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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment

Recommendation ITU-T L.1200

ITU-T

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Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment

Summary

Recommendation ITU-T L.1200 specifies the direct current (DC) interface between the power feeding system and ICT equipment connected to it. It also describes normal and abnormal voltage ranges, and immunity test levels for ICT equipment to maintain the stability of telecommunication and data communication services. The specified interface is operated from a DC power source of up to 400 V to allow increased power consumption and equipment power density, in order to obtain higher energy efficiency and reliability with less material usage than using a lower voltage such as –48 VDC or AC UPS power feeding solutions.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T L.1200	2012-05-29	5

Keywords

Data centre, direct current, energy efficiency, ICT equipment, power feeding system, reliability, telecommunication centre.

FOREWORD

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Introduction

This Recommendation specifies a power feeding system for ICT equipment with a DC voltage of up to 400 V.

This Recommendation takes into consideration the improvements in energy efficiency as well as the reduction in greenhouse gas (GHG) emissions and raw materials that are enabled by using the 'up to 400 VDC' power feeding system. The 'up to 400 VDC' power feeding system was developed, due to increased power consumption and equipment power density, in order to obtain a higher energy efficiency with less material consumption than using a lower voltage such as –48 VDC or AC UPS power feeding solutions. One of the advantages of 'up to 400 VDC' power feeding is that it reduces intermediate power conversion stages (e.g., the inverter and power factor compensator can be eliminated) and it is lower current usage than –48 V feeding for the same power requirement, thereby improving the efficiency and reliability of the entire power feeding system.

This Recommendation is concerned with the requirements for the interface between the power feeding system and telecommunication and ICT equipment. It also includes requirements relating to its stability, safety and measurement. Reliability and scalability are easier to improve in DC compared to AC because phase synchronization and inverters are not required. The system architecture is also simpler.

The purpose of the 'up to 400 VDC' interface is to facilitate interworking of different loads, standardization of power feeding systems for ICT equipment, and installation, operation and maintenance of ICT equipment and systems with different origins.

In addition, the DC interface can also simplify the use of renewable energy power sources with DC output such as photovoltaic generators and fuel cell systems.

Recommendation ITU-T L.1200

Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment

1 Scope

This Recommendation is aimed at providing compatibility between the power feeding system and ICT equipment installed at telecommunication centres, data centres and customer premises. This Recommendation deals with the requirements for an up to 400 VDC interface between power feeding system and ICT equipment.

This Recommendation covers the following main items:

- The identification of a power feeding system with the same characteristics for all ICT equipment defined in any location where an up to 400 VDC interface is used, e.g., telecommunication centres, radio base stations, data centres and customer premises.
- The 'up to 400 VDC' voltage range in normal and abnormal service conditions at the interface defined in this Recommendation.
- Behaviour during voltage variation, dips, short interruptions, transients, inrush current, grounding, etc.

The general requirements for safety and earthing and bonding are out of the scope of this Recommendation unless specific requirements are not defined in current standards.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[IEC 60445] IEC 60445 (2010), *Basic and safety principles for man-machine interface, marking, and identification – Identification of equipment terminals, conductor terminations, and conductors*.

[IEC 61000-4-5] IEC 61000-4-5 (2005), *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*.

[IEC 61000-4-29] IEC 61000-4-29 (2000), *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*.

[ETSI EN 300-132-3-1] ETSI EN 300-132-3-1 (2012), *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 subpart 1: direct current (DC) up to 400 V solution*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 abnormal DC voltage range: DC voltage range at interface P where ICT equipment may not operate within its specification, but is not damaged.

3.2.2 DC voltage range: DC voltage range at interface P.

3.2.3 ICT equipment: Information and communication equipment (e.g., switch, transmitter, router, server, and peripheral devices) used in telecommunication centres, data centres and customer premises.

3.2.4 interface P: Interface, physical point, at which power feeding system is connected to operate ICT equipment. Refer to Figure 1.

3.2.5 normal DC voltage range: DC voltage range at interface P where ICT equipment operates within its specification.

3.2.6 power feeding system: Power source to which ICT equipment is intended to be connected.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current (also when used as a suffix to units of measurement)

DC Direct Current (also when used as a suffix to units of measurement)

EMC Electromagnetic Compatibility

GHG Green House Gas

ICT Information and Communication Technology

PE Protective Earth

Rg Resistance for the grounding system

UPS Uninterruptible Power Supply

U_T Reference test voltage

V_o output Voltage of power feeding system

VDC Volts DC

5 Conventions

None.

