White Paper

Implications of the new changes in IEC 61000-4-2, edition 3, on ESD Generators

» Content

1 Introduction

This technical note addresses the changes introduced in the new Edition 3 of IEC 61000-4-2, published in 2025, which replaces Edition 2 from 2008.

Several updates have been made in Edition 3, with the most significant changes regarding ESD generators focusing on discharge current calibration. The standard introduces a new additional calibration parameter, I_{p2}, aimed at ensuring test result comparability between different ESD generators on the market. Additionally, a conditional air discharge calibration has been introduced, depending on the type of ESD tip used.

The following chapters will explore and discuss all key changes and their implications for the EMC PARTNER ESD3000.

2 Short overview of ESD standard history

ESD Standard	Edition	Published in
IEC 801-2	Edition 1	1984
IEC 801-2	Edition 2	1991
IEC 1000-4-2	Edition 1	1995
IEC 1000-4-2	Edition 2	1996
IEC 61000-4-2	Edition 2	2008
IEC 61000-4-2	Edition 3	2025 (New)

Table 1: ESD standard history

3 Overview of new changes in Edition 3

Technical changes with respect to edition 2 are as follows:

1) addition of air discharge calibration requirement for ESD generator
2) improvement of the current calibration procedure
3) improvement of the measurement uncertainty considerations

Further changes:

1) addition of an informative annex E for test pints selection and number of impulses
2) addition of a normative annex I for test setups for special EUTs
3) addition of an informative annex J for wearable devices

In this paper, however, we will focus solely on the technical changes directly related to ESD generator modifications.

4 Introduction of the new calibration parameter I_{p2}

4.1 General

According to the standard, ESD generators shall be calibrated at test levels from 1 to 4 as specified in Table 2 using both polarities. For contact discharge, the calibration procedure shall be conducted as specified in the standard IEC 61000-4-2 and shall be performed in contact discharge mode. With the introduction of I_{p2}, five parameters must now be measured during calibration.

1) I_{p1} 1st peak value of the discharge current [A];
2) I_{p2} 2nd peak value of the discharge current [A];
3) I_{30} value of the current at 30 ns
4) I_{60} value of the current at 60 ns;
5) t_r rise time of the current [ns];

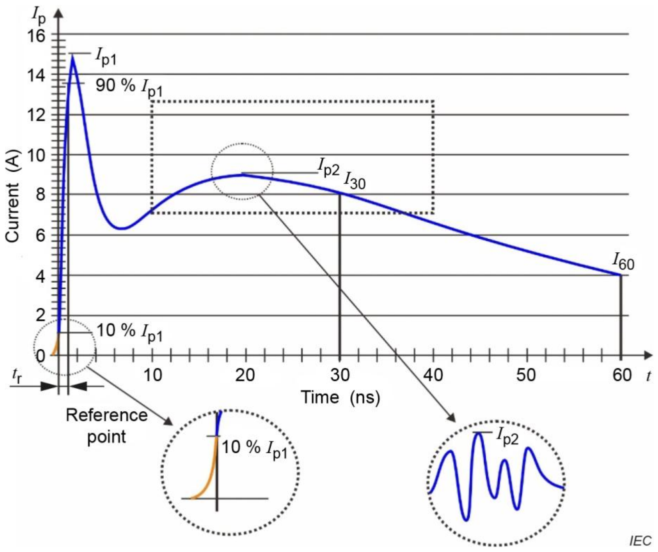

Figure 1: Ideal contact discharge waveform at 4 kV

Source: ESD standard IEC 61000-4-2 Edition 3

Level		Associated voltage level	First peak Current I_{p1} of discharge (± 15 %)	Rise time t_r (± 15 %)	Second peak I_{p2} of discharge (-20 %/+40 %)	Current I_{30} at 30 ns (±30 %)	Current I_{60} At 60 ns (±30 %)
CD	AD	kV	A	ns	A	A	A
1	1	2	7.5	0.8	4.5	4.0	2.0
2	2	4	15.0	0.8	9.0	8.0	4.0
3	---	6	22.5	0.8	13.5	12.0	6.0
4	3	8	30.0	0.8	18.0	16.0	8.0
---	4	15	56.3	0.8	33.8	30.0	15.0

Table 2: Discharge current waveform parameters

4.2 Background of I_{p2} introduction

A new calibration parameter, I_{p2}, has been introduced to improve the accuracy and consistency of ESD generator testing. According to the new standard, I_{p2} represents the maximum discharge current observed within a specific time window—ranging from 10 ns to 40 ns—after the current reaches 10% of the first peak of the discharge current.

The standard committee highlights that previous round-robin tests have demonstrated that ringing, a phenomenon that occurs irregularly in many ESD generators on the market, has a significant impact on calibration results, particularly within the 10 ns to 40 ns time window. Ringing is an unwanted oscillation or fluctuation in current that can distort the shape of the discharge current waveform, leading to inaccurate calibration measurements.

