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Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 2: Earthing and cabling

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Compatibilité électromagnétique (CEM) - Partie 5: Guides d'installation et d'atténuation - Section 2: Mise à la terre et câblage

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Partie 5: Guides d'installation et d'atténuation – Section 2: Mise à la terre et câblage

Electromagnetic compatibility (EMC) –

Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling

International Electrotechnical Commission 3, rue de Varembé Geneva, Switzerland
Telefax: +41 22 919 0300 e-mail: inmail@iec.ch IEC web site http: //www.iec.ch

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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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3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

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The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when 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;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 61000-5-2, which is a technical report of type 3, has been prepared by subcommittee 77B: High frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

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

Committee draft	Report on voting
77B/168/CDV	77B/183/RVC

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

INTRODUCTION

IEC 61000-5 is part of the IEC 61000 series, 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 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 sections which are published either as international standards or as technical reports.

These sections of IEC 61000-5 will be published in chronological order and numbered accordingly.

The recommendations presented in this technical report address the EMC concerns of the installation, not the safety aspects of the installation nor the efficient transportation of power within the installation. Nevertheless, these two prime objectives are taken into consideration in the recommendations concerning EMC. These two primary objectives can be implemented concurrently for enhanced EMC of the installed sensitive apparatus or systems without conflict by applying the recommended practices presented in this technical report and the relevant safety requirements such as those of IEC 60364. As each installation is unique, it is the responsibility of the designer to select the relevant recommendations most appropriate to a particular installation, with corresponding implementation by the installer.

It is important to note that the recommendations presented in this technical report do not seek to preclude existing installation practices, when they have been shown to perform satisfactorily. Special mitigation methods might not be necessary when the equipment satisfy applicable emissions and immunity standards. In particular, some installation practices such as a "Star Network" or "Isolated Bonding Network" for earthing are based on different approaches to EMC that have been found satisfactory for specific installations when correctly applied and the **topology maintained** by competent specialists. Nevertheless, the approach recommended here is more generally applicable to all types of facilities, especially when signals are exchanged between different apparatus.

Clauses 1-3 provide the usual general information of the IEC 61000 documents on EMC.

Clause 4 provides an overview and introduction of the general approach to applying EMC concepts in the design of installations.

Clause 5 provides recommendations on the design and implementation of the earthing system, including the earth electrode and the earthing network.

Clause 6 provides basic information on the design and implementation of bonding for apparatus or systems to earth or to the earthing network.

Clause 7 provides recommendations on the selection, erection, and connection practices for cables used for low-voltage a.c. and d.c. power supply, for input and output signals serving control and command, as well as those used for other communications within the premises.

Clause 8 provides information on related mitigation techniques.

Clause 9 provides information on verification and test methods.

Informative annexes provide information on the supporting concepts, including bibliographic citations, from which the recommendations of this technical report have been drawn.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling

1 Scope

This technical report (type 3) covers guidelines for the earthing and cabling of electrical and electronic systems and installations aimed at ensuring electromagnetic compatibility (EMC) among electrical and electronic apparatus or systems. More particularly, it is concerned with earthing practices and with cables used in industrial, commercial, and residential installations. This technical report is intended for use by installers and users, and to some extent, manufacturers of sensitive electrical or electronic installations and systems, and equipment with high emission levels that could degrade the overall electromagnetic (EM) environment. It applies primarily to new installations, but where economically feasible, it may be applied to extensions or modifications to existing facilities.

2 Reference documents

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60050(826):1982, *International Electrotechnical Vocabulary (IEV) – Chapter 826: Electrical installations of buildings*
Amendment 1: 1990
Amendment 2: 1995

IEC 61000-2-5:1995, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 5: Classification of electromagnetic environments – Basic EMC publication*

IEC 61000-5-1:1996, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 1: General considerations – Basic EMC publication*

IEC 61024-1:1990, *Protection of structures against lightning – Part 1: General principles*

ISO/IEC 11801:1995, *Information technology – Generic cabling for customer premises*

Note that other documents are listed in the Bibliography in informative annex D. This bibliographic listing includes documents that were used in developing the present report, documents cited in support of a recommendation, and documents suggested as further reading for complementary information.

3 Definitions

For the purposes of this technical report, the definitions given in IEC 60050(161) and IEC 60050(826) apply, as well as the definitions listed below.

A list of acronyms is provided at the end of this clause.

3.1
bonding
the act of connecting together exposed conductive parts and extraneous conductive parts of apparatus, systems, or installations that are at essentially the same potential [new WG2]

NOTE – For safety purposes, bonding generally involves (but not necessarily) a connection to the immediately adjacent earthing system.

3.2
common mode voltage
the mean of the phasor voltages appearing between each conductor and a specified reference, usually earth or frame [IEV 161-04-09]

3.3
common mode conversion
the process by which a differential mode voltage is produced in response to a common mode voltage [IEV 161-04-10]

3.4
common mode circuit
the full current loop or closed circuit for the CM current, including the cable, the apparatus, and the nearby parts of the earthing system [new WG2]

3.5
differential mode voltage
the voltage between any two of a specified set of active conductors [IEV 161-04-08]

3.6
differential mode circuit
the full current loop or closed circuit for the intended signal or power, including a cable and the apparatus connected to it at both ends [new WG2]

NOTE – Instead of “differential mode”, the terms “normal mode” and “serial mode” are sometimes used.

