

Australian/New Zealand Standard™

Electromagnetic compatibility (EMC)

Part 4.2: Testing and measurement techniques—Electrostatic discharge immunity test



AS/NZS IEC 61000.4.2:2013

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Australian/New Zealand Standard™

Electromagnetic compatibility (EMC)

Part 4.2: Testing and measurement techniques—Electrostatic discharge immunity test

Originated as AS/NZS 61000.4.2:2002.
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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee TE-003, Electromagnetic Interference, to supersede AS/NZS 61000.4.2:2002.

The objective 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 may occur from personnel to objects near vital equipment.

This Standard is identical with, and has been reproduced from IEC 61000-4-2, Ed.2.0 (2008), *Electromagnetic compatibility (EMC), Part 4-2: Testing and measurement techniques—Electrostatic discharge immunity test*.

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number appears on the cover and title page while the International Standard number appears only on the cover.
- (b) In the source text 'this part of IEC 61000' should read 'this Australian/New Zealand Standard'.
- (c) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian Standards, as follows:

<i>Reference to International Standard</i>		<i>Australian Standard</i>	
IEC		AS	
60068	Environmental testing	60068	Environmental testing
60068-1	Part 1: General and guidance	60068.1	Part 1: General and guidance

Only international references that have been adopted as Australian or Australian/New Zealand Standards have been listed.

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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.

NOTES

AUSTRALIAN/NEW ZEALAND STANDARD

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 defines 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 may occur from personnel to objects near vital equipment.

This standard defines:

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

This standard gives specifications for test 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 of the IEC. 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.

In order not to impede the task of coordination and standardization, the product committees or users and manufacturers are strongly recommended to consider (in their future work or revision of old standards) the adoption of the relevant immunity tests specified in this standard.

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*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

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3 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

air discharge method

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

3.2

antistatic material

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

3.3

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 This term is based on the "uncertainty" approach.

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

[IEV 311-01-09]

3.4

conformance test

test on a representative sample of the equipment with the objective of determining whether the equipment, as designed and manufactured, can meet the requirements of this standard

3.5

contact discharge method

method of testing in which the electrode 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

3.6

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

3.7

degradation (of performance)

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

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

[IEV 161-01-19]

3.8

direct application

application of the discharge directly to the EUT

3.9

electromagnetic compatibility (EMC)

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

[IEV 161-01-07]

3.10**electrostatic discharge (ESD)**

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

[IEV 161-01-22]

3.11**energy storage capacitor**

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

NOTE This element may be provided as a discrete component or a distributed capacitance.

3.12**EUT**

equipment under test

3.13**ground reference plane (GRP)**

flat conductive surface whose potential is used as a common reference

[IEV 161-04-36]

3.14**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 %

3.15**immunity (to a disturbance)**

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

[IEV 161-01-20]

3.16**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

3.17**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 Unless otherwise specified, the lower and upper values are fixed at 10 % and 90 % of the pulse magnitude.

[IEV 161-02-05, modified]

3.18**verification**

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

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

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

4 General

This standard relates to equipment, systems, subsystems and peripherals which may be involved in static electricity discharges owing to environmental and installation conditions, such as low relative humidity, use of low-conductivity (artificial-fiber) carpets, vinyl garments, etc., which may exist in all locations classified in standards relevant to electrical and electronic equipment (for more detailed information, see Clause A.1).

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 standard.

5 Test levels

The preferred range of test levels for the ESD test is given 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 given in Table 1. The voltages shown are different for each method due to the differing methods of test. This does not imply that the test severity is equivalent between test methods.

Details concerning the various parameters which may influence the voltage to which the human body may be charged are given in Clause A.2. Clause A.4 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.4 and A.5.

