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*European Standard (Telecommunications series)*

**Environmental Engineering (EE);  
Power supply interface at the input to  
telecommunications equipment;  
Part 2: Operated by direct current (dc)**

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**Reference**

REN/EE-02008[4]

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## Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Environmental Engineering (EE).

The present document concerns the requirements for the interface between telecommunications equipment and its power supply, and includes requirements relating to its stability and measurement. Various other references and detailed measurement and test arrangements are contained in informative annexes.

The present document is part 2 of a multi-part deliverable covering Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment, as identified below:

Part 1: "Operated by alternating current (ac) derived from direct current (dc) sources";

**Part 2: "Operated by direct current (dc)";**

Part 3: "Operated by rectified current source, alternating current source or direct current source up to 400 V".

<b>National transposition dates</b>	
Date of latest announcement of this EN (doa):	31 January 2008
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 July 2008
Date of withdrawal of any conflicting National Standard (dow):	31 July 2008

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# 1 Scope

The present document contains requirements for:

- the output performance of the direct current (DC) power equipment at the interface "A";
- the input of the telecommunications equipment connected to interface "A" powered by DC.

The DC voltage at interface "A" may be derived from the AC primary supply. The DC supply may incorporate a backup battery.

If any other equipment e.g. datacom equipment, are connected to interface "A" in parallel to telecommunications equipment, all requirements addressed in clause 4 of the present document must be fulfilled.

The present document aims at providing compatibility between the power supply equipment and the power consuming telecommunications equipment, and also between different system blocks connected to the same power supply.

NOTE 1: The present document is applicable only to  $-48 V_{DC}$  power supply interfaces. However, during a transitional period, other DC voltages may be used in existing installations. Annex A gives guidance on working in conjunction with existing  $-60 V_{DC}$  supply systems.

The power supply interface, interface "A", is a physical point to which all the requirements are related (see figure 1).

This point is situated between the power supply system(s) and the power consuming telecommunications equipment.

NOTE 2: Interface "A" is located at the power terminals of the telecommunications equipment. Subject to the installation preconditions this point may be located at any other point between the power supply system and the telecommunications equipment by mutual agreement of the relevant parties.

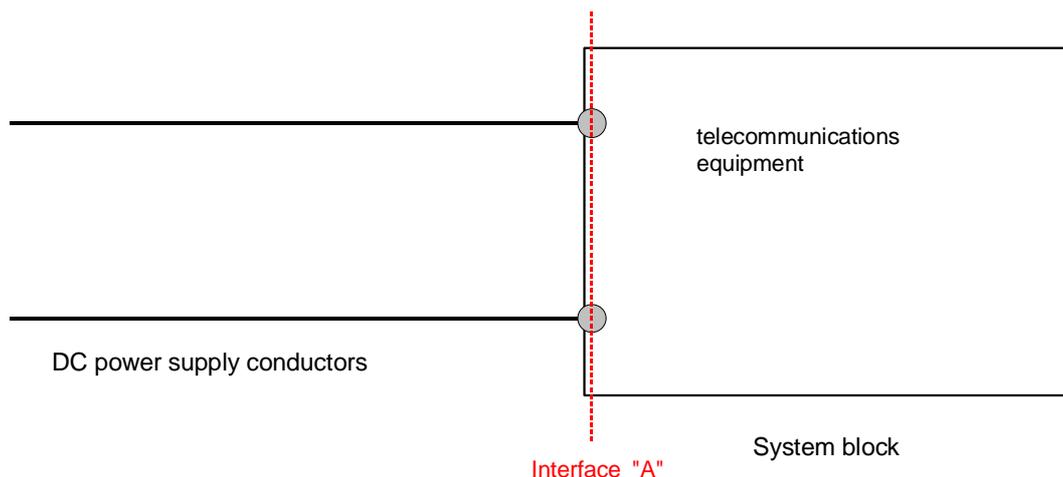
The requirements at interface "A" apply to:

- the output of the power supply equipment or power supply installation of telecommunications centres;
- the power supply input of telecommunications equipment installed at telecommunication centres;
- telecommunications equipment, installed in customers' premises, whose DC interface "A" is also used by equipment requiring a supply to this specification.

NOTE 3: Normally there is more than one load unit connected to interface "A". In these cases, interface "A" will undergo further restrictions with respect to noise limits or other disturbances specified in clause 4.8.

NOTE 4: Disturbances on the power supply interface "A" relating to the continuous wave phenomena below 20 kHz are covered within the present document.

NOTE 5: An example of a configuration in which interface "A" is identified is given in annex D.



**Figure 1: Identification of interface "A"**

The purpose of the present document is:

- to use a power supply system with the same characteristics for all telecommunications equipment defined in the area of application;
- to facilitate inter working of different (types of) load units;
- to facilitate the standardization of telecommunications equipment;
- to facilitate the installation, operation and maintenance in the same network of equipment and telecommunications systems from different origins.

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## 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 and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

- [1] IEC 60269-1: "Low-voltage fuses - Part 1: General requirements".
- [2] CENELEC EN 60934: "Circuit-breakers for equipment (CBE)".
- [3] ETSI EN 300 253: "Environmental Engineering (EE); Earthing and bonding of telecommunication equipment in telecommunication centres".
- [4] ITU-T Recommendation Q.551: "Transmission characteristics of digital exchanges".
- [5] ITU-T Recommendation Q.552: "Transmission characteristics at 2-wire analogue interfaces of digital exchanges".

- [6] ITU-T Recommendation Q.553: "Transmission characteristics at 4-wire analogue interfaces of digital exchanges".
- [7] ITU-T Recommendation Q.554: "Transmission characteristics at digital interfaces of digital exchanges".
- [8] ITU-T Recommendation O.41: "Psophometer for use on telephone-type circuits".
- [9] CENELEC EN 61000-4-5: "Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test".

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## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

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

**abnormal voltage range:** range of steady-state voltage over which the equipment will not be expected to maintain normal service but will survive undamaged

**customer premises:** any location which is the sole responsibility of the customer

**fully equipped equipment:** generally there are several maximum configurations because different boards can be used in the same slots

NOTE: The fully-equipped equipment configuration shall be the configuration that corresponds to the maximum power consumption measured at  $-48 V_{DC}$  e.g. not in standby mode.

**interface "A":** terminals at which the power supply is connected to the system block

NOTE 1: See also figure 1.

NOTE 2: This is a functional definition and not an exact depiction of the physical location.

**load unit:** power-consuming equipment, that is part of a system block

**maximum continuous input current:** maximum continuous input current, stated by the manufacturer, for a fully-equipped equipment under test connected to interface "A", at nominal voltage (accordance clauses 4.6 and 4.7.1 of the present document)

**nominal voltage:** nominal value of the voltage that designates the type of supply

**normal service:** service mode where telecommunications equipment operates within its specification

**normal service voltage range:** range of steady-state voltages over which the equipment will maintain normal service

**power supply:** power source to which telecommunications equipment is intended to be connected

**system block:** functional group of equipment depending for its operation and performance on its connection to the same power supply

NOTE: A system block may consist of equipment or a functional group of equipment. Different examples of configurations at interface "A" are given in annex D.

**telecommunication centre:** location where telecommunications equipment is installed and which is the sole responsibility of the operator

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

$I_t$	instantaneous surge current (see clause 4.7.1)
$I_m$	maximum continuous input current
$L$	inductance of inductive element of LISN
$R$	resistance of resistive element of LISN
$t$	time
$Z_c$	capacitive impedance of immunity measurement circuit
$Z_m$	resistive impedance of immunity measurement circuit

## 3.3 Abbreviations

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

CDN	Coupling/Decoupling Network
DC	direct current

NOTE: Also when used as a suffix to units of measurement.

EMC	ElectroMagnetic Compatibility
EUT	Equipment Under Test
LISN	Line Impedance Stabilization Network
RF	Radio Frequency
rms	root mean square

NOTE: Also when used as a suffix to units of measurement.

# 4 Requirements

## 4.1 Nominal voltage

The nominal value of the voltage at interface "A" shall be  $-48 V_{DC}$  (positive conductor is connected to earth).

NOTE 1: In most cases the voltage of interface "A" will be complemented by a 24 cell lead-acid battery.

NOTE 2: During a transitional period, other DC voltages may be used in existing installations. Annex A gives guidance on merging equipment with existing  $-60 V_{DC}$  supply systems.

## 4.2 Normal service voltage range at interface "A"

The normal service voltage range for the  $-48 V_{DC}$  nominal supply at interface "A" shall be  $-40,5 V_{DC}$  to  $-57,0 V_{DC}$ .

NOTE 1: The minimum voltage is based on the voltage drop in the distribution network and a battery cell end of discharge voltage.

NOTE 2: The voltages specified are measured at interface "A". It should be noted that if interface "A" is at any point other than the telecommunications equipment interface there will be a voltage drop between interface "A" and the equipment terminals.

NOTE 3: When the voltage is in the range  $-40,5 V_{DC}$  to  $-44,0 V_{DC}$  it is recognized that there may be a slight degradation of service performance.

