

INTERNATIONAL STANDARD

**Transformers, power supplies, reactors and similar products – EMC
requirements**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**TRANSFORMERS, POWER SUPPLIES, REACTORS
AND SIMILAR PRODUCTS –****EMC requirements**

FOREWORD

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International standard IEC 62041 has been prepared by Technical Committee 96: Transformers, reactors, power supply units and combinations thereof.

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

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

- the inclusion of a clause on tests in series production;
- the inclusion of a new clause on measurement uncertainty, and
- the status of a harmonized standard for this third edition.

It has the status of a product family EMC standard in accordance with IEC Guide 107:2009,

Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications.

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

| | |
|-------------|------------------|
| FDIS | Report on voting |
| 96/465/FDIS | 96/467/RVD |

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

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

This standard is to be used in conjunction with the IEC 61558 series.

In this standard, the following print types are used:

- requirements proper: in roman type;
- *test specifications: in italic type;*
- explanatory matter: in smaller roman type.

In the text of this publication, the words in **bold** are defined in Clause 3 of this document and in the IEC 61558 series.

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

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

NOTE The attention of the National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC publication in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this publication be adopted for implementation nationally not earlier than 12 months or not later than 3 years from the date of publication.

The transitional period is no longer than 3 years after the publication of this standard.

TRANSFORMERS, POWER SUPPLIES, REACTORS AND SIMILAR PRODUCTS –

EMC requirements

1 Scope

This document is applicable to transformers, reactors and power supply units covered by the IEC 61558 series of standards. This document deals with the electromagnetic compatibility requirements for emission and immunity within the frequency range 0 Hz to 400 GHz. No tests need to be performed at frequencies where no requirements are specified.

For associated transformers, associated reactors and associated power supply units either supplied with or incorporated into an appliance or equipment the relevant EMC standard for that appliance or equipment applies.

This document covers normal operating conditions only. Other operations of the transformers, reactors and power supply units (e.g. simulated faults in the electric circuitry for testing purposes or functional safety due to the effects of the electromagnetic phenomena, or evaluation of human being for exposure to electromagnetic fields (EMF)) have not been taken into consideration in this document.

Requirements are specified for each port considered. If requirements are different the most severe takes precedence.

This document may also be used as a guide to test transformers, reactors and power supply units separately before these are incorporated into an appliance or equipment.

NOTE When **EUT (Equipment under test)** is used, it covers **transformers, reactors and power supply** units where applicable.

This document does not apply to:

- uninterruptible power supplies (UPS) covered by IEC 62040 (all parts);
- power supply units covered by IEC 61204,
(i.e. DC-DC converters, DC power and distribution equipment and power supply units for use in applications covered by IEC 60950-1, IEC 61010-1, IEC 60601-1 and IEC 60065);
- power supplies and converters for use with or in products covered by IEC 61347 (all parts).

2 Normative references

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

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

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current $\leq A$ per phase and not subject to conditional connection*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current $\leq 75 A$ and subject to conditional connection*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current $> 16 A$ and $\leq 75 A$ per phase*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3 : Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

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

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-34, *Electromagnetic compatibility (EMC) – Part 4-34: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

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

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61558 (all parts), *Safety of power transformers, power supplies, reactors and similar products*

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

CISPR 16-1-1:2015, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

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

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

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

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

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

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

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

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

3.1.1 equipment under test

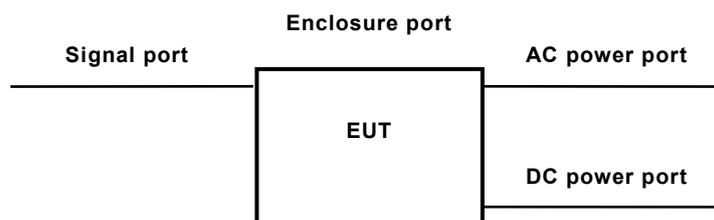
transformers, reactors and power supply units where applicable

3.1.2 port

particular interface of the specified **EUT** with the external electromagnetic environment.

Note 1 to entry: Examples of ports of interest are shown in Figure 1. The enclosure port is the physical boundary of the equipment (e.g. enclosure). The enclosure port provides for radiated and electrostatic discharge (ESD) energy transfer, whereas the other ports provide for conducted energy transfer, either by direct injection or by induction.

Note 2 to entry: In some cases, different **ports** may be combined.



