

NoiseKen

**Electrostatic Discharge
Testing
Guide Book**

According to IEC 61000-4-2 Ed.2

Noise Laboratory Co., Ltd.

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1 Objective

1.1 What the IEC 61000-4-2 is and why we need it

This ESD Testing Guide Book describes in detail how to perform the test based on IEC 61000-4-2. The purpose of this test is to simulate electrostatic discharge generated by human body intervention and evaluate immunity of electronic equipment. This test method is called Human Body Model (HBM).

Electrostatic discharges can be felt as an electric shock when you get into or out of a car or touch a door knob after walking on carpet when the atmosphere is dry. This electrostatic phenomenon has a great adverse effect on malfunction of electronic equipment.

IEC 61000-4-2 is a basic standard of electrostatic discharge immunity test which simulates malfunction of electronic equipment caused by electrostatic discharge generated by human intervention, and not only Europe, but other countries in the world also using this basic standard.

Any other errors caused by electrostatic discharge between equipment and equipment, apparatus or instruments without intervention of human being are not within the scope of this guide book.

1.2 How to read this guide book and Points to Note

This guide book is basically a flow chart form up to "3. Test method ". (In this guide book, flowcharts are shown together with table of contents of each chapter for easier reading.)Please search for related places and read through. For example, if a test room or test site has already been prepared, skip the "2. Preparation of the Test Room" and proceed to "3. Test method" according to your purpose.

1.3 Contents and flowcharts of each chapter

This guide book consists of following five chapters. Please go on reading by referring to flowcharts at the end of this chapter.

1.3.1 Contents of each chapter

Part 1 - Purpose

It becomes this editing which you are reading now which states purpose of the test, how to read, and the outline of each chapter.

Part 2 - Test Room Preparation

It explains about necessary environment, equipment for the test

Part 3 - Test method

It describes the test method when actually conducting the test.

Part 4 - Summary of test results

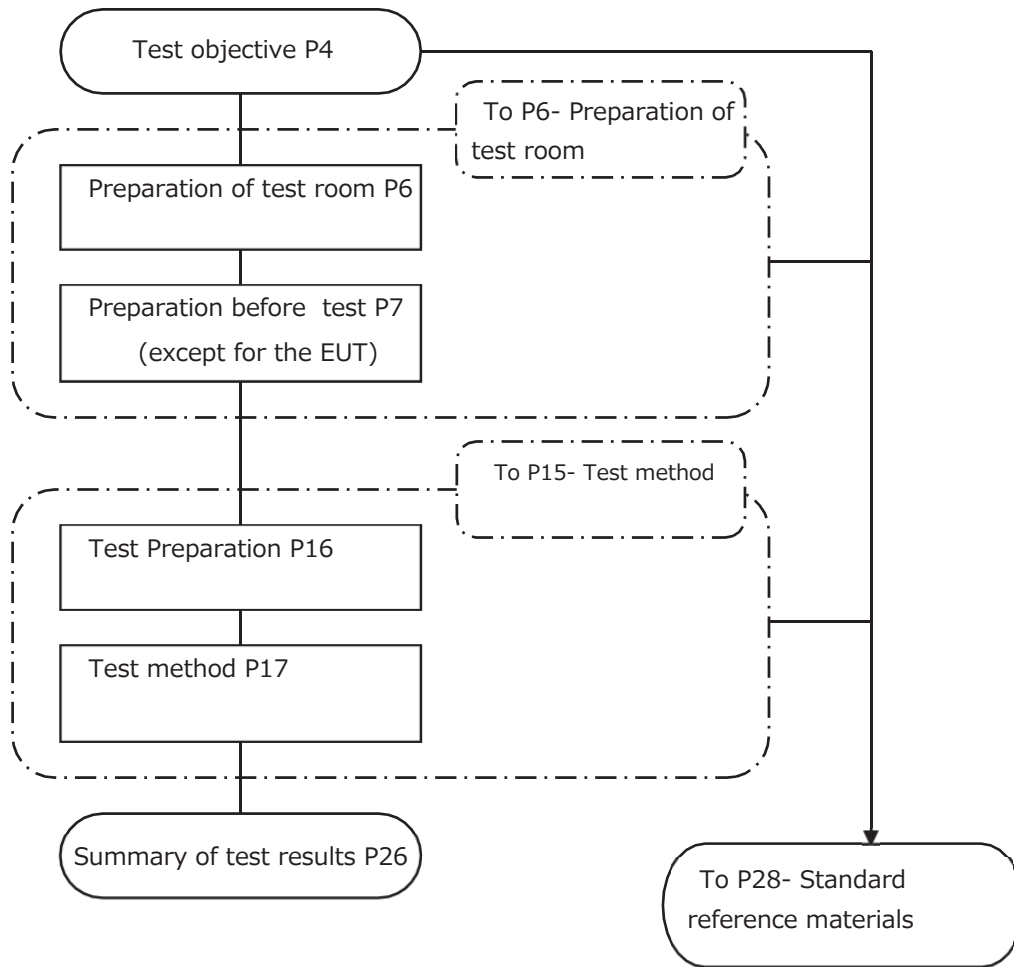
It describes how to put together the results of the test and how to write the test report.

Part 5 - Reference materials

This chapter includes excerpts and explanations of the standards referenced in chapters 1 to 4.

1.3.2 Flowchart of reading this guide book.

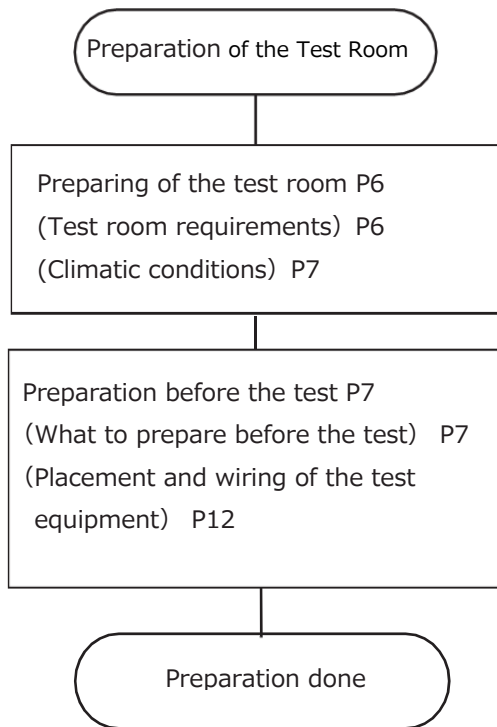
The configuration of this manual is as shown in the following flowchart. Since it is segmented into each stage of conducting the electrostatic discharge test, please read as necessary.



2 Preparation of the Test Room

2.1 Flowchart of preparation of the Test Room

Please prepare the necessary environment, equipment etc. for the test in accordance with IEC 61000-4-2 according to the flow chart.

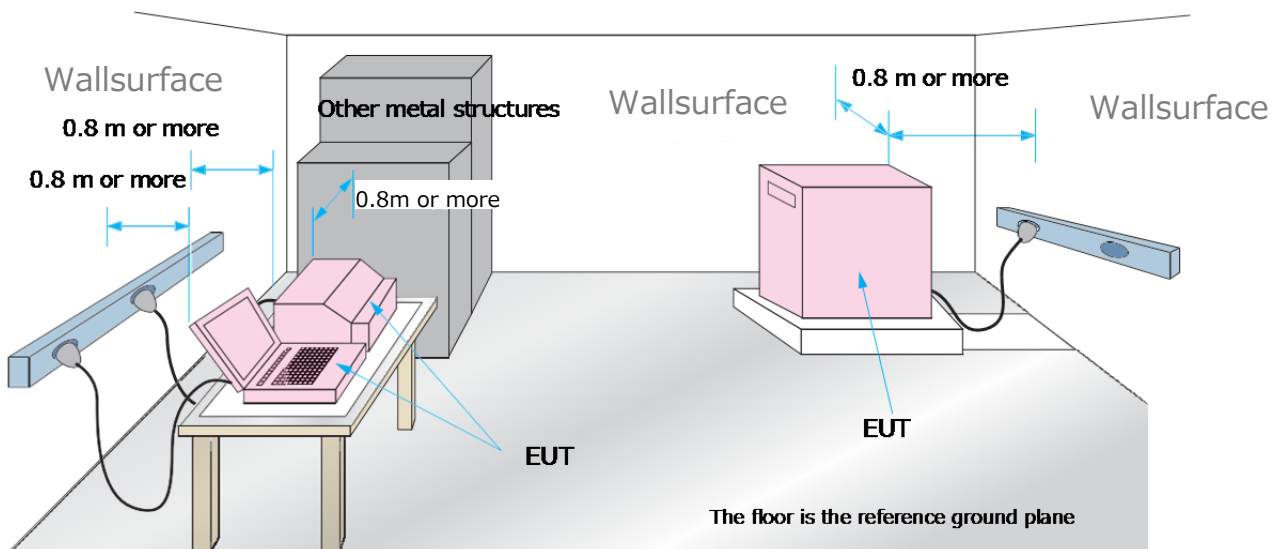


2.2 Preparation of the Test Room

The environmental conditions such as the size of the test room and the temperature required to conduct the test according to IEC 61000-4-2 are described below.

2.2.1 Requirements for the Test Room

Prepare a place where you can secure enough distance of more than 0.8m as shown in figure below.



2.2.2 Climatic and other environmental conditions

Devices brought in from places of different meteorological environment must be fully adapted to surrounding test environment before conducting the test.

Also, in order to quantitatively stabilize the discharge state, it is necessary first to adjust the climatic conditions of the laboratory.

In order to perform air discharge testing according to IEC 61000-4-2, the conditions shown in the following table must be satisfied.

If you are unable to meet the conditions, adjust the environment to satisfy the conditions by referring to (1) to (3) described below.

Ambient Temperature	15 °C - 35 °C
Relative Humidity	30 % - 60 %
Air Pressure	86 kPa (860 mbar) - 106 kPa (1060 mbar)
Electromagnetic environment	Level not to influence the test results

【Regarding climatic conditions for conducting air discharge testing】

Discharge phenomena accompanied by air discharge generates very large variations due to differences in climatic conditions, and will also vary even under the same climatic conditions.

Therefore, although above climatic conditions are prescribed in the standards, the discharge phenomenon of air discharge carried out under this climatic condition will not result in reproducibility of the test.

(1) Temperature adjustment

It seems that temperature can be adjusted comparatively easily (air conditioning machine and others are used to cool the room if the temperature is high, and heat the room if the temperature is low). However, during the test, it is necessary to monitor so as not to deviate from the temperature requirement range. Normally, if it is comfortable for the test worker, it is assumed that the temperature is generally within the required range.

(2) Humidity adjustment

Regarding humidity adjustment control, it is a slightly confounded task. Humidifying if it is low, dehumidifying if it is high, but it is difficult to be controlled in a short time like heat cooling control. In some cases, you may have to operate a humidifier / dehumidifier throughout the day.

(3) Air pressure adjustment

Air pressure is possible to be adjusted with a large-scale special device, but it is generally impossible. However, it is thought that it is never out of the request range unless an unprecedented low pressure typhoon comes. Also, because weather conditions need to be recorded, prepare measuring instrument. (You can also use information from the meteorological observatory without measuring instruments, but altimetry correction is required because the weather stations are announcing at 0 m pressure(Correct 1.2 kPa minus every 100 m higher).)

【Explanation】

At 1250 m above sea level the air pressure is 86 kPa at standard atmospheric pressure 101.3 kPa (0 m). 86 kPa is the lower limit of the required range. If the atmospheric pressure is approaching and the atmospheric pressure announced by the meteorological observatory is 99.5 kPa, at this altitude the lower limit will be less than 1.8 kPa. For example, in the case of a high altitude of 850 m above sea level, if a typhoon of 96 kPa (0 m) comes, the lower limit will be reached.

2.3 Preparation before the test

Prepare the test equipment to be used when the necessary environment of the laboratory for conducting the electrostatic discharge immunity test according to IEC 61000-4-2 is in place. Please prepare the following.

2.3.1 What to prepare before testing

(1) ESD Generator <Electrostatic Simulator>

When conducting an electrostatic discharge immunity test, please use a generator satisfying the specifications in the following table.

Table: General specifications

Energy storage capacity (Cs)	150 pF
Discharge resistance (Rd)	330 Ω
Output voltage Contact discharge * 1	2kV ~ 8 kV
Output voltage Air discharge * 1	2kV ~ 15 kV ※ 3
Accuracy of voltage display	± 5 %
Output voltage polarity	Positive and negative (switchable)
Retention time	5 seconds or more
Discharge operation mode * 2	Single discharge (discharge interval is 1 second or longer)
Waveform of discharge current	See figure

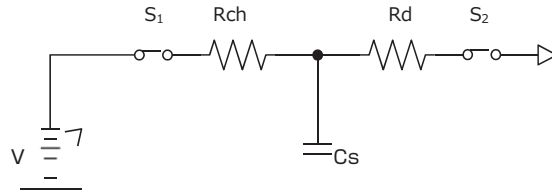
* 1 Open circuit voltage measured with discharge electrode.

* 2 For the preliminary test of the generator, the discharge repetition rate should be at least 20 times per 1 second.

