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TECHNICAL SPECIFICATION

colour inside

BASIC EMC PUBLICATION

Electromagnetic compatibility (EMC) – Part 5-8: Installation and mitigation guidelines – HEMP protection methods for the distributed infrastructure

IEC/TS 61000-5-8:2009(E)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5-8: Installation and mitigation guidelines – HEMP protection methods for the distributed infrastructure

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 61000-5-8, which is a technical specification, has been prepared by subcommittee 77C: High power transient phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This Technical Specification forms Part 5-8 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107 [1][1)].

This document is being issued in the Technical Specification series of publications (according to the ISO/IEC Directives, Part 1, 3.1.1.1) as a “prospective standard for provisional application” in the field of protection of the infrastructure against HEMP because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this Technical Specification will be carried out not later than 3 years after its publication with the options of: extension for another 3 years; conversion into an International Standard; or withdrawal.

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

Enquiry draft	Report on voting
77C/192/DTS	77C/196/RVC

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.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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.

A bilingual version of this publication may be issued at a later date.

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 publication using a colour printer.

1) Figures in square brackets refer to the Bibliography.

INTRODUCTION

IEC 61000 is published in separate parts 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 (in so far as they do not fall under the responsibility of the product committees)

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 and published either as International Standards or 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: 61000-6-1).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5-8: Installation and mitigation guidelines – HEMP protection methods for the distributed infrastructure

1 Scope

The aim of this part of IEC 61000 is to provide guidance on how to protect the distributed infrastructure (power, telecommunications, transportation and pipeline networks, etc.) from the threat of a high altitude electromagnetic pulse (HEMP). In order to accomplish this goal, it is necessary to describe the special aspects of the HEMP threat to electrical/electronic systems that are connected and distributed in nature. In particular a nuclear burst at a typical altitude of 100 km will illuminate the Earth to a ground radius from the point directly under the burst to a range of 1 100 km. This means that any distributed and connected infrastructure such as power or telecommunications will observe disturbances simultaneously over a wide area. This type of situation is not normally considered in the EMC or HEMP protection of facilities that are part of a distributed network as the impact of a local disturbance is usually evaluated only locally.

This publication provides general information concerning the disturbance levels and protection methods for all types of distributed infrastructures. Due to its importance to all other parts of the infrastructure, the distributed electric power system (power substations, generation plants and control centres) and its protection are described in more detail. While the telecommunication system is also critical to most of the other distributed infrastructures, the protection of the telecommunication network from HEMP and other electromagnetic threats is covered by the work done by ITU-T.

2 Normative references

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

IEC 60050(161), *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

IEC 61000-2-9, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 9: Description of HEMP environment – Radiated disturbance*

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

IEC 61000-2-11, *Electromagnetic compatibility (EMC) – Part 2-11: Environment – Classification of HEMP environments*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-23, *Electromagnetic compatibility (EMC) – Part 4-23: Testing and measurement techniques – Test methods for protective devices for HEMP and other radiated disturbances*

IEC 61000-4-24, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 24: Test methods for protective devices for HEMP conducted disturbance*

IEC 61000-4-25, *Electromagnetic compatibility (EMC) – Part 4-25: Testing and measurement techniques – HEMP immunity test methods for equipment and systems*

IEC/TR 61000-5-3, *Electromagnetic compatibility (EMC) – Part 5-3: Installation and mitigation guidelines – HEMP protection concepts*

IEC/TR 61000-5-6, *Electromagnetic compatibility (EMC) – Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences*

IEC/TS 61000-5-9, *Electromagnetic compatibility (EMC) – Part 5-9: Installation and mitigation guidelines – System-level susceptibility assessments for HEMP and HPEM*

IEC 61000-6-6, *Electromagnetic compatibility (EMC) – Part 6-6: Generic standards – HEMP immunity for indoor equipment*

IEC 61850 (all parts), *Communication networks and systems in substations*

3 Terms and definitions

For the purposes of this document, the definitions contained in IEC 60050(161) as well as the following apply.

3.1
distributed infrastructure
the portions of the infrastructure of a society that are connected either physically or through real-time communications over distances of hundreds of kilometres, and include electrical and electronic controls to operate that infrastructure

NOTE This normally includes the electric power system, the telecommunications system, pipeline networks, and the transportation system.

3.2
E1, E2, E3
terminology for the early, intermediate and late-time HEMP electric fields. E1 is for times less than 1 microsecond, E2 for times between 1 microsecond and 1 second and E3 is for times greater than 1 second.

NOTE See IEC 61000-2-9 for additional information.