IEC

Figure 1 – Ports covered by Table A.1 to Table A.16

3.1.3

enclosure port

physical boundary of the **EUT** which electromagnetic fields may radiate through or impinge on

3.1.4

cable port

port at which a conductor or a cable is connected to the **EUT**

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

3.1.5

signal port

port at which a conductor or cable intended to carry signals is connected to the **EUT**

Note 1 to entry: Examples are analogue inputs, outputs and control lines, data busses, communication networks, etc.

3.1.6

power port

port at which a conductor or cable carrying the primary electrical power needed for the operation (functioning) of an **EUT** is connected

3.1.7

public mains network

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

3.1.8

low voltage

voltage having a value below a conventionally adopted limit

Note 1 to entry: For the distribution of AC electric power, the upper limit is generally accepted to be 1 000 V.

[SOURCE: IEC 60050-151:2001, 151-15-03]

3.2 Abbreviations

| | |
|------|---------------------------------|
| AC | Alternating Current |
| AM | Amplitude Modulation |
| DC | Direct Current |
| EUT | Equipment Under Test |
| FAR | Fully Anechoic Room |
| ISN | Impedance Stabilization Network |
| LV | Low Voltage |
| OATS | Open Area Test Site |

SAC Semi Anechoic Chamber
 TEM Transverse Electromagnetic Mode

4 General considerations

4.1 Categories

EUT are classified according to the incorporation of components and electronic circuits as follows:

- category 0: **EUT** with or without passive protection components and without electronic circuits,
- category 1: **EUT** with passive components, and without electronic circuits,
- category 2: **EUT** with electronic circuits.

NOTE 1 Examples of passive protection components are fuses, thermal links, thermal cut-outs, circuit-breakers, PTC's, NTC's and resistors.

NOTE 2 Examples of passive components are capacitors, inductors, diodes, LED's, relays, VDR's.

NOTE 3 Examples of electronic circuits are active semiconductors.

4.2 Measurement uncertainty

Compliance testing with the limits described in this document shall be carried out statistically according to Table 1. Emission tests shall be executed in accordance with Annex A by using at least 5 samples. In case of exceptional conditions, the sum of test samples can be reduced to 3 or 4 samples.

The requirements are fulfilled, if the measured emissions of all individual samples are in compliance with the limits and the gap to the limit is not smaller than specified in Table 1.

Table 1 – Additional acceptance limit for statistical determination

| | | | | |
|----------------------------------|-----|-----|-----|-----|
| Sample size | 3 | 4 | 5 | 6 |
| Additional acceptance limit (dB) | 3,8 | 2,5 | 1,5 | 0,7 |

This procedure shall not be used to show the non-compliance of the product.

NOTE This procedure is based on CISPR TR 16-4-3.

Compliance is constituted by

$$x_{\max} + k_E \times \sigma_{\max} < L$$

where

x_{\max} is the highest (unfavourable) value of all samples of the sample size;

k_E is the coefficient taken from the Table 2 in view of sample size;

σ_{\max} is the conservative standard regression of product group;

L is the permissible limit.

Table 2 – Values of k_E according to CISPR TR 16-4-3:2004, Table C.1

| | | | | |
|-------------------|------|------|------|------|
| Sample size | 3 | 4 | 5 | 6 |
| Coefficient k_E | 0,63 | 0,41 | 0,24 | 0,12 |

IEC/CISPR/TR 16-4-3 recommends $\sigma_{\max} = 6$ dB for conducted emissions. For radiated emissions the same value of σ_{\max} can be used. Values shown in Table 1 constitute a simple multiplication of k_E and $\sigma_{\max} = 6$ dB.

Table 1 is only valid for sample sizes up to 6. If more samples are used to check compliance, a different procedure may be used (binominal distribution without additional gap to the limit).

4.3 Routine tests (production tests)

The assessment of compliance with the requirements of this document shall be carried out by normative tests. The uncertainty of measurement shall be taken into account.

Wherever possible, the measurement uncertainty shall be covered in accordance with CISPR 16-4-2.

NOTE 1 Measurements conducted at the place of installation, the share of place is not taken into account.

Measurements carried out at distances smaller than 10 m, higher uncertainty may need to be used.

Table 3 – Uncertainties for emission tests

| Test | Uncertainty dB |
|--|-------------------|
| Conducted emissions (150 kHz to 30 MHz) using a 50Ω/50μH ISN ^a | 3,44 |
| Radiated emissions (30 MHz to 200 MHz) – Horizontal polarisation – 10 m ^b | 5,05 |
| Radiated emissions (30 MHz to 200 MHz) – Vertical polarisation – 10 m ^b | 5,03 |
| Radiated emissions (200 MHz to 1 GHz) – Horizontal polarisation – 10 m ^c | 5,21 |
| Radiated emissions (200 MHz to 1 GHz) – Vertical polarisation – 10 m ^c | 5,22 |
| ^a Impedance stabilisation network (ISN). ^b Uncertainty for the use of biconical antennas. ^c Uncertainty for the use of logarithmical-periodical antennas. | |

5 Product documentation

The user documentation and/or manual shall contain details of any special measures required to be taken by the purchaser or user to ensure the EMC compliance of the EUT with the requirements of this publication. One example would be the need to use shielded or special cables.