To address these challenges, the measurement aims to ensure that all ESD generators reduce ringing to the values specified in Table 2, which provides the acceptable thresholds for the amplitude of ringing. By adhering to these standards, it is expected that ESD generators will deliver more consistent and reliable performance across different devices and manufacturers.

Based on these insights, the ESD current waveform remains unchanged, but the specification for the calibration parameters has been updated. The new specification was calculated by averaging the current waveforms of all currently available ESD generators. This update ensures that the current waveform specification reflects the most accurate and representative data available, helping to standardize testing procedures and improve the overall reliability of ESD generator calibration.

4.3 Implications on actual and future EMC PARTNER products

The EXT-IMU E, which serves as an extension for the IMU compact generators, as well as the standalone ESD3000 generator equipped with the DM1 (contact discharge up to 10 kV) and DN1 (contact discharge up to 30 kV) modules, remain unaffected by the introduction of the I_{p2} measurement across all four test levels, as outlined in Table 1. Therefore, the performance and calibration of these devices are consistent and reliable, even with the incorporation of the new parameter.

In addition, a new discharge return cable has been introduced for the ESD3000 generator. This new cable design is specifically intended to further reduce the ringing effects in the I_{p2} range, thereby enhancing the accuracy of calibration. It also offers improvements in ergonomics, making it easier for users to handle and operate the generator during testing procedures. The new and previous cables both meet the requirements as per standard IEC 61000-4-2 (ED3).

Figure 2: EXT-IMU E

Figure 3: ESD3000

Figure 4: New return cable

The ESD3000DM1 and ESD3000DN1 modules were tested in contact discharge (CD) mode at test level 4, corresponding to an electrostatic discharge (ESD) voltage of 8 kV. Figures 5 and 6 illustrate the resulting current waveforms, with the reference current waveform in the background adhering to the specifications outlined in IEC 61000-4-2: 2025. The detailed measurement data, including key parameters such as peak current and pulse duration, is provided in Tables 3 and 4 for further analysis.

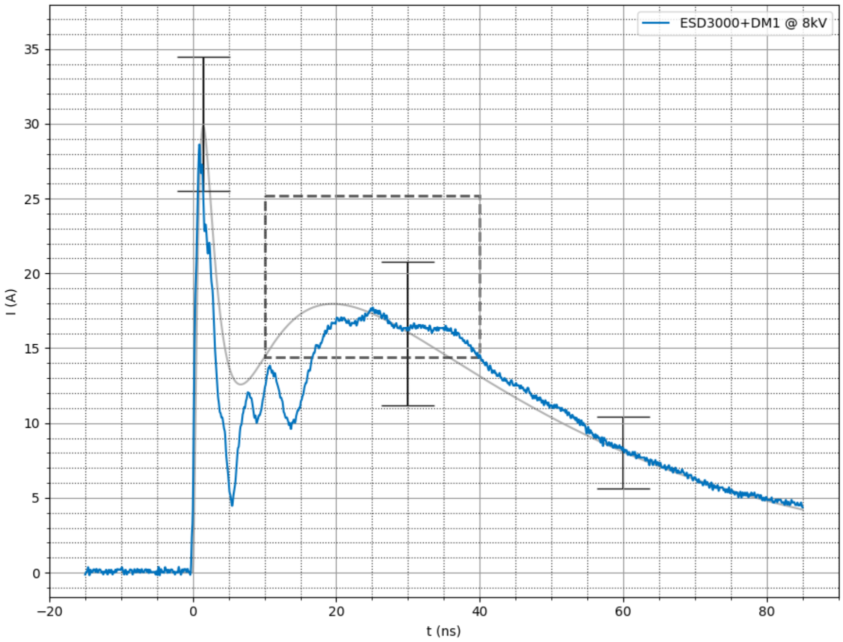

Figure 5: Example Waveform with ESD3000 + DM1 with a new cable @ 8 kV

	I_{p1} (±15%)	I_{p2} (-20%/+40%)	I_{30} (±30%)	I_{60} (±30%)	Rise time t_r (±25%)
Nominal	30 A	18 A	16 A	8 A	800 ps
Value	28.6 A	17.7 A	16.4 A	8.4 A	809 ps
Deviation	-4.7 %	-1.7 %	+2.5 %	+5 %	+1.1 %

Table 3: Measurements ESD3000 + DM1 with a new cable @ 8 kV

As shown in Table 3, DM1 clearly meets the requirements of the standard. The absence of ringing in the time window from 10 ns to 40 ns indicates stable performance, ensuring that both I_{p2} and I_{30} remain close to their respective nominal values. This stability indicates that the system operates within the expected ranges, minimizing any deviations that could affect overall performance.

