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European Standard

Environmental Engineering (EE);
Power supply interface at the input to telecommunications and datacom (ICT) equipment;
Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V;
Sub-part 1: Direct current source up to 400 V

Reference

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Keywords

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Contents

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Foreword

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

The present document concerns the requirements for the interface between telecommunication or datacommunication equipment (so called telecommunications and datacom (ICT) equipment) and its power supply. It includes requirements relating to its stability and measurement. Various other references and detailed measurement and test arrangements are contained in informative annexes.

The introduced interface operated by DC source up to 400 V is considering power consumption increase and equipment power density increase in order to get higher energy efficiency with less material than with low voltage -48 VDC or permanent AC powering solution.

The DC interface could also simplify the use of renewable energy with DC output such as photovoltaic generator.

The present document is part 3-1 of a multi-part deliverable covering Environmental Engineering (EE); Power supply interface at the input to telecommunication and datacom (ICT) equipment, as identified below:

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

Part 2: "Operated by -48 V direct current (dc)";

Part 3-0: "Operated by rectified current source, alternating current source or direct current source up to 400 V, Sub-part 0: Overview";

Part 3-1: "Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 1: Direct current source up to 400 V";

Part 3-2: "Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 2: Alternating up to 400 V solution";

Part 3-3: "Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 3: Rectified current up to 400 V solution".

The parts 3-0 to 3-3 are the result of a revision of EN 300 132-3 [3]. This revision was necessary, because the present document was not clear. Sub-parts have been introduced for voltage interfaces A3 up to 400 V.

National transposition dates	
Date of adoption of this EN:	9 February 2012
Date of latest announcement of this EN (doa):	31 May 2012
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 November 2012
Date of withdrawal of any conflicting National Standard (dow):	30 November 2012

1 Scope

The present document contains requirements for:

- the output performance of the power equipment at the interface A3;
- the input of the telecommunications and datacom (ICT) equipment connected to interface A3.

The voltage at interface A3 defined in the present document is DC voltage between 260 V and 400 V.

The DC power can be supplied by the battery backup of a DC power system.

The present document aims at providing compatibility between the power supply equipment and both the telecommunications and datacom (ICT) equipment, and the different load units connected to the same interface A3 (e.g. control/monitoring, cooling system, etc.).

The purpose of the present document is:

- to identify a power supply system with the same characteristics for all telecommunications and datacom (ICT) equipment defined in the area of application; the area of application may be any location where the interface A3 is used i.e. telecommunication centers, Radio Base Stations, datacenters and customer premises;
- to facilitate interworking of different (types of) loads;
- to facilitate the standardization of power supply systems for telecommunications and datacom (ICT) equipment;
- to facilitate the installation, operation and maintenance in the same network of telecommunications and datacom (ICT) equipment and systems from different origins.

General requirements for safety and EMC are out of the scope of the present document series unless specific requirement not defined in existing safety or EMC standards.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) 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 the present clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] IEC/EN 60947-2: "Low-voltage switchgear and controlgear - Part 2: Circuit-breakers".

[2] IEC/EN 60269-1: "Low-voltage fuses - Part 1: General requirements".

[3] IEC/EN 61000-4-5: "Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test".

[4] IEC/EN 61000-4-29: "Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests".

[5] IEC/EN 60898-2: "Circuit-breakers for overcurrent protection for household and similar installations - Part 2: Circuit-breakers for a.c. and d.c. operation".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI ETS 300 132-1: "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".

[i.2] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (DC)".

[i.3] IEC 60050-601: "International Electrotechnical Vocabulary. Chapter 601: Generation, transmission and distribution of electricity - General".

[i.4] ETSI EN 300 253: "Environmental Engineering (EE); Earthing and bonding of telecommunication equipment in telecommunication centres".

[i.5] ETSI EN 300 386: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Telecommunication network equipment; ElectroMagnetic Compatibility (EMC) requirements".

[i.6] IEC/EN 60950-1: "Information technology equipment - Safety - Part 1: General requirements".

[i.7] CENELEC EN 62368-1 Ed. 1.0: "Audio/Video, Information and Communication Technology Equipment - Part 1: Safety requirements".

[i.8] IEC/EN 60445: "Basic and safety principle for man-machine interface, marking and identification-Identification of equipment terminals, conductor terminations, and conductors".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

abnormal service voltage ranges: steady-state voltage ranges over which the telecommunications and datacom (ICT) equipment will not be expected to maintain normal service but will survive undamaged

area of application: any location where the interface A3 is used i.e. telecommunication centers, Radio Base Stations, datacenters andcustomer premises

compliance criteria:

Criteria a): The apparatus shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended.

Criteria b): Temporary loss of function or degradation of performance, which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention.

NOTE: In the present document, the apparatus is the telecommunications and datacom (ICT) equipment.

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

interface A3: interface, physical point, at which power supply is connected in order to operate the telecommunications and datacom (ICT) equipment

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

nominal voltage: value of the voltage by which the electrical installation or part of the electrical installation is designated and identified

normal operating condition: typical environmental and powering conditions for operation of telecommunications and datacom (ICT) equipment, power supply, power distribution and battery

normal operating voltage: typical value of the voltage at A3 interface within the normal operating voltage range

normal operating voltage range: the voltage range at A3 interface where the system operates most of the time, e.g. in general linked to battery floating voltage

normal service: service mode where telecommunications and datacom (ICT) equipment operates within its specification

normal service voltage range: range of the steady-state voltage at the A3 interface over which the equipment will maintain normal service

operating voltage: value of the voltage under normal conditions, at a given instant and a given point (A3 interface) of the system

power supply: power supply to which telecommunications and datacom (ICT) equipment is intended to be connected

reference test voltage: voltage used as a reference to define the test voltage in the present document. The test voltage may be also a percentage of this voltage

system block: functional group of telecommunications and datacom (ICT) equipment depending for its operation and performance on its connection to the same power supply

telecommunications and datacom (ICT) equipment: in this context, telecommunications and datacom (ICT) equipment means telecommunication or datacommunication equipment that is a part of ICT equipment definition

telecommunication centre: any location where telecommunications and datacom (ICT) equipment is installed and is the sole responsibility of the operator

3.2 Symbols

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

I_m	maximum steady state current drain at 260 VDC at interface A3
I_{mss}	maximum steady state current drain in the abnormal service voltage range at interface A3
I_n	current rating of the over-current protective device
I_p	peak inrush current at interface A3
I_{UT}	maximum steady state current drain at U_T at interface A3
T_{50}	time duration of the inrush current pulse at 50 % of Ip

3.3 Abbreviations

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

AC Alternating Current

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

CB Circuit Breaker
DC Direct Current

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

EMC ElectroMagnetic Compatibility
EUT Equipment Under Test
HOD High-Ohmic Distribution
ICT Information and Communication Technology

LOD	Low-Ohmic Distribution
MTTR	Mean Time To Repair
N	Neutral conductor
PE	Protective Earth
U_T	Reference Test Voltage
VAC	Volts Alternating Current
VDC	Volts Direct Current
VRLA	Valve Regulated Lead Acid

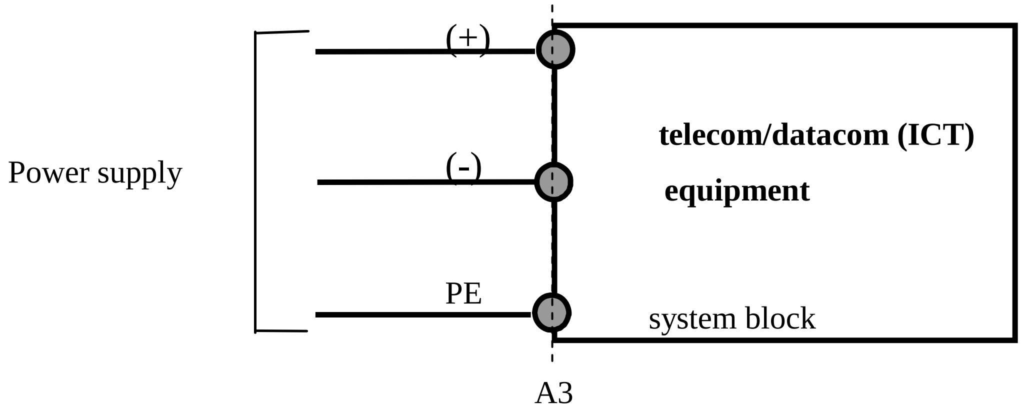
4 Interface A3

The power supply interface, interface A3 of figure 1, is a physical point to which all the requirements are related. This point is situated between the power supply system(s) and the power consuming telecommunications and datacom (ICT) equipment.