## 4.3 Abnormal service voltage range at interface "A"

### 4.3.1 Abnormal service voltage under steady-state conditions

Telecommunications equipment operated at  $-48\text{ V}_{\text{DC}}$  shall not suffer any damage when subjected to the following voltage ranges:

$0,0\text{ V}_{\text{DC}}$	to	$-40,5\text{ V}_{\text{DC}}$	and
$-57,0\text{ V}_{\text{DC}}$	to	$-60,0\text{ V}_{\text{DC}}$	

### 4.3.2 Recovery from steady state abnormal voltage

Following the restoration of the supply to the normal voltage range, the power conversion and management systems on the load side of interface "A" shall automatically restore service. The telecommunications equipment shall then resume operation according to its specifications. The abnormal service voltage shall not lead to the disconnection of the power supply e.g. by causing circuit breakers, fuses or other such devices to operate.

NOTE: It is acceptable that the system may restart when the voltage is  $-40,5\text{ V}$  or greater within the nominal service voltage range and/or after a time delay.

### 4.3.3 Voltage transients

Voltage transients may occur at interface "A" when faults occur in the power distribution system. These transients are characterized by a voltage drop in the range:  $0\text{ VDC}$  to  $40,5\text{ VDC}$ , followed by an overvoltage often in excess of the maximum steady state abnormal service voltage range and dependent upon the power distribution up to interface "A" and the equipment connected to interface "A".

The performance of telecommunication equipment against this abnormal overvoltage shall be verified using the combination wave generator defined in the basic standard EN 61000-4-5 [9]. This generator has the pulse shape of  $1,2\text{ }\mu\text{s}$ -rise time/ $50\text{ }\mu\text{s}$ -duration in open circuit and  $8\text{ }\mu\text{s}$ -rise time/ $20\text{ }\mu\text{s}$ -duration in short circuit. The voltage transient wave generator test circuit is shown in figure 2.

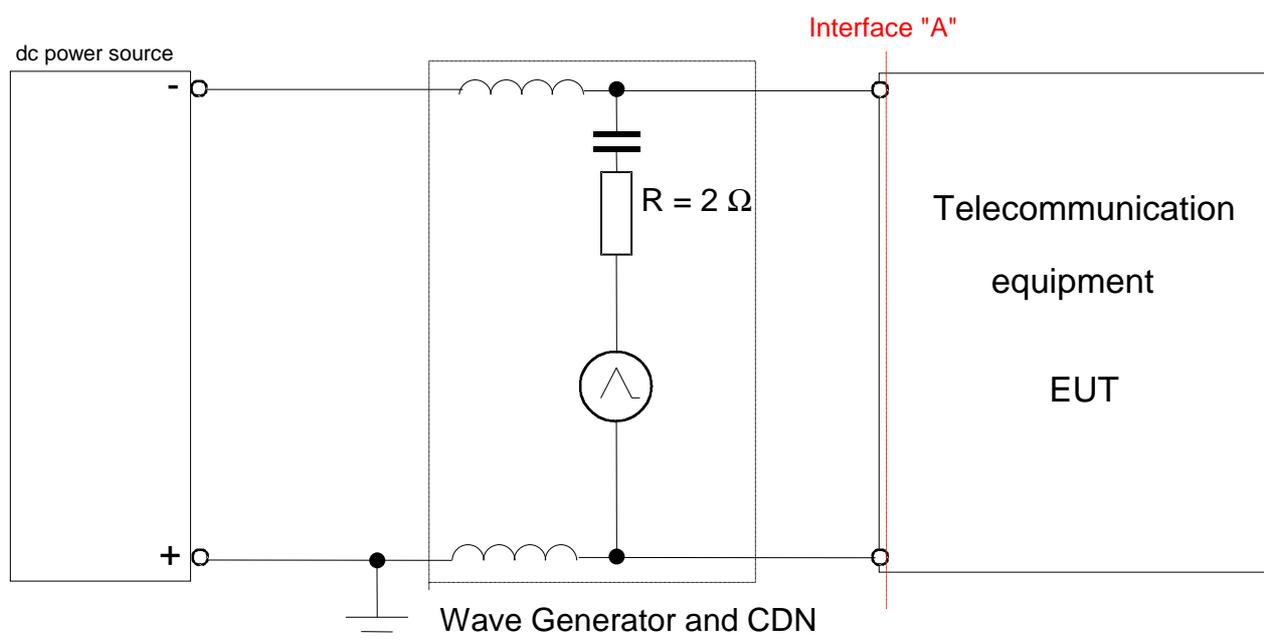


Figure 2: Voltage transient generator wave test circuit

The test has to be performed applying an overvoltage of 500V (positive polarity, reference of the generator shall be connected to the positive pole of battery) at the interface "A" of the telecommunication equipment with 2 Ohm impedance of the test generator. The test has to be performed in the following two battery configuration:

- positive of battery connected to ground;
- positive of battery **not** connected to ground.

Telecommunications equipment operated at a nominal voltage shall not be damaged when subjected to these transients.

Telecommunication equipment with battery input redundancies (e.g. battery "B1" and battery "B2") shall be tested applying the overvoltage at each battery input at a time.

NOTE: TR 100 283 (see bibliography) provides guidance for the protection of telecommunications equipment from the transients.

#### 4.3.4 Recovery from voltage transients

After the occurrence of a voltage transient, as described in clause 4.3.3, telecommunications equipment shall continue to function within its operational specification without requiring manual intervention. The abnormal service shall not lead to the disconnection of power supply units e.g. by causing circuit breakers, fuses and other such devices to operate.

NOTE 1: In sensitive equipment, momentary and temporary interruption of the service may occur as a result of such transients at interface "A". Lengthening of the interruption to service (equipment is not functioning as intended) due to the recovery of software shall be taken in account. More detailed information about the service interruption shall be provided by the manufacturer on the request of the operator.

NOTE 2: To prevent system malfunctioning additional arrangements concerning the power supply system may be necessary.

For example:

- Dual feeding system.
- High Ohmic distribution system.
- Independent power distribution.

### 4.4 Voltage changes due to the regulation of the power supply

Telecommunication equipment may be subjected to a voltage change at interface "A" as a result of regulation of the voltage by the power supply system e.g. end cell switching.

This test applies to the telecommunication equipment connected to interface "A". The test can also be applied separately to each subpart of the equipment connected to the same interface "A".

#### 4.4.1 Test conditions

Telecommunication equipment shall be subjected to a single maximum transition rate of the voltage at interface "A" with an amplitude of  $6\text{ V} \pm 10\%$  for both the fall and rise time of the voltage and a change rate within the range 3 V/ms to 7 V/ms.

It is assumed that the voltage at interface "A" remains within the normal service voltage range during the test.

#### 4.4.2 Performance criteria

During and after the occurrence of such a transition voltage, the telecommunication equipment shall fulfil the following performance criteria.

The tested part of the telecommunication equipment shall operate according to the specification and no loss of data or false alarm shall occur.

## 4.5 Supply protection at interface "A"

The supply at interface "A" shall be protected by circuit breakers, fuses or other such devices.

The energy content of the inrush current shall also be taken into account when specifying the power supply system up to interface "A".

## 4.6 Maximum current drain following abnormal service

The maximum current drain at any voltage in the normal and abnormal voltage range at interface "A" lasting for longer than 1 second shall not exceed 1,5 times the maximum continuous current drain at nominal working voltage of  $-48 V_{DC}$ .

NOTE 1: The current should not exceed this level at any time, also when the equipment is feed by a nearly empty battery, not only during restoration. This is mandatory to protect fuses.

NOTE 2: For shorter times see Inrush Current Graph (see figure 3).

