



**BSI Standards Publication**

## **Electromagnetic compatibility (EMC)**

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Part 4-2: Testing and measurement techniques —  
Electrostatic discharge immunity test

# National foreword

This British Standard is the UK implementation of EN IEC 61000-4-2:2025. It is identical to IEC 61000-4-2:2025. It supersedes BS EN 61000-4-2:2009, which will be withdrawn on 30 April 2028.

The UK participation in its preparation was entrusted to Technical Committee GEL/210, EMC - Policy committee.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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English Version

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(IEC 61000-4-2:2025)

Compatibilité électromagnétique (CEM) - Partie 4-2:  
Techniques d'essai et de mesure - Essai d'immunité aux  
décharges électrostatiques  
(IEC 61000-4-2:2025)

Elektromagnetische Verträglichkeit (EMV) - Teil 4-2: Prüf-  
und Messverfahren - Prüfung der Störfestigkeit gegen die  
Entladung statischer Elektrizität  
(IEC 61000-4-2:2025)

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European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

## **European foreword**

The text of document 77B/896/FDIS, future edition 3 of IEC 61000-4-2, prepared by SC 77B "High frequency phenomena" of IEC/TC 77 "Electromagnetic compatibility" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61000-4-2:2025.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2026-04-30 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2028-04-30 document have to be withdrawn

This document supersedes EN 61000-4-2:2009 and all of its amendments and corrigenda (if any).

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Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

## **Endorsement notice**

The text of the International Standard IEC 61000-4-2:2025 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

- |               |      |                              |
|---------------|------|------------------------------|
| IEC 61000-6-1 | NOTE | Approved as EN IEC 61000-6-1 |
| IEC 62368-1   | NOTE | Approved as EN IEC 62368-1   |

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTROMAGNETIC COMPATIBILITY (EMC) –****Part 4-2: Testing and measurement techniques –  
Electrostatic discharge immunity test****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.
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IEC 61000-4-2 has been prepared by subcommittee 77B: High-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility. It is an International Standard.

It forms Part 4-2 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 2008. This edition constitutes a technical revision.

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

- a) added a calibration requirement for ESD generators with air discharge tip;
- b) added a normative annex for test setups for particular kind of equipment (see Annex I);

- c) added an informative annex for wearable devices (see Annex J);
- d) added an informative annex on how to select test points and give guidance on how to specify the number of pulses for direct contact discharges (see Annex E);
- e) moved Clause 9 into a new informative annex (see Annex K);
- f) improved current calibration procedure;
- g) improved measurement uncertainty considerations with examples of uncertainty budgets;
- h) moved post-installation tests into a new informative Annex G since they cannot be performed in a controlled environment.

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

| Draft        | Report on voting |
|--------------|------------------|
| 77B/896/FDIS | 77B/897/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

A list of all parts in 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](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

## INTRODUCTION

IEC 61000-4 is a part of the IEC 61000 series, according to the following structure:

### **Part 1: General**

General consideration (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 or as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

This part of IEC 61000 is an International Standard which gives immunity requirements and test procedures related to electrostatic discharge.

## **ELECTROMAGNETIC COMPATIBILITY (EMC) –**

### **Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test**

#### **1 Scope**

This part of IEC 61000 relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges from operators directly and from personnel to adjacent objects. It additionally specifies ranges of test levels which relate to different environmental, and installation conditions and establishes test procedures.

The objective of this document is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which can occur from personnel to objects near the equipment.

This document specifies:

- ideal waveform of the discharge current;
- range of test levels;
- test equipment;
- test setup;
- test procedure;
- calibration procedure;
- measurement uncertainty.

This document gives specifications for tests performed in laboratories and guidance to post-installation tests.

This document is not intended to specify the tests to be applied to particular apparatus or systems. The main aim is to give a general basic reference to all concerned product committees. The product committees remain responsible for the appropriate choice of the tests and the severity level to be applied to their equipment.

This document excludes tests intended to evaluate the ESD sensitivity of devices during handling and packaging. It is not intended for use in characterizing the performance of ESD protection circuits.

#### **2 Normative references**

There are no normative references in this document.

### 3 Terms, definitions and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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

##### **accessible**

surfaces of the EUT which can be touched by means of the air discharge tip of the ESD generator

[SOURCE: IEC 60050-442:1998, 442-01-15, modified – “part” has been replaced by “surfaces of the EUT” and “standard test finger” has been replaced by “air discharge tip of the ESD generator”.]

##### 3.1.2

##### **air discharge method**

method of testing in which the charged tip of the test generator is moved towards the EUT until it touches the EUT

##### 3.1.3

##### **calibration**

set of operations which establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

Note 1 to entry: This term is based on the "uncertainty" approach.

Note 2 to entry: The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

[SOURCE: IEC 60050-311:2001, 311-01-09]

##### 3.1.4

##### **contact discharge method**

method of testing in which the tip of the test generator is kept in contact with the EUT or coupling plane and the discharge is actuated by the discharge switch within the generator

##### 3.1.5

##### **coupling plane**

metal sheet or plate, to which discharges are applied to simulate electrostatic discharge to objects adjacent to the EUT

##### 3.1.6

##### **degradation (in performance)**

undesired departure in the operational performance of any device, equipment or system from its intended performance

Note 1 to entry: The term "degradation" can apply to temporary or permanent failure.