An examples of configurations in which interface A3 is identified are given in annex B.

Interface A3 is located at the power terminals of the telecommunications and datacom (ICT) equipment or system as defined by the manufacturer in accordance to IEC 60445 [i.8].

NOTE: Subject to the installation preconditions, this point may be located at any other point between the power supply system and the telecommunications and datacom (ICT) equipment by mutual agreement of the relevant parties.



(+) Positive DC terminal.
(-) Negative DC terminal.
PE Protective Earth.

Figure 1: General identification of the interface A3

5 DC interface requirements

The definition of the DC interface voltages ranges and typical operating voltage values are illustrated in annex H.

5.1 Nominal voltage

The nominal voltage is a normative definition used to enable differentiating power interfaces as defined in IEC 60050-601 [i.3].

The selected battery in general determines this nominal voltage, the operating voltage and the normal service voltage range in the system.

NOTE 1: For example, 336 V is a nominal voltage defined with 168 lead-acid battery cells multiplied by the nominal cell voltage 2 V. This nominal DC voltage is equivalent to 48 V multiplied by 7. It allows the use of existing 48 V battery rack (e.g. Lithium battery racks). There may be other nominal voltage defined with different number of cells e.g. 156 lead-acid battery cells that lead to 312 V nominal voltage. Other battery technologies are possible in the future and will influence nominal voltage as well. For detailed calculation, refer to the annex C.

NOTE 2: Sometimes, the nominal voltage is not linked to the nominal battery voltage e.g. in architectures that include a boost converter in the battery string.

5.2 Normal service voltage range at interface A3

The normal service voltage range at powering interface A3 of telecommunications and datacom (ICT) equipment shall be as follows:

- minimum voltage: 260 VDC;
- maximum voltage: 400 VDC.

NOTE 1: The voltage at the output of the power supply must take into account the voltage drop in the cable at maximum steady current I_m and/or the maximum battery charge to stay in the normal service voltage range at the interface A3 as explained in annexes A, B and C.

NOTE 2: For examples on how to calculate normal service voltage range, refer to annex C.

5.3 Normal operating voltage range at interface A3

The normal operating voltage range at interface A3 is defined by the voltage levels where the system will operate most of the time under normal operating conditions; this range shall be within the normal service voltage range.

The normal operating voltage is a typical voltage inside the normal operating voltage range.

NOTE 1: Examples of normal operating voltages are 354 V and 380 V.
354 V corresponds to 156 VRLA cells in floating mode (351 V to 359 V with 2.25 V to 2.30 V per cell) and with no voltage drop in the power distribution.
380 V corresponds to 168 VRLA cells in floating mode (378 V to 386 V with 2.25 V to 2.30 V per cell) and with no voltage drop in the power distribution.

NOTE 2: For examples on how to calculate normal operating voltage range, refer to annex C.

5.4 Reference test voltage (U_T) at interface A3

The reference test voltage (U_T) for telecommunications and datacom (ICT) equipment is defined at:

$$U_T = 365 \text{ V} +/- 15 \text{ V}$$

NOTE: The powering solution should work in any site even with very long power cables i.e. U_T at the input of telecommunications and datacom (ICT) equipment is lower than power supply output. For constant power telecommunications and datacom (ICT) equipment, the current is increasing as a function of decreasing voltage.

5.5 Abnormal service voltage ranges at interface A3

The telecommunications and datacom (ICT) equipment may be subjected to steady state voltage out of the normal service voltage range. Limits of abnormal service voltage range are defined as follows:

- $0 \text{ V} < U < 260 \text{ V}$
- $400 \text{ V} < U < 410 \text{ V}$

For example, it may be undervoltage and overvoltage at battery end of discharge or end of charge and rectifier regulation failures.

NOTE 1: From design point of view, that means that there is an hardware voltage limitation inside the rectifier in case the software fails, and MTTR is long.

After the restoration of the supply from the abnormal service voltage range to the normal service voltage range, the telecommunications and datacom (ICT) equipment shall fulfil the following performance criteria:

- the telecommunications and datacom (ICT) equipment shall not suffer any damage;
- the telecommunications and datacom (ICT) equipment shall be able to automatically resume operation according to its specifications when the voltage comes back into the normal service voltage range.

NOTE 2: The second criterion implies that abnormal service voltage should not lead to the disconnection of power supply units e.g. by causing circuit breakers, fuses or other such devices to operate.

6 Abnormal conditions: Voltage variations, voltage dips, short interruptions and voltage surges at interface A3

Under abnormal conditions, voltage values outside the normal service voltage range may occur for short time.

The deviations from the steady-state voltage at the A3 interface may be caused by:

- Voltage variations.
- Voltage dips.
- Voltage interruptions.
- Voltage surges.

The tests for voltage dips, short interruption and voltage variations shall be conducted in accordance with standard EN 61000-4-29 [4].

The tests for voltage surges shall be conducted in accordance with standard EN 61000-4-5 [3].

Specific criteria to telecommunications and datacom (ICT) equipment are defined in each test table below. The detailed specification of the generator is in annex F. The tests shall be performed on individual modules/subsystems.

6.1 Voltage variations

Voltage	Duration	Compliance Criteria on telecommunications and datacom (ICT) equipment	Comments
From U_T to 260 V, back to U_T	1 min	Criteria a) Normal performance	Test of minimum operating voltage at A3 within the normal service voltage range
From U_T to 400 V, back to U_T	1 min	Criteria a) Normal performance	Test of maximum operating voltage at A3 within the Normal Service Voltage Range
From U_T to 410 V, back to U_T	1 s	Criteria b) Temporary loss of function or degradation of performance, automatic recovery to normal performance after the test	Test of voltage rise variation entering abnormal service voltage range
From U_T to 420 V, back to U_T	10 ms	Criteria b) Temporary loss of function or degradation of performance, automatic recovery to normal performance after the test	Test of voltage rise variation outside abnormal service voltage range

6.2 Voltages dips

Voltage	Duration	Compliance Criteria on telecommunications and datacom (ICT) equipment	Comments
From U_T to 260 V, back to U_T	10 ms	Criteria a) Normal performance	Test of minimum operating voltage at A3 within the Normal Service Voltage Range

6.3 Short interruptions

Voltage	Supply Network	Duration	Compliance Criteria on telecommunications and datacom (ICT) equipment	Comments
U_T to 0 V back to U_T	Low Impedance (short circuit)	10 ms	Criteria a) Normal performance	Test of holdup time during fault clearing due to a short-circuit in the system
U_T to 0 V back to U_T	High Impedance (open circuit)	1 s	Criteria b) Temporary loss of function or degradation of performance, automatic recovery to normal performance after the test	Test of automatic recovery after an extended (> 1 s) interruption of the operating voltage at interface A3

NOTE 1: With reference to sections 6.1.1 and 6.1.2 of EN 61000-4-29 [4] the definition of Low Impedance is an generator output impedance < 0,5 Ω and High Impedance > 100 k Ω.