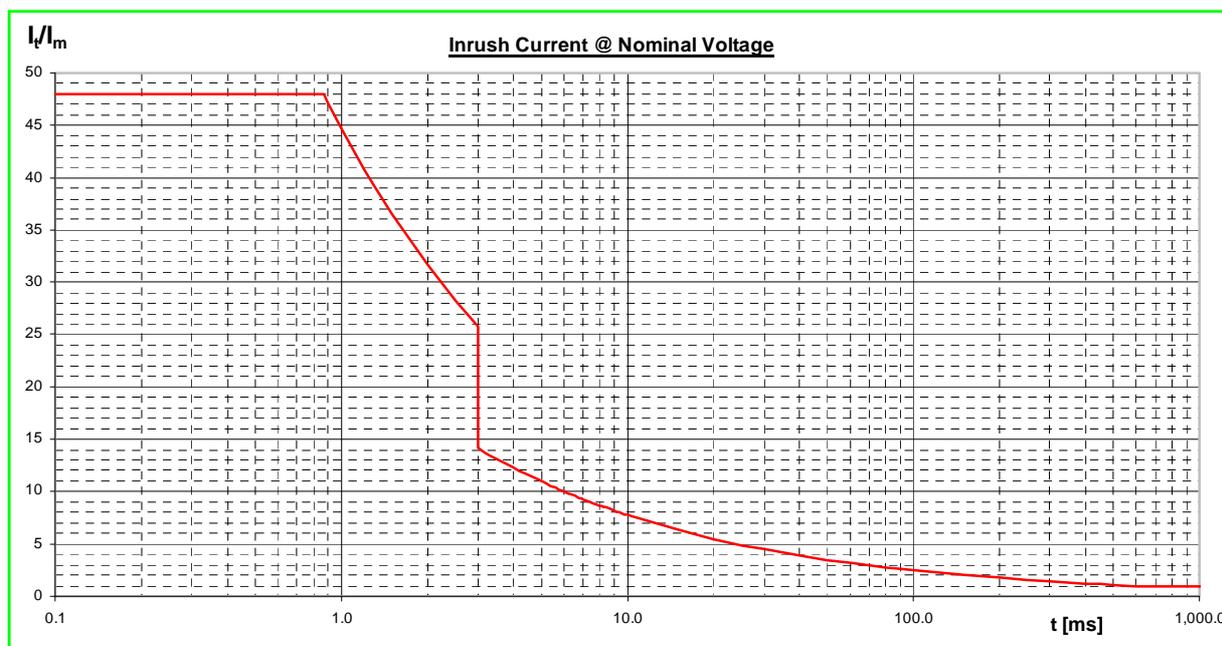
## 4.7 Inrush Current on connection of interface "A"

### 4.7.1 Limits

Refer to the test configuration of figure 4. The ratio of the instantaneous inrush current  $I_t$  to maximum continuous current  $I_m$  at interface "A", when the switch is closed at nominal voltage  $-48V_{DC}$ , shall not exceed the limits shown in figure 3.

The parameters are defined as follows:

- $I_t$  inrush current (magnitude of instantaneous value);
- $I_m$  maximum continuous input current for a fully-equipped equipment under test connected to interface "A", at nominal voltage.



**Figure 3: Maximum inrush current characteristics for telecommunications equipment at nominal voltage and maximum load**

NOTE 1: This graph is a combined graph for both fuses and (Hydraulic) Magnetic Circuit Breakers. Fuses according IEC 60269-1 [1] (gG type), Magnetic Circuit Breakers according EN 60934 [2].

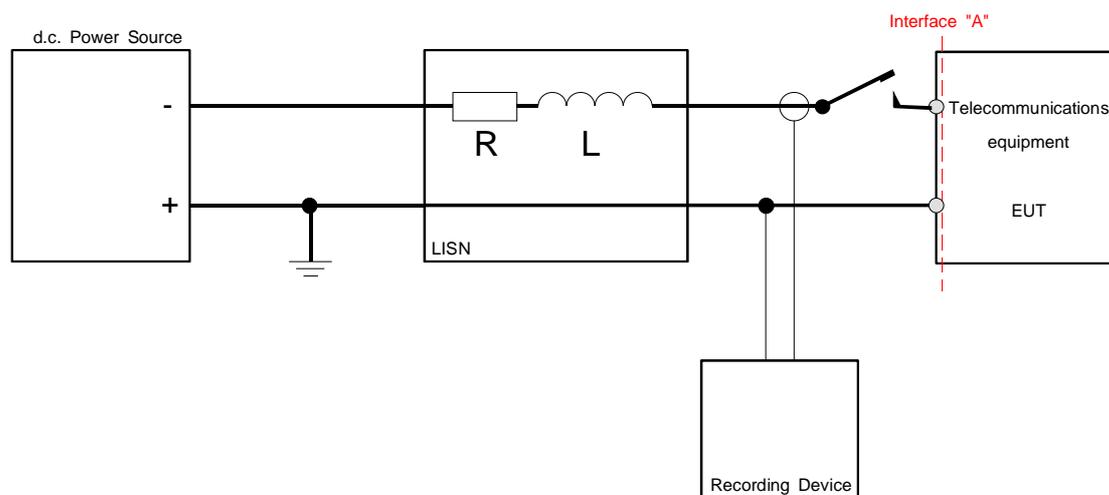
NOTE 2: See also annexes B and F.

## 4.7.2 Measurements

The circuit for measuring the surge current drawn by the equipment shall be as shown in figure 4. The test circuit is designed to operate with a single switch as shown.

NOTE: Small magnitude current pulses for charging RF filter capacitors should not be considered as the starting point of the inrush measurement. These pulses are not part of the inrush pulse but are before the inrush current pulse.

Annex B gives guidance on taking these measurements.



$$R \leq \frac{1V}{I_m(@48V)}$$

$$10\mu H \leq L \leq 20\mu H$$

NOTE 1: Resistance R includes the resistance of inductor L.

NOTE 2: The LISN could be the connecting cable (EUT to power supply), providing that the length has an inductance of 10  $\mu$ H to 20  $\mu$ H and an equivalent resistance.

NOTE 3: The intention of the LISN is to simulate a power network over which a voltage drop **not greater than 1 V** will appear in case of nominal current.

NOTE 4: While carrying out the surge current test, the voltage of the DC Power Source at the input of the LISN, as shown in figure 4, shall fall by no more than 2 V due to current limitation or internal impedance of the DC Power Source.

**Figure 4: Inrush current test circuit for DC interfaces**

## 4.8 Conducted immunity requirements of the telecommunications equipment at interface "A"

NOTE: Annex C gives an example of a test arrangement for the injection of noise at interface "A".

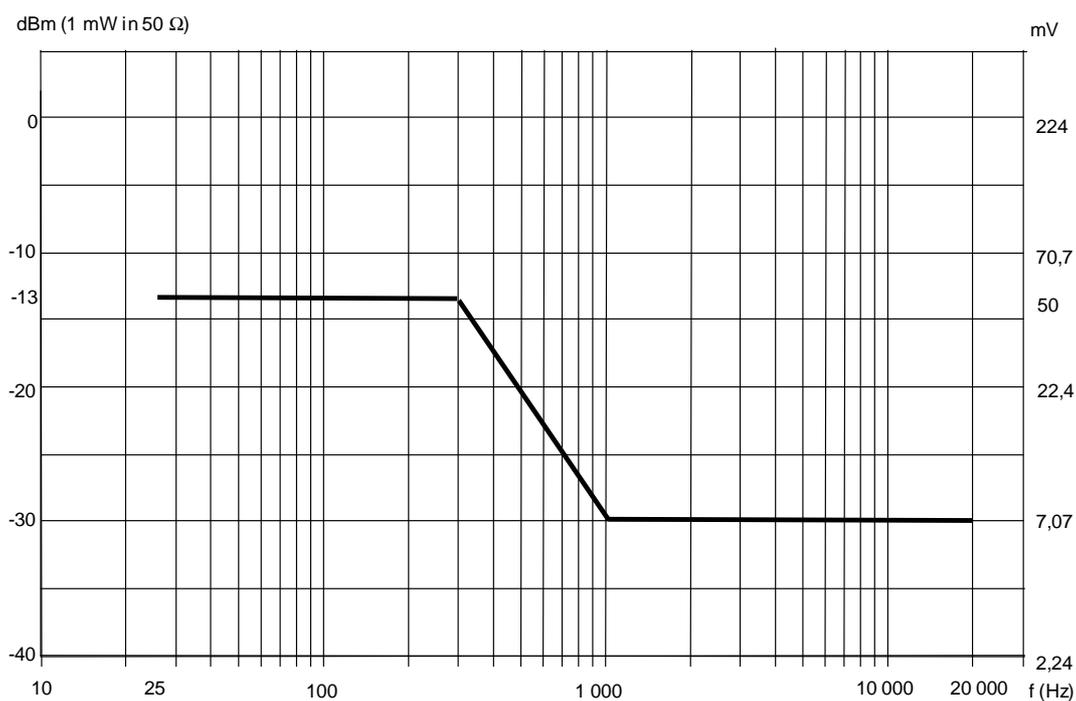
### 4.8.1 Immunity to narrowband noise

The telecommunications equipment shall meet its specification when the level of narrowband noise at interface "A" does not exceed the limits shown in figure 5.

The values shown refer to the maximum bandwidths as given in table 1.