6 Applicability

The application of tests for evaluation of immunity depends on the particular apparatus, its configuration, its **ports**, its technology and its operating conditions.

Tests shall be applied to the relevant **ports** of the **EUT** according to Table A.1 to Table A.16. Tests shall only be carried out where the relevant **ports** exist.

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

7 Test equipment

The description of the measurement, the measurement instrumentation, the measurement methods and the measurement set up to be used is given in Tables A.1 to A.16.

8 Conditions during testing

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

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

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

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

Where applicable, additional information on **EUT** configuration can be found in CISPR 16-2 (all parts) and CISPR 32.

9 Measurement procedures

9.1 Emission

The **equipment under test (EUT)** shall be tested in the operating mode producing the largest emission in the frequency band being investigated, e.g. based on limited pre-tests and consistent with normal applications. The configuration of the test sample shall be varied to achieve maximum emission consistent with typical applications and installation practice.

The emission requirements for **EUT** covered by this document are given on a **port by port** basis. These requirements are stated in Tables A.9 to A.16.

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

9.2 Immunity

The **equipment under test (EUT)** shall be tested in the expected most susceptible operating mode e.g. identified by performing limited pre-tests. This mode shall be consistent with

normal applications. The configuration of the test sample shall be varied to archive maximum susceptibility with typical applications and installation practice.

The immunity test requirements for **EUT** covered by this document are given on a **port by port** basis.

Tests shall be conducted in a well-defined and reproducible manner.

The tests shall be carried out individually as single tests in sequence. The tests may be performed in any order. If requirements are in conflict the most severe takes precedence.

The description of the test, relevant generator, appropriate methods, and the set up to be used are given in basic standards, which are referred to in Tables A.1 to A.8.

The contents of these basic standards are not repeated here, however modifications or additional information and test levels needed for the practical application of the tests are given in this document.

10 Performance criteria

The variety and the diversity of the **EUT** within the scope of this document makes it difficult to define precise criteria for the evaluation of the immunity test results.

If, as a result of the application of the tests defined in this document, the apparatus becomes dangerous or unsafe, the apparatus shall be deemed to have failed the test.

A functional description and a definition of performance criteria, during or as a consequence of the EMC testing, shall be provided by the manufacturer and noted in the test report, based on one of the following criteria for each test as specified in Tables A.1 to A.8.

Performance criterion A: The **EUT** shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the **EUT** is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the **EUT** if used as intended.

Performance criterion B: The **EUT** shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the **EUT** is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is however allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the **EUT** if used as intended.

Performance criterion C: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

11 Requirements

11.1 Immunity

The immunity requirements applicable to equipment covered within the scope of this publication shall be selected from Tables A.1 to A.8 as specified below. Where requirements are different the most severe takes precedence.

All **EUT** directly powered by the AC network shall meet the requirements of Table A.7, table clauses 7.2 and 7.3, for current less than 16 A per phase and Table A.8, table clauses 8.2 and 8.3, for current more than 16 A per phase as regards voltage dips and interruptions of the mains supply caused generally by faults on the network.

Category 0 **EUT** are not sensitive to normal electromagnetic perturbations. Consequently, they are deemed to fulfil the immunity requirements without testing.

Category 1 **EUT** shall fulfil the immunity requirements for electrostatic discharges, electrical fast transients and surges as follows:

- for electrostatic discharge, refer to Table A.1 and Table A.2, as applicable;

NOTE 1 Some passive components such as small capacitors (e.g. Y-type), diodes, LEDs or relays can be sensitive to electrostatic discharges.

- for electrical fast transient/burst, refer to Table A.3, Table A.4, Table A.5, Table A.6, Table A.7 and Table A.8, as applicable;

NOTE 2 Some passive components such as small capacitors (e.g. Y-type), diodes, LEDs, or relays can be sensitive to electrical fast transients.

- for surge, refer to Table A.4, Table A.5, Table A.6, Table A.7 and Table A.8, as applicable.

NOTE 3 Some passive components such as small capacitors (e.g. Y-type), diodes, LED or relays can be sensitive to surges.

