Final draft ETSI ES 203 726 V1.0.0 (2022-06)

ETSI STANDARD

Environmental Engineering (EE); Progressive migration of Information and Communication Technology (ICT) site to 400 VDC sources and distribution

Reference
DES/EE-0260

Keywords
energy efficiency, power supply, site engineering

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Executive summary

The present document gives explanation, requirements and guidance for increasing the use of up to 400 V Direct Current (400 VDC) power systems and the distribution to Information and Communication Technology (ICT) equipment. It includes 400 VDC remote powering up to 400 VDC of distributed ICT equipment, the option of interconnection of local renewable energy sources and their connection to DC power nanogrids and other users, extending the resilience capability of the telecommunication network and ICT sites to grid failures and climate change.

Introduction

Telecommunication network energy consumption and cost are increasing at a rate of several percentage points per year as reported in Trends in worldwide ICT electricity consumption from 2007 to 2012 [i.11]. The use of up to 400 V Direct Current (400 VDC) architecture (as presented in Table 1, Annex B and Annex C) can result in significant savings.

The use of up to 400 VDC solutions result in energy savings with higher efficiency and reduced distribution losses, reduction in maintenance cost due to higher reliability and lower unavailability, savings in space for power equipment in Information and Communication Technology (ICT) rooms (each square metre being of high cost) and, finally, more simplicity in site installation and development.

Different levels of saving and improvement result from a comparison of up to 400 VDC solutions to -48 V solutions (copper savings) or to Uninterrupted Power Supply (UPS) solutions (reliability, efficiency, easier installation). 400 VDC remote power can be beneficial.

As for the power system, energy savings in addition to those resulting from efficiency improvements depend on the load in the telecommunication or data centre. Energy efficiency should be evaluated at the system level, including the general distribution cabling and voltage conversion stages, as well as the internal power circuits inside the load downstream of the power interface, i.e. conversion architecture in the system (e.g. dual inputs, local back-up, AC/DC rectifier losses).

Indirect savings of up to 400 VDC solutions relate to lifecycle in the production and recycling phase as there should be less passage through copper and electronics as well as less battery usage for given output power and system dependability. Battery capacity and dependability savings are achieved by removing inverter losses if replacing AC UPS or by reducing -48 V distribution losses.

The present document specifies requirements for a safe migration of an existing site to a unified up to 400 VDC powering feeding system, power distribution and the power interface of telecommunication/ICT equipment. It includes requirements relating to the stability, cabling, earthing, as well as bonding and measurement, for the existing site.

The main significant components of up to 400 VDC equipment and additional progressive migration equipment are presented in Figures 2 and 3. These are schematic diagrams that do not show all the electrical arrangement details. The architecture under consideration complies with Recommendation ITU-T L.1204 [14] on electrical architecture, including energy storage defined in ETSI TS 103 553-1 [i.1] or Recommendation ITU-T L.1220 [i.2], technically equivalent, and with ETSI ES 203 474 [9] or Recommendation ITU-T L.1205 [15], technically equivalent, for DC coupling of a local Renewable Energy (REN) system on site or with DC nano/micro grid interconnecting sites with REN sources and storage or ICT equipment requiring remote powering. Smart DC nanogrids are under study as reported in Intelligent DC Microgrid Living Lab [i.12].

The migration simplifies the use of up to 400 VDC combined with REN and DC nanogrids and should extend resilience capability of telecommunication networks sites to grid failures and climate change.

The present document was developed jointly by ETSI TC EE and ITU-T Study Group 5. It is published respectively by ITU and ETSI as Recommendation ITU-T L.1207 [i.3] and ETSI ES 203 726 (the present document), which are technically-equivalent.