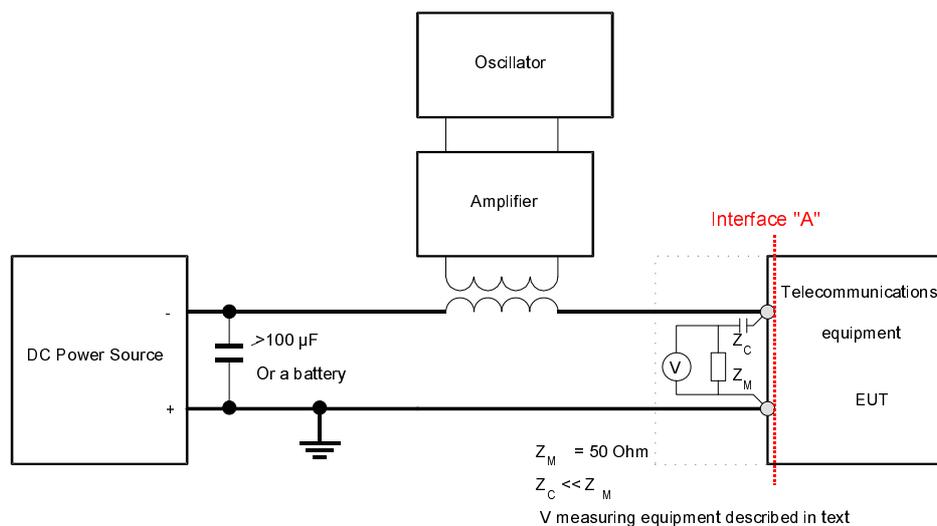
**Table 1**

Frequency range	Resolution bandwidth
25 Hz to 10 kHz	10 Hz
> 10 kHz to 20 kHz	200 Hz or 300 Hz



**Figure 5: Immunity level of narrow-band noise at interface "A"**

The recommended method of measurement is with a spectrum analyser having the bandwidths shown in table 1 for the relevant frequency ranges. The measuring circuit is shown in figure 6.



**Figure 6: Example of a typical test arrangement for immunity measurement at interface "A"**

When checking compliance to this requirement the rms value of the injected noise current shall be limited to 5 % of the actual DC current level. Compliance is achieved when the first of the following levels is reached:

- the maximum noise voltage value; or
- the maximum injected noise current level.

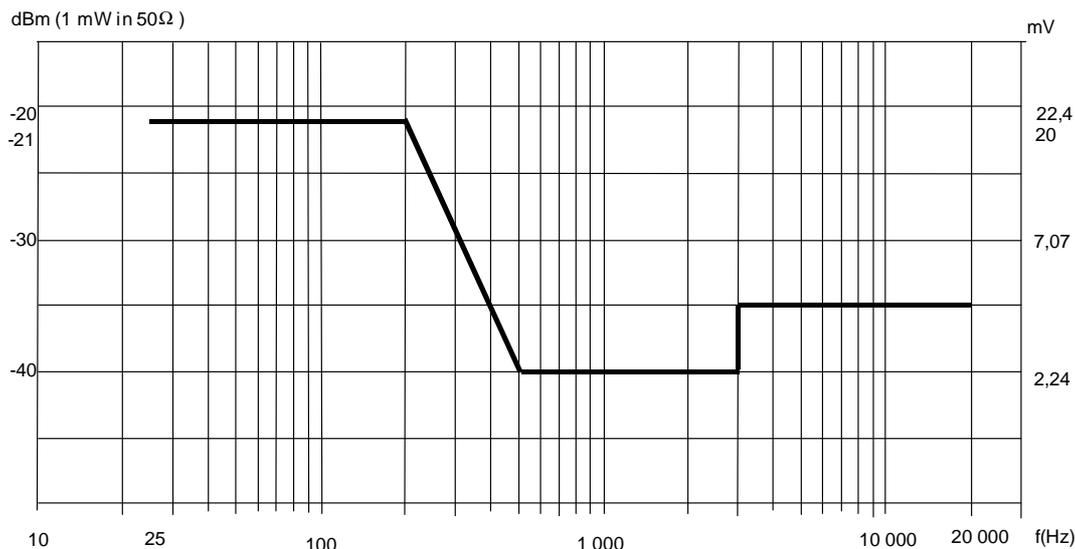
## 4.9 Conducted emissions requirements of the telecommunications equipment at interface "A"

The maximum level of noise re-injected to the power supply system at interface "A" from the telecommunications equipment is shown in figure 7.

The values shown refer to the bandwidths as given in table 2.

**Table 2**

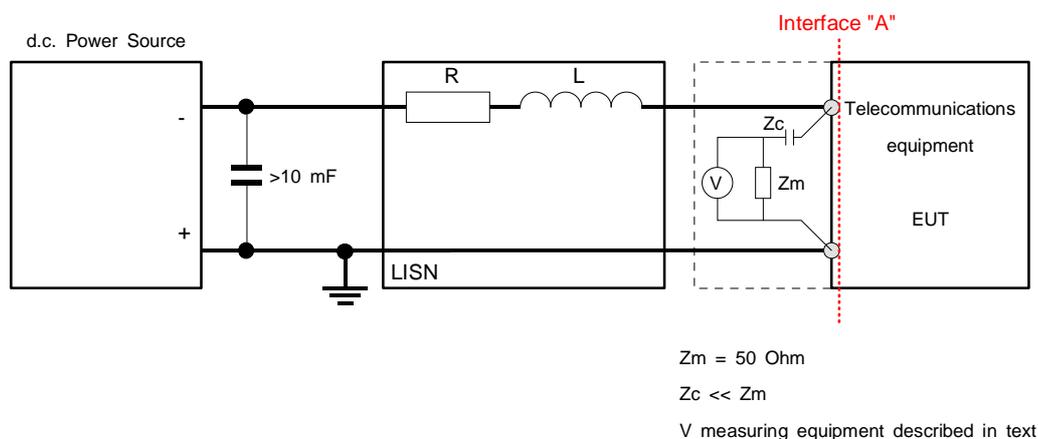
Frequency range	Resolution bandwidth
25 Hz to 10 kHz	10 Hz
> 10 kHz to 20 kHz	200 Hz or 300 Hz



**Figure 7: Maximum levels of narrowband noise**

The measurement shall be made with a spectrum analyser having the bandwidths shown in table 2 for the relevant frequency ranges.

The measurement circuit shall be as shown in figure 8. During the measurement the telecommunications equipment shall be powered at the nominal voltage and operated at rated load conditions.



$$R \leq \frac{1V}{I_m (@48V)}$$

$$10\mu H \leq L \leq 20\mu H$$

**Figure 8: Measuring circuit for re-injected narrow-band and wide-band noise**

NOTE 1: Resistance R includes the resistance of inductor L.

NOTE 2: The LISN could be the connecting cable (EUT to power supply), providing that the length has an inductance of 10  $\mu$ H to 20  $\mu$ H and an equivalent resistance.

NOTE 3: The intention of the LISN is to simulate a power network over which a voltage drop **not greater than** 1 V will appear in case of nominal current.

In case there is need to evaluate the wideband noise amplitude in this frequency band, in annex E there is the method of calculation or eventually the method of measurement.

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## 5 Earthing and bonding

Earthing and bonding of the telecommunications equipment in telecommunications centres is covered by EN 300 253 [3].

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## 6 Electrical safety requirements

The present document does not cover safety requirements, they are covered by relevant safety standards.

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## 7 EMC requirements

The present document does not cover EMC requirements, they are covered by relevant EMC standards.

## Annex A (informative): -60 V<sub>DC</sub> systems

When equipment is added to existing -60 V<sub>DC</sub> systems the requirements given in table A.1, deviating from the requirements of the present document, may be used.

NOTE: This variation may be necessary due to established national practice which cannot be changed for a long period of time, for instance when an existing network structure is based on -60 V<sub>DC</sub> power feeding.

**Table A.1**

<b>Nominal value of the supply voltage</b>	-60,0 V <sub>DC</sub>
<b>Normal service voltage range at interface "A"</b>	-50,0 V <sub>DC</sub> to -72,0 V <sub>DC</sub>
<b>Abnormal service voltage range at interface "A"</b>	0 V <sub>DC</sub> to -50,0 V <sub>DC</sub> and -72,0 V <sub>DC</sub> to -75,0 V <sub>DC</sub>

## Annex B (informative): Guide for measuring inrush current and for transferring the recorded pulses onto the limit chart

### B.1 Measurement

- Use a storage oscilloscope, which can record values of  $di/dt$  of at least  $10 \text{ A}/\mu\text{s}$ .
- When measuring the DC supply, use a time base setting which enables readings of the pulse width to be taken at different current levels (figure B.1 reports a result of inrush pulse simulation measurement).
- Take several readings to ensure that the worst case value has been recorded.

