

Environmental Engineering (EE); Guidance for power distribution to telecommunication and datacom equipment



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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Environmental Engineering (EE).

1 Scope

The present document gives guidance on installation, connection and operation of power supply systems for telecommunication / datacom installations and equipments. Also considered are items of equipment with their own power supply, which are connected to form installations.

The present document contains definitions for power supply and distribution systems not used in ETS/EN 300 132 series [5] to [7].

2 References

For the purposes of this Technical Report (TR) the following references apply:

- [1] CENELEC HD 472 S1: "Nominal voltages for low-voltage public electricity supply systems".
- [2] ETSI EN 300 386: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Telecommunication network equipment; Electro Magnetic Compatibility (EMC) requirements".
- [3] CENELEC EN 60950-1: "Information technology equipment - Safety - Part 1: General requirements".
- [4] CENELEC EN 60896-2: "Stationary lead-acid batteries - General requirements and methods of test - Part 2: Valve regulated types".
- [5] ETSI ETS 300 132-1: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources".
- [6] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)".
- [7] ETSI EN 300 132-3: "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".
- [8] ETSI EN 302 099: "Environmental Engineering (EE); Powering of equipment in access network".
- [9] ETSI EN 300 253: "Environmental Engineering (EE); Earthing and bonding of telecommunication equipment in telecommunication centres".
- [10] ITU-T Recommendation K.20: "Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents".
- [11] ITU-T Recommendation K.21: "Resistibility of telecommunication equipment installed in costumer premises to overvoltages and overcurrents".
- [12] CENELEC HD 384 (all parts): "Electrical installations of buildings".
- [13] ETSI EN 301 489-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements".
- [14] CENELEC EN 61000-3-2: "Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current up to and including 16 A per phase)".
- [15] CENELEC EN 61000-3-3: "Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection".
- [16] ITU-T Recommendation P.53: "Psophometer for use on telephone-type circuits".

- [17] CENELEC EN 50310: "Application of equipotential bonding and earthing in buildings with information technology equipment".
- [18] CENELEC EN 61000-4-11: "Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests".
- [19] CENELEC EN 50174-2: "Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings".
- [20] CENELEC EN 62040-1-1: "Uninterruptible power systems (UPS) - Part 1-1: General and safety requirements for UPS used in operator access areas".
- [21] CENELEC EN 62040-1-2: "Uninterruptible power systems (UPS) - Part 1-2: General and safety requirements for UPS used in restricted access locations".
- [22] CENELEC EN 60896-11: "Stationary lead-acid batteries - Part 11: Vented types - General requirements and methods of tests".
- [23] CENELEC EN 62310-1: "Static transfer systems (STS) - Part 1: General and safety requirements".
- [24] IEC/prEN 60896-22: "Stationary Lead-Acid Batteries, Part 22: Valve regulated types, Requirements".
- [25] 19 Pfl1: "Voltage limits for 60 V consumers in telecommunication installations of the Deutsche Telekom".

3 Definitions and abbreviations

3.1 Definitions

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

current-using equipment: may be both a further power supply system or a telecommunication equipment

NOTE: The telecommunication equipment with associated power supply may be considered as telecommunication installation or telecommunication equipment.

disturbance: electromagnetic disturbance having components in the radio frequency range

immunity: ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

power supply system: power supply system is an electrical equipment, which makes available energy obtained from a primary power source (e.g. ac distribution) in a form suitable for the current-using equipment

radio interference: degradation of the reception of a wanted signal caused by radio frequency disturbance

supply voltage: is the voltage preferably obtained from the public distribution system or other primary electric power sources

Transfer Switch (TS): used in the UPS: integrated automatic bypass switch, which can be fully static, fully electromechanical or hybrid

3.2 Abbreviations

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

ac	alternating current
dc	direct current
MBS	Maintenance Bypass Switch

NOTE: For the manual bypass switch for the on-board bypass of the UPS.

MOS	Metal Oxide Semiconductor
PSI	Power Supply Interface
SBS	Systems Bypass Switch
SD	Safe Disconnection
STS	Static Transfer Switches (for the stand-alone static switches)
TS	Transfer Switch
UPS	Uninterruptible Power Supply

4 Types of power supply systems

In telecommunication installations and equipment the designation of a power supply system refers to its output.

In this sense there are dc and ac supplies. The operating modes described below are basic forms, which may be developed into more complex arrangements.

4.1 DC supply

4.1.1 Mains operation

The current-using equipment is supplied with dc voltage obtained by a rectifier from the ac system (see figure 1).

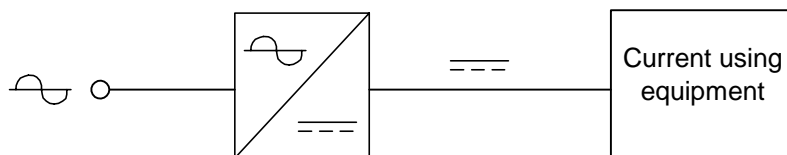


Figure 1: Principle of mains operation

4.1.2 Battery operation

The current-using equipment is supplied from a battery. Both primary and secondary cells (accumulators) can be used as batteries. The accumulator is disconnected from the current-using equipment for charging (see figure 2).

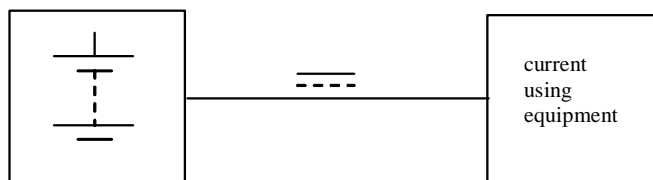


Figure 2: Principle of battery operation

4.1.3 Floating/Parallel operation

The current-using equipment is connected continuously to a rectifier and battery (see figure 3).

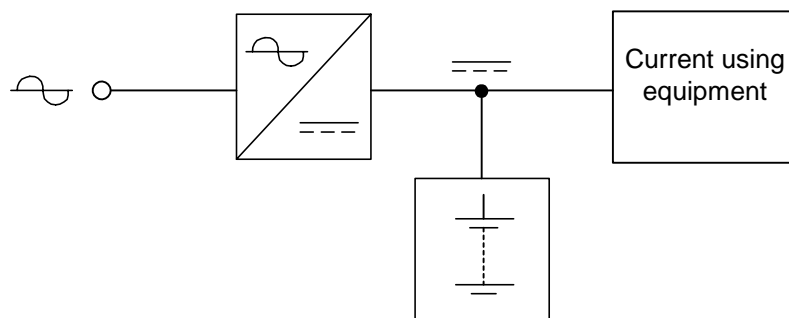


Figure 3: Principle of parallel operation

The current-using equipment is supplied in parallel operation; the rectifier being dimensioned in such a way that it can cover the total power consumption of the current-using equipment and in addition supply an appropriate charging current for the battery (see figure 3).

