analyzer or test receiver with characteristics as defined in CISPR 16-1-1 shall be used.

~~Precautions which can be taken in the use of a spectrum analyzer are given in Annex B.~~

7.3.2 Artificial network (AN)

7.3.2.1 General

The artificial network (AN) is required to provide a defined termination impedance for the EUT's AC mains power port or DC power port under test at radio frequencies at the point of measurement. The AN will also provide isolation of the equipment under test from ambient noise on the respective AC or DC power lines.

7.3.2.2 Artificial mains network (AMN)

Measurement of the disturbance voltage at low voltage AC mains power ports shall be made using an artificial mains network (V-AMN) as specified in CISPR 16-1-2.

7.3.2.3 Artificial DC network (DC-AN)

~~Measurement of the disturbance voltage at low voltage DC power ports shall be made either using the 150 Ω artificial mains Delta-network specified in 4.7 of CISPR 16-1-2:2014 (see also CISPR 16-1-2:2014, Figure A.2) or the 150 Ω artificial d.c. network specified in Annex I of this standard.~~ Measurement of the disturbance voltage at low voltage DC power ports shall be made using the 150 Ω artificial mains Delta-network specified in 4.7 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017. Figure A.2 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017 shows a suitable circuit for a delta-network, and another example for a 150 Ω Δ-AN is shown in Figure A.7 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017. For simplified wording, any of these networks intended for use with measurements at low voltage DC power ports is further on denoted as DC-AN.

7.3.3 Voltage probe

The voltage probe shown in Figure 1 shall be used when the artificial mains network (V-AMN) cannot be used. The probe is connected sequentially between each line and the reference earth chosen (metal plate, metal tube). The probe consists mainly of a decoupling capacitor and a resistor such that the total resistance between the line and earth is at least 1 500 Ω. The effect on the accuracy of measurement of the capacitor or any other device which ~~may~~ can be used to protect the measuring receiver against dangerous currents shall be either less than 1 dB or allowed for in calibration. The voltage probe shall meet the requirements specified in CISPR 16-1-2:2014, Clause 5.

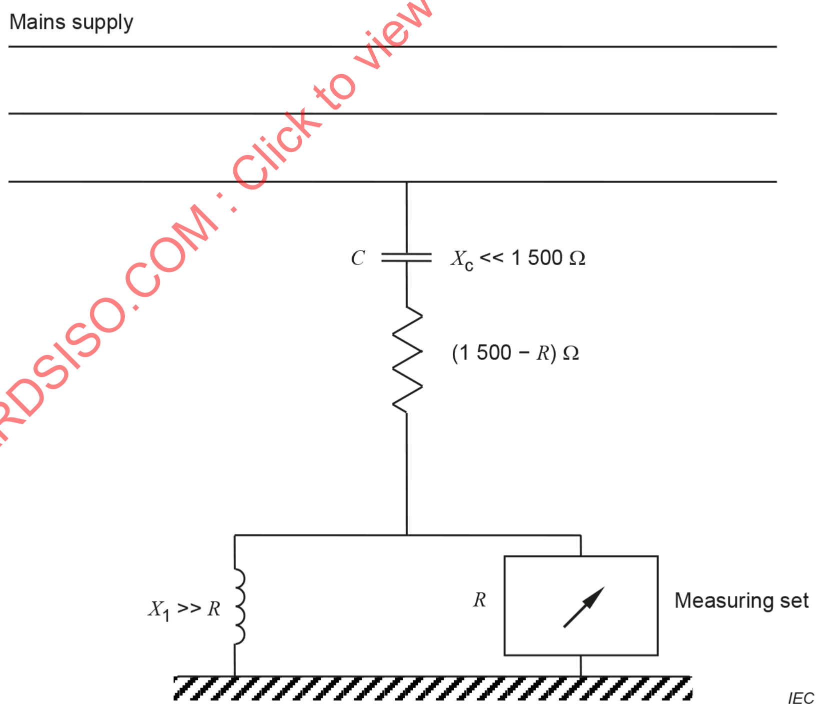


Figure 1 – Circuit for disturbance voltage measurements on mains supply

7.3.4 Antennas

7.3.4.1 Frequency range below 30 MHz

In the frequency range below 30 MHz the antenna shall be a loop as specified in CISPR 16-1-4. The antenna shall be supported in the vertical plane and be rotatable about a vertical axis. The

~~lowest point~~ centre of the loop shall be 1,3 m above ground level, in each orientation of the loop antenna.

7.3.4.2 Frequency range from 30 MHz to 1 GHz

7.3.4.2.1 General

In the frequency range from 30 MHz to 1 GHz the antenna used shall be as specified in CISPR 16-1-4.

Other antennas may be used provided the results can be shown to be within ±2 dB of the results which would have been obtained using a balanced dipole antenna.

7.3.4.2.2 Open-area test site (OATS) and semi-anechoic chamber (SAC)

For measurements on an OATS or in a SAC, the centre of the antenna shall be varied between 1 m and 4 m height for maximum indication at each test frequency. The nearest point of the antenna to the ground shall be not less than 0,2 m. Measurements shall be performed with the antenna oriented in both horizontal and ~~subsequently in~~ vertical polarizations.

7.3.4.2.3 Fully-anechoic room (FAR)

For measurements in a FAR, the antenna height is fixed at the geometrical middle height of the validated test volume. Measurements shall be performed with the antenna oriented in both horizontal and ~~subsequently in~~ vertical polarizations.

7.3.4.2.4 Other sites

For measurements *in situ* the centre of the antenna shall be fixed at (2,0 ± 0,2) m height above the ground.

7.3.4.3 Frequency range from 1 GHz to 18 GHz

In the frequency range from 1 GHz to 18 GHz, the antenna used shall be as specified in CISPR 16-1-4.

7.3.5 Artificial hand

In order to simulate the influence of the user's hand, the application of the artificial hand is required for hand-held equipment during the mains disturbance voltage measurement.

The artificial hand consists of metal foil which is connected to one terminal (terminal M) of an RC element consisting of a capacitor of 220 pF ± 20 % in series with a resistance of 510 Ω ± 10 % (see Figure 2); the other terminal of the RC element shall be connected to the reference ground of the measuring system (see CISPR 16-1-2). The RC element of the artificial hand may be incorporated in the housing of the artificial mains network.

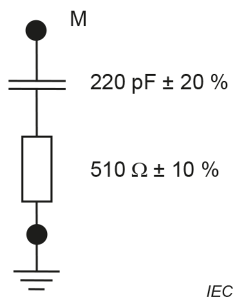


Figure 2 – Artificial hand, RC element

7.4 Frequency measurement

For equipment which is intended to operate with a fundamental frequency in one of the designated bands listed in Table 1, the frequency shall be checked with measuring equipment having an inherent error of measurement not greater than 1/10 of the permissible tolerance for the mid-band frequency of the designated band. The frequency shall be measured over all the load range from the lowest power normally used up to the maximum.

7.5 Configuration of equipment under test

7.5.1 General

Consistent with typical applications of the equipment under test, the level of the disturbance shall be maximized by varying the configuration of the equipment. An example of a typical setup for measurements of radiated disturbances from a table-top EUT is provided in Figure 3. The measurement arrangement shall be typical of normal installation practice and centred to the turntable's vertical axis.

NOTE 1 The extent to which this subclause is applicable to the measurement of an installation *in situ* will depend on the flexibility inherent in each particular installation. The provisions of this subclause apply to *in situ* measurements in so far as a particular installation allows for the position of cables to be varied and different units within the installation to be operated independently, the extent to which the position of the installation can be moved within the premises, etc.

For measurement of radiated disturbances on an OATS or in a SAC with a separation distance of 3 m the assessment of the radiation from the cabling of the EUT shall be restricted to those fractions of interconnecting cables (see 7.5.2) and mains cables (see 7.5.3) which are within the test volume not exceeding ~~1,2~~ 1,5 m diameter times 1,5 m height above ground.

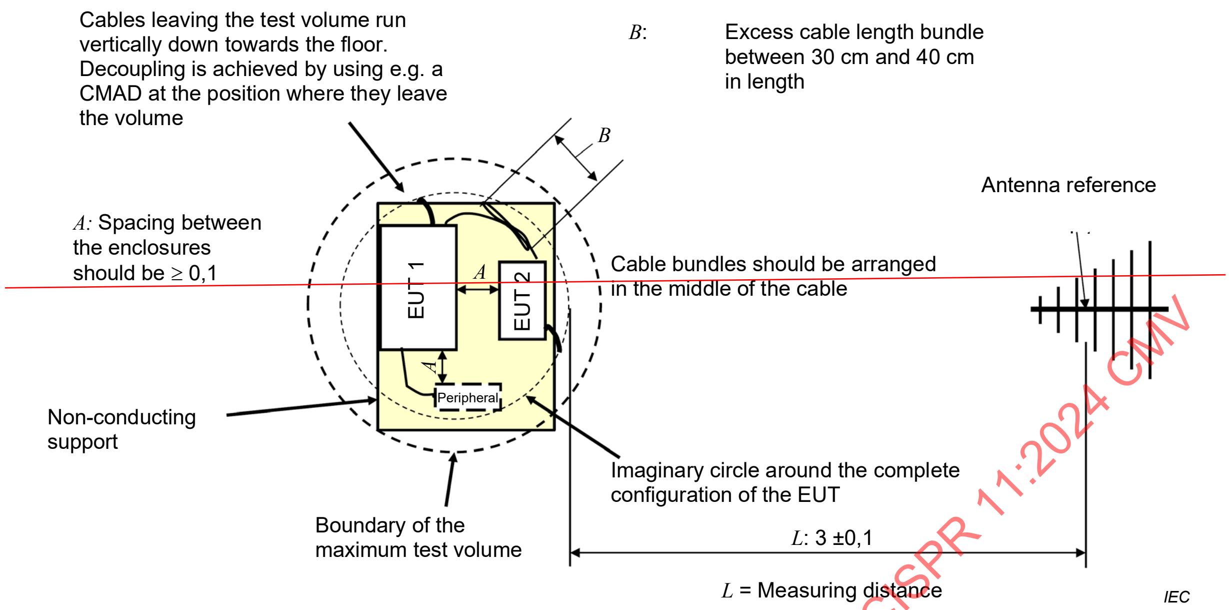
For the measurement of radiated disturbances in a FAR, all cables dropping to the floor shall be visible from the position of the antenna reference point for at least 80 cm, see Figure 3b.

~~Peripheral~~ Associated equipment not fitting into the test volume shall be excluded from the measurements or decoupled from the test environment. If cables to ~~peripheral~~ associated equipment cannot be extended to run out of test volume, then the ~~peripheral~~ associated equipment shall be placed within the imaginary circle around the complete configuration of the EUT.

The measuring distance is defined from the reference point of the antenna to the boundaries of an imaginary circle around the complete configuration of the EUT, see Figure 3a.

NOTE 2 Restriction of radiation assessment to the cable fractions inside the test volume can be achieved for example by application of CMADs to the cables at the position where they leave the test volume. CISPR 16-2-3 gives further guidance on the application of CMADs.

Dimensions in metres



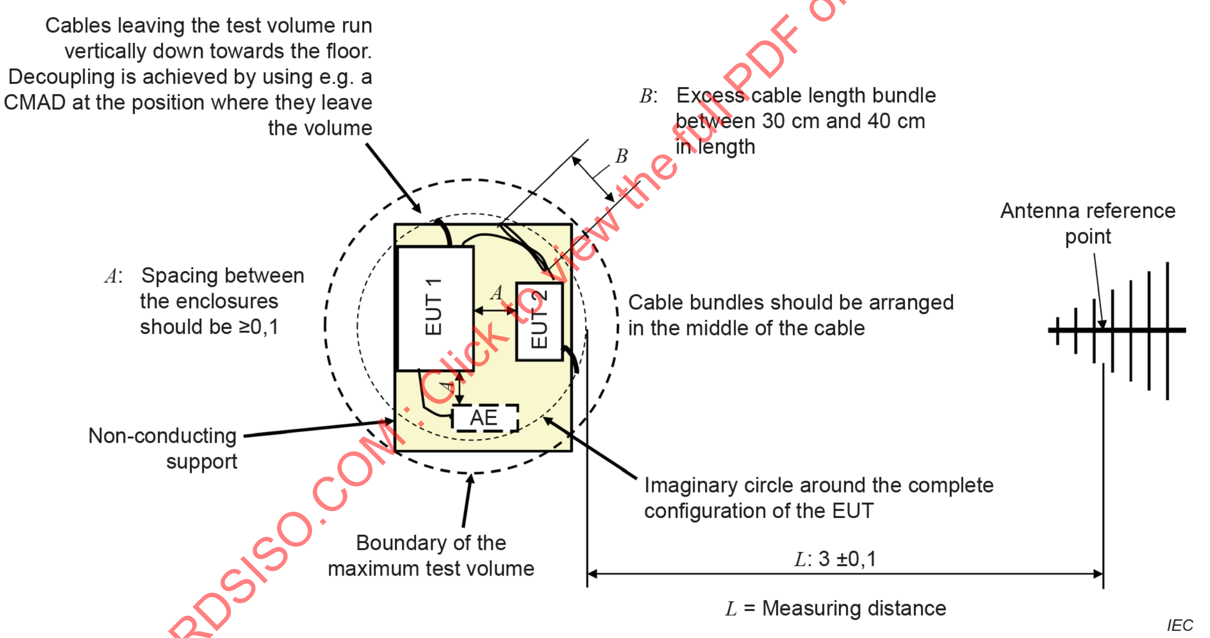
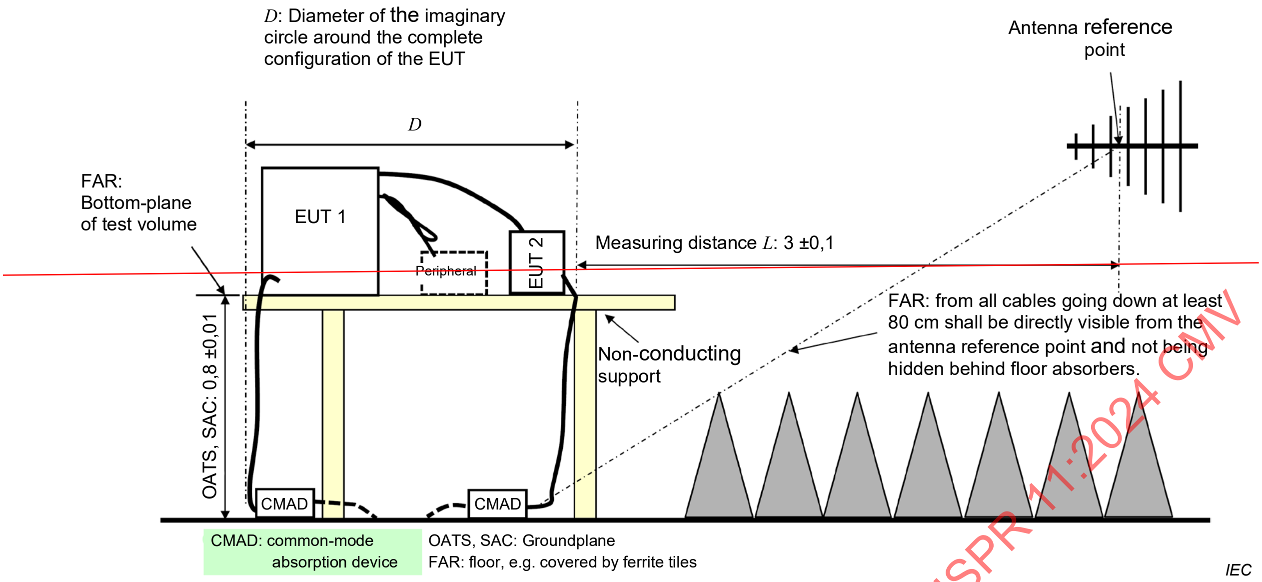


Figure 3a – Top view

Dimensions in metres



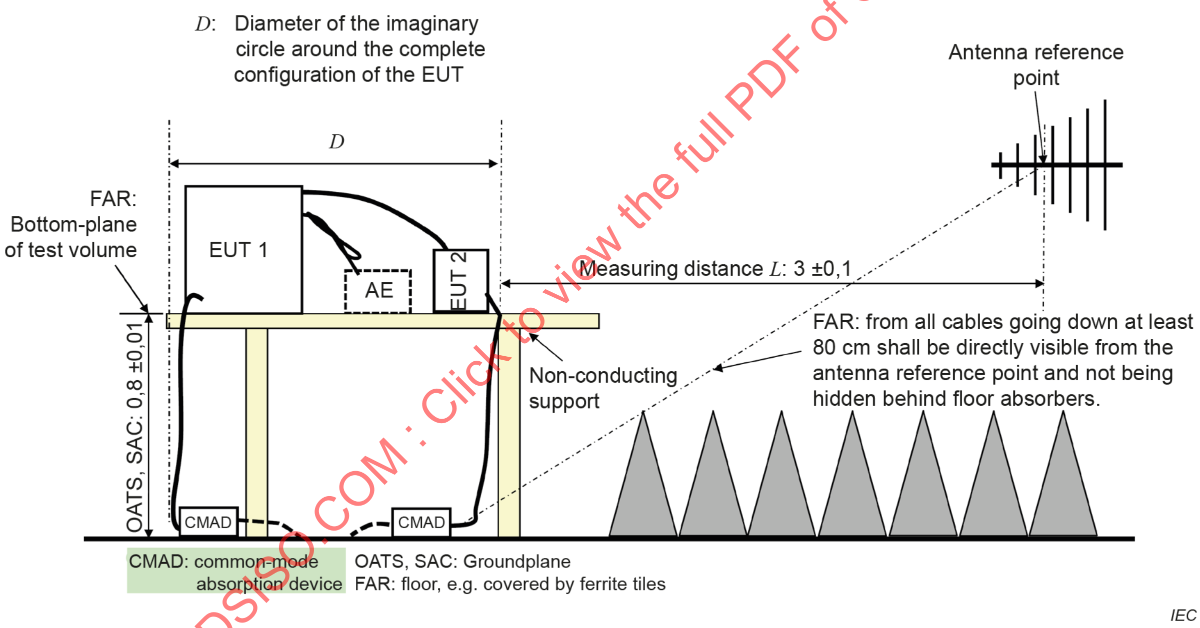
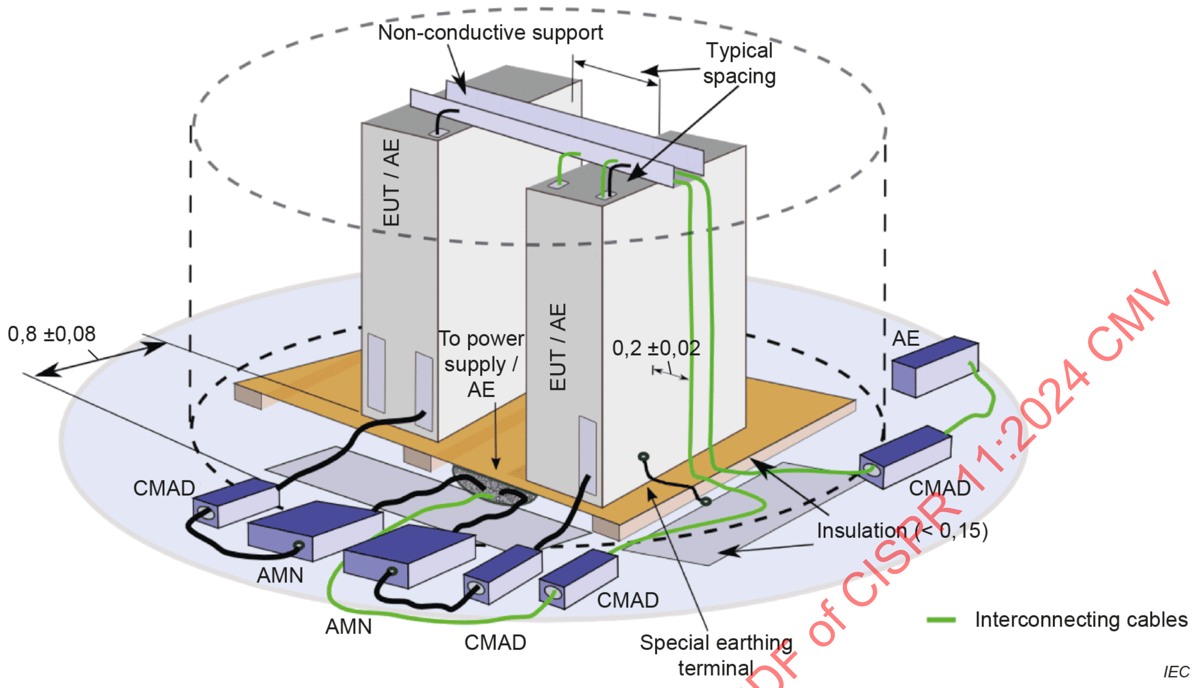


Figure 3b – Side view

Figure 3 – Example for a typical cable arrangement for measurements of radiated disturbances in 3 m separation distance, Table-top EUT

An example of a typical unified test set up for floor standing equipment suitable for measurement of conducted as well as radiated disturbances is shown in Figure 4. Further examples of typical arrangements of the EUT and associated peripherals are given in CISPR 16-2-3 and CISPR 16-2-1.

Dimensions in metres



NOTE CMADs are not used for conducted disturbance measurements.

Figure 4 – Example for a typical test set up for measurement of conducted and/or radiated disturbances from a floor standing EUT, 3D view

The configuration of the equipment under test, including the exact placement of the CMAD and the type of test site used for the measurement, shall be documented in the test report.

7.5.2 ~~Interconnecting~~ EUT cables and components

This subclause applies to equipment in which there are interconnecting cables between various parts of the equipment, or systems where a number of components are interconnected.

NOTE 1 The observation of all provisions in this subclause ~~permits~~ ensures the application of the results of an evaluation to a number of system configurations using the same types of equipment and cables as tested, but no other, each system configuration being in effect a subsystem of the one evaluated.

Interconnecting cables shall be of the type and length specified in the individual equipment requirements. If the length can be varied, the length shall be selected to produce maximum emissions when performing field strength measurements.

If shielded or special cables are used during the tests then the use of such cables shall be specified in the instruction manual.

The connection of signal leads, except for the leads supplied ~~by the manufacturer~~ with the EUT, is not required during radio-frequency emission measurements for portable test and measurement apparatus, group 1, or those intended for use in laboratories and operated by competent persons. Examples are signal generators, network and logic analysers, and spectrum analysers.

Excess lengths of cables shall be bundled at the approximate centre of the cable with bundles ~~of 30 cm~~ up to 40 cm in length. If it is impracticable to do so the disposition of the excess cable shall be noted precisely in the test report.

Where there are multiple interface ports all of the same type, connecting a cable to just one of that type of port is sufficient provided that it can be shown that the additional cables would not significantly affect the results.

Any set of results shall be accompanied by a complete description of the cable and equipment orientation so that results can be reproduced. If there are conditions of use, those conditions shall be specified, documented and included in the instructions for use.

If a given type of equipment can perform separately any one of a number of functions then the equipment shall be tested while performing each of these functions. For systems which may include a number of different components, one of each type of component which is included in the system configuration shall be included in the evaluation.

A system which contains a number of identical components, but has been evaluated using only one of those components, does not require further evaluation if the initial evaluation was satisfactory.

NOTE 2 This is possible because it has been found that in practice emissions from identical modules are not additive.

When equipment is being evaluated which interacts with other equipment to form a system then the evaluation may be carried out using either additional equipment to represent the total system or with the use of simulators. In either method care shall be taken to ensure that the equipment under test is evaluated with the effects of the rest of the system or simulators satisfying the ambient noise conditions specified in 7.2. Any simulator used in lieu of actual equipment shall properly represent the electrical and in some cases the mechanical characteristics of the interface, especially with respect to radio-frequency signals and impedances, as well as cable configuration and types.

NOTE 3 This procedure is ~~required~~ intended to facilitate the evaluation of equipment which will be combined with other equipment from different manufacturers to form a system.

When performing conducted disturbance measurements on wired network ports, the EUT shall be arranged and operated in accordance with CISPR 32.

7.5.3 Connection to the electricity supply network on a test site

7.5.3.1 Connection to the laboratory AC mains network

7.5.3.1.1 General

Where ~~necessary~~ applicable the mains power from the laboratory's electricity power supply network shall be provided through the artificial mains network (AMN) specified in 7.3.2.2.

For connection to the AMN or to the test site's electricity supply network, appropriate lengths of mains cables shall be used. If the manufacturer's installation instructions specify a particular type of mains cable for use with the EUT, connection to the AMN or to the test site's electricity supply network shall be made with that cable type.

Mains power at the nominal voltage shall be supplied.

7.5.3.1.2 ~~Connection to the laboratory a.c. mains network for measurement of conducted disturbances and for radiated disturbances in the range up to 30 MHz~~ Conducted and radiated disturbance measurements up to 30 MHz

When performing measurements on a test site, the artificial mains network (V-AMN) specified in 7.3.2.2 ~~is to~~ shall be used whenever possible. The enclosure of the V-AMN shall be located so that its closest surface is no less than 0,8 m from the nearest boundary of the equipment under test.

Where a flexible mains cord is provided by the manufacturer with the EUT, this shall be 1 m long or, if in excess of 1 m, the excess cable shall be folded to and forth to form a bundle not exceeding 0,4 m in length.

Where a mains cable is specified in the manufacturer's installation, instructions a 1 m length of the type specified shall be connected between the test unit and the AMN.

Earth connections, where required for safety purposes, shall be connected to the reference "earth" point of the AMN and where not otherwise provided or specified by the manufacturer shall be 1 m long and run parallel to the mains connection at a distance of not more than 0,1 m.

Other earth connections (e.g. for EMC purposes) either specified in the installation manual or supplied by the manufacturer with the EUT for connection to the same terminal as the safety earth connection shall also be connected to the reference earth of the AMN.

Ancillary low voltage AC mains ports shall be connected to the laboratory AC mains network via one or more separate artificial mains networks (V-AMN) as specified in 7.3.2.2.

Where the equipment under test is a system comprising more than one unit, each unit having its own power cord, the point of connection for the AMN is determined from the following rules:

a) each mains cable which is terminated in a mains supply plug of a standard design (e.g., IEC TR 60083 [23]) shall be tested separately;
b) mains cables or terminals which are not specified by the manufacturer to be connected to another unit in the system for the purposes of supplying mains power shall be tested separately;
c) mains cables or terminals which are specified by the manufacturer to be connected to another unit in the system for the purposes of supplying mains power shall be connected to that unit, and the mains cables or terminals of that unit are connected to the AMN;
d) where a special connection is specified, the necessary hardware to effect the connection shall be used during the evaluation of the equipment under test.

7.5.3.1.3 Connection to the laboratory a.c. mains network for measurement of radiated disturbances in the range 30 MHz to 18 GHz Radiated disturbance measurements in the range 30 MHz to 18 GHz

Connection to the laboratory's electricity supply network may be provided with or without the use of an AMN allocated inside the test environment, see Figure 4. For measurement arrangements not including an AMN, grounding and earthing of the EUT shall be guaranteed by adherence to the principles set out in 7.5.3.1.2 as far as possible.

If the measurement arrangement does not include an AMN, then excessive lengths of mains cables do not need to be bundled and allocated inside the test volume. They may be accommodated someplace outside the test volume or test environment. For decoupling of radiation from these excessive cable lengths it is however recommended to carefully terminate these mains cables at the location where they leave the test volume. For this decoupling use of CMADs is recommended. For measurements with a separation distance of 3 m, this decoupling is mandatory, see 7.5.1.

7.5.3.2 Connection to the laboratory DC power supply or other DC power source

When performing measurements on a test site, the 150 Ω artificial DC network (DC-AN) specified in 7.3.2.3 is to shall be used whenever possible. The enclosure of the DC-AN shall be located so that its closest surface is 0,8 m from the nearest boundary of the equipment under test.

Where the DC-AN is used as voltage probe, the EUT's DC power port under test shall be decoupled from the DC power source by means of suitable common mode decoupling devices such as ferrite tubes, CMADs or a CDN as specified in 6.2.2 and 6.2.3 of IEC 61000-4-6:~~2013~~2023 which ~~are to~~ shall be clamped at or ~~to~~ be inserted in the DC power cable connecting the DC power source with the measurement arrangement for the EUT, see also Figure 12, Figure 13 and Figure 14. If a CDN according to IEC 61000-4-6 is used for decoupling purposes, its RF power input port shall not be terminated with a 50 Ω resistive load.

Connection ~~is to~~ shall be made to a suitable DC power source. The DC output voltage of this power source shall be adjustable to provide a voltage level within the rated operation range for the respective type of EUT.

NOTE 1 For supply of the EUT's DC power port under test, a dedicated laboratory DC power source, appropriate (sets of) batteries or also other DC energy sources such as e.g. fuel cell modules can be used, provided that they allow for continuous and stable voltage, current, etc. ~~necessary~~ applicable for power converters under rated output operating conditions, throughout the measurement.

Care should be taken when selecting the laboratory DC power source and installing it in the measurement arrangement. It is recommended to select and install only such a DC power source which provides for a good galvanic insulation and also sufficient RF decoupling of both DC power terminals from the laboratory reference ground plane. Internal decoupling capacitors at the DC power source's terminals used for internal suppression of asymmetric disturbances ~~may~~ can provide an unwanted bypass for the common mode 150 Ω termination impedance of the DC-AN used for the measurements. This ~~may~~ can cause saturation effects in the mitigation filter of the power converter under test, in particular at the operation frequency (i.e. the switching frequency) of the power converter and its harmonics, which are usually ~~allocated~~ in the range from 2 kHz to some 20 kHz. Saturated mitigation filters ~~do however~~ lead to incorrect and invalid measurement results since the power converter is not operated as intended during the measurements. For guidance on prevention of saturation effects caused by the configuration of the test site, see information in Annex E.

Where a particular type of DC power cable is specified in the ~~manufacturer's~~ installation instructions, this shall be used during ~~testing~~ the measurements.

For testing, a cable length as short as possible shall be connected between the equipment under test and the DC-AN respecting the proximity of the boundary conditions defined above.

Where the equipment under test has more than one DC power port of the same type, the number of DC power ports needed to operate the equipment at its rated power shall be connected to the DC-AN for the measurements. All other DC power ports shall be terminated with a suitable 150 Ω common mode termination impedance. Multiple ports galvanically connected in parallel (such as bus bars or strips for connection to multiple cables) are considered to represent one single port only.

NOTE 2 For these other terminations, any suitable device can be used. This includes e.g. use of further 150 Ω networks according to CISPR 16-1-2, further DC-ANs as specified in 7.3.2.3, or also use of 150 Ω coupling/decoupling devices (CDN) as defined in IEC 61000-4-6.

Ancillary DC power ports shall be connected to an appropriate separate laboratory DC power source or battery, via a suitable 150 Ω common mode termination impedance.

NOTE 3 If a separate mains-connected laboratory DC power source is used, then it can be appropriate to also insert another EMI filter in the connection to that power source. Diagrams showing suitable setups for the test site are found in Annex D.

7.5.4 Measurements of robots 10

For disturbance measurements of robots, the following conditions shall apply:

a) For radiated emissions, the EUT boundary shall be the smallest circle fully enclosing the footprint of all fixed parts of the robot and corresponding EUT cables, ignoring any portion of the robot that moves during normal operation; an example is illustrated in Figure 5. However, when an emission failing the limit is estimated to originate from a portion of the moving arm/element that can be outside of the EUT boundary during the operation of the robot, this shall be investigated and, if confirmed, the emission shall be re-measured with the measurement antenna relocated at the limit distance from this specific portion on the moving arm/element of the robot; in this case, the investigation and the results obtained from the re-measurement shall be documented in the test report.

b) The EUT arrangement shall be such that the mobile portions of the robot can move freely, as in normal operation, during the test.

c) In the case of a fixed robot, the installation instructions shall be respected in all cases. To ensure stable robot operation, the robot shall be rigidly fixed and one of the following electrical conditions shall be fulfilled as required in the installation instructions:

   – remain insulated, or

   – grounded to dedicated grounding/earthing point.

d) A mobile robot shall be supported above the ground plane at the required height (up to 15 cm, 40 cm or 80 cm, depending on if the EUT is floor-standing or tabletop and if the measurement is radiated, conducted with a VCP, or conducted without a VCP) by means of an insulating support that allows the propulsion system of the robot to move freely. If the free movement of the propulsion system of the robot is not possible when using an insulating support of the maximum allowed thickness, this may be increased, as appropriate; in this case, the actual thickness of the insulating support shall be documented in the test report.

Example setups for floor-standing robots are shown in Figure 6 and Figure 7 (for conducted and radiated disturbance measurements, respectively), while Figure 8 and Figure 9 illustrate an example combination EUT (consisting of both floor-standing and tabletop/wall-mount units).

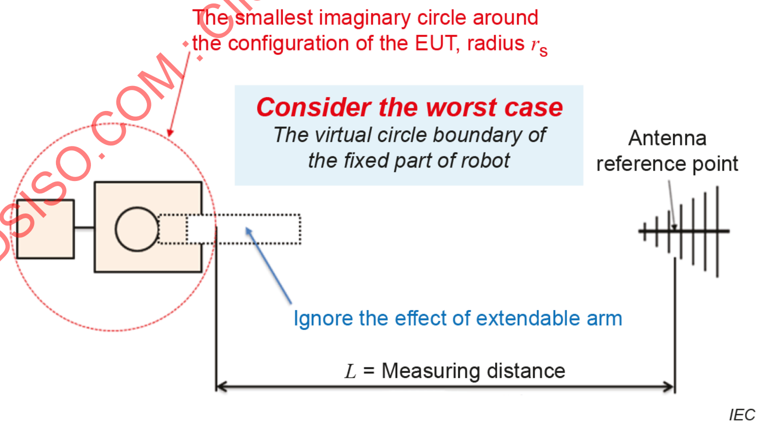


Figure 5 – EUT boundary determination for radiated disturbance measurements of robots with extendable/moving arm

Dimensions in centimetres

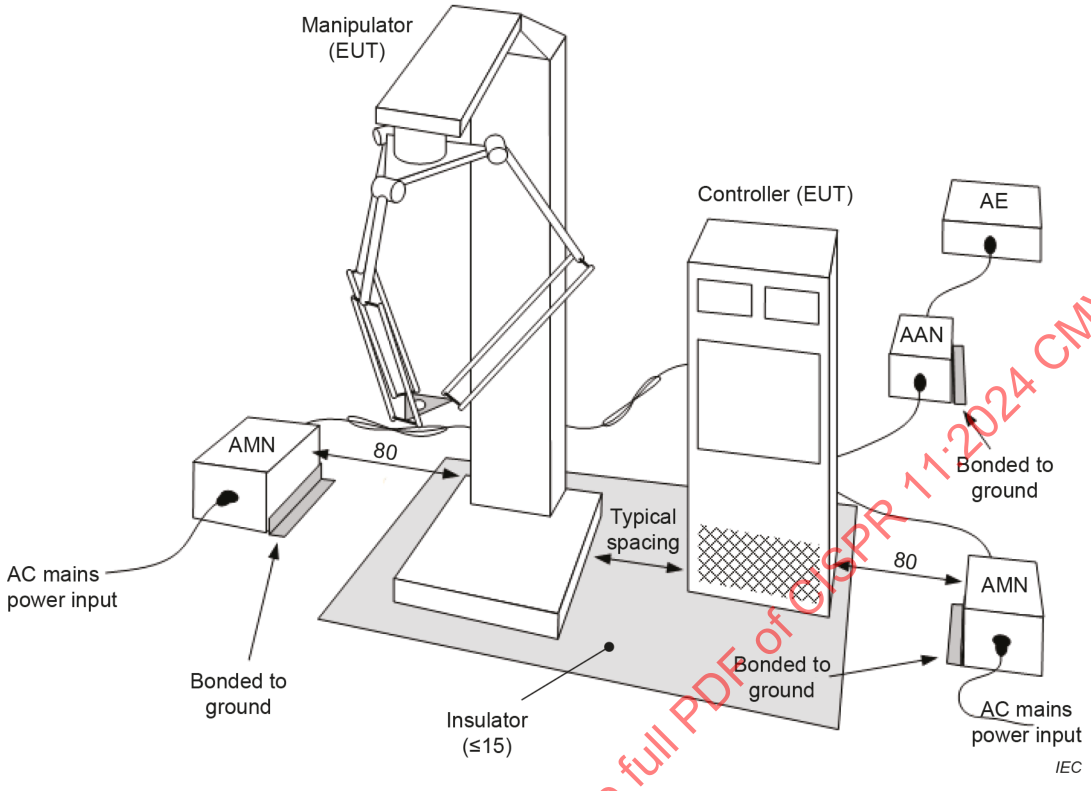
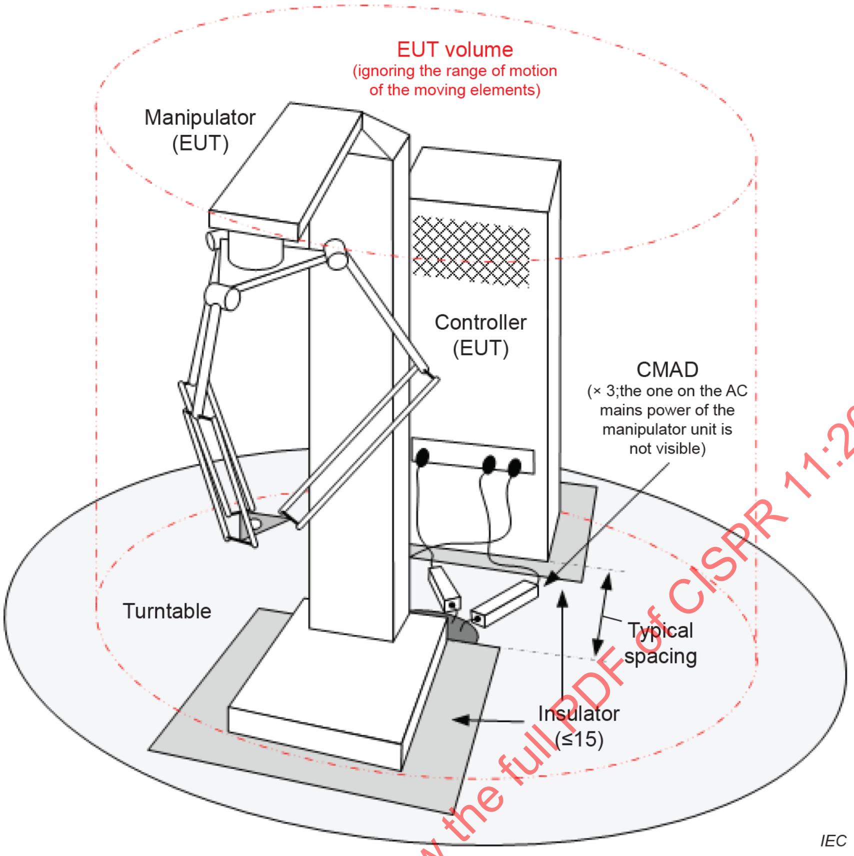


Figure 6 – Example of a typical test setup for conducted disturbance measurement on a floor-standing robot system

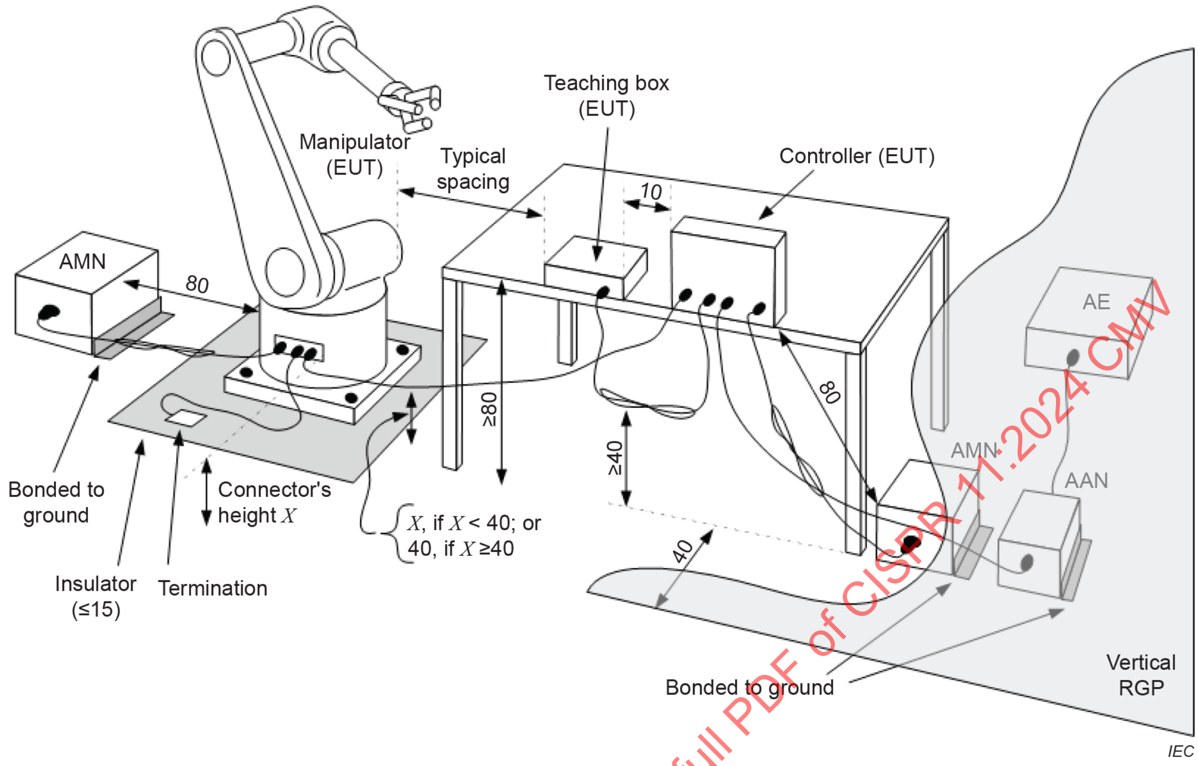
Dimensions in centimetres



CMADs might not be available for the power rating or diameter of the cables of the EUT, or the cable might be too short.

Figure 7 – Example of a typical test setup for radiated disturbance measurement on a floor-standing robot system

Dimensions in centimetres

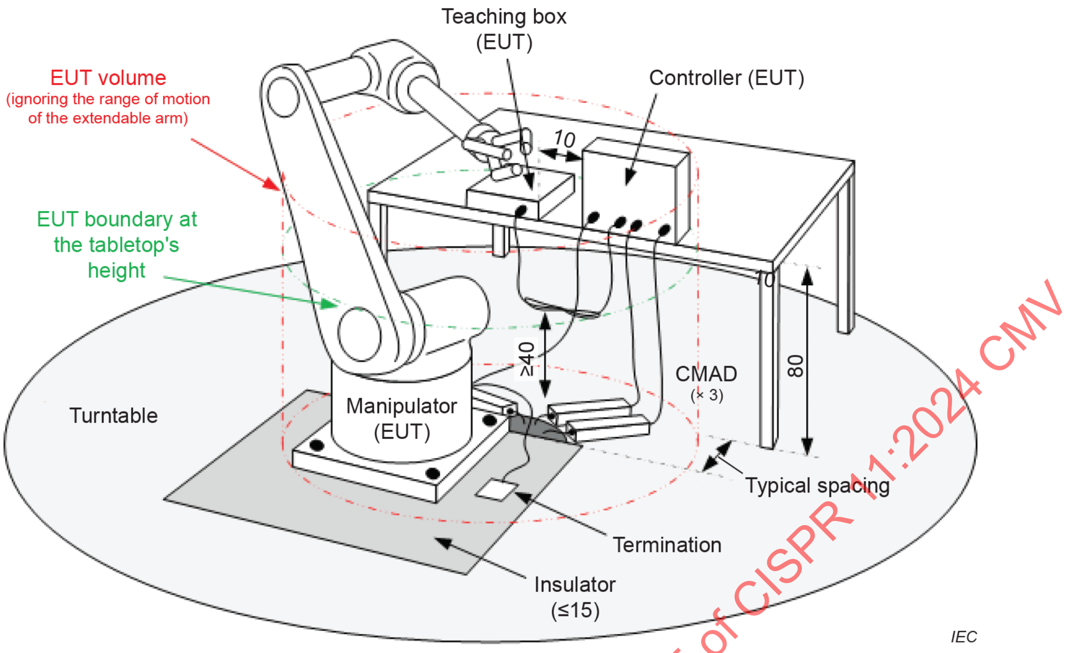


Wall-mount equipment, such as the controller illustrated above, shall be arranged as tabletop EUT, in accordance with CISPR 16-2-1.

NOTE The robot system illustrated here is a combination EUT, including both tabletop and floor-standing units.

Figure 8 – Example of a typical test setup for conducted disturbance measurement on a combination robot system

Dimensions in centimetres



Wall-mount equipment, such as the controller illustrated above, shall be arranged as tabletop EUT, in accordance with CISPR 16-2-3.

CMADs might not be available for the power or diameter of the cables of the EUT, or the cable might be too short.

NOTE The robot system illustrated here is a combination EUT, including both tabletop and floor-standing units.

Figure 9 – Example of a typical test setup for radiated disturbance measurement on a combination robot system

7.6 Load conditions of the EUT

7.6.1 General

Load conditions of the equipment under test are specified in this subclause. Equipment not covered by this subclause ~~are to~~ shall be operated so as to maximize the disturbance generated while still conforming with normal operating procedures as provided in the operating manual of the equipment.

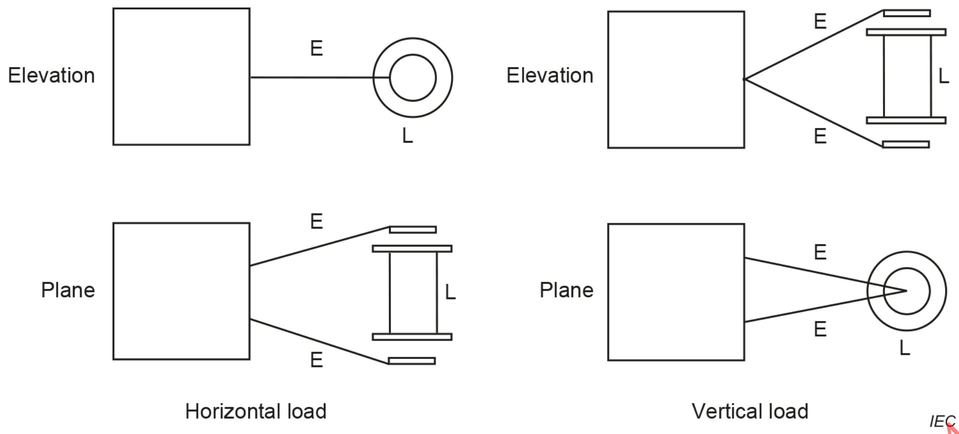
7.6.2 Medical equipment

7.6.2.1 Therapeutic equipment using frequencies from 0,15 MHz to 400 MHz

All measurements shall be made under operating conditions as provided for in the operating manual of the equipment. The output circuit to be used to load the equipment depends on the nature of the electrodes with which it ~~is to~~ shall be used.

For equipment of the capacitive type, a dummy load shall be used for the measurements. The general arrangement is shown in Figure 10. The dummy load shall be substantially resistive and capable of absorbing the rated maximum output power of the equipment.

The two terminals of the dummy load shall be at opposite ends of the load and each terminal shall be joined directly to a circular flat metal plate having a diameter of 170 mm ± 10 mm. Measurements shall be made with each of the output cables and capacitive electrodes supplied with the equipment. The capacitive electrodes ~~are to~~ shall be disposed parallel to the circular metal plates at the ends of the dummy load, the spacing between them being adjusted to produce the appropriate power dissipation in the dummy load.



E = electrode arms and cables

L = dummy load

Figure 10 – Disposition of medical equipment (capacitive type) and dummy load

Individual measurements shall be made with the dummy load both horizontal and vertical (see Figure 10). In each case, the equipment, together with the output cables, capacitive electrodes and dummy load, shall be rotated around its vertical axis during measurements of electromagnetic radiation disturbance in order that the maximum value can be measured.

NOTE The following arrangement of lamps has been found suitable for testing many types of equipment in the power range tested:

a) nominal output power 100 W to 300 W:

four lamps 110 V/60 W in parallel, or five lamps 125 V/60 W in parallel;

b) nominal output power 300 W to 500 W:

four lamps 125 V/100 W in parallel, or five lamps 150 V/100 W in parallel.

For equipment of the inductive type, measurements shall be made using the cables and coils supplied with the equipment for the treatment of the patient. The test load shall consist of a vertical tubular container of insulating material, having a diameter of 10 cm, filled to a height of 50 cm with a solution consisting of 9 g of sodium chloride to 1 l of distilled water.

The container shall be placed within the coil with the axis of the container coincident with the axis of the coil. The centres of the coil and the liquid load shall also coincide.

Measurements shall be made at both maximum and half-maximum power and, where the output circuit can be tuned, it shall be tuned to resonance with the fundamental frequency of the equipment.

All measurements shall be made under all operating conditions as provided in the operating manual of the equipment.

7.6.2.2 UHF and microwave therapeutic equipment using frequencies above 400 MHz

Measurements shall be made with the output circuit of the equipment connected to a non-radiating resistive load having the same value as the characteristic impedance of the cable used to supply the equipment load.

7.6.2.3 Ultrasonic therapy equipment

Measurements shall be made with the transducer connected to the generator. The transducer shall be dipped in a non-metallic container having a diameter of about 10 cm and filled with distilled water.

Measurement shall be made at both maximum and half-maximum power and, where the output circuit can be tuned, it shall be tuned to resonance and then detuned. The specifications in the operating manual of the equipment ~~are to~~ shall be considered.

It is recommended to measure the maximum output of the equipment in accordance with the method published in IEC 61689 [12] or using a derived arrangement, if ~~necessary~~ applicable.

7.6.3 Industrial equipment

The load used when industrial equipment is tested may be either the load used in service or an equivalent device.

Where means for connecting auxiliary services such as water, gas, air, etc. are provided, connection of these services to the equipment under test shall be made by insulating tubing not less than 3 m long. When testing with the load used in service, the electrodes and cables shall be disposed in the manner of their normal use. Measurements shall be made at both maximum output power and at half-maximum output power. Equipment which will normally operate at zero or very low output power shall also be tested in these conditions.

Industrial induction heating and dielectric heating equipment should be tested in a configuration and with a load that is equivalent to actual or intended use. Where the equipment may be configured for a variety of loads or the load is not available, the load as specified in IEC 61922 [12] for induction heating and IEC 61308 [13] for dielectric heating equipment may be used. Industrial resistance heating equipment shall be tested with or without the charge, as specified ~~by the manufacturer~~ in the product documentation.

NOTE A circulating water load has been found suitable for many types of dielectric heating equipment.

Industrial microwave heating equipment shall ~~conform to~~ comply with the limits of radiation in Clause 6 when loaded according to IEC 61307 or with a load used in practice. The load shall be varied as required to produce maximum power transfer, frequency variation or harmonic variation depending on the characteristics under examination.

7.6.4 Scientific, laboratory and measuring equipment

Scientific equipment shall be tested under normal operating conditions. Laboratory and measuring equipment shall be operated as intended. Any RF output ports shall be terminated in a matching non-radiating load.

7.6.5 Microwave cooking appliances

Microwave cooking appliances shall be operated with all normal components such as shelves in place, and with a load of 1 l of tap water initially at 20 °C ± 5 °C placed at the centre of the load-carrying surface provided ~~by the manufacturer~~ with the EUT.

The water container shall be a cylindrical container of borosilicate glass of an external diameter of 190 mm ± 5 mm and a height of 90 mm ± 5 mm, see also IEC 60705 [14].

Detailed information on the measurement procedure to be used in the frequency range above 1 GHz is found in 9.4.

7.6.6 Other equipment in the frequency range 1 GHz to 18 GHz

Other equipment shall ~~conform to~~ comply with the limits of radiation in Clause 6 when tested with a dummy load consisting of a quantity of tap water in a non-conductive container. The size and shape of the container, its position in the equipment and the quantity of water contained therein shall be varied as required to produce maximum power transfer, frequency variation or harmonic radiation depending on the characteristics under examination.

7.6.7 Electric welding equipment

For arc welding equipment, the welding operation during the test is simulated by loading the equipment with a conventional load. Arc striking and stabilizing devices shall be switched on during the emission measurements. The load conditions and the test configuration for arc welding equipment are specified in IEC 60974-10[15].

For equipment for resistance welding, the welding operation during the test is simulated by short-circuiting the welding circuit. The load conditions and the test configuration for equipment for resistance welding are specified in IEC 62135-2.

The start of the measurements according to this document shall be delayed by up to 5 s after the welding equipment under test has been taken into operation.

7.6.8 ISM RF lighting equipment

ISM RF lighting equipment shall ~~conform to~~ comply with the limits in 6.3 when tested as delivered by the manufacturer under normal operating conditions. ~~In case of ISM RF lighting equipment,~~ The EUT shall be operated until the magnetron oscillating frequency is stabilized. The start of any measurement according to this document shall hence be delayed by at least 15 min.

7.6.9 Medium voltage (MV) and high voltage (HV) switchgear

For equipment used in medium or high voltage switchgear, the start of any measurements according to this document shall be delayed until switching actions related to the main or primary circuit are finished (e.g. switching actions of breakers or disconnectors).

7.6.10 Grid connected power converters

7.6.10.1 Connection to the laboratory AC mains or similar load

The power converter under test shall be connected to the laboratory AC mains network via the artificial mains network (V-AMN) specified in 7.3.2.2, whenever possible. If such connection is not possible or not intended, then the power converter under test can be connected to an appropriate resistive load and the laboratory AC mains network in parallel, via the artificial mains network (V-AMN) specified in 7.3.2.2.

Connection to an appropriate resistive load is also recommended for power converters solely intended for use in island low voltage AC mains installations which are not connected to another public low voltage AC mains power distribution network. For advice, consult the installation instructions of the ~~manufacturer~~ EUT.

Alternatively the AC supply power for the laboratory DC power source ~~can~~ may be taken from the AC output lines of the GCPC via the V-AMN without connecting the resistive load. The output AC power of the GCPC will be used to contribute to the required DC input power for that GCPC, thus the resistive load is not necessary in this case, see Figure D.1.

For suitable test site configurations, see Annex D.

7.6.10.2 Connection to another appropriate load

For power converters intended to be supplied from AC power sources, the DC power port under test shall be connected to a suitable resistive load or other adequate energy storage via an 150 Ω artificial network (DC-AN) as specified in 7.3.2.3. The EUT shall be connected to an appropriate load within the rated operational range for the respective type of EUT.

NOTE An example of a type of GCPC intended to be supplied from an AC power source is a power converter intended for assembly into an off-board charging station for electric vehicles (EV).

7.6.11 Robots 11

Robots shall be tested in operating modes and under load conditions which are representative of normal use in the intended application according to the instruction manual.

The compliance evaluation of robots shall consider each operating mode listed in Table 22, for fixed robots, or in Table 23, for mobile robots. Either each operating mode shall be tested separately, or an engineering analysis (which can include both measurements and analysis of the robot's characteristics and design) shall be performed for determining the mode of operation that results in the highest emission level relative to the applicable limit and the final measurement shall be performed on that mode.

Table 22 – Operation modes for fixed robots

Operation mode	Description
Mode 1	The robot is powered on but in its idle mode of operation (static state).
Mode 2	Normal operation mode at rated load, rated speed, defined maximum pose and trajectory (e.g. cube location which refers to 6.8 of ISO 9283:1998[16]).
Mode 3	Similar to mode 2, but with all corresponding parameters (e.g., load) set at approximately the middle of their specified range.

Table 23 – Operation modes for mobile robots

Operation mode	Description
Mode 1 [a]	Battery charging mode: the battery charging level is less than or equal to 20 % at the beginning of the test and remains less than 80 % for the entire duration of the test; the robot is in charging mode, with its main function(s) idle.
Mode 2 [a]	Normal operation mode at rated load and at rated speed. If the robot cannot operate at the same time at its rated load and rated speed, these two modes shall be evaluated in turn.
Mode 3 [a]	Similar to mode 2, but with all corresponding parameters (e.g., load) set at approximately the middle of their specified range.
[a] If the robot can be placed in both its normal mode of operation and in battery charging mode at the same time, then both mode 1 and mode 2 (or mode 1 and mode 3) can be evaluated for compliance with the limits through a single test, with the EUT connected to AC mains power. The test report shall specify how the EUT was placed in both operating modes for the test.	

If, based on the specific design, construction and functionality of the robot under test, it is estimated that other modes of operation can create significant emissions, then these other modes of operation should also be evaluated, in addition to the modes listed in Table 22 or Table 23.

7.7 Recording of test-site measurement results

7.7.1 General

~~Any~~ The results obtained from measurements of conducted and/or radiated radio-frequency disturbances shall be recorded in the test report. If the results are not recorded in a continuous way and/or in graphical form over the frequency range observed, then the minimum requirements to the recordings set out in 7.7.2 and 7.7.3 shall apply.

The test report shall contain a statement underlining that the measurement instrumentation uncertainty (MIU) was determined according to CISPR 16-4-2 and was also considered when determining compliance with the limits for the ~~tested individual equipment or the number of items in the sample of series-produced equipment~~ EUT.

The test report may include the numerical values of the MIU which the test laboratory has determined for each test performed. If the uncertainty budgets specified in CISPR 16-4-2 are exceeded, then the test report shall include the numerical values of the MIU of the test instrumentation actually used.

7.7.2 Conducted emissions

Of those conducted emissions above $(L - 20\text{ dB})$, where L is the limit level in logarithmic units, the record shall include at least the disturbance levels and the frequencies of the six highest disturbances in each observed frequency range from each mains port belonging to the EUT. The record shall also include an indication upon which the conductor of the mains port carried the observed disturbance(s).

7.7.3 Radiated emissions

Of those radiated emissions above $(L - 10\text{ dB})$, where L is the limit level in logarithmic units, the record shall include at least the disturbance levels and the frequencies of the six highest disturbances in each observed frequency range. The record shall include the antenna polarization, antenna height and turntable rotation position if applicable for each reported disturbance. In case of test site measurements, the measurement distance actually selected and used (see 6.2.2 and 6.3.2) shall also be recorded in the test report.

8 Special provisions for test site measurements (9 kHz to 1 GHz)

8.1 Ground planes

For the measurement of radiated disturbances at an open-area test site (OATS) and in a semi-anechoic chamber (SAC) and for the measurement of conducted disturbances on any test site, a ground plane shall be used.

The requirements for the radiation test site are given in 8.3 and, for the ground plane for the measurement of conducted disturbances, in 8.2.

The relationship of the equipment under test to the ground plane shall be equivalent to that occurring in use. Except at the ~~manufacturer’s~~ EUT's intended grounding locations, a floor standing EUT shall be insulated from the ground plane by a dielectric material with thickness of up to 15 cm. Direct connection to earth (i.e. to the ground plane) shall be done

a) either according to the ~~manufacturer's~~ EUT's instructions,
b) or, if the equipment under test is fitted with a special earthing terminal, then this terminal shall be connected to earth (i.e. be bonded to the ground plane) with a lead as short as possible, see also Figure 4.

~~A ground plane shall be used for the measurement of radiated disturbances, at an OATS and in a SAC, and for the measurement of conducted disturbances, at any test site. The requirements for the radiation test site are given in 8.3 and, for the ground plane for the measurement of conducted disturbances, in 8.2.~~

8.2 Measurement of conducted disturbances

8.2.1 General

For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network, see 7.5.3.

The measurement of conducted disturbances ~~may~~ shall be carried out using one of the following methods:

a) on an OATS or in a SAC, with the equipment under test having the same configuration as used during the radiation measurement (for floor-standing equipment only);

b) above or near a ~~metal~~ reference ground plane; or

c) within a screened room. Either the floor or one wall of the screened room shall act as the reference ground plane.

Option a) shall be used where the test site contains a metal ground plane. In options b) and c) the test unit, if non-floor-standing, shall be placed 0,4 m from the ground plane. Floor-standing test units shall be placed on the ground plane, the point(s) of contact being insulated from the ground plane but otherwise consistent with normal use. All test units shall be at least 0,8 m from any other metal surface.

The reference ground terminals of the artificial networks (V-AMNs and DC-ANs) used during the measurements shall be connected to the reference ground plane with a conductor as short as possible.

The power and signal cables shall be oriented in relation to the ground plane in a manner equivalent to actual use and precautions taken with the layout of the cables to ensure that spurious effects do not occur.

When the equipment under test is fitted with a special earthing terminal, this shall be connected to earth with a lead as short as possible. Equipment without special earthing terminal shall be tested as normally connected, e.g. any earthing being obtained through the mains supply.

8.2.2 Measurements on grid connected power converters

8.2.2.1 Measurement of the disturbance voltage at AC power ports

The disturbance voltage at the low voltage AC power port of the power converter shall be measured using the usual method of measurement for disturbance voltages at AC mains ports, see also CISPR 16-2-1.

The disturbance voltage at the ancillary low voltage AC power port of the power converter, if applicable, shall be measured using the usual method of measurement for voltages at AC mains ports, see also CISPR 16-2-1.

For power converters which cannot be measured with the V-network (V-AMN), the disturbance voltage at the low voltage AC mains power port can be measured with the high-impedance voltage probe according to CISPR 16-1-2:2014, Clause 5. In this case, the laboratory AC power source shall be connected directly to the AC power port under test. For conditions of use of the high-impedance voltage probe, see 7.3.3.

~~Likewise~~ Alternatively, for measurements on power converters with a rated throughput power > 20 kVA, a V-network (V-AMN) ~~can~~ may be used as a voltage probe as specified in 7.4.4.4 of CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD:2017. The laboratory AC power source shall be connected to the AC power port under test via an inductance of 30 μH to 50 μH. The inductance ~~may~~ can be realized by a choke, a power cable length of 50 m, or an isolation transformer. A suitable measurement arrangement is shown in Figure 13 and Figure 14.