* 3 When the maximum test voltage to be used is lower, it is not necessary to use a generator with air discharge capacity of 15 kV

Table: Contact discharge current waveform parameters

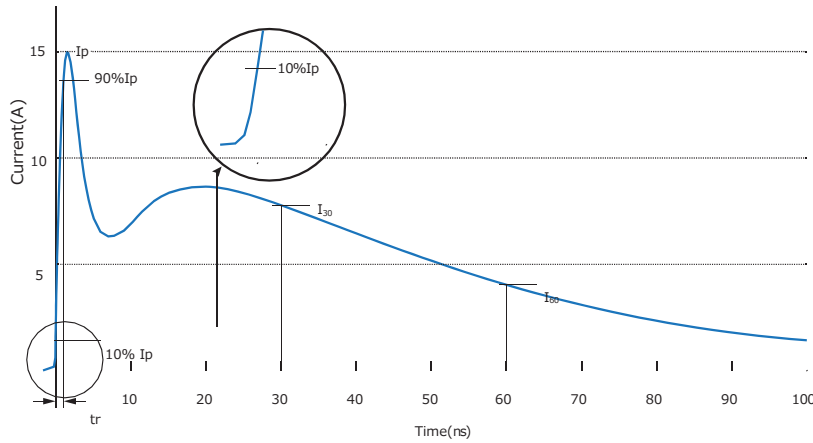
level	Indicated voltage kV	Peak current I_p ($\pm 1.5\%$) A	Rise time T_r ($\pm 25\%$) ns	Current at 30ns ($\pm 30\%$) A	Current at 60ns ($\pm 30\%$) A
1	2kV	7.5A	0.8ns	4A	2A
2	4kV	15A	0.8ns	8A	4A
3	6kV	22.5A	0.8ns	12A	6A
4	8kV	30A	0.8ns	16A	8A



Energy Storage capacitor C_s : 150pF

Discharge resistor R_d : 330 Ω

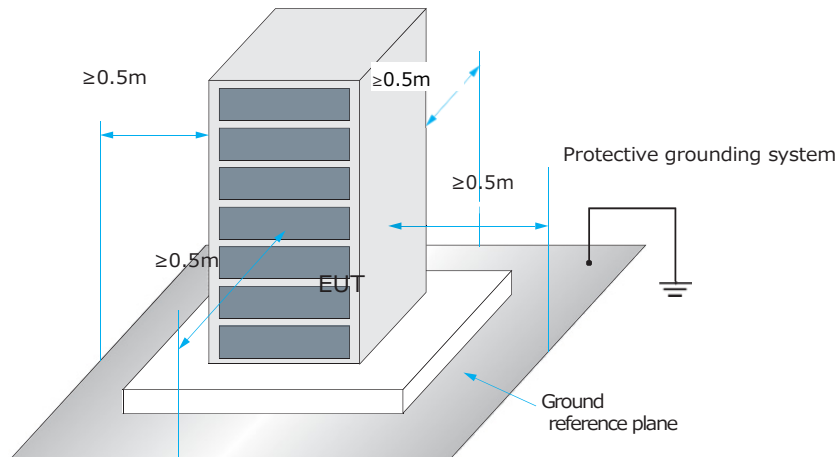
Simplified electrical schematic of ESD generator

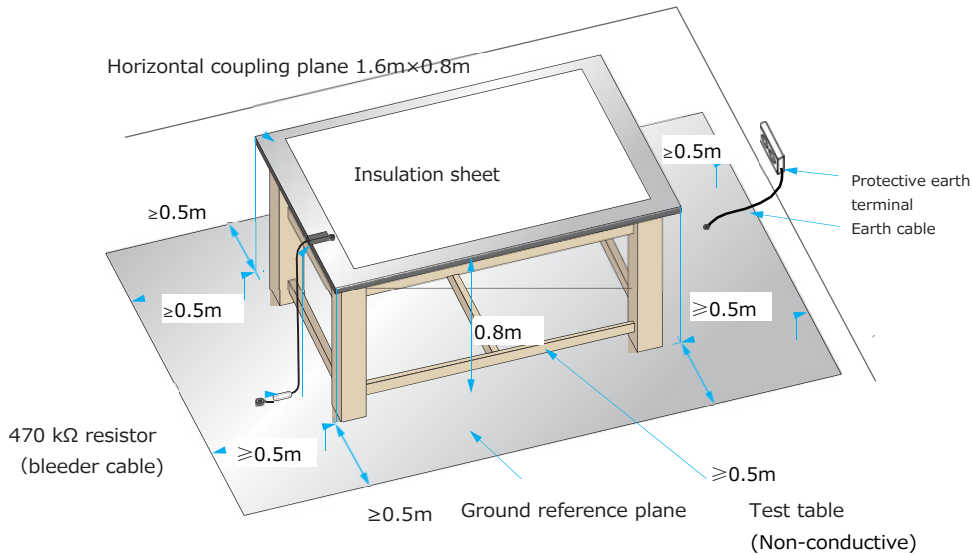


Typical discharge current waveform

(2) Reference ground plane (ground plane)

- The reference ground plane is a plate with a thickness of min. 0.25 m and min. 0.5m larger than all sides of the EUT or horizontal coupling plate (as applicable) made of copper or aluminum as shown in the figure. This plate must be connected to a protective grounding system.
- If using a metal other than the above, the thickness of the plate must be at least 0.65 mm.
- The reference ground plane must be placed on the floor.



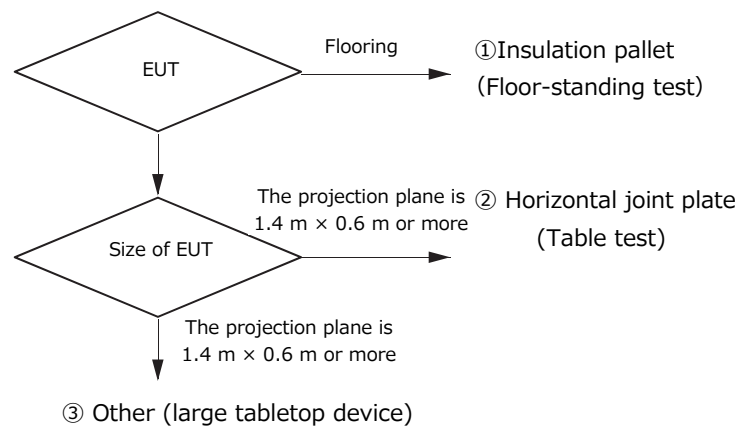


【About protective grounding system】

This is a grounding conductor which is installed separately from the power supply line in order to protect from an electric shock due to leakage caused by a malfunction or insulation degradation in the electrical equipment. When performing an ESD test, connection of the ground reference plane to a protective ground system is just for safety reason. No type or class requirement is applicable. EST test discharge currents never flow to the protective ground system, thus, grounding system will not affect test results.

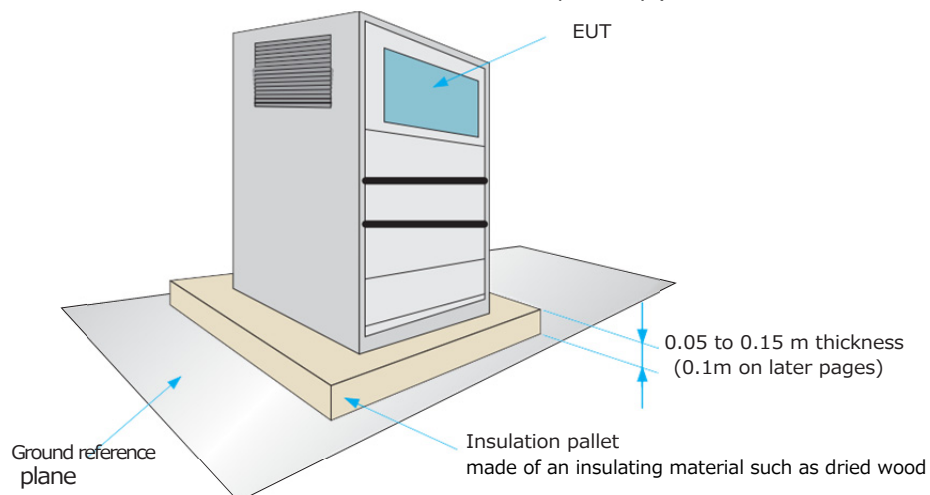
(3) Horizontal coupling plate or insulation pallet <Fixtures on table-top and floor-standing>

An insulation pallet is required If the EUT is a floor-standing type. However in the case of a table-top device, the preparation is differed n depending on its size. Please refer to flowchart below.



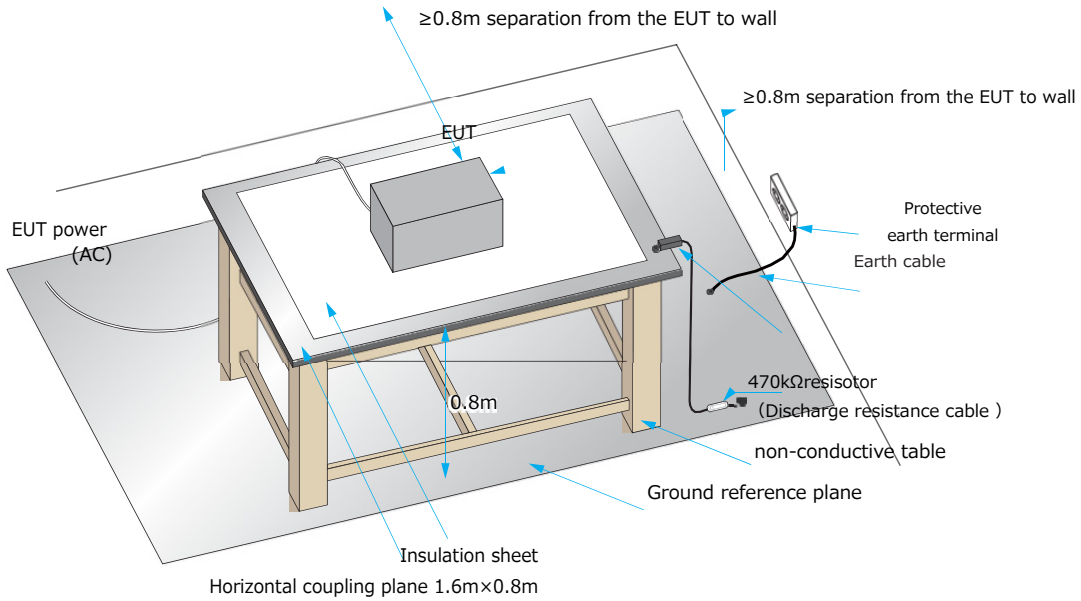
① When preparing an insulating pallet

Prepare an insulation support if the EUT is a floor-standing type. This is an insulator made of materials such as dried wood which thickness is 0.05 to 0.15 m to be placed on the ground reference plane. (This guide book uniforms 0.1m thickness for test results compatibility)



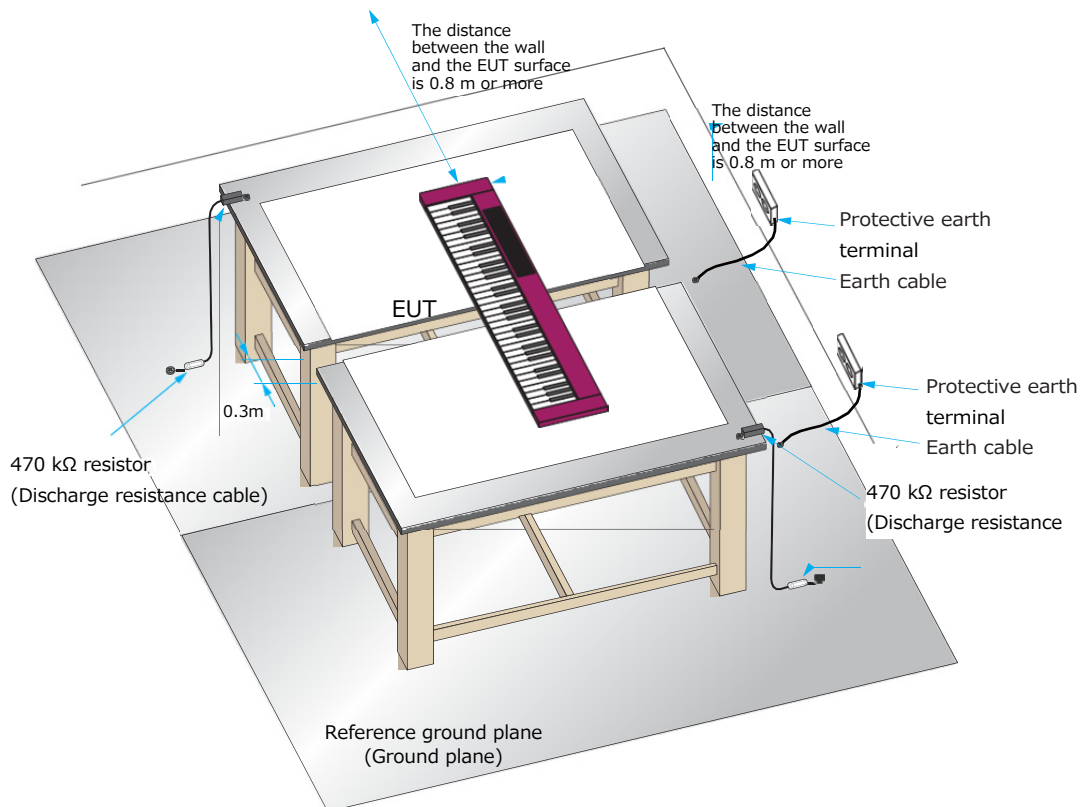
② When preparing horizontal coupling plate (tabletop test)

Horizontal coupling plane is a metal (copper or aluminum) which size is 1.6m length x 0.8m width and thickness is min. 0.25mm. In case a table-top type EUT, install a HCP on top of non-conductive tables with height of 0.8m +/-10%.



③ Other (large size tabletop EUT)

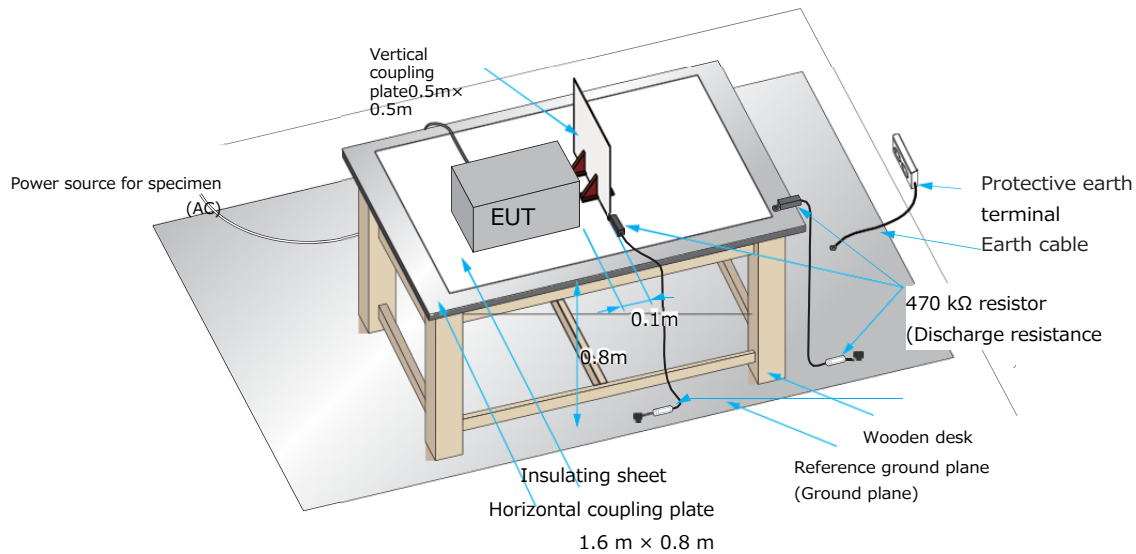
If the EUT is too large to keep the margin of 0.1 m away from the edge of the horizontal coupling plate, prepare another one. The two horizontal coupling plates are close to 0.3 m and each is connected to the reference ground plane with discharge resistance cables. Do not directly join two horizontal coupling plates.



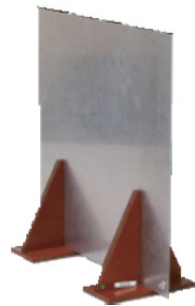
(4) Vertical coupling plate

It is used for indirect discharge test. It is unnecessary when conducting a direct discharge test.