With this configuration the battery is continuously ready for operation in a fully charged condition. If the mains ac voltage is outside of the specification (e.g. fails, reduction of voltage, high harmonics), the current-using equipment continues to be supplied without interruption.

Parallel operation includes a very common charging mode known as floating mode and other charging modes such as intermittent charge.

Floating charge is a charging mode where the self-discharge of the battery is compensated by maintaining a sufficient voltage to the battery. The charging voltage can be varied due to temperature compensation.

Intermittent charge is a charging mode where the self-discharge of the battery is compensated by periodically raising the voltage of rectifiers for short periods. Between these periods the rectifier voltage is left lower than it should be in floating mode. The aim is to reduce plate corrosion and loss of water, as well as to reduce the risk of thermal runaway. This may help to prolong the life span of batteries used in outdoor equipments or areas with high ambient temperature.

4.1.3.1 DC switch operation

The power requirement of the current using equipment is normally provided by a rectifier. A disconnected battery is maintained in a charged condition by a separate charger. If the rectifier fails, the current-using equipment is switched to the battery and supplied by the latter (see figure 4).

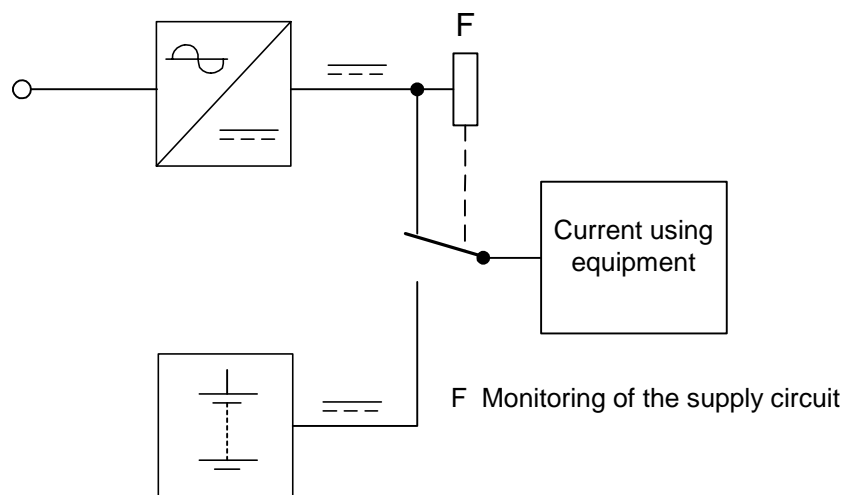


Figure 4: Principle of dc switch operation

4.1.3.1.1 Switch operation with interruption

The power supply of the equipment is briefly interrupted when the current-using equipment is switched between the rectifier and the battery.

The battery is not charged in this case by the main power supply but can be recharged in any mode (floating, intermittent) as previously described by a separate charger. Sizing of the primary ac power source and associated protection systems must take into account the maximum load of the telecom equipment and battery charging power. Battery charging power depends on the battery capacity and required charging-time. Generally, the charging power is from 10 % to 100 % of the power supply of telecom equipment. This solution separates the functions of charging and supplying power to the current-using equipment and allows both to be optimized separately.

4.1.3.1.2 Switch operation without interruption

The current-using equipment is switched by switching equipment without interruption between the rectifier and the battery. The distance from the power source to the switching equipment as well as the input circuit of the current-using equipment should be considered.

4.1.3.2 DC converter operation

The current-using equipment is supplied with a dc voltage obtained by a dc converter from a dc voltage system (see figure 5).

If the dc/dc converter is isolated in accordance with EN 60950-1 [3], different earth connections at input and output are requested. These connections must be in accordance with EN 300 253 [9] and EN 50310 [17].

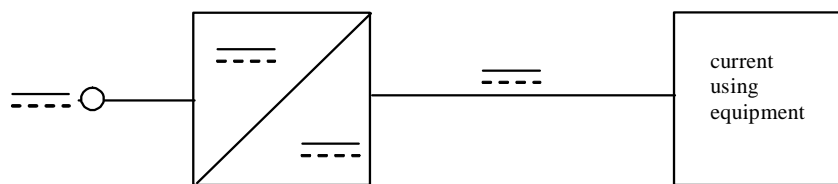


Figure 5: Principle of dc converter operation

4.1.3.3 Redundant dc distribution

For high availability services or hot operation and maintenance on installation, power supply distribution redundancy may be required. It is commonly achieved by independent inputs de-coupled at the input of the current-using equipment in the distribution frame. Another solution is to couple several converters in a minimum of $n+1$ redundancy at the output.

It should be noted that the cabling and protection device of each feed of redundant distribution systems must be sized to allow for the maximum load of the current-using equipment.

It should be noted that redundancy is easier to achieve in dc systems than it is in ac systems as there is no phase difference. However, differences in voltage levels have to be considered for load-sharing purposes.

The design of redundant power distribution systems should consider the use of independent power sources.

The input current of dc/dc converters in redundant distribution systems will increase as a result of a fault condition e.g. short circuit on the output of any one dc/dc converter. Protection against internal short circuits in a dc/dc converter may be achieved by an active circuit at the input (MOS switch for example).

Protection against overvoltage caused by short circuits release may be achieved by active circuits at the output of the dc/dc converter (MOS switch for example).

4.2 AC supply

4.2.1 Mains operation

The current-using equipment is supplied with ac voltage directly from an ac supply circuit, e.g. a consumer installation or a distribution system (see figure 6).



Figure 6: Principle of mains operation

4.2.2 Inverter operation

The current-using equipment is supplied with ac voltage obtained from an inverter fed by a dc supply system (see figure 7).

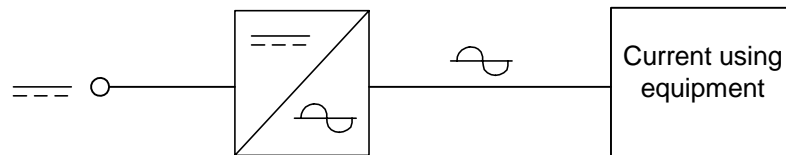


Figure 7: Principle of inverter operation

4.2.3 AC switch operation

4.2.3.1 AC switch operation with interruption

If the mains ac voltage fails, the current-using equipment is transferred to another ac supply after a time delay i.e. due to an interruption or phase failure. (See figure 8).

