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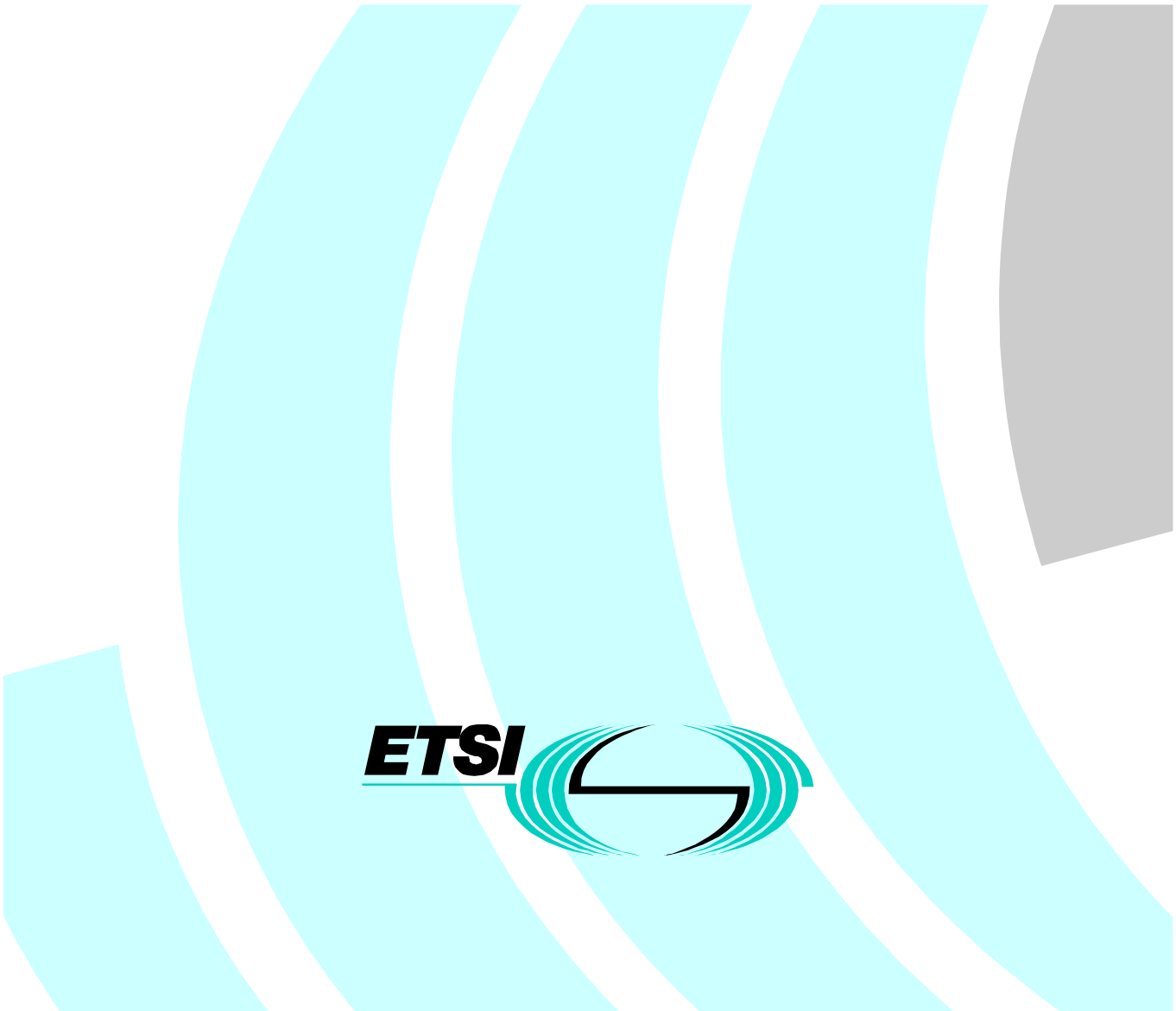
Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Classification of the electromagnetic environment conditions for equipment in telecommunication networks



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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document should be used by the standardization committees to define the ElectroMagnetic Compatibility (EMC) requirements for the telecommunication equipment, depending by the locations where these are intended to be installed.

