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Technical Report

**Environmental Engineering (EE);
Reverse powering of access network unit
by end-user equipment: A4 interface**

Reference
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Contents

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Foreword

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

Introduction

To build increased Broadband access networks, one solution is the GPON using FTTC or FFTB or any other common equipment with optical fibre input and copper pairs close to a cluster of customers. Today, the power supply is obtained by local electrical mains connection or by remote power distribution on pairs from a central office. But, sometimes, there is not enough copper or the length of the copper is too long to allow remote powering over the telecom networks and connection to the local electrical mains is not possible or too expensive. Thus, it is advisable to extent the range of possible powering solutions by using a solution called reverse powering or back feeding.

ETSI ATTM TM6 is developing a Technical Report to consider powering options for remote DSL nodes (TR 102 629 [i.21]) which requires powering interface standardization.

Thepresent document introduces a possible revision for complement to EN 302 099 [i.3].

In that solution, the line termination equipment supplies the power to the ONU or ONT through the final distribution copper line to the home. This is under consideration in ITU-T SG15 [i.22] in the GPON powering issue. In that case, there is an injection of power in the pair at the level of one client or one client group network termination (individual or building). At first sight, this seems strange to require from a customer to provide power for common equipment to several customers, but this concept is already used for common radio equipment linked to a cluster of customers. Sharing the power can be seen as equivalent to share WIFI resources in an ad'hoc network architectures.

Alternatively, one can think about a combination of power sources located at the curb and at the customer premises such that subscribers are only powering the services they use.

1 Scope

The present document scope is the back feeding or reverse powering architecture that can supply power to access network unit such as ONU or ONT or remote DSL unit from the customer through its final distribution access copper pair.

As a minimum, the present document defines a power interfaces over the customer copper pair to the access network unit (remote DSL unit or ONU such as FTTC or FTTB cabinet) defined in TR 102 629 [i.21].

Other important issues are under discussion in the present document: overlay of PSTN on the same pair and back-up (autonomy, locations, environments and safety), reliability and monitoring aspects are also addressed.

Other issues about local laws, unbundling rules, and cost are out of the scope.

2 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 reference document (including any amendments) applies.

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

2.1 Normative references

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

Not applicable.

2.2 Informative references

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 EN 300 019-1-4: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weatherprotected locations".

[i.2] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)".

[i.3] ETSI EN 302 099: "Environmental Engineering (EE); Powering of equipment in access network".

[i.4] IEC EN 60896-21: "Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test".

[i.5] IEC EN 60950-22: "Information technology equipment -Safety - Equipment to be installed outdoors".

[i.6] IEC EN 50272-2: "Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries".

[i.7] ETSI TS 102 533: "Environmental Engineering (EE) Measurement Methods and limits for Energy Consumption in Broadband Telecommunication Networks Equipment".

[i.8] IEC TR 62102 (second edition): "Electrical safety - Classification of interfaces for equipment to be connected to information and communications technology networks".

[i.9] IEC EN 60950-1: "Information Technology Equipment - Safety".

[i.10] Directive 2002/22/EC modified by 2007/0248 (COD): "European Directives on universal service".

[i.11] Code Of Conduct on Energy Consumption of Broadband Communication Equipment European Commission Directorate-General, Joint Research Centre.

[i.12] ETSI ES 202 971: "Access and Terminals (AT); Public Switched Telephone Network (PSTN); Harmonized specification of physical and electrical characteristics of a 2-wire analogue interface for short line interface".

[i.13] IEC TS 62367: "Safety aspects for xDSL signals on circuits connected to telecommunication networks (DSL: Digital Subscriber Line)".

[i.14] IEC TS 60479-1: "Effects of current on human beings and livestock -Part 1: General aspects".

[i.15] IEC 60 364-4-41: "Low voltage electrical installations part 4-41 Protection for safety protection against electrical shock".

[i.16] ETSI EN 300 253: "Environmental Engineering (EE); Earthing and bonding of telecommunication equipment in telecommunication centres".

[i.17] IEC EN 60364-1: "Low voltage electrical installations - Part 1: Fundamentals principles, assessment of general characteristics, definition".

[i.18] ETSI ES 202 336-1: "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.19] IEC EN 60950-21: "Information technology equipment - Safety - Part 21: Remote power feeding".

[i.20] IEC TS 61201: "Use of conventional touch voltage limits - Application guide".

[i.21] ETSI TR 102 629: "Access, Terminals, Transmission and Multiplexing (ATTM); Reverse Power Feed for Remote Nodes".

[i.22] ITU-T SG15- WD GR07 (WP 1/15): "GPON powering issue".

[i.23] IEC EN 60364-4-41: "Electrical installations of buildings - Part 4-41: Protection for safety - Protection against electric shock".