The vertical coupling plate is 0.5 m x 0.5 m in size and 0.25 mm or more in thickness and is made of copper or aluminum.



As for the vertical coupling plate, it is necessary to insulate it by using a holding tool as shown in the picture.



Vertical coupling plane (for table-top equipment) Model : 03-00005A

Vertical coupling plane for floor-standing equipment Model : 03-00034A

(5) Discharge resistance cables

It is a cable used for wiring the horizontal coupling plate / vertical coupling plate to the reference ground plane. A 470 kΩ resistor is connected to both ends as shown in the figure. There is no provision of wire diameter, material etc. of cable.

【Discharge resistance cable specification Explanation 1】

The resistor used for the discharge resistance cable needs to have bigger withstand voltage than the test requirement because the discharge voltage is applied during indirect discharge. Although no large current flows for cables, use a cable with certain cross sectional area to some extent so as not to have inductance as much as possible.

【Discharge resistance cable specification Explanation 2】

The bleeder resistors at both ends of the discharge resistance cable purpose the gradual ESD elimination, prevent any change in total length of the conductor (change of resonance point occurs) while connecting conductive cable to HCP and VCP. The resistors need to be attached as close as possible to ends of the cable in order to avoid resonance in the cable.



Discharge resistance cable Model : 05-00054B

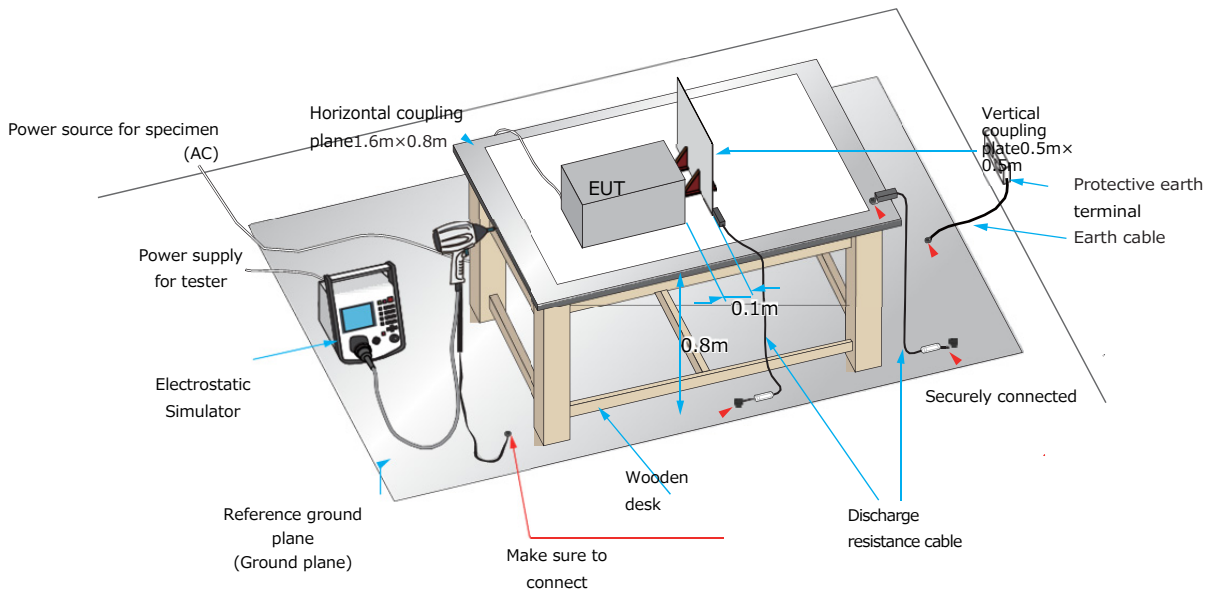
2.3.2 Placement and wiring of test equipment

Securely connect the EUT to the protective ground if there is a protective ground terminal on it. The EUT whose installation specifications or design precludes connection to any grounding system (equipment with no grounding terminal, battery-operated equipment or operated via an AC adaptor) shall not be connected to the protective ground. If there is a possibility that the EUT is operated with its grounding terminal not grounded to the protective ground, the EUT shall be tested with floating from the ground as well. For ungrounded equipment, also refer to 3.3.3 “Testing for ungrounded equipment”

Connect the discharge return cable of the ESD gun securely to the reference ground plane.

The discharge return cables of the gun and discharge resistance cables can be connected anywhere on the reference ground plane.

Also connect the horizontal and vertical coupling plates to the reference ground plane by using discharge resistance cables. Also, connect the reference ground plane to the protective grounding system.

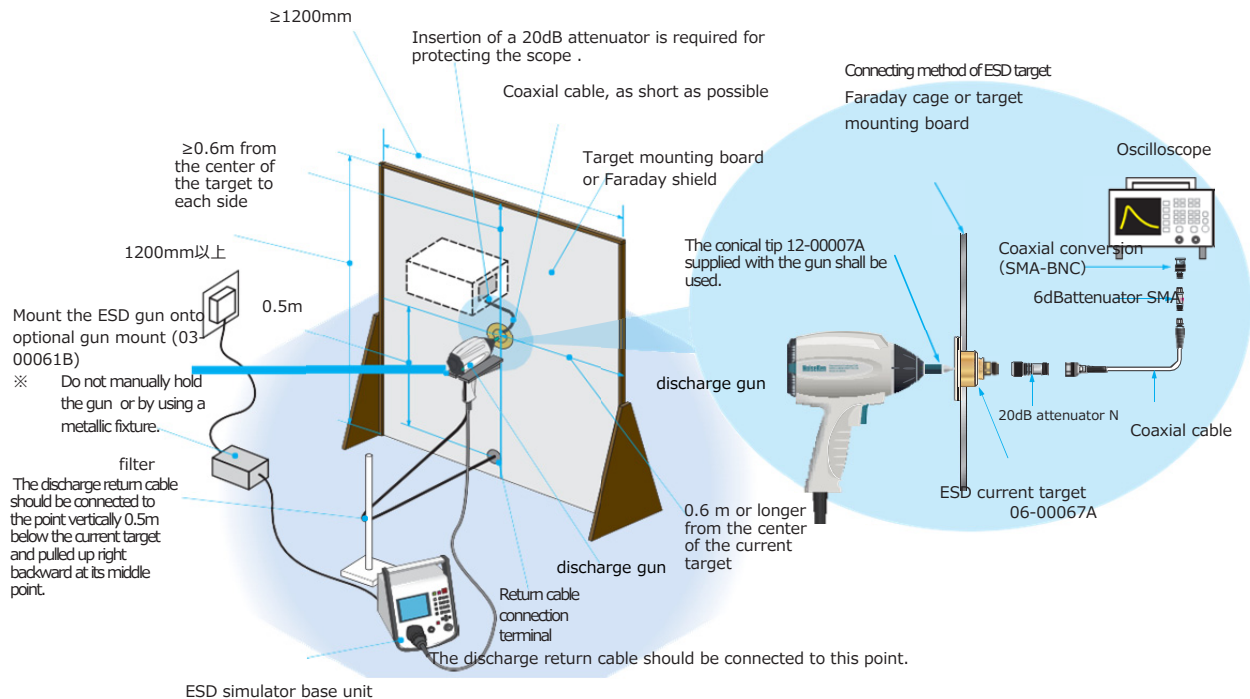


2.3.3 Waveform verification

(1) Required items

Description	Model number	Note
ESD simulator base unit	ESS-S3011A or B3011A	
Discharge gun	GT-30RAetc.	
Oscilloscope	—	Measurement bandwidth $\geq 2\text{GHz}$
ESD current target	06-00067A	
Target mounting board or Faraday case	03-00027A, 03-00052B, FC-200	03-00052B recommended
Coaxial cable	02-00132A	
Attenuator (6dB)	00-00010A	
Attenuator (20dB)	00-00011A	
Discharge gun mount	03-00061B	
Ground cable positioner	03-00060A	

(2) Set-up



※③The above illustration is an example of measurement using a current target mounting board.

Follow the set-up and procedures below:

- ① Mount the ESD current target (06-00067A) onto the center of the board.
 - *A wall of a shielded room can also be used if 0.6m or longer clearance from the center of the ESD target is achieved.
- ② Set the scope.
 - Select 50Ω input impedance.
 - For protection of the scope and for impedance matching, make the attenuators and cable connections as shown in the above illustration.
- ③ Bring the conical (sharp) tip into contact with the ESD current target. Place the ESD simulator in Contact Discharge mode.
- ④ The discharge return cable should be connected to the point vertically 0.5m below the current target and pulled up right backward at its middle point.
- ⑤ Set the desired polarity, voltage and number of discharges. Set discharge interval to 1s or longer.

[Output waveform specifications]

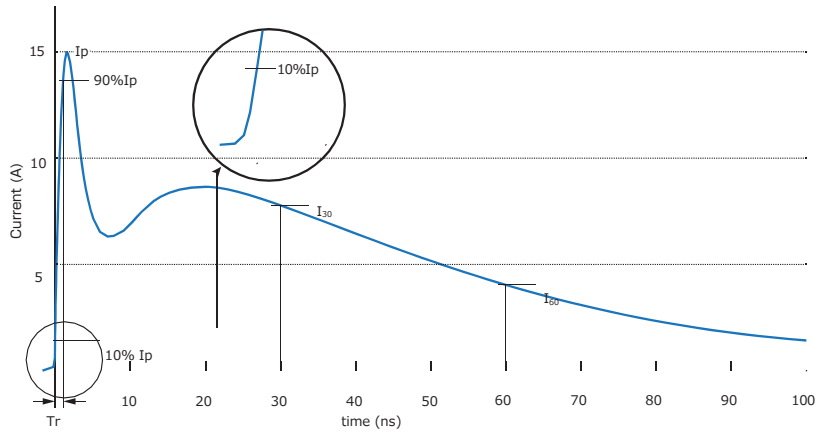


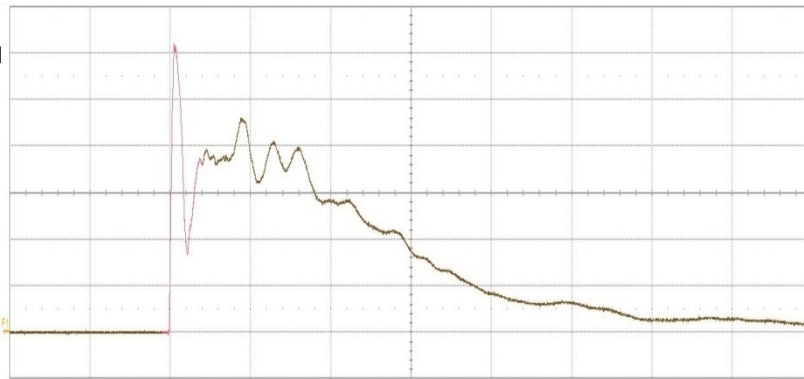
Table: Discharge current waveform parameters

level	Indicated voltage kV	Peak current I_p ($\pm 15\%$) A	Rise time t_r ($\pm 25\%$) ns	Current at 30ns ($\pm 30\%$) A	Current at 60ns ($\pm 30\%$) A
1	2kV	7.5A	0.8ns	4A	2A
2	4kV	15A	0.8ns	8A	4A
3	6kV	22.5A	0.8ns	12A	6A
4	8kV	30A	0.8ns	16A	8A

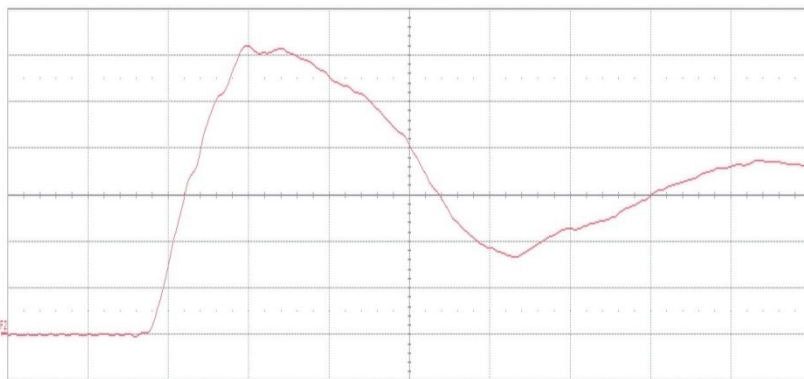
Parameters for contact discharge waveform

※ The above table shows the specifications as per the IEC 61000-4-2 ed2.0.

[Waveform example]



Entire waveform
5A/div 20ns/div



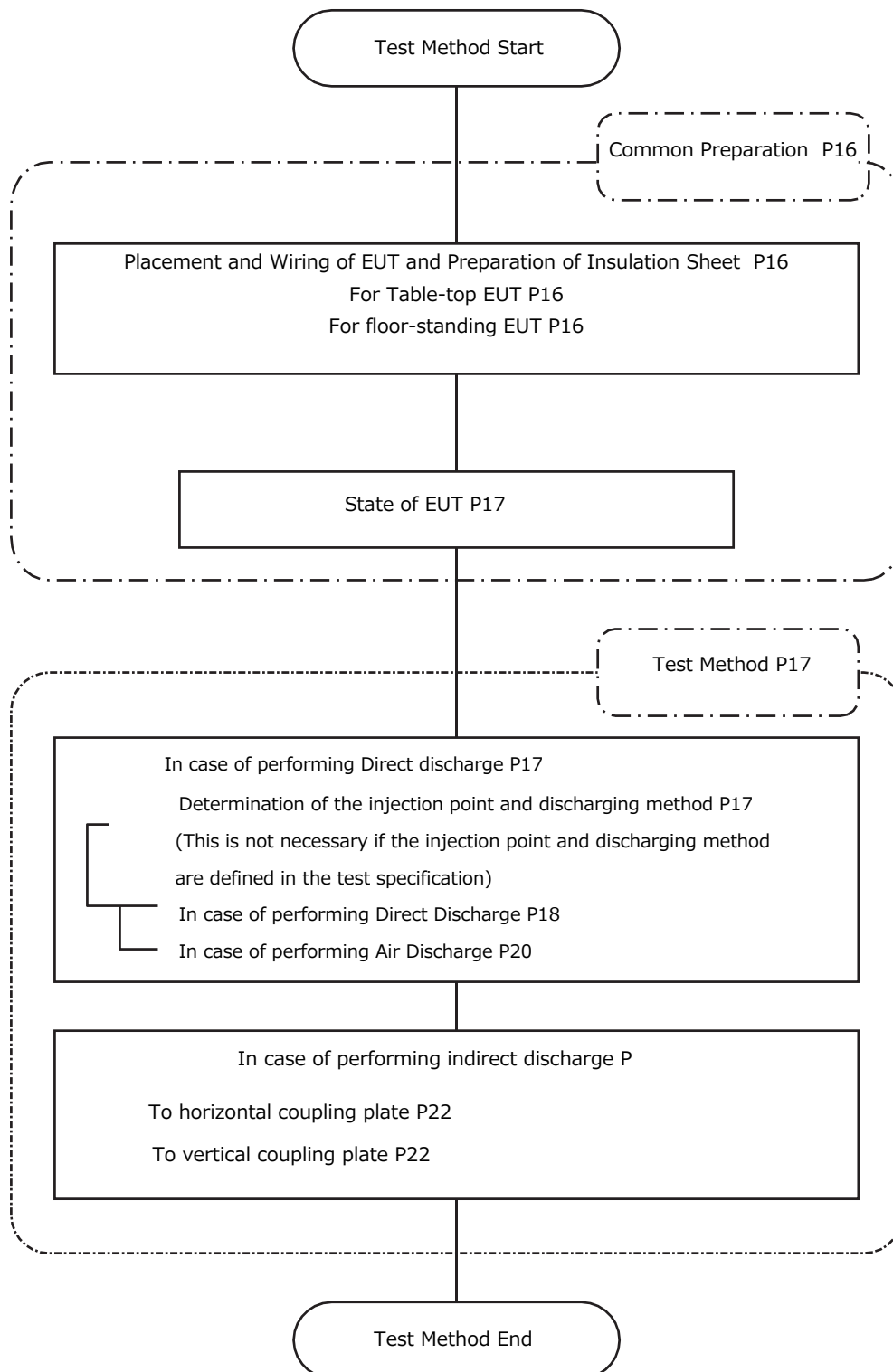
Leading edge
5A/div 1ns/div

● This combination (NoiseKen ESD current target with 20dB and 6dB attenuators) generates 1V scope input against 10A discharge current.