1 Scope

The present document provides information on the electromagnetic environmental conditions encountered where telecommunications equipment is installed and is a compilation of data concerning electromagnetic environmental conditions.

In the present document only locations for equipment that are in the telecommunication network are considered.

Only some of the data is based on comprehensive environmental surveys. Such surveys are rarely reported in available literature. Consequently, estimated values are often used when the electromagnetic environmental conditions are stated. In order to characterize the electromagnetic environment, it is necessary to make certain assumptions on the installation practice. If these assumptions are not satisfied in a particular case, the environmental characteristic may not apply.

Each environment is characterized in two ways:

- by a short verbal description of its assumed attributes;
- by a quantitative statement of the characteristic severities of the crucial environmental phenomena.

It is only possible to specify the appropriate EMC requirements following the assessment of the severity of the electromagnetic environment. This in turn will be helpful in ensuring that the telecommunications network equipment has the sufficient intrinsic immunity to enable it to operate as intended in its environment.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ETS 300 132-1 (1996): "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources".

[2] ETS 300 132-2 (1996): "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)".

[3] IEC 60364-3 (1993): "Electrical installations of buildings, Part 3: Assessment of general characteristics".

[4] ETS 300 253 (1995): "Equipment Engineering (EE); Earthing and bonding of telecommunication equipment in telecommunication centres".

[5] ITU-T Recommendation K.27 (1996): "Bonding configurations and earthing inside a telecommunication building".

[6] IEC/TR2 1000-2-5 (1995): "Electromagnetic Compatibility (EMC) Part 2: Environment-Section 5: Classification of electromagnetic environments. Basic EMC publication".

[7] IEC Publication No. 60050 (161): "International Electrotechnical Vocabulary; Chapter 161: Electromagnetic compatibility".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

The definitions taken from the IEC Publication No. 60050 (161) [7] have reference in parentheses:

Audio (low) Frequency (AF): frequency interval from 0 Hz to 20 kHz. It may sometimes be convenient to extend the use of this term to include the range of frequencies up to 150 kHz.

continuous disturbance (161-02-11): electromagnetic disturbance the effects of which on a particular device or equipment cannot be resolved into a succession of distinct effects.

duration (of a voltage change) (161-08-03): interval of time for the voltage to increase or decrease from the initial value to the final value.

duration (of a pulse): interval of time between the instants at which the instantaneous value of a pulse reaches 50 % of the pulse magnitude for the first and last time.

environment, environmental conditions: electromagnetic conditions external to the equipment, to which it is subjected at a certain time. The environmental conditions comprise a combination of single environmental parameters and their severities.

environmental class: representation of the environment on locations with similar properties. They are specified and standardized to provide an operational frame of reference for:

- requirements on the environment;
- immunity requirements.

The class is described using an envelope of environmental conditions expressed in terms of a number of environmental parameters and their characteristic severities or other characteristics. The environmental parameters specified for the class are limited to those which may affect equipment performance.

environmental parameters: present one or more properties of the electromagnetic environment.

interface "A": terminals at which a power supply is connected to the telecommunications equipment.

power supply: power source (within the scope of the present document) to which telecommunications equipment is intended to be connected.

pulse (161-02-02): abrupt variation of short duration of a physical quantity followed by a rapid return to the initial value.

Radio Frequencies (RF): frequency range above 150 kHz.

rise time (of a pulse) (161-02-05): interval of time between the instants at which the instantaneous value of a pulse first reaches a specified lower value and then a specified upper value.

NOTE: Unless otherwise specified, the lower and upper values are fixed at 10 % and 90 % of the pulse magnitude.

shielding effectiveness: for a given external source, the ratio of electric or magnetic field strength at a point before and after the placement of the shield in question.

surge (voltage) (161-08-11): transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage.

telecommunication network: network operated under a licence granted by a national telecommunications authority which provides telecommunications between network termination points (NTPs) (i.e. excluding terminal equipment beyond the NTPs).

transient (adjective or noun) (161-02-01): pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval which is short compared with the timescale of interest.