[i.24] The New Product Safety Standard for Communication Technology Equipment
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3 Abbreviations

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

AC	Alternating Current
ANU	Access Network Unit
BBCoC	Broadband Code of Conduct
CO	Central Office
CPE	Customer Premises Equipment (equivalent to End-User Equipment)
DC	Direct Current
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Module
FTTC	Fibre to the Cabinet
FTTB	Fibre to the Building

HGW	Home Gate Way
G-PON	Gigabit capable Passive Optical Network
LCA	Life Cycle Assessment
NT	Network Termination
NTE	Network Termination Equipment
OF	Optical Fibre
ONT	Optical Network Termination
ONU	Optical Network Unit
PC	Personal Computer
PON	Passive Optical Network
POTS	Plain Old Telephony Service
PSTN	Phone Subscriber Transmission Network
RFT	Remote Feeding Telecommunication
SELV	Safety Extra Low Voltage
VRLA	Valve regulated lead acid

4 Power interfaces between the Network Termination and the Optical Network Unit or remote DSL unit

4.1 Back feeding or Reverse Powering Architecture

A typical example of the power architecture of backfeeding (or reverse powering) is proposed on figure 1 in order to define reverse power interface A4.

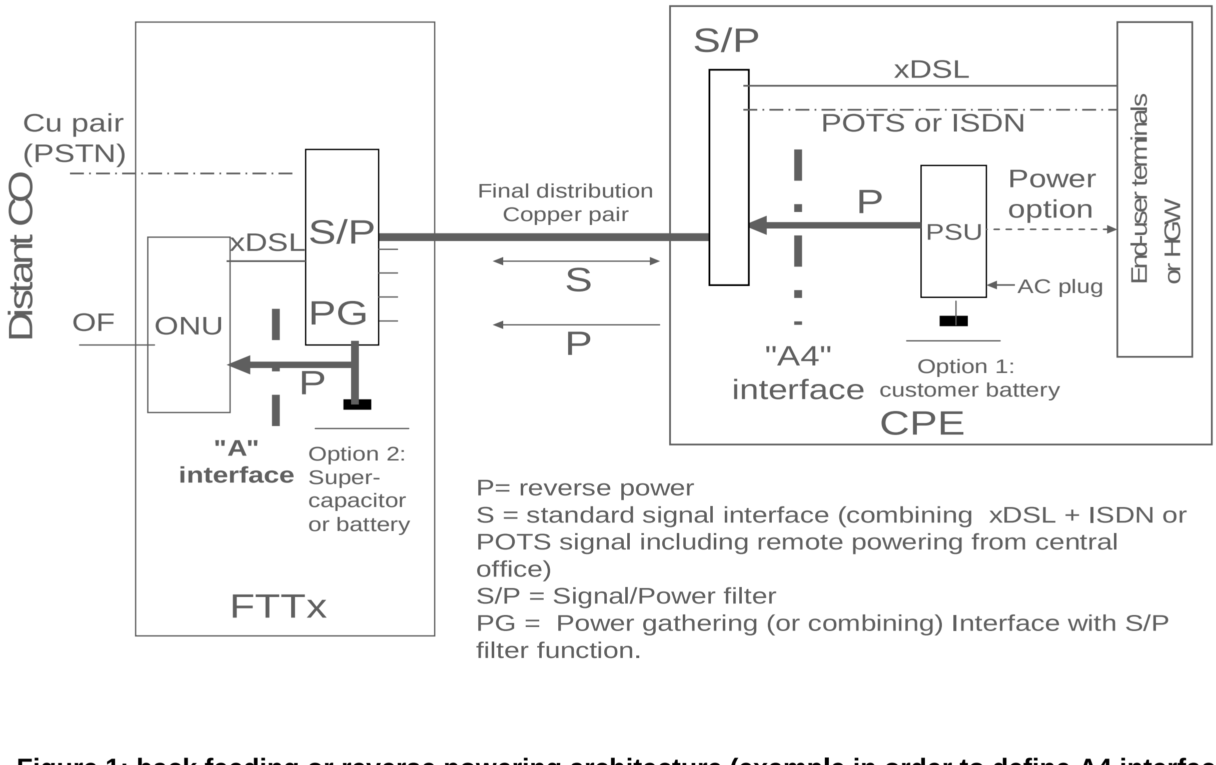

Figure 1: back feeding or reverse powering architecture (example in order to define A4 interface)

The remote cabinet (ONU or remote DSL unit or ...) under consideration (more generally ANU) is generally located in FTTB or FFTC cabinet or underground chamber. The telecom node equipment is common to N customer (x=Building, Curb, Node, …), and is generally powered through 48 V interface A as defined in EN 300 132-2 [i.2] by a power gathering interface PG receiving pairs from customer through a filter separating signal S and power P (S/P_{filter}). The S/P_{filter} is out of the scope of the present document. The interface on the different telecom existing line should not be affected by reverse powering, so that there should be no change for the existing central office equipment or home terminals. The voltage on the distribution line between the customer and the telecom node equipment may be different than the POTS voltage or ISDN voltage if the distance or power load needs higher voltage to allow power transport with an acceptable efficiency.

The pairs are powered by customer wall adapters though an S/P_{filter} connected to the home phone pair network defined by ES 202 971 [i.12]. The same wall adapter may be used to power the client home gateway, often called "box".