Table 1 – Test levels

Contact discharge		Air discharge	
Level	Test voltage kV	Level	Test voltage kV
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15
x ^a	Special	x ^a	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 generator

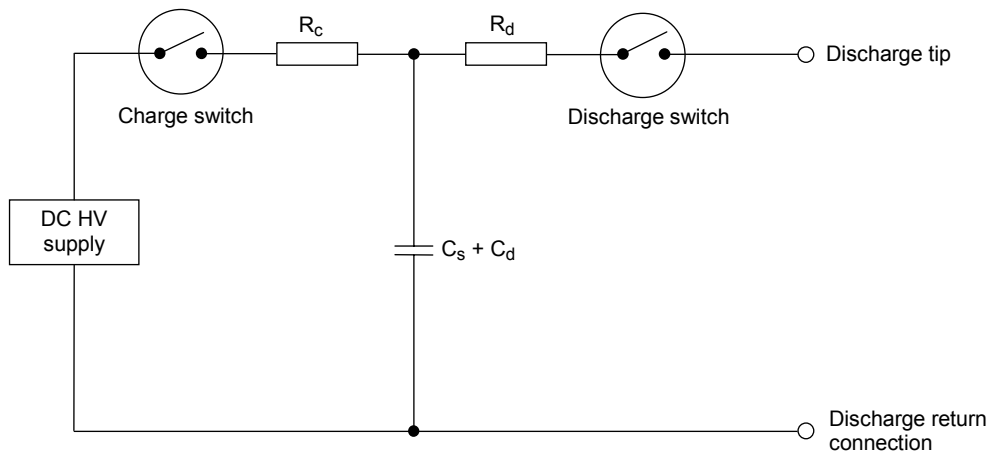
6.1 General

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 tips of the discharge electrode (see Figure 3);
- discharge return cable;
- power supply unit.

A simplified diagram of the ESD generator is given in Figure 1. Constructional details are not given.



NOTE 1 C_d is a distributed capacitance which exists between the generator and its surroundings.

NOTE 2 $C_d + C_s$ has a typical value of 150 pF.

NOTE 3 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 when evaluated according to the procedures in Annex B. Therefore, neither the diagram in Figure 1, nor the element values are specified in detail.

6.2 Characteristics and performance of the ESD generator

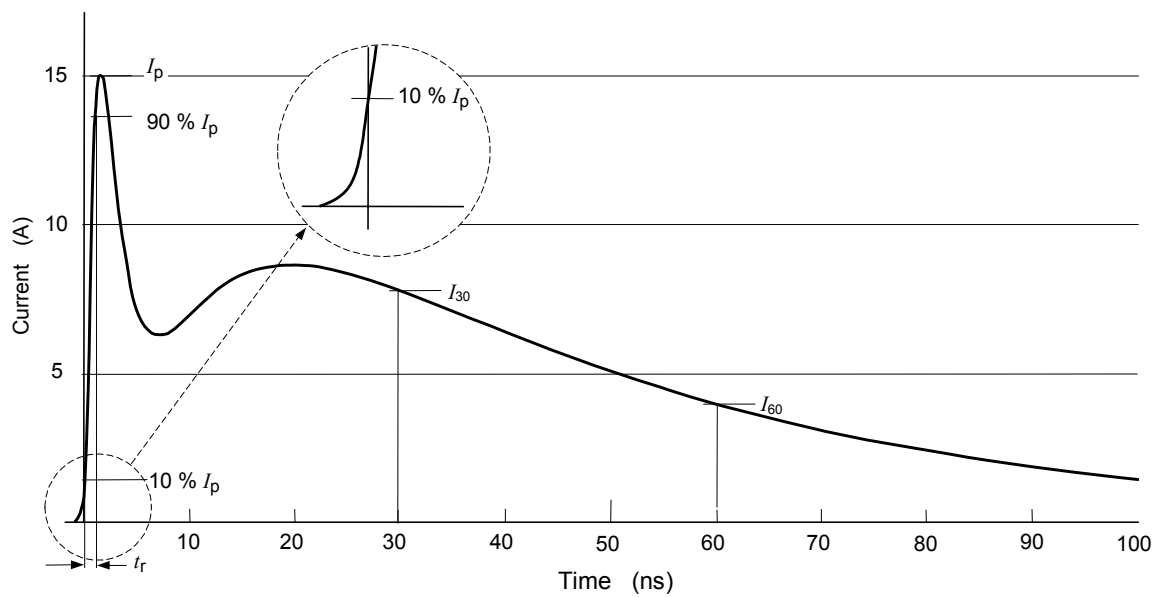
The test generator shall meet the specifications given in Tables 2 and 3. Figure 2 shows an ideal current waveform and the measurement points referred to in Tables 2 and 3. Conformance with these specifications shall be demonstrated according to the methods described in Annex B.