[SOURCE: IEC 60050-161:1990, 161-01-19]

**3.1.7****direct application**

application of the discharge directly to the EUT

**3.1.8****electromagnetic compatibility****EMC**

ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:2018, 161-01-07]

**3.1.9****electrostatic discharge****ESD**

transfer of electric charge between bodies of different electric potential in proximity or through direct contact

Note 1 to entry: Literature and teaching generally refer to transfers of charge, although strictly speaking charge carriers (IEV 113-06-25) are transferred.

[SOURCE: IEC 60050-161:2014, 161-01-22]

**3.1.10****energy storage capacitor**

capacitor of the ESD generator representing the capacity of a human body charged to the test voltage value

Note 1 to entry: This element can be provided as a discrete component or a distributed capacitance.

**3.1.11****holding time**

interval of time within which the decrease of the test voltage due to leakage, prior to the discharge, is not greater than 10 %

**3.1.12****immunity (to a disturbance)**

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-20]

**3.1.13****indirect application**

application of the discharge to a coupling plane in the vicinity of the EUT to simulate personnel discharge to objects which are adjacent to the EUT

**3.1.14****reference ground plane****RGP**

flat conductive surface that is at the same electric potential as reference ground, which is used as a common reference, and which contributes to a reproducible parasitic capacitance with the surroundings of the equipment under test (EUT)

Note 1 to entry: In some regions, the term 'earth' is used in place of 'ground'.

[SOURCE: IEC 60050-161:2014, 161-04-36, modified – Note 1 has been removed.]

**3.1.15****rise time**

interval of time between the instants at which the instantaneous value of a pulse first reaches the specified lower and upper limits

Note 1 to entry: Unless otherwise specified, the lower and upper values are fixed at 10 % and 90 % of the pulse magnitude.

[SOURCE: IEC 60050-161:1990, 161-02-05, modified, modified – the domain has been deleted and, in the definition, "value and then a specified upper value" has been deleted and "and upper limits" has been added.]

**3.1.16****verification**

set of operations which is used to check the test equipment system (e.g. the test generator and the interconnecting cables) and to gain confidence that the test system is functioning

Note 1 to entry: Details of verification are given in 7.2.2.

Note 2 to entry: The methods used for verification can be different from those used for calibration.

Note 3 to entry: For the purpose of this document this definition is different from the definition given in IEC 311-01-13.

**3.2 Abbreviated terms**

|     |                               |
|-----|-------------------------------|
| AD  | Air discharge                 |
| AE  | Auxiliary equipment           |
| CD  | Contact discharge             |
| EMC | Electromagnetic compatibility |
| ESD | Electrostatic discharge       |
| EUT | Equipment under test          |
| FT  | Fourier transform             |
| HCP | Horizontal coupling plane     |
| HV  | High voltage                  |
| IC  | Integrated circuit            |
| IFT | Inverse Fourier transform     |
| MU  | Measurement uncertainty       |
| PE  | Protective earth              |
| RGP | Reference ground plane        |
| VCP | Vertical coupling plane       |
| VNA | Vector network analyzer       |

**4 General**

This document relates to equipment, systems, subsystems and peripherals which can be involved in static electricity discharges as a result of environmental and installation conditions, such as low relative humidity, use of low-conductivity (artificial-fibre) carpets, synthetic-fabric garments, etc., which can exist in all locations classified in standards relevant to electrical and electronic equipment. Detailed information is specified in Annex A.

NOTE From the technical point of view, the precise term for the phenomenon would be static electricity discharge. However, the term electrostatic discharge (ESD) is widely used in the technical world and in technical literature. Therefore, it has been decided to retain the term electrostatic discharge in the title of this document.

Electrostatic discharges are categorized as contact discharges and air discharges. In addition, contact discharges are categorized as direct discharges and indirect discharges. Direct discharges are applied to conductive surfaces while indirect discharges are applied to coupling planes in the vicinity of EUTs.

## 5 Test levels

The preferred range of test levels for the ESD test is specified in Table 1.

Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied. Voltages for each test method are specified in Table 1. The voltages shown are different for each method due to the differing test methods. This does not imply that the test severity is equivalent between test methods.

Details concerning the various parameters which can influence the voltage to which the human body can be subjected are given in Clause A.2. Clause A.8 also contains examples of the application of the test levels related to environmental (installation) classes.

For air discharge testing, the test shall be applied at all test levels in Table 1 up to and including the specified test level. For contact and indirect discharge testing, the test shall be applied at the specified test level.

For further information on test level variations and applications between air and contact discharge, refer to Annex A, specifically Clause A.3 through Clause A.7.