1 Scope

The present document defines solutions for progressive migration of Information and Communication Technology (ICT) sites (telecommunication and data centres) to up to 400 V Direct Current (400 VDC) distribution and direct use of up to 400 VDC powering ICT equipment from 400 VDC sources. The present document also defines different major use case options and migration scenarios, such as:

- migration to an up to 400 VDC of telecommunication site power solution;
- migration to an up to 400 VDC of data centre power solution;
- migration with up to 400 VDC power transfer between existing -48 V centralized sources to high power density -48 V equipment, such as routers;
- integration of up to 400 VDC remote powering;
- combined architecture with up to 400 VDC and AC sources and distributions possibly using hybrid power interfaces on ICT equipment.

For each of these, the present document describes many possible options and characteristics, such as:

- migration architecture with up to 400 VDC/-48 V conversion to power existing -48 V equipment using existing -48 V room distribution;
- conditions for tripping overcurrent protection devices without -48 V batteries;
- migration architecture with up to 400 VDC/AC inverter as an alternative to the AC UPS to power existing AC equipment;
- use of local up to 400 VDC for remote powering of ICT equipment;
- coupling up to 400 VDC systems to a local REN source or to a DC microgrid;
- possibility of conversion between battery and up to 400 VDC distribution, e.g. for long power distribution or short-circuit current or battery technology (e.g. lithium-ion).

The present document also gives a saving assessment frame reference to define the best migration scenario and its steps by considering energy, resource, environmental impact and cost savings based on functional aspects such as modularity, flexibility, reliability, efficiency and distribution losses, as well as maintenance evolution when migrating from -48 V or Alternating Current (AC) to up to 400 VDC solutions. This also includes consideration of load architecture evolution dependent on use cases (e.g. telecommunication site, data centres).

2 References

2.1 Normative 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 referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://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.

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

[1] ETSI EN 300 132-1 (V2.1.1) (2019): "Environmental Engineering (EE); Power supply interface at the input to Information and Communication Technology (ICT) equipment; Part 1: Alternating Current (AC)".

[2] ETSI EN 300 132-2 (V2.6.1) (2019): "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 2: -48 V Direct Current (DC)".

[3] ETSI EN 300 132-3 (V1.2.1) (2003): "Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V".

[4] ETSI EN 300 253 (V2.2.1) (2015): "Environmental Engineering (EE); Earthing and bonding of ICT equipment powered by -48 VDC in telecom and data centres".

[5] ETSI EN 301 605 (V1.1.1) (2013): "Environmental Engineering (EE); Earthing and bonding of 400 VDC data and telecom (ICT) equipment".

[6] ETSI ES 202 336-2 (V1.1.1) (2009): "Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (Power, Cooling and environment systems used in telecommunication networks); Part 2: DC power system control and monitoring information model".

[7] ETSI ES 203 199 (V1.3.1) (2015): "Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services".

[8] ETSI ES 203 408 (V1.1.1): "Environmental Engineering (EE); Colour and marking of DC cable and connecting devices".

[9] ETSI ES 203 474 (V1.1.1): "Environmental Engineering (EE); Interfacing of renewable energy or distributed power sources to 400 VDC distribution systems powering Information and Communication Technology (ICT) equipment".

[10] ETSI TS 103 531 (V1.1.1): "Environmental Engineering (EE); Impact on ICT equipment architecture of multiple AC, -48 VDC or up to 400 VDC power inputs".

[11] Recommendation ITU-T L.1200 (2012): "Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment".

[12] Recommendation ITU-T L.1202 (2015): "Methodologies for evaluating the performance of an up to 400 VDC power feeding system and its environmental impact".

[13] Recommendation ITU-T L.1203 (2016): "Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems".

[14] Recommendation ITU-T L.1204 (2016): "Extended architecture of power feeding systems of up to 400 VDC".

[15] Recommendation ITU-T L.1205 (2016): "Interfacing of renewable energy or distributed power sources to up to 400 VDC power feeding systems".

[16] Recommendation ITU-T L.1206 (2017): "Impact on ICT equipment architecture of multiple AC, -48 VDC or up to 400 VDC power inputs".

[17] Recommendation ITU-T L.1320 (2014): "Energy efficiency metrics and measurement for power and cooling equipment for telecommunications and data centres".