NOTE 2: The purpose of the second test above (High Impedance) is to test the performance of the system during a power start-up of the system from 0 V (i.e. all system capacitors are fully discharged). This reflects reset of a tripped circuit-breaker on A3 interface or a DC interruptions in the network caused by voltage transcients. This reset can also occur with recovery of A3 interface voltage following the restoration of 230 VAC mains after an AC mains interruption longer than the battery backup time.

6.4 Voltage surges

Voltage surges may occur at interface A3 when faults (e.g. short circuits) occur in the power distribution system.

The voltage surges due to short-circuit and protective device clearance are characterized by a voltage drop in the steady state abnormal service voltage range: 0 VDC to 260 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 A3 and the telecommunications and datacom (ICT) equipment connected to interface A3.

NOTE 1: The purpose of the present clause is thus to address the energy and the subsequent so-called "Fuse blowing transient" associated with a short-circuit condition.

NOTE 2: Other voltage surges induced from other external sources belong to EMC generic requirements.

NOTE 3: Due to the lack of commercial test generator for testing the voltage surges according to the present clause references are however given to EMC standard in order to re-use the so-called combination wave generator specified in EN 61000-4-5 [3].

Test Voltage	Supply Network	Generator output impedance	Wave shape	Energy level reference	Compliance Criteria on telecommunications and datacom (ICT) equipment	Comments
500 V	Line to Line	2 ohm	1.2/50 µs (8/20 µs)	1 Ws	Critera a) Normal performance	Test of voltage rise variation outside abnormal service voltage range (e.g. after fuse blow, switching) Test voltage polarity shall be the same as A3 interface
500 V	Line to ground	2 ohm	1.2/50 µs (8/20 µs)	1 Ws	Critera a) Normal performance	Test of voltage rise variation outside abnormal service voltage range (e.g. after fuse blow, switching) Test voltage polarity shall be the same as A3 interface
2 kV	Line to line	2 ohm	1,2/50 µs (8/20 µs)	10 Ws	Criteria b) Temporary loss of function degradation of performance, automatic recovery to Normal Performance after the test	Test of automatic system recovery after a line-to-line short-circuit condition. Test voltage polarity shall be the same as A3 interface
2 kV	Line to ground	2 ohm	1,2/50 µs (8/20 µs)	10 Ws	Criteria b) Temporary loss of function degradation of performance , automatic recovery to Normal Performance after the test	Test of automatic system recovery after a line-to-ground (line-to-PE) short-circuit condition. Test voltage polarity shall be the same as A3 interface

NOTE 4: The grounding arrangement (positive pole or negative pole connected to ground, or mid-point to ground, etc.) determines the polarity of the test voltage in the table above. For example, for a +400 VDC power supply having its negative pole connected to ground, the polarity of the test voltage should be *positive only*.

See annex G for details, which is inside the abnormal service voltage range.

NOTE 5: Lengthening of the interruption to service (equipment is not functioning as intended) due to the recovery of software should be declared in the test report (i.e. details about the service interruption).

NOTE 6: 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.

NOTE 7: Special precautions are normally taken in power distribution network to fulfil compliance criteria a) for mission critical telecommunications and datacom (ICT) equipment ie. to prevent functional disturbances due to the voltage surges treated in the present clause.

7 DC Supply protection

The supply at interface A3 shall be protected, (when operating on DC current), by DC rated fuses in compliance with IEC/EN 60269-1 [2] or DC rated circuits breakers in compliance with IEC/EN 60947-2 [1] or IEC/EN 60898-2 [5].

Annex E gives a guideline on the selection and sizing of the over-current protective devices.

The energy content of the inrush current shall also be taken into account when specifying the power supply system up to interface A3.

8 Maximum steady state current

8.1 Maximum steady state current I_m, in the normal service voltage range

Im is the maximum steady state current at the minimum voltage (260 VDC) at interface A3 for fully equipped and fully loaded telecommunications and datacom (ICT) equipment. Operating current at any voltage in the normal service voltage range shall not exceed I_m after 1 s.

8.2 Maximum steady state current in the abnormal service voltage range

The maximum steady state current drain I_{mss} at any voltage in the abnormal service voltage range at interface A3 lasting for longer than 1 s shall not exceed 1,2 times $I_{m.}$

NOTE 1: In case of constant power load characteristics, the factor 1,2 allows the lowest value of the input voltage range of the dc/dc-converter to be 217 V (260/1,2) at start up.

NOTE 2: The current should not exceed I_{mss} at any time, for example, when the telecommunications and datacom (ICT) equipment is fed by a nearly empty battery, or during the voltage restoration in order. This should avoid the operation of the overcurrent protection devices (fuses, circuit breakers).

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

9 Inrush current on connection to interface A3

9.1 Limits

When equipment is switched on, the initial current is called inrush current, until the equipment reaches a steady state. A current pulse, exceeding the steady state current, can often be observed.

NOTE 1: For example, when no current limitation is applied, a pulse peak value of more than 250 A can be observed for an equipment having a steady state current of 1 A.

The inrush current pulse shall be limited in magnitude and in time duration to avoid protective devices clearance by excess of current and energy passing through them. This requirement is not applicable on telecommunications and datacom (ICT) equipment with power consumption max 250 W at U_T and protected by protective device rated min 2 A. The energy content in unlimited inrush current of max 250 W equipment is under normal conditions below the level required for clearance of the protective device rated min 2 A.

When power is applied at the test voltage of U_T at interface A3 (as defined in annex B), the ratio I_p / I_{UT} shall not exceed the limits shown in figure 3. Pulse time duration T_{50} (at 50 % of I_p) and inrush current pulse reflecting approximation of energy content are defined in figure 2.

NOTE 2: For pulse duration $T_{50} < 0,5$ ms, the inrush current is not considered due to too low "energy content" to trip a protective device.

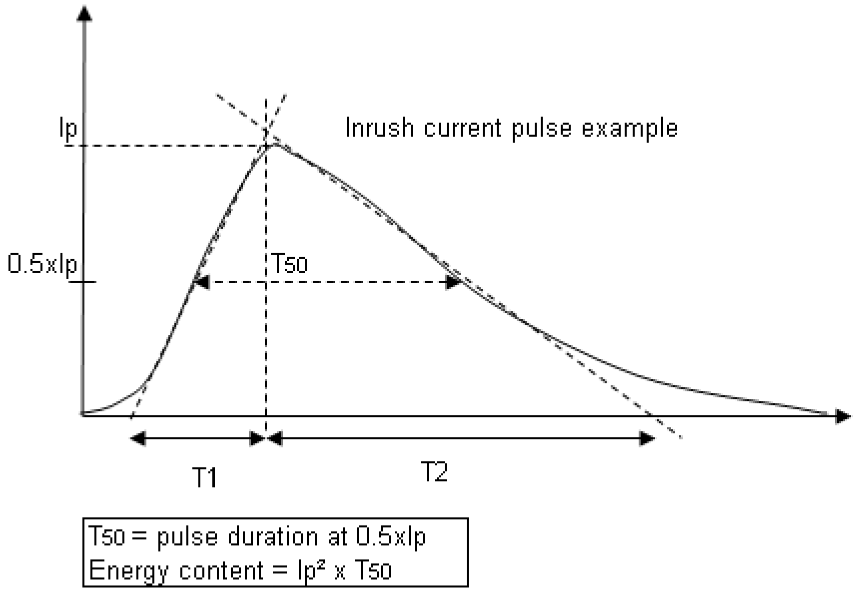


Figure 2: Inrush current pulse shape used to approximately define the energy content of the pulse