The power interface with the pair between customer and ANU is called A4 and located in figure 1.

NOTE : With the same voltage interface as DSL over POTS or ISDN, the filter is very similar to existing one.

4.2 Backfeeding or Reverse Powering Architecture Options

There should be a compatibility with other architecture such as remote powering or mains power supply which is very simple when the power input interface of the ANU or remote DSL is the interface A [i.2].

There may be options such as back-up in the FTTx or/and in the customer premises.

There should be also possible contributions between different power supplies for example:

- When there is not enough remote pairs, a part of the power can be provided by reverse powering, e.g. the energy for the common parts could be provided from the CO, while the energy for the single line could be provided by each customer.

NOTE 1: This can be useful to allow initial powering at installation with few customers, or in special area or time where a lot of customers shut down their systems (e.g. tourist area with great variation of numbers of permanent customers)

- When there is a mains interruption, back-up can be provided through to the CPE by the reverse powering battery back-up. In that case the powering is not reverse and should be compliant with EN 302 099 [i.3].

NOTE 2: This should probably be limited in power for some essential service. It is out of the scope of the present document to define these services.

4.3 A4 interface at the pair interface arrival

The A4 interface is of type TNV-1 according to TS 60479-1 [i.14] and EN 60950-1 [i.9] in Network Environment 1 as defined in TR 62102 [i.8] (the circuits connected to telecommunication network are usually TNV-type; besides in case of cloud to cloud lightning just above the building the possibility to have induced surges on the vertical pairs, usually not shielded, is not reduced), i.e. the voltage is 60 V maximum and peaks are limited according to TR 62102 [i.8], TS 62367 [i.13] and EN 60950-1 [i.9].

NOTE: There is a possibility of using other voltages beyond SELV as long as they have sufficient safety features built in ITU-T Q2 (ISDN). Considering the risk with children, this should not be recommended for residential use, but only for professional use (e.g. non public area in office premises). This is not described in the present document. Earthing and grounding should be addressed in detail in respect to EN 300 253 [i.16]

For information EN 60364-1 [i.17] and EN 60364-4-41 [i.23] safety standard should be considered.

See details of current effect on human in annex C.

The power interface A of the ANU or remote DSL equipment is 48 V [i.2], i.e. 40,5 V to 57 V in normal range. It is not recommended to add a voltage converter (step-up) for reliability and efficiency reasons. That means limited voltage drop and power loss in the pairs. Annex A gives maximum power values depending on line section and line length considering A interface minimum voltage.

15 W is the limit according to EN 60950-1 [i.9] for the power on a telecommunication network and the A4 interface is be designed in order to limit the output current to a value that does not cause damage to the telecommunication wiring system due to overheating, under any load condition as required by the same EN 60950-1 [i.9]. The S/P_{filter} should be dimensioned for the maximum current of 250 mA at 60 V.

This give also a limit for the energy cost per user. The power should be fairly supported by customer by a method to split almost equally the power between reverse powering lines e.g. at the combiner level.

NOTE 1: The overlay of back feeding with POTS on the pair between customer and the telecom node is possible. There should be circuitry to avoid a power collision between the phone remote powering and low frequency signals with the reverse powering. There are several possible solutions with detection of 80 V - 50 Hz ringing signal from central office side or phone off hook from customer phone side. There should be no change in the operation of the terminals of a common customer installation with several POTS or DSL telecom equipment plugs, e.g. the power injector can be connected on any existing plug independently of terminals or anywhere in parallel on the customer home or office telecom line installation. QoS in general and particularly diaphone should not be affected. See some details in annex B. The solution proposed should limit the voltage and current to avoid destruction of the telecom device plugged on the domestic network.

NOTE 2: The reverse powering should be always on even when using DSL standby low power mode, to be independent from DSL line status modes (L0, L2, L3 modes).

4.4 ANU Power consumption

The power consumption is based on the target value per line of TR 102 533 [i.7] measured at the A interface. The power consumption for one ANU port has to be compliant with BBCoC values [i.11]. It should be calculated not including the power loss in the copper line from end user A4 power interface to ANU power interface.

Starting from 01/01/2008, VDSL2 line power should be lower than 2,5 W for ANU with less than 100 ports, including common equipments in addition to ports, fans, monitoring in full service mode L0 at the 48 VDC "A" interface defined in EN 300 132-2 [i.2]. If standby modes are available, this will reduce the end-user power consumption and improve back-up autonomy.

The ANU using reverse powering is probably limited to some hundreds customers. The maximum power should probably be limited to 250 W, in order that low power fans be sufficient to maintain outdoor cabinet under EN 300 019-1-4 [i.1] environmental conditions.

4.5 Back-up options

If a life-line service is required for phone call in case of crisis as understood in EU directive [i.10], there is an energy back-up to cover mains electrical interruption.

NOTE 1: Another possible reason for back-up of the the network elements e.g. ANU or NT equipment might be for some operator that the clients have batteries in their terminals (mobiles, portable PC) and they will not accept to lose telecom service in case of electrical interruption (excepting very long energy outage).