3.2 Abbreviations

For the purposes of the present document the following abbreviations apply:

AC	Alternating Current
DC	Direct Current
EMC	Electro-Magnetic Compatibility
ESD	Electrostatic Discharge
ISDN	Integrated Services Digital Network
RF	Radio Frequency
rms	root-mean-square

4 Application area

The present document applies to telecommunication equipment installed and controlled by the network operator which is installed in telecommunications centres, outdoor locations and customer's premises. It does not make references to equipment dependent details.

5 Characteristics of environments

5.1 Telecommunication centres

The internal electrical power distribution is a 48 V DC nominal (alternatively 60 V DC) (according to ETS 300 132-2 [2]) and a 230 V/400 V AC nominal 50 Hz (according to ETS 300 132-1 [1]). It is assumed that switching of loads on the DC supply seldom occurs, and therefore, has not been taken into account.

Battery back-up is available at 48 V DC (alternatively 60 V DC).

NOTE 1: Local emergency generators are not assumed.

Primary protection on incoming cables is not assumed.

NOTE 2: If primary protection is present, differential mode transients could occur.

Internal AC power cables are kept separate at some distance to DC power cables and signal cables in order to reduce mutual coupling. No separation is assumed between DC power cables and signal cables. Normal practice is to use grounded, metallic cable supports.

Cables from telecommunication centres to customers' premises are assumed to be unshielded.

Some Electrostatic Discharge (ESD) preventive measures are either incorporated in the building installation (e.g. charge dissipating floors) or through guidelines for handling and operation of the equipment (e.g. use of wrist-straps, charge dissipating shoes). Some distance to high power broadcast transmitters is assumed. In cases where radio communication transmitters are present on the premises, it is assumed that special precautions are taken in order to prevent exposure to the emitted field.

Restriction on the use of mobile radio equipment is assumed in telecommunication centres.

NOTE 3: The telecommunication operator cannot control the external radio frequency environment.

It is assumed that the building has no external lightning protection system.

NOTE 4: The effects of direct lightning strike to the building are not considered here.

5.1.1 Class 1 - major telecommunication centres

This environmental class applies to major telecommunication centres in dedicated locations controlled by the network operator. These would typically be located in urban areas.

The telecommunication centre has its own electricity power transformed from the public distribution network.

The AC power distribution inside the building is of the type TN-S, or IT (defined in IEC Standard 60364-3 [3]).

External signal lines may be of any type, size or length normally entering via underground routes. There exists a risk of coupling to high voltage electricity lines or electric traction lines. A dedicated earthing and bonding network is implemented according to ETS 300 253 [4] (or ITU-T Recommendation K.27 [5]).

The shielding effectiveness from the building structure may give a frequency dependent attenuation of about 10 dB provided that the structural reinforcement elements of the building are adequately bonded together to form an integral mesh.

5.1.2 Class 2 - minor telecommunication centres

This environmental class applies to telecommunication centres in dedicated locations controlled by the network operator. These would typically be located in rural areas serving the local community, and may often be unmanned.

The telecommunication centre may draw its electrical power from the public supply network either via a dedicated transformer or from a transformer shared with the local community.

The AC power distribution inside the building may be of the type TN-S, TN-C, TT or IT (defined in IEC Standard 60364-3 [3]).

External signal lines may be overhead cables of considerable length. There is a high risk of coupling to high voltage electricity lines or electric traction lines.

A dedicated earthing and bonding network is implemented according to ETS 300 253 [4] (or ITU-T Recommendation K.27 [5]).

No shielding effectiveness from the building structure can be assumed.

5.2 Class 3 - outdoor locations

This environmental class applies to an unattended telecommunications site such as street furniture, telephone boxes, repeaters and amplifiers on trunk cables, or to concentrators and cable distribution boxes.

This environmental class may apply to equipment buried below ground level.

Repeaters on submarine cables are not covered by this class.

DC power may also be supplied from the telecommunication centre 48 V DC, (alternatively 60 V DC) or higher voltages. Voltages up to 120 V DC can be expected for ISDN basic rate remote supply systems. Only the 48 V DC (alternatively 60 V DC) systems are included at present.

Remote supplies of digital transmission systems using ± 110 V DC, of carrier frequency systems using 270 V DC or even ± 600 V DC are considered as being intrinsic to the systems and are not considered as being environmental parameters.