3 Test method

3.1 Flowchart of preparation of the test room

Please prepare the necessary environment, equipment etc. for the test compliant to IEC 61000-4-2 according to the flow chart below.

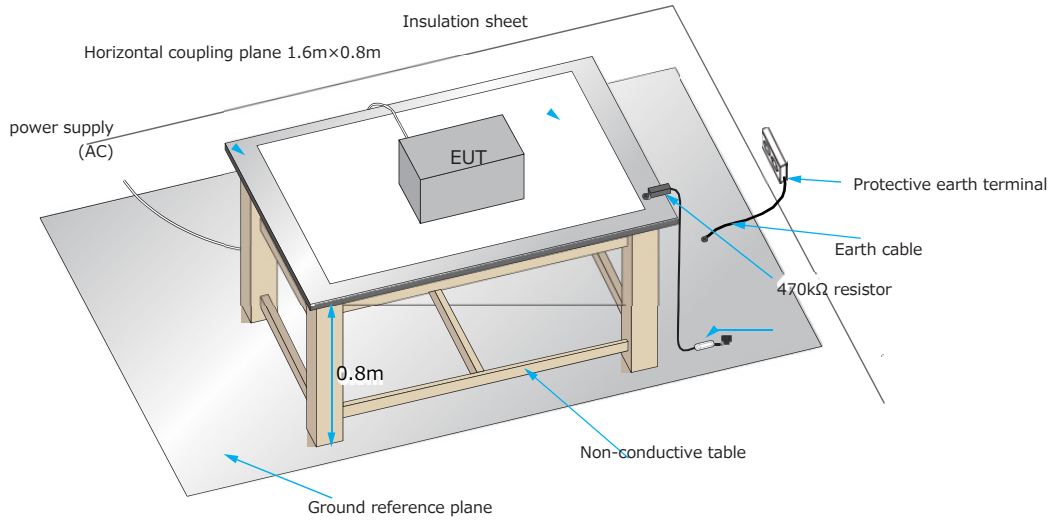


3.2 Common Preparation (placement, wiring etc.)

Following preparations are common to all electrostatic discharge immunity tests.

3.2.1 Placement and Wiring of the EUT and Preparation of the Insulation Sheet

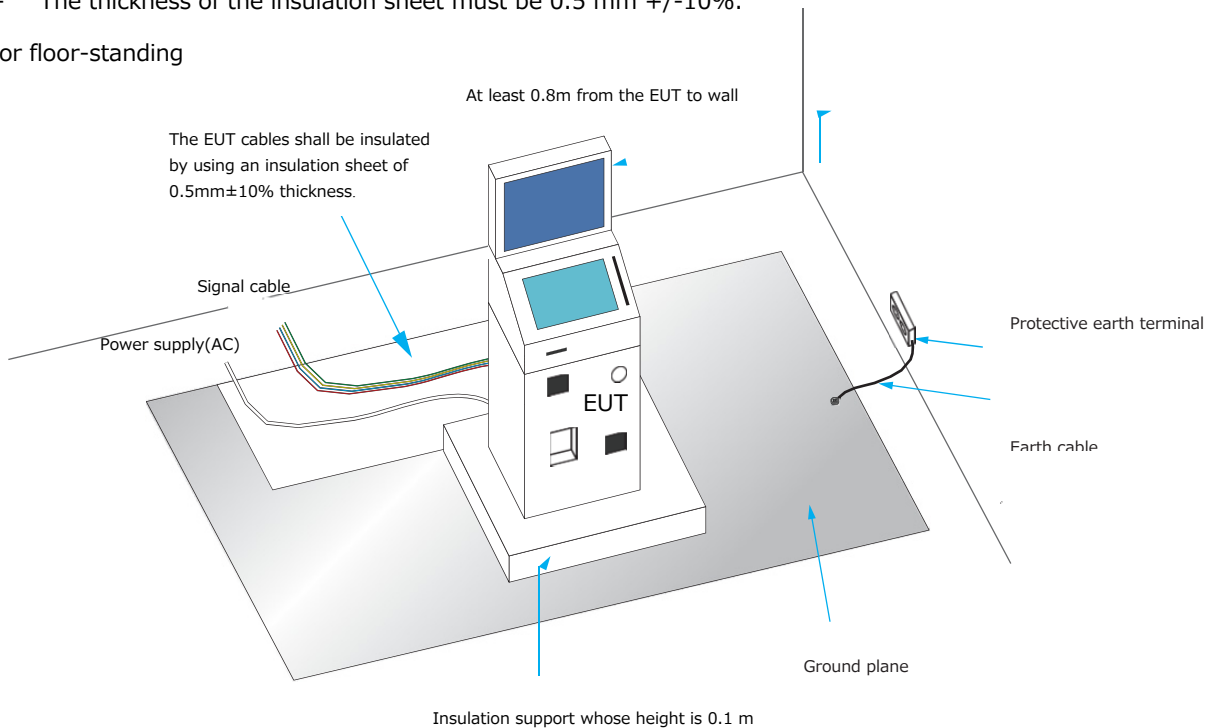
(1) For a table-top EUT



The insulation sheet on HCP needs to be at least as large as the foot print size of the EUT. Since VCP is desirable to be placed on the sheet entirely as well, size of the sheet should be devised.

- Securely connect the EUT to the protective earth in accordance with the product specification in case there is a protective ground terminal on it.
- The thickness of the insulation sheet must be 0.5 mm +/-10%.

(2) For floor-standing



Prepare an insulation support whose height is 0.1 m on the ground plane and place the EUT on the support. The EUT cables (power supply cable and signal cables) shall be insulated by using an insulation sheet of 0.5mm±10% thickness from the ground plane.

If there is a protective ground terminal on the EUT, securely connect the EUT to the protective ground system in accordance with the product specifications.

3.2.2 Status of EUT

Turn on the EUT and place it in operating state. Since it is necessary to perform testing in each operation mode of the EUT, connect any additional external apparatus or auxiliary components and turn on the power supplies for these additional components.

(Connect any items which are required for the operation such as a keyboard, monitor and mouse and so on if the EUT is a PC. When the EUT is a DVD player, connect a display and insert a DVD or CD disk to let it play. The mains power supply can be used for the additional external components.

Test program or software is required to run all the standard operation modes of the EUT. Using some specialized software is possible if it can be proven that the EUT runs in wide range of its operation with the software.

3.3 Test Method

The tests in IEC 61000-4-2 are categorized to be two tests as Direct Discharge Test and Indirect Discharge Test. Forward to the either one with judgment which is appropriate for the application based on following explanation. If the test purpose is to obtain a product certification in accordance with the standard, both the direct and indirect discharges have to be performed.

The direct discharge testing simulates charge transfer from a human body to the EUT when he/she touches the EUT. That is the test method whether a soft failure happens in operation of the EUT or not due to the transient electromagnetic field which is generated when a charged human body (normally a finger) is approaching the EUT surface and at some instance a breakdown of the air has occurred.

To represent this event, when conducting an air discharge, the charged tip (round tip) is moved from a distance toward the insulating surface of the EUT until it touches the EUT. A discharge is actuated by a breakdown of an air gap, to say, a spark. As you can easily understand the said explanation, all of ESD events in the real field are air discharges. It is well known, however, that air discharges are variable and lack reproducibility. The IEC 61000-4-2 standard adopts the air discharge testing to better simulate real world events and the contact discharge testing for better reproducibility. For the contact discharge testing, the discharge tip (sharp tip) is brought into contact with a metallic part of the EUT, and the discharge is actuated by the discharge switch in the discharge gun.

The indirect discharge testing simulates a discharge from a human body to a metallic object located close to an electronic product and the resultant electromagnetic fields.

3.3.1 In case of performing Direct Discharge

Both contact discharge and air discharge are there in the direct discharge method and either one is selected depending on surface conditions of the EUT. Contact discharge is the method where a conical tip is brought into contact with a metallic part of the EUT first and a discharge is actuated by the discharge switch in the discharge gun. In order to pursue a secure contact, a conical tip is used.

On the other hand, in case there is no metallic surface on the EUT, and the operator may often touch insulated surfaces, air discharges shall be applied by approaching the charged tip of the ESD gun to the targeted surface.

In case of air discharge, a round discharge tip is used. The advantage of this shape is dispersion toughness of the electric charge comparing to the conical tip. Perform the discharge within 5 seconds to prevent the electric charge from dissipating.

(1) Determination of the injection point and discharging method

It is not necessary to perform preliminary testing in case application points and discharge method are specified in the test specification. Perform testing in accordance with the specifications. If not specified, follow the following procedure.

(a) Determination of the application points (preliminary test testing)

Preliminary testing shall be performed in order to select points or areas of the EUT are sensitive to interference from ESD pulses. Based on preliminary testing, applications points shall be selected.

- Although both conical shaped discharge tip and round shaped discharge tip can be used, the conical one might scratch the surface.
- Set the ESD simulator to repetitive discharges mode and move the ESD gun along the surfaces of the EUT.
- Since points or locations which are prone to be weak against electrostatic discharge are where it is easy to be discharged due to insulation breakdown of air, set those as applications points.
- The EUT or a part of the EUT may become charged after the first discharge and this may prevent any subsequent discharges. In this case, ground the EUT with an appropriate conductor to neutralize the electric charge.

Note:

There may be a case that the EUT works abnormally when the electrical charges have been released (electrostatic neutralization) from the EUT. This error can be prevented by discharging the accumulated charges via a high resistance (few kΩ to few MΩ). Refer to 3.3.3 "Testing for ungrounded equipment". Automatic removal of the residual charges using a relay is also available (automated ESD eliminator).

(b) Locations excluded from ESD application

Unless otherwise stated in the relevant Product Standard or other, the following points can be excluded.

- 1) Points or surfaces that are only accessible during maintenance
Points that the operators are accessible to but are that is rare such as where changing the batteries or the cassette in a telephone answering machine
- 2) Points that are no longer accessible after installation
For example, base of table-top and floor-standing equipment, wall side of wall mounting equipment, or connector parts that are plugged in after installation
- 3) Connector 1
In case high frequency connectors for measurement or communication that are vulnerable against the electrical noise are there and the warning label has been affixed nearby.
- 4) Connector 2
Application points are defined as following table based on material combination used for the shell and cover.
In case the cover purposes to protect pins, affix a warning label indicating this on or close to it. This is to minimize the injection to signal pins. If the shell is made of metal, it is likely that a discharge can go to the shell before the pins.

Shell	Cover	Discharge method
Metallic	None	Contact discharge to shell
Metallic	Metallic	Contact discharge to shell or cover
Metallic	Non-metallic	Contact discharge to shell (if possible)
		Air discharge to cover
Non-metallic	None	Air discharge to pin
Non-metallic	Metallic	Contact discharge to cover
Non-metallic	Nonmetallic	Air discharge to cover

(c) Determination either contact discharge or air discharge is applicable to the each application point

The contact discharge is the prioritized method. Apply air discharges when the contact discharge is impossible. See the following descriptions for the information as to which method should be selected.

- Contact discharge

Perform contact discharges to metallic parts that human body might touch during normal operation.

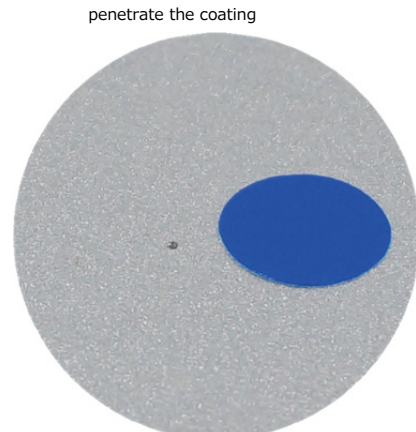
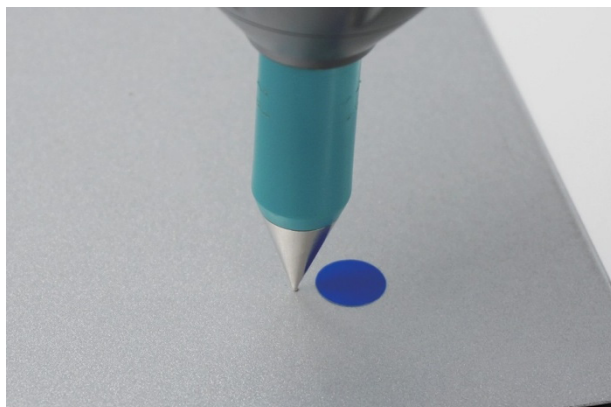
- Air discharge

Perform air discharges to insulated non-metallic parts that human body might touch during normal operation. Generally, in case metallic parts are present, it is adequate to only apply contact discharges to the metallic parts. However, if the EUT includes insulated parts that an operator might touch during normal operation, performing air discharges to those parts is required.

(2) In case of performing contact discharge

Determine application points based on the following guidance and perform contact discharges.