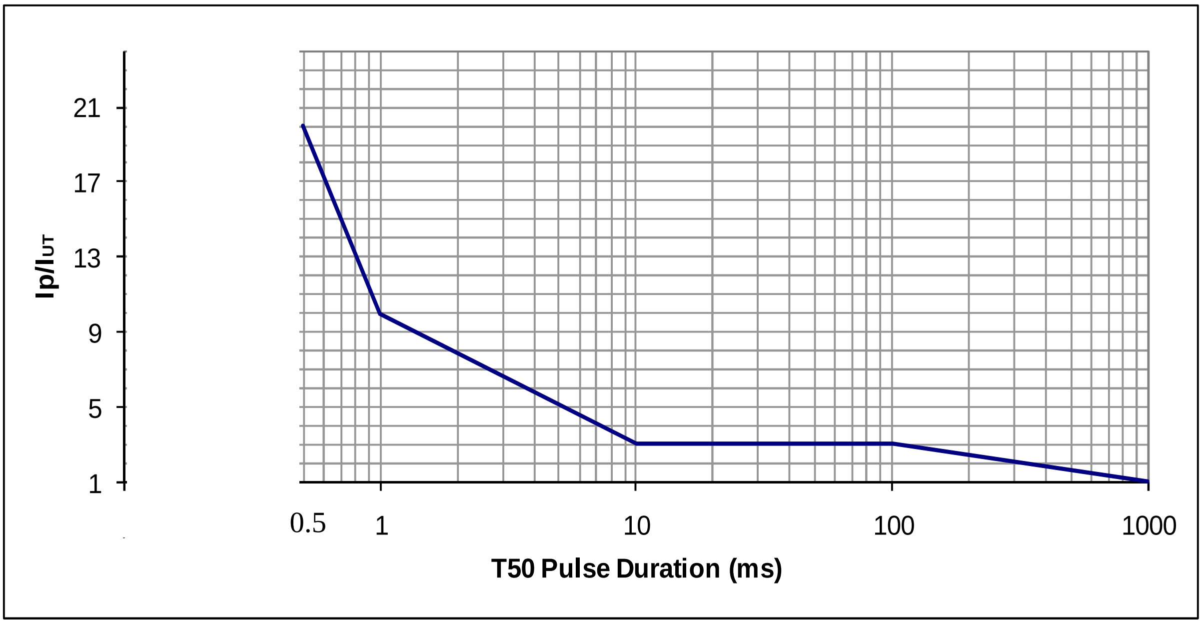


Figure 3: Maximum inrush current characteristics for telecommunications and datacom (ICT) equipment > 250 W at U_T

NOTE 3: This graph is a combined graph for fuses, hydraulic magnetic and thermal magnetic circuit breakers. Fuses according IEC/EN 60269-1 [2] (gG type), circuit breakers according IEC/EN 60947-2 [1] and IEC/EN 60898-2 [5].

9.2 Measurements

The test generator and test set-up for inrush current measurement are shown in figure 4.

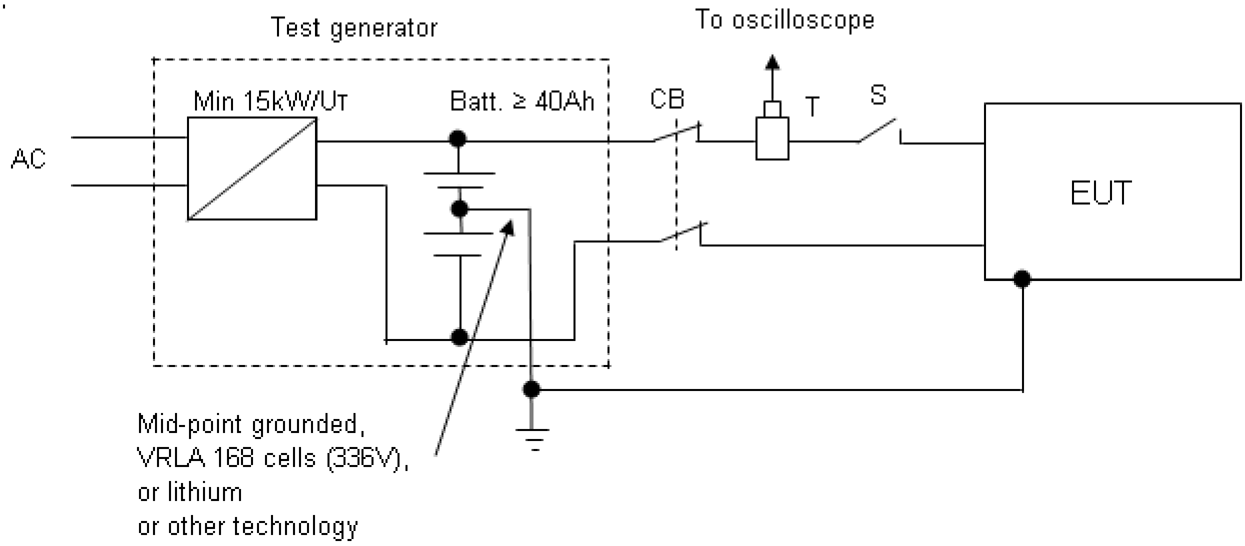


Figure 4: Inrush current test set-up

- The oscilloscope shall be galvanic isolated from the AC mains, (i.e. through isolation transformer).
- CB - 2-pole circuit breaker, with minimum rating 63 A/440 VDC, breaking capacity min. 6k A.
- S - Manual switch or contactor for peak current 10 kA, T_{50} < 10 ms and 400 VDC.
- T - Current transducer (low-ohmic shunt or clamp-on meter with enough bandwidth).
- Total connection resistance (cable + current transducer + CB + switch) < 40 mΩ.
- A short cabling of low inductance and resistance (e.g. < 2 m, twisted cable or two-core cable) shall be used.
- More information and guidelines for inrush current measurement can be found in annex D.

10 Earthing and Bonding

Earthing and bonding of telecommunications and datacom (ICT) equipment operated by direct current (DC) source up to 400 V are not covered by the present document

NOTE: Earthing and bonding for -48 V system are defined in EN 300 253 [i.4]. An adaptation of the present document should be used for direct current (DC) source up to 400 V.

11 Electrical Safety requirements

The safety requirements are not covered by the present document.

NOTE: Information technology equipment safety is defined in IEC/EN 60950-1 [i.6] for mains-powered or battery-powered information technology equipment, including business equipment and associated equipment, with rated voltage not exceeding 600 V. EN 62368-1 [i.7] brings some information. Electrical installation and power supply safety is covered by relevant IEC standards.

12 EMC requirements at the input of telecommunications and datacom (ICT) equipment

EMC requirements are not covered by the present document.

NOTE 1: Telecommunications and datacom (ICT) equipment EMC is defined in EN 300 386 [i.5], other EMC requirements for the building power distribution are covered by relevant IEC standards and interference between distribution are covered by relevant ITU-T recommendations.

Narrow band noise, is not applicable, for this A3 interface.

NOTE 2: Specific needs to power legacy telecommunications and datacom (ICT) equipment from a common 400 VDC source may appear. In general the solution is to use converters (400 VDC/-48 VDC) from A3 interface to A interface defined in EN 300 132-2 [i.2]. For such converters, the noise req uirements of EN 300 132-2 [i.2] are applicable at the A interface.

Annex A (informative): Power supply considerations

The increase of service and the new packet switching network has led to more telecommunications and datacom (ICT) equipment in the same existing telecommunication centres. The power consumption related to the standard phone services with telecommunications and datacom (ICT) equipment in -48 V decreases, but the power needed by these new services and packet networks increases and the power interface is generally ac voltage, the standard interface in the computer field.