External signal lines may be of any type, size or length. There is a high risk of coupling to high voltage electricity lines and to electric traction lines.

Remote repeaters in rural areas are equipped with overvoltage protection devices. A local ground electrode might not be present in all cases. Other outdoor locations may not be protected.

The class does not apply to installations in areas of high keraunic levels. An external lightning protection system cannot be assumed.

NOTE: The effects of direct lightning strike to the building are not considered here.

The outdoor locations are considered as being low risk areas in terms of electrostatic charges.

The distance to electricity distribution transformers may be small and the mains frequency related magnetic field exposure may be high.

Some distance to high power broadcasting transmitters and amateur radio transmitters are assumed. However, mobile and portable radio transmitters may come very close.

The installation is enclosed in some housing or cabinet for weather protection purposes. The enclosure may be used to shield against electromagnetic fields.

5.3 Class 4 - customers' premises

This environmental class (location) encompasses the locations "type 1", "type 2", "type 3" and "type 4" as defined in the document IEC 1000-2-5 [6].

As a first approach to a quantitative characteristic an attempt has been made to fit the "disturbance levels" specified by IEC 1000-2-5 [6] into tables 2 to 7. There rarely exists a one-to-one correspondence between the environmental parameters given in the present document and the "phenomena" introduced by IEC. Disturbances neglected by the IEC have been included and vice versa, and even in cases where a certain phenomenon has been included in both places, differences remain in the attributes chosen to characterize the disturbance.

In tables 2 to 7, values given in brackets means that they are not specified by the IEC.

It is emphasized that all four types of customers' premises are covered by the specification.

6 Attributes of customers' premises

Table 1

Media	Attributes
Radiated:	- no amateur radio closer than 20 m; - no broadcast transmitter closer than 1 km; - paging and portable communication systems; - high concentration of ITE; - possible presence of diathermy therapy equipment; - possible proximity of local substation; - possible presence of audio/hearing aid systems.
AC power:	- relatively high network impedance; - cables or overhead lines; - high harmonic levels (ITE, lighting, ASD); - roof-top mounted equipment (lightning exposure); - significant lightning exposure.
DC power:	- not applicable.
Signal/control:	- overhead telecom cables or lines; - cables or short overhead spans; - close coupling between signal systems and switched power systems; - significant lightning exposure; - control lines are usually short, less than 10 m.
Reference:	- abundant metallic structures which may or may not be bonded, earthed or grounded; - frequent interfaces of power and telecom (including local) systems; - local ground can be absent or present high impedance; - multiple local grounds might not be co-ordinated.
Additional notes:	- interfaces with customer systems; - HV lines might be routed over buildings.

7 Notation to tables 2 to 7

In tables 2 to 7, the following notation has been used:

Correlated parameters: correlated parameter values are arranged vertically and separated by ";" e.g.

A; B; C; ...
a; b; c; ...

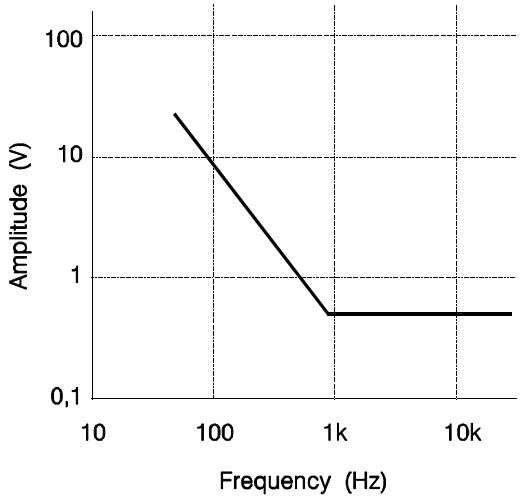
Functional relations: functional relations are always piecemeal linear and defined by their break-points. A discontinuity where a parameter changes from a to b is written "a/b" e.g.

f1 - f2 - f3
a1 - a2 - a3

or f1 - f2 - f3
a1 - a2/b1 - b2

Such relations state the frequency dependence of a parameter, and in that case, the linear interpolation between break-points is made using logarithmic scales on both axes.

