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SERIES L: ENVIRONMENT AND ICTS, CLIMATE
CHANGE, E-WASTE, ENERGY EFFICIENCY;
CONSTRUCTION, INSTALLATION AND PROTECTION
OF CABLES AND OTHER ELEMENTS OF OUTSIDE
PLANT

Extended architecture of power feeding systems of up to 400 VDC

Recommendation ITU-T L.1204

ITU-T

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Recommendation ITU-T L.1204

Extended architecture of power feeding systems of up to 400 VDC

Summary

Recommendation ITU-T L.1204 describes the extended architecture of power feeding systems of up to 400 V direct current (VDC) for information and communication technology (ICT) equipment in telecommunication centres, data centres and customer premises. It describes aspects such as configuration, redundancy, power distribution and monitoring, in order to construct safe, reliable and manageable power feeding systems. This Recommendation can be used also as an architecture reference model for future Recommendations e.g., on the performance of DC power feeding systems.

This Recommendation describes extended power feeding architectures using up to 400 VDC e.g., hybrid redundant DC and alternating current (AC) power feeding based on Recommendation ITU-T L.1201.

History

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FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Introduction

Power feeding systems of up to 400 V direct current (VDC) have been developed to cope with an increase in power consumption and equipment power density. In this Recommendation, consideration is given to improvements in energy efficiency, as well as the reduction in greenhouse gas (GHG) emissions and raw materials use.

The up to 400 VDC interface between the power feeding system and any information and communication technology (ICT) equipment connected to it is specified in [ITU-T L.1200]. This Recommendation specifies architectures of up to 400 VDC power feeding systems and aims to provide a safe architecture reference for an up to 400 VDC power feeding system with reliability and manageability adapted to requirements.

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 gives lower current usage than a –48 VDC power feeding system for the same power requirement.

Many papers have assessed the potential gains of using DC power feeding systems for ICT equipment in telecommunication centres, data centres and customer premises, e.g., [b-CCSA YD/T 2378], [b-Tanaka, 2012], [b-Shuguang, 2012], [b-Marquet, 2013], and these papers refer to many other references.

The common range of energy saving is generally up to 15% depending on the legacy solution based on the alternating current uninterruptible power supply (AC UPS) that is replaced and especially if the best class of DC power feeding system is used. This saving could be applied to the 200 TWh of datacentre energy consumption assessed at the global level e.g., in [b-Koomey, 2011].

Improvements in reliability and availability vary between factors of 2 for a simple architecture to 20 for a full end-to-end redundant architecture; this is based on many of the papers listed in the bibliography: [b-Kervarrec, 2004], [b-Han, 2007], [b-Tsumura, 2008], [b-Bauer, 2006] and [b-Liu, 2010].

Compared to a centralized –48 VDC architecture, a reduction of 10% to 50% in copper usage has been precisely recorded, while for a decentralized –48 VDC architecture, a reduction of 60% in battery sizes was reached [b-Tanaka, 2012].

Many studies show that there is a reduction in the initial set-up costs that can be as high as 20%, and a reduction in the running costs where savings could come from making fewer site interventions and trips. Also, there is, in general, less maintenance with modular rectifiers because the system is easier to operate with ICT equipment working directly, backed up by the battery power directly coupled to the DC outputs.

Additional gains are presumed in the simplification of connecting renewable DC sources or other distributed generators (fuel cells, DC engine generators, DC wind generators, etc.).

Due to the urgency to find a solution to the growing power problem, it is believed that interim solutions applicable in the short term could be considered. One of these is the use of up to 400 VDC only as means to transport energy from the 48 V energy system to the 48 V powered equipment. This could then evolve through the deployment of powered equipment able to be directly fed through an up to 400 VDC power feeding system.

For complementary information on power architectures specified in this Recommendation, it may be useful to refer to [b-ITU-T L.1300], [b-IEC 60896], [b-IEC TS 60479-1], [b-IEC 60950-1], [b-IEEE 1184], [b-IEEE 1491] and [b-ETSI TR 102 121].

