

Electromagnetic compatibility (EMC) —

Part 5: Installation and mitigation guidelines

Section 2: Earthing and cabling

ICS 33.100

National foreword

This British Standard reproduces verbatim IEC 61000-5-2:1997 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee GEL/210, Electromagnetic compatibility, to Subcommittee GEL/210/10, EMC — High frequency disturbances, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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**Part 5: Installation and mitigation guidelines –
Section 2: Earthing and cabling**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –**Part 5: Installation and mitigation guidelines –
Section 2: Earthing and cabling**

FOREWORD

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- 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 Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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.

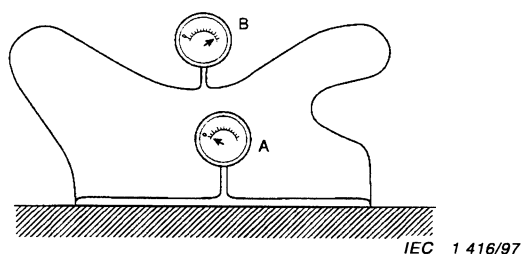
The task of the earthing system, in these conditions, is to be a path to the soil for currents, while maintaining voltage differences between any two points of an installation (touch and step voltages) as low as possible. Generally, national regulations specify maximum voltage values for personnel safety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

In the past, the power system fault current was generally used to define the earthing system (Kouteynikoff, 1980 [1]; Kuussaari, 1978 [2]; Lu, 1980 [3])¹. An unfortunate consequence of this situation is the fact that the resistance of this path became the usual criterion. This approach may still be correct for phenomena with a typical frequency of 50 Hz or 60 Hz but is certainly inappropriate for high-frequency aspects, where the inductive phenomena along the path may be predominant. Today, it would be better to characterize the earthing system by its impedance.

5.2 Requirements concerning EMC

The secondary goal of an earthing system is to serve as a common voltage reference and to contribute to the mitigation of disturbances in installations with sensitive and interconnected electronic and electrical systems.

The objective of an earthing system which presents, in all situations, an absolute voltage reference is obtainable only in theory, as shown in figure 1 (case A). Sometimes, an attempt is made to describe the ideal objective of zero volt voltage difference between any two points by the word "equipotential". However, the concept of potential is applicable to static electricity and d.c. only. In practice, induction makes the voltage between any two points greater than zero. In the case B of figure 1, the path followed by the voltmeter leads adds an inductive voltage to the near-zero voltage of case A. Likewise, interconnections between equipment, located some distance away from each other, and depending upon having a common reference, might be routed as in case A or as in case B. The extraneous voltage induced in the loop of case B can then produce a shift in the reference voltages which will depend on the actual routing. Even at 50 Hz or 60 Hz, this situation already exists in earthing systems. In theory, only a large, solid, well-conducting plane could be considered as a voltage reference. This condition would be measurable only if the voltmeter leads were run tightly against the reference plane. This concept will be discussed further and applied in clause 7.



NOTE – In case A, the voltmeter leads are maintained close to the reference plane, and the difference of voltage indicated by the voltmeter is low. In case B, the lengthy path of the voltmeter leads allows induction of an extraneous voltage in the loop.

Figure 1 – Demonstration of the fallacy of the "equipotentiality" concept as a universal rule, especially at high frequency

The earthing system contributes to the mitigation of disturbances by the fact it is the path for return currents, between a source of disturbances (see IEC 61000-2-5 for a list and description of sources) and sensitive electronic apparatus or systems and also a voltage reference for protective devices (filters, etc...). In other words, disturbances may be described in terms of currents, even in the case of radiated fields where the electromagnetic energy is transformed into current by the sensitive apparatus or systems which act as an antenna.

For the EMC aspects, modern electronic apparatus or systems are sensitive to currents and voltages many decades lower than those taken in consideration for personnel safety. This difference of point of view should be recognized, especially for technologies depending on low-level signals.

¹ Figures in square brackets refer to the bibliography given in annex D.

5.3 Design of the earthing system

The requirements described in 5.1 and 5.2, that is, shunting of unwanted power-frequency and high-frequency currents, and lowering the voltage difference between two points of the system, are the same for:

- lightning;
- personnel safety;
- installation protection;
- EMC.

Each one of these considerations places constraints on the design:

- lightning and personnel safety dictate the design of the earth electrode;
- safety and installation protection dictate the size for the earthing conductors;
- the EMC behaviour requirements determine the layout of the earthing network.