Figure 1 shows an example of frequency dependence.



Audio frequency voltage Common mode	Frequency (kHz) Amplitude (V)	0,05 - 1 - 20 20 - 0,5 - 0,5

Figure 1

Universal values: if a single parameter value applies over the whole range, only a single number is stated.

Intervals: where a detail parameter Q may assume any value in an interval, and where it is impossible to state which value constitutes the most severe condition, the parameter is specified by the interval: q1 to q2.

8 Characteristic severities of environmental parameters

In tables 2 to 7, the characteristic severities and other characteristics of the relevant environmental parameters are stated for the environmental class for telecommunication network equipment.

It is often not feasible to model the disturbances/parameters in every detail. For instance the temporal evolution of transients is much too complex to be described realistically. In such cases, simplified models are used which select the characteristic details as appropriate to the standardized test pulses. This approach presumes that the test pulses do emphasize the crucial features.

In case of continuous disturbances, the postulated frequency dependence and modulation mode are gross simplifications of reality. A frequency analysis will show that the disturbances are confined within narrow frequency bands separated by "silent" intervals. This complicated (and time dependent) pattern is replaced by a smooth frequency variation using few levels of amplitude.

The environmental parameters are arranged in tables according to the coupling path. Six coupling-paths are included:

1) **signal lines entering the building**, which includes all telecommunications lines of the extended networks where metallic conductors are used;

2) **signal lines remaining within the building**, which includes all signal lines in the local installation using metallic conductors. They are of relatively short lengths, and are confined to the local premises;

3) **AC power mains** is the low voltage distribution network (230 V/400 V, 50 Hz);

4) **DC power** distribution is the local power distribution system at 48 V (alternatively 60 V). DC supplies integrated in the equipment are not included;

5) **radiation** covers coupling to the internal wiring of the equipment via electromagnetic fields. Radiation picked up by the connected wires or cables is included in the conducted coupling-paths stated above;

6) **discharge of static electricity (ESD)** may take place directly to the equipment or to other metallic objects in its vicinity. ESD is taken into account as a separate parameter.

Table 2: Conducted disturbances on signal lines entering the building

Environmental parameter		Class 1	Class 2	Class 3	Class 4
DC Voltage Common mode (note 1)	Amplitude V Impedance MΩ		500 > 1		(500) (> 1)
16 2/3 Hz voltage common mode (note 2)	Amplitude V rms Impedance Ω	20 100	50 100		(50) (100)
50 Hz voltage differential mode	Amplitude V rms Impedance Ω Duration min		240 10 to 600 about 10		(240) (10 to 600) (about 10)
50 Hz voltage common mode	Amplitude V rms Impedance Ω Duration s	(note 3)	300 100 0,5		(300) (100) (0,5)
Audio frequency voltage common mode	Frequency kHz Amplitude V rms	0,05 - 1 - 20 20 - 0,5 - 0,5	0,05 - 1 - 20 30 - 0,75 - 0,75		
	Impedance Ω	100	100		300
Radio frequency voltage common mode, amplitude modulated (note 4)	Frequency MHz Amplitude V rms	0,15 to 100 1	0,15 to 100 3		0,01 to 0,15 1
	Frequency MHz Amplitude V rms				0,1 to 30 10
	Frequency MHz Amplitude V rms				30 to 150 3
Electrical fast transients	Amplitude V peak	250		500	1 000 (note 5)
Common mode (high frequency, low energy)	Rate of occurrence events/week	Several		Several	Several
	Rise time ns	1 to 100		1 to 100	5
	Impedance Ω	40 to 80		40 to 80	50
Surge common mode	Amplitude V peak Rise time µs	300; 1 000 1 to 1 000	300; 1 000; 3 000 1 to 1 000	300; 1 000; 3 000 1 to 1 000	500; 1 000 10; 1
(Low frequency, high energy)	Duration µs	< 3 000	< 3 000	< 3 000	1 000; 50
	Rate of occurrence events/year	6; 0,5	6; 0,5; 0,2	30; 3; 1	Multiple
	Impedance Ω	20 to 40	20 to 40	20 to 40	20 to 300; 1 to 10

