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Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment; electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems

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Electromagnetic compatibility (EMC)

Part 2:
Environment
Section 1: Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC)

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FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This section of IEC 1000-2, which has the status of a technical report, has been prepared by IEC Technical Committee No. 77: Electromagnetic compatibility between electrical equipment including networks.

The text of this section is based on the following documents:

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
77(CO)26	77(CO)30	77(CO)32	77(CO)34

Full information on the voting for the approval of this section can be found in the Voting Reports indicated in the above table.

INTRODUCTION

IEC 1000 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 9: Miscellaneous

Each part is further subdivided into sections which can be published either as International Standards or Technical reports.

These standards and reports will be published in chronological order and numbered accordingly.

This section is a Technical Report serving as a reference document for those associated parts of IEC 1000 that give values of compatibility level, for example IEC 1000-2-2.

ELECTROMAGNETIC COMPATIBILITY (EMC)

Part 2: Environment

Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems

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1 Scope

This section of IEC 1000-2 is concerned with conducted disturbances in the frequency range up to 10 kHz with an extension for mains signalling systems. Separate sections give numerical compatibility levels for different system voltage levels.

This section does not deal with the application of compatibility levels to assess, for example, the permissible interference emission from specific items of equipment or installations, because other system parameters, such as its impedance as a function of frequency, have also to be considered. Furthermore, it does not prejudge the specification of immunity levels by the product committees but merely provides a guide.

The disturbance phenomena considered are:

- harmonics;
- inter-harmonics;
- voltage fluctuations;
- voltage dips and short supply interruptions;
- voltage unbalance;
- mains signalling;
- power frequency variation;
- d.c. components.

The object of this section is to give information on the various types of disturbances that can be expected on public power supply systems. It is a reference document for those associated parts that give values of compatibility level.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this section of IEC 1000-2. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this section of IEC 1000-2 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid international standards.

IEC 38: 1983, *IEC standard voltages.*

IEC 50(161): 1990, *International Electrotechnical Vocabulary (IEV), Chapter 161: Electromagnetic Compatibility.* (Under consideration.)

IEC 146: 1985, *Semiconductor convertors. Second impression 1985 incorporating: Supplement 146A (1974) and Amendment No. 1 (1975).*

IEC 555-3: 1982, *Disturbances in supply systems caused by household appliances and similar electrical equipment. Part 3: Voltage fluctuations.*

IEC 868: 1986, *Flickermeter. Functional and design specifications.*

IEC 1000-2-2: 1990, *Electromagnetic compatibility (EMC). Part 2: Environment. Section 2: Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems.*

3 Definitions

The definitions are taken from IEC 50(161): International Electrotechnical Vocabulary (IEV), Chapter 161: Electromagnetic compatibility.

The relevant basic definitions are:

3.1 *Electromagnetic compatibility; EMC (abbreviation) (IEV 161-01-07)*

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

3.2 *(Electromagnetic) compatibility level (IEV 161-03-10)*

The specified maximum electromagnetic disturbance level expected to be impressed on a device, equipment or system operated in particular conditions.

NOTE - In practice the electromagnetic compatibility level is not an absolute maximum level, but may be exceeded with a small probability.

3.3 *Electromagnetic disturbance (IEV 161-01-05)*

Any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter.

NOTE - An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

3.4 *Disturbance level (not defined in IEV 161)*

The value of a given electromagnetic disturbance, measured in a specified way.

3.5 *Limit of disturbance (IEV 161-03-08)*

The maximum permissible electromagnetic disturbance level, as measured in a specified way.

3.6 *Immunity level (IEV 161-03-14)*

The maximum level of a given electromagnetic disturbance incident on a particular device, equipment or system for which it remains capable of operating at a required degree of performance.

3.7 *(Electromagnetic) susceptibility (IEV 161-01-21)*

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

NOTE - Susceptibility is a lack of immunity.

4 Purpose of specifying electromagnetic compatibility levels

NOTE - An interpretation of the basic definitions for practical application in IEC is in preparation. The main results are considered in this clause.

From the definition of electromagnetic compatibility level it can be seen that it is a reference value by means of which the disturbance level on the system and the immunity level for various equipment types can be coordinated.

For practical purposes the "limit of disturbance" is the maximum disturbance level appearing with a certain probability in the electromagnetic environment of a device, equipment or system. This is the reference value to which the other levels have to be related, in order to avoid causing interference.