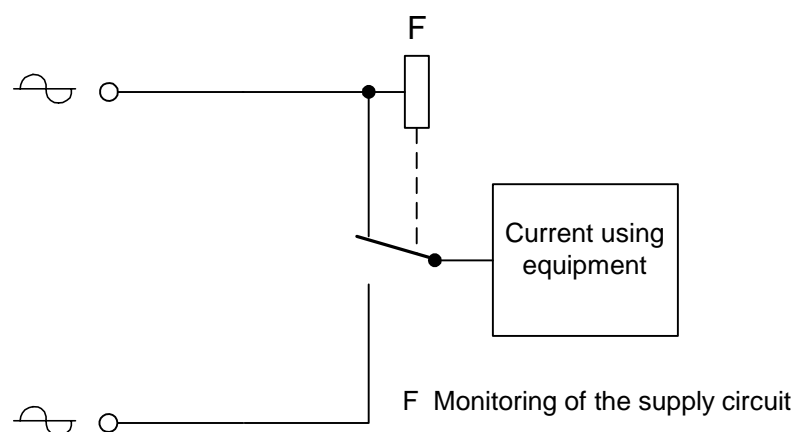


Figure 8: Principle of ac switch operation WITH interruption

4.2.3.2 AC switch operation without interruption (STS)

The current-using equipment usually operates with very fast switch-over of ac sources without an adverse effect (see figure 9).

Zero-time switching requires phase and amplitude synchronization of inputs. Generally, a circuit controls this before switch-over. If synchronization is lost it is possible to achieve switch-over after an introduced time delay (see EN 61000-4-11 [18]). This allows inverter or UPS redundancy.

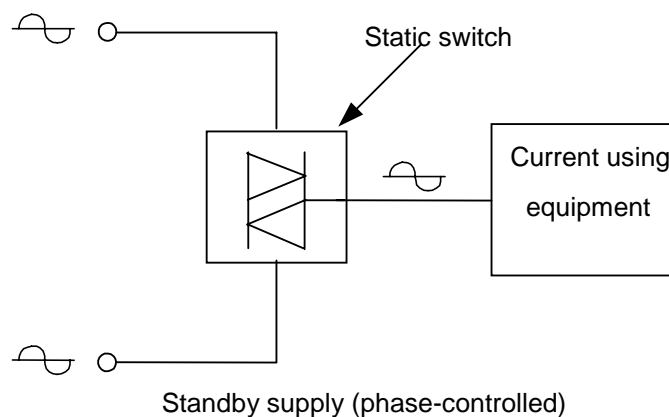


Figure 9: Principle of ac switch operation WITHOUT interruption

In some cases, the static switch can be shunted by mechanical contactors that operate slowly but are more robust to power disturbances. They can withstand the very high short-circuit current available from the ac mains.

A general description and safety requirements of STS are contained in EN 62310-1 [23].

4.2.3.3 AC uninterruptible power supply systems (UPS)

The current-using equipment is supplied with ac voltage from an UPS.

Several configurations exist for static and rotary UPS: online, offline, interactive, as described in standards EN 62040-1-1 [20] and EN 62040-1-2 [21].

The **on-line configuration** is shown in figures 10a to 10d. The load current path under normal operation is via the rectifier and inverter. This system normally incorporates a Static Bypass Switching device (SBS) which provides uninterrupted (synchronized) transfer of the load to the mains supply in the event of an inverter failure. Power efficiency is typically in the range of 85 % to 93 %.

The **off-line configuration** is shown in figures 10e to 10g. The load current path under normal operation is a direct feeding from the mains supply. Separate functions of power conditioning and battery charging are possible. The power efficiency of off-line mode is much higher (97 % to 99 %), but the mains filtering is lower.

In figure 10e the inverter can be used in either active or passive standby mode. In active standby mode the inverter output contactor is closed and the inverter output is synchronized to the mains supply. In passive standby mode the inverter output contactor is open and the inverter output has to be synchronized to the mains supply. If synchronization is not possible, a supply interruption and a phase shift at the output may occur during load transfer. In some off-line UPS the inverter is not rated for continuous operation.

Some UPS can be operated in either on-line or off-line mode. This can be selected by the user.

The line-interactive configuration is a combination of the two previous configurations. Normal operation is similar to the off-line configuration but the inverter is operated to improve input current distortion. In some cases the inverter is used in reverse mode to charge the battery. The off-line configuration - normal operation - is shown in figure 10h. The other operating modes are the same as shown for the off-line UPS in figures 10f to 10g. The power efficiency of the line-interactive mode is in the range 93 % to 97 %.

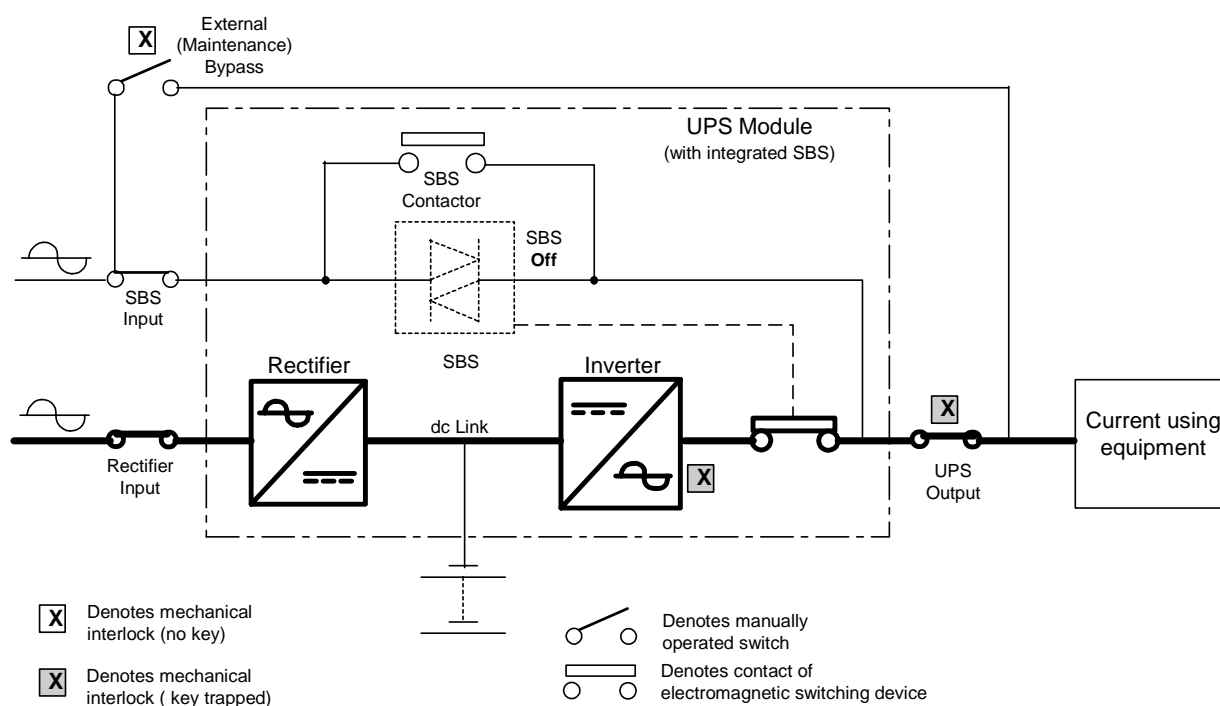
Figures 10a to 10g are examples of possible UPS configurations.