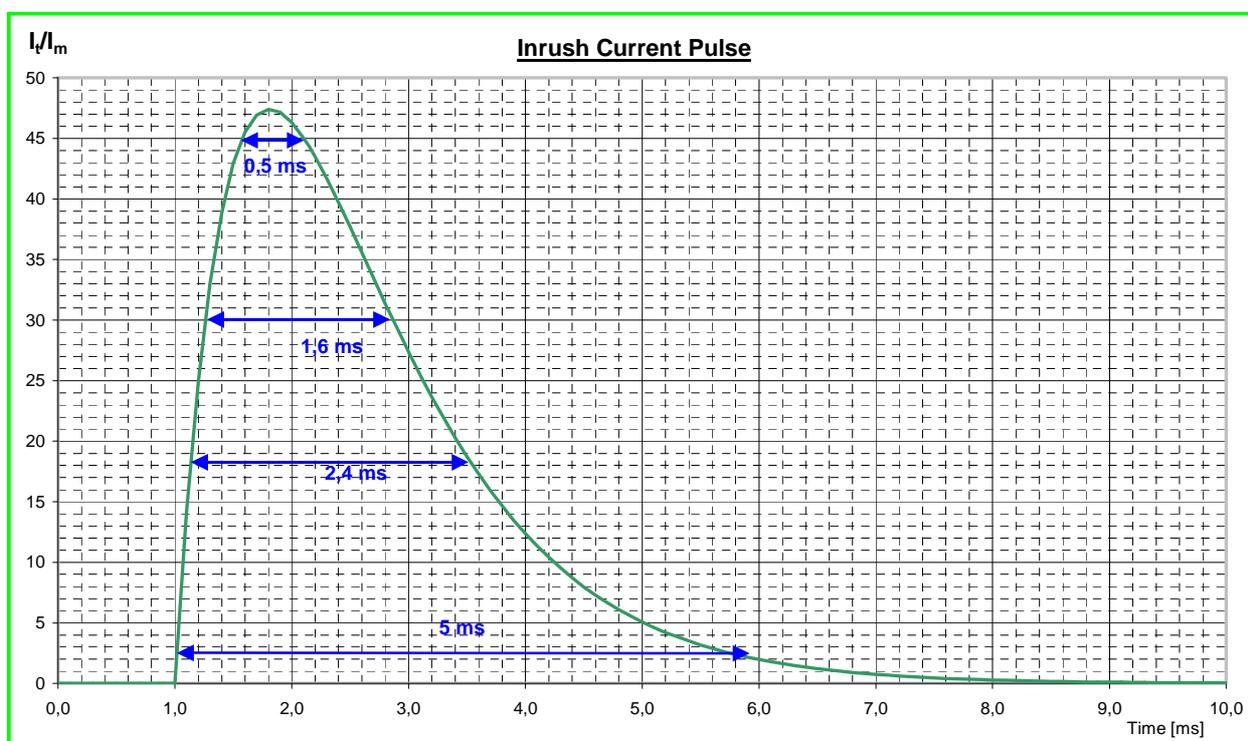


Figure B.1: Example of current pulse and associated measurements

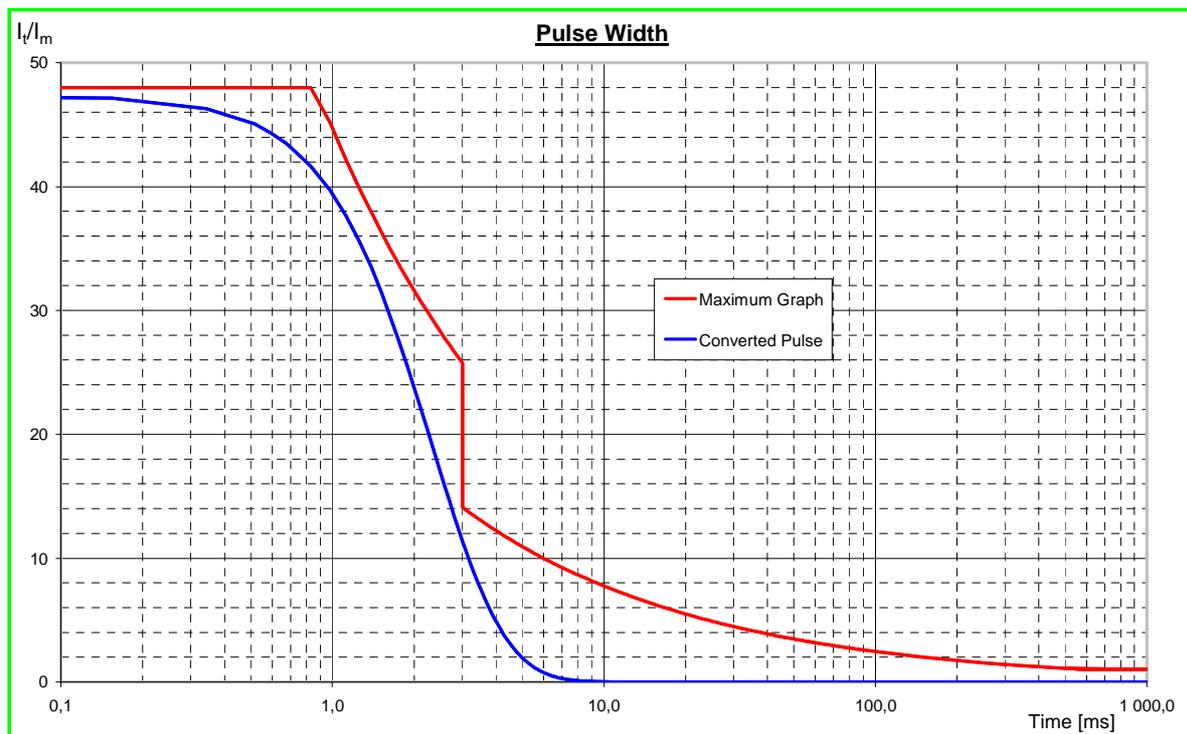
### B.2 Pulse waveform transformation

- For a single pulse from the DC system, proceed as follows:
  - measure the width of the current pulse at different levels;

NOTE 1: Small magnitude current pulses for charging RF filter capacitors should not be considered. Clause B.3 contains example oscillogram showing measurements of typical equipment RF capacitor charging current and inrush current pulses.

- plot the current ratios against their corresponding time values points onto the limit curve of figure 3;
- draw an interpolation curve between the plotted points.

- b) The interpolation curve should not cross the limit curve at any point. Use more points from the recorded pulse in critical areas where the interpolated curve has insufficient accuracy. Figure B.2 shows the DC pulse of figure B.1 transferred onto the limit chart of figure 3.



**Figure B.2: Example of values for a typical inrush current ratio plotted against limit curve**

NOTE 2: Occasionally, more than one inrush pulse may appear, due to special arrangements for limiting the amplitude of single pulses or because the load (telecommunications equipment) starts in sequences. Under these conditions, the limit should be interpreted separately for each different start-up sequence where there is more than 1 second between each. The protective device in the distribution network should not operate.

- c) When from the load or from the limited amplitude of single pulses you have more then one inrush current this limit should be interpreted as shown in figure B.3 - the width obtained is the addition of the width of the individual pulses (e.g. 1,6 ms + 0,8 ms). This is depending of the frequency and the level of the impulses and practical from the time for demagnetisation of the anchor in the circuit breaker.