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)
<p>NOTE 1 Open circuit voltage measured at the discharge electrode of the ESD generator.</p> <p>NOTE 2 The generator should be able to generate at a repetition rate of at least 20 discharges per second for exploratory purposes.</p> <p>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.</p>	

Table 3 – Contact discharge current waveform parameters

Level	Indicated voltage kV	First peak current of discharge ±15 % A	Rise time t_r (±25 %) ns	Current (±30 %) at 30 ns A	Current (±30 %) at 60 ns A
1	2	7,5	0,8	4	2
2	4	15	0,8	8	4
3	6	22,5	0,8	12	6
4	8	30	0,8	16	8
<p>The reference point for measuring the time for the current at 30 ns and 60 ns is the instant when the current first reaches 10 % of the 1st peak of the discharge current.</p> <p>NOTE The rise time, t_r, is the time interval between 10 % and 90 % value of 1st peak current.</p>					



IEC 2206/08

Figure 2 – Ideal contact discharge current waveform at 4 kV

The equation for the idealized waveform of 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

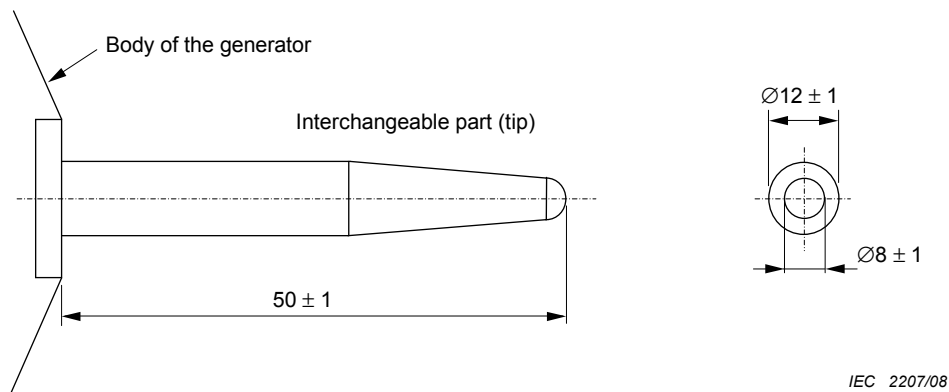
$$\tau_1 = 1,1 \text{ ns}; \tau_2 = 2 \text{ ns}; \tau_3 = 12 \text{ ns}; \tau_4 = 37 \text{ ns};$$

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

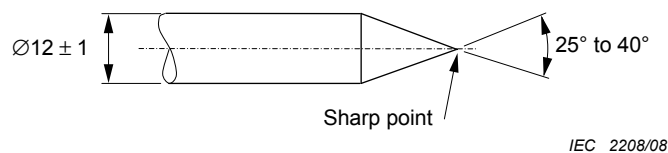
$$n = 1,8.$$

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 electrodes shall conform to the shapes and dimensions shown in Figure 3. The electrodes may be covered with insulated coatings, provided the discharge current waveform specifications are met.



3a) – Discharge electrode for air discharges



3b) – Discharge electrode for contact discharges

Figure 3 – Discharge electrodes of the ESD generator

For the air discharge test method the same generator is used and the discharge switch has to be closed. The generator shall be fitted with the round tip shown in Figure 3a). Because the same ESD generator is used no further specifications for the air discharge method exist.

The discharge return cable of the test generator shall be $(2 \pm 0,05)$ m long, and constructed to allow the generator to meet the waveform specification. 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 or identical with the cable used during calibration.

In cases where a 2 m length of the discharge return cable is insufficient, (e.g. for tall EUTs), a length up to 3 m may be used. The waveform specification shall be met with the cable(s) used during testing.

6.3 Verification of the ESD setup

The purpose of verification is to ensure that the ESD test setup is operating. The ESD test setup includes:

- the ESD generator;
- the discharge return cable;
- the 470 k Ω bleeder resistors;
- the ground reference plane, and,
- all of the connections that form the discharge path.

Examples for the ESD test setup are given in Figure 4 for table-top equipment and in Figure 5 for floor-mounted equipment.

To verify the proper ESD test setup, one verification method may be to observe that at low voltage settings, a small spark is created during air discharge to the coupling plane and a larger spark is created at higher settings. It is essential to verify the ground strip connection and location prior to this verification.

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

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

7 Test setup

7.1 Test equipment

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 at insulating surfaces.