During maintenance or intervention on the upstream bypass line with upstream breakers open it is necessary to take into account that possible failure in the control or in the power part of the automatic bypass integrated into the UPS can generate a risk of electric shock upstream the bypass input terminals.

To avoid this, backfeed protection has to be provided on the bypass line.

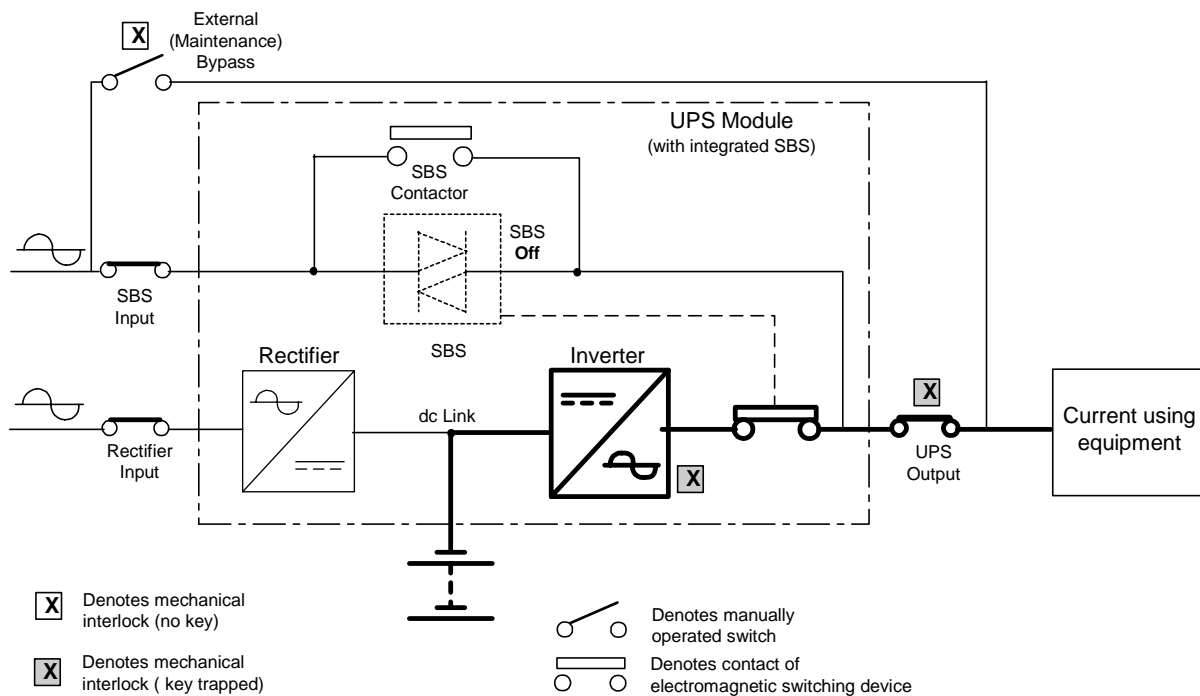
Electric shock hazard shall not appear on the input of the backfeed protecting device under normal condition and single fault condition on a component (such as in the control logic or in the power static switch) upon loss of the bypass ac voltage.

For high power or fixed installation UPS, the backfeed isolator device could be external to the UPS. In this case, the UPS supplier shall specify the type of the suitable isolating device to be used and provide the functional specifications of the control circuit/command (driven by the UPS) for the external isolator.



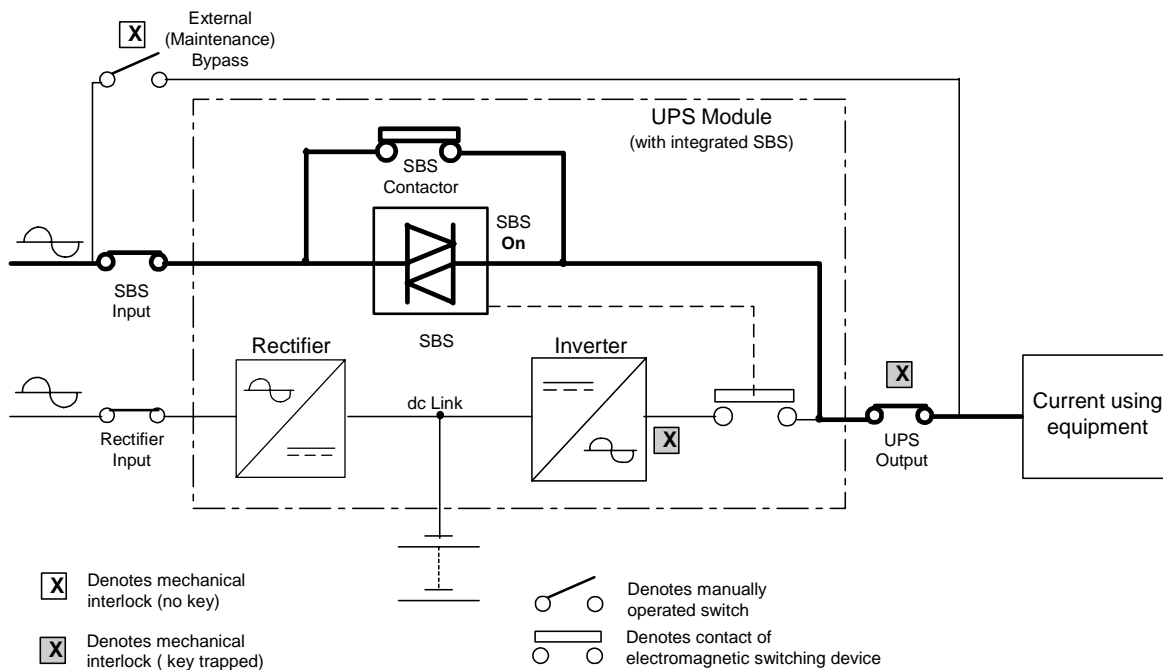
NOTE: Bold lines indicate the load current path.

