

Australian/New Zealand Standard™

Electromagnetic compatibility (EMC)

Part 2.4: Environment—Compatibility levels in industrial plants for low- frequency conducted disturbances



AS/NZS 61000.2.4:2009

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-034, Power Quality.

The objective of this Standard is to specify numerical compatibility levels for electromagnetic disturbances in industrial plants in the frequencies up to 9 kHz. The compatibility levels apply to industrial and non-public power distribution systems at voltages up to 35 kV and a frequency of 50 Hz or 60 Hz. Power supply systems used on ships, aircraft, offshore platforms and railways are excluded.

This Standard is identical with, and has been reproduced from IEC 61000-2-4, Ed. 1.0 (2002), *Electromagnetic compatibility (EMC)—Part 2-4: Environment—Compatibility levels in industrial plants for low-frequency conducted disturbances*.

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- (b) In the source text ‘this part of IEC 61000’ should read ‘this Australian/New Zealand Standard’.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

The term ‘informative’ is used to define the application of the annex to which it applies. An informative annex is only for information and guidance.

CONTENTS

	<i>Page</i>
Introduction	iv
1 Scope	1
2 Normative references	2
3 Definitions	2
3.1 General definitions	2
3.2 Phenomena-related definitions	4
4 Electromagnetic environment classes	6
5 Compatibility levels	6
5.1 General comment	6
5.2 Voltage deviations	7
5.3 Voltage dips and short interruptions	7
5.4 Voltage unbalance (imbalance)	7
5.5 Temporary power-frequency variation	7
5.6 Harmonics	8
5.7 Interharmonics	8
5.8 Voltage components at higher frequencies (above 50th harmonic)	9
5.9 Transient overvoltages	9
5.10 DC component	9
6 Compatibility levels	10
Annex A (informative) Explanations and examples for interharmonics	13
Annex B (informative) Examples of expected disturbance levels in typical industrial networks	15
Annex C (informative) Interharmonic and voltages at higher frequencies	23
Bibliography	30

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, published either as International Standards, 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: 61000-3-11).

Detailed information on the various types of disturbances that can be expected on public power supply systems can be found in IEC 61000-2-1 and IEC 61000-2-12.

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Australian/New Zealand Standard**Electromagnetic compatibility (EMC)****Part 2.4: Environment—Compatibility levels in industrial plants for low-frequency conducted disturbances**

1 Scope

This part of IEC 61000 is concerned with conducted disturbances in the frequency range from 0 kHz to 9 kHz. It gives numerical compatibility levels for industrial and non-public power distribution systems at nominal voltages up to 35 kV and a nominal frequency of 50 Hz or 60 Hz.

Power supply systems on ships, aircraft, offshore platforms and railways are not included.

The compatibility levels specified in this standard apply at the in-plant point of coupling. At the power input terminals of equipment receiving its supply from the above systems, the severity levels of the disturbances can, for the most part, be taken to be the same as the levels at the in-plant point of coupling. In some situations this is not so, particularly in the case of a long feeder dedicated to the supply of a particular load, or in the case of a disturbance generated or amplified within the installation of which the equipment forms a part.

Compatibility levels are specified for electromagnetic disturbances of the types which can be expected at any in-plant point of coupling (IPC) within industrial plants or other non-public networks, for guidance in

- a) limits to be set for disturbance emission into industrial power supply systems (including the planning levels defined in 3.1.5);

NOTE 1 A very wide range of conditions is possible in the electromagnetic environments of industrial and other non-public networks. These are approximated in this standard by the three classes described in Clause 4. However, it is the responsibility of the operator of such a network to take account of the particular electromagnetic and economic conditions, including equipment characteristics, in setting the above-mentioned limits.

- b) the choice of immunity levels for the equipment within these systems.

The disturbance phenomena considered are:

- voltage deviations;
- voltage dips and short interruptions;
- voltage unbalance;
- power-frequency variations;
- harmonics up to order 50;
- interharmonics up to the 50th harmonic;
- voltage components at higher frequencies (above 50th harmonic);
- d.c. component;
- transient overvoltages.

The compatibility levels are given for different classes of the electromagnetic environment determined by the characteristics of the supply network.

NOTE 2 Compatibility levels at the point of common coupling (PCC) on public networks are specified in IEC 61000-2-2 for low-voltage networks and IEC 61000-2-12 for medium-voltage networks. Technical reports IEC 61000-3-6 and IEC 61000-3-7 describe the approach of supply authorities to the limitation of emissions from installations and large loads.