Category 2 **EUT** shall fulfil the immunity requirements for electrostatic discharges, electrical fast transients, surges, conducted radio-frequency disturbances, radiated radio-frequency disturbances and for voltage dips and interruptions as follows:

- for electrostatic discharge, refer to Table A.1 and Table A.2, as applicable;
- for electrical fast transient/burst, refer to Table A.3, Table A.4, Table A.5, Table A.6, Table A.7 and Table A.8, as applicable;
- for surge, refer to Table A.4, Table A.5, Table A.6, Table A.7 and Table A.8, as applicable;
- for conducted disturbances, inducted by radio-frequency fields, refer to Table A.3, Table A.4, Table A.5, Table A.6, Table A.7 and Table A.8, as applicable;
- for radiated, radio-frequency electromagnetic fields, refer to Table A.1 and Table A.2, as applicable;
- for **voltage** dips and short interruptions, refer to Table A.7 and Table A.8, as applicable.

The necessity to conduct some of the tests may be determined in accordance with the electrical characteristics and the specific application of the particular **transformer**. In such cases the rationale for not conducting the tests shall be stated in the test report.

11.2 Emission

The emission requirements for equipment covered within the scope of this publication shall be selected from Tables A.9 to A.16 as specified below. Where requirements are different the most severe takes precedence.

EUT according to Category 0 as defined in 4.1 having a working voltage not exceeding 700 V do not generate electromagnetic interferences with a considerable level and as a consequence are deemed to fulfil the emission requirements without testing.

EUT according to Category 0 as defined in 4.1 having a working voltage exceeding 700 V are considered to generate electromagnetic interference. Consequently, the following requirements in accordance with CISPR 32 and CISPR 14-1 shall be carried out:

- for conducted radio disturbances, refer to Table A.15 and Table A.16, as applicable;
- for radiated radio disturbances, refer to Table A.9 and Table A.10, as applicable.

Category 1 **EUT** having a **working voltage** not exceeding 700 V shall fulfil the following requirements given in IEC 61000-3-2, IEC 61000-3-3, IEC 61000-3-11, IEC 61000-3-12, CISPR 32, and CISPR 14-1:

- for harmonics and flicker, refer to Table A.11;
- for conducted radio disturbances, refer to Table A.15 and Table A.16, as applicable.

Category 1 **EUT** having a **working voltage** exceeding 700 V shall fulfil the following requirements given in IEC 61000-3-2, IEC 61000-3-3, IEC 61000-3-11, IEC 61000-3-12, CISPR 32 and CISPR 14-1:

- for harmonics and flicker, refer to Table A.11;
- for conducted radio disturbances, refer to Table A.15 and Table A.16, as applicable;
- for radiated radio disturbances, refer to Table A.9 and Table A.10, as applicable.

Category 2 **EUT** shall fulfil the following requirements given in IEC 61000-3-2, IEC 61000-3-3, IEC 61000-3-11, IEC 61000-3-12, CISPR 32 and CISPR 14-1:

- for harmonics and flicker, refer to Table A.11;
- for conducted radio disturbances, refer to Table A.15 and Table A.16, as applicable;
- for radiated radio disturbances, refer to Table A.9 and Table A.10, as applicable.

Annex A (informative)

Tables for immunity and emission limits

This Annex contains tables defining requirements to be selected in accordance with the criteria specified in Clause 11.

Table A.1 – Immunity requirements for enclosure ports for equipment intended for use in residential, commercial and light-industrial environments according to IEC 61000-6-1

| Table clause | Environmental phenomena | | Test specifications | Units | Basic standards | Remarks | Performance criterion |
|---|--|-------------------|------------------------|-------------------------------|----------------------------|--|-----------------------|
| 1.1 | Radio-frequency electromagnetic field, amplitude modulated | | 80 to 1 000 3 80 | MHz V/m % AM (1 kHz) | IEC 61000-4-3 ^a | The test level specified is the RMS value of the unmodulated carrier. | A |
| 1.2 | Radio-frequency electromagnetic field, amplitude modulated | | 1,4 to 2,0 3 80 | GHz V/m % AM (1 kHz) | IEC 61000-4-3 ^a | The test level specified is the RMS value of the unmodulated carrier. ^b | A |
| 1.3 | Radio-frequency electromagnetic field, amplitude modulated | | 2,0 to 2,7 1 80 | GHz V/m % AM (1 kHz) | IEC 61000-4-3 ^a | The test level specified is the RMS value of the unmodulated carrier. ^b | A |
| 1.4 | Electro-static discharge | Contact discharge | ±4 (charge voltage) | kV | IEC 61000-4-2 | See basic standard for applicability of contact and/or air discharge test. | B |
| | | Air discharge | ±8 (charge voltage) | kV | | | B |
| ^a IEC 61000-4-20 may be used for small EUTs as defined in IEC 61000-4-20:2010, 6.1. | | | | | | | |
| ^b The frequency range has been selected to cover the frequencies with the highest potential risk of a disturbance. | | | | | | | |