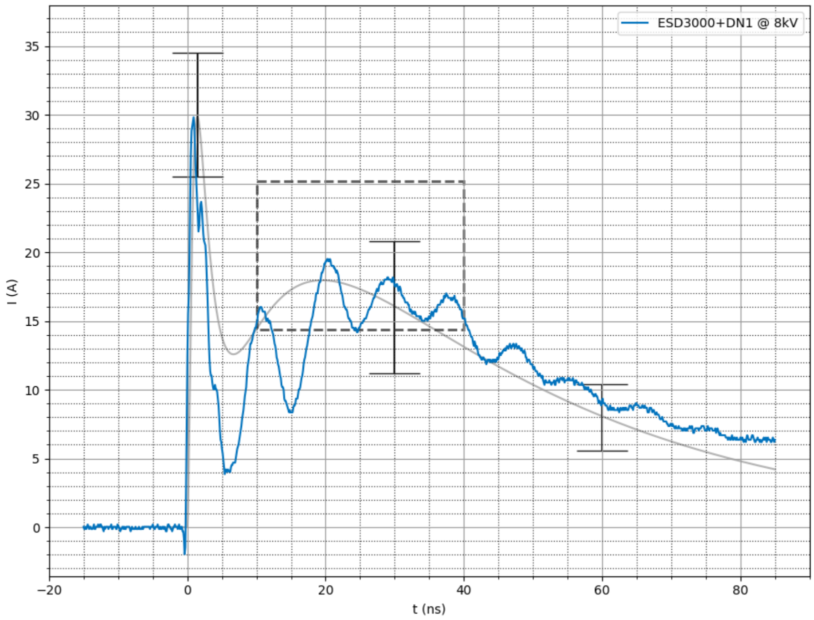

Figure 6: Example of Waveform with ESD3000 + DN1 with a new cable @ 8 kV

	I_{p1} (±15%)	I_{p2} (-20%/+40%)	I_{30} (±30%)	I_{60} (±30%)	Rise time t_r (±25%)
Nominal	30 A	18 A	16 A	8 A	800 ps
Value	29.8 A	19.5 A	17.7 A	9 A	696 ps
Deviation	-0.7 %	+8.3 %	+10.6 %	+12.5 %	-13 %

Table 4: Measurements ESD3000 + DN1 with a new cable @ 8 kV

As shown in Table 4, DN1 meets the standard's specifications, demonstrating compliance with the defined performance criteria. The parameter I_{p2} remains within the specified tolerance range, indicating that the ringing effect is effectively managed and does not significantly impact the measurement accuracy. While the presence of ringing does influence I_{30}, it still remains within the permissible tolerance of ±30%, ensuring that the overall current waveform characteristics adhere to the standard's requirements.

Additionally, as illustrated in Figures 5 and 6, the measured current waveform may exhibit some degree of ringing, which is a common phenomenon in electrostatic discharge (ESD) testing. The inclusion of a specific time window for peak current evaluation plays a crucial role in ensuring reproducibility across different test environments. This is particularly important because ESD generators from different manufacturers may exhibit variations in their discharge behaviour due to differences in circuit design, component tolerances, and overall system characteristics. By specifying a well-defined measurement window, the standard helps to mitigate discrepancies and ensures that results remain comparable, thereby enhancing the reliability of ESD compliance assessments.

5 Introduction of additional air discharge calibration

5.1 General requirements

The air discharge test is required by almost all product standards. However, prior to Edition 3, procedures or requirements for air discharge calibration for current waveform were not available. Air discharge calibration is very difficult to reproduce, because it is influenced by numerous factors such as approach speed, humidity, and the design of ESD generators. These factors lead to variations in pulse rise time and discharge current.

To address this issue, the standards committee adopted a pragmatic and practical approach. Round robin tests were conducted using various commercially available ESD generators. The results showed that the discharge current shape is independent of the discharge tips (i.e. air discharge and contact discharge), if the calibration is carried out in contact discharge mode, provided that no additional active or passive elements are used. Consequently, the new Edition 3 of the standard limits air discharge calibration to measuring the open-circuit voltage at the air discharge tip at maximum test voltage using a resistive high-voltage divider (Figure 7).

However, if the tips contain passive or active components, an additional and conditional air discharge current waveform calibration using a 2 Ω current target is required at any level between 2 kV and 15 kV. This calibration must be performed in contact discharge mode, but with the air discharge tip mounted.

5.2 Impact on the EMC PARTNER generator ESD3000

The EMC PARTNER ESD3000 generator features stainless-steel tips without any additional passive or active components (see Figures 8 and 9). This significantly simplifies the calibration process. As a result, only DC voltage calibration using the ESD-VERI-V (see Figure 7) is required, saving time and costs.

