IEC 61000-4-20

Edition 3.0 2022-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides

Compatibilité électromagnétique (CEM) – Partie 4-20: Techniques d'essai et de mesure – Essais d'émission et d'immunité dans les guides d'onde TEM

IEC 61000-4-20:2022-02(en-fr)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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 It also gives information on projects, replaced and withdrawn publications.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 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

IEC 61000-4-20

Edition 3.0 2022-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides

Compatibilité électromagnétique (CEM) –
Partie 4-20: Techniques d'essai et de mesure – Essais d'émission et d'immunité dans les guides d'onde TEM

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 33.100.10; 33.100.20

ISBN 978-2-8322-1083-0

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides

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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61000-4-20 has been prepared by subcommittee 77B: High frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility, in cooperation with CISPR (International Special Committee on Radio Interference) subcommittee A: Radio-interference measurements and statistical methods.

It forms Part 4-20 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

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

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

a) provide information on the testing of large EUTs (including cables);

b) apply the work on measurement uncertainties by adapting the work completed in CISPR and TC 77 (for emissions and immunity);

c) update the validation procedure for the test volume regarding field uniformity and TEM mode verification;

d) provide information concerning two-port and four-port TEM waveguides;

e) add a new informative annex (Annex I) dealing with transient TEM waveguide characterization; and

f) add information dealing with dielectric test stands for EUTs.

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

Draft	Report on voting
77B/853/FDIS	77B/855/RVD

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

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

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

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

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

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

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

INTRODUCTION

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

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

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

This part is an International Standard which gives emission, immunity and HEMP and IEMI transient testing requirements.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides

1 Scope

This part of IEC 61000 focuses on emission and immunity test methods for electrical and electronic equipment using various types of transverse electromagnetic (TEM) waveguides. These types include open structures (for example striplines and electromagnetic pulse simulators) and closed structures (for example TEM cells). These structures can be further classified as one-port, two-port, or multi-port TEM waveguides. The frequency range depends on the specific testing requirements and the specific TEM waveguide type.

The object of this document is to describe

– TEM waveguide characteristics, including typical frequency ranges and equipment-under-test (EUT) size limitations;

– TEM waveguide validation methods for electromagnetic compatibility (EMC) tests;

– the EUT (i.e. EUT cabinet and cabling) definition;

– test set-ups, procedures, and requirements for radiated emission measurements in TEM waveguides; and

– test set-ups, procedures, and requirements for radiated immunity testing in TEM waveguides.

NOTE Test methods are defined in this document to measure the effects of electromagnetic radiation on equipment and the electromagnetic emissions from the equipment concerned. The simulation and measurement of electromagnetic radiation is not adequately exact for the quantitative determination of effects for all end-use installations. The test methods defined are structured for a primary objective of establishing adequate reproducibility of results at various test facilities for qualitative analysis of effects.

This document does not intend to specify the tests to be applied to any particular apparatus or system(s). The main intention of this document is to provide a general basic reference for all interested product committees of the IEC. For radiated emission measurements, product committees select emission limits and measurement methods in consultation with CISPR standards. For radiated immunity testing, product committees remain responsible for the appropriate choice of immunity tests and immunity test limits to be applied to equipment within their scope. This document describes test methods that are separate from those of IEC 61000-4-3 [34].[1]

---

[1] Numbers in square brackets refer to the Bibliography.

These other distinct test methods may be used when so specified by product committees, in consultation with CISPR and TC 77.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

CISPR 16-1-4, *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*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

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

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

3.1.1
anechoic material
material that exhibits the property of absorbing, or otherwise reducing, the level of electromagnetic energy reflected from that material

3.1.2
broadband transmission-line termination
termination which combines a low-frequency discrete-component load, to match the characteristic impedance of the TEM waveguides (typically 50 Ω), and a volume of high-frequency anechoic material

3.1.3
characteristic impedance
for any constant phase wave-front, magnitude of the ratio of the voltage between the inner conductor and the outer conductor to the current on either conductor and which is independent of the voltage/current magnitudes and depends only on the cross-sectional geometry of the transmission line

Note 1 to entry: TEM waveguides are typically designed to have a characteristic impedance of 50 Ω. TEM waveguides with a characteristic impedance of 100 Ω are often used for transient testing.