Table A.2 – Immunity requirements for enclosure ports for equipment intended for use in industrial environments according to IEC 61000-6-2

| Table clause | Environmental phenomena | Test specifications | Units | Basic standards | Remarks | Performance criterion | |
|---|--|-------------------------|----------------------------|----------------------------|--|--|---|
| 2.1 | Radio-frequency electromagnetic field, amplitude modulated | 80 to 1 000 10 80 | MHz V/m % AM (1 kHz) | IEC 61000-4-3 ^a | The test level specified is the RMS value of the unmodulated carrier. | A | |
| 2.2 | Radio-frequency electromagnetic field, amplitude modulated | 1,4 to 2,0 3 80 | GHz V/m % AM (1 kHz) | IEC 61000-4-3 ^a | The test level specified is the RMS value of the unmodulated carrier. ^b | A | |
| 2.3 | Radio-frequency electromagnetic field, amplitude modulated | 2,0 to 2,7 1 80 | GHz V/m % AM (1 kHz) | IEC 61000-4-3 ^a | The test level specified is the RMS value of the unmodulated carrier. ^b | A | |
| 2.4 | Electro-static discharge | Contact discharge | ±4 (charge voltage) | kV | IEC 61000-4-2 | See basic standard for applicability of contact and/or air discharge test. | B |
| | | Air discharge | ±8 (charge voltage) | kV | | | B |
| ^a IEC 61000-4-20 may be used for small EUTs as defined in IEC 61000-4-20:2010, 6.1. | | | | | | | |
| ^b The frequency range has been selected to cover the frequencies with the highest potential risk of a disturbance. | | | | | | | |

Table A.3 – Immunity requirements for signal ports for equipment intended for use in residential, commercial and light industrial environments according to IEC 61000-6-1

| Table clause | Environmental phenomena | Test specifications | Units | Basic standards | Remarks | Performance criterion |
|--|-----------------------------|------------------------|--|-----------------|--|-----------------------|
| 3.1 | Radio-frequency common mode | 0,15 to 80 3 80 | MHz V % AM (1 kHz) | IEC 61000-4-6 | The test level specified is the RMS value of the unmodulated carrier. ^{a,b} | A |
| 3.2 | Fast transients | ± 0,5 5/50 5 | kV (open circuit test voltage) T_r/T_h ns Repetition frequency kHz | IEC 61000-4-4 | Capacitive clamp used ^b | B |
| ^a The test level can also be defined as the equivalent current into a 150 Ω load. | | | | | | |
| ^b Applicable only to ports interfacing with cables whose total length according to the manufacturer's functional specification may exceed 3 m. | | | | | | |

Table A.4 – Immunity requirements for signal ports for equipment intended for use in industrial environments according to IEC 61000-6-2

| Table clause | Environmental phenomena | Test specifications | Units | Basic standards | Remarks | Performance criterion |
|---|-----------------------------|------------------------|--|-----------------|---|-----------------------|
| 4.1 | Radio-frequency common mode | 0,15 to 80 10 80 | MHz V % AM (1 kHz) | IEC 61000-4-6 | The test level specified is the RMS value of the unmodulated carrier. ^{a,b,c} | A |
| 4.2 | Fast transients | ± 1 5/50 5 | kV (open circuit test voltage) T_r/T_h ns Repetition frequency kHz | IEC 61000-4-4 | Capacitive clamp used ^c | B |
| 4.3 | Surge Line to earth | 1,2/50 (8/20) ± 1 | T_r/T_h µs kV (open circuit test voltage) | IEC 61000-4-5 | see ^{d,e} | B |
| <p>^a The test level can also be defined as the equivalent current into a 150 Ω load.</p> <p>^b The radio frequency responses are excluded to ITU: 47 MHz to 68 MHz; here is valid 3 V.</p> <p>^c Applicable only to ports interfacing with cables whose total length according to the manufacturer's functional specification may exceed 3 m.</p> <p>^d Applicable only to ports interfacing with cables whose total length according to the manufacturer's functional specification may exceed 30 m.</p> <p>^e If through the influence of the decoupling-/coupling-network intended function of the specimen cannot be assured, this test is not required.</p> | | | | | | |

