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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

Modal verbs terminology

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

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Introduction

As various Operators consider the deployment of fibre-fed remote nodes that contain xDSL DSLAM equipment, it is necessary to consider the means of powering such remotely located equipment. One such method, known as "reverse power feed", transmits the power from the customer premises to the fibre-fed remote node using the distribution-side copper network. The present document defines a reverse power feed transmission standard which allows Operators to source suitably compliant equipment for inclusion in their networks. The reverse power feed methodology can be used to power a remote node hosting any metallic transmission system (e.g. G.fast [i.4], VDSL2 [i.3], etc.).

1 Scope

The present document defines architectures and specifications for reverse powering of remote network nodes from one or multiple CPEs. The architectures describe how to combine reverse power feed with the data only, VoIP and POTS line services. Start-up protocols are defined to ensure proper interaction between the line services and the reverse power system. Operations and maintenance requirements for managing the reverse power feed and power combining within the remote network node are specified. The present document also identifies power splitter and POTS Adapter requirements.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

[1] 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".

[2] CENELEC EN 60950-1: "Information Technology Equipment - Safety, Part 1: General requirements (IEC 60950-1:2005 + Cor.:2006 + A1:2009, modified)".

[3] ETSI ES 203 021: "Access and Terminals (AT); Harmonized basic attachment requirements for Terminals for connection to analogue interfaces of the Telephone Networks; Update of the technical contents of TBR 021, EN 301 437, TBR 015, TBR 017".

[4] Broadband Forum: "TR-301 Architecture and Requirements for Fiber to the Distribution Point", Issue 1.

[5] Broadband Forum: "TR-286 Testing of Metallic Line Testing (MELT) functionality on xDSL Ports".

[6] IEC 61000-4-11: "Testing and measuring techniques - Voltage dips, short interruptions and voltage variations immunity tests".

[7] ETSI TS 101 952-1: "Access network xDSL splitters for European deployment; Part 1: Generic specification of xDSL over POTS splitters".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Void.

[i.2] NICC ND 1645 (V1.1.2) (2011-06): "NGA Telephony; Architecture and requirements".

NOTE: Available at http://www.niccstandards.org.uk/files/current/ND1645v1.1.2.pdf?type=pdf.

[i.3] Recommendation ITU-T G.993.2: "Very high speed digital subscriber line transceivers 2 (VDSL2)".

[i.4] Recommendation ITU-T G.9700: "Fast access to subscriber terminals (G.fast) - Power spectral density specification".

[i.5] Recommendation ITU-T G.9701: "Fast access to subscriber terminals (G.fast) - Physical layer specification".

[i.6] ETSI TS 101 271 (V1.2.1): "Access, Terminals, Transmission and Multiplexing (ATTM);Access transmission systems on metallic access cables; Very High Speed digital subscriber line system (VDSL2) [Recommendation ITU-T G.993.2 modified]".

[i.7] Recommendation ITU-T G.998.4, Annex E: "Low Power Mode operation with ITU-T G.993.2 and G.993.5".

[i.8] Recommendation ITU-T G.9701, Amendment 1 (2014): "Support of Low power operation and all functionality necessary to allow transceivers to be deployed as part of reverse powered (and possibly battery operated) network equipment".

[i.9] Recommendation ITU-T G.992.5: "Asymmetric digital subscriber line 2 transceivers (ADSL2)- Extended bandwidth ADSL2 (ADSL2plus)".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

bypass mode: operational state of the POTS adapters or power splitter where there is a metallic connection to the exchange or to an ATA

normal mode: operational state of the POTS adapters or power splitter where there is no metallic connection to the exchange or to an ATA

normal operation: state of a system (i.e. a DPU reversely powered by a PSE) reached after the start-up procedure has been completed

POTS adapter: device that provides DC isolation between reverse power feed and POTS

power splitter: device that performs a frequency splitting/combining function between the services being carried (which can include POTS and xDSL based services) and the injected DC electrical power

service splitter: low pass filter that separates baseband POTS from xDSL frequencies

NOTE: The relevant specifications for the service splitter can be found in ETSI TS 101 952-1 [7].

start-up mode: start-up procedure of a system (powering part of a DPU and PSE).