3.1.4
correlation algorithm
mathematical routine for converting TEM waveguide voltage measurements to open-area test sites (OATS), semi-anechoic chamber (SAC), or free space field strength levels

3.1.5
EUT type
grouping of products with sufficient similarity in electromagnetic characteristics to allow testing with the same test installation and the same test protocol

3.1.6
exit cable
cable that connects the EUT to equipment external to the TEM waveguide or cable exiting the usable test volume

Note 1 to entry: The usable test volume is specified in 5.2.1.

3.1.7
forward power
P_{fwd}
power that is applied to the port of the waveguide

3.1.8
forward power for immunity testing
P_{test}
forward power required to establish the test field strength E_{test} during immunity testing

Note 1 to entry: See Equation (16) and Equation (17) for the constant forward power (5.2.2.4.1) and constant field strength (5.2.2.4.2) methods, respectively.

3.1.9
four-port TEM waveguide
TEM waveguide with two input/output ports at each end

3.1.10
hyper-rotated TEM waveguide
TEM waveguide that has been reoriented such that its ortho-axis is normal to the surface of the Earth

Note 1 to entry: Additional details are given in [6].

3.1.11
inner conductor
septum
inner conductor of a coaxial transmission-line system, often flat in the case of a rectangular cross-section, and which can be positioned symmetrically or asymmetrically with respect to the outer conductor

3.1.12
interconnecting cable
cable that connects subcomponents of the EUT within the test volume but does not exit the test volume

3.1.13
manipulator
any type of manual or automatic non-metallic test set-up support similar to a turntable, and capable of supporting an affixed EUT throughout numerous positions as required by a correlation algorithm or test protocol

Note 1 to entry: An example of a manipulator design is shown in Figure A.2 in Clause A.7.

3.1.14
one-port TEM waveguide
TEM waveguide with a single input/output port

Note 1 to entry: Such TEM waveguides typically feature a broadband transmission-line termination at the non-port end.

3.1.15
ortho-angle
angle that the diagonal of a cube makes to each side face at the trihedral corners of the cube

Note 1 to entry: Assuming that the cube is aligned with the TEM waveguide cartesian coordinate system, the azimuth and elevation angles of the projection of the cube diagonal are 45°, and the angles to the face edges are 54,7°.

Note 2 to entry: Figure A.2 a) in Clause A.7 shows a diagram of the ortho-angle.

Note 3 to entry: When associated with the EUT, this angle is usually referred to as the ortho-axis.

3.1.16
outer conductor
outer conductor of a coaxial transmission line system, often having a rectangular cross-section

3.1.17
primary field component
primary component
electric field component aligned with the intended test polarization

Note 1 to entry: In conventional two-port TEM cells, the septum is parallel to the horizontal floor, and the primary mode electric field vector is vertical at the transverse centre of the TEM cell.

3.1.18
resultant field
amplitude
root-sum-squared values in V/m of the primary and the two secondary electric field components

3.1.19
secondary field component
secondary component
in a cartesian coordinate system, either of the two electric field components orthogonal to the primary field component and orthogonal to each other

3.1.20
stripline
terminated transmission line consisting of two or more parallel plates between which a wave is propagated in the transverse electromagnetic mode to produce a specific field for testing purposes

Note 1 to entry: Striplines usually have open sides for EUT access and monitoring.

3.1.21
TEM cell
closed TEM waveguide, often a rectangular coaxial transmission line, in which a wave is propagated in the transverse electromagnetic mode to produce a specific field for testing purposes and with an outer conductor completely enclosing an inner conductor

3.1.22
TEM waveguide
open or closed transmission line system, in which a wave is propagated in the transverse electromagnetic mode to produce a specific field for testing purposes