Two different types of tests can be distinguished:

- type (conformance) tests performed in laboratories;
- post installation tests performed on equipment in its final installed conditions.

The preferred test method is that of type tests performed in laboratories.

The EUT shall be arranged in accordance with the manufacturer's instructions for installation (if any).

7.2 Test setup for tests performed in laboratories

7.2.1 Test requirements

The following requirements apply to tests performed in laboratories under environmental reference conditions outlined in 8.1.

A ground reference plane (GRP) shall be provided on the floor of the laboratory. It shall be a metallic sheet (copper or aluminum) of 0,25 mm minimum thickness; other metallic materials may be used but they shall have at least 0,65 mm minimum thickness.

The ground reference plane (GRP) shall project beyond the EUT or the horizontal coupling plane (when applicable) by at least 0,5 m on all sides, and shall be connected to the protective grounding system.

Local safety regulations shall always be met.

The EUT shall be arranged and connected according to its functional requirements.

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

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

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

The discharge return cable of the ESD generator shall be connected to the ground reference plane. Only in cases where the length of the cable exceeds the length necessary to apply the discharges to the selected points, the excess length shall, where possible, be placed non-inductively off the ground reference plane. The discharge return cable shall not come closer than 0,2 m to other conductive parts in the test setup except the ground reference plane.

NOTE 1 It is allowed to connect the discharge return cable to the metallic wall of the test laboratory provided that wall is electrically bonded to the GRP.

The connection of the earth cables to the ground reference plane and all bondings shall be of low impedance, for example by using mechanical clamping devices for high frequency applications.

Where coupling planes are specified, for example to allow indirect application of the discharge, they shall be constructed from a metallic sheet (copper or aluminum) of 0,25 mm minimum in thickness (other metallic materials may be used but they shall have at least 0,65 mm minimum in thickness) and shall be connected to the GRP via a cable with a 470 k Ω resistor located at each end. These resistors shall be capable of withstanding the discharge voltage. The resistors and cables shall be insulated to avoid short circuits to the GRP when the cable lies on the GRP.

NOTE 2 The 470 k Ω bleeder resistors which are contained in the grounding cables of the HCP and VCP (see Figures 4 to 8) 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. The resistors should be capable of withstanding the maximum discharge voltage applied to the EUT plane during the test. They should be positioned close to each end of the grounding cable in order to create a distributed resistance.

Additional specifications for the different types of equipment are given below.

7.2.2 Table-top equipment

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

A horizontal coupling plane (HCP), $(1,6 \pm 0,02)$ m $\times$ $(0,8 \pm 0,02)$ m, shall be placed on the table. The EUT and its cables shall be isolated from the coupling plane by an insulating support $(0,5 \pm 0,05)$ mm in thickness.

NOTE It is recommended that the insulating properties are maintained.

If the EUT is too large to be located 0,1 m minimum from all sides of the HCP, an additional, identical HCP shall be used, placed $(0,3 \pm 0,02)$ m from the first HCP. The table has to be enlarged or two tables may be used. The HCPs shall not be bonded together, other than via resistive cables to the GRP.

Any mounting feet associated with the EUT shall remain in place.

An example of the test setup for table-top equipment is given in Figure 4.

