IEC 61000-4-24

Edition 2.0 2015-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-24: Testing and measurement techniques – Test methods for protective devices for HEMP conducted disturbance

Compatibilité électromagnétique (CEM) –
Partie 4-24: Techniques d'essai et de mesure – Méthodes d'essai pour les dispositifs de protection pour perturbations conduites IEMN-HA

IEC 61000-4-24:2015-11(en-fr)

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-24: Testing and measurement techniques – Test methods for protective devices for HEMP conducted disturbance

FOREWORD

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International Standard IEC 61000-4-24 has been prepared by subcommittee 77C: High power transient phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms Part 4-24 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

This second edition cancels and replaces the first edition published in 1997. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) A new Clause 5: Measurement method for HEMP combination filters, which contains 5.1 Verification setup, 5.2 Measurement setup, 5.3 Measurement instrument, 5.4 Test modes, 5.5 Measurement procedures, 5.6 Evaluation of test results, which introduced performance criteria of filter, and 5.7 Test report.

b) A new informative Annex A: Investigation for the establishment of a measurement setup, which was based on Clause 5.

c) A new informative Annex B: Test method for the quantitative determination of the direct response behaviours of a coaxial surge protector.

The text of this standard is based on the following documents:

FDIS	Report on voting
77C/245/FDIS	77C/250/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This standard is part of the IEC 61000 series of standards, according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as international standards, as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

The IEC has initiated the preparation of standardized methods to protect civilian society from the effects of high power electromagnetic (HPEM) environments. Such effects could disrupt systems for communications, electric power, information technology, etc.

This part of IEC 61000 is an international standard that establishes the required test procedures for protective devices for HEMP conducted disturbance, such as gas discharge tubes, varistors, two-port SPDs and HEMP combination filters.

The application of this standard is, however, not dependent on access to other sections and parts of the IEC 61000, except for those specifically referred to.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-24: Testing and measurement techniques – Test methods for protective devices for HEMP conducted disturbance

1 Scope

This part of IEC 61000 deals with methods for testing protective devices for HEMP conducted disturbance. It includes two-terminal elements, such as gas discharge tubes, varistors, and two-port SPDs, such as HEMP combination filters. It covers testing of voltage breakdown and voltage-limiting characteristics but also methods to measure the residual voltage and/or the residual current, peak rate of rise and root action for the case of very fast changes of voltage and current as a function of time.

This standard does not cover insertion loss measurement methods.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61000-2-10, *Electromagnetic compatibility (EMC) – Part 2-10: Environment – Description of HEMP environment – Conducted disturbance*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

3.1 Terms and definitions

3.1.1
feed-through device
two-port device, which is designed to feed a signal through an electromagnetic barrier (shield)

Note 1 to entry: Typically it is in good electrical contact with the barrier and has one port on each side of the barrier, thus maintaining the isolation of the barrier.

3.1.2
gas discharge tube
device with two or three metal electrodes hermetically sealed so that gas mixture and pressure are under control, and designed to protect apparatus or personnel from high transient voltages

3.1.3
HEMP
high-altitude electromagnetic pulse
electromagnetic pulse produced by a nuclear explosion outside the earth's atmosphere

Note 1 to entry: Typically above an altitude of 30 km.

[SOURCE: IEC 61000-1-3:2002, 3.10]

3.1.4
HEMP combination filter
filter combined with voltage limiting devices, so that this combination can attenuate the residual current pulse passing through it

3.1.5
norms
scalar quantities that characterise the features of a waveform

Note 1 to entry: Norms are used to characterise features of a waveform that relate to susceptibility mechanisms.

3.1.6
peak rate of rise
maximum absolute value of the first derivative of a current waveform $I(t)$ with respect to time, dI/dt, expressed in units of ampere per second

3.1.7
PCI
pulsed current injection.
test method for measuring the performance of a protective device

Note 1 to entry: A HEMP threat-relatable transient is injected on the input of the protective device and the residual transient stress is measured on its output.

Note 2 to entry: This note applies to the French language only.

3.1.8
peak current
maximum absolute value of a current waveform, $I(t)$, expressed in units of ampere

3.1.9
primary protection element
first protective element seen from the unprotected side of a protection measure, diverting the main part of the surge current

3.1.10
protected side
side of a protection measure where the equipment is situated that has to be protected

3.1.11
protective device
electrical component such as a filter, gas discharge tube, metal oxide varistor (or other), for protection against conducted disturbance, or a shield, gasket, waveguide trap (or other), for protection against radiated disturbance, which is used to limit any conducted or radiated stress. Such an element or a combination of several of them thus forms part of the conceptual EM barrier for a system

[SOURCE: IEC 61000-5-5:1996, 3.20]

3.1.12
root action
norm of a current waveform $I(t)$ defined by

$$\sqrt{\int_0^\infty |I(t)|^2 dt}$$

Note 1 to entry: Where the load impedance is known, the energy in W/s or J can be calculated.

3.1.13
SPD
surge protective device
device that is intended to limit transient over-voltages and divert surge currents. It contains at least one non-linear component that is intended to limit surge voltages and divert surge currents

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC TR 61000-5-6:2002, 3.23, modified – a note has been added.]