Compliance with the requirements of this document can be shown in verifying that the limits of the disturbance voltage at AC mains power ports specified in Table 2 or in Table 4 are met.

8.2.2.2 Measurement of the disturbance voltage at DC power ports

8.2.2.2.1 General

Measurements at DC power ports shall only ~~need to~~ be performed on the following types of equipment:

a) power conversion equipment intended for assembly into photovoltaic power generating systems;

b) grid connected power converters (GCPCs) intended for assembly into energy storage systems.

Unless any specific operating condition is specified ~~by the manufacturer~~, the input conditions for the EUT shall be adjusted resulting in maximum disturbance voltage levels.

NOTE The operating conditions~~, as defined by the manufacturer,~~ are chosen to represent the worst case emissions.

Power converters with a rated throughput power > 20 kVA shall be measured while they are operated at an operational point for which feeding to the grid or providing output power to another appropriate load is possible. The DC input voltage shall be within the rated operation range.

Where the power converter is intended for connection to more than one DC power string and consequently is furnished with more than one DC power port, measurements of the disturbance voltage shall be performed in sequence at each of these ports. All other DC power ports not used during the respective measurement shall be terminated with a suitable 150 Ω common mode termination impedance, see 7.5.3.2. Multiple ports galvanically connected in parallel (such as bus bars or strips for connection to multiple cables) are considered to represent one single port only.

~~The disturbance voltage at the d.c. power port of the power converter shall be measured using the usual method of measurement for disturbance voltages at a.c. mains power ports, see also CISPR 16-2-1. This implies the following:~~

- ~~Where unsymmetrical mode (UM) disturbance voltages are measured, compliance with the limits shall be verified for both measured unsymmetrical disturbance voltage levels, i.e. for the voltage levels measured from the plus terminal (pole) to reference ground and from the minus terminal (pole) to reference ground.~~
- ~~Where common mode (CM) and differential mode (DM) disturbance voltages are measured, compliance with the limits shall be verified for measured disturbance voltage levels of both modes, i.e. for the level of the common mode (CM) disturbance voltage as well as for the level of the differential mode (DM) disturbance voltage.~~

~~If the DC-AN according to Annex I allows for measurement of UM, DM and CM disturbances, then it is sufficient to verify compliance with the limits either for UM disturbances (Method A), or for CM and DM disturbances (Method B). The choice of the method used for the measurement is left to the discretion of the user of this standard.~~

The disturbance voltage at the DC power port of the power converter shall be measured using the DC-AN which is specified in 7.3.2.3. Compliance with the limits shall be verified for measured disturbance voltage levels of both modes, i.e. for the level of the common mode (CM) disturbance voltage as well as for the level of the differential mode (DM) disturbance voltage.

If the installation instructions accompanying the power converter contains information that the DC power port is solely intended for connection to

- a battery or other kind of local DC power source and/or;
- if the power converter and a battery or other kind of local DC power source is intended for incorporation in a higher order final equipment (comprising of one or more enclosures);

then this port can be exempted from the measurement.

8.2.2.2.2 Measurement procedure 1

8.2.2.2.2.1 General

The DC-AN is used as standardized 150 Ω common mode termination of the EUT and as decoupling network to the laboratory DC power source. A typical measurement arrangement is shown in Figure 11.

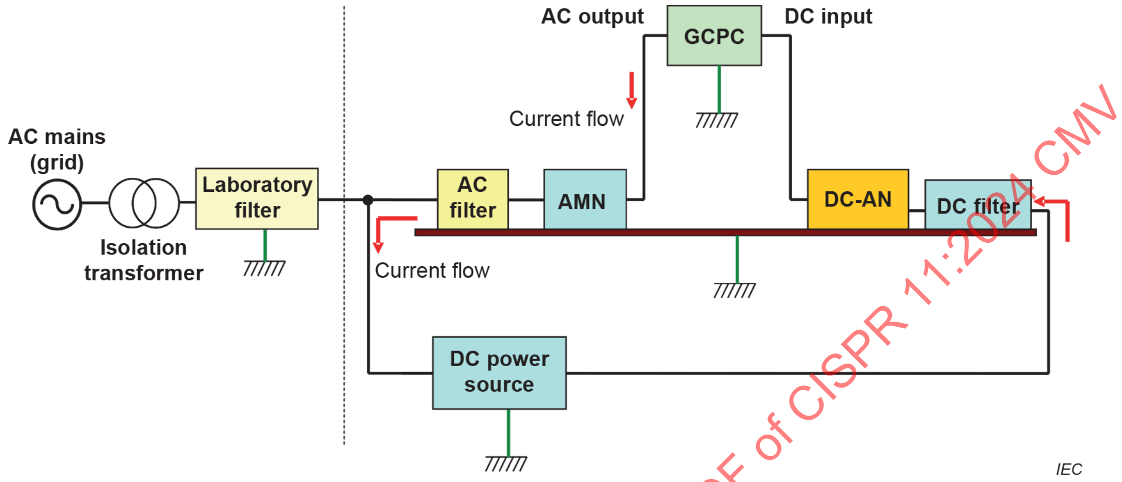


Figure 11 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with the DC-AN used as termination and decoupling unit to the laboratory DC power source

8.2.2.2.2.2 Compliance criterion

Compliance with the requirements of CISPR 11 can be shown in verifying that the limits for the disturbance voltage specified in Table 3 or in Table 5 are met.

8.2.2.2.3 Measurement procedure 2

8.2.2.2.3.1 General

For measurements on power converters with a rated throughput power > 20 kVA, a DC-AN can be used as voltage probe. For an adequate decoupling of the EUT from the DC power source, the laboratory DC power source shall be connected to the DC power port under test via a common mode inductance of 90 µH to 150 µH. The common mode inductance may be realized by ferrite tubes, common mode absorbing devices, or a CDN as specified in 6.2.2 and 6.2.3 of IEC 61000-4-6:~~2013~~2023. Since a CDN according to IEC 61000-4-6 is used only as a decoupling network, its RF power input port shall not be terminated with a 50 Ω resistive load as shown in Figure 12.

NOTE It is up to the operator of the laboratory to ensure that the measurement results obtained with such measurement arrangements are not obstructed or invalidated by dominating disturbances from the laboratory DC power source. Appropriate EMI filters can be used to decouple the EUT from the DC power source. But be aware not to apply too heavy additional common mode capacitive loading to the EUT. Further guidance on suitable decoupling of the laboratory DC power source from the measuring arrangement can be found in Annex E.

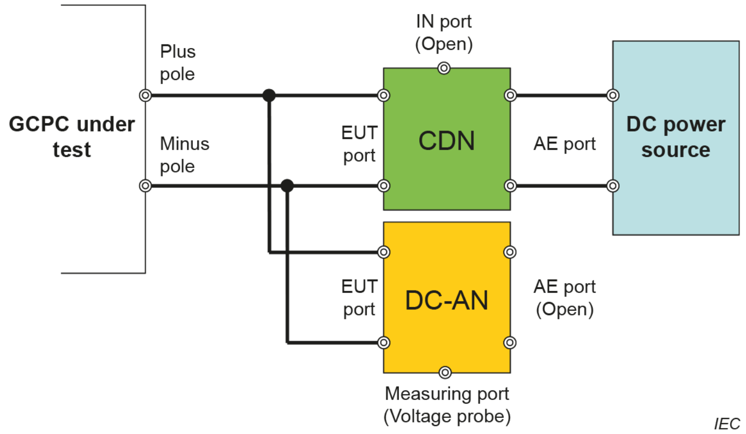


Figure 12 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with the DC-AN used as termination and voltage probe

8.2.2.2.3.2 Measurement of the common mode (CM) disturbance voltage

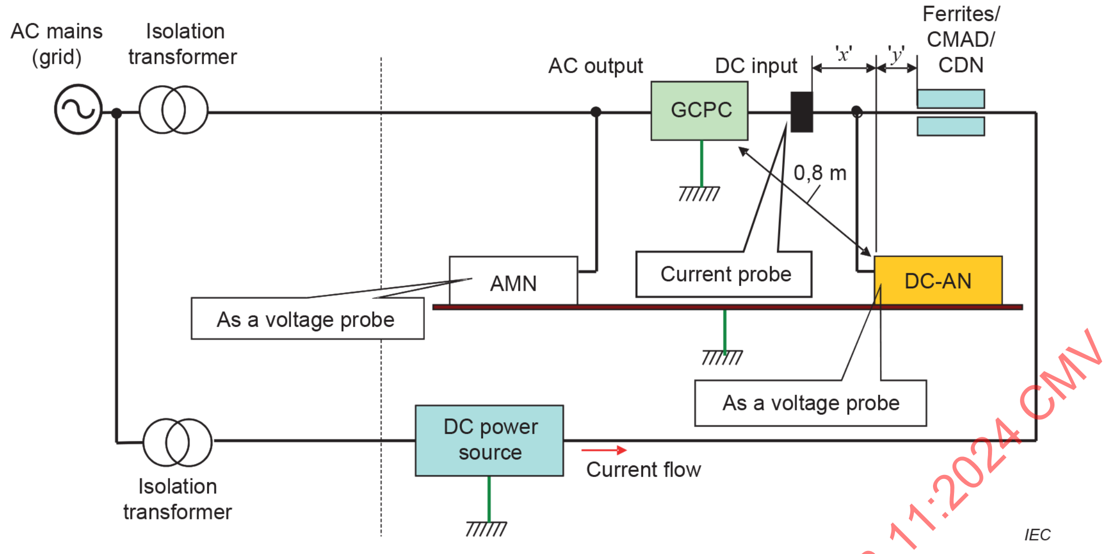
Measurements of the disturbance voltage at the DC power port shall be carried out with the DC-AN used as voltage probe, see Figure 12, Figure 13 and Figure 14.

With the DC-AN, the common mode disturbance voltage at the DC power port of the power converter shall be measured.

8.2.2.2.3.3 Measurement of the common mode (CM) disturbance current

The common mode disturbance current at the DC power cable leading to the laboratory DC power source shall be measured using a current probe according to CISPR 16-1-2.

Care shall be taken in order not to alter the termination conditions of the EUT when performing measurements with the current probe. The current probe shall be located a maximum of 30 cm away from the DC-AN. The current probe shall also be in place when performing measurements of the CM disturbance voltage. A suitable measurement arrangement is shown in Figure 13 and Figure 14.



NOTE 'x' and 'y' denote the spacing between the current probe and the DC-AN, and the DC-AN and the ferrite tube(s) / CMAD / CDN, respectively. Spacing x is ≤ 0,3 m and y is 0,1 m.

Figure 13 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with the DC-AN used as voltage probe and with a current probe – 2D diagram

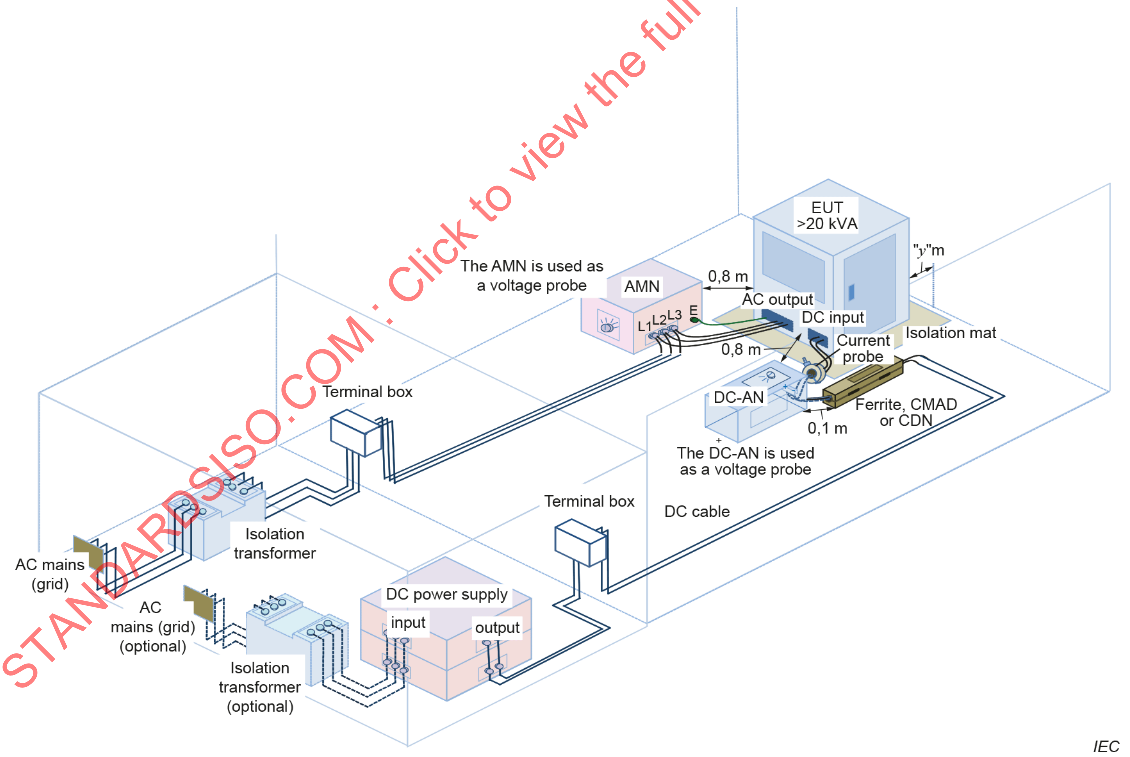


Figure 14 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with a DC-AN used as voltage probe and with a current probe – 3D diagram

8.2.2.2.3.4 Compliance criteria

For measurements according to Figure 13, compliance with the limits shall be verified for the measured common mode disturbance voltage and the measured common mode disturbance current. The EUT meets the requirements of this document if it can be shown that it meets both the limits of the disturbance voltage and the disturbance current specified in Table 3.

8.2.3 Handheld equipment which is normally operated without an earth connection

For this equipment, additional measurements shall be made using the artificial hand described in 7.3.5.

The artificial hand shall be applied only on handles and grips and those parts of the appliance specified as such by the ~~manufacturer~~ product specification. Failing the ~~manufacturer's~~ specification, the artificial hand shall be applied in the following way.

The general principle in applying the artificial hand is that the metal foil shall be wrapped around all handles (one artificial hand per handle), both fixed and detachable, supplied with the equipment.

Metalwork which is covered with paint or lacquer is considered as exposed metalwork and shall be directly connected to the terminal M of the RC element.

When the casing of the equipment is entirely of metal, no metal foil is needed, but the terminal M of the RC element shall be connected directly to the body of the equipment.

When the casing of the equipment is of insulating material, a metal foil shall be wrapped around the handles.

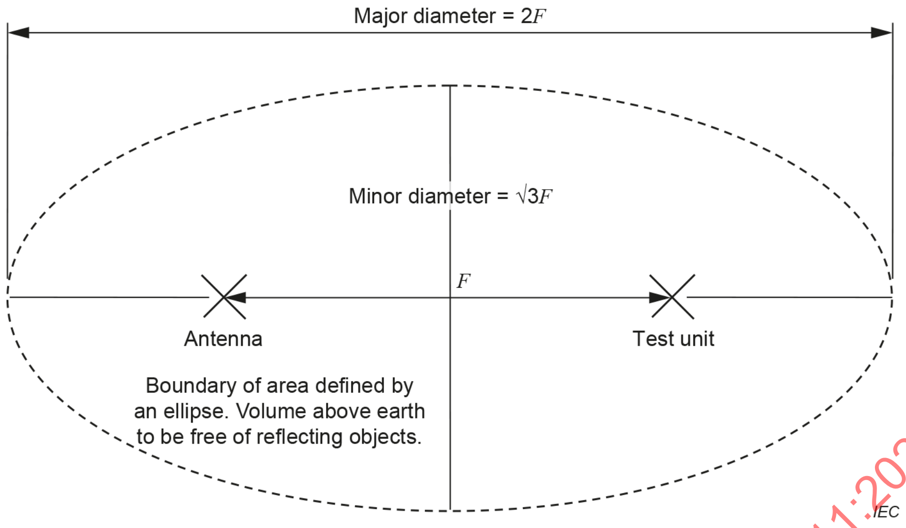
When the casing of the equipment is partly metal and partly insulating materials, and has insulating handles, a metal foil shall be wrapped around the handles.

8.3 OATS and SAC for measurements in the range 9 kHz to 1 GHz

8.3.1 General

The radiation test site shall be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit adequate separation between the antenna, test unit and reflecting structures.

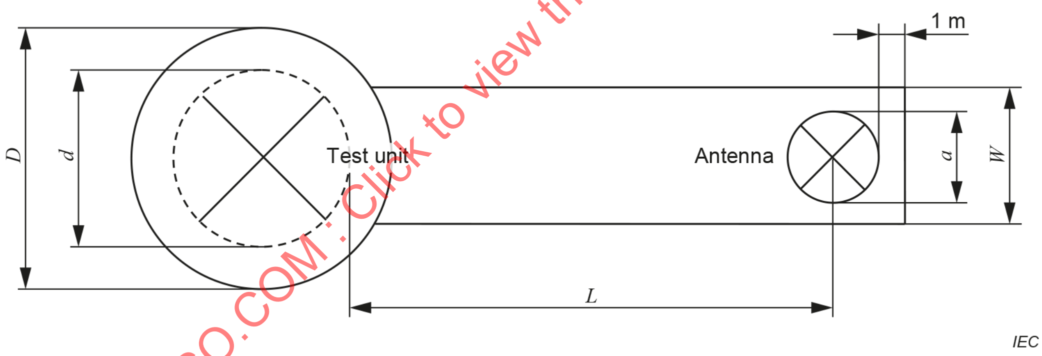
A radiation test site which meets the criteria is within the perimeter of an ellipse having a major axis equal to twice the distance between the foci and a minor axis equal to this distance multiplied by the square root of three ~~times of this distance~~. The equipment under test and the measuring equipment are placed at each of the foci respectively. The path length of any ray reflected from an object on the perimeter of this radiation test site will be twice the length of the direct path length between the foci. This radiation test site is depicted in Figure 15.



NOTE For the values of F (measuring distance), see Clause 6.

Figure 15 – Radiation test site

For the 10 m test site, the natural ground plane shall be augmented with a ground plane of metal which shall extend at least 1 m beyond the boundary of the equipment under test at one end and at least 1 m beyond the measurement antenna and its supporting structure at the other end (see Figure 16). The ground plane shall have no voids or gaps other than any perforations which do not exceed 0,1 λ at 1 GHz (about 30 mm).



D = (d + 2) m, where d is the maximum test unit dimension

W = (a + 1) m, where a is the maximum dimension of the antenna

L = measuring distance in m

Figure 16 – Minimum size of metal ground plane

8.3.2 Validation of the radiation test site (9 kHz to 1 GHz)

Test sites shall be validated according to CISPR 16-1-4 in the frequency ranges where the standard defines requirements.

8.3.3 Disposition of equipment under test (9 kHz to 1 GHz)

For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network, see 7.5.3.1 or 7.5.3.2.

If it is possible to do so, the equipment under test shall be placed on a turntable. The separation between the equipment under test and the measuring antenna shall be the horizontal distance between the reference point of the measuring antenna and the nearest part of the boundary of the equipment under test in one rotation.

8.3.4 Radiation measurements (9 kHz to 1 GHz)

The separation distance between the antenna and the equipment under test shall be as specified in Clause 6. If the field strength measurement at a certain frequency cannot be made at the specified distances because of high ambient noise levels (see 7.2), measurements at this frequency may be made at a closer distance but not less than 3 m. In this case, the test report shall record the distance actually used and the circumstances of the measurement.

For equipment under test located on a turntable, the turntable shall be rotated fully with a measurement antenna oriented for both horizontal and vertical polarization. The highest recorded level of the electromagnetic radiation disturbance at each frequency shall be recorded.

For equipment under test not located on a turntable, the measurement antenna shall be positioned at various points in azimuth for both horizontal and vertical polarization. Care shall be taken that measurements be taken in the directions of maximum radiation and the highest level at each frequency be recorded.

NOTE At each azimuthal position of the measurement antenna, the radiation test site requirements specified in 8.3.1 are met.

8.4 Alternative radiation test sites for the frequency range 30 MHz to 1 GHz

Measurements may be performed on radiation test sites which do not have the physical characteristics described in 8.3. Evidence shall be obtained to show that such alternative sites will yield valid results. An alternative radiation test site in the frequency range 30 MHz to 1 GHz is acceptable if the horizontal and vertical site attenuation measurements made as per 6.3 of CISPR 16-1-4:~~2010/AMD1:2012~~2019 are within ± 4 dB of the theoretical site attenuation as given in Table 2 of CISPR 16-1-4:~~2010/AMD1:2012~~2019.

Alternative radiation test sites shall allow for, and be validated for, the measurement distance in the frequency range 30 MHz to 1 GHz specified elsewhere in Clause 6 and/or Clause 8 of this document.

8.5 FAR for measurements in the range 30 MHz to 1 GHz

A fully-anechoic room (FAR) used for measurement of radiated disturbances in the frequency range 30 MHz to 1 GHz shall comply with the requirements in CISPR 16-1-4.

The use of the FAR is restricted to table-top equipment. The size of the EUT suitable to be measured in a FAR is limited by the validated test volume of the given FAR. The test volume of the FAR is validated according to CISPR 16-1-4, and documented in the site validation report.

NOTE For measurements at 3 m separation distance, this validated test volume will likely limit the applicability of the FAR to ~~small size equipment, see definition 3.17~~ *small EUT* (see 3.1.32).

For measurements in the FAR, the test setup shall be, as far as applicable, the same as described in 8.3 for measurements on an OATS or in a SAC. Further information on performance of emission measurements in a FAR in the range 30 MHz to 1 GHz is found in 7.4 of CISPR 16-2-3:~~2010/AMD 2:2014~~2016.

9 Radiation measurements: 1 GHz to 18 GHz

9.1 Test arrangement

The equipment under test shall be placed on a turntable at a suitable height. Power at the normal voltage shall be supplied. For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network, see 7.5.3.

9.2 Receiving antenna

The measurements shall be made with a directive antenna of small aperture capable of making separate measurements of the vertical and horizontal components of the radiated field. The height above the ground of the centre line of the antenna shall be the same as the height of the approximate radiation centre of the equipment under test. The distance between the receiving antenna and the EUT shall be 3 m.

However, a 10 m measurement may also be used, provided the entire measurement system (from the antenna to the measurement instrument) has sufficient sensitivity to detect EUT emissions that are at least 6 dB below the applicable limit, in the specified limit detector.

9.3 Validation ~~and calibration~~ of test site

Test sites shall be validated according to CISPR 16-1-4.

9.4 Measuring procedure

9.4.1 General

9.4.1.1 General requirements for both group 1 and group 2 equipment

The measurements shall take place in free-space conditions, i.e. the reflections on the ground shall not influence the measurements, see CISPR 16-1-4.

The usage of absorbers shall be done according to CISPR 16-2-3.

The general measuring procedure above 1 GHz specified in CISPR 16-2-3 should be consulted for guidance. Measurements shall be made with the antenna in both horizontal and ~~subsequently~~ vertical polarizations. In both cases, the turntable with the equipment under test shall be rotated. It shall be ascertained that, when the equipment under test is switched off, the level of background noise is at least 10 dB below the reference limit, since otherwise the reading ~~may~~ can be significantly affected.

9.4.1.2 Flowchart for measurements on group 2 equipment

A flow chart showing the measurement procedure is shown in Figure 17.

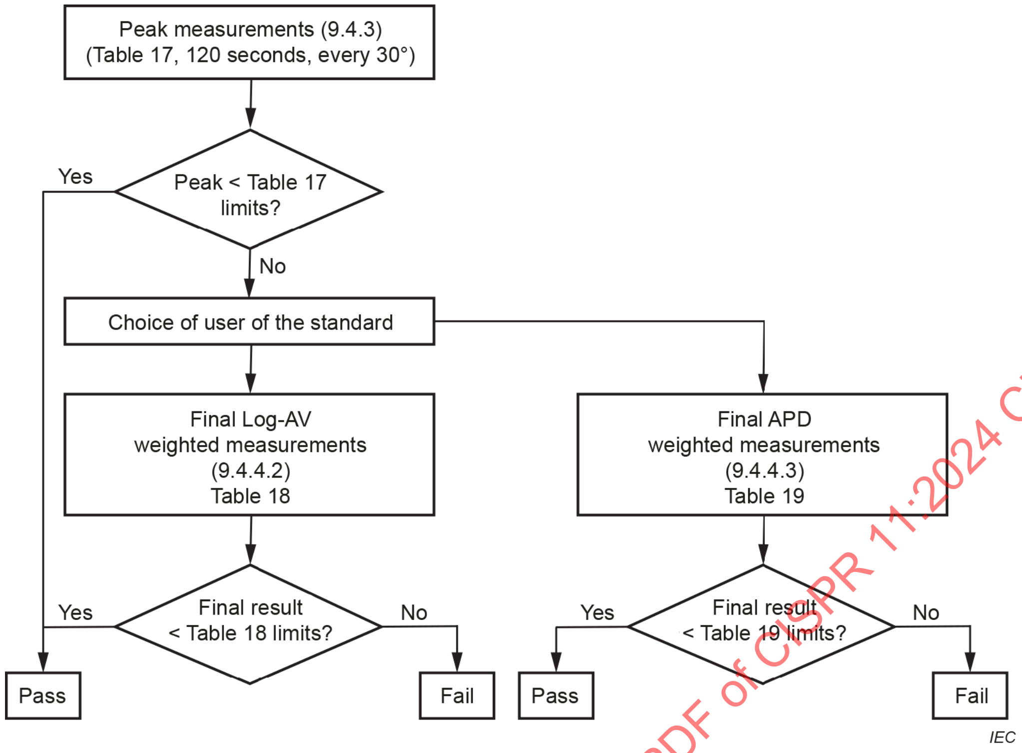


Figure 17 – Decision tree for the measurement of emissions from 1 GHz to 18 GHz of group 2 equipment operating at frequencies above 400 MHz

9.4.2 Operating conditions of the EUT (group 2 equipment only)

For microwave ovens, a warm-up period of at least 5 min shall be performed before the measurement.

For all measurements, the starting phase of the EUT (a few seconds) ~~is to~~ shall be ignored.

During the measurements, the microwave oven under test is operated at maximum microwave power setting.

Some microwave ovens automatically turn to an intermittent operation mode if operated for a long time at their highest microwave power setting. In such cases, the measurement shall be stopped for a while to allow cooling down until the microwave oven is able to operate at its maximum power setting without intermittence.

During the measurement, the water load should be exchanged to cold water before it starts to boil. For load conditions of microwave ovens during the measurements, see also 7.6.5.

9.4.3 Peak measurements (group 2 equipment only)

Peak measurements in the range above 1 GHz shall be made for both polarizations of the antenna with the azimuth of the EUT varying every 30° (starting position perpendicular to the front surface plane of the EUT, i.e. in a position perpendicular to the front door, in case of microwave ovens). At each of these 12 positions, a measurement in maximum-hold mode over the full frequency range 1 GHz to 18 GHz shall be made for a period of 2 min.

During the measurement, the water load should be exchanged to cold water before it starts to boil. The measurement at the particular frequency where this happened ~~needs to~~ shall be re-started.

NOTE 1 If the measurements are carried out in frequency subranges, the measurement time for each subrange is accordingly shorter. For example, the measuring time for a subrange 1 GHz to 2,4 GHz would be about 10 s and the time for a subrange 2,5 GHz to 18 GHz would be about 110 s.

If the emissions from the EUT in this frequency range are very stable, the measurement time at each azimuth/polarization may be reduced, e.g. to 20 s.

The obtained measurement result(s) shall be compared to the peak limit (see Table 17).

If the EUT passes the peak measurement, then the final test result is PASS, see Figure 17.

If the EUT does not pass the peak measurement, final weighted measurements shall be carried out, see Figure 17.

NOTE 2 In the frequency range 11,7 GHz to 12,7 GHz, in some countries unwanted emissions from ISM equipment can cause radio frequency interference for reception facilities of satellite broadcasting systems even when they comply with the limits for the final weighted measurements.

9.4.4 Weighted measurements (group 2 equipment only)

9.4.4.1 General

In cases where readings obtained during the peak measurement in the range 1 GHz to 18 GHz exceed the limits specified in Table 17, an additional series of measurements with a weighting function shall be performed.

In preparation of the final measurement, the whole frequency range shall be divided into 7 sub-ranges from 1 GHz to 18 GHz, in accordance with Table 24.

For every subrange where the EUT did not meet the limits of Table 17, identify the frequency of the highest emission level from the peak measurements. These frequencies are the centre frequencies to be used for the series of weighted measurements, as shown in Table 24.

Table 24 – Frequency subranges to be used for weighted measurements

Harmonics of 2,45 GHz Order no.	Frequency sub-ranges GHz
Not defined	1,0 to 2,4
2	2,5 to 6,125 [a]
3	6,125 to 8,575
4	8,575 to 11,025
5	11,025 to 13,475
6	13,475 to 15,925
7	15,925 to 18,0

[a] Measurements in the ISM band 5,720 GHz to 5,880 GHz are excluded, see Table 1.

For demonstration of the fluctuating nature of a disturbance, two alternative methods for weighted measurements are available, see also decision tree in Figure 17.

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

During the measurement, the water load should be exchanged to cold water before it starts to boil. The measurement at the particular frequency where this happened ~~needs to~~ shall be re-started.

9.4.4.2 Log-AV weighting according to Table 18

Weighted measurements with the Log-AV method (see Table 18) shall be performed at the azimuth position of the EUT and with the antenna polarization where the maximum peak emission occurred during the preliminary measurement. A minimum of 5 consecutive sweeps in max-hold mode shall be performed.

These weighted measurements shall be performed with the spectrum analyzer in logarithmic display mode (using the logarithmic amplifier, not a mathematical unit conversion of the displayed values).

NOTE A video bandwidth of 10 Hz together with logarithmic amplification provides a level closer to the average level of the measured signal in logarithmic values. This result is lower than the average level that would be obtained in linear mode.

Measurements with the Log-AV weighting function shall be performed in the frequency subranges (see Table 24) where the EUT did not meet the limits of Table 17 around the centre frequencies identified in the previous step, within a frequency span of 20 MHz.

Compare the measurement results to the limits of Table 18.

If the EUT passes the measurement with the Log-AV weighting function (Table 18), then the final test result is PASS, see Figure 17.

9.4.4.3 APD weighting according to Table 19

As an alternative to 9.4.4.2, an APD measurement for a period of 30 s shall be performed at the azimuth of the EUT and the polarization of the antenna where the maximum emission was found during the preliminary peak measurements. Measurements shall be made at the following 5 spot frequencies:

f_s,	
f_s + 5 MHz,	f_s – 5 MHz,
f_s + 10 MHz,	f_s – 10 MHz,

where f_s is the frequency with the highest peak emission in one of the frequency subranges, defined in Table 24, see 9.4.4.1.

Compare the measurement results to the limits of Table 19.

If the EUT passes the measurement with the APD weighting function (Table 19), then the final test result is PASS, see Figure 17.

10 Measurement *in situ*

For equipment which is not tested on a radiation test site, measurements shall be made after the equipment has been installed on the user's premises. Measurements shall be made from the exterior wall outside the building in which the equipment is situated at the distance specified in 6.4.

Measurements *in situ* at the place of operation of the equipment to be assessed shall be performed and documented in accordance with 7.7 of CISPR 16-2-3:~~2010.~~2016 and CISPR 16-2-3:2016/AMD1:2019. Further advice for *in situ* measurements is also found in CISPR TR 16-2-5 [17].

The number of measurements made in azimuth shall be as great as reasonably practical, but there shall be at least four measurements in orthogonal directions, and measurements in the direction of any existing radio systems which ~~may~~ can be adversely affected.

For the larger commercial microwave ovens, it is necessary to ensure that the measurement results are not affected by near field effects. CISPR 16-2-3 should be consulted for guidance.

11 Safety precautions for emission measurements on ISM RF equipment

ISM RF equipment is inherently capable of emitting levels of electromagnetic radiation that are hazardous to human beings. Before testing for electromagnetic radiation disturbance, the ISM RF equipment should be checked with a suitable radiation monitor.

12 Measurement uncertainty

Determining compliance with the limits in this document shall be based on the results of the compliance measurements taking into account the considerations on measurement instrumentation 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 also be included in the test report.

For *in situ* measurements, the contribution of uncertainty due to the site itself is excluded from the uncertainty calculation.

NOTE When performing measurements at distances less than 10 m, higher measurement uncertainties ~~may have to be taken into account~~ can occur.

Annex A
(informative)

Examples of equipment classification 12

A.1 General

Many types of equipment in the scope of this document contain two or more types of interference sources, for example an induction heater might incorporate semiconductor rectifiers in addition to its heating coil. For testing purposes, the equipment is defined in terms of the purpose for which it was designed. For example, the induction heater incorporating semiconductor rectifiers is tested as an induction heater (with all disturbances meeting the prescribed limits whatever the source of disturbance) and is not tested as if it were a semiconductor power supply.

The document gives general definitions of group 1 and group 2 equipment and for official purposes the group to which a particular piece of apparatus belongs ~~shall be~~ is identified from these definitions. It will, however, be helpful to users of the document to have a comprehensive list of types of apparatus which have been identified as belonging to a particular group. This will also help in developing the specification where variations in test procedures ~~may~~ can be found by experience to be necessary in dealing with specific types of apparatus.

The lists of group 1 and group 2 equipment given in A.2 and A.3 are not exhaustive.

A.2 Group 1 equipment

A.2.1 General Group 1 equipment

Group 1 equipment contains ~~all~~ the equipment in the scope of this document which is not classified as group 2 equipment.

~~General~~ Examples:

Laboratory equipment

Medical electrical equipment

Scientific equipment

Semiconductor converters

Industrial electroheating equipment with operating frequencies less than or equal to 9 kHz

Machine tools

Industrial process measurement and control equipment

Semiconductor manufacturing equipment

A.2.2 Detailed Group 1 equipment

Examples: Signal generators, measuring receivers, frequency counters, flow meters, spectrum analysers, weighing machines, chemical analysis machines, electronic microscopes, switched-mode power supplies and semiconductor converters (when not incorporated in an equipment), semiconductor rectifiers/inverters, grid connected power converters (GCPC), DC-DC converters for solar panels, resistance heating equipment with built-in semiconductor AC power controllers, arc furnaces and metal melting ovens, plasma and glow discharge heaters, X-ray diagnostic equipment, computerized tomography equipment, patient monitoring equipment, ultrasound diagnostic and therapy equipment, ultrasound washing machines, regulating controls and equipment with regulating controls incorporating semiconductor devices with a rated input current in excess of 25 A per phase, industrial automated guided vehicle (AGV) without wireless power transfer

NOTE Though AGV can be considered as vehicles, due to their sole use in industrial environments they are considered as industrial products in the scope of this document. Future types of AGV for the residential environment are intended to be covered by CISPR 12 [12] (keyword: autonomous driving).

A.3 Group 2 equipment

A.3.1 General Group 2 equipment

Group 2 equipment contains ~~all~~ the ISM RF equipment in which radio-frequency energy in the frequency range 9 kHz to 400 GHz is intentionally generated and used or only used locally, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material, for inspection/analysis purposes, or for transfer of electromagnetic energy.

~~*General*~~ *Examples:*

Microwave-powered UV irradiating apparatus

Microwave lighting apparatus

Industrial induction heating equipment operating at frequencies above 9 kHz

Inductive or capacitive power transfer/charging equipment [a]

Dielectric heating equipment

Industrial microwave heating equipment

Microwave ovens

Medical electrical equipment

Electric welding equipment

Electro-discharge machining (EDM) equipment

Demonstration models for education and training

[a] Inductive or capacitive power transfer apparatus normally subject to this document, but forming part of equipment subject to other CISPR standards is excluded from the scope of this document.

A.3.2 Detailed Group 2 equipment

Examples: Metal melting, billet heating, component heating, soldering and brazing, arc welding, arc stud welding, resistance welding, spot welding, tube welding, industrial laser oscillator exited by high-frequency discharge, wood gluing, plastic welding, plastic preheating, industrial food processing~~, biscuit~~ and baking, food thawing, paper drying, textile treatment, adhesive curing, material preheating, short-wave diathermy equipment, microwave therapy equipment, magnetic resonance imaging (MRI), medical HF sterilizers, high-frequency (HF) surgical equipment, crystal zone refining, demonstration models of high-voltage Tesla transformers, belt generators, etc.

Annex B
(informative)

Precautions to be taken in the use of a spectrum analyzer (see 7.3.1) 13

Most spectrum analyzers have no radio-frequency selectivity: that is, the input signal is fed directly to a broadband mixer, where it is heterodyned to a suitable intermediate frequency. Microwave spectrum analyzers are obtainable with tracking radio-frequency pre-selectors which automatically follow the frequency being scanned by the receiver. These analyzers overcome to a considerable degree the disadvantages of attempting to measure the amplitudes of harmonic and spurious emissions with an instrument which can generate such components in its input circuits.

In order to protect the input circuits of the spectrum analyzer from damage when measuring weak disturbance signals in the presence of a strong signal, a filter should be provided in the input to give at least 30 dB of attenuation at the frequency of the strong signal. A number of such filters may be required to deal with different operating frequencies.

Many microwave spectrum analyzers employ harmonics of the local oscillator to cover various portions of the tuning range. Without radio-frequency pre-selection, such analyzers may display spurious and harmonic signals. It thus becomes difficult to determine whether a displayed signal is actually at the indicated frequency, or is generated within the instrument.

Many ovens, medical diathermy equipment and other microwave ISM RF equipment receive their input power from rectified a.c. but unfiltered energy sources. Consequently, their emissions are simultaneously modulated in amplitude and frequency. Additional AM and FM are caused by the movement of stirring devices used in ovens.

These emissions have spectral line components as close together as 1 Hz (due to modulation by the oven stirring device), and 50 Hz or 60 Hz (due to the modulation at mains frequency). Considering that the carrier frequency is generally rather unstable, distinguishing these spectral line components is not feasible. Rather, it is the practice to display the envelope of the true spectrum by employing an analyzer bandwidth which is larger than the frequency interval between spectral components (but as a rule small in relation to the width of the spectral envelope).

When the analyzer bandwidth is wide enough to contain a number of adjacent spectral lines, the indicated peak value increases with bandwidth up to the point where the analyzer bandwidth is comparable to the width of the spectrum of the signal. It is essential, therefore, to obtain agreement to use a specified bandwidth in order to compare the amplitudes displayed by different analyzers when measuring emissions typical of present heating and therapeutic devices.

It has been indicated that many oven emissions are modulated at a rate as low as 1 Hz. It has been observed that the displayed spectral envelopes of such emissions are irregular, appearing to vary from scan to scan, unless the number of scans per second is low compared with this lowest frequency component of the modulation.

A suitable rate for investigation of the emission may require 10 s or more to accomplish one scan. Such low scanning rates are not suitable for visual observation unless suitable storage is employed, such as that provided by a storage-type cathode ray tube, a photograph, or a chart recording device. Some attempts have been made to increase the useful scanning frequency by removing or stopping the stirring devices in the oven. However, this may be considered unsatisfactory because the amplitude, frequency and shape of the spectrum are found to vary with the position of the stirrers.

Annex B
(normative)

Measurement of electromagnetic radiation disturbance in the presence of signals from radio transmitters

For equipment under test having a stable operating frequency so that the reading of the CISPR quasi-peak measuring receiver does not vary by more than ± 0,5 dB during measurement, the electric field strength of the electromagnetic radiation disturbance can be calculated sufficiently accurately from the expression:

$$E_g^{1,1} = E_t^{1,1} - E_s^{1,1}$$

where

E_g is the electromagnetic radiation disturbance (μV/m);

E_t is the measured value of electric field strength (μV/m);

E_s is the electric field strength of the radio transmitter signal (μV/m).

In most cases the results of radiated emission measurements are expressed in logarithmic units, for example dB(μV/m). Those results shall be converted into linearly expressed values (μV/m) before applying the above formula.

The formula has been found to be valid when unwanted signals are from AM or FM sound and television transmitters having a total amplitude up to twice the amplitude of the electromagnetic radiation disturbance which ~~is to~~ shall be measured.

It is advisable to restrict the use of the formula to cases where it is not possible to avoid the disturbing effect of radio transmitters. If the frequency of the electromagnetic radiation disturbance is unstable then a panoramic receiver or spectrum analyzer should be used, and the formula is not applicable.

Annex D
(informative)

Propagation of interference from industrial radio-frequency equipment at frequencies between 30 MHz and 300 MHz 14

For industrial radio-frequency equipment which is situated on or near ground level, the attenuation of the field with distance from source, at a height of between 1 m and 4 m above ground, depends on the ground and on the nature of the terrain. A model for electric field propagation above plane-earth in the region from 1 m to 10 km from the source is described in [15][3].

Although the influence of the nature of the ground, and of the obstacles on it, on the actual attenuation of the electromagnetic wave increases with frequency, an average attenuation coefficient can be taken for the frequency range 30 MHz to 300 MHz.

As ground irregularity and clutter increase, the electromagnetic fields will be reduced because of shadowing, absorption (including attenuation caused by buildings and vegetation), scattering, divergence and defocusing of the diffracted waves [16]. The attenuation can then be described only on a statistical basis. For distances from the source greater than 30 m, the expected or median field strength at a defined height varies as $1/D^n$ where D is the distance from the source, and n varies from about 1,3 for open country areas to about 2,8 for heavily built-up urban areas. It seems from the different measurements for all kinds of terrain that an average value of n = 2,2 can be used for approximate estimations. Large deviations of measured values of field strengths from those predicted from the average field strength/distance law occur, with standard deviations of up to about 10 dB in an approximately log-normal distribution. The polarization of the field cannot be predicted. These results are in agreement with measurements in a number of countries.

The screening effect of buildings on the radiation is a very variable quantity, depending on the material of the buildings, the wall thickness and the amount of window space. For solid walls without windows, the attenuation depends on their thickness relative to the wavelength of the radiation and an increase in attenuation with frequency may be expected.

Generally, however, it is considered unwise to expect buildings to give protection of much more than 10 dB.

[3] Figures in square brackets refer to the Bibliography.

Annex C
(informative)

Recommendations of CISPR for protection of certain radio services in particular areas

C.1 General

The ITU develops usage provisions aiming at the efficient use of the radio frequency spectrum and local control of radiated RF disturbances at the place of operation of individual ISM RF applications. The respective provisions of the ITU relating to usual residential and/or industrial environments are recognised by CISPR and incorporated into the main body of this document. Apart from these provisions, additional ITU provisions ~~may~~ can apply for the *operation and use* of *individual* ISM RF applications in particular environments, i.e. in "particular areas", which are not addressed in the main body of this document. The CISPR regards these ITU provisions and their national derivatives as recommendations since they ~~may~~ can only apply to *individual* ISM RF applications used in *particular areas* under *in situ* conditions.

C.2 Recommendations for protection of safety-related radio services

ISM RF equipment should be designed to avoid fundamental operations or radiation of high-level spurious and harmonic signals in bands used for safety-related radio services. A list of these bands is provided in Table C.2.

~~NOTE~~ For the protection of specific safety-related radio services, in particular areas, an individual installation can be required to meet the limits specified in Table C.1.

Table C.1 – Limits for electromagnetic radiation disturbances for *in situ* measurements to protect specific safety-related radio services in particular areas

Frequency range MHz	Limits		Measuring distance *D* from the outer face of the exterior wall outside the building in which the equipment is situated
	Electric field Quasi-peak dB(μV/m)	Magnetic field Quasi-peak dB(μA/m)	Distance *D* m
0,283 5 to 0,526 5	–	13,5	30
74,6 to 75,4	30	–	10
108 to 137	30	–	10
242,95 to 243,05	37	–	10
328,6 to 335,4	37	–	10
960 to 1 215	37	–	10

Table C.2 – Frequency bands allocated for safety-related radio services

Frequency MHz	Allocation/Use
0,010 to 0,014	Radionavigation (Omega on board ships and aircraft only)
0,090 to 0,11	Radionavigation (LORAN-C and DECCA)
0,283 5 to 0,526 5	Aeronautical radionavigation (non-directional beacons)
0,489 to 0,519	Maritime safety information (coastal areas and shipboard only)
1,82 to 1,88	Radionavigation (LORAN-A region 3 only, coastal areas and on board ships only)
2,173 5 to 2,190 5	Mobile distress frequency
2,090 55 to 2,091 05	Emergency position indicating radio beacon (EPIRB)
3,021 5 to 3,027 5	Aeronautic mobile (search and rescue operations)
4,122 to 4,210 5	Mobile distress frequency
5,678 5 to 5,684 5	Aeronautic mobile (search and rescue operations)
6,212 to 6,314	Mobile distress frequency
8,288 to 8,417	Mobile distress frequency
12,287 to 12,579 5	Mobile distress frequency
16,417 to 16,807	Mobile distress frequency
19,68 to 19,681	Maritime safety information (coastal areas and shipboard only)
22,375 5 to 22,376 5	Maritime safety information (coastal areas and shipboard only)
26,1 to 26,101	Maritime safety information (coastal areas and shipboard only)
70 to 520	TETRAPOL
74,6 to 75,4	Aeronautical radionavigation (marker beacons)
108 to 137	Aeronautical radionavigation (108 MHz to 118 MHz VOR, 121,4 MHz to 123,5 MHz distress frequency SARSAT uplink, 118 MHz to 137 MHz air traffic control)
136 to 200	Project 25
136 to 174	EDACS
156,2 to 156,837 5	Maritime mobile distress frequency
242,9 to 243,1	Search and rescue (SARSAT uplink)
328,6 to 335,4	Aeronautical radionavigation (ILS glideslope indicator)
360 to 520	Project 25
380 to 385	Air-Ground-Air operation (AGA)
380 to 430	TETRA1
380 to 512	EDACS
390 to 395	Air-Ground-Air operation (AGA)
399,9 to 400,05	Radionavigation satellite
406 to 406,1	Search and rescue (emergency position-indicating radio beacon (EPIRB), SARSAT uplink)
410 to 415	GoTa
410 to 430	CDMA-PAMR
420 to 425	GoTa
450 to 470	TETRA1; CDMA-PAMR
452 to 457,5	GoTa
462 to 467,5	GoTa
746 to 870	Project 25; TETRAPOL
806 to 821	DIMRS; EDACS; FHMA; GoTa
824 to 849	GoTa
850 to 860	IDRA
851 to 866	DIMRS; EDACS; FHMA; GoTa
869 to 894	GoTa
870 to 876	CDMA-PAMR
870 to 888	TETRA1; TETRAPOL
896 to 901	EDACS; FHMA
905 to 915	IDRA

Frequency MHz	Allocation/Use
915 to 921	CDMA-PAMR
915 to 933	TETRA1; TETRAPOL
935 to 940	EDACS; FHMA
960 to 1 238	Aeronautical radionavigation (TACAN), air traffic control beacons
1 300 to 1 350	Aeronautical radionavigation (long range air search radars)
1 453 to 1 477	IDRA
1 501 to 1 525	IDRA
1 544 to 1 545	Distress frequency-SARSAT downlink (1 530 MHz to 1 544 MHz mobile satellite downlink can be pre-empted for distress purposes)
1 545 to 1 559	Aeronautical mobile satellite (R)
1 559 to 1 610	Aeronautical radionavigation (GPS)
1 610 to 1 625,5	Aeronautical radionavigation (radio altimeters)
1 645,5 to 1 646,5	Distress frequency-uplink (1 626,5 MHz to 1 645,5 MHz mobile satellite uplink can be pre-empted for distress purposes)
1 646,5 to 1 660,5	Aeronautical mobile satellite (R)
1 850 to 1 910	GoTa
1 920 to 1 980	GoTa
1 930 to 1 990	GoTa
2 110 to 2 170	GoTa
2 700 to 2 900	Aeronautical radionavigation (terminal air traffic control radars)
2 900 to 3 100	Aeronautical radionavigation (radar beacons – coastal areas and shipboard only)
4 200 to 4 400	Aeronautical radionavigation (altimeters)
5 000 to 5 250	Aeronautical radionavigation (microwave landing systems)
5 350 to 5 460	Aeronautical radionavigation (airborne radars and beacons)
5 600 to 5 650	Terminal Doppler weather radar – wind shear
9 000 to 9 200	Aeronautical radionavigation (precision approach radars)
9 200 to 9 500	Radar transponders for maritime search and rescue. Maritime radar beacons and radionavigation radars. Airborne weather and ground mapping radar for airborne radionavigation, particularly under poor visibility conditions
13 250 to 13 400	Aeronautical radionavigation (Doppler navigation radars)

C.3 Recommendations for protection of specific sensitive radio services

For the protection of specific sensitive radio services, in particular areas, it is recommended to avoid fundamental operations or the radiation of high level harmonic signals in the bands. Some examples of these bands are listed for information in ~~Annex G~~ Table C.3.

NOTE For the protection of specific sensitive services, in particular areas, national authorities can request additional suppression measures or designated separation zones for cases where harmful interference ~~may~~ can occur.

Table C.3 – Frequency bands allocated for sensitive radio services

Frequency MHz	Allocation/Use
0,135 7 to 0,137 8	Amateur radio services
0,472 to 0,479	Amateur radio services
1,80 to 2,00	Amateur radio services
3,50 to 4,00	Amateur radio services
5,25 to 5,45	Amateur radio services
7,00 to 7,30	Amateur radio services
10,100 to 10,150	Amateur radio services
13,36 to 13,41	Radio astronomy
14,00 to 14,35	Amateur radio services
18,068 to 18,168	Amateur radio services
21,00 to 21,45	Amateur radio services
24,89 to 24,99	Amateur radio services
25,5 to 25,67	Radio astronomy
28,00 to 29,7	Amateur radio services
29,3 to 29,55	Satellite downlink (Amateur Radio Satellite Services)
37,5 to 38,25	Radio astronomy
50 to 54	Amateur radio services
70,0 to 70,5	Amateur radio services
73 to 74,6	Radio astronomy
137 to 138	Satellite downlink
144 to 146	Amateur radio services
145,8 to 146	Satellite downlink (Amateur Radio Satellite Services)
149,9 to 150,05	Radionavigation satellite downlink
240 to 285	Satellite downlink
322 to 328,6	Radio astronomy
400,05 to 400,15	Standard frequency and time signal
400,15 to 402	Satellite downlink
402 to 406	Satellite uplink 402,5 MHz
406,1 to 410	Radio astronomy
430 to 440	Amateur radio services
435 to 438	Satellite downlink (Amateur Radio Satellite Services)
608 to 614	Radio astronomy
1 215 to 1 240	Satellite downlink
1 240 to 1 300	Amateur Radio Services
1 260 to 1 270	Satellite uplink
1 350 to 1 400	Spectral line observation of neutral hydrogen (radio astronomy)
1 400 to 1 427	Radio astronomy
1 435 to 1 530	Aeronautical flight test telemetry
1 530 to 1 559	Satellite downlink
1 559 to 1 610	Satellite downlink
1 610,6 to 1 613,8	Spectral line observations of OH radical (radio astronomy)
1 660 to 1 710	1 660 MHz to 1 668,4 MHz: Radio astronomy 1 668,4 MHz to 1 670 MHz: Radio astronomy and radiosonde 1 670 MHz to 1 710 MHz: Satellite downlink and radiosonde

Frequency MHz	Allocation/Use
1 718,8 to 1 722,2	Radio astronomy
2 200 to 2 300	Satellite downlink
2 300 to 2 450	Amateur radio services
2 310 to 2 390	Aeronautical flight test telemetry
2 655 to 2 900	2 655 MHz to 2 690 MHz: Radio astronomy and satellite downlink 2 690 MHz to 2 700 MHz: Radio astronomy
3 260 to 3 267	Spectral line observations (radio astronomy)
3 332 to 3 339	Spectral line observations (radio astronomy)
3 345,8 to 3 358	Spectral line observations (radio astronomy)
3 400 to 3 475	Amateur radio services
3 400 to 3 410	Satellite downlink
3 600 to 4 200	Satellite downlink
4 500 to 5 250	4 500 MHz to 4 800 MHz: Satellite downlink 4 800 MHz to 5 000 MHz: Radio astronomy 5 000 MHz to 5 250 MHz: Aeronautical radionavigation
5 650 to 5 950	Amateur radio services
6 650 to 6 675,2	Radio astronomy
7 250 to 7 750	Satellite downlink
8 025 to 8 500	Satellite downlink
10 000 to 10 500	Amateur radio services
104 50 to 10 500	Satellite downlink
10 600 to 12 700	10,6 GHz to 10,7 GHz: Radio astronomy 10,7 GHz to 12,2 GHz: Satellite downlink 12,2 GHz to 12,7 GHz: Direct broadcast satellite
14 470 to 14 500	Spectral line observations (radio astronomy)
15 350 to 15 400	Radio astronomy
17 700 to 21 400	Satellite downlink
21 400 to 22 000	Broadcast satellite (Region 1 and Region 2)
22 010 to 23 120	22,01 GHz to 22,5 GHz: Radio astronomy 22,5 GHz to 23,0 GHz: Broadcast satellite (Region 1) (22,81 GHz to 22,86 GHz is also radio astronomy) 23,0 GHz to 23,07 GHz: Fixed/intersatellite/mobile (used to fill in the gap between frequency bands) 23,07 GHz to 23,12 GHz: Radio astronomy
23 600 to 24 000	Radio astronomy
24 000 to 24 500	Amateur radio services
31 200 to 31 800	Radio astronomy
36 430 to 36 500	Radio astronomy
38 600 to 40 000	Radio astronomy
above 400 GHz	Numerous bands above 400 GHz are designated for radio astronomy, satellite downlink, etc.

Annex F
(informative)

Frequency bands allocated for safety-related radio services 15

Frequency MHz	Allocation/use
0,010 – 0,014	Radionavigation (Omega on board ships and aircraft only)
0,090 – 0,11	Radionavigation (LORAN-C and DECCA)
0,283 5 – 0,526 5	Aeronautical radionavigation (non-directional beacons)
0,489 – 0,519	Maritime safety information (coastal areas and shipboard only)
1,82 – 1,88	Radionavigation (LORAN-A region 3 only, coastal areas and on board ships only)
2,173 5 – 2,190 5	Mobile distress frequency
2,090 55 – 2,091 05	Emergency position indicating radio beacon (EPIRB)
3,021 5 – 3,027 5	Aeronautic mobile (search and rescue operations)
4,122 – 4,210 5	Mobile distress frequency
5,678 5 – 5,684 5	Aeronautic mobile (search and rescue operations)
6,212 – 6,314	Mobile distress frequency
8,288 – 8,417	Mobile distress frequency
12,287 – 12,579 5	Mobile distress frequency
16,417 – 16,807	Mobile distress frequency
19,68 – 19,681	Maritime safety information (coastal areas and shipboard only)
22,375 5 – 22,376 5	Maritime safety information (coastal areas and shipboard only)
26,1 – 26,101	Maritime safety information (coastal areas and shipboard only)
74,6 – 75,4	Aeronautical radionavigation (marker beacons)
108 – 137	Aeronautical radionavigation (108 MHz to 118 MHz VOR, 121,4 MHz to 123,5 MHz distress frequency SARSAT uplink, 118 MHz to 137 MHz air traffic control)
156,2 – 156,837 5	Maritime mobile distress frequency
242,9 – 243,1	Search and rescue (SARSAT uplink)
328,6 – 335,4	Aeronautical radionavigation (ILS glideslope indicator)
399,9 – 400,05	Radionavigation satellite
406 – 406,1	Search and rescue (emergency position-indicating radio beacon (EPIRB), SARSAT uplink)
960 – 1 238	Aeronautical radionavigation (TACAN), air traffic control beacons
1 300 – 1 350	Aeronautical radionavigation (long range air search radars)
1 544 – 1 545	Distress frequency SARSAT downlink (1 530 MHz to 1 544 MHz mobile satellite downlink may be pre-empted for distress purposes)
1 545 – 1 559	Aeronautical mobile satellite (R)
1 559 – 1 610	Aeronautical radionavigation (GPS)
1 610 – 1 625,5	Aeronautical radionavigation (radio altimeters)
1 645,5 – 1 646,5	Distress frequency uplink (1 626,5 MHz to 1 645,5 MHz mobile satellite uplink may be pre-empted for distress purposes)
1 646,5 – 1 660,5	Aeronautical mobile satellite (R)
2 700 – 2 900	Aeronautical radionavigation (terminal air traffic control radars)
2 900 – 3 100	Aeronautical radionavigation (radar beacons – coastal areas and shipboard only)
4 200 – 4 400	Aeronautical radionavigation (altimeters)
5 000 – 5 250	Aeronautical radionavigation (microwave landing systems)
5 350 – 5 460	Aeronautical radionavigation (airborne radars and beacons)
5 600 – 5 650	Terminal Doppler weather radar – wind shear
9 000 – 9 200	Aeronautical radionavigation (precision approach radars)
9 200 – 9 500	Radar transponders for maritime search and rescue. Maritime radar beacons and radionavigation radars. Airborne weather and ground mapping radar for airborne radionavigation, particularly under poor visibility conditions
13 250 – 13 400	Aeronautical radionavigation (Doppler navigation radars)

Annex G
(informative)

Frequency bands allocated for sensitive radio services

Frequency MHz	Allocation/Use
0,135 7 – 0,137 8	Amateur Radio Service
0,472 – 0,479	Amateur Radio Service
1,80 – 2,00	Amateur Radio Service
3,50 – 4,00	Amateur Radio Service
5,25 – 5,45	Amateur Radio Service
7,00 – 7,30	Amateur Radio Service
10,100 – 10,150	Amateur Radio Service
13,36 – 13,41	Radio astronomy
14,00 – 14,35	Amateur Radio Service
18,068 – 18,168	Amateur Radio Service
21,00 – 21,45	Amateur Radio Service
24,89 – 24,99	Amateur Radio Service
25,5 – 25,67	Radio astronomy
28,00 – 29,7	Amateur Radio Service
29,3 – 29,55	Satellite downlink (Amateur Radio Satellite Service)
37,5 – 38,25	Radio astronomy
50 – 54	Amateur Radio Service
70,0 – 70,5	Amateur Radio Service
73 – 74,6	Radio astronomy
137 – 138	Satellite downlink
144 – 146	Amateur Radio Service
145,8 – 146	Satellite downlink (Amateur Radio Satellite Service)
149,9 – 150,05	Radionavigation satellite downlink
240 – 285	Satellite downlink
322 – 328,6	Radio astronomy
400,05 – 400,15	Standard frequency and time signal
400,15 – 402	Satellite downlink
402 – 406	Satellite uplink 402,5 MHz
406,1 – 410	Radio astronomy
430 – 440	Amateur Radio Service
435 – 438	Satellite downlink (Amateur Radio Satellite Service)
608 – 614	Radio astronomy
1 215 – 1 240	Satellite downlink
1 240 – 1 300	Amateur Radio Service
1 260 – 1 270	Satellite uplink
1 350 – 1 400	Spectral line observation of neutral hydrogen (radio astronomy)
1 400 – 1 427	Radio astronomy
1 435 – 1 530	Aeronautical flight test telemetry
1 530 – 1 559	Satellite downlink
1 559 – 1 610	Satellite downlink
1 610,6 – 1 613,8	Spectral line observations of OH radical (radio astronomy)
1 660 – 1 710	1 660 MHz to 1 668,4 MHz: Radio astronomy 1 668,4 MHz to 1 670 MHz: Radio astronomy and radiosonde 1 670 MHz to 1 710 MHz: Satellite downlink and radiosonde
1 718,8 – 1 722,2	Radio astronomy

Frequency bands allocated for sensitive radio services *(list continued)*

Frequency MHz	Allocation/Use
2 200 – 2 300	Satellite downlink
2 320 – 2 450	Amateur Radio Service
2 310 – 2 390	Aeronautical flight test telemetry
2 655 – 2 900	2 655 MHz to 2 690 MHz: Radio astronomy and satellite downlink 2 690 MHz to 2 700 MHz: Radio astronomy
3 260 – 3 267	Spectral line observations (radio astronomy)
3 332 – 3 339	Spectral line observations (radio astronomy)
3 345,8 – 3 358	Spectral line observations (radio astronomy)
3 400 – 3 475	Amateur Radio Service
3 400 – 3 410	Satellite downlink
3 600 – 4 200	Satellite downlink
4 500 – 5 250	4 500 MHz to 4 800 MHz: Satellite downlink 4 800 MHz to 5 000 MHz: Radio astronomy 5 000 MHz to 5 250 MHz: Aeronautical radionavigation
5 650 – 5 950	Amateur Radio Service
7 250 – 7 750	Satellite downlink
8 025 – 8 500	Satellite downlink
10 000 – 10 500	Amateur Radio Service
104 50 – 10 500	Satellite downlink
10 600 – 12 700	10,6 – 10,7 GHz: Radio astronomy 10,7 – 12,2 GHz: Satellite downlink 12,2 – 12,7 GHz: Direct broadcast satellite
14 470 – 14 500	Spectral line observations (radio astronomy)
15 350 – 15 400	Radio astronomy
17 700 – 21 400	Satellite downlink
21 400 – 22 000	Broadcast satellite (Region 1 and Region 2)
22 010 – 23 120	22,01 GHz to 22,5 GHz: Radio astronomy 22,5 GHz to 23,0 GHz: Broadcast satellite (Region 1) (22,81 GHz to 22,86 GHz is also radio astronomy) 23,0 GHz to 23,07 GHz: Fixed/intersatellite/mobile (used to fill in the gap between frequency bands) 23,07 GHz to 23,12 GHz: Radio astronomy
23 600 – 24 000	Radio astronomy
24 000 – 24 500	Amateur Radio Service
31 200 – 31 800	Radio astronomy
36 430 – 36 500	Radio astronomy
38 600 – 40 000	Radio astronomy
above 400 GHz	Numerous bands above 400 GHz are designated for radio astronomy, satellite downlink, etc.

Annex H
(informative)

Statistical assessment of series produced equipment against the requirements of CISPR standards 16

H.1 Significance of a CISPR limit

A CISPR limit is a limit which is recommended to national authorities for incorporation in national standards, relevant legal regulations and official specifications. It is also recommended that international organizations use these limits. The significance of the limits for *type approved* appliances shall be that on a statistical basis at least 80 % of the mass-produced appliances comply with the limits with at least 80 % confidence.