[18] Recommendation ITU-T L.1410 (2014): "Methodology for environmental life cycle assessments of information and communication technology goods, networks and services".

[19] IEC 60364 (all parts): "Low-voltage electrical installations".

2.2 Informative 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 referenced document (including any amendments) applies.

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

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 TS 103 553-1 (V1.1.1): "Environmental Engineering (EE); Innovative energy storage technology for stationary use; Part 1: Overview".

[i.2] Recommendation ITU-T L.1220 (2017): "Innovative energy storage technology for stationary use - Part 1: Overview of energy storage".

[i.3] Recommendation ITU-T L.1207 (2018-05): "Progressive migration of a telecommunication/information and communication technology site to 400 VDC sources and distribution".

[i.4] ETSI EN 302 099 (V2.1.1) (2014): "Environmental Engineering (EE); Powering of equipment in access network".

[i.5] Recommendation ITU-T K.48 (2017): "EMC requirements for telecommunication equipment - Product family Recommendation".

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

[i.7] IEC 62368-1: "Audio/video, information and communication technology equipment - Part 1: Safety requirements".

[i.8] ETSI EN 300 132-3-1 (V2.1.1) (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; Sub-part 1: Direct current source up to 400 V".

[i.9] ETSI EN 300 386 (V2.1.1) (2016): "Telecommunication network equipment; ElectroMagnetic Compatibility (EMC) requirements; Harmonised Standard covering the essential requirements of the Directive 2014/30/EU".

[i.10] ETSI TR 100 283 (V2.2.1) (2007): "Environmental Engineering (EE); Transient voltages at Interface "A" on telecommunications direct current (dc) power distributions".

[i.11] Van Heddeghem W., Lambert S., Lannoo B., Colle D., Pickavet M., Demeester P. (2014): "Trends in worldwide ICT electricity consumption from 2007 to 2012". Computer Communications, 50, 64-76.

NOTE: Available at https://doi.org/10.1016/j.comcom.2014.02.008.

[i.12] Aalborg University: "Intelligent DC Microgrid Living Lab".

[i.13] Tsumura T, Takeda T, Hirose K (2008): "A tool for calculating reliability of power supply for information and communication technology systems". In Intelec 2008 - IEEE 30th International Telecommunications Energy Conference, 21.3, 6 pp., San Diego.

[i.14] Marquet D, Tanaka T, Murai K, Tanaka T, Babasaki T (2013): "DC power wide spread in Telecom/Datacenter and in home/office with renewable energy and energy autonomy". In Intelec 2013 - IEEE 35th International Telecommunications Energy Conference, Smart Power and Efficiency, pp. 499-504, Hamburg.

[i.15] Caltech Berkeley 2017 Vossos V, Johnson K, Kloss M, Khattar M, Gerber D, Brown R: "Review of DC power distribution in buildings: A technology and market assessment" pp.71.

[i.16] Schneider WP 118 Rasmussen N (undated): "High-efficiency AC power distribution for data centers". White Paper 128. Rueil-Malmaison: Schneider Electric. 19 pp.

[i.17] CE+T Intelec 2016 Frebel F. (eFFiciency research), Bleus P. Bomboir O. (CE+T Power, sa): "Transformer-less 2 kW non isolated 400 VDC/230 VAC single stage micro inverter". In Intelec 2016 - IEEE International Telecommunications Energy Conference, Austin.

NOTE: Available at https://ieeexplore.ieee.org/document/7749105.

[i.18] CATR Intelec 2012 Qi S, Hou F, Jing H: "Study and application on high voltage DC power feeding system for telecommunications in China". In Intelec 2012 - IEEE 34th International Telecommunications Energy Conference, pp. 9.1. 5, Scottsdale.

NOTE: Available at https://ieeexplore.ieee.org/xpl/conhome/6362321/proceeding.

