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BASIC EMC PUBLICATION

Electromagnetic compatibility (EMC) – Part 5-9: Installation and mitigation guidelines – System-level susceptibility assessments for HEMP and HPEM

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5-9: Installation and mitigation guidelines – System-level susceptibility assessments for HEMP and HPEM

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 61000-5-9, 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 5-9 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107 [1][1].

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
77C/190/DTS	77C/194/RVC

Full information on the voting for the approval of this technical specification 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

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: IEC 61000-6-1).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5-9: Installation and mitigation guidelines – System-level susceptibility assessments for HEMP and HPEM

1 Scope

The aim of this part of IEC 61000 is to present a methodology to assess the impact of High-altitude Electromagnetic Pulse (HEMP) and High Power Electromagnetic (HPEM) environments on electronic systems. In this context a system refers to a collection of sub-systems, equipment and components brought together to perform a function. (A more complete definition is given in 3.20.) The techniques associated with this methodology and their advantages and disadvantages will be presented along with examples of how the techniques can be applied to evaluate the susceptibility of electronic systems such as those found in installations. This work is closely related to the evaluation of EMC system level susceptibility.

The purpose of this Technical Specification is to provide information on available methods for the assessment of system-level susceptibility as a result of HEMP and HPEM environments. The advantages and disadvantages of the methods will be discussed along with examples of how the techniques should be employed.

Typical systems have external connections, wired or wireless, and the assessment of these are included within this specification.

This specification gives general guidance. It does not cover safety issues nor does it conflict with ITU-T efforts concerning the protection of telecommunications equipment [2][2].

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/TR 61000-1-5:2004, *Electromagnetic compatibility (EMC) – Part 1-5: General – High power electromagnetic (HPEM) effects on civil systems*

IEC 61000-2-9:1996, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 9: Description of HEMP environment – Radiated disturbance. Basic EMC publication*

IEC 61000-2-10:1998, *Electromagnetic compatibility (EMC) – Part 2-10: Environment – Description of HEMP environment – Conducted disturbance*

IEC 61000-2-13:2005, *Electromagnetic compatibility (EMC) – Part 2-13: Environment – High-power electromagnetic (HPEM) environments – Radiated and conducted*

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2 Figures in square brackets refer to the Bibliography.

IEC/TR 61000-4-32:2002, *Electromagnetic compatibility (EMC) – Part 4-32: Testing and measurement techniques – High-altitude electromagnetic pulse (HEMP) simulator compendium*

IEC 61000-4-33:2005, *Electromagnetic compatibility (EMC) – Part 4-33: Testing and measurement techniques – Measurement methods for high-power transient parameters*

IEC 61000-4-35:2009, *Electromagnetic compatibility (EMC) – Part 4-35: Testing and measurement techniques – HPEM simulator compendium*

IEC/TR 61000-5-3:1999, *Electromagnetic compatibility (EMC) – Part 5-3: Installation and mitigation guidelines – HEMP protection concepts*

IEC/TS 61000-5-4:1996, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 4: Immunity to HEMP – Specifications for protective devices against HEMP radiated disturbance. Basic EMC Publication*

IEC 61000-5-5:1996, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 5: Specification of protective devices for HEMP conducted disturbance. Basic EMC Publication*

IEC/TR 61000-5-6:2002, *Electromagnetic compatibility (EMC) – Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences*

IEC 61000-5-7:2001, *Electromagnetic compatibility (EMC) – Part 5-7: Installation and mitigation guidelines – Degrees of protection provided by enclosures against electromagnetic disturbances (EM code)*

3 Terms and definitions

For the purposes of this document the terms and definitions of IEC 60050-161 as well as the following apply.

3.1
aperture coupling regime
frequency range where aperture coupling dominates; this is typically between 200 MHz to 18 GHz

3.2
back-door coupling
coupling of EM energy to equipment via connecting cables or apertures (not via antennas or sensors

NOTE Detailed discussion of back-door coupling can be found in Clause 5.