**Table 1 – Test levels**

| Level                                                      | Test voltage      |               |
|------------------------------------------------------------|-------------------|---------------|
|                                                            | Contact discharge | Air discharge |
| 1                                                          | 2 kV              | 2 kV          |
| 2                                                          | 4 kV              | 4 kV          |
| 3                                                          | 6 kV              | 8 kV          |
| 4                                                          | 8 kV              | 15 kV         |
| NOTE Product committees can specify different test levels. |                   |               |

## 6 Test equipment

### 6.1 Overview

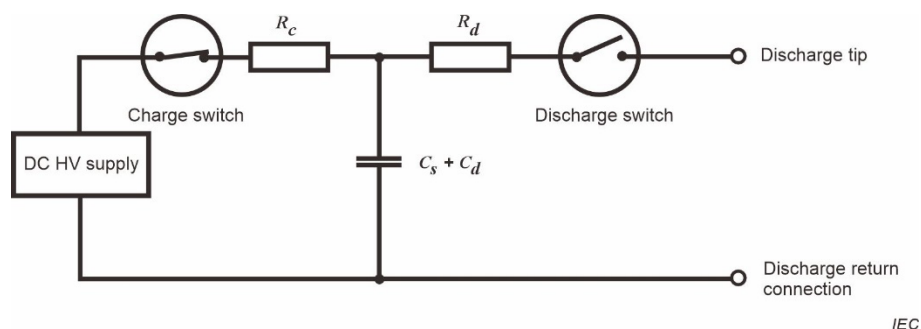
The ESD generator is designed to meet the characteristics in 6.2.2 and shall be calibrated in accordance with the procedure in 6.3 using a current measurement system calibrated in accordance with Annex B.

## 6.2 ESD generator

### 6.2.1 General

A simplified circuit diagram of an ESD generator is shown in Figure 1. Although construction details (shape, size, weight, materials, etc.) of the generator are not specified, the following main items are used in the design of an ESD generator:

- charging resistor  $R_c$ ;
- energy-storage capacitor  $C_s$ ;
- distributed capacitance  $C_d$ ;
- discharge resistor  $R_d$ ;
- voltage indicator;
- discharge switch;
- charge switch;
- interchangeable discharge tips (see Figure 3 and Figure 4);
- discharge return cable;
- power supply unit.



#### Components

$C_d$  is a distributed capacitance which exists between the generator and its surroundings.

$C_s + C_d$  has a typical value of 150 pF.

$R_d$  has a typical value of 330  $\Omega$ .

**Figure 1 – Simplified diagram of the ESD generator**

The ESD generator shall meet the requirements specified in 6.2.2 and indicated in Figure 2 when evaluated in accordance with the procedures in 6.3. Therefore, neither the diagram in Figure 1, nor the component values are specified in detail.

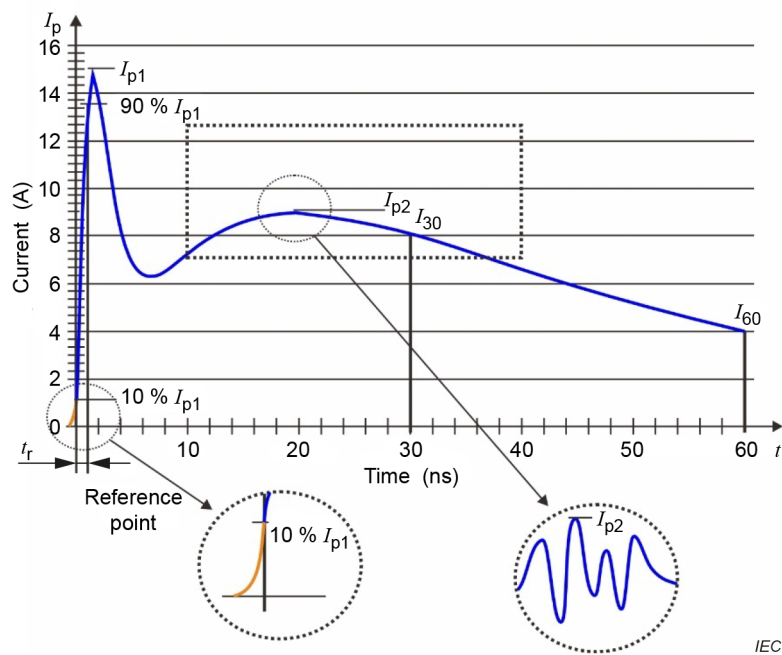


**Figure 2 – Ideal contact discharge current waveform at 4 kV**

A formula to generate the waveform in Figure 2,  $I(t)$ , is as follows:

$$I(t) = \frac{I_1}{k_1} \times \frac{\left(\frac{t}{\tau_1}\right)^n}{1 + \left(\frac{t}{\tau_1}\right)^n} \times \exp\left(\frac{-t}{\tau_2}\right) + \frac{I_2}{k_2} \times \frac{\left(\frac{t}{\tau_3}\right)^n}{1 + \left(\frac{t}{\tau_3}\right)^n} \times \exp\left(\frac{-t}{\tau_4}\right)$$

where

$$k_1 = \exp\left(-\frac{\tau_1}{\tau_2} \left(\frac{n\tau_2}{\tau_1}\right)^{1/n}\right)$$

$$k_2 = \exp\left(-\frac{\tau_3}{\tau_4} \left(\frac{n\tau_4}{\tau_3}\right)^{1/n}\right)$$

and

$\tau_1 = 1,1$  ns;  $\tau_2 = 2,0$  ns;  $\tau_3 = 12,0$  ns;  $\tau_4 = 37,0$  ns;

$I_1 = 16,6$  A (at 4 kV);  $I_2 = 9,3$  A (at 4 kV);

$n = 1,8$ .

