IEC 61000-2-10

Edition 2.0 2021-11

INTERNATIONAL STANDARD

colour inside

BASIC EMC PUBLICATION

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

IEC 61000-2-10:2021-11(en)

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CONTENTS

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 2-10: Environment – Description of HEMP environment – Conducted disturbance

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 61000-2-10 has been prepared by subcommittee 77C: High power transient phenomena, of IEC technical committee 77: Electromagnetic compatibility. It is an International Standard.

It forms Part 2-10 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 1998. This edition constitutes a technical revision.

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

a) a new Annex E has been added to describe the time waveform characteristics of the response of simple linear antennas to aid in the development of test methods;
b) technical support for this waveform is provided in Annex E.

c) a procedure to use the waveforms presented in Annex E along with the peak values previously provided in Annex C is provided.

The text of this International Standard is based on the following documents:

Draft	Report on voting
77C/318/FDIS	77C/321/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

The committee has decided that the contents of this document 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 document 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

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 (insofar as these limits 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, 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).

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

This part of IEC 61000 is an international standard that establishes the HEMP conducted disturbances that are the result of coupling by the radiated HEMP disturbances.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 2-10: Environment – Description of HEMP environment – Conducted disturbance

1 Scope

This part of IEC 61000 defines the high-altitude electromagnetic pulse (HEMP) conducted environment that is one of the consequences of a high-altitude nuclear explosion.

Those dealing with this subject consider two cases:

– high-altitude nuclear explosions;
– low-altitude nuclear explosions.

For civil systems the most important case is the high-altitude nuclear explosion. In this case, the other effects of the nuclear explosion such as blast, ground shock, thermal and nuclear ionizing radiation are not present at the ground level.

However, the electromagnetic pulse associated with the explosion can cause disruption of, and damage to, communication, electronic and electric power systems thereby upsetting the stability of modern society.

The object of this document is to establish a common reference for the conducted HEMP environment in order to select realistic stresses to apply to victim equipment to evaluate their performance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 61000-2-9, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 9: Description of HEMP environment – Radiated disturbance*

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
angle of elevation ψ
angle ψ measured in the vertical plane between a flat horizontal surface such as the ground and the propagation vector

SEE: Figure 1.

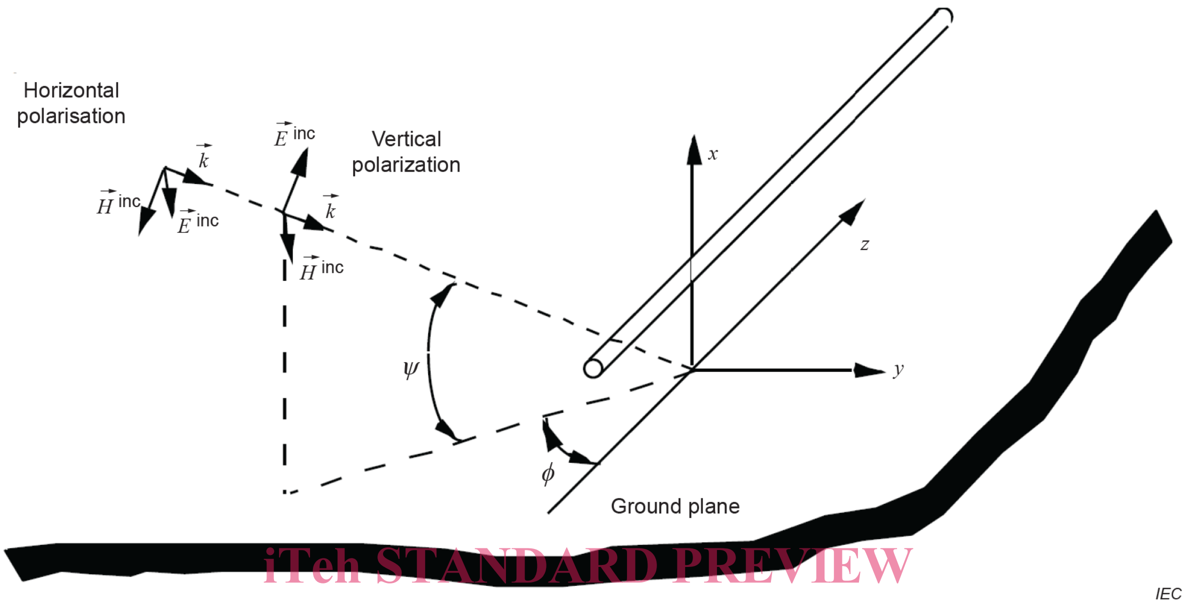

Figure 1 – Geometry for the definition of polarization and of the angles of elevation ψ and azimuth ϕ

3.2
azimuth angle ϕ
angle between the projection of the propagation vector on the ground plane and the principal axis of the victim object

Note 1 to entry: It is the *z* axis for the transmission line of Figure 1.