3.2 Symbols

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

Ω	Ohm
µF	micro Farad
nF	nano Farad
R	2-wire analogue presented interface
U-R	Reference point at CPE containing both DC power and service data
U-R2	Reference point at CPE containing the filtered service data
U-R2P	Reference point at CPE containing the injected DC power
U-R2S	Reference point at CPE containing the baseband POTS and the converted POTS signalling
U-O	Reference point at DPU containing both DC power and service data
U-O2	Reference point at DPU containing the filtered service data
U-O2O	Reference point at DPU containing the baseband POTS and the converted POTS signalling
U-O2P	Reference point at DPU containing the extracted DC power

3.3 Abbreviations

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

AC	Alternating Current
ACM	Alternating Current Mains
ADSL	Asymmetric Digital Subscriber Line
ATA	Analogue Telephone Adapter
BAT	Battery
BBA	Battery Back-up Available
CO	Central Office
CP	Customer Premises
CPE	Customer Premises Equipment
CPE ME	CPE's Management Entity
CPF	Common Power Feed
DC	Direct Current
DGL	Dying Gasp Loss
DN	Distribution Network
DP	Distribution Point
DPU	Distribution Point Unit
DPU ME	DPU's Management Entity
DR	Diode/Resistor
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
ELC	Error Line Condition
EXPSW	Exchange Sharing the in-premises Wiring
FSK	Frequency Shift Keying
FTTdp	Fibre To The distribution point
FTU	G.fast Transceiver Unit

NOTE: See Recommendation ITU-T G.9701 [i.5].

FTU-O	FTU at the DPU
FTU-R	FTU at the remote site
HON	Higher Order Node
IFN	Intensity of current Feed Now
LPF	Low Pass Filter
LR	Long Range
LSU	Last Start Up

MDSU	Metallic Detection based Start-Up protocol
ME	Management Entity
MELT	Metallic Loop Test
NMS	Network Management System
NT	Network Termination
NTE	Network Termination Equipment
OAM	Operations And Maintenance
OHP	Off-Hook Phone
PC	Power Class
PHY	Physical (layer)
PMA	Persistent Management Agent
PME-C	CPE's Power Management Entity
PME-D	DPU's Power Management Entity
PMT	Power Management Transceiver
POTS	Plain Old Telephony Service
PRP	POTS Remote Copper Reconfiguration (RCR) Protocol
PS	Power Splitter
PSD	Power Spectral Density
PSE	Power Source Equipment
PSU	Power Supply Unit/Combiner
PT	PRP Trigger
PTID	PRP Trigger IDentification
RBW	Resolution Bandwidth
RC	Resistor/Capacitor
RCR	Remote Copper Reconfiguration
RING	The other leg of a twisted pair
RPCE	Reverse Power Control Entity
RPF	Reverse Power Feed
RPFA	Reverse Power Feed Architecture
RPFA-DRP	Reverse Power Feed Architecture - Derived POTS
RPFA-DRPSW	Reverse Power Feed Architecture - Derived POTS Sharing in-premises Wiring
RPFA-EXP	Reverse Power Feed Architecture - Exchange POTS
RPFA-EXPSW	Reverse Power Feed Architecture - Exchange POTS Sharing in-premises Wiring
RPFA-NOP	Reverse Power Feed Architecture - No POTS
RPFA-NOPBB	Reverse Power Feed Architecture - No POTS with Broadband Bypass
R_{SIG}	Signal Resistor
SCF	Switch Control Function
SF	Switching Function
SG	Service Gateway
SIG	Signature
SR	Short Range
SS	Service Splitter
TIP	One leg of a twisted pair
TNV	Telecommunication Network Voltage
UPS	Uninterrupted Power Supply
VA	Volt Ampere
VDSL	Very high speed Digital Subscriber Line
VoIP	Voice over Internet Protocol
VPSE	Steady state voltage from PSE
VTU	VDSL2 Transceiver Unit at DSLAM

NOTE: See Recommendation ITU-T G.993.2 [i.3].

VTU-O	VTU at the ONU
VTU-R	VTU at the remote site
xDSL	unspecified DSL variant
xTU-O	FTU-O or VTU-O
xTU-R	FTU-R or VTU-R
ZRC	Zener/Resistor/Capacitor
ZT-RCR	Zero Touch Remote Copper Reconfiguration
ZT-LAC	Zero Touch Link Auto Configuration

4 Introduction to Reverse Power Feed

The basic architecture of a fibre-fed remote node with reverse power feed is shown in Figure 1.