[i.19] CAICT Intelec 2017 Qi S, Sun W, Wu Y: "Comparative analysis on different architectures of power supply system for data center and telecom center". In Intelec 2017 - IEEE International Telecommunications Energy Conference, pp. 26-29, Queensland.

[i.20] DCC+G Fraunhofer 2014 Wunde B: "380VDC in commercial buildings and offices". Presentation at Vicor Seminar 2014. 71 slides.

NOTE: Available at http://dcgrid.tue.nl/files/2014-02-11%20-%20Webinar%20Vicor.pdf.

[i.21] Fraunhofer Safety Intelec 2017 Kaiser J et al.: "Safety consideration for the operation of bipolar DC grids". In Intelec 2017 - IEEE International Telecommunications Energy Conference, pp. 327-334, Queensland.

[i.22] Fraunhofer Droop Intelec 2017 Wunder B et al.: "Droop controlled cognitive power electronics for DC microgrids". In Intelec 2017 - IEEE International Telecommunications Energy Conference, pp. 335-342, Queensland.

[i.23] Void.

[i.24] Fujitsu-NTT-Appliance coupler-Intelec 2017 Kiryu K, Tanaka T, Sato K, Seki K, Hirose K: "Development of appliance coupler for LVDC in information communication technology (ICT) equipment with having a protection of inrush current and arc". In Intelec 2017 - IEEE International Telecommunications Energy Conference, pp. 343-346, Queensland.

[i.25] level3-Eltek Intelec 2016 Ambriz A. (Level 3 Communications), Kania M. (Eltek): "A service provider's decision to move from 48V to 380V powering: The problem statement, technical assessment, financial analysis and practical implementation plan". In Intelec 2016 - IEEE International Telecommunications Energy Conference, Austin.

NOTE: Available at https://ieeexplore.ieee.org/document/7749117.

[i.26] NTT Intelec 1999 Yamashita T, Muroyama S, Furubo S, Ohtsu S: "270 V DC System - A highly efficient and reliable power supply system for both telecom and datacom systems". In Intelec 1999 - IEEE 21st International Telecommunication Energy Conference, PI 1-3. 5 pp., Copenhagen.

[i.27] NTT-f Intelec 2016 Hiroya Yajima, Kenichi Usui, Toshiyuki Hayashi (R&D and datacenter, NTT Facilities Japan): "Energy-saving effects of super computers by using on-site solar power and direct HVDC feeding systems". In Intelec 2016 - IEEE International Telecommunications Energy Conference, Austin.

NOTE: Available at https://ieeexplore.ieee.org/document/8214133.

[i.28] NTT-f Intelec 2011 Hirose K, Tanaka T, Babasaki T, Person S, Foucault O, Sonnenberg BJ, Szpek M: "Grounding concept considerations and recommendations for 400 VDC distribution system". In Intelec 2011 - IEEE 33rd International Telecommunications Energy Conference, 8 pp., Amsterdam.

[i.29] NTT Intelec 2012 Tanaka T, Hirose K, Marquet D, Sonnenberg BJ, Szpek M: "Analysis of wiring design for 380-VDC power distribution system at telecommunication sites". In Intelec 2012 - IEEE 34th International Telecommunications Energy Conference, 15.2. 5 pp., Scottsdale.

[i.30] OCP Orange: "400 VDC power feeding architecture", OCP 2017.

NOTE: Available at http://www.opencompute.org/wiki/Telcos.

[i.31] OCP Murata (2017): "Open compute power solutions". 4 pp.

NOTE: Available at https://www.avnet.com/wps/wcm/connect/onesite/584cd2d9-7c90-4465-83bc-15501e9bc430/Murata-ocp-EN-Brochure.pdf?MOD=AJPERES&CVID=lMbA3cq&CVID=lMbA3cq.

[i.32] Orange Intelec 2011 Marquet D, Foucault O, Acheen J, Turc JF, Szpek M, Brunarie J: "Pre roll-out field test of 400 VDC power supply: The new alliance of Edison and Tesla towards energy efficiency". In Intelec 2011 - IEEE 33rd International Telecommunications Energy Conference, 8 pp., Amsterdam.