## 6.2.2 General characteristics

### 6.2.2.1 Specifications of the ESD generator

The parameters of the ESD generator are specified in Table 2 and Table 3.

**Table 2 – General ESD generator parameters**

| Parameters                             | Values                                       |
|----------------------------------------|----------------------------------------------|
| Output voltage, contact discharge mode | At least 2 kV to 8 kV, nominal               |
| Output voltage, air discharge mode     | At least 2 kV to 15 kV, nominal <sup>a</sup> |
| Tolerance of output voltage            | ±5 %                                         |
| Polarity of output voltage             | Positive and negative                        |
| Holding time, air discharge mode       | ≥ 5 s                                        |
| Discharge mode of operation            | Single discharges <sup>b</sup>               |

The "open-circuit" voltage is measured at the discharge tip of the ESD generator.

<sup>a</sup> It is not necessary to use a generator with 15 kV air discharge capability if the maximum test voltage to be used is lower.

<sup>b</sup> The generator should be able to generate at a repetition rate of at least 20 discharges per second for exploratory purposes.

**Table 3 – Discharge current waveform parameters**

| Level |     | Associated voltage level (Table 2) | First peak current $I_{p1}$ of discharge (±15 %) | Rise time <sup>a</sup> $t_r$ (±25 %) | Second peak current <sup>b</sup> $I_{p2}$ of discharge (-20 %/+40 %) | Current $I_{30}$ at 30 ns (±30 %) | Current $I_{60}$ at 60 ns (±30 %) |
|-------|-----|------------------------------------|--------------------------------------------------|--------------------------------------|----------------------------------------------------------------------|-----------------------------------|-----------------------------------|
| CD    | AD  | kV                                 | A                                                | ns                                   | A                                                                    | A                                 | A                                 |
| 1     | 1   | 2                                  | 7,5                                              | 0,8                                  | 4,5                                                                  | 4,0                               | 2,0                               |
| 2     | 2   | 4                                  | 15,0                                             | 0,8                                  | 9,0                                                                  | 8,0                               | 4,0                               |
| 3     | --- | 6                                  | 22,5                                             | 0,8                                  | 13,5                                                                 | 12,0                              | 6,0                               |
| 4     | 3   | 8                                  | 30,0                                             | 0,8                                  | 18,0                                                                 | 16,0                              | 8,0                               |
| ---   | 4   | 15                                 | 56,3                                             | 0,8                                  | 33,8                                                                 | 30,0                              | 15,0                              |

The reference point for the time values is the instant when the current first reaches 10 % of the 1<sup>st</sup> peak of the discharge current.

All current and voltage values are given as absolute values. The respective polarity of the discharge applies to all values.

<sup>a</sup> The rise time,  $t_r$ , is the time interval between 10 % and 90 % value of 1<sup>st</sup> peak current.

<sup>b</sup> This is the maximum current which occurs in the time frame of 10 ns to 40 ns from the reference point.

The generator should be provided with means of preventing unintended radiated or conducted emissions, either of pulse or continuous type, so as not to disturb the EUT or AE by parasitic effects (see Annex D).

The discharge return cable of the ESD generator shall be at least 2 m long. In cases where a 2 m length of the discharge return cable is insufficient, (e.g. for tall EUTs), a longer cable (e.g. 3 m) may be used. The length of the discharge return cable shall be measured from the ESD generator body to the end of the connecting point. It shall be sufficiently insulated to prevent the flow of the discharge current during the ESD test to personnel or conducting surfaces other than via its termination.

The discharge return cable used for testing shall be the same cable used during calibration.

### 6.2.2.2 Characteristics of the contact discharge tip

The contact discharge tip shall be constructed in accordance with Figure 3. The discharge tip with the dimensions in Figure 3 may be covered with insulated coatings, provided the discharge current waveform specifications are met.

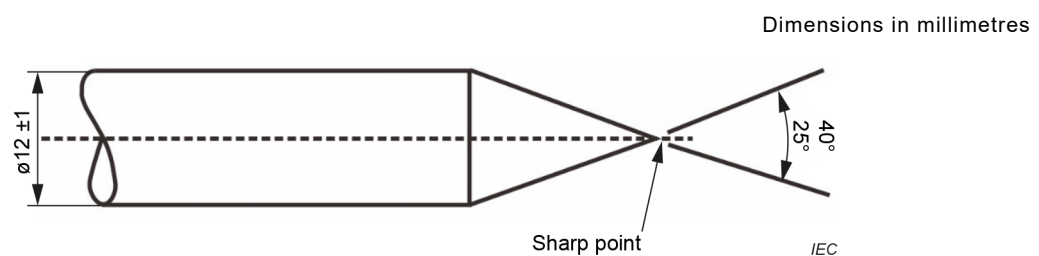


Figure 3 – Contact discharge tip of the ESD generator

### 6.2.2.3 Characteristics of the air discharge tip

The air discharge tip shall be constructed according to Figure 4. The discharge tip with the dimensions in Figure 4 may be covered with insulated coatings, provided the discharge current waveform specifications are met.