Figure 10a: On-line ac UPS - normal operation



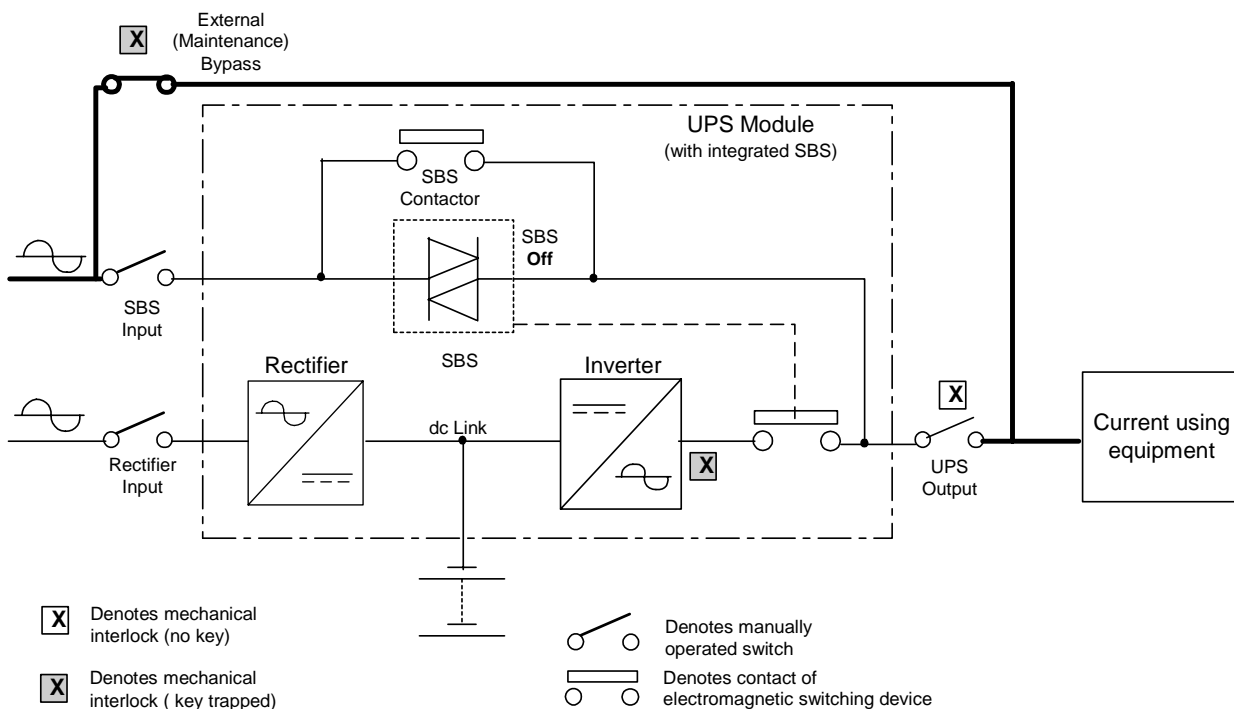
NOTE: Bold lines indicate the load current path.

Figure 10b: On-line ac UPS - battery operation



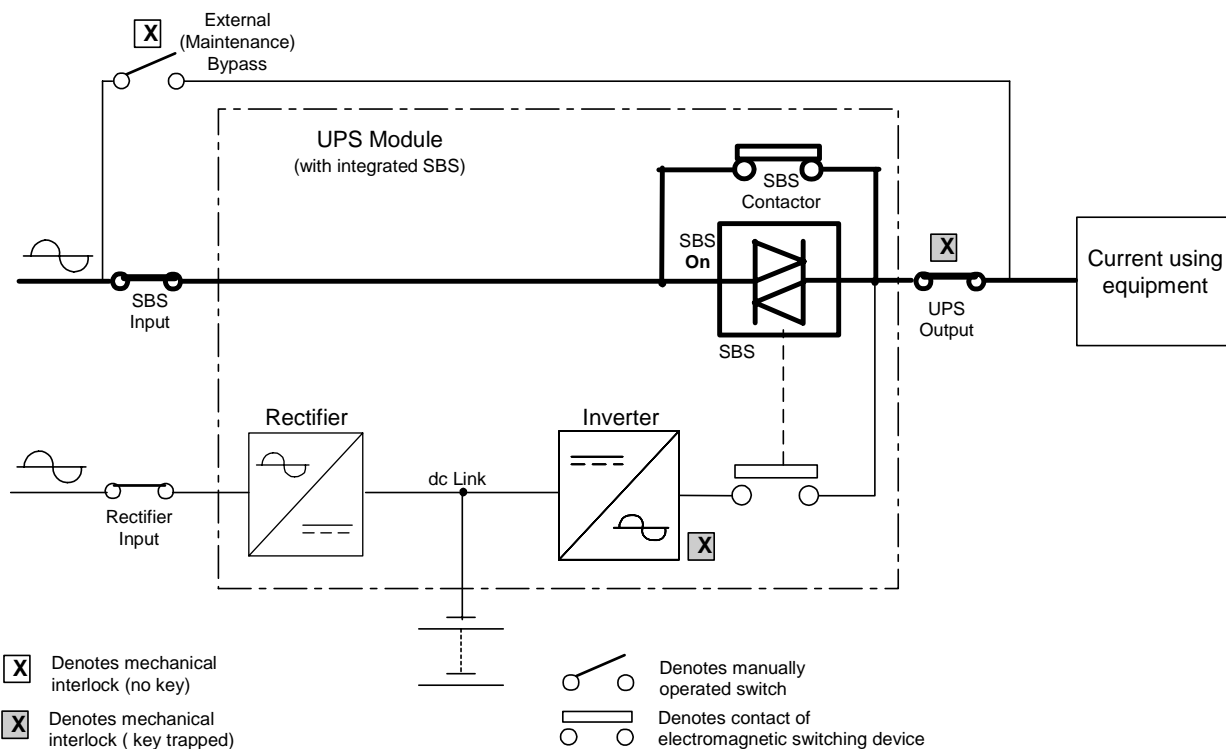
NOTE: Bold lines indicate the load current path.

Figure 10c: On-line ac UPS - SBS operation



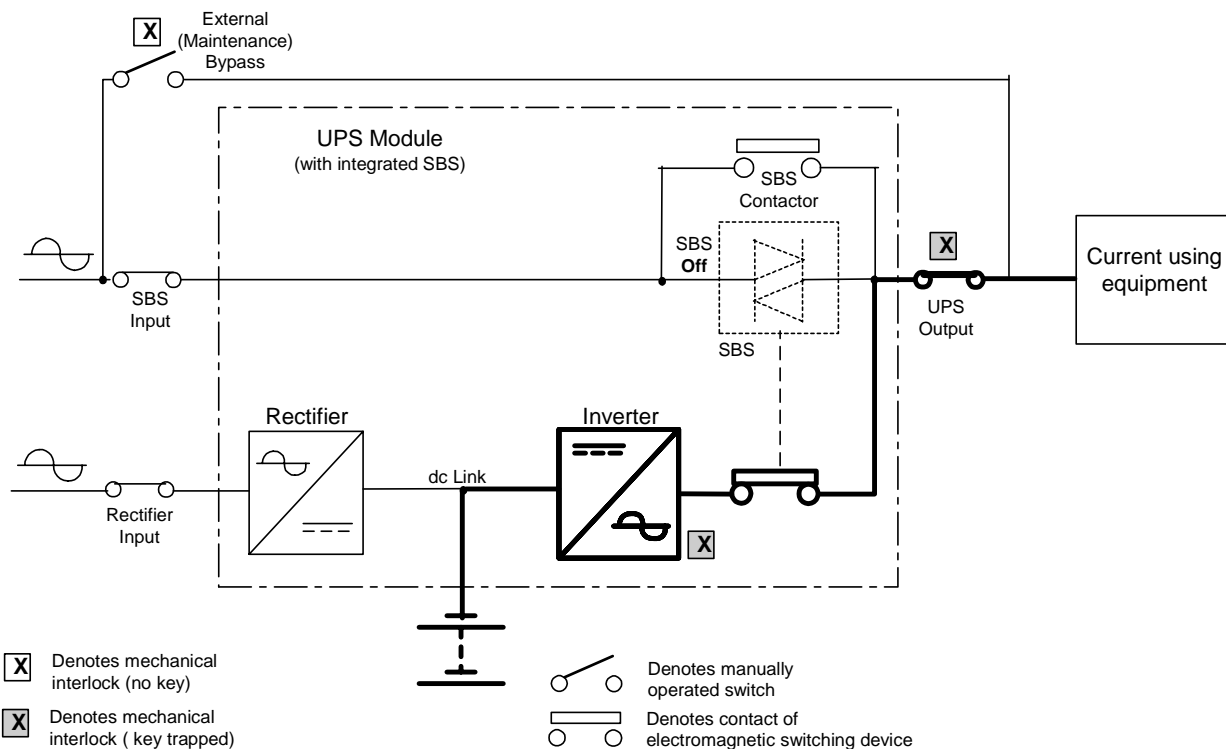
NOTE: Bold lines indicate the load current path.