NOTE 1: 1MΩ source impedance included in order to take into account e.g. cable fault location equipment. DC power plants for traction systems causing DC potential differences on the telecommunication lines are not take into account. The induced voltages from geomagnetic activity are also not included.
NOTE 2: Only applicable in Austria, Germany, Norway, Sweden and Switzerland.
NOTE 3: For Major Telecommunications Centres (Class 1), 50 Hz Common Mode Voltage due to earth faults in nearby high voltage electricity systems is not taken into account. The probability of this phenomena occurring is extremely low.
NOTE 4: As the primary coupling occurs in the last few metres of the signal line, it takes advantage of the shielding effects in the building (e.g. metallic framework) of the Major Telecommunications Centre (Class 1). Hence, 1V can be assumed. For environmental classes 1, 2 and 3, disturbance in the frequency range 20 kHz to 150 kHz is unlikely.
NOTE 5: Only specified for "type 3 Locations" of IEC1000-2-5 [6].

Table 3: Conducted disturbances on signal lines remaining within the building

Environmental parameter		Class 1	Class 2	Class 3	Class 4
Audio Frequency Voltage Common mode	Frequency kHz	0,05 - 1 - 20		Not Applicable	0,05 - 1 - 20
	Amplitude V rms	5 - 0,2 - 0,2			10 - 0,5 - 0,5
	Impedance Ω	100			300
Radio frequency Voltage Common mode, Amplitude modulated (note 1)	Frequency MHz Amplitude V rms	0,15 to 100 1	0,15 to 100 < 3 (note 2)	Not Applicable	0,01 to 0,15 1
	Frequency MHz Amplitude V rms				0,1 to 30 10
	Frequency MHz Amplitude V rms				30 to 150 3
Electrical fast transients Common mode (high Frequency, Low energy)	Amplitude V peak	250		Not Applicable	1 000 (note 3)
	Rate of occurrence events/week	Several			Several
	Rise time ns	1 to 100			5
	Impedance Ω				50

NOTE 1: For environmental classes 1, 2 and 3, disturbance in the frequency range 20 kHz to 150 kHz is unlikely.
NOTE 2: Value depending on length of cable.
NOTE 3: Only specified for "type 3 locations" of IEC 1000-2-5 [6].

Table 4: Conducted disturbances on AC power units

Environmental parameter		Class 1	Class 2	Class 3	Class 4
Voltage variation	Voltage change %	± 10	+10/-15	+10/-15	± 8
Voltage fluctuation	Voltage change %	-50 to -20; +20			10 to 99
	Duration ms	10 to 1500			< 3 000
	Rate of occurrence events/day	100 to 0,01			unspecified
Voltage interruption	Duration ms	10; 20; 40; 100 to 700			< 6 000
	Rate of occurrence events/day	10; 1; 0,1; 0,05			unspecified
Radio frequency Voltage Common mode, Amplitude modulated (note 1)	Frequency MHz Amplitude V rms	0,15 to 100 1 (note 2)	0,15 to 100 3		0,01 to 0,15 1
	Frequency MHz Amplitude V rms				0,1 to 30 10
	Frequency MHz Amplitude V rms				30 to 150 3
Electrical fast transients Common mode and differential mode (High frequency, Low energy)	Amplitude V peak	1 000			(1 000)
	Rate of occurrence events/day	1			(1)
	Rise time ns	1 to 100			(1 to 100)
Surge line/neutral (Low frequency, High energy)	Amplitude kV peak	2	2; 4	2; 4	(2; 4)
	Rise time µs	0,5 to 10	0,5 to 10	0,5 to 10	(0,5 to 10)
	Duration µs	< 100	< 100; < 100	< 100	(< 100)
	Rate of occurrence events/year	20	100; 3	100; 3	(100; 3)
Surge line/ground (Low frequency, High energy)	Amplitude kV peak	(note 3)	2; 4	2; 4	(1; 4)
	Rise time µs		0,5 to 10	0,5 to 10	10; 1
	Duration µs		< 100; < 100	< 100	1 000; 50
	Rate of occurrence events/year		100; 3	100; 3	Multiple
	Impedance Ω	10 - 20			20 to 300; 1 to 10

NOTE 1: For environmental classes 1, 2 and 3, disturbance in the frequency range 20 kHz to 150 kHz is unlikely.
NOTE 2: It takes advantage of the shielding effects in the building (e.g. metallic framework) of the major telecommunications centre (class 1). Hence, 1 V can be assumed.
NOTE 3: Not applicable because major telecommunications centres (class 1) have their own electricity power transformers.