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Table A.5 – Immunity requirements at input and output DC power ports for equipment intended for use in residential, commercial and light-industrial environments according to IEC 61000-6-1

| Table clause | Environmental phenomena | Test specifications | Units | Basic standards | Remarks | Performance criterion |
|---|---|---------------------------------|--|-----------------|---|-----------------------|
| 5.1 | Radio-frequency common mode | 0,15 to 80 3 80 | MHz V % AM (1 kHz) | IEC 61000-4-6 | The test level specified is the RMS value of the unmodulated carrier. ^{a,b} | A |
| 5.2 | Surges line-to-earth line-to-line | 1,2/50 (8/20) ± 0,5 ± 0,5 | T_r/T_h µs kV (open circuit test voltage) kV (open circuit test voltage) | IEC 61000-4-5 | For application to input ports ^c | B |
| 5.3 | Fast transients | ± 0,5 5/50 5 | kV (open circuit test voltage) T_r/T_h ns Repetition frequency kHz | IEC 61000-4-4 | For application to input ports ^d | B |
| <p>^a The test level can also be defined as the equivalent current into a 150 Ω load.</p> <p>^b Applicable only to ports interfacing with cables whose total length according to the manufacturer's functional specification may exceed 3 m.</p> <p>^c Not applicable to input ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging. Apparatus with a DC power input port intended for use with an AC – DC power adapter shall be tested on the AC power input of the AC – DC power adaptor specified by the manufacturer or, where none is so specified, using a typical AC – DC power adaptor. DC ports which are not intended to be connected to a DC distribution network are treated as signal ports.</p> <p>^d Not applicable to input ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging. Apparatus with a DC power input port intended for use with an AC – DC power adapter shall be tested on the AC power input of the AC – DC power adaptor specified by the manufacturer or, where none is so specified, using a typical AC – DC power adaptor. The test is applicable to DC power input ports intended to be connected permanently to cables longer than 3 m.</p> | | | | | | |

Table A.6 – Immunity requirements at input and output DC power ports for equipment intended for use in industrial environments according to IEC 61000-6-2

| Table clause | Environmental phenomena | Test specifications | Units | Basic standards | Remarks | Performance criterion |
|---|---|---|--|-----------------|--|-----------------------|
| 6.1 | Radio-frequency common mode | 0,15 to 80 10 80 | MHz V % AM (1 kHz) | IEC 61000-4-6 | The test level specified is the RMS value of the unmodulated carrier. ^{a,b} | A |
| 6.2 | Surges line-to-earth (common mode) line-to-line (differential mode) | 1,2/50 (8/20) ± 0,5 ± 0,5 | T_r/T_h µs kV (open circuit test voltage) kV (open circuit test voltage) | IEC 61000-4-5 | For application to input ports ^c | B |
| 6.3 | Fast transients | ± 2 5/50 5 | kV (open circuit test voltage) T_r/T_h ns Repetition frequency kHz | IEC 61000-4-4 | For application to input ports ^d | B |
| <p>^a The test level can also be defined as the equivalent current into a 150 Ω load.</p> <p>^b The radio frequency responses are excluded to ITU: 47 MHz to 68 MHz; here is valid 3 V.</p> <p>^c Not applicable to input ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging. Apparatus with a DC power input port intended for use with an AC – DC power adapter shall be tested on the AC power input of the AC – DC power adaptor specified by the manufacturer or, where none is so specified, using a typical AC – DC power adaptor. DC ports which are not intended to be connected to a DC distribution network are treated as signal ports.</p> <p>^d Not applicable to input ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging. Apparatus with a DC power input port intended for use with an AC – DC power adapter shall be tested on the AC power input of the AC – DC power adaptor specified by the manufacturer or, where none is so specified, using a typical AC – DC power adaptor. The test is applicable to DC power input ports intended to be connected permanently to cables longer than 3 m.</p> | | | | | | |

