UPDATE ON ESD TESTING ACCORDING TO IEC 61000-4-2

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SUMMARY

CE Mark testing to meet the EMC requirements of EC Council Directive 89/336/EEC requires testing according to EN 61000-4-2. EN 61000-4-2 is issued by CENELEC and they use IEC standard IEC 61000-4-2 as the reference standard for ESD testing. ESD testing can be destructive to electronic circuits and the test setup for the test is very important in assuring a successful test. This paper covers some of the basics of the ESD testing requirements, addresses how to verify the ESD waveform and provides an update on proposed changes to the IEC 61000-4-2.

INTRODUCTION

The IEC 61000-4-2 Edition 1.2 issued in April 2001 is the reference document for EN 61000-4-2: 1995/A2: 2001. This became the controlling ESD document effective December 1, 2003. Edition 1.2 of the IEC document consolidates amendment 1 of the 1998 issue and amendment 2 of the 2000 issue. Amendment 1 was made effective by CENELEC January 1, 2001 and amendment 2 is the change that took effect in December 2003. Amendment 1 clarifies ESD testing of ungrounded EUT’s such as those using non-conductive bezels, direct application of the ESD pulse to points only accessible during normal use of the EUT and discharges to the horizontal coupling plane under the EUT (see Figure 1 below). Amendment 2 clarifies the classification of test results and the information to be included in the test report.

UPDATE ON PROPOSED ESD SPECIFICATION CHANGES

The IEC committee for ESD issued edition 2 of IEC 61000-4-2 for vote in April of 2003. This second edition created much discussion in the EMC testing arena once it was circulated since it meant that users might have to purchase new ESD simulators to meet the new requirements. Edition 2 addressed the need to reduce differences in test results among the various simulator manufactures. EMC test engineers have long noted that EUT’s could either pass or fail ESD testing depending upon the simulator used for testing. The simulators are all fully compliant with the IEC standard, yet the test results are somehow different.

It has been observed that the actual ESD discharge waveform of the human body is smooth and that very little electric field energy is radiated. IEC 61000-4-2 Edition 2 sought to address the test result differences by eliminating the ringing on the discharge waveform and by reducing the electric field radiation from the ESD simulator. Edition 2 also discusses the ESD target used in the ESD waveform verification in detail as well as providing test set-up guidance for performing the ESD test and pulse verification.
Edition 2 is very similar to the ANSI C63.16 (draft version) on ESD Test Methodologies and Criteria for Electronic Equipment. In October of 2003 the IEC national committee members rejected approval of IEC 61000-4-2 Edition 2.

BACKGROUND ON ESD TESTING

ESD is coupled to electronic or electrical products by direct human contact to the product or indirect contact from the human to the product via metal objects. ESD is an everyday event that can cause destructive damage to electronic circuitry. This can render the circuit inoperative either permanently or worse, causing damage that has a “time-bomb” effect. This is when an integrated circuit is not damaged enough to stop working after the ESD event, but it slowly degrades over time to eventually fail for what appears to be no apparent reason.

The difficulty that the standards organizations have faced is how to simulate the actual ESD event with a tester, how to define and verify the ESD waveform and how to create a laboratory ESD test set-up that can be used to compare test results among various EUT's. Figure 1 below shows the recommended ESD test set-up for tabletop equipment according to IEC 61000-4-2 (Figure 5). In Figure 1 we are using a battery powered ESD simulator. It is important to duplicate the recommend IEC test set-up in order to have reproducible results. Of particular importance is the ground return cable of the ESD simulator. Care must be taken that this cable is fully extended and not twisted or crimped in any way. This insures that the injected current waveform is correct.