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.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

IEC 60050-101, *International Electrotechnical Vocabulary (IEV) – Part 101: Mathematics*

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

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics*

~~IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*~~

AS/NZS 61000.2.2, *Electromagnetic compatibility (EMC), Part 2.2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

~~IEC 61000-2-12: *Electromagnetic compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems*¹~~

AS/NZS 61000.2.12, *Electromagnetic compatibility (EMC), Part 2.12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems*

3 Definitions

For the purposes of this part of IEC 61000, the definitions given in chapter 161 and parts 101 and 551 of IEC 60050 (IEV) as well as the following apply.

3.1 General definitions

3.1.1

(electromagnetic) disturbance

any electromagnetic phenomenon which, by being present in the electromagnetic environment, can cause electrical equipment to depart from its intended performance

[IEV 161-01-05, modified]

¹To be published.

3.1.2**disturbance level**

amount or magnitude of an electromagnetic disturbance, measured and evaluated in a specified way

[IEV 161-03-01, modified]

3.1.3**electromagnetic compatibility****EMC**

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[IEV 161-01-07]

NOTE 1 Electromagnetic compatibility is a condition of the electromagnetic environment such that, for every phenomenon, the disturbance emission level is sufficiently low and immunity levels are sufficiently high so that all devices, equipment and systems operate as intended.

NOTE 2 Electromagnetic compatibility is achieved only if emission and immunity levels are controlled such that the immunity level of devices, equipment and systems, at any location, are not exceeded by the disturbance level at that location, resulting from the cumulative emission of all sources and other factors such as circuit impedances. Conventionally, compatibility is said to exist if the probability of the departure from intended performance or of the adverse effect is sufficiently low. See Clause 4 of IEC 61000-2-1.

NOTE 3 Where the context requires it, compatibility may be understood to refer to a single disturbance or class of disturbances.

NOTE 4 Electromagnetic compatibility is a term used also to describe the field of study of the adverse electromagnetic effect which devices, equipment and systems undergo from each other or from electromagnetic phenomena.

3.1.4**(electromagnetic) compatibility level**

specified electromagnetic disturbance level used as a reference level in a specified environment for coordination in the setting of emission and immunity limits

[IEV 161-03-10, modified]

NOTE By convention, the compatibility level is chosen so that there is only a small probability that it will be exceeded by the actual disturbance level.

3.1.5**planning level**

level of a particular disturbance in a particular environment, adopted as a reference value for the limits to be set for the emission of large loads and installations, in order to coordinate those limits with all the limits adopted for equipment intended to be connected to the power supply system

NOTE The planning level is locally specific and is adopted by those responsible for planning and operating the power supply network in the relevant area. (For further explanation, see Annex A of IEC 61000-2-2.)

3.1.6**point of common coupling****PCC**

point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected

[IEV 161-07-15, modified]

3.1.7**in-plant point of coupling****IPC**

point on a network inside a system or an installation, electrically nearest to a particular load, at which other loads are, or could be, connected

NOTE The IPC is usually the point for which electromagnetic compatibility is to be considered.

3.2 Phenomena-related definitions

The definitions below that relate to harmonics are based on the analysis of system voltages or currents by the Discrete Fourier Transform method (DFT). This is the practical application of the Fourier Transform as defined in IEC 60044-1. See Annex A.

NOTE The Fourier Transform of a function of time, whether periodic or non-periodic, is a function in the frequency domain and is referred to as the frequency spectrum of the time function, or simply spectrum. If the time function is periodic the spectrum is constituted of discrete lines (or components). If the time function is not periodic, the spectrum is a continuous function indicating components at all frequencies.

Other definitions related to harmonics or interharmonics are given in IEC and other standards. Some of those other definitions, although not used in this standard, are discussed in Annex A.

3.2.1

fundamental frequency

frequency, in the spectrum obtained from a Fourier transform of a time function, to which all the frequencies of the spectrum are referred. For the purposes of this standard, the fundamental frequency is the same as the power supply frequency

[IEC 60044-1, modified]

NOTE 1 In the case of a periodic function, the fundamental frequency is generally equal to the frequency of the function itself. (See A.1.)

NOTE 2 In case of any remaining risk of ambiguity, the power supply frequency should be referred to the polarity and speed of rotation of the synchronous generator(s) feeding the system.

NOTE 3 This definition may be applied to any industrial power supply network, without regard to the load it supplies (a single load or a combination of loads, rotating machines or other loads), and even if the generator feeding the network is a semiconductor converter.