The assessment of conformity of equipment tested on a test site shall be based on measurement results obtained in accordance with the specifications of Clause 7. For equipment in series production, there shall be 80 % confidence that at least 80 % of manufactured items comply with the limits given (compliance criterion), see CISPR 16-4-3. Statistical assessment procedures providing such a confidence level are specified in H.3.1, H.3.2 and H.3.3.

NOTE When applying another statistical assessment procedure than one of those referred to above or specified in CISPR 16-4-3, the user of this standard can be invited to show evidence that the compliance criterion set out above is also met when applying this other method.

Measurement results obtained for an equipment measured in its place of use and not on a test site shall be regarded as relating to that installation only, and shall not be considered representative of any other installation and so shall not be used for the purpose of a statistical assessment.

H.2 Type tests

As a rule, the positive result of a *type test* on a given appliance according to the respective CISPR standard will be recognized as *approval of the type* if the type test was performed

H.2.1 either on a sample of appliances of the type using one of the statistical methods of evaluation in accordance with H.3,

H.2.2 or, for simplicities sake, on one appliance only. In this case subsequent tests are necessary from time to time on appliances taken at random from the production line.

NOTE Recognition of a *type test* made on only one appliance of series-produced equipment as *type approval* may depend on national or regional regulation. National or regional authorities may rely on different quality assurance systems to be maintained by the manufacturer. Consult respective national or regional regulations.

H.3 Statistical assessment of series produced equipment

H.3.1 Assessment based on a general margin to the limit

The assessment is positive when the measured values from all items of the sample are under the limit L, and the margin to that limit is not smaller than the general margin given in Table H.1 below.

Table H.1 – General margin to the limit for statistical evaluation

Sample size (n)	3	4	5	6
General margin to the limit (dB)	3,8	2,5	1,5	0,7

This method can be used to get a quick final pass-decision. If the conditions are not fulfilled, this does not yet mean that a product is non-compliant. To determine non-compliance, the measured results shall be evaluated by one of the methods in H.3.2. (use of non-central t-distribution) or H.3.3 (use of binomial distribution).

NOTE The newly introduced method in this subclause is based on CISPR 16-4-3.

The values in Table H.1 have been calculated with the following methodology: Compliance is given, when

$$x_{max} + k_E \sigma_{max} \leq L$$

where

x_{max} is the highest (worse) measured value of all items in the sample;

k_E is the coefficient from the table below, depending on the sample size;

σ_{max} is a conservative value for the expected maximum standard deviation in a product group, and which is calculated as 2 times the expected standard deviation;

L is the limit specified in this standard.

The quantities x, L and σ_{max} are expressed in logarithmic terms while k_E, as an ordinary factor, is given in absolute numerical value, see table in this NOTE.

Sample size (n)	3	4	5	6
Coefficient k_E	0,63	0,41	0,24	0,12

CISPR 16-4-3 recommends a value σ_{max} = 6,0 dB for both the disturbance voltage and the disturbance power. For radiated disturbances, measured on equipment in the scope of this standard, the same value for σ_{max} has been assumed. The values for the general margin to the limit in Table H.1 above are a simple multiplication of this 6,0 dB with the coefficient k_E. In Table H.1 values are given only for a sample size up to n = 6 because for n = 7 or higher the method given in H.3.3 can be applied, where the binomial distribution without an additional margin is used.

H.3.2 Assessment based on the non-central t-distribution

H.3.2.1 Normal procedure

The measurements shall be performed on a sample of not less than five and not more than 12 pieces of equipment of the type in series production, but if in exceptional circumstances five pieces of equipment are not available a sample of three or four may be used.

NOTE The assessment made on a sample of the measurement results obtained for a sample of size n relates to all identical units and allows for the variations that can be expected to arise due to quantity production techniques.

Compliance is achieved when the following relationship is met:

$$\overline{X} + kS_n \leq L$$

where

$\overline{X}$ is the arithmetic mean value of the disturbance levels of n items of equipment in the sample;

S_n is the standard deviation of the sample where

$$S_n^2 = \frac{1}{n-1} \times \sum \left(X - \overline{X} \right)^2$$

X is the disturbance level of an individual equipment;

L is the permitted limit;

k is the factor derived from tables of the non-central t-distribution which ensures with 80 % confidence that 80 % or more of the production is below the limit. Values of k as a function of n are given in Table H.2.

$\bar{X}$, X and L are expressed logarithmically: dB(μV), dB(μV/m) or dB(pW).

S_n is expressed in logarithmic term, i.e. in dB.

Table H.2 – The non-central t-distribution factor k as a function of the sample size n

n	3	4	5	6	7	8	9	10	11	12
k	2,04	1,69	1,52	1,42	1,35	1,30	1,27	1,24	1,21	1,20

H.3.2.2 Extended procedure

When applying the procedure as in H.3.2.1 a given sample of equipment which causes fluctuating disturbances may fail to meet the compliance criterion. In such cases the extended assessment procedure defined in this clause can be used.

The statistical assessment shall be carried out separately for the following frequency subranges:

Conducted disturbances:
a) 150 kHz to 500 kHz
b) 500 kHz to 5 MHz
c) 5 MHz to 30 MHz

Radiated disturbances below 1 GHz:
a) 30 MHz to 230 MHz
b) 230 MHz to 500 MHz
c) 500 MHz to 1 000 MHz

Radiated disturbances above 1 GHz:
a) 1,0 GHz to 4,5 GHz
b) 4,5 GHz to 18 GHz

NOTE For group 2 equipment, there may be no need to fully or continuously cover the frequency subranges defined above, see respective information in 6.3.2.4, Table 13.

Compliance of the sample is judged from the following modified relationship:

$$\bar{X} + kS_n \le 0$$

The value of k depends on the sample size n and is stated in Table H.2 above.

For determination of compliance, the standard deviation formula as in H.3.2.1 shall be used:

$$S_n^2 = \frac{1}{n-1} \times \sum \left(X - \bar{X}\right)^2$$

where

$\bar{X}$ is the arithmetic mean value of the disturbance levels of n items of equipment in the sample;

X is the margin of the disturbance level of an individual item of equipment to the respective limit. X is to be determined as follows: for each of the defined frequency ranges, the margins between the measured values (readings) and the limit are defined. The resulting margin X is negative where the measured value is below the limit, and positive, where it is higher than the limit. For the n^{th} individual item of the sample, X_n is the value of the margin at the frequency where the margin curve shows its maximum.

NOTE If all measured values are below the limit, X_n is the smallest margin to the limit. If some of the measured values are above the limit, X_n is the largest margin by which the limit is exceeded.

X, $\bar{X}$ and S_n are expressed logarithmically, i. e. in dB.

If all measured values are below the limit and the statistical assessment failed only due to a high standard deviation, it shall be investigated whether this high standard deviation has been unjustifiably caused by a maximum of X_n at the borderline between two frequency subranges. In this case the assessment can be done according to H.3.3.

NOTE The Figure H.1 below illustrates the possible difficulties if a maximum of the measured disturbances occurs near the borderline between two frequency sub-ranges. "U" is the measured disturbance voltage; "f" is the frequency. Here two units with different characteristics out of a sample are shown. For broadband disturbances the value of the maximum as well as the frequency of the maximum can change from unit to unit, differences as between unit 1 and unit 2 in a sample are typical. An average value and standard deviation is calculated for all units (of which two are shown) for each subrange. In this example the calculated standard deviation is much higher for subrange 1 than subrange 2 (e.g. consider how different the values of X_1 and X_2 are at the borderline). Even though the average for subrange 1 is much lower than subrange 2, after taking into consideration the high value of S_n multiplied by the factor out of Table H.2, in rare cases this could lead to the sample set failing the given criteria. Since this is simply a consequence of the way in which the frequency subranges have been defined, no statistically meaningful conclusion can be drawn regarding compliance.

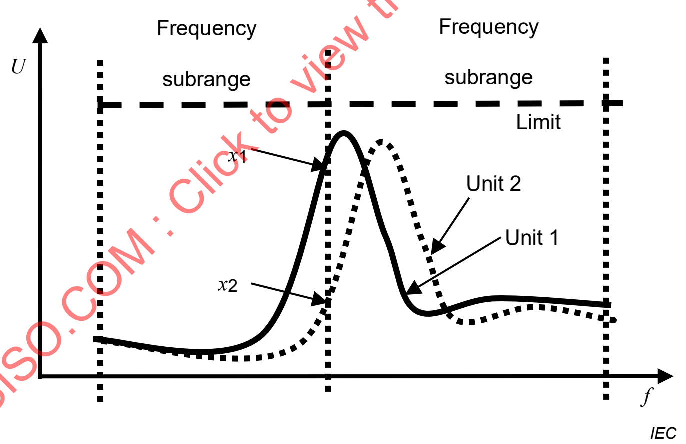


Figure H.1 – An example of possible difficulties

H.3.3 Assessment based on the binomial distribution

Compliance is judged from the condition that the number of appliances with a disturbance level above the appropriate limit may not exceed a number of c in a sample of total size n, see Table H.3.

Table H.3 – Application of the binomial distribution

Sample size (n)	7	14	20	26	32
Number of samples c exceeding the limit L	0	1	2	3	4

H.3.4 Equipment produced on an individual basis

All equipment not produced in series shall be tested on an individual basis. Each individual item of equipment is required to meet the limits when measured by the methods specified.

Annex I
(normative)

Artificial Network (AN) for the assessment of disturbance voltages at d.c. power ports of semiconductor power converters 17

I.1 General information and purpose

The artificial network for the assessment of disturbance voltages at d.c. power ports (DC-AN) provides a defined common mode (CM) 150 Ω termination impedance for the d.c. power port of the power converter under test during measurements of conducted RF disturbances at standardized test sites. It is constructed to provide, in the intended frequency range from 150 kHz to 30 MHz, well defined termination impedances for symmetric (or differential mode – DM) as well as asymmetric (or common mode – CM) disturbance components. The values of these termination impedances are specified in Clause I.4.

Further, the DC-AN is furnished with a decoupling network (i.e. an LC-filter) such that sufficient decoupling is provided between its EUT port and its AE port, in order to prevent RF disturbances from the laboratory d.c. power source to affect obtained measuring results. Having asymmetric decoupling capacitors with some 100 nF to about 1 µF capacitance only the construction of that filter prevents, in most cases, saturation effects in mitigation filters the power converters may be furnished with and this way provides for valid, reliable and repeatable measurement results.

I.2 Structures for a DC-AN

I.2.1 AN suitable for measurement of unsymmetrical mode (UM) disturbances

Similar to the V-AMN, the AN shall allow for measurement of the unsymmetrical mode disturbance voltage level at a single terminal (or conductor or pole, respectively) of the EUT's d.c. power port under test, relative to laboratory reference ground. An appropriate AN would hence be e.g. a pseudo V-AN, a kind of delta network. For layout and design, the principles set out in CISPR 16-1-2 shall be observed. A circuit diagram of a suitable Delta-network is found in Figure I.1.

NOTE Due to constraints in design of true V-ANs for a certain defined ratio of the DM to CM termination impedance, construction of a pseudo V-AN may require use of a third shunting resistor connecting to the two power terminals of the EUT port of the AN. Such shunting resistors as R_2 in Figure I.1 or R_3 in Figure I.4 do not have any impact on the required DM and CM termination impedances and provide for these termination impedances also during measurement of UM disturbance voltages. For calculation of the termination impedance for UM disturbance voltages the delta-to-star conversion formula for resistor networks can be used. Further, these termination impedances can also be measured directly at the EUT power terminals of the AN in relation to common ground in using an appropriate network analyser. Distinction in V- and Delta-ANs is kept for traditional reasons only. UM disturbance voltages can also easily be measured with Delta-ANs when they are furnished with respective measuring ports.

I.2.2 AN suitable for measurement of common mode (CM) and differential mode (DM) disturbances

A Delta-AN shall allow for measurement of the symmetric (or differential mode – DM) disturbance voltage level between (any) two terminals different from those at ground potential (or conductors or poles, respectively) of the EUT's d.c. power port under test. It shall further allow for measurement of the asymmetric (or common mode – CM) disturbance voltage level at the virtual common HF junction of two (or more) terminals (or conductors or poles, respectively) of the EUT’s d.c. power port under test, relative to laboratory reference ground. For layout and design, the principles set out in CISPR 16-1-2 shall be observed. An example of a suitable Delta-network is found e.g. in CISPR 16-1-2:2014, Clause A.6 Figure A.2. This figure is also replicated in Figure I.2.

I.2.3 AN suitable for measurement of UM, CM and DM disturbances

As an option the Delta-AN may also provide for the measurement of the unsymmetrical mode disturbance voltage level at a single terminal (or conductor or pole, respectively) of the EUT's d.c. power port, relative to laboratory reference ground, just like a V-network. For layout and design, the principles set out in CISPR 16-1-2 shall be observed. Examples for practical implementations of combined pseudo V- and Delta-ANs of several manufacturers are given in Figure I.3 to Figure I.5.

I.3 Employment of DC-ANs for compliance measurements

I.3.1 General

For the measurements, pseudo V-ANs as well as Delta-ANs meeting the requirements in I.4 can be used. Other artificial networks specified in CISPR 16-1-2 can also be used if providing an asymmetric or common mode (CM) 150 Ω termination for the port under test to laboratory reference ground, and if being furnished with an appropriate low CM-blocking capacity decoupling LC-filter.

NOTE Presently the 150 Ω artificial mains V-network specified in CISPR 16-1-2:2014, 4.5 cannot be used for measurements of conducted disturbances at LV d.c. power ports, since providing a common mode termination impedance of 75 Ω only. Such a V-network does not meet the most essential technical parameter specified in Table I.1 Pos. 3, i.e. the value of 150 Ω, for the common mode termination impedance. Negotiations in definition of systematic corrections for measurement results obtained in use of such networks have not been started yet.

Selection of the type of AN is left to the user of this standard. Each type of AN provides for measurement results which have the same confidence level as results obtained when using the established V-network. Information on aspects of measurement uncertainty in respect of artificial mains networks (AMN) is found in CISPR 16-4-2:2011, Clause 4. This information is also valid when employing DC-ANs which comply with the specification in I.4.

If a combined AN is used, then it suffices to just apply it either for measurement of unsymmetrical mode (UM), or for measurement of both, common mode (CD) and differential mode (DM) disturbances.

In any case the assessment of the RFI potential of a given port under test in the frequency range 150 kHz to 30 MHz is only completed, if measurement results were obtained and recorded either for the two composite unsymmetrical mode (UM) disturbance components, or for both, the asymmetric or common mode (CM) and the symmetric or differential mode (DM) disturbance components as well.

I.3.2 Pseudo V-AN

In the pseudo V-network an assessment of these components is only possible in combination as composite unsymmetrical mode (UM) disturbance voltages, the level of which can be different for each terminal of the given port under test, due to internal HF imbalance of the EUT to common ground. These are the “classical” terminal disturbance voltages which can be compared with the established limits directly and which hence constitute the established EMC requirements, for example for a.c. mains ports.

Compliance with the limits is verified only where both measured unsymmetrical mode (UM) disturbance voltage levels are equal to or less than the respective limit.

I.3.3 Delta-AN

In the Delta-network asymmetric or common mode (CM) and symmetric or differential mode (DM) disturbance components can be measured and assessed separately, for each port under test.

Compliance with the limits is verified only where both, the measured common mode (CM) disturbance voltage level and the measured differential mode (DM) disturbance voltage level are equal to or less than the respective limit.

I.4 Normative technical requirements for the DC-AN

I.4.1 Parameters and associated tolerances in the range 150 kHz to 30 MHz

Table I.1 – Parameters and associated tolerances in the range 150 kHz to 30 MHz

Pos.	Description of the parameter	Nominal value and tolerance
1	Type of the DC-AN	Delta-network suitable for measurements at one d.c. power string or port (plus pole, minus pole and reference ground)
2	Calibrated frequency range	150 kHz to 30 MHz (measurement range)
3	CM termination impedance at the EUT port, magnitude	(150 ± 30) Ω
4	CM termination impedance at the EUT port, phase	(0 ± 40)°
5	DM termination impedance at the EUT port, magnitude	(150 ± 30) Ω
6	DM termination impedance at the EUT port, phase	(0 ± 40)°
7	Longitudinal conversion loss (LCL) at the EUT port [a]	≥ 26 dB (symmetrical 150 Ω system) (measured according to CISPR 16-1-2)
8	CM insertion loss AE port – EUT port	≥ 20 dB (asymmetrical 50 Ω system)
9	DM insertion loss AE port – EUT port	≥ 20 dB (symmetrical 150 Ω system) > 40 dB, with external capacitor
10	Discharge resistors for decoupling capacitors in the d.c. current path	≥ 1,5 MΩ

[a] The LCL of the AN should be significantly larger than the internal LCL of the EUT. During the measurement of unsymmetrical disturbance voltages only disturbance components from internal mode conversion DM to CM in the EUT need to be assessed. The statistical mean value of the LCL of installed PV generators has already been taken into account when determining the limits for the DC power input port of GCPCs.

NOTE The parameters in Table I.1 have been derived in developing modern implementations of the 150 Ω CISPR network described in CISPR 16-1-2 for use with measurements at low voltage d.c. power ports of GCPCs for photovoltaic power generating systems.

Measuring ports shall be protected from low frequency components of voltage transients appearing when switching the laboratory d.c. power source on and off. Furthermore, secure galvanic connection shall be guaranteed to the AN's ground in order to drain transient discharge currents through the coupling capacitors when switching the laboratory source off.

Decoupling capacitors in the d.c. current path shall be bypassed with high resistance discharge resistors, see position 10.

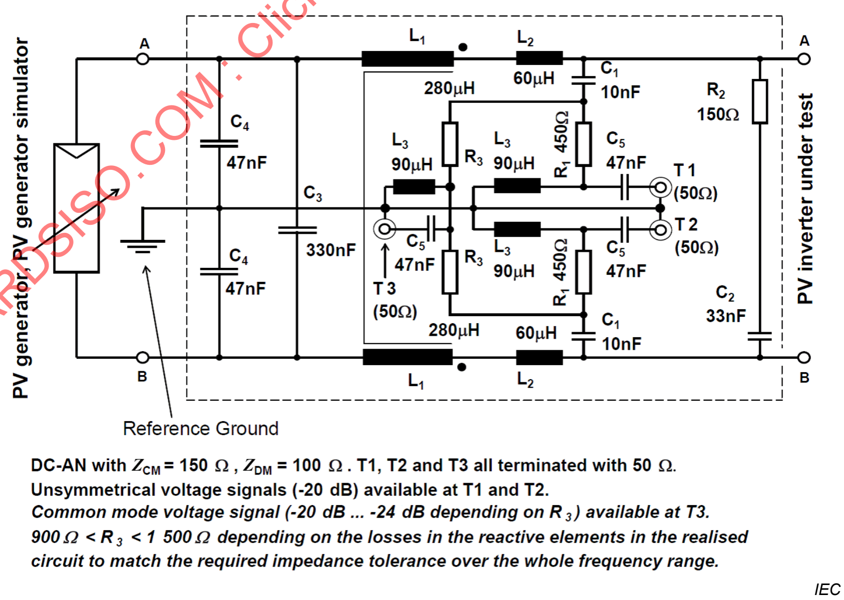
I.4.2 Parameters and associated tolerances in the range 9 kHz to 150 kHz

Table I.2 – Parameters and associated tolerances in the range 9 kHz to 150 kHz

Pos.	Description of the parameter	Nominal values and tolerances
2	Extended frequency range	9 kHz – 150 kHz (includes the operation frequency of GCPCs)
3	CM termination impedance at the EUT port, magnitude	≥ 10 Ω (AE port open)
4	CM termination impedance at the EUT port, phase	not specified
5	DM termination impedance at the EUT port, magnitude	≥ 1 Ω (AE port open)
6	DM termination impedance at the EUT port, phase	not specified
7	Longitudinal conversion loss (LCL) at the EUT port	≥ 26 dB, in the range 10 kHz to 150 kHz (symmetrical 150 Ω system) (measured according to CISPR 16-1-2)
8	CM insertion loss of AE port to EUT port	≥ 20 dB at 150 kHz (asymmetrical 50 Ω system), decreasing with decreasing frequency with 40 dB/decade
9	DM insertion loss of AE port to EUT port	≥ 20 dB at 150 kHz > 40 dB with external capacitor (symmetrical 150 Ω system), decreasing with decreasing frequency with 40 dB/decade

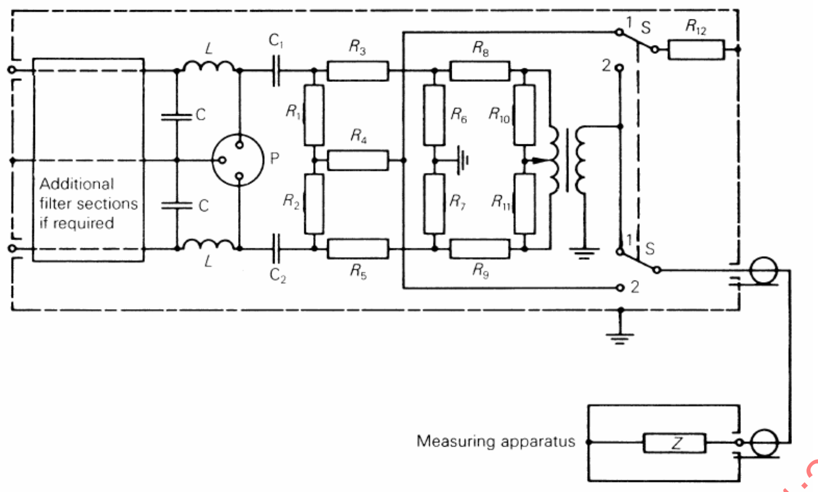
NOTE The parameters in Table I.2 have been derived in developing modern implementations of the 150 Ω CISPR network described in CISPR 16-1-2 for use with measurements at low voltage d.c. power ports of GCPCs for photovoltaic power generating systems.

I.5 Examples of practical implementations of DC-ANs



NOTE Measuring port T3 can be used for measurement of asymmetric or common mode (CM) disturbance components.

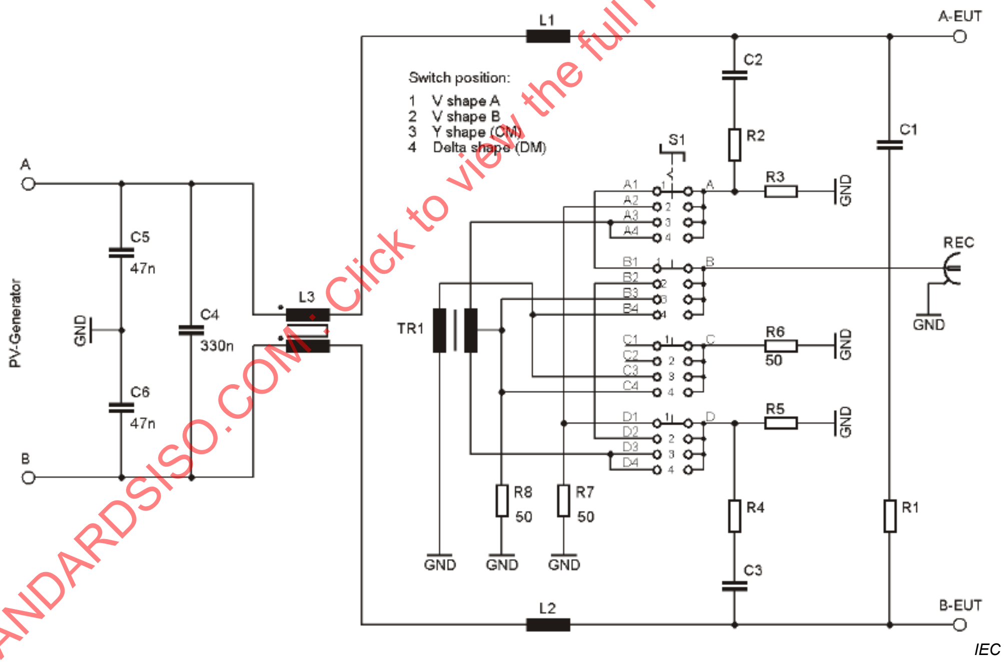
Figure I.1 – Practical implementation of a 150 Ω DC-AN suitable for measurement of UM disturbances (Example)



P is the connection for apparatus under test
1 for the symmetrical component
2 for the asymmetrical component

IEC

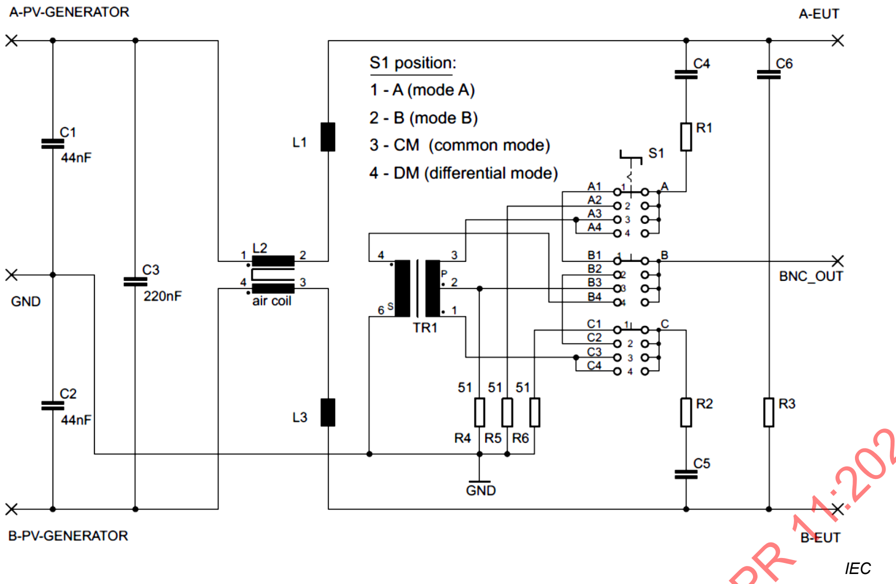
~~**Figure I.2 – Practical implementation of a 150 Ω DC-AN suitable for measurement of CM and DM disturbances (Example, see also Figure A.2 in CISPR 16-1-2:2014)**~~



IEC

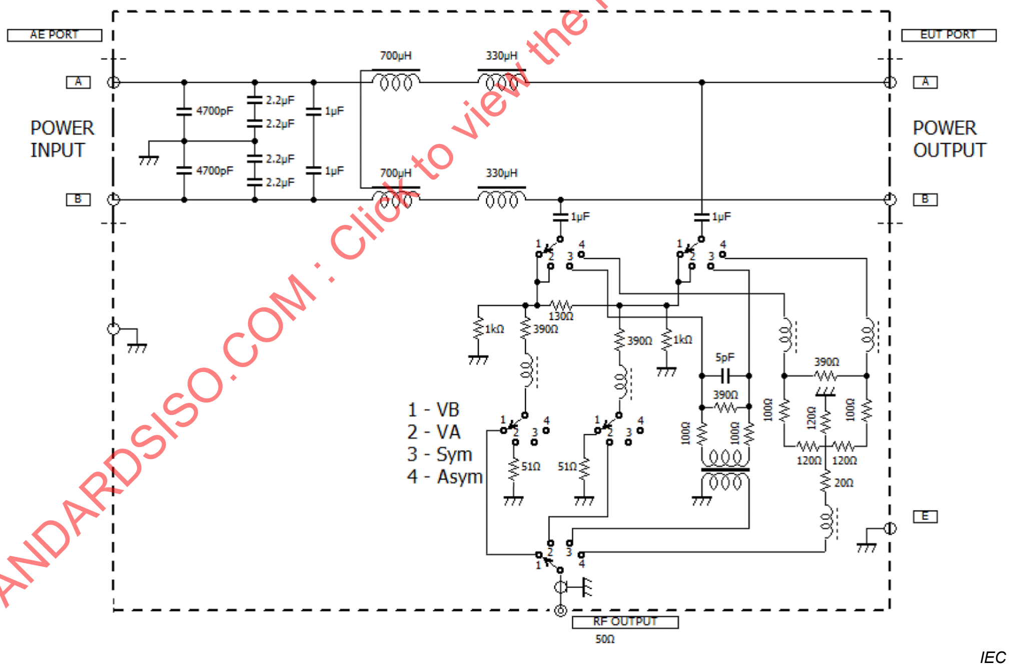
~~NOTE Mode 1 and mode 2 represent employment of the artificial network for measurement of unsymmetrical mode (UM) or "terminal" disturbance voltages.~~

~~**Figure I.3 – Practical implementation of a 150 Ω DC-AN suitable for measurement of UM, or CM and DM disturbances (Example 1)**~~



NOTE Mode A and mode B represent employment of the artificial network for measurement of unsymmetrical mode (UM) or "terminal" disturbance voltages.

Figure I.4 – Practical implementation of a 150 Ω DC-AN suitable for measurement of UM, or CM and DM disturbances (Example 2)



NOTE Mode 1 and mode 2 represent employment of the artificial network as pseudo V-network, i.e. for measurement of unsymmetrical or "terminal" disturbance voltages. In use as pseudo V-network, i.e. in mode 1 or mode 2 the DM termination impedance is 100 Ω. In use as Delta-network, i.e. in mode 3 and mode 4, the DM termination impedance is 150 Ω.

Figure I.5 – Practical implementation of a 150 Ω DC-AN suitable for measurement of UM, or CM and DM disturbances (Example 3)

Annex D
(informative)

Measurements on Grid Connected Power Converters (GCPC) – Setups for an effective test site configuration

D.1 General information and purpose

For measurement of disturbance terminal voltages on grid connected power converters (GCPC) intended for supply of electric energy into AC mains grids and similar AC mains installations (see Definition 3.1.15), connection to an appropriate laboratory DC power supply is necessary on the DC input side of the GCPC, while connection to an appropriate laboratory AC power source or AC mains grid is necessary on the AC output side.

The DC power is fed into the DC input power ports of the GCPC, and not consumed in the GCPC, and so almost completely converted to AC power and output to the AC side. If the AC power output from the GCPC is not consumed by a resistive load etc., the AC power current can reversely be carried into the laboratory AC power source, and so the equipment ~~may~~ can be damaged. In addition, there are some countries where reverse power flow into the AC mains is restricted or prohibited by national law and regulations. Thus, the global setup of the test site used for the measurements needs attention, and a proper and appropriate setup ~~may~~ can even enable simplification of the test arrangement and configuration for the equipment under test (EUT). Examples of suitable setups for the test site are described below.

D.2 Setup of the test site

D.2.1 Block diagram of test site

The measurement arrangement and configuration for the EUT can be simplified by use of a test site having a configuration as shown in Figure D.1 or in Figure D.2. For this setup, the AC output of the GCPC is connected to the AC input of the laboratory DC power supply through the V-AMN used in the measurement arrangement. The laboratory DC power supply converts AC power into DC power, and it is supplied to the DC input of the GCPC. Thus, the current circulates from the AC output to the DC input of the GCPC. The advantages of this site configuration are that the DC power supply consumes the AC output power of the GCPC, and so a resistive load is not required to prevent AC power currents from flowing into the laboratory AC power source.

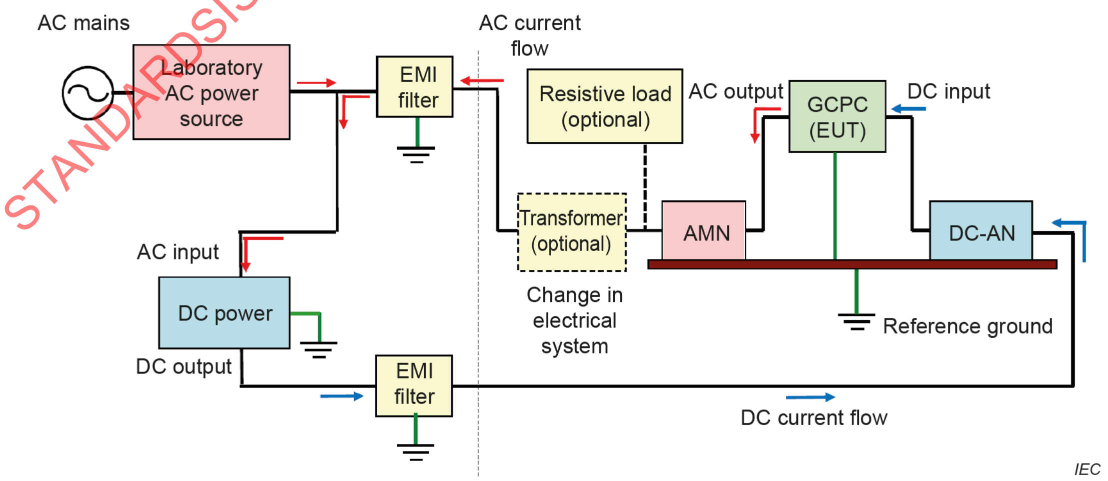
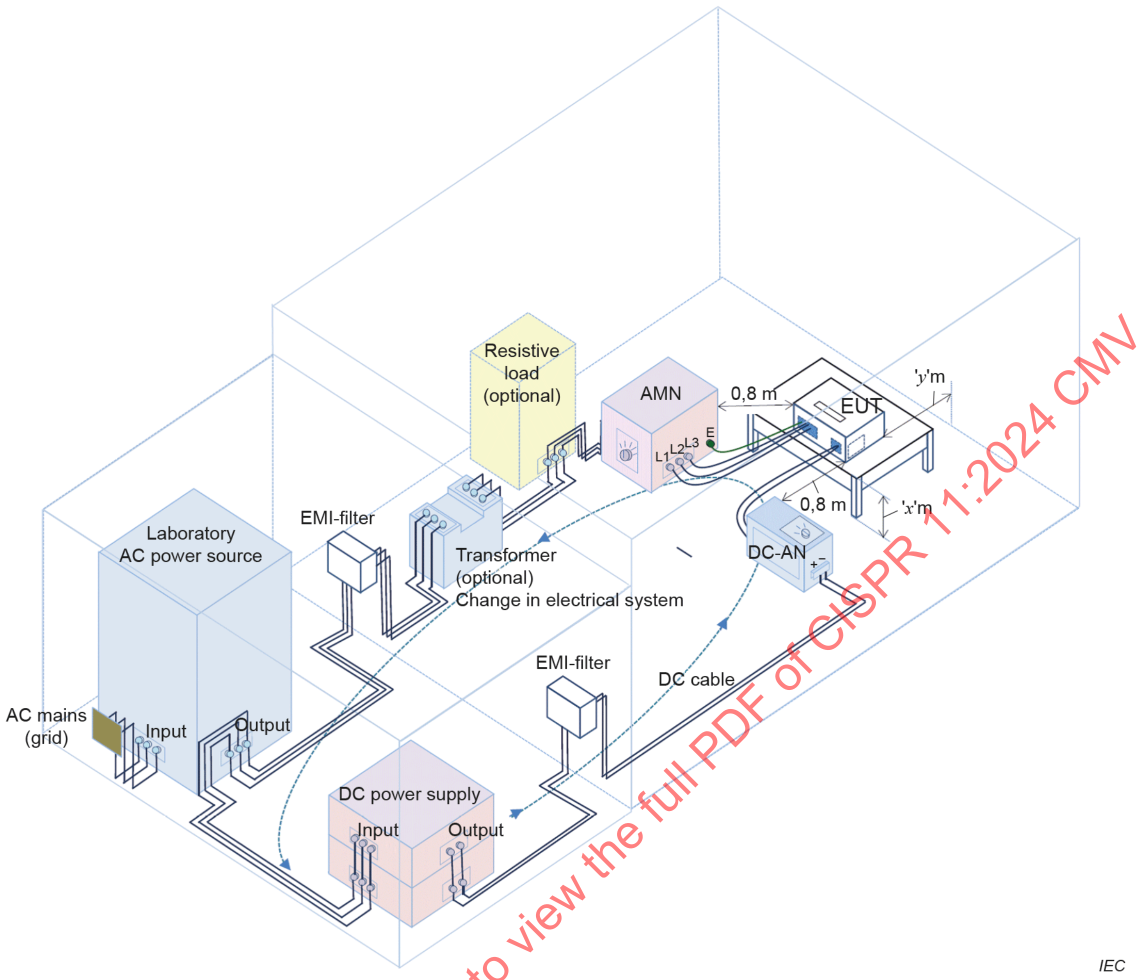


Figure D.1 – ~~Setup of the test site (Case 1) – 2D diagram~~ Test setup for Case 1 (schematic)



NOTE The distances defined as '*x*' and '*y*' in the diagram refer to those as detailed in CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017, 7.4.1.

Figure D.2 – ~~Setup of the test site (Case 1) – 3D diagram~~ Test setup for Case 1 (3D view)

Consequently, the laboratory AC power source ~~needs to~~ shall provide only the total power losses in the test arrangement, once the measurements are started. Because the laboratory AC power source is used, its AC voltage and frequency can easily be adjusted conforming to the specifications for the AC output side of the GCPC. Reverse AC power current does not flow into the AC power source, and so it cannot be damaged.

D.2.2 DC power supply

The laboratory's DC power supply shall have enough output power to operate the GCPC at its rated AC output power. In addition, a control for adjusting properly its DC output voltage is necessary. In case of the test ~~site~~ setup as shown in Figure D.1 or in Figure D.2, the electrical system of AC input to the DC power supply shall match with that of the AC output of the GCPC.

D.2.3 AC power source

The laboratory's AC power source shall be of the CVCF-type (constant voltage constant frequency type) such that it can adjust to the nominal AC output power voltage and frequency of the GCPC under test. In case of the setup as shown in Figure D.1 or in Figure D.2, its power is only just enough to supply the total power losses in the test arrangement, and so a larger power is unnecessary.

D.2.4 Other components

In many cases the DC power supply itself is provided with filters on the input and output side. As shown in Figure D.1 or in Figure D.2, additional EMI filters can be placed on the input and output side of the DC power supply to mitigate conducted disturbances which are generated.

In case the electrical systems of the AC output of the GCPC, the AC input of the DC power supply and the output of the AC power source do are not accord like of the same type such as single phase-three-wire, or single phase-two-wire system, a proper transformer shall be inserted as shown in Figure D.1 or in Figure D.2 to appropriately convert the electrical systems.

D.3 Other test setups

D.3.1 Configuration comprising laboratory AC power source and resistive load

On the other hand, There are some cases where each electrical system cannot basically be matched, such as three-phase input of the DC power supply with a single phase AC output of the GCPC (EUT), etc. (There is also the reverse case). In such cases, the AC output of the GCPC cannot directly be connected to the AC input of the DC power supply as shown in Figure D.1 and Figure D.2. In this case, another resistive load is connected in parallel with the laboratory AC power source as shown in Figure D.3 and Figure D.4 and the AC power of the GCPC (EUT) shall be consumed by that resistive load. As a result, the resistive load prevents the AC output power current of the GCPC from flowing reversely into the laboratory AC power source, if it has enough power to exceed the maximum AC output power of the GCPC.

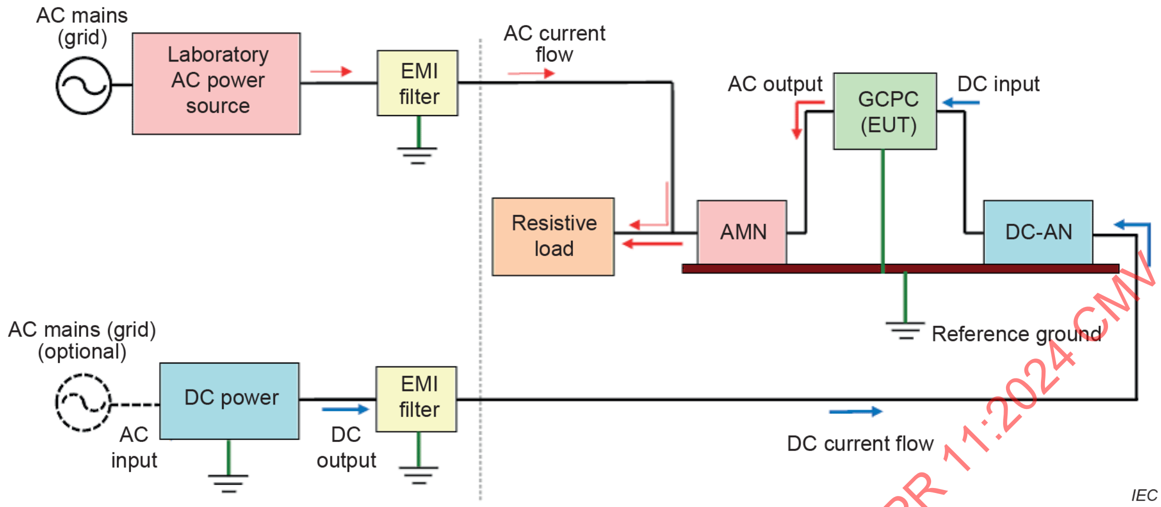
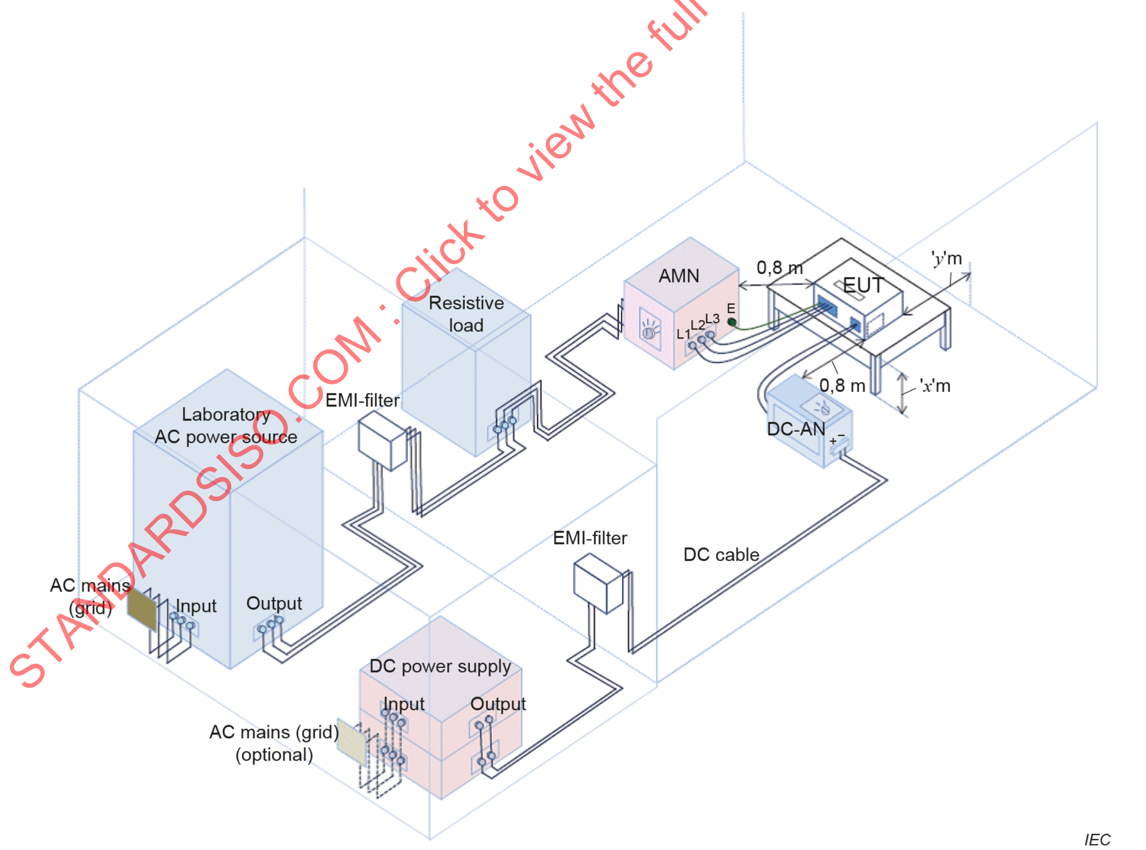


Figure D.3 – ~~Setup of the test site (Case 2) – 2D diagram~~ Test setup for Case 2 (schematic)



NOTE The distances defined as '*x*' and '*y*' in the diagram refer to those as detailed in CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017, 7.4.1.

Figure D.4 – ~~Setup of the test site (Case 2) – 3D diagram~~ Test setup for Case 2 (3D view)

D.3.2 Configuration with reverse power flow into the AC mains

This setup example shows the case where the laboratory AC power source (see Figure D.3 or Figure D.4) is not connected to the AC output side of the GCPC.

In case the AC output of the GCPC is connected to the AC mains through a filter as shown in Figure D.5 and Figure D.6, the AC output current of the GCPC flows to the AC mains, and therefore it is not required to connect the resistive load as shown in the previous setup, Case 2. But in this case, there is a disadvantage that the AC power voltage and frequency cannot be adjusted conforming to the specifications of the AC output side of the GCPC.

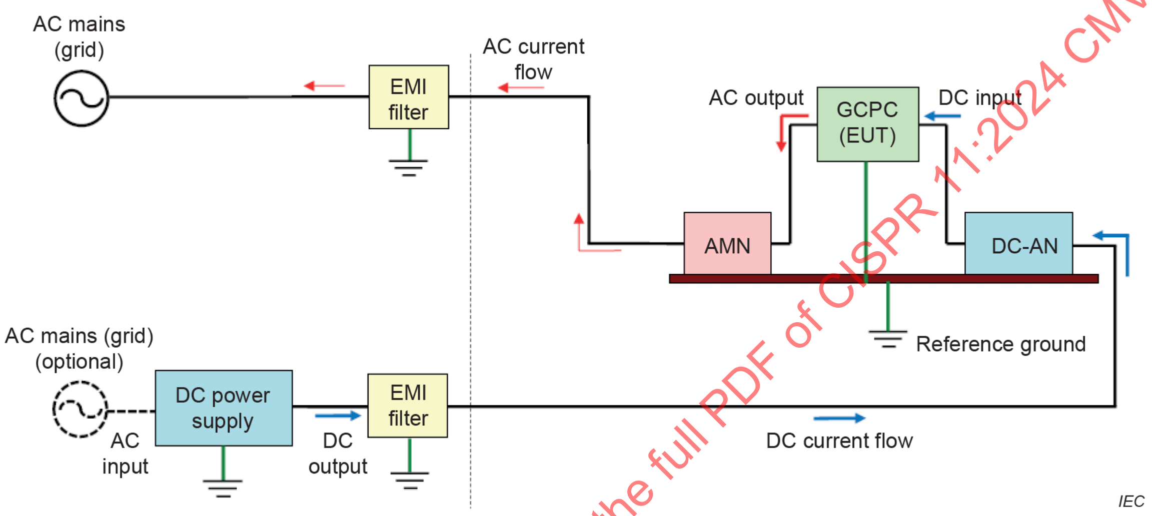
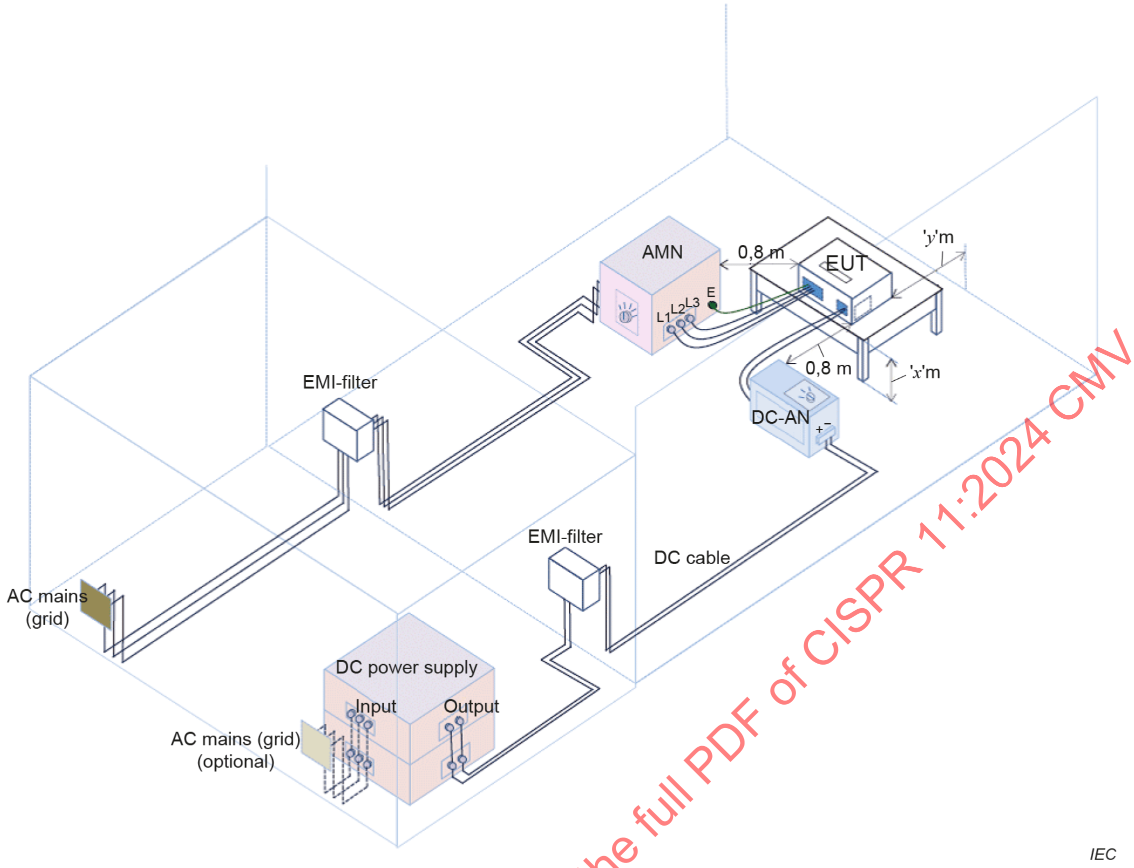


Figure D.5 – ~~Setup of the test site (Case 3) – 2D diagram~~ Test setup for Case 3 (schematic)



NOTE The distances defined as '*x*' and '*y*' in the diagram refer to those as detailed in CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017, 7.4.1.

Figure D.6 – ~~Setup of the test site (Case 3) – 3D diagram~~ Test setup for Case 3 (3D view)

Annex E
(informative)

~~Test site configuration and instrumentation –~~ Guidance on prevention of saturation effects in mitigation filters of transformer-less power converters during ~~type~~ tests ~~according to this standard~~

E.1 General information and purpose

Most types of power converters use operation or switching frequencies in the range of a couple of 100 Hz up to 25 kHz. The measurement results obtained in the range of interest (150 kHz to 30 MHz) are sometimes seriously invalidated by the effective total common mode (CM) impedance of the whole DC power supply chain in the test environment in the range of about 500 Hz to 150 kHz. If the operation frequency of the power converter under test coincides with the frequency of the series resonance dip(s) in the effective total common mode (CM) impedance in the whole laboratory DC power supply chain, excessive CM disturbance currents ~~may~~ can appear at the operation frequency and ~~may~~ can saturate the built-in EMI filters (as e.g. common mode chokes) in the EUT. Consequently, it will cause serious performance degradation of the filters in the measuring frequency range 150 kHz to 30 MHz. Performance degradation of the filters means that excessive RF disturbance levels will be recorded causing the power converter under test eventually to FAIL proving compliance with the requirements specified in this document.

It ~~shall~~ can be said that such mode of operation of power converters prominently deviates from the operation conditions in normal use. Hence additional countermeasures should be taken at test site configuration level in order to operate the power converters as intended in normal use, in ~~type~~ tests according to this document.

As a matter of course, CM decoupling capacitors shall be employed, in conjunction with suitable series inductors, as LP-filters decouple the termination impedance at the EUT port of the artificial network (AN) e.g. from influences of the laboratory DC power source at the AE port of this AN. The specifications of the DC-AN ~~as in Annex I Table I.2~~ guarantee that the CM termination impedance at the EUT port of the AN remains at least at values of 10 Ω or more, at the series resonance of its internal LC LP decoupling filter. This will prevent the saturation effects mentioned above in most of the practical testing cases. For the magnitude-versus-frequency characteristics of the CM termination impedance of the AN in the range 9 kHz to 150 kHz, consult the specifications provided by the manufacturer.

Considering now mitigation of common mode RF currents in the whole laboratory DC power supply chain at the test site, this mitigation and involved additional CM decoupling capacitors and common mode chokes (as e.g. in the EMI filters at the site) ~~may~~ can interact with the characteristics of the built-in LC LP decoupling filter of the AN, and ~~may~~ can cause frequency shifts of the series resonance dip(s) of the effective total common mode (CM) impedance experienced at the EUT port of this AN.

It is hence strongly recommended to adjust the magnitude-versus-frequency characteristics of the total effective CM termination impedance at the EUT port of the AN to the conditions needed for the given type of power converter under test. Such adjustments can be made by variation of the value of the CM blocking capacitance in the laboratory's DC power supply chain and/or by insert of additional series inductors or common mode chokes. This annex describes possible countermeasures to avoid saturation effects due to unfortunate characteristics of the test site instrumentation used in the laboratory DC power supply chain.

Attention is drawn to the user of such test setups in regard of hazardous voltages due to high earth leakage currents. Advice should be sought from duly qualified personnel before switching on the laboratory's system power sources to ensure that injury or damage is not caused to test personnel or equipment.

E.2 Recommendations for avoidance of saturation effects in the range 9 kHz to 150 kHz

If excessive levels of disturbance are observed during measurements of conducted RF disturbances at LV DC power ports of power converters in the range 150 kHz to 30 MHz, then this may can be caused by saturation effects appearing at the operation frequency of the EUT allocated someplace in the range below 150 kHz. To avoid such conditions, it is recommended to observe the guidance given below.

1) For measurements at LV DC power ports of power converters use only ANs complying with the technical requirements of the 150 Ω artificial mains Delta-network according to 4.7 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017, or according to Annex I of this standard.
2) Apply good test site engineering and check whether the whole measuring instrumentation (DC-AN excluded) and test site configuration are suitable for use with measurements on power electronics operated in switching mode conditions at operating frequencies (fundamental frequencies) allocated in the range below 150 kHz. Depending on the implemented technology and nominal power throughput, power converters may can use fundamental or switching mode frequencies in the range from a couple of 100 Hz up to about 150 kHz.
3) Whenever possible insert additional common mode (CM) absorbing devices such as ferrite tubes, CMADs or also 150 Ω CDNs according to IEC 61000-4-6, between the AE port of the AN and the laboratory DC power supply port allocated in the test environment. For this purpose an extended length of the DC power supply cable can be used too. In coiled form it introduces an additional decoupling inductor (i.e. a common mode choke) put in series to the laboratory's common mode current circuit. In any case, one should check the efficiency of the added common mode rejection devices, since for most of them one will not find specifications of technical characteristics in the range below 30 MHz.
4) Avoid coincidence of the fundamental or operating frequency of the power converter under test with the frequency of the series resonance dip in the CM impedance of the whole DC power supply chain consisting of the laboratory DC power source, the EMI filters used in the installation of the OATS or SAC, and the AN. The frequency of the resonance dip in the CM impedance of the power supply chain can be shifted by changing the capacitance of the effective CM decoupling capacitor. Addition of external CM decoupling capacitors is recommended at the interface between the AE port of the AN and the laboratory DC power supply port allocated in the test environment. Be aware that a line of capacitors with different capacitances may can be needed if the testing business comprises power converters implementing various technologies, power throughput classes and the like. Remember that the operation frequency may can be allocated someplace between a couple of 100 Hz up to about 150 kHz.

E.3 Detailed advice

E.3.1 General

The following descriptions are found for a decoupling circuit of the DC-AN in Clause I.1 Information about a DC-AN can be found in CISPR 16-1-2 and summarized as:

"Further, the DC-AN is furnished with a decoupling network (i.e. an LC-filter) such that sufficient decoupling is provided between its EUT port and its AE port, in order to prevent RF disturbances from the laboratory DC power source to affect obtained measuring measurement results. Having asymmetric decoupling capacitors with some 100 nF to about 1 µF capacitance only, the construction of that filter prevents, in most cases, saturation effects in mitigation filters the power converters under test may be furnished with, and this way provides for valid, reliable and repeatable measurement results.

However, if the laboratory DC power source is applied in measurement of RF disturbances as shown in Figure E.1, the CM RF current caused by the EUT does not only flow through the decoupling capacitors composing the decoupling circuit of the DC-AN, but also through the decoupling capacitors the laboratory DC power source and the EMI filter of the test site are furnished with. In addition, in almost all cases the capacitance of the decoupling capacitors such equipment is furnished with ~~may~~ can be much larger than 100 nF.

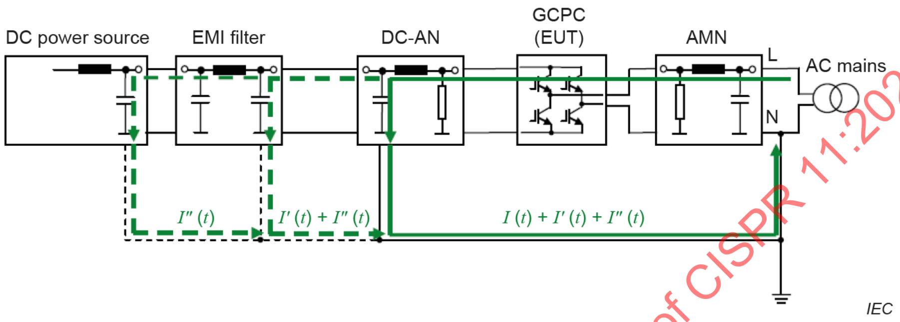


Figure E.1 – Flow of the common mode RF current at test site configuration level

An obvious countermeasure for prevention of these additional contributions to the total effective RF CM current at the operation frequency of the power converter under test ~~is to~~ shall increase the CM decoupling loss in between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment.

This decoupling loss can be increased by insert of additional series inductors (preferred countermeasure) and/or by employment of additional CM decoupling capacitors at the interface in between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment (countermeasure for shifting the frequency of the series resonance dip in the CM termination impedance at the EUT port of the DC-AN).

E.3.2 Insert of series inductors (or common mode chokes) in the laboratory's DC power supply chain

If some suitable EMI clamp devices etc. which attenuate the common mode RF current in 9 kHz to 150 kHz are inserted between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment as shown in Figure E.2, the capacitances of the decoupling capacitors the DC power source and EMI filter are equipped with can be neglected. For such additional decoupling, extended lengths of DC power cable could be used too, if arranged to form an air coil.

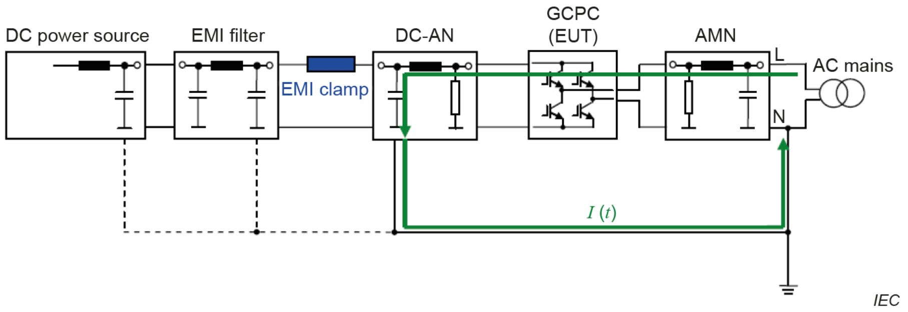


Figure E.2 – Blocking of flow of common mode RF current by insert of series inductors

ATTENTION – Proper equipment such as EMI clamp devices which can attenuate the common mode RF current in the range 9 kHz to 150 kHz ~~may~~ might not be available from the market. Preferred measure should hence be insertion of series inductivities.

As mentioned above, because the effective magnitude of capacitance of decoupling capacitors of all the laboratory measuring systems including the laboratory DC power source ~~may~~ can cause saturation effects in mitigation filters the transformer-less power converter is equipped with, it is necessary to use laboratory DC power sources and EMI filters with low capacitance common mode decoupling capacitors only. Observe however that use of CM decoupling capacitors with low capacitance only ~~may~~ can also reduce suppression of RF disturbances generated by the laboratory DC power source. If extremely large RF disturbances occur during ~~type~~ tests on transformer-less power converters which are thought to be caused by saturation of the built-in mitigation filters, then it should be considered to use batteries as DC power source.

E.3.3 Employment of additional common mode decoupling capacitors at the interface between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment

For an increase of the decoupling loss between the laboratory DC power supply chain and the measurement arrangement additional CM decoupling capacitors can be connected between the AE port (i.e. the decoupling circuit) of the DC-AN and the laboratory DC power supply port allocated in the test environment as shown in Figure E.3.

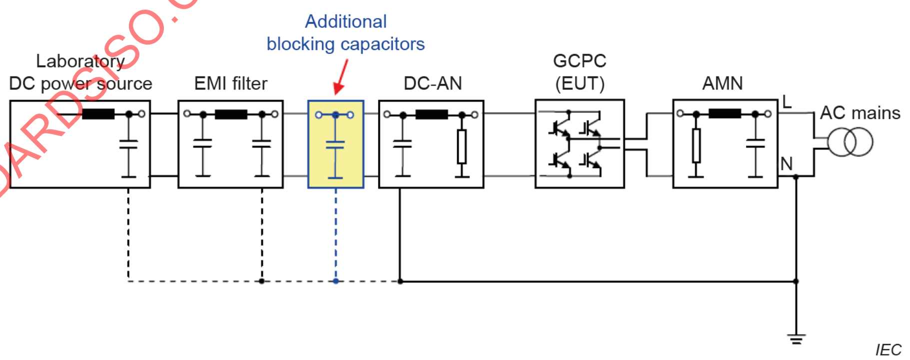


Figure E.3 – Blocking of flow of common mode RF current by employment of additional CM decoupling capacitors

The effect of such a countermeasure is that it shifts the series resonance dip in the magnitude-versus-frequency characteristics of the CM termination impedance at the EUT port of the DC-AN to lower frequencies, this way avoiding possible coincidences in frequency of that resonance dip and the operation or fundamental frequency of the power converter under test. If the operation frequency does not coincide with that series resonance frequency, saturation effects in the EUT can be avoided. It is quite obvious that such a countermeasure shall be carefully adjusted to the given type of power converter, due to the wide range of possibly involved operation frequencies. Individual adjustment of the additional CM blocking capacitance ~~may~~ could be necessary in most cases.