3.3
composite waveform
waveform which maximizes the important features of a waveform

3.4
coupling
interaction of the HEMP field with a system to produce currents and voltages on system surfaces and cables

Note 1 to entry: Voltages result from the induced charges and are only defined at low frequencies with wavelengths larger than the surface or gap dimensions

3.5
direction of propagation of the electromagnetic wave
direction of the propagation vector $\vec{k}$, perpendicular to the plane containing the vectors of the electric and magnetic fields

Note 1 to entry: See Figure 2.

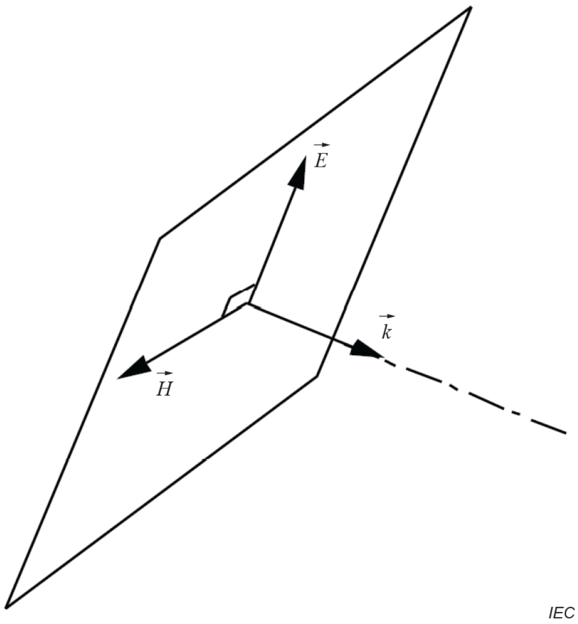

Figure 2 – Geometry for the definition of the plane wave

3.6
E1
early-time HEMP electric field

3.7
E2
intermediate-time HEMP electric field

3.8
E3
late-time HEMP electric field

3.9
electromagnetic pulse
EMP
any electromagnetic field waveform abruptly rising and falling in the time domain created by a nuclear detonation at any altitude

3.10
geomagnetic dip angle
θ_{dip}
dip angle of the geomagnetic flux density vector $\vec{B}_e$, measured from the local horizontal in the magnetic north-south plane

Note 1 to entry: θ_{dip} = 90° at the magnetic north pole, –90° at the magnetic south pole (see Figure 3).

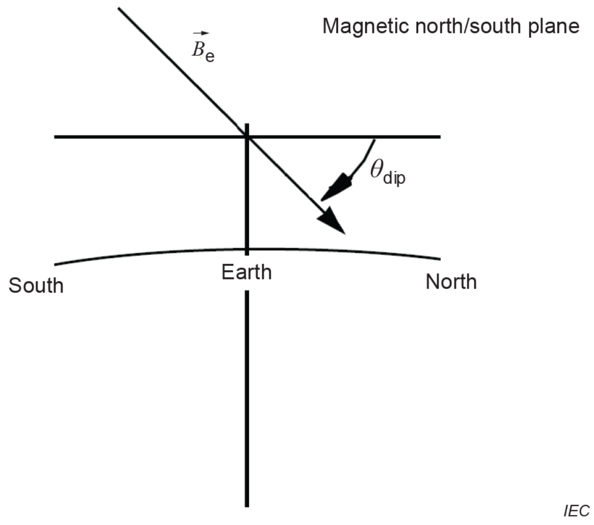

Figure 3 – Geomagnetic dip angle

3.11
high-altitude electromagnetic pulse
HEMP
high-altitude electromagnetic pulse created by a high-altitude nuclear explosion

3.12
high-altitude nuclear explosion
height of burst above 30 km altitude

3.13
horizontal polarization
position of the electromagnetic wave in which the magnetic field vector is in the incidence plane and the electric field vector is perpendicular to the incidence plane and thus parallel to the ground plane

Note 1 to entry: This type of polarization is also called perpendicular or transverse electric (TE) (see Figure 1).

3.14
incidence plane
plane formed by the propagation vector and the normal to the ground plane

3.15
low-altitude nuclear explosion
height of burst below 1 km altitude

3.16
NEMP
nuclear EMP
all types of EMP produced by a nuclear explosion

3.17
point-of-entry
PoE
physical location (point) on an electromagnetic barrier, where EM energy can enter or exit a topological volume, unless an adequate PoE protective device is provided

Note 1 to entry: 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.

