IEC 61000-4-2 ESD Ed.2.0 2008
Immunity to the discharge of electrostatic electricity

Accelonix EMC workshop 17-9-2019
Electrostatic Discharge (ESD)

- ESD is the most common EMC test performed. ESD is a good starting point.

- The setup is not complex and is very economical

- The application of the actual standards gives good results. A product tested according the ESD standards will have a high immunity to the ESD in the „real world“

Note: The methodology and the levels defined by the standards exceed the conditions met in the „real world“
Discharge to victim equipment

- Triboelectric charging through motion
- Body capacitance maintains charge voltage
- Return current path

(Electrostatic Discharge (ESD))
Electrostatic voltages

Guideline for the selection of the test levels

<table>
<thead>
<tr>
<th>Class</th>
<th>rel humidity at low as</th>
<th>Antistatic material</th>
<th>Synthetic material</th>
<th>max. voltage [kV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35%</td>
<td>x</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td>x</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>50%</td>
<td>x</td>
<td>x</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>10%</td>
<td>x</td>
<td>x</td>
<td>15</td>
</tr>
</tbody>
</table>

Means of Generation 10-25% RH 65-90% RH

- Walking across carpet: 35'000 V 1'500 V
- Walking across vinyl tile: 12'000 V 250 V
- Worker at bench: 6'000 V 100 V
- Poly bag picked up from bench: 20'000 V 1'200 V
- Chair with urethane foam: 18'000 V 1'500 V
Body discharge of human being

- Discharging by a metallic tool
Simplified diagram of ESD-Simulators

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**
Modes of discharges

Contact Discharge

Air Discharge
Test Levels

• For air discharge all test levels up to requirement have to be tested.
• For contact discharge only the specified test levels have to be tested (however, we recommend to continue testing as for air discharge).
• Maximum 1 discharge per second
• min. 10 discharges with stronger polarity

<table>
<thead>
<tr>
<th>Level</th>
<th>Air discharge</th>
<th>Contact discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 kV</td>
<td>2 kV</td>
</tr>
<tr>
<td>2</td>
<td>4 kV</td>
<td>4 kV</td>
</tr>
<tr>
<td>3</td>
<td>8 kV</td>
<td>6 kV</td>
</tr>
<tr>
<td>4</td>
<td>15 kV</td>
<td>8 kV</td>
</tr>
</tbody>
</table>
**Specification contact discharges:**

- According to EN 61000-4-2:2009

<table>
<thead>
<tr>
<th>Level</th>
<th>Indicated voltage [kV]</th>
<th>First peak current of discharge [A] (±15%)</th>
<th>Rise time $t_r$ with discharge switch [ns] (±25%)</th>
<th>Current at 30ns [A] (±30%)</th>
<th>Current at 60ns [A] (±30%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>7.5</td>
<td>0.8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>15</td>
<td>0.8</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>22.5</td>
<td>0.8</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>30</td>
<td>0.8</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

The reference point for measuring the time for the current at 30ns and 60ns is the instant when the current reaches 10% of the 1st peak of the discharge current.

**NOTE:** The rise time $t_r$ is the interval between 10% and 90% value of the 1st peak current.
Tools needed
- DSO with a bandwidth of at least 2GHz
- Faraday cage
- Pellegrini target

At voltage levels +/- 2kV, +/- 4kV, +/- 6kV, +/- 8kV:

Four parameters need to be measured at each voltage level:
- Initial peak current
- Rise time between 10% and 90% of the initial peak
- Current value at 30ns
- Current value at 60ns

The time domain for the initial peak and rise time measurement is recommended to be set to 1ns/Div.
For the current measurement at 30nS and 60ns a setting of 10ns/Div is recommended as being appropriate.
ESD waveform verification

For example:
A discharge current of 7.5A will give a voltage reading of 1.5V on the DSO
Set-up for calibration of ESD pulses

NOTE 1  The generator should be installed on a tripod or equivalent non-metal low loss support.

NOTE 2  The generator should be powered in the same way as it will be used during test.

NOTE 3  A reversed setup compared to Figure B.5 can also be used.

Pellegrini target

<table>
<thead>
<tr>
<th>TECHNICAL DATA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring Resistor</td>
<td>20ohm ±5%</td>
</tr>
<tr>
<td>Design</td>
<td>As per IEC 61000-4-2, Ed.2:2008 and EN 61000-4-2:2009</td>
</tr>
<tr>
<td>Output</td>
<td>Coaxial SMA Connector</td>
</tr>
<tr>
<td>Attenuator</td>
<td>An additional attenuator must be connected to the output of the CTR 2 depending on the input capability of the oscilloscope.</td>
</tr>
<tr>
<td>Insertion loss</td>
<td>±0.5dB up to 1 GHz and ±1.2dB up to 4GHz</td>
</tr>
<tr>
<td>ESD test voltage</td>
<td>±30kV</td>
</tr>
<tr>
<td>Dimensions</td>
<td>70mm (diameter) x 30mm</td>
</tr>
<tr>
<td>Weight</td>
<td>Approx. 400g</td>
</tr>
</tbody>
</table>
Set-up for the calibration of ESD pulses

Please observe that the ground return cable shall be pulled backwards at its mid point to form a large loop. This is of high importance as the ground return cable may heavily influence the ESD pulses, especially at the measuring point at 30ns and 60ns. If this fact is not properly observed you may see oscillations on the scope disturbing the pulse characteristic.
Summary of the essential changes from previous Ed.1.0

