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Title: BS EN IEC 61000-4-2 Electromagnetic compatibility (EMC)

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

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- ii) affects other national standard(s)
- iii) requires additional national guidance or information

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



77B/864/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: IEC 61000-4-2 ED3	
DATE OF CIRCULATION: 2023-03-31	CLOSING DATE FOR COMMENTS: 2023-06-23
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IEC SC 77B : HIGH FREQUENCY PHENOMENA	
SECRETARIAT: France	SECRETARY: Mr Franck GRUFFAZ
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 44,TC 61,TC 62,SC 65A,TC 66,TC 77,SC 77A,TC 82,TC 108,TC 124,CIS/B,CIS/F,CIS/I	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☒ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE: Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test

NOTE FROM TC/SC OFFICERS:

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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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- International Standard IEC 61000-4-2 has been prepared by subcommittee 77B: High-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.
- This third edition cancels and replaces the second edition published in 2008 and constitutes a technical revision.
- It forms Part 4-2 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.
- The main changes with respect to the second edition of this standard are the following:
- Add a calibration requirement for ESD generators with air discharge tip;
 - Add a normative annex for test setups for specific equipment;
 - add a test method for wall mounted equipment and wearable devices (see Annex);
 - add an informative annex for wearable devices;

- 142 • add an informative annex for improvement of how to select test points and give guidance
143 on how to specify the number of pulses for direct contact discharges;
- 144 • improvement of the current calibration procedure;
- 145 • improvement of the measurement uncertainty considerations with examples of uncertainty
146 budgets;
- 147 • Because post installation tests cannot be performed in a controlled environment, this test
148 method has been moved into a new Annex H.

149 The text of this standard is based on the following documents:

FDIS	Report on voting
77B/xxx/FDIS	77B/xxx/RVD

150
151 Full information on the voting for the approval of this standard can be found in the report on
152 voting indicated in the above table.

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

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

156 The committee has decided that the contents of this publication will remain unchanged until
157 the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in
158 the data related to the specific publication. At this date, the publication will be

- 159 • reconfirmed,
160 • withdrawn,
161 • replaced by a revised edition, or
162 • amended.

163

INFORMATION TO NATIONAL COMMITTEES

This section is provided to National Committees for information and will be removed from the standard at next stage.

For clarification of misunderstandings or misinterpretation arising due to comparison between IEC 61000-4-2 Edition 2 and future Edition 3, the following issues are addressed:

1. Changing the calibration specifications for ESD generators outlined in this CD

Background: IEC 61000-4-2 Edition 2 defines four calibration parameters – namely I_p , t_r , I_{30} , I_{60} . This has never been changed since the publication of the first ESD standard. The currents I_{30} and I_{60} are just static single points randomly selected. Round robin tests in the past have shown, that ringing, which occurs randomly in current available generators, significantly impacts test results within the 10 – 40 ns window and that I_{p2} plays a major role. Therefore, the ringing should be reduced.

Rationale: The goal of MT12 is to reduce ringing particular occurring within the 10 – 40 ns window. MT12 had performed some round robin tests of ESD generators on the market and the outcome of those were reflected in 77B/841/CD (1st CD of maintenance). This resulted into a change of the waveform specification, which was calculated by taking the average wave forms of currently available generators. This was not appropriate because the wave form specified in Edition 2 is defined as the “Ideal contact discharge current waveform” supported by all NCs explaining why the waveform specification of Edition 2 was re-introduced in 77B/858/CD (2nd CD of maintenance). In order to achieve the goal of MT12, recent several investigations have demonstrated, that the maximum value of I_{p2} should be specified for calibration instead of I_{30} , which in any way also is within the proposed window because the maximum of (+) I_{p2} has a major influence on test results.

As a result, this CD (3rd CD of maintenance) includes the calibration of I_{p2} with the waveform specifications outlined in Edition 2! It is not the intention of MT12 to require that the wave form should be within the “dotted” window. Depending on the outcome of ongoing investigations, MT12 may come to the conclusion, that the calibration setup currently in Figure B.5 needs to be changed with respect to the cable layout of the ground return cable.