3.3
equipment
this term is not limited and includes modules, devices, apparatuses, subsystems, complete systems and installations

[IEV 151-11-25, modified]

3.4
HEMP
high-altitude electromagnetic pulse

3.5
HEMP coupling
interaction of the HEMP field with a system to produce currents and voltages on system surfaces and cables. Voltages result from the induced charges and are only defined at low frequencies with wavelengths larger than the surface or gap dimensions

3.6
installation
combination of apparatuses, components and systems assembled and/or erected (individually) in a given area; for physical reasons (e.g. long distances between individual items) it is in many cases not possible to test an installation as a unit

[IEV 151-11-26, modified]

3.7
point-of-entry
PoE
physical location (point) on an electromagnetic barrier, where EM energy may enter or exit a topological volume, unless an adequate PoE protective device is provided

NOTE A PoE is not limited to a geometrical point. PoEs are classified as aperture PoEs or conductive PoEs according to the type of penetration. They are also classified as architectural, mechanical, structural or electrical PoEs according to the functions they serve.

3.8
pulse width
time interval between the points on the leading and trailing edges of a pulse at which the instantaneous value is 50 % of the peak pulse amplitude, unless otherwise stated

3.9
rectified impulse
RI
integral of the absolute value of a time waveform's amplitude over a specified time interval

3.10
rise time (of a pulse)
time interval between the instants in which the instantaneous amplitude of a pulse first reaches specified lower and upper limits, namely 10 % and 90 % of the peak pulse amplitude, unless otherwise stated

[IEV 161-02-05, modified]

3.11
severity
the probability that a level of HEMP environment will be less than the stated value

NOTE For example a 90 % severity level of current induced on an elevated, randomly oriented conductor is 1,5 kA. This means that only 10 % of currents would exceed this value.

3.12
short-circuit current
the value of current that flows when the output terminals of a circuit are shorted

NOTE This current is normally of interest when checking the performance of surge protection devices.

[IEV 441-11-07, modified and IEV 603-02-26, modified]

3.13
source impedance
impedance presented by a source of energy to the input terminals of a device or network

3.14
system
combination of apparatuses and/or active components constituting a single functional unit and intended to be installed and operated to perform (a) specific task(s)

4 General

The publications developed to protect civil systems from the threat of high-altitude electromagnetic pulse (HEMP) in the past have mainly covered the methods to protect important equipment, systems and installations against the threat of a severe electromagnetic pulse environment at the location of the system of interest. IEC 61000-2-9 recommends that an early-time (E1) HEMP with a peak value of 50 kV/m be used to design protection and to perform radiated tests, if the system of interest is fully exposed to the environment. It is well known that the HEMP field will vary across the Earth, however, since the location of a burst is not known in advance, system specifications have usually considered the maximum field level likely to be found anywhere at the Earth's surface.

In the same manner IEC 61000-2-10 indicates that the full HEMP field will illuminate and couple to all conductors, including cables and wires, creating a conducted HEMP environment, which may flow into connected equipment. For the early-time (E1) HEMP environment, the levels of currents induced will vary due to the polarization and angle of incidence of the HEMP field and the orientation of the conductor to the HEMP propagation. This means that large variations of currents are possible for randomly oriented above-ground conductors ranging from a 50 % severity value of 500 A to a 99 % severity value of 4 kA (based on a cumulative probability density function).

While the two examples above refer to the early-time HEMP environment, the intermediate-time (E2) and late-time (E3) HEMP waveforms are also a concern to very long conductors, such as exposed power lines and telephone wires. As indicated in IEC 61000-2-10, the peak currents that are induced may be determined from the peak electric field, the length of the conductor and the resistance of the conductor over the exposed coupling length.

For high voltage power transmission lines, the late-time (E3) HEMP induces currents on the order of hundreds of amperes for tens of seconds; these currents are likely to create half-cycle saturation in high voltage transformers and will also produce severe harmonics that can disrupt the voltage regulation of the network [2].[2]

For telecommunication lines the late-time (E3) HEMP environment has the ability to induce currents of up to tens of amperes for tens of seconds that are high enough to trip safety protection systems and to shut down each exposed line [3]. The currents induced are lower in telecommunication lines as the resistance per unit length of these lines is much higher than for power transmission cables.

Given these threats to important infrastructures, this publication provides methods to determine the appropriate levels of electromagnetic radiated and conducted disturbances for particular types of distributed infrastructures. In addition, these disturbances are compared to other natural EM environments that have well defined protection and test methods. This publication concludes with recommended protection strategies and methods that vary due to the cost versus effectiveness considerations involved, especially given a low probability event such as HEMP.

5 Description of the distributed infrastructure

Each critical infrastructure is dependent upon other infrastructures as shown in Figure 1. This figure is an example that describes in a simplified way the many interdependencies between them (not all connections are shown). The interdependence of critical infrastructures is likely to create difficulties in the ability to recover from the widespread disruption and damage that could be caused by an HEMP attack due to the large area impacted within a short time.

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2 Figures in square brackets refer to the Bibliography.