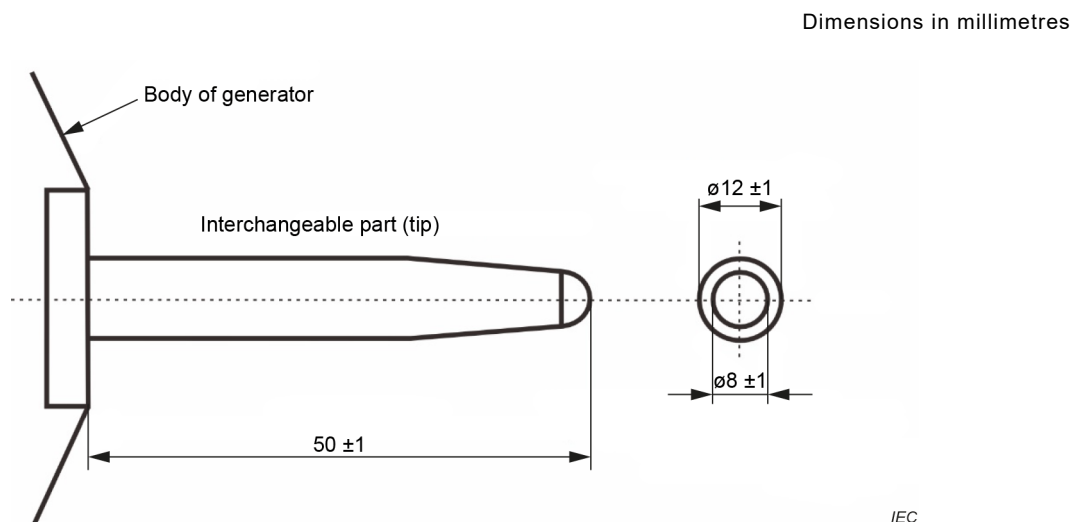


Figure 4 – Air discharge tip of the ESD generator

## 6.3 Calibration of the characteristics of the ESD generator

### 6.3.1 General

The ESD generator including the respective discharge tips (air and contact) shall be calibrated to ensure that they meet the specifications given in Table 2 and Table 3. It shall be demonstrated that these specifications are fulfilled using the test equipment specified in 6.3.2 with the test setup described in 6.3.3 and the calibration method specified in 6.3.4.

The calibration of the ESD generator shall be performed within the range of the climatic conditions as specified in 8.2.1. The ESD generator shall be powered in the same way as it is used for testing, i.e. two calibrations are applicable for ESD generators that may be powered by either mains or battery when both supplies are used for testing.

ESD generators shall be calibrated at test levels 1 through 4 as specified in Table 1 with both polarities.

For contact discharge, the complete calibration procedure as specified in 6.3.4 shall be performed at all test levels stated above with the contact discharge tip mounted.

For air discharge, if the contact and air discharge tips consist of a conductor with no additional active or passive electronic components, the calibration can be limited to the measurement of the open circuit voltage at the air discharge tip at the maximum test voltage used for air discharge. Otherwise, it is sufficient to additionally perform the air discharge calibration according to 6.3.4.3 at one of the levels specified in Table 1 with the ESD generator used in contact discharge mode but with the air discharge tip mounted.

NOTE 1 Some generators cannot be calibrated at 15 kV air discharge. If air discharge calibration cannot be performed at 15 kV, then the next lower air discharge voltage level specified in Table 3 can be used for calibration.

NOTE 2 The process in 6.3 is specified for calibration purposes. A procedure for verification of the generator before testing is specified in 7.2.2.

NOTE 3 Information of the components used within the discharge tips can be obtained from the manufacturer.

NOTE 4 Comparable calibration results of an ESD evaluation is extremely important. This is particularly the case when tests are conducted using ESD generators from different manufacturers, or when testing is expected to extend over a long period of time. It is essential that repeatability be a driving factor in the evaluation. It is useful for the ESD generator to be calibrated periodically.

### 6.3.2 Equipment required for ESD generator calibration

The following equipment is required for calibrating ESD generators:

- high-voltage meter capable of measuring voltages of at least 15 kV. For open circuit output voltage calibration, a resistive high voltage divider connected to a voltmeter shall be used. The overall accuracy of the high voltage divider including voltmeter shall be  $\pm 1$  % of reading. The minimum input resistance of the high voltage divider depends on the model of ESD generator and shall be specified by the manufacturer of the generator. Alternatively, an electrostatic voltmeter with the same accuracy can be used.

NOTE 1 A typical value for high voltage divider input resistance is in the range of 10 G $\Omega$  to 100 G $\Omega$

NOTE 2 Protective measures can be taken so that no corona discharges occur within the measuring setup, as they would influence the measuring result.

- oscilloscope with a bandwidth of  $\geq 2$  GHz and a sampling rate of  $\geq 8$  GS/s;
- coaxial current target-attenuator-cable chain with the coaxial current target calibrated in accordance with Annex B.