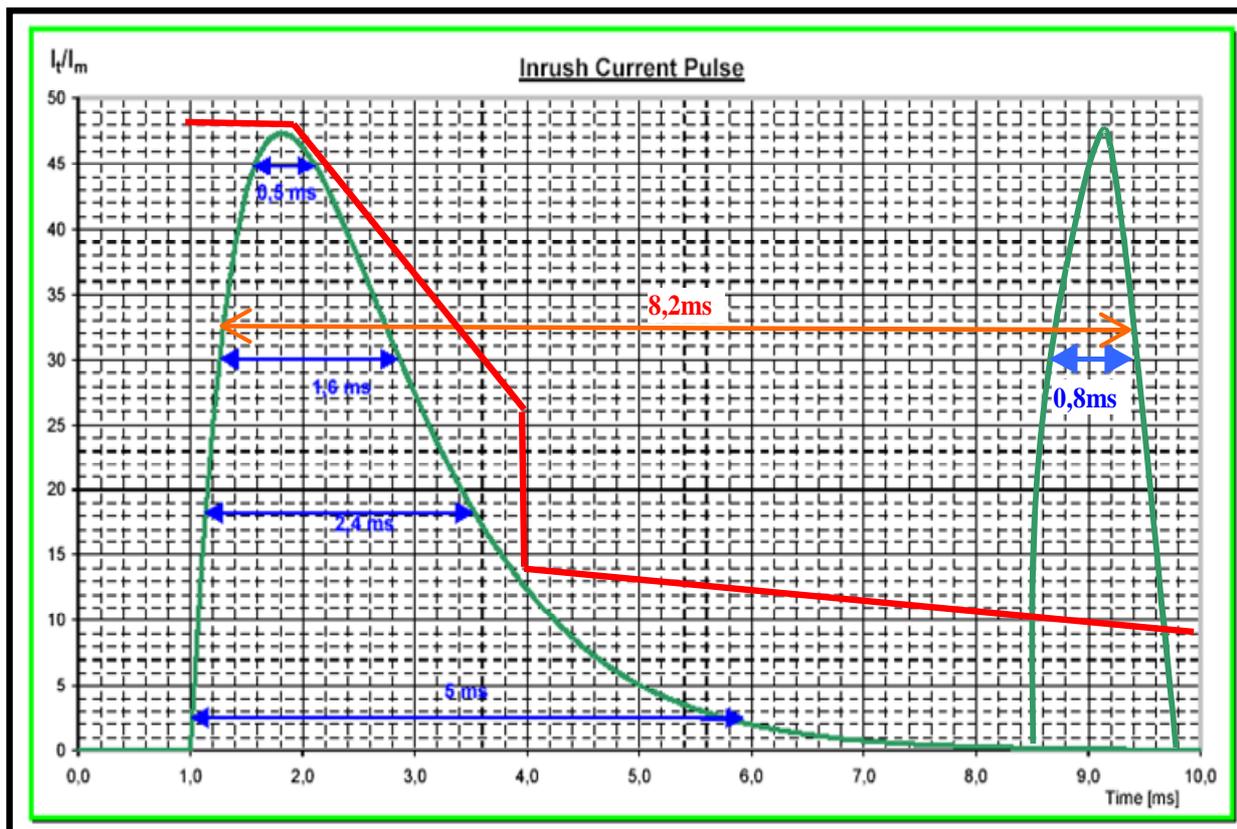
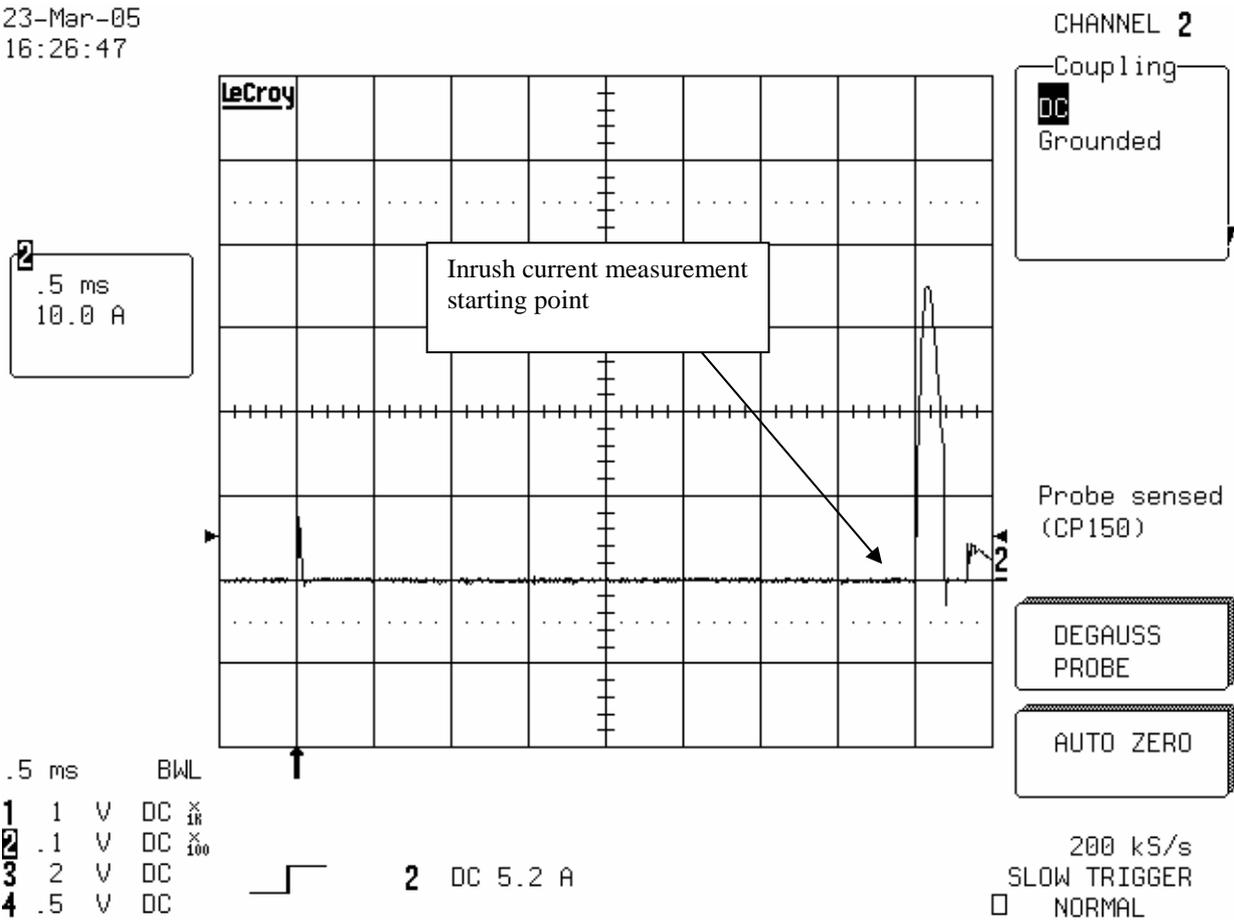


Figure B.3: The width obtained is the addition of the width of the individual pulses (1,6 ms + 0,8 ms)

### B.3 Measurement of inrush current with filter capacitor current pulses

23-Mar-05  
16:26:47

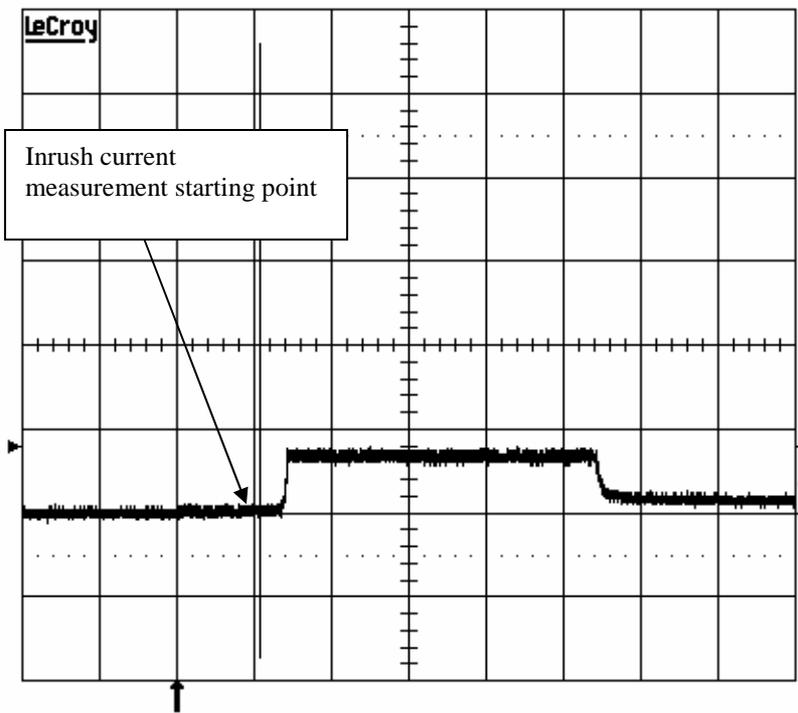


NOTE: In this example the inrush current measurement starting point shall be set at the beginning of the biggest pulse.