5.3.1 Earth electrode

For the earth electrode design, the first step should be the knowledge of the resistivity of the soil. This resistivity is a function of nature and homogeneity of soil, climatic conditions etc. Soil resistivity values versus nature of soil vary on a large scale, from a few ohm-meters to 10 000 $\Omega \cdot m$. For more details see the documents listed in the bibliography (annex D).

The earth electrode geometry should be adapted to the importance of the installation. A limited earth electrode (such as a cable or rod) may be used only in the case of very small installations such as a room or stand-alone apparatus or system.

In general, for buildings or plants, the best solution for the electrode is a meshed network buried under and around the building or the plant. In old buildings where these objectives may be difficult to attain, other measures and more careful attention to EMC concerns will be necessary. It is important to note that this recommendation does not seek to preclude existing installation practices, when they have shown to perform satisfactorily.

The meshed network of the earth electrode is often complemented by radial cables and/or earth rods at connection points of cables coming from lightning rods, high-voltage apparatus or systems, and apparatus or systems with large fault currents returning through the earthing system.

The earth electrode as a general rule should be set in natural soil, not in backfill materials and, if possible, in damp earth. Figure 2 gives an example of an earth electrode principle diagram for a plant.

Some practical points are important because they influence the long-term electrode quality.

- Solid conductors are preferably used because they are less subject to corrosion than stranded conductors.
- For the same reason (corrosion), connections between conductors are welded and not implemented by mechanical clamping. Some buildings have a concrete-encased earth electrode. This electrode is located within, and near the bottom of a concrete foundation that is in direct contact with the soil. This solution, correct for residential or office buildings, might not, on its own, have the performances required for industrial buildings.

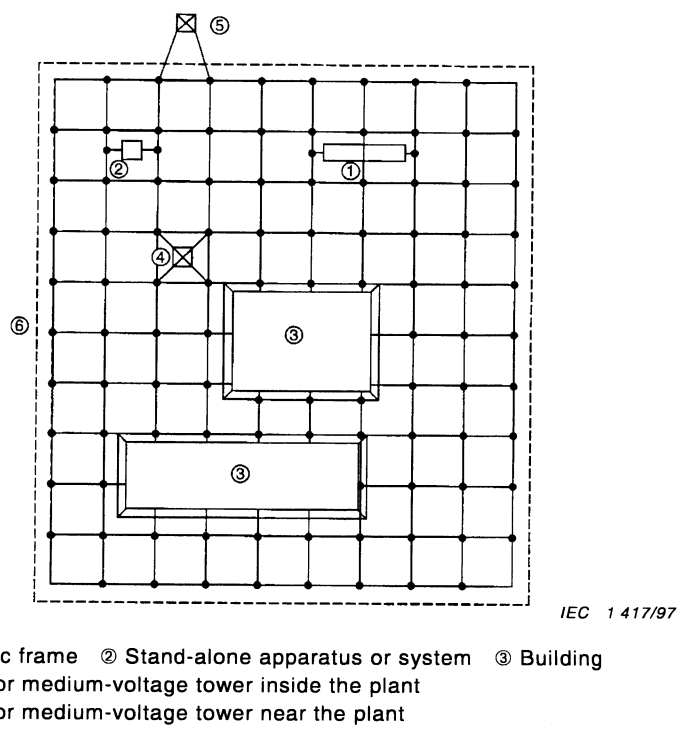
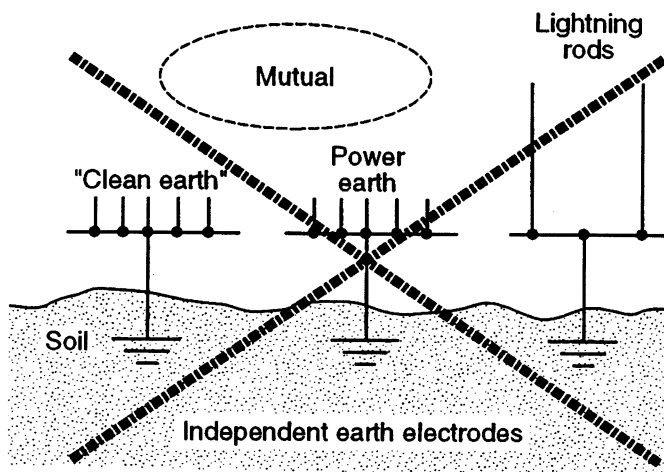