3.7
(electromagnetic) disturbance level
the level of an electromagnetic disturbance existing at a given location, which results from all contributing disturbance sources [IEV 161-03-29]

3.8
equipotential bonding
electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential [IEV 826-04-09]

3.9
earth; ground (USA)
the conductive mass of the earth, whose electric potential at any point is conventionally taken as equal to zero [IEV 826-04-01]

3.10
earth electrode
a conductive part or a group of conductive parts in intimate contact with and providing an electrical connection with earth [IEV 826-04-02]

3.11
earthing network
conductors of the earthing system, not in contact with the soil, connecting apparatus, systems, or installations to the earth electrode or to other means of earthing [new WG2]

3.12
earthing
the act of connecting exposed conductive parts of apparatus, systems or installations to the earth electrode or other elements of the earthing system [new WG2]

3.13
earthing system
the three-dimensional electrical circuit which performs the earthing [new WG2]

NOTE – The earthing system includes two parts: the earth electrode and the earthing network.

3.14
electrically independent earth electrodes
earth electrodes located at such a distance from one another that the maximum current likely to traverse one of them does not significantly affect the potential of the others [IEV 826-04-04]

3.15
(electromagnetic) compatibility level
the specified electromagnetic disturbance level used as a reference level for co-ordination in the setting of emission and immunity limits [IEV 161-03-10]

3.16
facility
something (as a hospital, factory, machinery...) that is built, constructed, installed or established to perform some particular function or to serve or facilitate some particular end [new WG2]

3.17
immunity margin
the ratio of the immunity limit to the electromagnetic compatibility level [IEV 161-03-16]

3.18
immunity level
the maximum level of a given electromagnetic disturbance, incident in a specified way on a particular device, equipment or system, at which no degradation of operation occurs
[IEV 161-03-14]

3.19
parallel-earthing conductor (PEC)
a conductor usually laid along the cable route to provide a low-impedance connection between the earthing arrangements at the ends of the cable route [new WG2]

3.20
port
specific interface of the specified apparatus with the external electromagnetic environment

3.21
surface transfer impedance (of a coaxial line)
the quotient of the voltage induced in the centre conductor of a coaxial line per unit length by the current on the external surface of the coaxial line [IEV 161-04-15]

3.22
transfer impedance (Z_t)
the ratio of the voltage coupled into one circuit to the current appearing in another circuit or another part of the same circuit [New WG2]

NOTE 1 – For the purposes of this technical report, the separate circuits may be physically separated but closely spaced cables, or the same cables operating in different modes.

NOTE 2 – Different localized contributions stem from the cable proper and from the apparatus.

3.23
acronyms

a.c.	alternating current	HF	high frequency
CM	common mode	IM	intermediate mode
d.c.	direct current	LF	low frequency
DM	differential mode	PE	protective earth
EM	electromagnetic	PEC	parallel-earthing conductor
EMC	electromagnetic compatibility		

4 General EMC considerations on installation of earthing and cabling systems

4.1 General

Different types of standards are available to define conditions for compliance with EMC requirements for electrical and electronic products, ranging from basic standards to dedicated product standards. However, these standards might not be sufficient, or appropriate, when EMC for sensitive installations is concerned. Therefore, installation guidelines are necessary to adapt to a maximum of situations. Mitigation methods might not be necessary when the equipment themselves have sufficiently high immunity levels.

Three main areas can be considered with regard to EMC:

– emitters: the source of the disturbances, influenced by the apparatus design;
– coupling paths: influenced by installation practices;
– susceptors: the potential victims, influenced by the apparatus design.

In order to assure EMC, three types of steps should be applied as necessary:

– at the source of disturbances: reduction of emissions;
– at the coupling: reduction of coupling;
– at the victim: increase of immunity.

This technical report addresses principally the mitigation achievable by reduction of the coupling through appropriate practices on the implementation of earthing and bonding, and the selection and installation of the various cables used in the facility.

4.2 EMC and safety (insulation) installation requirements

Attention is drawn to the fact that EMC protection and insulation/safety requirements can have common aspects, such as earthing and protection against overvoltages and lightning. It is important to bear in mind that the safety aspects procedures for personnel protection take precedence over EMC protection procedures. In some cases, there might be an alleged conflict between safety-related procedures and EMC-related procedures. ***Safety must always prevail, so that in such cases alternate EMC-related measures must be sought*.**

4.3 Equipment and installation ports

To provide a transition from the overall concept of coupling between environment and apparatus to the detailed specifics, it is useful to consider the concept of “ports”, as discussed in IEC 61000-5-1. By identifying such ports, protective steps can be specifically related to the nature of the EM phenomenon, its coupling path, and its impact on the functional elements of the apparatus (immunity) or its impact on the environment (emissions).

The IEC 61000-5 documents address in detail the mitigation and installation practices with consideration the ports and the associated EM phenomena. In the present technical report, clauses 5 and 6 deal with the earth port, and clause 7 deals with the power ports and the signal and control ports.

5 Earthing and bonding

5.1 Requirements concerning safety

The primary goal of an earthing system is to assure personnel safety and protection of installations against damage. Two important phenomena are lightning and power system faults. These can cause circulation of large currents, which might create hazardous voltages in installation structures. An important point to be noted is that these two phenomena are external to installations (as a general rule for the power system) and the earth (soil) is the only path for currents to return to the sources. In some countries the neutral conductor is also a path for these currents.

The amplitude of currents is comprised between a few amperes and tens of kiloamperes for power system faults and lightning. From the frequency spectrum viewpoint, these two phenomena produce signals whose frequencies are between 50/60 Hz to several megahertz.

The task of the earthing system, in these conditions, is to be a path to the soil for currents, while maintaining voltage differences between any two points of an installation (touch and step voltages) as low as possible. Generally, national regulations specify maximum voltage values for personnel safety including provision for protective earth (PE) conductor practices. However, these PE conductors alone are generally not sufficient to fulfill the EMC requirements.