**Figure B.4: Example of inrush current measurement with evidence of a pulse due to a filter capacitor**

25-May-06  
15:15:45

5 ms  
10.0mV



CHANNEL 1

Coupling  
DC50Ω  
Grounded  
DC1MΩ  
Grounded  
AC1MΩ

V/div Offset  
NORMAL  
ECL TTL

Global BWL  
OFF  
25MHz 200MHz

Probe Atten  
x1  
x2  
x5  
x10  
x20

5 ms

- 1 10 mV 50Ω
- 2 2 V DC
- 3 .5 V AC
- 4 .5 V AC

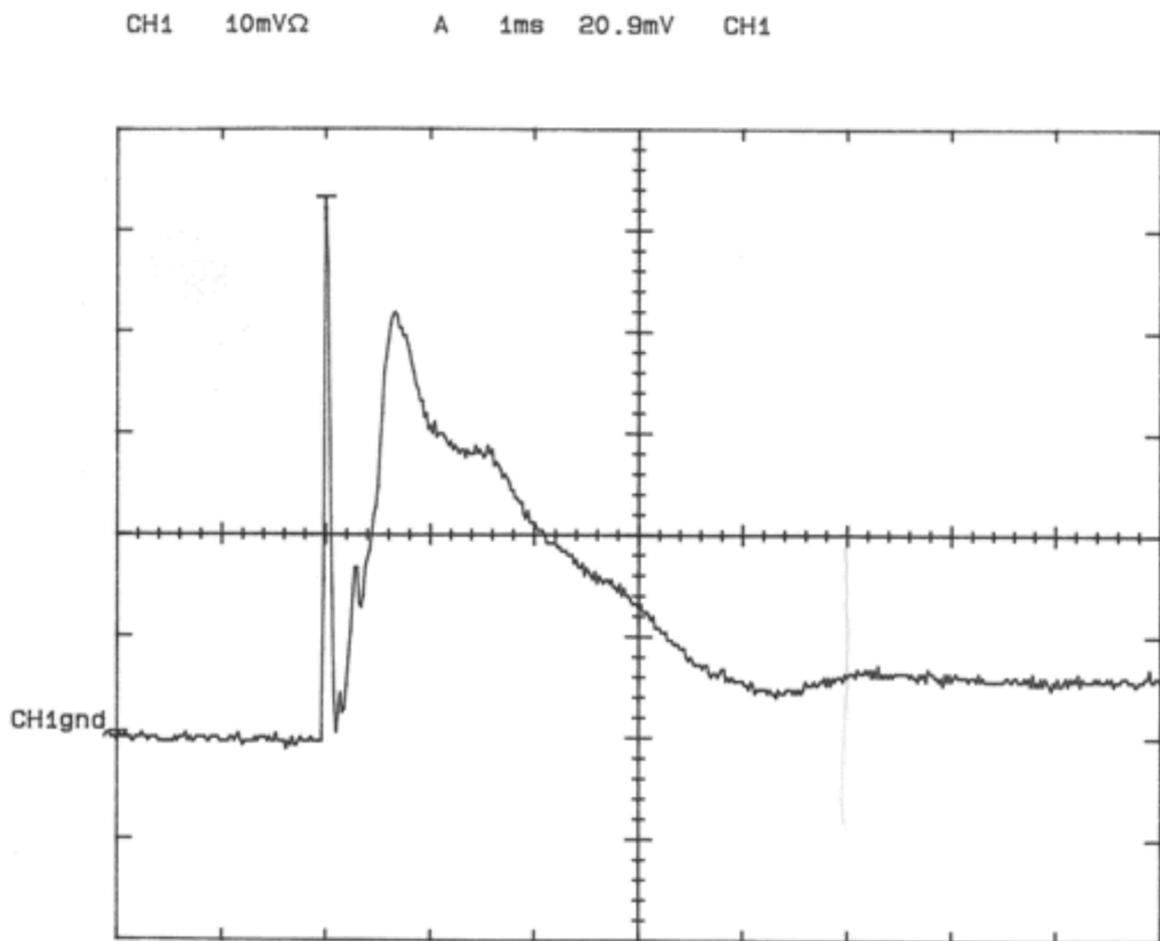
1 DC 8.0mV

1 MS/s

STOPPED

NOTE: In this example the inrush current measurement starting point shall be set at the beginning of the single pulse.

**Figure B.5: Example of inrush current measurement with no evidence of a pulse due to a filter capacitor**



NOTE: In this example the inrush current measurement starting point shall be set at the beginning of the filter capacitor charging pulse.

**Figure B.6: Example of inrush current measurement with no separation between the filter capacitor charging pulse and inrush current pulse (note time scale)**

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## Annex C (informative): Test arrangements for the injection of electrical noise at interface "A"

- a) Clause 4.8 defines the maximum levels of noise, which may be present at interface "A". The method of injecting noise for testing purposes is not critical provided that the maximum levels in clause 4.8 for narrowband noise are not exceeded.
- b) The test configuration shown in figure 6 is an example of how noise may be injected at interface "A". Further details of this test may be found in MIL-STD-461E (see bibliography). The required ratio  $Z_c \ll Z_m$  is fulfilled with:

$$C = 10\,000\ \mu\text{F} \text{ and } |Z_{c, 25\ \text{Hz}}| = 640\ \text{m}\Omega.$$

## Annex D (informative): Identification of interface "A"

Interface "A" is defined as the terminals at which the telecommunications equipment is connected to the power supply (installation). This is shown in figure D.1.

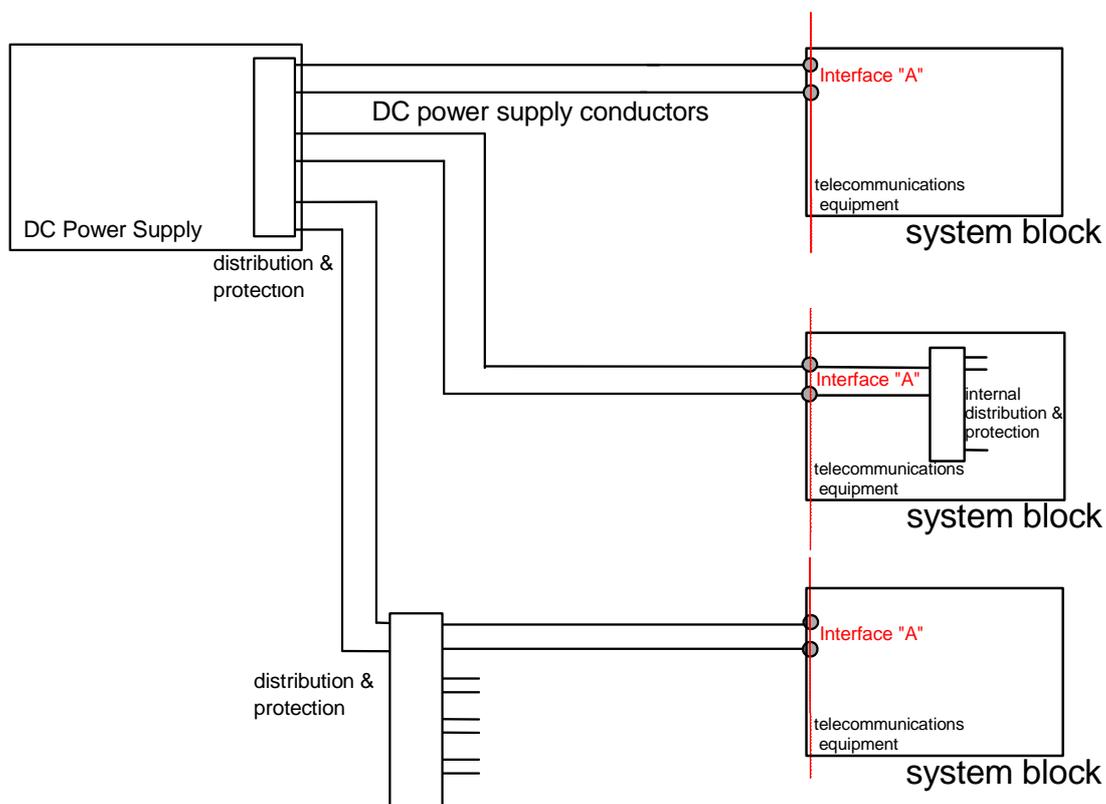


Figure D.1: Identification of interface "A" (three proposed examples)

## Annex E (informative): Wideband noise

### E.1 Emission of wideband noise

The maximum wideband noise levels shall be as follows:

- a) 25 Hz to 5 kHz:  $P_{\text{pso}}=0,08$  mW ( $U_{\text{pso,eff}} = 2$  mV measured on 50 ohm): (via ITU-T Weighting Filter for commercial telephone circuits);

NOTE: In ITU-T Recommendations Q.551 [4] to Q.554 [7] (digital exchanges) the analogue noise contribution is limited to 200 picowatts psophometrically weighted, corresponding to  $-67$  dBm<sub>p</sub> (reference 1 mW). This limitation may require dedicated precautions to reduce the reinjected noise on the DC distribution to a lower level (e.g.  $0,4$  mV<sub>pso,rms</sub>).

- b) 25 Hz to 20 kHz:  $U_{\text{rms}} = 20$  mV: (flat/unweighted).

Both measurements shall be made with a psophometer conforming to ITU-T Recommendation O.41 [8]. The measurement circuit shall be as shown in figure 8. During the measurement the telecommunications equipment shall be powered at the nominal voltage ( $-48$  V<sub>DC</sub>) of interface "A" and the rated load condition.

#### E.1.1 Assessment of wideband noise

Wideband (psophometric) noise can be measured or calculated using the guidance given in ITU-T Recommendation O.41 [8].

### E.2 How to calculate wideband emission

The results of the measure of the noise emitted in the DC line obtained using the narrowband methods reported in clause 4.9.1 can be used to obtain the value of the wideband noise via a simple calculation.

The measurements shall be made with a psophometer conforming to ITU-T Recommendation O.41 [8].

This ITU-T Recommendation contains the definition of the psophometric weighting filter.

The measured power is defined by this formula:

$$P_p = \frac{1}{(F_2 - F_1)} \int_{F_1}^{F_2} \frac{V^2(f)}{10^{-3} |Z_n(F_0)|} 10^{W(f)/10} df$$

$P_p$  is the psophometric power  $W(f)$  is the weighting filter of the psophometer with the limiting frequencies  $F_1 = 16,66$  Hz and  $F_2 = 6$  kHz as given in table E.1.  $Z_n(F_0)$  is the input impedance of the instrument at the reference frequency  $F_0$ .  $V$  is the unknown voltage to be measured.

The weighting filter is reported in table E.1 and shown in figure E.1.