**FIGURE 1: ESD test set-up according to IEC 61000-4-2 for tabletop equipment**
Figure 2 below shows the ESD generator current waveform for contact discharge tests as specified in Figure 3 of IEC 61000-4-2 Ed. 1.2. This is the waveform characteristic that the ESD generator must conform to. Figure 2 of the IEC standard supplies a typical arrangement for verification of ESD generator performance. We show a typical verification arrangement in Figure 3 below. The parameters of the ESD generator waveform to be verified are:

- Initial peak current
- Rise time from 10% to 90% of the initial peak current
- Current level at 30 ns
- Current level at 60 ns

![ESD generator output current waveform according to IEC 61000-4-2](image)

Table 1 below lists the waveform parameters specified for the ESD generator. This is Table 2 in IEC 61000-4-2. As stated above, this waveform is verified only during contact discharge and not air discharge. IEC 61000-4-2 Edition 1.2 does not address the air discharge waveform. This issue was discussed in Edition 2, but this edition has been rejected as noted in the update on specifications above. The draft version of ANSI C63.16 does address air discharge pulse characteristics.
Verification of the ESD current discharge waveform is critical for accurate testing of EUT’s for ESD immunity. To perform the pulse verification, a wide-band oscilloscope is used to observe the voltage waveform developed across a 2 ohm target during an ESD generator contact discharge. The oscilloscope must be mounted in a shielded enclosure (the IEC standard recommends a Faraday cage-see Figure 2 of IEC 61000-4-2). The oscilloscope must be shielded from the ESD discharge to prevent radiating the ESD signal into the oscilloscope input resulting in erroneous readings. The IEC standard recommends an oscilloscope of 1GHz bandwidth and the 2 ohm target must also have a 1 GHz bandwidth. We recommend that the scope bandwidth be 2GHz minimum in order to more accurately measure the pulse rise time.

<table>
<thead>
<tr>
<th>Level</th>
<th>nominal voltage</th>
<th>peak value current of discharge ± 10%</th>
<th>rise time tr with discharge switch [ns]</th>
<th>current at 30ns [A]</th>
<th>(± 30%) at 60ns [A]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>7.5</td>
<td>0.7 to 1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>15</td>
<td>0.7 to 1</td>
<td>8</td>
<td>4</td>
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<tr>
<td>3</td>
<td>6</td>
<td>22.5</td>
<td>0.7 to 1</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>30</td>
<td>0.7 to 1</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

**TABLE 1: Current waveform parameters for contact discharge pulse verification**
The target construction is given in Annex B of IEC 61000-4-2. It uses one-quarter watt cylindrical resistors in parallel to create the 2 ohm resistance (this target is often called the Pellegrini target). We recommend the use of a target made by EM Test, the CTR-2. This target uses surface mount resistors and the response is flat to within ±1dB to 4GHz. Figure 3 below shows the block diagram of the ESD verification system. The shielded room is used in place of the Faraday cage. The CTR-2 current target is mounted in the shielded room wall.

As noted above, the ESD generator ground strap is fully extended and all cables in the measuring chain are kept as short as possible. The door to the shielded room is closed during the verification process to prevent ESD signal radiation to the oscilloscope. Figure 4 shows details of the test setup for pulse verification. Figure 5 shows the CTR-2 current target used in pulse verification. Figure 6 contains pictures of a typical verification setup.
FIGURE 4: Details of the ESD pulse verification setup

FIGURE 5: Front and rear view of the CTR-2 current target
FIGURE 6: Pictures of the an actual ESD pulse verification setup

FIGURE 7: Typical ESD waveform as obtained from verification process

Figure 7 shows the ESD waveform that is obtained when all the precautions we have outlined above are observed. It is important to follow each step in the process carefully and to obtain a verification waveform relatively free of ringing to be able to achieve repeatable test results.
CONCLUSION

This paper provides an update on the status of the IEC 61000-4-2 ESD specification. The proposed edition 2 standard has been rejected, but the EMC tester should still make every effort to obtain repeatable test results for ESD testing. To do this, great care must be taken in the ESD test setup and the ESD pulse verification process as outlined in this paper.