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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 61000-4-24 edition 2.1 contains the second edition (2015-11) [documents 77C/245/FDIS and 77C/250/RVD] and its amendment 1 (2023-08) [documents 77C/330/FDIS and 77C/331/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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 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.

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 document and its amendment will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 61000-2-10:2021, *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
GDT
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.

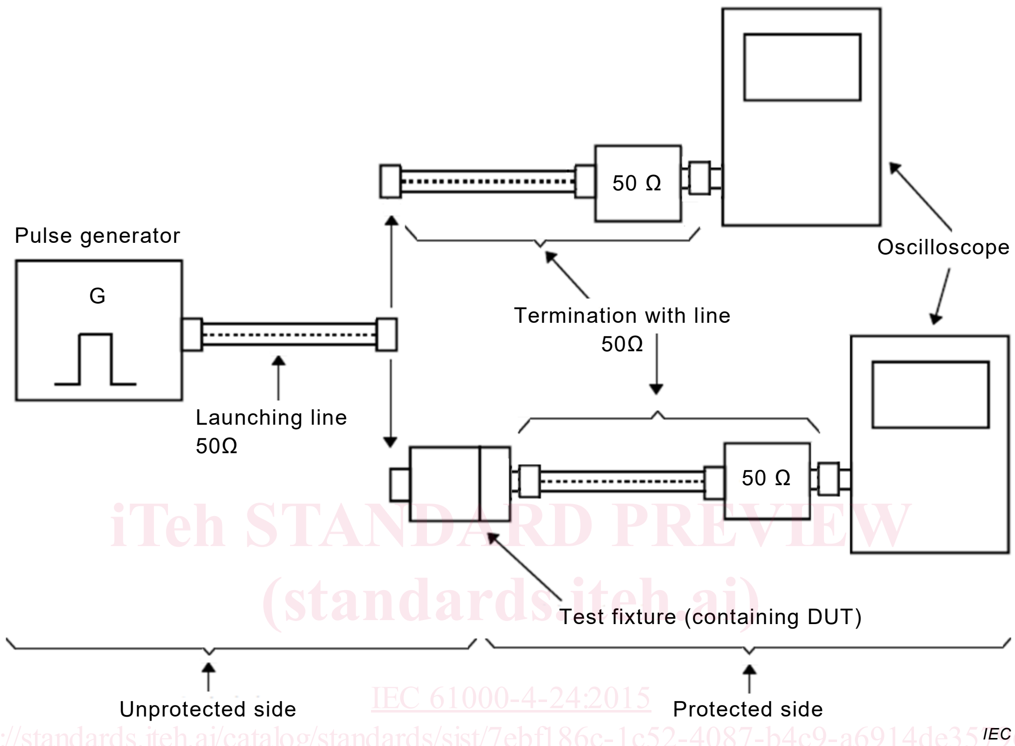

Figure 1 – Test setup for testing protective devices

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