6 DC power feeding interface specification

This clause describes the DC power feeding interface to ICT equipment in data centres, telecommunication centres and customer premises.

6.1 Definition of DC power feeding interface

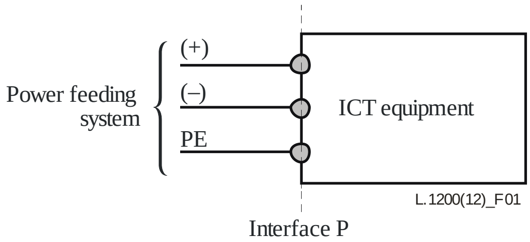

Figure 1 – Definition of interface P

The power feeding interface, shown as interface P in Figure 1, is a physical point at which all the requirements apply. This point is situated between the power feeding system and ICT equipment in accordance with [IEC 60445].

In this clause, all specifications are defined at the input of ICT equipment.

Figure 2 shows a typical use of interface P.

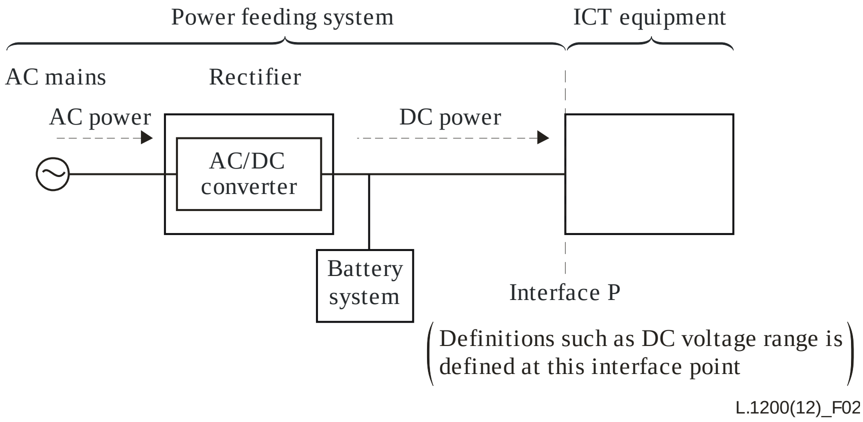

Figure 2 – Illustration of power feeding system and ICT equipment

6.2 Voltage range at interface P

6.2.1 Normal DC voltage range

The maximum environmental benefit will only be achieved by transitioning towards a single voltage interface: the target solution.

However, it is also recognized that there have already been some regional developments in DC for powering ICT equipment. To take advantage of the benefits resulting from a single voltage range interface (the target solution), a transitional period will be specified during which a transitional solution is allowed towards the single DC voltage range at the input of the ICT equipment.

The target delay for full implementation of the target solution shall be as short as possible from the date of publication of this Recommendation.

Target solution

This solution has the following characteristics:

The normal voltage range is the range of steady-state voltage over which ICT equipment shall maintain a specified normal service.

– The minimum voltage is 260 V.

– The maximum voltage is 400 V.

The voltage at the output of the power supply must take into account the voltage drop in the cable at a maximum steady current.

Any new ICT equipment or electrical room installation compliant with this Recommendation shall use this target voltage range (260-400 V).

Transitional solution

The transitional voltage range over which ICT equipment shall maintain a specified normal service is 192 V-288 V.

This can be used for the migration of DC systems towards the recommended target voltage range for a limited time in some regions.

6.2.2 Abnormal DC voltage range

ICT equipment may be subjected to steady-state voltage out of the normal DC voltage range for the target solution. The limits of an abnormal DC voltage range for the target solution are defined as follows:

– $0 \text{ V} < U < 260 \text{ V}$.

– $400 \text{ V} < U < 410 \text{ V}$.

After the restoration of the supply from the abnormal DC voltage range to the normal DC voltage range, the ICT equipment shall not incur any damage and will be able to automatically resume operation according to its specifications when the voltage comes back into the normal DC voltage range.

6.3 Reference test voltage (U_T) at interface P

Reference test voltages (U_T) for the target solution at interface P for ICT equipment are defined as $U_T = 380$ V or $U_T = 300$ V depending on system requirements.

NOTE – Different U_T can be defined because there can be different operating voltages inside the target voltage range.

6.4 Abnormal conditions

Under abnormal conditions, voltage values outside the normal DC voltage range for the target solution may occur for a short time. The deviations from the steady-state voltage at interface P may be caused by:

– voltage variations;

– voltage dips;

– voltage interruptions;

– voltage surges/transients.