3.2.2

fundamental component (or fundamental)

component whose frequency is the fundamental frequency

3.2.3

harmonic frequency

frequency which is an integer multiple of the fundamental frequency. The ratio of the harmonic frequency to the fundamental frequency is named harmonic order. (Recommended notation " h ")

3.2.4

harmonic component

any of the components having a harmonic frequency. Its value is normally expressed as an r.m.s. value

For brevity, such a component may be referred to simply as a harmonic

3.2.5

interharmonic frequency

any frequency which is not an integer multiple of the fundamental frequency

NOTE 1 By extension from harmonic order, the interharmonic order is the ratio of interharmonic frequency to the fundamental frequency. This ratio is not an integer. (Recommended notation " m ")

NOTE 2 In the case where $m < 1$, the term sub-harmonic frequency may also be used.

3.2.6

interharmonic component

component having an interharmonic frequency. Its value is normally expressed as an r.m.s. value.

For brevity, such a component may be referred to simply as an interharmonic

NOTE For the purpose of this standard, and as stated in IEC 61000-4-7, the time window has a width of 10 fundamental periods (for 50 Hz systems) or 12 fundamental periods (for 60 Hz systems), i.e. approximately 200 ms. The difference in frequency between two consecutive interharmonic components is, therefore, approximately 5 Hz.

3.2.7

total harmonic distortion

THD

ratio of the r.m.s. value of the sum of all the harmonic components up to a specified order (recommended notation "H") to the r.m.s. value of the fundamental component

$$THD = \sqrt{\sum_{h=2}^{h=H} \left(\frac{Q_h}{Q_1} \right)^2}$$

where:

Q represents either current or voltage;

Q_1 is the r.m.s. value of the fundamental component;

h is the harmonic order;

Q_h is the r.m.s. value of the harmonic component of order h ;

H is 50 for the purpose of the compatibility levels in this standard.

NOTE THD takes account of harmonics only. For the case where interharmonics are to be included, see A.3.1.

3.2.8

voltage unbalance (imbalance)

condition in a polyphase system in which the r.m.s. values of the line-to-line voltages (fundamental component), or the phase angle between consecutive line-to-line voltages, are not all equal. The degree of the inequality is usually expressed as the ratios of the negative and zero sequence components to the positive sequence component

[IEV 161-08-09, modified]

NOTE 1 Generally voltage unbalance, in relation to three-phase systems, is considered through its negative phase sequence only. However, in some circumstances, the zero sequence component should also be considered.

NOTE 2 Several approximations give reasonably accurate results for the levels of unbalance normally encountered (ratio of negative to positive sequence components):

$$\text{e.g. voltage unbalance} = \sqrt{6 \times \frac{U_{12}^2 + U_{23}^2 + U_{31}^2}{(U_{12} + U_{23} + U_{31})^2}} - 2$$

where U_{12} , U_{23} , U_{31} are the three fundamental line-to-line voltages.

3.2.9

voltage deviation

increase or decrease of the r.m.s. supply voltage normally due to the variation of the load on the supply network or a part of it, or a rapid voltage change repeated, or not, due to a rapid change of load (see the first paragraph of 4.2 of IEC 61000-2-2); the part of transients with no remaining effects is excluded

NOTE Some voltage deviations may be fast changes due to adaptation of the voltage network to the load conditions (example: voltage taps changes of transformers, permanent effect of capacitor bank switching). Voltage fluctuation, which may cause flicker is a different phenomenon (series of voltage changes or cyclical voltage changes). Voltage variations and voltage fluctuations are the major types of voltage changes.

3.2.10

voltage dip (voltage sag)

sudden reduction of the voltage at a particular point on an electricity supply system below a dip threshold voltage, followed by its recovery after a brief interval

NOTE 1 Typically a dip is associated with the occurrence and termination of a short circuit or other extreme current increase on the system or installations connected to it.

NOTE 2 Generally the threshold corresponds to the minimum value of the tolerance band.

3.2.11

transient overvoltage

oscillatory or non-oscillatory overvoltage, highly damped and up to a few ms in duration. Compatibility level is related to the peak value line to earth

NOTE The origin of transient overvoltages is generally atmospheric or in operations in the network (switching, fuses). Its rise time may be from less than 1 μ s to a few ms.

4 Electromagnetic environment classes

Several classes of electromagnetic environment can be defined, but for simplicity only three are considered and defined in this standard, as follows.

- Class 1 This class applies to protected supplies and has compatibility levels lower than those on public networks. It relates to the use of equipment very sensitive to disturbances in the power supply, for instance electrical instrumentation in laboratories, some automation and protection equipment, some computers, etc.
- Class 2 This class applies generally to PCCs and to IPCs in the environments of industrial and other non-public power supplies. The compatibility levels of this class are generally identical to those of public networks. Therefore, components designed for supply from public networks may be used in this class of industrial environment.
- Class 3 This class applies only to IPCs in industrial environments. It has higher compatibility levels than those of class 2 for some disturbance phenomena. For instance, this class should be considered when any of the following conditions are met:
- a major part of the load is fed through converters;
 - welding machines are present;
 - large motors are frequently started;
 - loads vary rapidly.

