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

**Impact on information and communication
technology equipment architecture of multiple
AC, -48 VDC or up to 400 VDC power inputs**

Recommendation ITU-T L.1206

ITU-T



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**ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION,
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OPTICAL FIBRE CABLES	
Cable structure and characteristics	L.100–L.124
Cable evaluation	L.125–L.149
Guidance and installation technique	L.150–L.199
OPTICAL INFRASTRUCTURES	
Infrastructure including node element (except cables)	L.200–L.249
General aspects and network design	L.250–L.299
MAINTENANCE AND OPERATION	
Optical fibre cable maintenance	L.300–L.329
Infrastructure maintenance	L.330–L.349
Operation support and infrastructure management	L.350–L.379
Disaster management	L.380–L.399
PASSIVE OPTICAL DEVICES	L.400–L.429
MARINIZED TERRESTRIAL CABLES	L.430–L.449

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T L.1206

Impact on information and communication technology equipment architecture of multiple AC, –48 VDC or up to 400 VDC power inputs

Summary

Recommendation ITU-T L.1206 discusses multiple power supply interfaces to information and communication technology (ICT) equipment operated by dual power input feeds with combinations of standardized –48 V direct current (DC) or alternating current (AC) sources, or DC source up to 400 V interfaces. Operational voltage and interface characteristics are detailed in ITU-T Recommendations and European Telecommunications Standards Institute (ETSI) relevant standards. This Recommendation also includes some details on the power architecture within the ICT equipment between the ICT power interface and the ICT end load.

History

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Table of Contents

	Page
1 Scope.....	1
2 References.....	1
3 Definitions	1
3.1 Terms defined elsewhere	1
3.2 Terms defined in this Recommendation.....	2
4 Abbreviations and acronyms	2
5 Conventions	3
6 Definition and requirements of multiple power interface configuration at the input of ICT equipment.....	3
6.1 Individual power interface used for multiple power interface configuration.....	3
6.2 Multiple power interface configurations and requirements.....	3
7 Combination dependence of A, A3 and A3ac interfaces for multiple power feeds	7
8 Backfeeding	10
Appendix I – Power input switch selector installation options.....	12
I.1 External switch selector installation and options for system interface connections	12
I.2 Switch selector installed within converter and interface connections.....	13
Appendix II – Power input switch selector – General functionality.....	15
II.1 General description of the power input switch selector	15
II.2 Input power monitoring	15
Appendix III – Backfeeding protection	16
III.1 Example of backfeeding protection.....	16
Appendix IV – Example of upstream conversion for dual –48 V power feed configuration at input of ICT equipment.....	18
Bibliography.....	19

Introduction

With the advantage of the emerging up to 400 Volt DC (VDC) power distribution, along with the use of traditional alternating current (AC) and –48 VDC power distribution for networks and information and communication technology (ICT) power feeding, a new multiple power supply interface is defined as being a combination of the standardized AC or direct current (DC) power system interface at the inputs of ICT systems.

This Recommendation provides details showing the ICT equipment front-end power architectures that include an on-board converter and the interconnection options between the converter and the ICT interface. These include switch selection and diode combiner solutions for multiple input feeds.

With an increase in the variation of potential power feeds to ICT equipment especially with the emergence of up to 400 VDC power networks, a clear indication of how a multiple input power feed is to be referenced and how these multiple power feeds can be best managed is crucial in ensuring that common and recognized approaches are adopted in the installation and configuration of future ICT equipment.

Appendix I presents options for the installation of a switch selector within ICT equipment and its operational attributes targeted for its reliable operation.

This Recommendation was developed jointly by the European Telecommunications Standards Institute (ETSI) and ITU-T Study Group 5, and published respectively by ITU and ETSI as Recommendation ITU-T L.1206 and ETSI Standard ETSI TS 103 531, which are technically equivalent.

Recommendation ITU-T L.1206

Impact on information and communication technology equipment architecture of multiple AC, –48 VDC or up to 400 VDC power inputs

1 Scope

This Recommendation is applicable to the case of multiple power feeding configurations at the input of information and communication technology (ICT) equipment in ICT systems. It defines the requirements for the power inputs combination of the three power interfaces: A (–48 V), P or A3 (up to 400 Volt DC (VDC)) and A3ac (AC) that could potentially be used for each input.

This Recommendation also provides details of the power structure within ICT equipment, between ICT equipment interfaces, and ICT equipment system loads that is inclusive of system power converters.

The input power configurations are categorized to allow for a better understanding, identification, impacts, and benefits of adopting each power feeding solution. The consequence on battery test function with the different dual power inputs combinations are indicated.

Requirements are given for avoiding the potential risk of voltage backfeeding from one input to the other and for general isolation requirements.

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

[ETSI EN 300 132-2] ETSI EN 300 132-2 V2.5.1 (2016-10), *Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by –48 V direct current (dc).*

[ETSI EN 300 132-3-1] ETSI EN 300 132-3-1 V2.1.1 (2012-02), *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.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

3.1.2 hot standby state of an item [b-ISO/IEC 2382-14]: Standby state providing for immediate operation upon demand.

NOTE 1 – A hot standby state may apply to redundant or stand-alone items.

NOTE 2 – In some applications, an item in a hot standby state is considered to be operating.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 combined power feeding: Function by which two power inputs feeds to information and communication technology (ICT) equipment are managed such that one input is always available to power a single power module within the ICT equipment, e.g., by using the reverse bias characteristic of a two-diode common cathode module or a dual MOSFET.

3.2.2 combiner: A device achieving the combined dependent power feed combination by diode or equivalent static electronic circuitry.

3.2.3 dependent power feed: Power feed associated with a single interface on the information and communication technology (ICT) equipment, but jointly associated to another power feed with a single power module within the ICT equipment via a managed power interface (switched or combined power feed).