[i.33] Orange Intelec 2016 Foucault O, Marquet D, le Masson S: "400 VDC Remote Powering as an alternative for power needs in new fixed and radio access networks". In Intelec 2016 - IEEE International Telecommunications Energy Conference, TS19.3, 9 pp, Austin.

[i.34] Orange Intelec 2017 Marquet D, Foucault O, Pichon JM,, Hirose K, Bianco C, Hockley R: "Telecom operators to accelerate the migration towards 400 volt direct current - Efficient powering for telecom/ICT equipment and coupling sites to smart energy microgrids". In Intelec 2017 - IEEE International Telecommunications Energy Conference, pp. 196-203, Queensland.

[i.35] Orange Intelec 1999 Marquet D, San Miguel F, Gabillet JP: "New power supply optimised for new telecom networks and services". In Intelec 1999 - IEEE 21st International Telecommunication Energy Conference, 25-1. 8 pp., Copenhagen.

[i.36] Orange Intelec 2005 Marquet D, Kervarrec G, Foucault O: "New flexible powering architecture for integrated service operators". In Intelec 2005 - IEEE 27th International Telecommunications Conference, pp. 575-580, Berlin.

[i.37] Schneider WP 151 Rasmussen N (undated): "Review of four studies comparing efficiency of AC and DC distribution for data centers". White Paper 151, Rueil-Malmaison: Schneider Electric, 12 pp.

[i.38] Schneider WP 127 Rasmussen N, Spitaels J (undated): "A quantitative comparison of high efficiency AC vs. DC power distribution for data centers". White Paper 127, Rev 2. Rueil-Malmaison: Schneider Electric, 23 pp.

[i.39] Telstra Intelec 2017 Yong M, Bettle D: "Deploying HVDC in existing network exchanges: Practical and financial benefits for telecommunications carriers". In Intelec 2017 - IEEE International Telecommunications Energy Conference, pp. 204-207, Queensland.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

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

NOTE: Available in ETSI EN 300 132-2 [2].

advanced battery: battery of more performant technology, e.g. lithium battery compared to mainly used legacy battery technology used in telecommunication and data centres, i.e. Valve-Regulated Lead-Acid (VRLA)

DC/DC converter: power electronic system that transfers energy from one DC voltage (level) to another DC voltage (level)

ICT equipment: device, in the telecommunication network infrastructure, that provides an ICT service

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

NOTE: Available in ETSI EN 300 132-2 [2].

interface A1: interface, physical point, at which AC power supply is connected in order to operate the telecommunications and datacom (ICT) equipment

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

NOTE: Available in ETSI EN 300 132-1 [1].

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

normal operation: operation in typical environmental and powering conditions for telecommunications and datacom (ICT) equipment, power supply, power distribution and battery at normal service

normal service: service mode where telecommunications and datacom (ICT) equipment operates within its specification which includes a defined restart time after malfunction or full interruption

NOTE: Available in ETSI EN 300 132-2 [2].

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

NOTE: Available in ETSI EN 300 132-2 [2].

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

NOTE: A power source can be at building level, room level, rack level or a unit inside ICT equipment that feeds power at a defined interface where it is required.

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

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

NOTE: Available in ETSI EN 300 132-3-1 [i.8].

3.2 Symbols

Void.

3.3 Abbreviations

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

4G	fourth Generation
5G	fifth Generation
AC	Alternating Current
AC ICT	AC Information & Communication Technology
AC UPS	AC Uninterruptable Power Supply
ATS	Automatic Transfer Switch
CAPEX	Capital Expenditure
DC	Direct Current
DCC	DC Components
DCC+G	DC Components and Grids
DoD	Depth of Discharge
EMC	ElectroMagnetic Compatibility
FTTx	Fibre To The x
HRMG	High Resistance Middle point Grounding
HVDC	High-Voltage Direct Current