E.4 Background information

Methods were studied of solving the saturation problem on the assumption that not a battery, but a laboratory DC power supply is used for measurements at transformer-less power converters. Figure E.4 shows an example of common mode impedance characteristics for a DC-AN ~~according to Table I.2~~. As shown in Figure E.4, it proves that there is a resonant point in the proximity of 20 kHz and the common mode impedance remarkably decreases at this resonant frequency.

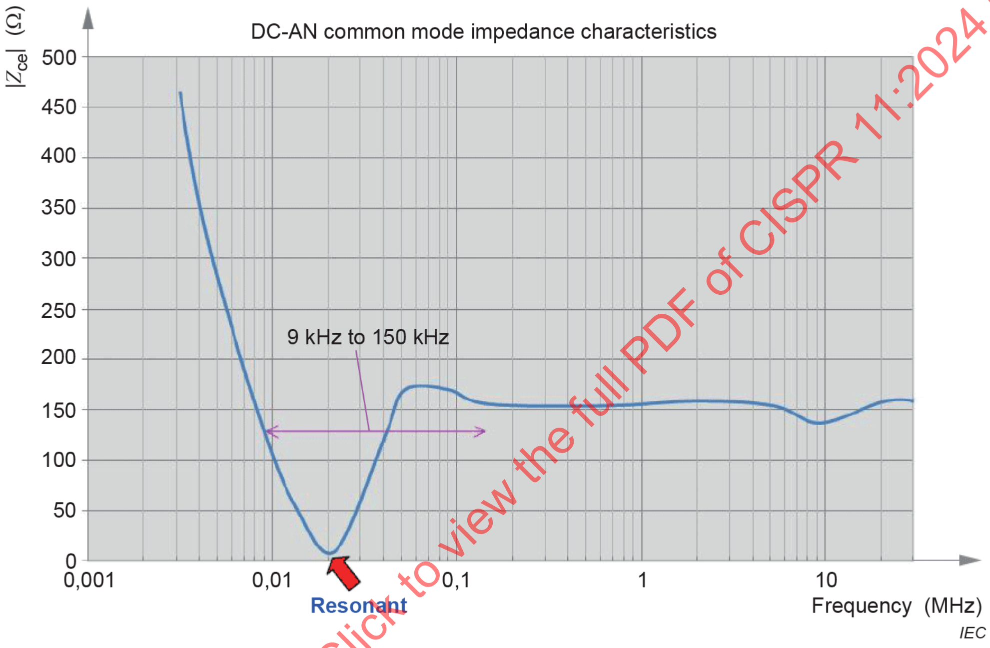


Figure E.4 – CM termination impedance at the EUT port of a DC-AN – Magnitude-versus-frequency characteristic in the range 3 kHz to 30 MHz, Example

The saturation of mitigation filters the power converter is furnished with, that currently becomes a problem, occurs because a large common mode current flows in case the resonant frequency (20 kHz) coincides with the operating frequency of the power converter (EUT). However, the resonant frequency is practically determined not only by the DC-AN, but also by the common mode impedance characteristics of all of the instrumentation used in the whole laboratory DC power supply chain including the DC power source, installed EMI filters and the like.

In case the effective resonant frequency caused by all of the laboratory measuring instrumentation coincides with the operating frequency of the power converter and so large common mode current flows, or in case it is necessary to confirm whether such conditions actually occur, the resonant frequency can be detuned from the operating frequency of the power converter by changing the capacitance of decoupling capacitors of the decoupling circuit of the DC-AN or adding the capacitance of decoupling capacitors as shown in Figure E.5 and so changing the resonant frequency, that is to say, the resonant point can be shifted as shown in Figure E.6. As a result, the common mode current can be reduced at the operating frequency of the power converter by avoiding saturation effects.

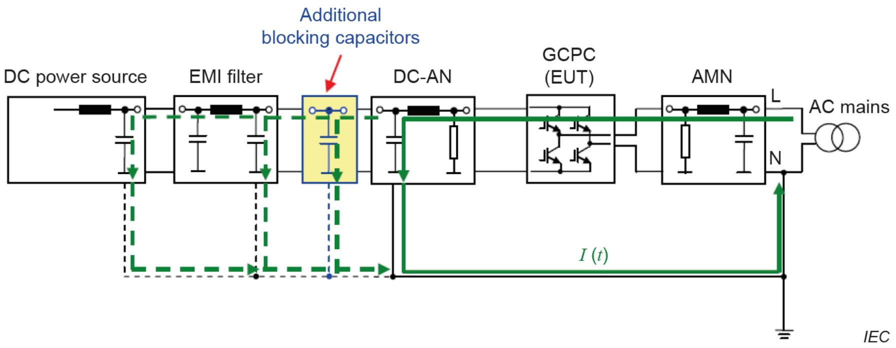


Figure E.5 – Prevention of saturation of mitigation filters by use of additional decoupling capacitors

In other words, if the measurement results in case the capacitance of decoupling capacitors is increased are the same as those in case it is unchanged, it can be concluded that the measurements of conductive disturbances have correctly been performed.

With exchange of hardware components in the DC-AN, it is possible to increase or decrease the capacitance of the CM decoupling capacitors by setting up switches for switching series and parallel connection of these decoupling capacitors as shown in Figure E.7. However, such measure cannot be recommended for application in normal laboratory practice since possibly violating the calibration of the respective DC-AN. However, switched-type combined external CM decoupling capacitors can be used, if ~~necessary~~ applicable. Application of such capacitors will always shift the series resonance of the DC-AN internal LC decoupling filter to lower frequencies than found in the manufacturer's specifications.

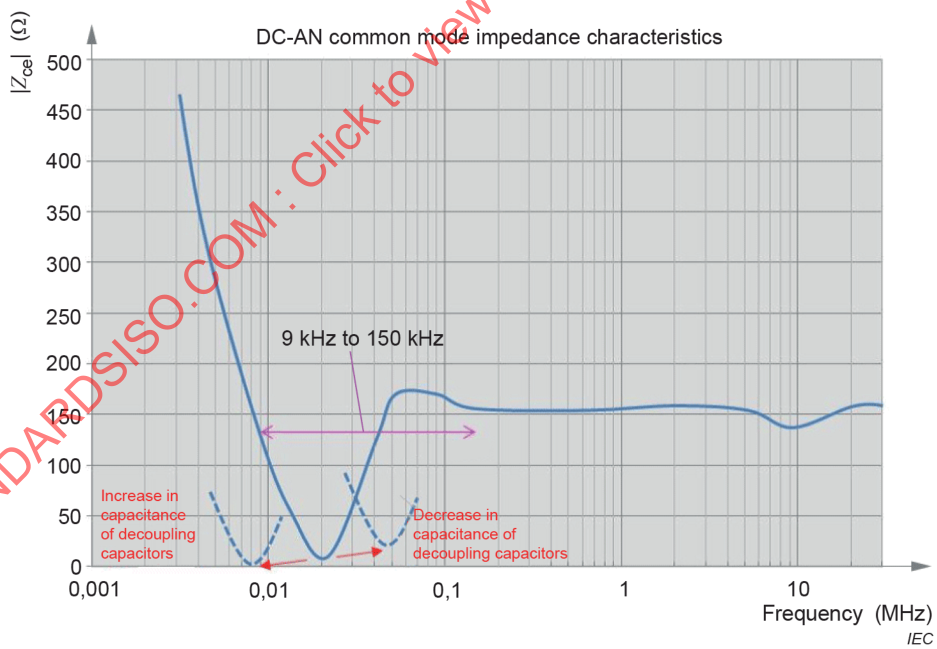


Figure E.6 – Change in the resonant frequency caused by the increase and decrease in the decoupling capacitor's capacitance

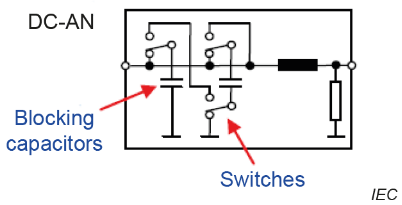


Figure E.7 – DC-AN circuit example where capacitance of blocking capacitors of the LC decoupling circuit can be increased or decreased

Annex F
(normative)

Additional requirements for equipment with radio functionality 18

F.1 Configuration of the EUT during emission tests

For the non-radio function, the configuration of the EUT shall be according to the requirements specified in 7.5.

The radio function shall be configured consistent with normal operation of the EUT. The configuration(s) used shall be recorded in the test report together with the rationale for these choices.

NOTE 1 The transmit mode of the radio function is part of the assessment under the appropriate radio regulations applicable to the radio technology used.

NOTE 2 To prevent saturation of the measuring receiver, the good practice is to include filter(s) rejecting the radio transmitter frequency in the measurement chain.

F.2 Radiated emissions

For radiated emissions, the EUT with the radio function in standby or receive mode shall be assessed against 6.2.2, 6.3.2 or 6.4.2 as appropriate.

Alternatively, the EUT may be assessed with the radio function in transmit mode. In this case, an emission failing the limit of 6.2.2, 6.3.2 or 6.4.2, as appropriate, may be ignored provided it is demonstrated that it originates from the radio portion of the EUT.

When applying Table 10 for determining the highest internal frequency of the EUT, the frequencies of the radio equipment (i.e. radio device, radio module, or radio assembly/circuitry included in the EUT) shall also be considered.

F.3 Conducted emissions

For conducted emissions, the EUT with the radio function in standby or receive mode shall be assessed against 6.2.1, 6.3.1, 6.4.1 or Table F.1, as appropriate. Alternatively, the EUT may be assessed with the radio function in transmit mode. In this case, an emission failing the limit of 6.2.1, 6.3.1, 6.4.1 or Table F.1, as appropriate, may be ignored provided it is demonstrated that it originates from the radio portion of the EUT.

Where the EUT has a port intended for the connection of an external antenna via coaxial cable longer than 3 m, the Class A or Class B requirements of Table F.1 shall apply to this port. One of the measurement procedures (and the corresponding ancillary equipment) specified in CISPR 32 for this type of EUT port shall be used (see Table A.11 of CISPR 32:2015, Table A.12 of CISPR 32:2015 and C.4.1.6 of CISPR 32:2015 and CISPR 32:2015/AMD1:2019).

Table F.1 – Disturbance voltage and current limits for group 1 and group 2 equipment measured on a test site (antenna port)

Frequency range MHz	Class A		Class B	
	Limits dB(µV)	**Limits** dB(µA)	**Limits** dB(µV)	**Limits** dB(µA)
	Detector	**Detector**	**Detector**	**Detector**
0,15 to 0,5	97 to 87 [a] Quasi-peak	53 to 43 [a] Quasi-peak	84 to 74 [a] Quasi-peak	40 to 30 [a] Quasi-peak
	84 to 74 [a] Average	40 to 30 [a] Average	74 to 64 [a] Average	30 to 20 [a] Average
0,5 to 30	87 Quasi-peak	43 Quasi-peak	74 Quasi-peak	30 Quasi-peak
	74 Average	30 Average	64 Average	20 Average

[a] decreasing linearly with logarithm of frequency

Limitations and restrictions:

The application of the voltage and/or current limits is dependent on the measurement procedure used. Refer to CISPR 32:2015/AMD1:2019, Table C.1 for applicability.

Excluding measurement uncertainty, all other elements within CISPR 32 shall be followed, including but not limited to selection of test method, test configuration, cable characteristics.

NOTE The voltage and current disturbance limits in this table consider the fact that the antenna port under test is presented with a common mode impedance of 150 Ω. Thus, the two limits are interrelated by: $V - I = 20 \log_{10}$ (150 Ω) = 44 dBΩ, where V and I are in logarithmic units (i.e. dBµV and dBµA, respectively).

Bibliography

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

[2] ISO 8373:2021, *Robotics – Vocabulary*

[3] IEC TR 60601-4-1:2017, *Medical electrical equipment – Part 4-1: Guidance and interpretation – Medical electrical equipment and medical electrical systems employing a degree of autonomy*

[4] IEC 62920:2017, *Photovoltaic power generating systems – EMC requirements and test methods for power conversion equipment*
IEC 62920:2017/AMD1:2021

[5] IEC 60050-713:1998, *International Electrotechnical Vocabulary (IEV) – Part 713: Radiocommunications: transmitters, receivers, networks and operation*

[6] IEEE Standard 1284.1, *IEEE Standard for Information Technology – Transport Independent Printer/System Interface (TIP/SI)*

[7] IEEE Standard 1394, *IEEE Standard for a High Performance Serial Bus*

[8] IEC 61000-6-3:2020, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments*

[9] IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

[10] IEC 60601-1-2:2014, *Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral standard: Electromagnetic disturbances – Requirements and tests*
IEC 60601-1-2:2014/AMD1:2020

[11] IEC TR 61000-2-5:2017, *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Description and classification of electromagnetic environments*

[12] IEC 61922:2002[4], *High-frequency induction heating installations – Test methods for the determination of power output of the generator*

[13] IEC 61308:2005[5], *High-frequency dielectric heating installations – Test methods for the determination of power output*

[14] IEC 60705:2010, *Household microwave ovens – Methods for measuring performance*

[15] IEC 60974-10:2020, *Arc welding equipment – Part 10: Electromagnetic compatibility (EMC) requirements*

[16] ISO 9283:1998, *Manipulating industrial robots – Performance criteria and related test methods*

4 This publication was withdrawn.

5 This publication was withdrawn.

[17] CISPR TR 16-2-5:2008, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-5: In situ measurements for disturbing emissions produced by physically large equipment*

[18] CISPR 12, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers*

[19] CISPR TR 16-4-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*
CISPR TR 16-4-3:2004/AMD1:2006

[20] CISPR TR 16-4-4:2007, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-4: Uncertainties, statistics and limit modelling – Statistics of complaints and a model for the calculation of limits for the protection of radio services* ~~(only available in English)~~

[21] CISPR 15:~~2013~~2018, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*

[22] IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*, available at www.electropedia.org

~~[6] IEC 60050-601:1985, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*~~

[23] IEC TR 60083:~~2009~~2015, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

~~[8] IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*~~

[24] IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

~~[10] IEC 60705:2010, *Household microwave ovens – Methods for measuring performance*~~

~~[11] IEC TR 61000-2-5:2011, *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Description and classification of electromagnetic environments*~~

~~[12] IEC 61308:2005, *High-frequency dielectric heating installations – Test methods for the determination of power output*~~

~~[13] IEC 61689:2013, *Ultrasonics – Physiotherapy systems – Field specifications and methods of measurement in the frequency range 0,5 MHz to 5 MHz* (only available in English)~~

~~[14] IEC 61922:2002, *High-frequency induction heating installations – Test methods for the determination of power output of the generator*~~

[25] IEC 61158-1:2023, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

[26] IEC 61689:2022, *Ultrasonics – Physiotherapy systems – Field specifications and methods of measurement in the frequency range 0,5 MHz to 5 MHz*

[27] ETSI EN 303 446-1 V1.2.1 (2019-10), *ElectroMagnetic Compatibility (EMC) standard for combined and/or integrated radio and non-radio equipment – Part 1: Requirements for equipment intended to be used in residential, commercial and light industry locations*

[28] ETSI EN 303 446-2 V1.2.1 (2019-10), *ElectroMagnetic Compatibility (EMC) standard for combined and/or integrated radio and non-radio equipment – Part 2: Requirements for equipment intended to be used in industrial locations*

[29] ETSI EG 203 367 V1.1.1 (2016-06), *Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the Directive 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment*

[30] Recommendation ITU-R M.1036-6:2019, *Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications in the bands identified for IMT in the Radio Regulations*

[31] Recommendation ITU-R M.1073-3:2012, *Digital cellular land mobile telecommunication systems*

[32] Recommendation ITU-R M.2009-2:2019, *Radio interface standards for use by public protection and disaster relief operations in accordance with Resolution 646 (Rev.WRC-15)*

[33] Recommendation ITU-R BT.2033-1:2015, *Planning criteria, including protection ratios, for second generation of digital terrestrial television broadcasting systems in the VHF/UHF bands*

[34] A.A. SMITH, Jr., *Electric field propagation in the proximal region, IEEE Transactions on electromagnetic compatibility*, Nov 1969, pp.151-163.

[16] CCIR Report 239-7:1990, *Propagation statistics required for broadcasting services using the frequency range 30 to 1 000 MHz*

[35] IEC Guide 107:2014, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*

[36] IEC 62135-2:2020, *Resistance welding equipment – Part 2: Electromagnetic compatibility (EMC) requirements*

List of comments

1 Equipment in general, also industrial, scientific and medical equipment is increasingly equipped with radio functionality. Additional requirements for the conducted and radiated disturbances are introduced to consider the situation when equipment incorporates radio functions.

2 Though robots for industrial, scientific and medical applications have been in the scope of this standard since ever, this edition contains some additional specifications, in particular related to measurement setups and operating modes, when measuring the disturbances produced by robots.

3 Some definitions related to equipment containing radio functionality are added as respective requirements are introduced in this standard (see also definitions 3.1.26, 3.1.27 and 3.1.28).

4 Some definitions related to robots are added as respective requirements are introduced in this standard (see also definitions 3.1.22 and 3.1.30).

5 Information regarding wired network ports are introduced as this edition newly contains requirements for this port.

6 Industrial, scientific and medical equipment is increasingly equipped with radio functionality. Additional requirements for the conducted and radiated disturbances are introduced to consider the situation when equipment incorporates radio functions.

7 Requirements for wired network ports are introduced in order to consider the potential of this port to produce relevant disturbances. The requirements are taken from the generic standards IEC 61000-6-3 and IEC 61000-6-4 which is inline with the approach given in IEC Guide 107.

8 This edition introduces limits for radiated disturbances above 1 GHz, for Group 1 equipment. This introduction considers the technological evolution of equipment with having components producing radiation in this frequency range, and also considers the approach described in IEC Guide 107. The limits for the radiated disturbances correspond to those used in the generic emission standards.

9 The term "type test" is no longer used in this document because measurements as specified in this standard can be done for any reason a user wish to do. Consequently, information about statistical assessment is removed. The respective information can be found on the CISPR B dashboard.

10 Information are added when measuring robots as some specific conditions need to be considered, for example how to deal with measurement distances in case of robots having mobile portions.

11 When measuring robots, information is needed which operation modes shall be considered, firstly in order to give guidance to users and secondly to improve reproducibility.

12 This annex is updated in particular with respect to equipment used in solar systems and for wireless power transfer.

13 This annex on precautions to be observed when using a spectrum analyzer was historically introduced when the first spectrum analyzers were used for EMC measurements. The information in this Annex is no longer needed as test engineers are meanwhile familiar with the usage of spectrum analyzers. General information when using spectrum analyzers can be found in the CISPR 16 series.

14 This annex is removed as it covers general information on the propagation of electromagnetic waves which is not specific to equipment in the scope of this standard.

15 This annex related to safety-related radio services is merged with the annex dealing with sensitive radio services into the new Annex C.

16 This annex is deleted as it was agreed that statistical assessment should not be part of a standard dealing with measurements. Statistical assessment can be part of conformity assessment and therefore the information of this annex will be moved onto the CISPR B dashboard as guidance document to users.

17 Specifications of a DC artificial network were necessary when introducing measurements on DC ports of high power equipment in the previous editions of this standard. This annex is deleted as all the relevant information is meanwhile available in the basic standard CISPR 16-1-2.

18 According to the clarification in the scope of this standard that equipment containing radio functionality is also subject to this standard, some requirements are introduced how to measure such type of equipment.

IEC®

CISPR 11

Edition 7.0 2024-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

PRODUCT FAMILY EMC STANDARD
NORME DE FAMILLE DE PRODUITS EN CEM

Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement

Appareils industriels, scientifiques et médicaux – Caractéristiques de perturbations radioélectriques – Limites et méthodes de mesure

CISPR 11:2024-02(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

____

INDUSTRIAL, SCIENTIFIC AND MEDICAL EQUIPMENT – RADIO-FREQUENCY DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard CISPR 11 has been prepared by CISPR Subcommittee B: Interference relating to industrial, scientific and medical radio-frequency apparatus, to other (heavy) industrial equipment, to overhead power lines, to high voltage equipment and to electric traction.

This seventh edition cancels and replaces the sixth edition published in 2015, Amendment 1:2016 and Amendment 2:2019. This edition constitutes a technical revision.

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

a) introduction of limits for radiated disturbances in the frequency range above 1 GHz for group 1 equipment in line with the requirements given in the generic emission standards;
b) introduction of limits for conducted disturbances on the wired network port in line with the requirements given in the generic emission standards;

c) introduction of requirements for equipment which incorporates radio transmit/receive functions;

d) introduction of definitions for various types of robots;

e) consideration of some particular conditions when measuring robots, such as measurement setups and operating modes of robots.

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

Draft	Report on voting
CIS/B/831/FDIS	CIS/B/837/RVD

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

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

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

This document has the status of a Product Family EMC standard in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications (2014)*.

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

The main content of this document is based on CISPR Recommendation No. 39/2 given below:

RECOMMENDATION No. 39/2

Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

The CISPR

CONSIDERING

a) that ISM RF equipment is an important source of disturbance;

b) that methods of measuring such disturbances have been prescribed by the CISPR;

c) that certain frequencies are designated by the International Telecommunication Union (ITU) for unrestricted radiation from ISM equipment,

RECOMMENDS

that the latest edition of CISPR 11 be used for the application of limits and methods of measurement of ISM equipment.

INTRODUCTION

This CISPR publication contains, amongst common requirements for the control of RF disturbances from equipment intended for use in industrial, scientific, and medical electrical applications, specific requirements for the control of RF disturbances caused by ISM RF applications in the meaning of the definition of the International Telecommunication Union (ITU), see also Definition 3.1.18 in this document. CISPR and ITU share their responsibilities for the protection of radio services in respect of the use of ISM RF applications.

The CISPR is concerned with the control of RF disturbances from ISM RF applications by means of an assessment of these disturbances either at a standardised test site or, for an individual ISM RF application which cannot be tested at such a site, at its place of operation. Consequently, this CISPR Publication covers requirements for both, equipment assessed by means of tests at standardised test sites or of individual equipment under *in situ* conditions.

The ITU is concerned with the control of RF disturbances from ISM RF applications during normal operation and use of the respective equipment at its place of operation (see Definition 1.15 in the ITU Radio Regulations(2020)). There, use of radio-frequency energy decoupled from the ISM RF application by radiation, induction or capacitive coupling is restricted to the location of that individual application.

This CISPR publication contains, in 6.3, the essential emission requirements for an assessment of RF disturbances from ISM RF applications at standardised test sites. These requirements allow for testing of ISM RF applications operated at frequencies up to 18 GHz. It further contains, in 6.4, the essential emission requirements for an *in situ* assessment of RF disturbances from individual ISM RF applications in the frequency range up to 1 GHz. All requirements were established in close collaboration with the ITU and enjoy approval of the ITU.

However, for operation and use of several types of ISM RF applications the manufacturer, installer and/or customer should be aware of additional national provisions regarding possible licensing and particular protection needs of local radio services and applications. Depending on the country concerned, such additional provisions can apply to individual ISM RF applications operated at frequencies outside designated ISM bands (see Table 1). They also can apply to ISM RF applications operated at frequencies above 18 GHz.

Recommendations of CISPR for the protection of radio services in particular areas are found in Annex C of this document.

INDUSTRIAL, SCIENTIFIC AND MEDICAL EQUIPMENT – RADIO-FREQUENCY DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

1 Scope

This document applies to industrial, scientific and medical electrical equipment operating in the frequency range 0 Hz to 400 GHz and to domestic and similar appliances designed to generate and/or use locally radio-frequency energy.

This document covers emission requirements related to radio-frequency (RF) disturbances in the frequency range of 9 kHz to 400 GHz.

For ISM RF applications in the meaning of the definition found in the ITU Radio Regulations (2020) (see Definition 3.1.18), this document covers emission requirements related to radio-frequency disturbances in the frequency range of 9 kHz to 18 GHz.

ISM equipment which incorporates radio transmit/receive functions (host equipment with radio functionality) is included in the scope of this document, see Annex F. However, the emission requirements in this document are not intended to be applicable to the intentional transmissions from a radio transmitter as defined by the ITU including their spurious emissions.

NOTE 1 This exclusion only applies to emissions from the intentional radio transmitter. However, combination emissions, for example emissions resulting from intermodulation between the radio and the non-radio subassemblies of the ISM equipment, are not subject to this exclusion.

NOTE 2 Emission requirements for induction cooking appliances are specified in CISPR 14-1 [1][1].

Requirements for ISM RF lighting equipment and UV irradiators operating at frequencies within the ISM frequency bands defined by the ITU Radio Regulations are contained in this document.

Robots used for industrial, scientific and medical applications are in the scope of this document.

EXAMPLE Welding robots, spraying robots, handling robots, processing robots, assembly robots, medical robots, education and experimental robots. A comprehensive list of robots in the scope of this document is given on the IEC EMC zone.

NOTE 3 Flying robots, domestic helper robots, toy robots and entertainment robots are examples of robots in the scope of other CISPR standards.

Equipment covered by other CISPR product and product family emission standards are excluded from the scope of 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.

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

1 Figures in square brackets refer to the Bibliography.

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

CISPR 16-1-4:2019, *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 16-1-4:2019/AMD1:2020
CISPR 16-1-4:2019/AMD2:2023

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 16-2-3:2016/AMD1:2019
CISPR 16-2-3:2016/AMD2:2023

CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measuring instrumentation uncertainty*
CISPR 16-4-2:2011/AMD1:2014
CISPR 16-4-2:2011/AMD2:2018

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission requirements*
CISPR 32:2015/AMD1:2019

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility*

IEC 60601-2-2:2017, *Medical electrical equipment – Part 2-2: Particular requirements for the basic safety and essential performance of high frequency surgical equipment and high frequency surgical accessories*

IEC 61000-4-6:2023, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61307:2011 [2], *Industrial microwave heating installations – Test methods for the determination of power output*

ITU Radio Regulations (2020), *Radio regulations* (available at http://www.itu.int/en/myitu/Publications/2020/09/02/14/23/Radio-Regulations-2020)

2 This publication was withdrawn.

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 terminology databases for use in standardization at the following addresses:

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

3.1.1
AC mains power port
port used to connect to a public low voltage AC mains power distribution network or other low voltage AC mains installation

3.1.2
associated equipment
AE
apparatus that is not part of the system under test, but needed to help exercise the EUT

[SOURCE: CISPR 16-2-3:2016, 3.1.5]

3.1.3
arc welding equipment
equipment for applying current and voltage and having the required characteristics suitable for arc welding and allied processes

3.1.4
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 this network, the V-network (V-AMN) which couples the unsymmetrical voltages, and the Delta-network, which couples the symmetric (DM) and the asymmetric (CM) voltages separately.

Note 2 to entry: The terms line impedance stabilization network (LISN) and V-AMN are used interchangeably.

[SOURCE: CISPR 16-1-2:2014/AMD1:2017, 3.1.6, modified – added Note 2]

3.1.5
boundary of the equipment under test
imaginary straight line periphery describing a simple geometric configuration encompassing the equipment under test

Note 1 to entry: All interconnecting cables are included within this boundary.

3.1.6
component
product which serves a specific function or functions and which is intended for use in a higher order assembled equipment or system

3.1.7
DC artificial network
artificial DC network
DC-AN
artificial network that provides defined termination to the EUT's DC power port under test while also providing the necessary decoupling from conducted disturbances originating from the laboratory DC power source or from the load

3.1.8
DC power port
port used to connect to a low voltage DC power generating system or energy storage, or to another source/load

Note 1 to entry: Such a system can be for example a photovoltaic or a fuel cell power generating system, or also a battery.

3.1.9
electro-discharge machining equipment
EDM equipment
all the necessary units for the spark erosion process including the machine tool, the generator, control circuits, the working fluid container and integral devices

3.1.10
electromagnetic radiation
phenomenon by which energy in the form of electromagnetic waves emanates from a source into space

Note 1 to entry: By extension, the term "electromagnetic radiation" sometimes also covers induction phenomena.

[SOURCE: IEC 60050-161:1990, 161-01-10]

3.1.11
equipment for resistance welding and allied processes
all equipment associated with carrying out the processes of resistance welding or allied processes

Note 1 to entry: Such equipment consists of e.g. power source, electrodes, tooling and associated control equipment, which can be a separate unit or part of a complex machine.

3.1.12
equipment with radio functionality
non-radio equipment (host equipment) including one or more radio devices or radio modules that can use host control function(s) and/or power supply

Note 1 to entry: The use of the included radio equipment can be for remote control (of the host equipment by an external equipment or vice versa) or for data exchange with external equipment.

Note 2 to entry: A radio device or radio module can be plugged-in, built-in or external.

3.1.13
fully-anechoic room
FAR
shielded enclosure, the internal surfaces of which are lined with radio-frequency-energy absorbing material (i.e. RF absorber) that absorbs electromagnetic energy in the frequency range of interest

3.1.14
fundamental frequency
fundamental ISM frequency
frequency on which the ISM equipment operates

Note 1 to entry: Electromagnetic RF energy at the fundamental frequency (of an ISM equipment) can be used in, or transmitted by, or received by the equipment. This energy can be generated in the equipment but used outside the equipment (e.g. X-ray diagnostic equipment), or generated outside and used in the equipment or generated and used in the equipment (e.g. switching mode power supply, RF sterilizer, microwave oven).

Note 2 to entry: Some ISM equipment categories do not have a fundamental ISM frequency. Examples: spectrum analyser, frequency counter.

3.1.15
grid connected power converter
GCPC
power converter connected to an AC mains power distribution network or other AC mains installation and used in a power generating system

3.1.16
high power electronic systems and equipment
one or more semiconductor power converters with a combined rated power greater than 75 kVA, or an equipment containing such converters

Note 1 to entry: Examples of such high power electronic equipment are semiconductor power converters for application in UPS (Uninterruptible Power Systems) and PDS (Power Drive Systems).

3.1.17
highest internal frequency
F_x
highest fundamental frequency generated or used within the EUT or highest frequency at which it operates

Note 1 to entry: This includes frequencies which are solely used within an integrated circuit.

3.1.18
industrial, scientific and medical applications
ISM applications
<of radio frequency energy> operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications

Note 1 to entry: Typical applications are the production of physical, biological, or chemical effects such as heating, ionisation of gases, mechanical vibrations, hair removal, acceleration of charged particles. A non-exhaustive list of examples is given in Annex A.

[SOURCE: ITU Radio Regulations Volume 1: 2020 – Chapter I, Definition 1.15, modified – added Note 1.]

3.1.19
ISM RF equipment and appliances
equipment or appliances designed to generate and/or use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications and information technology and other applications covered by other CISPR publications

Note 1 to entry: The abbreviation "ISM RF" is used throughout this document for such equipment or appliances only.

3.1.20
industrial robot
automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or fixed to a mobile platform for use in automation applications in an industrial environment

Note 1 to entry: The industrial robot includes:

- the manipulator, including robot actuators controlled by the robot controller;
- the robot controller;
- the means by which to teach and/or program the robot, including any communications interface (hardware and software).

Note 2 to entry: Industrial robots include any auxiliary axes that are integrated into the kinematic solution.

Note 3 to entry: Industrial robots include the manipulating portion(s) of mobile robots, where a mobile robot consists of a mobile platform with an integrated manipulator or robot.

[SOURCE:ISO 8373:2021[2], 3.6]

3.1.21
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".]

3.1.22
medical robot
robot intended to be used as medical electrical equipment or medical electrical system

[SOURCE: IEC TR 60601-4-1:2017[3], 3.20]

3.1.23
open-area test site
OATS
facility used for measurements of electromagnetic fields the intention for which is to simulate a semi-free-space environment over a specified frequency range that is used for radiated emission testing of products

Note 1 to entry: An OATS typically is located outdoors in an open area and has an electrically-conducting ground plane.

3.1.24
photovoltaic power generating system
electric power generating system which uses the photovoltaic effect to convert solar power into electricity

3.1.25
power conversion equipment
electrical device converting one form of electrical power to another form of electrical power with respect to voltage, current, frequency, phase and the number of phases

[SOURCE: IEC 62920:2017/AMD1:2021[4], 3.2]

3.1.26
radio device
assembly consisting of one or more radio transmitters and/or receivers, capable to function on a stand-alone basis with or without additional accessories

Note 1 to entry: These accessories can be incorporated in the assembly or connected to it from outside. Examples of accessories are: external antenna, remote control, headsets, power supply, display, etc.

3.1.27
radio module
assembly consisting of one or more radio transmitters and/or receivers, intended to be incorporated in a host equipment

Note 1 to entry: A radio module can incorporate a power supply or any other accessories.

Note 2 to entry: A radio module can be plugged-in, built-in or external.

3.1.28
radio transmitter
device producing radio-frequency energy intended to be radiated by an antenna for the purpose of radiocommunication or radiodetermination

[SOURCE: IEC 60050-713:1998[5], 713-08-01 – modified – "apparatus" replaced with "device", deletion of "normally", addition of "or radiodetermination".]

3.1.29
rated load
<for robots> maximum load that can be applied to the mechanical interface or mobile platform in normal operating conditions without degradation of any performance specification

Note 1 to entry: The rated load includes the inertial effects of the end effector, accessories and workpiece, where applicable.

[SOURCE: ISO 8373:2021[2], 7.2.1]

3.1.30
robot
programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation or positioning

Note 1 to entry: A robot includes the control system.

Note 2 to entry: Examples of mechanical structure of robots are manipulator, mobile platform and wearable robots.

[SOURCE: ISO 8373:2021[2], 3.1]

3.1.31
semi-anechoic chamber
SAC
shielded enclosure, in which five of the six internal surfaces are lined with radio-frequency energy absorbing material (i.e. RF absorber) that absorbs electromagnetic energy in the frequency range of interest, and the bottom horizontal surface is a conducting ground plane for use with OATS test set-ups

3.1.32
small equipment under test
small EUT
equipment under test, either positioned on a table top or standing on the floor, which, including its cables, fits in a cylindrical volume of 1,5 m diameter and 1,5 m height (as measured from the floor)

Note 1 to entry: At an OATS or in a SAC, the radiated emission measurement distance of 3 m is applicable only to small EUTs

[SOURCE: CISPR 16-2-3:2016 and CISPR 16-2-3:2016/AMD1:2019, 3.1.35, modified – The definition was reworded and a Note to entry was added]

3.1.33
spark erosion
removal of material in a dielectric working fluid by electro-discharges, which are separated in time and randomly distributed in space, between two electrically conductive electrodes (the tool electrode and the work piece electrode), and where the energy in the discharge is controlled

3.1.34
wired network port
port for the connection of a communication device/system intended to be interconnected to widely dispersed systems by direct connection to a single-user or multi-user network

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

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

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 1284.1 [6] (parallel printer), Universal Serial Bus (USB), IEEE Standard 1394[7] ("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 many product standards, this port was defined as a telecommunications or network port.

[SOURCE: IEC 61000-6-3:2020[8], 3.1.3, modified — In the definition, addition of "device/system". Deletion of Note 1 to entry. Addition of Notes 2, 3 and 4 to entry.]

3.2 Abbreviated terms

AGV	Automated guided vehicle
AMN	Artificial mains network
AN	Artificial network
APD	Amplitude probability distribution
CATV	Cable television
CDN	Coupling-decoupling network
CM	Common mode
CMAD	Common mode absorption device
CVCF	Constant voltage constant frequency
DM	Differential mode
EDM	Electro-discharge machining
EMC	Electromagnetic compatibility
EUT	Equipment under test
FAR	Fully anechoic room
FSOATS	Free space open area test site
GCPC	Grid connected power converter
ISDN	Integrated services digital network

LAN	Local area network
LV	Low voltage
OATS	Open area test site
PDS	Power drive system
PSTN	Public switched telephone network
RF	Radio frequency
SAC	Semi-anechoic chamber
UM	Unsymmetrical mode
UPS	Uninterruptible power supply
USB	Universal serial bus
VCP	Vertical coupling plane
xDSL	All digital subscriber line technologies (e.g., ADSL, SDSL, etc.)

4 Frequencies designated for ISM use

Certain frequencies are designated by the International Telecommunication Union (ITU) for use as fundamental frequencies for ISM RF applications (see also Definition 3.1.18). These frequencies are listed in Table 1.

NOTE In individual countries different or additional frequencies can be designated for use by ISM RF applications.

Table 1 – Frequencies in the radio-frequency (RF) range designated by ITU for use as fundamental ISM frequencies

Centre frequency MHz	**Frequency range** MHz	**Maximum radiation limit** [a]	**Number of appropriate footnote to the table of frequency allocation of the ITU Radio Regulations** [b]
6,780	6,765 to 6,795	Under consideration	5.138
13,560	13,553 to 13,567	Unrestricted	5.150
27,120	26,957 to 27,283	Unrestricted	5.150
40,680	40,66 to 40,70	Unrestricted	5.150
433,920	433,05 to 434,79	Under consideration	5.138 in Region 1, except countries mentioned in 5.280
915,000	902 to 928	Unrestricted	5.150 in Region 2 only
2 450	2 400 to 2 500	Unrestricted	5.150
5 800	5 725 to 5 875	Unrestricted	5.150
24 125	24 000 to 24 250	Unrestricted	5.150
61 250	61 000 to 61 500	Under consideration	5.138
122 500	122 000 to 123 000	Under consideration	5.138
245 000	244 000 to 246 000	Under consideration	5.138

[a] The term "unrestricted" applies to the fundamental and all other frequency components falling within the designated band. Outside of ITU designated ISM bands the limits for the disturbance voltage and radiation disturbance in this document apply.

[b] Resolution No. 63 of the ITU Radio Regulations applies (see Radio Regulations (2020), Volume 3).

5 Classification of equipment

5.1 Separation into groups

In order to simplify identification of the relevant limits, the equipment in the scope of this document is categorized into two groups, i.e. into group 1 and group 2.

Group 1 equipment: group 1 contains all equipment in the scope of this document which is not classified as group 2 equipment.

Group 2 equipment: group 2 contains all ISM RF equipment in which radio-frequency energy in the frequency range 9 kHz to 400 GHz is intentionally generated and used or only used locally, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material, for inspection/analysis purposes, or for transfer of electromagnetic energy.

NOTE See Annex A for examples of the separation of equipment into group 1 or 2.

5.2 Division into classes

In accordance with the intended use of equipment in the electromagnetic environment, this document defines two classes of equipment, namely class A and class B.

Class A equipment is the equipment suitable for use in all locations other than those allocated in residential environments and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class A equipment shall meet class A limits.

An arc welding equipment which contains arc striking or stabilizing devices and stand-alone arc striking or stabilizing devices for arc welding shall be classified as class A equipment.

Class B equipment is the equipment suitable for use in locations in residential environments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class B equipment shall meet class B limits.

5.3 Documentation for the user

The manufacturer and/or supplier of equipment shall ensure that the user is informed about the class and group of the equipment, either by labelling or by the accompanying documentation. In both cases the manufacturer/supplier shall explain the meaning of both the class and the group in the documentation accompanying the equipment.

The documentation accompanying the equipment shall contain details of any precautions to be observed by the purchaser or user to ensure that regular operation and use of the equipment in the field does not cause harmful radio frequency interference (RFI). In the framework of this document, these details concern information about:

- the possibility of radio frequency interference originating from operation of class A equipment in certain environments,
- special precautions to be observed when connecting class A equipment to a low voltage power supply network, see Footnotes to table b and c in Table 2, Footnote to table b in Table 3 and Footnote to table c in Table 8, respectively,
- measures which can be taken at installation level to reduce emissions from installed class A equipment, see Footnote to table c in Table 2 and Footnote to table a in Table 12.

For class A equipment, the instructions for use accompanying the product shall contain the following text:

Caution: This equipment is not intended for use in residential environments and might not provide adequate protection to radio reception in such environments.

6 Limits of electromagnetic disturbances

6.1 General

For measurements at standardized test sites, the requirements specified hereafter constitute the requirements for tests.

Class A equipment may be measured either on a test site or *in situ* as preferred by the manufacturer.

NOTE 1 Due to size, complexity or operating conditions some equipment can be measured in situ in order to show compliance with the radiation disturbance limits specified herein.

Class B equipment shall be measured on a test site.

NOTE 2 The limits have been determined on a probabilistic basis taking into account the likelihood of interference. In cases of interference, additional provisions can apply.

The lower limit shall apply at all transition frequencies.

Measuring apparatus and methods of measurement are specified in Clause 7, Clause 8 and Clause 9.

Where this document gives options for testing particular requirements with a choice of test methods, compliance may be shown against any of the test methods, using the specified limits with the restrictions provided in the relevant tables. In any situation where it is necessary to retest the equipment, the test method originally chosen should be used in order to ensure consistency of the results.

For equipment with radio functionality, the additional requirements of Annex F shall apply.

6.2 Group 1 equipment measured on a test site

6.2.1 Limits for conducted disturbances

6.2.1.1 General

The equipment under test shall meet either:

a) both the average limit specified for measurements with an average detector and the quasi-peak limit specified for measurements with a quasi-peak detector (see 7.3); or

b) the average limit when using a quasi-peak detector (see 7.3).

The limits for the LV DC power ports specified hereafter apply only to the following types of equipment:

1) power conversion equipment intended for assembly into photovoltaic power generating systems;
2) grid connected power convertors (GCPCs) intended for assembly into energy storage systems.

6.2.1.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz limits are not specified.

6.2.1.3 Frequency range 150 kHz to 30 MHz

Limits for the disturbance voltage at low voltage AC mains power ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site using the 50 Ω/50 µH CISPR artificial mains network (V-AMN) or the CISPR voltage probe (see 7.3.3 and Figure 1) are given in Table 2 and Table 4.

Limits for conducted disturbances at low voltage DC power ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site using the 150 Ω CISPR network (DC-AN) (see 7.3.2.3) and/or the current probe (see CISPR 16-1-2) are given in Table 3 and Table 5.

Limits for conducted disturbances at wired network ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site are given in Table 7.

For measurements at LV DC power ports, the applicability criteria in accordance with Table 6 apply.

Table 2 – Disturbance voltage limits for class A group 1 equipment measured on a test site (AC mains power port)

Frequency range MHz	**Rated power of ≤ 20 kVA [a]**		**Rated power of > 20 kVA and ≤ 75 kVA [b, a]**		**High power electronic systems and equipment, Rated power of > 75 kVA [c, a]**	
	Quasi-peak dB(µV)	**Average** dB(µV)	**Quasi-peak** dB(µV)	**Average** dB(µV)	**Quasi-peak** dB(µV)	**Average** dB(µV)
0,15 to 0,50	79	66	100	90	130	120
0,50 to 5	73	60	86	76	125	115
5 to 30	73	60	90 decreasing linearly with logarithm of frequency to 73	80 decreasing linearly with logarithm of frequency to 60	115	105

At the transition frequency, the more stringent limit shall apply.

For class A equipment intended to be connected solely to isolated neutral or high impedance earthed (IT) industrial power distribution networks (see IEC 60364-1[9]) the limits for equipment with a rated power > 75 kVA can be applied, regardless of its actual rated power.

NOTE A rated input or output power of 20 kVA corresponds for example to a current of approximately 29 A per phase in case of 400 V three-phase power supply networks and to a current of approximately 58 A per phase in case of 200 V three phase power supply networks.

[a] The selection of the appropriate set of limits shall be based on the rated AC power stated by the product documentation.

[b] These limits apply to equipment with a rated power > 20 kVA and intended to be connected to a dedicated power transformer or generator and which is not connected to low voltage (LV) overhead power lines. For equipment not intended to be connected to a user specific power transformer the limits for ≤ 20 kVA apply. Information shall be provided on installation measures that can be used to reduce emissions from the installed equipment. In particular, it shall be indicated that this equipment is intended to be connected to a dedicated power transformer or generator and not to LV overhead power lines.

[c] These limits apply only to high power electronic systems and equipment with a rated power greater than 75 kVA when intended to be installed as follows:

- installation is supplied from a dedicated power transformer or generator, which is not connected to Low Voltage (LV) overhead power lines,
- installation is physically separated from residential environments by distance greater than 30 m or by a structure which acts as a barrier to radiated phenomena,
- the product documentation shall indicate that this equipment meets the disturbance voltage limits for high power electronic systems and equipment of rated input power >75 kVA and provide information on installation measures to be applied by the installer. In particular, it shall be indicated that this equipment is intended to be used in an installation which is powered by a dedicated power transformer or generator and not by LV overhead power lines.

Table 3 – Limits for conducted disturbances of class A group 1 equipment measured on a test site (DC power port)

Frequency range MHz	Rated power of ≤ 20 kVA [a]		Rated power of > 20 kVA to ≤ 75 kVA [a, b, c]				Rated power of > 75 kVA [a, b, c]			
	Voltage limits		Voltage limits		Current limits		Voltage limits		Current limits	
	QP dB(µV)	**AV** dB(µV)	**QP** dB(µV)	**AV** dB(µV)	**QP** dB(µA)	**AV** dB(µA)	**QP** dB(µV)	**AV** dB(µV)	**QP** dB(µA)	**AV** dB(µA)
0,15 to 5	97 to 89	84 to 76	116 to 106	106 to 96	72 to 62	62 to 52	132 to 122	122 to 112	88 to 78	78 to 68
5 to 30	89	76	106 to 89	96 to 76	62 to 45	52 to 32	122 to 105	112 to 92	78 to 61	68 to 48

In certain frequency ranges, the limits in this table decrease linearly with logarithm of frequency.

[a] The selection of the appropriate set of limits shall be based on the rated AC power stated by the product documentation.

[b] These limits apply to equipment with a rated power > 20 kVA and intended to be installed in a large photovoltaic power generating system by a professional. In the manual accompanying the product, information shall be provided on mitigation measures that can be used to reduce emissions from the installed equipment, with the goal of preventing harmful interference to radio reception in a distance of 30 m from the installation. In particular it shall be indicated that this equipment can be equipped with additional filtering and that installation is physically separated from residential environments by distance greater than 30 m. The installer is invited to check the mitigated installation against CISPR 11 *in situ* measurements as indicated in 6.4.

[c] Either the voltage limits or the current limits apply.

Table 4 – Disturbance voltage limits for class B group 1 equipment measured on a test site (AC mains power port)

Frequency range MHz	**Quasi-peak** dB(µV)	**Average** dB(µV)
0,15 to 0,50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0,50 to 5	56	46
5 to 30	60	50

At the transition frequency, the more stringent limit shall apply.

For diagnostic X-ray generators operating in intermittent mode the quasi-peak limits of Table 2 or Table 4 can be relaxed by 20 dB.

Table 5 – Disturbance voltage limits for class B group 1 equipment measured on a test site (DC power port)

Frequency range MHz	**Quasi-peak** dB(μV)	**Average** dB(μV)
0,15 to 0,50	84 Decreasing linearly with logarithm of frequency to 74	74 Decreasing linearly with logarithm of frequency to 64
0,50 to 30	74	64

Table 6 – Applicability of measurements at DC power ports

Cable length *L*	**Class B group 1 equipment**	**Class A group 1 equipment**
L < 3 m	No measurements are required	No measurement are required
3 m ≤ *L* < 30 m	For measurements, the limits in Table 5 apply The frequency range for measurement starts at a frequency equal to: *f*(MHz) = 60/*L*	For measurements, the limits in Table 3 apply [a] The frequency range for measurement starts at a frequency equal to: *f*(MHz) = 60/*L*
L ≥ 30 m	For measurements, the limits in Table 5 apply	For measurements, the limits in Table 3 apply [a]

L: maximum length of a cable (in metres) connected to an LV DC power port, and provided with the product or as specified in the product documentation. Where no maximum cable length is specified, *L* shall be considered as longer than 30 m.

This table applies unless specific conditions are given in the applicable product standard leading at least to the same level of protection of radio reception. Product standards can define specific conditions according to their particular application with the purpose of avoiding radiation.

[a] No limits apply if the equipment is installed using good engineering practice regarding EMC.

Examples of good engineering practice are:

– symmetrical DC port line configuration,

– installation internal to the building,

– grounded metallic cable trays,

– use of shielded cables,

– manage a separation distance that acts as a barrier from residential environment (e.g. greater than 30 m).

If exception [a] is used, the installer can refer to CISPR 11 for *in situ* measurement.

Table 7 – Limits for conducted disturbances measured on a test site (wired network port)

Frequency range MHz	Class A				Class B			
	Voltage		Current		Voltage		Current	
	QP	AV	QP	AV	QP	AV	QP	AV
	dB(μV)	dB(μV)	dB(μA)	dB(μA)	dB(μV)	dB(μV)	dB(μA)	dB(μA)
0,15 to 0,5	97 to 87	84 to 74	53 to 43	40 to 30	84 to 74	74 to 64	40 to 30	30 to 20
0,5 to 30	87	74	43	30	74	64	30	20

In the frequency range from 0,15 MHz to 0,5 MHz, the limits in this table decrease linearly with the logarithm of frequency.

Excluding measurement uncertainty, all other elements within CISPR 32 shall be applied, including but not limited to the selection of measurement procedures, test configuration, cable characteristics and ancillary equipment (current probe, capacitive voltage probe and/or artificial network).

NOTE 1 The voltage and current disturbance limits are based on a common mode impedance of 150 Ω for the wired network port under test.

NOTE 2 The application of the voltage and/or current disturbance limits is dependent on the port type and on the measurement procedure used; see Table C.1 of CISPR 32:2015/AMD1:2019.

6.2.2 Limits of electromagnetic radiation disturbance

6.2.2.1 General

The equipment under test shall meet the quasi-peak limits when using a quasi-peak detector.

6.2.2.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz, limits are not specified.

6.2.2.3 Frequency range 150 kHz to 1 GHz

In the frequency range 150 kHz to 30 MHz, limits are not specified.

In the frequency range above 30 MHz, the limits refer to the electric field strength component of the electromagnetic radiation disturbance.

The electromagnetic radiation disturbance limits for the frequency range 30 MHz to 1 GHz for group 1, classes A and B equipment are specified in Table 8 and Table 9, respectively. Recommendations for the protection of specific safety-related radio services are given in Annex C and Table C.1.

On an open-area test site (OATS) or in a semi-anechoic chamber (SAC), class A equipment can be measured at a nominal distance of 3 m, 10 m or 30 m (see information in Table 8), and class B equipment at a nominal distance of 3 m or 10 m (see information in Table 9). A measuring distance less than 10 m is allowed only for equipment that complies with the definition for *small EUT* (see 3.1.32).

In a fully-anechoic room (FAR) class A or class B equipment can be measured at a nominal distance of 3 m (see information in Table 8 and Table 9), provided that the EUT fits into the validated test volume of the given FAR. In conjunction with measurements according to this document, the use of the FAR is restricted to table-top equipment.

Table 8 – Electromagnetic radiation disturbance limits for class A group 1 equipment measured on a test site

Frequency range MHz	OATS or SAC				FAR	
	10 m measuring distance rated power of		3 m measuring distance [a] rated power of		3 m measuring distance [a, b] rated power of	
	≤ 20 kVA [c]	> 20 kVA [c, d]	≤ 20 kVA [c]	> 20 kVA [c, d]	≤ 20 kVA [c]	> 20 kVA [c, d]
	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)
30 to 230	40	50	50	60	52 decreasing linearly with logarithm of frequency to 45	62 decreasing linearly with logarithm of frequency to 55
230 to 1 000	47	50	57	60	52	55

On an OATS or in a SAC, class A equipment can be measured at a nominal distance of 3 m, 10 m or 30 m. In case of measurements at a separation distance of 30 m, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance.

At the transition frequency, the more stringent limit shall apply.

In the frequency range 30 MHz to 230 MHz, the limit for measurements in the FAR decreases linearly with the logarithm of frequency.

[a] The 3 m separation distance applies only to *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR.

[c] The selection of the appropriate set of limits shall be based on the rated AC power stated in the product documentation.

[d] These limits apply to equipment with a rated power of > 20 kVA and intended to be used at locations where there is a distance greater than 30 m between the equipment and third party sensitive radio communications. It shall be indicated in the technical documentation that this equipment is intended to be used at locations where the separation distance to third party sensitive radio services is > 30 m. If these conditions are not met, then the limits for ≤ 20 kVA apply.

Table 9 – Electromagnetic radiation disturbance limits for class B group 1 equipment measured on a test site

Frequency range MHz	OATS or SAC		FAR
	10 m measuring distance	3 m measuring distance [a]	3 m measuring distance [a, b]
	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)	Quasi-peak dB(μV/m)
30 to 230	30	40	42 Decreasing linearly with logarithm of frequency to 35
230 to 1 000	37	47	42

On an OATS or in a SAC, class B equipment may be measured at a nominal distance of 3 m or 10 m.

At the transition frequency, the more stringent limit shall apply.

[a] The 3 m separation distance applies only to *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR.

For medical electrical equipment intended to be permanently installed in shielded locations, further provisions with regard to the measurement arrangement and load conditions are found in IEC 60601-1-2 [10].

6.2.2.4 Frequency range 1 GHz to 18 GHz

The equipment shall meet the electromagnetic radiation disturbance limits specified in Table 11 up to the maximum measurement frequency determined in accordance with Table 10. If the highest internal frequency F_x is not known, measurements shall be performed up to 6 GHz. The equipment shall meet both the peak and the average limits. If the measurements using peak detector pass the average limit, there is no need to apply the average detector.

In the frequency range 6 GHz to 18 GHz limits are not specified.

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. Only the average limits shall apply to disturbances from arcs and sparks, while both the peak and average limits shall apply to all other disturbances from such devices.

Measurements may be performed at distances of 3 m or 10 m taking into account the EUT size criterion as specified in 3.1.32. When using the 10 m distance, the limits of Table 11 shall be modified as follows:

$$Limit\ (10\ m) = Limit\ (3\ m) - 20\ \log\ (10/3)$$

where both limits are expressed in dB(µV/m).

Table 10 – Required highest frequency for radiated measurements

Highest internal frequency **F_x**	**Highest measured frequency**
F_x ≤ 108 MHz	1 GHz
108 MHz < F_x ≤ 500 MHz	2 GHz
500 MHz < F_x ≤ 1 GHz	5 GHz
F_x > 1 GHz	5 × F_x up to a maximum of 6 GHz
NOTE F_x is defined in 3.1.17.	

Table 11 – Electromagnetic radiation disturbance limits for group 1 equipment measured on a test site

Frequency range GHz	**Limits for a measurement distance of 3 m** dB(µV/m)			
	Class A		**Class B**	
	Peak	Average	Peak	Average
1 to 3	76	56	70	50
3 to 6	80	60	74	54
At the transitional frequency, the more stringent limit shall apply.				

6.2.2.5 Frequency range 18 GHz to 400 GHz

In the frequency range 18 GHz to 400 GHz, limits are not specified.

6.3 Group 2 equipment measured on a test site

6.3.1 Limits for conducted disturbances

6.3.1.1 General

The equipment under test shall meet either:

a) both the average limit specified for measurements with an average detector and the quasi-peak limit specified for measurements with a quasi-peak detector (see 7.3); or

b) the average limit when using a quasi-peak detector (see 7.3).

6.3.1.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz, limits are not specified.

6.3.1.3 Frequency range 150 kHz to 30 MHz

Limits for the disturbance voltage at low voltage AC mains power ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site using the 50 Ω/50 µH CISPR artificial mains network (V-AMN) or the CISPR voltage probe (see 7.3.3 and Figure 1) are given in Table 12 and Table 13, except for the ITU designated frequency bands listed in Table 1 where no limits apply.

For electric welding equipment the limits of Table 12 or Table 13 apply in active mode of operation. In stand-by (or idle) mode, the limits of Table 2 or Table 4 apply.

For ISM RF lighting devices operating in dedicated ISM frequency bands (defined by the ITU in Table 1) the limits of Table 13 apply.

Limits for conducted disturbances at wired network ports in the frequency range 150 kHz to 30 MHz for equipment measured on a test site are given in Table 7.

Table 12 – Disturbance voltage limits for class A group 2 equipment measured on a test site (AC mains power port)

Frequency range MHz	Rated power of ≤ 75 kVA [a, b]		Rated power of > 75 kVA [a, c]	
	Quasi-peak dB(µV)	Average dB(µV)	Quasi-peak dB(µV)	Average dB(µV)
0,15 to 0,50	100	90	130	120
0,50 to 5	86	76	125	115
5 to 30	90 decreasing linearly with logarithm of frequency to 73	80 decreasing linearly with logarithm of frequency to 60	115	105
At the transition frequency, the more stringent limit shall apply.				

[a] Selection of the appropriate set of limits shall be based on the rated AC power stated in the product documentation.

[b] For class A equipment with a rated power ≤ 75 kVA intended to be connected solely to isolated neutral or high impedance earthed (IT) industrial power distribution networks (see IEC 60364-1[9]) the limits defined for group 2 equipment with a rated power > 75 kVA may be applied.

[c] Information shall be provided on installation measures that can be used to reduce emissions from the installed equipment.

NOTE A rated input or output power of 75 kVA corresponds for example to a current of approximately 108 A per phase in case of 400 V three phase power supply networks and to a current of approximately 216 A per phase in case of 200 V three phase power supply networks.

High-frequency (HF) surgical equipment shall meet the limits of Table 2 or Table 4 specified for group 1 equipment in stand-by mode of operation. For high-frequency (HF) surgical equipment operating at frequencies outside designated ISM bands (see Table 1), these limits also apply at the operating frequency and inside the designated frequency bands. The related measurements shall be performed in a test arrangement in accordance with IEC 60601-2-2.

Table 13 – Disturbance voltage limits for class B group 2 equipment measured on a test site (AC mains power port)

Frequency range MHz	Quasi-peak dB(µV)	Average dB(µV)
0,15 to 0,50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0,50 to 5	56	46
5 to 30	60	50
At the transition frequency, the more stringent limit shall apply.		

6.3.2 Limits of electromagnetic radiation disturbance

6.3.2.1 General

The equipment under test shall meet the limits when using a measuring instrument with a peak, quasi-peak or average detector as indicated in the appropriate table.

Up to 30 MHz the limits refer to the magnetic component of the electromagnetic radiation disturbance. Above 30 MHz, the limits refer to the electric field strength component of the electromagnetic radiation disturbance.

6.3.2.2 Frequency range 9 kHz to 150 kHz

In the frequency range 9 kHz to 150 kHz, limits are not specified.

6.3.2.3 Frequency range 150 kHz to 1 GHz

Except for the designated frequency range listed in Table 1, the electromagnetic radiation disturbance limits for the frequency range 150 kHz to 1 GHz for group 2 class A equipment are specified in Table 14 and for group 2 class B equipment in Table 16.

The limits in Table 14 and Table 16 apply to all electromagnetic disturbances at all frequencies not exempted according to Table 1 footnote a.

For class A equipment for resistance welding, the limits of Table 14 apply in the frequency range 30 MHz to 1 GHz in active mode of operation. In stand-by (or idle) mode, the limits of Table 8 apply. For class B equipment for resistance welding, the limits of Table 16 apply in active mode of operation. In stand-by (or idle) mode, the limits of Table 9 apply.

For class A arc welding equipment, the limits of Table 15 apply in active mode of operation. In stand-by (or idle) mode, the limits of Table 8 apply. For class B arc welding equipment, the limits of Table 9 apply in active mode of operation and in stand-by (or idle) mode.

For class A EDM equipment the limits of Table 15 apply.

For ISM RF lighting devices operating in dedicated ISM frequency bands (in Table 1 as defined by the ITU) the limits of Table 16 apply.

For high-frequency (HF) surgical equipment, the limits of Table 8 or Table 9 apply. High-frequency (HF) surgical equipment shall meet the respective limits when tested in stand-by mode of operation.

Recommendations for the protection of specific safety services are given in Annex C and Table C.1.

On an open-area test site (OATS) or in a semi-anechoic chamber (SAC), class A equipment may be measured at a nominal distance of 3 m, 10 m or 30 m, and class B equipment at a nominal distance of 3 m or 10 m (see Table 14 and Table 16).

In the frequency range 30 MHz to 1 GHz, a measuring distance of 3 m is allowed only for equipment which complies with the definition given in 3.1.32.

In a fully-anechoic room (FAR) class A or class B equipment may be measured at a nominal distance of 3 m, provided that the EUT fits into the validated test volume of the given FAR. In conjunction with measurements according to this document, use of the FAR is restricted to table-top equipment.

For group 2 class A or class B equipment other than EDM or arc welding, measurements in the FAR in the range 30 MHz to 1 GHz shall be supplemented by measurement of the magnetic component of the disturbance field strength in the range 150 kHz to 30 MHz, at an OATS or in a SAC; see also footnote b in Table 14 and footnote c in Table 16.

Table 14 – Electromagnetic radiation disturbance limits for class A group 2 equipment measured on a test site

Frequency range MHz	OATS or SAC						FAR
	Limits for a measuring distance *D* in m						
	D = 30 m		*D* = 10 m		*D* = 3 m [a]		*D* = 3 m [a, b]
	Electric field Quasi-peak dB(μV/m)	Magnetic field Quasi-peak dB(μA/m)	Electric field Quasi-peak dB(μV/m)	Magnetic field Quasi-peak dB(μA/m)	Electric field Quasi-peak dB(μV/m)	Magnetic field Quasi-peak dB(μA/m)	Electric field Quasi-peak dB(μV/m)
0,15 to 0,49	–	33,5	–	57,5	–	82	–
0,49 to 1,705	–	23,5	–	47,5	–	72	–
1,705 to 2,194	–	28,5	–	52,5	–	77	–
2,194 to 3,95	–	23,5	–	43,5	–	68	–
3,95 to 11	–	8,5	–	18,5	–	68 to 28,5	–
11 to 20	–	8,5	–	18,5	–	28,5	–
20 to 30	–	–1,5	–	8,5	–	18,5	–
30 to 47	58	–	68	–	78	–	80 to 78
47 to 54,56	40	–	50	–	60	–	60
54,56 to 68	40	–	50	–	60	–	60 to 59
68 to 80,872	53	–	63	–	73	–	72
80,872 to 81,848	68	–	78	–	88	–	87
81,848 to 87	53	–	63	–	73	–	72 to 71
87 to 134,786	50	–	60	–	70	–	68 to 67
134,786 to 136,414	60	–	70	–	80	–	77
136,414 to 156	50	–	60	–	70	–	67 to 66
156 to 174	64	–	74	–	84	–	80
174 to 188,7	40	–	50	–	60	–	56
188,7 to 190,979	50	–	60	–	70	–	66
190,979 to 230	40	–	50	–	60	–	56 to 55
230 to 400	50	–	60	–	70	–	65
400 to 470	53	–	63	–	73	–	68
470 to 1 000	50	–	60	–	70	–	65

On an OATS or in a SAC, class A equipment may be measured at a nominal distance of 3 m, 10 m or 30 m. A measuring distance less than 10 m is allowed only for equipment which complies with the definition given in 3.1.32.