Figure 10d: On-line ac UPS - external bypass operation



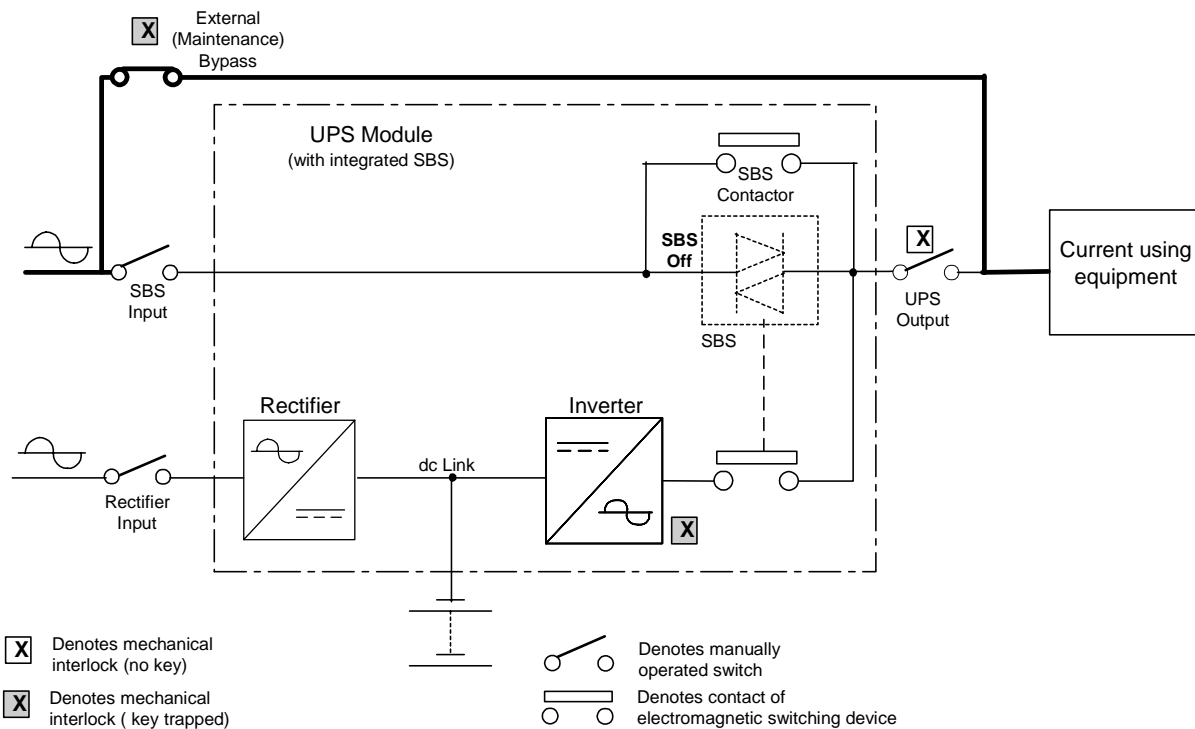
NOTE: Bold lines indicate the load current path.

Figure 10e: Off-line ac UPS - normal operation



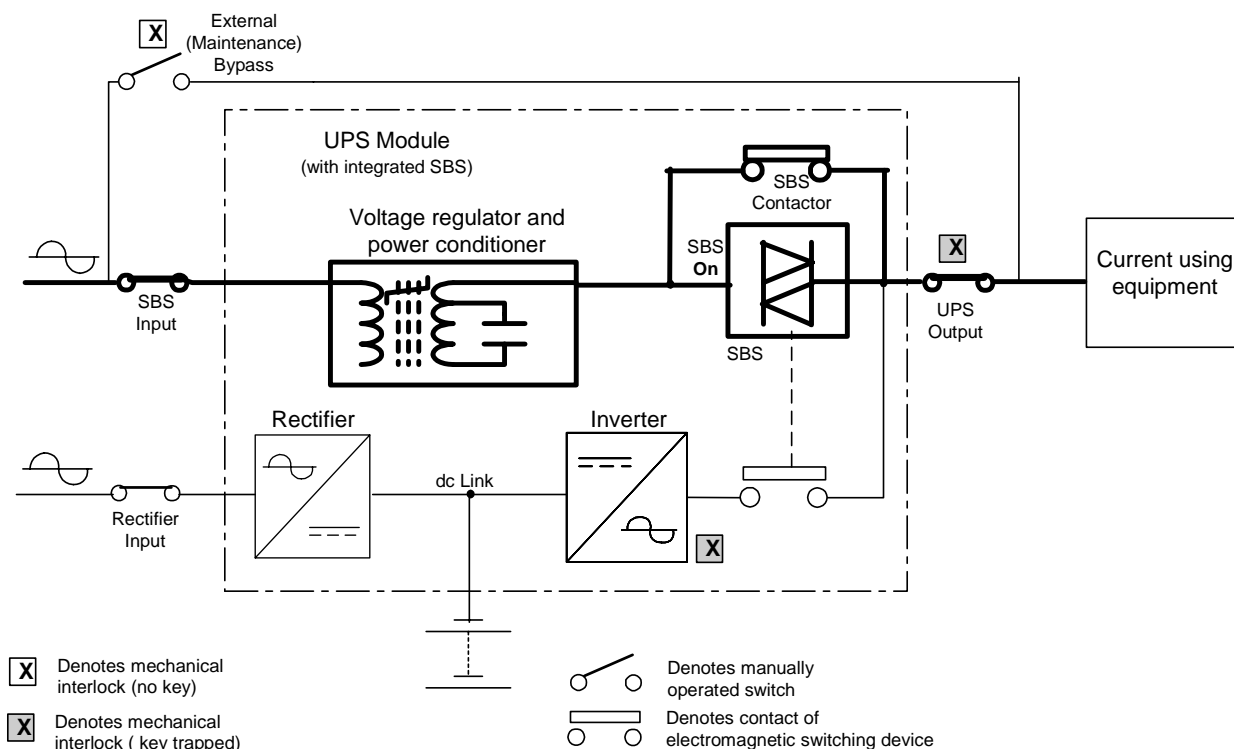
NOTE: Bold lines indicate the load current path.