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Table A.7 – Immunity requirements at input and output AC power ports for equipment intended for use in residential, commercial and light-industrial environments according to IEC 61000-6-1

| Table clause | Environmental phenomena | Test specifications | Units | Basic standards | Remarks | Performance criterion |
|--|-----------------------------|--------------------------|--|--|---|-------------------------|
| 7.1 | Radio-frequency common mode | 0,15 to 80 3 80 | MHz V % AM (1 kHz) | IEC 61000-4-6 | The test level specified is the RMS. value of the unmodulated carrier. ^a | A |
| 7.2 | Voltage dips | 0 | % residual voltage | IEC 61000-4-11 (≤ 16 A) | Voltage shift at zero crossing ^b | B |
| | | 0,5 | circle | | | IEC 61000-4-34 (> 16 A) |
| | | 0 | % residual voltage | IEC 61000-4-34 (> 16 A) | | |
| | | 1 | circle | | | IEC 61000-4-34 (> 16 A) |
| 70 | % residual voltage | | C | | | |
| | | 25/30 at 50/60 Hz | circle | | | |
| 7.3 | Voltage interruptions | 0 250/300 at 50/60 Hz | % residual voltage cycle | IEC 61000-4-11 (≤ 16 A) IEC 61000-4-34 (> 16 A) | Voltage shift at zero crossing ^b | C |
| 7.4 | Surges line-to-earth | 1,2/50 (8/20) ± 2 | T_r/T_h μs kV (open circuit test voltage) | IEC 61000-4-5 | | B |
| | line-to-line | ± 1 | kV (open circuit test voltage) | | | |
| 7.5 | Fast transients | ± 1 | kV (open circuit test voltage) | IEC 61000-4-4 | | B |
| | | 5/50 5 | T_r/T_h ns Repetition frequency kHz | | | |
| ^a The test level can also be defined as the equivalent current into a 150 Ω load. ^b Applicable only to input ports . | | | | | | |

Table A.9 – Requirements for radiated emissions for equipment intended for use in residential, commercial and light-industrial environments according to IEC 61000-6-3

| Table clause | Port | Frequency range | Limits | Basic Standard | Applicability note | Remarks |
|--------------|--|---|--|---|---|--|
| 9.1 | Enclosure Test facility: OATS or SAC | 30 MHz to 230 MHz 230 MHz to 1 000 MHz | 30 dB(μ V/m) quasi-peak at 10 m 37 dB(μ V/m) quasi-peak at 10m | The measurement instrumentation shall be as defined in Clause 4 of CISPR 16-1-1:2015. The measuring antennas shall be as defined in 4.4 of CISPR 16-1-4:2010/AMD1:2012. The measuring site shall be as described in Clause 5 of CISPR 16-1-4:2010/AMD1:2012. The measurement method shall be as specified in 7.2 of CISPR 16-2-3:2016. | See ^{a, b} and ^e | May be measured at 3 m distance using the limits increased by 10 dB. As stated in CISPR 16-2-3 the antenna height shall be varied between 1 m to 4 m. Additional guidance on the test method can be found in CISPR 16-2-3:2016 7.3 and Clause 8. |
| 9.2 | Enclosure Test facility: FAR | 30 MHz to 230 MHz 230 MHz to 1 000 MHz | 42 dB(μ V/m) to 35 dB(μ V/m) quasi-peak at 3 m Limit reducing linearly with the logarithm of the frequency 42 dB(μ V/m) quasi peak at 3 m | The measurement instrumentation shall be as defined in Clause 4 of CISPR 16-1-1:2015. The measuring antennas shall be as defined in 4.4 of CISPR 16-1-4:2010/AMD1:2012. The measuring site shall be as described in clause 5.4.7 of CISPR 16-1-4:2010/AMD1:2012. The measurement method shall be as specified in 7.4 of CISPR 16-2-3:2016. | See ^{a, b} and ^e Only applicable to table top equipment. | May be measured at greater distances with the limits decreased by 20 dB/decade (relative to distance) The limitations on EUT size in CISPR 16-1-4 apply. |
| 9.3 | Enclosure Test facility: TEM Waveguide | 30 MHz to 230 MHz 230 MHz to 1 000 MHz | 30 dB(μ V/m) quasi-peak 37 dB(μ V/m) quasi-peak The small- EUT correction factor given in A.4.3 of IEC 61000-4-20:2010 shall be used. The limit relates to the measurement distance of 10 m | IEC 61000-4-20 | See ^{a, b} and ^e Only applicable to battery powered equipment not intended to have external cables attached. Restricted to equipment complying with the definition 6.2 in IEC 61000-4-20:2010. | |
| 9.4 | Enclosure Test facility: OATS, | 1 GHz to 3 GHz | 70 dB(μ V/m) quasi-peak at 3 m 50 dB(μ V/m) average at 3 m | The measurement instrumentation shall be as defined in Clause 5 and Clause 6 of CISPR 16-1-1. | See ^{a, c, d} and ^e | May be measured at greater distances with the limits decreased by |