2. static (deterministic) failure approach vs. statistical approach

Due to a tie situation between the supporters and opponents on whether Annex H (escalation strategy) should be normative or informative, MT12 came to the conclusion to remove Annex H because Annex H reflects a statistical approach, which is not in-line with the deterministic failure approach mentioned in other basic standards (e.g. IEC 61000-4-3); i.e. if one failure occurs during the ESD test which is beyond the acceptable performance criterion, the EUT fails the test.

3. Test setups for specific EUTs

MT12 decided at its last meeting, that unless otherwise requested by product committees MT12 will not add specific test setups in their basic standards. MT12 also prefers to have the two basic test setups (i.e. table-top and floor standing) in the main text while other EUT specific test setups are summarized in an normative Annex (see current Annex I).

166 INTRODUCTION

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

168 Part 1: General

169 General consideration (introduction, fundamental principles)

170 Definitions, terminology

171 Part 2: Environment

172 Description of the environment

173 Classification of the environment

174 Compatibility levels

175 Part 3: Limits

176 Emission limits

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

179 Part 4: Testing and measurement techniques

180 Measurement techniques

181 Testing techniques

182 Part 5: Installation and mitigation guidelines

183 Installation guidelines

184 Mitigation methods and devices

185 Part 6: Generic standards

186 Part 9: Miscellaneous

187 Each part is further subdivided into several parts, published either as international standards
188 or as technical specifications or technical reports, some of which have already been published
189 as sections. Others will be published with the part number followed by a dash and a second
190 number identifying the subdivision (example: IEC 61000-6-1).

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

193

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 object of this standard 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 to the equipment.

This standard specifies:

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

This standard gives specifications for tests performed in "laboratories" and "post-installation tests" performed on equipment in the final installation.

This standard does not intend to specify the tests to be applied to particular apparatus or systems. Its main aim is to give a general basic reference to all concerned product committees. The product committees (or users and manufacturers of equipment) remain responsible for the appropriate choice of the tests and the severity level to be applied to their equipment.

NOTE This document excludes tests intended to evaluate the ESD sensitivity of devices for handling and packaging or to evaluate the performance of the ESD protection circuits.

2 Normative references

The following referenced documents are indispensable for the application 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) – Chapter 161: Electromagnetic compatibility*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this part of IEC 61000, the following terms and definitions apply and are applicable to the restricted field of electrostatic discharge; not all of them are included in IEC 60050(161) [IEV].

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]

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 static dissipative material

material exhibiting properties which minimize charge generation when rubbed against or separated from the same or other similar materials

3.1.4 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]

3.1.5 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

3.1.6 coupling plane

metal sheet or plate, to which discharges are applied to simulate electrostatic discharge to objects adjacent to the EUT; HCP: Horizontal Coupling Plane; VCP: Vertical Coupling Plane

3.1.7 degradation (in performance)

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

NOTE to entry The term "degradation" can apply to temporary or permanent failure.

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

3.1.8 direct application

application of the discharge directly to the EUT

276 **3.1.9**
277 **electromagnetic compatibility (EMC)**
278 ability of equipment or a system to function satisfactorily in its electromagnetic environment
279 without introducing intolerable electromagnetic disturbances to anything in that environment

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

281 **3.1.10**
282 **electrostatic discharge (ESD)**
283 transfer of electric charge between bodies of different electric potential in proximity or through
284 direct contact

285 NOTE to entry Literature and teaching generally refer to transfers of charge, although strictly speaking charge
286 carriers (113-06-25) are transferred.

