

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



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**

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iTeh STANDARD

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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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
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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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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## INTRODUCTION

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

### **Part 1: General**

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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

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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.

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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].<sup>1</sup>

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<sup>1</sup> 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 60050-161 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>  
<https://standards.iteh.ai/catalog/standards/sist/d89f9e97-d29f-47ab-a924-012c16863bd3/iec-61000-4-20-2022>

#### 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  $\Omega$ ), 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  $\Omega$ . TEM waveguides with a characteristic impedance of 100  $\Omega$  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** $P_{\text{fwd}}$ 

power that is applied to the port of the waveguide

**3.1.8****forward power for immunity testing** $P_{\text{test}}$ 

forward power required to establish the test field strength  $E_{\text{test}}$  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