Moreover, the density of electronic integration in telecommunication and computer fields increases, requiring more power density. Generally higher current is needed on the powering wire.

As a consequence, the nominal voltages proposed in the present document have been defined with consideration to the:

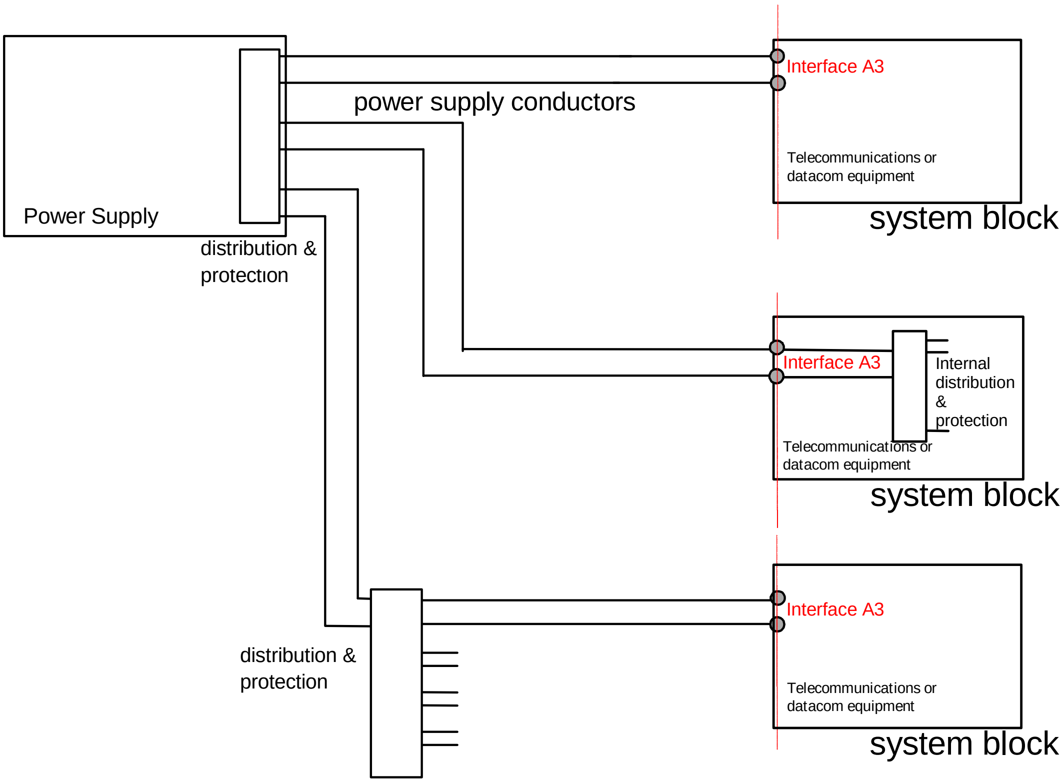
- need to unify the power supply of the telecommunications and datacom (ICT) equipment and the Information Technology Equipment;
- desire to decrease the losses in the power distribution wire as well as copper cross-section;
- need to maintain a highly reliable power source for telecommunication centres or data-centers;
- enabling the use of the same DC interface in customer premises for powering telecommunications and datacom (ICT) equipment.

The corresponding power supply can be based on a range of different configurations including:

- mains + rectifier;
- mains + rectifier + battery;
- rectifier + battery + other DC source input (e.g. from renewable energy controller of photovoltaic type);
- mains + back-up generator (e.g. diesel generator) at the input;
- any redundancy and modularity of the previous solution;
- if a DC energy storage device (e.g. battery) is used, it should be selected/designed to fit into the normal service voltage range;
- selection should take account of:
  - battery charging voltage($\leq$ 400 V);
  - battery end of discharge voltage and voltage drop in the distribution system.

Annex B (normative): Identification of interface A3

Interface A3 is defined as the terminals at which the telecommunications and datacom (ICT) equipment is connected to the power supply. This is shown in figure B.1.



NOTE 1: The figure is a drawing of the power system and does not show the PE conductor.

NOTE 2: In normal operation the voltage at the output of the power supply is always higher than the voltage at the interface A3, due to voltage drop in the distribution cables.

Figure B.1: Identification of interface A3 (three possible configurations)

Annex C (informative): Calculation of the extreme DC voltage range at interface A3

The battery voltage range between charge and discharge conditions defines the DC voltage range. For the example of calculation, only the lead-acid battery composed of 168 cells or 156 cells, is considered. Other battery technologies are also possible in the future with different voltage range that should be inside the normal service voltage range.

Battery voltage range:

- The high voltage at end of fast charge of lead acid battery is limited to 2,375 V per cell which is the same as for the 48 V interface maximum value in boost mode, e.g. 168 x 2,375 V = 399 V.
- This maximum voltage may correspond also to a value close to 7 time x 57 = 399 V as defined in EN 300 132-2 [i.1].
- The maximum normal voltage is set around 400 V at the input of telecommunications and datacom (ICT) equipment.
- The low voltage at end of fast discharge of lead acid battery (i.e. 15 mn discharge rate) is limited to 1,65 V per cell. The maximum voltage drop should also be taken into account.
- The minimum normal voltage is therefore equal to: 1,65 V x 168 = 277 V, which allows a voltage drop in the cable of 17 V in case of minimum 260 V at input of the telecommunications and datacom (ICT) equipment.
- Another calculation can be 1,7 x 156 = 265 V, and it allows 5 V voltage drop with the same minimum voltage at input of telecommunications and datacom (ICT) equipment.
- The minimum normal voltage is then set at 260 V at the input of telecommunications and datacom (ICT) equipment with some margin.

In the following, are also given examples of calculation of operating voltage and operating voltage range for 168 lead-acid battery cells with temperature effect and voltage drop in the cable. The battery operating voltage range is defined by the reference cell floating voltage range from 2,18 V to 2,27 V between 20 °C and 25 °C and the temperature voltage coefficient of -3 mV/°C from 0 °C to 40 °C. The minimum telecommunications and datacom (ICT) equipment operating voltage range is then the battery voltage minus the voltage drop in the DC distribution cable. Assuming constant power, the drop is lower at operating voltage than at end of battery discharge.

- Without voltage drop in the cable:
  - the minimum operating voltage with reference minimum floating voltage cell is at 40 °C is:

    (2,18 - (0,003 x (40-20)) x 168 = 356 V;
  - the maximum operating voltage is at 0 °C with reference maximum floating voltage cell is:

    (2,27 - (0,003 x (0-20))) x 168 = 391 V;
  - at 20 °C, the operating voltage with reference minimum floating cell voltage cell is:

    2,18 x 168 = 366 V;
  - telecommunications and datacom (ICT) equipment minimum operating voltage range considering for example maximum 12 V drop in the cable is therefore 356 - 12 = 348 V.

NOTE: In worst condition for efficiency, the voltage at the input of telecommunications and datacom (ICT) equipment with 16 V drop is then 350 V. This is equivalent to 2 V drop in 48 V with e.g. 1 V on each plus and minus cable.

Considering all temperature, battery reference floating voltage, and voltage drop, the operating voltage is then ranging from 348 V to 391 V.