3.1.14
two-port SPD
SPD which is not only a shunting device, but consists of a separated input port on the unprotected side and an output port on the protected side

Note 1 to entry: Typically two-port SPDs are "black boxes" with non-linear shunting devices to ground and a circuit between input and output ports.

3.1.15
two-terminal element
electrical element where a current enters in one terminal and leaves through a second terminal

Note 1 to entry: A two-terminal element is a one-port device. Typically two-terminal SPD's are devices shunting to ground.

3.1.16
unprotected side
side of a protection measure from which the surge event is expected

3.1.17
waveform norm
parameter that is determined from a mathematically well-defined operation on a waveform or signal (such as an integration of the waveform), which yields a scalar number that permits a comparison of various waveforms or their effects

[SOURCE: IEC 61000-4-33:2005, 3.10]

3.2 Abbreviated terms

DUT	Device under test

4 Test methods for protective devices (excluding filter) for conducted disturbance

4.1 General

The actual behaviour of a protective device under HEMP conditions depends very much on how it is integrated into its place of use and other attendant circumstances (e.g. quality of shielding between the protected and unprotected side of a protection element). The following test methods take this into account. They are defined so that the results obtained are as far as possible related to the qualities of the device under test (DUT), and the test arrangement does not differ too much from practical protection arrangements.

NOTE Clause 4 is intended to apply for a protective device such as gas discharge tubes, varistors and two-port SPDs, excluding the HEMP combination filter. For a HEMP combination filter, Clause 5 applies.

4.2 Test setup

The test setup consists of a pulse generator (G), a launching line, a test fixture for the DUT, and a termination with a connecting line and oscilloscope (see Figure 1). Various source impedances may be used, but the example shown in Figure 1 uses 50 Ω. Other values could be specified.

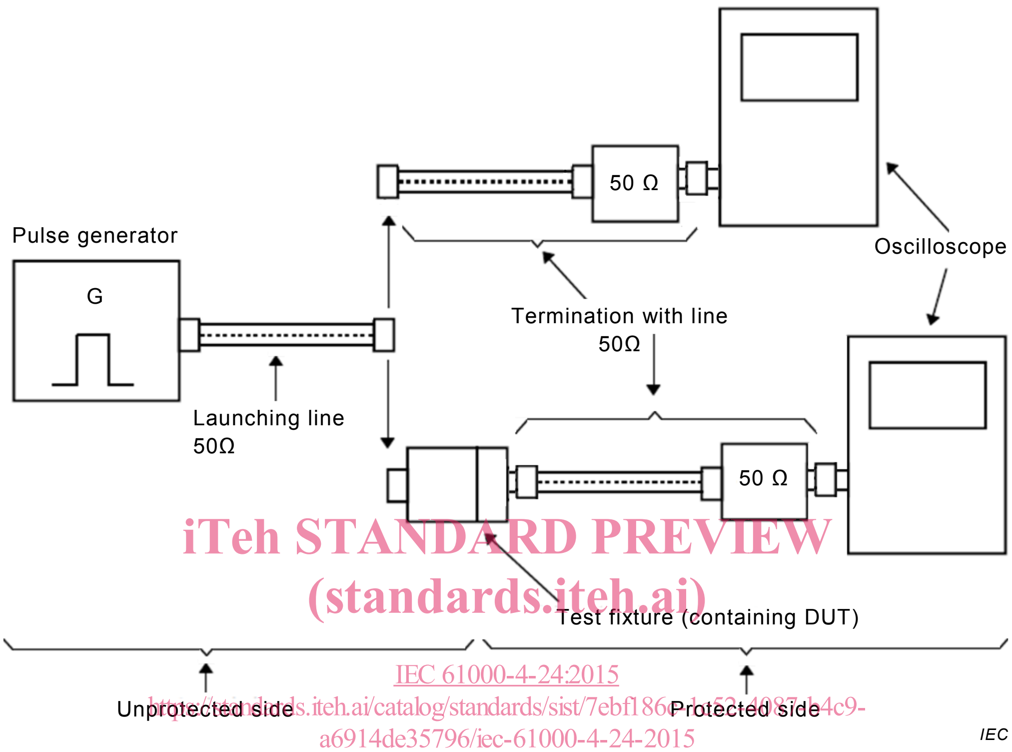


Figure 1 – Test setup for testing protective devices

To prevent parasitic coupling between the pulse generator and the oscilloscope, both the unprotected and protected side of the setup shall be entirely shielded. It is recommended to use cables with multiple braided wire shields or solid shields. The cable and connectors shall be capable of withstanding the high voltage pulse without a breakdown. Grounding loops shall be avoided.