- 1) If there is no problem with a preliminary test, select one point in the each area that is equivalent to the size of a palm.
- 2) Do it onto metallic parts that human body might touch for operation.
- 3) Do it one by one when multiple units exist.
- 4) Although no stipulation about I/O terminals in IEC 61000-4-2, sometime it is done in the Product Group standard. It is also necessary when the product is evaluated.
- 5) In case an intended point is coated, use the conical discharge tip so as to for the contact discharge to the conducting substrate. (Coating declared as insulating by the manufacturer shall be submitted to air discharges only)



6) When the EUT has no grounding connection such as battery operated products, also see 3.3.3 "Testing for ungrounded equipment". Typical points to where the contact discharge shall be applied are shown by blue arrows. Red round stickers show typical air discharge points.



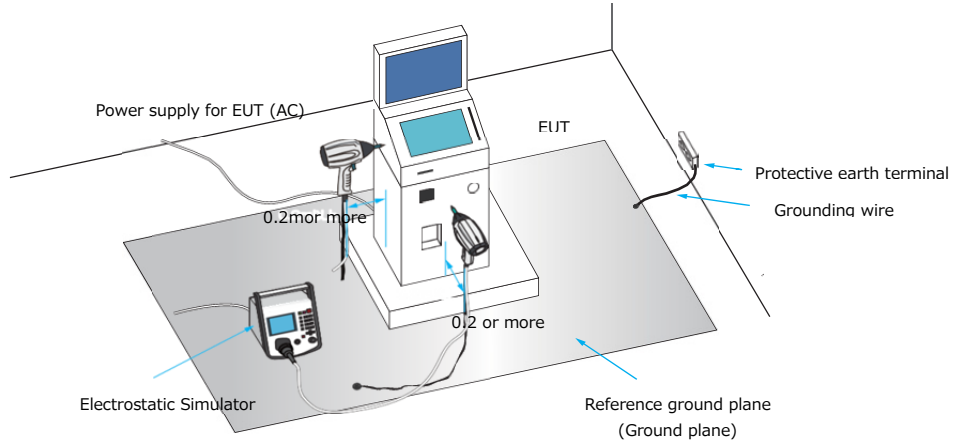
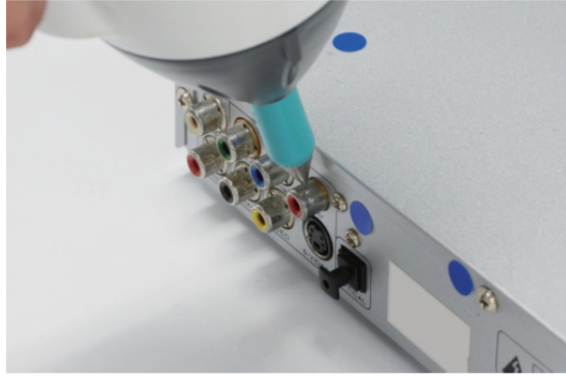
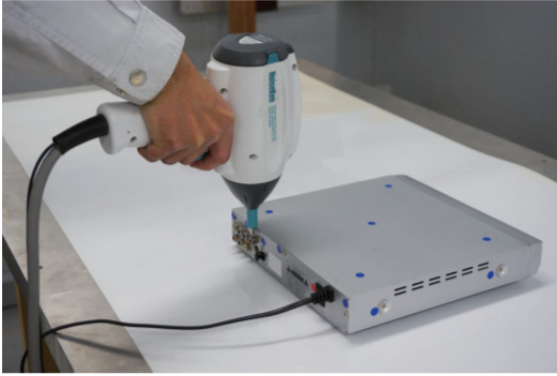
- Apply contact discharges to the selected or specified points.

Use the conical discharge tip.

- Place the ESD simulator in contact discharge mode, hold the ESD gun perpendicular to and bring the tip into contact with the point, and trigger a discharge.
- For test voltages, refer to Chapter 5 "reference materials"
- Conduct at least 10 discharges in each polarity to each point. A one second interval between each discharge is recommended.
- Keep the discharge return cable at least 0.2 m away the EUT.
- Do not touch anything other than the ESD gun grip during the test.

Note: For table-top equipment testing, test results are easily affected by nearby conducting materials. The operator (human body) also affects the test result. Actions such as putting your face too close to the EUT to look at it closely during testing may lead to test result variations. Especially, if the EUT has not good ESD immunity, this variation tends to be large.





- (3) In case of performing the air discharge, perform it upon determination of test points based on the following guidance.
- 1) Do it onto non-metallic parts that human body might touch for operation (internal metallic parts though a clearance on the enclosure)
 - 2) If there is no problem with the preliminary test, select one test point in the each area that is equivalent to the size of a palm except for the control area.
 - 3) Do it one by one when multiple units exist.
 - 4) There are no rules about I/O terminals in IEC 61000-4-2 but they are referred to in product group standards. It is also necessary when the product is evaluated.
 - 5) When the EUT has no grounding connection such as battery operated products, also see 3.3.3 "Testing for ungrounded equipment".
Test points for air discharges are marked with red arrows in the below photos.

*Round blues stickers show tests points for contact discharges.



Perform the air discharge to the air discharge points which is set or required.

- Use the round discharge tip.
 - How to correct perform air discharges, follow the following steps.
1. Place the ESD simulator in air discharge mode and, press and hold the trigger and approach the ESD gun until its tip touches onto the EUT. It is permitted to move (rotate) the EUT so that the gun can be close to it if necessary (such as difficulty to move the gun close to the EUT).
 2. Move the ESD gun away from the EUT with it trigger pressed, and then release the trigger.
 - Testing shall be done for test level 1 first, level 2 second, and level 3 third in this order up to the required level.
 - For test levels, refer to chapter 5 "Reference materials"
 - Conduct at least 10 discharges in each polarity to each point. One second or longer interval between each discharge is all right.
 - Keep the discharge return cable at least 0.2 m away from the EUT.
 - Do not touch anything other than the ESD gun grip during the test.

Explanatory note 1

Air discharges are phenomena where discharge current rise times and peak amplitudes vary depending on ark discharge path length. (Normally, rise times get slower and peak values got lower when the length gets greater.) Because the frequency components of the discharge are also varied, it is necessary to test at all test levels from level 1 up to the required level.

Explanatory note 2

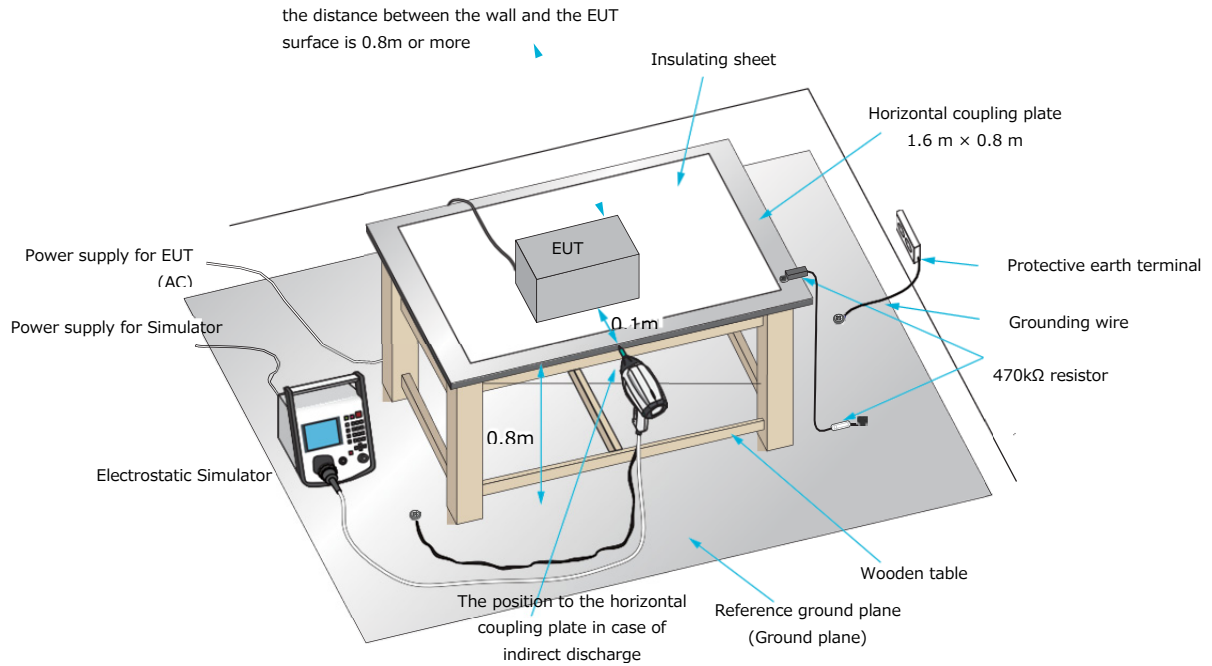
Air discharges are phenomena where different test voltages generate discharges to different application points.



3.3.2 In case of performing indirect discharge

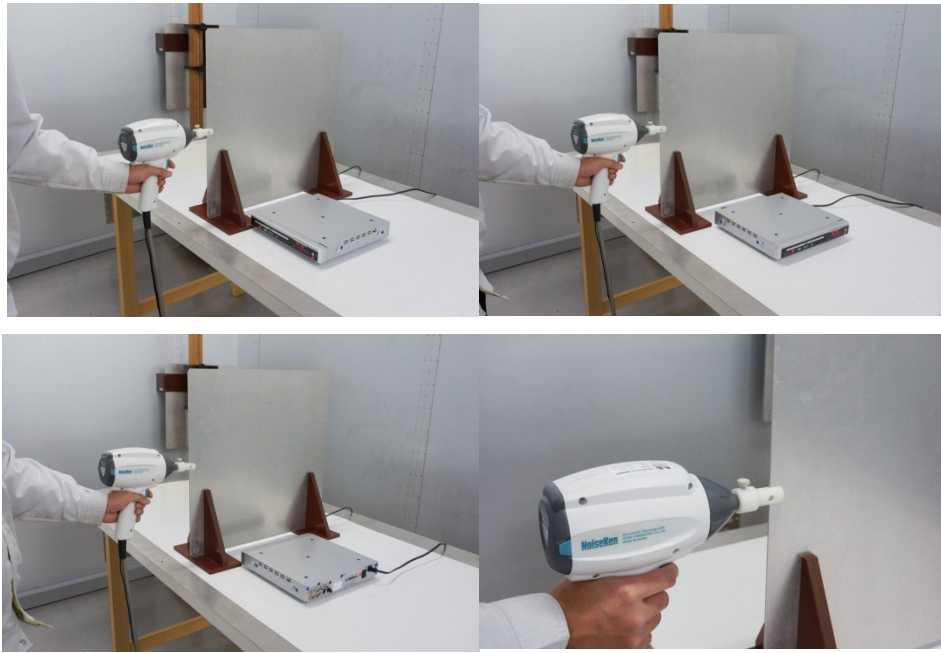
(1) In case of performing discharge to horizontal coupling plate

- Use the conical discharge tip.
- Place the EUT 0.1m away from an edge of the HCP.
- Bring the discharge tip into contact with the center of the edge. Discharges shall be done to the HCP from the discharge gun positioned horizontally to the HCP.
- Rotate the EUT so that testing shall be done for the four sides.
- For test levels, refer to chapter 5 "Reference materials"
- Conduct at least 10 discharges in each polarity to each side. A one second interval between each discharge is recommended.
- Keep the discharge return cable at least 0.2 m away from the EUT.
- Do not touch anything other than the ESD gun during the test.



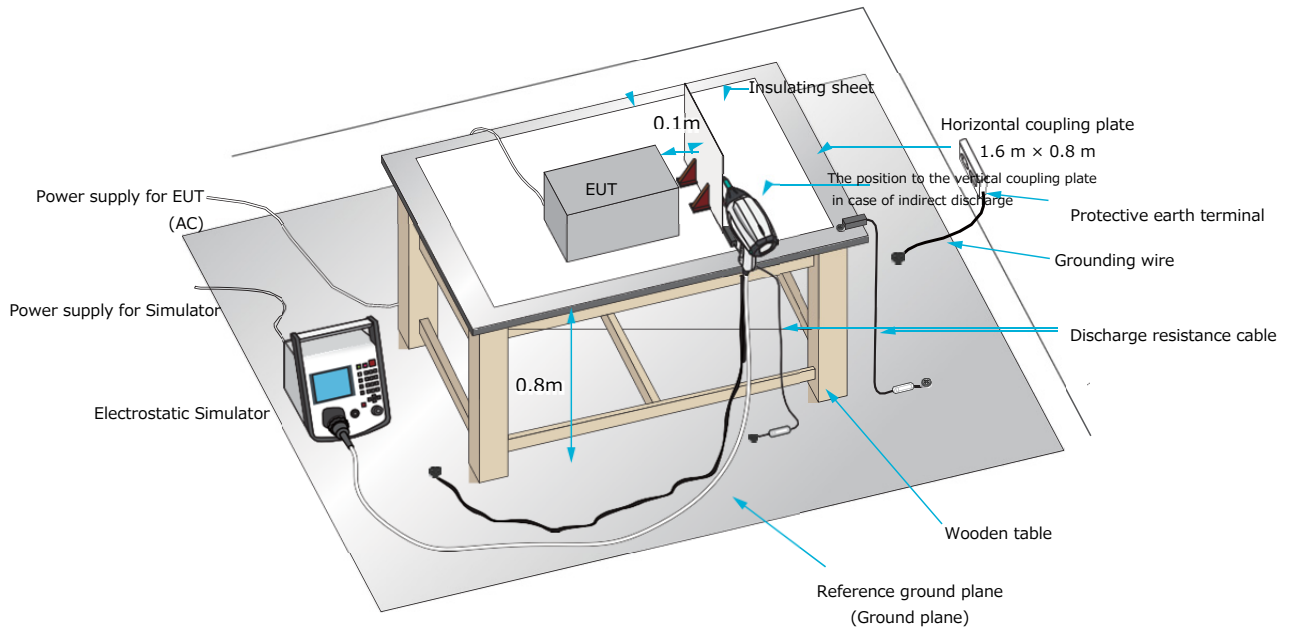
(2) In case of performing discharge to the vertical coupling plate