Recommendation ITU-T L.1204

Extended architecture of power feeding systems of up to 400 VDC

1 Scope

This Recommendation specifies a power feeding architecture for power feeding systems of up to 400 V direct current (VDC) at telecommunications centres, datacentres and customer premises [ITU-T L.1200]. This Recommendation aims to provide a reference of power feeding architecture for an up to 400 VDC power feeding system with high reliability, safety and manageability. This Recommendation covers the following items for power feeding systems of up to 400 VDC:

- 1) configuration of power feeding systems of pure up to 400 VDC and hybrid power feeding systems with up to 400 VDC and alternating current (AC) power feeding systems;
- 2) requirements of the main basic elements for power feeding systems of up to 400 VDC, such as rectifiers, power distribution units (PDUs), batteries and distribution power lines;
- 3) monitoring and management functions.

This Recommendation ensures a safe, operable, electromagnetic compatibility- (EMC)-compliant and reliable cohabitation of power feeding systems of up to 400 VDC with AC and –48 VDC [ETSI EN 300 132-2] systems in sites combining these power feeding interfaces.

The full description of a battery, grid AC supply, backup generator and power supply units (PSUs) in ICT equipment and renewable or distributed energy sources are outside of the scope of this Recommendation, but indications are given on their influence on the architecture of power feeding systems of up to 400 VDC.

This Recommendation describes extended power feeding architectures using up to 400 VDC e.g., hybrid redundant DC and alternating current (AC) power feeding based on [ITU-T L.1201].

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.

- | | |
|----------------|---|
| [ITU-T K.20] | Recommendation ITU-T K.20 (2016), <i>Resistibility of telecommunication equipment installed in a telecommunication centre to overvoltages and overcurrents.</i> |
| [ITU-T L.1200] | Recommendation ITU-T L.1200 (2012), <i>Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment.</i> |
| [ITU-T L.1201] | Recommendation ITU-T L.1201 (2014), <i>Architecture of power feeding systems of up to 400 VDC</i> |
| [ITU-T L.1202] | Recommendation ITU-T L.1202 (2015), <i>Methodologies for evaluating the performance of an up to 400 VDC power feeding system and its environmental impact.</i> |

[ITU-T L.1203]	Recommendation ITU-T L.1203 (2016), <i>Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems.</i>
[ETSI EN 300 132-2]	ETSI EN 300 132-2 V2.4.16 (2016), <i>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>
[ETSI EN 301 605]	ETSI EN 301 605 V1.1.1 (2013), <i>Environmental Engineering (EE); Earthing and bonding of 400 VDC data and telecom (ICT) equipment.</i>
[ETSI ES 202 336-1]	ETSI ES 202 336-1 V1.2.1 (2011), <i>Environmental Engineering (EE); Monitoring and Control Interface for Infrastructure Equipment (Power, Cooling and Building Environment Systems used in Telecommunication Networks) Part 1: Generic Interface.</i>
[IEC 60364-1]	IEC 60364-1 (2005), <i>Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions.</i>
[IEC 60364-4-41]	IEC 60364-4-41 (2005), <i>Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock.</i>

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 distributed power source [ITU-T L.1201]: A local electrical power source where energy is produced close to the user and distributed by a microgrid by opposition to a centralized power plant with a long distance electricity transport grid. This local power source can be an individual user power system or a small collective energy power plant for a group of customers. It can include energy sources or storage or cogeneration of heat and electricity using any primary energy renewable or not.

3.1.2 ICT equipment [ITU-T L.1200]: Information and communication equipment (e.g., switch, transmitter, router, server, and peripheral devices) used in telecommunication centres, data centres and customer premises.

3.1.3 interface P [ITU-T L.1200]: Interface, physical point, at which a power feeding system is connected to operate ICT equipment.

3.1.4 renewable energy [ITU-T L.1201]: This is mainly non-fossil fuel converted into electricity (e.g., solar energy, wind, water flow, biomass).

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
CPU	Central Processing Unit
DC	Direct Current
EMC	Electromagnetic Compatibility
FC	Fuel Cell

GHG	Greenhouse Gas
ICT	Information and Communication Technology
IMD	Insulation Monitoring Device
IP	Internet Protocol
MTTR	Mean Time To Repair
PDU	Power Distribution Unit
PSU	Power Supply Unit
PV	Photovoltaic
REST	Representational State Transfer
TCP	Transmission Control Protocol
UPS	Uninterruptible Power Supply
VRLA	Valve-Regulated Lead Acid
WG	Wind Generator

5 Conventions

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

5.1 Earthing configurations

[IEC 60364-1] distinguishes three families of earthing arrangements, using the two-letter codes TN, TT and IT.