3.2.4 independent power feed: Power feed associated with a single interface on the information and communication technology (ICT) equipment and a single power module within the same ICT equipment used in a multiple power feeding interface.

3.2.5 interface "A": Terminals at which the –48 VDC power supply is connected to the ICT equipment system block.

NOTE – This new definition is a “modified version” of the one found in [ETSI EN 300 132-3-1] associated to Figure 1 and Annex A. This power interface is a functional definition and not an exact depiction of the physical location.

3.2.6 interface "A3": Terminals at which the up to 400 VDC power supply is connected to the ICT equipment system block.

NOTE – This new definition is a "modified version" of the one found in [ETSI EN 300 132-3-1] associated to Figure 1 and Annex A. This power interface is a functional definition and not an exact depiction of the physical location.

3.2.7 interface "A3ac": Interface, physical point, at which AC power supply is connected in order to operate the ICT equipment.

NOTE – This new definition is a "modified version" of the one found in [ETSI EN 300 132-3-1] associated to Chapter 4, Figure 1 and Annex B. This power interface is a functional definition and not an exact depiction of the physical location.

3.2.8 switched power feeding: Method by which two power inputs feeds to information and communication technology (ICT) equipment are managed such that one input is always available to power a single power module within the ICT equipment with the use of a switch.

3.2.9 switch selector: A device achieving the switched dependent power feed selection by a power switch.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
A+	Pole plus of input A
A–	Pole minus of input A

B+	Pole plus of input B
B-	Pole minus of input
BCONV	Converter
D	Diode
DC	Direct Current
ICT	Information and Communication Technology
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
SwSelect	Switch Selector
VAC	Volt AC
VDC	Volt DC

5 Conventions

None.

6 Definition and requirements of multiple power interface configuration at the input of ICT equipment

6.1 Individual power interface used for multiple power interface configuration

The power supply interfaces presented in Figures 1 to 6, are the physical inter-connection points to which all the requirements are related. This point is situated between the power supply system(s) and ICT equipment.

Definitions of configurations in which "A", "P(A3)" and "A3ac" interfaces presented as individual interface references are shown in the following documents:

- [b-ETSI EN 300 132-1] Annex C (AC supply) – A3ac interface;
- [ETSI EN 300 132-2] Annex E (–48 VDC supply) – A interface;
- [ITU-T L.1200] – P interface (up to 400 VDC supply) equivalent to [ETSI EN 300 132-3-1] Annex B – A3 interface.

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

6.2 Multiple power interface configurations and requirements

For the case of multiple power interface configurations on ICT equipment (e.g., power supply unit with dual feeds), each power interface shall comply with at least one of the applicable standards detailed in clause 6.1.

The multiple power interfaces shall be identified by using each of the individual interface definitions in sequence, for example, an ICT interface comprised of one AC supply (A3ac) and one AC supply (A3ac) shall be named A3ac/A3ac.

In regard to the contents presented within this Recommendation, interface "A3ac/A3ac", "A3ac/A3", "A3/A3", "A3ac/A", "A/A", and "A/A3" are located at the power terminals of the ICT equipment or system as defined by the manufacturer in accordance with [b-IEC 60445].

Table 1 shows all of the interface options for multiple power feeds to ICT equipment. For simplification, the table makes the assumption of a maximum combination of two power feeds. Power interfaces will be configured for any ICT equipment installation and the individual interface shall be in accordance with the input power feed selected.

Table 1 – Interface configuration options for multiple power feeds to ICT equipment

	AC	400 VDC	-48 VDC
AC	A3ac/A3ac (Figure 1)	A3ac/A3 (Figure 2)	A3ac/A (Figure 4)
400 VDC	A3ac/A3 (Figure 2)	A3/A3 (Figure 3)	A3/A (Figure 6)
-48 VDC	A3ac/A (Figure 4)	A3/A (Figure 6)	A/A (Figure 5)

6.2.1 Configuration AC / AC

Figure 1 presents the interface A3ac/A3ac for a multiple power feed consisting of two AC power feeds. The interface and operational voltage characteristics for an AC power feed are detailed in [b-ETSI EN 300 132-1].

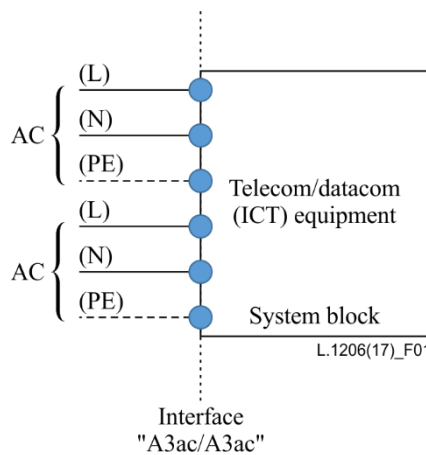


Figure 1 – General identification of the A3ac/A3ac interface for multiple power feeds for dual AC inputs

6.2.2 Configuration AC / 400 VDC

The AC interface and the interface for up to 400 VDC power feeds have the interface references of "A3ac" and "A3", respectively and as such the combination of these two reference interfaces when used together on ICT equipment is presented as "A3ac/A3". The interface "A3ac/A3" for multiple power feeds consisting of one AC power feed and one up to 400 VDC power feed is shown in Figure 2.