Figure 2 – Schematic plan view of a typical earth electrode

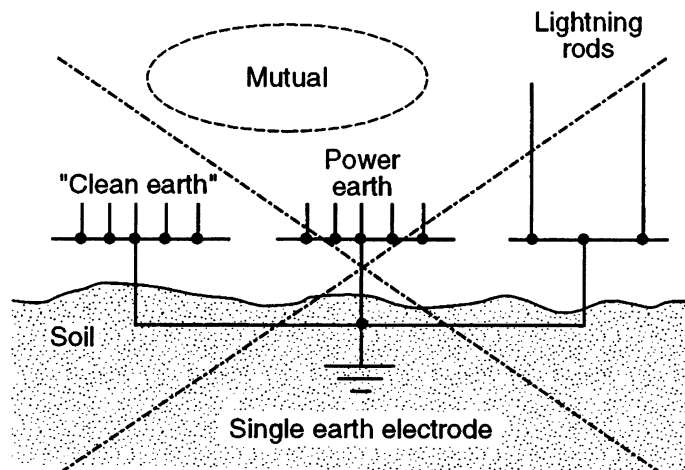
The use of independent, "isolated" (see definition in 3.14) earth electrodes for computer or electronic systems (figure 3) is not recommended (and may be forbidden in some countries). There are always links by the soil or by parasitic elements (capacitances and mutual inductances) in the installation. In case of lightning or power system fault, dangerous transient voltages (for personnel safety and for EMC) can occur between this isolated earthing system and other parts of the installation.



IEC 1 418/97

NOTE – In an attempt to obtain a "clean" earthing network, for example to be used as a reference for signals, the earth electrodes have not been bonded. This approach is not suitable for EMC, and is a safety hazard; in fact, regulatory codes prohibit this practice in some countries.

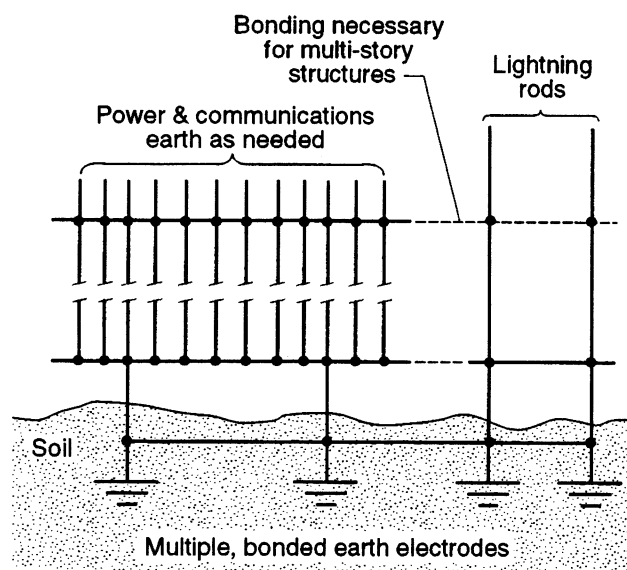
Figure 3 – Misconception of "dedicated", "independent", or "isolated" earth electrodes



IEC 1 419/97

NOTE – In an attempt to obtain a so-called "clean" or "instrument" earthing network, for example to be used as a reference for signals, the earthing network is separated into a signal and a power earthing network. When properly installed **and the topology maintained**, this approach has been found satisfactory, but it is not recommended for general use. It is suitable for safety (at power frequencies); it is generally not suitable for high-frequency EMC concerns.

Figure 4 – The concept of a single earth electrode



IEC 1 420/97

NOTE – This two-dimensional conceptual representation, similar in format to figures 3 and 4, is actually a three-dimensional network, as shown in figure 7. It is the recommended approach in the general case, for safety as well as for EMC. As noted for figure 4, this recommendation does not exclude other, well-demonstrated and well-maintained special configurations.

Figure 5 – Recommended configuration for the earth electrodes and earthing network

5.3.2 Earthing network

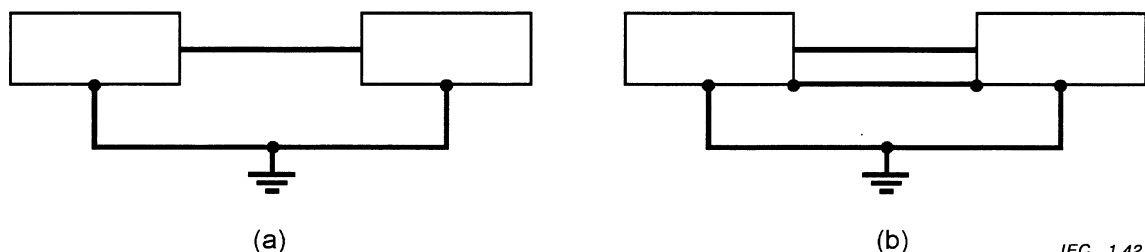
The earthing network is generally designed and implemented by the facility builder to have an impedance as low as possible in order to divert the power fault currents as well the HF currents without passing through the electronic apparatus or systems. Different earthing network layouts exist and may give satisfaction to their users. But some of these earthing network layouts require observing specific conditions to be effective. For example, a central administration or large organization with appropriate structures may design and maintain every aspect of an earthing system from soil resistivity measurement to the final control. 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.**

These specific conditions are generally not fulfilled by the typical user of an installation. Therefore, the guidance given in this technical report is intended for this typical user, rather than the organizations with established and successful approaches.