The first letter indicates the connection between earth and the power-supply equipment (generator or transformer):

"T" – Direct connection of a point with earth (Latin: terra).

"I" – No point is connected with earth (isolation), except perhaps via a high impedance.

The second letter indicates the connection between earth and the electrical device being supplied:

"T" – Direct connection of a point with earth.

"N" – Direct connection to neutral at the origin of installation, which is connected to the earth.

6 Configuration of power feeding systems of up to 400 VDC

A typical configuration of a power feeding system in the end-to-end power chain is shown in Figure 1, which provides a functional description of a power system without any redundancy.

The power feeding system of up to 400 VDC is powered by an AC supply (e.g., AC grid with AC backup generator) and feeds power to interface P. The power feeding system of up to 400 VDC consists of a rectifier, a battery, a power distribution unit (PDU) and power distribution lines.

The rectifier converts AC power to DC power and regulates DC voltage. It feeds power to interface P through a PDU. Power supply units (PSUs) installed in the input of ICT equipment convert the power to operate loads, such as central processing units (CPUs) and peripherals in ICT equipment. The battery can be recharged using DC power by the same rectifier, which has charging control functions. Distribution power lines connect the battery to the rectifier, the rectifier to the PDU and the PDU to interface P.

This clause presents several configurations of power feeding systems of up to 400 VDC with regard to reliability, safety and manageability.

System configuration should be chosen taking into account user requirements and the features of the system configuration. The main items to consider in the choice of configuration for the up to 400 VDC power system are as follows:

- reliability and availability requirements;
- delay for intervention;
- simplicity of maintenance and the skill of maintenance staff: without or with voltage (hotplug);
- redundancy level inside ICT equipment.

NOTE 1 – [b-ITU-T L.1001] adapters with a DC power interface as defined in [ITU-T L.1200], also enabling ICT terminal devices powered by the DC power feeding system may be used in telecommunication or data communication rooms and in a tertiary office, even without a small dedicated AC UPS.

NOTE 2 – The input of the rectifiers in terms of voltage, current and frequency should be compliant with the specification of the AC power grid.

NOTE 3 – Reliability, availability and efficiency performance assessment are defined in [ITU-T L.1202].

NOTE 4 – The AC power supply (AC grid, AC backup generator, e.g., diesel generator, gas turbine generator) and the PSU in ICT equipment are outside the scope of this Recommendation, as are power feeding systems of up to 400 VDC with renewable energy or distributed power sources. However, systems with renewable energy or distributed power sources are described in Appendix V.

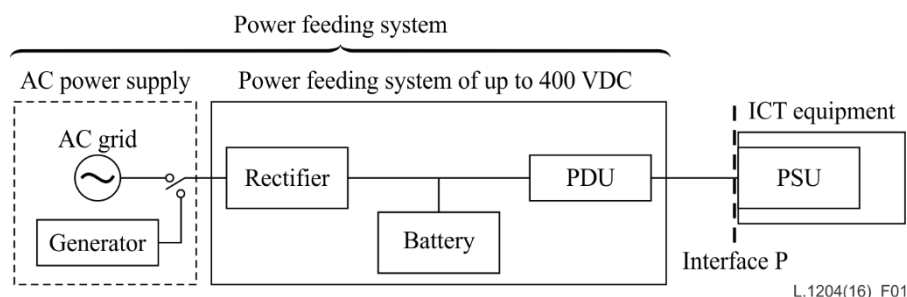


Figure 1 – Typical power feeding system configuration integrating a power feeding system of up to 400 VDC

6.1 Basic single DC power feeding system configuration

The simplest configuration of an up to 400 VDC power feeding system, as shown in Figure 2, includes only the following main elements: rectifier, PDU and distribution power lines. This system is more cost-effective than other configurations. However, there are neither backup AC or DC power sources nor any redundancy. Therefore, this power feeding system of up to 400 VDC is not able to feed power to devices such as CPUs and peripherals in the case of electrical outage of the AC grid, failure of one element of the power feeding system (rectifier, PSU, distribution power lines) or failure of the PSU.