Figure 10f: Off-line ac UPS - battery-inverter operation



NOTE: Bold lines indicate the load current path.

Figure 10g: Off-line ac UPS - external bypass operation



NOTE 1: Rectifier and inverter in operation. Inverter synchronized to mains supply but not carrying load current.

NOTE 2: Bold lines indicate the load current path.

Figure 10h: Line-interactive ac UPS - normal operation

As with dc power supply systems, the battery can be charged in floating mode or other modes such as intermittent. The battery charging power may be between 10 % to 100 % of the UPS output power. The UPS input power can be twice the output power. In an off-line UPS the rectifier may be dimensioned for battery charging only.

The voltage of batteries used in UPS may be much higher than 48 V and the battery may not be connected to earth.

4.2.4 Reliability and redundancy

Battery reliability is determined by the failure mode. An internal short circuit within a single cell has little effect on output autonomy, but a UPS high current rate battery must be chosen to avoid internal cell opening. Another simple solution currently observed is to have at least two battery branches or overall UPS redundancy, but without doubling the battery capacity.

Such configurations are often required to enable battery replacement or UPS maintenance to be carried out safely and without risk of power outage.

Redundancy of distribution is achieved on the input side by two mains inputs as shown in figure 10a.

5 Power supply interfaces in telecommunication installations

Figure 11 shows the basic forms of interfaces necessary for power supply systems in telecommunication installations which may be developed into more arrangements. The following Power Supply Interfaces (PSI) are defined:

- PSI 1 interface to power supply circuit, see clause 5.1;
- PSI 2 interface to distribution system, see clause 5.2;
- PSI 3 interface to telecommunication system, see clause 5.3.

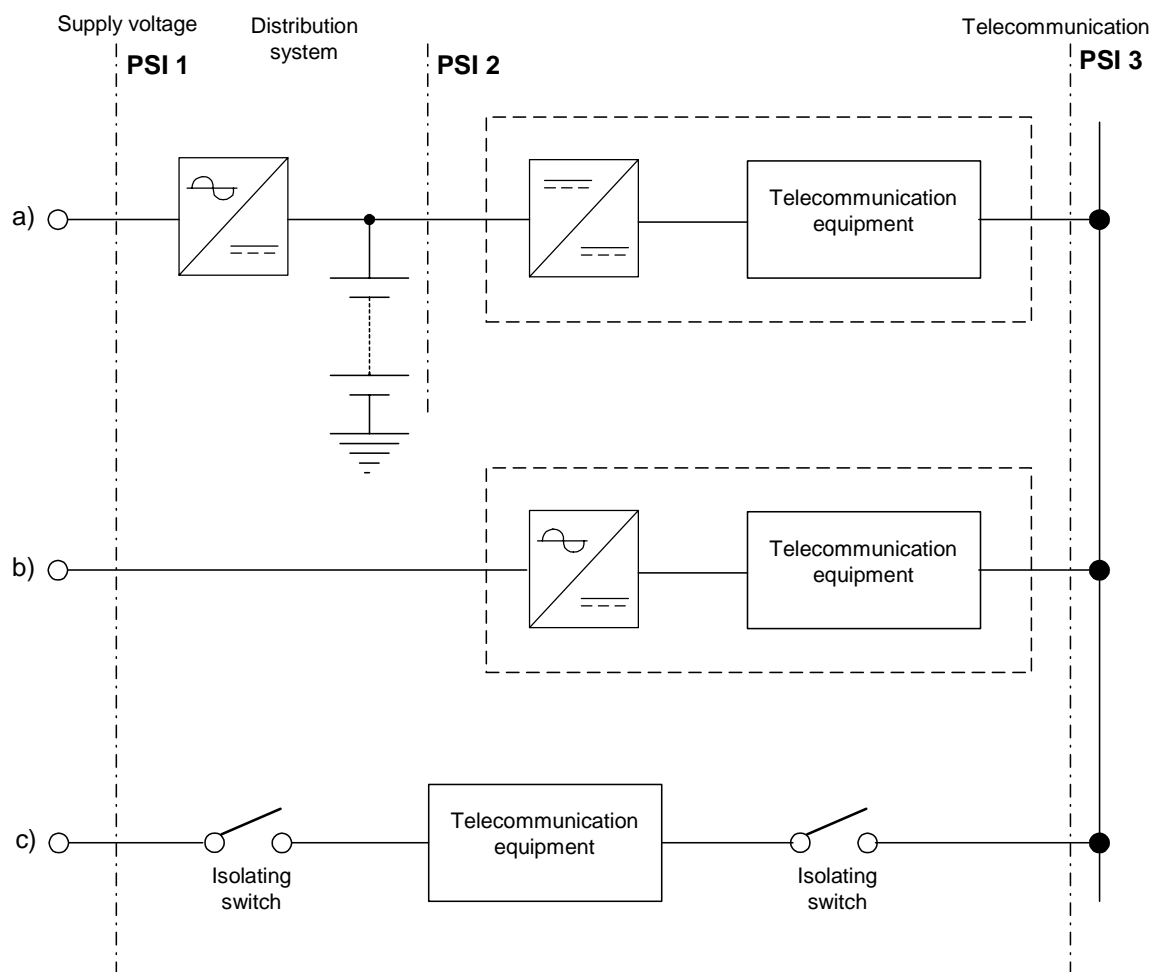


Figure 11: Basic forms of the Power Supply Interfaces (PSI)

The Safe Disconnection (SD) e.g. isolating switch shall be ensured either in the power supply equipment or in additional equipment (see figure 11):

- usual construction of a telecommunication installation with secondary dc distribution system;
- decentralized telecommunication equipment;
- equipment, e.g. computer. The safe disconnection is required between PSI 1 and PSI 3, if it is not installed in the equipment.

5.1 PSI 1 interface between primary power and telecommunication installations and equipment

PSI 1 interface is the power interface between the public mains (commercial ac) and the fed equipment. It fits with the voltage defined in HD 472 S1 [1].

Signals may also be present at the PSI 1 interface (e.g. from centralized multi-service control systems).

5.1.1 Connection conditions

HD 472 S1 [1] applies to the nominal voltages and nominal voltage ranges.

5.1.2 Harmonics and superimposition

The telecommunication power supply equipment shall meet the requirements according to the present document. In particular it shall not be adversely affected by the audio-frequency centralized multi-service control systems operated e.g. on the distribution network (or consumer installation).