There are different possible back-up solutions (see figure 2):

1) Energy storage in the ANU: in normal operation, power is fed from the end-user. In case of end-user mains interruption, ANU is powered by the back-up and power should be sent back from this storage to the end-user NT in case of mains interruption at the user side. If there is a mains failure in the customers premises than all the customers equipment (TV, PC, etc.) will not work anyway so this is possibly not required unless end-user devices equipped with battery (see note 1).

2) Energy storage in the end-user NT power supply with back feeding function.

3) Both solution: in case of end-user mains interruption, ANU and end-user NT are powered by their own local back-up.

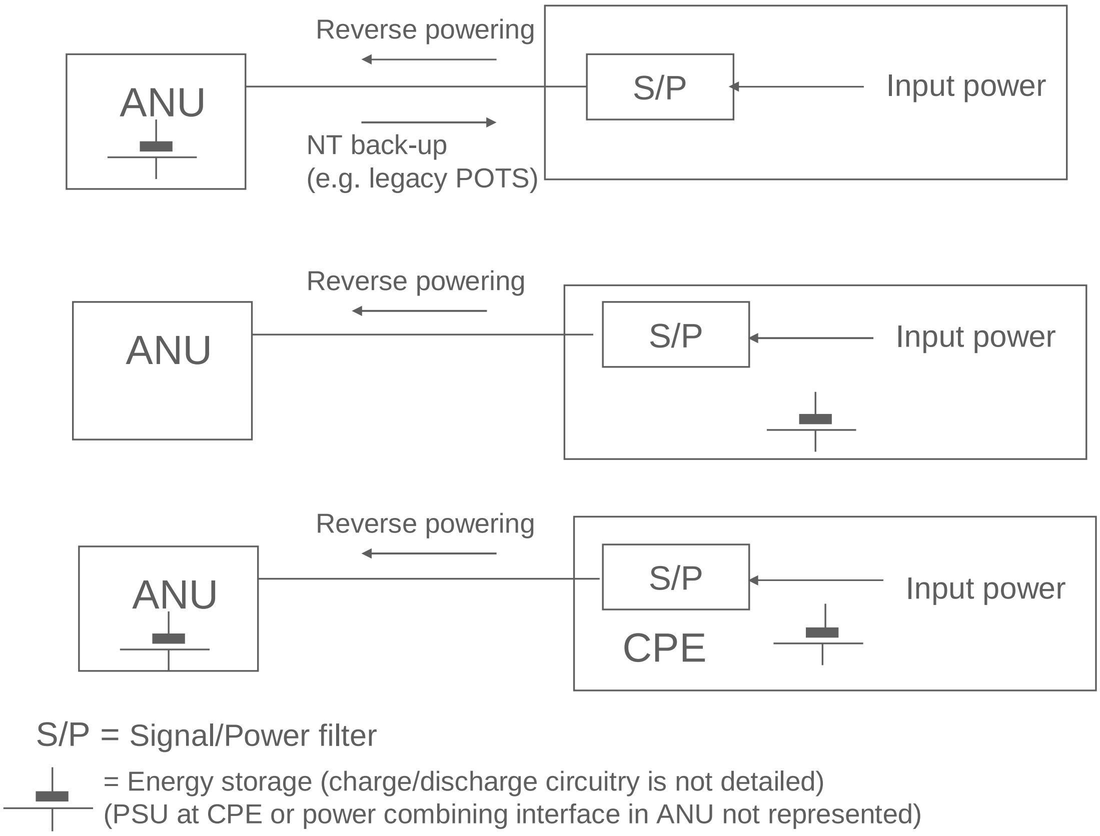

Figure 2: Backup options (example of implementation in the case of an ONU)

The back-up can be obtained by using different kind of storage:

- Case 3: super-capacitor bank at the ANU side to cover mains disturbance or very short interruption of some seconds. Voltage and temperature impacts cell lifetime, so they should be carefully chosen. The cell voltage balance is controlled. Organic electrolyte leakage is avoided by limiting overvoltage due to toxicity and gas explosion hazard risk.

- All case: rechargeable batteries at the ANU side or NT side to cover minutes or hours of mains break. Automatic test and monitoring is very convenient to detect failures and provide useful information to decide of battery replacement. Several technologies can be used. The battery installation is defined in EN 50272-2 [i.6], e.g. as well as gas exhaust quantity limit depending of normal use or abuse. It is recommended to avoid too many distributed electrochemical storage (batteries) in the field because of maintenance.

Case 1 and 3: battery at NT side are in better environment conditions than in outdoor ANU side. These battery should be replaceable and of VRLA or sealed type in technology such as lead-acid, NiMH, NiZn or Lithium-ion. The user can be responsible for maintenance. The operator should propose a simple replacement and recycling process.

VRLA battery should be compliant with EN 60896-21 [i.4].

The whole ANU equipment should be compliant with EN 60950-22 [i.5] for safe installation.