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

288 **3.1.11**
289 **energy storage capacitor**
290 capacitor of the ESD-generator representing the capacity of a human body charged to the test
291 voltage value

292 NOTE to entry This element can be provided as a discrete component or a distributed capacitance.

293 **3.1.12**
294 **EUT**
295 equipment under test

296 **3.1.13**
297 **holding time**
298 interval of time within which the decrease of the test voltage due to leakage, prior to the
299 discharge, is not greater than 10 %

300 **3.1.14**
301 **immunity (to a disturbance)**
302 ability of a device, equipment or system to perform without degradation in the presence of an
303 electromagnetic disturbance

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

305 **3.1.15**
306 **indirect application**
307 application of the discharge to a coupling plane in the vicinity of the EUT to simulate
308 personnel discharge to objects which are adjacent to the EUT

309 **3.1.16**
310 **reference ground plane (RGP)**
311 flat conductive surface that is at the same electric potential as reference ground, which is
312 used as a common reference, and which contributes to a reproducible parasitic capacitance
313 with the surroundings of the equipment under test (EUT)

314 NOTE to entry In some regions, the term 'earth' is used in place of 'ground'.

315 [SOURCE: IEC 60050-161:2014, 161-04-36]

316 **3.1.17**
317 **rise time**
318 interval of time between the instants at which the instantaneous value of a pulse first reaches
319 the specified lower and upper limits

320 NOTE to entry Unless otherwise specified, the lower and upper values are fixed at 10 % and 90 % of the pulse
321 magnitude.

322 [SOURCE: IEC 60050-161:1990, 161-02-05, modified]

323 3.1.18

324 verification

325 set of operations which is used to check the test equipment system (e.g. the test generator
326 and the interconnecting cables) and to gain confidence that the test system is functioning.
327 Details are given in 7.2.2.

328 NOTE 1 The methods used for verification may be different from those used for calibration.

329 NOTE 2 For the purpose of this basic EMC standard this definition is different from the definition given in
330 IEC 311-01-13.

331 3.2 Abbreviated terms

332	AD	Air Discharge
333	AE	Auxiliary Equipment
334	CD	Contact Discharge
335	EMC	Electro-Magnetic Compatibility
336	ESD	Electro-Static Discharge
337	EUT	Equipment Under Test
338	HCP	Horizontal Coupling Plane
339	HV	High Voltage
340	MU	Measurement Uncertainty
341	PE	Protective Earth
342	RGP	Reference Ground Plane
343	VCP	Vertical Coupling Plane

344 4 General

345 This standard relates to equipment, systems, subsystems and peripherals which can be
346 involved in static electricity discharges owing to environmental and installation conditions,
347 such as low relative humidity, use of low-conductivity (artificial-fiber) carpets, vinyl garments,
348 etc., which can exist in all locations classified in standards relevant to electrical and electronic
349 equipment (for more detailed information, see Annex A).

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

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

357 5 Test levels

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

359 Contact discharge is the preferred test method. Air discharges shall be used where contact
360 discharge cannot be applied. Voltages for each test method are given in Table 1. The
361 voltages shown are different for each method due to the differing test methods. This does not
362 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 charged 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 discharge testing, the test shall be applied at the specified test level only unless otherwise specified by product committees.

Further information is given in Clauses A.3 – 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
x ^a	special	special
^a "x" can be any level, above, below or in between the others. The level shall be specified in the dedicated equipment specification. If higher voltages than those shown are specified, special test equipment may be needed.		

6 Test equipment

6.1 Overview

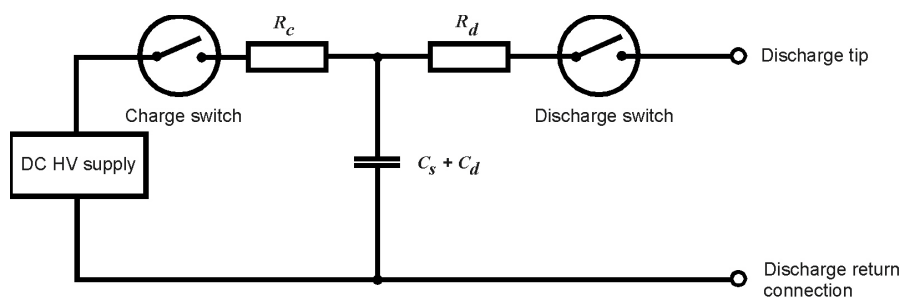
The characteristics in 6.2.2 and the calibration procedure in 6.3 and Annex B ensure the correct operation of the ESD generator so that the intended waveform is delivered to the EUT.