		
Figure 7: ESD-VERI-V	Figure 8: air discharge tip	Figure 9: contact discharge tip

6 New Setup for current waveform calibration

Edition 3 of the standard introduces an optimized calibration setup with several key changes compared to Edition 2:

1) New dimensions for the vertical calibration plane – The plane must now have a minimum size of 1.2 × 1.6 m, ensuring a more standardized test environment.
2) New introduced Reference Ground Plane (RGP) – The dimensions of the RGP must have at least 1.5 × 1.2 m, providing a more consistent grounding setup.
3) Revised target placement – The target is now positioned at 1 m above the ground (previously 0.5m), improving measurement accuracy.
4) Adjusted ground point location – The ground point must now be placed 0.5 m from Ground point, ensuring a more controlled grounding condition.

These modifications enhance the calibration process, leading to more precise and repeatable measurements while aligning with industry advancements and best practices.

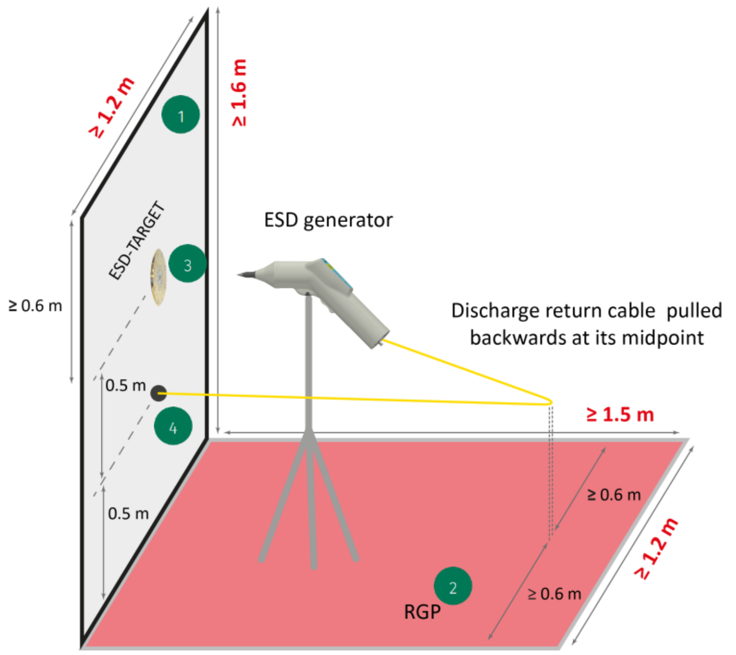

Figure 10: Arrangement for calibration of ESD generator performance

7 Introduction of an informative annex E

7.1 General

Edition 3 of the new standard addresses a common challenge in ESD testing: the selection of appropriate test points based on the Equipment Under Test (EUT). One of the key issues is that different test laboratories often apply varying criteria when determining test points, leading to inconsistencies in test results. The updated guidance in Edition 3 helps standardize this selection process by clearly defining which test points should be included and which can be excluded. This clarification not only simplifies the decision-making process for test engineers but also ensures greater comparability and reproducibility of test results across different laboratories, ultimately improving the reliability of ESD compliance assessments.

7.2 Selection of ESD test points and number of pulses

The standard provides examples of recommended test points for electrostatic discharge (ESD) testing:

- ✓ Contact discharge should be applied to ungrounded metal surfaces, metal shells of connectors, or the levers of switches.
- ✓ Air discharge is suitable for components such as display enclosures of Class II equipment or the insulated shells of coaxial cables.

Additionally, the standard specifies certain test points that should be excluded from the test plan. For instance, outer metal enclosures that are connected to protective earth (PE) and do not have electronic sub-assemblies directly mounted, should not be subjected to ESD testing. Furthermore, air discharge should be avoided on all parts that are in close proximity to metallic components, as the discharge may be unintentionally diverted to these metal parts. This diversion could lead to overtesting of the equipment under test (EUT), potentially resulting in misleading test results. Instead, a controlled contact discharge test should be conducted directly on metallic parts using the appropriate contact discharge test levels.

The informative Annex E of the standard also provides guidance on the recommended number of positive and negative pulses to be applied during testing. According to Annex E:

- ✓ For EUTs with analogue circuits, 10 positive and 10 negative pulses can be applied.
- ✓ For EUTs with digital circuits, 20 positive and 20 negative pulses can be applied.

However, the specific requirements of the relevant product standard must also be taken into consideration, as it may include different test conditions regarding the number of pulses. Adhering to these requirements ensures that the testing process remains aligned with industry regulations and accurately reflects the robustness of the EUT.

8 Relevant products

a) ESD generator ESD3000


ESD3000


ESD3000DM1


ESD3000DN1

b) ESD extension for IMU series EXT-IMU E


EXT-IMU E

c) Accessories


ESD-VERI-V


ESD-TARGET2 DN

9 Reference Documents

IEC 61000-4-2: 2025

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