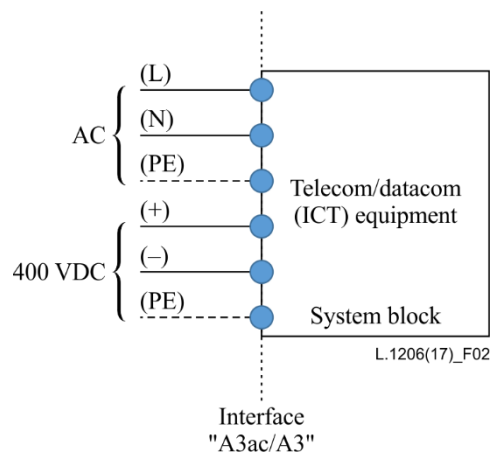


Figure 2 – General identification of the A3ac/A3 interface for multiple power feeds for AC and up to 400 VDC inputs

The interface and operational voltage characteristics for an AC power feed are detailed in [b-ETSI EN 300 132-1] and the interface and operational voltage characteristics for up to 400 VDC power feeds are detailed in [ETSI EN 300 132-3-1].

6.2.3 Configuration 400 VDC / 400 VDC

Figure 3 presents the interface "A3/A3" for a multiple power feed consisting of two, up to 400 VDC power feeds. The interface and operational voltage characteristics for up to 400 VDC power feeds are detailed in [ETSI EN 300 132-3-1].

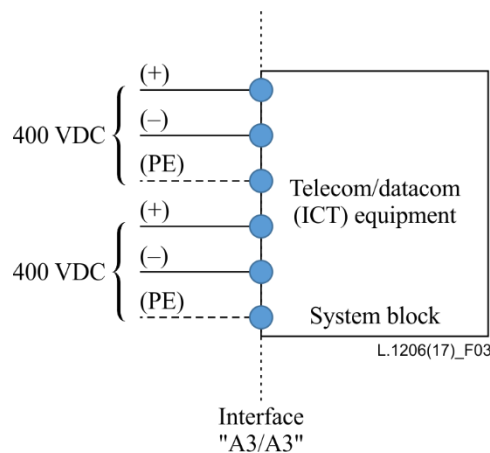


Figure 3 – General identification of the A3/A3 interface for multiple power feeds for dual of up to 400 VDC inputs

6.2.4 Configuration AC / -48 VDC

Figure 4 presents the interface "A3ac/A" for a multiple power feed consisting of one AC power feed and one -48 VDC power feed. In this instance, the AC and -48 VDC interfaces have interface structures that are termed "A3ac" and "A", respectively.

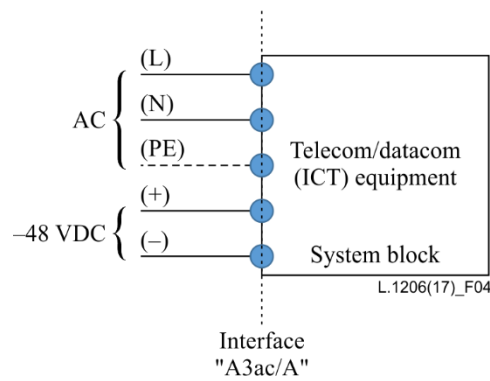
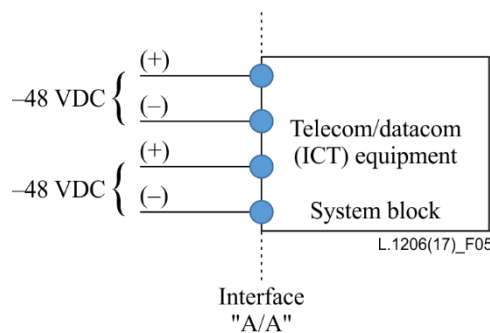


Figure 4 – General identification of the A3ac/A interface for multiple power feeds for AC and –48 VDC inputs

The interface and operational voltage characteristics for an AC power feed are detailed within [b-ETSI EN 300 132-1] and the interface and operational voltage characteristics for the –48 VDC power feed are detailed in [ETSI EN 300 132-2].

6.2.5 Configuration –48 VDC / –48 VDC

Figure 5 presents interface "A/A" for a multiple power feed consisting of two –48 VDC power feeds. The interface and operational voltage characteristics for a –48 VDC power feed are detailed in [ETSI EN 300 132-2].



NOTE – It is possible that some energy conversion parts be upstream interface A. See Appendix IV for detailed information.

Figure 5 – General identification of the A/A interface for multiple power feeds for dual –48 VDC inputs

6.2.6 Configuration –48 VDC / 400 VDC

Figure 6 presents interface "A3/A" for a multiple power feed consisting of one up to 400 VDC power feed and one –48 VDC power feed. The –48 VDC interface and the interface for up to 400 VDC power feeds have the interface references of A and A3, respectively and as such the combination of these two reference interfaces when used together on ICT equipment is presented as "A3/A".

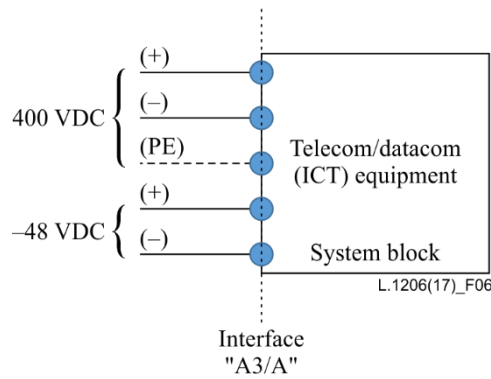


Figure 6 – General identification of the A3/A interface for multiple power feed for up to 400 VDC and –48 VDC inputs

The interface and operational voltage characteristics for a –48 VDC power feed are detailed within [ETSI EN 300 132-2] and the interface and operational voltage characteristics for up to 400 VDC power feed are detailed within [ETSI EN 300 132-3-1].

7 Combination dependence of A, A3 and A3ac interfaces for multiple power feeds

Table 2 presents alternate power architecture structures between the interfaces detailed in clause 6 and the load interface of the ICT equipment. Table 2 shows that when there is a dependent power feed, a managed redundancy function is required for its proper operation. This can be clearly seen with the switched and combined input configurations presented (architectures 7 to 11). The power structures presented include the ICT equipment on-board power converters and any power management solutions that allow for the controlled supervision of the input powers presented at the ICT equipment interface to ensure continued operation of the ICT equipment in the event of any one preferred input power feed failing.