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

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

Specific criteria for ICT equipment are defined in the tables below which display testing details. The detailed specifications of the generator are in Annex F of [ETSI EN 300-132-3-1]. The tests shall be performed on individual modules/subsystems.

Compliance criteria are as follows:

Criteria a) ICT equipment 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 for when the ICT equipment is used as intended.

Criteria b) Temporary loss of function or degradation of performance should cease after the disturbance ceases and the equipment under test should return to its normal performance level, without operator intervention.

6.4.1 Voltage variation

The voltage variation at interface P shall be tested by referring to [ETSI EN 300-132-3-1]. The condition and compliance criteria for testing are in Table 1.

Table 1 – Test levels, duration and compliance criteria for voltage variation

Voltage	Duration	Compliance criteria on 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 interface P within the normal DC voltage range.
From U_T to 400 V, back to U_T	1 min	Criteria a) Normal performance	Test of maximum operating voltage at interface P within the normal DC 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 increase variation entering the abnormal DC 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 increase variation outside the abnormal DC voltage range.

6.4.2 Voltage dips

The voltage interruption at interface P shall be tested by referring to [ETSI EN 300-132-3-1]. The condition and compliance criteria for testing are in Table 2.

Table 2 – Test levels, duration and compliance criteria for voltage dips

Voltage	Duration	Compliance criteria on ICT equipment	Comments
From U_T to 260V, back to U_T	10 ms	Criteria a) Normal performance	Test of minimum operating voltage at interface P within the normal DC voltage range.

6.4.3 Short interruptions

The short interruption at interface P shall be tested by referring to [ETSI EN 300-132-3-1]. The condition and compliance criteria for testing are in Table 3.

Table 3 – Test levels, duration and compliance criteria for short interruptions

Voltage	Supply network	Duration	Compliance criteria on ICT equipment	Comments
U_T to 0 V back to U_T	Low impedance (short circuit)	10 ms	Criteria a) Normal performance	Test of hold-up 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 P.

NOTE 1 – With reference to clauses 6.1.1 and 6.1.2 of [IEC 61000-4-29] the definition of low impedance is a 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 the reset of a tripped circuit-breaker on interface P or DC interruptions in the network caused by transient voltage. This reset can also occur with the recovery of interface P voltage following the restoration of AC mains after an AC mains interruption longer than the battery backup time.

6.4.4 Voltage surges/transients

The voltage surges at interface P shall be tested by referring to [IEC 61000-4-5] and [ETSI EN 300-132-3-1]. The condition and compliance criteria for testing are in Table 4.

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

The voltage surges due to short circuits and protective device clearance are characterized by a voltage drop in the abnormal voltage range, followed by an overvoltage often in excess of the maximum abnormal voltage range and dependent upon the power distribution up to interface P and the ICT equipment connected to interface P.

The purpose of this clause is thus to address the energy and subsequent so-called "fuse blowing surge" associated with a short circuit.

Other voltage surges induced from other external sources, e.g., faults on the AC mains or lightning, belong to EMC generic requirements and are outside the scope of this Recommendation.

Due to the lack of commercial test generators for testing voltage surges, according to this clause, references are, however, given for the EMC standard to reuse the so-called combination generator specified in [IEC 61000-4-5].

Table 4 – Test levels, wave shape and compliance criteria for voltage surges/transients

Test voltage	Supply network	Wave shape	Compliance criteria on ICT equipment	Comments
500 V	Line to line	1.2/50 µs (8/20 µs)	Criteria a) Normal performance	Test of voltage increase variation outside the abnormal voltage range (e.g., due to fuse blow, switching). Test voltage polarity shall be the same as for interface P.

Table 4 – Test levels, wave shape and compliance criteria for voltage surges/transients

Test voltage	Supply network	Wave shape	Compliance criteria on ICT equipment	Comments
500 V	Line to ground	1.2/50 μs (8/20 μs)	Criteria a) Normal performance	Test of voltage increase variation outside the abnormal voltage range (e.g., due to fuse blow, switching). Test voltage polarity shall be the same as for interface P.
2 kV	Line to line	1.2/50 μs (8/20 μs)	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 for interface P.
2 kV	Line to ground	1.2/50 μs (8/20 μs)	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 for interface P.

NOTE 1 – 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 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.