6.2 ESD generator

6.2.1 General

A simplified diagram of the ESD generator is given in Figure 1. Constructional details are not given. The test generator consists, in its main parts, of

- 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.



IEC

Components

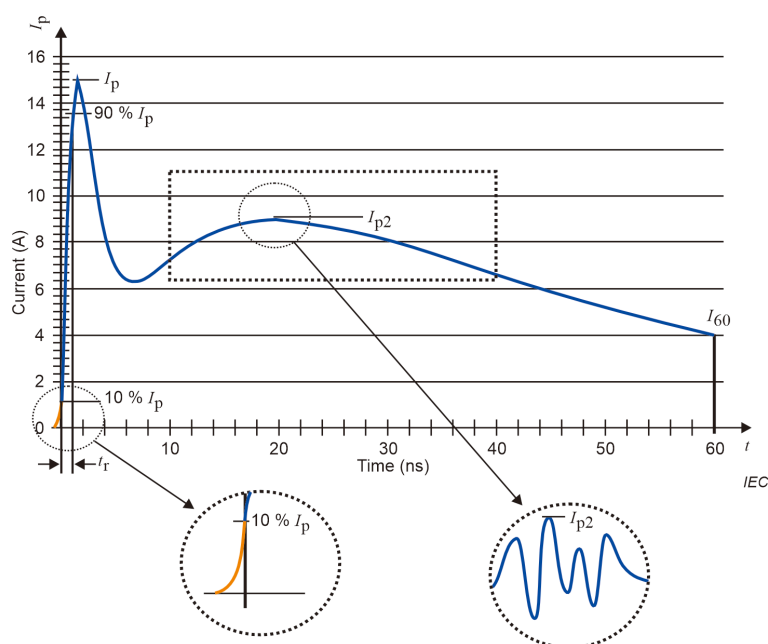
C_d is a distributed capacitance which exists between the generator and its surroundings.

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

R_d has a typical value of 330 Ω .

Figure 1 – Simplified diagram of the ESD generator

The generator shall meet the requirements given in 6.2.2 and indicated in Figure 2 when evaluated according to the procedures in Annex B. Therefore, neither the diagram in Figure 1, nor the component values are specified in detail.



IEC

Figure 2 – Contact discharge current waveform at 4 kV

An equation 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

405

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

406

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

407 and

408 $\tau_1 = 1,1 \text{ ns}$; $\tau_2 = 2,0 \text{ ns}$; $\tau_3 = 12,0 \text{ ns}$; $\tau_4 = 37,0 \text{ ns}$;409 $I_1 = 16,6 \text{ A}$ (at 4 kV); $I_2 = 9,3 \text{ A}$ (at 4 kV);410 $n = 1,8$.411 **6.2.2 General characteristics**412 **6.2.2.1 Specifications of the ESD generator**

413 The characteristics of the ESD generator are given in Table 2 and Table 3.

414

Table 2 – General specifications

Parameters	Values
Output voltage, contact discharge mode (see NOTE 1)	At least 1 kV to 8 kV, nominal
Output voltage, air discharge mode (see NOTE 1)	At least 2 kV to 15 kV, nominal (see NOTE 3)
Tolerance of output voltage	±5 %
Polarity of output voltage	Positive and negative
Holding time	≥5 s
Discharge mode of operation	Single discharges (see NOTE 2)
NOTE 1 Open circuit voltage measured at the discharge tip of the ESD generator.	
NOTE 2 The generator should be able to generate at a repetition rate of at least 20 discharges per second for exploratory purposes.	
NOTE 3 It is not necessary to use a generator with 15 kV air discharge capability if the maximum test voltage to be used is lower.	