4.3 Pulse generator

The pulse generator shall produce a normally rectangular voltage pulse into a matched termination. The output voltage (into a matched termination) shall be adjustable to a value 2 times higher than the expected limiting voltage of the DUT. Both polarities shall be available. The characteristics of a pulse generator are as follows:

– characteristic impedance: 50 Ω or an alternative value
– pulse wavefront , du/dt: at least 1 kV/ns
– pulse duration: at least 20 ns

4.4 Launching line

The launching line consists of a coaxial cable with a characteristic impedance of 50 Ω or the value specified. The cable between the pulse generator and the DUT shall be long enough so that reflections from the DUT do not arrive at the pulse generator during the pulse front. To achieve this condition, the one-way propagation time along the cable shall be greater than half the front time of the pulse. Due to the frequency-dependent attenuation of the cable, the steepness of the pulse front may be lowered and thus adjusted to the desired value, by further extending the launching line.

4.5 Test fixtures

4.5.1 General

Test fixtures are mechanical setups with coaxial connectors on both the unprotected and the protected terminals. Their task is to hold the DUT. Two different types of test fixtures may be used. They are referred to as type A and type B as described below.

4.5.2 Type A fixtures

Gas discharge tubes intended to be used for protection of coaxial high-frequency applications may be tested in corresponding, commercially available holders. The protective device is inserted between the inner and outer conductor of the coaxial setup, with a minimum of influence on the characteristic impedance. Such holders allow the inherent properties of the device to be measured explicitly and with good repeatability.

4.5.3 Type B fixtures

4.5.3.1 General

Type B fixtures are universal and apply in principle to all kinds of two-terminal or two-port protective devices, whether they have a feed-through or non-feed-through configuration. However, measurements on low-voltage devices like protective diodes and varistors may be strongly influenced by inductive overshoot due to high dI/dt.

NOTE By ensuring the test fixture lead lengths are as short as practically possible, the risk of inductive influence can be mitigated.

The fixture is composed of three parts: the unprotected shell, the partition screen and the protected shell (see Figure 2).

4.5.3.2 Unprotected shell

The dimensions and cross-section shape may be adapted to the size of the DUT. The shell may be cut into two parts in the axial direction for better access to the solder points. If not otherwise stated, the length of the wire from the unprotected connector (P_1) to the input-contact of the DUT (P_2) shall not be longer than the length of the current path in the DUT between points P_2 and the grounding contact of the DUT (P_3).

4.5.3.3 Partition screen

Feed-through protective devices shall be inserted in the partition screen in the same way as in actual application.

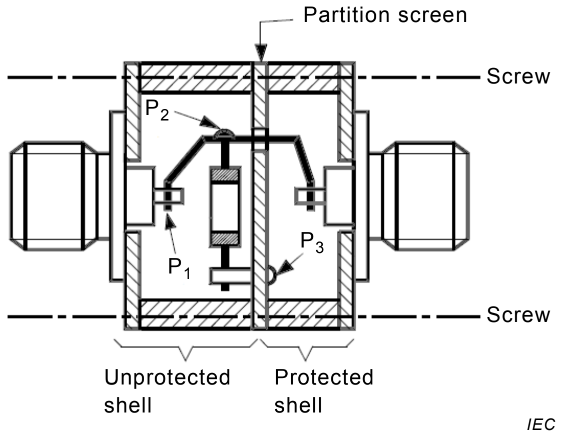
Non-feed-through devices shall be passed through a hole in the partition screen as shown in Figure 2a) and 2b). The wire passing through the partition screen shall be insulated. A feed-through capacitor or other feed-through element shall not be used. A non-feed-through DUT may be placed close to the screen but shall not touch it, except if it is to be installed on to a metal wall in actual applications (as shown in Figure 2c)).

4.5.3.4 Protected shell

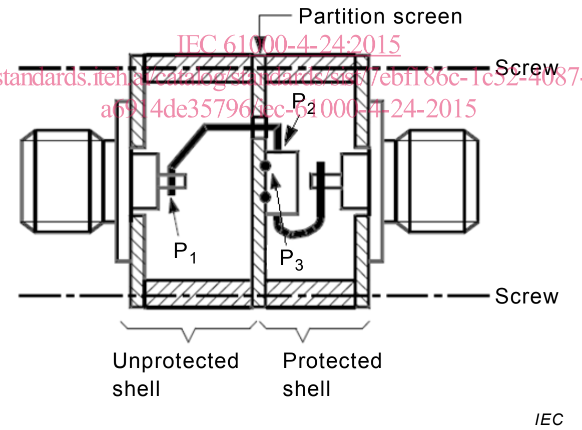
The protected shell serves as transition to the protected connector. The protected shell shall be made as short as possible. The length of the connection between point P_2 and the protected connector shall be as short as possible.

4.6 Termination

The termination shall be matched to the characteristic impedance of the test setup within the 3 dB-bandwidth of the oscilloscope. It shall be of the feed-through type, followed by a high-impedance, voltage-dividing probe of the oscilloscope or be part of the first stage of an attenuator in front of the oscilloscope. The line between the test fixture and termination shall have the same impedance as the termination. It shall be as short as possible. Its attenuation shall be less than 0,5 dB at the upper 3 dB cut-off frequency of the oscilloscope. Make sure that the termination withstands the test pulses without degradation.



a) Example of a type B test fixture with a two-terminal DUT in non-feed-through configuration



The DUT may alternatively be in the unprotected shell.

b) Example of a test fixture with a two-port DUT in non-feed-through configuration