NOTE: Audio-frequency centralized multi-service control systems with frequencies of 100 Hz to 2 000 Hz are operated in public distribution networks. Sinusoidal signals up to 10 s long are transmitted, the amplitude being 9 % of the mains voltage amplitude.

5.1.3 Radio interference

All equipment in the telecommunications installation shall comply with the limits according to EN 300 386 [2] or EN 301 489-1 [13]. The cable routing and shielding is described in EN 50174-2 [19].

5.1.4 Disturbances on the customer installation

The effects of the power supply system or telecommunication equipment connected at interface PSI 1 on the supply circuit (including the distribution system) shall satisfy the test conditions and limits established by the relevant applicable standards on disturbance on the main distribution EN 61000-3-2 [14] and EN 61000-3-3 [15].

NOTE: If equipment with a reduced angle of current flow or large current distortion is operated in a three-phase ac customer installation, the thermal load of the neutral conductor may assume three times the value of the load of an outer conductor even with symmetrical load distribution to the three outer conductors. It may be necessary to take this into account in the dimensioning of the installation.

5.1.5 Further sources of supply voltage

Further sources of supply voltage may be stand-by power supply systems, industrial systems, fuel-operated mechanical own current-generating sets (e.g. diesel-electric units or turbine generator sets), thermoelectric generators, fuel cells, solar generators and wind power installations.

Specifications for the supply of telecommunication power supply equipment from these power sources, which do not meet the condition of clauses 5.1.1 to 5.1.4, and should be agreed between the integrator/manufacturer and the operator.

5.2 PSI 2 interface

PSI 2 interface is the power interface between the power supply and the distribution system.

A PSI 2 interface exists, if it serves primarily for supply of current-using equipment, and rating according to EN 60950-1 [3] is **not** exceeded.

5.2.1 Connection conditions

Dc and ac voltages up to rating according to EN 60950-1 [3] may occur at the PSI 2 interface.

The nominal voltage of the battery is used for the determination of the rating class when using battery systems (see EN 60896-2 [4] and EN 60896-11 [22]).

Nominal values according to EN 300 132-2 [6] are to be used for -48V dc distribution systems. Annex A of EN 300 132-2 [6] gives guidance on working in conjunction with existing -60 V_{dc} supply systems.

Nominal values according to EN 300 132-3 [7] are to be used for equipment connected to distribution systems operated by rectified current source, alternating current source or direct current source up to 400 V.

5.2.2 Radio interference

All equipment in the telecommunications installation shall comply with the limits according to EN 300 386 [2] or EN 301 489-1 [13]. The cable routing and shielding is described in EN 50174-2 [19].

5.2.3 Interference voltage

In dc distribution systems with telephone subscriber feed the permissible limit of the interference voltage U_{St} depends on the requirements with regard to interference voltages at the PSI 3 interface and the damping properties of the subscriber feed circuit.

NOTE 1: In conventional distribution systems the interference U_{St} (superimposed ac voltage, weighted with A-filter according to ITU-T Recommendation P.53 [16]) may be up to 2 mV at 48 V or 60 V and up to 1 mV at 24 V.

This value results in distribution systems with 48 V or 60 V as a result of the emitted permissible dc source interference voltage of about 1,8 mV and the vectorial addition of the interference components.

The interference voltages present in the distribution system consist of the proportion of the dc source and the total of the effects of the connected current-using equipment. The level of the permissible effects of current-using equipment depends on the arrangement of the distribution system.

NOTE 2: In a conventional distribution system for 48 V or 60 V the superimposition effect is a maximum of 0,1 mV. (Superimposed ac voltage, weighted with a-filter according to ITU-T Recommendation P.53 [16] and measured on a simulation according to annex A).

5.3 PSI 3 interface between telecommunication installations or equipment and the telecommunication networks

A PSI 3 interface, if present, primarily provides power and data to the telecommunication equipment and constitutes the connection to the telecommunication network. The interface conditions shall always be used, if a power supply unit or equipment with own power supply (e.g. modem, computer) is to be connected to the telecommunication network.

5.3.1 Connection conditions

Only voltages of rating class according EN 302 099 [8] are used at the PSI 3 interface.

If equipment not meeting these requirements is to be connected at the PSI 3 interface, safe separation of the PSI 3 interface shall be ensured by additional measures.

NOTE: The resistibility of telecommunication equipment to overvoltages and overcurrent is defined in ITU-T Recommendations K.20 [10] and K.21 [11].

If items of equipment satisfying the leakage current conditions according to EN 60950-1 [3] are connected together, the leakage currents at the PSI 3 interface may add up to larger values than approved for the individual equipment. This applies in particular in the case of a fault.

5.3.2 Operation with remote supply or current

See EN 302 099 [8].

5.3.3 Operation with ringing ac voltage

See EN 60950-1 [3].

5.3.4 Radio interference

All equipment in the telecommunications installation shall comply with the limits according to EN 300 386 [2] or EN 301 489-1 [13]. The cable routing and shielding is described in EN 50174-2 [19].

5.3.5 Interference voltage

The permissible interference voltage on the PSI 3 interface shall be agreed between the installer and operator depending on the application.

NOTE: In conventional analog telephone subscriber connection the interference voltage (superimposed ac voltage, weighted with a filter according to ITU-T Recommendation P.53 [16]) may be up to 0,2 mV.

5.4 Cabling and routing

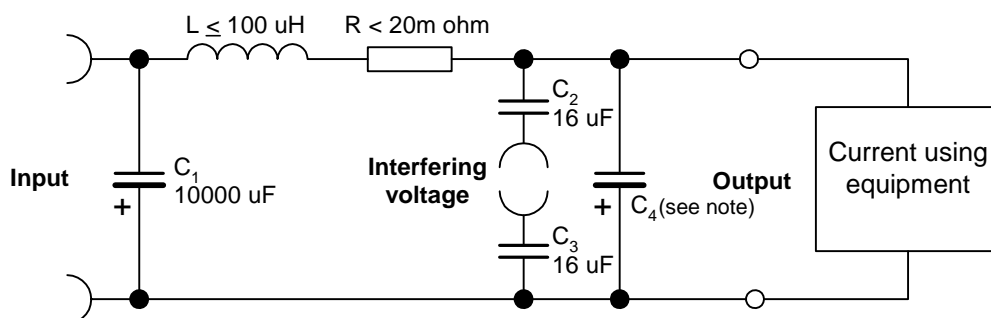
See clause 5.2.2.

6 Earthing and equipotential bonding

See EN 300 253 [9] and EN 50310 [17].

Annex A: Principle of artificial dc mains network for measurement of disturbance

Principle of artificial dc mains network for measurement of disturbance according to clause 5.2.3 (from 19 Pfl1, see bibliography).



NOTE: Simulation of conventional environment of the current-using equipment.

Figure A.1: Measuring circuit

History

Document history		
V1.1.1	January 2004	Publication
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