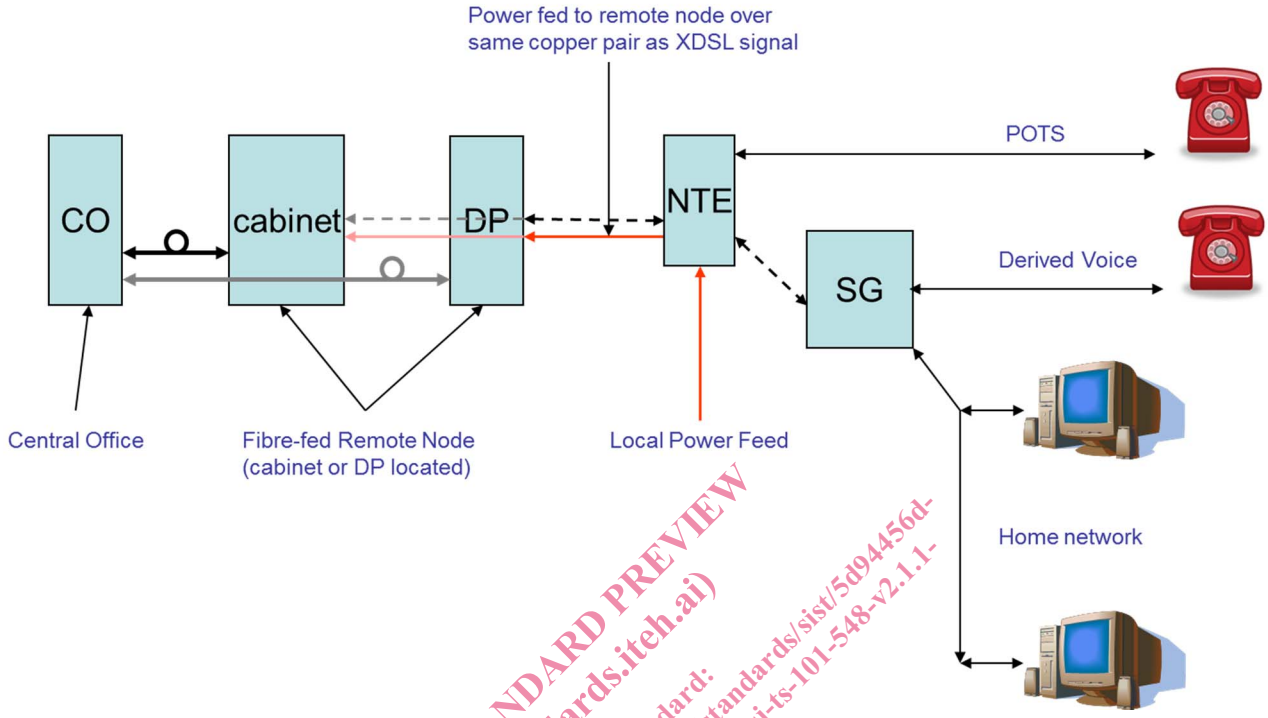

Figure 1: Generic Fibre-fed Remote Node Architecture with reverse power feed

Figure 1 shows power being injected at the NTE from a local power source (located within the home and/or building) which traverses the local loop to power a fibre-fed remote node which can be located at either the distribution point (DP) or street cabinet using the same copper pair cable that is used to transmit the xDSL to/from the home/fibre-fed remote node. A metallic POTS service is shown at the NTE. Voice services can also be implemented as a derived service from the service gateway (SG).

An issue with regards to reverse powered fibre-fed nodes is that of who or what is responsible for the powering of common circuitry contained within the node. It is easy to envisage that an individual user should be responsible for the powering of the remote line terminating/driver electronics corresponding to his particular circuit. However, it is not so easy to determine who or what is responsible for powering of say the DPU that terminates the fibre link.

There may be occasions where only a single user is providing power to the remote node but this may not be sufficient to power all of the remote node electronics for proper operation.

It is recognized that one single (i.e. generic) specification cannot consider all possible architectural variants, therefore the present document has been organized as a series of architecture options and equipment shall adhere to one or more of these options.

In the present document, two different implementations of power source equipment (PSE) for Customer Premises are considered: standalone (i.e. a two box model where the PSE and NTE are separate) or integrated (i.e. a single box model where the PSE and NTE are integrated). In these implementations, the power splitter (PS) may either be integrated or stand alone.

5 Reverse Power Feed Architecture

5.1 Basics of RPF

Reverse power feed is one of three DPU powering methods defined in TR-301 [4]. Here, the DPU draws its power from the customer premises via the copper lines between those premises and the DPU. The reverse power feed capacity and DPU power consumption need to be such that the DPU can be fully operational when only a single customer is connected. Any back-up battery would be located in the customer premises.

The other two methods are:

- Forward Power from a Network Power Node. In this case, any back-up battery would be located at the network power node.
- Local Power from AC mains source. In this case, any back-up battery would be located at the network power node.

The combination of reverse powering with one or both of the other two methods is outside the scope of the present document.

Reverse powering shall have two power splitters (one located at the customer premises and another at the remote node) to enable power to be inserted at the customer end of a link and extracted at the remote node. Each power splitter performs a frequency splitting and combining function between the services being carried (which can include POTS and xDSL based services) and the injected DC electrical power.