At the transition frequency, the more stringent limit shall apply. In certain frequency ranges, the limit for magnetic field strength and for measurements in the FAR decreases linearly with the logarithm of frequency.

[a] In the frequency range 30 MHz to 1 GHz, the 3 m measuring distance applies only to *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR. In the range below 30 MHz, such group 2 equipment shall be measured at an OATS or in a SAC (see limits in the respective magnetic field column in this table).

Table 15 – Electromagnetic radiation disturbance limits for class A EDM and arc welding equipment measured on a test site

	OATS or SAC		FAR
Frequency range MHz	**10 m measuring distance**	**3 m measuring distance** [a]	**3 m measuring distance** [a, b]
	Quasi-peak dB(μV/m)	**Quasi-peak** dB(μV/m)	**Quasi-peak** dB(μV/m)
30 to 230	80 Decreasing linearly with logarithm of frequency to 60	90 Decreasing linearly with logarithm of frequency to 70	102 Decreasing linearly with logarithm of frequency to 75
230 to 1 000	60	70	75

On an OATS or in a SAC, class A equipment may be measured at a nominal distance of 3 m, 10 m or 30 m. In case of measurements at a separation distance of 30 m, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance.

[a] The 3 m separation distance applies only to *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR.

Table 16 – Electromagnetic radiation disturbance limits for class B group 2 equipment measured on a test site

Frequency range MHz	OATS or SAC					FAR	
	Limits for a measuring distance D in m						
	D = 10 m		D = 3 m [a]		D = 3 m	D = 3 m [b]	
	Electric field				Magnetic field	Electric field	
	Quasi-peak	Average [c]	Quasi-peak	Average [c]	Quasi-peak	Quasi-peak	Average [c]
	dB(μV/m)		dB(μV/m)		dB(μA/m)	dB(μV/m)	
0,15 to 30	–	–	–	–	39 to 3		
30 to 80,872	30	25	40	35	–	42 to 39	37 to 34
80,872 to 81,848	50	45	60	55	–	59	54
81,848 to 134,786	30	25	40	35	–	39 to 37	34 to 32
134,786 to 136,414	50	45	60	55	–	57	52
136,414 to 230	30	25	40	35	–	37 to 35	32 to 30
230 to 1 000	37	32	47	42	–	42	37

On an OATS or in a SAC, class B equipment may be measured at a nominal distance of 3 m or 10 m.

At the transition frequency, the more stringent limit shall apply. In certain frequency ranges, the limit for magnetic field strength and for measurements in the FAR decrease linearly with the logarithm of frequency.

[a] In the frequency range 30 MHz to 1 GHz, the 3 m separation distance applies only to *small EUT* (see 3.1.32).

[b] The table-top equipment shall fit into the validated test volume of the FAR. In the range below 30 MHz, such group 2 equipment shall be measured at an OATS or in a SAC (see limits in the respective magnetic field column in this table).

[c] The average limits apply to magnetron driven equipment and microwave ovens only. If magnetron driven equipment or microwave ovens exceed the quasi-peak limit at certain frequencies, then the measurement shall be repeated at these frequencies with the average detector and the average limits specified in this table apply.

6.3.2.4 Frequency range 1 GHz to 18 GHz

The limits in the frequency range 1 GHz to 18 GHz apply only to group 2 equipment operating at frequencies above 400 MHz. The limits specified in the Table 17 to Table 19 apply only to RF disturbances appearing outside designated ISM bands as listed in Table 1.

The electromagnetic radiation disturbance limits for the frequency range 1 GHz to 18 GHz are specified in Table 17 to Table 19. The equipment shall meet either the limits of Table 17, or at least the limits of Table 18 or Table 19 (see decision tree in 9.4.1, Figure 17).

ISM RF lighting devices operating in dedicated ISM frequency bands (in Table 1, as defined by the ITU) shall either meet the class B limits of Table 17 or at least the limits of Table 18.

For microwave-powered UV irradiators, the limits specified in Table 17 apply.

Recommendations for the protection of specific safety services are given in Annex C and Table C.1.

Table 17 – Electromagnetic radiation disturbance peak limits for group 2 equipment operating at frequencies above 400 MHz

Frequency range GHz	**Limits for a measurement distance of 3 m** **Peak** dB(μV/m)	
1 to 18	**Class A**	**Class B**
Within harmonic frequency bands	82 [a]	70
Outside harmonic frequency bands	70	70

Peak measurements with a resolution bandwidth of 1 MHz and a video signal bandwidth (VBW) higher than or equal to 1 MHz. The recommended VBW is 3 MHz.

NOTE In this table, "harmonic frequency bands" means the frequency bands which are multiples of the ISM bands allocated above 1 GHz.

[a] At the upper and lower edge frequencies of harmonic frequency bands, the more stringent limit of 70 dB(μV/m) applies.

Table 18 – Electromagnetic radiation disturbance weighted limits for group 2 equipment operating at frequencies above 400 MHz

Frequency range GHz	**Limits for a measuring distance of 3 m weighted** dB(μV/m)
1 to 2,4	60
2,5 to 5,725	60
5,875 to 18	60

Weighted measurements shall be performed with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz.

To check conformance with the limits of this table, weighted measurements shall be performed in all the following frequency ranges, in which the limit of Table 17 was exceeded during the peak measurement:

a) 1,0 GHz to 2,4 GHz [a];

b) 2,5 GHz to 6,125 GHz (outside the band 5,72 GHz to 5,88 GHz) [a];

c) 6,125 GHz to 8,575 GHz;

d) 8,575 GHz to 11,025 GHz;

e) 11,025 GHz to 13,475 GHz [b];

f) 13,475 GHz to 15,925 GHz;

g) 15,925 GHz to 18,0 GHz [a].

At subranges where the limit of Table 17 was exceeded, a weighted measurement shall be performed with a span of 20 MHz around the centre frequency adjusted to the frequency of the highest disturbance level in the respective subrange.

[a] In cases where the frequency of highest emission during peak measurement is found closer than 10 MHz from the frequency edges 1 GHz, 2,4 GHz, 2,5 GHz, 5,72 GHz, 5,88 GHz or 18 GHz, the span for weighted measurements shall remain 20 MHz, but in such a case, the centre frequency shall be adjusted so that the frequency edges are not exceeded.

[b] In any case, a final weighted measurement shall be performed at the frequency of the highest emission, which exceeds the limit of Table 17 in the frequency range 11,7 GHz to 12,7 GHz for satellite downlink. If the highest disturbance level in this subrange is outside of the range for satellite downlink, in this subrange two final measurements shall be performed.

Table 19 – Electromagnetic radiation disturbance APD level corresponding to 10^{-1} limits for class B group 2 equipment operating at frequencies above 400 MHz

Frequency range GHz	**Limits for a measurement distance of 3 m** **APD level corresponding to 10^{-1}** dB(μV/m)
1 to 2,4	70
2,5 to 5,725	70
5,875 to 18	70

To check conformance with the limits of this table, APD measurements shall be performed in all the following frequency subranges, in which the limit of Table 17 was exceeded during the peak measurement:

a) 1,0 GHz to 2,4 GHz [a];

b) 2,5 GHz to 6,125 GHz (outside the band 5,72 GHz to 5,88 GHz) [a];

c) 6,125 GHz to 8,575 GHz;

d) 8,575 GHz to 11,025 GHz;

e) 11,025 GHz to 13,475 GHz [b];

f) 13,475 GHz to 15,925 GHz;

g) 15,925 GHz to 18,0 GHz [a].

Final APD measurements shall be performed at 5 frequencies as explained in 9.4.4.3.

[a] In cases where the frequency of highest emission during peak measurement is found closer than 10 MHz from the frequency edges 1 GHz, 2,4 GHz, 2,5 GHz, 5,72 GHz, 5,88 GHz or 18 GHz, final APD measurements shall be omitted at frequencies outside the corresponding bands listed here.

[b] In any case, final APD measurements shall be performed around the frequency of the highest emission, which exceeds the limit of Table 17 in the frequency range 11,7 GHz to 12,7 GHz for satellite downlink. If the highest disturbance level in this subrange is outside of the range for satellite downlink, in this subrange two final measurements shall be performed.

NOTE An APD level corresponding to 10^{-1} means that the amplitude of the disturbance exceeds the specified level during the observation time with a probability of 10 %.

6.4 Group 1 and group 2 class A equipment measured in situ

6.4.1 Limits for conducted disturbances

Under *in situ* conditions, an assessment of conducted disturbances is not required.

6.4.2 Limits of electromagnetic radiation disturbance

The limits given in Table 20 apply to class A group 1 equipment and the limits given in Table 21 apply to class A group 2 equipment.

Table 20 – Electromagnetic radiation disturbance limits for class A group 1 equipment measured *in situ*

Frequency range MHz	Limits with measuring distance 30 m from the outer face of the exterior wall of the building in which the equipment is situated	
	Electric field **Quasi-peak** dB(μV/m)	**Magnetic field** **Quasi-peak** [a] dB(μA/m)
0,15 to 0,49	–	13,5
0,49 to 3,95	–	3,5
3,95 to 20	–	–11,5
20 to 30	–	–21,5
30 to 230	30	–
230 to 1 000	37	–

At the transition frequency, the more stringent limit shall apply.

If local conditions do not allow for measurements at 30 m, then a larger distance may be used. In this case, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance.

[a] These limits apply in addition to the limits in the frequency range 30 MHz to 1 GHz to radiated disturbances originating from the operation frequency and its harmonics appearing in the frequency range 150 kHz to 30 MHz, caused by the installed class A group 1 equipment with a rated power exceeding 20 kVA. In the event that the ambient noise level exceeds the above limits, the emissions of the EUT shall not increase this noise floor by more than 3 dB.

Table 21 – Electromagnetic radiation disturbance limits for class A group 2 equipment measured *in situ*

Frequency range MHz	Limits for a measuring distance of D in m from the exterior wall of the building	
	Electric field **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** dB(µA/m)
0,15 to 0,49	–	23,5
0,49 to 1,705	–	13,5
1,705 to 2,194	–	18,5
2,194 to 3,95	–	13,5
3,95 to 20	–	–1,5
20 to 30	–	–11,5
30 to 47	48	–
47 to 68	30	–
68 to 80,872	43	–
80,872 to 81,848	58	–
81,848 to 87	43	–
87 to 134,786	40	–
134,786 to 136,414	50	–
136,414 to 156	40	–
156 to 174	54	–
174 to 188,7	30	–
188,7 to 190,979	40	–
190,979 to 230	30	–
230 to 400	40	–
400 to 470	43	–
470 to 1 000	40	–
At the transition frequency, the more stringent limit shall apply.		

For group 2 equipment measured *in situ*, the measuring distance D from the exterior wall of the building in which the equipment is situated equals $(30 + x/a)$ m or 100 m whichever is smaller, provided that the measuring distance D is within the boundary of the premises. In the case where the calculated distance D is beyond the boundary of the premises, the measuring distance D equals x or 30 m, whichever is longer.

For the calculation of the above values:

x is the distance in m between the exterior wall of the building in which the equipment is situated and the boundary of the user's premises in each measuring direction;

a = 2,5 for frequencies lower than 1 MHz;

a = 4,5 for frequencies equal to or higher than 1 MHz.

7 Measurement requirements

7.1 General

The requirements specified in Clause 7, together with the limits specified in Clause 6, constitute the essential EMC requirements of this document.

Specific requirements for making measurements on a test site are given in Clause 8 and Clause 9, for making measurements *in situ* in Clause 10.

The requirements of the present clause are to be met for both test site and *in situ* measurements.

Measurements shall only be performed in frequency ranges where limits are specified in Clause 6.

For equipment with radio functionality, the additional requirements of Annex F shall apply.

Components or subassemblies for higher order equipment or systems which are intended to be only assembled at their respective place of operation can also be tested according to the requirements of this document. For testing purposes in the framework of this document, such components or subassemblies shall be regarded as stand-alone equipment. Components or subassemblies for which compliance with the relevant requirements cannot be shown when measured at a test site can also be assessed *in situ* when being installed into the higher order system, in which case the provisions of 6.4 shall apply.

NOTE 1 The environments encompassed in this document are residential, commercial and industrial environments as described in IEC 61000-2-5 [11]. Adherence of equipment to the requirements of this document will allow for its operation and use in these environments without resulting in an increased risk of RFI. There can also exist other IEC product standards which allow for compliance testing of components or subassemblies of higher order systems but which encompass other environments than those specified in IEC 61000-2-5 [11]. Choice of this document or the other appropriate IEC product standard for compliance testing of components or subassemblies is up to the manufacturer.

NOTE 2 Examples for such components include, but are not limited to: power converters used for distributed generation and supply of electric energy into LV AC mains networks or installations or, by means of their own dedicated transformer, into MV power distribution networks, but also power electric subassemblies intended for supply of higher order systems with power from LV AC mains networks.

7.2 Ambient noise

A test site shall allow emissions from the equipment under test to be distinguished from ambient noise. The suitability in this respect can be determined by measuring the ambient noise levels with the equipment under test inoperative and ensuring that the ambient noise levels are at least 6 dB below the limits specified in 6.2 or 6.3, as appropriate for the measurement being carried out. Further information on compliance testing in the presence of ambient noise is found in CISPR 16-2-1:2014, 6.2.2 and CISPR 16-2-3:2016/AMD1:2019, 6.2.2.

It is not necessary to reduce the ambient noise level to 6 dB below the specified limit where the combination of the ambient noise plus the emission from the equipment under test does not exceed the specified limit. Under these conditions the equipment under test is considered to satisfy the specified limit.

When carrying out measurements of conducted RF disturbances, local radio transmissions can increase the ambient noise level at some frequencies. A suitable radio-frequency filter may be inserted between the artificial network (V-AMN and/or DC-AN) and the respective laboratory AC mains supply or DC power source, or measurements may be performed in a shielded enclosure. The components forming the radio-frequency filter should be enclosed in a metallic screen directly connected to the reference ground of the measuring system. The requirements for the impedance of the artificial network shall be satisfied at the frequency of measurement when the radio-frequency filter is connected.

If, when measuring radiated RF disturbances, the 6 dB ambient noise conditions cannot be met, then the antenna may be located at a distance closer to the equipment under test than specified in Clause 6 (see 8.3.4). Further advice on measurement conditions in presence of high level ambient noise is found in Annex B.

7.3 Measuring equipment

7.3.1 Measuring instruments

Receivers with quasi-peak detectors shall be in accordance with CISPR 16-1-1. Receivers with average detectors shall be in accordance with CISPR 16-1-1.

NOTE 1 Both detectors can be incorporated in a single receiver and measurements carried out by alternately using the quasi-peak detector and the average detector.

NOTE 2 The average detector in CISPR 16-1-1 is commonly referred to as "CISPR-Average". This is to emphasize that the average detector used in a CISPR receiver obtains a measurement result that is equivalent to the peak reading of a meter with a time constant as defined in CISPR 16-1-1.

The measuring receiver used shall be operated in such a way that a variation in frequency of the disturbance being measured does not affect the results.

NOTE 3 Measuring instruments having other detector characteristics can be used provided the measurement of the disturbance values can be proved to be the same. Attention is drawn to the convenience of using a panoramic receiver or a spectrum analyzer, particularly if the working frequency of the equipment under test changes appreciably during the work cycle.

To avoid the possibility of the measuring instrument incorrectly indicating non-compliance with the limits, the measuring receiver shall not be tuned closer to the edge of one of the bands designated for ISM use than the frequency at which its 6 dB bandwidth point aligns with the edge of the designated band.

When making measurements on high power equipment, care should be taken to ensure that screening and the spurious response rejection characteristics of the measuring receiver are adequate.

For measurements at frequencies above 1 GHz, a spectrum analyzer or test receiver with characteristics as defined in CISPR 16-1-1 shall be used.

7.3.2 Artificial network (AN)

7.3.2.1 General

The artificial network (AN) is required to provide a defined termination impedance for the EUT's AC mains power port or DC power port under test at radio frequencies at the point of measurement. The AN will also provide isolation of the equipment under test from ambient noise on the respective AC or DC power lines.

7.3.2.2 Artificial mains network (AMN)

Measurement of the disturbance voltage at low voltage AC mains power ports shall be made using an artificial mains network (V-AMN) as specified in CISPR 16-1-2.

7.3.2.3 Artificial DC network (DC-AN)

Measurement of the disturbance voltage at low voltage DC power ports shall be made using the 150 Ω artificial mains Delta-network specified in 4.7 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017. Figure A.2 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017 shows a suitable circuit for a delta-network, and another example for a 150 Ω Δ-AN is shown in Figure A.7 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017. For simplified wording, any of these networks intended for use with measurements at low voltage DC power ports is further on denoted as DC-AN.

7.3.3 Voltage probe

The voltage probe shown in Figure 1 shall be used when the artificial mains network (V-AMN) cannot be used. The probe is connected sequentially between each line and the reference earth chosen (metal plate, metal tube). The probe consists mainly of a decoupling capacitor and a resistor such that the total resistance between the line and earth is at least 1 500 Ω. The effect on the accuracy of measurement of the capacitor or any other device which can be used to protect the measuring receiver against dangerous currents shall be either less than 1 dB or allowed for in calibration. The voltage probe shall meet the requirements specified in CISPR 16-1-2:2014, Clause 5.

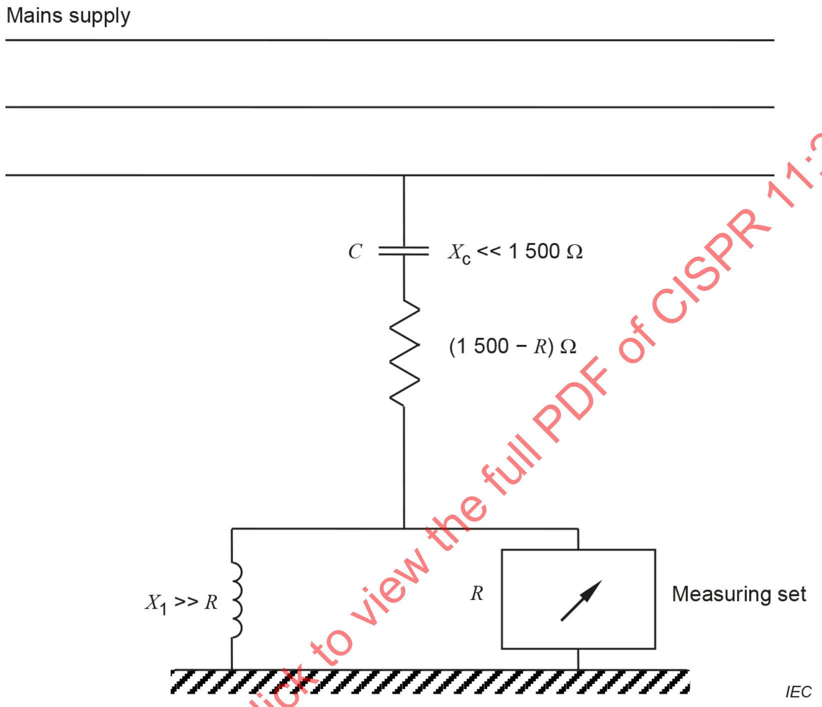


Figure 1 – Circuit for disturbance voltage measurements on mains supply

7.3.4 Antennas

7.3.4.1 Frequency range below 30 MHz

In the frequency range below 30 MHz the antenna shall be a loop as specified in CISPR 16-1-4. The antenna shall be supported in the vertical plane and be rotatable about a vertical axis. The centre of the loop shall be 1,3 m above ground level, in each orientation of the loop antenna.

7.3.4.2 Frequency range from 30 MHz to 1 GHz

7.3.4.2.1 General

In the frequency range from 30 MHz to 1 GHz the antenna used shall be as specified in CISPR 16-1-4.

Other antennas may be used provided the results can be shown to be within ±2 dB of the results which would have been obtained using a balanced dipole antenna.

7.3.4.2.2 Open-area test site (OATS) and semi-anechoic chamber (SAC)

For measurements on an OATS or in a SAC, the centre of the antenna shall be varied between 1 m and 4 m height for maximum indication at each test frequency. The nearest point of the antenna to the ground shall be not less than 0,2 m. Measurements shall be performed with the antenna oriented in both horizontal and vertical polarizations.

7.3.4.2.3 Fully-anechoic room (FAR)

For measurements in a FAR, the antenna height is fixed at the geometrical middle height of the validated test volume. Measurements shall be performed with the antenna oriented in both horizontal and vertical polarizations.

7.3.4.2.4 Other sites

For measurements *in situ* the centre of the antenna shall be fixed at (2,0 ± 0,2) m height above the ground.

7.3.4.3 Frequency range from 1 GHz to 18 GHz

In the frequency range from 1 GHz to 18 GHz, the antenna used shall be as specified in CISPR 16-1-4.

7.3.5 Artificial hand

In order to simulate the influence of the user's hand, the application of the artificial hand is required for hand-held equipment during the mains disturbance voltage measurement.

The artificial hand consists of metal foil which is connected to one terminal (terminal M) of an RC element consisting of a capacitor of 220 pF ± 20 % in series with a resistance of 510 Ω ± 10 % (see Figure 2); the other terminal of the RC element shall be connected to the reference ground of the measuring system (see CISPR 16-1-2). The RC element of the artificial hand may be incorporated in the housing of the artificial mains network.

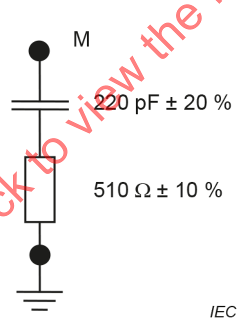


Figure 2 – Artificial hand, RC element

7.4 Frequency measurement

For equipment which is intended to operate with a fundamental frequency in one of the designated bands listed in Table 1, the frequency shall be checked with measuring equipment having an inherent error of measurement not greater than 1/10 of the permissible tolerance for the mid-band frequency of the designated band. The frequency shall be measured over all the load range from the lowest power normally used up to the maximum.

7.5 Configuration of equipment under test

7.5.1 General

Consistent with typical applications of the equipment under test, the level of the disturbance shall be maximized by varying the configuration of the equipment. An example of a typical setup for measurements of radiated disturbances from a table-top EUT is provided in Figure 3. The measurement arrangement shall be typical of normal installation practice and centred to the turntable's vertical axis.

NOTE 1 The extent to which this subclause is applicable to the measurement of an installation *in situ* will depend on the flexibility inherent in each particular installation. The provisions of this subclause apply to *in situ* measurements in so far as a particular installation allows for the position of cables to be varied and different units within the installation to be operated independently, the extent to which the position of the installation can be moved within the premises, etc.

For measurement of radiated disturbances on an OATS or in a SAC with a separation distance of 3 m the assessment of the radiation from the cabling of the EUT shall be restricted to those fractions of interconnecting cables (see 7.5.2) and mains cables (see 7.5.3) which are within the test volume not exceeding 1,5 m diameter times 1,5 m height above ground.

For the measurement of radiated disturbances in a FAR, all cables dropping to the floor shall be visible from the position of the antenna reference point for at least 80 cm, see Figure 3b.

Associated equipment not fitting into the test volume shall be excluded from the measurements or decoupled from the test environment. If cables to associated equipment cannot be extended to run out of test volume, then the associated equipment shall be placed within the imaginary circle around the complete configuration of the EUT.

The measuring distance is defined from the reference point of the antenna to the boundaries of an imaginary circle around the complete configuration of the EUT, see Figure 3a.

NOTE 2 Restriction of radiation assessment to the cable fractions inside the test volume can be achieved for example by application of CMADs to the cables at the position where they leave the test volume. CISPR 16-2-3 gives further guidance on the application of CMADs.

Dimensions in metres

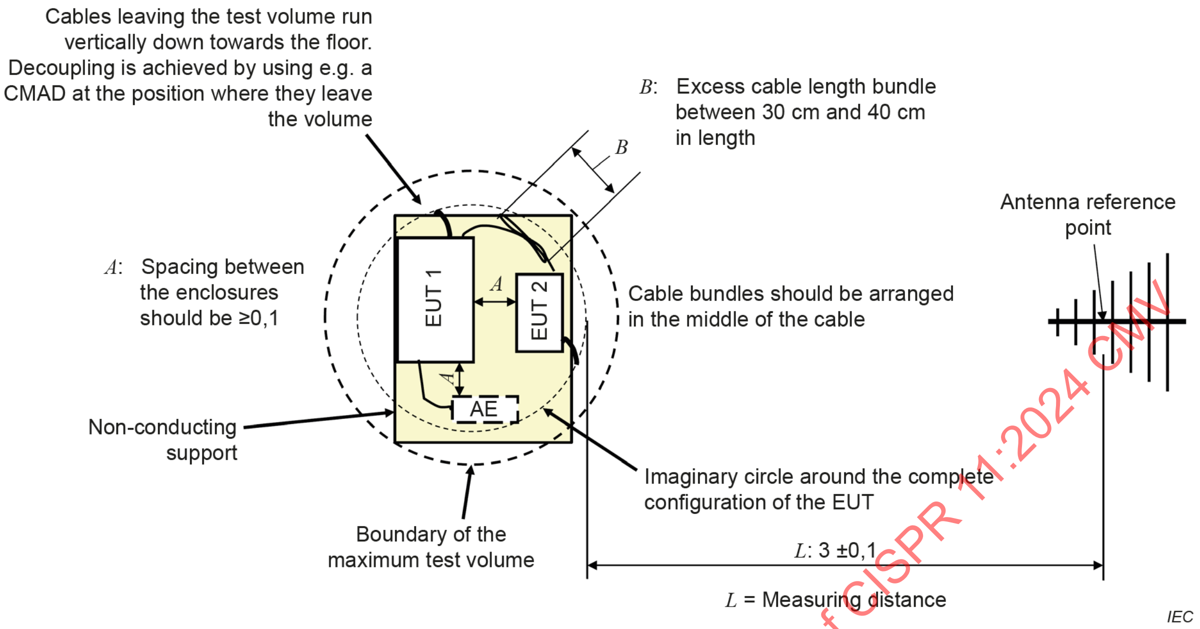


Figure 3a – Top view

Dimensions in metres

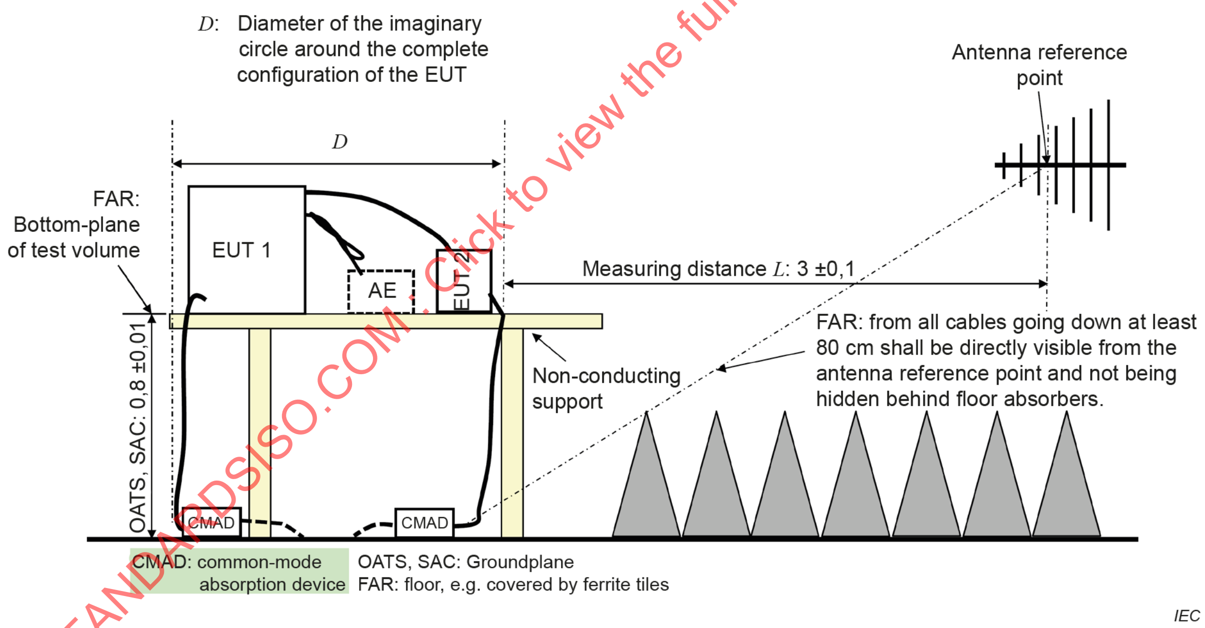
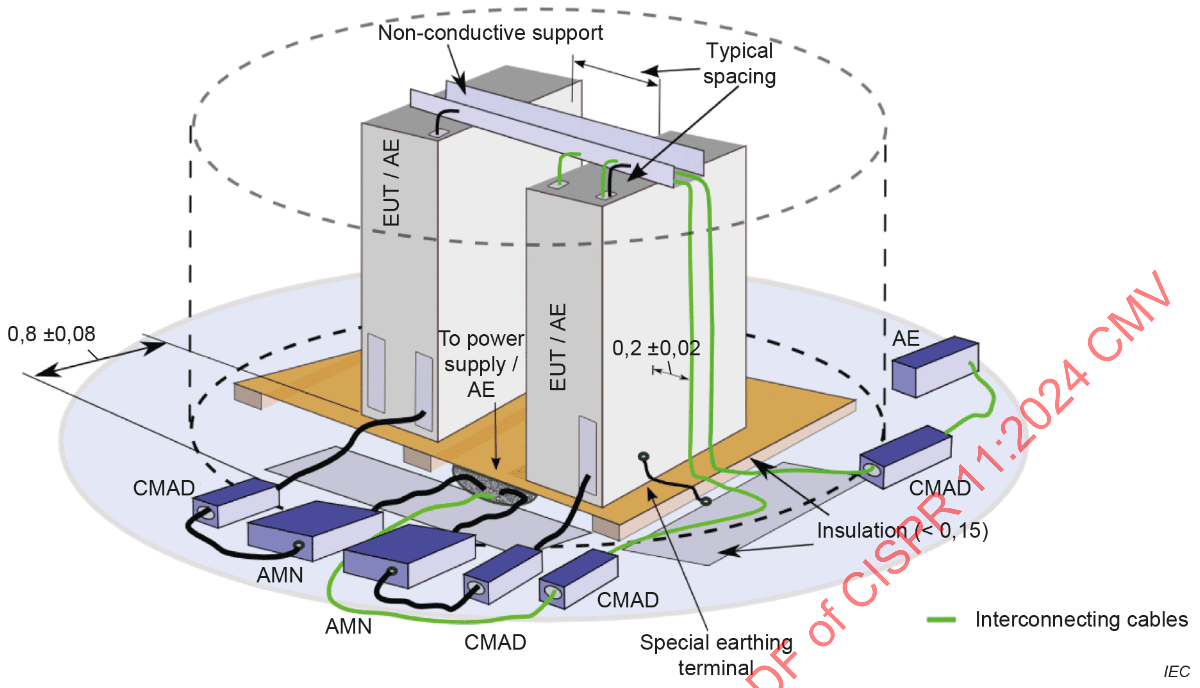


Figure 3b – Side view

Figure 3 – Example for a typical cable arrangement for measurements of radiated disturbances in 3 m separation distance, Table-top EUT

An example of a typical unified test set up for floor standing equipment suitable for measurement of conducted as well as radiated disturbances is shown in Figure 4. Further examples of typical arrangements of the EUT and associated peripherals are given in CISPR 16-2-3 and CISPR 16-2-1.

Dimensions in metres



NOTE CMADs are not used for conducted disturbance measurements.

Figure 4 – Example for a typical test set up for measurement of conducted and/or radiated disturbances from a floor standing EUT, 3D view

The configuration of the equipment under test, including the exact placement of the CMAD and the type of test site used for the measurement, shall be documented in the test report.

7.5.2 EUT cables and components

This subclause applies to equipment in which there are interconnecting cables between various parts of the equipment, or systems where a number of components are interconnected.

NOTE 1 The observation of all provisions in this subclause ensures the application of the results of an evaluation to a number of system configurations using the same types of equipment and cables as tested, but no other, each system configuration being in effect a subsystem of the one evaluated.

Interconnecting cables shall be of the type and length specified in the individual equipment requirements. If the length can be varied, the length shall be selected to produce maximum emissions when performing field strength measurements.

If shielded or special cables are used during the tests then the use of such cables shall be specified in the instruction manual.

The connection of signal leads, except for the leads supplied with the EUT, is not required during radio-frequency emission measurements for portable test and measurement apparatus, group 1, or those intended for use in laboratories and operated by competent persons. Examples are signal generators, network and logic analysers, and spectrum analysers.

Excess lengths of cables shall be bundled at the approximate centre of the cable with bundles up to 40 cm in length. If it is impracticable to do so the disposition of the excess cable shall be noted precisely in the test report.

Where there are multiple interface ports all of the same type, connecting a cable to just one of that type of port is sufficient provided that it can be shown that the additional cables would not significantly affect the results.

Any set of results shall be accompanied by a complete description of the cable and equipment orientation so that results can be reproduced. If there are conditions of use, those conditions shall be specified, documented and included in the instructions for use.

If a given type of equipment can perform separately any one of a number of functions then the equipment shall be tested while performing each of these functions. For systems which may include a number of different components, one of each type of component which is included in the system configuration shall be included in the evaluation.

A system which contains a number of identical components, but has been evaluated using only one of those components, does not require further evaluation if the initial evaluation was satisfactory.

NOTE 2 This is possible because it has been found that in practice emissions from identical modules are not additive.

When equipment is being evaluated which interacts with other equipment to form a system then the evaluation may be carried out using either additional equipment to represent the total system or with the use of simulators. In either method care shall be taken to ensure that the equipment under test is evaluated with the effects of the rest of the system or simulators satisfying the ambient noise conditions specified in 7.2. Any simulator used in lieu of actual equipment shall properly represent the electrical and in some cases the mechanical characteristics of the interface, especially with respect to radio-frequency signals and impedances, as well as cable configuration and types.

NOTE 3 This procedure is intended to facilitate the evaluation of equipment which will be combined with other equipment from different manufacturers to form a system.

When performing conducted disturbance measurements on wired network ports, the EUT shall be arranged and operated in accordance with CISPR 32.

7.5.3 Connection to the electricity supply network on a test site

7.5.3.1 Connection to the laboratory AC mains network

7.5.3.1.1 General

Where applicable the mains power from the laboratory's electricity power supply network shall be provided through the artificial mains network (AMN) specified in 7.3.2.2.

For connection to the AMN or to the test site's electricity supply network, appropriate lengths of mains cables shall be used. If the manufacturer's installation instructions specify a particular type of mains cable for use with the EUT, connection to the AMN or to the test site's electricity supply network shall be made with that cable type.

Mains power at the nominal voltage shall be supplied.

7.5.3.1.2 Conducted and radiated disturbance measurements up to 30 MHz

When performing measurements on a test site, the artificial mains network (V-AMN) specified in 7.3.2.2 shall be used whenever possible. The enclosure of the V-AMN shall be located so that its closest surface is no less than 0,8 m from the nearest boundary of the equipment under test.

Where a flexible mains cord is provided with the EUT, this shall be 1 m long or, if in excess of 1 m, the excess cable shall be folded to and forth to form a bundle not exceeding 0,4 m in length.

Where a mains cable is specified in the installation, instructions a 1 m length of the type specified shall be connected between the test unit and the AMN.

Earth connections, where required for safety purposes, shall be connected to the reference "earth" point of the AMN and where not otherwise provided or specified by the manufacturer shall be 1 m long and run parallel to the mains connection at a distance of not more than 0,1 m.

Other earth connections (e.g. for EMC purposes) either specified in the installation manual or supplied with the EUT for connection to the same terminal as the safety earth connection shall also be connected to the reference earth of the AMN.

Ancillary low voltage AC mains ports shall be connected to the laboratory AC mains network via one or more separate artificial mains networks (V-AMN) as specified in 7.3.2.2.

Where the equipment under test is a system comprising more than one unit, each unit having its own power cord, the point of connection for the AMN is determined from the following rules:

a) each mains cable which is terminated in a mains supply plug of a standard design (e.g., IEC TR 60083 [23]) shall be tested separately;
b) mains cables or terminals which are not specified by the manufacturer to be connected to another unit in the system for the purposes of supplying mains power shall be tested separately;
c) mains cables or terminals which are specified by the manufacturer to be connected to another unit in the system for the purposes of supplying mains power shall be connected to that unit, and the mains cables or terminals of that unit are connected to the AMN;
d) where a special connection is specified, the necessary hardware to effect the connection shall be used during the evaluation of the equipment under test.

7.5.3.1.3 Radiated disturbance measurements in the range 30 MHz to 18 GHz

Connection to the laboratory's electricity supply network may be provided with or without the use of an AMN located inside the test environment, see Figure 4. For measurement arrangements not including an AMN, grounding and earthing of the EUT shall be guaranteed by adherence to the principles set out in 7.5.3.1.2 as far as possible.

If the measurement arrangement does not include an AMN, then excessive lengths of mains cables do not need to be bundled and located inside the test volume. They may be accommodated outside the test volume or test environment. For decoupling of radiation from these excessive cable lengths it is however recommended to carefully terminate these mains cables at the location where they leave the test volume. For this decoupling use of CMADs is recommended. For measurements with a separation distance of 3 m, this decoupling is mandatory, see 7.5.1.

7.5.3.2 Connection to the laboratory DC power supply or other DC power source

When performing measurements on a test site, the 150 Ω artificial DC network (DC-AN) specified in 7.3.2.3 shall be used whenever possible. The enclosure of the DC-AN shall be located so that its closest surface is 0,8 m from the nearest boundary of the equipment under test.

Where the DC-AN is used as voltage probe, the EUT's DC power port under test shall be decoupled from the DC power source by means of suitable common mode decoupling devices such as ferrite tubes, CMADs or a CDN as specified in 6.2.2 and 6.2.3 of IEC 61000-4-6:2023 which shall be clamped at or be inserted in the DC power cable connecting the DC power source with the measurement arrangement for the EUT, see also Figure 12, Figure 13 and Figure 14. If a CDN according to IEC 61000-4-6 is used for decoupling purposes, its RF power input port shall not be terminated with a 50 Ω resistive load.

Connection shall be made to a suitable DC power source. The DC output voltage of this power source shall be adjustable to provide a voltage level within the rated operation range for the respective type of EUT.

NOTE 1 For supply of the EUT's DC power port under test, a dedicated laboratory DC power source, appropriate (sets of) batteries or also other DC energy sources such as e.g. fuel cell modules can be used, provided that they allow for continuous and stable voltage, current, etc. applicable for power converters under rated output operating conditions, throughout the measurement.

Care should be taken when selecting the laboratory DC power source and installing it in the measurement arrangement. It is recommended to select and install only such a DC power source which provides for a good galvanic insulation and also sufficient RF decoupling of both DC power terminals from the laboratory reference ground plane. Internal decoupling capacitors at the DC power source's terminals used for internal suppression of asymmetric disturbances can provide an unwanted bypass for the common mode 150 Ω termination impedance of the DC-AN used for the measurements. This can cause saturation effects in the mitigation filter of the power converter under test, in particular at the operation frequency (i.e. the switching frequency) of the power converter and its harmonics, which are usually in the range from 2 kHz to some 20 kHz. Saturated mitigation filters lead to incorrect and invalid measurement results since the power converter is not operated as intended during the measurements. For guidance on prevention of saturation effects caused by the configuration of the test site, see information in Annex E.

Where a particular type of DC power cable is specified in the installation instructions, this shall be used during the measurements.

For testing, a cable length as short as possible shall be connected between the equipment under test and the DC-AN respecting the proximity of the boundary conditions defined above.

Where the equipment under test has more than one DC power port of the same type, the number of DC power ports needed to operate the equipment at its rated power shall be connected to the DC-AN for the measurements. All other DC power ports shall be terminated with a suitable 150 Ω common mode termination impedance. Multiple ports galvanically connected in parallel (such as bus bars or strips for connection to multiple cables) are considered to represent one single port only.

NOTE 2 For these other terminations, any suitable device can be used. This includes e.g. use of further 150 Ω networks according to CISPR 16-1-2, further DC-ANs as specified in 7.3.2.3, or also use of 150 Ω coupling/decoupling devices (CDN) as defined in IEC 61000-4-6.

Ancillary DC power ports shall be connected to an appropriate separate laboratory DC power source or battery, via a suitable 150 Ω common mode termination impedance.

NOTE 3 If a separate mains-connected laboratory DC power source is used, then it can be appropriate to also insert another EMI filter in the connection to that power source. Diagrams showing suitable setups for the test site are found in Annex D.

7.5.4 Measurements of robots

For disturbance measurements of robots, the following conditions shall apply:

a) For radiated emissions, the EUT boundary shall be the smallest circle fully enclosing the footprint of all fixed parts of the robot and corresponding EUT cables, ignoring any portion of the robot that moves during normal operation; an example is illustrated in Figure 5. However, when an emission failing the limit is estimated to originate from a portion of the moving arm/element that can be outside of the EUT boundary during the operation of the robot, this shall be investigated and, if confirmed, the emission shall be re-measured with the measurement antenna relocated at the limit distance from this specific portion on the moving arm/element of the robot; in this case, the investigation and the results obtained from the re-measurement shall be documented in the test report.

b) The EUT arrangement shall be such that the mobile portions of the robot can move freely, as in normal operation, during the test.

c) In the case of a fixed robot, the installation instructions shall be respected in all cases. To ensure stable robot operation, the robot shall be rigidly fixed and one of the following electrical conditions shall be fulfilled as required in the installation instructions:

   – remain insulated, or

   – grounded to dedicated grounding/earthing point.

d) A mobile robot shall be supported above the ground plane at the required height (up to 15 cm, 40 cm or 80 cm, depending on if the EUT is floor-standing or tabletop and if the measurement is radiated, conducted with a VCP, or conducted without a VCP) by means of an insulating support that allows the propulsion system of the robot to move freely. If the free movement of the propulsion system of the robot is not possible when using an insulating support of the maximum allowed thickness, this may be increased, as appropriate; in this case, the actual thickness of the insulating support shall be documented in the test report.

Example setups for floor-standing robots are shown in Figure 6 and Figure 7 (for conducted and radiated disturbance measurements, respectively), while Figure 8 and Figure 9 illustrate an example combination EUT (consisting of both floor-standing and tabletop/wall-mount units).

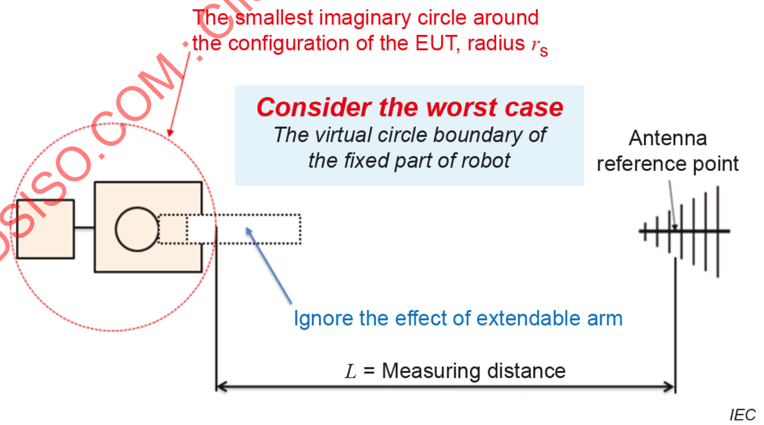


Figure 5 – EUT boundary determination for radiated disturbance measurements of robots with extendable/moving arm

Dimensions in centimetres

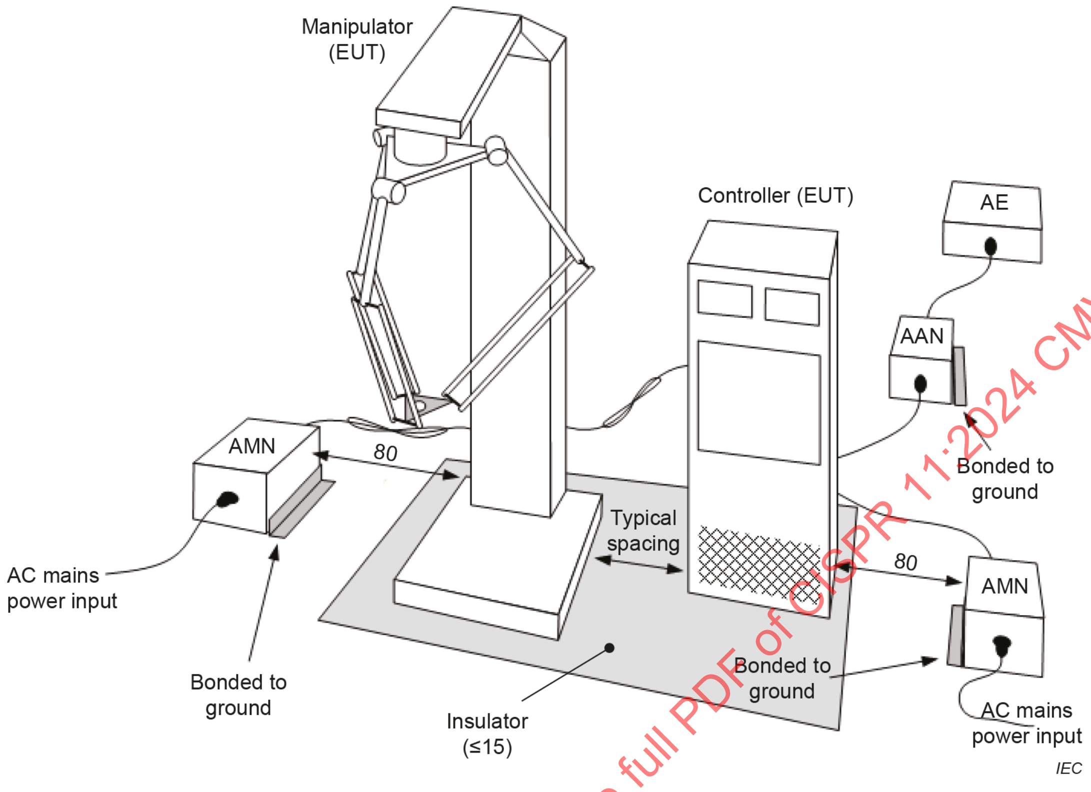
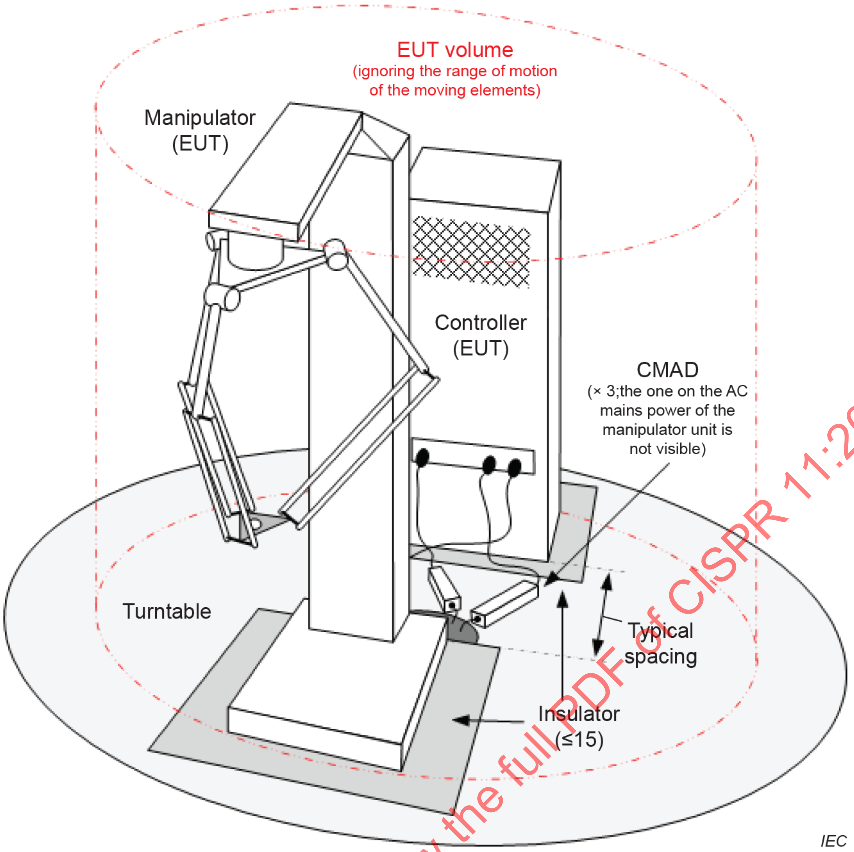


Figure 6 – Example of a typical test setup for conducted disturbance measurement on a floor-standing robot system

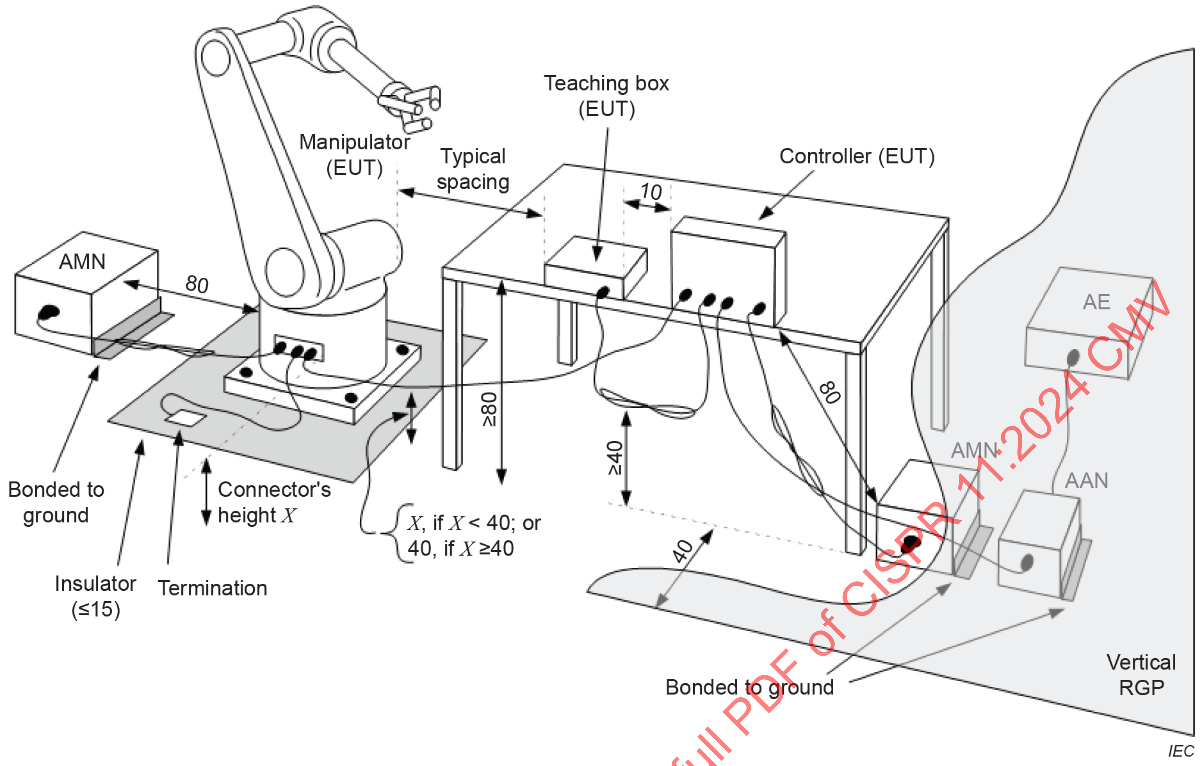
Dimensions in centimetres



CMADs might not be available for the power rating or diameter of the cables of the EUT, or the cable might be too short.

Figure 7 – Example of a typical test setup for radiated disturbance measurement on a floor-standing robot system

Dimensions in centimetres

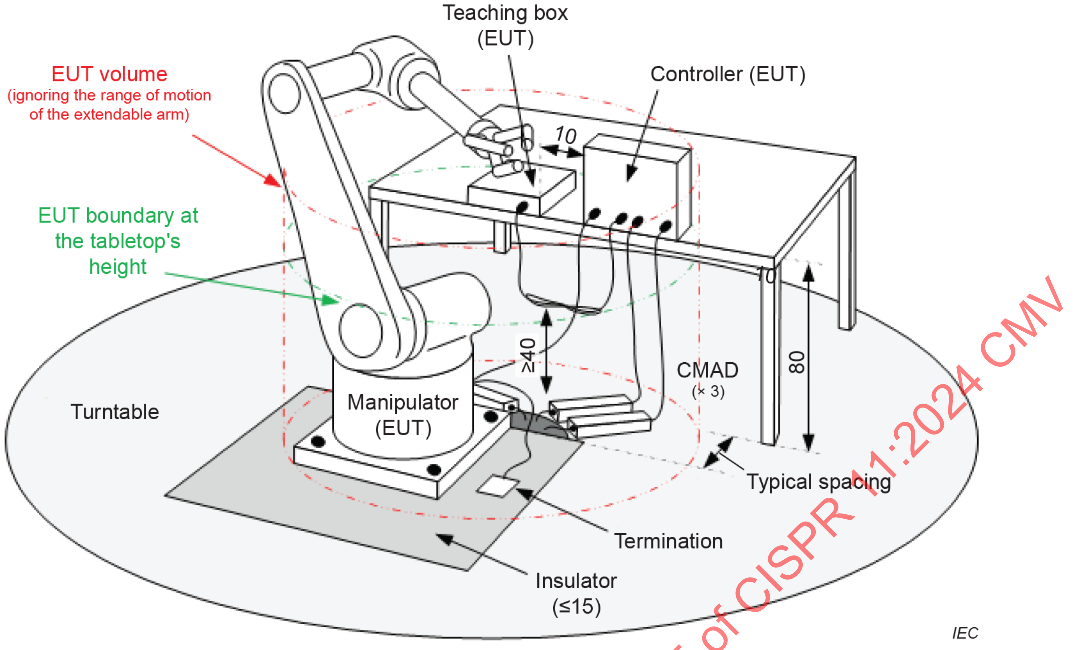


Wall-mount equipment, such as the controller illustrated above, shall be arranged as tabletop EUT, in accordance with CISPR 16-2-1.

NOTE The robot system illustrated here is a combination EUT, including both tabletop and floor-standing units.

Figure 8 – Example of a typical test setup for conducted disturbance measurement on a combination robot system

Dimensions in centimetres



Wall-mount equipment, such as the controller illustrated above, shall be arranged as tabletop EUT, in accordance with CISPR 16-2-3.

CMADs might not be available for the power or diameter of the cables of the EUT, or the cable might be too short.

NOTE The robot system illustrated here is a combination EUT, including both tabletop and floor-standing units.

Figure 9 – Example of a typical test setup for radiated disturbance measurement on a combination robot system

7.6 Load conditions of the EUT

7.6.1 General

Load conditions of the equipment under test are specified in this subclause. Equipment not covered by this subclause shall be operated so as to maximize the disturbance generated while still conforming with normal operating procedures as provided in the operating manual of the equipment.

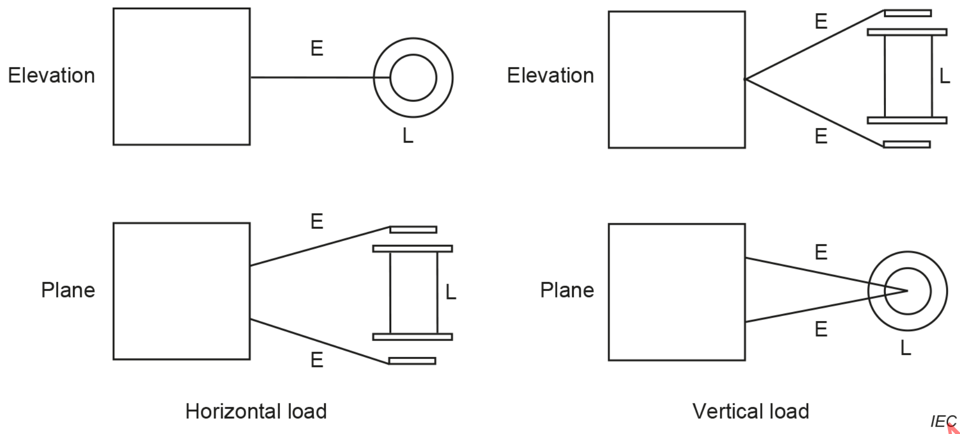
7.6.2 Medical equipment

7.6.2.1 Therapeutic equipment using frequencies from 0,15 MHz to 400 MHz

All measurements shall be made under operating conditions as provided for in the operating manual of the equipment. The output circuit to be used to load the equipment depends on the nature of the electrodes with which it shall be used.

For equipment of the capacitive type, a dummy load shall be used for the measurements. The general arrangement is shown in Figure 10. The dummy load shall be substantially resistive and capable of absorbing the rated maximum output power of the equipment.

The two terminals of the dummy load shall be at opposite ends of the load and each terminal shall be joined directly to a circular flat metal plate having a diameter of 170 mm ± 10 mm. Measurements shall be made with each of the output cables and capacitive electrodes supplied with the equipment. The capacitive electrodes shall be disposed parallel to the circular metal plates at the ends of the dummy load, the spacing between them being adjusted to produce the appropriate power dissipation in the dummy load.



E = electrode arms and cables

L = dummy load

Figure 10 – Disposition of medical equipment (capacitive type) and dummy load

Individual measurements shall be made with the dummy load both horizontal and vertical (see Figure 10). In each case, the equipment, together with the output cables, capacitive electrodes and dummy load, shall be rotated around its vertical axis during measurements of electromagnetic radiation disturbance in order that the maximum value can be measured.

NOTE The following arrangement of lamps has been found suitable for testing many types of equipment in the power range tested:

a) nominal output power 100 W to 300 W:

four lamps 110 V/60 W in parallel, or five lamps 125 V/60 W in parallel;

b) nominal output power 300 W to 500 W:

four lamps 125 V/100 W in parallel, or five lamps 150 V/100 W in parallel.

For equipment of the inductive type, measurements shall be made using the cables and coils supplied with the equipment for the treatment of the patient. The test load shall consist of a vertical tubular container of insulating material, having a diameter of 10 cm, filled to a height of 50 cm with a solution consisting of 9 g of sodium chloride to 1 l of distilled water.

The container shall be placed within the coil with the axis of the container coincident with the axis of the coil. The centres of the coil and the liquid load shall also coincide.

Measurements shall be made at both maximum and half-maximum power and, where the output circuit can be tuned, it shall be tuned to resonance with the fundamental frequency of the equipment.

All measurements shall be made under all operating conditions as provided in the operating manual of the equipment.

7.6.2.2 UHF and microwave therapeutic equipment using frequencies above 400 MHz

Measurements shall be made with the output circuit of the equipment connected to a non-radiating resistive load having the same value as the characteristic impedance of the cable used to supply the equipment load.

7.6.2.3 Ultrasonic therapy equipment

Measurements shall be made with the transducer connected to the generator. The transducer shall be dipped in a non-metallic container having a diameter of about 10 cm and filled with distilled water.

Measurement shall be made at both maximum and half-maximum power and, where the output circuit can be tuned, it shall be tuned to resonance and then detuned. The specifications in the operating manual of the equipment shall be considered.

It is recommended to measure the maximum output of the equipment in accordance with the method published in IEC 61689 [12] or using a derived arrangement, if applicable.

7.6.3 Industrial equipment

The load used when industrial equipment is tested may be either the load used in service or an equivalent device.

Where means for connecting auxiliary services such as water, gas, air, etc. are provided, connection of these services to the equipment under test shall be made by insulating tubing not less than 3 m long. When testing with the load used in service, the electrodes and cables shall be disposed in the manner of their normal use. Measurements shall be made at both maximum output power and at half-maximum output power. Equipment which will normally operate at zero or very low output power shall also be tested in these conditions.

Industrial induction heating and dielectric heating equipment should be tested in a configuration and with a load that is equivalent to actual or intended use. Where the equipment may be configured for a variety of loads or the load is not available, the load as specified in IEC 61922 [12] for induction heating and IEC 61308 [13] for dielectric heating equipment may be used. Industrial resistance heating equipment shall be tested with or without the charge, as specified in the product documentation.

NOTE A circulating water load has been found suitable for many types of dielectric heating equipment.

Industrial microwave heating equipment shall comply with the limits of radiation in Clause 6 when loaded according to IEC 61307 or with a load used in practice. The load shall be varied as required to produce maximum power transfer, frequency variation or harmonic variation depending on the characteristics under examination.

7.6.4 Scientific, laboratory and measuring equipment

Scientific equipment shall be tested under normal operating conditions. Laboratory and measuring equipment shall be operated as intended. Any RF output ports shall be terminated in a matching non-radiating load.

7.6.5 Microwave cooking appliances

Microwave cooking appliances shall be operated with all normal components such as shelves in place, and with a load of 1 l of tap water initially at 20 °C ± 5 °C placed at the centre of the load-carrying surface provided with the EUT.

The water container shall be a cylindrical container of borosilicate glass of an external diameter of 190 mm ± 5 mm and a height of 90 mm ± 5 mm, see also IEC 60705 [14].