5 Progressive installation issue

There is a threshold of number of customer with reverse powering option to obtain enough power for the full ANU.

This addresses the issue of not powering unused port.

Standby mode associated to battery can also help to reduce the mean power of the ANU with few customers.

However, theres is a risk of overload if the traffic is higher than planed.

6 Failure detection, alarms, reparation and control monitoring

The power gathering interface in the network equipment detects that a customer pair gives no longer power. Each operator will define how to manage the no-power event. For example, the no power event is used to send warning to the customer, and to generate alarm under some conditions: event persistence, event periodicity, etc.

Optional ANU back-up:

- Batteries: a discharge test should be performed periodically and alarm set if capacity is lower than a preset threshold.
- Super-capacitors: the discharge voltage is a good indicator of the charge available and so of autonomy. The mains interruptions are sufficient to operate the test. The voltage and current can be monitored to detect a failure of the capacitor.

Customer optional battery:

- A discharge test can be manually defined by the user and test report given by LED or any other way. The user will be in charge of replacing the battery if replacement condition is reached.
- The control-monitoring interface should use as far as possible the ES 202 336-1 [i.18] generic control monitoring interface. This interface is most likely in the APU.

7 Reliability, dependability and contract between operator and customer

Today, in most general case, the network maintenance is the responsibility of the operator. The end-user equipment (terminals or gateway) maintenance can partially be the responsibility of the user. With reverse powering, the ANU power emitter device and back-up device maintenance can also be the responsibility of the user.

One issue is to detect that the customer has disconnected the reverse powering or shut down power or that there is a failure. Then warnings can be sent to the user, to ask him for maintenance. There should be a contract with the customer to describe these cases, but this is to define by each operator in agreement with regulator.

EXAMPLE: Another important aspect is possible customers' complaints towards the supply of electrical energy to the Operator's ANU from their own budget, especially when the kWh cost gets higher due to energy crisis. One solution to minimize these complaints is to use a solution that split equally the power between the reverse powering lines.
The operator proposes an uninterrupted service in case of mains outage for x hours only if the customer provides power to the network. The operator does not guaranty service reliability and QoS if the end-users equipment is not maintained in proper operation.

8 Regulatory aspects

These regulatory aspects are not solved in the scope of the present document

Problem may occur when there is change of contract or operator.

Annex A: Backfeeding Power as a function of output voltage and pairs size and length

The calculation is made as follows. The injected voltage is Uin=60 V and the maximum injected power Pm = 15 W.

The line résistance is:

$$Rline = \rho l / s$$

With $\rho = 2.10^{-8}$ Ωm at relatively high average temperature, copper section s in m², line length in m.

The line current I is:

$$I = MIN(Pm / Uin, (Uin - U\min) / Rline)$$

Where Umin is the minimum accepted end voltage.

The received power at the end of the line is then:

$$P = (Uin - Rline.I).I$$

The usable power for telecom equipment in ONU or FTTx depends of the Power Gathering Interface efficiency (generally higher than 80 %).

Figure A.1 shows for example that 8 W is available at 200 m and 1 W at 1 500 m on 0,4 mm pair section at 50 V end line voltage from 60 V injected on the pair, but respectively 13 W and 2,4 W is available at 40 V end line voltage at the same distances.

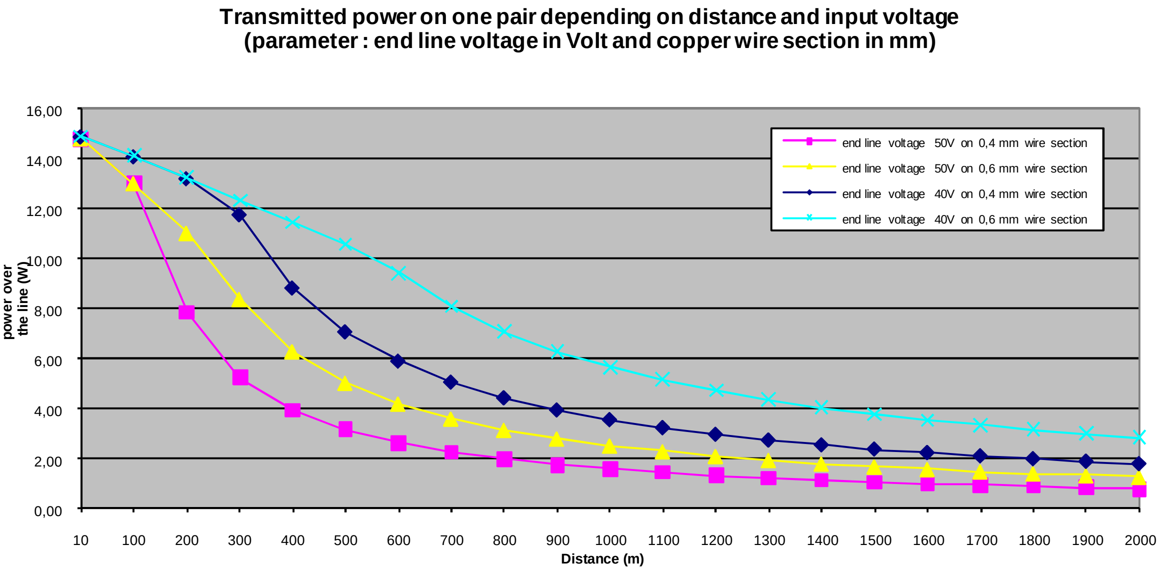

Figure A.1: Back feeding power function of distance at 60 V injection

Figure A.2 shows the available power with 120 V (e.g. -60 V and +60 V refered to ground) injection in the line

NOTE: The end line voltage should be understood as -50/+50 V i.e. 100 V and respectively -40/+40 V i.e. 80 V.