- Amendment limit deviations for the waveform of the current pulse:
  - first discharge current peak +/-15%
  - rise time: 0.8ns +/-25%
- For calibration each single pulse must meet the waveform specification.
- Distance test set-up to walls or other metallic parts: >0.8m
- Ground return line can be connected on the metallic wall of the laboratory, if this is extensively connected with the reference ground surface.
- 2m ground return line is not allowed to hold in the hand.
- Figures were changed, also the VCP has been included at floor-standing devices
- The use of an air ionizer is not allowed.
- At contact discharge it is not a must to test each test level individually up to the demanded level, this only applies to air discharge.
Test set-up for table top devices according IEC 61000-4-2
Test set-up ESD according to EN61000-4-2

- **Test table with horizontal coupling plane (HCP)**
- **Set of grounding resistors of 2 x 470 kOhm each**
- **Grounding of reference plane**
- **ESD gun with grounding of 2m length**
- **Reference ground plane**
- **Vertical coupling plane (VCP)**
- **isolated support**
- **EUT**

**Reference**

- ground
grounding
table
horizontal
coupling

**Equipment**

- EUT
- ESD gun
- Grounding of reference plane
- Test table with horizontal coupling plane (HCP)
- Set of grounding resistors of 2 x 470 kOhm each
- Vertical coupling plane (VCP)
- Isolated support

**Test Description**

The test set-up follows the guidelines of EN61000-4-2 for ElectroStatic Discharge (ESD) testing. The setup includes a test table with a horizontal coupling plane (HCP) to simulate a real-world environment. An EUT is placed on the table, which is connected to a grounding system consisting of a set of grounding resistors of 2 x 470 kOhm each. An ESD gun, equipped with grounding of 2m length, is used to simulate an ESD event. The isolation support ensures that the test setup remains stable and unaffected by external disturbances.
The horizontal coupling plane (HCP) must have a size of $(1.6 \pm 0.2)\text{m} \times (0.8 \pm 0.2)\text{m}$.

The HCP is 0.8m above the ground plane (GRP) on an non-metallic table and is connected via $2 \times 470 \text{k}\Omega$ to the GRP.

The ground plane (GRP) shall project beyond the EUT or the dimensions of the HCP by at least 0.5m and shall be connected to the protective grounding system.

The HCP shall project beyond the EUT including connection lines by at least 10 cm to all sides.

The EUT table has to provide a distance of $>0.8\text{m}$ to any other conducting structures.

The EUT and cables shall be isolated from the coupling plane by an insulating support $(0.5 \pm 0.05)\text{mm}$ thick.

The grounding ratio of the EUT shall be according to the real ratio, i.e. if the EUT is additionally grounded in practice, then this has to be considered as well in the test set-up. Attention, but not at HCP!

The return cable of the test gun or discharge circuit respectively has to be connected with the GRP and has to be leaded in a distance of $\geq 0.2\text{m}$ to the EUT and its lines while discharging.

The tester is not allowed to hold the return cable in the hand.

The test gun is kept in a $90^\circ$ angle to the discharge point. If this is not possible, it has to be stated into the test report.
Direct discharge as contact discharge
Indirect discharge on HCP
Indirect discharge on VCP
Test points according to EN 61000-4-2

- **Direct discharge**
  - All accessible points (touchable by user)
  - Housing: edges, angles, surfaces, slots, indicator parts
  - Operating parts: switches, buttons, plugs, etc.
  - Interfaces with metallic housing: only contact discharge on plug housing
  - Interfaces with isolated housing: only air discharge on plug housing
  - In certain cases product standards can request the discharge on pins

- **Indirect discharge**
  - Edge of vertical coupling plane, VCP with 10 cm distance to each EUT side.
  - Edge of horizontal coupling plane, EUT with each side with 10 cm distance to the discharge point.
Test procedure for ungrounded devices

• Problem:
  – A prior loaded test point cannot discharge itself completely.

• Consequences:
  – Cascading of test voltage (over-tested)
  – Too low discharge current (under-tested)
  – Non-reproducible behavior of EUT

• Remedy:
  – Removing load before next discharge:
  – Fixing an discharge connection (2 x 470kΩ) on supply point (see figure right hand)
  – Discharging manually with carbon fiber brush in line with discharge connection (2 x 470kΩ)
  – Increasing time between discharges!?!?
  – According to the new standard it is not allowed to use an ionisator
Test set-up for ungrounded floor standing devices
Test set-up for floor-standing devices, post installation
For informative testing:

If you want to strengthen the ESD noise current, connect the reference ground plane or the Ground return line direct to the EUT housing. Depending on the ground point, certain coupling paths could be simulated.
Summary electrostatic discharge ESD

• Interference source:
  – Static charging by load separation due to friction of badly conductive materials. When approaching variably charged elements the interfering charge exchange happens.

• Parameter:
  – Sporadic, pulse-shaped, high-energy, high-frequency, broadband disturbancies arise as single pulses
  – Standard: Rise times in ns range with amplitudes of 2kV, 4kV, 6kV, 8kV, 12kV, 15kV, 20kV, 25kV.
  – Practise: Amplitudes of several 10kV.

• Impact:
  – Impact of signal in data processing fields (Logic error and its consequences).
  – Impact of analogue signals and controls.
  – Destruction of semiconductors.
ESD Simulators

Current ESD simulators from the AMETEK CTS product lines

- dito
- NX30 NX30.1
- NSG 435
- NSG 437
- NSG 438
- NSG 439
Thank you!

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