Table 5: Conducted disturbances on the DC power distribution (48 V nominal assumed)

Environmental parameter		Class 1	Class 2	Class 3	Class 4
Voltage variation	Voltage V	40,5/57			(40,5/57)
Voltage fluctuation and interruption	Voltage V	0 to 40,5; 57 to 60			(0 to 40,5;57 to 60)
	Duration ms	< 50			(< 50)
	Rate of occurrence events/year	3			(3)
Audio frequency Voltage Differential mode	Frequency kHz Amplitude mV rms	0,025 - 0,3 - 1 - 20 - 150 50 - 50 - 7 - 7/50 - 50			(0,025-0,3-1-20-150) (50-50-7-7/50-50)
Radio frequency Voltage Common mode, Amplitude modulated	Frequency MHz Amplitude V rms	0,15 to 100 1	0,15 to 100 < 3 (note 1)	0,15 to 100 1	(0,15 to 100) < 3 (note 1)
Electrical fast transients	Amplitude V peak	250			(250)
Common mode (High frequency, Low energy)	Rate of occurrence events/week	Several			(Several)
	Rise time ns	1 to 100			(1 to 100)
Surge	Amplitude V	200		Not applicable	(200)
Common mode and	Rise time µs	5			(5)
Differential mode	Duration µs	50			(50)
(note 2)	Rate of occurrence events/year	3			(3)

NOTE 1: Value depending on length of cable.
NOTE 2: From fuse blowing.
NOTE 3: Class 3 does not apply to remote 48 V DC supplies via the signal lines.
NOTE 4: Not considered by the IEC.

Table 6: Radiated disturbances

Environmental parameter		Class 1	Class 2	Class 3 (note 3)	Class 4 (note 4)
Audio frequency Magnetic Field	Frequency Hz Amplitude A/m rms	50 to 20 000 10 to 0,025	50 to 20 000 3 to 0,008	50 to 20 000 10 to 0,025	16;50 to 20 000 1; 0,015
	Frequency Hz Amplitude A/m rms				50; 100 to 3 000 10; 1,8 to 0,6
Radio frequency Electromagnetic field	Frequency MHz Amplitude V/m rms	0,15 to 1 000 1	0,15 to 1 000 3	0,15 to 1 000 10	0,09 to 1 000 3 (note 2)
Amplitude modulated (note 1)	Frequency MHz Amplitude V/m rms				27 10
Radio frequency Electromagnetic field Pulse modulated (note 1)	Frequency GHz Amplitude V/m peak	1 to 20 1	1 to 20 3	1 to 20 10	1 to 40 unspecified
Pulse Electromagnetic field	Frequency MHz Amplitude mV/m/kHz	0,01 to 300 100 to 1		Not applicable	
	Frequency MHz Amplitude dB ref kTB				0,01 to 1 117
	Frequency MHz Amplitude dB ref kTB Frequency MHz Amplitude dB ref kTB Frequency MHz Amplitude dB ref kTB				1 to 10 77 10 to 100 57 100 to 1 000 37
Lightning Electromagnetic pulse	Amplitude A/m Rise time µs	Not applicable	500 0,2	Not applicable	Specified by the slew rate 100 V/m/ns
	Duration µs		100		
	Rate of occurrence events/year		0,1		

NOTE 1: In cases where mobile communications are permitted, field strengths in the range from 3 to 10 V/m may be experienced at communication frequencies.
NOTE 2: In the vicinity of amateur radio transmitters the field strength may reach 10 V/m at the transmitter frequencies.

Table 7: Electrostatic charge

Environmental Parameter		Class 1	Class 2	Class 3	Class 4
Electrostatic Voltage	Amplitude kV peak	4		2	Specified by the slew rate (40 A/ns, 8 A/m/ns, or 1 000 V/m/ns)

History

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