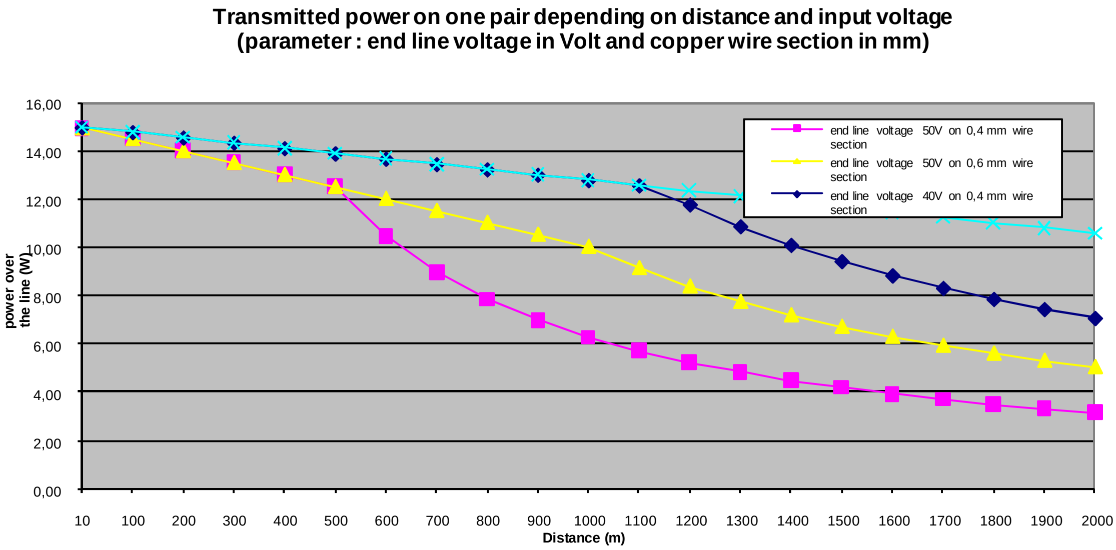

Figure A.2: Back feeding power function of distance at 120 V injection (+60 V -60 V)

Annex B: Backfeeding principle in overlay of PSTN +DSL

Figure B.1 shows the principle to avoid central office PSTN DC voltage collision with back feeding DC. This is an example with 2 telecom wall socket. Only one port of the power gathering unit is shown, the other being similar.

If the phone is off hook (line connection), a current is detected by the wall adaptor generator used for back feeding and back feeding current injection is stopped on customer side. Then the relay detecting no more back feeding current switches to central office (position 1 of the relay in figure B.1).

If the phone comes back to on hook position (line disconnection), the PSTN remote current stopped which is detected by I line sensor in the power gathering unit and the relay switches to ANU (position 2 of the relay in figure B.1). No current is seen by the WA and back feeding starts again.

NOTE 1: To cover any case of loss of reverse powering, another source should be provided at the telecom node e.g. a local battery.

NOTE 2: The PSTN application imposes a very complicated filter with very large bandwidth. This filter can become much simpler for in band voice application. The definition of the filter is out of the scope of the present document.