Table 3 – Discharge current waveform parameters

Level		Indicated voltage	First peak current I_p of discharge ($\pm 15\%$)	Rise time t_r ($\pm 25\%$)	Second peak current I_{p2} of discharge (see note 2) ($\pm 30\%$)	Current at 60 ns ($\pm 30\%$)
CD	AD	kV	A	ns	A	A
1	1	2	7,5	0,8	4,5	2,0
2	2	4	15,0	0,8	9,0	4,0
3	---	6	22,5	0,8	13,5	6,0
4	3	8	30,0	0,8	18,0	8,0
---	4	15	56,3	0,8	33,8	15,0

The reference point for measuring the time for the current at 60 ns is the instant when the current first reaches 10 % of the 1st peak of the discharge current.

NOTE 1 The rise time, t_r , is the time interval between 10 % and 90 % value of 1st peak current.

NOTE 2 This is the maximum current which occurs in the time frame of 10 to 40 ns from the reference point.

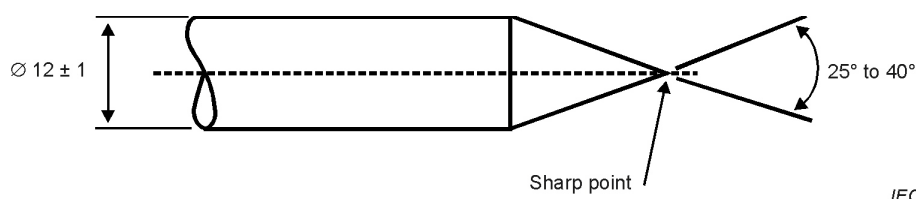
The generator should be provided with means of preventing unintended radiated or conducted emissions, either of pulse or continuous type, so as not to disturb the EUT or auxiliary test equipment by parasitic effects (see Annex D).

The discharge return cable of the test generator shall be at least 2 m long, and constructed to allow the generator to meet the specifications. 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 is 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 to personnel or conducting surfaces other than via its termination, during the ESD test.

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 according to 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.

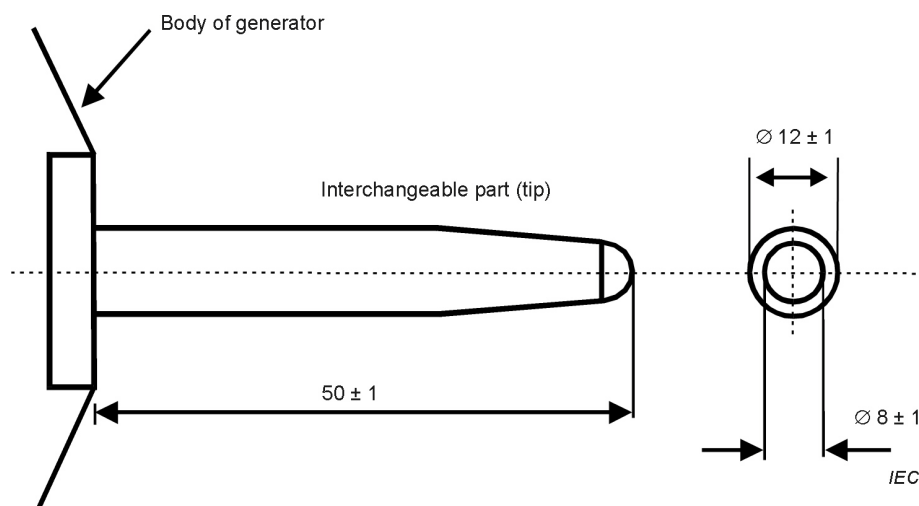


Figure 4 – Air discharge tip of the ESD generator without insulated coating

6.3 Calibration of the characteristics of the ESD generator

The ESD generator characteristics shall be calibrated in order to establish that they meet the requirements of this standard.

The ESD generator including the respective discharge tips (air and contact) shall meet the specifications given in Table 2 and Table 3. It shall be demonstrated that these specifications are fulfilled using the calibration methods described in Annex B.

If the contact- and air discharge tips consist of a conductor without any electronic components, the calibration procedure for the air discharge tip can be limited to the measurement of open circuit voltage at the discharge electrode at the maximum test voltage used.

NOTE 1 Some generators cannot be calibrated at 15 kV air discharge. In this case, a calibration at a lower level is generally sufficient.