NOTE 3 – Special precautions are normally taken in power distribution networks to fulfil compliance criteria a) for mission critical ICT equipment, i.e., to prevent functional disturbances due to the voltage surges treated in this clause.

6.5 Inrush current

The inrush current pulse shall be limited in magnitude and in time duration to avoid protective devices clearance by excess current and energy passing through them.

The inrush current of ICT equipment at interface P shall be tested by referring to [ETSI EN 300-132-3-1].

Appendix I

Information on grounding method

(This appendix does not form an integral part of this Recommendation.)

I.1 Basic configuration

All cabinets/chassis in the 'up to 400 VDC' system should have a protective earth (PE). A high resistance R_g connected between each power line and ground at the output section of the rectifier shall be neutral. By using R_g, the ground-fault current should be controlled to be less than 20 mA. A protective circuit, such as a fuse/circuit-breaker, should be installed in the positive and negative power lines because both poles of the power line have a $V_o/2$ voltage to the ground level. (An example of the basic configuration is shown in Figure I.1.) Because of the necessity to ensure human safety, and due to the low level ground fault current, the power system should have a leakage current detector and an alarm function.

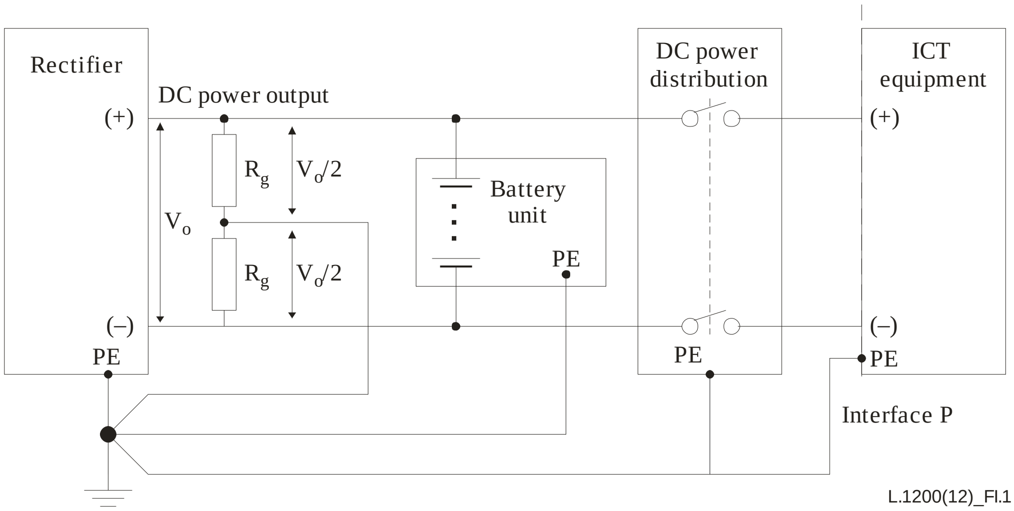

Figure I.1 – Example of the basic configuration of a grounding system for an 'up to 400 VDC' system

I.2 Specification for PE at interface P

The power lines and PE ports (PE ports are connected to the metallic enclosure of the equipment on Figures I.1 and I.2) at interface P of the PSU should be isolated. To ensure protection against any stray current, the input and output power ports of the PSU should be isolated; namely, the power converter should be isolated e.g., by a transformer (see Figure I.2).

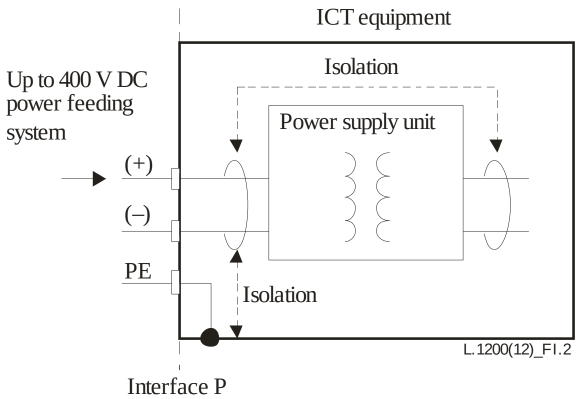

Figure I.2 – Grounding system configuration for an 'up to 400 VDC' system

The safety, earthing and bonding should use ITU-T work and other standards from IEC and ETSI.

In particular the use of interface P should maintain compliance with [b-IEC 60950-1].

If there is a need for monitoring including alarms, the interface protocol might be based on [b-ETSI ES 202 336-1] and [b-ETSI ES 202 336-2].

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