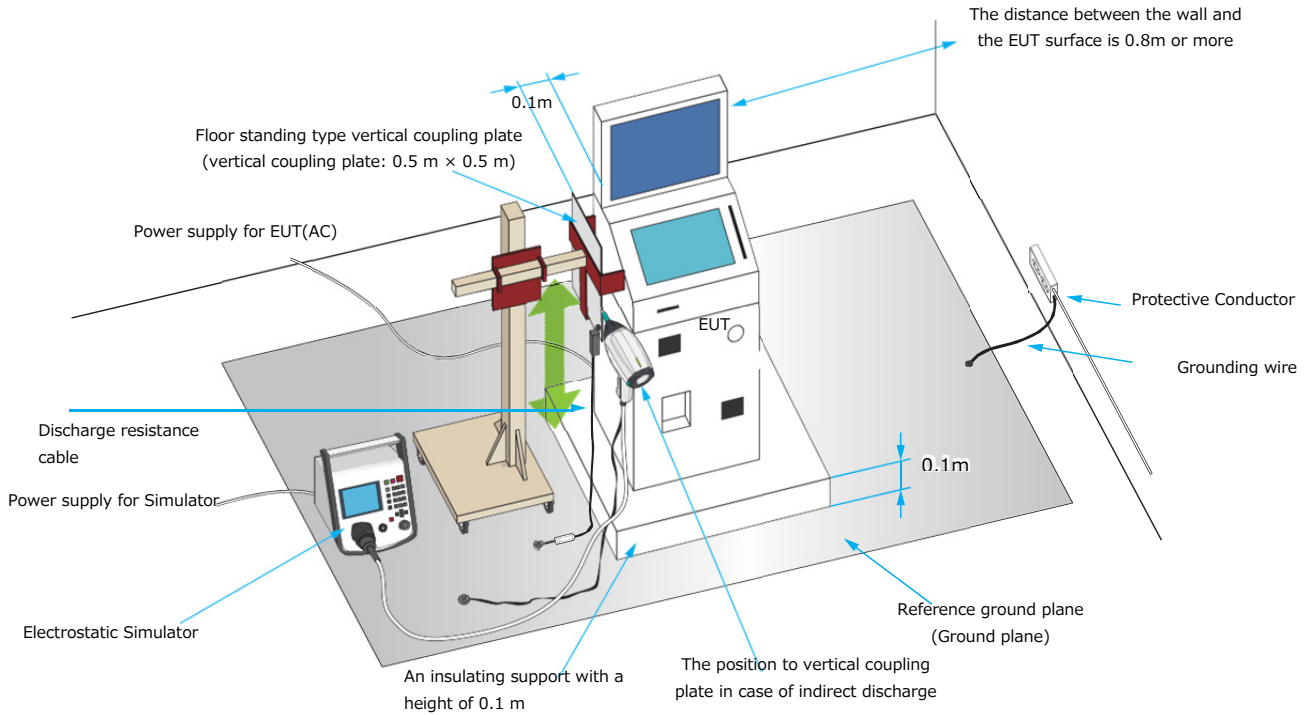
- Use the conical discharge tip.
- Discharge to the all sides of the EUT.
- Place a VCP 0.1m away from the EUT.
(the VCP shall be grounded to the ground reference plane via a cable with an 470 kΩ resistor at each end)
- Discharge the ESD gun with contacting it to the center of one vertical edge of the VCP. Hold the gun perpendicularly to the edge.
- If the side of the EUT is much larger than the VCP, move it so that it covers the whole side of the EUT by separate testing.
- Although the VCP can stick out from HCP, it is recommended to place the VCP on the insulation sheet on the HCP.
- For test levels, refer to chapter 5 "Reference materials"
- Conduct at least 10 discharges in each polarity to each side. A one second interval between each discharge is recommended.
- Keep the discharge return cable at least 0.2 m away from the EUT.
- Do not touch anything other than the ESD gun during the test.



Using the guide like the photo will make the discharge easier.

The distance between the wall and the EUT surface is 0.8m or more





3.3.3 Test method for the non-grounded EUT

For testing the EUT whose installation specifications or design precludes connection to any grounding system (equipment with no grounding terminal, battery-operated equipment or operated via an AC adaptor), removal of the residual charges on the EUT shall be performed before each discharge to correctly simulate a single discharge event. Also the points where the same story shall apply includes connector shells, pin to battery connection, antenna and other metallic parts.

There are two ways to remove the residual charges.

- 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 fiber brush with bleeder resistors (for example, $2 \times 470 \text{ k}\Omega$) in the grounding cable.

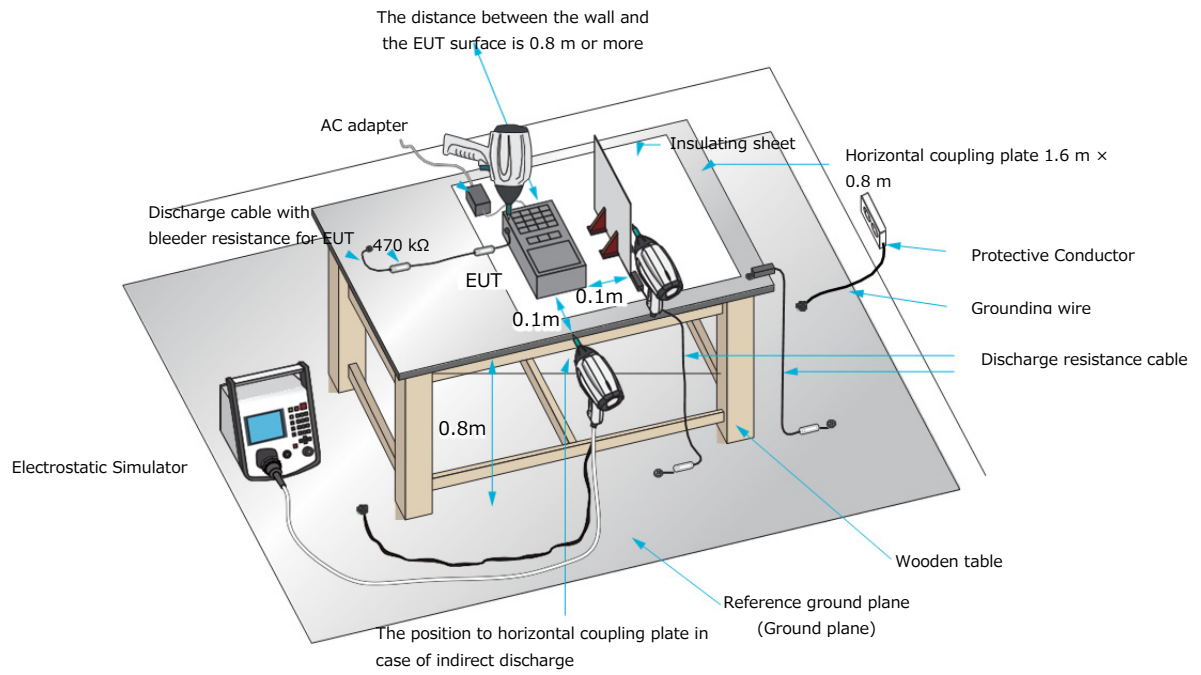
[1] For table-top EUT

Connect the discharge point the EUT with the HCP through a bleeder cable with two 470 k Ω resistors.

[2] For floor-standing EUT

Connect the discharge point the EUT with the ground reference plane through a bleeder cable with two 470 k Ω resistors.

One of two 470 k Ω shall be connected to the EUT with the shortest possible length, preferably within a 20mm distance. If test results are different between with and without a cable, adopt the result without the cable. The same application method as those for direct and indirect discharges is also applicable. At least 10 discharges shall be applied in each polarity. One second or longer interval is applicable.



ESD Elimination Brush Model : 05-00125A



Discharge resistance cable Model : 05-00054B

4 The summary of test results

4.1 Necessary information for test report

The basic measure for concluding and arranging the test result is repeatability of the test so that another operator can perform the same test with the same conditions in the next opportunity. In other words, the test is required to be characterized quantitatively. Therefore, the necessary information must be listed up and memorized.

In case of obtaining accreditation from a certification organization, at least the following information must be required. (Followings are referred to EN 45001.)

Accordingly, some of the information may be unnecessary if the evaluation is performed for some private purpose.

Please refer to "Example of Test Report" on P84 which is the standard form of Noise Laboratory Co., Ltd., for the reference.

4.1.1 Management of test reports

(1) Report management and types

Manage reports of the tests results by assigning the control numbers.

There may be various formats for the reports. In order to prevent the alteration after they are made, please specify the total page numbers and each page number of the total page number on each page.

(2) Customer name and address

This information is required when taking on the test requested by another party with contracts such as a test site.

(3) Clarification of responsibility for examination

It is necessary to clearly state the name title, or similar insignia (signature or stamp) of who is responsible technically, and the issue date.

4.1.2 Test environment

(1) Date of the test

State the date when the test conforming to IEC 61000-4-2 is performed.

(2) Location of the test site

In case the test is taken on in a public or similar test site, it is necessary to state the name and address of the site. Also specify the building and room in which the test is performed. The same manner should be taken even when the test is performed in own premises.

(3) Environment such as temperature and humidity

State the conditions inside the test room such as temperature, humidity, atmospheric pressure and electromagnetic environment, etc.

4.1.3 EUT and Test Equipment

(1) Name and description of EUT

State the general name and equipment name of the EUT. The general type means functional category of the EUT such as "radio", "TV", or "washing machine". The equipment name should also include the model name such as "PCA-**1", and the name or nickname of the equipment such as "libretto" or "VAIO".

If the test is performed with sampling, specifying the serial number is necessary to identify the EUT. Also specify how and why the EUT was selected.

(2) Identification number of test equipment

Record the name, serial number, and other description of the ESD simulator. (State expiration and frequency of the calibration)

4.1.4 Test method and result

(1) Test method

Although it is not necessary to state the method in case the test purposes accreditation according to the Standard, clearly state the reason and the method if the test procedure does not conform to IEC 61000-4-2, such as a case that horizontal coupling plate is not used for the test.

(2) Test results

In the test report, the judgment result based on the evaluation level must be stated.

Also, if minor quality degradation occurs, the effect of the test must be stated.

Below, we will describe judgment by evaluation level.

The test report must include the evaluation result based on evaluation levels.

Also, if minor decline of the quality level is detected, the effect of the test needs to be stated.

The evaluation criteria in the evaluation levels are described as below.

(a) There are two different evaluation level criteria that are the common standard and product group standard for performing the electrostatic discharge immunity test according to IEC 61000-4-2.

Define the detailed operational conditions in function of the EUT and the degradation or loss of the functional specifications previous to the test for the following evaluation levels.

(I) IEC61000-4-2 evaluation level

In IEC 61000-4-2, the criteria for evaluating the test results are divided into four levels based on the functional specifications and operational conditions in the EUT unless the evaluation criteria are specified separately in the applicable standard or product specification. Define own standard based on the following four levels.

1. Normal operation within the tolerance of the specification
2. Temporary degradation or loss in the operation or the function which is able to be recovered by a self-recovery function.
3. Temporary degradation or loss in the operation or the function which needs to be recovered by user intervention or reset in the system.
4. Unrecoverable degradation due to damage to equipment (parts), software or loss of data

(II) Evaluation level according to common standard or product group standard

For reference, details of the general evaluation criteria in as the common standard and as the product group standard are given in Chapter 5 MATERIALS FROM STANDARD .

(b) Record of influence and exclusion in the test

When a minor reduction of the function or performance occurs, it must be necessary to record how and what phenomenon has did. (Recording this information is recommended to avoid problems when the test is resumed.)

Also, record the reason if any test is excluded from the test standard. This may occur in cases such as presumption for risk that the electrostatic discharge would destroy the EUT.

【Mild function and degradation of performance】

It is the phenomenon that a blinking LED for a short time and a slight movement indicator needle.

4.1.5 Others

(1) Appendix

In addition to making tables and graphs of the test results, also make layout diagrams or similar to record the system configuration and what auxiliary equipment is used.

(2) Record uncertainties in the evaluation

Record any uncertainties in the evaluation. For example, if 8 times are "Level 2" and the rest 2 times are "Level 3" in 10 times of the test result, record the reason why "Level 2" is selected including the process to reaching the decision.

5 Standard reference materials

5.1 IEC 61000-4-2 Ed2 Standard outline

5.1.1 General

This is a standard applied to the immunity evaluation of electronic equipment against electrostatic discharge generated directly from the operator or from nearby objects under such conditions that chemical fiber carnival, and clothing are used in a low relative humidity environment. This standard stipulates that a charged human body carries a metal in hand and assumes a case where it discharges to an electronic device and conducts a test by using a circuit for simulating the current waveform generated at that time.

5.1.2 Test level

The test level for ESD is shown below.

Level	Test voltage (Contact Discharge)	Test voltage (Air Discharge)
1	2kV	2kV
2	4kV	4kV
3	6kV	8kV
4	8kV	15kV
X	Special	Special

5.1.3 Generator specification and output waveform verification

■ Specification of electrostatic discharge simulator

When conducting an electrostatic test, use a simulator that meets the following specifications.

Energy storage capacity (Cs)	150 pF
Discharge resistance (Rd)	330 Ω
Output voltage Contact discharge ※ 1	Minimum, 1kV ~ 8 kV, Nominal
Output voltage air discharge ※ 1	Minimum, 1kV ~ 15 kV, Nominal ※ 3
Accuracy of voltage display	± 5 %
Output voltage polarity	Positive and negative (switchable)
Holding time of voltage	5 seconds or more
Discharge operation mode ※ 2	Single discharge (discharge interval is 1 second or longer)
Waveform of discharge current	See the figure below

※ 1 Open circuit voltage measured at discharge electrode.

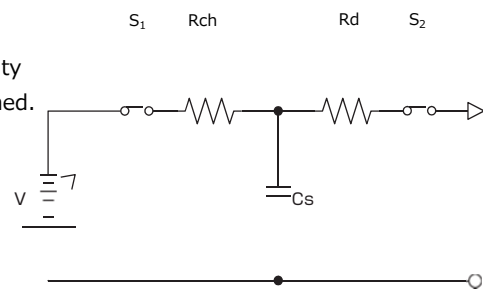
※ 2 For preliminary testing, the generator shall be able to discharge at a discharge repetition rate of at least 20 times per second

※ 3 If the maximum test voltage used is lower than this, it is not necessary to use a generator with 15 kV air discharge capability

■ Feature of electrostatic discharge simulator

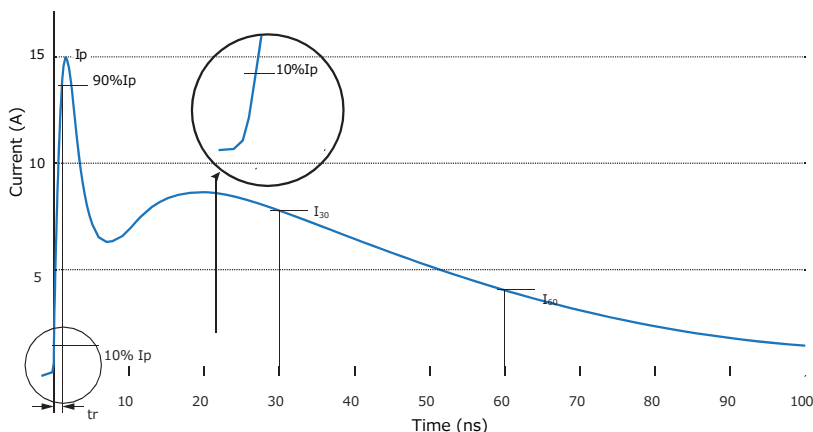
In order to compare the test results obtained with different static electricity generators, the characteristics shown in the table below must be confirmed.