Within the remote node, if it operates with multiple power-fed lines then there shall be a power extraction and combiner unit. The purpose of this unit is to combine the multiple power feed inputs to produce a single power source output. The power load should be shared amongst the input power sources.

The technical specifications in the present document shall apply to each architecture described below as one of the six options shown in Table 1. The optional reverse power battery backup at the customer premises is illustrated in block BAT for each reference model.

Table 1: Architecture Options for Reverse Power Feed

Option	Name	Description
1	RPFA-NOP	Reverse Power Feed Architecture - No POTS
2	RPFA-EXP	Reverse Power Feed Architecture - Exchange POTS
3	RPFA-EXPSW	Reverse Power Feed Architecture - Exchange POTS Sharing in-premises Wiring
4	RPFA-DRP	Reverse Power Feed Architecture - Derived POTS
5	RPFA-DRPSW	Reverse Power Feed Architecture - Derived POTS Sharing in-premises Wiring
6	RPFA-NOPBB	Reverse Power Feed Architecture - No POTS with Broadband Bypass

5.2 Reverse Power Feed and POTS Co-Existence

5.2.1 Overview

Table 1, option 2 to option 5 involve reverse power feed co-existing with POTS - whether this is exchange based POTS (RPFA-EXP, RPFA-EXPSW) or derived POTS (RPFA-DRP, RPFA-DRPSW).

When a POTS service is present on the same wire pair as reverse power feed (option 2, option 3 and option 5) the POTS DC signalling/low frequency signalling will be translated so that it uses another part of the baseband spectrum, but the basic analogue voice signal remains essentially untouched. At the CP, the signalling is restored and POTS is presented as normal.

When POTS is provided by derived voice service (option 4 and option 5), low power (L2) modes [i.7] and [i.8] may be used to provide the voice service even when the entire payload is not required by other services.

In order to achieve co-existence between reverse power feed and POTS, various adapters are required as described in clause 5.2.2 for use in the reverse power feed reference models.

5.2.2 POTS Adapters

5.2.2.1 General

The following three different types of POTS Adapter are specified for use in the reverse power feed reference models:

1) POTS Adapter - E (POTSA-E).

2) POTS Adapter - C (POTSA-C).

3) POTS Adapter - D (POTSA-D).

Where reverse power feed and POTS signals traverse the same copper wires, a signalling system shall be implemented to allow the signalling at the POTS interface based on off-hook/on-hook DC impedance, presence/absence of ringing signal, and in those jurisdictions requiring it, line reversal for Calling Number ID alerting to be communicated across the copper pair from the DPU to the POTS terminals. This functionality can be provided by the various POTS Adapters described in clauses 5.2.2.2, 5.2.2.3 and 5.2.2.4.

5.2.2.2 POTS Adapter - E (POTSA-E)

POTS Adapter - E is the single adapter located at the DPU and this adapter shall perform the following functions:

1) Translate the downstream DC and low frequency POTS signalling into an in-band or out-of-band signalling system.

2) Translate the signals from the upstream in-band or out-of-band signalling system into DC and low frequency POTS signalling.

POTSA-E may provide a relay by-pass when un-powered (for life-line operation) or when signalled to provide direct access to the exchange to allow operations such as line-test to be performed.

5.2.2.3 POTS Adapter - C (POTSA-C)

POTS Adapter - C is the single adapter located at the NT module and this adapter shall perform the following functions:

1) Translate the upstream DC and low frequency POTS signalling from the POTS Terminal into an in-band or out-of-band signalling system.

2) Translate the downstream in-band or out-of-band signalling system into POTS signalling towards the POTS Terminal.

3) Provide sufficient current limit and DC voltage to supply one or more phone devices.

4) Provide a pre-defined rate of change of current increase when a phone device goes off-hook to allow for the detection of phone devices going off-hook that do not have the correct POTS Adapter fitted.

POTSA-C may provide relay by-pass when un-powered (for lifeline operation) or when signalled to provide direct access to the exchange to allow operations such as line-test to be performed.

5.2.2.4 POTS Adapter - D (POTSA-D)

POTS Adapter - D is the adapter that can be attached to every phone device connected to the in-premises wiring on the home network. This adapter operates in the presence of reverse powering. This adapter shall perform the following functions:

1) Translate the signals from the upstream DC and low frequency POTS signalling from the POTS Terminal into an in-band or out-of-band signalling system.

2) Translate the signals from the downstream in-band or out-of-band signalling system into POTS signalling towards the POTS Terminal.