| Table clause | Port | Frequency range | Limits | Basic Standard | Applicability note | Remarks |
|--|------------|-----------------|---|---|--------------------|---|
| | SAC or FAR | 3 GHz to 6 GHz | 74 dB(µV/m) quasi-peak at 3 m 54 dB(µV/m) average at 3 m | The measuring antennas shall be as defined in 4.5 of CISPR 16-1-4. The measuring site shall be as described in Clause 8 of CISPR 16-1-4. The measurement method shall be as specified in 7.3 of CISPR 16-2-3. | | 20 dB/decade (relative to distance). For SAC and OATS facilities absorber may be required to archive free space conditions as defined in CISPR 16-1-4. |
| <p>^a For apparatus containing devices operating at frequencies less than 9 kHz measurements only need to be performed up to 230 MHz.</p> <p>^b The apparatus is deemed to comply with the enclosure port requirement below 1 GHz if meets the requirements defined in one or more of the table clauses 1.1, 1.2 or 1.3.</p> <p>^c If the highest internal frequency of the EUT is less than 108 MHz, the measurement shall only be made up to 1 GHz. If the highest internal frequency of the EUT is between 108 MHz and 500 MHz, the measurement shall only be made up to 2 GHz. If the highest internal frequency of the EUT is between 500 MHz and 1 GHz, the measurement shall only be made up to 5 GHz. If the highest internal frequency of the EUT is above 1 GHz, the measurement shall only be made up to 6 GHz. Where the highest internal frequency is not known, tests shall be performed up to 6 GHz.</p> <p>^d 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 current in inductors, or when devices contain or control subsystems that create static electricity (such as paper handling devices). The average limits apply to disturbances from arcs or sparks, and both peak and average limits apply to other disturbances from such devices.</p> <p>^e At transitional frequencies the lower limit applies.</p> | | | | | | |

Table A.10 – Requirements for radiated emissions ports for equipment intended for use in industrial environments according to IEC 61000-6-4

| Table clause | Port | Frequency range | Limits | Basic Standard | Applicability note | Remarks |
|--------------|--|---|--|---|--|---|
| 10.1 | Enclosure Test facility: OATS or SAC | 30 MHz to 230 MHz 230 MHz to 1 000 MHz | 40 dB(µV/m) quasi-peak at 10 m 47 dB(µV/m) quasi-peak at 10 m | The measurement instrumentation shall be as defined in Clause 4 of CISPR 16-1-1:2015. The measuring antennas shall be as defined in 4.4 of CISPR 16-1-4:2010/AMD1:2012. The measuring site shall be as described in Clause 5 of CISPR 16-1-4:2010/AMD1:2012. The measurement method shall be as specified in 7.2 of CISPR 16-2-3:2016. | See ^a , ^b and ^e | May be measured at 30 m distance using the limits increased by 10 dB. As stated in CISPR 16-2-3 the antenna height shall be varied between 1 m to 4 m. Additional guidance on the test method can be found in CISPR 16-2-3:2016 7.3 and Clause 8. |

| Table clause | Port | Frequency range | Limits | Basic Standard | Applicability note | Remarks |
|--------------|--|---|---|--|--|--|
| 10.2 | Enclosure Test facility: FAR | 30 MHz to 230 MHz | 52 dB(μ V/m) to 45 dB(μ V/m) quasi-peak at 3 m Limits decrease linearly with the logarithm of the frequency | The measurement instrumentation shall be as defined in Clause 4 of CISPR 16-1-1:2015. The measuring antennas shall be as defined in 4.4 of CISPR 16-1-4:2010/AMD1:2012. | See ^{a, b} and ^e Only applicable to table top equipment. | May be measured at greater distances with the limits decreased by 20 dB/decade (relative to distance) The limitations on EUT size in CISPR 16-1-4 apply. |
| | | 230 MHz to 1000 MHz | 52 dB(μ V/m) quasi peak at 3 m | The measuring site shall be as described in 5.4.7 of CISPR 16-1-4:2010/AMD1:2012. The measurement method shall be as specified in 7.4 of CISPR 16-2-3:2016. | | |
| 10.3 | Enclosure Test facility: TEM Waveguide | 30 MHz to 230 MHz 230 MHz to 1 000 MHz | 40 dB(μ V/m) quasi-peak 47 dB(μ V/m) quasi-peak The small- EUT correction factor given in A.4.3 of IEC 61000-4-20:2010 shall be used. The limit relates to the OATS measurement distance of 10 m | IEC 61000-4-20 | See ^{a, b} and ^e Only applicable to battery powered equipment not intended to have external cables attached. Restricted to equipment complying with the definition 6.2 in IEC 61000-4-20:2010. | |

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