3.3
cable coupling regime
frequency range where cable coupling dominates; this is typically between 500 kHz and 400 MHz

3.4
coupling
transfer of electromagnetic energy from source to victim

3.5
E/E/PE equipment
equipment that employs electrical, electronic or programmable electronic technologies

3.6
equipment
general designation which includes modules, devices, apparatuses, subsystems, complete systems and installations

3.7
equipment under test
EUT
refers to the equipment being tested

3.8
front-door coupling
coupling of EM energy to equipment via antennas and/or sensors

NOTE Detailed discussion of front-door coupling can be found in Clause 5.

3.9
HEMP
High-altitude Electromagnetic Pulse

3.10
high-level illumination
HLI
use of high-level (>100 V/m) signals to assess the immunity or susceptibility

3.11
HPEM
High Power Electromagnetic

3.12
immunity
ability of a device equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-20]

3.13
installation
combination of apparatuses, components and systems assembled and/or erected (individually) in a given area

NOTE For physical reasons (e.g. long distances between individual items) it is in many cases not possible to test an installation as a unit.

3.14
low-level continuous wave
LLCW
use of low-level signals (typically <1 V/m) to characterise the coupling of an external electromagnetic environment to an internally induced current, voltage or field (magnetic or electric)

3.15
margin
usually expressed in dB, this in the amount added to a result to improve confidence or to allow for uncertainties

3.16
norm
mathematical function used to describe a parameter of a waveform; several norms can be used to describe the 'uniqueness' of a waveform

3.17
pulsed current injection
PCI
use of current injection methods to assess the immunity or susceptibility with a pulsed waveform as opposed to more traditional continuous wave (CW) signals

3.18
surface current injection
SCI
injection of current directly on to the surface of an equipment box of system skin

3.19
susceptibility
inability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-21]

3.20
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

4.1 Introduction

HEMP occurs as a result of a high-altitude nuclear explosion and can cover several millions of square kilometres with electric field strengths of up to tens of kV/m. Further discussion of HEMP can be found in IEC 61000-2-9 and IEC 61000-2-10.

HPEM is the collective name given to a set of high power radio frequency (RF) sources that are capable of generating high levels of RF at ranges <1 km. The waveforms generated by these types of sources vary and include Ultra Wideband (UWB), Damped Sine (DS) also known as Non-Nuclear EMP (N2EMP) and High power Microwave (HPM). Further discussion of these sources can be found in IEC 61000-2-13.

This specification discusses methods available for the assessment of systems as defined in 4.2 (not distributed civil infrastructure[3]) to the effects of HEMP and HPEM. Typical system examples are vehicles, aircraft and small ships. The techniques can be applied to larger systems such as buildings, however, with careful consideration.

The assessment methodology discussed in this specification is not appropriate for geographically large connected or distributed systems. However, the techniques may be applicable to individual components, equipments, subsystems or systems contained within a large connected or distributed system.

The assessment methodology may be used to determine the status of a particular system with respect to its hardening to HEMP and/or HPEM environments.

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3 Distributed civil infrastructure is discussed in IEC 61000-5-8.

It is important to note that the assessment methodology presented within this specification should help to assist in reducing the risk of detrimental system performance due to exposure to HEMP and HPEM environments. This methodology can be applied during the design and development phases of a system. A full system-level test using the HEMP or HPEM environment of interest is an important part of this methodology. Information on worldwide HEMP and HPEM simulators can be found in IEC 61000-4-32 and IEC 61000-4-35 respectively.

4.2 Systems and subsystems

In the context of this specification, a system may consist of several subsystems which are each comprised of several equipments which, in turn, consist of several components. Figure 1 shows a typical system architecture.

A system can also be considered to be a set of **supplied equipments** located within a **defined physical boundary** that are **interconnected** in order to perform a defined function.

The defined physical boundary may be

the outer hull (for systems located on military platforms – vehicles, aircraft and ships),

the outer building wall (for systems located within buildings).

The **interconnection** may be either

wireline (using either metallic or optical cables),

or wireless,

and the interconnection is made for the purpose of either

exchanging information,

or receiving or supplying electrical power.

Any physical connection (i.e. wireline or wireless) with supplied equipment that does not originate from within the system's defined physical boundary is an **interface**. Interfaces may be permanent (in the case of buildings, where a permanent connection with wireline power and telecommunications infrastructure can be expected) or temporary (in the case of military platforms, where the inherent mobility of the platform prevents permanent wireline interfacing).