Annex D (informative): Guide for defining inrush current energy, measuring inrush current and test generator peak inrush current drive capability

The criteria for defining an accepted inrush current energy content is related to the risk of clearance of the applied protective device. Circuit breakers in general requires less current energy content for clearance than fuses at the same current rating. That is why the tripping characteristics of hydraulic magnetic and thermal magnetic circuit breakers have been used as the basis for selection of limits for inrush current. The inrush current limits have been selected to meet circuit breaker tripping characteristic requirement Curve C (7 x I_n DC at 0,1 s) with enough safe margin. The inrush current limits for pulses below 10 ms have been selected based on tests of required pre-arc energy for clearance of circuit breakers and data from circuit breaker manufacturers.

The pre-arc energy is the energy content required for opening the contact in the circuit breaker (creation of arc) and reaching the cut-off current limit. The "point of no return" is reached and the fault current is falling down to zero.

D.1 Measurement

The procedure to measure inrush current is as follows:

a) Use a storage oscilloscope, which can record values of di/dt of at least 10 A/µs.

b) Make sure that the battery is fully charged at rectifier output floating voltage 380 V ± 5 V (valid for 168 VRLA cells).

c) The test is performed at the output voltage level U_T of the rectifier. The battery should be able to provide a minimum current, I_p of 1 500 A at short circuit (see clause D.2).

D.2 Test generator peak inrush current drive capability

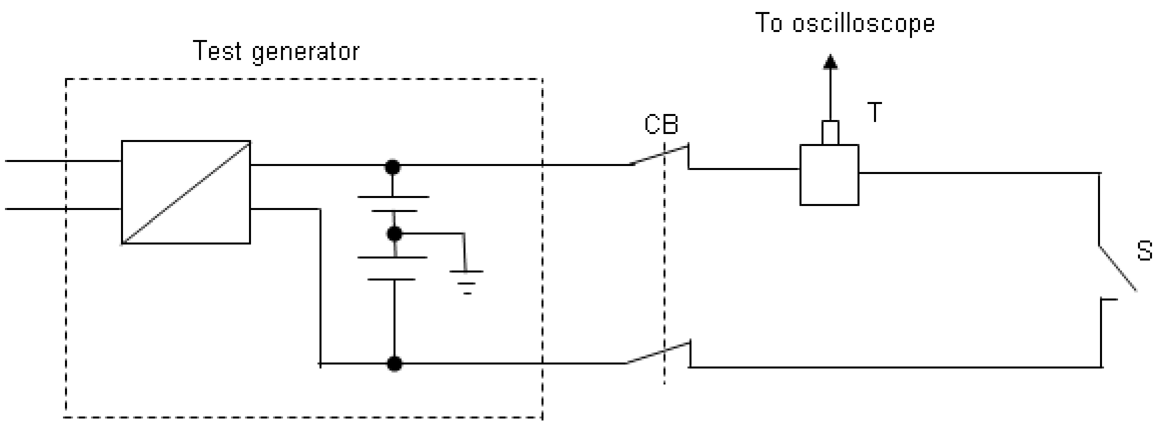


Figure D.1: Test set-up for measuring test generator peak inrush current drive capability in short circuit test

- T- Current transducer (low-ohmic shunt or high bandwidth clamp-on).
- CB - 2-pole circuit breaker, ≥63 A/440 VDC, breaking capacity min. 6 kA.

- S - Manual switch or contactor for peak current 10 kA, T_{50} < 10 ms and 400 VDC.
- Total connection resistance < 40 mΩ, (total resistance of cable + current transducer + CB + switch/contactor).

EXAMPLE: 63 A/440 V CB plus 2 m x 6 mm² cable bring a resistance of 20-25 mΩ at short circuit.

The measured peak short circuit current shoud be greater than 1 500 A. If the level of 1 500 A is not reached, it may depend either on too high battery resistance (more strings in parallel or higher Ah is recommended).

D.3 Example of inrush current waveform

The figure D.2 shows a typical inrush current pulse to a small telecommunications and datacom (ICT) equipment with a power rating less than 250 W fed by 350 VDC.

NOTE: The equipment is originally designed for 230 VAC and has no built-in active or passive current limiting device its input.

Ip = 54 A, T50= 0,7 ms and I_{UT} = 0,43 A (150 W) => Ip/I_{UT} = 125.

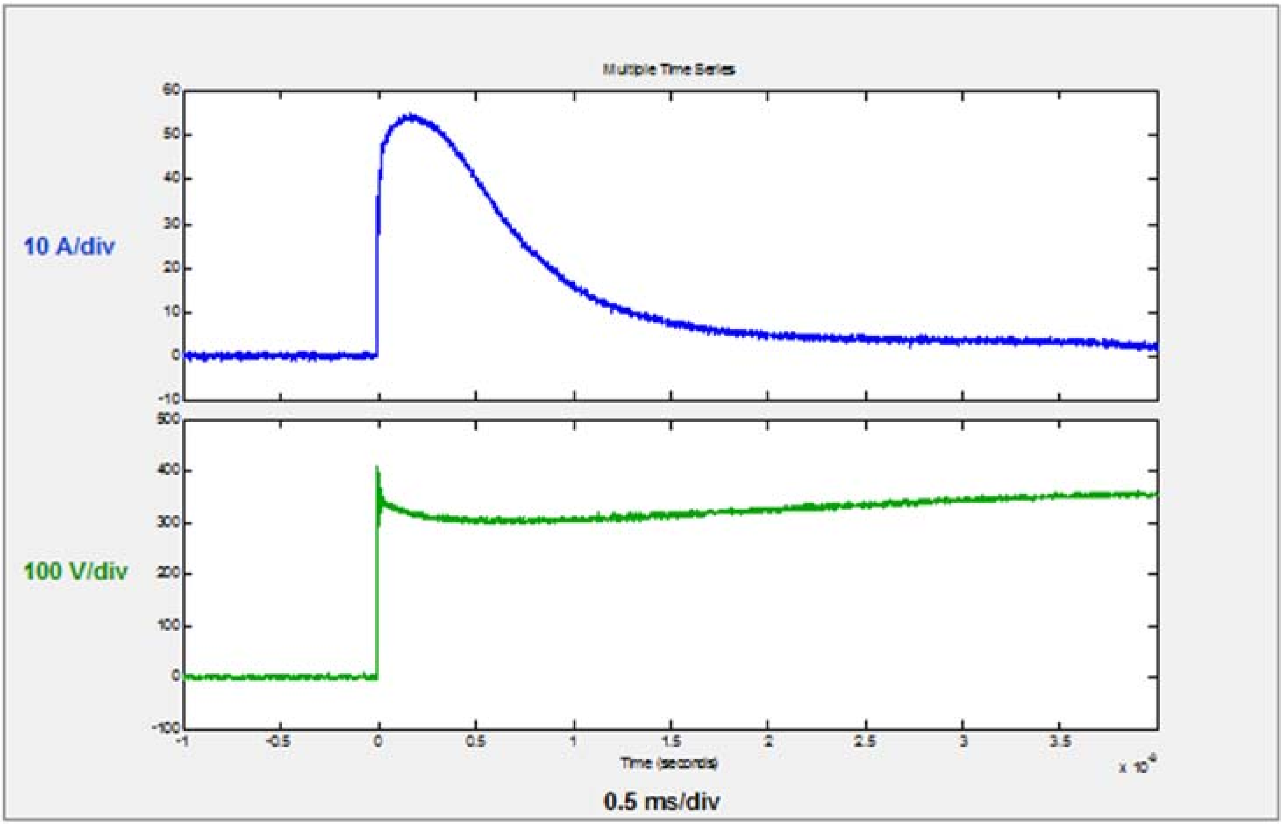


Figure D.2: Example of inrush current measured on small telecommunications and datacom (ICT) equipment

Annex E (informative): Dimensioning of over-current protective devices

It is common practice to use fuses or breakers in the DC network distribution with a nominal trip value, which is > 1,5 times I_m (1,5 = 1,2 x 1/0,8). This takes into account:

- A factor of 1,2 for maximum steady state current in abnormal service voltage range.
- A safety factor of 0,8 that includes temporary over load, technology, ageing, de-latch current, etc.