3.18
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

3.19
rectified impulse
integral of the absolute value of a time waveform's amplitude over a specified time interval

3.20
rise time
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

3.21
short-circuit current
value of current that flows when the output terminals of a circuit are shorted

Note 1 to entry: This current is normally of interest when checking the performance of surge protection devices.

3.22
source impedance
impedance presented by a source of energy to the input terminals of a device or network

3.23
vertical polarization
position of the electromagnetic wave in which the electric field vector is in the incidence plane, and the magnetic field vector is perpendicular to the incidence plane and thus parallel to the ground plane

Note 1 to entry: See Figure 1.

Note 2 to entry: This type of polarization is also called parallel or transverse magnetic (TM).

4 General

A high-altitude (above 30 km) nuclear burst produces three types of electromagnetic pulses which are observed on the earth's surface:

1) early-time HEMP (fast);
2) intermediate-time HEMP (medium);
3) late-time HEMP (slow).

Historically most of the interest has been focused on the early-time HEMP which was previously referred to simply as HEMP. Here the term high-altitude EMP or HEMP will be used to include all three types. The term nuclear electromagnetic pulse (NEMP) covers many categories of nuclear EMPs including those produced by surface bursts (source region EMPs (SREMPs)) or created on space systems (system generated EMPs SGEMPs)).

Because the HEMP is produced by a high-altitude detonation, other nuclear weapon environments such as gamma rays, heat and shock waves at the earth's surface are not observed at the earth's surface. HEMP was reported from high-altitude nuclear tests in the South Pacific by the U.S. and over the USSR during the early 1960s, producing effects on electronic equipment on the ground far from the burst location.

This document presents the conducted HEMP environment induced on metallic lines, such as cables or power lines, external and internal to installations, and external antennas.

5 Description of HEMP environment, conducted parameters

5.1 Introductory remarks

The electromagnetic field generated by a high-altitude nuclear explosion described in IEC 61000-2-9 can induce currents and voltages in all metallic structures. These currents and voltages propagating in conductors represent the conducted environment. This means that the conducted environment is a secondary phenomenon, a consequence of the radiated field alone.

All metallic structures (i.e., wires, conductors, pipes, ducts, etc.) will be affected by the HEMP. The conducted environment is important because it can direct the HEMP energy to sensitive electronics through signal, power, and grounding connections. It should be noted that there are two distinct categories of conductors: external and internal conductors (with regard to a building or any other enclosure). While this can seem simplistic, this separation is critical in terms of the information to be provided in this document.

The difference between these two types of conductors is explained by electromagnetic topology. In general, external conductors are those which are located outside of a building and are completely exposed to the full HEMP environment. This category includes power, metallic communication lines, antenna cables, and water and gas pipes (if metallic). For the purposes of this document, the conductors can be elevated above the ground or buried in the earth. Internal conductors are those which are located in a partially or completely shielded building where the HEMP fields have been reduced by the building. This is a much more complex situation, because the HEMP field waveforms will be significantly altered by the building shield, and the coupling to internal wires and cables is consequently very difficult to calculate, although some measured data are available from simulated HEMP tests.

In this document the external conducted common mode environments are calculated using simplified conductor geometries and the specified HEMP environments for the early, intermediate, and late-time waveforms. These conducted external environments are intended to be used to evaluate the performance of protection devices outside of a building, and because of variations in telecom and power systems, the effects of transformers and telephone splice boxes are not considered here. This process results in approximate, but well-defined waveforms that are needed to test protective elements on external conductors in a standardized manner. For the internal conductors, a procedure is defined to estimate the conducted environments appropriate for equipment testing. For unshielded multiconductor wires, it is assumed that the line-to-ground currents are equal to the common-mode current.

5.2 Early-time HEMP external conducted environment

For the early-time HEMP, the high-amplitude electric field couples efficiently to antennas and to any exposed lines such as power and telephone lines. The antenna coupling mechanism is extremely variable and dependent on the details of the antenna design. In many cases, it is advisable to perform continuous wave (CW) testing of an antenna and to "combine" the response function of the antenna with the incident HEMP environment using a convolution technique. However, simple formulae have been provided to compute the response of thin antennas (see 5.5). For long lines, it is possible to perform a comprehensive set of common mode calculations that are reliable and depend only upon a few parameters. These parameters include conductor length, exposure situation (above ground or buried), and the surface ground conductivity (for depths between 0 m and 5 m). In addition, because the HEMP coupling is dependent on angle of elevation and polarization (see Figure 1), it is possible to statistically examine the probability of producing particular levels of current.