NOTE 2 If the difference between air- and contact discharge tip is limited to the characteristics as in 6.2.2.2, 6.2.2.3, a calibration for the air discharge tip at any level is generally sufficient.

7 Test setup

7.1 General

The test setup consists of the test generator, EUT and auxiliary instrumentation necessary to perform direct and indirect application of discharges to the EUT in the following manner:

- a) contact discharge to the 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 specification.

7.2 Test equipment

7.2.1 General

The ESD test setup includes:

- the ESD generator;
- the discharge tips;

- 465 – the discharge return cable;
- 466 – the bleeder resistors;
- 467 – the HCP (if applicable) and VCP;
- 468 – the insulating support;
- 469 – the RGP.

470 Examples for the ESD test setup are given in Figure 5 and Figure 7 for table-top equipment
471 and in Figure 6 and Figure 8 for floor standing equipment.

472 **7.2.2 Verification of the ESD setup**

473 The purpose of verification is to ensure that the ESD test system is operating. To verify the
474 proper operation of the ESD test system, one verification method can be to observe that at
475 low voltage settings, a small spark is created during the approach of the discharge tip to the
476 coupling plane and a larger spark is created at higher voltage settings. Both discharge tips
477 need to be verified. If available, a self-verification procedure of the ESD test system can also
478 be applied.

479 Rationale: Since waveforms from ESD generators do not typically change in minor ways (for
480 example, the rise time and duration of the waveform do not drift), the most likely ESD
481 generator failures would be that no voltage was delivered to the discharge tip or that no
482 voltage control was present. Any of the cables, resistors or connections along the discharge
483 path can be damaged, loose or missing, resulting in no discharge.

484 It is recommended that the ESD test setup is verified prior to testing.

485 **7.3 Test setup for tests performed in laboratories**

486 **7.3.1 General**

487 The test setups described in this clause are generally called basic test setups, which consists
488 of table-top equipment and floor-standing equipment. For particular kind of equipment,
489 Annex I shall apply for additional or further test setups in addition to this clause.

490 **7.3.2 Test conditions**

491 The following requirements apply to tests performed in laboratories under environmental
492 reference conditions outlined in 8.2.

493 The RGP shall be a metallic sheet (copper or aluminum) of 0,25 mm minimum thickness;
494 other metallic materials may be used but they shall have 0,65 mm minimum thickness.

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

497 Local safety regulations shall always be met.

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

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

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

504 NOTE 1 The external power supply unit including the cable creates a parasitic capacitance to the RGP and
505 influences the discharge current waveform. Therefore it is important to have the same setup for both – testing and
506 calibration.

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

509 The discharge return cable of the ESD generator shall be connected to the RGP. In cases
510 where the length of the cable exceeds the length necessary to apply the discharges to the
511 selected points, the excess length shall be kept off the RGP. The discharge return cable shall
512 not come closer than 0,2 m to other conductive parts in the test setup and shall not be held by
513 operators during testing.

514 NOTE 2 The discharge return cable can be connected to the metallic wall of the test laboratory provided that wall
515 is electrically bonded to the RGP.

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

518 Where coupling planes are specified, for example to allow indirect application of the
519 discharge, they shall be constructed from a metallic sheet (copper or aluminum) of 0,25 mm
520 minimum thickness (other metallic materials may be used but they shall have 0,65 mm
521 minimum thickness). The coupling planes shall be connected to the RGP via a cable with two
522 ($470 \pm 10 \%$) k Ω resistors located up to 10 cm from each end (i.e. bleeder resistor cable).
523 These resistors shall be capable of withstanding the discharge voltage. The resistors and
524 cables shall be insulated to avoid short circuits to the RGP when the cable lies on the RGP.

525 NOTE 3 The ($470 \pm 10 \%$) k Ω resistors which are contained in the bleeder resistor cables of the HCP and VCP
526 (see Figure 5, Figure 6, Figure 7, Figure 8, Figure I.1) are used to prevent the charge applied to the planes
527 disappearing instantly after the discharge of the ESD generator to the plane. This increases the impact of the ESD
528 event to the EUT. Technology and materials of these resistors can be chosen in order to minimize inductance; e.g.
529 metal film resistors have lower inductance than wirewound resistors. They are positioned close to each end of the
530 grounding cable in order to create a distributed resistance.