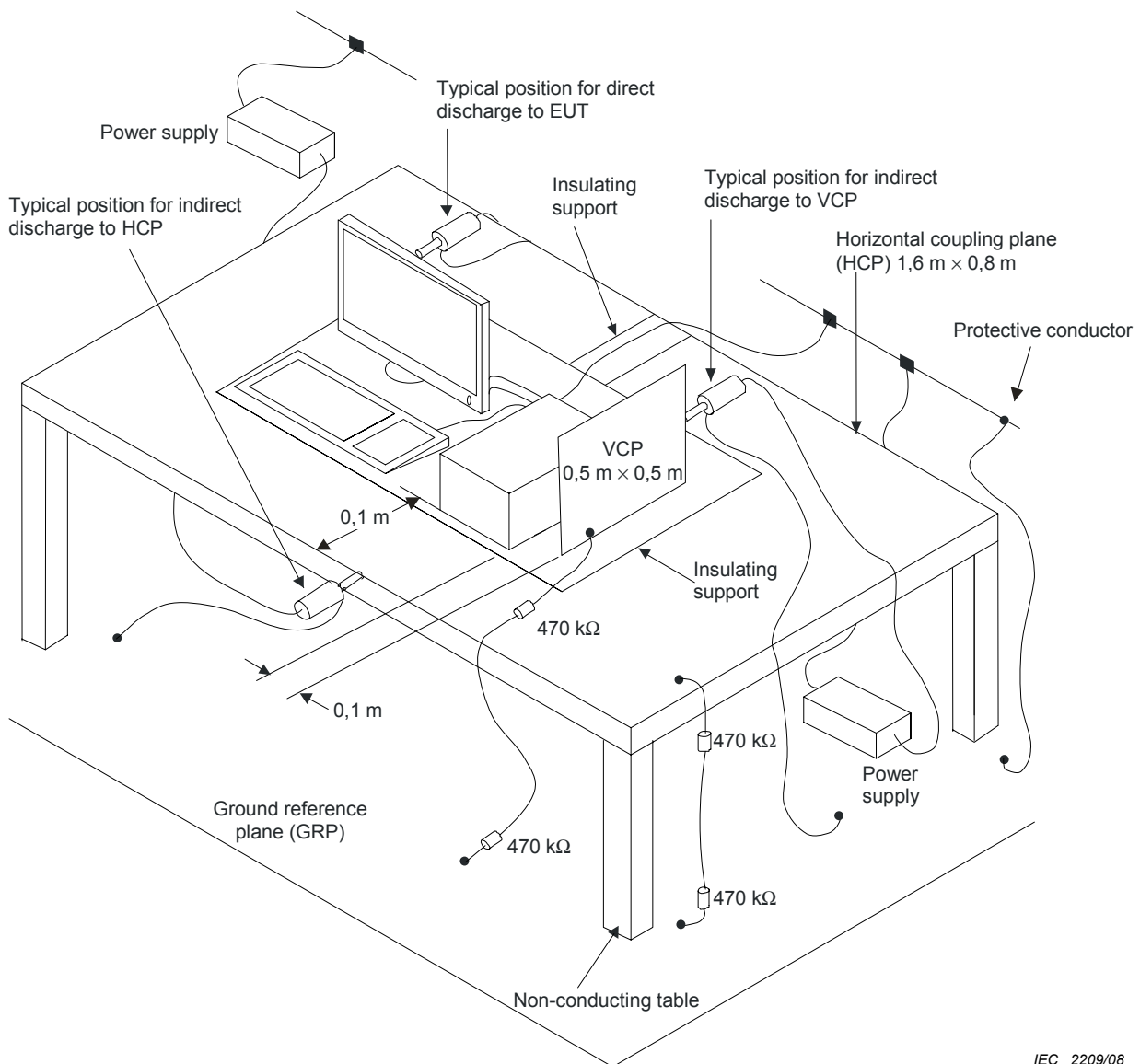


Figure 4 – Example of test set-up for table-top equipment, laboratory tests

7.2.3 Floor-standing equipment

The EUT shall be isolated from the ground reference plane by an insulating support of 0,05 m to 0,15 m thick. The EUT cables shall be isolated from the ground reference plane by an insulating support of $(0,5 \pm 0,05)$ mm. This cable isolation shall extend beyond the edge of the EUT isolation.

An example of the test setup for floor-standing equipment is given in Figure 5.