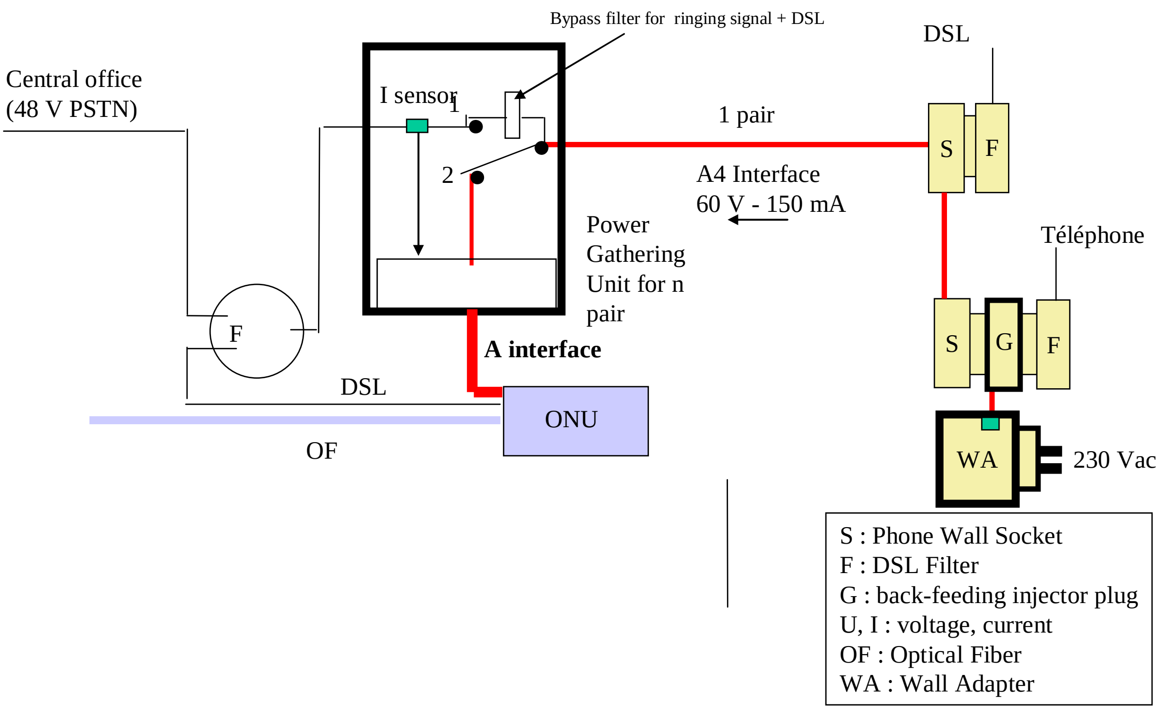

Figure B.1: Principle to avoid central office PSTN DC voltage collision with back feeding DC

NOTE: The current on the pair is given as an example in figure B.1, which should be in the limit defined by the interface A4.

Annex C: Safety consideration for remote feeding

General

The electrical safety should be clearly defined for ANU and for CPE.

Remote power supply equipment in ANU should be operated in restricted access locations according to EN 60950-1 [i.9], clause 1.2.7.3. Remotely fed equipment e. g. a repeater or DSLAM should also be accommodated in locations with limited access.

In restricted area, limit values during normal operation and during single fault conditions are defined in EN 60950-21 [i.19], clause 6.

Voltage range

According the EN 60950-1 [i.9], EN 60950-21 [i.19] and TR 62102 [i.8] are listed the different current categories.

Table C.1: Current circuit categories

Category	AC_{peak}	DC	transient (ext.)
SELV	≤ 42,4 V	≤ 60 V	-
TNV-1	≤ 42,4 V	≤ 60 V	yes
TNV-2	42,4 ≤ U ≤ 70,7 V	60 ≤ U ≤ 120 V	-
TNV-3	42,4 ≤ U ≤ 70,7 V	60 ≤ U ≤ 120 V	yes
hazardous	> 70,7 V	> 120 V	-/yes
Remote feeding	-	I ≤ 60 mA	yes
Current limited circuit	I_{peak} ≤ 0,7 mA (70 mA at f > 100 kHz)	I ≤ 2 mA	-
ELV	≤ 42,4 V	≤ 60 V	-

Remote power interfaces according TR 62102 [i.8].

Table C.2: Remote power interfaces [i.8]

Interface or connection point	Documents relevant for the interface	Approximate operating voltage	Earthing	Network environment per Clause 6	EN 60950 series circuit category
RFT-C Remote power feeding	EN 60950-21 [i.19]	< 1 500 V d.c.; 60 mA	yes/no	1	RFT-C
RFT-V Remote power feeding	EN 60950-21 [i.19]	100 VA ±200 V d.c. leakage current 10 mA by 10 kΩ after 10 s	yes/no	1	RFT-V
RFT-V Remote power feeding	EN 60950-21 [i.19]	100 VA +140 V d.c.	yes/no	1	RFT-V
RPS Remote power supply	EN 60950-21 [i.19]	110 V d.c.	no	1	TNV-3

Refer to [i.24] for more information.

Safety Considerations and aspects

For safety considerations and aspects for remote power feeding see EN 60950-21 [i.19], annex A (informative).The limit for interface A4 at Customer Premises, which are not only restricted area but private or public area should be compliant with national rules or laws and chosen in order to master the risk of electrical hazards on human body.

In addition, there is possibility of large contact area with salted water e.g. working condition with immersion in melted salted snow from outside at the ANU or salted water from bath or washing at home.

It can be useful to refer to the guide TS 61201 ed2.0 [i.20] and to determine specific touch voltage limits considering different physiological effects, environmental conditions, contact conditions, etc. for AC and pure DC with no significant AC component.

Body impedance values and current through body calculation:

The following information is based on **TS 60479-1 [i.14]**.

The parameters of determination of the impedance are:

- Current type (DC or AC), DC current is current with a ripple less than 10 % note 1 p 55), AC impedance is in a range of frequency 50 Hz to 60 Hz.
- Voltage (because the impedance is not a constant value and depends a lot on voltage).
- Circuit path e.g. hand to hand, both foot to left hand, etc.
- Area of contact (large arround 10 000 mm², medium arround 1 000 mm² and small around 100 mm²).
- Condition of contact (dry, water wet, salted water wet).
- Percentile of population (5 %, 50 % and 95 %).