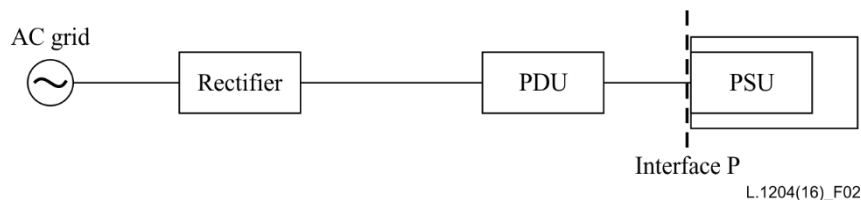


Figure 2 – Simplest system configuration of up to 400 VDC power feeding system

6.2 Power feeding system of up to 400 VDC with backup solution

In order to provide power to interface P without interruption due to electrical outages of the AC grid or the failure of a rectifier, the power feeding system of up to 400 VDC can integrate a battery and it can be fed by an AC power supply with a backup power source such as a generator.

Figure 3 shows the power feeding system of up to 400 VDC with a battery and an AC backup generator.

The batteries provide power to interface P instead of the rectifier if the rectifier fails or the AC power supply is interrupted. The battery can be configured with redundancy that is obtained by two or more strings. The battery redundancy allows a partial tolerance to battery fault, i.e., a battery string can fail in an open circuit without losing its backup ability, but battery-operating time (discharge time) is reduced. This also allows for battery maintenance without complete loss of its backup function during a battery cell or battery string replacement.

If an AC backup generator is installed, the length of the battery-operating time is less critical. However, a battery's main function is to provide power during the starting time of the AC backup generator. Therefore, on installation of an AC backup generator, batteries should be also installed.

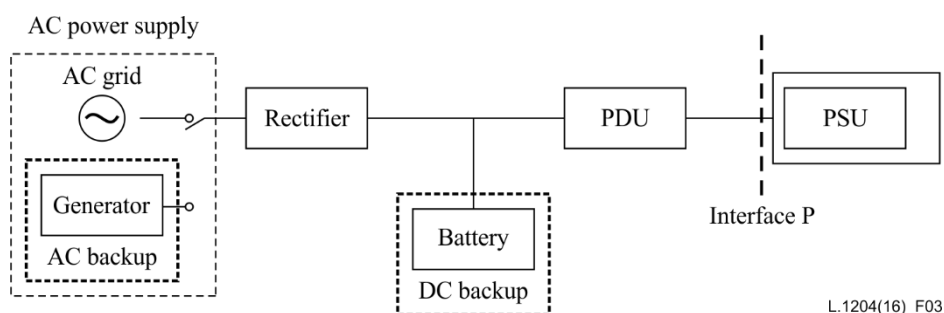


Figure 3 – Power feeding system of up to 400 VDC with backup solution

NOTE 1 – The AC power supply can be ensured by an AC power source (the AC grid and an AC backup generator). The AC power source can be in a single or redundant configuration depending on the required level of power availability. The rectifier can be powered from multiple AC grid distribution paths if one of the AC grid distribution paths fails. The same is possible from the AC backup generator.

NOTE 2 – It is also possible to have a DC backup generator coupled to the DC power chain at the output of a rectifier.

NOTE 3 – Other configurations can improve the availability such as:

- A connection arrangement for an external emergency mobile AC generator to power the site if AC power supply problems occur (e.g., due to long duration AC grid maintenance by the electricity supplier or due to common mode failures of the AC grid and local AC backup generator).
- A connection arrangement of a DC backup generator directly to the DC power chain on the DC bus that is useful if the AC power path to the rectifier's input fails (e.g., due to fire in the AC distribution).

NOTE 4 – Other configurations of power functionalities are possible where the battery is not directly connected to the DC output of rectifiers. Some configurations can optimize the rectifiers by removing charger function and are presented in Appendix IV with a separate charger for batteries and a voltage booster option.