NOTE 3 An example of a suitable target is specified in Annex C.

- attenuator(s) with sufficient power capability as necessary.

### 6.3.3 Setup for ESD generator current waveform calibration

The coaxial current target shall be mounted in a vertical calibration plane as shown in Figure 5. The RGP with dimensions as specified in Figure 5 and which encompasses the projection of the pulled back discharge return cable onto the RGP shall be electrically connected to the vertical calibration plane.

The generator shall be installed on a tripod or on an equivalent non-conductive support. The discharge tip shall be perpendicular to the vertical calibration plane.

The ESD generator shall make contact with the centre conductor of the coaxial current target to ensure electrical contact.

The connection for the discharge return cable shall be made as shown in Figure 5. The discharge return cable shall be pulled backwards at the middle of the cable, forming a triangle. During calibration, the discharge return cable shall not lay on the RGP or be held by operators.

Any external power supply of the ESD generator shall be placed on the RGP as shown in Figure 5. No conductive objects shall be placed within the dimensions (e.g. 1,5 m × 1,2 m) of the calibration setup in Figure 5. The cable between the power supply and the ESD generator shall be routed along the RGP and the vertical calibration plane.

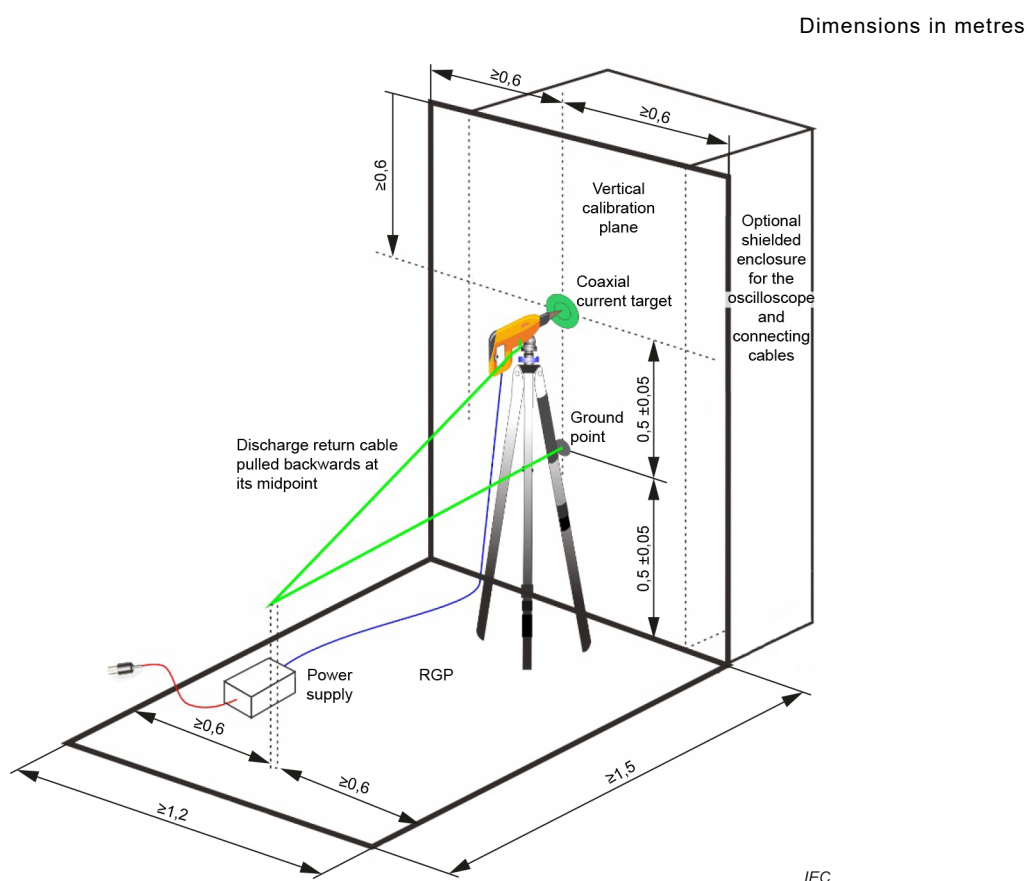


**Figure 5 – Arrangement for calibration of ESD generator performance**

Shielding of the oscilloscope is not necessary if it can be proven by measurement that parasitic coupling paths onto the measurement system do not influence the calibration results.

The measurement system can be declared sufficiently immune (i.e. no shielding necessary) if no triggering of the oscilloscope results when:

- the oscilloscope trigger level is set to  $\leq 10\%$  of the lowest test level, and
- the ESD generator is discharged with the highest test level to the outer ring of the coaxial current target (instead of to the centre conductor).

#### 6.3.4 Procedure for the ESD generator calibration

#### 6.3.4.1 General

All measured values and at least one discharge current waveform shall be recorded in the calibration report.

#### 6.3.4.2 Measuring the open-circuit output voltage

Measure the open-circuit output voltage of the ESD generator with the discharge switch activated and verify that it meets the requirements specified in Table 2.