Level	Display voltage kV	Peak current Ip (±15%) A	Rise time tr (±25%) ns	Current at 30 ns (±30%) A	Current at 60 ns (±30%) A
1	2kV	7.5A	0.8ns	4A	2A
2	4kV	15A	0.8ns	8A	4A
3	6kV	22.5A	0.8ns	12A	6A
4	8kV	30A	0.8ns	16A	8A



Capacitor capacitance Cs: 150 pF
Discharge resistance Rd: 330 Ω

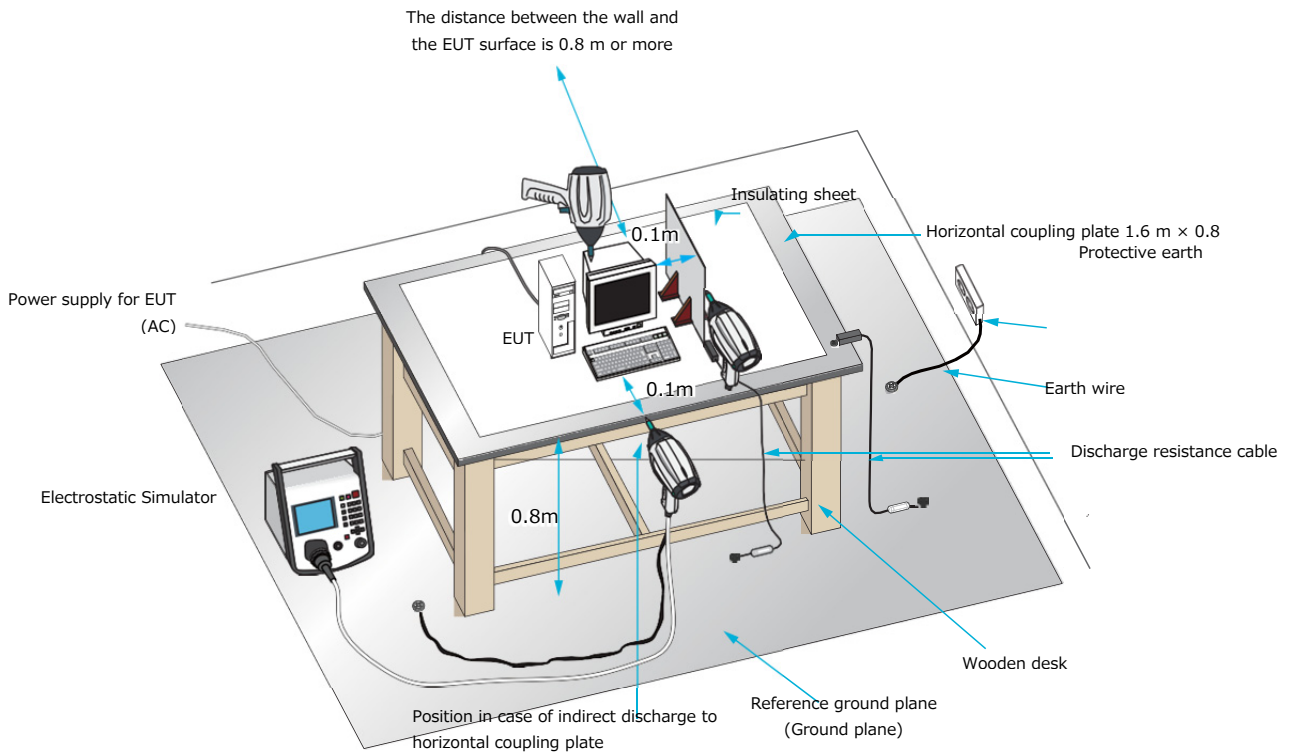
Simplified diagram of electrostatic simulator



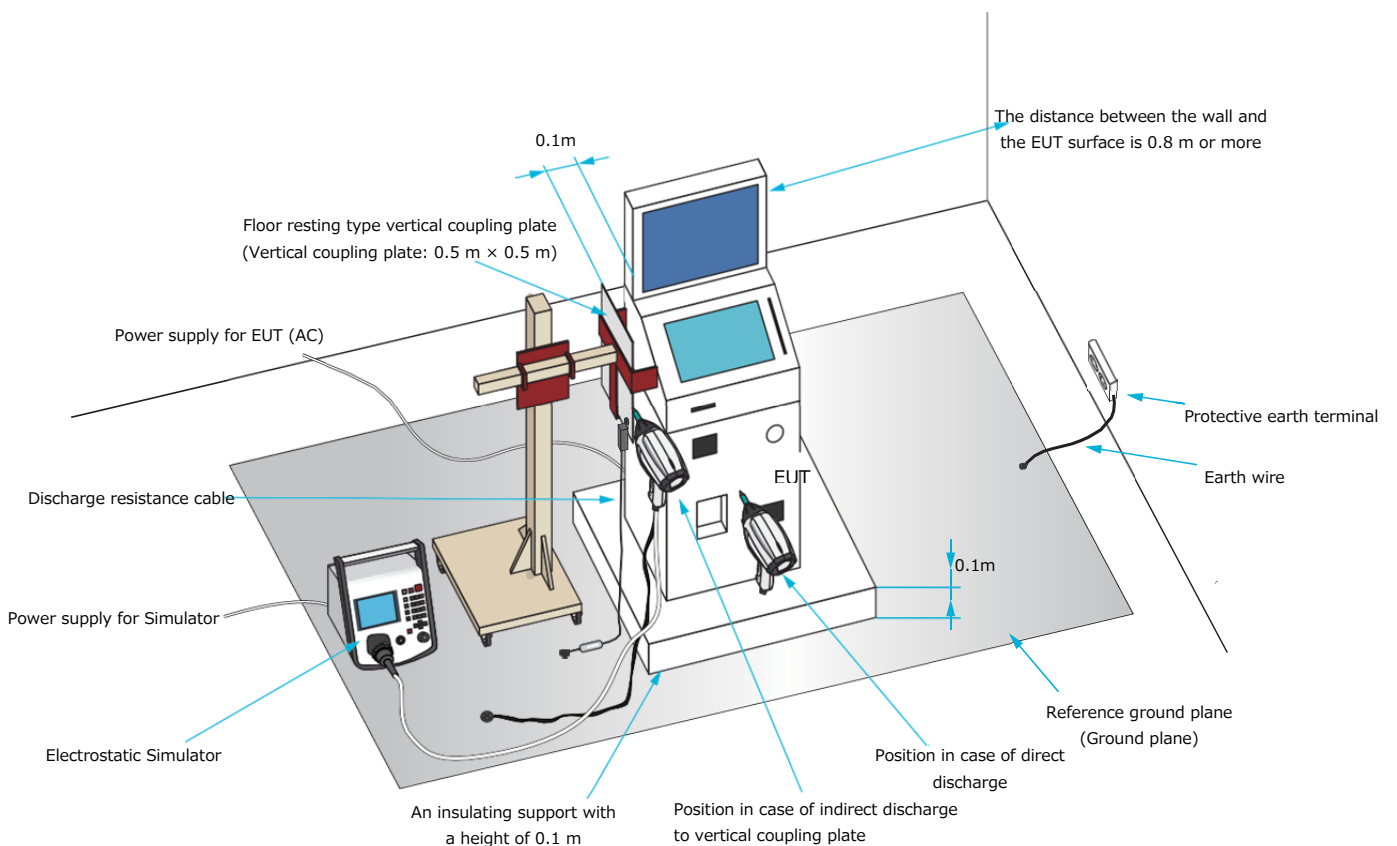
Feature of discharge current waveform and waveform

5.1.4 Arrangement of a test equipment

■ Explanation of arrangement of test equipment for table equipment



■ Explanation of arrangement of test equipment for floor-standing equipment



5.2 Evaluation Criteria

Although the test result must be evaluated based on the level criteria when the test is performed according to IEC 61000-4-2, the levels are different depending on the standard which is desired. Followings are examples in case of EN 61000 - 6, CISPR 24.

5.2.1 EN61000-6

EN 61000-6-1, EN 61000-6-2

Performance evaluation criterion A

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

Performance evaluation criterion B

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

Performance evaluation criterion C

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

5.2.2 CISPR24

Performance evaluation criterion A

The EUT shall continue to operate as intended without operator intervention. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the EUT is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user may reasonably expect from the equipment if used as intended.

Performance evaluation criterion B

The EUT shall continue to operate as intended without operator intervention after the test. No degradation of performance or loss of function is allowed, after the application of the phenomena below a performance level specified by the manufacturer, when the EUT is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is allowed. however, no change of operating state or stored data is allowed to persist after the test.

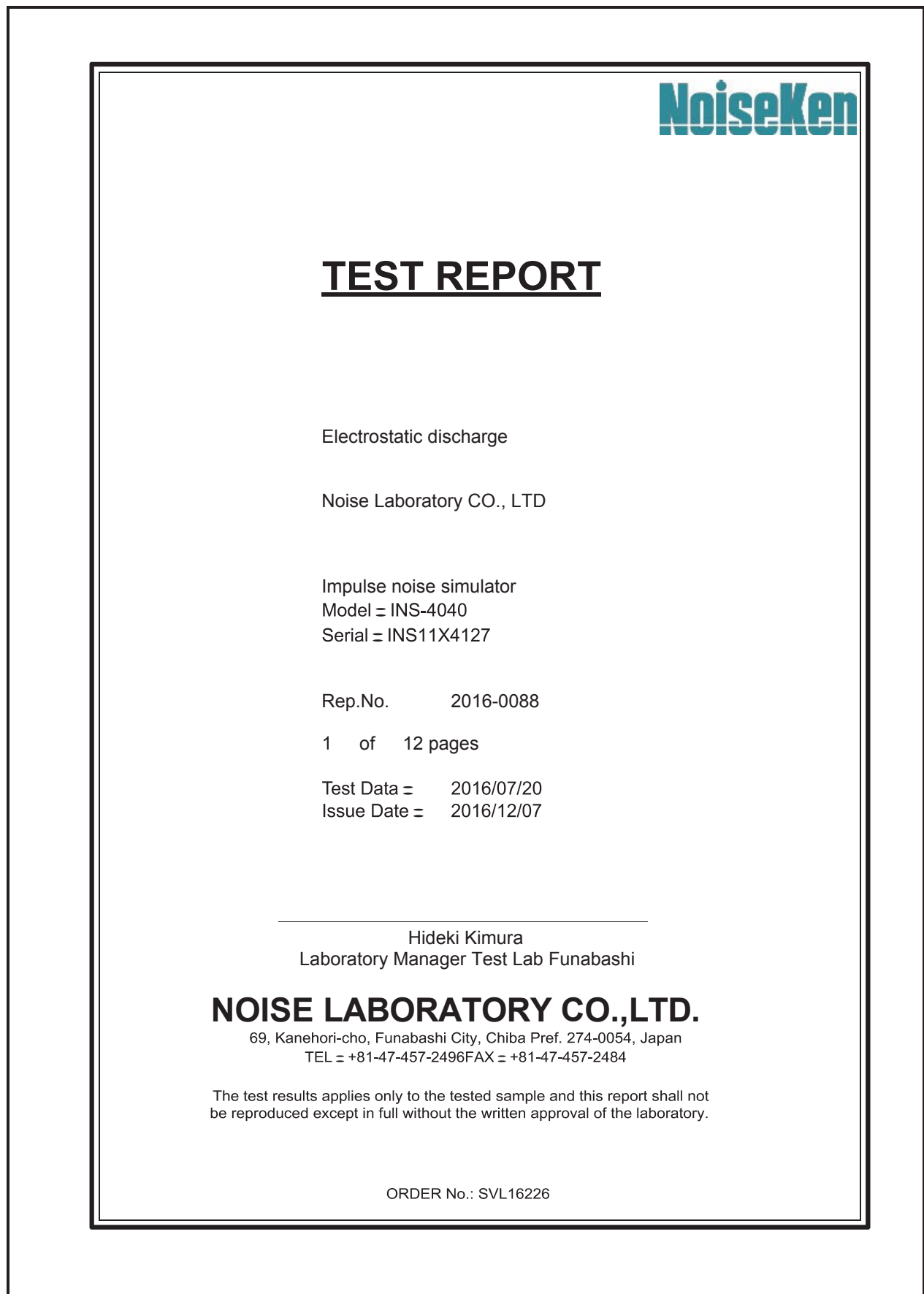
If the minimum performance level (or the permissible performance loss) is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user may reasonably expect from the EUT if used as intended.

Performance criterion C

During and after testing, a temporary loss of function is allowed, provided the function is self-recoverable, or can be restored by the operation of the controls or cycling of the power to the EUT by the user in accordance with the manufacturer's instructions.