Table 2 – Alternate power structures within ICT equipment between ICT power input interface and ICT equipment load inclusive of power converter

System config	Supply configuration (Note 2)	Interface	Battery test	Power structure	Architecture
1	AC / AC Direct power feed Independent power feeds (1)	A3ac/A3ac (Figure 1)	Ok	Two separate AC power feeds to the ICT equipment detailed as A ₁ and B ₁ . Direct power feed connection from the ICT interface to a converter. Each converter and interface used in the ICT equipment is effectively doubled A ₁ / A _n and B ₁ / B _n .	

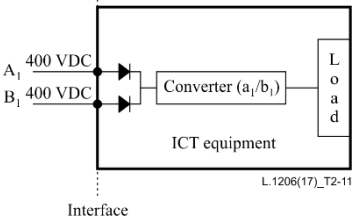
Table 2 – Alternate power structures within ICT equipment between ICT power input interface and ICT equipment load inclusive of power converter

System config	Supply configuration (Note 2)	Interface	Battery test	Power structure	Architecture
2	AC / up to 400 VDC Direct power feed Independent power feeds (1)	A3ac/A3 (Figure 2)	Ok	One AC and one up to 400 VDC power feed to the ICT equipment. (as for System configuration 1)	<p style="text-align: right; font-size: small;">L.1206(17)_T2-2</p>
3	Up to 400 VDC / up to 400 VDC Direct power feed Independent power feeds (1)	A3/A3 (Figure 3)	Ok	Two separate up to 400 VDC power feeds to the ICT equipment. (as for System configuration 1)	<p style="text-align: right; font-size: small;">L.1206(17)_T2-3</p>
4	AC / -48 VDC Direct power feed Independent power feeds (1)	A3ac/A (Figure 4)	Ok	One AC and one -48 VDC power feed to the ICT equipment (as for System configuration 1)	<p style="text-align: right; font-size: small;">L.1206(17)_T2-4</p>
5	Up to 400 VDC / -48 VDC Direct power feed Independent power feeds (1)	A3/A (Figure 6)	Ok	One up to 400 VDC and one -48 VDC power feed to the ICT equipment. (as for System configuration 1)	<p style="text-align: right; font-size: small;">L.1206(17)_T2-5</p>

Table 2 – Alternate power structures within ICT equipment between ICT power input interface and ICT equipment load inclusive of power converter

System config	Supply configuration (Note 2)	Interface	Battery test	Power structure	Architecture
6	-48 VDC / -48 VDC Direct power feed Independent power feeds (1)	A/A (Figure 5)	Ok	Two separate -48 VDC power feed to the ICT equipment. (as for System configuration 1)	<p style="text-align: right;">L.1206(17)_T2-6</p>
7	AC /AC switch selection Dependent power feeds (2), (3)	A3ac/A3ac (Figure 1)	Ok	Two separate AC power feeds to the ICT equipment detailed here as A ₁ and B ₁ . An input selection by a switch selector is placed between the ICT equipment power interface and one internal converter. A power feed from either ICT equipment interface is selected to power the converter.	<p style="text-align: right;">L.1206(17)_T2-7</p>
8	AC / up to 400 VDC switch selection Dependent power feeds (2), (3)	A3ac/A3 (Figure 2)	Ok	One AC and one up to 400 VDC power feeds to the ICT equipment. (as for System configuration 7)	<p style="text-align: right;">L.1206(17)_T2-8</p>
9	Up to 400 VDC / up to 400 VDC switch selection Dependent power feeds (2), (3)	A3/A3 (Figure 3)	Ok	Two separate up to 400 VDC power feeds to the ICT equipment. (as for System configuration 7)	<p style="text-align: right;">L.1206(17)_T2-9</p>
10	-48 VDC / -48 VDC diode combiner Dependent power feeds (2), (4)	A/A (Figure 5)	No (Note 1)	Two separate -48 VDC power feeds to the ICT equipment detailed as A ₁ and B ₁ . A diode combiner is placed between the ICT equipment interface and one converter. The input power feed connected to the diode with the higher DC voltage potential is automatically selected as the main powering supply of the ICT equipment by	<p style="text-align: right;">L.1206(17)_T2-10</p>

Table 2 – Alternate power structures within ICT equipment between ICT power input interface and ICT equipment load inclusive of power converter

System config	Supply configuration (Note 2)	Interface	Battery test	Power structure	Architecture
				reverse biasing the diode connected to the lower DC voltage potential.	
11	Up to 400 VDC / up to 400 VDC diode combiner Dependent power feeds (2), (4)	A3/A3 (Figure 3)	No (Note 1)	Two separate up to 400 VDC power feeds to the ICT equipment. (as for System configuration 10)	
<p>NOTE 1 – The diode combiner configuration cannot be used in a single battery test scenario as this configuration offers no isolation of the battery line under test. In order to achieve battery testing a switch needs to be added in series with the diodes such that each of the DC feeds can be isolated separately.</p> <p>NOTE 2 – The definitions of independent power feed, dependent power feed, switched power feeding, and combined power feeding are reported in this table as (a), (b) with a = 1 or 2, b = 3 or 4 where (1), (2), (3), (4) are described as follows:</p> <p>(1) Independent power feeding is defined as a multiple power input interface feeding a set of power supply coupled in parallel on their outputs to a single load within the ICT equipment.</p> <p>(2) Dependent power feeding is a multiple power input interface associated with a single load interface in the ICT equipment. The inputs are switched or combined in managed power interface defined in (3) and (4) in order to power the single power supply within the ICT equipment.</p> <p>(3) Switched power feeding is a method by which two power inputs are managed such that one input is always available to power a single power module within the ICT equipment with the use of an input power switch selector.</p> <p>(4) Combined power feeding is a method by which two power inputs are managed such that one input is always available to power a single power module within the ICT equipment by using the reverse bias characteristic of a two-diode common cathode module.</p>					

Mixed system configurations with dependent power feedings (switched or combined) that present either –48 VDC and up to 400 VDC or a –48 VDC and an AC supply are not considered as viable solutions and as such are not presented in Table 2 as the voltage differential between the –48 VDC and the stated high-voltage input supply in both these system configurations is too large to develop a practical ICT on-board converter.