Individual **supplied** pieces of **equipment** may themselves be individual systems (i.e. subsystems, or sub-subsystems, and so forth) that should themselves have been subject to the methods contained within this specification.

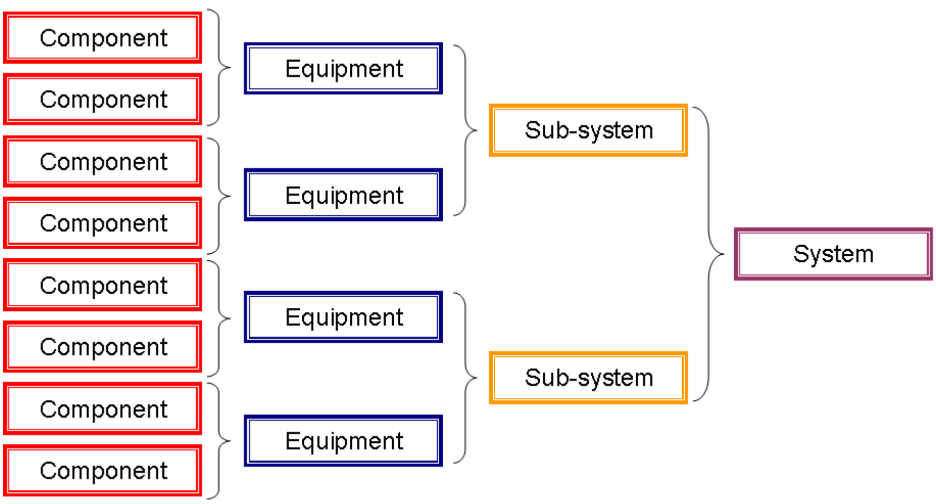

Figure 1 – Example system architecture

For example, a vehicle (system) may consist of an engine management unit (subsystem) which consists of circuit boards (equipment) and integrated circuits (component).

5 Interaction mechanisms and protection methods

5.1 General

Within IEC 61000-1-5, the terms deliberate penetration and inadvertent penetration are used to describe the penetration of EM energy into a system. This specification uses the terms back-door coupling and front-door coupling (see Figure 2) since they better relate to the fundamental difference that exists regarding the possibility to protect a system without degrading its function. While careful back-door shielding should not degrade the function of a system at all, protection against in-band front-door coupling may degrade the function of the system.

5.2 Front-door coupling

The radiation couples to equipment ports intended for wireless communication or other interaction with the external environment. Hence, they cannot easily be fully shielded against electromagnetic radiation without loosing or severely degrading their function. Examples are antennas and sensors.

Front-door coupling can be subdivided into first and second order, as follows.

a) Front-door coupling, first order (in-band)

The frequency of the radiation coincides, at least partly, with the working frequency of the equipment. An example is a telecom base-station irradiated in its pass band.

b) Front-door coupling, second order (out-of-band)

The frequency of the radiation does not coincide with the working frequency of the equipment. An example is a HF radio antenna exposed to high power microwaves.

5.3 Back-door coupling

The radiation couples to electronic circuits through imperfections (apertures) in the electromagnetic shield enclosing the electronics, or directly to the electronic circuit boards. In the case of a shielded structure this leakage gives rise to a diffuse and complex field pattern within the structure. The apertures can be unintentional or intentional. An example of the former is a paint, or an oxide, layer in a shielding joint between conductive surfaces. Examples of the latter are holes for drainage or ventilation. The radiation may also couple directly to an external wire connected to a component or a subsystem [3]. The reason to define such a wire as back-door coupling and not as a second-order front-door coupling is motivated by the fact that the wire could be shielded without degrading the function of the equipment.

It is important to note that HEMP or HPEM disturbances can be radiated or conducted in nature. It follows therefore, that the source of the front-door or back-door coupling can be radiated or conducted in nature. It should be noted that conducted disturbances cannot only be out-of-band but also occur under normal operating conditions (in-band and out-of-band). Examples of this include transient overvoltages much higher than the voltage under normal operation or surge currents flowing in a system.

This specification deals mainly with back-door coupling although some attention is given to front-door coupling in Annex H.