#### 6.3.4.3 Measuring the current waveform parameters

Follow the steps specified below to verify if the current waveform of an ESD generator is within specifications. Record the waveform of five discharges for both polarities and measure the following parameters (see Figure 2 and Table 3) for each discharge:

- $I_{p1}$  1<sup>st</sup> peak value of the discharge current [A];
- $I_{p2}$  2<sup>nd</sup> peak value of the discharge current [A];
- $I_{30}$  value of the current 30 ns after the reference point (10 % of  $I_{p1}$ ) [A];
- $I_{60}$  value of the current 60 ns after the reference point (10 % of  $I_{p1}$ ) [A];
- $t_r$  rise time of the current [ns];

Verify that each value is within the limits specified in Table 3.

At least one recorded waveform of a contact discharge at 8 kV positive polarity shall be included in the calibration report.

### 7 Test setup

#### 7.1 General

The test setup consists of the EUT and AE as well as the ESD generator necessary to perform direct and indirect application of discharges to the EUT in the following manner:

- a) contact discharge to conductive surfaces and to coupling planes;
- b) air discharge to non-conductive surfaces.

The EUT shall be set up and operated in accordance with the product's specifications.

#### 7.2 Test equipment

##### 7.2.1 General

The ESD test setup includes:

- the ESD generator;
- the discharge tips;
- the discharge return cable;
- the bleeder resistor cables;
- the HCP (if applicable) and VCP;
- the insulating support;
- the RGP.

Examples of the ESD test setup for table-top equipment are shown in Figure 6 and Figure 8 and for floor-standing equipment in Figure 7 and Figure 9.

### 7.2.2 Verification of the ESD test equipment

The purpose of verification is to ensure that the ESD test equipment is operating as intended. One verification method can be to observe that at low voltage settings, a small spark is created during the approach of the discharge tip to the coupling plane and a larger spark is created at higher voltage settings. Both discharge tips shall be verified. Other methods of verification may be applied, for example self-verification.

**NOTE** Current waveform parameters from ESD generators do not typically change, for example rise time drift and drift of the duration of the waveform. The most likely ESD generator failures would be that no voltage is delivered to the discharge tip or that no voltage control is present. Any of the cables, resistors or connections along the discharge path can be damaged, loose or missing, resulting in no discharge.

## 7.3 Test setup for tests performed in laboratories

### 7.3.1 General

The test setups specified in 7.3 are basic test setups for table-top equipment and floor-standing equipment. For other kinds of equipment, if applicable, Annex I shall apply in addition to the requirements in 7.3.

### 7.3.2 Test conditions

The following requirements apply to tests performed in laboratories under environmental reference conditions specified in 8.2.

The RGP shall be a copper or aluminium sheet or plate of 0,25 mm minimum thickness; other metallic materials may be used but they shall have 0,65 mm minimum thickness.

The RGP shall project beyond the EUT and the horizontal coupling plane (where applicable) by at least 0,5 m on all sides and shall be connected to the protective grounding system. Local safety regulations can apply.

A minimum distance of 0,8 m shall be provided between the EUT and the walls of the laboratory and any other metallic structures.

The EUT and the ESD generator (including any external power supply) shall be grounded in accordance with their installation specifications. No additional grounding connections are allowed.

Any external power supply of the ESD generator shall be placed on the RGP.

The positioning of the power and signal cables of the EUT shall be representative of installation practice.

The discharge return cable of the ESD generator shall be connected to the RGP. In cases where the length of the cable exceeds the length necessary to apply the discharges to the selected points, the excess length shall be kept off the RGP and shall not be bundled or wound. The discharge return cable shall not come closer than 0,1 m to other conductive parts in the test setup.

The discharge return cable may be connected to the metallic wall of the test laboratory provided that wall is electrically bonded to the RGP.

The connections to the RGP and all bondings shall be of low impedance (e.g.  $\leq 0,1 \Omega$ ), for example by using mechanical clamping devices.

Where coupling planes are specified, for example to allow indirect application of the discharge, they shall be constructed from a copper or aluminium sheet of 0,25 mm minimum thickness. Other metallic materials may be used but they shall have 0,65 mm minimum thickness. The coupling planes shall be connected to the RGP via a cable with two  $(470 \pm 10 \%)$  k $\Omega$  resistors located up to 10 cm from each end (i.e. bleeder resistor cable). These resistors shall be capable of withstanding the discharge voltage. The resistors and cables shall be insulated to avoid short circuits to the RGP when the cable lies on the RGP.

NOTE 1 The  $(470 \pm 10 \%)$  k $\Omega$  resistors which are contained in the bleeder resistor cables of the HCP and VCP (see Figure 6, Figure 7, Figure 8, Figure 9, Figure I.1, Figure I.2) are used to prevent the charge applied to the planes disappearing instantly after the discharge of the ESD generator to the plane. This increases the impact of the ESD event to the EUT. They are positioned close to each end of the grounding cable in order to create a distributed resistance.

NOTE 2 Unless product committees decide otherwise, ESD tests on ceiling-mounted equipment are generally not applicable because such equipment is not touched by the user after installation.

Any mounting feet associated with the EUT shall remain in place. Any AE can be placed anywhere (e.g. outside the test environment, RGP, HCP). Interconnecting cables between the EUT and the AE may be decoupled either to protect the AE from discharges or because the EUT specification requires decoupled cables.