The class applicable for new plants and extensions of existing plants cannot be determined *a priori* and should relate to the type of equipment and process under consideration.

NOTE 1 Class 1 environments normally contain equipment which requires protection by such apparatus as uninterruptible power systems (UPS), filters or surge suppressers.

NOTE 2 In some cases, highly sensitive equipment may require compatibility levels lower than the ones relevant to class 1 environments. The compatibility levels are then to be agreed upon case by case (controlled environment).

NOTE 3 The supply to highly disturbing loads, such as arc-furnaces and large converters which are generally supplied from a segregated busbar, frequently has disturbance levels in excess of class 3 (harsh environment). In such special situations, the compatibility levels should be agreed upon.

NOTE 4 Taking account of diversity of industrial environments, different classes can be relevant for different phenomena in any given network.

5 Compatibility levels

5.1 General comment

The compatibility levels are set down for the various disturbances on an individual basis only. However, the electromagnetic environment usually contains several disturbances simultaneously, and the performance of some equipment can be degraded by particular combinations of disturbances. See Clause A.2 of IEC 61000-2-2.

Levels are provided in Table 1 to Table 5. See also guidance for interharmonics in Annex C.

IPCs should be categorized according to their compatibility levels. To enable the selection of specific equipment or devices such as rotating machines, power-capacitor banks, filters, it may be necessary to obtain a specific description of the voltage deviations that may be present at the equipment terminals. The technical committees responsible for the relevant product standards will specify the information to facilitate the proper selection of components. They should also take into account the compatibility levels in this standard when specifying the supply operating conditions of the equipment.

Compatibility levels are given at the IPCs, but this does not imply that disturbances at these levels will satisfy the emission requirements at the PCC. This fact is to be carefully considered when selecting the equipment.

NOTE 1 Equipment operating within class 1 is generally low-voltage equipment.

NOTE 2 To illustrate disturbance levels caused by power converters in various industrial environments, a few examples of calculated results are given in Annex B.

NOTE 3 The compatibility levels of class 3 cover the possible disturbances in industrial environments. For a specific installation it is expected that only some types of disturbances occur with the level pertaining to class 3. Since equipment or devices have different sensitivities to the various types of disturbances, a specific equipment or device may be used conditionally with a class 3 supply depending on the actual disturbance levels.

NOTE 4 Disturbance levels, which have both time and location variations, cannot be controlled at all locations and at all times. Therefore, evaluation should be made for the entire industrial system being considered, rather than at a specific location within that system.

5.2 Voltage deviations

See Table 1. For class 3, voltage deviations resulting in supply voltages in the range $0,85 U_C$ to $0,9 U_C$ are expected for a duration not longer than 60 s. For longer durations the range $0,9 U_C$ to $1,1 U_C$ applies.

NOTE 1 Voltage fluctuation leading to flicker is generally of concern only to lighting equipment. This should be connected to a class 2 supply. The compatibility levels of IEC 61000-2-2 apply.

NOTE 2 In certain circumstances, some equipment might be sensitive to rapid voltage changes.

5.3 Voltage dips and short interruptions

For class 1 IPCs, a protection provided by UPSs is considered and dips are not expected.

For a discussion of the other aspects of these phenomena see Clause B.3.

5.4 Voltage unbalance (imbalance)

In this standard, voltage unbalance is considered only in relation to the negative phase sequence component, this being the component relevant to possible interference with equipment connected to the power supply systems covered by this standard. In this Standard, voltage unbalance is considered in relation to long-term effect, i.e. for durations equal to or higher than 10 min.

NOTE 1 Some protection equipment may be sensitive to the zero sequence voltage component. Care should be taken of this aspect at the installation level.

NOTE 2 Zero sequence voltages are of concern mainly for harmonics multiples of 3.

NOTE 3 Electronic converters produce characteristic harmonic orders due to their topology when used under their rated operating conditions. Different operating conditions such as unbalance, non-ideal commutation instants, etc. may cause other harmonic orders to be produced.

The voltage unbalance caused by a single-phase load connected line-to-line is in practice equal to the ratio of the load power to the network three-phase short circuit power. If no substantial single-phase load is present, the compatibility levels of class 2 may be applied.

5.5 Temporary power-frequency variation

The compatibility levels of power-frequency deviations of the public network apply to industrial plants fed from the public power supply.