In some cases, this maximum disturbance level is the result of the superposition of several sources (e.g. harmonics), in other cases it is produced by a single source (e.g. non-repetitive voltage dip).

It must be emphasized that in general, the disturbance level is not a single value, but varies with position and time. In practice, the statistical distribution of the disturbance must be considered.

The maximum disturbance level may be derived from actual network measurements or, possibly, theoretical study.

Because of this variability of the disturbance level, it is often very difficult or even impossible to determine the actual highest level of disturbance which may appear very infrequently. It is also generally not economical to define the compatibility level in terms of this highest value to which most devices would not be exposed most of the time.

It therefore seems appropriate to define the compatibility level not as the "maximum value" of a disturbance but as the level of the disturbance that would be exceeded in only a small or very small number of cases - the aim being for the compatibility level to cover at least 95 % or so of situations.

The immunity level of equipment should be equal to the compatibility level or higher.

The immunity level has to be checked by an appropriate test. Determining its value and the test procedure is the responsibility of a relevant Technical Committee (or is subject to agreement between the parties involved).

The susceptibility level of equipment is the level of disturbance which would disturb the function of the equipment. It should be equal to, or higher than, the immunity level fixed for the tests.

The susceptibility level should be fixed by the manufacturer taking into account anticipated service conditions and the specified immunity limit. The susceptibility level may require consideration in statistical terms.

The compatibility level is intended to serve as a reference value for trouble-free operation, in particular for public power supply systems to which items of equipment are connected by independent consumers not normally in contact with each other.

The relation between the different levels of disturbance taking into account the statistical features is illustrated by figure 1.

In dedicated or independent systems, servicing for example only one customer's equipment of a particular kind, other compatibility levels may be agreed.

5 Harmonics

5.1 *Description of the phenomenon*

Harmonics are sinusoidal voltages or currents having frequencies that are whole multiples of the frequency at which the supply system is designed to operate (e.g. 50 Hz or 60 Hz).

Harmonic disturbances are generally caused by equipment with a non-linear voltage/current characteristic. Such equipment may be regarded as current sources of harmonics.

The harmonic current from the different sources produces harmonic voltage drops across the impedance of the network. This phenomenon is represented in figure 2 in a simplified way. In reality, the different harmonic currents add vectorially.

As a result of the connection of reactive loads (e.g. power factor correction capacitors) and the effect of cable capacitance, shunt and series resonance may occur in the network and cause a voltage magnification even at a point remote from the distorting load.

5.2 *Sources of harmonics*

Harmonic currents are generated to a small extent and at low distortion levels by generation, transmission and distribution equipment and to a larger extent, at relatively large distortion levels, by industrial and domestic loads. Normally there are only a few

sources generating significant harmonic currents in a network; the individual harmonic power rate of the majority of the other devices is low.

The following sources generate significant harmonic currents in a network:

- equipment with phase-control and high power;
- uncontrolled rectifiers, especially with capacitive smoothing (e.g. used in televisions, frequency converters, and self-ballasted lamps), because these harmonics are in phase to each other and there is no compensation in the network.

Sources may produce harmonics at a constant or varying level, depending on the method of operation.

5.2.1 *Generation, transmission and distribution equipment*

This category covers equipment used by utilities to supply electricity, especially generators, transformers and more recently, though to a limited extent, equipment like static compensators and frequency converters.

Since it is impossible for the designer of a generator to obtain a pure sine wave, rotating machines generally represent a source of harmonics. However the magnitude of these harmonics is normally negligible as proper selection of slots per pole, coil pitches etc. ensures that almost sinusoidal generated waveshape can be obtained. However, unbalanced operation will result in the generation of third and higher harmonics.

Distortion from transformers is caused by the saturation of iron in the magnetic circuit of the transformer coil.

5.2.2 *Industrial loads*

Industrial loads which may be a source of significant levels of harmonic distortion include power converters (rectifiers), induction furnaces, arc furnaces etc.

Electronic power equipment may have a significant influence on the level of disturbance of networks. The use of this type of equipment is increasing in terms of numbers and the unit ratings involved.

According to theory, the characteristic harmonic current of power converters will be of the order:

$$n = p \times m \pm 1$$

where

- n is the harmonic order;
- p is the pulse number of the converter;
- m is any integer (1, 2, 3 ...).