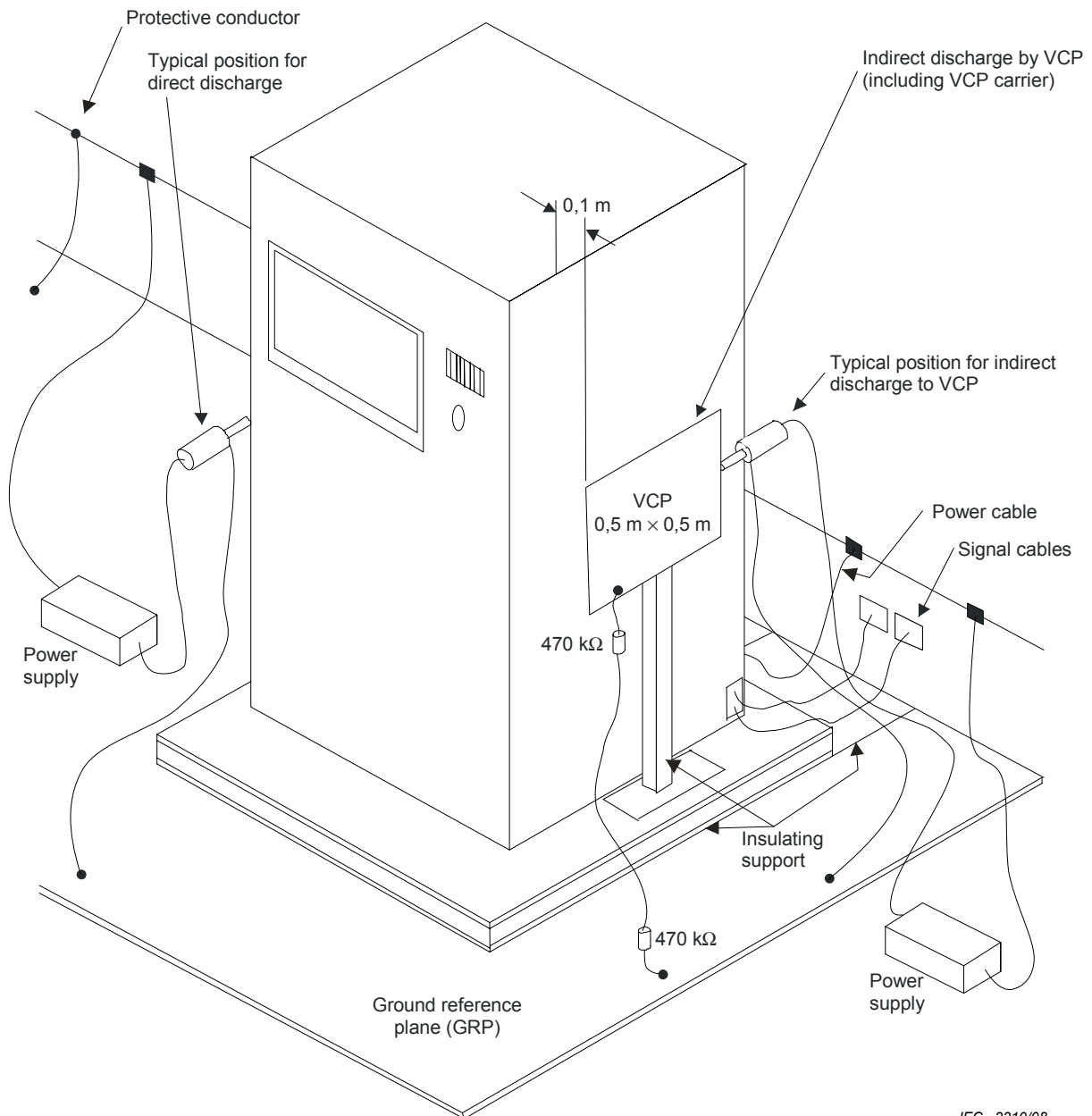


Figure 5 – Example of test setup for floor-standing equipment, laboratory tests

Any mounting feet associated with the EUT shall remain in place.

7.2.4 Ungrounded equipment

7.2.4.1 General

The test setup described in this subclause 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 (class II equipment).

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 be charged at an unrealistically high charge, by accumulating several ESD discharges on the capacitance of the class II insulation, and then discharge at the breakdown voltage of the insulation with a much higher energy.

The general test setup shall be identical to the ones described in 7.2.2 and 7.2.3 respectively.

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

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

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

A cable with 470 k Ω bleeder resistors, similar to the one used with the HCP and VCP is the preferred device to remove charges; see 7.2.

As the capacitance between EUT and HCP (table-top) and between EUT and GRP (floor-standing) is determined by the size of the EUT, the cable with bleeder resistors may remain installed during the ESD test when functionally allowed. In the cable with bleeder resistors, one resistor shall be connected as close as possible, preferably less than 20 mm from the EUT test point. The second resistor shall be connected near the end of the cable attached to the HCP for table-top equipment (see Figure 6), or GRP for floor-standing equipment (see Figure 7).

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

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

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

NOTE In case of dispute concerning the charge decay, the charge on the EUT can be monitored by a non-contacting electric field meter. When the charge has decayed below 10 % of the initial value, the EUT is considered to be discharged.