For the more conservative estimate at CPE, it is recommended to use table 9 (total body impedance for a current path hand to hand for small surface area of contact in salted water -wet conditions at touch voltage 25 to 200 Vac 50/60 Hz) These conditions cover be the case of children with wet hands touching both wires. The impedance of children seems to be higher, but it is better to stay with lower value of impedance (clause 4.5.1).

Clause 4.5.4 indicates that for large surface areas of contact in water-wet and saltwater-wet conditions the total body resistance in DC may be determined with sufficient accuracy from tables 2 and 3, while neglecting small differences of between AC and DC which may exist in the voltage range below 100 V. For all other cases, the tables for AC can be used for a conservative estimate.

According to note 1 of table 10, when there is no limitation in time of the current flow, the human impedance for dc current decreases after 0,1 s and then after complete rupture of the skin approaches the internal body resistance.

Time-Current limits

Clause 6 describes the effect of DC current.

Table 12 gives the heart-current factor F (0,04 to 1,5) for different current paths through the body.

The effect of current is higher from hand to foot (factor 1 e.g. wire to ground current through body) than from hand to hand (factor 0,4 e.g wire to wire current through body). With the reference current Iref conducted from left hand to both feet, the same effect is observed with current divided by Iref/F when using another current path such as hand to hand.

Table 13 defines the time-current zones for dc for hand to feet pathway:

DC- 1 zone up to 2 mA is the no reaction zone.

DC- 2 > 2 mA, is the no harmful zone but involuntary muscular effect can be observed.

DC - 3 is a dangerous zone but generally with no irreversible effect on body.

DC - 4 is the dangerous zone with ventricular fibrillation risk.

Figure 22 shows these zones with the information of time-current or charge flow though human body from left hand to both feet.

For example, the current threshold is stabilized at its minimum after 2 s, the limit b-c1 (DC2 to DC3 boundary) is around 25 mA and the limit c1-c2(DC3 to DC4 boundary) is is 150 mA according table 13 definition and figure 22.

The heart factor of 0,4 should be used for hand to hand current safety limits which means a much higher limit of IR/0,4 =60 mA to exit from DC2 area, which is the same value of EN 60950-21 [i.19], informative annex A.

As a result some indications extracted from TS 61201 ed2.0 [i.20] table 2 are given:

Conditions	**Safety maximum limits**	**Large area (hand to feet, large touch area at least for feet or body in case of grounded output voltage)**	**Small Area (hand to hand small touch area in case of insulated power supply and connectors)**
Salted wet condition			
	DC-2 (no harmful muscular effect)	25 mA, 14 V	25 mA, 112 V
	DC-3 (dangerous but not irreversible effect)	140 mA, 75 V	350 mA, 467 V
Dry condition			
	DC-2 (no harmful muscular effect)	25 mA, 28 V	25 mA, 156 V
	DC-3 (dangerous but not irreversible effect)	140 mA, 94 V	350 mA,470 V

For maximum safety the 25 mA limit for long duration should be taken into account, which means that a full insulation of connectors and power supply is at least required to reduce area avoid salted wet ground current through large contact area and limit hand to hand current through very small contact area.

NOTE 1: Annex D of TS 61201 ed2.0 [i.20] indicates that conventional voltage limits based on these thresholds (for example 50 V ac. or 120 Vdc.) are generally acceptable in practice because external factors have reduced the risk such as small contact area (finger rather than full hand contact), additional resistance in series (any clothing), non conductive accessible surfaces. Table D.2 illustrates maximum contact areas corresponding to given touch voltages that in turn relate to commonly used voltage limits. Safety factors should be applied in the selection of limits by users of the present document leading to smaller maximum allowable contact areas. 60 Vdc to 120 Vdc can be used with small surface area lower (< 1 cm^2).

NOTE 2: TS 60479-1 [i.14], table 2 gives for short contact (< 0,1 s), hand to hand, water wet condition, for 50 % population, 2 000 Ω at 50 V, 1 675 Ω at 100 V, 1 400 Ω at 150 V. For 5 % population the resistance is about divided by 2.
Clause 4.6 indicates that this resistance for a current path hand to hand or hand to foot and large surface areas of contact can be taken as equal to 500 Ω for a percentile rank of 5 % for AC and for DCC. The values for 50 % and 95 % of the population can be taken as equal to 750 Ω and 1 000 Ω respectively (similar to table 1). Moreover, the values depend only little on the surface areas of contact and on conditions of the skin.
Taking into account this worse resistance i.e. the lowest resistance value, the 25 mA (DC-2) threshold is passed at 12 V and 18,76 V for average population, and 140 mA (DC-3) threshold respectively at 70 V and 105 V.

It appears clearly that exact calculation of voltage/current limit requires further study to assess reasonable risks under reasonable conditions.

History

Document history		
V1.1.1	June 2010	Publication