The concept of independent, dedicated earth electrodes (presumably in accordance with definition 3.14, illustrated by figure 3), each serving a separate earthing network, is a misconception that not only will not promote EMC, but is a serious safety hazard. In some countries, national codes prohibit such practice. The use of a separate "clean" electronic earthing network and a "dirty" power earthing network is not recommended to achieve EMC, even with the use of a single earth electrode (figure 4). Although not universally accepted, IEC 61024-1 subclause 3.1.2b) requires bonding *"at vertical intervals not exceeding 20 m for structures of more than 20 m in height. Bonding bars shall be connected to the horizontal ring conductors which bond the down-conductors"*. This arrangement is shown schematically in figure 5.

It is recognized that some of the recommendations of this technical report might be difficult to implement in an old building. Nevertheless, some improvements of the earthing network are possible. Examples include a raised floor with meshed earthing network underneath, or the interconnection of all the chassis of the apparatus exchanging signals (figure 6). Other installation mitigation methods can also complement these.

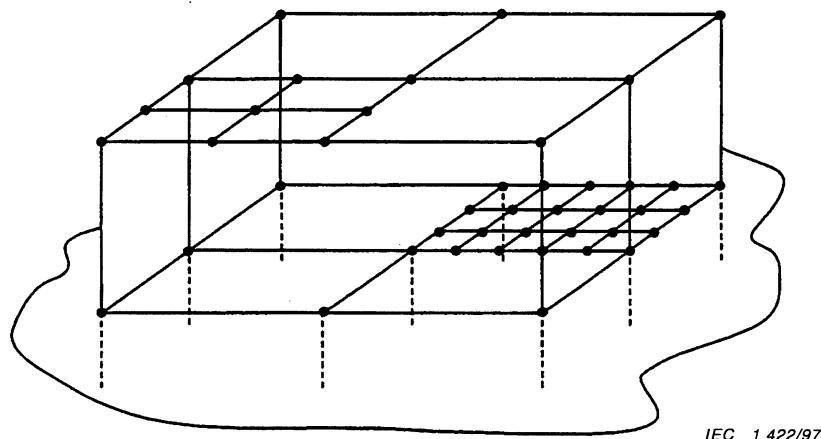
One often-cited objection to a meshed earthing network is that this approach results in earth loops, a situation viewed as undesirable because of noise problems. In fact, the noise problems can be reduced by the methods described in clause 7. In any event, a perceived need for separating earthing networks because of noise problems should never lead to adopting unsafe practices.



NOTE – In (a), a loop is formed that involves the signal cable shield, an undesirable situation. In (b), the loop between the two chassis mitigates the involvement of the signal cable.

Figure 6 – Loops involving signal cables and earthing network

As a typical installation may have many floors, each floor should have its own earthing network (generally implemented as a mesh, see figure 7), and all these networks should be connected to one another and to the earth electrode. A minimum of two connections are required (redundancy should be built-in) to be sure, in case one of the conductors breaks, that no part of the earthing network becomes isolated. Practically, more than two connections are used to have a better symmetry for current circulation, to minimize voltages differences, and to decrease the global impedance between two floor levels.



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NOTE – Each floor has its mesh grid, the grids are interconnected at several points between floors, and some floor grids are reinforced as needed in some areas.