NOTE: Temperature derating factor should be additionally considered depending on chosen technology for the protective device.

Annex F (informative): Test generator for voltage dips, short interruptions and voltage variations

The specification of the test generator should be in accordance with EN 61000-4-29 [4]:

- Output voltage range (Uo): up to 440 V (360 V or higher according to EN 61000-4-29 [4]).
- Short interruptions, dips, and variations of the output voltage: as given in tables in clauses 6.1, 6.2 and 6.3.
- Output voltage variation with the load (0 to rated current): less than 5 %.
- Ripple content: less than 1 % of the output voltage.
- Rise and fall time of the voltage change, generator loaded with 100 ohm resistive load: between 1,2/µs and 50 µs.
- Overshoot/undershoot of the output voltage, generator loaded with 100 ohm resistive load: less than 10 % of the change in voltage.
- Output current (steady state) (Io): up to 25 A.

NOTE 1: The slew rate of the voltage change at the output of the generator can range from a few V/µs up to hundreds V/µs, depending on the output voltage change.

NOTE 2: EN 61000-4-29 [4] considers generator with a voltage up to 360 VDC only but permits the use of generator with higher voltage capability provided that the other specifications (output voltage variation with the load, rise and fall time of the voltage change, etc.) are preserved.

The test generator steady state power/current capability should be at least 20 % greater than the EUT power/current ratings.

The test generator, during the generation of short interruptions, should be able to:

- operate in "low impedance" condition, absorbing inrush current from the load (if any);
- or operate in "high impedance" condition, blocking reverse current from the load.

The test generator, during the generation of voltage dips and voltage variations should operate in "low impedance" condition.

Annex G (informative): Details of the voltage transient measurement in the most common case of distribution and protective devices

A protective device operation transient results from a low impedance fault to ground on the equipment side of a protective device (fuse or circuit breaker) connected to a power distribution bus. The bus voltage is reduced due to high current flowing to ground through the protective device and the short ground. When the protective device opens, the release energy stored in the inductance of the bus causes an initial high voltage overshoot of short duration, followed by a longer interval voltage overshoot that decays toward the steady state bus voltage.

In the present document, in clause 6.4, tests are defined to verify the susceptibility of the equipment when a short circuit or overload condition occurs on the power distribution bus.

The technique to reduce the effect propagation of a short circuit or overload condition on the power distribution bus (i.e. transient voltage dip at Interface A3) is to isolate the fault. The fault isolation can be achieved using High-Ohmic Distributions (HOD) or Low-Ohmic Distributions (LOD).

In the HOD, the equipment and the sub-parts of the equipment, are connected separately to the battery with sufficient impedance. The high impedance can be achieved with long cables and in some cases additional resistors are installed. With this distribution the undervoltage effects are reduced on the other equipment connected to the battery.

In the LOD, the equipment and the sub-parts of the equipment are connected to the battery with as low impedance as possible and hold-up capacitors are installed at the power entrance point of the equipment, or equipment sub-parts, to reduce the undervoltage effects in case of short circuit of one of equipment.

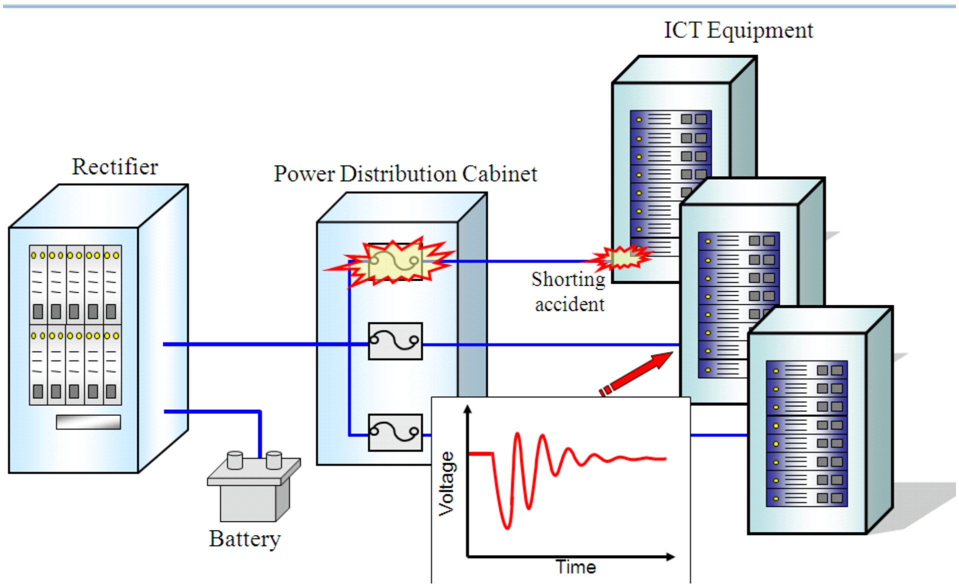


Figure G.1: Definition of transient voltage impact

Experiences of fuse/ circuit breaker blowing transients on 48 VDC distribution systems and on 400 VDC systems have been carried out. The transient is measured at interface A3 on one equipment, when the fault occurs on another equipment interface A3 (see figure G.1 and the case of a shorting accident).

The parameters of the proposed tests are:

- Cable lengths (between the power system and the load) of 3 m, 10 m, 30 m and 50 m; cables being sized with a maximum voltage drop of 10 V between the power system and the load.
- Load of 1 kW via a DC/DC converter to simulate a telecommunications and datacom (ICT) equipment.
- A suitable test generator defined in existing EMC standards for use in testing 400 VDC telecommunications and datacom (ICT) equipment being identified from existing solutions.

- Existing circuit breakers and fuses for 400 V being representative of the majority of possible solutions chosen after a worldwide collection of information.

NOTE 1: The fault current can reach kA, the voltage transient level voltage more than 200 V and the overvoltage last some tens of µs to tens of ms.

NOTE 2: The simulation principle of figure G.1 has been implemented in the simulator circuit of figure G.2. The floating battery voltage is 380 V. With a very short line of 3 m the maximum observed voltage transient is obtained.

With a prototype fuse of 30 A, the voltage at interface A3 (figure G.3) stays above 350 VDC, and below 405 VDC. The voltage drop is in the normal service voltage range while the voltage peak is in the abnormal service voltage range (400 VDC to 410 VDC). The time duration is 0,1 ms.

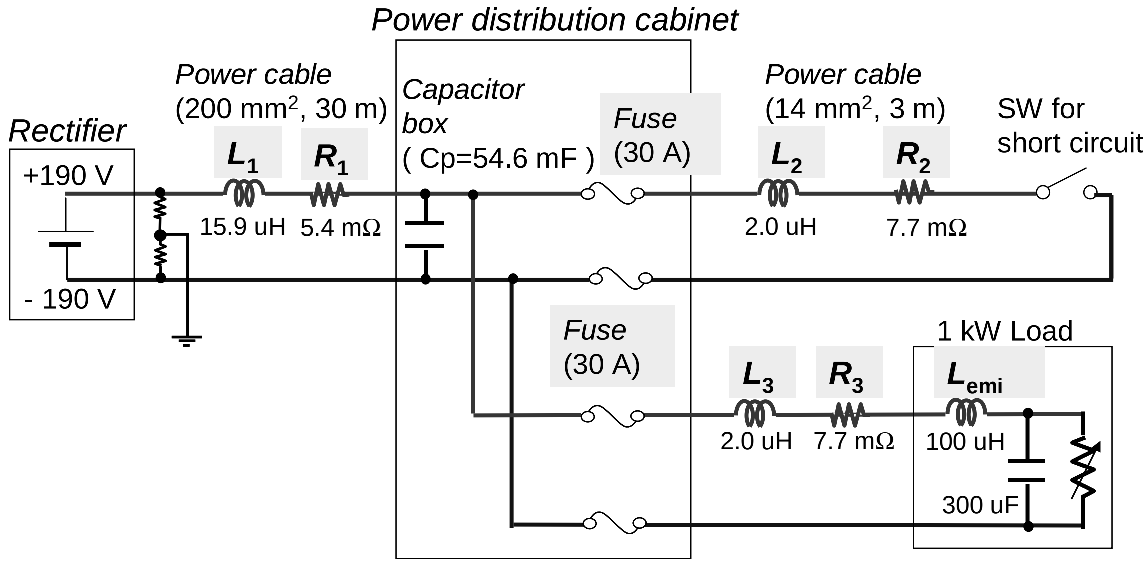


Figure G.2: Example of simulation circuit for short circuit and voltage transient measurement