Detailed information on the measurement procedure to be used in the frequency range above 1 GHz is found in 9.4.

7.6.6 Other equipment in the frequency range 1 GHz to 18 GHz

Other equipment shall comply with the limits of radiation in Clause 6 when tested with a dummy load consisting of a quantity of tap water in a non-conductive container. The size and shape of the container, its position in the equipment and the quantity of water contained therein shall be varied as required to produce maximum power transfer, frequency variation or harmonic radiation depending on the characteristics under examination.

7.6.7 Electric welding equipment

For arc welding equipment, the welding operation during the test is simulated by loading the equipment with a conventional load. Arc striking and stabilizing devices shall be switched on during the emission measurements. The load conditions and the test configuration for arc welding equipment are specified in IEC 60974-10[15].

For equipment for resistance welding, the welding operation during the test is simulated by short-circuiting the welding circuit. The load conditions and the test configuration for equipment for resistance welding are specified in IEC 62135-2.

The start of the measurements according to this document shall be delayed by up to 5 s after the welding equipment under test has been taken into operation.

7.6.8 ISM RF lighting equipment

ISM RF lighting equipment shall comply with the limits in 6.3 when tested as delivered by the manufacturer under normal operating conditions. The EUT shall be operated until the magnetron oscillating frequency is stabilized. The start of any measurement according to this document shall hence be delayed by at least 15 min.

7.6.9 Medium voltage (MV) and high voltage (HV) switchgear

For equipment used in medium or high voltage switchgear, the start of any measurements according to this document shall be delayed until switching actions related to the main or primary circuit are finished (e.g. switching actions of breakers or disconnectors).

7.6.10 Grid connected power converters

7.6.10.1 Connection to the laboratory AC mains or similar load

The power converter under test shall be connected to the laboratory AC mains network via the artificial mains network (V-AMN) specified in 7.3.2.2, whenever possible. If such connection is not possible or not intended, then the power converter under test can be connected to an appropriate resistive load and the laboratory AC mains network in parallel, via the artificial mains network (V-AMN) specified in 7.3.2.2.

Connection to an appropriate resistive load is also recommended for power converters solely intended for use in island low voltage AC mains installations which are not connected to another public low voltage AC mains power distribution network. For advice, consult the installation instructions of the EUT.

Alternatively the AC supply power for the laboratory DC power source may be taken from the AC output lines of the GCPC via the V-AMN without connecting the resistive load. The output AC power of the GCPC will be used to contribute to the required DC input power for that GCPC, thus the resistive load is not necessary in this case, see Figure D.1.

For suitable test site configurations, see Annex D.

7.6.10.2 Connection to another appropriate load

For power converters intended to be supplied from AC power sources, the DC power port under test shall be connected to a suitable resistive load or other adequate energy storage via an 150 Ω artificial network (DC-AN) as specified in 7.3.2.3. The EUT shall be connected to an appropriate load within the rated operational range for the respective type of EUT.

NOTE An example of a type of GCPC intended to be supplied from an AC power source is a power converter intended for assembly into an off-board charging station for electric vehicles (EV).

7.6.11 Robots

Robots shall be tested in operating modes and under load conditions which are representative of normal use in the intended application according to the instruction manual.

The compliance evaluation of robots shall consider each operating mode listed in Table 22, for fixed robots, or in Table 23, for mobile robots. Either each operating mode shall be tested separately, or an engineering analysis (which can include both measurements and analysis of the robot's characteristics and design) shall be performed for determining the mode of operation that results in the highest emission level relative to the applicable limit and the final measurement shall be performed on that mode.

Table 22 – Operation modes for fixed robots

Operation mode	Description
Mode 1	The robot is powered on but in its idle mode of operation (static state).
Mode 2	Normal operation mode at rated load, rated speed, defined maximum pose and trajectory (e.g. cube location which refers to 6.8 of ISO 9283:1998[16]).
Mode 3	Similar to mode 2, but with all corresponding parameters (e.g., load) set at approximately the middle of their specified range.

Table 23 – Operation modes for mobile robots

Operation mode	Description
Mode 1 [a]	Battery charging mode: the battery charging level is less than or equal to 20 % at the beginning of the test and remains less than 80 % for the entire duration of the test; the robot is in charging mode, with its main function(s) idle.
Mode 2 [a]	Normal operation mode at rated load and at rated speed. If the robot cannot operate at the same time at its rated load and rated speed, these two modes shall be evaluated in turn.
Mode 3 [a]	Similar to mode 2, but with all corresponding parameters (e.g., load) set at approximately the middle of their specified range.
[a] If the robot can be placed in both its normal mode of operation and in battery charging mode at the same time, then both mode 1 and mode 2 (or mode 1 and mode 3) can be evaluated for compliance with the limits through a single test, with the EUT connected to AC mains power. The test report shall specify how the EUT was placed in both operating modes for the test.	

If, based on the specific design, construction and functionality of the robot under test, it is estimated that other modes of operation can create significant emissions, then these other modes of operation should also be evaluated, in addition to the modes listed in Table 22 or Table 23.

7.7 Recording of test-site measurement results

7.7.1 General

The results obtained from measurements of conducted and/or radiated radio-frequency disturbances shall be recorded in the test report. If the results are not recorded in a continuous way and/or in graphical form over the frequency range observed, then the minimum requirements to the recordings set out in 7.7.2 and 7.7.3 shall apply.

The test report shall contain a statement underlining that the measurement instrumentation uncertainty (MIU) was determined according to CISPR 16-4-2 and was also considered when determining compliance with the limits for the EUT.

The test report may include the numerical values of the MIU which the test laboratory has determined for each test performed. If the uncertainty budgets specified in CISPR 16-4-2 are exceeded, then the test report shall include the numerical values of the MIU of the test instrumentation actually used.

7.7.2 Conducted emissions

Of those conducted emissions above (L – 20 dB), where L is the limit level in logarithmic units, the record shall include at least the disturbance levels and the frequencies of the six highest disturbances in each observed frequency range from each mains port belonging to the EUT. The record shall also include an indication upon which the conductor of the mains port carried the observed disturbance(s).

7.7.3 Radiated emissions

Of those radiated emissions above (L – 10 dB), where L is the limit level in logarithmic units, the record shall include at least the disturbance levels and the frequencies of the six highest disturbances in each observed frequency range. The record shall include the antenna polarization, antenna height and turntable rotation position if applicable for each reported disturbance. In case of test site measurements, the measurement distance actually selected and used (see 6.2.2 and 6.3.2) shall also be recorded in the test report.

8 Special provisions for test site measurements (9 kHz to 1 GHz)

8.1 Ground planes

For the measurement of radiated disturbances at an open-area test site (OATS) and in a semi-anechoic chamber (SAC) and for the measurement of conducted disturbances on any test site, a ground plane shall be used.

The requirements for the radiation test site are given in 8.3 and, for the ground plane for the measurement of conducted disturbances, in 8.2.

The relationship of the equipment under test to the ground plane shall be equivalent to that occurring in use. Except at the EUT's intended grounding locations, a floor standing EUT shall be insulated from the ground plane by a dielectric material with thickness of up to 15 cm. Direct connection to earth (i.e. to the ground plane) shall be done

a) either according to the EUT's instructions,
b) or, if the equipment under test is fitted with a special earthing terminal, then this terminal shall be connected to earth (i.e. be bonded to the ground plane) with a lead as short as possible, see also Figure 4.

8.2 Measurement of conducted disturbances

8.2.1 General

For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network, see 7.5.3.

The measurement of conducted disturbances shall be carried out using one of the following methods:

a) on an OATS or in a SAC, with the equipment under test having the same configuration as used during the radiation measurement (for floor-standing equipment only);
b) above or near a reference ground plane; or
c) within a screened room. Either the floor or one wall of the screened room shall act as the reference ground plane.

Option a) shall be used where the test site contains a metal ground plane. In options b) and c) the test unit, if non-floor-standing, shall be placed 0,4 m from the ground plane. Floor-standing test units shall be placed on the ground plane, the point(s) of contact being insulated from the ground plane but otherwise consistent with normal use. All test units shall be at least 0,8 m from any other metal surface.

The reference ground terminals of the artificial networks (V-AMNs and DC-ANs) used during the measurements shall be connected to the reference ground plane with a conductor as short as possible.

The power and signal cables shall be oriented in relation to the ground plane in a manner equivalent to actual use and precautions taken with the layout of the cables to ensure that spurious effects do not occur.

When the equipment under test is fitted with a special earthing terminal, this shall be connected to earth with a lead as short as possible. Equipment without special earthing terminal shall be tested as normally connected, e.g. any earthing being obtained through the mains supply.

8.2.2 Measurements on grid connected power converters

8.2.2.1 Measurement of the disturbance voltage at AC power ports

The disturbance voltage at the low voltage AC power port of the power converter shall be measured using the usual method of measurement for disturbance voltages at AC mains ports, see also CISPR 16-2-1.

The disturbance voltage at the ancillary low voltage AC power port of the power converter, if applicable, shall be measured using the usual method of measurement for voltages at AC mains ports, see also CISPR 16-2-1.

For power converters which cannot be measured with the V-network (V-AMN), the disturbance voltage at the low voltage AC mains power port can be measured with the high-impedance voltage probe according to CISPR 16-1-2:2014, Clause 5. In this case, the laboratory AC power source shall be connected directly to the AC power port under test. For conditions of use of the high-impedance voltage probe, see 7.3.3.

Alternatively, for measurements on power converters with a rated throughput power > 20 kVA, a V-network (V-AMN) may be used as a voltage probe as specified in 7.4.4.4 of CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD:2017. The laboratory AC power source shall be connected to the AC power port under test via an inductance of 30 μH to 50 μH. The inductance can be realized by a choke, a power cable length of 50 m, or an isolation transformer. A suitable measurement arrangement is shown in Figure 13 and Figure 14.

Compliance with the requirements of this document can be shown in verifying that the limits of the disturbance voltage at AC mains power ports specified in Table 2 or in Table 4 are met.

8.2.2.2 Measurement of the disturbance voltage at DC power ports

8.2.2.2.1 General

Measurements at DC power ports shall only be performed on the following types of equipment:

a) power conversion equipment intended for assembly into photovoltaic power generating systems;

b) grid connected power converters (GCPCs) intended for assembly into energy storage systems.

Unless any specific operating condition is specified, the input conditions for the EUT shall be adjusted resulting in maximum disturbance voltage levels.

NOTE The operating conditions are chosen to represent the worst case emissions.

Power converters with a rated throughput power > 20 kVA shall be measured while they are operated at an operational point for which feeding to the grid or providing output power to another appropriate load is possible. The DC input voltage shall be within the rated operation range.

Where the power converter is intended for connection to more than one DC power string and consequently is furnished with more than one DC power port, measurements of the disturbance voltage shall be performed in sequence at each of these ports. All other DC power ports not used during the respective measurement shall be terminated with a suitable 150 Ω common mode termination impedance, see 7.5.3.2. Multiple ports galvanically connected in parallel (such as bus bars or strips for connection to multiple cables) are considered to represent one single port only.

The disturbance voltage at the DC power port of the power converter shall be measured using the DC-AN which is specified in 7.3.2.3. Compliance with the limits shall be verified for measured disturbance voltage levels of both modes, i.e. for the level of the common mode (CM) disturbance voltage as well as for the level of the differential mode (DM) disturbance voltage.

If the installation instructions accompanying the power converter contains information that the DC power port is solely intended for connection to

- a battery or other kind of local DC power source and/or;
- if the power converter and a battery or other kind of local DC power source is intended for incorporation in a higher order final equipment (comprising of one or more enclosures);

then this port can be exempted from the measurement.

8.2.2.2.2 Measurement procedure 1

8.2.2.2.2.1 General

The DC-AN is used as standardized 150 Ω common mode termination of the EUT and as decoupling network to the laboratory DC power source. A typical measurement arrangement is shown in Figure 11.

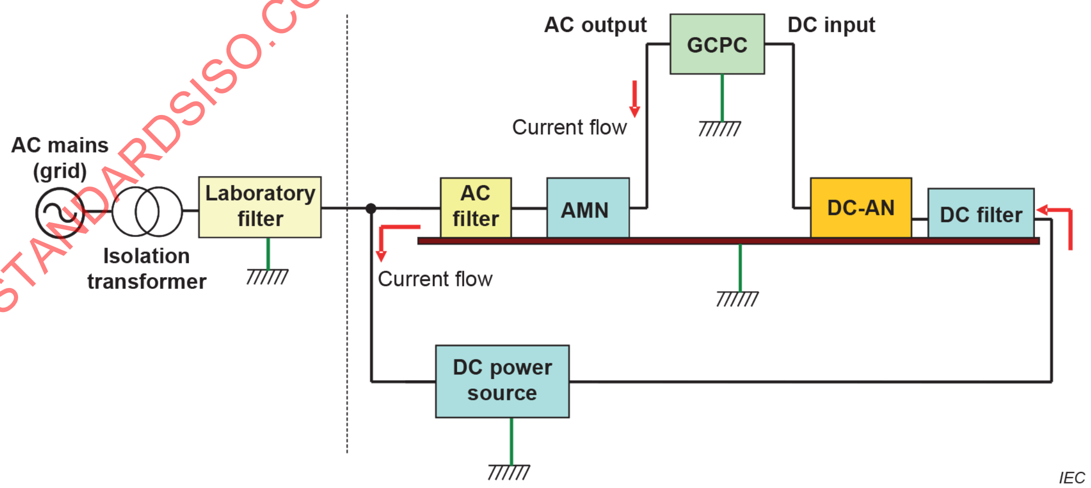


Figure 11 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with the DC-AN used as termination and decoupling unit to the laboratory DC power source

8.2.2.2.2.2 Compliance criterion

Compliance with the requirements of CISPR 11 can be shown in verifying that the limits for the disturbance voltage specified in Table 3 or in Table 5 are met.

8.2.2.2.3 Measurement procedure 2

8.2.2.2.3.1 General

For measurements on power converters with a rated throughput power > 20 kVA, a DC-AN can be used as voltage probe. For an adequate decoupling of the EUT from the DC power source, the laboratory DC power source shall be connected to the DC power port under test via a common mode inductance of 90 μH to 150 μH. The common mode inductance may be realized by ferrite tubes, common mode absorbing devices, or a CDN as specified in 6.2.2 and 6.2.3 of IEC 61000-4-6:2023. Since a CDN according to IEC 61000-4-6 is used only as a decoupling network, its RF power input port shall not be terminated with a 50 Ω resistive load as shown in Figure 12.

NOTE It is up to the operator of the laboratory to ensure that the measurement results obtained with such measurement arrangements are not obstructed or invalidated by dominating disturbances from the laboratory DC power source. Appropriate EMI filters can be used to decouple the EUT from the DC power source. But be aware not to apply too heavy additional common mode capacitive loading to the EUT. Further guidance on suitable decoupling of the laboratory DC power source from the measuring arrangement can be found in Annex E.

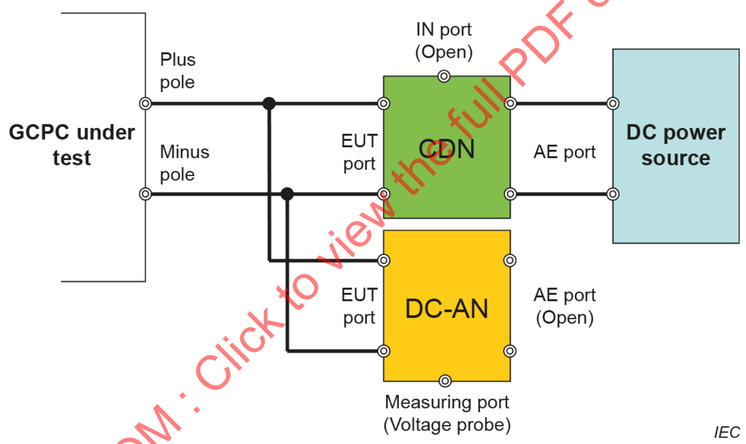


Figure 12 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with the DC-AN used as termination and voltage probe

8.2.2.2.3.2 Measurement of the common mode (CM) disturbance voltage

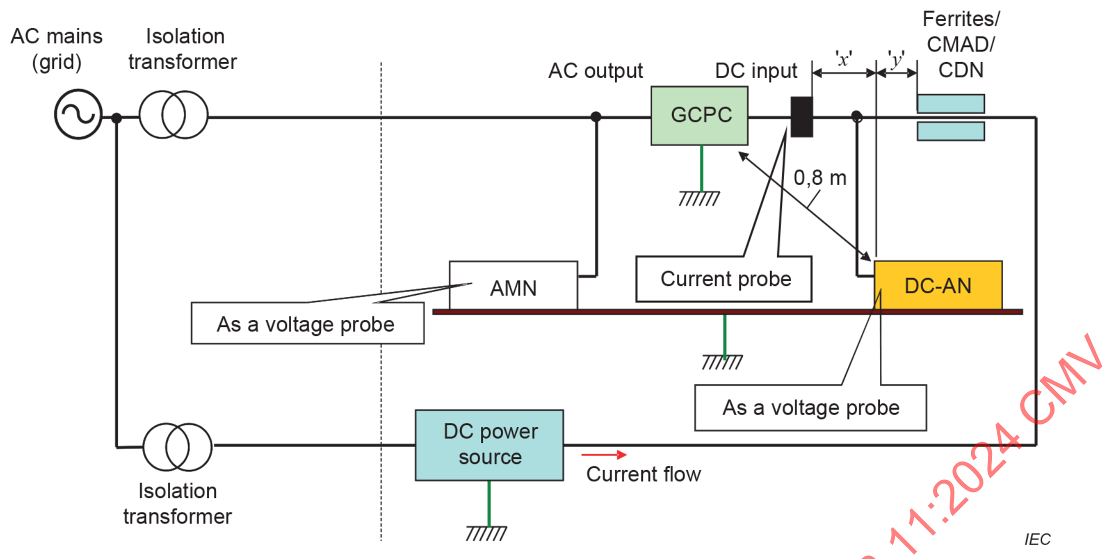
Measurements of the disturbance voltage at the DC power port shall be carried out with the DC-AN used as voltage probe, see Figure 12, Figure 13 and Figure 14.

With the DC-AN, the common mode disturbance voltage at the DC power port of the power converter shall be measured.

8.2.2.2.3.3 Measurement of the common mode (CM) disturbance current

The common mode disturbance current at the DC power cable leading to the laboratory DC power source shall be measured using a current probe according to CISPR 16-1-2.

Care shall be taken in order not to alter the termination conditions of the EUT when performing measurements with the current probe. The current probe shall be located a maximum of 30 cm away from the DC-AN. The current probe shall also be in place when performing measurements of the CM disturbance voltage. A suitable measurement arrangement is shown in Figure 13 and Figure 14.



NOTE 'x' and 'y' denote the spacing between the current probe and the DC-AN, and the DC-AN and the ferrite tube(s) / CMAD / CDN, respectively. Spacing x is ≤ 0,3 m and y is 0,1 m.

Figure 13 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with the DC-AN used as voltage probe and with a current probe – 2D diagram

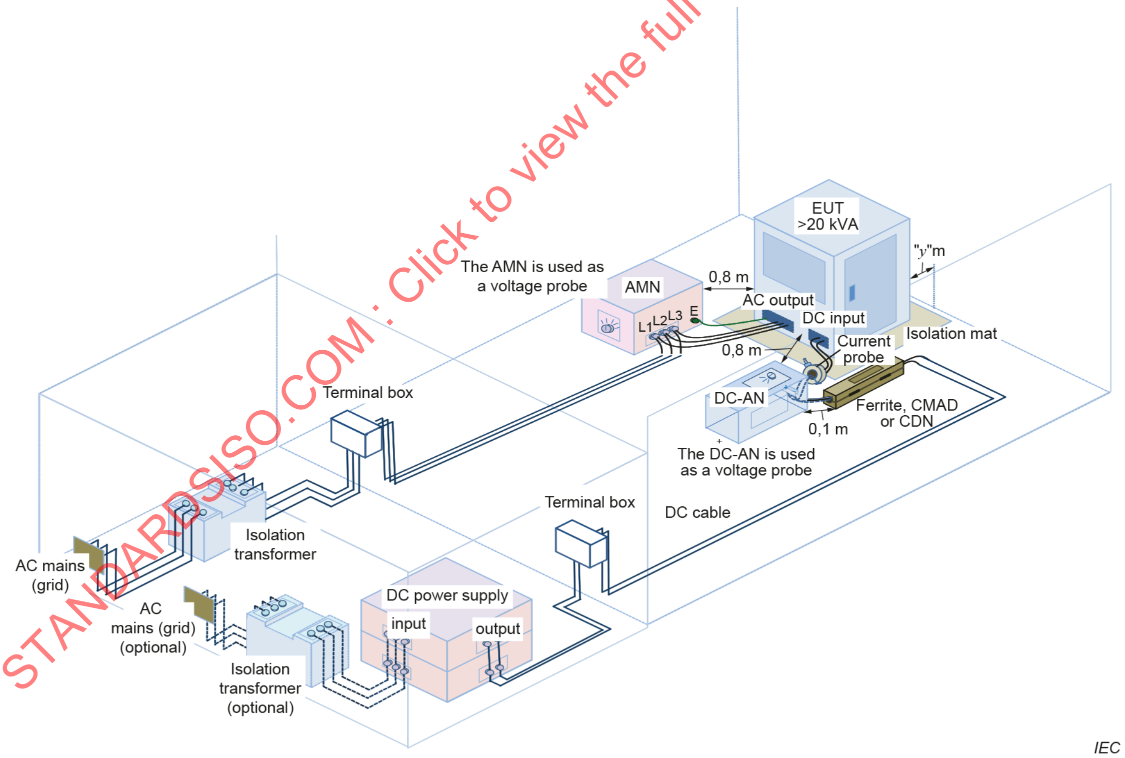


Figure 14 – Typical arrangement for measurement of conducted disturbances at LV DC power ports with a DC-AN used as voltage probe and with a current probe – 3D diagram

8.2.2.2.3.4 Compliance criteria

For measurements according to Figure 13, compliance with the limits shall be verified for the measured common mode disturbance voltage and the measured common mode disturbance current. The EUT meets the requirements of this document if it can be shown that it meets both the limits of the disturbance voltage and the disturbance current specified in Table 3.

8.2.3 Handheld equipment which is normally operated without an earth connection

For this equipment, additional measurements shall be made using the artificial hand described in 7.3.5.

The artificial hand shall be applied only on handles and grips and those parts of the appliance specified as such by the product specification. Failing the specification, the artificial hand shall be applied in the following way.

The general principle in applying the artificial hand is that the metal foil shall be wrapped around all handles (one artificial hand per handle), both fixed and detachable, supplied with the equipment.

Metalwork which is covered with paint or lacquer is considered as exposed metalwork and shall be directly connected to the terminal M of the RC element.

When the casing of the equipment is entirely of metal, no metal foil is needed, but the terminal M of the RC element shall be connected directly to the body of the equipment.

When the casing of the equipment is of insulating material, a metal foil shall be wrapped around the handles.

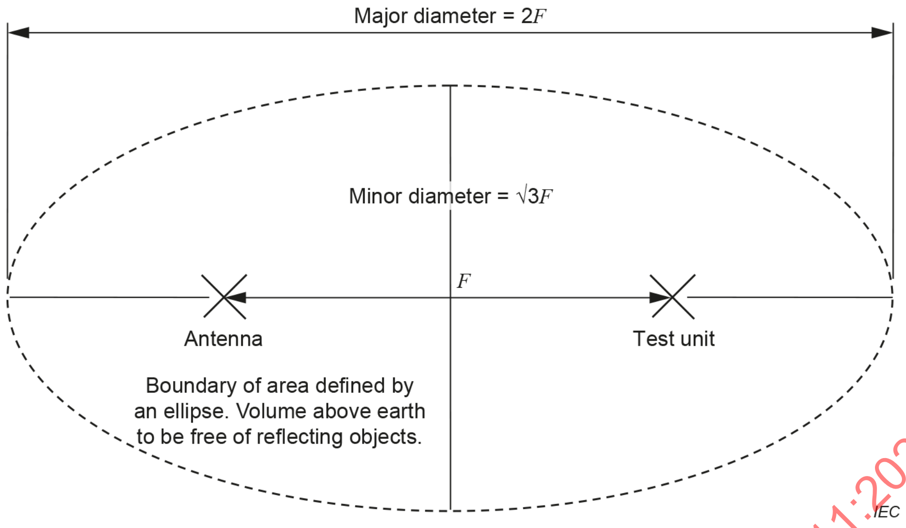
When the casing of the equipment is partly metal and partly insulating materials, and has insulating handles, a metal foil shall be wrapped around the handles.

8.3 OATS and SAC for measurements in the range 9 kHz to 1 GHz

8.3.1 General

The radiation test site shall be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit adequate separation between the antenna, test unit and reflecting structures.

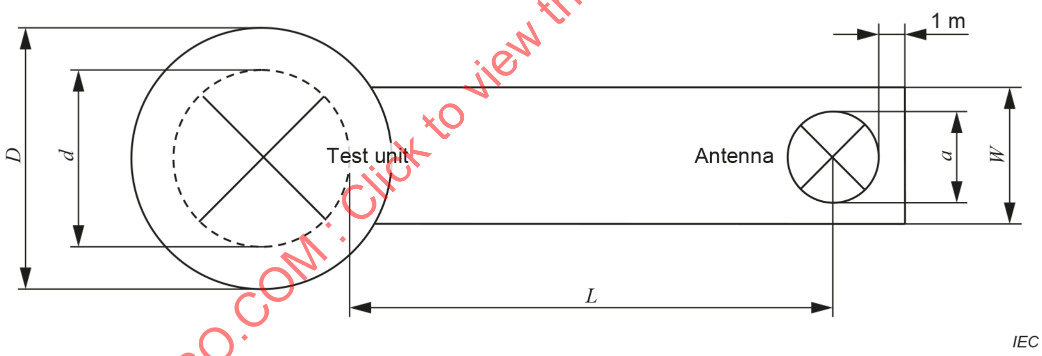
A radiation test site which meets the criteria is within the perimeter of an ellipse having a major axis equal to twice the distance between the foci and a minor axis equal to this distance multiplied by the square root of three. The equipment under test and the measuring equipment are placed at each of the foci respectively. The path length of any ray reflected from an object on the perimeter of this radiation test site will be twice the length of the direct path length between the foci. This radiation test site is depicted in Figure 15.



NOTE For the values of F (measuring distance), see Clause 6.

Figure 15 – Radiation test site

For the 10 m test site, the natural ground plane shall be augmented with a ground plane of metal which shall extend at least 1 m beyond the boundary of the equipment under test at one end and at least 1 m beyond the measurement antenna and its supporting structure at the other end (see Figure 16). The ground plane shall have no voids or gaps other than any perforations which do not exceed 0,1 λ at 1 GHz (about 30 mm).



D = (d + 2) m, where d is the maximum test unit dimension

W = (a + 1) m, where a is the maximum dimension of the antenna

L = measuring distance in m

Figure 16 – Minimum size of metal ground plane

8.3.2 Validation of the radiation test site (9 kHz to 1 GHz)

Test sites shall be validated according to CISPR 16-1-4 in the frequency ranges where the standard defines requirements.

8.3.3 Disposition of equipment under test (9 kHz to 1 GHz)

For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network, see 7.5.3.1 or 7.5.3.2.

If it is possible to do so, the equipment under test shall be placed on a turntable. The separation between the equipment under test and the measuring antenna shall be the horizontal distance between the reference point of the measuring antenna and the nearest part of the boundary of the equipment under test in one rotation.

8.3.4 Radiation measurements (9 kHz to 1 GHz)

The separation distance between the antenna and the equipment under test shall be as specified in Clause 6. If the field strength measurement at a certain frequency cannot be made at the specified distances because of high ambient noise levels (see 7.2), measurements at this frequency may be made at a closer distance but not less than 3 m. In this case, the test report shall record the distance actually used and the circumstances of the measurement.

For equipment under test located on a turntable, the turntable shall be rotated fully with a measurement antenna oriented for both horizontal and vertical polarization. The highest recorded level of the electromagnetic radiation disturbance at each frequency shall be recorded.

For equipment under test not located on a turntable, the measurement antenna shall be positioned at various points in azimuth for both horizontal and vertical polarization. Care shall be taken that measurements be taken in the directions of maximum radiation and the highest level at each frequency be recorded.

NOTE At each azimuthal position of the measurement antenna, the radiation test site requirements specified in 8.3.1 are met.

8.4 Alternative radiation test sites for the frequency range 30 MHz to 1 GHz

Measurements may be performed on radiation test sites which do not have the physical characteristics described in 8.3. Evidence shall be obtained to show that such alternative sites will yield valid results. An alternative radiation test site in the frequency range 30 MHz to 1 GHz is acceptable if the horizontal and vertical site attenuation measurements made as per 6.3 of CISPR 16-1-4:2019 are within ± 4 dB of the theoretical site attenuation as given in Table 2 of CISPR 16-1-4:2019.

Alternative radiation test sites shall allow for, and be validated for, the measurement distance in the frequency range 30 MHz to 1 GHz specified elsewhere in Clause 6 and/or Clause 8 of this document.

8.5 FAR for measurements in the range 30 MHz to 1 GHz

A fully-anechoic room (FAR) used for measurement of radiated disturbances in the frequency range 30 MHz to 1 GHz shall comply with the requirements in CISPR 16-1-4.

The use of the FAR is restricted to table-top equipment. The size of the EUT suitable to be measured in a FAR is limited by the validated test volume of the given FAR. The test volume of the FAR is validated according to CISPR 16-1-4, and documented in the site validation report.

NOTE For measurements at 3 m separation distance, this validated test volume will likely limit the applicability of the FAR to *small EUT* (see 3.1.32).

For measurements in the FAR, the test setup shall be, as far as applicable, the same as described in 8.3 for measurements on an OATS or in a SAC. Further information on performance of emission measurements in a FAR in the range 30 MHz to 1 GHz is found in 7.4 of CISPR 16-2-3:2016.

9 Radiation measurements: 1 GHz to 18 GHz

9.1 Test arrangement

The equipment under test shall be placed on a turntable at a suitable height. Power at the normal voltage shall be supplied. For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network, see 7.5.3.

9.2 Receiving antenna

The measurements shall be made with a directive antenna of small aperture capable of making separate measurements of the vertical and horizontal components of the radiated field. The height above the ground of the centre line of the antenna shall be the same as the height of the approximate radiation centre of the equipment under test. The distance between the receiving antenna and the EUT shall be 3 m.

However, a 10 m measurement may also be used, provided the entire measurement system (from the antenna to the measurement instrument) has sufficient sensitivity to detect EUT emissions that are at least 6 dB below the applicable limit, in the specified limit detector.

9.3 Validation of test site

Test sites shall be validated according to CISPR 16-1-4.

9.4 Measuring procedure

9.4.1 General

9.4.1.1 General requirements for both group 1 and group 2 equipment

The measurements shall take place in free-space conditions, i.e. the reflections on the ground shall not influence the measurements, see CISPR 16-1-4.

The usage of absorbers shall be done according to CISPR 16-2-3.

The general measuring procedure above 1 GHz specified in CISPR 16-2-3 should be consulted for guidance. Measurements shall be made with the antenna in both horizontal and vertical polarizations. In both cases, the turntable with the equipment under test shall be rotated. It shall be ascertained that, when the equipment under test is switched off, the level of background noise is at least 10 dB below the reference limit, since otherwise the reading can be significantly affected.

9.4.1.2 Flowchart for measurements on group 2 equipment

A flow chart showing the measurement procedure is shown in Figure 17.

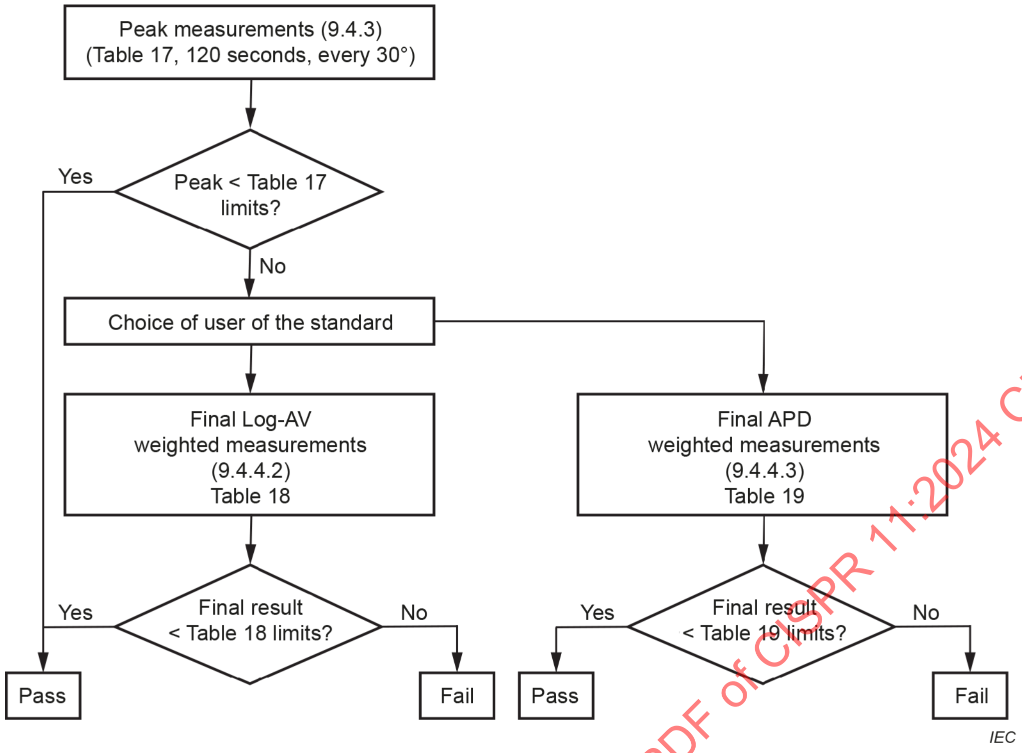


Figure 17 – Decision tree for the measurement of emissions from 1 GHz to 18 GHz of group 2 equipment operating at frequencies above 400 MHz

9.4.2 Operating conditions of the EUT (group 2 equipment only)

For microwave ovens, a warm-up period of at least 5 min shall be performed before the measurement.

For all measurements, the starting phase of the EUT (a few seconds) shall be ignored.

During the measurements, the microwave oven under test is operated at maximum microwave power setting.

Some microwave ovens automatically turn to an intermittent operation mode if operated for a long time at their highest microwave power setting. In such cases, the measurement shall be stopped for a while to allow cooling down until the microwave oven is able to operate at its maximum power setting without intermittence.

During the measurement, the water load should be exchanged to cold water before it starts to boil. For load conditions of microwave ovens during the measurements, see also 7.6.5.

9.4.3 Peak measurements (group 2 equipment only)

Peak measurements in the range above 1 GHz shall be made for both polarizations of the antenna with the azimuth of the EUT varying every 30° (starting position perpendicular to the front surface plane of the EUT, i.e. in a position perpendicular to the front door, in case of microwave ovens). At each of these 12 positions, a measurement in maximum-hold mode over the full frequency range 1 GHz to 18 GHz shall be made for a period of 2 min.

During the measurement, the water load should be exchanged to cold water before it starts to boil. The measurement at the particular frequency where this happened shall be re-started.

NOTE 1 If the measurements are carried out in frequency subranges, the measurement time for each subrange is accordingly shorter. For example, the measuring time for a subrange 1 GHz to 2,4 GHz would be about 10 s and the time for a subrange 2,5 GHz to 18 GHz would be about 110 s.

If the emissions from the EUT in this frequency range are very stable, the measurement time at each azimuth/polarization may be reduced, e.g. to 20 s.

The obtained measurement result(s) shall be compared to the peak limit (see Table 17).

If the EUT passes the peak measurement, then the final test result is PASS, see Figure 17.

If the EUT does not pass the peak measurement, final weighted measurements shall be carried out, see Figure 17.

NOTE 2 In the frequency range 11,7 GHz to 12,7 GHz, in some countries unwanted emissions from ISM equipment can cause radio frequency interference for reception facilities of satellite broadcasting systems even when they comply with the limits for the final weighted measurements.

9.4.4 Weighted measurements (group 2 equipment only)

9.4.4.1 General

In cases where readings obtained during the peak measurement in the range 1 GHz to 18 GHz exceed the limits specified in Table 17, an additional series of measurements with a weighting function shall be performed.

In preparation of the final measurement, the whole frequency range shall be divided into 7 sub-ranges from 1 GHz to 18 GHz, in accordance with Table 24.

For every subrange where the EUT did not meet the limits of Table 17, identify the frequency of the highest emission level from the peak measurements. These frequencies are the centre frequencies to be used for the series of weighted measurements, as shown in Table 24.

Table 24 – Frequency subranges to be used for weighted measurements

Harmonics of 2,45 GHz Order no.	Frequency sub-ranges GHz
Not defined	1,0 to 2,4
2	2,5 to 6,125 [a]
3	6,125 to 8,575
4	8,575 to 11,025
5	11,025 to 13,475
6	13,475 to 15,925
7	15,925 to 18,0

[a] Measurements in the ISM band 5,720 GHz to 5,880 GHz are excluded, see Table 1.

For demonstration of the fluctuating nature of a disturbance, two alternative methods for weighted measurements are available, see also decision tree in Figure 17.

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

During the measurement, the water load should be exchanged to cold water before it starts to boil. The measurement at the particular frequency where this happened shall be re-started.

9.4.4.2 Log-AV weighting according to Table 18

Weighted measurements with the Log-AV method (see Table 18) shall be performed at the azimuth position of the EUT and with the antenna polarization where the maximum peak emission occurred during the preliminary measurement. A minimum of 5 consecutive sweeps in max-hold mode shall be performed.

These weighted measurements shall be performed with the spectrum analyzer in logarithmic display mode (using the logarithmic amplifier, not a mathematical unit conversion of the displayed values).

NOTE A video bandwidth of 10 Hz together with logarithmic amplification provides a level closer to the average level of the measured signal in logarithmic values. This result is lower than the average level that would be obtained in linear mode.

Measurements with the Log-AV weighting function shall be performed in the frequency subranges (see Table 24) where the EUT did not meet the limits of Table 17 around the centre frequencies identified in the previous step, within a frequency span of 20 MHz.

Compare the measurement results to the limits of Table 18.

If the EUT passes the measurement with the Log-AV weighting function (Table 18), then the final test result is PASS, see Figure 17.

9.4.4.3 APD weighting according to Table 19

As an alternative to 9.4.4.2, an APD measurement for a period of 30 s shall be performed at the azimuth of the EUT and the polarization of the antenna where the maximum emission was found during the preliminary peak measurements. Measurements shall be made at the following 5 spot frequencies:

f_s,	
f_s + 5 MHz,	f_s – 5 MHz,
f_s + 10 MHz,	f_s – 10 MHz,

where f_s is the frequency with the highest peak emission in one of the frequency subranges, defined in Table 24, see 9.4.4.1.

Compare the measurement results to the limits of Table 19.

If the EUT passes the measurement with the APD weighting function (Table 19), then the final test result is PASS, see Figure 17.

10 Measurement *in situ*

For equipment which is not tested on a radiation test site, measurements shall be made after the equipment has been installed on the user's premises. Measurements shall be made from the exterior wall outside the building in which the equipment is situated at the distance specified in 6.4.

Measurements *in situ* at the place of operation of the equipment to be assessed shall be performed and documented in accordance with 7.7 of CISPR 16-2-3:2016 and CISPR 16-2-3:2016/AMD1:2019. Further advice for *in situ* measurements is also found in CISPR TR 16-2-5 [17].

The number of measurements made in azimuth shall be as great as reasonably practical, but there shall be at least four measurements in orthogonal directions, and measurements in the direction of any existing radio systems which can be adversely affected.

For the larger commercial microwave ovens, it is necessary to ensure that the measurement results are not affected by near field effects. CISPR 16-2-3 should be consulted for guidance.

11 Safety precautions for emission measurements on ISM RF equipment

ISM RF equipment is inherently capable of emitting levels of electromagnetic radiation that are hazardous to human beings. Before testing for electromagnetic radiation disturbance, the ISM RF equipment should be checked with a suitable radiation monitor.

12 Measurement uncertainty

Determining compliance with the limits in this document shall be based on the results of the compliance measurements taking into account the considerations on measurement instrumentation 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 also be included in the test report.

For *in situ* measurements, the contribution of uncertainty due to the site itself is excluded from the uncertainty calculation.

NOTE When performing measurements at distances less than 10 m, higher measurement uncertainties can occur.

Annex A
(informative)

Examples of equipment classification

A.1 General

Many types of equipment in the scope of this document contain two or more types of interference sources, for example an induction heater might incorporate semiconductor rectifiers in addition to its heating coil. For testing purposes, the equipment is defined in terms of the purpose for which it was designed. For example, the induction heater incorporating semiconductor rectifiers is tested as an induction heater (with all disturbances meeting the prescribed limits whatever the source of disturbance) and is not tested as if it were a semiconductor power supply.

The document gives general definitions of group 1 and group 2 equipment and for official purposes the group to which a particular piece of apparatus belongs is identified from these definitions. It will, however, be helpful to users of the document to have a comprehensive list of types of apparatus which have been identified as belonging to a particular group. This will also help in developing the specification where variations in test procedures can be found by experience to be necessary in dealing with specific types of apparatus.

The lists of group 1 and group 2 equipment given in A.2 and A.3 are not exhaustive.

A.2 Group 1 equipment

A.2.1 General Group 1 equipment

Group 1 equipment contains the equipment in the scope of this document which is not classified as group 2 equipment.

Examples: Laboratory equipment
Medical electrical equipment
Scientific equipment
Semiconductor converters
Industrial electroheating equipment with operating frequencies less than or equal to 9 kHz
Machine tools
Industrial process measurement and control equipment
Semiconductor manufacturing equipment

A.2.2 Detailed Group 1 equipment

Examples: Signal generators, measuring receivers, frequency counters, flow meters, spectrum analysers, weighing machines, chemical analysis machines, electronic microscopes, switched-mode power supplies and semiconductor converters (when not incorporated in an equipment), semiconductor rectifiers/inverters, grid connected power converters (GCPC), DC-DC converters for solar panels, resistance heating equipment with built-in semiconductor AC power controllers, arc furnaces and metal melting ovens, plasma and glow discharge heaters, X-ray diagnostic equipment, computerized tomography equipment, patient monitoring equipment, ultrasound diagnostic and therapy equipment, ultrasound washing machines, regulating controls and equipment with regulating controls incorporating semiconductor devices with a rated input current in excess of 25 A per phase, industrial automated guided vehicle (AGV) without wireless power transfer

NOTE Though AGV can be considered as vehicles, due to their sole use in industrial environments they are considered as industrial products in the scope of this document. Future types of AGV for the residential environment are intended to be covered by CISPR 12 [12] (keyword: autonomous driving).

A.3 Group 2 equipment

A.3.1 General Group 2 equipment

Group 2 equipment contains the ISM RF equipment in which radio-frequency energy in the frequency range 9 kHz to 400 GHz is intentionally generated and used or only used locally, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material, for inspection/analysis purposes, or for transfer of electromagnetic energy.

Examples: Microwave-powered UV irradiating apparatus
Microwave lighting apparatus

Industrial induction heating equipment operating at frequencies above 9 kHz

Inductive or capacitive power transfer/charging equipment [a]

Dielectric heating equipment

Industrial microwave heating equipment

Microwave ovens

Medical electrical equipment

Electric welding equipment

Electro-discharge machining (EDM) equipment

Demonstration models for education and training

[a] Inductive or capacitive power transfer apparatus normally subject to this document, but forming part of equipment subject to other CISPR standards is excluded from the scope of this document.

A.3.2 Detailed Group 2 equipment

Examples: Metal melting, billet heating, component heating, soldering and brazing, arc welding, arc stud welding, resistance welding, spot welding, tube welding, industrial laser oscillator exited by high-frequency discharge, wood gluing, plastic welding, plastic preheating, industrial food processing and baking, food thawing, paper drying, textile treatment, adhesive curing, material preheating, short-wave diathermy equipment, microwave therapy equipment, magnetic resonance imaging (MRI), medical HF sterilizers, high-frequency (HF) surgical equipment, crystal zone refining, demonstration models of high-voltage Tesla transformers, belt generators, etc.

Annex B
(normative)

Measurement of electromagnetic radiation disturbance in the presence of signals from radio transmitters

For equipment under test having a stable operating frequency so that the reading of the CISPR quasi-peak measuring receiver does not vary by more than ± 0,5 dB during measurement, the electric field strength of the electromagnetic radiation disturbance can be calculated sufficiently accurately from the expression:

$$E_g^{1,1} = E_t^{1,1} - E_s^{1,1}$$

where

E_g is the electromagnetic radiation disturbance (μV/m);

E_t is the measured value of electric field strength (μV/m);

E_s is the electric field strength of the radio transmitter signal (μV/m).

In most cases the results of radiated emission measurements are expressed in logarithmic units, for example dB(μV/m). Those results shall be converted into linearly expressed values (μV/m) before applying the above formula.

The formula has been found to be valid when unwanted signals are from AM or FM sound and television transmitters having a total amplitude up to twice the amplitude of the electromagnetic radiation disturbance which shall be measured.

It is advisable to restrict the use of the formula to cases where it is not possible to avoid the disturbing effect of radio transmitters. If the frequency of the electromagnetic radiation disturbance is unstable then a panoramic receiver or spectrum analyzer should be used, and the formula is not applicable.

Annex C
(informative)

Recommendations of CISPR for protection of certain radio services in particular areas

C.1 General

The ITU develops usage provisions aiming at the efficient use of the radio frequency spectrum and local control of radiated RF disturbances at the place of operation of individual ISM RF applications. The respective provisions of the ITU relating to usual residential and/or industrial environments are recognised by CISPR and incorporated into the main body of this document. Apart from these provisions, additional ITU provisions can apply for the *operation and use* of *individual* ISM RF applications in particular environments, i.e. in "particular areas", which are not addressed in the main body of this document. The CISPR regards these ITU provisions and their national derivatives as recommendations since they can only apply to *individual* ISM RF applications used in *particular areas* under *in situ* conditions.

C.2 Recommendations for protection of safety-related radio services

ISM RF equipment should be designed to avoid fundamental operations or radiation of high-level spurious and harmonic signals in bands used for safety-related radio services. A list of these bands is provided in Table C.2.

For the protection of specific safety-related radio services, in particular areas, an individual installation can be required to meet the limits specified in Table C.1.

Table C.1 – Limits for electromagnetic radiation disturbances for *in situ* measurements to protect specific safety-related radio services in particular areas

Frequency range MHz	Limits		Measuring distance D from the outer face of the exterior wall outside the building in which the equipment is situated
	Electric field **Quasi-peak** dB(µV/m)	**Magnetic field** **Quasi-peak** dB(µA/m)	**Distance D** m
0,283 5 to 0,526 5	–	13,5	30
74,6 to 75,4	30	–	10
108 to 137	30	–	10
242,95 to 243,05	37	–	10
328,6 to 335,4	37	–	10
960 to 1 215	37	–	10

Table C.2 – Frequency bands allocated for safety-related radio services

Frequency MHz	Allocation/Use
0,010 to 0,014	Radionavigation (Omega on board ships and aircraft only)
0,090 to 0,11	Radionavigation (LORAN-C and DECCA)
0,283 5 to 0,526 5	Aeronautical radionavigation (non-directional beacons)
0,489 to 0,519	Maritime safety information (coastal areas and shipboard only)
1,82 to 1,88	Radionavigation (LORAN-A region 3 only, coastal areas and on board ships only)
2,173 5 to 2,190 5	Mobile distress frequency
2,090 55 to 2,091 05	Emergency position indicating radio beacon (EPIRB)
3,021 5 to 3,027 5	Aeronautic mobile (search and rescue operations)
4,122 to 4,210 5	Mobile distress frequency
5,678 5 to 5,684 5	Aeronautic mobile (search and rescue operations)
6,212 to 6,314	Mobile distress frequency
8,288 to 8,417	Mobile distress frequency
12,287 to 12,579 5	Mobile distress frequency
16,417 to 16,807	Mobile distress frequency
19,68 to 19,681	Maritime safety information (coastal areas and shipboard only)
22,375 5 to 22,376 5	Maritime safety information (coastal areas and shipboard only)
26,1 to 26,101	Maritime safety information (coastal areas and shipboard only)
70 to 520	TETRAPOL
74,6 to 75,4	Aeronautical radionavigation (marker beacons)
108 to 137	Aeronautical radionavigation (108 MHz to 118 MHz VOR, 121,4 MHz to 123,5 MHz distress frequency SARSAT uplink, 118 MHz to 137 MHz air traffic control)
136 to 200	Project 25
136 to 174	EDACS
156,2 to 156,837 5	Maritime mobile distress frequency
242,9 to 243,1	Search and rescue (SARSAT uplink)
328,6 to 335,4	Aeronautical radionavigation (ILS glideslope indicator)
360 to 520	Project 25
380 to 385	Air-Ground-Air operation (AGA)
380 to 430	TETRA1
380 to 512	EDACS
390 to 395	Air-Ground-Air operation (AGA)
399,9 to 400,05	Radionavigation satellite
406 to 406,1	Search and rescue (emergency position-indicating radio beacon (EPIRB), SARSAT uplink)
410 to 415	GoTa
410 to 430	CDMA-PAMR
420 to 425	GoTa
450 to 470	TETRA1; CDMA-PAMR
452 to 457,5	GoTa
462 to 467,5	GoTa
746 to 870	Project 25; TETRAPOL
806 to 821	DIMRS; EDACS; FHMA; GoTa
824 to 849	GoTa
850 to 860	IDRA
851 to 866	DIMRS; EDACS; FHMA; GoTa
869 to 894	GoTa
870 to 876	CDMA-PAMR
870 to 888	TETRA1; TETRAPOL
896 to 901	EDACS; FHMA
905 to 915	IDRA

Frequency MHz	Allocation/Use
915 to 921	CDMA-PAMR
915 to 933	TETRA1; TETRAPOL
935 to 940	EDACS; FHMA
960 to 1 238	Aeronautical radionavigation (TACAN), air traffic control beacons
1 300 to 1 350	Aeronautical radionavigation (long range air search radars)
1 453 to 1 477	IDRA
1 501 to 1 525	IDRA
1 544 to 1 545	Distress frequency-SARSAT downlink (1 530 MHz to 1 544 MHz mobile satellite downlink can be pre-empted for distress purposes)
1 545 to 1 559	Aeronautical mobile satellite (R)
1 559 to 1 610	Aeronautical radionavigation (GPS)
1 610 to 1 625,5	Aeronautical radionavigation (radio altimeters)
1 645,5 to 1 646,5	Distress frequency-uplink (1 626,5 MHz to 1 645,5 MHz mobile satellite uplink can be pre-empted for distress purposes)
1 646,5 to 1 660,5	Aeronautical mobile satellite (R)
1 850 to 1 910	GoTa
1 920 to 1 980	GoTa
1 930 to 1 990	GoTa
2 110 to 2 170	GoTa
2 700 to 2 900	Aeronautical radionavigation (terminal air traffic control radars)
2 900 to 3 100	Aeronautical radionavigation (radar beacons – coastal areas and shipboard only)
4 200 to 4 400	Aeronautical radionavigation (altimeters)
5 000 to 5 250	Aeronautical radionavigation (microwave landing systems)
5 350 to 5 460	Aeronautical radionavigation (airborne radars and beacons)
5 600 to 5 650	Terminal Doppler weather radar – wind shear
9 000 to 9 200	Aeronautical radionavigation (precision approach radars)
9 200 to 9 500	Radar transponders for maritime search and rescue. Maritime radar beacons and radionavigation radars. Airborne weather and ground mapping radar for airborne radionavigation, particularly under poor visibility conditions
13 250 to 13 400	Aeronautical radionavigation (Doppler navigation radars)

C.3 Recommendations for protection of specific sensitive radio services

For the protection of specific sensitive radio services, in particular areas, it is recommended to avoid fundamental operations or the radiation of high level harmonic signals in the bands. Some examples of these bands are listed for information in Table C.3.

NOTE For the protection of specific sensitive services, in particular areas, national authorities can request additional suppression measures or designated separation zones for cases where harmful interference can occur.

Table C.3 – Frequency bands allocated for sensitive radio services

Frequency MHz	**Allocation/Use**
0,135 7 to 0,137 8	Amateur radio services
0,472 to 0,479	Amateur radio services
1,80 to 2,00	Amateur radio services
3,50 to 4,00	Amateur radio services
5,25 to 5,45	Amateur radio services
7,00 to 7,30	Amateur radio services
10,100 to 10,150	Amateur radio services
13,36 to 13,41	Radio astronomy
14,00 to 14,35	Amateur radio services
18,068 to 18,168	Amateur radio services
21,00 to 21,45	Amateur radio services
24,89 to 24,99	Amateur radio services
25,5 to 25,67	Radio astronomy
28,00 to 29,7	Amateur radio services
29,3 to 29,55	Satellite downlink (Amateur Radio Satellite Services)
37,5 to 38,25	Radio astronomy
50 to 54	Amateur radio services
70,0 to 70,5	Amateur radio services
73 to 74,6	Radio astronomy
137 to 138	Satellite downlink
144 to 146	Amateur radio services
145,8 to 146	Satellite downlink (Amateur Radio Satellite Services)
149,9 to 150,05	Radionavigation satellite downlink
240 to 285	Satellite downlink
322 to 328,6	Radio astronomy
400,05 to 400,15	Standard frequency and time signal
400,15 to 402	Satellite downlink
402 to 406	Satellite uplink 402,5 MHz
406,1 to 410	Radio astronomy
430 to 440	Amateur radio services
435 to 438	Satellite downlink (Amateur Radio Satellite Services)
608 to 614	Radio astronomy
1 215 to 1 240	Satellite downlink
1 240 to 1 300	Amateur Radio Services
1 260 to 1 270	Satellite uplink
1 350 to 1 400	Spectral line observation of neutral hydrogen (radio astronomy)
1 400 to 1 427	Radio astronomy
1 435 to 1 530	Aeronautical flight test telemetry
1 530 to 1 559	Satellite downlink
1 559 to 1 610	Satellite downlink
1 610,6 to 1 613,8	Spectral line observations of OH radical (radio astronomy)
1 660 to 1 710	1 660 MHz to 1 668,4 MHz: Radio astronomy 1 668,4 MHz to 1 670 MHz: Radio astronomy and radiosonde 1 670 MHz to 1 710 MHz: Satellite downlink and radiosonde

Frequency MHz	**Allocation/Use**
1 718,8 to 1 722,2	Radio astronomy
2 200 to 2 300	Satellite downlink
2 300 to 2 450	Amateur radio services
2 310 to 2 390	Aeronautical flight test telemetry
2 655 to 2 900	2 655 MHz to 2 690 MHz: Radio astronomy and satellite downlink 2 690 MHz to 2 700 MHz: Radio astronomy
3 260 to 3 267	Spectral line observations (radio astronomy)
3 332 to 3 339	Spectral line observations (radio astronomy)
3 345,8 to 3 358	Spectral line observations (radio astronomy)
3 400 to 3 475	Amateur radio services
3 400 to 3 410	Satellite downlink
3 600 to 4 200	Satellite downlink
4 500 to 5 250	4 500 MHz to 4 800 MHz: Satellite downlink 4 800 MHz to 5 000 MHz: Radio astronomy 5 000 MHz to 5 250 MHz: Aeronautical radionavigation
5 650 to 5 950	Amateur radio services
6 650 to 6 675,2	Radio astronomy
7 250 to 7 750	Satellite downlink
8 025 to 8 500	Satellite downlink
10 000 to 10 500	Amateur radio services
104 50 to 10 500	Satellite downlink
10 600 to 12 700	10,6 GHz to 10,7 GHz: Radio astronomy 10,7 GHz to 12,2 GHz: Satellite downlink 12,2 GHz to 12,7 GHz: Direct broadcast satellite
14 470 to 14 500	Spectral line observations (radio astronomy)
15 350 to 15 400	Radio astronomy
17 700 to 21 400	Satellite downlink
21 400 to 22 000	Broadcast satellite (Region 1 and Region 2)
22 010 to 23 120	22,01 GHz to 22,5 GHz: Radio astronomy 22,5 GHz to 23,0 GHz: Broadcast satellite (Region 1) (22,81 GHz to 22,86 GHz is also radio astronomy) 23,0 GHz to 23,07 GHz: Fixed/intersatellite/mobile (used to fill in the gap between frequency bands) 23,07 GHz to 23,12 GHz: Radio astronomy
23 600 to 24 000	Radio astronomy
24 000 to 24 500	Amateur radio services
31 200 to 31 800	Radio astronomy
36 430 to 36 500	Radio astronomy
38 600 to 40 000	Radio astronomy
above 400 GHz	Numerous bands above 400 GHz are designated for radio astronomy, satellite downlink, etc.

Annex D
(informative)

Measurements on Grid Connected Power Converters (GCPC) – Setups for an effective test site configuration

D.1 General information and purpose

For measurement of disturbance terminal voltages on grid connected power converters (GCPC) intended for supply of electric energy into AC mains grids and similar AC mains installations (see Definition 3.1.15), connection to an appropriate laboratory DC power supply is necessary on the DC input side of the GCPC, while connection to an appropriate laboratory AC power source or AC mains grid is necessary on the AC output side.

The DC power is fed into the DC input power ports of the GCPC, and not consumed in the GCPC, and so almost completely converted to AC power and output to the AC side. If the AC power output from the GCPC is not consumed by a resistive load etc., the AC power current can reversely be carried into the laboratory AC power source, and so the equipment can be damaged. In addition, there are some countries where reverse power flow into the AC mains is restricted or prohibited by national law and regulations. Thus, the global setup of the test site used for the measurements needs attention, and a proper and appropriate setup can even enable simplification of the test arrangement and configuration for the equipment under test (EUT). Examples of suitable setups for the test site are described below.

D.2 Setup of the test site

D.2.1 Block diagram of test site

The measurement arrangement and configuration for the EUT can be simplified by use of a test site having a configuration as shown in Figure D.1 or in Figure D.2. For this setup, the AC output of the GCPC is connected to the AC input of the laboratory DC power supply through the V-AMN used in the measurement arrangement. The laboratory DC power supply converts AC power into DC power, and it is supplied to the DC input of the GCPC. Thus, the current circulates from the AC output to the DC input of the GCPC. The advantages of this site configuration are that the DC power supply consumes the AC output power of the GCPC, and so a resistive load is not required to prevent AC power currents from flowing into the laboratory AC power source.

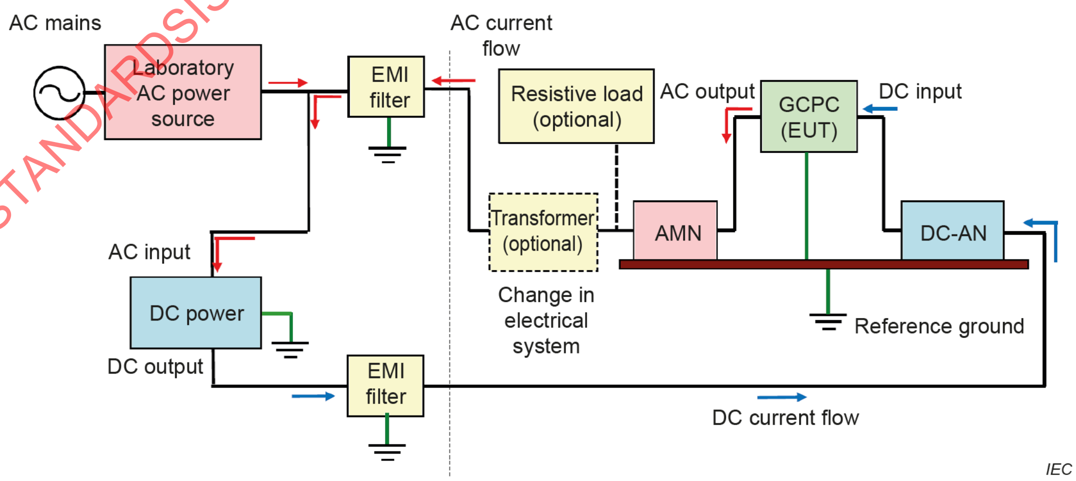
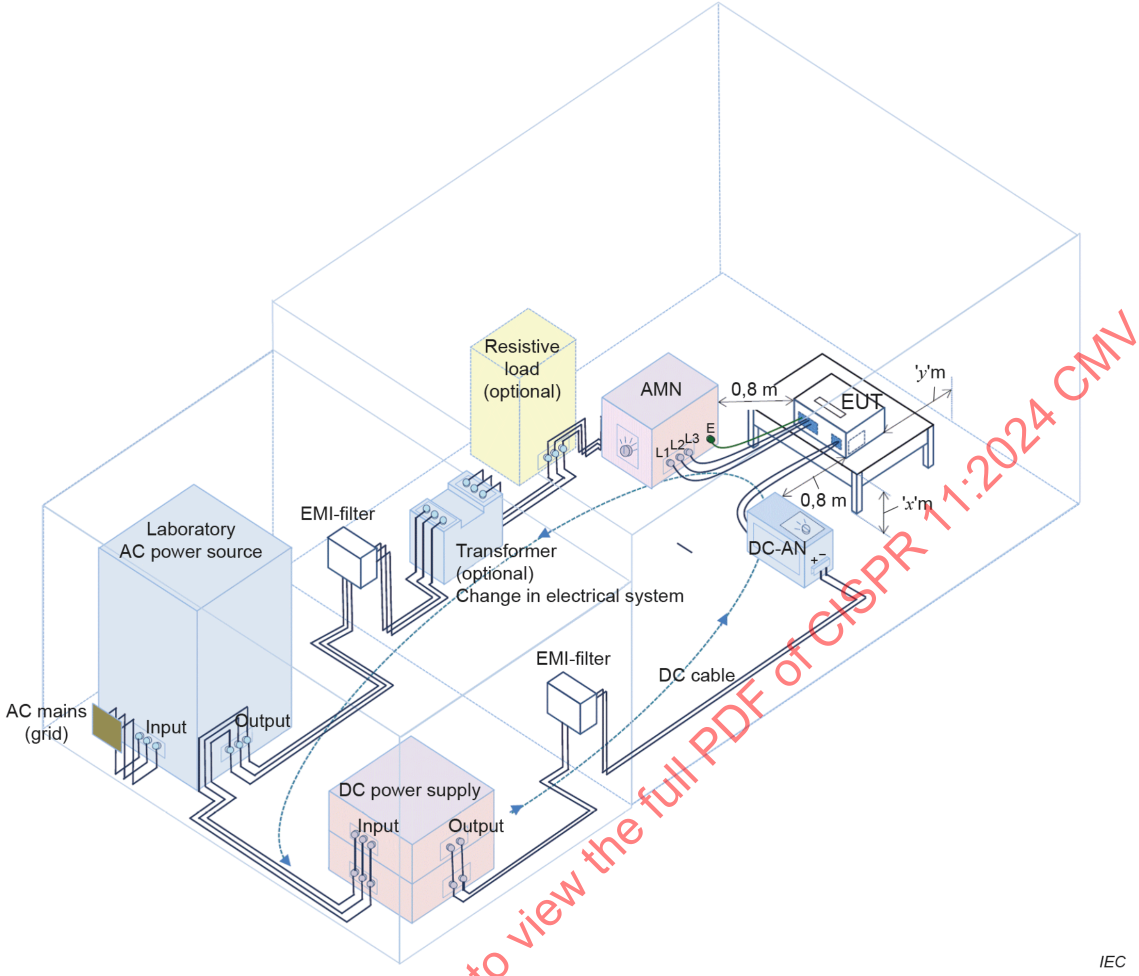


Figure D.1 – Test setup for Case 1 (schematic)



NOTE The distances defined as '*x*' and '*y*' in the diagram refer to those as detailed in CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017, 7.4.1.