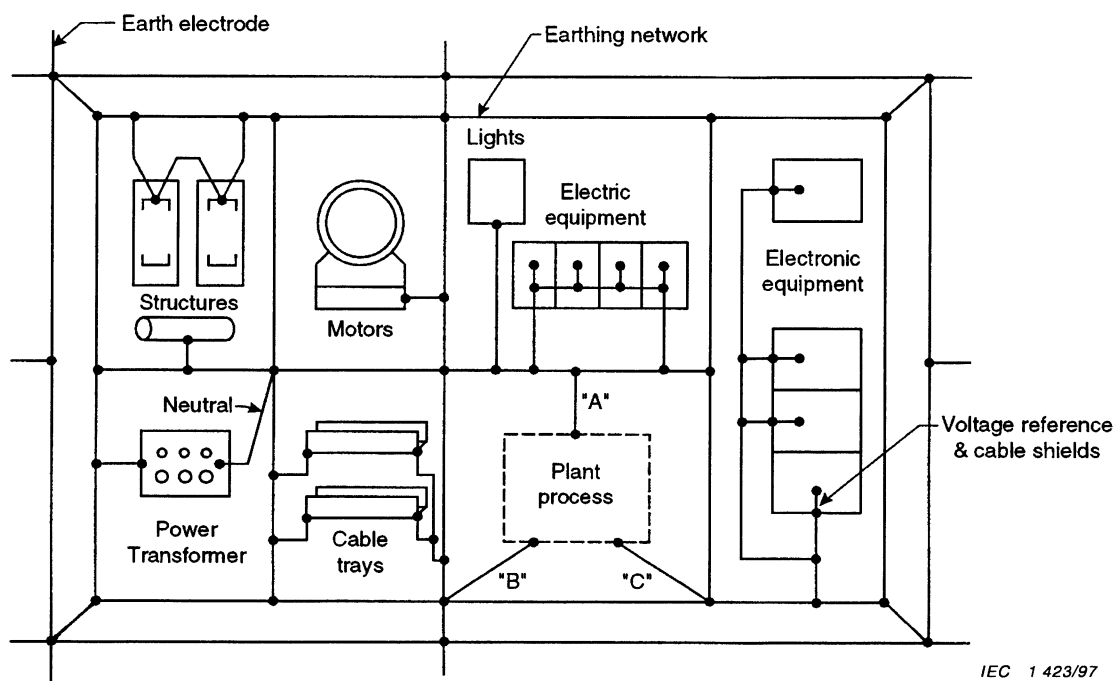
Figure 7 – A three-dimensional schematic of the recommended approach for the earthing network

These multiple and parallel paths have different resonance frequencies. So, if there is for a given frequency a path with a high impedance, this path is certainly shunted by another which has not the same resonance frequency. Globally, over a large frequency spectrum (d.c. to tens of megahertz), a multitude of paths gives a low impedance system.

Each room of the building should have earthing network conductors to allow bonding of apparatus or systems, cable trays, structures: slab reinforcement of buildings, water pipes, gutters, supports, frames etc. In particular cases, such as control or computer rooms with raised floor, an earth reference plane or earthing straps in the area of electronic systems can be used to improve the earthing of sensitive equipment and to protect the interconnecting cables.

The arrangement of sensitive or high-power apparatus or system to be installed in the building may require local reinforcement of the earthing network, for example: in control or computer rooms, near a power transformer, etc. A way to decrease coupling between electromagnetic interference (EMI) sources and a sensitive device is distance. This principle should be also applied to the earthing network. Different zones should be created, for example: electronic zone, machine zone, etc. These zones are interconnected by the earthing network, but layout of the installation should be such that distance should be as large as possible between sources and sensitive apparatus or systems as shown in figure 8.

A motor with a potentially large fault current should not be bonded on the same earthing conductor as sensitive electronics (common impedance coupling should be carefully avoided). It is recommended to connect the various apparatus at the nodes of the earthing network in order to improve the EMC performance of the installation.



NOTE – The topology of connections "B" and "C" provides better EMC performance than the topology "A". Details of connections may vary with specific cases.

Figure 8 – General principles for bonding of various apparatus or systems to the earthing network

Some organizations, where central engineering has made tight control of the design and implementation possible, have successfully applied an approach where each floor has its own isolated meshed earthing network, the so-called "Hybrid-Earth" [4] (see figure A.1). A main feature is the strict cable routing concept which demands that all cables enter the specific system at one interface, similar to the example of figure A.2 (which is topologically equivalent). This approach offers the advantage of minimizing noise problems sometimes associated with an integral meshed network, but it requires carefully maintaining the isolation between the specific isolated meshed network and extraneous conductive parts.

The main physical difference between the earth electrode and the earthing network concerns their implementation. There is little risk of corrosion inside buildings (generally) so that it is possible to use stranded cables for conductors and mechanical tightening for the connection of conductors.

5.3.3 Lightning rod down-conductors

These conductors, which are part of the earthing network, are specific for many reasons. The amplitude and the equivalent frequencies of the lightning currents require that more than one down conductor be used for each lightning rod:

- to decrease the impedance of the path;
- to limit the current in one conductor;
- to avoid the risk of a lightning rod becoming disconnected from the down conductor.

From the EMC point of view, these multiple conductors present the advantage of limiting the inductive effects inside the building if the layout of the installation is such that these conductors are not too close to sensitive electronic apparatus or systems (there is generally poor attenuation from building walls for electric and magnetic fields).