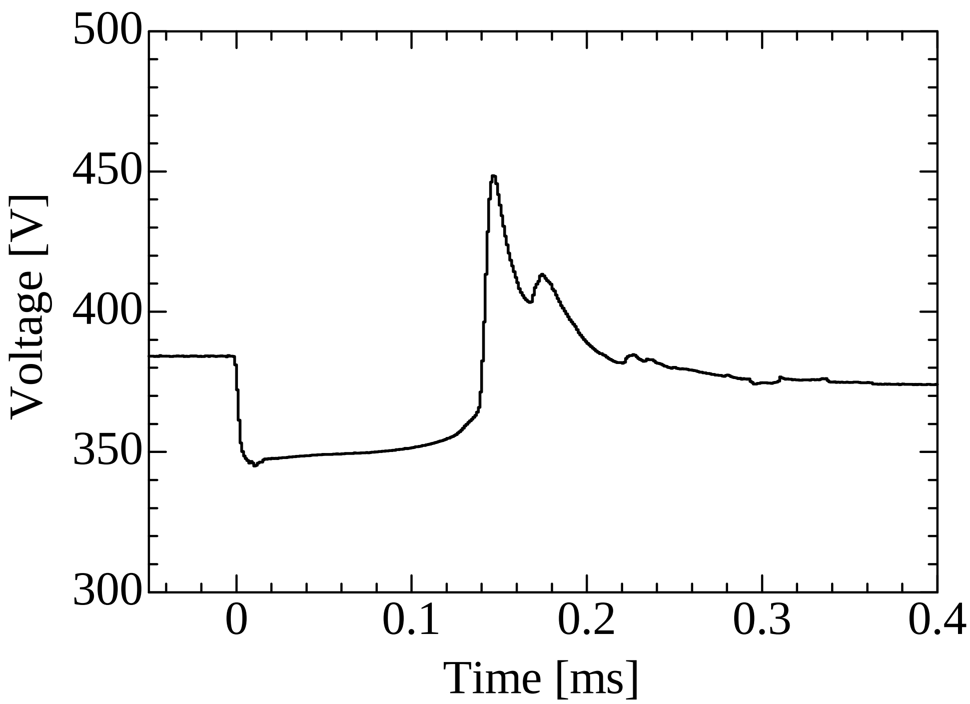


Figure G.3: Example of result of short circuit and voltage transient measurement on simulation circuit described in figure G.2

Annex H (informative): Diagram of voltage ranges and values at the interface A3

The present annex provides a diagram of the voltage definition contained in the present document (figure H.1).

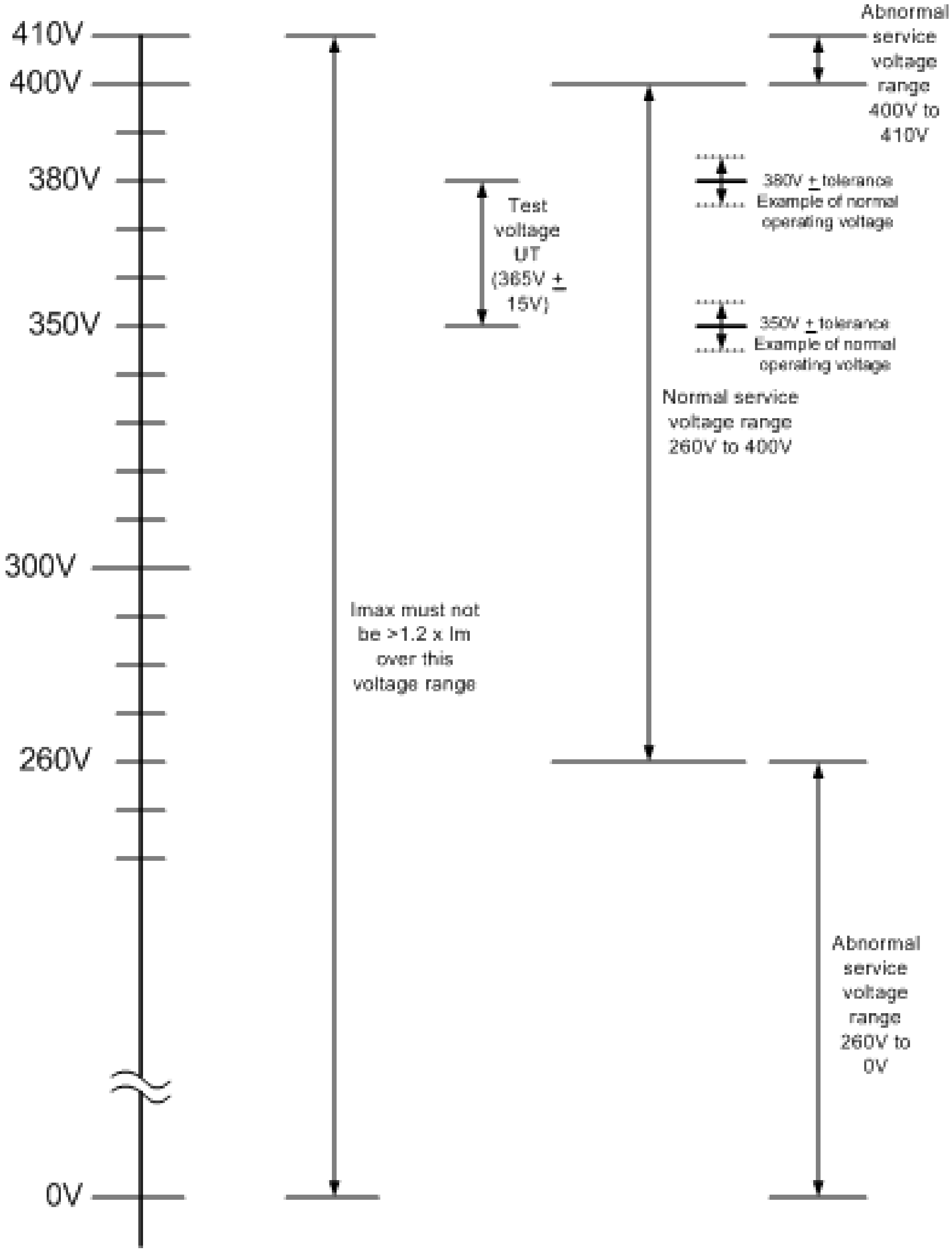


Figure H.1: Diagram of DC voltage ranges and values at the interface A3

History

Document history		
V1.2.1	August 2003	Publication as EN 300 132-3
V2.1.1	October 2011	One-step Approval Procedure OAP 20120209: 2011-10-12 to 2012-02-09
V2.1.1	February 2012	Publication