Figure D.2 – Test setup for Case 1 (3D view)

Consequently, the laboratory AC power source shall provide only the total power losses in the test arrangement, once the measurements are started. Because the laboratory AC power source is used, its AC voltage and frequency can easily be adjusted conforming to the specifications for the AC output side of the GCPC. Reverse AC power current does not flow into the AC power source, and so it cannot be damaged.

D.2.2 DC power supply

The laboratory's DC power supply shall have enough output power to operate the GCPC at its rated AC output power. In addition, a control for adjusting properly its DC output voltage is necessary. In case of the test setup as shown in Figure D.1 or in Figure D.2, the electrical system of AC input to the DC power supply shall match with that of the AC output of the GCPC.

D.2.3 AC power source

The laboratory's AC power source shall be of the CVCF-type (constant voltage constant frequency type) such that it can adjust to the nominal AC output power voltage and frequency of the GCPC under test. In case of the setup as shown in Figure D.1 or in Figure D.2, its power is only just enough to supply the total power losses in the test arrangement, and so a larger power is unnecessary.

D.2.4 Other components

In many cases the DC power supply itself is provided with filters on the input and output side. As shown in Figure D.1 or in Figure D.2, additional EMI filters can be placed on the input and output side of the DC power supply to mitigate conducted disturbances which are generated.

In case the electrical systems of the AC output of the GCPC, the AC input of the DC power supply and the output of the AC power source are not of the same type such as single phase-three-wire, or single phase-two-wire system, a proper transformer shall be inserted as shown in Figure D.1 or in Figure D.2 to appropriately convert the electrical systems.

D.3 Other test setups

D.3.1 Configuration comprising laboratory AC power source and resistive load

There are some cases where each electrical system cannot basically be matched, such as three-phase input of the DC power supply with a single phase AC output of the GCPC (EUT), etc. There is also the reverse case. In such cases, the AC output of the GCPC cannot directly be connected to the AC input of the DC power supply as shown in Figure D.1 and Figure D.2. In this case, another resistive load is connected in parallel with the laboratory AC power source as shown in Figure D.3 and Figure D.4 and the AC power of the GCPC (EUT) shall be consumed by that resistive load. As a result, the resistive load prevents the AC output power current of the GCPC from flowing reversely into the laboratory AC power source, if it has enough power to exceed the maximum AC output power of the GCPC.

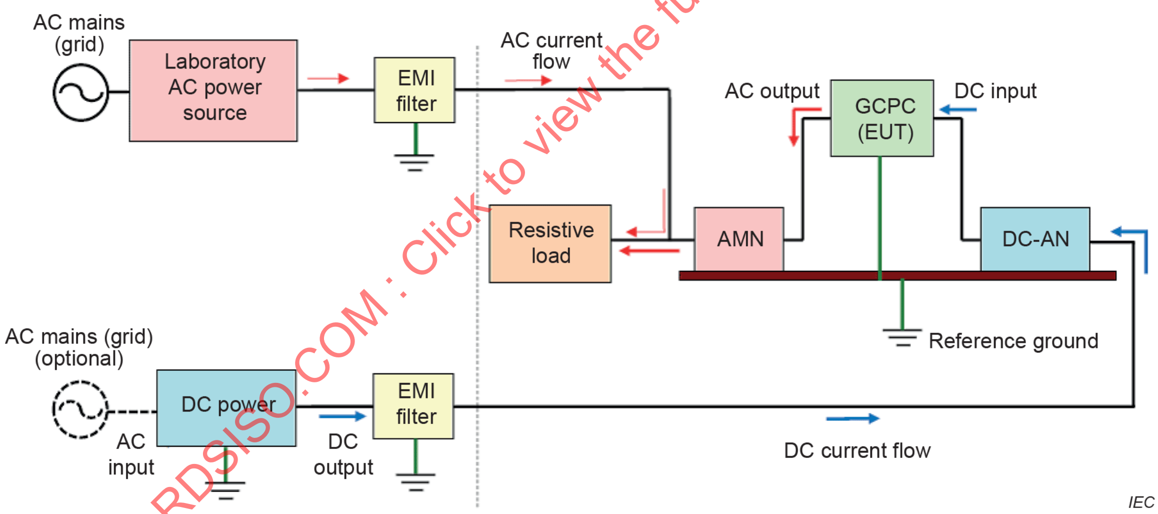
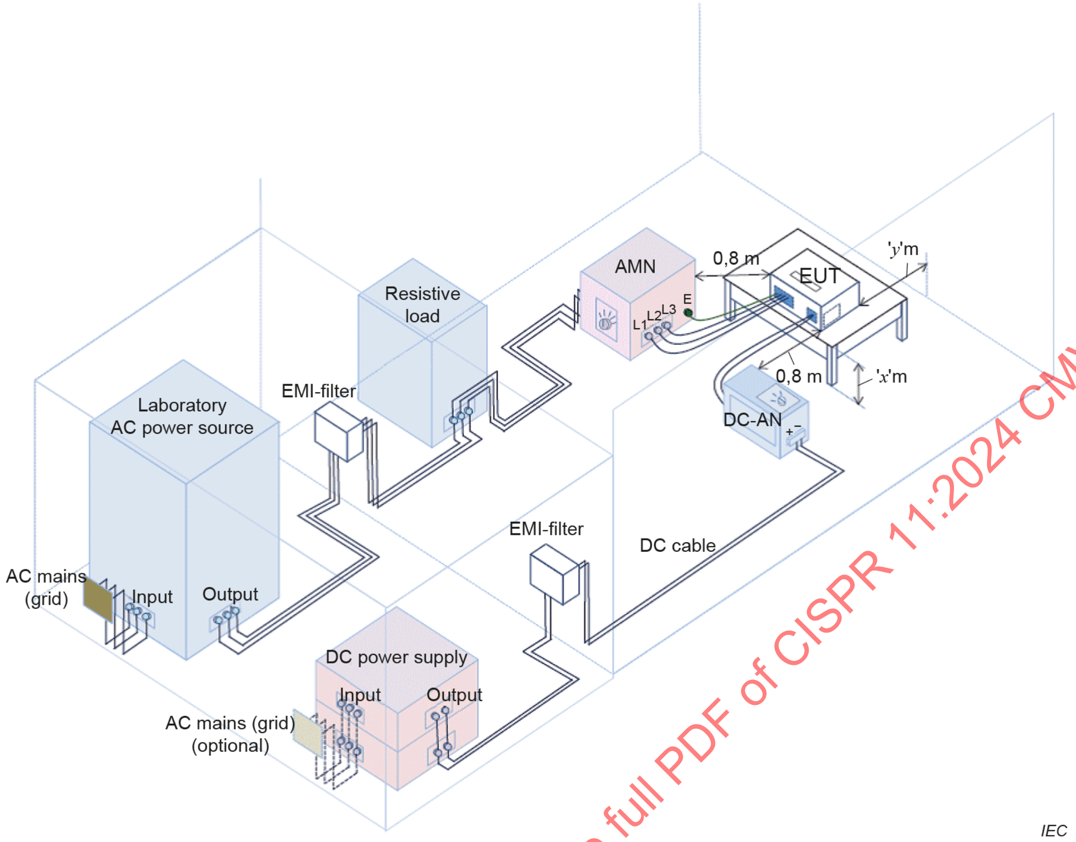


Figure D.3 – Test setup for Case 2 (schematic)



NOTE The distances defined as '*x*' and '*y*' in the diagram refer to those as detailed in CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017, 7.4.1.

Figure D.4 – Test setup for Case 2 (3D view)

D.3.2 Configuration with reverse power flow into the AC mains

This setup example shows the case where the laboratory AC power source (see Figure D.3 or Figure D.4) is not connected to the AC output side of the GCPC.

In case the AC output of the GCPC is connected to the AC mains through a filter as shown in Figure D.5 and Figure D.6, the AC output current of the GCPC flows to the AC mains, and therefore it is not required to connect the resistive load as shown in the previous setup, Case 2. But in this case, there is a disadvantage that the AC power voltage and frequency cannot be adjusted conforming to the specifications of the AC output side of the GCPC.

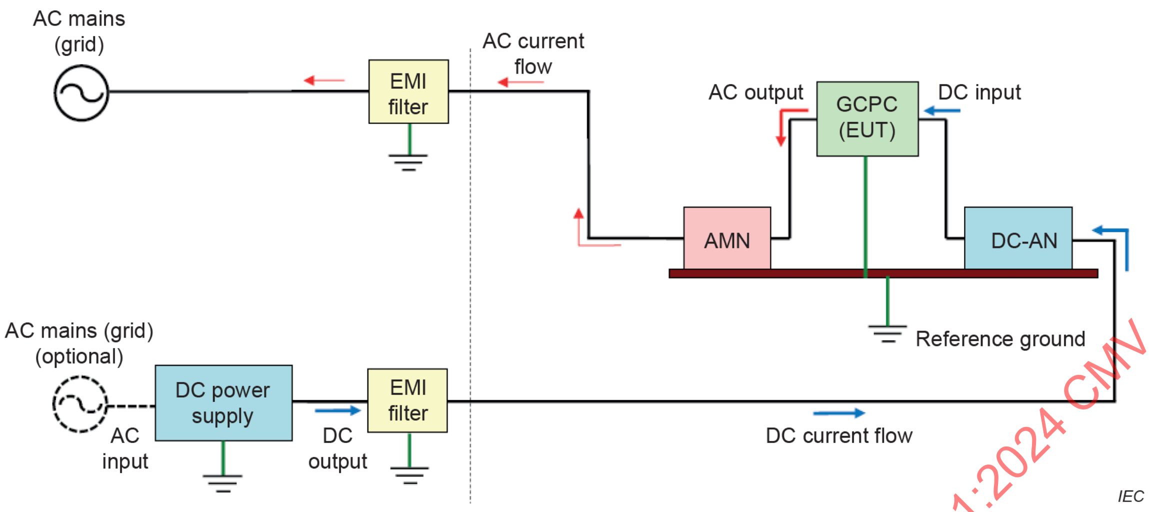
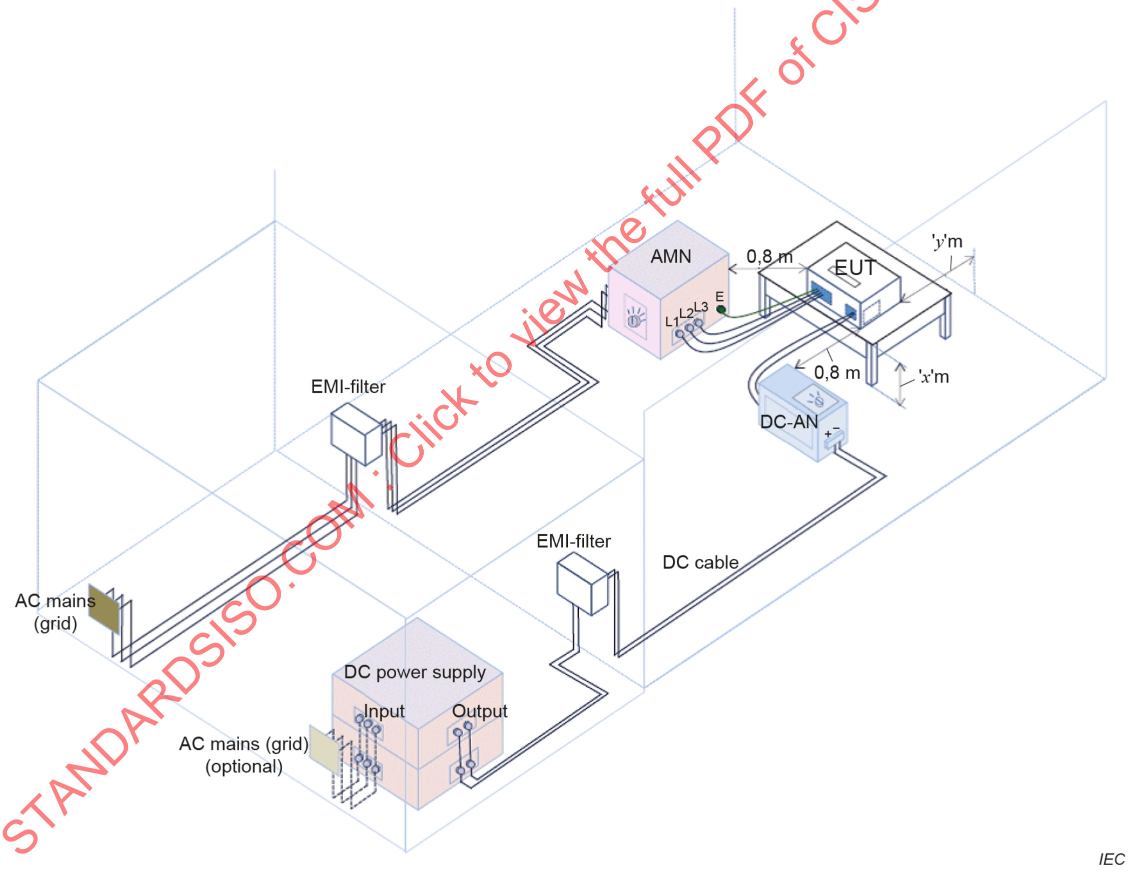


Figure D.5 – Test setup for Case 3 (schematic)



NOTE The distances defined as '*x*' and '*y*' in the diagram refer to those as detailed in CISPR 16-2-1:2014 and CISPR 16-2-1:2014/AMD1:2017, 7.4.1.

Figure D.6 – Test setup for Case 3 (3D view)

Annex E
(informative)

Guidance on prevention of saturation effects in mitigation filters of transformer-less power converters during tests

E.1 General information and purpose

Most types of power converters use operation or switching frequencies in the range of a couple of 100 Hz up to 25 kHz. The measurement results obtained in the range of interest (150 kHz to 30 MHz) are sometimes seriously invalidated by the effective total common mode (CM) impedance of the whole DC power supply chain in the test environment in the range of about 500 Hz to 150 kHz. If the operation frequency of the power converter under test coincides with the frequency of the series resonance dip(s) in the effective total common mode (CM) impedance in the whole laboratory DC power supply chain, excessive CM disturbance currents can appear at the operation frequency and can saturate the built-in EMI filters (as e.g. common mode chokes) in the EUT. Consequently, it will cause serious performance degradation of the filters in the measuring frequency range 150 kHz to 30 MHz. Performance degradation of the filters means that excessive RF disturbance levels will be recorded causing the power converter under test eventually to FAIL proving compliance with the requirements specified in this document.

It can be said that such mode of operation of power converters prominently deviates from the operation conditions in normal use. Hence additional countermeasures should be taken at test site configuration level in order to operate the power converters as intended in normal use, in tests according to this document.

As a matter of course, CM decoupling capacitors shall be employed, in conjunction with suitable series inductors, as LP-filters decouple the termination impedance at the EUT port of the artificial network (AN) e.g. from influences of the laboratory DC power source at the AE port of this AN. The specifications of the DC-AN guarantee that the CM termination impedance at the EUT port of the AN remains at least at values of 10 Ω or more, at the series resonance of its internal LC LP decoupling filter. This will prevent the saturation effects mentioned above in most of the practical testing cases. For the magnitude-versus-frequency characteristics of the CM termination impedance of the AN in the range 9 kHz to 150 kHz, consult the specifications provided by the manufacturer.

Considering now mitigation of common mode RF currents in the whole laboratory DC power supply chain at the test site, this mitigation and involved additional CM decoupling capacitors and common mode chokes (as e.g. in the EMI filters at the site) can interact with the characteristics of the built-in LC LP decoupling filter of the AN, and can cause frequency shifts of the series resonance dip(s) of the effective total common mode (CM) impedance experienced at the EUT port of this AN.

It is hence strongly recommended to adjust the magnitude-versus-frequency characteristics of the total effective CM termination impedance at the EUT port of the AN to the conditions needed for the given type of power converter under test. Such adjustments can be made by variation of the value of the CM blocking capacitance in the laboratory's DC power supply chain and/or by insert of additional series inductors or common mode chokes. This annex describes possible countermeasures to avoid saturation effects due to unfortunate characteristics of the test site instrumentation used in the laboratory DC power supply chain.

> Attention is drawn to the user of such test setups in regard of hazardous voltages due to high earth leakage currents. Advice should be sought from duly qualified personnel before switching on the laboratory's system power sources to ensure that injury or damage is not caused to test personnel or equipment.

E.2 Recommendations for avoidance of saturation effects in the range 9 kHz to 150 kHz

If excessive levels of disturbance are observed during measurements of conducted RF disturbances at LV DC power ports of power converters in the range 150 kHz to 30 MHz, then this can be caused by saturation effects appearing at the operation frequency of the EUT allocated someplace in the range below 150 kHz. To avoid such conditions, it is recommended to observe the guidance given below.

1) For measurements at LV DC power ports of power converters use only ANs complying with the technical requirements of the 150 Ω artificial mains Delta-network according to 4.7 of CISPR 16-1-2:2014 and CISPR 16-1-2:2014/AMD1:2017.
2) Apply good test site engineering and check whether the whole measuring instrumentation (DC-AN excluded) and test site configuration are suitable for use with measurements on power electronics operated in switching mode conditions at operating frequencies (fundamental frequencies) allocated in the range below 150 kHz. Depending on the implemented technology and nominal power throughput, power converters can use fundamental or switching mode frequencies in the range from a couple of 100 Hz up to about 150 kHz.
3) Whenever possible insert additional common mode (CM) absorbing devices such as ferrite tubes, CMADs or also 150 Ω CDNs according to IEC 61000-4-6, between the AE port of the AN and the laboratory DC power supply port allocated in the test environment. For this purpose an extended length of the DC power supply cable can be used too. In coiled form it introduces an additional decoupling inductor (i.e. a common mode choke) put in series to the laboratory's common mode current circuit. In any case, one should check the efficiency of the added common mode rejection devices, since for most of them one will not find specifications of technical characteristics in the range below 30 MHz.
4) Avoid coincidence of the fundamental or operating frequency of the power converter under test with the frequency of the series resonance dip in the CM impedance of the whole DC power supply chain consisting of the laboratory DC power source, the EMI filters used in the installation of the OATS or SAC, and the AN. The frequency of the resonance dip in the CM impedance of the power supply chain can be shifted by changing the capacitance of the effective CM decoupling capacitor. Addition of external CM decoupling capacitors is recommended at the interface between the AE port of the AN and the laboratory DC power supply port allocated in the test environment. Be aware that a line of capacitors with different capacitances can be needed if the testing business comprises power converters implementing various technologies, power throughput classes and the like. Remember that the operation frequency can be allocated someplace between a couple of 100 Hz up to about 150 kHz.

E.3 Detailed advice

E.3.1 General

Information about a DC-AN can be found in CISPR 16-1-2 and summarized as: the DC-AN is furnished with a decoupling network (i.e. an LC-filter) such that sufficient decoupling is provided between its EUT port and its AE port, in order to prevent RF disturbances from the laboratory DC power source to affect obtained measurement results. Having asymmetric decoupling capacitors with some 100 nF to about 1 µF capacitance only, the construction of that filter prevents, in most cases, saturation effects in mitigation filters the power converters under test may be furnished with, and this way provides for valid, reliable and repeatable measurement results.

However, if the laboratory DC power source is applied in measurement of RF disturbances as shown in Figure E.1, the CM RF current caused by the EUT does not only flow through the decoupling capacitors composing the decoupling circuit of the DC-AN, but also through the decoupling capacitors the laboratory DC power source and the EMI filter of the test site are furnished with. In addition, in almost all cases the capacitance of the decoupling capacitors such equipment is furnished with can be much larger than 100 nF.

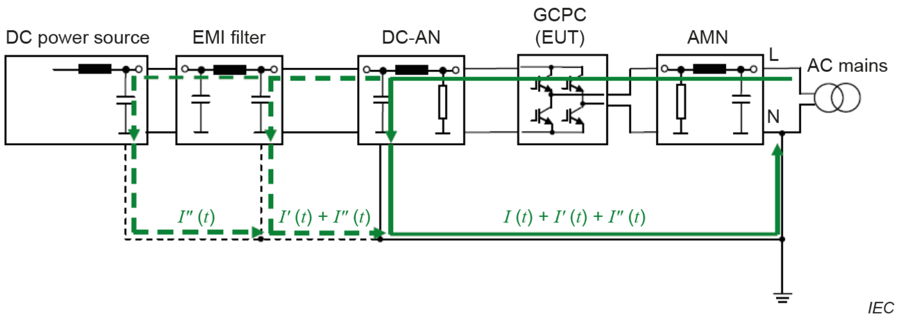


Figure E.1 – Flow of the common mode RF current at test site configuration level

An obvious countermeasure for prevention of these additional contributions to the total effective RF CM current at the operation frequency of the power converter under test shall increase the CM decoupling loss in between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment.

This decoupling loss can be increased by insert of additional series inductors (preferred countermeasure) and/or by employment of additional CM decoupling capacitors at the interface in between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment (countermeasure for shifting the frequency of the series resonance dip in the CM termination impedance at the EUT port of the DC-AN).

E.3.2 Insert of series inductors (or common mode chokes) in the laboratory's DC power supply chain

If some suitable EMI clamp devices etc. which attenuate the common mode RF current in 9 kHz to 150 kHz are inserted between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment as shown in Figure E.2, the capacitances of the decoupling capacitors the DC power source and EMI filter are equipped with can be neglected. For such additional decoupling, extended lengths of DC power cable could be used too, if arranged to form an air coil.

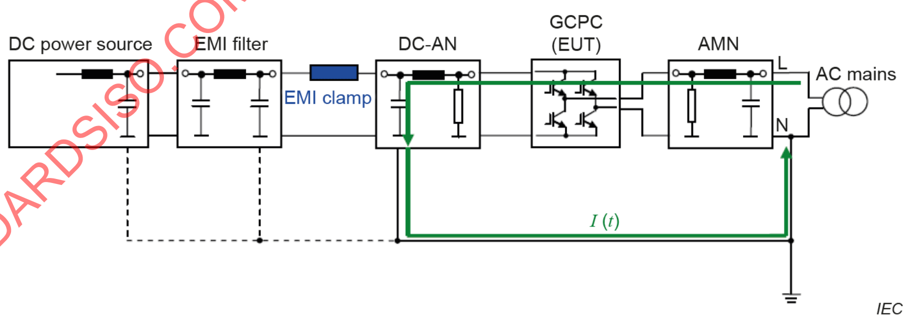


Figure E.2 – Blocking of flow of common mode RF current by insert of series inductors

ATTENTION – Proper equipment such as EMI clamp devices which can attenuate the common mode RF current in the range 9 kHz to 150 kHz might not be available from the market. Preferred measure should hence be insertion of series inductivities.

As mentioned above, because the effective magnitude of capacitance of decoupling capacitors of all the laboratory measuring systems including the laboratory DC power source can cause saturation effects in mitigation filters the transformer-less power converter is equipped with, it is necessary to use laboratory DC power sources and EMI filters with low capacitance common mode decoupling capacitors only. Observe however that use of CM decoupling capacitors with low capacitance only can also reduce suppression of RF disturbances generated by the laboratory DC power source. If extremely large RF disturbances occur during tests on transformer-less power converters which are thought to be caused by saturation of the built-in mitigation filters, then it should be considered to use batteries as DC power source.

E.3.3 Employment of additional common mode decoupling capacitors at the interface between the AE port of the DC-AN and the laboratory DC power supply port allocated in the test environment

For an increase of the decoupling loss between the laboratory DC power supply chain and the measurement arrangement additional CM decoupling capacitors can be connected between the AE port (i.e. the decoupling circuit) of the DC-AN and the laboratory DC power supply port allocated in the test environment as shown in Figure E.3.

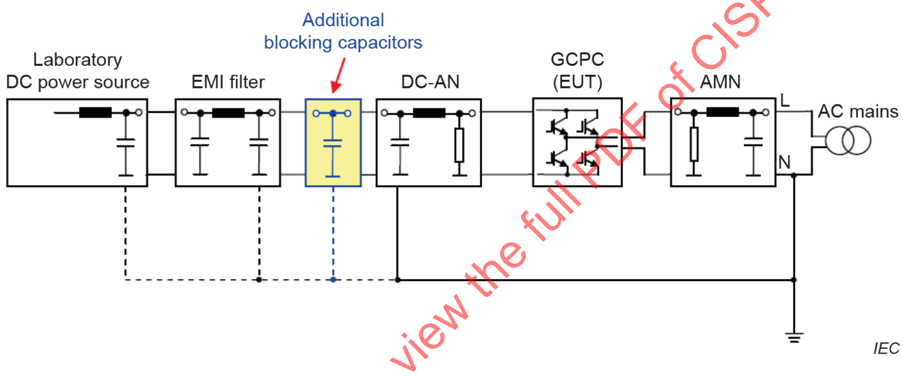


Figure E.3 – Blocking of flow of common mode RF current by employment of additional CM decoupling capacitors

The effect of such a countermeasure is that it shifts the series resonance dip in the magnitude-versus-frequency characteristics of the CM termination impedance at the EUT port of the DC-AN to lower frequencies, this way avoiding possible coincidences in frequency of that resonance dip and the operation or fundamental frequency of the power converter under test. If the operation frequency does not coincide with that series resonance frequency, saturation effects in the EUT can be avoided. It is quite obvious that such a countermeasure shall be carefully adjusted to the given type of power converter, due to the wide range of possibly involved operation frequencies. Individual adjustment of the additional CM blocking capacitance could be necessary in most cases.

E.4 Background information

Methods were studied of solving the saturation problem on the assumption that not a battery, but a laboratory DC power supply is used for measurements at transformer-less power converters. Figure E.4 shows an example of common mode impedance characteristics for a DC-AN. As shown in Figure E.4, it proves that there is a resonant point in the proximity of 20 kHz and the common mode impedance remarkably decreases at this resonant frequency.

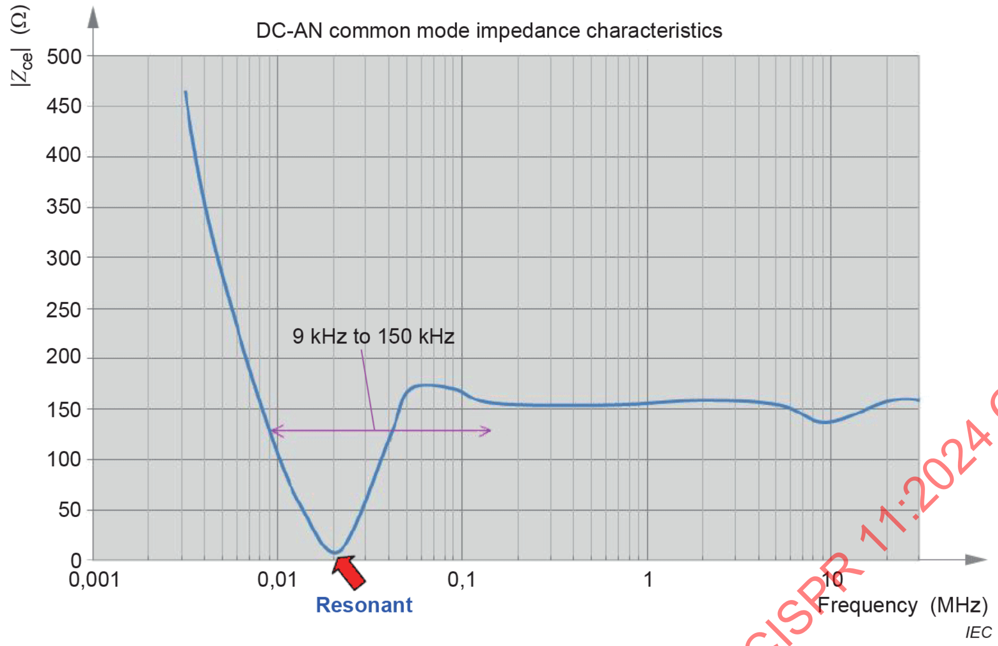


Figure E.4 – CM termination impedance at the EUT port of a DC-AN – Magnitude-versus-frequency characteristic in the range 3 kHz to 30 MHz, Example

The saturation of mitigation filters the power converter is furnished with, that currently becomes a problem, occurs because a large common mode current flows in case the resonant frequency (20 kHz) coincides with the operating frequency of the power converter (EUT). However, the resonant frequency is practically determined not only by the DC-AN, but also by the common mode impedance characteristics of all of the instrumentation used in the whole laboratory DC power supply chain including the DC power source, installed EMI filters and the like.

In case the effective resonant frequency caused by all of the laboratory measuring instrumentation coincides with the operating frequency of the power converter and so large common mode current flows, or in case it is necessary to confirm whether such conditions actually occur, the resonant frequency can be detuned from the operating frequency of the power converter by changing the capacitance of decoupling capacitors of the decoupling circuit of the DC-AN or adding the capacitance of decoupling capacitors as shown in Figure E.5 and so changing the resonant frequency, that is to say, the resonant point can be shifted as shown in Figure E.6. As a result, the common mode current can be reduced at the operating frequency of the power converter by avoiding saturation effects.

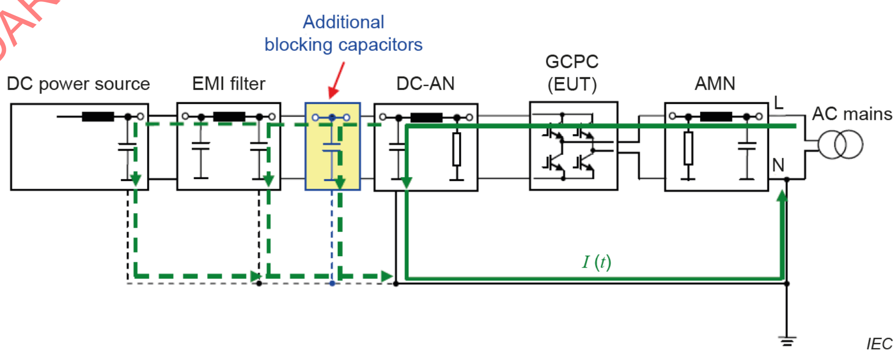


Figure E.5 – Prevention of saturation of mitigation filters by use of additional decoupling capacitors

In other words, if the measurement results in case the capacitance of decoupling capacitors is increased are the same as those in case it is unchanged, it can be concluded that the measurements of conductive disturbances have correctly been performed.

With exchange of hardware components in the DC-AN, it is possible to increase or decrease the capacitance of the CM decoupling capacitors by setting up switches for switching series and parallel connection of these decoupling capacitors as shown in Figure E.7. However, such measure cannot be recommended for application in normal laboratory practice since possibly violating the calibration of the respective DC-AN. However, switched-type combined external CM decoupling capacitors can be used, if applicable. Application of such capacitors will always shift the series resonance of the DC-AN internal LC decoupling filter to lower frequencies than found in the manufacturer's specifications.

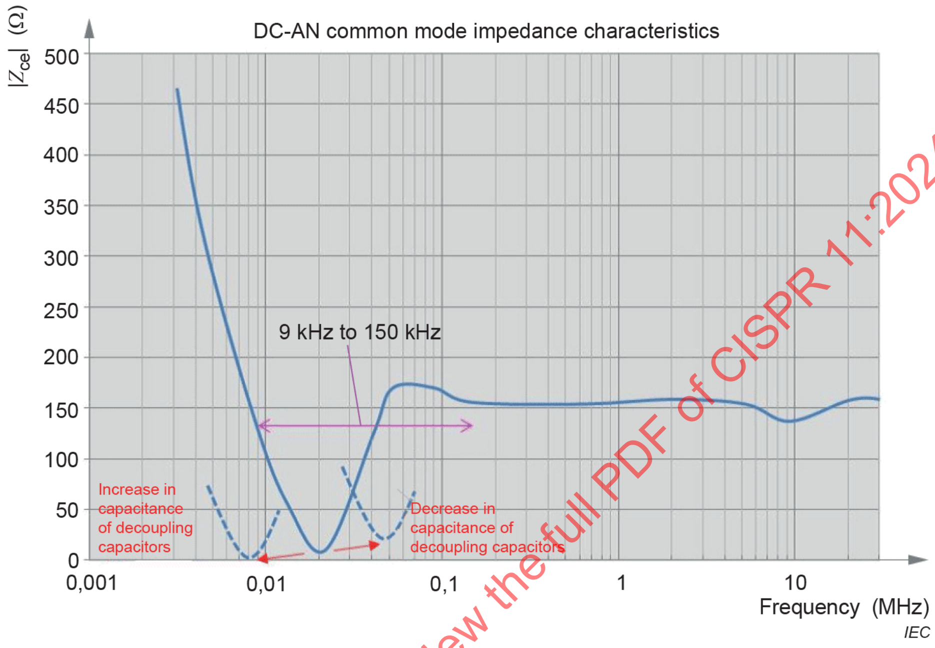


Figure E.6 – Change in the resonant frequency caused by the increase and decrease in the decoupling capacitor's capacitance

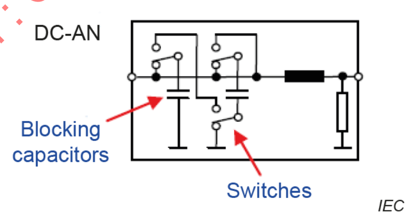


Figure E.7 – DC-AN circuit example where capacitance of blocking capacitors of the LC decoupling circuit can be increased or decreased

Annex F
(normative)

Additional requirements for equipment with radio functionality

F.1 Configuration of the EUT during emission tests

For the non-radio function, the configuration of the EUT shall be according to the requirements specified in 7.5.

The radio function shall be configured consistent with normal operation of the EUT. The configuration(s) used shall be recorded in the test report together with the rationale for these choices.

NOTE 1 The transmit mode of the radio function is part of the assessment under the appropriate radio regulations applicable to the radio technology used.

NOTE 2 To prevent saturation of the measuring receiver, the good practice is to include filter(s) rejecting the radio transmitter frequency in the measurement chain.

F.2 Radiated emissions

For radiated emissions, the EUT with the radio function in standby or receive mode shall be assessed against 6.2.2, 6.3.2 or 6.4.2 as appropriate.

Alternatively, the EUT may be assessed with the radio function in transmit mode. In this case, an emission failing the limit of 6.2.2, 6.3.2 or 6.4.2, as appropriate, may be ignored provided it is demonstrated that it originates from the radio portion of the EUT.

When applying Table 10 for determining the highest internal frequency of the EUT, the frequencies of the radio equipment (i.e. radio device, radio module, or radio assembly/circuitry included in the EUT) shall also be considered.

F.3 Conducted emissions

For conducted emissions, the EUT with the radio function in standby or receive mode shall be assessed against 6.2.1, 6.3.1, 6.4.1 or Table F.1, as appropriate. Alternatively, the EUT may be assessed with the radio function in transmit mode. In this case, an emission failing the limit of 6.2.1, 6.3.1, 6.4.1 or Table F.1, as appropriate, may be ignored provided it is demonstrated that it originates from the radio portion of the EUT.

Where the EUT has a port intended for the connection of an external antenna via coaxial cable longer than 3 m, the Class A or Class B requirements of Table F.1 shall apply to this port. One of the measurement procedures (and the corresponding ancillary equipment) specified in CISPR 32 for this type of EUT port shall be used (see Table A.11 of CISPR 32:2015, Table A.12 of CISPR 32:2015 and C.4.1.6 of CISPR 32:2015 and CISPR 32:2015/AMD1:2019).

Table F.1 – Disturbance voltage and current limits for group 1 and group 2 equipment measured on a test site (antenna port)

Frequency range MHz	**Class A**		**Class B**	
	Limits dB(μV)	**Limits** dB(μA)	**Limits** dB(μV)	**Limits** dB(μA)
	Detector	**Detector**	**Detector**	**Detector**
0,15 to 0,5	97 to 87 [a] Quasi-peak	53 to 43 [a] Quasi-peak	84 to 74 [a] Quasi-peak	40 to 30 [a] Quasi-peak
	84 to 74 [a] Average	40 to 30 [a] Average	74 to 64 [a] Average	30 to 20 [a] Average
0,5 to 30	87 Quasi-peak	43 Quasi-peak	74 Quasi-peak	30 Quasi-peak
	74 Average	30 Average	64 Average	20 Average

[a] decreasing linearly with logarithm of frequency

Limitations and restrictions:

The application of the voltage and/or current limits is dependent on the measurement procedure used. Refer to CISPR 32:2015/AMD1:2019, Table C.1 for applicability.

Excluding measurement uncertainty, all other elements within CISPR 32 shall be followed, including but not limited to selection of test method, test configuration, cable characteristics.

NOTE The voltage and current disturbance limits in this table consider the fact that the antenna port under test is presented with a common mode impedance of 150 Ω. Thus, the two limits are interrelated by: $V - I = 20 \log_{10}$ (150 Ω) = 44 dBΩ, where V and I are in logarithmic units (i.e. dBμV and dBμA, respectively).

Bibliography

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

[2] ISO 8373:2021, *Robotics – Vocabulary*

[3] IEC TR 60601-4-1:2017, *Medical electrical equipment – Part 4-1: Guidance and interpretation – Medical electrical equipment and medical electrical systems employing a degree of autonomy*

[4] IEC 62920:2017, *Photovoltaic power generating systems – EMC requirements and test methods for power conversion equipment*
IEC 62920:2017/AMD1:2021

[5] IEC 60050-713:1998, *International Electrotechnical Vocabulary (IEV) – Part 713: Radiocommunications: transmitters, receivers, networks and operation*

[6] IEEE Standard 1284.1, *IEEE Standard for Information Technology – Transport Independent Printer/System Interface (TIP/SI)*

[7] IEEE Standard 1394, *IEEE Standard for a High Performance Serial Bus*

[8] IEC 61000-6-3:2020, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments*

[9] IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

[10] IEC 60601-1-2:2014, *Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral standard: Electromagnetic disturbances – Requirements and tests*
IEC 60601-1-2:2014/AMD1:2020

[11] IEC TR 61000-2-5:2017, *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Description and classification of electromagnetic environments*

[12] IEC 61922:2002[3], *High-frequency induction heating installations – Test methods for the determination of power output of the generator*

[13] IEC 61308:2005[4], *High-frequency dielectric heating installations – Test methods for the determination of power output*

[14] IEC 60705:2010, *Household microwave ovens – Methods for measuring performance*

[15] IEC 60974-10:2020, *Arc welding equipment – Part 10: Electromagnetic compatibility (EMC) requirements*

[16] ISO 9283:1998, *Manipulating industrial robots – Performance criteria and related test methods*

3 This publication was withdrawn.

4 This publication was withdrawn.

[17] CISPR TR 16-2-5:2008, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-5: In situ measurements for disturbing emissions produced by physically large equipment*

[18] CISPR 12, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers*

[19] CISPR TR 16-4-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*
CISPR TR 16-4-3:2004/AMD1:2006

[20] CISPR TR 16-4-4:2007, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-4: Uncertainties, statistics and limit modelling – Statistics of complaints and a model for the calculation of limits for the protection of radio services*

[21] CISPR 15:2018, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*

[22] IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*, available at www.electropedia.org

[23] IEC TR 60083:2015, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

[24] IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

[25] IEC 61158-1:2023, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

[26] IEC 61689:2022, *Ultrasonics – Physiotherapy systems – Field specifications and methods of measurement in the frequency range 0,5 MHz to 5 MHz*

[27] ETSI EN 303 446-1 V1.2.1 (2019-10), *ElectroMagnetic Compatibility (EMC) standard for combined and/or integrated radio and non-radio equipment – Part 1: Requirements for equipment intended to be used in residential, commercial and light industry locations*

[28] ETSI EN 303 446-2 V1.2.1 (2019-10), *ElectroMagnetic Compatibility (EMC) standard for combined and/or integrated radio and non-radio equipment – Part 2: Requirements for equipment intended to be used in industrial locations*

[29] ETSI EG 203 367 V1.1.1 (2016-06), *Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the Directive 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment*

[30] Recommendation ITU-R M.1036-6:2019, *Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications in the bands identified for IMT in the Radio Regulations*

[31] Recommendation ITU-R M.1073-3:2012, *Digital cellular land mobile telecommunication systems*

[32] Recommendation ITU-R M.2009-2:2019, *Radio interface standards for use by public protection and disaster relief operations in accordance with Resolution 646 (Rev.WRC-15)*

[33] Recommendation ITU-R BT.2033-1:2015, *Planning criteria, including protection ratios, for second generation of digital terrestrial television broadcasting systems in the VHF/UHF bands*

[34] A.A. SMITH, Jr., *Electric field propagation in the proximal region, IEEE Transactions on electromagnetic compatibility*, Nov 1969, pp.151-163

[35] IEC Guide 107:2014, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*

[36] IEC 62135-2:2020, *Resistance welding equipment – Part 2: Electromagnetic compatibility (EMC) requirements*

___

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

____

APPAREILS INDUSTRIELS, SCIENTIFIQUES ET MÉDICAUX – CARACTÉRISTIQUES DE PERTURBATIONS RADIOÉLECTRIQUES – LIMITES ET MÉTHODES DE MESURE

AVANT-PROPOS

1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments du présent document de l'IEC peuvent faire l'objet de droits de brevets. L'IEC ne prend pas position quant à la preuve, à la validité et à la portée de ces droits de propriété. À la date de publication du présent document, l'IEC n'a reçu aucune déclaration relative à des droits de brevets, qui pourraient être exigés pour la mise en œuvre du présent document. Toutefois, il est rappelé aux responsables de cette mise en œuvre qu'il ne s'agit peut-être pas des informations les plus récentes, qui peuvent être obtenues dans la base de données disponible à l'adresse https://patents.iec.ch. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets.

La Norme internationale CISPR 11 a été établie par le sous-comité B du CISPR: Perturbations relatives aux appareils industriels, scientifiques et médicaux à fréquences radioélectriques, aux autres appareils de l'industrie lourde, aux lignes électriques aériennes, aux appareils à haute tension et aux appareils de traction électrique.

Cette septième édition annule et remplace la sixième édition parue en 2015, l'Amendement 1:2016 et l'Amendement 2:2019. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) introduction de limites pour les perturbations rayonnées dans la plage de fréquences supérieure à 1 GHz pour les appareils du groupe 1, conformément aux exigences données dans les normes d'émission génériques;
b) introduction de limites pour les perturbations conduites sur l’accès de réseau câblé conformément aux exigences données dans les normes d'émission génériques;
c) Introduction d’exigences relatives aux appareils qui intègrent des fonctions d’émission/réception radio;
d) introduction de définitions pour les différents types de robots;
e) prise en considération de certaines conditions particulières lors de la mesure des robots, comme les configurations de mesure et les modes de fonctionnement des robots.

Le texte de ce document est issu des documents suivants:

Projet	Rapport de vote
CIS/B/831/FDIS	CIS/B/837/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l’élaboration de cette Norme internationale est l’anglais.

Ce document a été rédigé selon les directives ISO/IEC, Partie 2, il a été développé selon les directives ISO/IEC, Partie 1 et les directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Le présent document a le statut d’une norme de famille de produits en CEM, conformément au Guide 107 de l’IEC, *Compatibilité électromagnétique – Guide pour la rédaction des publications sur la compatibilité électromagnétique (2014)*.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé, ou
- révisé.

IMPORTANT – Le logo "colour inside" qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

Le contenu principal du présent document est fondé sur la Recommandation n° 39/2 du CISPR rappelée ci-dessous:

RECOMMANDATION n° 39/2

Limites et méthodes de mesure des caractéristiques de perturbations électromagnétiques des appareils industriels, scientifiques et médicaux (ISM) à fréquences radioélectriques

Le CISPR

CONSIDERANT

a) que les appareils ISM à fréquences radioélectriques constituent une source importante de perturbations;

b) que les méthodes de mesure de ces perturbations ont été spécifiées par le CISPR;

c) que certaines fréquences sont désignées par l'Union Internationale des Télécommunications (UIT) pour un rayonnement non limité provenant des appareils ISM;

RECOMMANDE

que la dernière édition de la CISPR 11 soit utilisée pour appliquer des limites et méthodes de mesure des caractéristiques des appareils ISM.

INTRODUCTION

Parmi les exigences communes relatives au contrôle des perturbations radioélectriques dues au matériel destiné à des applications industrielles, scientifiques et électromédicales, la présente publication du CISPR contient des exigences spécifiques relatives au contrôle des perturbations radioélectriques dues à des applications ISM à fréquences radioélectriques au sens de la définition donnée par l'Union Internationale des Télécommunications (UIT). Voir également la Définition 3.1.18 du présent document. Le CISPR et l'UIT se partagent la responsabilité de la protection des services radio en matière d'utilisation des applications ISM à fréquences radioélectriques.

Le CISPR est concerné par le contrôle des perturbations radioélectriques dues à des applications ISM à fréquences radioélectriques par le moyen d’une évaluation de ces perturbations, soit sur un site d'essai normalisé, soit, dans le cas d’une application ISM à fréquences radioélectriques qui ne peut pas être soumise à l’essai sur un tel site, sur son lieu de fonctionnement. Par conséquent, la présente publication du CISPR couvre les exigences relatives à l'évaluation des deux sortes d'appareils, à savoir, les appareils évalués par des essais sur des sites d'essai normalisés ou les appareils spécifiques évalués dans des conditions *in situ*.

L'UIT est concerné par le contrôle des perturbations radioélectriques dues à des applications ISM à fréquences radioélectriques pendant le fonctionnement normal et l'utilisation de l'appareil correspondant sur son lieu de fonctionnement (voir la Définition 1.15 dans le règlement des radiocommunications de l'UIT (2020)). Là, l'utilisation de l'énergie radioélectrique découplée de l'application ISM à fréquences radioélectriques par couplage rayonnant, inductif ou capacitif est limitée à l'emplacement de cette application.

Le paragraphe 6.3 de la présente publication du CISPR contient les exigences essentielles relatives aux émissions pour une évaluation des perturbations radioélectriques dues à des applications ISM à fréquences radioélectriques sur des sites d'essai normalisés. Ces exigences permettent des essais sur les applications ISM à fréquences radioélectriques qui fonctionnent à des fréquences jusqu'à 18 GHz. Le paragraphe 6.4 contient par ailleurs les exigences essentielles relatives aux émissions pour une évaluation *in situ* des perturbations radioélectriques dues à des applications ISM à fréquences radioélectriques dans la plage de fréquences jusqu'à 1 GHz. Toutes les exigences ont été établies en étroite collaboration avec l'UIT et jouissent de l'approbation de l'UIT.

Toutefois, pour le fonctionnement et l'utilisation de plusieurs types d'applications ISM à fréquences radioélectriques, il convient que le fabricant, l'installateur et/ou le client connaissent les dispositions nationales complémentaires concernant la réglementation et les besoins particuliers de protection des services et applications radio locaux. Selon le pays concerné, ces dispositions complémentaires peuvent s'appliquer à des applications ISM à fréquences radioélectriques qui fonctionnent à des fréquences situées à l'extérieur des bandes ISM désignées (voir le Tableau 1). Elles peuvent aussi s'appliquer à des applications ISM à fréquences radioélectriques qui fonctionnent à des fréquences supérieures à 18 GHz.

L’Annexe C du présent document donne des recommandations du CISPR relatives à la protection des services radio dans des zones particulières.

APPAREILS INDUSTRIELS, SCIENTIFIQUES ET MÉDICAUX – CARACTÉRISTIQUES DE PERTURBATIONS RADIOÉLECTRIQUES – LIMITES ET MÉTHODES DE MESURE

1 Domaine d'application

Le présent document s'applique aux appareils industriels, scientifiques et électromédicaux qui fonctionnent dans la plage de fréquences de 0 Hz à 400 GHz, ainsi qu'aux appareils domestiques et similaires conçus pour produire et/ou utiliser, dans un espace réduit, de l'énergie radioélectrique.

Le présent document couvre les exigences d'émission relatives aux perturbations radioélectriques dans la plage de fréquences de 9 kHz à 400 GHz.

Pour les applications industrielles, scientifiques et médicales (ISM) à fréquences radioélectriques, au sens de la définition fournie par le règlement des radiocommunications de l'UIT (2020) (voir la Définition 3.1.18), le présent document couvre les exigences d'émission relatives aux perturbations à fréquences radioélectriques dans la plage de fréquences de 9 kHz à 18 GHz.

Les appareils ISM qui intègrent des fonctions d'émission/réception radio (équipement hôte avec une fonctionnalité radio) sont inclus dans le domaine d'application du présent document, voir l'Annexe F. Toutefois, les exigences d'émission du présent document ne sont pas destinées à s'appliquer aux transmissions intentionnelles d'un émetteur radio tel que défini par l'UIT, y compris leurs émissions parasites.

NOTE 1 Cette exclusion s'applique uniquement aux émissions de l'émetteur radio intentionnel. Toutefois, les émissions combinées, par exemple les émissions qui résultent de l'intermodulation entre la radio et les sous-ensembles non radioélectriques de l'appareil ISM, ne sont pas soumises à cette exclusion.

NOTE 2 Les exigences d'émission pour les appareils de cuisson à induction sont spécifiées dans la CISPR 14-1 [1][1].

Les exigences relatives aux appareils d'éclairage ISM à fréquences radioélectriques et aux générateurs de rayonnement UV qui fonctionnent dans les bandes de fréquences ISM définies par le règlement des radiocommunications de l'UIT sont spécifiées dans le présent document.

Les robots utilisés pour les applications industrielles, scientifiques et médicales relèvent du domaine d'application du présent document.

EXEMPLE Robots de soudage, robots de pulvérisation, robots de manutention, robots de traitement, robots d'assemblage, robots médicaux, robots éducatifs et expérimentaux. Une liste exhaustive des robots qui relèvent du domaine d'application de la présente norme est donnée dans la zone CEM de l'IEC.

NOTE 3 Les robots volants, les robots d'aide domestique, les robots jouets et les robots de divertissement sont des exemples de robots qui relèvent du domaine d'application des autres normes CISPR.

Les appareils couverts par d'autres normes de produits du CISPR et d'autres normes d'émission de famille de produits n'entrent pas dans le domaine d'application du présent document.

1 Les chiffres entre crochets renvoient à la Bibliographie.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

CISPR 16-1-1:2019, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure*

CISPR 16-1-2:2014, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-2: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Dispositifs de couplage pour la mesure des perturbations conduites*
CISPR 16-1-2:2014/AMD1:2017

CISPR 16-1-4:2019, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-4: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Antennes et emplacements d'essai pour les mesures des perturbations rayonnées*
CISPR 16-1-4:2019/AMD1:2020
CISPR 16-1-4:2019/AMD2:2023

CISPR 16-2-1:2014, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-1: Méthodes de mesure des perturbations et de l'immunité – Mesures des perturbations conduites*
CISPR 16-2-1:2014/AMD1:2017

CISPR 16-2-3:2016, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-3: Méthodes de mesure des perturbations et de l'immunité – Mesurages des perturbations rayonnées*
CISPR 16-2-3:2016/AMD1:2019
CISPR 16-2-3:2016/AMD2:2023

CISPR 16-4-2:2011, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 4-2: Incertitudes, statistiques et modélisation des limites – Incertitudes de mesure de l'instrumentation*
CISPR 16-4-2:2011/AMD1:2014
CISPR 16-4-2:2011/AMD2:2018

CISPR 32:2015, *Compatibilité électromagnétique des équipements multimédia – Exigences d'émission*
CISPR 32:2015/AMD1:2019

IEC 60050-161:1990, *Vocabulaire Electrotechnique international (IEV) – Partie 161: Compatibilité électromagnétique*

IEC 60601-2-2:2017, *Appareils électromédicaux – Partie 2-2: Exigences particulières pour la sécurité de base et les performances essentielles des appareils d'électrochirurgie à courant haute fréquence et des accessoires d'électrochirurgie à courant haute fréquence*

IEC 61000-4-6:2023, *Compatibilité électromagnétique (CEM) – Partie 4-6: Techniques d'essai et de mesure – Immunité aux perturbations conduites, induites par les champs aux fréquences radioélectriques*

IEC 61307:2011[2], *Installations industrielles de chauffage à hyperfréquence – Méthodes d'essai pour la détermination de la puissance de sortie*

Règlement des radiocommunications de l'UIT (2020), *Règlement des radiocommunications, disponible à l'adresse* http://www.itu.int/en/myitu/Publications/2020/09/02/14/23/Radio-Regulations-2020)

3 Termes, définitions et abréviations

3.1 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 60050-161 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

3.1.1
accès d'alimentation secteur en courant alternatif
accès utilisé pour le raccordement à un réseau public de distribution secteur d'énergie en courant alternatif à basse tension ou autre installation secteur en courant alternatif à basse tension

3.1.2
matériel associé
AE
appareil ne faisant pas partie du système en essai, mais nécessaire au bon fonctionnement du matériel en essai (EUT)

Note 1 à l'article: L'abréviation "AE" est dérivée du terme anglais développé correspondant "associated equipment".

[SOURCE: CISPR 16-2-3:2016, 3.1.5]

3.1.3
matériel de soudage à l'arc
matériel destiné à appliquer un courant et une tension et ayant les caractéristiques exigées adaptées au soudage à l'arc et aux procédés connexes

3.1.4
réseau fictif d'alimentation
AMN
réseau permettant d'envoyer une impédance RF définie à l'EUT, de coupler la tension perturbatrice au récepteur de mesure et de découpler le circuit d'essai de l'alimentation

Note 1 à l'article: Il existe deux types principaux de réseaux fictifs: le réseau en V (AMN en V) qui délivre les tensions dissymétriques, et le réseau en delta (AMN en Δ) qui délivre les tensions symétriques (en mode différentiel) et asymétriques (en mode commun) séparément.

Note 2 à l'article: Les termes "réseau de stabilisation d'impédance de ligne" (RSIL) et "AMN en V" sont interchangeables.

Note 3 à l'article: L'abréviation "AMN" est dérivée du terme anglais développé correspondant "artificial mains network".

2 Cette publication a été supprimée.

[SOURCE: CISPR 16-1-2:2014/AMD1:2017, 3.1.6, modifié – ajout de la Note 2]

3.1.5
limite du matériel en essai
périmètre imaginaire de lignes droites décrivant une configuration géométrique simple qui englobe le matériel en essai

Note 1 à l'article: Tous les câbles d'interconnexion sont inclus à l'intérieur de ce périmètre.

3.1.6
composant
produit qui sert une ou plusieurs fonctions particulières et qui est destiné à être utilisé dans un matériel ou système assemblé de niveau supérieur

3.1.7
réseau fictif en courant continu
réseau en courant continu fictif
DC-AN
réseau fictif qui sert de terminaison définie de l'accès en courant continu en essai du matériel en essai, fournissant également le découplage nécessaire des perturbations conduites provenant de la source d'alimentation en courant continu de laboratoire ou de la charge

Note 1 à l'article: L'abréviation "DC-AN" est dérivée du terme anglais développé correspondant "DC artificial network".

3.1.8
accès d'alimentation en courant continu
accès utilisé pour le raccordement à un système de production d'énergie en courant continu à basse tension, à un système de stockage d'énergie ou à une autre source/charge

Note 1 à l'article: Il peut par exemple s'agir d'un système de production d'énergie photovoltaïque, à pile à combustible ou également d'une batterie.

3.1.9
matériel d'usinage par décharges électriques
matériel EDM
tous les composants nécessaires au procédé d'électroérosion incluant la machine-outil, le générateur, les circuits de commande, le réceptacle de fluide de travail et les dispositifs intégrés

Note 1 à l'article: L'abréviation "EDM" est dérivée du terme anglais développé correspondant "electro-discharge machining".

3.1.10
rayonnement électromagnétique
processus par lequel une source fournit de l'énergie vers l'espace extérieur sous forme d'ondes électromagnétiques

Note 1 à l'article: Le sens du terme "rayonnement électromagnétique" est quelquefois étendu aux phénomènes d'induction.

[SOURCE: IEC 60050-161:1990, 161-01-10]

3.1.11
matériel de soudage par résistance et procédés connexes
tous les matériels associés à la réalisation des procédés de soudage par résistance ou des procédés connexes

Note 1 à l'article: Ces matériels consistent, par exemple, en une source d'alimentation, des électrodes, l'outillage et le matériel de contrôle associé, qui peuvent consister en une unité séparée ou une partie d'une machine complexe.

3.1.12
équipement avec une fonctionnalité radio
équipement non radioélectrique (équipement hôte) avec au moins un dispositif radioélectrique ou module radioélectrique et qui peut utiliser une ou plusieurs fonctions de commande hôtes et/ou l’alimentation électrique

Note 1 à l’article: L’utilisation des équipements radioélectriques inclus peut concerner la commande à distance (de l’équipement hôte par un équipement externe ou inversement) ou les échanges de données avec des équipements externes.

Note 2 à l’article: Un dispositif radioélectrique ou un module radioélectrique peut être enfiché, intégré ou externe.

3.1.13
chambre totalement anéchoïque
FAR
enceinte blindée dont les surfaces intérieures sont revêtues d'un matériau absorbant l’énergie radioélectrique (c'est-à-dire un absorbeur RF) qui atténue l'énergie électromagnétique dans la plage de fréquences concernée

Note 1 à l'article: L’abréviation "FAR" est dérivée du terme anglais développé correspondant "fully-anechoic room".

3.1.14
fréquence fondamentale
fréquence ISM fondamentale
fréquence de fonctionnement de l’appareil ISM

Note 1 à l’article: L’énergie RF électromagnétique à la fréquence fondamentale (d’un appareil ISM) peut être utilisée, transmise ou reçue par l’appareil. Cette énergie peut être générée dans l’appareil, mais utilisée en dehors de l’appareil (par exemple, équipement de diagnostic à rayons X), ou générée à l’extérieur et utilisée dans l’appareil ou générée et utilisée à l’intérieur de l’appareil (par exemple, source de puissance à mode de commutation, stérilisateur RF, four à micro-ondes).

Note 2 à l’article: Certaines catégories d’appareils ISM n’ont pas de fréquence ISM fondamentale. Exemples: analyseur de spectre, fréquencemètre.

3.1.15
convertisseur de puissance connecté au réseau
GCPC
convertisseur de puissance connecté à un réseau de distribution électrique en courant alternatif ou autre installation secteur en courant alternatif et utilisé dans un système de production d'énergie

Note 1 à l'article: L’abréviation "GCPC" est dérivée du terme anglais développé correspondant "grid connected power converter".

3.1.16
systèmes et appareils électroniques haute puissance
un ou plusieurs convertisseurs de puissance à semiconducteurs dont la puissance assignée combinée est supérieure à 75 kVa, ou appareil contenant ce type de convertisseurs

Note 1 à l’article: Il s'agit, par exemple, de convertisseurs de puissance à semiconducteurs destinés aux applications dans les alimentations sans interruption (ASI) et les entraînements électriques de puissance (EEP).

3.1.17
fréquence interne la plus élevée
F_x
fréquence fondamentale la plus élevée générée ou utilisée dans l’EUT ou fréquence la plus élevée à laquelle il fonctionne

Note 1 à l’article: Ceci inclut les fréquences qui sont uniquement utilisées dans un circuit intégré.

3.1.18
applications industrielles, scientifiques et médicales
applications ISM
<de l'énergie radioélectrique> fonctionnement d'appareils ou d'installations conçus pour produire et utiliser, dans un espace réduit, de l'énergie radioélectrique pour des applications industrielles, scientifiques, médicales, domestiques ou analogues, à l'exclusion des applications relevant du domaine des télécommunications

Note 1 à l'article: Les effets physiques, biologiques ou chimiques tels que l'échauffement, l'ionisation des gaz, les vibrations mécaniques, l'épilation et l'accélération des particules chargées sont des applications types. Une liste non exhaustive d'exemples est donnée à l'Annexe A.

[SOURCE: Règlement des radiocommunications de l'UIT Volume 1: 2020 – Chapitre I, Définition 1.15, modifié – Ajout de la Note 1.]

3.1.19
appareils et installations ISM à fréquences radioélectriques
appareils ou installations conçus pour produire et/ou utiliser, dans un espace réduit, de l'énergie radioélectrique pour des applications industrielles, scientifiques, médicales, domestiques ou analogues, à l'exclusion des applications relevant du domaine des télécommunications et des techniques de l'information et des autres applications couvertes par d'autres publications du CISPR

Note 1 à l'article: L'abréviation "ISM à fréquences radioélectriques" ou "ISM RF" est utilisée dans l'ensemble du présent document pour ce type d'appareils ou d'installations uniquement.