8 Backfeeding

When ICT equipment has more than one supply connection, there is the risk of backfeeding. In the context of multiple voltages feeding, backfeeding relates to a potential situation where a hazardous voltage from one live power input of the multiple power feed, is fed back to another "dead" power input of the multiple power feed and, as such, may be hazardous to operators and/or service personnel. The ICT equipment shall prevent hazardous voltage from being present on the input terminals after interruption of the input power.

The solution for backfeed protection is as follows:

- 1) basic insulation between different power inputs provided by mechanical isolation gap;
- 2) functional insulation between different power inputs with the addition of an automatic switch (isolation). The function of the automatic switch is to 'open' after the interruption of the input power (see Appendix III).

Table 3 describes the backfeed protection solution required for the configurations of ICT equipment's power input feeds.

Table 3 – Backfeeding protection requirement for multiple power feedings to ICT equipment

Converter	Feeds	Input characteristic	Inputs	Backfeed protection	Possible supply sources
Converter a ₁ ... a _n	Feed A or Feed B	Independent power feeding (1) (Note)	Individual power feeding	Default by converter design	–48 VDC, AC, up to 400 VDC
Converter b ₁ ... a _n					
Converter x	Feed A and Feed B	Dependent power feedings (2) (Note)	Switched (3) (Note)	Requires additional preventative measures (justification in clause 8)	AC, up to 400 VDC
Converter x	Feed A and Feed B	Dependent power feedings (2) (Note)	Combined (4) (Note)	Requires additional preventative measures if hazardous voltages used (justification in clause 8)	–48 VDC, up to 400 VDC
NOTE – The configuration referred to as (n) in this table are defined in Note 2 of Table 2.					

Appendix I

Power input switch selector installation options

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

This appendix presents several installation options for integration of the switch power feed selector within ICT equipment. These should be considered on their merit for the site in terms of cost, product line and against any potential space-saving opportunities.

I.1 External switch selector installation and options for system interface connections

Figure I.1 presents a proposal for the installation of a switch selector as a separate front module within the ICT equipment. The figure also shows the plug/socket interface options that would be used for this approach. In this proposal, the switch selector module is configured with hardwired 'flying leads'. Each of these leads is terminated in an appropriate interface plug/socket that allows for a direct connection to both the ICT equipment's incoming interface power sockets and the outgoing feed to the ICT equipment's on-board converter. The flying lead cable length used on the switch selector module can either be pre-set for a specific installation requirement or set at a length that allows for a more generic installation solution.

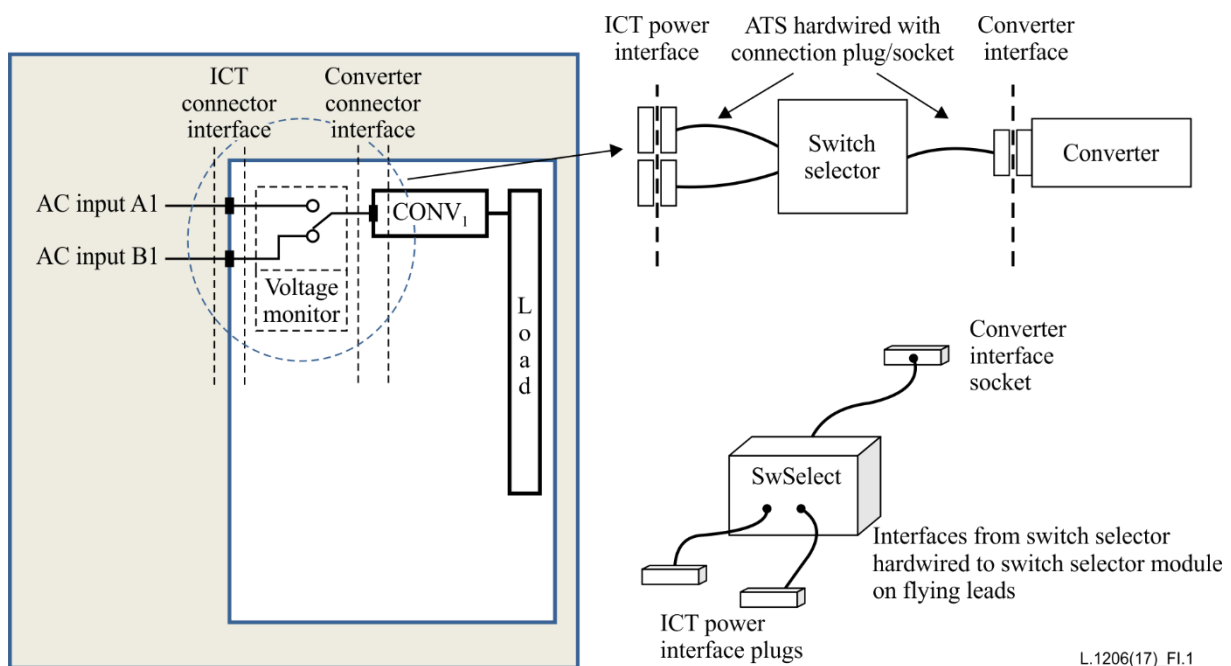


Figure I.1 – Switch selector module with plug/socket hardwired cable flying leads allowing for installation to the ICT input power feed interfaces and the ICT on-board converter

To provide further flexibility to the switch selector modules when installed as a separate front module within the ICT equipment, a further iteration would see "male" and "female" connectors placed onto the switch selector module itself (Figure I.2). In this way, the plug/socket connections become separate cable assemblies providing connection between the switch selector module and the ICT equipment/converter. The cable assemblies can be manufactured to meet specific installation requirements of the site or manufactured with common lengths allowing for a more generic installation solution.