Table E.1: Psophometric weight

Frequency (Hz)	Relative weight (dB)
16,66	-85,0
50	-63,0
100	-41,0
200	-21,0
300	-10,6
400	-6,3
500	-3,6
600	-2,0
700	-0,9
800	0,0
900	+0,6
1 000	+1,0
1 200	0,0
1 400	-0,9
1 600	-1,7
1 800	-2,4
2 000	-3,0
2 500	-4,2
3 000	-5,6
3 500	-8,5
4 000	-15,0
4 500	-25,0
5 000	-36,0
6 000	-43,0

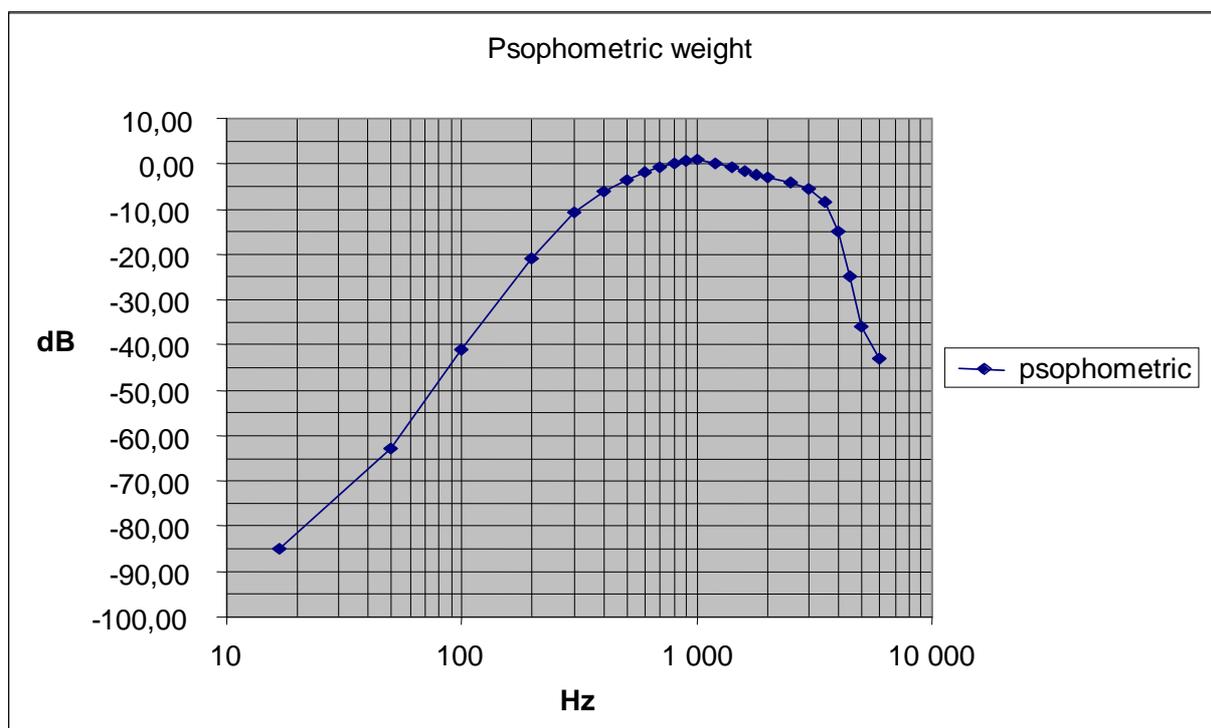
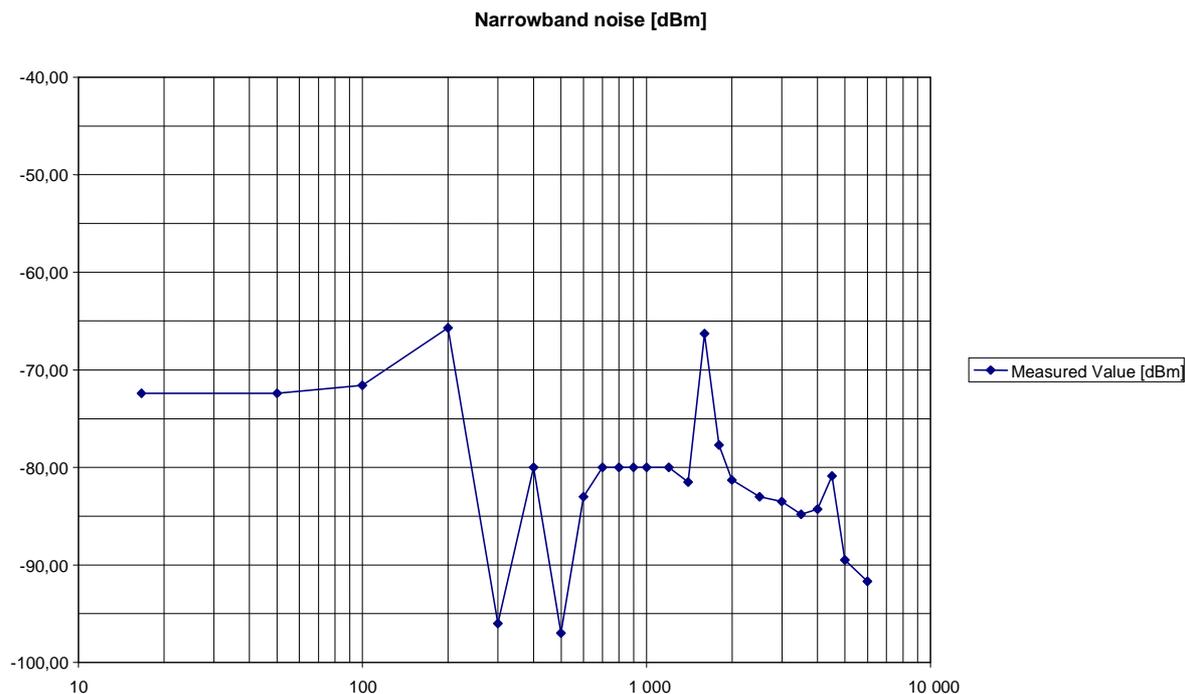


Figure E.1: Psophometric filter frequency response

Starting with measurements obtained from using the narrowband method it is possible to calculate the result of total power using the formula given above.

However, the calculation can be done using a simplified approximate method:

For example consider the measured noise shown in figure E.2.



**Figure E.2: Example of narrowband measure**

In table format, the noise measured has the values reported in table E.2. The values are given at the frequency reported in table E.2. The simplified method considers only the noise and the weighting factor at some frequencies and substitutes the integral calculation of the formula with a simple sum.

With this assumption the formula is:

$$P_w = \sum 10^{(P_{noise}(f)+W(f))/10}$$

In this formula:

- $P_{noise}(f)$  is the value of the noise power in dBm at frequency  $f$ .
- $W(f)$  is the value of the weighting filter at frequency  $f$  in dB.
- $P_w$  is the value of the wideband noise with the ITU-T Weighting Filter;  $P_w$  is expressed in mW.
- The unweighted noise can be calculated with the same method considering the weight equal to 0 dB.
- With the example of the noise of figure E.2 and applied the formula above result a value of wideband noise weighted of: 2,41436E-07 mW (-66 dBm) corresponding at 3,5  $\mu$ V.

**Table E.2: Narrowband values**

<b>Freq (Hz)</b>	<b>Measured Value (dBm)</b>
16,66	-72,40
50	-72,40
100	-71,60
200	-65,70
300	-96,00
400	-80,00
500	-97,00
600	-83,00
700	-80,00
800	-80,00
900	-80,00
1 000	-80,00
1 200	-80,00
1 400	-81,50
1 600	-66,30
1 800	-77,70
2 000	-81,30
2 500	-83,00
3 000	-83,50
3 500	-84,80
4 000	-84,30
4 500	-80,90
5 000	-89,50
6 000	-91,70

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## Annex F (informative): Protection dimensioning

It is common practice to use fuses or breakers in the DC network distribution with a nominal trip value, which is  $>1,66$  times  $I_m$  at nominal voltage. This takes into account:

- The static current into interface "A" will increase when the voltage at interface "A" decreases (constant power load).
- According clause 4.6, the maximum current drain during restoration shall not exceed 1,5 times the nominal current, so the protection device shall withstand  $1,5 \times I_m$  as a minimum.
- It is not recommended to load fuses and breakers with the nominal trip current but to use a safety margin (e.g. 90 % or less).
- Equipment inrush current can cause circuit breaker mechanism to "de-latch" earlier than indicated by circuit-breaker time/current characteristic. After de-latching of the circuit-breakers the contacts will open even if the current falls to zero. De-latching performance must therefore be considered when selecting circuit breakers.

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## Annex G (informative): Bibliography

- IEC 60664-1: "Insulation co-ordination for equipment within low voltage systems".
- ETSI TR 100 283: "Equipment Engineering (EE); Transient voltages at interface "A" on telecommunications direct current (dc) power distributions".
- IEC 60364-4-41: "Electrical installations of buildings - Part 4: Protection for safety - Chapter 41: Protection against electric shock".
- US Department of Defence MIL-STD-461E: "Requirements for the control of electromagnetic interference characteristics of subsystems and equipment".
- ETSI EN 300 386: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Telecommunication network equipment; ElectroMagnetic Compatibility (EMC) requirements".
- ETSI EG 201 212: "Electrical safety; Classification of interfaces for equipment to be connected to telecommunication networks".
- CENELEC TR 62102: "Electrical safety; Classification of interfaces for equipment to be connected to information and communication technology networks".
- CENELEC EN 50310: "Application of equipotential bonding and earthing in buildings with information technology equipment".
- CENELEC EN 60950-1: "Safety of information technology equipment".

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## History

<b>Document history</b>		
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