531 NOTE 4 Unless Product Committees decide otherwise, ESD tests on ceiling mounted equipment are generally not
532 applicable because such equipment is not touched by the user after installation.

533 Any mounting feet associated with the EUT shall remain in place. Any AE can be placed
534 outside the test environment or on the RGP. Interconnecting cables between the EUT and the
535 AE can be decoupled.

536 7.3.3 Table-top equipment

537 The test setup shall consist of a non-conductive table, ($0,8 \pm 0,08$) m high, standing on the
538 RGP.

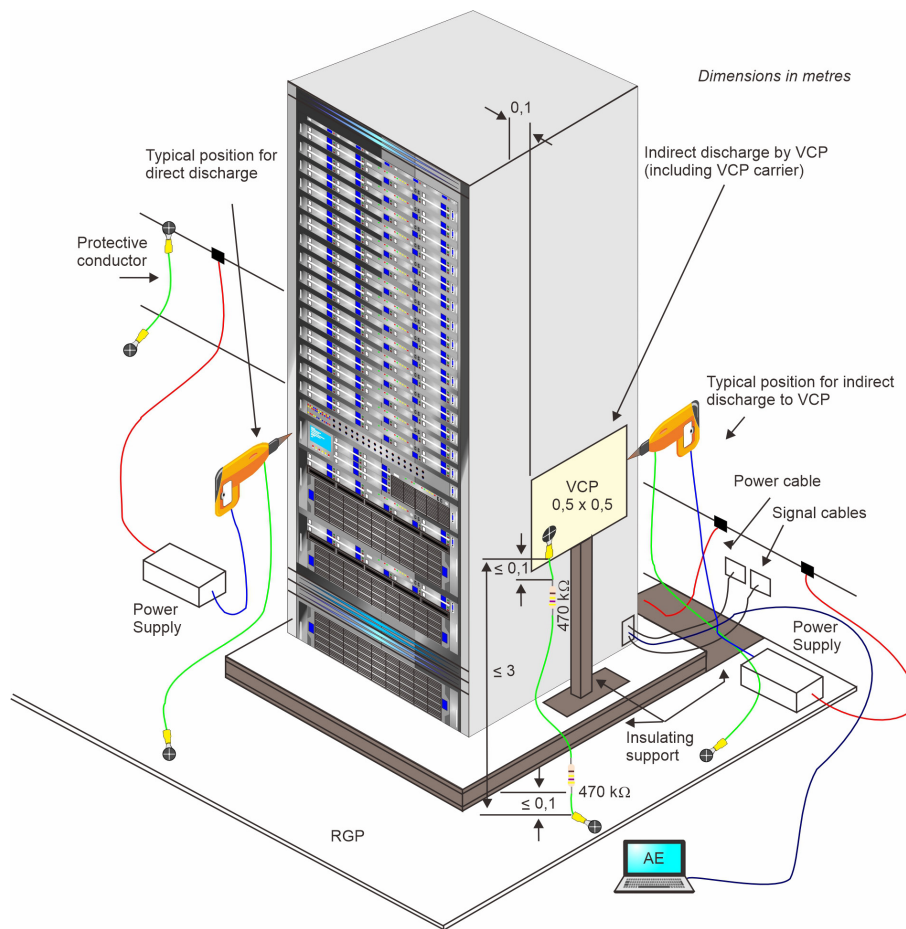
539 The HCP shall be placed on the table. The HCP shall have a minimum area of 1,28 m² and
540 shall be large enough to ensure that the EUT can be placed at least 0,1 m from the periphery
541 of the HCP.

542 NOTE 1 The HCP can have different shapes (e.g. square, rectangular, circular).

543 NOTE 2 The HCP can be a combination of different HCPs that are bonded together with a low impedance; i.e.
544 continuous connection along the edge

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

547 The EUT and its cables shall be isolated from the HCP by an insulating support ($0,5$
548 $\pm 0,05$) mm in thickness. The HCP bleeder resistor cable shall be connected on the opposite
549 side of the HCP injection point. The HCP bleeder resistor cable assembly shall have a
550 maximum length of 1,5 m and shall be held apart from the HCP and RGP.