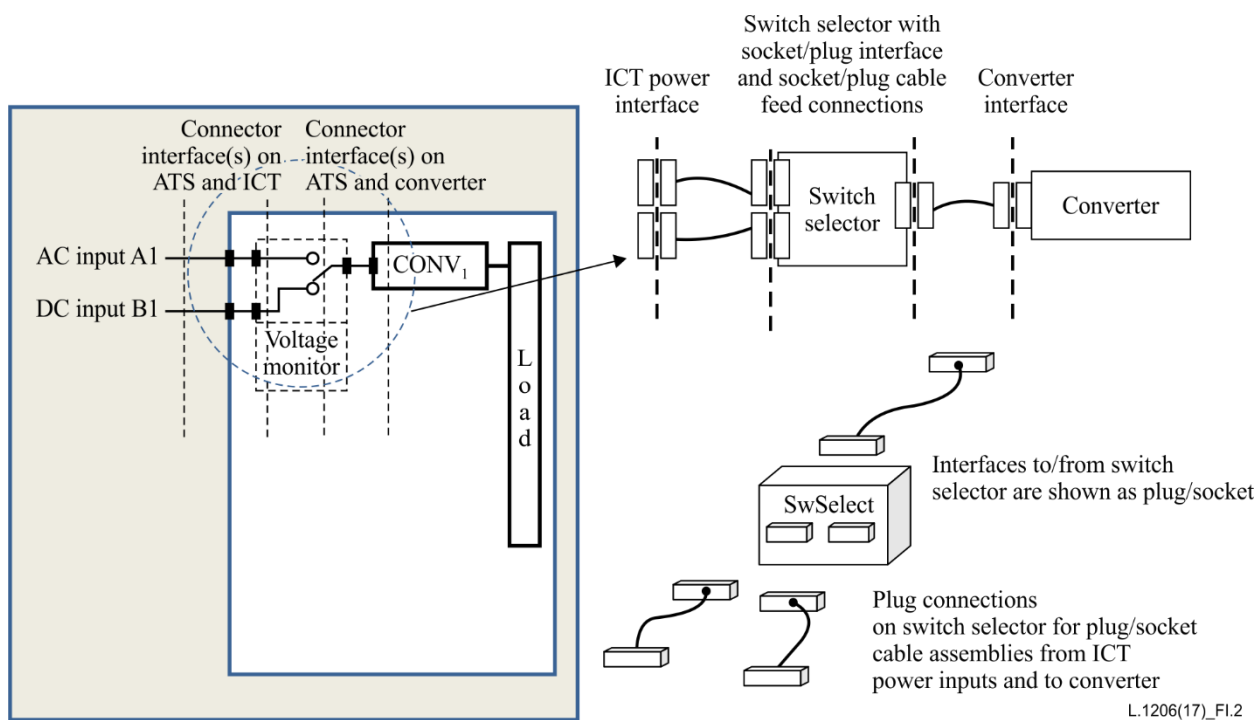


Figure I.2 – Switch selector module with plug/socket cable assemblies allowing for installation to the ICT input power feed interfaces and the ICT on-board converter

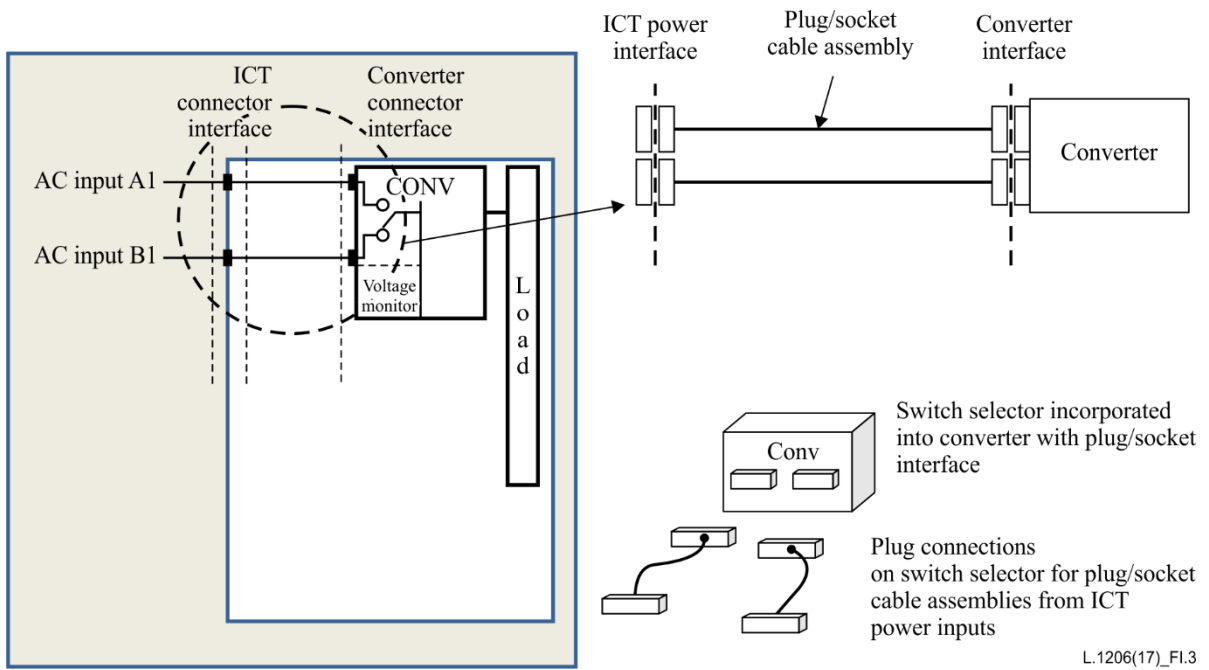
I.2 Switch selector installed within converter and interface connections

Figure I.3 presents a further alternative installation option of a switch selector. In this approach, the switch selector (separate front module) is moved out of the ICT equipment and placed within the ICT equipment on the converter electronic board. This provides some space-saving opportunities.