5.3 Example of Test Reports

Followings are example of test reports formed by Noise Laboratory Co., Ltd.
(an example of NoiseKen's "square wave impulse noise simulator" as an EUT)



Summary

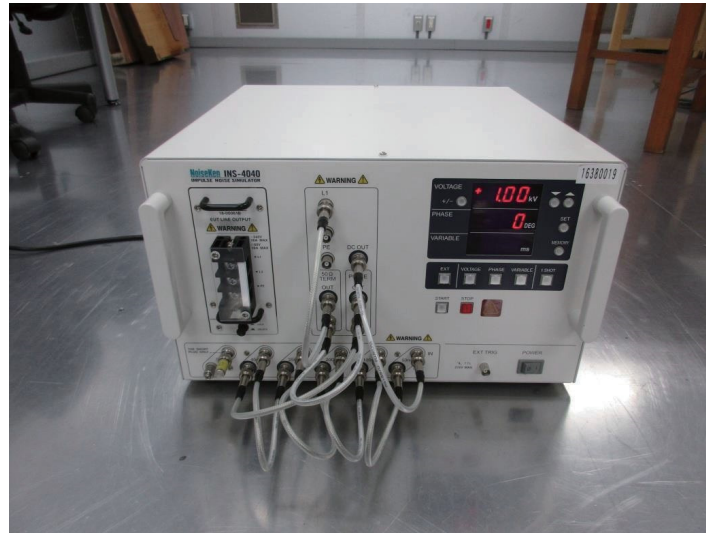
Type of Test: Electrostatic discharge
Regulation(s): EN61326-1:2013
Test method(s): IEC61000-4-2:2008
Test result: **PASS**
Test date: 2016/07/20
Client: Noise Laboratory CO., LTD
Address: 1-4-4,Chiyoda,Chuo-
ku,SagamiharaCity, Kanagawa Pref.
252-0237,Japan
Tel:+81-42-712-2041 Fax:+81-42-712-2040

Test sample: Impulse noise simulator
Model: INS-4040
Serial: INS11X4127
Clock frequency: -MHz
Power supply: AC 230V(50Hz)
Phase: Single phase

Test place: Noise Laboratory Co., Ltd.
69, Kanehori-cho, Funabashi City, Chiba
Pref. 274-0054, Japan

NoiseKen engineer: K.Ogata _____
Engineer Test Lab Funabashi

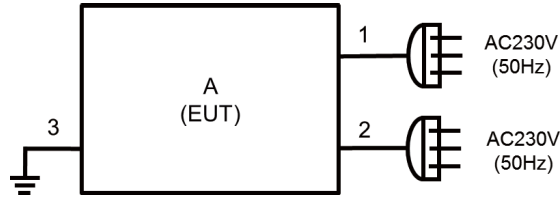
Equipment under Test



Test sample: Impulse noise simulator
Model: INS-4040
Serial: INS11X4127
EUT type: Floor-stand
Operation mode: Normal operation
Power on state (AC 230V)
EUT line input power (AC 230V)

Equipment under Test

System configuration diagram:



«Equipment used»

A:	Equipment	Impulse noise simulator
	Brand	NoiseKen
	Model	INS-4040
	Serial	INS11X4127
	Note	EUT

«Cable used»

1:	Cable name	AC power cable
	Length[m]	2.0m
	Shield	No
	Note	-
2:	Cable name	EUT line input power cable
	Length[m]	1.5m
	Shield	No
	Note	-
3:	Cable name	GND cable
	Length[m]	0.15m
	Shield	No
	Note	-

Test equipment

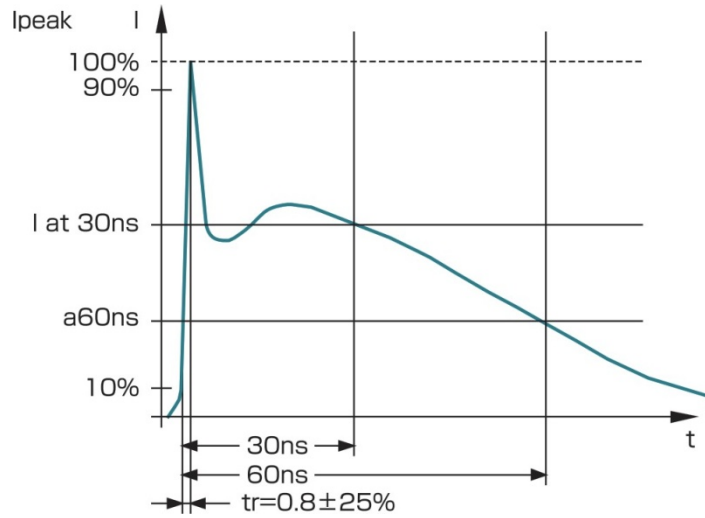
ESD simulator	NoiseKen	Model	ESS-S3011
		Serial	ESS1181864
		LastCal.	2016/06
		Cal.int.	1Year(s)
Discharge gun	NoiseKen	Model	GT-30R
CR constant (150pF/330Ω)		Serial	ESS1223279
		LastCal.	2016/06
		Cal.int.	1Year(s)



ESD simulator / Discharge gun

Test conditions

Regulation(s) EN61326-1:2013
Test method(s): IEC61000-4-2:2008
Test Level: «Direct discharge»
 Contact ... 4kV
 «Indirect discharge»
 VCP ... 4kV
Polarity: + and-
Test times: 10 times /point
Interval: 1s
CR Constant: 150 pF / 330Ω

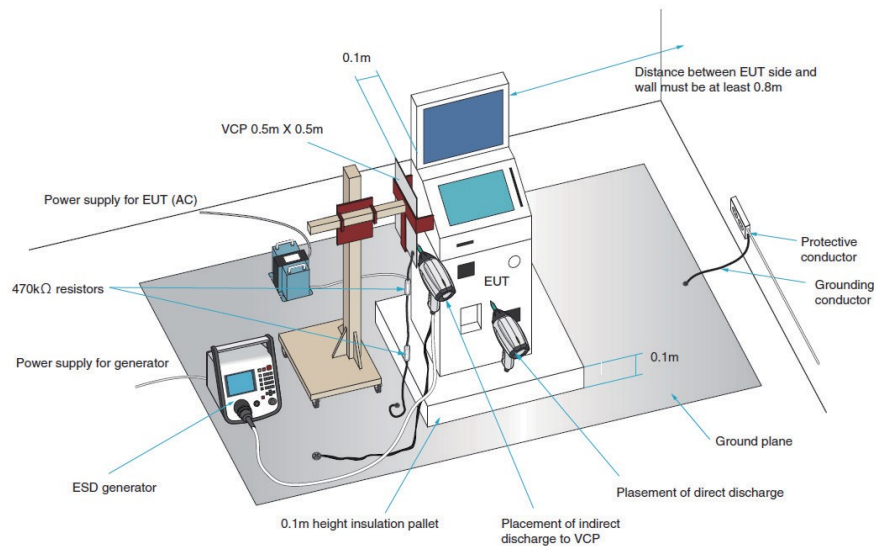


Discharge current waveform

Test environment

Facility: Shield roomNo.2
Temperature: 23°C - 23°C
Humidity: 51% - 50%
Insulating support height: 10cm

Test setup:



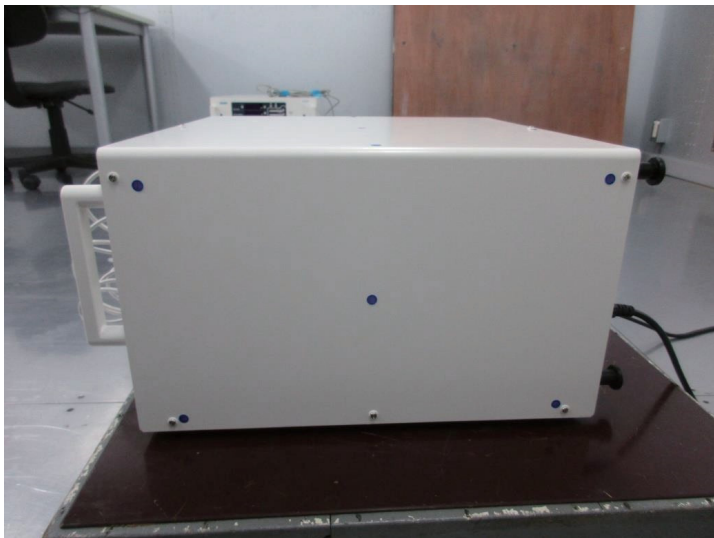
Typical Test setup

Setup photo(s)



Test point
(Front side)

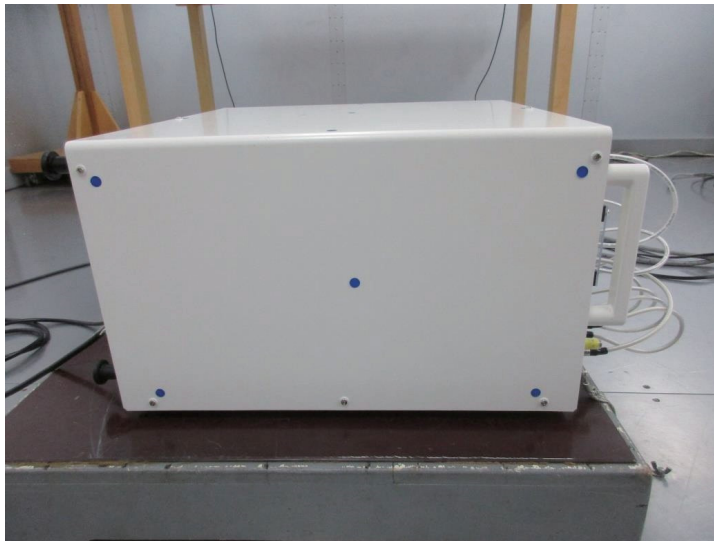
● : Contact discharge



Test point
(Right side)

● : Contact discharge

Setup photo(s)



Test
point(Left
side)

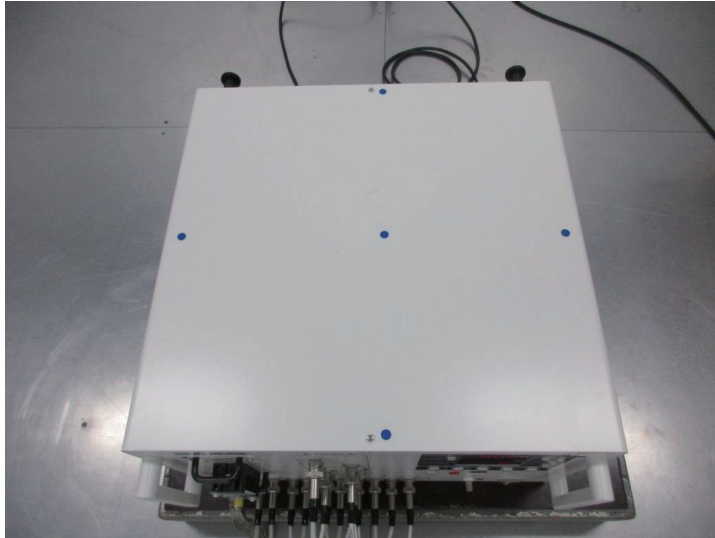
● :Contact discharge



Test point
(Rear side)

● :Contact discharge

Setup photo(s)



Test
point(Top
side)

● :Contact discharge



Indirect discharge
(VCP)

Judgement

«Performance criteria»

- A) The equipment shall continue to operate as intended during and after the test.
No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended.

- B) The equipment shall continue to operate as intended after the test. During the test, degradation of performance is allowed.
No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended.

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

Test result

«Direct discharge Test (Contact discharge)»

	Surface	Front		Right		Left		Rear		Top	
	Quantities	6 point(s)		5 point(s)		5 point(s)		6 point(s)		5 point(s)	
	Polarity	+		+		+		+		+	
Level	2.0 kV										
	4.0 kV	A	A	A	A	A	A	A	A	A	A
	6.0 kV										

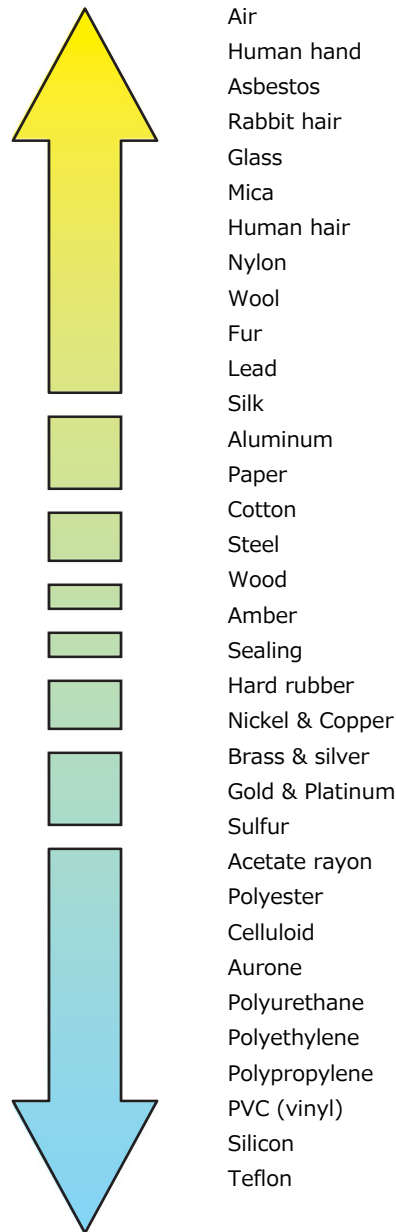
«Indirect discharge Test (VCP)»

	Surface	Front		Right		Left		Rear		Top	
	Quantities	1 point(s)		1 point(s)		1 point(s)		1 point(s)			
	Polarity	+		+		+		+		+	
Level	2.0 kV										
	4.0 kV	A	A	A	A	A	A	A	A		
	6.0 kV										

5.4 Various data on electrostatic discharge phenomenon

(1) A triboelectric series of substances in an order of positive to negative charging as a result of the triboelectric effect (DOD-HDBK-263)

Positive (+)



- Air
- Human hand
- Asbestos
- Rabbit hair
- Glass
- Mica
- Human hair
- Nylon
- Wool
- Fur
- Lead
- Silk
- Aluminum
- Paper
- Cotton
- Steel
- Wood
- Amber
- Sealing
- Hard rubber
- Nickel & Copper
- Brass & silver
- Gold & Platinum
- Sulfur
- Acetate rayon
- Polyester
- Celluloid
- Aurone
- Polyurethane
- Polyethylene
- Polypropylene
- PVC (vinyl)
- Silicon
- Teflon

Negative (-)

(2) Charged recording data (DOD-HDBK-263)

Static electricity generation phenomenon	Generated voltage	
	Relative humidity 10% ~ 20%	65% ~ 95%
Walk on the carpet	35000	1500
Walk on a vinyl floor	12000	250
A person sitting in a chair and working	6000	100
Vinyl envelope of work instructions	7000	600
Poly bags picked up from the chair	20000	1200
Work chair with polyurethane stuck	18000	1500

5.5 References

- IEC 61000-4-2
Electromagnetic compatibility (EMC) -
Part 4-2: Testing and measurement techniques - Electrostatic discharge
immunity test
Basic EMC Publication First
edition: 1995/01
Amendment 1:1998/01
Amendment 2: 2000/11
Edition 1.2: 2001/04
Edition 2.0: 2008/12
- ISO 10605
Road vehicles — Test methods for electrical disturbances from electrostatic discharge
- DOD HDBK 263
Electrostatic Discharge Control Handbook For Protection Of Electrical And Electronic Parts, Assemblies And Equipment
(Excluding Electrically Initiated Explosive Devices)Metric
- Electromagnetic compatibility JIS C 1000-4-2 : 1999
Part 4: Test and Measurement Techniques Section 2: Electrostatic Discharge Immunity Test
- (CISPR Practical Reference Book - Volume 1) CISPR24
- Limit value and measurement method on immunity characteristics
of information technology equipment - supervised by Tetsuo Ikeda
- IEC 1000 series 1996 edition
Issued Kansai Electronic Industry Promotion
Center Editorial Electromagnetic Disturbance
Subcommittee
- Science Timeline Heisei
19th Author Tokyo
Astronaut Publisher
Kiyoshi Ebihara Issued
Maruzen Co., Ltd.
- NOISE TECHNICAL REPORT 1975~1996 Issued Noise
Laboratory Co., Ltd.
- Noise countermeasure manual
Issued by Noise Laboratory Co., Ltd.
- IEC 77B/563/CDV IEC61000-4-2 Ed2.0 DRAFT

5.6 Noise Laboratory compatible products Model list

The product list related to the electrostatic test of Noise Laboratories Co., Ltd. used in this manual is shown below. Please contact us at the time of ordering.