### 7.3.3 Table-top equipment

The test setup shall consist of a non-conductive support,  $(0,8 \pm 0,08)$  m high, standing on the RGP. The table may be replaced by any non-conductive support.

The HCP shall be placed on the table and connected to the RGP with the HCP bleeder resistor cable. The bleeder resistor cable shall have a maximum length of 1,5 m and shall be held apart from the HCP and RGP.

NOTE Generally the HCP bleeder resistor cable assembly is connected to the edge of the HCP in a vertical line to the RGP i.e. short connection (refer to Figure 6).

The HCP shall have a minimum area of 1,23 m<sup>2</sup> and shall be large enough to ensure that the EUT can be placed at least 0,1 m from the periphery of the HCP. The HCP may have different shapes (e.g. square, rectangular, circular). The HCP may be a combination of different HCPs that shall be bonded together with a low impedance; i.e. continuous connection along the edge.

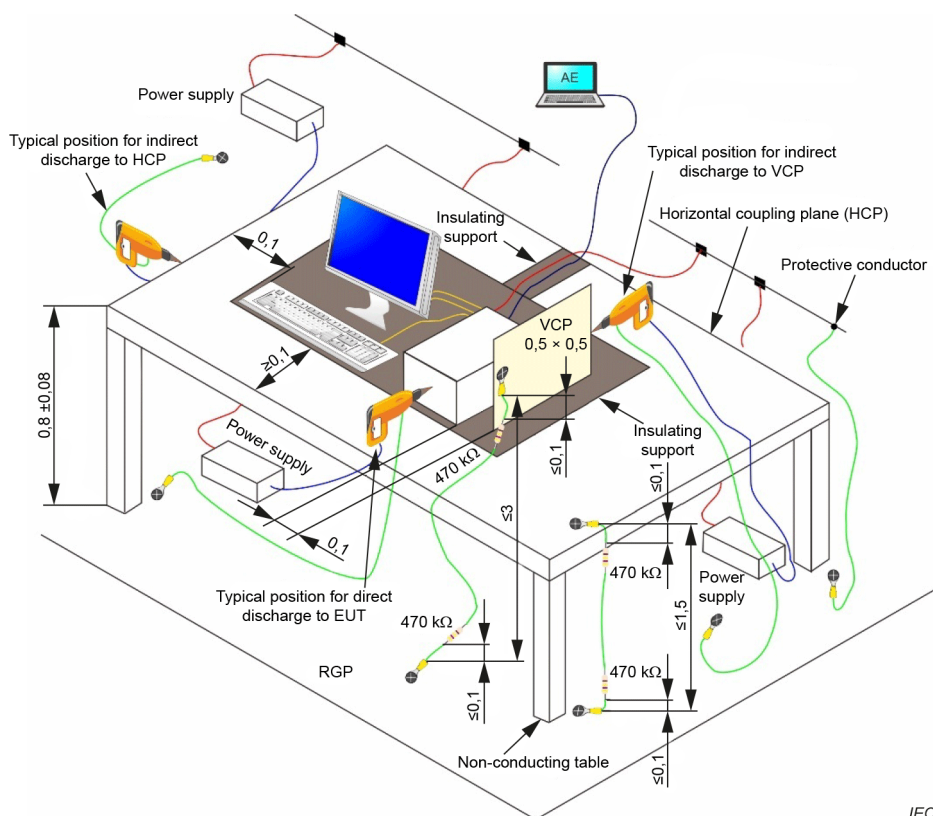
The size of the HCP shall correlate with the size of the EUT; i.e. the HCP shall not project more than 0,8 m beyond any edge of the EUT.

The EUT and its cables shall be separated from the HCP by an insulation with a thickness of  $(0,5 \pm 0,05)$  mm. The HCP bleeder resistor cable shall be connected to the HCP.

When performing indirect discharges, a square VCP of side length of  $(0,5 \pm 0,005)$  m shall be placed on a non-conductive support and shall be located  $(0,1 \pm 0,01)$  m from the side of the EUT. The VCP shall be isolated from the HCP and only be connected to the RGP by the VCP bleeder resistor cable. The VCP bleeder resistor cable assembly shall have a maximum length of 3 m and shall not be bundled.

An example of the test setup for table-top equipment is shown in Figure 6.

Dimensions in metres



IEC

Figure 6 – Example test setup for table-top equipment

### 7.3.4 Floor-standing equipment

The EUT shall be isolated from the RGP by a non-conductive support with a height of  $(0,1 \pm 0,05)$  m. The EUT cables shall be isolated from the RGP by an insulating support of  $(0,5 \pm 0,05)$  mm.

When performing indirect discharges, a square VCP of side length of  $(0,5 \pm 0,005)$  m shall be placed on the table and shall be located  $(0,1 \pm 0,01)$  m from the side of the EUT. The VCP shall be connected to the RGP by the VCP bleeder resistor cable. The VCP bleeder resistor cable assembly shall have a maximum length of 3 m and shall not be bundled.

An example test setup for floor-standing equipment is shown in Figure 7.