3.1.20
robot industriel
un ou plusieurs manipulateurs à commande automatique, reprogrammables, multiapplications, pouvant être programmé suivant trois axes ou plus, pouvant être fixes ou fixés sur une plateforme mobile, destinés à être utilisés dans les applications d'automatisation dans un environnement industriel

Note 1 à l'article: Le robot industriel inclut:

- le manipulateur, y compris les actionneurs du robot commandés par la commande du robot;
- la commande du robot;
- les moyens qui permettent de faire apprendre et/ou de programmer le robot, y compris toute interface de communication (matériel et logiciel).

Note 2 à l'article: Les robots industriels comprennent tout axe auxiliaire intégré dans la solution cinématique.

Note 3 à l'article: Les robots industriels comprennent la ou les parties assurant des fonctions de manipulation des robots mobiles, où un robot mobile consiste en une plate-forme mobile avec un manipulateur ou un robot intégré.

[SOURCE: ISO 8373:2021 [2], 3.6]

3.1.21
basse tension
BT
ensemble des niveaux de tension utilisés pour la distribution d'énergie électrique et dont la limite supérieure généralement admise est de 1 000 V en tension alternative ou 1 500 V en tension continue

[SOURCE: IEC 60050-601:1985, 601-01-26, modifié – ajout des mots "ou 1 500 V en tension continue"]

3.1.22
robot médical
robot destiné à être utilisé comme appareil électromédical ou comme système électromédical

[SOURCE: IEC TR 60601-4-1:2017 [3], 3.20]

3.1.23
site d'essai en espace libre
OATS
installation utilisée pour les mesurages des champs électromagnétiques, dont le but est de simuler un environnement semi-libre sur une plage de fréquences spécifiée utilisée pour les essais d'émissions rayonnées des produits

Note 1 à l'article: Un OATS est généralement un site en extérieur non protégé, dont le plan de masse est électriquement conducteur.

Note 2 à l'article: L'abréviation "OATS" est dérivée du terme anglais développé correspondant "open-area test site".

3.1.24
système de production d'énergie photovoltaïque
système de production d'énergie électrique qui utilise l'effet photovoltaïque pour convertir l'énergie solaire en électricité

3.1.25
équipement de conversion de puissance
dispositif électrique convertissant une forme d'énergie électrique en une autre forme d'énergie électrique en ce qui concerne la tension, le courant, la fréquence, la phase et le nombre de phases

[SOURCE: IEC 62920:2017/AMD1:2021 [4], 3.2]

3.1.26
dispositif radioélectrique
assemblage composé d'un émetteur et/ou récepteur radioélectrique ou plus, capable de fonctionner de manière autonome avec ou sans accessoires complémentaires

Note 1 à l'article: Ces accessoires peuvent être incorporés dans l'assemblage ou lui être connecté de l'extérieur. Une antenne externe, une commande à distance, les casques audio, l'alimentation électrique, l'affichage, etc. sont des exemples d'accessoires.

3.1.27
module radioélectrique
assemblage composé d'un émetteur et/ou récepteur radioélectrique ou plus, destiné à être incorporé dans un équipement hôte

Note 1 à l'article: Un module radioélectrique peut comprendre une alimentation électrique ou tout autre accessoire.

Note 2 à l'article: Un module radioélectrique peut être enfiché, intégré ou externe.

3.1.28
émetteur radioélectrique
dispositif produisant de l'énergie radioélectrique destinée à être rayonnée par une antenne, en vue d'assurer une radiocommunication ou une radiodétermination

[SOURCE: IEC 60050-713:1998 [5], 713-08-01 – modifié – "appareil" remplacé par "dispositif", suppression de "en principe", ajout de "ou une radiodétermination".]

3.1.29
charge nominale
<pour les robots> charge maximale qui peut être appliquée à l'interface mécanique ou à la plateforme mobile, pour des conditions normales de fonctionnement, sans dégradation des performances annoncées

Note 1 à l'article: La charge nominale inclut les effets inertiels du terminal, des accessoires et de la pièce, le cas échéant.

[SOURCE: ISO 8373:2021 [2], 7.2.1]

3.1.30
robot
mécanisme programmable actionné avec un degré d'autonomie pour effectuer des opérations de locomotion, de manipulation ou de positionnement

Note 1 à l'article: Un robot inclut le système de commande.

Note 2 à l'article: Exemples de structures mécaniques de robots: manipulateur, plateforme mobile, et robot portable.

[SOURCE: ISO 8373:2021 [2], 3.1]

3.1.31
chambre semi-anéchoïque
SAC
enceinte blindée dans laquelle cinq des six surfaces internes sont revêtues d'un matériau absorbant les fréquences radioélectriques (c'est-à-dire un absorbeur RF) qui atténue l'énergie électromagnétique dans la plage de fréquences concernée et dont la surface horizontale inférieure est un plan de masse de référence conducteur destiné à être utilisé avec les montages d'essai dans les sites d'essai en espace libre (OATS)

Note 1 à l'article: L'abréviation "SAC" est dérivée du terme anglais développé correspondant "semi-anechoic chamber".

Note 2 à l'article: L'abréviation "OATS" est dérivée du terme anglais développé correspondant "open-area test site".

3.1.32
petit matériel en essai
petit EUT
matériel en essai, posé sur table ou posé au sol, qui, câbles compris, est adapté pour l'insertion dans un volume cylindrique d'un diamètre de 1,5 m et d'une hauteur de 1,5 m, mesuré à partir du sol

Note 1 à l'article: Au niveau d'un OATS ou dans une SAC, la distance (3 m) de mesure des émissions rayonnées est applicable uniquement aux petits EUT.

Note 2 à l'article: L'abréviation "EUT" est dérivée du terme anglais développé correspondant "equipment under test".

[SOURCE: CISPR 16-2-3:2016 et CISPR 16-2-3:2016/AMD1:2019, 3.1.35, modifié – La définition a été reformulée et une Note à l'article a été ajoutée]

3.1.33
électroérosion
enlèvement de matière dans un fluide diélectrique de travail par des décharges électriques, réparties dans le temps et distribuées aléatoirement dans l'espace, entre deux électrodes électriquement conductrices (une électrode servant d'outil et l'autre de pièce de travail), avec une maîtrise de l'énergie des décharges

3.1.34
accès de réseau câblé
accès pour le raccordement d'un dispositif/système de communications destiné à être relié à des systèmes largement étendus par connexion directe à un réseau à utilisateur unique ou multiutilisateur

Note 1 à l'article: Des exemples de ces réseaux incluent CATV, RTPC, RNIS, xDSL, LAN et les réseaux similaires.

Note 2 à l'article: Ces accès peuvent prendre en charge des câbles blindés ou non blindés et peuvent également transporter l'alimentation en courant alternatif ou courant continu, ce qui constitue une partie intégrale de la spécification relative aux télécommunications.

Note 3 à l'article: Un accès généralement prévu pour l'interconnexion des composants d'un système en essai (RS-232, RS-485, bus de terrain dans le domaine d'application de l'IEC 61158-1, norme IEEE 1284.1 [6] (imprimante parallèle), bus série universel (USB), norme IEEE 1394 [7] (Fire Wire), par exemple) et utilisé selon ses spécifications fonctionnelles (pour la longueur maximale du câble connecté, par exemple) n'est pas considéré comme un accès de réseau câblé.

Note 4 à l'article: Dans de nombreuses normes de produits, cet accès a été défini comme étant un accès de télécommunication ou de réseau.

Note 5 à l'article: L'abréviation "USB" est dérivée du terme anglais développé correspondant "universal serial bus".

[SOURCE: IEC 61000-6-3:2020 [8], 3.1.3, modifié — Dans la définition, ajout de "dispositif/système". Suppression de la Note 1 à l'article. Ajout des Notes 2, 3 et 4 à l'article.]

3.2 Abréviations

AGV	(Automated guided vehicle) véhicule à guidage automatique
AMN	(Artificial mains network) réseau fictif d'alimentation
AN	(Artificial network) réseau fictif
ASI	Alimentation sans interruption
BT	Basse tension
CATV	(Cable television) télévision par câble
CDN	(Coupling-decoupling network) réseau de couplage/découplage
CM	(Common mode) mode commun
CMAD	(Common mode absorption device) dispositif d'absorption en mode commun
CVCF	(Constant voltage constant frequency) tension constante à fréquence constante
DM	(Differential mode) mode différentiel
DPA	Distribution de probabilité des amplitudes
EDM	(Electro-discharge machining) matériel d'usinage par décharges électriques
EEP	Entraînements électriques de puissance
CEM	Compatibilité électromagnétique
EUT	(Equipment under test) matériel en essai
FAR	(Fully anechoic room) chambre totalement anéchoïque
FSOATS	(Free space open area test site) site d'essai ouvert en espace libre
GCPC	(Grid connected power converter) convertisseur de puissance connecté au réseau
RNIS	Réseau numérique à intégration de services
LAN	(Local area network) réseau local
OATS	(Open area test site) site d'essai en espace libre
PSTN	(Public switched telephone network) réseau téléphonique public commuté
RF	(Radio frequency) fréquence radioélectrique
SAC	(Semi-anechoic chamber) chambre semi-anéchoïque
UM	(Unsymmetrical mode) mode dissymétrique
USB	(Universal serial bus) bus série universel
VCP	(Vertical coupling plane) plan de couplage vertical
xDSL	Toutes les techniques de ligne d'abonné numérique (par exemple, ADSL, SDSL, etc.)

4 Fréquences désignées pour être utilisées par les appareils ISM

L'Union Internationale des Télécommunications (UIT) a désigné certaines fréquences comme étant des fréquences fondamentales pour les applications ISM à fréquences radioélectriques (voir aussi la Définition 3.1.18). Ces fréquences sont énumérées dans le Tableau 1.

NOTE Dans certains pays, des fréquences différentes ou supplémentaires peuvent être désignées pour une utilisation par les applications ISM RF.

Tableau 1 – Fréquences dans la plage de fréquences radioélectriques, désignées par l'UIT comme étant des fréquences fondamentales pour les appareils ISM

Fréquence centrale MHz	**Plage de fréquences** MHz	**Limite de rayonnement maximale** [a]	**Numéro de la note de bas de tableau appropriée du tableau des attributions de fréquences des règlements des radiocommunications de l'UIT**[b]
6,780	6,765 à 6,795	À l'étude	5.138
13,560	13,553 à 13,567	Sans restriction	5.150
27,120	26,957 à 27,283	Sans restriction	5.150
40,680	40,66 à 40,70	Sans restriction	5.150
433,920	433,05 à 434,79	À l'étude	5.138 dans la Région 1, sauf pour les pays mentionnés en 5.280
915,000	902 à 928	Sans restriction	5.150 dans la Région 2 seulement
2 450	2 400 à 2 500	Sans restriction	5.150
5 800	5 725 à 5 875	Sans restriction	5.150
24 125	24 000 à 24 250	Sans restriction	5.150
61 250	61 000 à 61 500	À l'étude	5.138
122 500	122 000 à 123 000	À l'étude	5.138
245 000	244 000 à 246 000	À l'étude	5.138

[a] L'expression "sans restriction" s'applique aux fréquences fondamentales et à toutes les autres composantes de fréquences comprises dans la bande désignée. En dehors des bandes de fréquences ISM désignées par l'UIT, les limites de tensions perturbatrices et de perturbations rayonnées du présent document s'appliquent.

[b] La résolution n° 63 du règlement des radiocommunications de l'UIT s'applique (voir le règlement des radiocommunications (2020), Volume 3).

5 Classification des appareils

5.1 Séparation en groupes

Pour simplifier l'identification des limites applicables, les appareils qui relèvent du domaine d'application du présent document sont classés en deux groupes: le groupe 1 et le groupe 2.

Appareils du groupe 1: le groupe 1 réunit tous les appareils compris dans le domaine d'application du présent document qui ne sont pas classés comme des appareils du groupe 2.

Appareils du groupe 2: le groupe 2 réunit tous les appareils ISM à fréquences radioélectriques dans lesquels de l'énergie radioélectrique dans la plage de fréquences comprises entre 9 kHz et 400 GHz est produite et utilisée volontairement ou uniquement utilisée dans un espace réduit sous forme de rayonnement électromagnétique, de couplage inductif et/ou capacitif, pour le traitement de la matière, à des fins d'examen ou d'analyse ou pour le transfert d'énergie électromagnétique.

NOTE Voir l'Annexe A pour des exemples de séparation des appareils en groupe 1 ou en groupe 2.

5.2 Division en classes

En fonction de l'utilisation prévue de l'appareil dans l'environnement électromagnétique, le présent document définit deux classes d'appareils, à savoir la classe A et la classe B.

Appareils de classe A appareils prévus pour être utilisés dans tous les emplacements autres que ceux attribués dans les environnements résidentiels et ceux directement connectés à un réseau d'alimentation électrique à basse tension qui alimente des bâtiments à usage domestique.

Les appareils de classe A doivent respecter les limites de la classe A.

Un matériel de soudage à l'arc qui contient des dispositifs d'amorçage ou de stabilisation d'arc et des dispositifs d'amorçage ou de stabilisation d'arc autonomes pour le soudage à l'arc doit être considéré comme un appareil de classe A.

Appareils de classe B appareils prévus pour être utilisés dans les emplacements dans les environnements résidentiels et dans les établissements directement connectés à un réseau d'alimentation électrique à basse tension qui alimente des bâtiments à usage domestique.

Les appareils de classe B doivent respecter les limites de la classe B.

5.3 Documentation pour l'utilisateur

Le fabricant et/ou le fournisseur de l'appareil doivent veiller à ce que l'utilisateur soit informé de la classe et du groupe de l'appareil, soit par un étiquetage, soit par la documentation d'accompagnement. Dans les deux cas, le fabricant/le fournisseur doivent expliquer dans la documentation d'accompagnement de l'appareil la signification de la classe et du groupe.

La documentation d'accompagnement de l'appareil doit préciser les précautions que l'acheteur ou l'utilisateur est tenu de prendre pour assurer que le fonctionnement normal et l'utilisation normale de l'appareil sur le terrain ne provoquent pas de brouillage radioélectrique (RFI – *radio frequency interference*) préjudiciable. Dans le cadre du présent document, ces précisions concernent:

- la possibilité de brouillage radioélectrique provenant du fonctionnement d'un appareil de classe A dans certains environnements;
- les précautions particulières à prendre lors du raccordement d'un appareil de classe A à un réseau d'alimentation électrique à basse tension, voir les notes de bas de tableau a et c du Tableau 2, la note de bas de tableau b du Tableau 3 et la note de bas de tableau c du Tableau 8, respectivement;
- les mesures qui peuvent être prises au niveau de l'installation pour réduire les émissions provenant d'un appareil de classe A installé, voir la note de bas de tableau c du Tableau 2 et la note de bas de tableau a du Tableau 12.

Pour les appareils de classe A, les instructions d'utilisation qui accompagnent le produit doivent contenir le texte suivant:

Mise en garde: Cet appareil n'est pas destiné à être utilisé dans des environnements résidentiels et peut ne pas assurer la protection adéquate à la réception radioélectrique dans ce type d'environnements.

6 Limites des perturbations électromagnétiques

6.1 Généralités

Pour les mesurages réalisés sur des sites d'essai normalisés, les exigences spécifiées ici constituent des exigences d'essai.

Les appareils de classe A peuvent être mesurés soit sur un site d'essai, soit *in situ*, selon la préférence du fabricant.

NOTE 1 En fonction de la taille, de la complexité ou des conditions de fonctionnement, certains appareils peuvent être mesurés *in situ* afin de démontrer la conformité aux limites de perturbations rayonnées spécifiées dans le présent document.

Les appareils de classe B doivent être mesurés sur un site d'essai.

NOTE 2 Les limites ont été déterminées sur une base probabiliste, compte tenu de la probabilité de brouillage. En cas de brouillage, des dispositions complémentaires peuvent s'appliquer.

La limite inférieure doit s'appliquer à toutes les fréquences de transition.

Les appareils et les méthodes de mesure sont spécifiés aux Articles 7, 8 et 9.

Lorsque le présent document fournit des options de vérification par essai d'exigences particulières avec un choix de méthodes d'essai, la conformité peut être démontrée, peu importe la méthode d'essai, à l'aide des limites spécifiées et avec les restrictions fournies dans les tableaux correspondants. Lorsqu'il s'avère nécessaire de soumettre l'appareil à un contre-essai, il convient d'utiliser la méthode d'essai initialement choisie, de manière à assurer la cohérence des résultats.

Pour les équipements avec une fonctionnalité radio, les exigences supplémentaires de l'Annexe F doivent s'appliquer.

6.2 Appareils du groupe 1 mesurés sur un site d'essai

6.2.1 Limites des perturbations conduites

6.2.1.1 Généralités

Le matériel en essai doit satisfaire:

a) à la fois à la limite moyenne spécifiée pour les mesurages effectués avec un détecteur de valeur moyenne et à la limite de quasi-crête spécifiée pour les mesurages effectués avec un détecteur de quasi-crête (voir 7.3); ou

b) à la limite moyenne lorsqu'un détecteur de quasi-crête est utilisé (voir 7.3).

Les limites des accès d'alimentation en courant continu à basse tension spécifiées ci-après s'appliquent uniquement aux types d'appareils suivants:

1) les équipements de conversion de puissance destinés à être montés dans les systèmes de production d'énergie photovoltaïque;

2) les convertisseurs de puissance connectés au réseau (GCPC) destinés à être montés dans les systèmes de stockage d'énergie.

6.2.1.2 Plage de fréquences comprises entre 9 kHz et 150 kHz

Dans la plage de fréquences comprises entre 9 kHz et 150 kHz, les limites ne sont pas spécifiées.

6.2.1.3 Plage de fréquences comprises entre 150 kHz et 30 MHz

Les limites pour les tensions perturbatrices aux accès d'alimentation secteur en courant alternatif à basse tension dans la plage de fréquences comprises entre 150 kHz et 30 MHz pour les appareils mesurés sur un site d'essai au moyen du réseau fictif d'alimentation 50 Ω /50 µH (AMN en V) du CISPR ou la sonde de tension du CISPR (voir 7.3.3 et la Figure 1) sont indiquées dans le Tableau 2 et le Tableau 4.

Les limites pour les perturbations conduites aux accès d'alimentation en courant continu à basse tension dans la plage de fréquences comprises entre 150 kHz et 30 MHz pour les appareils mesurés sur un site d'essai au moyen du réseau 150 Ω du CISPR (DC-AN) (voir 7.3.2.3) et/ou la sonde de courant (voir la CISPR 16-1-2) sont indiquées dans le Tableau 3 et le Tableau 5.

Les limites pour les perturbations conduites aux accès de réseaux câblés dans la plage de fréquences comprises entre 150 kHz et 30 MHz pour les appareils mesurés sur un site d'essai sont indiquées dans le Tableau 7.

S'agissant des mesurages réalisés au niveau des accès d'alimentation en courant continu BT, les critères d'applicabilité s'appliquent conformément au Tableau 6.

Tableau 2 – Limites de tensions perturbatrices des appareils de classe A, groupe 1, mesurées sur un site d'essai (accès d'alimentation secteur en courant alternatif)

Plage de fréquences MHz	Puissance assignée de ≤ 20 kVA [a]		Puissance assignée de > 20 kVA et ≤ 75 kVA [b, a]		Systèmes et appareils électroniques haute puissance, puissance assignée de > 75 kVA [c,a]	
	Quasi-crête dB(µV)	Moyenne dB(µV)	Quasi-crête dB(µV)	Moyenne dB(µV)	Quasi-crête dB(µV)	Moyenne dB(µV)
0,15 à 0,50	79	66	100	90	130	120
0,50 à 5	73	60	86	76	125	115
5 à 30	73	60	90 décroissant linéairement avec le logarithme de la fréquence jusqu'à 73	80 60	115	105

À la fréquence de transition, la limite la plus sévère doit s'appliquer.

Pour les appareils de classe A destinés à être connectés uniquement aux réseaux industriels de distribution d'énergie à neutre isolé ou mis à la terre à impédance élevée (voir l'IEC 60364-1 [9]), les limites pour les appareils de puissance assignée > 75 kVA peuvent être appliquées, quelle que soit leur puissance assignée réelle.

NOTE Une puissance d'entrée ou de sortie assignée de 20 kVA correspond, par exemple, à un courant d'environ 29 A par phase dans le cas de réseaux d'alimentation triphasés de 400 V, et à un courant d'environ 58 A par phase dans le cas de réseaux d'alimentation triphasés de 200 V.

[a] Le choix de l'ensemble approprié de limites doit reposer sur la puissance en courant alternatif assignée indiquée par la documentation du produit.

[b] Ces limites s'appliquent aux appareils de puissance assignée > 20 kVA et destinés à être connectés à un transformateur ou un générateur de puissance réservé, et qui ne sont pas reliés aux lignes électriques aériennes à basse tension (BT). Pour les appareils qui ne sont pas destinés à être connectés à un transformateur de puissance spécifique à l'utilisateur, les limites pour une puissance assignée ≤ 20 kVA s'appliquent. Des informations sur les mesures d'installation qui peuvent être utilisées pour réduire les émissions provenant de l'appareil installé doivent être communiquées. En particulier, il doit être indiqué que cet appareil est destiné à être connecté à un transformateur ou générateur de puissance réservé et non à des lignes électriques aériennes à basse tension.

[c] Ces limites s'appliquent uniquement aux systèmes et appareils électroniques haute puissance de puissance assignée supérieure à 75 kVA, s'ils sont destinés à être installés comme suit:

- l'installation est assurée à partir d'un transformateur ou générateur de puissance réservé, et qui n'est pas connecté à des lignes électriques aériennes à basse tension (BT),
- l'installation se situe physiquement à au moins 30 m des environnements résidentiels ou en est séparée par une structure qui fait office de barrière contre les phénomènes de rayonnement,
- la documentation du produit doit indiquer que cet appareil satisfait aux limites de tensions perturbatrices pour les systèmes et appareils électroniques haute puissance de puissance d'entrée assignée > 75 kVA et donner des informations relatives aux mesures d'installation à appliquer par l'installateur. En particulier, il doit être indiqué que cet appareil est destiné à être utilisé dans une installation alimentée par un transformateur ou générateur de puissance réservé et non par des lignes électriques aériennes à basse tension.

Tableau 3 – Limites de perturbations conduites des appareils de classe A, groupe 1, mesurées sur un site d'essai (accès d'alimentation en courant continu)

Plage de fréquences MHz	Puissance assignée de ≤ 20 kVA [a]		Puissance assignée de > 20 kVA à ≤ 75 kVA [a, b, c]				Puissance assignée de > 75 kVA [a, b, c]			
	Limites de tension		Limites de tension		Limites de courant		Limites de tension		Limites de courant	
	Quasi-crête dB(μV)	Moyenne dB(μV)	Quasi-crête dB(μV)	Moyenne dB(μV)	Quasi-crête dB(μA)	Moyenne dB(μA)	Quasi-crête dB(μV)	Moyenne dB(μV)	Quasi-crête dB(μA)	Moyenne dB(μA)
0,15 à 5	97 à 89	84 à 76	116 à 106	106 à 96	72 à 62	62 à 52	132 à 122	122 à 112	88 à 78	78 à 68
5 à 30	89	76	106 à 89	96 à 76	62 à 45	52 à 32	122 à 105	112 à 92	78 à 61	68 à 48

Dans certaines plages de fréquences, les limites indiquées dans ce tableau diminuent de manière linéaire avec le logarithme de la fréquence.

[a] Le choix de l'ensemble approprié de limites doit reposer sur la puissance en courant alternatif assignée indiquée par la documentation du produit.

[b] Ces limites s'appliquent aux appareils de puissance assignée > 20 kVA et destinés à être installés dans un grand système de production d'énergie photovoltaïque par un professionnel. Dans le manuel accompagnant le produit, des informations doivent être communiquées sur les mesures d'atténuation qui peuvent être utilisées pour réduire les émissions générées par les appareils installés, avec pour objectif d'éviter les brouillages préjudiciables pour la réception radioélectrique à une distance de 30 m de l'installation Il doit notamment être indiqué que cet appareil peut être équipé d'un filtrage supplémentaire et que l'installation est physiquement séparée de plus de 30 m des environnements résidentiels. L'installateur est invité à vérifier l'installation atténuée par rapport aux mesurages *in situ* de la CISPR 11 comme cela est indiqué au paragraphe 6.4.

[c] Les limites de tension ou les limites de courant s'appliquent.

Tableau 4 – Limites de tensions perturbatrices des appareils de classe B, groupe 1, mesurées sur un site d'essai (accès d'alimentation secteur en courant alternatif)

Plage de fréquences MHz	Quasi-crête dB(μV)	Moyenne dB(μV)
0,15 à 0,50	66 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 56	56 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 46
0,50 à 5	56	46
5 à 30	60	50

À la fréquence de transition, la limite la plus sévère doit s'appliquer.

Pour les générateurs de rayons X utilisés pour le diagnostic et qui fonctionnent en mode intermittent, les limites de quasi-crête du Tableau 2 ou du Tableau 4 peuvent être relâchées de 20 dB.

Tableau 5 – Limites de tensions perturbatrices des appareils de classe B, groupe 1, mesurées sur un site d'essai (accès d'alimentation en courant continu)

Plage de fréquences MHz	Quasi-crête dB(μV)	Moyenne dB(μV)
0,15 à 0,50	84 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 74	74 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 64
0,50 à 30	74	64

Tableau 6 – Applicabilité des mesurages aux accès d'alimentation en courant continu

Longueur de câble L	Appareils de classe B groupe 1	Appareils de classe A groupe 1
L < 3 m	Aucun mesurage n'est exigé	Aucun mesurage n'est exigé
3 m ≤ L < 30 m	Pour les mesurages, les limites indiquées dans le Tableau 5 s'appliquent La plage de fréquences pour le mesurage débute à une fréquence égale à: f(MHz) = 60/L	Pour les mesurages, les limites indiquées dans le Tableau 3 s'appliquent [a] La plage de fréquences pour le mesurage débute à une fréquence égale à: f(MHz) = 60/L
L ≥ 30 m	Pour les mesurages, les limites indiquées dans le Tableau 5 s'appliquent	Pour les mesurages, les limites indiquées dans le Tableau 3 s'appliquent [a]

L: longueur maximale d'un câble (en mètres) connecté à un accès d'alimentation en courant continu basse tension, et équipé du produit ou selon les spécifications de la documentation du produit. Lorsqu'aucune longueur de câble maximale n'est spécifiée, L doit être considérée comme supérieure à 30 m.

Ce tableau s'applique à moins que des conditions particulières ne soient fournies dans la norme de produit applicable, ce qui donne lieu au minimum au même niveau de protection de la réception radioélectrique. Les normes de produits peuvent définir des conditions particulières selon leur application particulière dans le but d'éviter les rayonnements.

[a] Aucune limite ne s'applique si l'appareil est installé au moyen de bonnes pratiques techniques pour ce qui concerne la CEM.

Les bonnes pratiques techniques sont, à titre d'exemple, les suivantes:

– la configuration des lignes d'accès à courant continu symétriques;
– l'installation interne au bâtiment;
– les chemins de câbles métalliques reliés à la terre;
– l'utilisation de câbles blindés;
– la prévision d'une distance de séparation qui fait office de barrière par rapport à l'environnement résidentiel (par exemple d'une valeur supérieure à 30 m).

Si l'exception [a] est utilisée, l'installateur peut se référer à la CISPR 11 pour les mesurages *in situ*.

Tableau 7 – Limites de perturbations conduites mesurées sur un site d'essai (accès de réseau câblé)

Plage de fréquences MHz	Classe A				Classe B			
	Tension		Courant		Tension		Courant	
	Quasi-crête	Moyenne	Quasi-crête	Moyenne	Quasi-crête	Moyenne	Quasi-crête	Moyenne
	dB(µV)	dB(µV)	dB(µA)	dB(µA)	dB(µV)	dB(µV)	dB(µA)	dB(µA)
0,15 à 0,5	97 à 87	84 à 74	53 à 43	40 à 30	84 à 74	74 à 64	40 à 30	30 à 20
0,5 à 30	87	74	43	30	74	64	30	20

Dans la plage de fréquences comprises entre 0,15 MHz et 0,5 MHz, les limites indiquées dans ce tableau diminuent de manière linéaire avec le logarithme de la fréquence.

À l'exclusion de l'incertitude de mesure, tous les autres éléments de la norme CISPR 32 doivent être appliqués, y compris, entre autres, la sélection des procédures de mesure, la configuration d'essai, les caractéristiques du câble et le matériel d'appoint (sonde de courant, sonde de tension capacitive et/ou réseau fictif).

NOTE 1 Les limites de perturbation de la tension et du courant sont fondées sur une impédance de mode commun de 150 Ω pour l'accès de réseau câblé en essai.

NOTE 2 L'application des limites de perturbation de la tension et/ou du courant dépend du type d'accès et de la procédure de mesure utilisée; voir le Tableau C.1 de la CISPR 32:2015/AMD1:2019.

6.2.2 Limites du rayonnement électromagnétique perturbateur

6.2.2.1 Généralités

Le matériel en essai doit respecter les limites de quasi-crête quand un détecteur de quasi-crête est utilisé.

6.2.2.2 Plage de fréquences comprises entre 9 kHz et 150 kHz

Dans la plage de fréquences comprises entre 9 kHz et 150 kHz, les limites ne sont pas spécifiées.

6.2.2.3 Plage de fréquences comprises entre 150 kHz et 1 GHz

Dans la plage de fréquences comprises entre 150 kHz et 30 MHz, les limites ne sont pas spécifiées.

Dans la plage de fréquences au-dessus de 30 MHz, les limites se réfèrent à la composante électrique du champ électromagnétique rayonné perturbateur.

Les limites du rayonnement électromagnétique perturbateur dans la plage de fréquences de 30 MHz à 1 GHz pour les appareils de classe A et de classe B, groupe 1, sont respectivement spécifiées dans le Tableau 8 et le Tableau 9. Des recommandations en matière de protection des services radio spécifiques liés à la sécurité sont données à l'Annexe C et dans le Tableau C.1.

Sur un site d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC), l'appareil de classe A peut être mesuré à une distance nominale de 3 m, de 10 m ou de 30 m (voir les indications du Tableau 8), et l'appareil de classe B à une distance nominale de 3 m ou de 10 m (voir les indications du Tableau 9). Une distance de mesure inférieure à 10 m est admise uniquement pour les appareils conformes à la définition de "*petit EUT*" (voir 3.1.32).

Dans une chambre totalement anéchoïque (FAR), un appareil de classe A ou de classe B peut être mesuré à une distance nominale de 3 m (voir les indications du Tableau 8 et du Tableau 9), à condition que l'EUT entre dans le volume d'essai validé de la FAR indiquée. Conjointement aux mesurages conformes au présent document, l'utilisation de la FAR est limitée au matériel sur table.

Tableau 8 – Limites du rayonnement électromagnétique perturbateur des appareils de classe A, groupe 1, mesurées sur un site d'essai

Plage de fréquences MHz	OATS ou SAC				FAR	
	Distance de mesure de 10 m puissance assignée de		Distance de mesure de 3 m [a] puissance assignée de		Distance de mesure de 3 m [a, b] puissance assignée de	
	≤ 20 kVA [c]	> 20 kVA [c, d]	≤ 20 kVA [c]	> 20 kVA [c, d]	≤ 20 kVA [c]	> 20 kVA [c, d]
	Quasi-crête dB(µV/m)	Quasi-crête dB(µV/m)	Quasi-crête dB(µV/m)	Quasi-crête dB(µV/m)	Quasi-crête dB(µV/m)	Quasi-crête dB(µV/m)
30 à 230	40	50	50	60	52 décroissant linéairement avec le logarithme de la fréquence jusqu'à 45	62 décroissant linéairement avec le logarithme de la fréquence jusqu'à 55
230 à 1 000	47	50	57	60	52	55

Sur un OATS ou dans une SAC, les appareils de classe A peuvent être mesurés à une distance nominale de 3 m, de 10 m ou de 30 m. Dans le cas de mesurages à une distance de séparation de 30 m, un facteur de proportionnalité inverse de 20 dB par décade doit être utilisé pour normaliser les données mesurées selon la distance spécifiée pour la détermination de la conformité.

À la fréquence de transition, la limite la plus sévère doit s'appliquer.

Dans la plage de fréquences comprises entre 30 MHz et 230 MHz, la limite applicable aux mesurages dans la FAR diminue de manière linéaire avec le logarithme de la fréquence.

[a] La distance de séparation de 3 m s'applique uniquement aux *petits EUT* (voir 3.1.32).

[b] Le matériel sur table doit entrer dans le volume d'essai validé de la FAR.

[c] Le choix de l'ensemble approprié de limites doit reposer sur la puissance en courant alternatif assignée indiquée par la documentation du produit.

[d] Ces limites s'appliquent aux appareils de puissance assignée > 20 kVA et destinés à être utilisés en des emplacements auxquels il existe une distance supérieure à 30 m entre l'appareil et les radiocommunications sensibles tierces. La documentation technique doit indiquer que ces appareils sont destinés à être utilisés en des emplacements auxquels la distance de séparation par rapport aux services radio sensibles tiers est > 30 m. Lorsque ces conditions ne sont pas satisfaites, alors les limites pour des valeurs ≤ 20 kVA s'appliquent.

Tableau 9 – Limites du rayonnement électromagnétique perturbateur des appareils de classe B, groupe 1, mesurées sur un site d'essai

	OATS ou SAC		FAR
Plage de fréquences MHz	**Distance de mesure de 10 m**	**Distance de mesure de 3 m** [a]	**Distance de mesure de 3 m** [a, b]
	Quasi-crête dB(µV/m)	**Quasi-crête** dB(µV/m)	**Quasi-crête** dB(µV/m)
30 à 230	30	40	42 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 35
230 à 1 000	37	47	42

Sur un OATS ou dans une SAC, les appareils de classe B peuvent être mesurés à une distance nominale de 3 m ou de 10 m.

À la fréquence de transition, la limite la plus sévère doit s'appliquer.

[a] La distance de séparation de 3 m s'applique uniquement aux *petits EUT* (voir 3.1.32).

[b] Le matériel sur table doit entrer dans le volume d'essai validé de la FAR.

Pour les appareils électromédicaux destinés à être installés de façon permanente dans des emplacements blindés, des dispositions supplémentaires par rapport au dispositif de mesure et aux conditions de charge sont données dans l'IEC 60601-1-2 [10].

6.2.2.4 Plage de fréquences comprises entre 1 GHz et 18 GHz

Les appareils doivent satisfaire aux limites de rayonnement électromagnétique perturbateur spécifiées dans le Tableau 11 jusqu'à la fréquence de mesure maximale déterminée conformément au Tableau 10. Lorsque la fréquence interne la plus élevée F_x n'est pas connue, les mesurages doivent être réalisés jusqu'à une fréquence de 6 GHz au plus. Les appareils doivent satisfaire à la fois aux limites de crête et aux limites moyennes. Lorsque les mesurages réalisés à l'aide du détecteur de crête dépassent la limite moyenne, il n'est pas nécessaire d'appliquer le détecteur de valeur moyenne.

Dans la plage de fréquences comprises entre 6 GHz et 18 GHz, les limites ne sont pas spécifiées.

Pour les mesurages d'émissions supérieurs à 1 GHz, les limites des détecteurs de crête ne doivent pas être appliquées aux perturbations produites par des arcs ou des étincelles qui sont des évènements de claquage à haute tension. De telles perturbations surviennent lorsque les dispositifs contiennent ou contrôlent des interrupteurs mécaniques qui commandent le courant dans les inducteurs, ou lorsque ces dispositifs contiennent ou contrôlent des sous-systèmes qui créent de l'électricité statique. Seules les limites moyennes doivent s'appliquer aux perturbations dues aux arcs et aux étincelles, tandis que les limites de crête et les limites moyennes doivent s'appliquer à toutes les autres perturbations dues à ces dispositifs.

Les mesurages peuvent être réalisés à des distances de 3 m ou de 10 m compte tenu du critère de taille de l'EUT comme cela est spécifié au paragraphe 3.1.32. Lorsque la distance de 10 m est utilisée, les limites du Tableau 11 doivent être modifiées comme suit:

Limite (10 m) = Limite (3 m) – 20 log (10/3)

où les deux limites sont exprimées en dB(µV/m).

Tableau 10 – Fréquence la plus élevée exigée pour les mesurages rayonnés

Fréquence interne la plus élevée F_x	Fréquence mesurée la plus élevée
$F_x \leq 108$ 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 × F_x jusqu'à une fréquence maximale de 6 GHz
NOTE F_x est définie au paragraphe 3.1.17.	

Tableau 11 – Limites du rayonnement électromagnétique perturbateur des appareils du groupe 1, mesurées sur un site d'essai

Plage de fréquences GHz	Limites pour une distance de mesure de 3 m dB(μV/m)			
	Classe A		Classe B	
	Crête	Moyenne	Crête	Moyenne
1 à 3	76	56	70	50
3 à 6	80	60	74	54
À la fréquence de transition, la limite la plus sévère doit s'appliquer.				

6.2.2.5 Plage de fréquences comprises entre 18 GHz et 400 GHz

Dans la plage de fréquences comprises entre 18 GHz et 400 GHz, les limites ne sont pas spécifiées.

6.3 Appareils du groupe 2 mesurés sur un site d'essai

6.3.1 Limites des perturbations conduites

6.3.1.1 Généralités

Le matériel en essai doit satisfaire:

a) à la fois à la limite moyenne spécifiée pour les mesurages effectués avec un détecteur de valeur moyenne et à la limite de quasi-crête spécifiée pour les mesurages effectués avec un détecteur de quasi-crête (voir 7.3); ou

b) à la limite moyenne lorsqu'un détecteur de quasi-crête est utilisé (voir 7.3).

6.3.1.2 Plage de fréquences comprises entre 9 kHz et 150 kHz

Dans la plage de fréquences comprises entre 9 kHz et 150 kHz, les limites ne sont pas spécifiées.

6.3.1.3 Plage de fréquences comprises entre 150 kHz et 30 MHz

Les limites pour les tensions perturbatrices aux accès d'alimentation secteur en courant alternatif à basse tension dans la plage de fréquences comprises entre 150 kHz et 30 MHz pour les appareils mesurés sur un site d'essai au moyen du réseau fictif d'alimentation 50 Ω/50 μH (AMN en V) du CISPR ou la sonde de tension du CISPR (voir 7.3.3 et la Figure 1) sont indiquées dans le Tableau 12 et le Tableau 13, sauf pour les bandes de fréquences désignées par l'UIT énumérées dans le Tableau 1 pour lesquelles aucune limite ne s'applique.

Pour le matériel de soudage électrique, les limites du Tableau 12 ou du Tableau 13 s'appliquent en mode de fonctionnement actif. En mode veille (ou au repos), les limites du Tableau 2 ou du Tableau 4 s'appliquent.

Pour les dispositifs d'éclairage ISM à fréquences radioélectriques qui fonctionnent dans les bandes de fréquences ISM réservées (définies par l'UIT dans le Tableau 1), les limites du Tableau 13 s'appliquent.

Les limites pour les perturbations conduites aux accès de réseaux câblés dans la plage de fréquences comprises entre 150 kHz et 30 MHz pour les appareils mesurés sur un site d'essai sont indiquées dans le Tableau 7.

Tableau 12 – Limites de tensions perturbatrices des appareils de classe A, groupe 2, mesurées sur un site d'essai (accès d'alimentation secteur en courant alternatif)

<table>
<tr><th rowspan="2">Plage de fréquences
MHz</th><th colspan="2">Puissance assignée ≤ 75 kVA [a, b]</th><th colspan="2">Puissance assignée
> 75 kVA [a, c]</th></tr>
<tr><th>Quasi-crête
dB(µV)</th><th>Moyenne
dB(µV)</th><th>Quasi-crête
dB(µV)</th><th>Moyenne
dB(µV)</th></tr>
<tr><td>0,15 à 0,50</td><td>100</td><td>90</td><td>130</td><td>120</td></tr>
<tr><td>0,50 à 5</td><td>86</td><td>76</td><td>125</td><td>115</td></tr>
<tr><td rowspan="3">5 à 30</td><td>90</td><td>80</td><td rowspan="3">115</td><td rowspan="3">105</td></tr>
<tr><td colspan="2">décroissant linéairement avec le logarithme de la fréquence jusqu'à</td></tr>
<tr><td>73</td><td>60</td></tr>
<tr><td colspan="5">À la fréquence de transition, la limite la plus sévère doit s'appliquer.</td></tr>
<tr><td colspan="5">c Le choix de l'ensemble approprié de limites doit reposer sur la puissance en courant alternatif assignée indiquée dans la documentation du produit.
b Pour les appareils de classe A de puissance assignée ≤ 75 kVA destinés à être connectés uniquement aux réseaux industriels de distribution d'énergie à neutre isolé ou mis à la terre à impédance élevée (voir l'IEC 60364-1 [9]), les limites définies pour les appareils du groupe 2 de puissance assignée > 75 kVA peuvent être appliquées.
c Des informations sur les mesures d'installation qui peuvent être utilisées pour réduire les émissions provenant de l'appareil installé doivent être communiquées.</td></tr>
</table>

NOTE Une puissance d'entrée ou de sortie assignée de 75 kVA correspond, par exemple, à un courant d'environ 108 A par phase dans le cas de réseaux d'alimentation triphasés de 400 V, et à un courant d'environ 216 A par phase dans le cas de réseaux d'alimentation triphasés de 200 V.

Les appareils d'électrochirurgie à courant haute fréquence (HF) doivent satisfaire aux limites du Tableau 2 ou du Tableau 4 spécifiées pour les appareils du groupe 1 en mode veille. Pour les appareils d'électrochirurgie à courant haute fréquence (HF), qui fonctionnent à des fréquences extérieures aux bandes ISM désignées (voir le Tableau 1), ces limites s'appliquent également à la fréquence de fonctionnement et à l'intérieur des bandes de fréquences désignées. Les mesurages associés doivent être réalisés selon une configuration d'essai conformément à l'IEC 60601-2-2.

Tableau 13 – Limites de tensions perturbatrices des appareils de classe B, groupe 2, mesurées sur un site d'essai (accès d'alimentation secteur en courant alternatif)

Plage de fréquences MHz	**Quasi-crête** dB(µV)	**Moyenne** dB(µV)
0,15 à 0,50	66 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 56	56 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 46
0,50 à 5	56	46
5 à 30	60	50
À la fréquence de transition, la limite la plus sévère doit s'appliquer.		

6.3.2 Limites du rayonnement électromagnétique perturbateur

6.3.2.1 Généralités

Le matériel en essai doit satisfaire aux limites lors de l'utilisation d'un appareil de mesure à détecteur de crête, de quasi-crête ou à détecteur de valeur moyenne, comme cela est indiqué dans le tableau approprié.

Jusqu'à 30 MHz, les limites se réfèrent à la composante magnétique du rayonnement électromagnétique perturbateur. Au-dessus de 30 MHz, les limites se réfèrent à la composante électrique du champ électromagnétique rayonné perturbateur.

6.3.2.2 Plage de fréquences comprises entre 9 kHz et 150 kHz

Dans la plage de fréquences comprises entre 9 kHz et 150 kHz, les limites ne sont pas spécifiées.

6.3.2.3 Plage de fréquences comprises entre 150 kHz et 1 GHz

Sauf pour la plage de fréquences désignée présentée dans le Tableau 1, les limites du rayonnement électromagnétique perturbateur dans la plage de fréquences de 150 kHz à 1 GHz pour les appareils de classe A, groupe 2, sont spécifiées dans le Tableau 14, et pour les appareils de classe B, groupe 2, dans le Tableau 16.

Les limites indiquées dans le Tableau 14 et dans le Tableau 16 s'appliquent à toutes les perturbations électromagnétiques de toutes les fréquences non exemptées, selon la note de bas de tableau a du Tableau 1.

Pour les appareils de classe A de soudage par résistance, les limites du Tableau 14 s'appliquent dans la plage de fréquences comprises entre 30 MHz et 1 GHz en mode de fonctionnement actif. En mode veille (ou au repos), les limites du Tableau 8 s'appliquent. Pour les appareils de classe B de soudage par résistance, les limites du Tableau 16 s'appliquent en mode de fonctionnement actif. En mode veille (ou au repos), les limites du Tableau 9 s'appliquent.

Pour le matériel de soudage à l'arc de classe A, les limites du Tableau 15 s'appliquent en mode de fonctionnement actif. En mode veille (ou au repos), les limites du Tableau 8 s'appliquent. Pour le matériel de soudage à l'arc de classe B, les limites du Tableau 9 s'appliquent en mode de fonctionnement actif et en mode veille (ou au repos).

Pour le matériel d'usinage par décharges électriques de classe A, les limites du Tableau 15 s'appliquent.

Pour les dispositifs d'éclairage ISM à fréquences radioélectriques qui fonctionnent dans les bandes de fréquences ISM réservées (définies par l'UIT dans le Tableau 1), les limites du Tableau 16 s'appliquent.

Pour les appareils d'électrochirurgie à courant haute fréquence (HF), les limites du Tableau 8 ou du Tableau 9 s'appliquent. Les appareils d'électrochirurgie à courant haute fréquence (HF) doivent satisfaire aux limites correspondantes lorsqu'ils sont soumis à l'essai en mode veille.

Des recommandations en matière de protection des services liés à la sécurité sont données à l'Annexe C et dans le Tableau C.1.

Sur un site d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC), l'appareil de classe A peut être mesuré à une distance nominale de 3 m, de 10 m ou de 30 m et l'appareil de classe B à une distance nominale de 3 m ou de 10 m (voir le Tableau 14 et le Tableau 16).

Dans la plage de fréquences comprises entre 30 MHz et 1 GHz, une distance de mesure de 3 m est admise uniquement pour les appareils conformes à la Définition 3.1.32.

Dans une chambre totalement anéchoïque (FAR), un appareil de classe A ou de classe B peut être mesuré à une distance nominale de 3 m, à condition que l'EUT entre dans le volume d'essai validé de la FAR indiquée. Conjointement aux mesurages conformes au présent document, l'utilisation de la FAR est limitée au matériel sur table.

Pour un appareil du groupe 2, classe A ou classe B, autre qu'un matériel d'usinage par décharges électriques (EDM) ou de soudage à l'arc, les mesurages réalisés dans la FAR dans la plage de 30 MHz à 1 GHz doivent être complétés par le mesurage de la composante magnétique de l'intensité du champ perturbateur dans la plage de 150 kHz à 30 MHz, sur un OATS ou dans une SAC. Voir également la note de bas de tableau b dans le Tableau 14 et la note de bas de tableau c dans le Tableau 16.

Tableau 14 – Limites du rayonnement électromagnétique perturbateur des appareils de classe A, groupe 2, mesurées sur un site d'essai

Plage de fréquences MHz	OATS ou SAC						FAR
	Limites pour une distance de mesure *D* en m						
	D = 30 m		*D* = 10 m		*D* = 3 m [a]		*D* = 3 m [a, b]
	Champ électrique Quasi-crête dB(µV/m)	Champ magnétique Quasi-crête dB(µA/m)	Champ électrique Quasi-crête dB(µV/m)	Champ magnétique Quasi-crête dB(µA/m)	Champ électrique Quasi-crête dB(µV/m)	Champ magnétique Quasi-crête dB(µA/m)	Champ électrique Quasi-crête dB(µV/m)
0,15 à 0,49	–	33,5	–	57,5	–	82	–
0,49 à 1,705	–	23,5	–	47,5	–	72	–
1,705 à 2,194	–	28,5	–	52,5	–	77	–
2,194 à 3,95	–	23,5	–	43,5	–	68	–
3,95 à 11	–	8,5	–	18,5	–	68 à 28,5	–
11 à 20	–	8,5	–	18,5	–	28,5	–
20 à 30	–	-1,5	–	8,5	–	18,5	–
30 à 47	58	–	68	–	78	–	80 à 78
47 à 54,56	40	–	50	–	60	–	60
54,56 à 68	40	–	50	–	60	–	60 à 59
68 à 80,872	53	–	63	–	73	–	72
80,872 à 81,848	68	–	78	–	88	–	87
81,848 à 87	53	–	63	–	73	–	72 à 71
87 à 134,786	50	–	60	–	70	–	68 à 67
134,786 à 136,414	60	–	70	–	80	–	77
136,414 à 156	50	–	60	–	70	–	67 à 66
156 à 174	64	–	74	–	84	–	80
174 à 188,7	40	–	50	–	60	–	56
188,7 à 190,979	50	–	60	–	70	–	66
190,979 à 230	40	–	50	–	60	–	56 à 55
230 à 400	50	–	60	–	70	–	65
400 à 470	53	–	63	–	73	–	68
470 à 1 000	50	–	60	–	70	–	65

Sur un OATS ou dans une SAC, les appareils de classe A peuvent être mesurés à une distance nominale de 3 m, de 10 m ou de 30 m. Une distance de mesure inférieure à 10 m est admise uniquement pour les appareils conformes à la Définition 3.1.32.

À la fréquence de transition, la limite la plus sévère doit s'appliquer. Dans certaines plages de fréquences, la limite applicable au champ magnétique et aux mesurages dans la FAR diminue de manière linéaire avec le logarithme de la fréquence.

[a] Dans la plage de fréquences comprises entre 30 MHz et 1 GHz, la distance de mesure de 3 m s'applique uniquement aux *petits EUT* (voir 3.1.32).

[b] Le matériel sur table doit entrer dans le volume d'essai validé de la FAR. Dans la plage inférieure à 30 MHz, ce type d'appareil du groupe 2 doit être mesuré sur un OATS ou dans une SAC (voir les limites dans la colonne "champ magnétique" correspondante du présent tableau).

Tableau 15 – Limites du rayonnement électromagnétique perturbateur pour le matériel d'usinage par décharges électriques et le matériel de soudage à l'arc de classe A, mesurées sur un site d'essai

	OATS ou SAC		FAR
Plage de fréquences MHz	**Distance de mesure de 10 m**	**Distance de mesure de 3 m** [a]	**Distance de mesure de 3 m** [a, b]
	Quasi-crête dB(μV/m)	**Quasi-crête** dB(μV/m)	**Quasi-crête** dB(μV/m)
30 à 230	80 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 60	90 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 70	102 Décroissant linéairement avec le logarithme de la fréquence jusqu'à 75
230 à 1 000	60	70	75

Sur un OATS ou dans une SAC, les appareils de classe A peuvent être mesurés à une distance nominale de 3 m, de 10 m ou de 30 m. Dans le cas de mesurages à une distance de séparation de 30 m, un facteur de proportionnalité inverse de 20 dB par décade doit être utilisé pour normaliser les données mesurées selon la distance spécifiée pour la détermination de la conformité.

[a] La distance de séparation de 3 m s'applique uniquement aux *petits EUT* (voir 3.1.32).

[b] Le matériel sur table doit entrer dans le volume d'essai validé de la FAR.

Tableau 16 – Limites du rayonnement électromagnétique perturbateur des appareils de classe B, groupe 2, mesurées sur un site d'essai

Plage de fréquences MHz	OATS ou SAC					FAR	
	Limites pour une distance de mesure D en m						
	D = 10 m		D = 3 m [a]		D = 3 m	D = 3 m [b]	
	Champ électrique				Champ magnétique	Champ électrique	
	Quasi-crête	Moyenne [c]	Quasi-crête	Moyenne [c]	Quasi-crête	Quasi-crête	Moyenne [c]
	dB(μV/m)		dB(μV/m)		dB(μA/m)	dB(μV/m)	
0,15 à 30	–	–	–	–	39 à 3		
30 à 80,872	30	25	40	35	–	42 à 39	37 à 34
80,872 à 81,848	50	45	60	55	–	59	54
81,848 à 134,786	30	25	40	35	–	39 à 37	34 à 32
134,786 à 136,414	50	45	60	55	–	57	52
136,414 à 230	30	25	40	35	–	37 à 35	32 à 30
230 à 1 000	37	32	47	42	–	42	37

Sur un OATS ou dans une SAC, les appareils de classe B peuvent être mesurés à une distance nominale de 3 m ou de 10 m.

À la fréquence de transition, la limite la plus sévère doit s'appliquer. Dans certaines plages de fréquences, la limite applicable au champ magnétique et aux mesurages dans la FAR diminue de manière linéaire avec le logarithme de la fréquence.

[a]	Dans la plage de fréquences comprises entre 30 MHz et 1 GHz, la distance de séparation de 3 m s'applique uniquement aux *petits EUT* (voir 3.1.32).
[b]	Le matériel sur table doit entrer dans le volume d'essai validé de la FAR. Dans la plage inférieure à 30 MHz, ce type d'appareil du groupe 2 doit être mesuré sur un OATS ou dans une SAC (voir les limites dans la colonne "champ magnétique" correspondante du présent tableau).
[c]	Les limites moyennes s'appliquent uniquement aux appareils à commande par magnétron et aux fours à micro-ondes. Lorsque les appareils à commande par magnétron ou les fours à micro-ondes dépassent la limite en quasi-crête à certaines fréquences, le mesurage doit alors être répété à ces fréquences avec le détecteur de valeur moyenne, et les limites moyennes spécifiées dans ce tableau s'appliquent.

6.3.2.4 Plage de fréquences comprises entre 1 GHz et 18 GHz

Les limites dans la plage de fréquences de 1 GHz à 18 GHz s'appliquent uniquement aux appareils du groupe 2 qui fonctionnent à des fréquences supérieures à 400 MHz. Les limites spécifiées du Tableau 17 au Tableau 19 s'appliquent uniquement aux perturbations radioélectriques qui apparaissent à l'extérieur des bandes ISM désignées, telles qu'énumérées dans le Tableau 1.

Les limites du rayonnement électromagnétique perturbateur dans la plage de fréquences de 1 GHz à 18 GHz sont spécifiées du Tableau 17 au Tableau 19. Les appareils doivent satisfaire soit aux limites du Tableau 17, soit au minimum aux limites du Tableau 18 ou du Tableau 19 (voir l'arbre de décision au paragraphe 9.4.1, Figure 17).

Les dispositifs d'éclairage ISM à fréquences radioélectriques qui fonctionnent dans les bandes de fréquences ISM réservées (définies par l'UIT dans le Tableau 1) doivent satisfaire soit aux limites de classe B du Tableau 17, soit au minimum aux limites du Tableau 18.

Pour les générateurs de rayonnement UV alimentés en micro-ondes, les limites spécifiées dans le Tableau 17 s'appliquent.

Des recommandations en matière de protection des services liés à la sécurité sont données à l'Annexe C et dans le Tableau C.1.

Tableau 17 – Limites en valeur crête du rayonnement électromagnétique perturbateur des appareils du groupe 2 fonctionnant à des fréquences supérieures à 400 MHz

Plage de fréquences GHz	Limites pour une distance de mesure de 3 m Crête dB(µV/m)	
1 à 18	**Classe A**	**Classe B**
Dans les bandes de fréquences harmoniques	82 [a]	70
À l'extérieur des bandes de fréquences harmoniques	70	70
Mesurages de crête avec une largeur de bande de résolution de 1 MHz et une largeur de bande du signal vidéo (VBW – *video signal bandwidth*) supérieure ou égale à 1 MHz. La largeur de bande du signal vidéo recommandée est de 3 MHz. NOTE Dans ce tableau, le terme "bandes de fréquences harmoniques" désigne les bandes de fréquences qui sont des multiples des bandes de fréquences ISM attribuées au-delà de 1 GHz.		
[a] Aux fréquences limites inférieure et supérieure des bandes de fréquences harmoniques, la limite la plus sévère de 70 dB(µV/m) s'applique.		

Tableau 18 – Limites pondérées du rayonnement électromagnétique perturbateur des appareils du groupe 2 fonctionnant à des fréquences supérieures à 400 MHz

Plage de fréquences GHz	**Limites pondérées pour une distance de mesure de 3 m** dB(µV/m)
1 à 2,4	60
2,5 à 5,725	60
5,875 à 18	60

Les mesurages pondérés doivent être effectués avec une largeur de bande de résolution de 1 MHz et une largeur de bande vidéo égale à 10 Hz.

Pour vérifier la conformité aux limites de ce tableau, les mesurages pondérés doivent être effectués dans toutes les plages de fréquences suivantes, dans lesquelles la limite du Tableau 17 a été dépassée pendant le mesurage de crête:

a) 1,0 GHz à 2,4 GHz [a];

b) 2,5 GHz à 6,125 GHz (à l'extérieur de la bande de 5,72 GHz à 5,88 GHz) [a];

c) 6,125 GHz à 8,575 GHz;

d) 8,575 GHz à 11,025 GHz;

e) 11,025 GHz à 13,475 GHz [b];

f) 13,475 GHz à 15,925 GHz;

g) 15,925 GHz à 18,0 GHz [a].

Dans les sous-plages dans lesquelles la limite du Tableau 17 a été dépassée, un mesurage pondéré doit être effectué avec une largeur de bande de 20 MHz autour de la fréquence centrale réglée en fonction de la fréquence du niveau de perturbation le plus élevé dans la sous-plage correspondante.

[a] Lorsque la fréquence de l'émission la plus élevée pendant le mesurage de crête se rapproche de 10 MHz des limites de fréquence 1 GHz, 2,4 GHz, 2,5 GHz, 5,72 GHz, 5,88 GHz ou 18 GHz, la largeur de bande pour les mesurages pondérés doit rester de 20 MHz, mais dans ce cas, la fréquence centrale doit être réglée de manière à ne pas dépasser les limites de fréquence.

[b] Dans tous les cas, un mesurage final pondéré doit être effectué à la fréquence de l'émission la plus élevée, qui dépasse la limite du Tableau 17 dans la plage de fréquences comprises entre 11,7 GHz et 12,7 GHz pour une liaison descendante satellite. Lorsque le niveau de perturbation le plus élevé dans cette sous-plage se situe hors de la plage pour une liaison descendante satellite, deux mesurages finaux doivent être effectués dans cette sous-plage.

Tableau 19 – Niveau de DPA du rayonnement électromagnétique perturbateur correspondant aux limites 10^{-1} pour les appareils de classe B, groupe 2, fonctionnant à des fréquences supérieures à 400 MHz

Plage de fréquences GHz	Limites pour une distance de mesure de 3 m Niveau de DPA correspondant à 10^{-1} dB(μV/m)
1 à 2,4	70
2,5 à 5,725	70
5,875 à 18	70

Pour vérifier la conformité aux limites de ce tableau, les mesurages de la DPA doivent être effectués dans toutes les plages de fréquences suivantes, dans lesquelles la limite du Tableau 17 a été dépassée pendant le mesurage de crête:

a) 1,0 GHz à 2,4 GHz [a];

b) 2,5 GHz à 6,125 GHz (à l'extérieur de la bande de 5,72 GHz à 5,88 GHz) [a];

c) 6,125 GHz à 8,575 GHz;

d) 8,575 GHz à 11,025 GHz;

e) 11,025 GHz à 13,475 GHz [b];

f) 13,475 GHz à 15,925 GHz;

g) 15,925 GHz à 18,0 GHz [a].

Les mesurages finaux de la DPA doivent être effectués à 5 fréquences, comme cela est expliqué au paragraphe 9.4.4.3.

[a] Lorsque la fréquence de l'émission la plus élevée pendant le mesurage de crête se rapproche de 10 MHz des limites de fréquence 1 GHz, 2,4 GHz, 2,5 GHz, 5,72 GHz, 5,88 GHz ou 18 GHz, les mesurages finaux de la DPA doivent être omis aux fréquences qui se situent à l'extérieur des bandes énumérées ici.

[b] Dans tous les cas, les mesurages finaux de la DPA doivent être effectués autour de la fréquence de l'émission la plus élevée, qui dépasse la limite du Tableau 17 dans la plage de fréquences comprises entre 11,7 GHz et 12,7 GHz pour une liaison descendante satellite. Lorsque le niveau de perturbation le plus élevé dans cette sous-plage se situe hors de la plage pour une liaison descendante satellite, deux mesurages finaux doivent être effectués dans cette sous-plage.

NOTE Un niveau de DPA correspondant à 10^{-1} signifie que l'amplitude de la perturbation dépasse le niveau spécifié pendant la période d'observation avec une probabilité de 10 %.

6.4 Appareils de classe A, groupe 1 et groupe 2, mesurés *in situ*

6.4.1 Limites des perturbations conduites

Dans des conditions *in situ*, une évaluation des perturbations conduites n'est pas exigée.

6.4.2 Limites du rayonnement électromagnétique perturbateur

Les limites données dans le Tableau 20 s'appliquent aux appareils de classe A, groupe 1 et les limites données dans le Tableau 21 s'appliquent aux appareils de classe A, groupe 2.

Tableau 20 – Limites du rayonnement électromagnétique perturbateur des appareils de classe A, groupe 1, mesurées *in situ*

Plage de fréquences MHz	Limites avec une distance de mesure de 30 m à partir de la face extérieure du mur extérieur du bâtiment dans lequel se trouve l'appareil	
	Champ électrique **Quasi-crête** dB(µV/m)	**Champ magnétique** **Quasi-crête** [a] dB(µA/m)
0,15 à 0,49	–	13,5
0,49 à 3,95	–	3,5
3,95 à 20	–	–11,5
20 à 30	–	–21,5
30 à 230	30	–
230 à 1 000	37	–

À la fréquence de transition, la limite la plus sévère doit s'appliquer.

Lorsque les conditions locales ne permettent pas des mesurages à 30 m, alors une distance plus importante peut être utilisée. Dans ce cas, un facteur de proportionnalité inverse de 20 dB par décade doit être utilisé pour normaliser les données mesurées à la distance spécifiée afin de déterminer la conformité.

[a] Ces limites s'appliquent en plus des limites dans la plage de fréquences comprises entre 30 MHz et 1 GHz aux perturbations rayonnées provenant de la fréquence de fonctionnement et de ses harmoniques, qui apparaissent dans la plage de fréquences comprises entre 150 kHz et 30 MHz, provoquées par les appareils de classe A, groupe 1, installés avec une puissance assignée qui dépasse 20 kVA. Lorsque le niveau de bruit ambiant dépasse les limites ci-dessus, les émissions de l'EUT ne doivent pas augmenter ce seuil de bruit de plus de 3 dB.