As seen in Figure I.3, the interface at the ICT equipment is still present, but there are now two input interfaces placed onto the converter for the two separate input supplies to the ICT equipment. Plug/socket cable assemblies provide the connections from the ICT equipment's external power interfaces to the ICT equipment on the converter electronic board.

This approach has advantages and disadvantages. The main advantage is in relation to the potential space saving within the ICT equipment by placing the switch selector module within the ICT on the converter electronic board. The disadvantage however is that the converter becomes quite specialized in its design, removing any system backward compatibility. In addition to this, the power interface for the converter becomes more complex (single to a dual power feed interface) which, along with the inclusion of the switch selector components, will impact the converter's cost and potentially its overall size.

The advantages and disadvantages in taking this approach should be considered by the equipment provider on a 'best case install basis' in terms of cost and potential space saved; however, after a further review of this solution, the disadvantages mentioned above clearly outweigh any potential advantages that could be gained.



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Figure I.3 – Switch selector placed on the ICT converter electronic board with cables assemblies allowing for connection from ICT power feed interfaces to the ICT on-board converter

Appendix II

Power input switch selector – General functionality

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

II.1 General description of the power input switch selector

The input switch selector defined in this Recommendation can include but is not inclusive of the following functions:

- actuator and drive circuitry that provides the power switch function and the drive capacity from low-level signal;
- power input switch with power contacts;
- semi-conductor contact management – can provide some additional control management of the switch contacts;
- voltage monitoring and detection circuit that monitors the incoming voltages supplies and provides a signal at the instance of supply voltage failure on the voltage supply wires also called rail(s);
- control logic that provides control and switch stable management.

The switch selector can comprise of, but is not limited to, a number of functional elements as listed above. In addition, the switch selector should include a voltage detection circuit. The purpose of this circuit is to monitor the incoming voltage supply rail(s) providing a signal to a switch selector actuator at the instance of a voltage failure being detected. The voltage detection circuit should be able to detect an incoming supply voltage failure on multiple AC/AC, DC/DC or any combination thereof.

The switch selector shall also include control/switch management functions to ensure that the switch not only operates in line with the converter hold-up time, but carries out this function in a controlled manner ensuring high levels of reliability. The switch selector could also include additional semi-conductor devices that may assist in its clean switch management.

The switch selector shall be fully compliant with creepage and clearance and voltage backfeed regulatory safety requirements at the targeted operational voltages. This shall include any additional protection circuitry required for its intended operational environment. This could include but not be limited to any electromagnetic interference (EMI) filtering and transient suppression necessary to comply with local or international regulatory standards.

II.2 Input power monitoring

The switch selector needs to be activated when an instance of an input voltage supply failure is detected. To ensure optimal performance, monitoring circuitry that can provide this function to a high level of reliability and accuracy should be included in its design.

The monitor interface should be capable of detecting multiple AC/AC, DC/DC or a mixture of both voltage types at voltage levels of 230 Volt AC (VAC) and up to 400 VDC.

The maximum switching time of the switch selector should be compatible with the ICT on-board converter hold-up time i.e., between 10 ms to 20 ms.

The voltage monitoring solution needs to provide a high level of immunity to any transient voltage events on the monitored incoming supplies and thus avoid any erratic toggling of the switch selector. In addition, the monitoring circuitry should also provide full immunity to any extraneous high voltage events that could potentially damage its operation.

Appendix III

Backfeeding protection

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

III.1 Example of backfeeding protection

For the two backfeeding protection methods listed in clause 8, the second method (2) is presented as an example below:

For this example, the DC operated equipment has at least two DC inputs of which both inputs are combined by the combiner module.

The combiner modules consist of D1, D2, D3 and D4 as detailed in Figure III.1. In this example, the components are presented as diodes, but can be replaced by a component that can provide the combiner function, which would include metal-oxide-semiconductor field-effect transistors (MOSFETs) or insulated gate bipolar transistors (IGBTs). These particular devices provide the additional benefit of reduced power dissipation, when compared with the diode, but come with the disadvantage of requiring a more complex drive/control interface. Placing two of these devices in a back-to-back configuration allows for complete control of the combiner function, i.e., providing full on/off functionality (Figure III.2). These components provide a functional insulation between the different power inputs.

In addition to the combiner module, an automatic switch (isolation) module is presented and placed in series with each DC input circuit. The automatic switch (isolation) module includes a switch element and a switch element control circuit.

The switch element used can take the form of a relay or any other component that offers a similar function, in that it shall provide a mechanical isolation that meets the functional insulation requirements.

In application, the switch element control circuit detects if power is present at interface (A+/A-, or B+/B-). If power is detected then the switch element sets to the "on" position; conversely if power is not detected, at these inputs, then the respective switch element sets to the "off" position. In this way, the switch element ensures that if the external supplies to the ICT equipment are removed or interrupted, the switch element contacts open, preventing any instance of voltage backfeeding to the respective disconnected input.