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Figure 6 – Example of test setup for floor-standing equipment

Any mounting feet associated with the EUT shall remain in place. Post-installation tests can be an alternative test method for large sized equipment or system, which do not fit into laboratories – see Annex H for details.

7.3.5 Particular requirements for ungrounded equipment

The test setup described in this clause is applicable to equipment or part(s) of equipment whose installation specifications or design precludes connection to any grounding system. This includes portable, battery-operated (internal and external) with or without charger (ungrounded power cable) and double-insulated equipment (e. g. class II equipment). It covers table-top equipment (see Figure 7) and floor-standing equipment (see Figure 8).

Rationale: Ungrounded equipment, or ungrounded part(s) of equipment, cannot discharge itself similarly to class I mains-supplied equipment. If the charge is not removed before the next ESD pulse is applied, it is possible that the EUT or part(s) of the EUT be stressed up to twice the intended test voltage. Therefore, this type of equipment or equipment parts could accumulate an unrealistically high charge from several ESD discharges onto the capacitance of the class II insulation, and then discharge at the breakdown voltage of the insulation with a much higher energy.

NOTE 1 For products that have user accessible floating pieces of metal, contact discharge to the floating metal could result in a secondary discharge inside the product and cause failures. Depending on the size of the gap between the floating exposed metal and internal ground structures, sometimes at lower voltage levels the secondary discharge may be directed closer to sensitive electronics or be more pronounced than higher levels. This is also true in cases where a grounding path that relies on a thin insulation layer like conductive adhesive exists. At higher voltage levels, ESD may always arc through the thin adhesive but at lower levels the spark may be forced to take a different path and cause failures. For products such as hand-held devices, Product Committees can define for contact discharges also to be applied at lower test levels.

593 The general test setup shall be identical to the ones described in 7.3.3, 7.3.4 and – if
594 applicable – Annex I respectively.

595 To simulate a single ESD event (either by air or by contact discharge), the charge on the EUT
596 shall be removed prior to each applied ESD pulse.

597 The charge on the metallic point or part to which the ESD pulse is to be applied, for example,
598 connector shells, battery charge pins, metallic antennas, shall be removed prior to each
599 applied ESD test pulse.

600 When one or more metallic accessible parts are subjected to the ESD test, the charge shall
601 be removed from the point where the ESD pulse is to be applied, as no guarantee can be
602 given about the resistance between this and other accessible points on the product.

603 A cable with 470 kΩ bleeder resistors, similar to the one used with the HCP and VCP is the
604 preferred device to remove charges; see 7.3.2.

605 As the capacitance between EUT and HCP (table-top) and between EUT and RGP (floor-
606 standing) is determined by the size of the EUT, the cable with bleeder resistors may remain
607 installed between the EUT and RGP during the ESD test when it will not affect the EUT
608 functioning.

609 The presence of the cable with the bleeder resistors can influence the test results of some
610 equipment. A test with the cable disconnected during the ESD pulse takes precedence over
611 the test with the cable installed during the test, provided that the charge has sufficiently
612 decayed between the successive discharges.

613 Therefore as an alternative, the following options may be used:

- 614 – the time interval between successive discharges shall be extended to the time
615 necessary to allow natural decay of the charge from the EUT;
- 616 – sweeping of the EUT with a grounded carbon fibre brush with bleeder resistors (for
617 example, $2 \times 470 \text{ k}\Omega$) in the grounding cable.

618 NOTE 2 To ensure the charge has decayed, the charge on the EUT can be monitored by a non-contacting electric
619 field meter. When the charge has decayed below 10 % of the test voltage, the EUT is considered to be discharged.

620 NOTE 3 Some ESD generators contain an automatic discharge function. The use of such a feature is deemed to
621 be equivalent with the use of a cable with bleeder resistors.