# ETSI TS 101 548-1 V2.2.1 (2018-06)

TECHNICAL SPECIFICATION

## Access, Terminals, Transmission and Multiplexing (ATTM); European Requirements for Reverse Powering of Remote Access Equipment; Part 1: Twisted pair networks

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# Foreword

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

The present document is part 1 of a multi-part deliverable covering the European requirements for reverse powering of remote access equipment, as identified below:

**Part 1: "Twisted pair networks";**

Part 2: "Coaxial cable networks".

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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 over twisted pair networks. 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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[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: "Electromagnetic compatibility (EMC) - Part 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".

[8] ETSI ES 203 021-3: "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; Part 3: Basic Interworking with the Public Telephone Networks".

[9] CENELEC EN 62368-1: "Audio/video, information and communication technology equipment - Part 1: Safety requirements".

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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)".

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# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

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

**Broadband bypass:** scenario whereby the DPU supports "Reverse Power Feed Architecture - No POTS with Broadband Bypass" (RPFA NOP-BB) as defined in clause 5.8

NOTE: The scenario whereby the DPU supports ZT-RCR defined in clause 7.4 whereby exchange POTS is not present on the line, but where there is an overlay DSL service (i.e. "naked" or "dry" DSL).

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

NOTE: This also refers to the the operational state of the stateless Switching Function (SF) specifically for the RPFA-NOPBB architecture option, where the xTU-R of the CPE is connected to the xTU-O of the CO/cabinet.

**metallic connection:** physical connectivity providing a DC path between two points, typically provided via a pair of twisted copper (or aluminium) wires

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

NOTE: This also refers to the operational state of the stateless Switching Function (SF), specifically for the RPFA-NOPBB architecture option, where the xTU-R of the CPE is connected to the xTU-O of the DPU.

**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 DC feed to allow a POTS service to share the same wires as those used by reverse power feed

**POTS DC feed:** DC current presented at a POTS adapter to power a plain old telephone

**POTS Remote Copper Reconfiguration (RCR):** scenario where POTS from the exchange may be provided to the subscriber and shall be disconnected by the DPU, prior to start-up of the DPU

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

NOTE: The power splitter does not include a DC-blocking high-pass function.

**RING:** other leg of a twisted pair

**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)

**TIP:** one leg of a twisted pair

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## 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 |
| PE | Power Extractor |
| 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 (including the combiner function if multiple lines are active) |
| PT | PRP Trigger |
| PTID | PRP Trigger IDentification |
| RBW | Resolution Bandwidth |
| RC | Resistor/Capacitor |
| RCR | Remote Copper Reconfiguration |
| 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 |
| $R_{SIG}$ | Signature Resistor |
| SCF | Switch Control Function |

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| | |
|---|---|
| SF | Switching Function |
| SG | Service Gateway |
| SIG | Signature |
| SR | Short Range |
| SS | Service Splitter |
| 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 |
| 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.

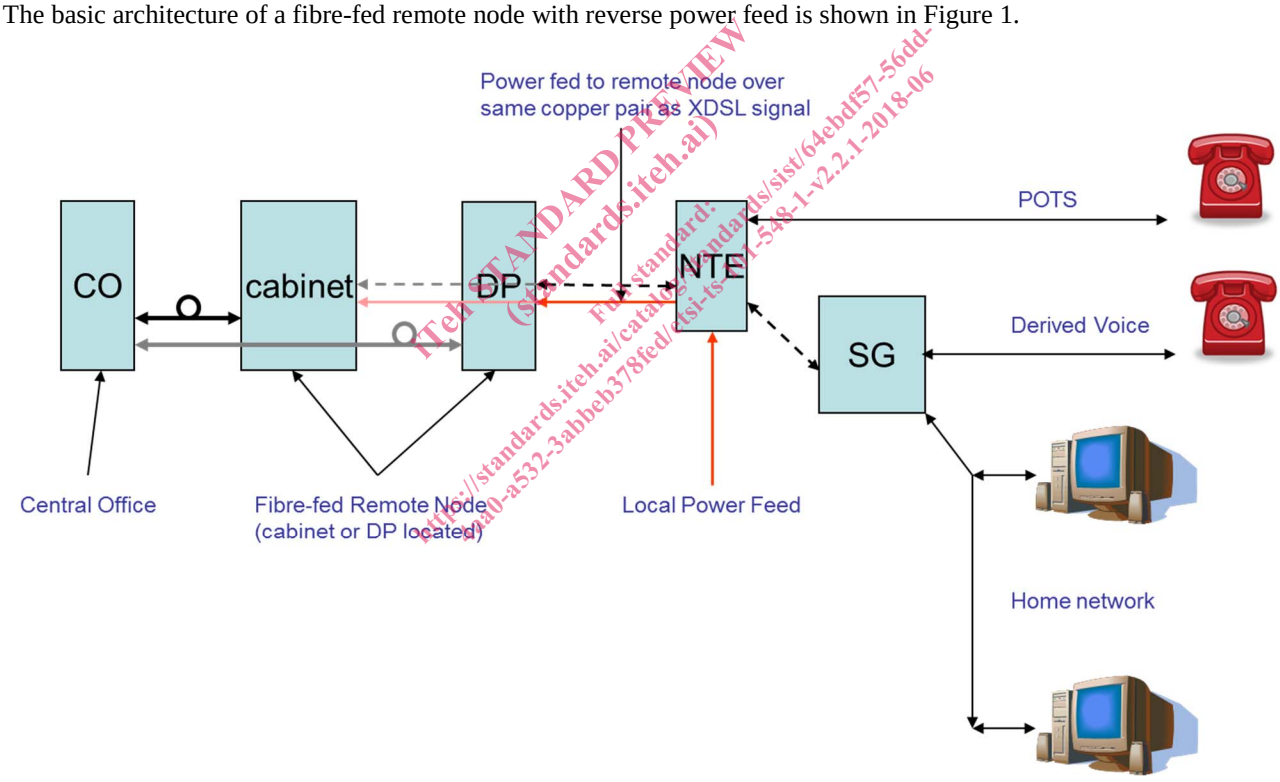


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**Figure 1: Generic Fibre-fed Remote Node Architecture with reverse power feed**

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 DPU location.

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 |

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# 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 feed will be removed and the 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, DC feed and the signalling are 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.

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### 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 feed 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) Restore the downstream DC feed while providing sufficient current limit and DC voltage to supply one or more phone devices.