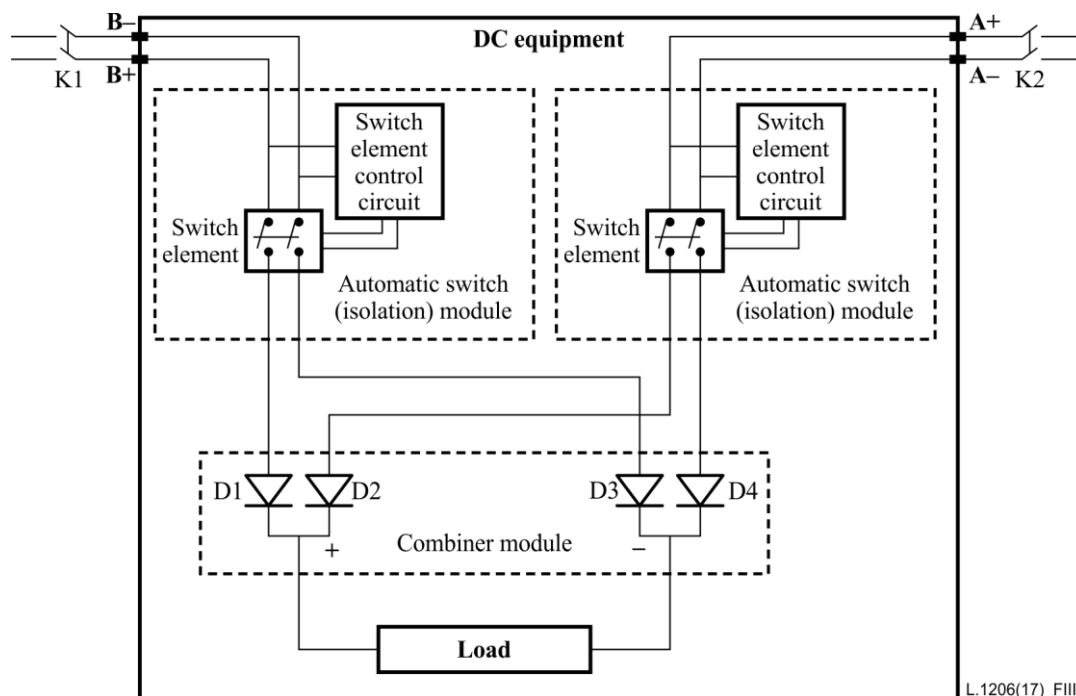


Figure III.1 – Circuit configuration for backfeeding protection when using a diode combiner interface for ICT equipment

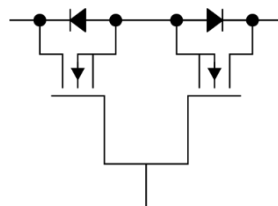


Figure III.2 – Back-to-back MOSFET replacement for diode module combiner providing a control on/off functionality

III.2 Battery test function

In addition to providing backfeeding protection, the circuit configuration presented in Figure III.1 can also provide the correct conditions for a battery test function to be carried out. With respect to Figure III.1 this test scenario would use the battery back-up input power line disconnected using either one of the mechanical switch modules as appropriate.

In this instance, the switch modules detailed as "automatic" would also be implemented with an operational override control function to open the respective switch modules contacts. Operator care or additional functional voltage monitoring would also be required to ensure that the supply of voltages to the ICT equipment remains within their operational voltage window, preventing any possibility of system shutdown during the battery test procedure.

As an alternative, where combiner diodes D1 to D4 detailed in Figure III.1 are replaced with back-to-back MOSFETs (Figure III.2), the battery test function can be carried out by switching off associate diode pairs.

Appendix IV

Example of upstream conversion for dual –48 V power feed configuration at input of ICT equipment

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

The proposed architecture is an example of an upstream conversion of AC (A3ac)/A (–48 VDC) and up to 400 VDC (A3)/A (–48 V) for dual input ICT equipment as shown in Figure IV.1.

The upstream power system can be composed of rack-level switching mode power supply in power cabinets. This may form a dual-partition power system feeding the –48 V dual power inputs to the ICT equipment. The cabinet can be common to several dual inputs.

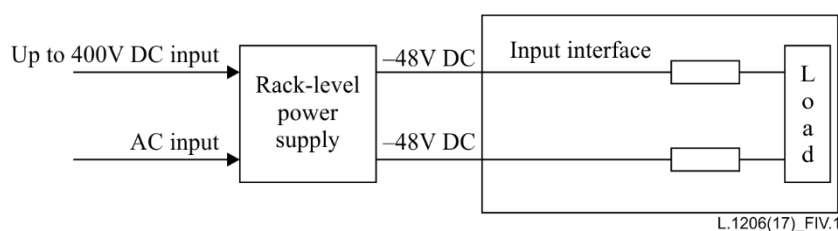


Figure IV.1 – Architecture of upstream AC and up to 400 VDC power system with rack-level power supply feeding in –48 VDC a dual power input equipment in A/A configuration

The dual-partition power supply system has two independent inputs and outputs and may have a unified monitoring module. The two inputs can be AC and up to 400 VDC interface, the outputs of the two separate partitions –48 VDC power supply are compatible with the existing ICT equipment in the telecommunication center.

The dual-partition power supply system can have a variety of operating modes as follows:

- 1) the main power is provided by the AC partition while using up to 400 VDC in hot standby mode;
- 2) the main power is provided by the up to 400 VDC partition while using AC in hot standby mode;
- 3) the power is equally shared between AC and up to 400 VDC partitions.

Several differences can be identified between configurations with external power supply system and dual input power supply solution embedded in ICT equipment as shown in Figure IV.1.

- 1) the capacity of an independent power supply should be at the same level;
- 2) there is only one control/monitoring module which manages and coordinates the operating parameters of the power modules of both partitions;
- 3) the input of the two partitions are AC input and up to 400 VDC and should be completely isolated;
- 4) the output voltages of the two partitions are –48 VDC and should be isolated, but each single partition output voltage can be adjusted according to the load;
- 5) dual-partition embedded switching mode power supply can have a variety of working modes.

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